Bailey, V. — Pocket gophers of the United States. (1895)

V. BAILEY
1895

BULLETIN No. 5.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ORNITHOLOGY AND MAMMALOGY

THE POCKET GOPHERS OF THE UNITED STATES

PREPARED UNDER THE DIRECTION OF DR. C. HART MERRIAM
CHIEF OF DIVISION

BY

VERNON BAILEY
CHIEF FIELD AGENT

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1895

GEORGIA GOPHER, GEOMYS TUZA (Ord.).

BULLETIN No. 5.

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF ORNITHOLOGY AND MAMMALOGY

THE POCKET GOPHERS OF THE UNITED STATES

PREPARED UNDER THE DIRECTION OF DR. C. HART MERRIAM
CHIEF OF DIVISION

BY

VERNON BAILEY
CHIEF FIELD AGENT

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1895

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., January 31, 1895.

SIR: I have the honor to transmit herewith Bulletin No. 5 of this division, treating of the habits, economic status, and means of destruction of the Pocket Gophers of the United States. It has been prepared by Vernon Bailey, chief field naturalist of the division, and is complementary to a technical paper on the group this day issued by the division (North American Fauna, No. 8).

Respectfully,

C. HART MERRIAM,
Chief of Division of Ornithology and Mammalogy.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	9
General habits	10
Underground life	10
Burrows	12
Mixing the soil	13
Hibernation denied	13
Food	14
Drink	14
Use of pouches	14
Abundance	16
Breeding	16
Disposition	16
Voice	17
Gophers as an article of food	17
The teeth	17
Structure and manner of attachment	17
The teeth as a cutting machine	18
Damage done by Gophers	19
Injury to roots, tubers, and garden vegetables	19
Injury to other farm crops	20
Injury to trees	20
Injury done by the burrows	20
Natural enemies of Gophers	20
Methods of destruction and exclusion	23
Bisulphide of carbon	23
Fumigation	23
Trapping	23
Poisoning	24
Use of wire netting	24
Trenches	25
Bounties	25
Objections to the bounty system	26
Geographic distribution of the Pocket Gophers	28
The species of *Geomys*	29
Habits of the Georgia Gopher (*Geomys tuza*)	31
Prairie Gopher (*Geomys bursarius*)	33
Plains Gopher (*Geomys lutescens*)	39
Louisiana Gopher (*Geomys breviceps*)	40
Sandy Gopher (*Geomys arenarius*)	43
Padre Island Gopher (*Geomys personatus*)	43
Baird's Gopher (*Cratogeomys castanops*)	44
Gray Gopher (*Thomomys talpoides*)	44

LIST OF ILLUSTRATIONS.

Frontispiece: Georgia Gopher (*Geomys tuza*).

Fig. 1. Face of Prairie Gopher (*Geomys bursarius*), showing grooved front teeth and opening of cheek pouches.

2. Face of Gray Gopher (*Thomomys talpoides*), showing plane front teeth and opening of cheek pouches.

3. Left forefoot of Padre Island Gopher (*Geomys personatus*), showing the rows of bristles which form brushes on the sides of the toes.

4. Outline of skull of Mexican Gopher, showing teeth in normal position.

5. Base of small apple tree with roots gnawed off by Pocket Gopher.

6. Map showing geographic distribution of the three genera of Pocket Gophers of the United States.

COLORED PLATES.

Red or Prairie Gopher (*Geomys bursarius*).

Gray Gopher (*Thomomys talpoides*).

COLORED MAP.

Geographic distribution of Gophers of the genera *Geomys* and *Cratogeomys*.

THE POCKET GOPHERS OF THE UNITED STATES.

INTRODUCTION.

The aim of the present bulletin is to give a popular account of the Pocket Gophers of the United States.

The name 'Gopher'[1] is applied to these animals throughout the greater part of the region they inhabit, though in the Southern States they are commonly called 'salamanders.' Since the real salamanders are lizard-like animals, once believed to live in the fire, it seems probable, as suggested by Dr. Goode, that the name was given to the Gophers from the sudden appearance of their fresh mounds on ground recently blackened by fire. In the Mississippi Valley the name Gopher is used for the ground squirrels as well as the Pocket Gophers, while in the south a burrowing turtle (*Gopherus polyphemus*) is called by the same name. From the Gophers' habit of living underground they are sometimes confounded with the moles. A greater mistake could not be made, for the moles belong to the widely different order of insectivores and are among the most beneficial of mammals.

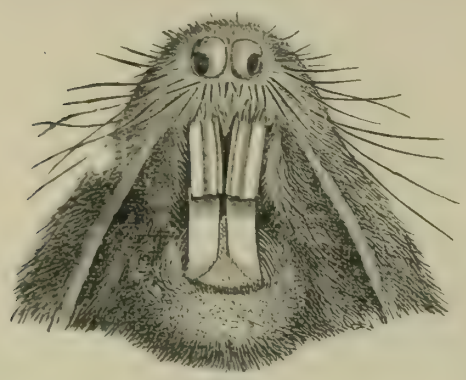
The Pocket Gophers are sturdy little animals, well adapted to underground life. Their bodies are stout and compact, their eyes are small, almost rudimentary, and their front feet are armed with strong, curved claws for digging. The appearance of a characteristic species is shown in the frontispiece. Gophers can lay no claim to beauty, either in graceful form or in pleasing contrast of colors; but their coats of plain earthy browns harmonize perfectly with the color of the soil. What seems like fur is in reality soft, silky hair, with a smoothness and gloss that repels the dirt and keeps the animal bright and clean though in constant contact with the soil. Such beauty as they have lies in their perfect adaptation to a peculiar mode of life.

Pocket Gophers belong among the rodents or gnawers. In general they may be recognized by their peculiar form, already described, and by the presence of cheek pouches opening outside of the mouth. The only other mammals having external cheek pouches are the pocket mice and kangaroo rats, which differ from the Gophers in slender, graceful forms, long tails, and long hind legs. The Gophers may be subdivided

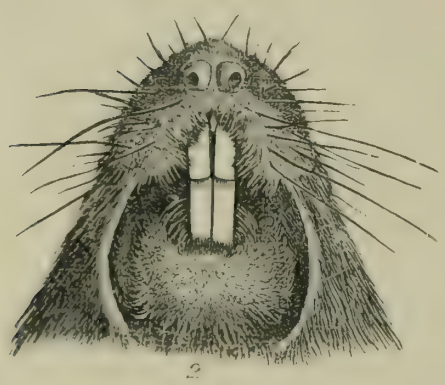
[1] From *Gaufre* of the early French explorers

into two groups, those with grooved front teeth and those with smooth front teeth (see figs. 1 and 2).

The harmfulness of these animals is perhaps best shown by the fact that single counties have paid for their destruction in one year as much as $14,000.* That animals living below the surface of the soil, rarely seen and to most people unknown, can be the cause of enough mischief to bring such a price upon their heads may surprise many people. A careless observer might travel for weeks over the western prairies and not be aware of their presence, and yet the buffalo and antelope in their past abundance were not one-tenth as numerous. Unlike larger animals, Gophers do not disappear before man unless as the result of his direct and continuous efforts toward their destruction. They remain in his fields working havoc among crops, killing his choicest trees, eating the roots from garden vegetables, and destroying meadows and fields of grain. They breed and multiply beneath his very feet, and work as silently and unobservedly as the frost, while the result of their work is shown above their tunnels by lines of whithering and dying plants.



1



2

FIG. 1.—Face of *Geomys bursarius*, showing grooved upper incisors and opening of cheek pouches.

FIG. 2.—Face of *Thomomys talpoides*, showing plane upper incisors and openings of cheek pouches.

There is another side to the question, and the Gophers should be given full credit for the important part they have played in mixing and enriching soils. Still, the verdict must go against them. We must protect our crops.

There is no demand for legislation or for any concerted action. The bounty system has been repeatedly tried and has always proved a failure and a waste of the funds of county or State, as shown beyond. There is little difficulty in destroying the Gophers on a farm, and once reduced their numbers may be easily controlled.

GENERAL HABITS.

Underground life.—Even where Gophers are so numerous as to be exceedingly troublesome, few people are familiar with them in life; they keep so close to their underground tunnels as to be rarely observed unless caught in traps. By patient watching a little brown head may

* Poweshiek County, Iowa, paid $14,000 in bounties, at the rate of 10 cents a scalp, in 1890.

sometimes be seen for an instant while the animal pushes a load of earth from a freshly opened hole; and on rare occasions the whole animal appears above ground but disappears again so quickly that the eye hardly catches its form. Still more rarely one may be met with following a road or path remote from its hole.

As Pocket Gophers spend their lives underground, their whole organization is modified in accordance with the needs of a subterranean existence. The different kinds, though numerous, are very much alike externally. They are short-legged, thickset animals, without an appreciable neck, without noticeable external ears, and with very small eyes. The feet are largely developed for digging. The forepaws in particular are very strong, are armed with long curved claws, and the sides of the toes are lined with rows of bristles that evidently serve in preventing the dirt from passing between the fingers (fig. 3), thus completing a more effective arrangement for keeping the tunnels clean, and for pushing the earth out of the openings in the burrows. The tail, which is of moderate length, is thick, fleshy, and usually devoid of hair, and is endowed with tactile sensibility.

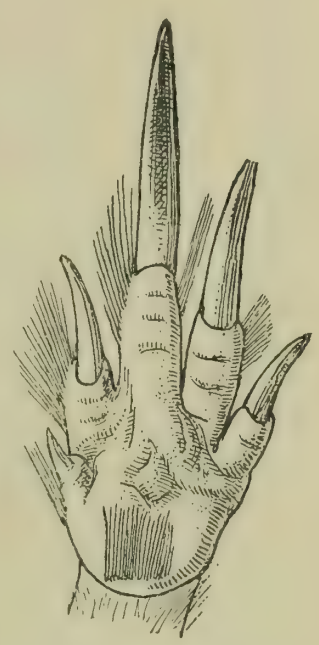


FIG. 3.—Left forefoot of *Geomys personatus*, showing the rows of bristles which form brushes on the sides of the toes.

The Pocket Gophers, in working their way through the earth in the construction of their tunnels, use the powerful upper front teeth as a pick to loosen the ground. At the same time the fore feet are kept in active operation, both in digging and in pressing the earth back under the body, and the hind feet are used in moving it still farther backward. When a sufficient quantity has accumulated behind the animal, he immediately turns in the burrow and by bringing the wrists together under the chin, with the palms of the hands held vertically, forces himself along by the hind feet, pushing the earth out in front. When an opening in the tunnel is reached the earth is discharged through it, forming a little hillock that resembles in a general way the hills thrown up by moles. In many Gophers there is a naked callosity or 'nasal pad' over the anterior half of the nose, which must be of great assistance in the construction of the tunnels.

The substance of the following notes on the habits of a live Gopher in captivity is from a technical paper recently published by Dr. C. Hart Merriam:*

A Pocket Gopher from Vernon, Texas, ran backward as rapidly and easily as forward. This method of progression was particularly noticeable when the animal could follow a runway or other accustomed route. When carrying food to one of his storehouses he rarely turned around,

* North American Fauna, No. 8, January 31, 1895.

but usually ran backward to the place of deposit, returning for more, and repeating the operation again and again, the to-and-fro movement suggesting a shuttle on its track. The well-known peculiarity of the external genitalia, which are so hidden and modified that the sexes are determined with difficulty, is doubtless the result of this habit, protecting the parts from injury when the animal is moving backward.

In all Pocket Gophers the tail is rather large and fleshy, and as a rule is naked or scantily haired. Its function had long been a puzzle, but the Gopher above mentioned used it as an organ of touch when running backward. The tail is doubtless endowed with special sensibility and is evidently of great value in warning the animals of the presence of an enemy in the rear when they are traveling backward in their dark tunnels.

In walking on soft ground the forefeet are usually held in the normal position, with the soles down, or inclined slightly inward. In walking on hard ground, however, the forefeet are turned sideways, their soles facing one another, so that the claws curve inward, and the animal walks on the outer or ulnar side of the foot. This method of using the forefoot in walking on hard substances was frequently observed, and enables the animal to walk comfortably where the long curved claws would be in the way if held in the normal position. It was also frequently noticed that the feet were held in the same position (horizontally) when at rest, and when used as a scoop in pushing loads of earth or sand out of the way. When thus engaged the feet were drawn back under the breast, the wrists near together and the long claws turned outward. By moving the body quickly forward the animal always succeeded in throwing ahead of it a considerable quantity of loose earth.

Burrows.—Gopher burrows seem to have neither beginning nor end. They are extended and added to year after year, and in many cases those dug by a single animal would measure a mile or more if straightened out. I have never attempted to ascertain the actual length of one, but feel secure in making the above statement. At the end of a year a Gopher may often be found within 20 rods of the point from which he started, but in traveling this distance he has paid no attention to the points of the compass. He follows a tender root for a few feet, then moves to one side, encounters a stone, and makes a second turn. A layer of mellow soil entices him off in another direction, and so on through a thousand devious crooks and turns. Sometimes the main passage swings around and crosses itself, or numerous side branches are extended varying distances. The main tunnel usually runs from 6 inches to a foot below the surface. At intervals varying from a few feet to a few rods openings are made through which to discharge the earth that makes the little piles called 'gopher hills.' The openings are closed by being packed so full of dirt that no trace of the runway is visible except the little mounds that mark its course. An average-sized gopher hill contains 5 or 6 quarts of earth, but the quantity

varies from a pint to a bushel. They are generally circular and a foot or more in diameter. The quantity of dirt in each varies greatly with different kinds of soil and according to the distance between the hills. In mellow soil both holes and hills are larger than in hard soil. I once counted the hills thrown out by three Gophers (*Geomys bursarius*) twelve days after a rain. The numbers were respectively 28, 35, and 40. As the Gophers work all summer and to some extent through the winter, the total quantity of earth brought to the surface and the total area covered are considerable. For example, in the central part of Minnesota, where the ground is unfrozen for seven months in the year, the lowest number in the three cases mentioned, 28 hills in twelve days, would result in 490 hills in seven months, or at least 500 square feet of ground covered over with subsoil in one year by one Gopher.

Mixing the soil.—That Gophers have done great good in preparing the land for cultivation can not be denied. For unknown ages they have been steadily at work plowing the ground, covering deeper and deeper the vegetable matter, loosening the soil, draining the land, and slowly but surely cultivating and enriching it. On the prairies that are swept each year by fire, the only vegetation remaining to decay and fertilize the soil is that which the gopher hills cover and protect from the flames. On poor, sandy soil the scant vegetation would dry up, blow away, and only a small amount find its way into the soil were not the gophers busy all summer burying the fresh plants. Carefully scrape away a gopher hill that has been standing for six months and a layer of decayed plants will be found under it. In a year or two new plants will spring up on the spot and draw their nourishment from the elements of former growths, these again in time to be buried and add their substance to the wealth of the soil. Hence it would be well to examine their habits carefully before condemning the Gophers that occupy wild pastures and idle land.

Hibernation.—Although Gophers are supposed to hibernate, there is abundant evidence that they do not. While all hibernating animals become very fat in autumn, as a preparation for their long winter's fast, Gophers never undergo such a change. Moreover, during snowy winters when the ground is not frozen they continue their work under the snow. When the snow is light, hills may be thrown up under it in the ordinary way, but if it becomes too hard to be readily pushed aside, the animals excavate tunnels in it into which they push the earth. As the snow disappears in spring cylinders of packed earth are frequently seen radiating from the closed ends of gopher holes. They are sometimes 20 feet long. Throughout the northern part of the gopher country the ground usually remains frozen during most of the winter. Then the Gophers do not appear at the surface at all, but are probably extending their tunnels below the frost, where food is obtained from deep running roots. To what extent they depend on the stores laid up in fall is hard to tell. Part of the supply is sometimes used,

but frequently the spring plowing turns out an untouched and moldy store left from the preceding year. Of course the supply of food encountered in extending their tunnels determines whether the stores shall be drawn upon.

Food.—The food consists chiefly of roots, tubers, and other rather hard vegetable substances, though grass and the succulent parts of plants are sometimes eaten. In agricultural districts the animals are highly injurious, destroying potatoes and other tubers in large quantities, and gnawing off the roots of fruit trees. When a burrow strikes the roots of a tree, it is carried around among them until one after another the smaller ones are cut off and eaten and the bark stripped from the larger ones so that the tree is almost invariably killed. If the tree is not large every root is sometimes cut off, and the first breeze tips it over.

Drink.—So far as known Pocket Gophers do not drink. Like other rodents of arid regions they obtain the necessary water from the plants on which they feed. Persons who have kept Gophers in confinement—Dr. Goode, Dr. Merriam, Professor Herrick, and Mr. J. B. Parvin—have never been able to make them drink.

Use of pouches.—Though their eyes are small and their range of vision limited, the Gophers lose little thereby in the dark underground passages. Touch, taste, and smell, take the place of sight as guides in selecting the roots with which they are constantly coming in contact while excavating their endless tunnels. They have broad, chisel-like teeth for cutting these roots, and large, fur-lined pockets in their cheeks in which to carry their food. Under cover of overhanging vegetation they fill these pouches with green leaves and stems to carry back and eat at leisure in their holes. In half a minute enough food for a good meal may be collected and stowed away, while a much longer time would be required to eat the same where collected. This arrangement is especially important to the Gophers from the fact that their sight is not keen. Probably their vision is better at night, or at least during the twilight, for then they are most active.

Chipmunks, squirrels, and ground squirrels take food in their mouths and with the tongue push it out between the teeth into an elastic pouch, just as boys put marbles in their cheeks. In the squirrels and chipmunks the cheek pouches communicate with the mouth. In the Pocket Gopher (also in all species of pocket mice and kangaroo rats) the pouches open from the *outside* along the front of the cheeks. They extend back under the skin to the shoulders, are lined with short hair, and are enveloped by muscles. The way in which Gophers fill their cheek pouches is thus described by Dr. Merriam in the technical paper already referred to:

A live *Geomys* from Vernon, Texas, has been carefully observed for the purpose of ascertaining how the reserve food is placed in the cheek pouches. The animal soon became sufficiently tame to eat freely from the hand, and was commonly fed bits of

potato, of which he was particularly fond. The manner of eating was peculiar and interesting, and showed an ability to use the huge forefeet and claws in a way previously unsuspected. After satisfying the immediate demands of hunger it was his practice to fill one or both cheek pouches. His motions were so swift that it was exceedingly difficult to follow them with sufficient exactness to see just how the operation was performed. If a whole potato was given him, or a piece too large to go into the pouch, he invariably grasped it between the forepaws and proceeded to pry off a small piece with the long lower incisors. He would then raise himself slightly on his hind legs and hold the fragment between his forepaws while eating, for he usually ate a certain quantity before putting any into the pouches. If small pieces were given him he took them promptly and passed them quickly into the pouches. Some pieces were thus disposed of at once; others were first trimmed by biting off projecting angles. As a rule one pouch was filled at a time, though not always, and the hand of the same side was used to push the food in. The usual course is as follows: A piece of potato, root, or other food is seized between the incisor teeth, and is immediately transferred to the forepaws, which are held in a horizontal position, the tips of the claws curving toward one another. If the food requires reduction in size, the trimming is done while held in this position. The piece is then passed rapidly across the side of the face with a sort of wiping motion which forces it into the open mouth of the pouch. Sometimes a single rapid stroke with one hand is sufficient; at other times both hands are used, particularly if the piece is large. In such cases the long claws of one hand are used to draw down the lower side of the opening, while the food is poked in with the other. It is obviously impossible for the animal to pass food from the mouth to the pouches without the aid of its foreclaws.

The most remarkable thing connected with the use of the pouches is the way they are emptied. The forefeet are brought back simultaneously along the sides of the head until they reach a point opposite the hinder end of the pouches; they are then pressed firmly against the head and carried rapidly forward. In this way the contents of the pouches are promptly dumped in front of the animal. Sometimes several strokes are necessary. I am not prepared to say that the animal can not empty the pouches by means of the delicate investing muscles, but I have never seen them emptied in any other way than that here described.

The pockets are often stuffed so full of pieces of roots, stems, and leaves as to distort the appearence of the animal's head. Roots and stems are cut in sections about an inch long, so as to fit the pockets nicely, and are packed in lengthwise. Leaves are folded or rolled to fill the smallest space.

Although it is commonly supposed that the pouches are used for carrying dirt out of the holes, the fact is they are never used for this purpose. In examining the pockets of more than a hundred specimens caught in traps I could find no evidence that any had been filled with earth. Occasionally specks of dirt from roots cling to the hairy inner surfaces; nothing more. If the pouches had been filled with earth, the short hairs would inevitably retain some of it. Furthermore, Gophers shot in the very act of pushing dirt from their holes had none in their pouches. The method of removing earth from the burrows, as observed in live Gophers, has been already described (p. 11).

The Gophers are industrious workers, and whatever food is found and not needed at once is carried to chambers in some part of the tunnel and stored. Frequently a plow breaks into these storehouses

and scatters their contents. Sometimes a peck of small potatoes, roots of coco grass, wild parsnip, wild sunflower, and other fleshy or bulbous roots are found in a single chamber.

Abundance.—Gophers are abundant over a large part of the Mississippi Valley, where I have estimated their numbers to be, in some places, three or four to the acre. This estimate will apply to considerable tracts of country throughout their range. In general they are most numerous on light, sandy soil. Farmers are sometimes of the opinion that Gophers injure their fields by bringing to the surface the bare clay or sand from below the reach of the plow. This may possibly be true in places where the soil is shallow and the subsoil poor, but they are, as already shown, more often a positive help to the agriculturist in mixing the soil.

Breeding habits.—Early in spring, before the snow is fairly gone, a male Gopher is sometimes found following a road or path. He has left his burrow and is seeking a mate. At this season a pair may be caught in one burrow, but at other times they are solitary. Apparently only the males leave the burrows in quest of mates, though positive information on the subject is difficult to obtain. The few that have thus come under my notice have been, without exception, males. The few facts known concerning the time of breeding and number of young are given under the head of the Prairie Gopher (*Geomys bursarius*).

Disposition.—In disposition the Pocket Gophers are naturally vicious. When caught in traps they fight with a ferocity that would be formidable in larger animals, and if nothing else comes within their reach they bite a steel trap with such force as to break off their teeth. They will bite through a heavy shoe with the greatest ease. They seem to have no sense of fear. The few that I have met away from their holes have, without any provocation on my part, attacked me with the utmost fury, as if bent upon killing and devouring me. They would bite at my feet or any part of my person that came within reach, all the time uttering a wheezy, panting sound, expressive of anger. Even the half-grown young show the same fierce disposition. No doubt they could be tamed and made gentle if taken when young, and might make as interesting pets as the one described by Dr. Merriam. Professor Herrick, speaking of one he had in captivity, says: "After a short time he became perfectly tame and an engaging pet."

My one effort at domesticating a Pocket Gopher was a failure, probably because the Gopher was old and hardened in his ways. He was placed in a large box in which a partition with a hole through it separated one-half, filled with dirt, from the other half, which was open. Plenty of food and nest material were placed in the box, but the Gopher paid little attention to them. His one effort was to burrow out of the box. Beginning at the hole in the partition he pushed the dirt through into the vacant side, then brought it back. The dirt was pushed, not carried in the pockets. For several days he worked almost

incessantly, moving the dirt back and forth. He would sometimes stop and scratch or gnaw the wood, but to no great extent. He would eat raw potatoes when no one was near, but would stop eating or working to try to fight anything that moved within his range of vision. He always tried to bite when I stroked him, and finally, after he had succeeded in putting his teeth through the end of my finger, I gave him his liberty.

The fierce disposition is just what might be expected from the solitary mode of life. From the time the young are half grown and big enough to start burrows of their own, each individual lives entirely alone, except during the short mating season in early spring. Living alone and in the dark for eleven months of the year is not calculated to develop a lovable disposition. To the same causes—darkness and solitude—may also be attributed the Gopher's small eyes and ears, narrow brain case, and undeveloped voice.

Voice.—The usual hissing sound made when angry seems to have no connection with the vocal organs, but to be the result of rapid inhalation and exhalation through the half-open mouth. Perhaps the hairy lining of the mouth aids in producing the sound. When the Gophers are caught and held firmly in the hand, or in any way hurt, they sometimes utter a sharp squeal that expresses either pain or a climax of rage. It is rarely heard, however. In handling a large number of the animals alive I can recall but three instances in which they gave vent to this cry.

Mr. Edwin A. Donald, in an interesting letter on the Pocket Gopher, says: "I have killed scores of them, and the only outcry, when struck, that I ever heard was on one occasion, when the animal gave a faint squeak, like a mouse, but not so loud. All the others I have killed died silent."

GOPHERS AS AN ARTICLE OF FOOD.

Unless they are too small, there is no reason why Pocket Gophers should not be used as food. Their habits are cleanly and in no way objectionable. They are strict vegetarians. Sometimes, from eating onions, leeks, or other strong plants, their flesh has an unpleasant odor, but usually it is sweet and tender. Mr. H. P. Attwater, of San Antonio, Texas, writes the division that "the German settlers on St. Charles Peninsula, in Aransas County, Texas, used to eat the Gophers, and pronounced them excellent."

THE TEETH.*

Structure and manner of attachment.—All of the Pocket Gophers have the same number of teeth, namely, 20; 10 above and 10 below. There are 5 on each side of each jaw—a large cutting tooth in front (the

* Abstract by Dr. Merriam of part of his article on the 'Dynamics of the Teeth,' from N. Am. Fauna, No. 8, 1895.

incisor) and 4 smaller grinding teeth behind (the premolar and molars). All of the teeth are simple, rootless, tubular prisms, closed at the top and open at the base. In life the lower part is filled with a soft pulp-like substance, supplied with blood vessels which replenish the tooth from below, enabling it to grow as long as the animal lives. The hardening of the pulp within the tooth forms the dentine and osteodentine; the enamel and cement are deposited on the outside. In the adult the enamel is attached to the outside in the form of vertical plates or bands like staves on a barrel.

Each incisor is provided with a single band of enamel, which covers the front face of the tooth and forms the chisel-like cutting edge. The premolar has 3 or 4 plates. The true molars have 2 each in the genus *Thomomys*. In the genus *Geomys* the last upper molar always has 3 plates and the lower molars 1 each. The upper intermediary molars

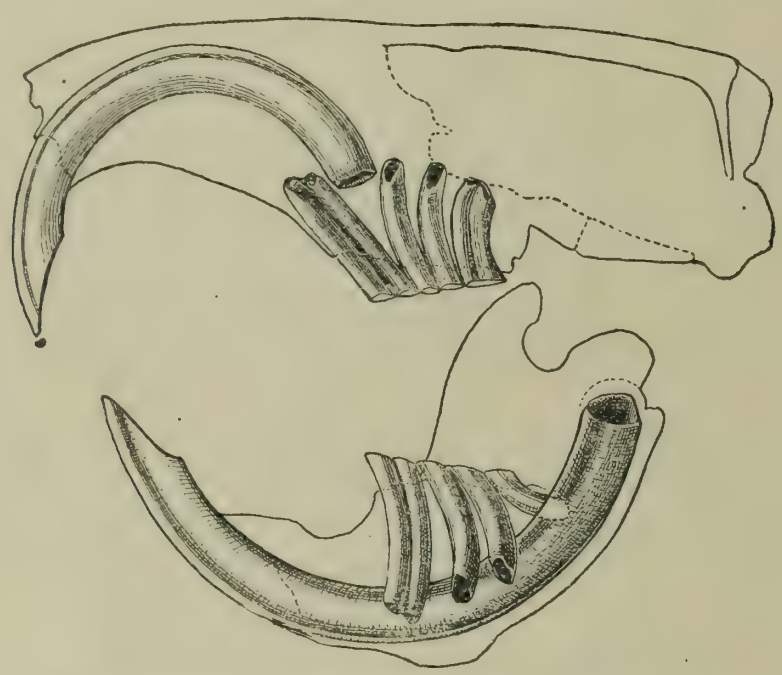


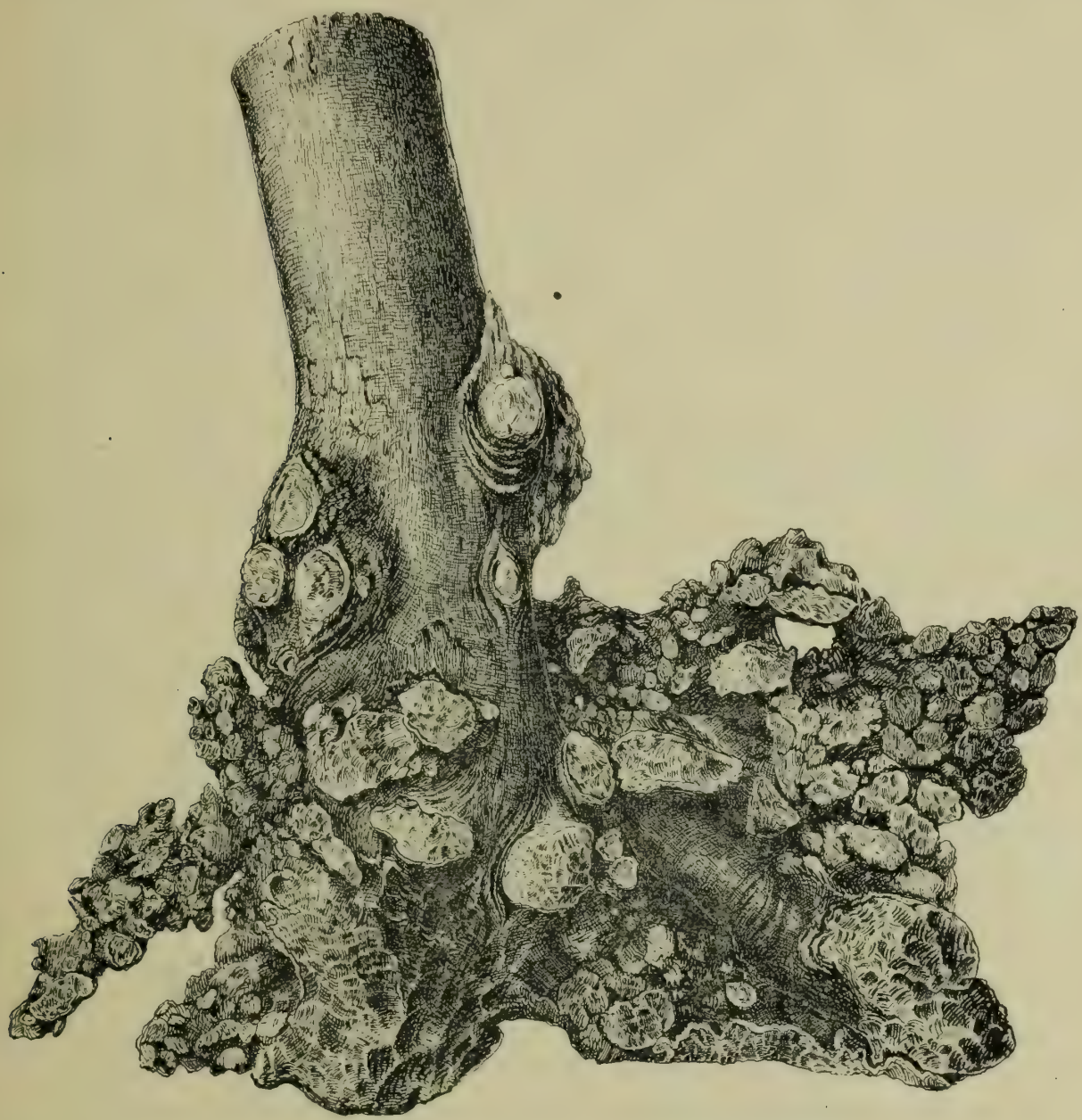
FIG. 4.—Outline of skull of Mexican Gopher, showing teeth in normal position.

have 2 each in *Geomys*, but only 1 in Baird's Gopher (*Cratogeomys castanops*). The free ends of the enamel plates project slightly beyond the rest of the tooth, forming effective cutting blades.

All of the teeth are attached to the sockets by means of vertical cushions which extend from root to gum. This method of attachment not only relieves the tender pulp at the base of the tooth from pressure, but gives to the cutting edge an elasticity that is highly effective.

The teeth as a cutting machine.—The destructiveness of the Gophers in cutting and slicing roots may be better understood from a study of the machinery that does the work. The upper front tooth or incisor is used chiefly to anchor the animal to the root operated on, while the lower incisor does most of the work, playing rapidly back and forth like a steam drill until a piece is cut off and passed into the mouth, where it is planed or sliced into fine particles, ready to be taken into the stomach for digestion. The cutting edges of the enamel plates of the molar teeth are the tools that reduce the food. In the Gophers of

the Mississippi Valley and Southern States, the plates are arranged in such a way that 38 distinct single cuts are made by the forward stroke of the jaw and 28 by the backward stroke. In a tame Gopher it was ascertained by actual count that 200 complete strokes are made each minute. On this basis the number of cuts made each minute on the forward stroke would be 7,600, and on the backward stroke 5,600, making a grand total of 13,200 cuts a minute while the jaws are in active operation.



IG. 5.—Root of apple-tree gnawed off by Pocket Gopher.

DAMAGE DONE BY GOPHERS.

Gophers injure farms in two different ways: By eating crops and by burrowing in hillsides, meadows, and the banks of artificial water courses. Full accounts of the damage done may be found in the special articles on the different species. Here it is necessary to mention the ravages in a general way only.

Injury to roots, tubers, and garden vegetables.—Gophers are especially fond of starchy, tuberous or bulbous roots like potatoes, turnips, car-

rots, beets, onions, and parsnips. These are cut below the surface and eaten on the spot, or carried away to be stored for future use.

Injury to other farm crops.—Certain crops, such as corn, wheat, oats, barley, rye, and alfalfa are cut above the ground and carried down into the burrows. Squashes, pumpkins, melons, and the like are sometimes gnawed into from below and the inside eaten out.

Injury to trees.—Gophers eat the roots of fruit trees and of trees planted for shade, ornament, or timber. Very great harm is done in this way. All the roots may be cut so that the tree falls at the first wind. The base of such a tree is shown in figure 5.

Mr. Byron Andrews, manager of the Boston Commonwealth, writes that at his farm in South Dakota Gophers have proved very troublesome in a 10-acre nursery of white ash trees five years from the seed. In one dry summer they cut away the roots of the young trees so that when touched the trees fell. "The Gophers would take every tree not missing one for ten or twelve feet in a row, and then cut across and go up the next row. In a few weeks they thus destroyed about one-half of the nursery.

Injury done by the burrows.—Gophers' burrows on hillsides often cause very serious washing in rainy weather. Meadows are damaged by the mounds of earth thrown out from the tunnels as well as by the tunnels themselves. Still greater injury is done by the burrows in the banks of canals and irrigating ditches. Thus, in about twelve years, a large irrigating canal nearly 25 miles long, at Riverside, Cal., became almost unfit for use on account of the holes bored in its banks by Gophers. In Weld County, Colo., suit was brought against the town of Greeley for damage done by the breakage of a canal caused by the burrowing of Gophers in the banks. One person secured a judgment of $750 on the ground that the town did not properly superintend the canal.

NATURAL ENEMIES OF POCKET GOPHERS.

From their manner of living below the surface of the ground and in holes carefully closed, Gophers would seem unusually safe from natural enemies. Compared with most mammals they are, but occasionally a fox or cat pounces upon one as it brings out a load of dirt in the twilight. Hawks and owls pick one up now and then and weasels often enter the burrows and dine upon the occupants. I have taken one from the stomach of a fox, while the stomach of a wildcat shot by Dr. C. Hart Merriam on San Francisco Mountain, Arizona, contained two.

As Gophers are most active during the evening and early night, more are captured by owls than by hawks. This is shown by Dr. A. K. Fisher, in his Hawk and Owl Bulletin, where it is stated that two were found in the stomachs of marsh hawks, four in red-tailed hawks, four in great horned owls, and eight in barn owls. The barn owl is

especially serviceable in destroying Gophers. The following extract from a letter by Clark P. Streator gives important testimony on the subject: "In examining a large number of nests, at all months of the year, I have found nothing but Gophers [*Thomomys*], except on one occasion, when there were one or two Brewer's blackbirds. On further investigation I found a deposit of pellets of nothing but Gopher hair and bones, which had been ejected by the owls, and had accumulated in a few instances to the extent of two or three cubic feet in the trees in which the birds lived. I also found that in the breeding season it was not uncommon to find six or more Gophers, that were not eaten by the young, lying about the nest. I have found Gophers in the nests at other times than the breeding season, but not in such abundance."

In Arizona, a few years ago, I discovered numerous small bones on the bottom of a cave. They were the bones of rodents, and evidently had been brought by owls and disgorged as pellets. In about a quart of these bones were 43 skulls of the Gopher common in that locality. Nothing is known as to what owl inhabited this cave. Several are common in the region.

Mr. Ernest E. Thompson, writing of the Gray Gopher (*Thomomys talpoides*) in Manitoba, says: "The earliest seasonal record that I have for this species is as follows: April 12, 1883, 'Snowy owl shot by Mr. Arthur S. Thompson, and brought to me, had in its claws a pocket mouse,* whose pouches were full of roots.' Mr. Miller Christy writes me from western Manitoba as follows: 'May 5, 1887, found a nest of the horned owl (*Bubo virginianus*) in a poplar tree on the prairie. Besides the two fledgling owls, it contained the remains of 20 pocket mice* in various stages of decay.' The above is all the evidence I can give to show that the animal ever appears above ground."

Badgers spend much time and energy in digging open gopher holes, but rarely succeed in catching the Gopher. After digging far enough to convince themselves that the burrow is interminable they abandon the effort, and with better results turn their attention to ground squirrels.

There are two enemies that more than all others hold in check the increase of the Pocket Gophers—the weasel and the bull snake. Of these, weasels rank first, bull snakes (*Pituophis*) second. Whenever a weasel enters a gopher hole the Gopher is his prey. There is no possibility of escape. The largest weasel is small enough to enter their burrows easily and travel quickly through them. In localities inhabited by weasels I have found much difficulty, even when old gopher hills were numerous, in catching enough Gophers for specimens. Mr. L. C. Cummings, a well-known nurseryman of Riverside, Cal., writes: "At one nursery we were bothered with Gophers; all at once the Gophers became scarce, and from one to four weasels could be seen nearly every day running through the nursery and over an adjoining hill. They

* Mr. Thompson uses the erroneous term 'pocket mouse' for these Gophers. Pocket mice are widely different animals and belong to another family.

killed all the Gophers. We have a few weasels yet, but do not know how long they will stay. As Gopher exterminators they have done well."

Notwithstanding these facts weasels are almost universally condemned, and killed whenever opportunity offers.

The bull snake or gopher snake, which often attains a length of more than 6 feet and is heavily built, enters a hole that by accident may have been left open, and, following the Gopher to the end, swallows him. Mr. B. H. Dutcher, a field naturalist of the division, contributes an interesting account of a case that fell under his observation at Cairo, Kans. He says: "On going to my gopher traps one morning I found that one of them had been drawn 3 or 4 inches into the burrow. Taking hold of the chain I attempted to pull out the trap, but met with a steady resistance somewhat greater than that of which I considered a Gopher capable. Increasing the strain, the opposing force was suddenly removed and the trap emerged from the hole, with a dead Gopher in its jaws. On examination, the hind end of the Gopher for about half its length was found to be wet and covered with slime. Surmising 'snake,' I proceeded to my next trap, some 30 or 40 feet away, where I found that a similar tragedy had taken place. Here a large yellow bull snake (*Pituophis*), perhaps 5 feet long, had either pushed or pulled the Gopher from the hole some 2 or 3 feet, and had then proceeded to try to swallow him. He had succeeded in his efforts until the Gopher's neck was reached, where an unexpected obstacle was encountered in the trap, the jaws of which were tightly clasped just behind the head. When found, the snake was tying himself up into knots in vain endeavors to engulf the trap also. On my seizing the trap chain and trying to pull his prey away from him, the snake suddenly loosened his hold and quickly drew his head away from the Gopher."

In one instance only have I found a full-grown Gopher in the stomach of one of these snakes, but the fact that they habitually feed on them gives the snake its name. Notwithstanding the fact that these snakes are known to be perfectly harmless, most people kill them at every opportunity.

From time to time it is announced that Gophers may be killed or driven away by the use of a certain plant supposed to be poisonous or exceedingly distasteful to them. Wherever this plant is grown, Gophers it is said, cease their depredations. So important is this matter that it has been investigated by the agricultural experiment station of the University of California.

From this study it appears that the plant is well known in gardens, both here and abroad. It is cultivated on account of its ornamental flowers and fruit and is known as the giant spurge, false caper, or cross of Malta (*Euphorbia lathyris*). In parts of Europe the fruit is used for pickling. The spurge has a milky juice and is somewhat poisonous,

serious sickness of children being caused by eating its attractive berry-like seed vessels. On the Gophers of the experiment station grounds, however, it had absolutely no effect, the animals thriving as well in fields where the spurge was grown as elsewhere. But the author of the bulletin, Mr. E. J. Wickson, states that the soil of the station garden "is a stiff adobe, and cases of success with the plant have been mostly reported from regions with sandy soils." (See Bull. 95, Calif. Agl. Experiment Station.)

METHODS OF DESTRUCTION AND EXCLUSION.

Bisulphide of carbon.—In most cases bisulphide of carbon is the simplest agent for the destruction of Gophers. It may be used as follows: Open the gopher hole where one of the freshest hills has been thrown out. Pour two tablepoonsful of bisulphide on a bunch of cotton, rags, tow, waste, or any such material and push it well down into the hole; then close the opening. The bisulphide quickly forms a heavy suffocating gas that flows down the hole and along the galleries. Wherever it overtakes the Gopher he is quickly killed. The whole operation is perfectly simple and easy. The only difficulty arises from the length of the tunnels, which is so great that the animals may be beyond the reach of the gas. Hence it is sometimes necessary to open the tunnel and introduce the bisulphide at two or more places.

The gas has a vile odor. It should be carefully kept from fire, as it is highly inflammable and explosive; otherwise no danger attends its use.

Fumigation.—Rude pumps, known as 'fumigators,' by means of which the fumes of burning sulphur may be forced into the burrows to suffocate the occupants, are extensively used in some parts of the West, particularly in California. They are, however, clumsy, expensive, and less effective than bisulphide of carbon.

Trapping.—Gophers are easily trapped, and once exterminated in a field, others do not soon come in. Their manner of traveling is so slow that only those near the edge of a field will work in during a summer. In the spring the males in their wanderings may settle down in a new place, but this does not often happen. The process of trapping is perfectly simple, although many farmers have assured me that Pocket Gophers can not be caught in traps. Hence a few directions may be useful. Having selected a fresh hill and observed from which direction the earth is pushed out, dig down on that side until the open hole is found. Enlarge the hole sufficiently to admit a No. 0 steel trap and remove such loose earth as may have fallen in. The trap should be set very lightly, placed well down in the hole, sunk in loose earth to the level of the runway, and partly concealed by a sprinkling of fine earth. Finding its hole open the Gopher proceeds to repair the breach, in doing which he steps on the trap and is caught. If loose earth is left in the burrow it will be pushed out in front of the animal, covering the trap, so that it will fail to spring.

Other methods of trapping Gophers have been tried with varying success, and numerous kinds of traps have been devised for the purpose. Five of these are figured in a bulletin of the Oregon Agricultural Experiment Station (Bull. No. 25, April, 1893). Many of them are clumsy and expensive, and few, if any, can compete with the common steel trap when the latter is properly used.

Poisoning.—Poisoning is a simpler and more expeditious method of destroying Gophers than trapping, but is more laborious than the use of bisulphide of carbon. The use of poison is always attended with danger, for in spite of all precaution, other animals than those for which it was intended are liable to get it.

The usual method is to insert a small quantity of arsenic or floured strychnine into a piece of potato and push the potato as far as possible into a fresh Gopher's hole and then close the opening securely. The Honorable J. Sterling Morton, Secretary of Agriculture, has found arsenic on white potatoes and apples efficacious in destroying Pocket Gophers at his home in eastern Nebraska.

Phosphorus has been used extensively in California, Washington, and Oregon in destroying ground squirrels, and to a less extent for Pocket Gophers. Mr. Allen Chattin, of Charter Oak, Iowa, states that he has entirely exterminated the Gophers from his own and several neighboring farms by the use of phosphorus. His recipe is as follows:

Put a stick of phosphorus in a 5-gallon can with a little cold water; next pour in hot water, not quite boiling, until the can is half full, and stir with a stick. When the phosphorus is melted add, while the water is stirred constantly, 2 pounds of sugar, and immediately after the sugar is dissolved thicken to a stiff batter with corn meal and flour, half-and-half. Now add wheat and stir until stiff. While adding the wheat add also 15 to 20 drops of oil of rhodium. The wheat will soak up all the water in the mass and it will become quite hard. Keep in a cool place. Small pieces may be chipped off as needed. Gophers may get too little strychnine to kill them, but no matter how small a piece of phosphorus they get it will finally prove fatal. Dig down to an open hole, drop in a small piece, put a clod to keep the hole from filling, and cover over with loose dirt to exclude the light.

It should be borne in mind that phosphorus is one of the most deadly poisons. I do not wish to be held responsible for recommending the use of this or any other poison on the farm.

Use of wire netting.—In Bulletin No. 5 of the Oregon Agricultural Experiment Station it is stated that young trees may be protected by a cylinder of wire netting 2 feet in diameter and 2 feet in length placed around the roots when the tree is planted. The top of the cylinder should be 4 to 6 inches below the surface of the ground, and the bottom may be left open. Netting with a three-quarter inch mesh is recommended.

Trenches.—It has been asserted that a field may be protected by a trench at the bottom of which oil cans are sunk at intervals. The Gophers in trying to enter the field are supposed to fall into the trench, along which they move until caught by the oil cans.

BOUNTIES.

So great is the harm done by Gophers that in many places bounties are offered for the animals' scalps or tails. Bounties have been paid most extensively in Iowa, North Dakota, South Dakota, and Minnesota, and from these States have been received detailed accounts of the results of the system. In these reports, however, the ground squirrels and Pocket Gophers are seldom discriminated, so it is hard to form a just estimate of the proportional sums paid for each. To give an idea of the large sums expended in attempts to reduce the numbers of these troublesome animals it may be stated that thousands of dollars are often paid annually by one county for this purpose.

The following table gives a detailed account of the sums expended in Gopher bounties by the State of Iowa, for which the best returns have been received (from county treasurers):

Table showing amounts paid in Gopher bounties in Iowa, by counties.

County.	Date.	Bounty on each Gopher.	Amount specified as paid for Gophers alone.	Total paid for Gophers and ground squirrels—not discriminated.
		Cents.		
Adams	1877–1880	8⅓		*$800.00
Carroll	1875	15		1,458.65
Do	1877	15		1,378.70
Cedar	None for 15 or 20 years			
Dallas	1868–69	10?		†440.00
Fremont	1888	5		*250.00
Do	1889			
Hancock	1888			†1,150.00
Humboldt	June 1, 1888, to July 1, 1888.	10		2,198.01
Do	1889	10		2,400.00
Ida	1871			10.99
Do	1872			35.84
Do	1873			90.50
Do	1874			126.25
Do	1875			71.58
Do	1876			225.79
Do	1877			371.01
Do	1878			994.29
Do	1879			73.00
Iowa	1889	15		*7,782.30
Do	Feb. 1, 1890	10		
Jackson	1867	15	$109.95	
Do	1868	15	1,176.80	
Do	1869	15	532.80	
Do	1870	15	177.25	
Do	1871		9.60	
Do	1872			*2,007.75
Lucas	No bounty for 20 years	10		
Mitchell	do			
Page	April 5, 1875	15	886.75	
Do	April, 1876	10	1,438.60	
Do	1877	10	2,785.95	
Do	1878		1,110.30	*6,221.60
Pottawattamie	No bounty for 10 years			

* Estimated. † Approximate.

Table showing amounts paid in Gopher bounties in Iowa, by counties—Continued.

County.	Date.	Bounty on each Gopher.	Amount specified as paid for Gophers alone.	Total paid for Gophers and ground squirrels—not discriminated.
		Cents.		
Ringgold		10		
Shelby	1870	10	$34.30	
Do	1871		481.50	
Do	1872		3.00	* $518.80
Tama	No bounty for 20 years			
Winneshiek	1887	5		
Boone	For 7 or 8 years previous to 1888.	10		
Franklin	1885	10		* 750.00
Do	1887			* 965.00
Do	1888			* 1,195.00
Do	1889			* 1,546.00
Buchanan	1868–1875	10		* 1,800.00
Johnson	No bounty for 20 years			
Greene	1869	10	337.10	
Do	1870	10	392.50	
Do	1871	10	256.80	
Do	1872	10	243.80	
Do	1873	10		* 1,327.80
Plymouth	1875–76	5		
Harrison	No bounty since 1874			
Marshall	1868	15		2,087.10
Do	866–1870	15		
Cerro Gordo	une 9, 1864, to Oct. 18, 1865.	10		* 954.45
Benton	1866	10	2,000.00	
Do	1867	20	10,000.00	
Do	1868	12½		
Do	June to December, 1868	10		* 1,800.00
Hamilton	1874 (?)			† 5,000.00
Madison	1864	4⅙		
Do	1865	16⅔		† 5,000.00

* Estimated. † Approximate.

OBJECTIONS TO THE BOUNTY SYSTEM.

The objections to the bounty system as a means of reducing the numbers of farm pests have been already stated in the publications of this division. The matter is of such importance, however, that certain facts of special interest in the present connection may well be repeated.

The experience of nearly all the States which have paid bounties for the destruction of injurious animals has been that the system is not only very expensive, but unsatisfactory. In the case of Montana the money in the treasury was exhausted before the act had been in operation six months, and yet the ground squirrels were not perceptibly diminished. The experience of Benton County, Iowa, with Pocket Gophers also shows the disastrous effects of offering high bounties. In 1866 a bounty of 10 cents per scalp was paid. The following year the bounty was increased to 20 cents, and amounted to $10,000. This caused the county to borrow $3,000, and still left Gopher warrants unpaid to the amount of $3,000 additional. The bounty was then reduced to 12½ cents for six months, then to 10 cents, and was finally abolished on January 1, 1869, the entire amount paid out in three years being about $18,000; but the Gopher, although greatly reduced in numbers, was not exterminated.

The result was hardly more successful in the Dakotas and Minnesota, and in several cases the bounties were withdrawn within a few months

after the passage of the law. The report received from Nelson County, N. Dak., showed that $4,363.25 had been paid for the destruction of spermophiles between April and July, 1887. The report states: "The attempt to put down the gopher raid was a failure, as it was impossible to follow the 1887 bounties without bankrupting the county. The county has 28 full townships and 227,000 acres under cultivation, which gives too much gopher lands." The county of Griggs, N. Dak., offered a bounty of 3 cents per tail for Gophers during the spring of 1887, and reported $5,200.60 paid out before the bounty was withdrawn. Mr. George R. Fralick, of Lamoure, N. Dak., wrote in 1888: "This county (Lamoure) has expended thousands of dollars to destroy the Gray Gopher, and there are thousands of them yet to destroy our crops."

In Minnesota, under the act of 1887, Meeker County paid bounties from May 1 to October 1, when the payments were discontinued, as it was said that there were as many Gophers as before, although $14,056.34 had been expended for the destruction of Pocket and Striped Gophers. In Nobles County the act of 1887 was accepted May 18, but the bounty was ordered discontinued after August 28. During this period the amount paid was $1,997.24, about 90 per cent of which was for Striped Gophers and the balance about equally divided between Pocket and Gray Gophers and blackbirds.

Several counties reported fraudulent payments of bounties. In Ramsey County, N. Dak., tails were received as evidence. This was unsatisfactory, as "it was proved that some of our clever young Americans divided the caudal appendage in two pieces and claimed bounty for each piece, or caught breeders, cut their tails off, and let them go, so as to give them a chance to raise more bounty-producing Gophers." The report from Madison County, Iowa, which offered bounties on the several species of Gophers indiscriminately, showed that bits of gopher hide with holes cut in them to imitate scalps were presented for payment. "This involved the county in lawsuits, and the bounty on scalps was repealed."

Dissatisfied with the effects of the bounty laws, the commissioners of several counties in North Dakota offered poison free of charge to the farmers for the destruction of Gophers. In the year 1888 Benson County distributed $100 worth of strychnine and reported the results satisfactory so far as the extermination of the pests was concerned, although some stock was poisoned. The number of Gophers killed during this year was said to be larger than during the previous year under the bounty act. In the spring of the same year Nelson County furnished $200 worth of the strychnine to the farmers, but reported the experiment unsuccessful. Wheat soaked in a solution of poison was used during May and June. These months were wet, and it was supposed that the moist ground destroyed in some measure the effects of the poison. During the years 1887 to 1889 Wells County furnished $500 worth of strychnine and reported the result successful.

In the State of Washington a large amount of money has also been expended in poison for the destruction of Townsend's Ground Squirrel (*Spermophilus townsendi*). Dr. J. W. Lockhardt, of St. John, Whitman County, under date of June 8, 1892, writes: "I think it no exaggeration to say that the farmers of this county (Whitman) spent $3,000 this year for the poison for this pest, and yet many acres of grain are already destroyed."

Evidently a bounty can be but a temporary expedient for the extermination of these or other animals. Even if a sufficient amount of money were appropriated to completely exterminate a species in a given locality, its numbers would soon be reduced to a certain limit where it would cease to be profitable to hunt the animals, and the bounty would consequently become inoperative.

Bounties offered for the destruction of harmful species seldom accomplish the desired end, and if success does finally result it is only after vastly larger expenditures than were at first thought necessary. After a harmful species—the wolf, for example—has become rather scarce in any section of country the offer of a bounty may lead to its complete extermination; and to attain such a result, it is certainly good economy to make the bounty large. Obviously, it is better to pay a large sum at once for the last few pairs of wolves in a district than to offer a bounty so small that it is little inducement to a hunter to spend his time in their pursuit. In this latter case the wolves easily hold their own for many years, or even increase slowly, while the aggregate bounties paid will far exceed all expectation. In order to be effective a bounty should be large enough to assure the destruction of the great majority of the individuals during the first year, and this is especially true of species which are very numerous and prolific. And yet the amount of money required for the payment of bounties in such cases would be so enormous as to make the plan impracticable.

A full discussion of this phase of the subject may be found in a section devoted to the question of bounties on the English sparrow.

GEOGRAPHIC DISTRIBUTION OF THE POCKET GOPHERS.*

The Pocket Gophers of the United States belong to three groups or genera which may be distinguished by the upper front teeth: *Geomys*, having two grooves on the face of each of these teeth; *Cratogeomys*, having a single deep groove, and *Thomomys*, having a single faint groove or none.

The area inhabited by the family stretches from the dry interior of British Columbia and the plains of the Saskatchewan southward to Costa Rica. In an east and west direction the group covers the continent from ocean to ocean, except that it is absent from the region north of the Savannah River and east of the Mississippi Valley. The family

* Abridged from a monographic revision of the *Geomyidæ*, N. Am. Fauna, No. 8, 1895.

is clearly of Sonoran origin and reaches its highest development on the southern part of the table-land of Mexico. The great majority of the species inhabit the upper and lower Sonoran zones, though a few specially modified forms range upward on favorable mountain sides through the Transition and even into the lower edge of the Boreal zone. On the other hand, two species inhabit the Tropical belt of Mexico.

The genus *Thomomys* has by far the most extended range of any of the three, inhabiting suitable localities from the Valley of Mexico and Mount Orizaba northward to British Columbia and the North Saskatchewan, and from the Pacific Coast eastward to the Great Plains. It is represented by numerous species.

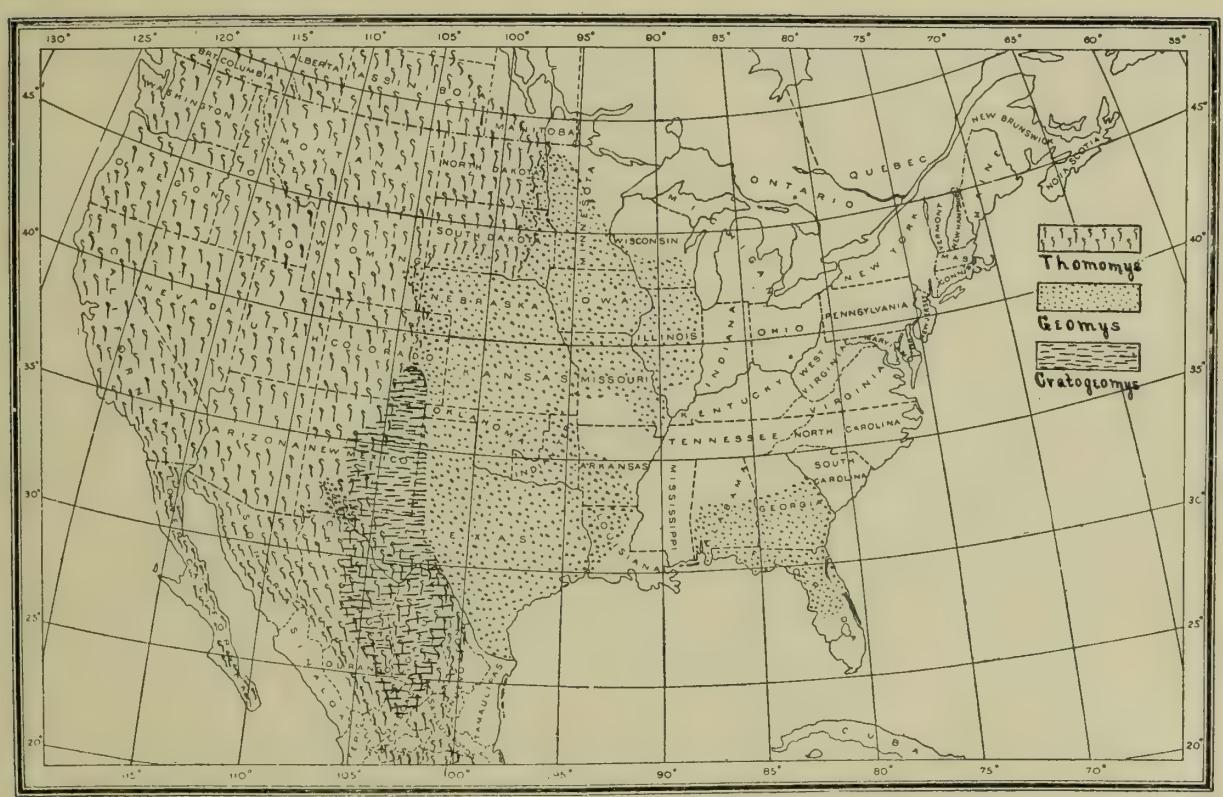


FIG. 6.—Geographic distribution of Pocket Gophers by genera.

The genus *Cratogeomys* inhabits the Great Plains of the United States from the Arkansas River in eastern Colorado southward, and extends far into Mexico (see fig. 6 and map 1, H).

The genus *Geomys* inhabits a broad belt across the middle part of the United States from the Red River Valley in northwestern Minnesota and northeastern North Dakota southward to the Mexican boundary along the Rio Grande; and also the southern half of Alabama and Georgia and the northern half of Florida. It does not occur west of eastern Wyoming, east-central Colorado, and the Rio Grande Valley in New Mexico (see fig. 6 and map 1).

THE SPECIES OF GEOMYS.

The Georgia Gopher (*Geomys tuza*), a rather large cinnamon-brown species, inhabits the pine barrens of eastern Georgia, where it is

locally known as the 'Salamander.' The same name is applied to the following subspecies:

The Florida Gopher (*Geomys tuza floridanus*) is a Florida form of *tuza*, as its name indicates, and does not differ materially in external appearance.

The Alabama Gopher (*Geomys tuza mobilensis*) inhabits southern Alabama and northwestern Florida and is a strongly marked form. It is very much darker than *tuza*.

The Prairie Gopher (*Geomys bursarius*) is the common Pocket Gopher of the northern Mississippi Valley, from eastern North Dakota and western Minnesota south to southeastern Missouri (see map 1, B). It is a dark liver-colored animal with pure white forefeet, in sharp contrast to the color of the surrounding parts, and has the longest claws of any of the species having two grooves on the upper incisors (see plate II).

The Plains Gopher (*Geomys lutescens*) is a pallid form of the *bursarius* type, inhabiting the arid sand hills of western Nebraska and extreme eastern Wyoming, and ranging thence southerly into northwestern Texas (see map 1, C).

The Louisiana Gopher (*Geomys breviceps*) inhabits the alluvial lands of Louisiana, Arkansas, and eastern Texas, the typical form coming from Prairie Mer Rouge, in Morehouse Parish. It extends thence northwesterly up the valley of the Arkansas River nearly to the Kansas border (see map 1, D). It is a rather small dark species. On the south, along the coast region of Texas, it splits up into the two following subspecies:

The Galveston Bay Gopher (*Geomys breviceps sagittalis*) inhabits the Gulf coast of Texas about Galveston Bay. It is smaller than true *breviceps*.

Attwater's Gopher (*Geomys breviceps attwateri*) inhabits the coastal plain and islands of Texas, from Nueces Bay northward to Matagorda Bay, and ranges into the interior nearly to San Antonio. It is considerably larger than typical *breviceps*.

The Texas Gopher (*Geomys texensis*) in its typical form inhabits central Texas (see map 1, E). On the north and northwest it probably passes into *lutescens*, while on the east it may intergrade with *breviceps*. It is much smaller than *bursarius* or *lutescens* and has a pure white belly. Its upper parts are reddish-brown, paler than *bursarius*, but darker and brighter than *lutescens*.

The Sandy Gopher (*Geomys arenarius*) inhabits a very restricted area in the upper Rio Grande Valley in extreme northern Chihuahua, western Texas, and southern New Mexico (see map 1, G). So far as known it is completely isolated, not coming in contact with any other species of the genus. It is of medium size, has a relatively long tail, and the upper parts are drab.

The Padre Island Gopher (*Geomys personatus*) inhabits Padre Island and the adjacent coast of Texas from Santa Rosa southward, extend-

ing inland as far as Carrizo, on the Rio Grande; its range, together with that of its subspecies *fallax*, thus coincides with the northern arm of the arid tropical belt along the Gulf coast (see map 1, F). In external appearance *personatus* much resembles *G. lutescens* of the Great Plains, from which it may be distinguished at once by its larger size, larger and more naked tail, and by important cranial characters.

Geomys personatus fallax inhabits a small area on the Gulf coast of Texas, immediately south of Nueces Bay. It is smaller and darker than true *personatus*.

HABITS OF THE GEORGIA GOPHER OR 'SALAMANDER' (*Geomys tuza*).

(Frontispiece.)

The Georgia Gopher inhabits the pine barrens of Georgia, and closely related forms are found in similar tracts in Alabama and Florida. The first description of the animal was written by a Member of Congress, the Honorable John Milledge, Representative from Georgia.

It was published by Dr. Mitchill in the New York Medical Repository in 1802 (Vol. V, p. 89), and runs as follows:

One of the little animals that burrows in the pine land, only known in Georgia, was caught by Mr. Stephen Pierce, living midway between Savannah and Augusta. Its body is of the length and thickness of a common-sized rat, and of the same color; the head between that of a rat and a mole, with small whiskers and short snout; the tail without hair, but shorter than that of a rat; the forefeet like those of a mole, with nails near an inch long; the hind feet like those of a rat, but the nails not of the same length, each foot having five claws; very sparkling small eyes; also short ears; teeth like a squirrel, and full as long. On both sides of the jaw, externally, are sacks or wallets where it deposits its food, and each will contain as much as can be put in a large tablespoon. Little or no fur, and the hair of the length of a wood rat. The whole face of the pine country is covered with little mounds made by this animal, of the circumference of a peck, and from 6 to 8 inches high. It is by no means active, but remarkably fierce. No common wooden place of confinement can hold it long, as it gnaws its way out. It lives entirely on roots, and is very fond of the sweet potato, and often proves injurious to the planter by getting under his stacks. It appears to move nearer the surface in the spring and fall than at any other season. It is surprising that though the work of this creature is seen throughout the country, in the region of the long-leaf pine, and in that region only, yet such is its skill in burrowing, and acuteness of hearing, that there is no animal in all our State so seldom caught or seen.

The best account that has been written of the Florida Pocket Gopher is from the pen of the eminent director of the United States National Museum, Dr. G. Brown Goode, by whom it was contributed to Coues' monographic paper on the group, published in 1875. Dr. Goode kept a number in confinement for several weeks and was thus enabled to make the following interesting observations on their habits. He says:

They may easily be confined in a wooden box, with sides 8 or 10 inches high, having dry sand 2 or 3 inches deep on the bottom. No cover is necessary; I have never seen one look up from the earth, and have rarely known them to attempt to escape. They require no water, and no food except sweet potatoes. A single potato of moderate size will feed a salamander for three days.

The senses of sight and hearing seem in them to be very dull. An object may be held within a short distance of their eyes without attracting their attention; but

the moment one is touched, he turns with a jump, snapping fiercely, much to the detriment of fingers which may be near. If two are confined in the same cage, the one does not seem aware of the presence of the other, unless they accidentally come in contact. Their eyes are small, dull, and without expression. Their sense of smell I judge to be very delicate, from the manner in which they approach the hills of potatoes. Their motions are surprisingly quick and energetic, their activity never ceasing from morning to night.

They are very pugnacious, and a rough-and-tumble combat between two vigorous males would seem terrific, if their size could be magnified a few diameters in the eye of the spectator. Every muscle of their compact, elastic, stout bodies is brought into action, and they plunge and bite with wonderful ferocity. A battle is usually followed by the death of one or both. I have examined them after death and found the whole anterior part of the body bruised almost to the consistency of paste, the bones of the legs crushed in four or five places. When two come together in the cage their salutation is a plunge and a bite.

I watched their burrowing with much interest. They dig by grubbing with the nose and a rapid shoveling with the long curved forepaws, assisted by the pushing of the hind feet, which removes the dirt from beneath the body and propel it back with great power a distance of 8 or 10 inches. When a small quantity of earth has accumulated in the rear of the miner, around he whirls with a vigorous flirt of the tail and joining forepaws before his nose, he transmutes himself into a sort of wheelbarrow, pushing the dirt before him to a convenient distance, and repeating the act until the accumulation is removed, then resuming his mining Any root or twig which blocks his way is quickly divided by his sharp chisel teeth. * * * The direction of the burrows may easily be traced by the loose hillocks of white sand which are thrown up along the line at intervals of 3 or 4 feet. These are the 'dumps' made by the burrower in throwing out his refuse accumulations. Each consists of about a peck of loose sand, and, by the casual observer, might easily be mistaken for an ant hill. No opening is visible, but by digging under the hill a hole is found, the mouth of the adit to the main tunnel, which may be 3 feet below the surface if made in cold weather, but perhaps not more than 6 inches if in summer. One of the mounds is thrown up in a very few moments. I have seen thirty raised in a single night on the line of one tunnel; this would represent nealy 100 feet of tunneling. I have seen one hundred and fifty in one continuous row raised in about two days; this would make between 400 and 500 feet of burrow completed in that short time, apparently by one little animal, an amount of work which may seem incredible to one who has not watched the restless movements of these animated plows, which are seemingly as well adapted for piercing the sand as birds are for cleaving the air. The burrows are about 2½ inches in diameter. * * * The nests are large chambers, 1 or 2 feet from the main tunnel, with which they are connected by side passages, which leave nearly at right angles. Here the miners lay up a supply of provisions and the chambers are often found to contain a half bushel of sweet potatoes cut up into chunks as large as peach stones, and of convenient size to be carried in the pockets. * * * In these side chambers the salamanders rear their young, building a nest of grass, pine needles, and live-oak leaves. I found them breeding in April.

Mr. Morris M. Green, who obtained specimens for the division at Pomona, Putnam County, Florida, in June, 1889, furnished the following notes respecting their habits:

The hills of the 'salamander,' as the Florida *Geomys* is called, are abundant in the pine woods and clearings, on rather low and moist land. Their tunnels were from 4 to 24 inches below the surface; the hills were thrown up at intervals of from 2 to 6 feet, and contained about a peck of dirt each. The night and early morning seemed to be their favorite time for working. It is very easy to trap a 'salamander' when fresh

mounds are found. By sweeping to one side the heaps of dirt, traces of the hole through which the earth was brought and its direction can be easily found. A minute's work with the spade will usually expose the tunnel lying to one side of the hill. Place a steel trap in the tunnel, and cover up the breach with a piece of pine bark or some palmetto 'fans.' If the breach is left open, the animals will carry dirt to shut out the light, and thus clog the trap, whereas if the opening is closed they will step in the trap and be caught. A break is often repaired within half an hour, or it may be left for nearly a day. In mending an opening it is astonishing how compactly the earth is packed; in one case an animal closed an opening so securely that the tunnel could not be found at all until another shaft was sunk in search of it.

A 'salamander' caught in a trap is a picture of fury and spite, biting at everything within reach of its jaws, and sometimes breaking its front teeth in venting its rage on the trap.

In the cheek pouches of one were some pieces of pine roots, and some grasses were found in the tunnels. The animals do serious injury to orange and pear trees by gnawing the roots. Sometimes the roots are gnawed off so completely that the tree can be pushed over with one hand. They also feed on sweet potatoes. But when an animal enters a garden or an orchard, and betrays itself by throwing up hills, there is no excuse for not ridding the place of it, as it may be easily caught in a steel trap. It is claimed that the 'salamander' works near the surface from September to March, retiring deeper in the ground during the hot season.

Mr. William J. Frank, of Cotton Plant, Fla., writes the division as follows respecting this Gopher:

They are very common in this part of the country, and do considerable damage to vegetables, especially potatoes. They tunnel under ground, and following the rows eat the potatoes from the hills. Mr. Walter Scott, at Rock Springs, says he lost 20 percent of his sweet potatoes by Pocket Gophers last August and September. Pocket Gophers sometimes destroy fruit trees, shrubs, etc., by cutting off the taproots. During the past year several peach, plum, and orange trees have been killed in this section by them.

HABITS OF THE RED OR PRAIRIE GOPHER (*Geomys bursarius*).

(Plate II.)

The Prairie Gopher is of much greater economic consequence than all the other species combined, for the reason that its home is in the fertile prairie region of the Mississippi Valley from central Missouri northward, covering the whole State of Iowa, nearly the whole of Illinois, and the richest and most densely populated agricultural lands of eastern Kansas, eastern Nebraska, eastern North and South Dakota, Minnesota, and southern Wisconsin.

The statement so often made that Pocket Gophers are prolific breeders has no foundation in fact. Only one litter of young is raised in a year, and as there are but two or three in a litter the rate of increase is slow. Judging from available facts their birth rate is less than half that of the ground squirrels, tree squirrels, chipmunks, mice, and most other small rodents. On the other hand, their mode of life protects them from a host of enemies that attack animals of less seclusive habits. They are early breeders. A female collected May 14, 1886, at Elk River, Minn., contained two embryos; and on the same day a nearly half-grown young was caught. At the same locality on April 29, 1888, I found a young hardly one-third grown that had come out of

the burrow during a cold rain and had been chilled to death. At Verdigris, Nebr., a female caught June 12, 1893, was nursing young. In southern Minnesota, in the latter part of May, my dog once dug out a nest containing two that could not have been a week old. They looked wonderfully like little babies. They had no visible hair, their complexion was a beautifully translucent pinky-white, their heads were round, and their little fat hands and fingers were touchingly babyish. Both eyes and ears were tightly sealed. They were helpless, and had the appearance of being born in a very rudimentary or undeveloped condition. The nest was a bed of soft grass and vegetable fibers on the bottom of an oval chamber in the burrow. Whether two is the usual number of young seems doubtful.*

Before the young are half grown they begin to run about in the burrow and strike off in side tunnels of their own. Sometimes they leave the parent burrow and begin a new one that does not connect with it. It is not uncommon to catch one when no more than half grown living in a burrow some distance from any other. Their hermit life has then fairly begun. By autumn they are practically full grown and have learned all the art of 'gopher mining.'

Numerous complaints have been received of the injury done to fruit and shade trees, hedges, and garden vegetables. On the prairies Gophers damage the groves of planted timber by gnawing the roots. They are especially troublesome in nurseries or wherever young trees are planted close together. Large trees are not often killed. Small ones are quickly ruined. The Honorable J. Sterling Morton, Secretary of Agriculture, states that on his farm in eastern Nebraska Pocket Gophers are particularly destructive to the horse-chestnut and ginkgo trees, gnawing off the roots in preference to those of other trees.

There is hardly a product of the garden or field that Gophers do not accept as food, but the starchy, tuberous, or bulbous roots are preferred to all else. Potatoes, turnips, carrots, beets, onions, and parsnips are favorites. Melons, squashes, and pumpkins are frequently gnawed and spoiled when a gopher hole happens to come up near them. Pumpkins and squashes are sometimes entered through a hole and the inside eaten out. It is not rare to find a gopher hole extending along a potato row and every hill entered and entirely cleaned out. Sometimes one row will be followed several rods and then another row attacked. One Gopher allowed in a potato field will do considerable damage and a larger number will easily ruin the crop. In fact, a number of cases have been reported where so much of the crop was taken by Gophers that the remainder was not considered worth harvesting.

---

* In many animals the number of young bears a definite relation to the number of teats. All of the Pocket Gophers have 6 teats, 3 on each side—2 inguinal and 1 pectoral. The former are situated close together at the posterior extremity of the belly; the latter are on each side of the breast. The number indicates that three is the usual number of young, with a probable variation of from two to six.

Corn is rarely injured to any great extent, but the depredations in fields of small grain—wheat, oats, barley, and rye—are serious. From the time the grain comes out of the ground it is covered and killed by the gopher hills, and later, as the stalks become taller, they are cut down and drawn into the holes for food. The standing grain conceals the animals and their work. Long galleries are extended through the mellow soil close to the surface and frequent openings are made through which to come out to carry down a fresh supply of provisions. These shallow galleries are usually found packed full of cut up heads and stalks of grain—the remains of half eaten meals, and stores that have never been needed. While standing in the shock a small amount of grain is sometimes destroyed by the Gopher entering from below and cutting off the heads of a few bundles. If left standing for an unusually long time a shock is sometimes nearly destroyed. Occasionally they come up under a grain stack and in the same manner eat and waste considerable grain. Usually they do not care for ripe grain or seeds unless found in the sheaf or in a stack, where it is eaten along with stalks, leaves, and heads. They are particularly fond of half-ripe grain, which apparently is not shelled but eaten with the head and chaff.

They do their worst mischief in meadows. The leaves and roots of grass and clover furnish an abundance of food, but the amount eaten is of comparatively little consequence. Every hill thrown up covers and kills the grass where it lies, so that a single Gopher working all summer in a meadow will destroy the crop over a considerable area; but even this is not the worst result. The hills usually contain more or less gravel and in mowing with a machine the knife keeps running through them, dulling, nicking, and sometimes breaking the sections. It frequently becomes necessary to raise the cutting-bar several inches to avoid them, thereby losing a percentage of the crop. The surface of the meadow is made rough by the presence of the hills, and the horses feet frequently break through into the tunnels. This not only causes the horses to stumble, but increases the roughness of the meadow by leaving open holes.

Mr. John N. Houghton, of Grinnell, Iowa, writes: "The chief cause of damage is the throwing up of so much dirt on meadow land as sometimes to render it almost impossible to cut the hay."

Mr. W. Head, of Bristow, Iowa, writes under date of January 5, 1887: "The Pocket Gophers cover much ground with their mounds. * * * The damage done to meadow land is enormous, whole acres often being covered."

Mr. Allen Chattin writes from Charter Oak, Iowa: "At the edge of a stream I had a fine timothy meadow in which the Pocket Gophers got to work. At wet times I could not run the mower, because the soft hills which they threw up would clog the machine."

From Turlington, Nebr., Mr. William N. Hunter writes: "The Pocket Gophers (*Geomys bursarius*) are getting very numerous and doing great damage, especially to the meadows and mowing ground, where their

mounds are a nuisance to the mowing machine. I have seen a string of mounds extend clear across a field of clover for nearly a quarter of a mile. They also do some damage to young orchards that have been sown to clover."

Mr. Peter Skoglund writes from Lake Andrew, Minn., under date of November, 1889: "Pocket Gophers do a good deal of damage to meadows by covering the grass with the earth they throw from their holes."

From London, Nebr., Mr. George A. Coleman writes: "Pocket Gophers are not particular as to their place of residence. They are found in orchards, meadows, and fields. They do great damage by burrowing and throwing up large hills, which are sometimes 4 feet across. I have seen them cover the ground so thickly that one could step from one hill to another. Let ten of them go to work in a 10-acre meadow and there would soon be very little grass left uncovered."

The above statement that gopher hills are sometimes 4 feet across, while correct, needs further explanation. It sometimes happens that the same hole is opened and dirt thrown out at different times until an unusually large hill is produced, the hole being stopped up during the intervals. The ordinary hills average 1 or 2 feet across.

Prof. L. L. Dyche, of Lawrence, Kans., writes:

Pocket Gophers are common everywhere throughout this section of the country. There must be as many as one per acre, or even more in certain localities. Nurserymen and gardeners have the most complaints to make against this "very troublesome little animal," the principal of which may be summed up in the following manner: They do some damage to young hedgerows by burrowing under them and cutting off the roots and underground stems. As a rule the damaged places are but a few feet in length, but some instances have been noted where a third or even a half of the plants have been destroyed for a distance of 100 feet. This usually happens where the Gopher's course crosses and recrosses the hedgerow. Other kinds of trees are sometimes killed in a like manner in nurseries and a few in young orchards. Potato farmers, particularly those raising sweet potatoes, complain that the Gophers work destruction on their crops from the time they are planted until they are removed from the fields. In some sweet-potato fields which I visited places from a few feet to 2 or 3 rods in length were found in the rows where the Gophers had either killed the vines while they were young or had cut up and carried away most of the potatoes after the latter were formed. Winter before last a farmer 1½ miles north of Lawrence lost 35 bushels of sweet potatoes taken by Gophers from a cellar which contained 500 bushels. The cellar was dug in sandy soil in the edge of the field where the potatoes were raised. The Gophers entered at the bottom of the cellar under the edge of the boards which lined one of its sides. The cavity from which the potatoes were removed was 4 feet deep on the side where the Gophers entered and extended a considerable distance into the interior. The hole from which the potatoes had been removed was packed solid with earth. This hole was undoubtedly filled up with earth as fast as the potatoes were removed, for there was no external evidence by settling of the potatoes on the top of the pile of the mischief which was going on underneath. After the potatoes were removed in the early spring traps were set, and two Gophers (apparently all which had been working upon the potatoes) were caught. Several reports have been noted to the effect that from 1 to 15 bushels of Irish potatoes have been removed by Gophers from potato heaps (called 'potato holes' by farmers) buried in fields. Some damage reported to have been done to cabbage and various other garden plants by eating

off roots and stems, and then usually pulling the plant down into the ground. Gopher hills in meadows are considered a great nuisance by those who run mowers, but no complaints have been made of their injuring the meadows other than that a little grass or grain is covered up.

Dr. A. K. Fisher says: "Both at Storm Lake, Iowa, and Round Lake, Minn., complaints were made of the damage done by Pocket Gophers in gnawing off the roots of fruit and shade trees. Mr. Lounsbury showed me an apple tree, fully 6 inches in diameter, all the roots of which had been cut off by Pocket Gophers. He had lost upward of 100 apple trees in the past few years by these destructive rodents. Vegetable gardens also suffer severely from their depredations."

Mr. D. W. Lounsbury writes from St. Joseph, Mo.: "On the farm of a friend here one-tenth of an orchard of 18 acres planted last spring (1888) was destroyed by Pocket Gophers."

Mr. Henry I. Warden, Keosauqua, Iowa, writes: "They are very destructive to young orchards. I have lost a good many trees by their eating off the roots. * * * I have seen hickory saplings 2 inches through with the roots all eaten off by Gophers. * * * I have always paid 25 cents per head for all caught on my place."

Mr. S. S. Dickinson, of Larned, Kans., writes as follows of Pocket Gophers: "Late in the fall and in the winter and spring they eat apple and other tree roots. They have destroyed 200 apple trees for me in the past two years."

From Reeder, Kans., Mr. George Briggs writes: "They are destructive to fruit trees, running underground and cutting all the roots off. Five percent of all the trees in this neighborhood have been killed by the Pocket Gopher. * * * Last year we planted one acre in peanuts, from which we raised 100 bushels; 25 bushels were destroyed by Gophers."

From Louisburg, Miami County, Kans., Mr. C. H. Aiken writes: "The Pocket Gophers are destructive here and possess no redeeming traits. They are rather difficult to catch. They throw up mounds in our meadows and cut off roots of young hedges, grapevines, etc."

Dr. G. S. Agersborg writes from Vermillion, S. Dak.: "*Geomys bursarius* is very destructive and seems to work underground entirely, eating carrots, parsnips, and tree seedlings, especially black walnut, to within 2 inches of surface. They store away potatoes for winter. I know of one instance where nearly 2 bushels were found in the bottom of a burrow."

From Anthony, Kans., Mrs. H. C. Bowens writes: "Our experience has been that they eat roots and fruit and undermine vegetables. They ate our sweet potatoes and Irish potatoes about an inch under ground, leaving the tops to die."

Mr. Edwin A. Donnell, of Zumbrota, Minn., says in a letter of December, 1886: "One of my neighbors plowed out two bushels of potatoes which had been gathered in one deposit, and were as clean as if they

had been washed." He also mentions another deposit in which a quantity of roots of quack grass and wild artichokes were found.

Mr. E. L. Brown, of Durand, Wis., writes under date of December 30, 1886: "Pocket Gophers are very injurious to grain, vegetables, and grass. I have seen as much as a half bushel of potatoes packed in a single hole. They sometimes come up under a pile of corn and carry it into the ground."

Mr. W. Head, writes on January 5, 1887, from Bristow, Iowa: "Two years ago, when I commenced to dig my potatoes, I found a great many mounds thrown up around and on top of potato hills; wherever I found these I did not find potatoes. The potatoes were often taken for a rod or more."

Mr. John N. Houghton, of Grinnell, Iowa, writes as follows: "*Geomys bursarius* is very common. He is very destructive to potatoes, and, in fact, to any garden vegetable growing underground, like carrots, parsnips, etc. I have plowed up half a bushel of wild morning-glory roots which he had stored for food, this being positive evidence in his favor."

Mr. D. W. Lounsbury, of St. Joseph, Mo., writes that nine-tenths of the potatoes in his garden were destroyed by Pocket Gophers.

Mr. H. J. Giddings, of Sabula, Iowa, says: "My experience with Pocket Gophers extends back to about 1867, when I commenced to trap them on my father's farm. At that time they were so numerous as to be a serious pest, doing great damage to meadows, young hedges, and orchards, and causing great damage by washing. This being a hilly country, the water following their runs started a great many ditches. I have known them to cut off 40 or 50 rods of hedge in a stretch, and have seen clover fields so full of their hills that the clover had to be cut several inches higher than usual to keep the machine out of the dirt. Now they are so few as to be of no concern. My farm contains 120 acres. Last year I caught one Gopher on it and one this year, to the present time, and to-day there is not one on the place. I believe the remedy to be for each farmer to catch the Gophers on his own place; that is the way we have done here. I can find no other cause for their great decrease."

Mr. George H. Berry, of Cedar Rapids, Iowa, writes of their destructive habits: "They injure grass crops by eating the bulbous roots of the coarser grasses, and by throwing up mounds of earth, thus annoying the mower and preventing the growth of grass for that season at least."

In an important paper on these animals, the late Robert Kennicott states:

Wherever they exist on cultivated land, the Gophers are very injurious. No animal is more complained of by our prairie farmers. Scarcely a crop escapes their ravages. They are said to desert the wild prairie to inhabit cultivated hay fields; and they particularly delight in clover and timothy meadows. Here they not only do mischief by devouring the roots of the plants, but impede the mowing and rak-

ing of the hay by inequalities of surface caused by their mounds. Grain fields are much injured by them while the plants are growing; and when the stacks are left standing after harvest, the Gophers burrow from below, and frequently cut up and drag into their holes, or otherwise completely destroy, entire sheaves. All root crops suffer severly from them. In passing below the surface, they gnaw the bottoms of carrots, beets, turnips, and other tap-rooted vegetables, without disturbing the tops or coming above ground. In fields of common and sweet potatoes, they work under the hills and remove the tubers, and thus sometimes destroy half or more of the crop before the dying vines give evidence of the mischief. Instances are related in which potato heaps, covered with earth and left out during winter, have been entered by the Gophers and the tubers carried off. They sometimes enter melons, pumpkins, and squashes, through holes at the bottom, and eat out all the fleshy part, and then fill the hollow rind with earth, leaving it in a condition to create much astonishment when harvested. They also feed upon bark of the roots of trees, as well as upon the fleshy roots of herbaceous plants. Some of our prairie farmers are greatly injured by their destruction of Osage-orange hedges. No small item of their injury is the gnawing and cutting off the roots of fruit trees. A considerable portion of all the trees have been killed annually in some young orchards in Iowa and Illinois; and several fruit growers inform me that they have seen as many as a dozen large bearing apple trees killed by them in a single orchard. Forest trees, 6 or 8 inches in diameter, have died in consequence of their roots being cut. (Report of Commissioner of Patents for 1857, p. 76, 1858.)

Contents of seven stomachs of Geomys bursarius.

Catalogue No.	Sex.	Date.	Locality.	Percentage of animal matter.	Percentage of vegetable matter.	Contents.
		1887.				
22	♀	May 28	Flandreau, S. Dak			11 large parasitic stomach worms; no food.
58	♀	June 10	Ortonville, Minn		100	Finely chewed roots.
59	♂	do	do		100	Do.
60	♀	do	do		100	Do.
69	♀	June 17	Fort Sisseton, S. Dak		100	Do.
76	♀	June 22	Browns Valley, Minn		100	Remains of roots.
122	♀	July 6	Travare, S. Dak		100	Finely chewed roots.

HABITS OF THE PLAINS POCKET GOPHER (*Geomys lutescens*).

The Plains Gopher, as its name implies, inhabits the semiarid plains instead of the fertile prairies. Its range is west and southwest of that of the Prairie Gopher, and it is not found north of southern South Dakota. It is common throughout the sandhills of western Nebraska and Kansas, and reaches into eastern Wyoming and Colorado. It is much paler than the Prairie species, its color closely matching that of the pale sand in which it is usually found. In habits it differs but little from the foregoing. Being considerably smaller, its burrows and hills are correspondingly smaller, so that in the western part of its range, where it meets the Gray Gopher (*Thomomys talpoides*), it is hard to tell from the size of the hills which species made them. On the contrary, the hills of the Gray and Prairie Gophers (*Thomomys talpoides* and *Geomys bursarius*) are easily distinguished by the difference in size.

In western Nebraska, where the light sand is constantly drifting into dunes and ridges that border the fertile valleys, the Gophers fairly

revel. Nowhere else have I seen their hills so numerous. In places the ground is half covered with them. The mellow sand is easily moved and many hills are thrown up each night. As every hill improves the soil by burying vegetation, it is evident that the Gophers have been of inestimable benefit to the land.

But the Gopher fails to appreciate the rights of property, and refuses to keep on his own side of the fence. Marrowfat peas, lima beans, and red clover suit his taste just as well as the wild plants of the same family, on which he has dined for untold generations. The farmer quite reasonably objects to having his garden destroyed, his wheat buried, his potatoes eaten, and the roots cut from the trees he has planted for timber or fruit. Consequently a relentless war of extermination is declared and much hard feeling entertained toward the poor, short-sighted rodent.

In this species we have one instance in which the number of young in a litter is known. A female captured by me at Kennedy, Nebr., April 12, 1890, contained two small embryos. The only other Pocket Gopher in which the number is positively known is the Prairie Gopher, in which, as already stated, two young were found in a nest, and in another case two embryos were found. Audubon makes the statement that six to seven are produced at a birth, and Kennicott places the number at five or six, but both are apparently stating what they have heard at second hand.

In the case of the above-mentioned female at Kennedy, Nebr., the young would have been born near the end of April, probably by the 25th. In the same locality, two years earlier, I found young Gophers about half grown, digging holes for themselves by the middle of June.

HABITS OF THE LOUISIANA GOPHER (*Geomys breviceps*).

In 1855 Professor Baird described this Gopher from specimens collected at Prairie Mer Rouge, Morehouse Parish, La. For years no other specimens were collected, and a doubt arose as to the validity of the species. In 1892 I visited Mer Rouge, secured many specimens, and became familiar with the habits of the animal.

All over the small original prairie, now mostly occupied by fields of cotton and corn, this Gopher is common, but is most noticeable in pastures and along roadsides. Throughout the surrounding timber none were found except along the roads and in old fields, and on the hilly land a few miles back from the river no trace of them could be found. The colony seems restricted to the flat, mellow prairie, and is prevented from extending to lower land by annual floods. In the other direction its range is limited by clay hills and standing timber. On the south and east the Mississippi floods check it abruptly. On the west the black wax land of Texas—a soil in which no burrowing mammal lives—proves a complete barrier.

Compared with some other species of *Geomys*, they are not very numerous. At Mer Rouge in one pasture of 20 acres 15 'salamanders' were caught, and at least one remained. Though less than one to the acre in this pasture, each had produced a long line of hills to cover the grass and remain for a year or more as unsightly blemishes on an otherwise smooth surface of grass and clover. One line of 16 hills extended in an unusually straight course for a distance of 100 feet. An average hill measured 15 by 24 inches and 5 inches high. Usually there were one or two hills thrown up in a night by each Gopher. As a rule, where the ground is full of roots the Gophers do not dig so extensively as on poor soils where the food is scarce, but here they are able to carry on their work all the year round. Even at the low estimate of one hill per day, it may be seen that in the course of a year 365 hills would cover considerable ground, and with an average of but one Gopher to 2 acres they might still be a nuisance to farmers.

A slight loss is suffered from their work in fields of cotton and corn, but the complaints are mainly of their depredations in pastures, meadows, orchards, and gardens. Grass is covered and hills are left in meadows, the roots of fruit trees are cut, and garden vegetables eaten.

Another accusation brought against the Gophers is that they carry the roots of coco or nut grass from place to place, often bringing them from a roadside or waste place and storing a quantity in burrows in gardens or fields where they are left to grow. This coco grass is the most troublesome weed with which the Southern farmers have to contend. It spreads by means of long rootstocks on which small tubers are borne at frequent intervals. When separated, each of these tubers will start a new plant, which spreads rapidly and is exceedingly tenacious of life. On this subject Mr. J. Ernest Breda, of Natchitoches, La., writes: "The Gopher has of late years increased considerably in this parish, which fact I attribute to the scarcity of hogs running at large. In ante-bellum days planters were anxious to prevent the spread of the nut grass, or coco grass, and when they found plots 1 or 2 feet in diameter thickly set in this weed, where the previous year not a suspicion of its presence had existed, they at once concluded that some ill-disposed negro had intentionally set it there, and the suspected one was sure of punishment. I have demonstrated in a dozen instances that these coco roots were brought and stored by the Gophers. Last spring, seeing in my orchard two fine starts of coco, each about a foot in diameter, I carefully dug for the roots and found gopher holes terminating in each deposit. On a small rise of ground between the two I found the nest, containing three hairless young. While excavating for a fish pond I have found nearly a half bushel of coco tubers deposited 2 feet under ground and gopher holes communicating with them from all sides."

None of the farmers about Mer Rouge knew how to catch the Gophers in a practical manner. Some had wasted much time in trying to dig them out, and in pouring water into their holes in the vain endeavor to drown them. The ease with which a field was cleared of Gophers by means of a few steel traps astonished and delighted the residents.

Mr. G. W. Heard, of Creek, Calcasieu Parish, La., informs us that salamanders are numerous in that region, and that they do considerable damage to hilly land by cutting their tunnels about 6 inches under ground, causing the land to wash badly.

Mr. E. L. Cannon, of Loretta, in the same parish, says: "Salamanders are quite numerous all over Louisiana, with the exception of the marshy lands on the coast. They are troublesome and destructive on some farms, particularly to potatoes and gardens. In one fall and winter my boys caught 104 on a farm half a mile square with one steel trap."

In examining the contents of 27 stomachs the food was found to consist wholly of roots and green herbage. Clover seems to be a favorite.

We had five Gophers cooked for dinner one day and all of the four persons who ate of them pronounced them excellent. There was no bad flavor and the meat was sweet and delicate. As an article of food there can be no possible objection to them. Their diet is purely vege table and their burrows are as fresh and clean as the newly-plowed soil from which come our turnips, beets, and potatoes.

Mr. H. P. Attwater has kindly contributed the following memorandum respecting the habits of *Geomys breviceps attwateri*, a subspecies of this Gopher, at Rockport, Tex.:

As soon as the warm weather sets in, from about May to September, very few Gophers are observed working. The soil is sandy, and at all times damp, dampness known as "natural subirrigation." In the hot weather the dampness does not come as near the surface as in the cooler months. I have thought that perhaps the Gophers travel deeper in summer, but now think the chief reason why they do not throw up hills in summer, as they do in fall and winter, is that during the summer months the soil is so full of roots, suckers, bulbs, etc., that they do not have far to go before finding all they can eat, and that the reason they work so much after the summer months are over is because they are hunting around to find some bulb or root which was their favorite food in summer, and which they commenced to find about the month of May and was over with in September. The animals are very abundant all over the peninsulas in Aransas County wherever the soil is sandy. There is hardly a foot of land that has not been 'plowed' several times over by Gophers, and I believe the fertility of some sections has in this way been greatly improved. I have noticed that the richer the land the richer the Gophers. Of course they do considerable damage to vegetable crops, especially to young fruit trees and cuttings just rooting. The samples sent you of mulberry trees cut by Gophers were from the Faulkners' ranch, on St. Charles peninsula, in the eastern part of the county. Mr. Samuel Walker, the manager of the ranch, told me that he killed over 250 Gophers in his young pear orchard between the 1st of March and April 15, 1893. This orchard was set out where sweet potatoes had grown the year before, and they came up again and covered the ground, and I think the potatoes attracted the Gophers in the first place more than the pear trees.

HABITS OF THE SANDY GOPHER (*Geomys arenarius*).

So far as known this species is limited to the narrow strip of bottom land along the Upper Rio Grande Valley from El Paso, Tex., to Las Cruces, N. Mex., and on the Mimbres River at Deming. It is abundant in the mellow sandy soil of the fertile valley, where it is absolutely surrounded by hard stony mesas and desert mountains. Below this point the Rio Grande flows through a deep canyon with rocky walls and scanty soil, which does not afford a suitable channel for the Gophers to extend their range. Near El Paso they are especially troublesome on farms that are irrigated, and thus made to yield the largest crops, though wherever it is possible to turn the water into the burrows they can be driven out.

Mr. J. Alden Loring, who was sent to the Upper Rio Grande Valley to work out the range of this species, secured a large series from Las Cruces, N. Mex., and Juarez, Chihuahua, Mexico, as well as at the type locality, El Paso, Tex. Mr. Loring says: "They are not very common on the Mexican side of the river, but extremely so on American soil, where they seem to thrive and grow fat. The places they most prefer are railroad embankments and irrigation ditches, where they were found both in sand and wet, dark clayey soil. Two were seen on February 5 just as they protruded their heads from their holes. Their faces were covered with dirt, and as soon as they had shaken it off they saw me and quickly dodged back. When these Gophers were caught I noticed that they walked with the claws of the front feet partially doubled under, which did not allow the sole of the foot to touch the ground."

HABITS OF THE PADRE ISLAND GOPHER (*Geomys personatus*).

This is one of the largest Pocket Gophers of the United States. Large specimens of the Prairie Gopher (*Geomys bursarius*) nearly or quite equal it in size, though apparently the present species averages slightly larger. A specimen collected on Padre Island by Mr. Lloyd weighed 1¼ pounds, and measured from tip of nose to tip of tail 310 mm. (12.18 inches), and another still larger measured 320 mm. (12.63 inches). Of the prairie species the largest in a series of 70 specimens measured 311 mm. (12.25 inches). Several species of Mexican gophers are considerably larger.

Geomys personatus was described by Mr. F. W. True from two specimens collected on Padre Island, Texas. Later a fine series was collected on the island by a field agent of the division, Mr. William Lloyd, who furnished the following notes on the habits of the animal: "Common, principally about the center of the island, but extending clear to the north end. Apparently they do not occur for a distance of 20 miles along the southern extremity of the island. Some peculiarities of habit are necessitated by their environment. Living in the

soft, loose sand, their holes might be easily broken into by predatory animals or washed open by rain but that the precaution is taken to pack them full of sand for a distance of 3 to 6 feet from the opening where the dirt is thrown out. Usually their burrows can not go very deep without reaching water, which was found standing in some of them. In no case did I find more than one Gopher in a burrow. They live in colonies, which are often a mile or more apart."

HABITS OF BAIRD'S GOPHER (*Cratogeomys castanops*).

This Gopher lives on the western part of the Great Plains south of the latitude of Las Animas, Colo. I have observed it in but one locality, Sierra Blanca, Tex., where it was living on the dry, gravelly mesa amid such desert plants as cactuses, mesquites, acacias, and yuccas. A preference for dry uplands appears to be characteristic of this species, as is further shown by the observations of Dr. A. K. Fisher, who furnishes the following note: "*Geomys castanops* and *Geomys lutescens* are about equally common at Las Animas, near Old Fort Lyon, Colo. The latter species is found mainly in the alfalfa fields, where the ground is kept wet by irrigation, though at least one specimen was taken in dry soil in close proximity to the other species. *G. castanops*, on the contrary, inhabits the dry, sandy mounds not reached by irrigation, and is most common in waste ground grown up with sunflowers, near railroads, and along the higher banks above the grassy bottoms bordering Purgatory Creek. They were difficult to capture on account of the dryness and looseness of the soil and consequent caving in of the burrows, caused by walking near where the traps were set. Six specimens were secured July 16–17, 1892."

HABITS OF THE GRAY POCKET GOPHER (*Thomomys talpoides*).

(Plate I.)

This species may be distinguished from the Prairie and Plains Gophers—the only species coming near it geographically—by smaller size, grayer color, slenderer form, and in all ages and conditions by the smooth front face of the upper incisors, which in *Geomys* are deeply grooved lengthwise.

The two animals are not known to occur in the same localities except along the eastern part of South Dakota and southeastern North Dakota, in which region their ranges meet and slightly overlap. Both have been taken at Portland, Traill County, and Valley City, Cass County, N. Dak.; and at Fort Sisseton, Marshall County, S. Dak. Why the two should not intermingle while separated by no apparent barrier is an unsolved problem in distribution. The separation does not appear to occur along any zonal line and can not be accounted for by difference in latitude, altitude, or humidity. Usually where their ranges meet there is a neutral strip between in which few, or none, of either occur. There are two possible solutions of the problem: Soil, and

the dispositions of the Gophers. In South Dakota *Geomys* inhabits the mellow soil of the James River Valley and its western branches, while *Thomomys* inhabits the high rolling prairies with heavy, clay soil that is waxy when wet and hard when dry. Thus the two species come nearest together where sandy valleys penetrate the high prairie. That *Geomys* invariably avoids hard or stony soils is shown by its absence from south western Missouri and the Ozark Mountains; from the clay prairies of southeastern Kansas, and the wax lands of Texas. On the other hand, *Thomomys* delights in the hardest soils and stony mountain sides. Thus it is easy to account for the limit of range of *Geomys* by soil. But while *Thomomys* inhabits hard soils it does not object to sandy and mellow soils. The reason it does not invade the range of *Geomys* may be that the latter, being the larger and more powerful animal, will not permit it to occupy the same ground.

The Gray Pocket Gopher is abundant over nearly the whole of the great prairie region of North and South Dakota. The little mounds of fresh, black soil thrown up along its lines of subterranean tunnels show the various turns and windings of its galleries. Save for these mounds there is nothing to indicate the presence of the animal or its burrows. Often one individual works all summer without going beyond the limits of an acre of ground. It is rarely seen above ground, coming out of its hole just far enough to push back the loose earth brought from its excavations and quickly returning for other loads, until enough is ejected at one place, when it retires and closes the entrance of the hole with damp earth. The progress of the burrow seems to be wholly without aim or design, bending and turning in conformity to the character of the soil, or following such roots and plants as suit the animal's taste.

The burrows, nests, and mounds of this species and the Prairie Gopher are much alike except that the Gray Gopher, being a smaller animal, makes smaller burrows and throws up mounds more frequently. Usually after some familiarity with both species it is not difficult to distinguish the mounds. While *Thomomys* ordinarily produces small hills, it often forms large ones by reopening the same hole and throwing out additional earth. Sometimes the Gopher throws out fresh earth at the same place every night, closing the hole during the day, until a compound hill of considerable size is formed. Following are the dimensions of some hills that I measured at Pembina, N. Dak., in 1887: 4 by 4 feet in diameter and 10 inches high; 4 by 5 feet and 9 inches high; 3 by 3 feet and 7 inches high; 4 by 5 feet and 6 inches high. The ordinary hill is about 12 inches across and 2 or 3 inches high.

Near the large hills there are usually no small ones, but the tunnel extends a considerable distance before another hill is started. Twenty-seven feet is the greatest distance I have measured between two hills. The ordinary sized hills are usually 4 to 10 feet apart.

In habits the Gray Gopher is as solitary as the other Gophers.

Except during the mating season in spring it is rare to find more than one in a burrow, and the animals must live in absolute solitude throughout the greater part of the year. No wonder that they develop dispositions of unusual ferocity, and are always ready to fight any animal that comes in their way. When caught they become furious, biting the trap so violently as to break off their teeth, jumping about frantically, and giving vent to their anger in wheezing hisses.

On the prairies their food consists mainly of roots. Some green herbage is eaten, and more rarely, seeds. The roots of leguminous plants furnish the greater part of the food. The pulpy roots of the prairie clover (*Psoralea argophylla*) are eaten to such an extent that the flesh of the Gophers is often permeated with their peculiar odor. The turnip-like bulbs of another species (*Psoralea esculenta*) are esteemed a choice morsel, as are also the roots of wild liquorice (*Glycyrrhiza lepidota*). Many rattleweeds and the like (*Astragalus* and *Oxytropis*) that abound on the prairies furnish them food, while other plants known to be eaten are aster, blazing star, milkweed, wild parsnip, grass, and wild onion. The latter often imparts a rank odor to their flesh. It is doubtful if the root of any plant is rejected. Roots of shrubs and trees are eaten whenever encountered, but as orchards are rare where this particular Gopher is found, their depredations in this line are not often serious.

Further west other closely related Gophers of identical habits and mode of life do immense damage in orchards, cutting the roots from fruit trees and killing shrubbery. Their depredations are especially serious in the fruit regions of California, Utah, and Colorado. Near Pyramid Lake, Nevada, I have seen a small apple orchard in which half the trees had been killed in this way. Apparently there was but a single Gopher in this orchard, but as the ground was kept clear of other vegetation it had lived entirely upon the roots of apple trees. A dozen trees were already dead and others were dying. With one hand I tipped over several of the dead ones and found the roots cut off and gone, eaten or carried away, close up to the stump. Unmistakable marks of the Gopher's teeth covered the ends where the roots were cut and the animal's holes wound about the remaining stumps. These particular trees were from 2 to 4 inches in diameter and 8 or 9 years old. The base of one of them is shown in fig. 5 (p. 19). One hundred dollars would not cover the loss occasioned by this one Gopher.

The stomachs of 37 Gray Pocket Gophers have been collected by field agents of the Division of Ornithology and Mammalogy and preserved in alcohol for critical examination in the laboratory. The material had been so thoroughly masticated that very little could be identified save in a general way, and while the results are not of great importance they prove conclusively what has heretofore been considered probable, namely, that no insects or earthworms are eaten by the Gophers, and that roots form the bulk of the food.

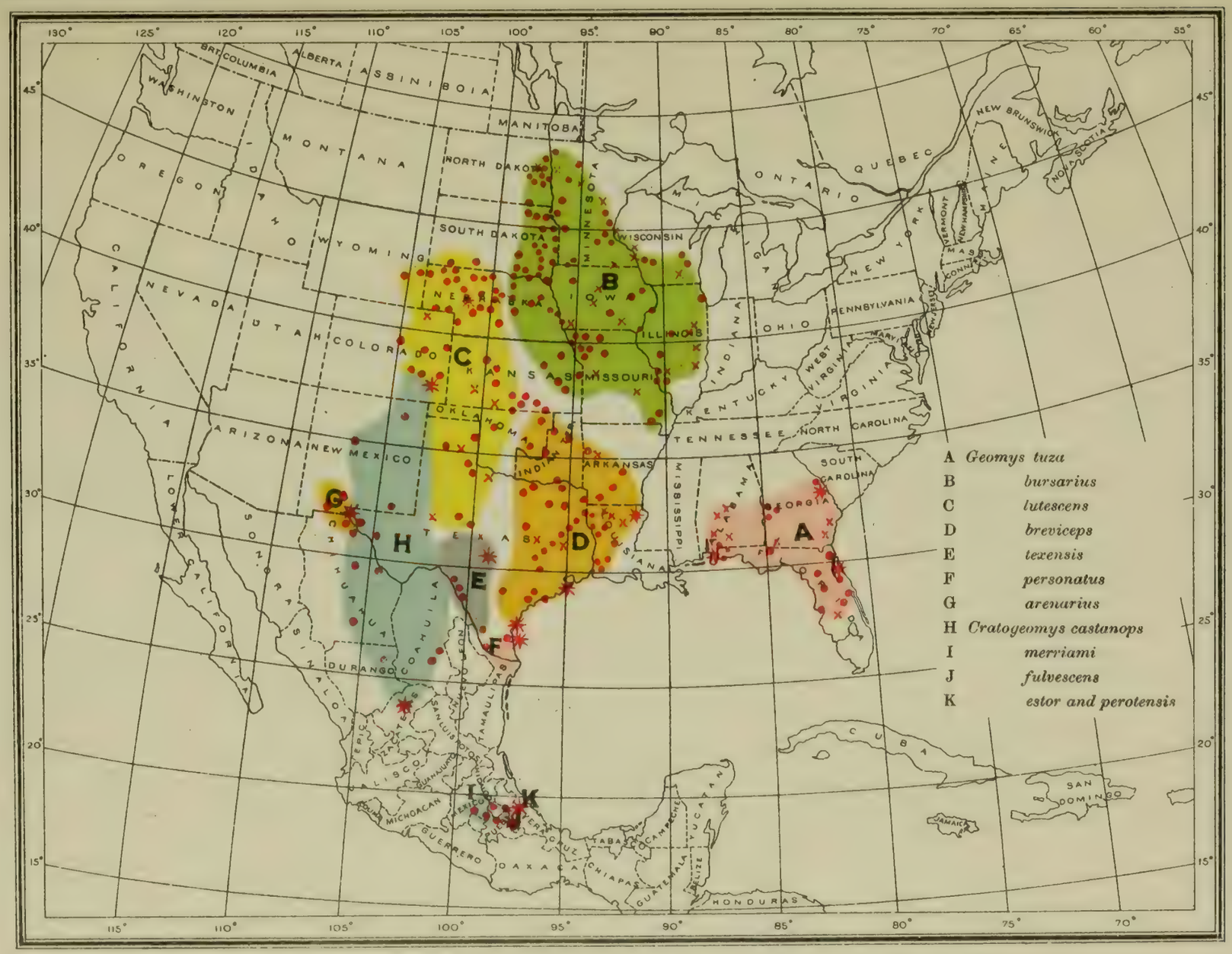
INDEX.

Page.

Alabama gopher 30
Attwater's gopher 30
Baird's gopher 44
Bisulphide of carbon, use of 23
Bounties 25
  objection to 26–28
Breeding habits 16
Burrows 12, 13
  injury done by 20
Coco grass, distribution of, by gophers 41
Cratogeomys castanops 44
Disposition 16, 17
Distribution 28, 29
Florida gopher 30
  habits of 31–33
Food 14
Fumigation 23
Galveston Bay gopher 30
Geomys arenarius 30, 43
  breviceps 30, 40–42
  breviceps attwateri 30, 42
  breviceps sagittalis 30
  bursarius 30, 33–39
  lutescens 30, 39–40
  personatus 30–31, 43–44
  personatus fallax 31
  texensis 30
  tuza 29–30, 31–33
  tuza floridanus 30, 31–33
  tuza mobilensis 30
Georgia gopher 29–30
Gophers, as food 17
Gray pocket gopher 44
  habits of 44–47
Habits in captivity 11–12, 14–15, 31–33

Page

Hibernation 13–14
Injury to farm crops 20, 34–39
  to meadows 35–37
  to orchards 36–37, 39, 46
  to roots, tubers, and garden vegetables . 19–20, 34, 37–39
  to trees 20, 34, 37, 46
Louisiana gopher 30
  habits of 40–42
Natural enemies 20–23
Nut grass, distribution of, by gophers 41
Padre Island gopher 30–31
  habits of 43–44
Plains gopher 30
  habits of 39–40
Poison 23, 24
Pouches, use of 14–16
Prairie gopher 30
  habits of 33–39
Progression, method of 11–12
Sandy gopher 30
  habits of 43
Tail as an organ of touch 12
Teeth 17–19
  as a cutting machine 18–19
  structure and manner of attachment of . 17–18
Texas gopher 30
Thomomys talpoides 44–47
Trapping 23–24
Trenches, use of 25
Tunnels, manner of construction 11
Underground life 10–12
Voice 17
Wire-netting, use of 24



DISTRIBUTION OF THE SPECIES OF *GEOMYS* AND *CRATOGEOMYS*.

Spots (•) = specimens in collection. Crosses (X) = records. Stars (✱) = type localities of species and subspecies.