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THE ECOLOGY AND ECONOMIC STATUS OF CITELLUS TRIDECEMLINEATUS

by

FREDRICK L. FITZPATRICK

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PUBLISHED BY THE UNIVERSITY, IOWA CITY

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INTRODUCTION

Citellus tridecemlineatus tridecemlineatus was first described by Dr. S. L. Mitchill, who gave it the common names "Thirteen-lined Ground Squirrel" and "Federation Ground Squirrel." The latter name was applied because of a fancied resemblance to thirteen lines of stars and stripes. (S. F. Baird, 1859, p. 316). The scientific name first applied by Mitchill in 1821 was *Sciurus tridecemlineatus.* The same species has likewise been referred to as *Spermophilus tridecemlineatus.* At present it is recognized as belonging to the genus *Citellus* and the species is divided into geographical races.

Various common names for this animal have been developed locally. Among them are the following: "Striped Prairie Squirrel," "Picket-pin," "Striped Gopher," "Striped Spermophile," "Striped Ground Squirrel," "Thirteen-lined Spermophile." Only the last two of these names are in any way suitable, for the rest tend to cause confusion with other species.

This rodent was selected as a problem for study because very little concrete scientific investigation has been made with regard to its habits. An examination of the bibliography will show that while a number of authors have touched upon the subject, the work has been universally general and may usually be summed up in one or two pages. In fact this species has not previously been the subject of a detailed general examination. All of the works cited, however, have some bearing on the problem and have been of value in its development.

Two spermophiles occur commonly in Iowa: *Citellus tridecemlineatus tridecemlineatus* (Mitchill), and a larger species, *Citellus franklini* (Sabine). They vary in abundance locally, but the first named form usually predominates in numbers and is therefore of most interest from an economic standpoint.

The economic status of *Citellus tridecemlineatus tridecemlineatus* has been a subject of discussion for some time. Certain counties have even gone so far as to offer a bounty for this species, but such plans proved impractical, resulting in too heavy drains on county funds.

Three general methods were employed in the course of this work.

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In the first case the animals were observed as to habits and general characteristics both in the field and in captivity. Then specimens were collected at different times of the year and studied as to parasites, stomach contents, and embryonic development. Finally, a large number of burrows were excavated, the results of this work being chronicled farther on. The investigations were carried on in different localities, and an attempt was made to include extremes of environment. With this in view the writer has made a number of trips to different parts of the state.

Some difficulty has been encountered in treating this subject coherently, for the habits are in every case dependent upon environment.

Before closing the introduction the writer wishes to express his indebtedness to Professor Henry F. Wickham for continuous aid and direction in the pursuit of this work. And also to Professors C. C. Nutting, H. R. Dill, and Dayton Stoner for encouragement and helpful suggestions.

A somewhat different acknowledgment is made in the case of Mr. R. A. Brown of Des Moines, who in the summer of 1922 made a collecting tour over the northern part of Iowa in company with the writer, and who proved to be of material aid in the securing and preservation of stomach contents.

GENERAL HABITS AND ENVIRONMENTAL CONDITIONS

DISTRIBUTION

Citellus tridecemlineatus tridecemlineatus occurs generally in the upper Mississippi valley from Ohio west to the plains, and from Missouri and Illinois northward into Minnesota, Wisconsin, and Michigan. To the westward this species is replaced by *Citellus tridecemlineatus pallidus,* which form is very similar in size and habits but somewhat lighter in coloration.

Iowa is almost in the center of the range covered by the Thirteen-lined Spermophile. Reports from all parts of the state point to a practically uniform distribution, the animals being common residents in most cases. The writer has selected the following counties as examples of areas in which this species is particularly abund ant: Clay, Dickinson, Emmet, Iowa, Jones, Louisa, Pocahontas and Polk. It must be remembered, however, that abundance in any locality is variable, being dependent on an ever fluctuating environment.

GENERAL CHARACTERISTICS

The Thirteen-lined Spermophile has a number of well defined habits. One of these is the characteristic attitude assumed when listening or attracted by approaching objects. The animals sit on their hind legs in an erect position which has gained for them the colloquial term "Picket-Pins." Undeniably curious in the presence of man these spermophiles will assume the erect attitude and stare at the intruder for an indefinitely long period of time. When crowded too closely they race rapidly to their holes and take immediate refuge. In the safety of their retreats they will often stick their heads out of the openings for brief intervals to watch the actions of their enemy, sometimes uttering their familiar call meanwhile, perhaps as a warning to other members of the species. They are quick and seemingly nervous in all of their actions.

The Thirteen-lined Spermophile is a strictly diurnal species. The animals prefer the warmer parts of the day for their activities above ground, particularly when the sun is shining. They come out of their retreats for successively shorter periods each day as the weather becomes colder.

The animals have a tendency toward colonialism and live in groups as a rule. Upland or lowland valleys with few or no trees are habitually inhabited by this species. Areas where the grass has been closely cut down by stock or where the short white clover dominates over the taller blue-grass are preferred, for, as will appear later, the animals are partially dependent upon the insects which they capture for food, and in the tall vegetation they would be at a great disadvantage. Heavy timberlands are not frequented although in open wood-lots there may be occasional burrows. Spermophiles are apparently independent of ponds and creeks for their water supply for their holes are often found on the crests of high broad divides. This particular subject, however, will be more fully treated in the succeeding chapter.

These spermophiles are not pugnacious as a rule. They usually take refuge by retreat into a burrow when an enemy approaches. The males engage in minor battles among themselves during the mating season, but the injuries sustained are usually negligible. (Stoner, 1918, p. 131).

SPRING APPEARANCE AND MATING

The first Thirteen-lined Spermophiles appear above ground between the fifteenth of March and the tenth of April, depending on the season. By this time all of the frost has been thawed out and the weather is reasonably mild. Their advent is usually preceded by several warm sunny days, but if the temperature falls the spermophiles will again become inactive until the weather moderates.

Mating does not take place immediately, but is deferred until about the second or third week in April. During the mating season the animals are unusually active and spend the greater part of the day above ground. They are conspicuous at this time of the year, as they call back and forth continually. The males engage in occasional fights for the possession of mates.

NESTS AND YOUNG

During the first week in May, females may often be observed re-excavating old burrows. If killed at this time a dissection will generally reveal the presence of well developed embryos. Some new burrows are constructed, but as a rule tunnels are merely hollowed out and new nests built. Dead grasses of the preceding year are used in the construction of these nests. Further information on this subject is contained in Chapter II. Dissection has shown that

not all of the females are fertilized and in one instance the writer detected a diseased condition of the developing embryos.

There is great variation in the number of young produced. Adult females of the preceding year show a general tendency toward having fewer offspring than the older females. They may be as few as four or as many as ten in number. Cory (1912, p. 141) quotes Dr. Hoy to the effect that the young are naked at birth, blind and remarkably embryonic. They do not have hair until they are twenty days old and the eyes do not open until the thirtieth day. During this period they are fed and otherwise cared for by the female. Much insect food is carried to the young.

About the middle of July, two-thirds grown young appear at the surface of the ground and begin to capture or otherwise secure their food. Some of them begin to dig out new burrows, some remain in the parental burrows, and still others wander to old unoccupied burrows or retreats in the near vicinity. The relative quiet of the reproductory season is broken now and the members of the species again resume their former habits.

It is well established that the males leave the females, or are driven off during the season when the young are produced, and assume wandering habits, going from place to place in search of food, and incidentally constructing many new retreats in the process of their travels.

LOCAL MIGRATION IN SEARCH OF FOOD

The activities of mating are carried on for the most part in the immediate vicinity of the place where the animals have hibernated. After mating, however, the individuals and particularly the males, tend to spread out in search of the most advantageous feeding grounds. Old outlying burrows at the borders of fields and along roadsides or in small isolated patches of grass are now reoccupied.

Early in the summer newly planted corn may be attacked to some extent, the amount of actual damage depending upon the number of spermophiles in the vicinity and the presence or lack of other foods. This particular topic will be developed under "Food Habits."

The writer has seen these spermophiles leave rather large areas entirely, during seasons when they were not being pastured and the grass had become long. For as previously explained, the short grass is of advantage to the species, and if it becomes tall in any locality there will be a forced migration of the spermophiles. This

is a general rule in regard to local distribution, but there are some few cases on record where spermophiles remained far out in hayfields during the early part of the summer when the grass averaged as much as a foot in height. Here they were no doubt practically dependent on vegetable foods.

Thirteen-lined Spermophiles will immediately encroach upon newly-mown fields where many insects are easily accessible on the fallen hay and grain. Here they will remain for a week or more, constructing shallow burrows into which they retreat at night or when threatened by any of their various natural enemies.

The abundance of natural enemies tends to affect distribution somewhat. For instance, a whole pasture may be depopulated of spermophiles by the attacks of a single Cooper's Hawk.

STORING OF FOOD

Thirteen-lined Spermophiles seem to have a rather moderately developed instinct to store food materials in their underground retreats. Such a practice is not essential, however, and is not resorted to in the majority of cases. The writer has found small caches of grain, principally corn, on several occasions. In some cases it seems that the food was stored in the fall and remained untouched until the following spring when the spermophiles came out of hibernation.

G. E. Johnson (1917, pp. 267-68) reports the following case in regard to storage of food: "The burrow occurred in a pasture near Canistota, S. Dak., fifteen rods from an oat field. The first nest was about two feet from the outside opening, the entrance running back under the first part of the burrow. This nest was filled entirely full with unshelled oat kernels and a little dry grass. The estimated number of seeds by counting one-sixteenth of them was 23,000 to 24,000. This nest was only seven inches below the surface of the ground, and may have been an emergency storehouse. The second nest was about sixteen feet from the first, measuring along the burrow, and was twelve inches below the surface of the ground. It was seven inches in diameter. It contained a handful of dry grass and about 4,000 oat kernels unshelled." Further on in the same paper, Johnson records the storing of wheat kernels in a similar manner.

It is the opinion of the writer that grain is sometimes stored when it is plentiful and easily obtained. Such storages are used in case of emergency when other food supplies fail, as in the late sum-

mer and fall after a frost when the insects are few in numbers. The members of this species eat insects when they are available, but evidently store grain during the harvest season, even if it is not the principal article of diet at the time.

PREPARATIONS FOR HIBERNATION

The first indications of cold weather in the fall result in a marked diminishment of activities on the part of *Citellus tridecemlineatus tridecemlineatus*. Some warm days during September will find these spermophiles above ground. There is some excavation going on, as old burrows are deepened, and nests are lined with grass in preparation for the coming winter. No doubt the great majority of the species simply remain in the deepest burrows. However, the writer has noted cases where this species took over much larger abandoned burrows of other animals in the fall. In one case, a spermophile was observed carrying nest materials into the former den of a woodchuck, at Iowa City, September 14, 1922. There is no doubt that in some cases they prefer the deeper burrows of other animals during the winter season, and are in this manner enabled to retreat below the frost line.

All existing observations seem to point to the fact that each individual constructs a separate hibernating cell or nest. Further, but one animal hibernates in a burrow ordinarily. In one case two hibernating nests were found off the passages of a common tunnel, but they were some twenty feet apart.

Just before hibernation is entered upon, all the openings of the burrow are plugged with dirt for a distance of from one to three feet. If there is a succeeding period of warm weather, the plugs may be removed temporarily, but they usually remain until the following spring, practically obliterating the signs of the burrow's presence.

HIBERNATION

As has been inferred, the degree of activity shown by *Citellus tridecemlineatus tridecemlineatus* is directly dependent upon temperature. Warm sunny days find the spermophiles above ground and extremely active. On the other hand, they are equally inactive during cool rainy weather, even in mid-summer. G. E. Johnson (1917, p. 268) reports a variation of 4° C. in the temperature of an individual during a single day. This phenomenon is not uncommon among animals which "hibernate" in the true sense of the word.

After closing its burrow a Thirteen-lined Spermophile curls itself up in the nest previously prepared for that purpose and gradually passes into the torpid condition known as hibernation while the surrounding earth is becoming cold. If the spermophile be removed now into warmer surroundings it will gradually revive, but will become torpid again if restored to the colder medium. Experimentation has shown that if the temperature of the spermophile's body be reduced below the freezing point death will result in a short time.

The life processes of the spermophile must be sufficient to counteract the cold influence of the walls of the burrow, for the animal hibernates in a medium which is often well below the freezing point. On the other hand, the vital activities must be reduced sufficiently that they will not cause too heavy a drain on the animal's store of fatty tissue.

Previous investigations as to the actual organic conditions of hibernation have been successfully conducted by Dr. P. R. Hoy (1875, pp. 148-50), who reports the following interesting facts: The pulse is reduced from 200 to 4 beats per minute. Respiration is reduced from 50 to practically zero. Temperature falls from 105° F. to 58° F. Circulation is very feeble and amputation of a limb may be accomplished with very little loss of blood. There is a prominent congestion of blood in the thoracic region. There is no muscular response to stimuli, not even if a nerve be severed.

STRUCTURE OF BURROWS AND RETREATS

FOREWORD

The examination of many burrows by means of excavation has made clear to the writer that their construction is dependent on a large number of varying conditions. The different kinds of burrows it is true, fall roughly into two classes: permanent and temporary, but exceptions to even the most general types are met with on every hand. It may be said that the Thirteen-lined Spermophiles show a certain aptitude to take advantage of favorable conditions in connection with the construction of burrows. This fact alone would account for considerable diversity of structure since this species inhabits a variety of soils under many changing conditions of agricultural development.

A great many factors must be taken into account if an attempt is made to correlate the structure of any burrow with environmental circumstances. The kind of soil may be considered as a determining element. Drainage, elevation, accessibility of food, character of vegetation and the number and variety of natural enemies serve as similar influences. In many cases a certain type of structure may be traced back to certain combinations of these factors.

In Iowa, Thirteen-lined Spermophiles are found both in the valleys and on the uplands. They migrate back and forth locally in order to take advantage of abundant food supplies. As an example of this the writer has often noted that these animals are particularly abundant on newly raked hay fields. The reason of course is obvious. Many of the insects that live on the hay in the early months of the summer are now left on the short stubble where they come within reach of the spermophiles. Accordingly many spermophiles migrate in from adjacent pastures to take advantage of this easily obtained food.

The Thirteen-lined Spermophiles never venture far from an underground retreat of some sort and this habit or instinct leads them to construct new burrows or renew old ones whenever they encroach upon new territory. Such burrows are usually of a temporary nature, for in many cases the vegetation grows up later in the season and the spermophiles return to the pasture where

the grass is shorter. This general example is cited to indicate the multitude of conditions which may directly affect the habits of this species and indirectly affect the construction of its burrows.

Local migration explains many things in connection with burrows that would otherwise remain a mystery. It explains the fact that the number of burrows is relatively large in proportion to the number of individuals living in the vicinity. As a rule at least half of the burrows in a given region will be unoccupied although at any time they may become reinhabited. In this connection it is of interest to note that the spermophiles are usually found singly in separate burrows as indicated in the treatment of general habits. This habit would also tend toward the construction of a comparatively large number of burrows and no doubt is nearly as important a factor as local migration itself.

G. E. Johnson (1917, p. 264) writes with reference to the burrows of *Citellus tridecemlineatus tridecemlineatus* as follows: "Approximately fifteen of these burrows were in the sandy regions of South Chicago (Nov. 11) and were of one type, about two feet in length and eight to fourteen inches in depth, and showing no evidence of recent occupancy. . . . The remaining burrows were in sod (humus) with clay subsoil. These ranged from four to twenty feet in length and from four to forty-six inches in depth. Of the seventy-eight burrows measured, thirty-seven per cent were two feet or less in length and nine inches or less in depth; while sixty-seven per cent were four feet or less in length and thirteen inches or less in depth; and only fourteen per cent were longer than six feet or deeper than seventeen inches."

The first burrows, referred to as being in the sandy region about Chicago, are no doubt examples of temporary structures which had been in use during the summer as a result of local abundance of food. As winter approached (remembering that there is little activity among the members of this species after the first of November) the spermophiles would naturally withdraw to older, deeper burrows, leaving the former in the unoccupied condition that they were found by Mr. Johnson. The last part of the quotation is included to substantiate a point brought out in the preceding pages; that there is a great variety of burrow structure and that there are many small temporary burrows in proportion to the number of long permanent tunnels. It will be observed that Mr. Johnson credits only fourteen per cent of the burrows as being longer than

six feet. He divides the remaining burrows into two classes, one group about two feet long, the other group about four feet in length. In the writer's opinion the latter two classes may to all intents and purposes be regarded as representing the same thing; simply refuges or places for temporary shelter. Mr. Johnson's observations likewise indicate at least a fundamental similarity between the conditions of construction existing in the region he refers to (Illinois) and the conditions to be found in Iowa.

Before closing the introduction it seems fitting to make some mention of the manner in which these animals dig. G. E. Johnson (ibid., p. 266) reports the keeping of a number of these animals in captivity and the observance of their digging habits. He is quoted in part as follows: "In digging, the ground squirrel makes a few, quick, alternating strokes with its fore legs throwing the sand about its hind legs. This is followed by a straightening of the body and quick alternating strokes by the hind legs which throw the soil back with great force, at the same time scattering it."

The writer has observed much the same process in the field, especially during the breeding season when the old males were roaming about constructing new retreats. In some cases the dirt seems to be scattered away from the hole, at least in part, but in many instances no apparent attempt is made to conceal the opening. The writer is of the opinion that the spermophiles do not try to hide their excavations, and that the dirt at the mouth of a hole is only scattered when it accumulates in such quantity that it interferes with the activities of the animal. Holes are eventually rendered inconspicuous by the washing away of loose dirt and regrowth of the sod. The fact that the animals habitually dig their burrows in exposed places, when in many cases locations under bushes or at the edges of hayfields and weed patches present themselves, argues against any very strong instinctive tendency to conceal the burrows.

As previously intimated, the concrete discussion of the subject will be divided into separate considerations of the temporary and the permanent burrows. As the separation into these two groups is based principally on length, no sharp line can be drawn between the two classes and the division is more or less artificial. Its use is justified, however, for it has enabled the writer to bring out the correlation of the animals' life habits and the types of burrows that are utilized. Specific cases and diagrams are included in the fol-

lowing pages, the examples being selected primarily to show diversity of structure. Habits which are closely dependent on burrow structure are necessarily included although they come more properly within the field of general habits. In order to treat the subject as coherently as possible the insects found in the different burrows are simply listed in this chapter as they form the subject matter for a later discussion.

TEMPORARY BURROWS

The structures which may be regarded as temporary burrows or retreats are usually short and of simple construction. For all practical purposes the length may be used to indicate the nature of any particular burrow.

The great majority of the burrows fall into this class. It is likely that even the permanent nesting burrows are at first shallow retreats, a few being dug out and developed because of natural advantages, while the most of the retreats are of only passing value dependent upon circumstances, and eventually fall into disuse.

In any pasture inhabited by the Thirteen-lined Spermophile a careful examination and some excavation will reveal the fact that there are many short burrows within a few yards of what are known to be old established dens. Further observation will show that most of these short tunnels or pockets (for they are often merely passage-ways under stumps, which require little effort on the animal's part in construction) are not developed during the summer but are used casually, nevertheless, by the inhabitants of the region. This condition varies in degree, and is dependent largely on the extent to which the animals are persecuted by natural enemies. For these short pockets are used principally as refuges into which the animals retire to eat the various food materials which they obtain above ground. Usually the walls of the tunnel, especially near the entrance, will show the presence of small bits of clover, grass or insect remains. The spermophiles increase their feeding territory and yet insure themselves against surprise attacks by constructing a number of these small refuges.

If stumps are present in the infested pasture, many holes will be found about their roots. Tunnels from the holes usually lead directly beneath the stumps, where natural cavities formed by decay are taken advantage of. There may be one or more than one opening, often there are two, and more rarely three. The openings

may be at the very edge of the stump or occasionally a foot or more away. Plate I, fig. 1, shows an example of this type.

A tunnel passes around the stump to join two holes on opposite sides. Often there is a natural central cavity beneath the stump, due to decay, and accessible from the tunnel at various points.

Plate I, fig. 2, shows a temporary retreat that was located in a pasture region among several permanent burrows. This little burrow measured some three and a half feet in total length and was not more than ten inches deep at any point. At the time of investigation both openings were plugged. This is often found to be the case when the burrow is not in use and no explanation can be given in most instances.

Occasionally these retreats under stumps are developed in an interesting and peculiar manner. As the stump decays it gradually falls apart or becomes overturned or otherwise broken away from the roots. This leaves the former retreat exposed or partially so at least. In hard soils, clays particularly, the roots will become partially pulverized while the soil is so dry and hard that it will not immediately fill the cavities caused by the decay. The spermophiles take advantage of this fact, and the writer has excavated many passages which occupied the spaces formerly filled by roots. In fact, the old bark was often found lining the walls. For the bark is thin and resistant and does not decay until the internal portion of the root has long been gone.

Plate I, fig. 3, is a diagram of a short burrow with two openings. It is included because the distal part of the burrow occupied the former position of a branching root which was mainly decayed away.

The writer was at a loss for some time in trying to account for some long burrows which took a fairly straight course and yet ended blindly after gradually becoming smaller in diameter up to the point that they would not permit the passage of a spermophile. Johnson (1917, p. 268) reports the discovery of some long tunnels that ended blindly and suggests that they might function as drains. No mention was made of any tapering in size so these burrows may not have been similar to those mentioned above. It is the opinion of the writer, however, that most of these cases can be explained by the fact that the passages occupy the positions of former roots.

It is difficult to say to just what extent the spermophiles utilize

old root passages. Probably they remove bits of decaying wood and otherwise hollow out the tunnels so formed to suit their conveniences. Burrows of this nature are, however, temporary retreats only. They are longer than the ordinary retreats because their construction is not dependent on the spermophile's efforts alone. Some of these longer retreats are no doubt remodeled eventually to become permanent nesting burrows as they are typically found in the hard soil of pastures where this species prefers to construct its more permanent homes. But in such case the constant use of the passages obliterates all traces of former relations with regard to the roots. Hence this feature is usually noticeable only in the temporary burrows.

An example of a temporary burrow which occupied the former position of a root is shown in the drawing on Plate II, fig. 1. This burrow had been in active use the entire summer until a few days before the time the excavation was made. (September 8). A short period of cold weather had put a stop to activities on the part of the spermophiles and the burrow was abandoned. It was located in an upland pasture, bare stump land for the most part.

The burrow had been plugged with loose dirt for a distance of a foot or more from the mouth. In one pocket about three feet from the external opening, a toad was found which had evidently selected this location in which to hibernate. The burrow followed the course of a decayed root. In fact, there were three holes near the one diagrammed, with burrows radiating from the location of a former stump. The walls of the passageway were lined with old bark and in some cases it was possible to remove whole cylinders of the latter without breaking it. As would be expected the tunnel became progressively smaller toward the distal end, and it was obvious that this portion was not used to any extent.

A somewhat different situation is shown in Plate II, fig. 2. This burrow was observed to be in use the year preceding its excavation, but had evidently not been used as a nesting burrow. At the time of excavation (August 14, 1922) there was much dirt in the passage from B to C and it was evident that the burrow was being lengthened. As in the previous case this burrow followed the course of a decayed root. There were two openings (A and B). The burrow was located in an upland pasture.

Cory (1912, p. 141) quotes Kennicott as saying that in Illinois the males leave the females during the season when the young are

produced and wander about digging temporary burrows or living in some abandoned ones for a few days at a time. He says that some of these burrows are as much as twenty feet in length and contain nests placed in side chambers.

The writer is inclined to believe that these longer burrows were not constructed for strictly temporary use but has noticed their presence if a summer retreat was well situated with reference to the food supply and was used quite regularly accordingly. However, this wandering habits of the males no doubt accounts for many of the short, abandoned and sometimes isolated burrows.

G. E. Johnson (1917, p. 264) mentions the discovery of short burrows in Illinois and says that they are evidently refuges used in journeys between a food source and permanent burrows some distance away. In the same article Johnson mentions that short burrows were found associated with deeper burrows in pastures.

But by no means all of the temporary shelters are of the same nature and location as the foregoing. The spermophiles move about locally with reference to the food supply. Their fondness for grasshoppers leads them into newly cut fields. Here they will remain until the conditions which facilitate the securing of food are no longer operating.

So we find many short retreats scattered over the hay and grain fields in the late summer. They are constructed in the rather loose soil and are very temporary, being obliterated during the winter or by plowing in the spring. Some of these burrows command a more favorable location, being preserved by the proximity of a fence or some other obstacle. In such cases they may even become permanent eventually, especially if they are near a pasture. For this sort of location is admirably suited to the animals' needs as they can feed on the short pasture during the summer and retreat into the holes in the grass of a neighboring field when threatened by natural enemies. Similarly, under such conditions many of their movements are concealed from other animals that prey upon them.

PERMANENT BURROWS

From the exterior there is no apparent difference between a permanent burrow and one of a temporary nature. The only indication of a permanent structure may be the fact that several holes are in close proximity, for there are almost invariably two openings to the old established burrows. Then, too, they are usually situ-

ated in hard soil, pastures being favored, for it is necessary to have the permanent home in ground that is not plowed constantly and is firm enough to prevent collapse of the passages from rains or freezing and thawing.

Plate III represents an upland pasture burrow which was at least three years old and perhaps much older. It was located on a hillside in hard, dry, well drained soil. The passages themselves indicated considerable age, being rather wider than the average and showing signs of wear.

Two interesting facts were made clear in the course of excavation. The pocket A, which incidentally marks the deepest point of the burrow, was used only for the dumping of wastes. This was found to be duplicated by similar conditions in previous excavations and in this instance the proof was conclusive. The pocket was over half filled with coprolites, many of them being of recent deposition.

The passageway B is of interest because it was hollowed out within a decayed root which came from the stump E, as indicated by the dotted lines.

No nests were present although this was an old burrow. This is explainable in that old nests are walled in during the summer and especially after the young are capable of caring for themselves. This burrow was excavated August 9, 1922, at which date the young would have left the parental home. Without doubt the enlargement at D marks the former site of a nest, used either for hibernation in winter or for the raising of young. It is notable that this is practically the deepest point in the burrow. The enlargement at C is no doubt due to constant use of the passage at this point. It is habitual with the spermophiles to carry food within the mouth of the burrow, where it can be eaten with more safety.

Plate IV, fig. 1, represents a burrow from the border of a dry creek bed in a pasture area. It was entered from the north where two openings gave access to the exterior. It will be noted that a short passage about four feet from the openings leads to a nest. This nest was of recent construction and in a good state of preservation. The date, July 27, 1923, indicates that this was about the end of the season that the young are in the nests.

The passage continued on nearly two feet from the nest, and was plugged with dirt after turning slightly. Coprolites were found

scattered on the floor of the pocket thus formed, which bears out the testimony of Plate III.

The plug having been removed, the tunnel was found to lead to another rather new nest, which was placed directly beneath a stump, between the spreading and decaying roots. A passage extended to the surface here, while a deeper tunnel continued through beneath the nest. This latter tunnel took a sharp bend to the left and assumed a more or less straight course for over six feet. This was followed by an elbow bend where an old nest was walled in. The materials of the nest were the usual grasses, but they were old and were mixed with bits of oak leaves, indicating that the nest had been there since the preceding fall and may have served as the retreat of a spermophile during the winter months. Some shells that represented corn grains were found mixed with the nest materials, and they too showed signs of considerable age. It is notable again that this nest was at the deepest point of the burrow, being some 28 inches below the surface.

Plate IV, fig 2, gives an example of a rather short shallow burrow that was evidently used as a place to raise young. There was one inhabitant at the time of excavation, a young male about two-thirds grown.

The nest was situated in an oval chamber about six inches in depth. This pocket had been partially filled with dead and fresh grasses mixed with loose dirt. This rude nest was covered with insect remains and bits of wilted clover which no doubt represented food that had been brought to the young. Several grubs were found in or about the nest. This burrow was excavated June 26, 1922. It was located in an upland field and had obviously been constructed the same year. It was of course much shorter than the average pasture burrow.

G. E. Johnson (1917, p. 264) brings out the relative scarcity of the long permanent burrows when he states that only six of nearly eighty burrows which he examined were found to be branched. He likewise states that the animals were observed to construct nests while in captivity, in which they slept when not active. The writer observed the same habit when experimenting with captive spermophiles. It must be remembered, however, that an animal does not necessarily react in a normal way when taken out of its natural environment.

In regard to nest structure the following is quoted from Johnson (ibid., p. 267):

"It is in the nest also that food is stored as was proved by the presence of grain in the nests of the three ground squirrels referred to, and in practically every nest examined in the field. Oats, wheat, corn, and weed seeds have been frequently found between the excavated space in the ground and the grassy nest that filled it. In the recently occupied burrows this food varied from considerable in the late summer to a small amount in the late autumn. The nests were usually found in the longer and deeper burrows. Of the seventy-eight burrows recorded twenty-two had nests connected with them. Two of these had two nests."

"Some of the nests were found to one side of the burrows, others at the ends of the burrows and still others in the direct course or at an angle of the burrow. . . . This nest was filled entirely full with unshelled oat kernels and a little dry grass. The estimated number of seeds by counting one-sixteenth of them was 23,000 to 24,000."

The writer's own experience with nests was somewhat similar to the above. Possibly there seemed to be less of a tendency to store grain, but this could be accounted for by varying local conditions as to the availability of food. The habit of storing grain is certainly not universal among the spermophiles.

Cory (1912, p. 141) quotes Kennicott as saying that the nests were sometimes as large as a half bushel, the interior being lined with soft material. The writer found no case of a nest this large. The largest were about ten inches in diameter and these were demonstrated to be nests used in rearing the young.

One phase of burrow structure remains to be touched upon; the type of retreat used during hibernation. Some work has been done on this subject previously, the information being collected by accidental discoveries of individuals undergoing hibernation. The testimony is to the general effect that the animals hibernate in nests in the deeper burrows. This is too well established to be questioned.

Interesting exceptions occur however. The writer observed two cases of spermophiles taking over abandoned burrows of larger animals, which were of course deeper and went down below the frost line. But the great majority of the spermophiles hibernate in their own burrows.

GENERAL CONCLUSIONS AND ECONOMIC BEARING

From the standpoint of agriculture the burrows themselves are harmless enough. They may even be of some slight benefit in allowing the rainfall to soak into the ground more completely. On golf links, parade grounds, parks and similar areas the holes may often become a serious nuisance.

If control measures are attempted in any locality, the significance of burrow structure has a direct bearing on the subject. For if poisoned grain, for instance, is to be laid in the burrows, the time to do it is obviously in the early spring when the animals first appear and may be found almost exclusively in pastures or near the deeper burrows. A little observation will show at once where the ground squirrels are to be found at this time. Later on in the summer the problem of extermination is made much more complicated by the scattering out of the individual spermophiles and the occupancy of the many small retreats. But, as will appear later, the necessity for control is the exception rather than the rule. And almost all of the serious damage done by this species is confined to the planting season.

As to the stage of grain and the relations of food to burrows, the subject is developed in a succeeding chapter on food habits. It is, however, of economic importance, and a study of burrow structure is necessary in order to fully understand it.

FOOD HABITS AND ECONOMIC STATUS

FOREWORD

While engaged in a field survey and study of *Citellus tridecemlineatus tridecemlineatus* some one hundred and twelve stomachs were preserved.

The writer found that the best method in preservation was to empty the stomach contents into a small wide-mouthed bottle of 70% alcohol. This was preferable to placing the entire stomach in preservative because when this latter method was employed the alcohol did not penetrate the rather thick stomach wall soon enough to prevent the beginning of decay.

The spermophiles chew their food well before swallowing it and the materials in the stomach are always well broken up even before the digestive juices have acted upon them to any considerable extent. Hence the stomach contents are quick to decay upon the animal's death.

The fact that these stomach contents are so well pulverized has an obvious disadvantage from the standpoint of the investigator, for in almost all cases it is impossible or at least impractical to attempt accurate identification of the insect remains. Occasionally, legs of grasshoppers are swallowed without being completely mutilated. Some larval segments may also remain more or less intact. Hulls of the common grains are sometimes swallowed entire, as are many weed seeds.

But fortunately, on the other hand, *Citellus tridecemlineatus tridecemlineatus* seems to prefer many of the common and well known grains as well as some of the common and conspicuous insects. So the work of identification was not entirely hopeless. It is the opinion of the writer that the results obtained are entirely dependable and quite characteristic of the species.

W. L. Burnett (1914, p. 11) mentions the same difficulties in identifying the stomach contents of *Citellus tridecemlineatus pallidus*. Furthermore he is of the opinion that it is somewhat easier to identify the vegetable materials than to identify the insect remains.

DATA GAINED FROM FORMER INVESTIGATIONS OF FOOD

C. P. Gillette (1889) examined some twenty-two stomachs of *Citellus tridecemlineatus tridecemlineatus*, the animals being killed between April 19 and August 2. He found that insects made up a large proportion of the food, and further, that the insects eaten were almost exclusively injurious. He stated it as his opinion that this animal was of decided benefit to gardens, lawns, meadows, and pastures. Similarly, he believed that this spermophile would be advantageous to cornfields if it could be prevented from digging up the newly planted grain, for it would destroy large numbers of cutworms before planting time.

J. M. Aldrich (1892) in summing up some examinations of the food of *Citellus tridecemlineatus tridecemlineatus* found that relatively large numbers of cut-worms, grasshoppers and crickets were eaten. Some neutral beetles were also found in the food materials. Aldrich seemed to think that this species was approximately neutral in its economic importance.

W. L. Burnett (1914, p. 10) gives some very interesting data with reference to *Citellus tridecemlineatus pallidus*. He states that a specimen kept in captivity would leave all other foods untouched when grasshoppers were available. The legs and wings of the grasshoppers were not eaten. This specimen would catch, kill, and eat mice as well as grasshoppers, when these animals were placed in its cage.

W. L. Burnett (ibid., p. 11) gives the following list of food materials eaten by *Citellus tridecemlineatus pallidus* where in captivity: sunflower seed, grass seed, dandelion seed, pumpkin seed, sugar beet seed, watermelon seed, muskmelon seed, young chickens, squash seed, speltz, beans, grasshoppers, crickets, beetles, alfalfa roots and leaves, corn, cane, oats, wheat, kaffir corn, rye, milo maize, peas, barley, peanuts and field mice.

Some forty-six stomachs of *Citellus tridecemlineatus pallidus* were examined by Burnett (ibid., p. 15). All of these specimens were taken in northern Colorado during the summers of 1912, 1913 and 1914. He found the stomachs to contain a rather high percentage of animal matter. Remains of grasshoppers, beetles and field mice predominated. Corn, alfalfa, spiders, caterpillars and in one case a bird feather, were found in the various stomachs.

DAMAGE

The principal charge against this species is that it destroys young crops. Corn crops are sometimes damaged to the extent that replanting becomes necessary.

The attacks usually occur along the margins of cornfields which are bordered by meadows. The spermophiles dig down at the base of each newly-sprouted corn stalk and in this manner obtain the planted grain. The young corn dies as a result.

Such depredations are quite common throughout the state of Iowa. Fortunately, however, the damage is so slight that it usually passes unnoticed. It is seldom that the corn is molested beyond the third row from the edge of the field. But occasionally, if the spermophites are present in large numbers the actual loss to the farmer may be considerable.

A few years ago when this species was somewhat more numerous in individuals, serious losses of young corn were not uncommon. Stoner (1918, p. 32) quotes an early report of Vernon Bailey to the effect that large fields of corn were sometimes destroyed and had to be planted over several times. Even fields of small grain were at times seriously damaged by spermophile invasions in the late eighties of the past century.

But according to all available reports the numbers of spermophiles have been very materially reduced in the last decade. It is perhaps safe to say that there has been a fifty per cent reduction in the preceding five years. Bounties have been offered for this species, and literature has been circulated about the country advising the people as to the different methods used in poisoning rodents.

With this loss in numbers has come corresponding reduction in the amount of damage done. Occasionally one hears accounts of attacks upon corn. The writer has recently investigated some of these claims and has found that they are very generally grossly exaggerated.

As far as attacks on oats, wheat, barley, rye, and similar crops are concerned, the damage is of little consequence. These grains may be attacked just after sprouting. But the destruction is never great enough to necessitate replanting. Occasionally the ripe grain is eaten or stored in the fall, as mentioned in preceding discussions. However, grasshoppers are easily obtainable at this season of the year, and *Citellus tridecemlineatus tridecemlineatus* prefers these insects to any other form of food.

It has been claimed that garden crops are sometimes injured by this species. The writer, however, has been unable to discover any real proof of this. No doubt peas, beans, and similar vegetables are sometimes taken, but certainly not in any considerable quantities Spermophiles kept in captivity would only eat peas, beans, and the seeds of other garden plants when no other foods were available.

There is little or no damage to pasture land because of the presence of burrows. No obstructions, such as piles of loose dirt, are thrown up by this species. Similarly, there is practically no injury to the grass because it almost always grows up to the very edges of the holes.

There is no doubt, however, that the burrows are somewhat of a nuisance to golf links, parade grounds, and similar areas where a smooth unbroken surface is desirable.

BENEFITS DERIVED

At the beginning of this consideration we are confronted by the fact that we cannot hope to determine the identity of many insect remains found in the stomachs of this species. For not only does this animal chew up its food very thoroughly, but it bites off and discards the heads, wings, and legs of the insects in most cases, and these rejected parts are the ones that lend themselves particularly well to identification. But the task is by no means hopeless, and it is possible to make some fairly accurate estimates.

Of the larvæ eaten in the spring it is safe to say that a great many are detrimental to agricultural pursuits. For they are of necessity species that live upon the cultivated crops and grasses. It has previously been determined that cut-worms constitute a regular article of diet at this season.

It is quite true that *Citellus tridecemlineatus tridecemlineatus* exercises little or no choice in the selection of insect food in the spring, probably because the insects are none too numerous at this time. But in the fall when insect life is abundant and diversified a very decided choice is exercised.

Perhaps the strongest argument in favor of the Thirteen-lined Spermophile is the fact that it consumes large quantities of grasshoppers in the latter part of the season. It is observable, both in the field and in the cases of animals kept in captivity, that the members of this species seem to prefer grasshoppers to any other food. Grasshopper remains may be identified among the stomach contents because in this case the enlarged proximal portions of the

hind legs are often swallowed entire. The heads, wings, and remaining leg parts are discarded. The appended chart (Plate V), shows what a large proportion of the food matter is made up of grasshoppers, particularly in the late summer and early fall. Some weed seeds are eaten by the Thirteen-lined Spermophile at every season of the year. Here, however, there is apparently very little choice in the selection of food, and whatever is most accessible is utilized. Seeds of rag weed, hemp, fox-tail, and pig weed are commonly eaten. But on the other hand clover seed forms a staple article of diet, whenever available. And ordinarily the eating of clover seed would be considered as disadvantageous to agricultural interests. So perhaps the good done in the destruction of weed seeds is counterbalanced by the harm done in consumption of clover seed.

ECONOMIC CONCLUSIONS WITH REGARD TO THE FOOD HABITS

C. P. Gillette (1889) believed that *Citellus tridecemlineatus tridecemlineatus* was advantageous to agricultural pursuits. He examined twenty-two stomachs and based his conclusions on the results of this investigation.

J. M. Aldrich (1892) investigated *Spermophilus tridecemlineatus*, and seemed inclined to consider this form about neutral in economic status. This work was done in the Dakotas, so the species referred to was undoubtedly what is known as *Citellus tridecemlineatus pallidus*.

W. L. Burnett (1914) collected forty-six stomachs of the western subspecies, *Citellus tridecemlineatus pallidus*. As in the case of the present investigation a large proportion of the food was found to consist of insect remains. Burnett probably considered this species to be neutral in its economic importance. It is interesting to note the answers he received to letters of inquiry that were sent out to some of the farmers of northern Colorado. In every case the farmers were quick to notice any depredations, but they failed to recognize that any good might result from the presence of this form. A parallel could be pointed out in the former public attitude toward many of our useful hawks and owls.

Vernon Bailey (1893, p. 42) examined stomach contents of this species and its geographical races. He came to the conclusion that it probably did more harm than good. Harm by virtue of the damage to young crops, and good because of the numbers and kinds

of insects eaten. The writer is inclined to think this was a very fair estimate. But as before intimated, since the numbers of spermophiles have been greatly reduced, the damage to young crops is negligible.

It is even likely that this species will not disturb the corn, if represented by only a moderate number of individuals. For when the spermophiles are not especially numerous, they can obtain enough food in the way of insect larvæ without leaving their natural haunts and invading the cultivated fields.

A glance at the appended chart will show the high percentage of insects eaten by *Citellus tridecemlineatus tridecemlineatus*. Further observations will show that the majority of these insects, taking an average for the season, are grasshoppers. It is safe to say that grasshoppers cause a five per cent annual loss to hay crops alone.

Without doubt, this species acts as an important natural check upon the increase of grasshoppers.

Man's attempts to disturb the balance in nature have quite commonly resulted in disaster from an agricultural standpoint, particularly when he has destroyed some species which acted as a natural check upon a noxious form. We find an example of this in the destruction of the Prairie Chicken and the succeeding increase in the numbers of grasshoppers.

It is the opinion of the writer that unless some very serious charge is brought against a species, it is the part of safety to leave the balance of nature undisturbed, especially in cases like the one under consideration where the animal preys upon an undesirable form.

As intimated in the preceding pages, these spermophiles are not numerous enough in most localities to destroy any great amount of young corn. Should they become too populous in a given area it is a simple matter to reduce their numbers practically overnight. Some effective means of eliminating these animals will be found in the following chapter. In conclusion, we may even admit that with the exception of grasshoppers, no discrimination is exercised in the choice of insect foods. Perhaps equal numbers of beneficial and harmful insects are destroyed. But in any event, if the damage to young corn is not serious, it is most emphatically desirable to retain this species as a check upon grasshoppers. For even a one per cent increase in the numbers of grasshoppers would mean a very large total loss to cultivated crops each year.

So as long as this species exists in moderate numbers it may be

regarded as a desirable element in the fauna of a given region. Certainly active measures to secure its elimination should not be necessary.

ANALYSIS OF STOMACH CONTENTS

In the following pages analyses of the materials found in eighty-two stomachs will be found. As previously stated, one hundred and twelve stomachs were collected in 1922 and 1923. All of these were examined, but a number of them proved to be empty. The latter have not been included in this appendix because they have no particular significance. They merely represented individuals killed in the early part of the day, probably before any food had been eaten.

Stomach No. 1—female; Iowa City, Iowa; May 14, 1922.
- 85% insect larvæ.
- 10% blue grass and white clover tips.
- 5% weed seeds.

Stomach No. 2—female; Iowa City, Iowa; May 14, 1922.
- 60% insect larvæ.
- 30% blue grass and white clover.
- 7% weed seeds.
- 3% unidentified vegetable materials.

Stomach No. 3—male; Iowa City, Iowa; May 14, 1922.
- 80% insect larvæ, at least one-half of them cutworms.
- 20% vegetable matter. Chiefly grass and white clover.

Stomach No. 4—male; Iowa City, Iowa; May 16, 1922.
- 20% insect larvæ.
- 40% corn.
- 25% grass and white clover.
- 5% various weed seeds.
- 10% unidentified vegetable materials.

Stomach No. 5—male; Williamsburg, Iowa; May 20, 1922.
- 40% insect remains. Evidently all larvæ.
- 40% corn.
- 20% grass, clover, and unidentified vegetable matter.

Stomach No. 6—female; Victor, Iowa; May 21, 1922.
- 45% insect remains.
- 20% corn.
- 20% clover and grass.
- 5% weed seeds.
- 10% unidentified vegetable materials.

Stomach No. 7—female; Victor, Iowa; May 21, 1922.
- Stomach nearly empty. Some signs of insect remains.

Stomach No. 8—male; Victor, Iowa; May 21, 1922.
- 30% insect remains.
- 60% white clover.

10% unidentified vegetable materials.

Stomach No. 9—female; Iowa City, Iowa; May 28, 1922.

20% white clover.
10% various weed seeds.
60% corn.
10% unidentified materials.

Stomach No. 10—male; Iowa City, Iowa; May 28, 1922.

40% white clover seed.
20% various weed seeds.
20% grass and clover.
20% unidentified matter.

Stomach No. 11—female; Iowa City, Iowa; May 28, 1922.

40% insect remains.
30% wheat.
15% blue grass and white clover.
15% unidentified.

Stomach No. 12—female; Iowa City, Iowa; May 28, 1922.

This stomach was practically empty. A few corn hulls were found.

Stomach No. 13—male; Iowa City, Iowa; May 29, 1922.

20% insect matter.
30% wheat.
40% grass and white clover.
10% unidentified.

Stomach No. 14—female; Iowa City, Iowa; June 2, 1922.

This specimen filled with the remains of a field mouse.

Stomach No. 15—female; Iowa City, Iowa; June 2, 1922.

30% insect remains.
10% corn.
20% white clover seed.
40% grass and clover.

Stomach No. 16—male; Iowa City, Iowa; June 3, 1922.

30% insect remains.
20% corn.
50% blue grass and clover.

Stomach No. 17—male; North Liberty, Iowa; June 4, 1922.

35% insect larvæ.
25% corn.
40% blue grass and clover.

Stomach No. 18—female; North Liberty, Iowa; June 4, 1922.

40% insect matter.
55% grass.
5% weed seed.

Stomach No. 19—female; Eagle Grove, Iowa; June 10, 1922.

40% insect larvæ.
40% grasses.
10% weed seed.
10% unidentified.

Stomach No. 20—male; Iowa City, Iowa; June 29, 1922.
60% remains of a field mouse.
30% insect larvæ.
10% grass, clover, and clover seed.
Stomach No. 21—female; Iowa City, Iowa; June 29, 1922.
60% white clover seed.
30% blue grass and white clover.
10% unidentified.
Stomach No. 22—female; Iowa City, Iowa; June 30, 1922.
70% white clover seed.
20% white clover tops.
10% grasses.
Stomach No. 23—female; Iowa City, Iowa; June 30, 1922.
30% insects.
40% white clover seed.
30% grass and white clover tops.
Stomach No. 24—male; North Liberty, Iowa; July 3, 1922.
Contained two young meadow mice.
Stomach No. 25—female; North Liberty, Iowa; July 3, 1922.
35% insect matter.
10% white clover seed.
50% blue grass and clover.
5% unidentified.
Stomach No. 26—male; North Liberty, Iowa; July 3, 1922.
Practically empty. A few white clover seeds were found.
Stomach No. 27—male; Iowa City, Iowa; July 7, 1922.
60% unidentified insect materials.
30% grasshoppers.
10% blue grass, white clover, and white clover seed.
Stomach No. 28—male; Midriver, Iowa; July 10, 1922.
10% grasshoppers.
20% other insects.
30% white clover seed.
30% white clover and blue grass.
10% unidentified.
Stomach No. 29—female; Midriver, Iowa; July 10, 1922.
90% blue grass.
10% white closer seed and some weed seed.
Stomach No. 30—female; Midriver, Iowa; July 10, 1922.
75% blue grass.
10% white clover seed.
15% weed seeds.
Stomach No. 31—male; Iowa City, Iowa; July 24, 1922.
20% grasshoppers.
30% white clover seed.
10% various seeds.
30% blue grass.
10% unidentified (some insect remains).

Stomach No. 32—male; Iowa City, Iowa; July 24, 1922.
10% grasshoppers.
20% unidentified insects.
20% various weed seeds.
10% oats.
40% blue grass.
Stomach No. 33—male; Iowa City, Iowa; August 6, 1922.
95% grasshoppers.
5% unidentified materials.
Stomach No. 34—female; Iowa City, Iowa; August 6, 1922.
Entirely filled with grasshoppers.
Stomach No. 35—male; Victor, Iowa; August 7, 1922.
90% grasshoppers.
10% grass and unidentified materials.
Stomach No. 36—male; Victor, Iowa; August 7, 1922.
90% grass and white clover.
5% white clover seed.
5% unidentified.
Stomach No. 37—male; Victor, Iowa; August 7, 1922.
Contained one small field mouse.
Stomach No. 38—female; Iowa City, Iowa; August 16, 1922.
Entirely filled with grasshoppers.
Stomach No. 39—female; Iowa City, Iowa; August 16, 1922.
60% grasshoppers.
40% grass and clover leaves.
Stomach No. 40—male; North Liberty, Iowa; August 17, 1922.
Entirely filled with grasshoppers.
Stomach No. 41—female; North Liberty, Iowa; August 17, 1922.
Entirely filled with grasshoppers.
Stomach No. 42—male; North Liberty, Iowa; August 17, 1922.
10% grasshoppers.
90% young oats.
Stomach No. 43—male; North Liberty, Iowa; August 17, 1922.
Practically empty. Some traces of grass were found.
Stomach No. 44—male; Iowa City, Iowa; August 18, 1922.
90% grasshoppers.
10% white clover.
Stomach No. 45—female; Iowa City, Iowa; August 18, 1922.
Almost empty. A few grasshopper remnants.
Stomach No. 46—male; Iowa City, Iowa; August 19, 1922.
60% grasshoppers.
40% grass and clover.
Stomach No. 47—male; Lake Okoboji, Iowa; September 4, 1922.
40% grasshoppers.
20% other insects.
30% corn.
10% weed seed.

Stomach No. 48—male; Lake Okoboji, Iowa; September 4, 1922.
60% grasshoppers.
40% grass and clover.
Stomach No. 49—female; Lake Okoboji, Iowa; September 4, 1922.
Practically full of new corn.
Stomach No. 50—male; Lake Okoboji, Iowa; September 4, 1922.
60% grasshoppers.
40% new corn.
Stomach No. 51—female; Lake Okoboji, Iowa; September 4, 1922.
Full of new corn.
Stomach No. 52—female; Lake Okoboji, Iowa; September 8, 1922.
30% grasshoppers.
60% corn.
10% unidentified.
Stomach No. 53—male; Lake Okoboji, Iowa; September 8, 1922.
Practically full of grasshoppers.
Stomach No. 54—female; Lake Okoboji, Iowa; September 8, 1922.
Practically full of grasshoppers.
Stomach No. 55—male; Milford, Iowa; September 10, 1922.
90% grasshoppers.
10% corn.
Stomach No. 56—male; Spencer, Iowa; September 10, 1922.
A few grasshoppers.
Stomach No. 57—male; Iowa City, Iowa; May 14, 1923.
About a quarter full of oats.
Stomach No. 58—female; Iowa City, Iowa; May 14, 1923.
A few hulls of corn were found in this specimen.
Stomach No. 59—female; Iowa City, Iowa; May 15, 1923.
60% insect larvæ.
40% grass.
Stomach No. 60—male; Iowa City, Iowa; May 16, 1923.
90% grass.
10% weed seeds.
Stomach No. 61—male; West Branch, Iowa; May 20, 1923.
10% insect remains.
80% weed seeds.
10% unidentified.
Stomach No. 62—female; Iowa City, Iowa; June 10, 1923.
10% insect remains.
40% white clover stems.
50% weed seeds.
Stomach No. 63—male; Iowa City, Iowa; June 10, 1923.
90% grass and white clover.
10% weed seeds.
Stomach No. 64—male; Millersburg, Iowa; June 12, 1923.
Half full of unidentifiable insect remains.
Stomach No. 65—female; Millersburg, Iowa; June 12, 1923.
Half full of insect remains.

Stomach No. 66—male; Columbus Junction, Iowa; June 20, 1923.
40% insect remains.
10% grass.
30% weed seeds.
Stomach No. 67—female; Iowa City, Iowa; June 26, 1923.
70% unidentified insect matter.
20% grass.
10% clover seed.
Stomach No. 68—male; Iowa City, Iowa; June 29, 1923.
20% unidentified insects.
10% grasshoppers.
40% grass and clover.
30% white clover seed.
Stomach No. 69—male; Iowa City, Iowa; June 29, 1923.
20% insects.
60% grass.
20% white clover seed.
Stomach No. 70—female; Midriver, Iowa; July 3, 1923.
Half full of white clover seed.
Stomach No. 71—female; Midriver, Iowa; July 3, 1923.
10% insects.
90% white clover seed.
Stomach No. 72—male; Marengo, Iowa; July 12, 1923.
40% grasshoppers.
40% grass.
20% clover seed.
Stomach No. 73—male; Marengo, Iowa; July 12, 1923.
A few grasshoper remnants.
Stomach No. 74—female; Iowa City, Iowa; July 30, 1923.
90% grasshoppers.
5% grass and clover.
5% unidentified.
Stomach No. 75—male; Iowa City, Iowa; August 2, 1923.
60% grasshoppers.
30% seeds, (mainly white clover).
10% unidentified material.
Stomach No. 76—male; Iowa City, Iowa; August, 1923.
60% grasshoppers.
20% new corn.
20% clover seed.
Stomach No. 77—male; Iowa City, Iowa; August 9, 1923.
20% unidentified insects.
80% grass and white clover stems.
Stomach No. 78—female; Brooklyn, Iowa; August 10, 1923.
Half full of small grasshoppers.
Stomach No. 79—male; Brooklyn, Iowa; August 10, 1923.
A few grasshopper remains.

Stomach No. 80—male; Colfax, Iowa; August 11, 1923.

30% grasshoppers.

70% oats.

Stomach No. 81—female; Iowa City, Iowa; September 2, 1923.

70% grasshoppers.

30% grass and white clover.

Stomach No. 82—female; Iowa City, Iowa; September 2, 1923.

A few grasshopper remains.

NATURAL ENEMIES AND ARTIFICIAL CONTROL

NATURAL ENEMIES

As natural enemies of *Citellus tridecemlineatus tridecemlineatus* some of the common hawks should receive special mention. The writer observed one instance where a Cooper's Hawk practically exterminated the ground squirrels of an upland pasture. The Red-tailed Hawk and its varieties are persistent enemies of the spermophile. Sharp-shinned Hawks, Marsh Hawks and Sparrow Hawks have been seen to attack this species.

The domestic cat should probably rank second as an agency in control. Certain cats seem to acquire a special liking for ground squirrels and become exceedingly adept at catching them.

Snakes kill considerable numbers of spermophiles. Bull snakes, blue-racers, hog-nosed snakes and occasionally garter snakes figure in this capacity.

Weasels and the smaller mink are effective enemies of the ground squirrel. Although they hunt principally at night, their slender forms permit them to enter many of the spermophile burrows with ease. There is no doubt that many ground squirrels meet death through these night attacks.

Wolves, foxes and eagles destroy ground squirrels, but in Iowa, at least, these animals are not present in sufficient numbers to serve as potent controlling factors.

Perhaps skunks and owls should be mentioned. But all of the species belonging to these groups are inclined to be nocturnal or crepuscular and do not come in contact with the strictly diurnal spermophiles very frequently.

External parasites are rather uncommon on *Citellus tridecemlineatus tridecemlineatus*. All of the individuals killed or trapped were carefully examined and in only a few cases were any parasites found. All of these were discovered during the latter part of April or early in May, just after the animals came out of hibernation. No parasites were found after May fifteenth, indicating that the spermophiles are able to dispose of the pests when they resume active life.

Over half of the parasites found were fleas. All of them be-

longed to the family *Pulicidae*. F. C. Bishopp (1915, p. 12) enumerates the fleas found on American ground squirrels as follows:

The Indian rat flea—*Xenopsylla cheopis* Roth.
The European rat flea—*Ceratophyllus fasciatus* Bose.
The human flea—*Pulex irritans* L.
The European mouse flea—*Leptopsylla musculi* Duges.
The dog flea—*Ctenocephalus canis* Curtis.
The squirrel fleas—*Hoplopsyllus anomalus* Baker and *Ceratophyllus acutus* Baker.
The cat flea—*Ctenocephalus felis* Bouche.

All of these fleas are parasitic on rats and other animals, including man. Some are known to carry the bubonic plague if there is a source of infection. The California ground squirrel *(Citellus beecheyi beecheyi)* was discovered as an agent in the transmissal of this disease, through the medium of parasitic fleas. (Lantz, 1921, pp. 12-13). It has been found necessary in the interests of human health to destroy large numbers of California Ground Squirrels over infected areas.

It is not beyond possibility that *Citellus tridecemlineatus tridecemlineatus* might aid indirectly in the spreading of similar infections, either now or in the future. But the inconsiderable numbers of parasites found on this species precludes the possibility that it will ever be a dangerous factor in human environment. At any rate, the same potential possibility occurs among man's domestic animals, whose infection-carrying parasites are legion compared with those of the spermophile.

In one case a mosquito was found upon the body of a Thirteen-lined Spermophile. Two small flies were likewise found.

Several arachnids belonging to the family *Ixodidae* were found clinging to the spermophiles. These ticks were the only parasites of importance noted, excepting of course, the fleas. Ticks, like fleas, are concerned in transmitting a parasite from the blood of one animal to that of another. A tick-borne parasite is *Piroplasma bigeminum*, responsible for the stock disease known as Texas fever. The ticks found on the spermophiles of the upper Mississippi Valley are probably non-injurious in this connection, although the potential possibility of spreading disease exists.

CONTROL MEASURES

When Thirteen-lined Spermophiles become so thick in a given locality as to actually menace young crops, active control measures are of course desirable.

The damage is only noticeable in the spring and this is the most opportune time to apply the remedy, for in the spring the range of the spermophile is more restricted than later in the season, and killing the adults at this time forestalls reproduction.

The use of poisoned baits is a quick and efficient method for destroying these animals. The baits should always be placed in the entrances of the burrows. Otherwise they would undoubtedly be eaten by useful species, both wild and domestic.

D. E. Lantz (1921, p. 15) gives the following formula for poisoning the smaller ground squirrels: "Mix 1 tablespoonful of laundry starch in ½ teacup of cold water, and stir it into ½ pint of boiling water to make a thin clear mucilage. Mix 1 ounce of powdered strychnine with 1 ounce of powdered bicarbonate of soda, and stir the mixture into the hot starch, making a smooth, creamy paste free from lumps. Stir in ¼ pint of heavy corn syrup and 1 tablespoonful of glycerin, and finally, 1 scant teaspoonful of saccharin. Apply to 20 quarts of oats, and mix thoroughly to coat every kernel. Each quart of the poisoned grain should make forty to sixty baits."

A similar formula is given by W. L. Burnett (1914, p. 15):

Whole corn	16 quarts
Powdered strychnine	1 ounce
Saccharine	1 teaspoonful
Flour	¾ pint
Salt	1 quart
Water	1 quart

As in the preceding case, the poison mixture is poured over the grain. Burnett's experiments showed that one or two poisoned kernels would kill a spermophile.

A slightly different but very effective method of exterminating the animals is carbon bisulphid, poured on balls of cotton, which are then pushed down the mouth of the burrow. The openings of the burrow are then closed. The carbon bisulphid will evaporate rapidly, and the spermophiles will be killed by the poisonous fumes. This method has the advantage that there is no chance of poisoning other animals unintentionally through its practice. It must be remembered that carbon disulphid is a highly explosive liquid and should not be handled near a fire or by an individual who is smoking.

Often considerable numbers of spermophiles may be killed by shooting them with a small-bore rifle. This requires accurate shoot-

ing and considerable effort and patience on the part of the hunter. Unless the ground squirrels are shot through the head or thorax they will crawl into their holes to die a lingering death.

Trapping is a still more unsatisfactory method. A number 0 or number 1 steel trap may be used to catch this species. Simply hollow out a cavity at the mouth of the burrow for the trap to rest in, and cover the set lightly with dirt. This means of extermination is not recommended because so many spermophiles escape after having their feet cut off.

On the whole, poisoning is much to be preferred. It is simple, fairly safe, and does not require as much time and effort as the other methods. Besides, the results are immediate and pronounced.

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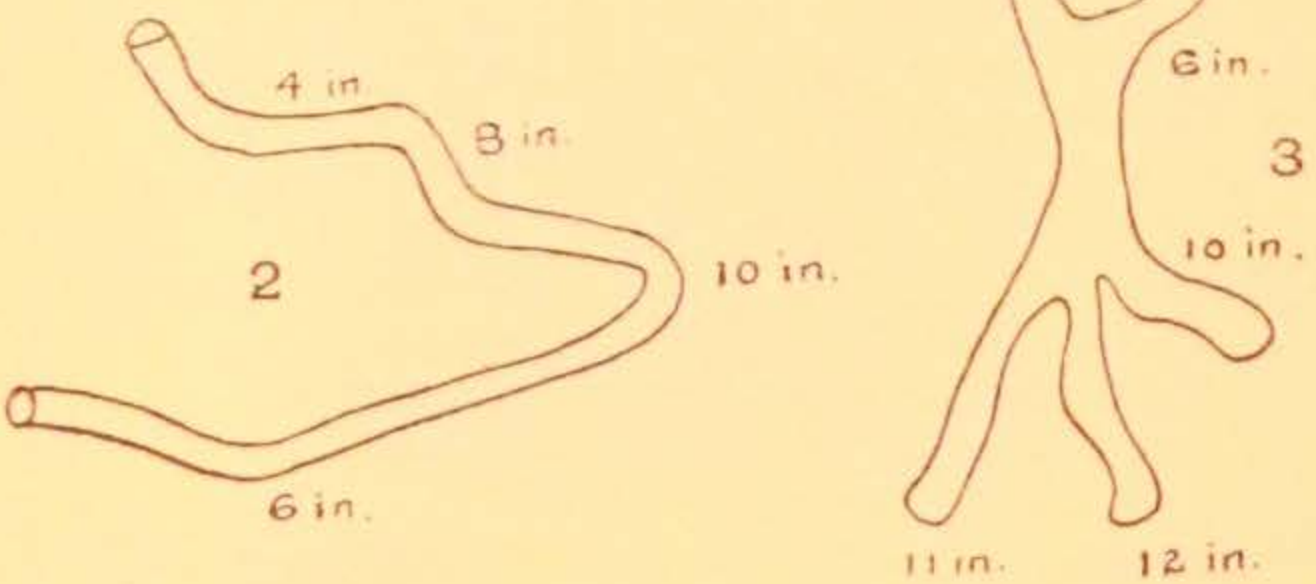
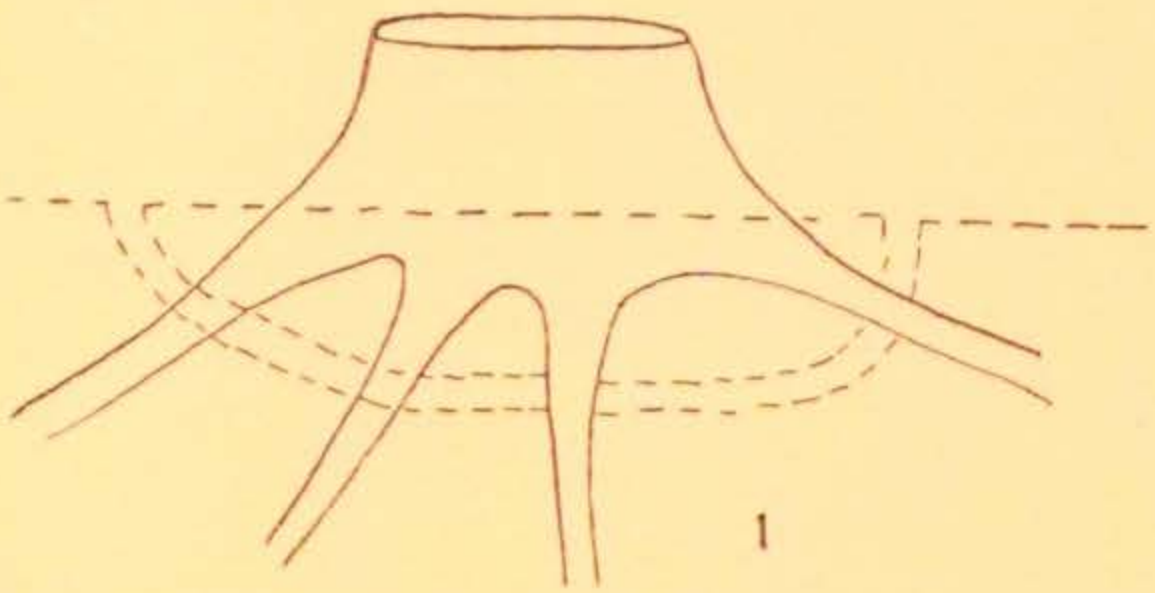
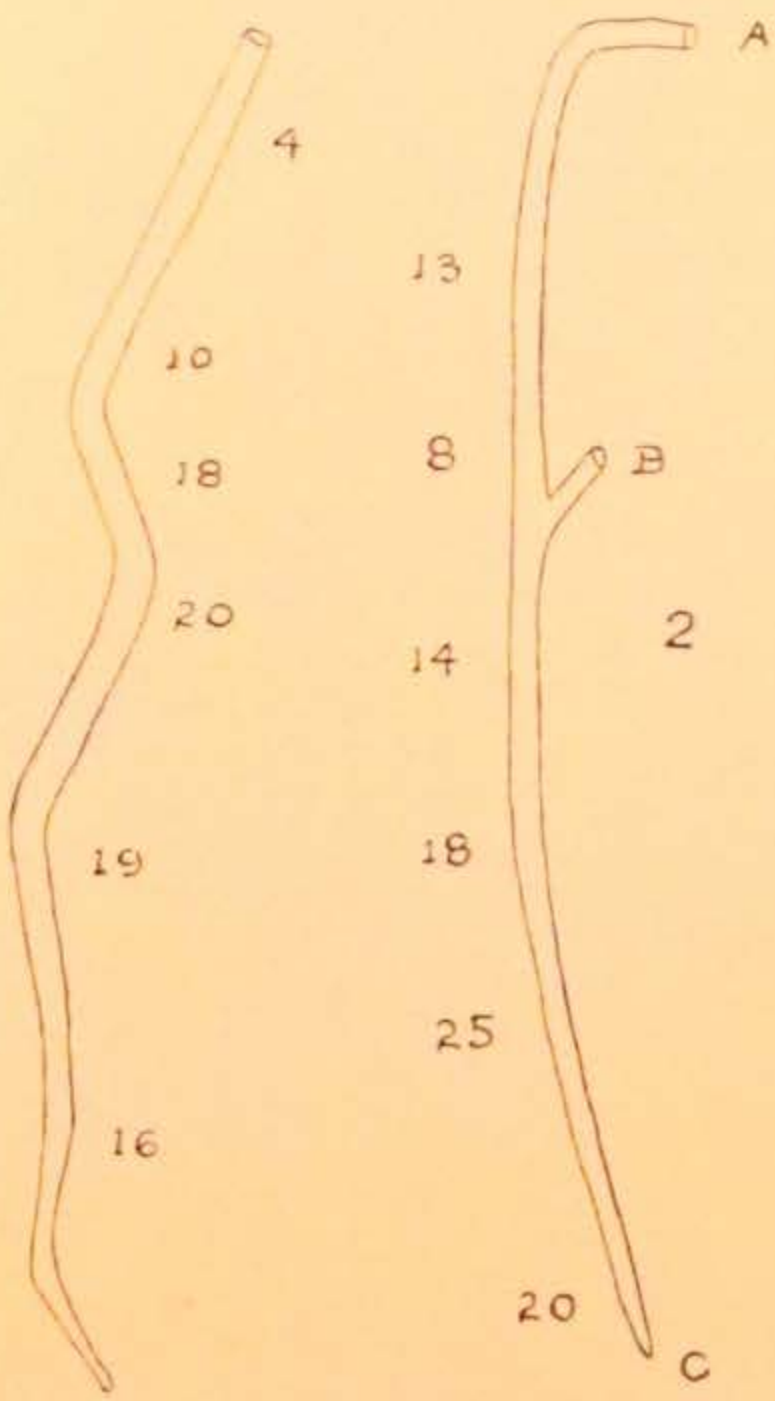




Temporary burrows



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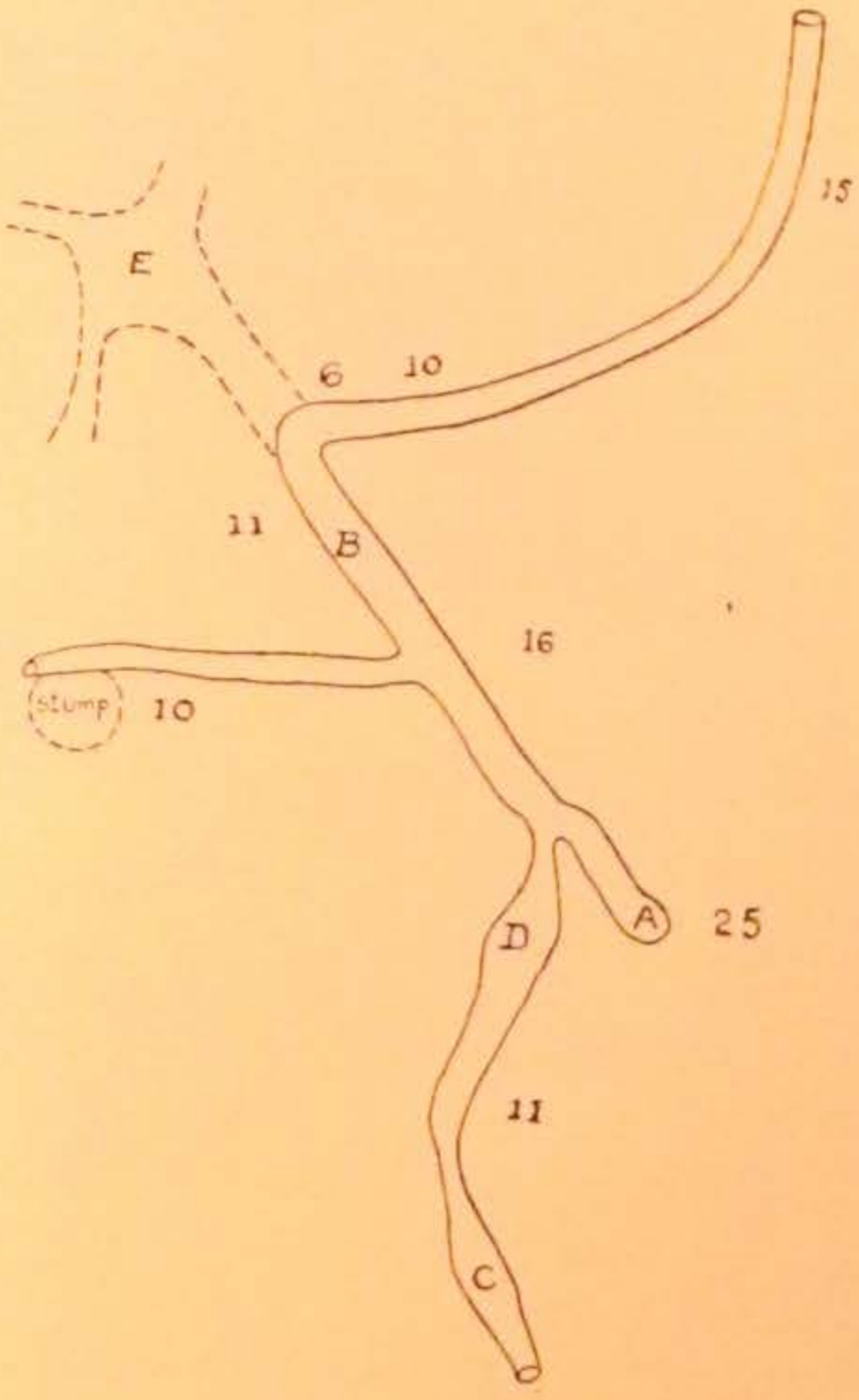

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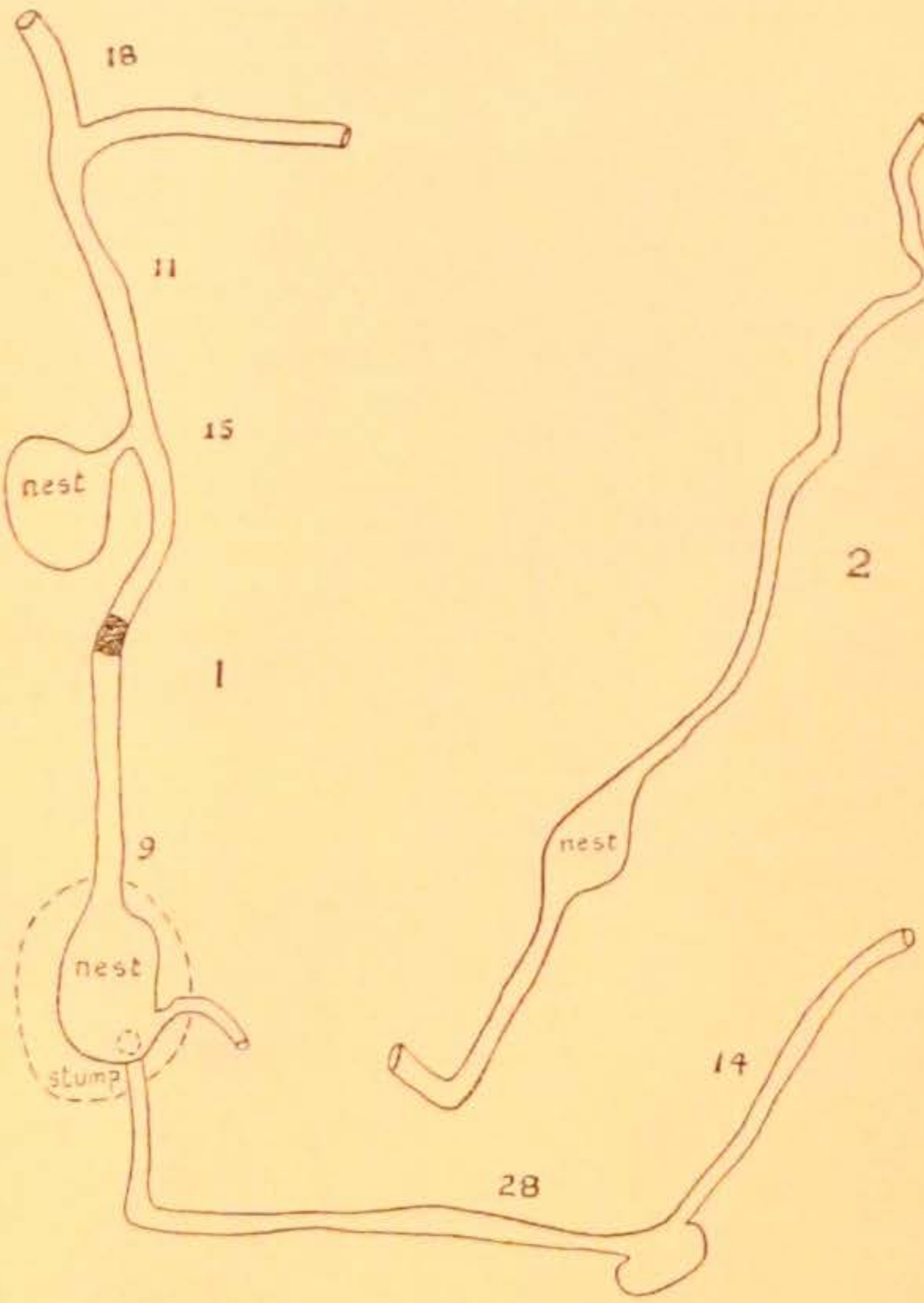

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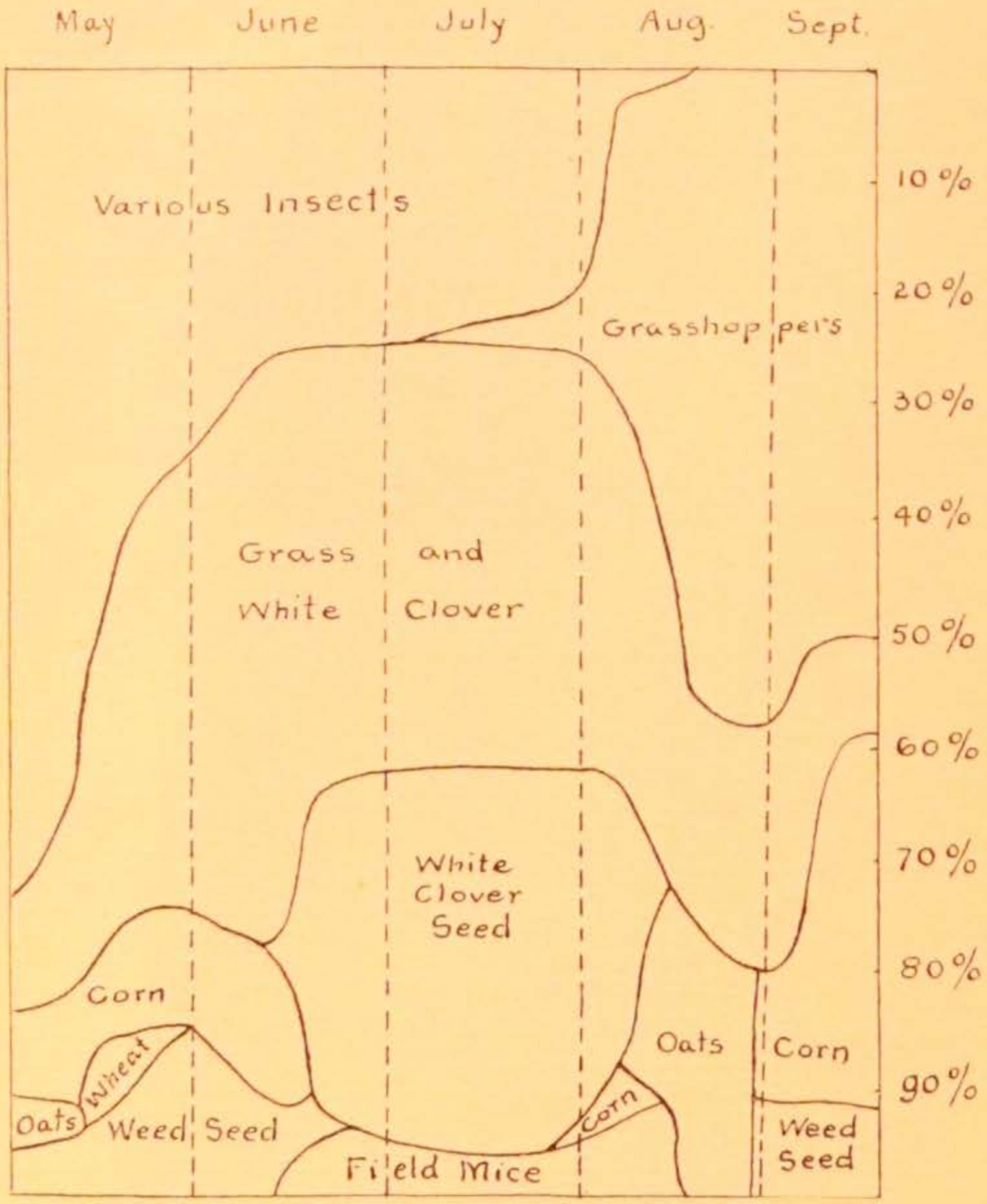
May
June
July
Aug.
Sept.
10 %
20 %
30 %
40 %
50 %
60 %
70 %
80 %
90 %
Various Insects
Grasshoppers
Grass and White Clover
White Clover Seed
Corn
Wheat
Oats
Weed Seed
Field Mice
Corn
Oats
Corn
Weed Seed

Food chart

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