AN INVESTIGATION OF THE FOOD COACTIONS
OF THE
NORTHERN PLAINS RED FOX

by

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FOREWORD

Here reported are the results of an investigation in which the Northern Plains red fox (*Vulpes regalis* Merriam) was examined as a living organism in a studied environment. The treatise deals with that phase of the red fox research undertaken in June, 1938, on the Moingona Fox Range; the work extends to July, 1941.

The coactions[1] resulting from the feeding of the red fox on its plant and animal associates formed the focal point of attention. Research on the foods of red foxes has had a strong seasonal bias, work usually being carried on in only one or two seasons. This study sought to obtain data with greater depth through continuous observation over a period of three years. The meaning of food availability was broadly engaged in this investigation because there is a tendency for predation to be proportional to the numbers of available prey (McAtee, 1933). Furthermore, as popular belief held that red foxes possessed remarkably efficient hunting prowess it was important to attempt an evaluation of the extent to which the foxes influenced the trends of prey animal populations.

For a background the study has the extensive research on red foxes in Iowa by Errington (1935 and 1937) and many general notes contem-

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[1]The word coaction has been used by Clements and Shelford (1939, p. 103) "---to designate the enormous range of interactions among plants, plants and animals, and animals alone, since it involves not only the idea of acting together, but also that of urging or compelling."

poraneously gathered on other fox ranges. There is considerable literature on red foxes and closely related forms of wild dogs, and references affecting the principles of predation are accumulating. Attention will be directed to these at appropriate places in the text.

THE MOINGONA FOX RANGE

In central Iowa the gently undulating prairie of the Wisconsin drift sheet is broken by the deep, narrow, eroded Des Moines River Valley. It is here in the Valley about five miles south of Boone, that the Moingona Fox Range is located. Continuous and intensive observations were made on an area of about 2010 acres, and an additional 4000 acres of surrounding lands were examined upon occasion. The boundary of the Range then is characterized by a limited elasticity, enclosing at maximum a little over 6000 acres. The areal description will be confined to the typical 2010-acre part.

This tract is conveniently bounded by land marks. The Des Moines River, limiting the area on the east and northeast, serves as a barrier against movement of the foxes in that direction except when frozen over in winter and even then it is seldom crossed. Elsewhere the area is bounded by roads: the Boles Hill Road on the northwest, Hull Road on the west and southwest and the River Road on the southeast. The River Road passes through the area along the river, and the School Road, an east-west roadway, divides it. The roads make all parts of the area accessible and aid materially in localizing "sign".

The rough terrain (Fig. 1) rises from about 860 feet above sea level at the Des Moines River on the east boundary to a little above 1100 feet on the upland in the southwest corner. Fingerlike, the relatively level upland reaches eastward toward the river in narrowing, irregularly outlined strips, terminating in one or more sloping ridges. At a level

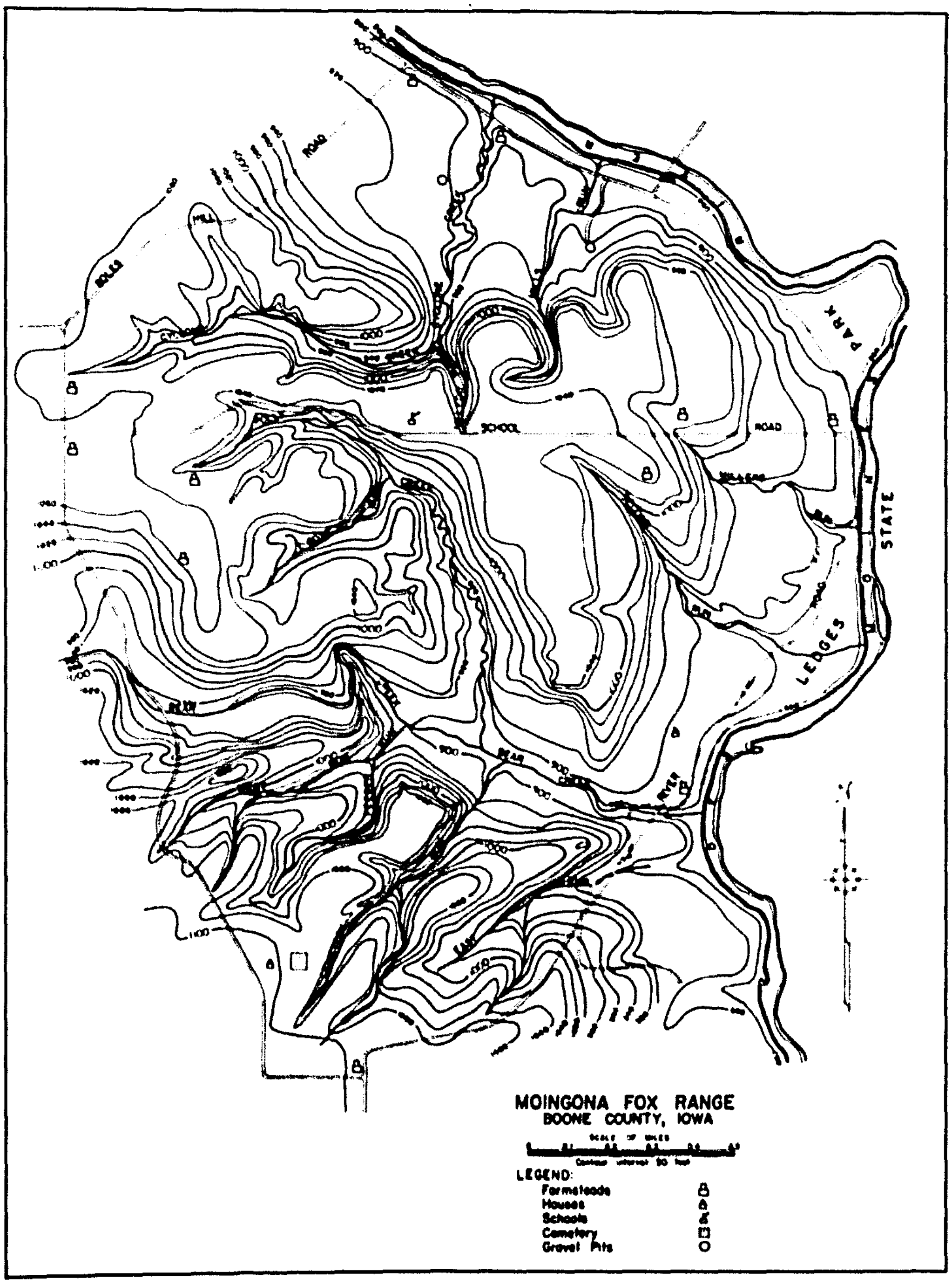


Fig. 1. Topography of the Moingona Fox Range

below the upland and overlooking the river are terraces, old bottomlands brought into relief by a decrease in the volume of the river and deepening of the Valley. The first bottoms or lowlands lie close to the river and extend a short distance west along Bear Creek. Reaching westward

reading fox "sign".

through the lowland, terrace and upland levels is a network of short streams and numerous drainage lines that add to the roughness of the steep phase of topography occupying over half the area. The slope classes in this steep phase average about 30-35 percent.

The soils of the area may be arranged in three groups according to origin and location: drift soils, terrace soils and bottomland soils (O'Neal and Deyoe, 1923). Clarion loam and Conover silt loam are found on the upland. All of the steeper slopes coincide with the soil area, Clarion loam (steep phase). Three soil types are represented on the terraces: O'Neill loam, Buckner silt loam and Waukesha loam. All of the first bottoms or lowland is occupied by Sarpy silt loam.

Fig. 3. Polly Creek, dry throughout most of the year, was ideal for "sign" reading. Most of the drainage lines on the Range were of this character.

Sandstone bedrock has been exposed in several places, particularly along Bear Creek where impressive ledges have been carved by the action of the running water and by weathering. Several large pockets of sand have been cut open on Polly Creek, forming sand slides on which the foxes sometimes seemed to find sport in play. Nearly all the streams and drainage lines had sandy bottoms that served admirably in recording foot prints and other "sign" of animals during snowless seasons. Polly Creek, dry throughout most of the year, was ideal for recording "sign"; over a mile of its length was sand from 6 to as much as 50 feet in width.

A wide range in annual temperature marks the region. In summer southwest winds may accompany periods during which the temperature ranges above 100° F. The winters are severe with cold, penetrating northwest winds. The last killing frost in spring usually occurs April 30 to May 10, and that of the fall is September 30 to October 5, leaving an average growing period of 153 days (Reed, 1940). Normal precipitation for the year is about 32 inches, of which the greater part is received during spring and summer and least in winter when it is generally in the form of snow. The climograph (Fig. 4) demonstrates the general month to month weather progression and the contrast of weather conditions during the three years of study.

The region is in an agricultural community. There were 11 farmsteads on the area and two small homes that could be occupied; there was a rural school and a small cemetery.

Although the area was once entirely forested it has now been greatly modified by local farm practices(Fig. 5). The upland terraces and some of the lowland have been cleared, and much of this is now under cultivation. The topography requires that the fields be small, scattered and frequently irregular in outline. As only the more level land can be cultivated, the plantings detour gullies and rough places in the fields. The fences, however, for convenience in stretching the wire are usually set in straight lines. In some places this leaves a substantial marginal area that is

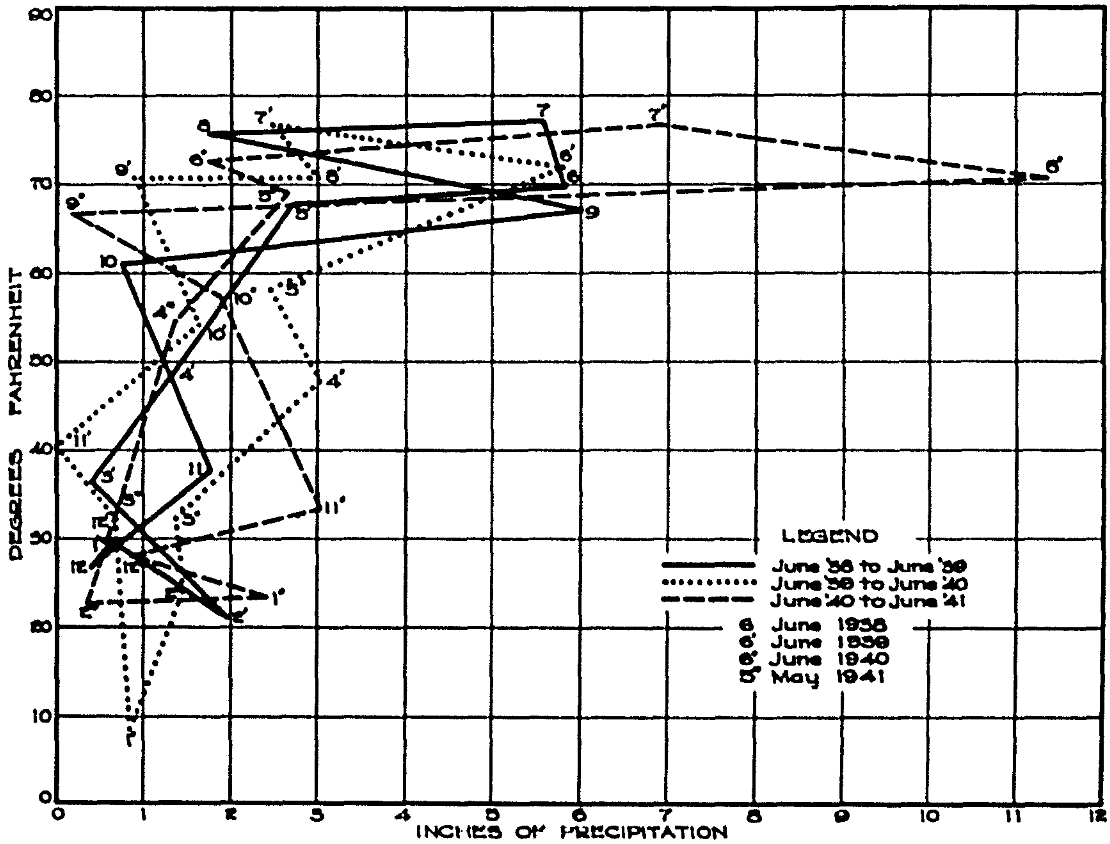


Fig. 4. Mean monthly temperatures and precipitation for each of the years studied.

unused except by the livestock that grazed in the fields after the harvest.

Of the 2010 acres only about 650 have been developed for planting, and this comprises nearly all the potentially tillable lands. A corn-oats-alfalfa rotation of crops seems to be more or less generally practiced. A percentage classification of the use of crop land during the course of the investigation was corn 44, alfalfa 28, oats 15, soybeans 6, wheat 3, cane 1, and fallow 3. About 1100 acres is in permanent pasture, and this lies largely on the steep, untillable slopes. The degree of grazing ranged from overgrazed to none; however, most of the available pasture area was grazed so closely as to leave no grassy cover suitable for mice. During the period of investigation horses, cattle, and a few sheep were the only livestock pastured. Each year there was some tree cutting in the pastures and field margins, largely to obtain fence posts and fire wood, and to permit greater growth of grasses for grazing. O'Neal and Deyoe (1923) recommended that the slopes be kept in forest except where a protective growth of blue grass (Poa pratensis) could be maintained. Indiscriminate removal of trees has resulted in some severe erosion.

Agricultural use of the land has severely modified the natural state of the biotic communities. Only fragments of the natural vegetation remain. Least disturbed is the vegetation on the lowland adjacent to the river and within the boundaries of the Ledges State Park. This part of the Park is undeveloped and so far as is known the timber has never been cut. Here many large cottonwoods (Populus deltoides), American elms (Ulmus americana), green ashes (Fraxinus pennsylvanica) and silver maples (Acer saccharinum) stand close and are heavily hung with riverside grape (Vitis vulpina). One American elm, a giant for this region, measure over nine feet in diameter

Fig. 5. Aerial photograph of the Moingona Fox Range

at its base. Dense thickets of sandbar willow (Salix interior) cover the lowest and newest of this first bottom. Colorful in winter is the gray bloom on the outer twigs of the young box elders (Acer negundo) encroaching on the field borders in the clearings. Somewhat characteristic of this level is the American elder (Sambucus canadensis) that may be seen here and there.

None of the vertebrate animals seem to mark the bottomland environment proper; however, the zone of lowland adjacent to open water is characterized by the muskrat (Ondatra zibethica) and Eastern green heron (Butorides virescens virescens). The muskrat remains through the year, but the heron is absent in winter. The opossum (Didelphis virginiana), raccoon (Procyon lotor hirtus) and mink (Mustela vison) are found more often here than elsewhere. The only Pennsylvania meadow mice (Microtus pennsylvanicus) trapped on the area were taken in bottomland clearings.

Except for the vegetation on a slope overlooking the river and within the boundaries of the Ledges State Park, the vegetation of the steep phase has been greatly disturbed. The gray squirrel (Sciurus carolinensis), characteristic of the undisturbed forest, was once common but disappeared shortly after clearing operations began. The ruffed grouse (Bonasa umbellus), also once common here, is gone. Judging from the remaining remnants, the major plant units were once oak-hickory (Quercus-Carya) and maple-linden (Acer-Tilia) communities, southerly exposures and upland largely grown to oak-hickory and northerly exposures to maple-linden with transition growths everywhere between. A hill top consocies of American aspen (Populus tremuloides) may be seen standing in bold relief among the disturbed hardwoods at several points. There is a scattering of red cedar (Juniperus virginiana) which seems to have escaped the clearing operations because of their novelty. The service-berry (Amelanchier canadensis), conspicuous in spring by its early flowering, bears the first fruits in

Fig. 6. Westward view from a cut over slope on the northern part of the Range

season to be eaten by the foxes. An interdispersal of typical southern plants and typical northern plants is indicated by a few large-toothed aspens (Populus grandidentata) and wild red cherry (Prunus pennsylvanica) from the north and the lance-leaved buckthorn (Rhamnus lanceolata) from the south. Hop-hornbeam (Ostrya virginiana) is common and in some cut over places seems to provide much of the woody structure. Blue beech (Carpinus caroliniana) can be found in several places. Western crab apple (Malus icensis) and several species of red haw (*Craetaegus* spp.) are present particulary in clearings. Prickly ash (*Zanthoxylum americanum*), hazelnut (*Corylus americana*) and sumac (*Rhus*) are common. Characteristic of the wooded slopes are spring beauty (*Claytonia virginica*), bloodroot (*Sanguinaria canadensis*), smooth solomon's seal (*Polygonatum commutatum*), star-flowered solomon's seal (*Vagnera stellata*), may apple (*Podophyllum peltatum*), early wake-robin (*Trillium nivale*), wild columbine (*Aquilegia canadensis*), and dutchman's breeches (*Bicuculla Cucullaria*). These are common except where the forest has been opened up and grazed; here bluegrass sod has become established. Characteristic herbs of the grazed bluegrass pasture are ragweed (*Ambrosia elatior*), vervain (*Verbena* spp.), some hemp (*Cannabis sativa*), great ragweed (*Ambrosia trifida*) and isolated great mullein (*Verbascum thapsus*).

An examination of the animals typifying these disclimax slopes reflects much of their nature. The Southern woodchuck (*Marmota monax monax*), gray Eastern chipmunk (*Tamias striatus griseus*), Western fox squirrel (*Sciurus niger rufiventer*) and Northern white-footed mouse (*Peromyscus leucopus noveboracensis*) seem to characterize the mammal fauna. All of the dens used by red foxes for rearing their young were also in these slopes.

It is difficult to determine which of the birds mark the environment of the slopes. Although present to some extent over the entire area, the Eastern cardinal (*Richmondena cardinalis cardinalis*), Eastern goldfinch (*Spinus tristis tristis*), black-capped chickadee (*Penthestes atricapillus atricapillus*), white-breasted nuthatch (*Sitta carolinensis carolinensis*), Northern blue jay (Cyanocitta cristata cristata), Northern downy woodpecker (Dryobates pubescens medianus), hairy woodpecker (Dryobates villosus villosus), and red-bellied woodpecker (Centurus carolinus) appear to spend a large part of their existence on the slopes. All are residents in the region. Of the migrants that come to nest, the red-eyed towhee (Pipilo erythropthalmus) seems to characterize the community of this steep phase best.

The terraces and upland are almost entirely in crop land; some is in pasture. On cultivated lands growths of small bur-grass (Cenchrus carolinianus), barnyard-grass (Echinochloa Crus-galli), crab grass(Syntherisma ischaemum and S. sanguinale), ragweed, yellow foxtail (Chaetochloa glauca), green foxtail-grass (C. viridis), and cockle-bur (Xanthium communs) characterize the weed stage. These relatively level crop lands are sometimes invaded from the prairie by the common badger (Taxidea taxus taxus) and the white-tailed jack rabbit (Lepus townsendii campanius). The thirteen-striped ground squirrel (Citellus tridecemlineatus tridecemlineatus) seems to have established itself in the undisturbed clearings. Characteristic mammals of the cultivated fields are the Baird white-footed mouse (Peromyscus maniculatus bairdi) and the prairie harvest mouse (Reithrodontomys megalotis dychei), and in all probability these mammals were not present when the region was entirely wooded. The prairie meadow mouse (Microtus ochrogaster) and Goss lemming mouse (Synaptomys cooperi gossii) are found in the cultivated lands but are most often trapped in the grassy fence rows around the fields. The cultivated openings have increased the attractiveness of the area for many species of birds, notably the

Eastern bob-white (Colinus virginianus virginianus). A few ring-necked pheasants (Phasianus colchicus torquatus) are present, and they remain close to the open fields. The fox does much of its hunting in and about the crop land clearings; probably the irregular opening of fields, such as is typical of this "river land", has been generally favorable to foxes.

The animals that have been mentioned are for the most part closely associated with certain phases of the environment. Some influential species are found everywhere and are not closely enough related to any one part of the environment to characterize it. The white-tailed deer (Odocoileus virginianus) has been re-established here by escape from a captive herd at the Ledges State Park. The presence of the deer, now free for several generations, restores to the country much of its former wildness. The domestic dog (Canis familiaris) population varies widely in density and kind. Domestic cats (Felis domestica) are present at local farmsteads and an occasional feral cat is resident, particularly in the fall and early winter. Raccoons are common on the bottomlands, but their "signs" can be found throughout the area. Focal points of mink activity are along Bear Creek and the Des Moines River; nevertheless, their tracks are often seen far up on the sandy drainage lines and occasionally on the upland. Striped skunks (Mephitis mephitis) usually remain close to their dens in the wooded slopes although they often feed in the fields and sometimes dig shallow dens there for rearing a family. Although found elsewhere the spotted skunk (Spilogale interrupta) is most common about the farm buildings. Opossum tracks are not uncommon, and this slow-moving mammal has been seen several times when its movements in dry leaves attracted the observer's attention away from the trail. The long-tailed weasel (Mustela frenata) does not seem especially abundant.

The avifauna of the area as a whole is greatly modified by migration, especially since the Des Moines River Valley seems to form a route of travel. Including migrants it is possible to list over 200 species and subspecies of birds from this locality of which only about 10 percent may be considered as resident. As elsewhere in this description only those species and subspecies that typify the region or are of influential importance need be mentioned. The Eastern red-tailed hawk (Buteo borealis borealis), Cooper's hawk (Accipter cooperi), Eastern sparrow hawk (Falco sparverius sparverius), Eastern screech owl (Otus asio naevius), Northern barred owl (Strix varia varia) and great horned owl (Bubo virginianus virginianus) are resident; however, their numbers are affected by the necessary control measures practiced at the nearby State Game Farm. This control is especially effective against the horned owl, never allowing it to become established long in the area. Eastern crows (Corvus brachyrhynchos brachyrhynchos) are always present though not abundant. A small colony of turkey vultures (Cathartes aura septentrionalis) are resident in summer. A western bird, the American magpie (Pica pica hudsonia), was recorded particularly during the winter of 1939-40.

The animal community is usually not greatly affected by the sportsmen who hunt the region, for the terrain and cover discourage exhaustive search for game. It has not been legal to take pheasants or quail in this region; the shooting then was largely confined to cottontails and fox squirrels.

Hunting was not managed on the area.

When one attacks a problem from the ecological point of view, the dynamics of the environment must be given equal consideration with its elements. The cyclic responses of this biotic community to the seasonal changes should be visualized, for they are reflected in a broad way in the feeding trends of the foxes. In addition here is an area, once entirely wooded, now extensively denuded of its trees and under intensive agricultural use. The environment is in a state of disturbance because of these cultural practices. The vegetation is affected by this land use, and largely symptomatic to this are modifications in the physical factors and animal life. The disturbance prevailing here, however, seems to have reached some constancy in extent and intensity. Because of this the environment, though frequently and violently disturbed by agricultural activities, has obtained a somewhat stabilized state of development.

FIELD TECHNIQUES

Direct observation of animals, desirable as it is, often proves so difficult that the results do not justify the effort required. This proved true for this investigation of the food coactions of the Northern Plains red fox. Greater returns were realized from concentrating on the scraps of evidence or "sign" left behind by the fox in its life's activity. It was necessary then to become proficient in locating, recognizing and interpreting "signs" of the fox and to some extent of its associates, and to remain constantly alert to possibilities for improving that proficiency.

The "Signs" of the Red Fox

The track is the most frequent form of evidence; it is distinctive, and it is readily identified on good tracking surfaces. Once thoroughly familiar with the configuration of the track and the gait spacings, an observer may detect the trail of a fox on almost any surface that is soft or loose enough to be disturbed under the weight of the passing animal. In general shape the track is oval with the longer axis taking the direction of travel. The toe pads are small, and the toes may be spread, particularly on the fore foot, on soft surfaces or when unusual weight is thrown on the fore foot as when reaching the bottom of a steep descent or when jumping. There is a structural difference between the fore and hind feet that may be used to separate them. In comparison with the

Fig. 7. Red fox tracks in mud. The upper impression is that of a hind foot while the lower one is of a fore foot.

fore foot, the heel pad of the hind foot is about half as wide, and the two middle toes together with their claws appear to converge (Figs. 7 and 8). The hind foot is slightly smaller than the fore foot, being generally about 95 percent as large. The two outside toes of each track seem to extend a little beyond the inside toe of the same position. The largest track measured on the area was that of a fore foot 2.8 inches long by 1.8 inches wide. Although tracks of adult males ordinarily are a little larger than those of adult females, however, this is not a

Fig. 8. Red fox tracks in wet sand. The lower impression is of a fore foot and the upper one of a hind foot.

reliable sex differential as tracks of an individual show variation in size on different tracking surfaces. Occasionally there is overlapping of size in adult males and females, and an additional variable is introduced by the presence of young animals. The mark of the heel pad in the track does not ordinarily project forward between the outermost toe prints on either fore or hind foot; it may appear to do this where the foot sinks deep in soft mud or snow. The characteristic heel pad of the fore foot is bar-shaped, straight-edged to the rear. On such surfaces as mud and wet snow that are fine enough to hold the impression, the furry nature of the foot may be clearly observed.

Fig. 9. The track pattern of the trotting red fox

The track patterns of the different gaits are similar to those of the domestic dog except that the tracks of the walking or trotting fox are usually in almost perfect registry, in line and not staggered (Fig. 9). It is scarcely possible to distinguish the walk from the trot by the spacing of the tracks. In those gaits the tracks may be anywhere from 9 to 16 inches apart. The fox may trot and take steps of exactly

Fig. 10. The track pattern of the galloping red fox

the same length as those of a walk; however, when strides of 14 to 16 inches appear frequently in the trail, the fox is almost certainly at an extended trot. In the gallop the tracks appear in groups of four (Fig. 10); with each bound the two fore feet strike the ground in line while the hind feet are still in the air; the hind feet then come to the earth, first the right and then the left, staggered, spread and in advance of the tracks left by the fore feet. The length of each group of tracks and the distance between the groups increase with the rate of speed. Extreme measurements between track groups in the gallop

Fig. 11. The trail of a red fox walking in deep snow

Fig. 12. The trail of a red fox attempting to gallop in deep snow

Fig. 13. The red fox found easier going along the fallen tree

on level ground were recorded as from 30 to 38 inches. Undoubtedly the size, age and condition of the fox affect the spacing of the tracks in the different gaits. It was thought that females in a late stage of pregnancy staggered their tracks noticeably in the walk and trot. The track patterns are modified in deep, loose snow where movement is difficult (Figs. 11, 12 and 13).

One familiar with red fox scent often becomes aware of this characteristic odor before other "sign" is detected. Stebler (1939) emphasized the value of distinguishing scents. Scent not only identifies the fox, but during periods when tracking conditions are poor it may be employed to determine the presence and whereabouts of the foxes. Scent often identifies the fox on difficult snow trails and thus reassures the observer. The method of urination, which appears to be after the fashion of the domestic dog, aids in determining sex. This should not be treated as a completely reliable method of segregating sexes, for males may urinate after the manner of females.

Although the fecal passage or scat may appear in many forms from a watery mass to a mucous coated bone fragment, it usually is cylindrical, compact, sectioned, and drawn down to a string or dull point on one end of each section and bluntly rounded on the other (Figs. 14 and 15). In overall length the scats of adult foxes range from short fragments to as much as 300 mm.; the average length of scats seems to be about 140 to 160 mm. Generally there are two to four sections to each passage; as many as nine were observed. One hundred scats from caged wild red

Fig. 14. Fecal passages of the red fox. Two-thirds natural size

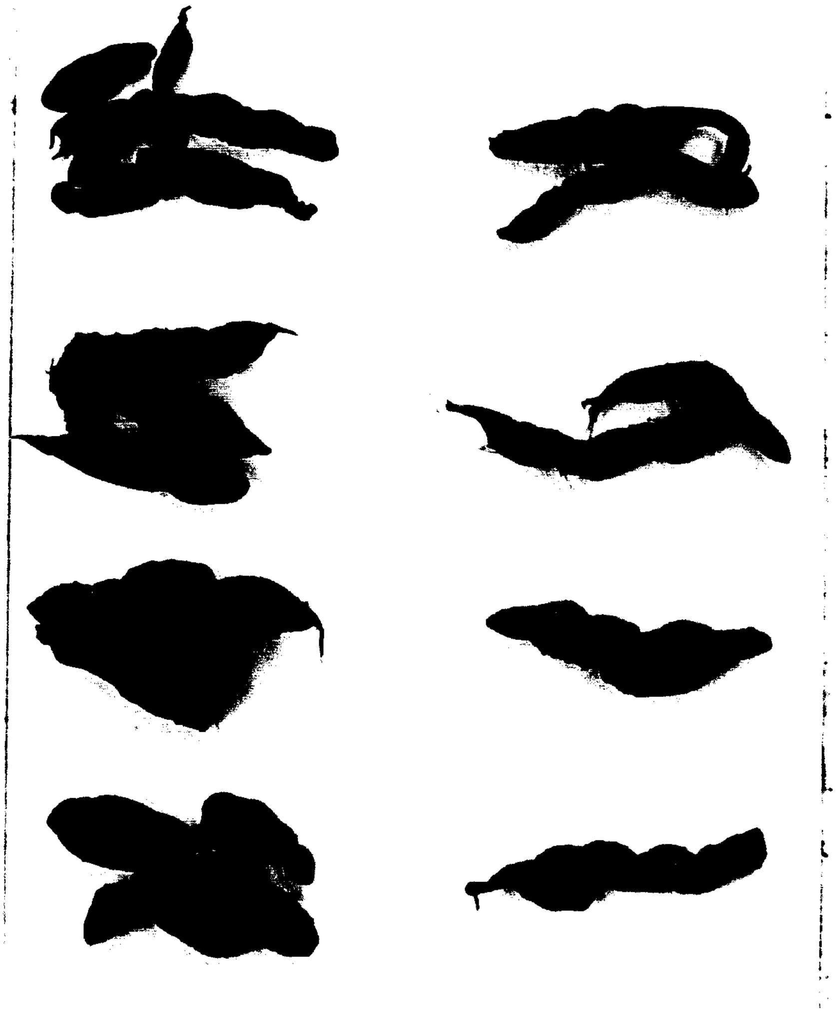


Fig. 15. Fecal passages of the red fox. One-half natural size. The somewhat larger passages on the left were from the Big Wall Lake Area where food was abundant while the smaller passages on the right were from the Moingona Fox Range where food seemed barely available. The passages were taken at random from collections made in February and March, 1941.

foxes were measured at their largest diameter; the average was 12.5 mm., the smallest was 8.2 mm., and the largest was 16.4 mm. Within these size limits the fecal passages of the captive animals noticeably varied in size directly with the amount of food eaten. The largest red fox scat found, apart from a few that appeared to have expanded after defecation because of excessive ground moisture or other cause, was 19 mm. in diameter. Scats containing the remains of fruits or insects are usually large in diameter, and possibly expansion occurs in drying after defecation.

There is a coating of mucous over the scat until removed by weather or insects. The mucous covering of the red fox scat is usually copious in contrast with scats of other carnivores, excepting other Canidae. This character strongly marks the red fox scat and frequently aids in identification. The dry mucus may often be rubbed off in a fine powder. In outward color the scat grades from black or dark brown to light gray; often a shade of green, appearing somewhere on the scat along with the basic color, seems to be somewhat characteristic of red fox feces.

Another aid in distinguishing the red fox scat is the odor associated with fresh passages. An observer may become familiar with the possibilities of recognizing this odor by handling feces of caged foxes that have been fed various kinds of natural foods. It is advisable to smell scats as they are collected in the field in order to become acquainted with the reaction of the odor to changing climatic conditions and to age. The characteristic odor does not remain long with the scat, and therefore may be employed to some extent in rough estimations of the age of fecal passages. At first it is possible to smell the odor on the outside of the scat, but as the outside dries it is necessary to break the passage open. Scats are found in which the odor is detectable in some of the sections and not in others, possibly indicating that the odor progressively loses strength. The odor is not always detected in fresh feces because it may be suppressed by the odor of food remains as when much fruit is eaten.

Fig. 16. The bedding place of a red fox

"Sign" is often present where the red fox beds down to rest and to dress its coat. The circular bedding spot is usually about 15 inches in diameter; its form may best be seen in the snow (Fig. 16). In the snow bed loose hairs are easily seen. There are times in winter, particularly when the trail is old and the snow has melted down and enlarged the

Fig. 17. Examples of loose fur tossed aside by the red fox dressing its coat. Actual size.

original tracks, that the evidence about a bed may be used to reassure the tracker that the trail is that of a red fox. In dressing its coat the fox uses its teeth as a card; loose hair accumulates in the mouth, and it is tossed aside in small bunches. Most of the bunches are marked by two holes about three millimeters in diameter (Fig. 17), presumably from the canine teeth. The hair also clings to burs and other hooked fruits (Fig. 18) that are plucked out of the coat. "Signs" of coat dressing are especially noticeable in spring when the animals are shedding.

In its feeding the red fox may leave characteristic marks other than tracks, scent and scats that are conclusive or give support to other evidence. They scratch into the bases of rotted stumps, and if the wood is yielding enough the stump may be practically demolished. The runways of the mole (Scalopus aquaticus) are ripped open in places; the openings seem to be the result of a few vigorous scratches with the fore foot in line with the runway (Fig. 19). A dead mole with a crushed skull may be lying nearby, for the fox seems to find this animal distasteful. Also not so desirable as food, weasels and shrews are commonly killed and left uneaten, a habit that has likewise been noted to some extent in the domestic cat. It is possible in some instances to inspect the teeth marks in the flesh or skin of prey. The teeth marks of a fox are of course typically carnivore, and most distinctive are the punctures of the canine teeth. The distance between the punctures of the right and left canines of either jaw may sometimes be measured and thus aid in identifying the predator.

The linear measurement between the tips of each pair of canines was

Fig. 18. Burdock (Arctium sp.) furs plucked out with loose fur and left by the red fox

Fig. 19. Mole runway ripped open by red fox

taken on 20 red fox skulls selected at random from animals killed in December and January in Iowa. The mean distance between the tips of the maxillar canines was 21.1 mm., the greatest 23.5 mm., and the least 18.3 mm.; the mean distance between the tips of the mandibular canines was 18.9 mm., the greatest 21.4 mm., and the least 17.4 mm. The marks of the canine teeth are seen principally in the pectoral region of the larger prey.

Experiments with caged adult red foxes indicated that about an average of one pound of food was eaten at a single feeding. For the staple food, cottontails and mice, mice are ordinarily bolted entire whereas unless more than one fox is feeding a part of the cottontail is left.

Fig. 20. Feathers sheared from the carcass of a ring-necked pheasant by the red fox

Fig. 21. Remains of cottontail left by young red foxes

In birds that are fed upon, the feathers are often neatly sheared off close to the base (Fig. 20). The part of the feather that is cut off re-remains on the feeding site to help identify the feeder as a fox, while the bases of the feathers still in the flesh are eaten and appear in the scats to reassure the worker that field identification of the scat as that of a fox was correct. Something of the strength of the jaws of the adult fox is seen in the ease with which the bones of cottontails, domestic chickens (Gallus gallus) and ring-necked pheasants are chewed up. The young fox, however, does not possess that same strength, and this may be seen in its feeding. While living in the dens the young commonly leave a cleanly licked pelvic girdle, hind legs and a section of the vertebral column (Fig. 21) when feeding on a cottontail.

There seems to be no set procedure with regard to the order in which parts of prey are eaten. It is obvious, however, that more often than not the head and neck of domestic chickens (Gallus gallus), ring-necked

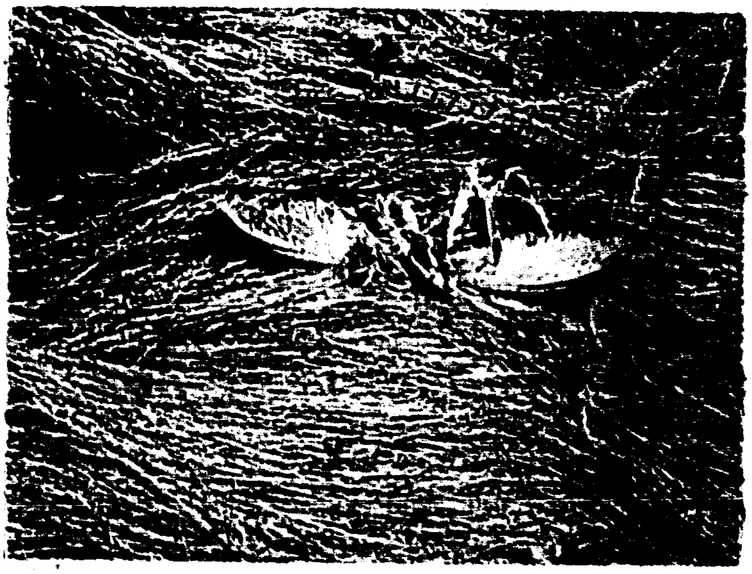


Fig. 22. Remains of ring-necked pheasant left by red foxes

pheasants and cottontails are among the parts first taken and that the hind quarters are among the last parts to be eaten. The abdominal viscera, feet and tail of cottontails are frequently left behind uneaten. In the U.S.S.R. Baranovskaia and Kolosov (1935) found that Vulpes vulpes did not eat the stomach and intestines of hares (Lepus europaeus), rabbits and larger rodents such as the hamster (Cricetus cricetus). That part of the wing largely beyond the humerus in large birds such as pheasants and domestic chickens (Fig. 22) is not usually eaten. Eggs, such as those

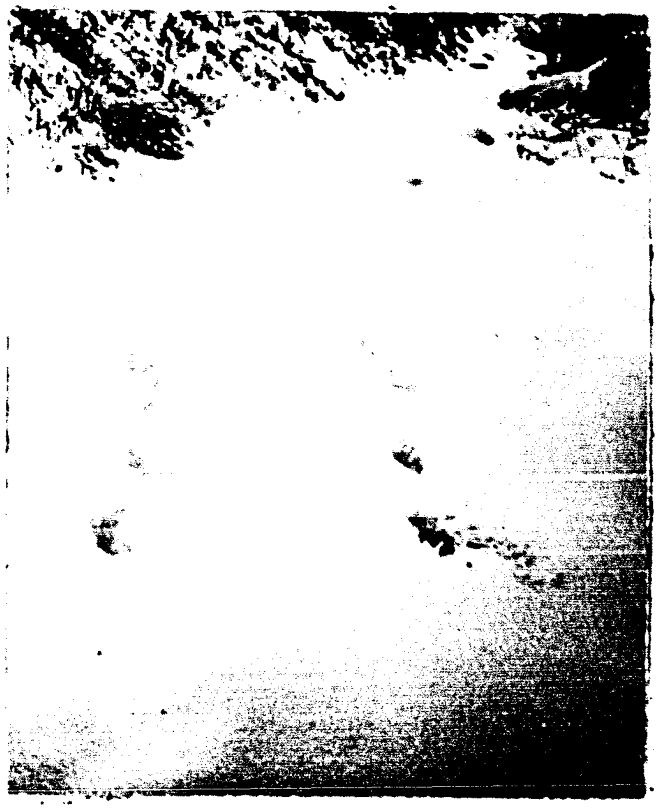


Fig. 23. Paired trails of red foxes
December 23, 1938

of the pheasant, that have been fed upon appear to have had about one-third of the shell bitten out, apparently most often from the side. A coarse, broken edge is seen on the remaining part, and it is usually licked clean of the last trace of contents.

These "signs", tracks, scent, scats and feeding evidences, aid the observer in learning of the populations, home ranges and food habits of foxes. In an investigation of food coactions it is also necessary to follow the events in the life history of the foxes. In addition to those already treated there are other "signs" that aid the observer in collecting life history data. Clotted blood in the urine along the trail of the female may be evidence of the flow of blood from the vagina that marks the close of pro-oestrum. Double and parallel trails (Fig. 23) may indicate a tendency to pair, and evidence of actual breeding may be seen on the trails. Where before foxes only visited or occasionally took refuge in dens, after breeding activity is underway they begin to scratch the accumulated debris and soil out of them. Several dens on the range are cleaned out, but most of the activity is generally centered about the den in which the young are to be born. Food offerings will often be brought to the chosen den even prior to the birth of the young. Whether there are many or few food remains about the den seems to vary with the abundance of available food; however, there is always enough general "sign" at a rearing den to identify the occupants.

Knowledge of the Country

It was essential that the observer become thoroughly familiar with the country as it related to the behavior of the red foxes. Familiarity with the country was best attained in winter on fox trails in the snow when vegetation was not so concealing and vision was good. This intimate acquaintance with the area and the fox's uses of it were invaluable during the warm weather months when there was no snow on the ground.

Foxes did not maintain well-beaten pathways except on the site of a much-used rearing den and where vegetative growth was so dense and unbroken that a pathway was necessary to allow movement. On the Moingona Fox Range the vegetation had been opened to such an extent that fox-made trails were not necessary. Nevertheless, general routes of travel along such land marks as ridges and drainage lines could be recognized. Of a less permanent nature were such routes of travel as stock trails, dead furrows and field roads. As a rule the fox usually did not follow the land mark for long; instead it seemed to come upon the land mark, pass along it for a short distance and then work away from it. In the aggregate, however, there seemed to be considerable traffic along strategically located routes. In addition to knowing the general routes of travel, it proved helpful to know every ground den and something of its history.

An accurate map of the country aided in the orderly recording of observations. An outline map traced from an aerial photograph was used in the field (Fig. 24). The section lines were drawn in and each was divided into 100 6.4-acre squares. These section divisions were then numbered from left to right, beginning in the northwest corner of each section. The divisions were used as a more accurate means of locating observations. For example, a scat found on a stock trail may be given an abbreviated locality record as follows: 20-73, which means that it was in division 73 of section 20. An additional note is usually added such as: "stock trail, 2 paces N of NE corner of fallow field".

Status of the Potential Foods

Phenological data, lists of the kinds, figures on the amounts and notes on the availability of potential fox foods were extremely important. In addition to knowing something of the kinds of natural foods available to the foxes, a knowledge of the kinds of domesticated plants and animals

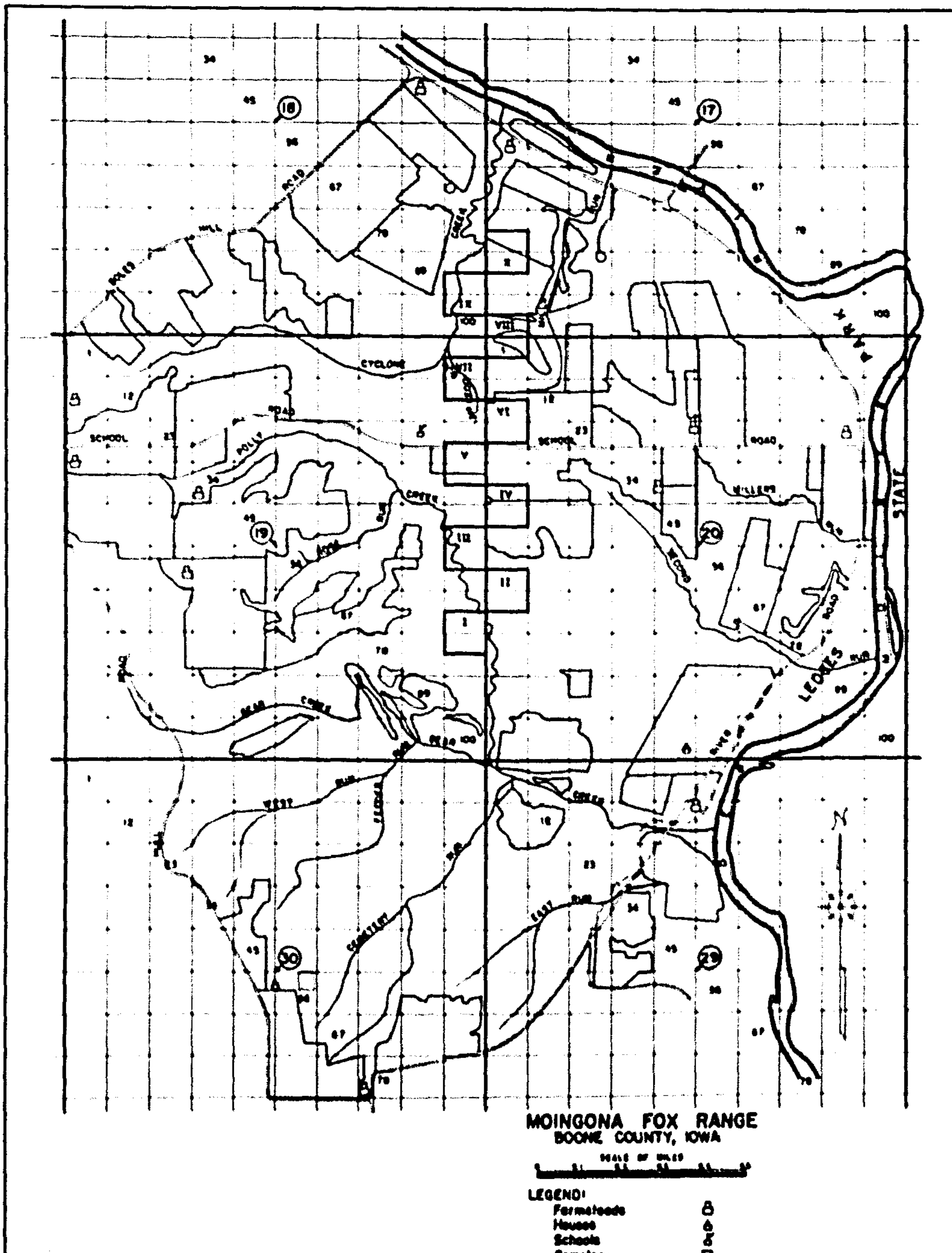


Fig. 24. Outline map showing grid system used in recording field evidence. The quadrats used in the estimations of prey populations are also shown.

that might be found on the local farms was helpful. For example, if it were known that barred rock chickens were kept on but one farm in the neighborhood and a barred rock chicken was found at a fox den, the observer had distinct advantages which he would not have had if nothing had been known about the kinds of chickens on the area.

Records were maintained on the availability of seasonal foods. For fruits the dates of ripening, falling to the ground and disappearance were noted. The appearance and disappearance of the various kinds of insects taken by the foxes were recorded. Information on the life histories of the local prey animals was collected whenever possible.

It was deemed advisable to record all circumstances which showed potentialities for affecting the availability of food. Disease might sweep domestic flocks in the neighborhood, and the dead might be discarded where foxes could find them. Severe weather might provide a food windfall for foxes by killing or incapacitating prey animals. During shooting seasons crippled and dead animals are lost in the coverts where foxes find and and eat them. Roadway casualties too serve as food. Harvest operations, burning, flooding, and drought often affect the availability of foods, and thus deserve attention.

Of value too were records of abundance of food. In addition to general notation of the relative amounts of food present from year to year specific inventories of prey populations were conducted. In order to quickly obtain some figures on the relative numbers of small mammals a line of 100 museum traps at 1-yard intervals were operated for one night in each of 3 selected parts of the area in October, 1938. In 1939 a more systematic inventory of small mammals was undertaken. One hundred traps for capturing small mammals alive were operated in lines of 10 in a purposive sampling of plots along a transect, 0.2 miles wide by 1.0 mile long, through the center of the range from south to north (Fig. 24). Each line of 10 traps was set on the north-south axis through the exact center of the 6.4 acre quadrats staggered regularly along the transect. At first the traps were placed at one-rod intervals; later the interval was increased to a chain. Throughout the period from March 1 to October 6 in 1939 and from June 1 to September 19 in 1940, commencing on or as near as possible to the first day of each month the traps were in constant operation until animals not previously taken ceased to appear with regularity. In 1939 conventional methods of marking the trapped animals were used, but in 1940 Monel metal fingerling tags were fastened deep in the ear. It was thought that such marking might yield added information if the tagged animal was found dead or was eaten by a fox and the tag, resistant to digestion, was recovered in analysis of the feces. The attempt was made to calculate the populations of small mammals to the acre according to the method suggested by Dice (1938). The method is based on the conclusion that a line of thoroughly efficient traps may be expected to denude an area extending for one-half the mean width of a cruising range on each side of the traps, and also for one-half the mean width of a cruising range beyond each end of the line. Sufficient figures to permit this calculation were obtained only for the Northern white-footed mouse. The mean width of the cruising range of this species was adapted from the studies of Burt (1940) and from contemporary work on the Moingona area. In conputing the population no attempt was made to differentiate between cruising ranges of the different age groups or sexes. It was thought fitting in this investigation to use a mean width of cruising range that would be reasonably representative of both sexes and the several age groups. The mean width of the cruising range used for the Northern white-footed mouse was 250 feet. For other species of small mammals the data did not support more than statements of relative abundance.

Cottontail populations were estimated in summer by the pellet count (Hendrickson, 1939) method and at other times by a flush count using a one-rod flushing front. The counts were made periodically on the same 10 6.4-acre quadrats used in the small mammal inventory. As a check on the data obtained from the systematic counting on the quadrats, additional counts were made at other places on the area.

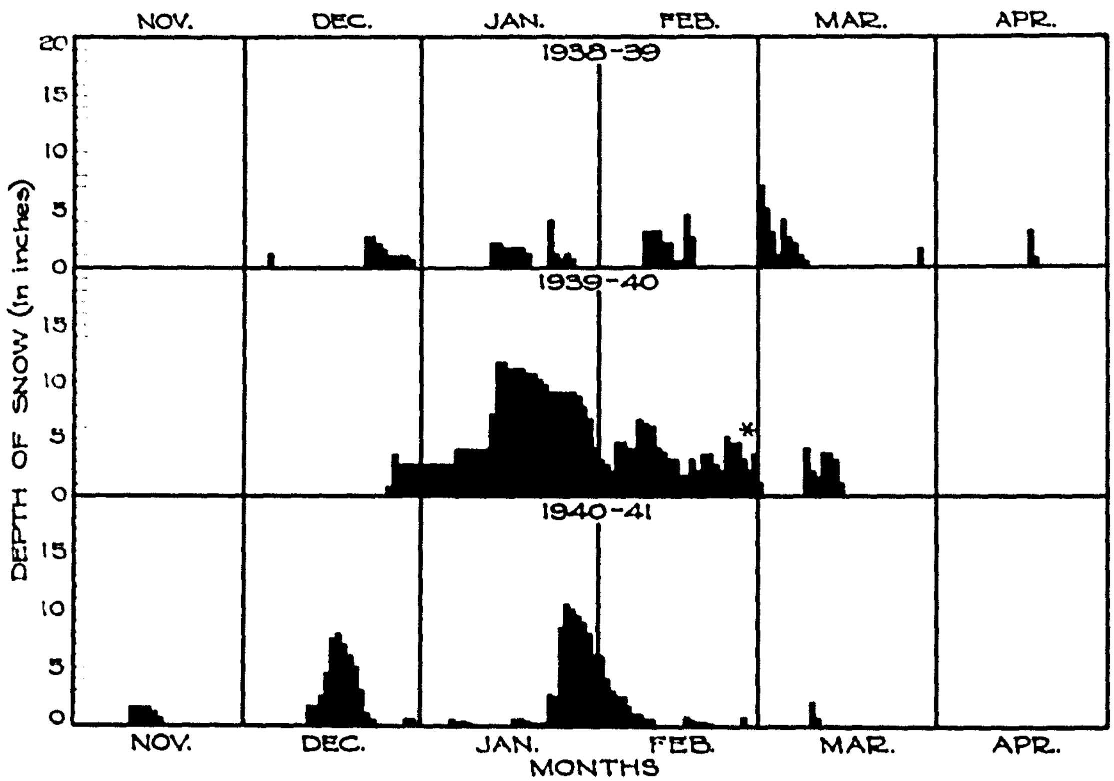
Covey track counts of bob-whites were made each winter according to the technique described by Errington and Hamerstrom (1936). These counts were made over the entire area. Throughout the late summer and early fall all quail families encountered were noted and where possible, counts of the number of individuals in each family were made. These random observations were only of general value in following population trends, but they often provided helpful leads as to the accurateness of the covey counts made each fall by beating the entire area. Although a specific effort was made to count the bob-whites on the area only in winter they were really under continuous observation, for whenever the search for fox "sign" took the observer through a covey range, it was often possible to obtain a covey track or flush count.

Ring-necked pheasants were not present in large numbers, and attempts to make counts of them were discouraging. As there were not many birds on the area, the concentrations of birds in winter were widely separated and a fair flushing count could be made at that time. Other estimates were based on an accumulation of direct observations made while working over the area for fox "sign" and making counts of other prey animals. Roadside counts of pheasants were made on the nearby prairie sections of Boone County, and this information was available for checking the population trend.

General Routine in the Field

The field routine underlying this investigation was centered primarily about the necessity of keeping constantly in touch with the activity of the resident foxes and of collecting fox scats with regularity. Field work was greatly simplified whenever a good tracking snow was on the ground, excepting that it was sometimes more difficult for the observer to get about. At such times, in order to check up on the current movements of the foxes after a new snow, all of the roads around and through the area were checked for fox tracks from a slow-moving car and by walking. The leads found in this manner were then used as a guide as to where the most productive tracking might be accomplished. The trails in the snow were not always easy to follow as was the case when the snow was deep and loose, encrusted, thawing or drifting. "Sign" found along trails in a good tracking snow, however, was usually excellent and furthermore could be dated as having been made by the fox sometime during the time interval since the last snow, the last thaw, or the last visit of the observer. Although the graph (Fig. 25) showing the depth of snow on the ground does not reveal actual tracking conditions, it does indicate something of the possibilities for following snow trails in this region. During snowless times field work was less productive. The entire area was then cruised periodically in order to maintain a perspective of the activity of the resident foxes. On such cruises a route was followed through all the places most likely to yield "sign" of foxes and yet touch in all parts of the range. The same procedure is followed whenever the focal point of fox activity was lost as when a family of young foxes moved to a new den. At other times observations were concentrated in the "hot spot" or current theater of activity; these observations too followed rather definite routes through the places most likely to yield information. Though of smaller size than the range, even the theater of activity could not be completely, thoroughly and systematically drilled out because there was neither sufficient time nor enough observers. Furthermore the results would not likely have justified the effort. The routes of observation were retraced as frequently as practicable in order that "sign" found might be dated as occuring sometime during the visit interval. "Must" visits over the routes were made through the current theaters of activity on the 1st, 8th, 16th and 22nd of each month, weather and other duties permitting.

Every effort was made to minimize undesirable contact with the foxes by the observer. No attempt was made to observe the foxes directly except at rearing dens, and then it was done largely to determine the number of young. Den sites were usually avoided until it was known that the family had moved to a new location. During periods when there was snow the observer almost always back-tracked on fresh trails in order to avoid



* Depth of snow on February 29, 1940 was 2.0 inches.

Fig. 25. Average depths of snow on the Moingona Fox Range during the three winters studied.

disturbing the foxes and creating an undesirable reaction. On those occasions when the trail was followed forward, the information obtained was not of the nature desired, and the time involved did not seem justified. The fox either detected the observer and thereafter was busy reacting mainly in relation to the tracker, or it was discovered bedded down resting. When found bedded down the fox usually remained at rest until started by the observer. When started, it escaped from view of the observer as rapidly as possible; if followed, it occupied itself mainly with escaping, and if the observer waited for a time before taking up the trail the fox was often again found curled up asleep. Thus, even when it was possible to observe directly by stalking the foxes along snow trails, the results failed to justify the effort expended.

In this research greatest returns were realized by concentrating on "sign" readings. It was first necessary for the observer to identify fox "sign" and to note its intensity in order to locate theaters of activity. As has already been pointed out, this was not difficult when a tracking snow was on the ground, but at other times the task became difficult. Along the routes taken by the observer at such times all bare surfaces were checked for tracks. When the ground was softened by rain or thaws tracks were registered on nearly any bare surface. Likely places were ditch and gully bottoms, sand bars, low terraces subject to flooding, roads, stock trails and stream margins. During dry periods negative evidence was unreliable because tracks registered only in isolated places along stream margins, around seepages and dusty roads or stock trails. Dusty stock trails and roads were not too good because the tracks there were soon concealed under the dust from passing traffic. Cultivatio of land for agricultural purposes also provided tracking opportunities, the "dead" furrows being especially used in plowed ground. Soil disturbances such as those produced by the Shaw pocket gopher (Geomys bursarius) seemed attractive to foxes. Sometimes after rains the foxes climbed up on the boulders with muddy feet and left recognizable prints. This tracking evidence was especially valuable in densely vegetated areas where there were few areas in which to read "sign". Sometimes it was important to distinguish tracks seen on one visit from those seen on another visit. This was done by scratching a circle in the soil around some of the old tracks and inscribing the date of the visit within the circle. Another method was to scratch a symbol on each trail along a stretch of the route and record the symbol used in the field notes for that day.

On snow trails two and even more foxes were known to have passed over the same trail, each stepping carefully in the tracks of the first. If the trail was followed, places such as on steep slopes appeared where the tracks separated. It has been pointed out that this may be used as a method of estimating the numbers of foxes in an area. Such estimations should be made with care, for in these observations the same fox was known to have circled and retraced its own trail. The foxes also followed in the tracks of other animals so that close scrutiny was necessary.

Then as the observer was able to find the theaters of activity by the tracks and other "sign", it was finally necessary to locate and interpret evidence of the feeding of the foxes. There seemed to be little rhyme or reason to where most of such evidence was observed; it was largely where you found it. It proved difficult to interpret, and there was a tendency for the observer to be teleological about feeding evidence, particularly where prey animals were concerned. More often than not the observer was forced to admit that the evidence did not clearly indicate that a fox fed on an animal, much less killed it when its remains were discovered. Food remains were located in caches beneath loose soil, organic debris or snow; this was so skillfully done that it was easily overlooked. The food was usually covered by standing back and pushing the material over the food with the nose so that no claw marks were left. The smaller feathers of birds and the tails of cottontails were often caught in the wind and blown several feet from the site at which the prey had been fed upon; on noting such remains it frequently proved worthwhile to work into the prevailing winds. Small feathers were sometimes found when they had settled into the tracks of a fox trail in deep snow. At first it appeared that the feathers had fallen from a bird carried by the fox. Later it was found by working from such feathers into the wind that they were often the cast off remains of the meal of a hawk or an owl.

In order to follow the food trend and to check on field observations on limited areas, it was necessary to collect fecal passages for food analysis. Fox scats were deposited in a variety of locations; those found, however, were usually in places where the vegetation was low, scant or absent. Seldom was a particular location used for defecating with any high degree of frequency. Red fox latrines, such as those of raccoons, mink and weasels, were not found in this study. Large numbers of the scats of young foxes may be collected on the site of the rearing dens. Such collections, however, were here held to a minimum, usually being withheld until the family had moved to a new den in order to minimize forced movement.

Although no one location was singled out as a regular place for defecation, there were some spots that were worthy of attention. Boulders were known to have been used as places for defecation, particularly when there was considerable water on the ground as in spring or after a hard rain (Fig. 26). Such locations were found to yield no more than about four or five scats during a year's observation. Foxes also defecated on or about small boulders (Fig. 27) that lay in somewhat isolated positions

Fig. 26. Fecal passage of a red fox on a boulder. March 21, 1939.

Fig. 27. Fecal passage of a red fox next to a boulder on the edge of a field.

along stock trails, dry stream beds and roads. It seemed that during wet periods the number of scats found on quick-drying surfaces such as stones, logs and low stumps increased. Sometimes a stretch of dry, sandy drainage line or a bare ridge would be found to yield 2 to 10 scats a week for as many as 6 weeks, and then none or very few might be found for several years. Such locations were usually located in late summer and were thought to indicate a focal point of family activity after the dens had been abandoned. An exceptional place of defecation was created on the Moingona area when a local farmer took an old farm dog into the woods and shot it.

It happened that the dog was left at a point about 100 yards from the den in which the fox pups were born that year, and the dog was shot shortly before the pups came. The foxes immediately began urinating and defecating on the dog's carcass. Seventeen scats were collected for analysis and as many more were thrown away because of difficulties encountered in estimating the time of defecation. Two other dogs were known to have been killed and left in the fields by neighboring farmers and though diligently watched they were never used as places of defecation by foxes. The collection of fecal passages in snow was largely a matter of getting on trails and following them until a scat was found (Fig. 2[illegible]). In more or less open fields where there were a great many trails it seemed conservative of time to cast over the field at intervals which permitted observation of all the ground. Scats and other "sign" were in this manner located without laboriously tracing out each of the trails. At times when there were no snow trails to follow, the observation routes along stock trails, drainage lines, ridges, streams and roads and certain places on and near these routes merited attention in the search for scats. Sandy washes, silt beds and gravel outcrops were examined for scats. Slightly elevated places such as low stumps, pocket gopher mounds, boulders and earth thrown up in cultivation seemed attractive to the defecating fox. Prey remains, once located, were examined on subsequent visits even though they consisted of nothing but a few feathers or a little hair, because foxes sometimes returned to these sites to defecate. Cow and horse dung and items that stood out along the trail such as sticks, rotted logs, stones, nuts, bones, pieces of china and the like appeared to be attractive places for defecation. It does not follow that all scats were found in such locations; as many more were

Fig. 28. Track pattern of a red fox during defecation.

found along the stock trails, field roads and drainage lines without apparent relationships to anything but the route itself.

When there were snow trails to follow it usually was a relatively easy matter to determine the period of time within which defecation occurred. On other occasions, the time of defecation was estimated from the date of the last observations in the locality together with such other "sign" as was present. On the routine trips over the area all the likely places of defecation were carefully and methodically inspected; if a scat was found on a subsequent trip it was usually dated as between visits. It seemed reasonable to expect that scats were missed for one reason or another even with the most exacting observation; therefore it was advisable to examine other evidence of time of defecation. In the examination the scat was usually tested for odor as it was determined with caged foxes that the characteristic odor associated with the scat was generally difficult to detect after several days exposure to the weather. If a scat was collected subsequent to a rain it could often be determined whether the scat was present before or after the rain. Following a light rain the pits left by the rain drops were visible on the soil around the scat but not under it, or small particles of soil might have been pitched up on the scat by the pelting drops. A severe rain storm would break up and wash away scats, particularly if composed of insect or fruit remains or previously pulled apart by arthropod scavengers. The age appearance of tracks around the scat was helpful. In extremely fresh scats the mucus was still intact and the scat was soft and moist. As might be expected the scat dries on the outside first, gradually drying through to the core. The effect of weather on the scat mucus may be employed to some extent in determining the probable period of defecation, but this method should be used with caution. In summer, observations on the arthropods attacking the scat seemed of assistance in estimating the time of defecation, for these scavengers did not appear to feed on old scats. Knowledge of the time of the last cultivation of fields often provided a definite time bracket for dating scats found in cultivated fields. This problem of dating scats for the period of time in which defecation probably occurred was largely a matter of applying common sense reasoning to each situation.

As the scats were collected they were placed in a paper bag, and the date when found, the probable time of defecation and the locality were written on the outside of the bag. They were then carried to the laboratory where the food remains in each were identified and recorded. The methods used in fecal analysis will be discussed under the section on food habits.

Another field technique that appeared worthy of attention was that of marking remains of prey found in the field. Monel metal fingerling tags as employed in censusing the small mammals were also used to mark food remains in order that they might be identified on subsequent visits. The fingerling tags were also folded up and shoved into the flesh of prey with the expectation of retrieving the tags from feces. Only three tags were recovered; these will be mentioned under the section on territory and movement. A more thorough application of this method might well result in valuable data on the movement of carnivorous mammals.

When good tracking snows were on the ground attempts were made to obtain quantitative measurements of the fox's relationship to the different cover types by recording the number of paces taken along the trail in each type. The method did not prove very productive because more often than not the trail of an individual could not be followed far enough to permit many measurements, and therefore the figures obtained were too few to permit analysis.

HOME RANGE, MOVEMENT AND LIFE HISTORY

That non-sedentary animals require particular space in which to live and reproduce their kind is axiomatic. In their nature these units of living space frequently reflect a kind of behavior pattern peculiar to individuals of the same species. The habitability of the units is largely determined by the availability of that food and shelter required by the occupying species. The innate social psychology of the species also influences the population within the home range. Thus, home ranges may be construed as being occupied by not only an individual of a species but also by a family or other social group. The workings of sociality may be seen in the intolerance for intrusion shown at specific times by the owner or owners of a territory for others of the same species or closely related forms.

Following an extensive review of literature relating to the theory of territory Nice (1941, p. 467) concluded that "Although a great many mammals have 'home ranges' in general these do not seem to be defended with the vigor shown by many birds and fishes". In this the red fox is no exception; for if proof of territorialism requires that emphasis be placed chiefly on defense of the individual or the social group then the data here to be reported do not strongly support territorial behavior. Perhaps failure to observe appreciable evidence of territorial defense in such a stealthy, wide-ranging animal as the red fox should not be construed as indicative of absence of territorialism, for this kind of behavior would not be easily seen. If, on the other hand, positive reaction to a particular place and familiarity with the environment are manifestations of territory then territorialism is characteristic of the red fox.

A continuous investigation of the food coactions of a species in a limited area generally reveals something of its home range, movement and life history, for a burning question in the definition of home range is the availability of suitable food. The relationships which these bear to feeding habits and diet require this inclusion here; an animal must feed within the limits of its living space.

Sportsmen who follow fox hounds know that red foxes tend to occupy particular areas, often locally known as ranges. Seton (1929) recalled that well-known foxes such as the "Mahogany Fox" of Hartford, Connecticut, "Baldy" of Berkely, Virginia and a black fox of Blacktail Creek, Wyoming, were reported as usually found within three or four miles of their presumed headquarters. This same writer also suggested that an individual red fox lived in an area of not more than five miles in diameter and did not ordinarily range that far. From n January, 1934, until the following August a red fox (Vulpes fulva) family was studied on the Edwin S. George Reserve near Pinckney, Michigan (Murie, 1936). Murie, reporting on this investigation, wrote that the foxes probably performed most of their hunting within the 1200 acres of the Reserve, but that their tracks were seen along the fence where they had passed in and out; it was thought that the area used for intensive hunting would probably have been considerably larger if the hunting had not been so much better within the Reserve than on the surrounding farms. Hamilton (1939, p. 304) held that "A red fox, when started by hounds, will circle in its own square mile of territory unless pressed, when the harassed beast will enter unfamiliar terrain. When the hounds are shaken, the fox soon returns to its own homesite." The observations made on the Moingona Fox Range indicated that an arc drawn on a one mile long radius would ordinarily circumscribe the movements of the resident individual, pair or family.

It seems logical that the size of the home range should be primarily limited by the extent of the red fox's search for available food. Life history events and the closely related intra-specific social relations, however, may be expected to influence the nature of the response to this fundamental need of food. The general activity of the red fox, naturally centering on the family as the social unit, annually progresses through a winter breeding and pre-denning period, a spring and early summer denning period, a late summer and early fall period in which the young live free of the den and family ties gradually relax, and a period of dispersal.

The red fox is monoestrous (Enders, 1938). In this region oestrum in the red fox usually occurs sometime during late December and early January. Evidence that the breeding season was underway could be found in the field if conditions for reading "sign" were suitable. Conditions on the Moingona area could scarcely be considered wholly adequate for observation during the breeding season. They were sufficient, however, to reveal fox trails almost everywhere on the range, possibly reflecting an absence of conservatism of habit at this time. Gradually there was a tendency for the tracks, scats, beds and other "sign" to increase in intensity in certain places; this usually marked the subsequent location of a family. Double and parallel trails of foxes traveling together (Fig. 23) were frequently seen. Blood, possibly marking the close of pro-oestrum, was found in the urine of a female fox on but two occasions, once on December 23, 1938, and again on January 24, 1941. At this time the males particularly seemed to increase their propensity to leave "scent". One male left its "scent" 12 times within a quarter of a mile after leaving its bed. Dens, often well concealed with snow, were visited and marked with "scent". The apparent directness with which those dens were located seemed to show a familiarity with the area that indicated an association with the range of considerable duration.

Serving to emphasize the sometimes dimly visible concentrations of "sign" of local foxes near the center of their ranges was the occasional trail of a transient fox. An excellent example of this was observed in good tracking snow on January 18, 1938. The trail was picked up about 100 yards southwest of the bridge across the Des Moines River. It was followed northwest across the river for about a mile beyond and when left it was seen proceeding in the same general direction up the river. It was also back-tracked southward through the area and for about a mile and a half beyond River Road where it was left still leading southward. Among fox hunters such an animal is often known as a "traveler", and the experienced hunter seldom attempts to stalk its trail.

Although there was again a confusing array of trails throughout the area in the winter of 1939-1940, by January 4 the observer noted a tendency for the "sign" to concentrate in two theaters, one north of School Road and the other south. Perhaps a manifestation of territorialism relating to this division of activity was an incident that occurred on January 10. While Charles Yocom and the writer were standing on School Road in the northwest corner of Section 20 between the two theaters of intense activity, a large red fox called attention to itself by yapping at the observers for several minutes from a position about 100 feet south of the road in a field of corn stubble. The animal was decidedly defiant in its manner. It finally retreated out of sight in a southeasterly direction; inspection of the tracks showed that it had approached from the southwest directly toward the position of the observers. Direct observations or "sign" readings indicating intra-specific strife were not made. This is the kind of behavior, however, which in animals such as foxes might easily escape attention.

The foxes became increasingly conservative in the extent of their movements as the time for bith of the young approached. About the time the pups were born the notes indicated that the scope of activity of the adults was within a one-half mile radius of the natal den. On February 28, 1939, an 8-inch snow ceased falling at 1:00 p.m. Careful inspection of the area showed that by noon of March 2 no fox trails were beyond 0.25 mile from the den. By March 4 much of the snow had melted; however, a new 3-inch snow ceased falling at 6:00 p.m. March 5, and on March 6 snow trails were found as much as 0.5 mile from the den. Several observations of pairs of foxes moving together or bedded down not far distant from each other were also made during the pre-denning period. Dens may have been visited and "scented" during the winter, but it was not until late February that they began to prepare dens for use by cleaning them out and enlarging them (Fig. 29). Many dens were conditioned in this way, and for this reason the den in which the pups were to be born was not always easy to determine. In

Fig. 29. A den opened up by a red fox

1941 as in 1939 and 1940 all the usual advance preparations for raising a family took place; dens were cleaned out, and food was even deposited in an entrance of one. The cubs, if there were any, were never seen. Probably a pregnant female fox shot near the cemetery late in February was out of the pair that had been in residence on the range. Fox "sign" continued to appear in the southwest part of the area in considerable amount until late in April; thereafter throughout the summer only an occasional track was found and then generally in the southeastern part of the area. On March 29 a 1-inch cube of beef heart was impregnated with a numbered Monel metal tag and left at a place where a fox had apparently fed on a cottontail in Polly Creek just opposite the den in which the young were born in 1939. Two days later, on March 31, a fox scat that had probably been defecated early that same morning was found on a rotted down stump almost exactly one-half a mile directly south of the place where the tag had been left. The tag was found in this scat when it was worked out in the laboratory. This may serve as fair evidence that a fox familiar with the area was still resident at that time.

Perhaps indicative of territorial behavior is an incident that began in the pre-denning period and extended into the denning period of the foxes in 1939. A local farm dog, too old to be of further use, was shot in mid-February at a point on the area about 200 yards southwest of the den in which the fox cubs were subsequently born (Fig. 30). When the dog carcass was inspected on February 18 there was no "sign" of foxes about it. By March 1, however, it was noted that there was especially heavy "sign" about the nearby den, indicating that this was probably the den in which the cubs would be born. On March 6 a strong odor of fox "scent" attracted attention to the nearby dog carcass; it had been liberally annointed with fox urine and decorated with a number of scats. On March 14 the dog carcass was again visited and 8 scats, defecated since the last visit, were collected for analysis. The carcass was still being heavily annointed with "scent". In addition a hind leg and the tail had been pulled free of the frozen body; the tail was nearby, but the leg had been dragged 200 yards to the north. When inspected again on March 21 the foxes seemed to have lost interest in the dog and only one scat was collected. It could not be determined in the field that the foxes had ever eaten any of the animal, and analysis of the scats did not reveal the remains of domestic dog. Perhaps this was a demonstration of contempt for an enemy of long standing, or it may have been in the nature of a warning to intruders. In the early spring of 1941 two

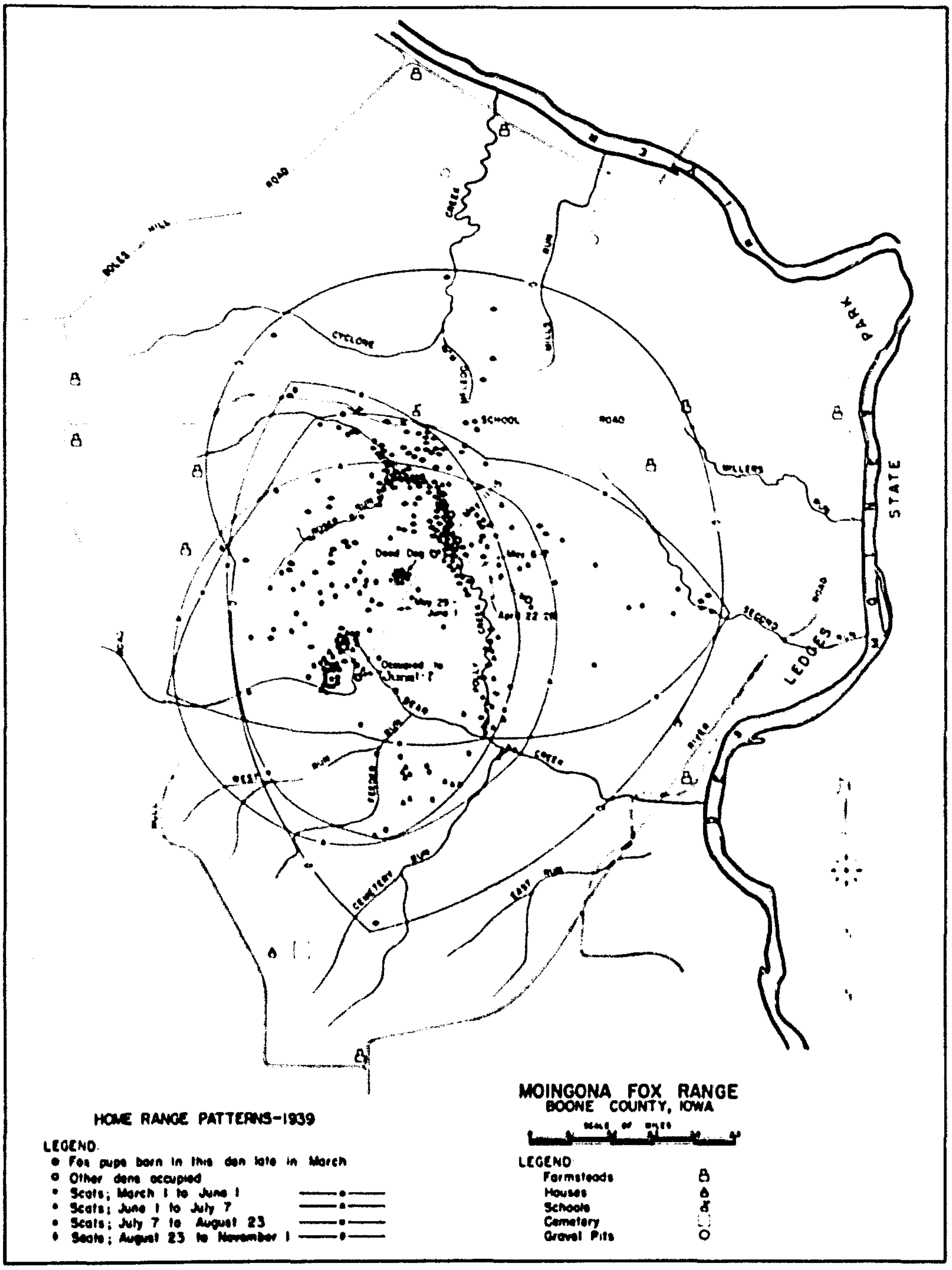


Fig. 30. Den sites, direction and time of movement between dens, scat locations and interpolated home ranges, 1939.

farm dogs were shot and left in the southern part of the area. Although their carcasses were carefully inspected on every visit to the area no evidence was ever found that they had even been approached by foxes though trails frequently passed nearby. As indicated earlier no fox pups were raised on the range that year, and this may have had something to do with the absence of interest in the dead dogs.

The experience of the silver fox fur industry indicates that the native red fox probably has a gestation period of about 51 days. The field evidence roughly supports a similar time between the breeding season and the birth of the young. In 1939 the fox pups were born in a den in the side of a deeply incised gully just off Polly Creek sometime late in March. Red fox pups seem to be able to appear at the entrance of the den when about three weeks of age. The fox pups remained in the den of their birth until they were four or five weeks old when sometime during the period between April 22 and 28 they moved into a new den about 0.25 mile to the southeast. All of the dens occupied and the sequence of their use in 1939 are shown in Fig. 30. Although it frequently meant failure to obtain scats and records of food items at the den the precaution of not approaching the den until it was relatively certain the occupants had departed usually was followed. The pups were seen for the first time at this second den; there appeared to be three in the litter. On May 6 or 7 the pups moved back into the natal den. This time two nearby dens were brought into use as outlying retreats. The pups were seen here twice before they went north about 0.1 mile to another den sometime between May 11 and 15; again three was the largest number in view at any one time. This den was evacuated sometime between May 29 and June 1 when the pups were from nine to ten weeks old.

The new den was about 0.5 mile to the southwest in a steep slope on Bear Creek. At this time the pups were known to have traveled as far as 0.25 mile from the den. All of the fox scats collected on the area exclusive of those picked up at the rearing dens were spotted in on the amp (Fig. 30); then together with tracks and all other "sign" located, an outline interpolation of the range occupied by the family from March 1 until the time of the move to the Bear Creek location was drawn. This interpolation of range, as all others made in this study, quite probably does not include all the extremes to which the adults may have gone, for when one considers the "thinness" of fox "sign" on the periphery of the home range the ease with which it might be passed over is evident. It is reasonable, however, to consider the outlined area as all that is ecologically significant, especially as related to this investigation of food coactions. What Howard (1920) has written of the lack of profit in attempting to find a point beyond which birds will under no circumstances wander might well be applied here.

The pups remained in the Bear Creek den until sometime during the period, June 1-7, when they appeared to have finally severed their ties with the den as home. The young were probably about 14 weeks old at that time. An interpoliation of the range occupied while the family was headquartering in the Bear Creek den is shown on the map (Fig. 30).

In 1940, as has already been reported, two familes of foxes established residence on the area. The female on the northern part of the area gave birth to her young in a den on Cyclone Creek (Fig. 31) about the second week of March; the young of the other family were born in a den on Second

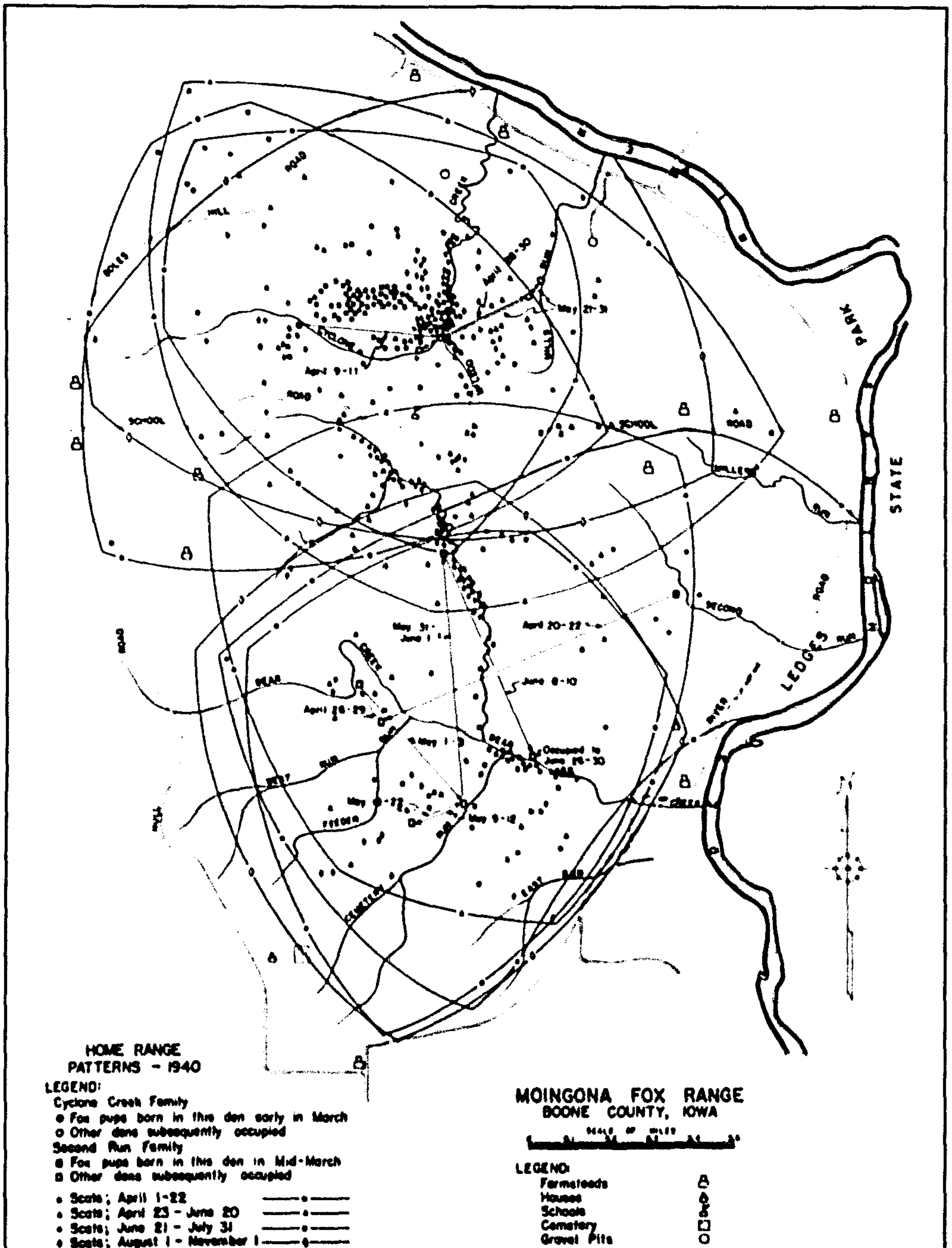


Fig. 31. Den sites, direction and time of movement between dens, scat locations and interpolated home ranges, 1940.

Run (Fig. 31) in mid-March. On April 8 it was possible to count six pups playing outside the Cyclone Creek natal den at one time. During April 9 to 11, when the pups were four or five weeks old the family moved east about 0.35 mile to a new den in the steep south bank of Cyclone Creek near the mouth of McLeod Run. It was possible to count the six pups in the litter several times during their stay in this den, particularly because the den site could easily be observed.

A dead cottontail was located on the butt of a hay stack in 19-3 on April 16; it was tagged in the ear with a metal tag. It was found about 0.65 mile away at the den site near McLeod Run on April 21, thus indicating something of the size of the range of an adult at that time. An interpolation of the range occupied during the period, April 1 - 22, appears in Fig. 31.

When the pups of the Cyclone Creek family were about seven or eight weeks old sometime between April 28 and 30 the family moved to a den on Mills Run. An indicated in Fig. 31 the Cyclone Creek family appeared to bring into simultaneous use several dens during the ensuing period, May 21 to 31. So far as was known the young foxes loosened their ties with the den as home after that. It was thought that they were then 12 or 13 weeks old. In order to make the time span for the range interpolations agree and to cause the mapping to be less formidable, the interpolation for the period, April 23 to June 20, extends almost three weeks beyond the time when the Cyclone Creek family ceased to live in the dens.

The pups of the Second Run family remained in the natal den until sometime between April 20 and 22. The largest number of pups seen here at one time was five. An interpolation of the range occupied from April 1 to 22 has been outlined (Fig. 31). When the pups of this family were near five weeks of age the family moved 0.75 mile southwest to a den in the north slope of the ridge between the junction of Bear Creek and Feeder Run. Between April 26 and 29 the family moved northwest 0.1 mile to a den that had been occupied by the foxes in 1939; sometime between May 1 and 3 they evacuated in favor of a den 0.35 mile to the southeast on Cemetery Run. The five pups in the litter were again counted here on May 8. This den was occupied until sometime between May 9 and 12 when the young moved 0.15 mile southwest to a new den. On May 22 some of the pups were again seen at the den on Cemetery Run. A young male of the litter was found dead within 200 feet of this den on May 31. The animal weighed 6.4 pounds, and its age was estimated at 11 weeks. It had died as a result of wounds, but the circumstances under which they were delivered could not be definitely determined. The thorax was punctured as by a single bullet, and the hind legs, particularly the right one, were severely hamstrung. The tooth marks in the skin were such as might even have been delivered by litter mates. The family immediately moved directly north 0.6 mile to the 1939 natal den, apparently recoiling from the danger. Sometime during the period, June 8 to 10, however, the family again moved south, this time 0.55 mile to a new location on a low bank on the north side of Bear Creek. They remained at this new den until sometime between June 26 and 30 after which they seemed to relax their ties with the den as home. The pups were then thought to have been about 15 weeks old. An interpolation of the territory occupied by this family from April 23 to June 20 has been mapped (Fig. 31).

Even after the pups terminated life in the dens the family ties seemed to continue unbroken into the fall. Of the Kenai red fox (*Vulpes kenaiensis*) in Mount McKinley National Park, Alaska, in 1926 Dixon (1938,pp. 160-161) wrote that "By July 6, the fox pups in the den on Savage River were old enough to leave their den and to follow their mother about on foraging expeditions for afield. Careful watch showed that they did not return to the home den to live after this date. By the first of August the young foxes were nearly grown and, although able to forage on their own account, continued to follow their mother about for some time . . . ." It is likely that the life history schedule of the Kenai red fox in the Mount McKinley National Park lags somewhat behind that of the Northern Plains red fox in Iowa.

Where dens formerly were the hubs of activity now there were rallying stations. These are clearly marked by the concentrations of scat locality marks on the home range maps (Figs. 30 and 31). All of the stations were characterized by the absence of tall, dense cover; stretches of dry sandy stream beds, closely grazed pastures and the more or less bare earth of well-cultivated cornfields seemed particularly attractive. Cornfields, while allowing freedom of movement, still provided excellent concealing cover.

In 1938 intensive observations were not undertaken until June 6. At that time the young foxes were occupying the den in which the pups of 1939 were born, and the same nearby dens were being used as outlying retreats. A squeaking noise produced by pursing the lips against the back of the hand was employed to coax two pups to the entrance of the main den. No more were ever seen. They continued to occupy these dens until late in June. Their activity then centered on a rallying station in the dry sandy bottom of

Polly Creek about 100 yards north of the den. This station continued to be in use until late September when the family moved out in accompaniment to the coming of some wood-cutting operations in that neighborhood. Another rallying station, if there was one, was not located.

After the period, June 1 to 7 in 1939, when the young released their ties with the dens they remained in the vicinity of the last den for about seven weeks. The rallying station was on a series of sand bars along Bear Creek near the den; it is well marked on the map (Fig. 31) by the concentration of scat locality records. An interpolation of the range occupied during this period is also shown on the map. After August 23 the "sign" of the family had definitely shifted northward, and a new rallying station was established in a part of Polly Creek near its junction with Rose Run and on a rounded, closely grazed ridge adjoining to the east (Fig. 32). Evidence of family activity was found in this general region until October 12. The young would then have been approaching seven months of age. If the family ties remained intact and another rallying station was established it was never found. A home range interpolation for this period is outlined on the map (Fig. 31).

In 1940 the Cyclone Creek family remained much in evidence on the sandy bed of the creek near its junction with McLeod Run. They abandoned this as a rallying station in mid-June, and although their "sign" was regularly observed, the whereabouts of the new rallying station was not located until early in July. Then it was finally discovered on the broad upland ridge north of Cyclone Creek where it had been deceptively concealed in the depths of a well-cultivated cornfield. This station is also well

Fig. 32. Closely grazed ridge included in the early fall rallying station of the red fox family in 1939.

marked by the locality records of scats collected during the period (Fig. 31). After August 1 the rallying station was back in the closely grazed bottoms including Cyclone Creek, mainly just north of the mouth of McLeod Run. It also included the southeast corner of a cornfield to the northwest. The scat locality records for this period show the rallying station by their concentration (Fig. 31). Evidence of the family continued to appear at this station more or less continuously until October 23; after that date the "sign" was more widely dispersed. The young would then have been about seven and a half months of age.

Fig. 33. Polly Creek in fall. The leaves on the ground proved distracting to the observer searching for "sign".

From sometime between June 26 to 30 and July 31 the Second Run family centered their activity at a rallying station along the sand bars in Bear Creek immediately east of the mouth of Polly Creek. The usual concentration of scats appeared there (Fig. 31). The unusually heavy rains in August may have forced them off the sand bars. Time did not permit further intensive observations on both families, so it was determined to work only the Cyclone Creek region and to limit observations in the southern part of the area to regular bi-monthly visits. As a result it was not possible to locate accurately rallying stations that might have been formed after the family moved off the Bear Creek sand bars on July 31. The few inspections made, however, indicated that one probably had been established to the south on the upland in the closely grazed pasture between Feeder and Cemetery Runs.

Beginning in late October it was obvious in the "sign" readings that some change in activity and in the social unit was taking place. The ground-concealing leaves fallen from trees and the subsequent freezing of the earth made "sign" reading difficult. In addition to covering the ground, the mere presence of the leaves was distracting to thorough inspection (Fig. 33), especially when there was enough wind to shift them about. The little snow that fell was seldom suited to tracking. Nevertheless it was apparent that the rallying stations were gone, and probably with them had gone most of the family ties. The "sign" that was located was more evenly and more widely dispersed than before. No direct evidence of the dispersal of the young was obtained; it was clearly seen, however, by late winter that at least the larger part of the population increment had gone some place. The red fox population on a single range is too small to permit the taking of a large enough number of individuals to provide significant data o age classification, and even then the transient young from other ranges would possibly complicate matters. No successful method of trapping and retrapping foxes has as yet been perfected, so nothing could be learned in this way. Only two animals were known to have been captured on the area; a male was trapped early in December, 1940, and a female was shot late in February, 1941; neither animal was thought to have been young of the year. Errington and Berry (1937) reported the capture, tagging and releasing of two young foxes in the vicinity of their den;

these were trapped the following winter 16 and 18 miles distant but in opposite directions.

Contributing in a limited way to knowledge of the movement of foxes in December was the subsequent recovery of a metal tag from a scat after it had been impregnated into the flesh of a cottontail found on the area on December 3, 1940. The scat containing the tag was collected 0.65 mile from the place where the cottontail had been located (Fig. 34).

Perhaps the history, so far as it is known, of the family that occupied the northern part of the area in 1940 offers the best leads as to what occurs at this season. The family, probably the same eight animals known to make up the unit until late May, was in evidence in the region until about Oct. 23d. The "sign" was all the time becoming more evenly and more widely scattered and perhaps somewhat less abundant. On about December 11 a large male thought not to have been one of the season's young was trapped in the northwest part of the area. Later, on December 17, in unusually good tracking snow averaging eight inches in depth it was possible to thoroughly trace out by following the outermost trails all of the area then occupied in the part of the area formerly occupied by the family (Fig. 34). This represented the scope of all the movement that occurred between 4:00 p.m. on December 16 and 4:00 p.m. on December 17. An area of approximately 25 acres had been involved in the movements. It was the movement of a single fox, probably a female as evidenced by the method of urination. After the inspection it was possible to examine the roads bounding this general part of the area; trails of other foxes were not found crossing the roads. Fox "sign" continued to appear in the northern part

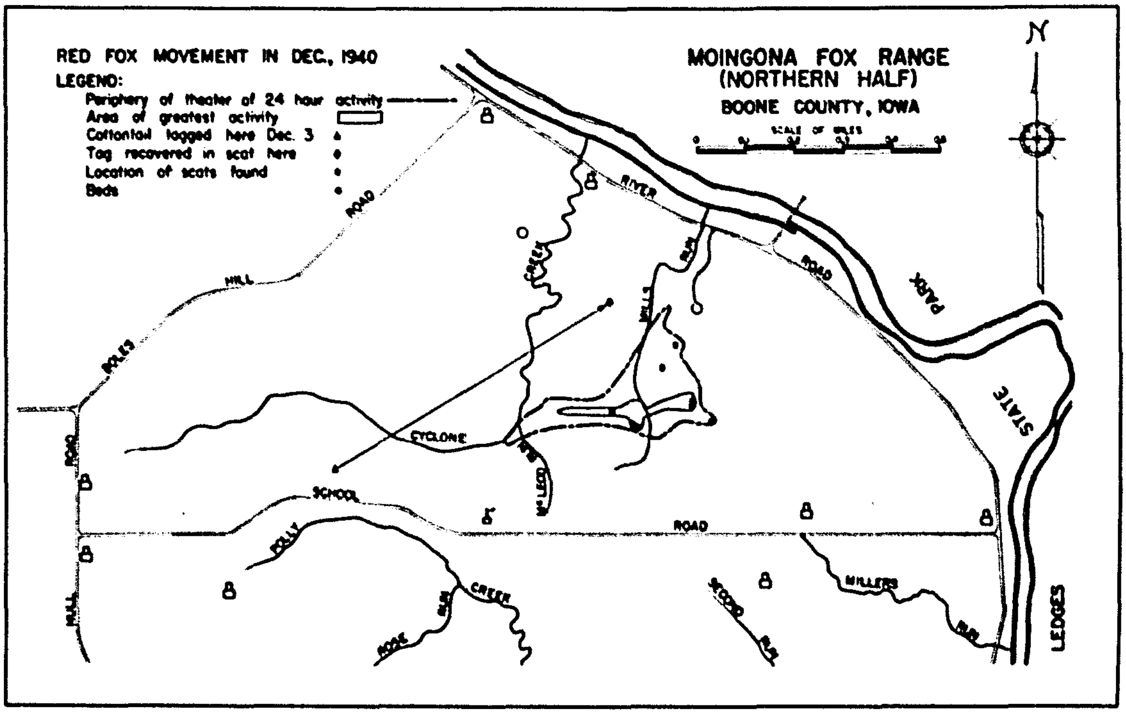


Fig. 34. Scope of activity of one red fox during a 24-hour period. Locality where consumed and place of recovery are also shown for Monel metal tag swallowed by a red fox.

of the area until early in January.

It is perhaps of value at this point to draw attention again to the fact that a female was shot late in February the following spring, 1941, in the southern part of the area after all the usual "signs" of breeding season had taken place, and that no young were raised on the area that season.

The foregoing account of territorial behavior, movement and population of the red foxes on the Moingona Fox Range was presented because of its relationship to the diet of the foxes. The home range is reflected in the diet because the animals naturally must feed within the limits of their range. The resulting differences in the items that appear in the diets of foxes living in widely separated regions are easily discerned; that such differences may appear in the diets of foxes occupying neighboring ranges will be brought out in the discussion of feeding trends.

FEEDING BEHAVIOR

Hunting Methods

Hunting behavior is the medium through which the feeding animal establishes its food coactions; knowledge of one affords insight into the other. Information on the hunting behavior of the red foxes in settled regions cannot be easily accumulated. Nevertheless even few data reveal basic behavior patterns. Further observation indicates that these patterns are standard, varying only in detail. The variations seem attributable more to attendant circumstances than to differences between individual foxes.

A stealthy approach or deliberate stalk was frequently employed by the fox for capturing certain kinds of prey. Cottontails were commonly taken in this manner, usually while resting in forms. Birds too were obtained by stalking. Sometimes the stalk was terminated by a final rush or leap, and at other times the rate of the stalk was not noticeably speeded up as the catch was made.

It is quite likely that a fox is almost constantly alert with all its senses to the possibility of obtaining food. On occasions, however, it was noted that foxes did not appear to detect prey within easy stalking distance. Fox trails were traced several times within 10 feet of cottontails resting in snowy forms. In each case it was known that the cottontail had been in the form when the fox passed because the "sign" showed that it had not moved out of the form from the time the snow had stopped falling until seen by the observer passing the trail (Fig. 35). It would be impossible to estimate the number that were passed undetected and undisturbed by the observer.

Although the stalking technique was usually directed at resting prey

Fig. 35. Form in which a cottontail remained under the snow until disturbed by the observer. It had been there at least during the 12-hour interval since the snow ceased falling as is attested by the tracks.

it was also applied with little variation to the capture of moving animals. An excellent example of this was found depicted in a late snow on March 11, 1941. A weasel (Mustela frenata) had passed through an open pasture at a moderate speed, 14 to 16 inch leaps, towards a gully in the steep slope immediately southwest of the junction of Polly and Bear Creeks. At the same time a fox had been traveling along the base of the slope at a walk or trot, for the tracks were spaced at 12 to 14 inch intervals. Evidently just as the weasel ascended a slight elevation of the terrain the fox became aware of its presence, for the tracks showed that it had stopped and turned toward that part of the weasel's trail then about 40 feet distant. The fox did not take out in direct pursuit of the weasel but climbed a slight elevation in the ground and again stopped to look in the direction of the weasel trail apparently to more fully take in the situation. It then continued at the same pace along the base of the slope possibly screened from the weasel by scattered gooseberry bushes. The weasel in the meantime continued on a straight but longer line of travel toward the gully. The stalk was perfectly timed, for the fox caught the weasel without so much as changing gait. The weasel must have been unaware of the danger up to the very end, for there was no change in the spacing of the tracks to indicate that it had changed pace or dodged. The weasel, in white winter pelage, was found where the fox had left it in a snow cache (Fig. 36) about 100 feet away.

Murie (1936) found that the foxes on the Edwin S. George Reserve near Pinckney, Michigan usually captured cottontails by out-sprinting them in relatively short races. In this study no cottontails were known

Fig. 36. Weasel in cache where it had been placed by a red fox.

to have been captured in this manner, and only three attempts were noted. These seemed to have failed because of the effectiveness with which the pursued cottontails used escape cover. In one instance escape was made possible by a woven wire fence grown over with grape vines. The fox gave up the chase at the fence even though the cottontail continued on across a 100-foot strip of open field before reaching security in a hole. Another time a fox found that scattered limbs, trimmed from a tree trunk and grown around with hemp, was too great an obstacle. Another cottontail made good its escape by running up hill through a partly broken over stand of great ragweed.

Effective escape cover militated against the fox in its attempt to capture cottontails through pursuit. As all successful stalks on cottontails known occurred in spaces relatively free of brushy or weedy ground cover it appeared that the fox might also have found it difficult to stalk if the obstacles in its path made movement too difficult. As the vegetation went down under the frost and snow there was a noticeable movement of cottontails into winter concentrations in brushy gullies and other locations offering cover. Tracks showed that foxes regularly inspected such places of concentration. This was particularly obvious during the deep snow and cold late in January, 1940.* At that time when one normally effective covert in a gully was drifted full of crusted snow three cottontails were taken there by foxes in two days. One animal had been captured while it rested in a form in the scant cover offered by the tips of rose bushes (*Rosa blanda*) barely projecting above the heavily crusted snow. The story of the capture of the other two could not be satisfactorily pieced together, possibly they were attacked while browsing on the tips of sumac and rose reaching above the snow.

Some prey, such as mice, were simply snatched out of cover that was inadequate in protection against the jaws of the fox (Fig. 37). It was possible to directly observe foxes hunting in this manner. When the quarry was apparently sensed the fox would pause and then raise the brush. The brush was snapped down as the animal gracefully pounced on the prey or its suspected hiding place. It seemed that the feet were brought into play to hold, frustrate or sense the movements of the prey. Evidence of this hunting behavior was observed in snow many times, and sometimes a mouse or

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Fig. 37. A red fox caught a mouse at the disturbed spot in the foreground.

evidence of one would be found nearby. Here it was seen that the fox might make an abrupt turn from the line of travel to leap on a spot as much as 10 feet away. It seems probable that in such cases the fox may be attracted by the squeaking of the mice in their snow blanketed, grassy retreats. The high pitched singing of mice must be easily audible to the sensitive ears of foxes. Note was made of instances in which foxes had thoroughly trampled small areas of dense, grassy cover. One is prompted to speculate whether the trampling was designed to stampede mice from hiding.

Access to some prey was obtained by digging or tearing open the retreat. Stumps, too decayed to resist the attack, were torn open. Such openings usually terminated in mouse nests, probably those of the Northern white-footed mouse. Mouse nests that were shallowly buried in the ground were pawed open. Perhaps most frequently observed was the digging into mole runways. As the moles did not seem so desirable as food the dead mole with broken skull and mouthed fur was often found at the digging, evidence of a successful hunt. Then, too, the fox may find the inspection of mole runways doubly attractive because of the other animals that inhabit them upon occasion. The willingness of the fox to dig for food was seen in connection with an experiment to determine the response of neighboring turkey vultures to food available at the den. A domestic chicken was placed on the earth outside a fox den that had just been evacuated, and after the vultures had picked it clean a heavy log was rolled over the remains. A visit two days later revealed that foxes had excavated the soil from beneath the log at the point where the chicken had been left. The undigestible remains of the bird did not appear to have repaid the fox for its effort because there was no evidence that any of the parts had been removed.

Field observation did not reveal the techniques for capturing insects, but it is likely that they were simply snapped up as encountered. A single observation was made of a red fox in late summer that leaped from the ground and snapped at a butterfly that flew overhead. Analyses of fecal passages containing insects seemed to indicate that the foxes lingered on especially productive grounds.

Fruits such as of the service-berry, American plum (*Prunus americana*) and wild black cherry (*Padus virginiana*) were picked up from the ground where they had fallen after ripening. Gooseberries (*Grossularia* spp.) were probably plucked from the bushes. Osgood (1904) reported an observation on the Alaska red fox (*Vulpes alascensis*) browsing on huckleberries.

Carrion foods required no hunting techniques other than those that led to the discovery although the foxes were quick to take advantage of circumstances that made suitable carrion foods available. Emergencies such as extreme cold left the hunting grounds of the foxes with a supply of carcasses, particularly of birds. The fox trails then led to weed patches, fence rows and overhung stream banks where birds often took refuge and sometimes died (Fig. 38). During the winter of 1939-1940 foxes were noted to have made regular trips along Bear Creek, turning in to inspect every overhung bank that might have offered protection to birds. Feather remains indicated the success of the hunt. It appears then that such carrion foods were located by deliberate examination of locations which past experience showed to be sources of food. Foxes also returned to carrion foods that they had killed on earlier expeditions. Other carrion seemed to have been located somewhat by chance, and certainly by less deliberate hunting.

Food Caches

The red fox, like other wild dogs, may deposit food that it does not eat in caches. A cache, as here understood, existed whenever food items

Fig. 38. A bob-white where it died in a covey roost under an overhung creek bank. Red foxes readily take advantage of such easily available food.

had been at least partly covered with soil or ground litter through the efforts of the fox. The cache was usually made by excavating a hole, depositing the food item therein and then pushing the excavated material over it with the nose. Naturally most of the caches were found during periods when snow was on the ground, and these were covered over with snow. Caches found at other times of the year were usually covered with the sand of dry runs. These, too, were probably found because disturbances were more easily seen here than elsewhere; it is possible, however, that the fox might find it easier to make caches in the loose sand than elsewhere, particularly when other soils are frozen or baked hard. One cache was located in a deep litter of twigs and leaves, and another was found in cultivated soil.

During the course of this study 109 food items were located together with unquestionable red fox "sign". A number of these were represented only by bits of fur and sheared feathers that remained after the fox had finished eating. Fifty-four, however, were in such condition as to have merited a cache. Of the 54 items 20 had been placed in 16 separate caches. The items in caches were: meadow mice, 7 (5 complete individuals in one cache, 1 cache represented only by the fore quarters, and another of a complete individual); cottontails, 6 (all entire except for 1 represented by the hind quarters and another by a hind leg); mole 1, Fig. 39); raccoon, 1 (hind quarters); long-tailed weasel, 1; Northern white-footed mouse, 1; white-breasted nuthatch, 1; a strip of cow hide and a piece of hog hide.

The data are too few and the technical obstacles too great to permit comparison of the seasonal degree with which foods were left in caches. Caches were found in every month of the year excepting May, September and October. It is of interest to observe that while snow was on the ground during the 1938-1939 season five caches were located; during a season of greater snow fall in 1939-1940 four caches were found and in 1940-1941 only a weasel was found in a cache. It was also evident that available food was somewhat scarce on the area in the 1940-1941 season. Of 60 food items that Murie (1936) found along fox trails early in 1934 on the Edwin S. George Reserve 26 were in caches. This is a greater frequency of caches than was found on the Moingona Fox Range, reflecting a greater surplus of available food on the Reserve. Other evidence which Murie presents also indicates

Fig. 39. Mole in red fox cache. The snow has been disturbed only enough to show the characteristic fore foot of the mole. The mole had been burrowing through this late snow when captured by the fox. March 6, 1939.

that food was available on the Reserve to a greater degree than on the Moingona Fox Range. It seems likely that the degree of caching may be used as coarse indicator of prey availability.

The 34 food items that could have been deposited in caches but were left exposed were: the hind quarters together with the skin from the back of a toad (Bufo americanus); swamp sparrow (Melospiza georgiana); the head and neck of a domestic chicken; an opossum; large short-tailed shrews (Blarina brevicauda), 4; small short-tailed shrews (Cryptotis parva), 2; moles, 9 (all entire except for one represented only by the fore quarters);

a half-grown mink; meadow mice, 2; white-footed mice, 7; and parts of 5 different cottontails, ranging from a single hind leg to an almost complete carcass. A number of these items do not appear to rank very high on the scale of food preferences of the fox.

It is supposed that caches serve as temporary stores of food to which the fox may return when it is hungry and without food. It is at once of interest then to check the records for caches to which foxes later returned. All of the items in caches eventually disappeared, but it was possible to trace the cause of disappearance to foxes in but three instances. Considering the difficulty of tracing the fate of carcasses and the fact that only 11 of the items in caches were among the more frequently eaten fox foods and the competition of other flesh eaters, this seems to indicate a fair degree of use. A complete history was obtained on one cache. On December 26 or 27, 1939, a fox killed a cottontail, ate the fore quarters and deposited the hind quarters in a cache. This cache was located on December 27. A 2.5-inch snow fell during the night, ceasing at about 6:00 a.m. on the 28th. The site of the cache was inspected that afternoon and it was seen that fox had opened the cache, readjusted the food and covered it over again. The trail of the fox led directly to the cache, showing that the fox had not found it necessary to cast about in order to find it. The cache was undisturbed when examined on January 1 and 4; however, on January 5 "sign" showed that a fox had opened the cache and eaten the contents. This food had been held in reserve for about one week. The assistance of the cold weather in keeping such foods in good condition should not be overlooked. It may be mentioned here that white-footed mice were placed in artificial caches under two to three inches of sand on a fox crossing in Polly Creek. Although the caches were maintained for two weeks and foxes passed over them frequently, they were never dug out. This possibly emphasizes the importance of place memory in relation to return to caches.

Foxes will also visit items that have been left uncovered. Some of these, such as moles, may be visited many times even though they are apparently little valued as food. The fox may leave scent and defecate during the visit, thus making repeated examination of such items of value to the food habits worker searching for scats. Fox "sign" will reappear where only traces of a former meal persist. Fox "sign" too appeared about dead animals or parts of animals for which the evidence would permit association of the fox in no other way except as a curious visitor. The remains of meals of other predators were inspected by foxes, and possibly some of the scraps were eaten. It was not positively determined that foxes obtained food from other predators; however, it seems unlikely that a hungry fox would pass up such food scraps as it might come upon.

Use of Food

On March 30, 1934, Murie (1936, p. 20) made observations on the Edwin S. George Reserve indicating that "Six rabbits had been killed during the night; a seventh rabbit and the fox squirrel may also have been taken during this time". There was never more than three cottontails known to have been killed during a single night on the Moingona Fox Range. It is obvious, however, that the fox may kill or come into possession of more food than it can eat. This surplus is seldom wasted, for if the fox does not got the remains later some animal associate probably will. This is particularly noticeable in winter when some animals find it difficult to obtain food.

Crows were repeatedly flushed from food left by foxes in winter. This was noted also by Murie (1936) in Michigan. There is much evidence to indicate that at other times of the year, too, crows keep a close watch on their fox neighbors. Several times cawing crows attracted the observer's attention to foxes that had been started and would have otherwise gone unseen. During the spring of 1940 a female fox was tethered out on the Range and observed for three days. Crows attended this fox for brief periods throughout each day, perching in nearby trees and cawing. None of the crows were known to have come to the ground to feed on the cottontails with which the fox was supplied.

There was usually a most complete economy of the kills. In most instances, however, only fragments of the story of this efficient use of food could be obtained. One fairly complete case history was noted. At 9:25 a.m. on December 29, 1939, the observer was attracted by a small flock of crows on the snow in almost the exact center of Quadrat V. The place was examined, and it was learned that the crows had just located a cottontail that had been placed in a cache by a fox. The head and left shoulder of the animal were exposed, revealing the absence of the left leg. When within about 100 feet of this same cache at about 1:00 p.m. a red-tailed hawk was chased from the carcass. About an hour later four magpies were flushed from their feeding on the cottontail. When the carcass was closely examined again at 4:35 p.m. nothing remained except the skull, a section of the vertebral column and three legs all picked clean. Mouse tracks and droppings were found on the site when examined the following morning, showing that they, too, found the spot attractive. January 1 the bones had disappeared and nothing remained to mark the place but scattered bits of fur.

In the spring other animals found and fed on the food that foxes brought to the dens for the young. There was never as much food litter on the den sites in the Moingona Fox Range as on other sites that were being examined at the same time. Possibly this was because of greater difficulty in obtaining food. Perhaps more of the food brought to the den was taken inside to protect it from animal associates, or again maybe the many neighbors contributing to the economic use of the foods made available tended to keep the den sites cleaned. The possible role of the turkey vulture in scavenging on den litter has been described (Scott, 1941a). Black-capped chickadees and white-breasted nuthatches were observed picking at mammal remains outside a den in early spring, possibly obtaining a substitute food during a scarcity of available insects.

During the summer months scavenging arthropods, too, took their toll of the food left behind by the fox. Ants were seen in large numbers on food items. About 20 ants (Prenolepis imparis) were collected from a Northern white-footed mouse that had been discarded by a fox. Other insects identified in the field on food left by foxes were: Diptera, undetermined eggs and larvae; Silpha spp.; and Necrophorus spp.

It was noted that even the fecal passages of the fox served as a source of food for certain animal associates. During the summer months insects literally tore the passages to bits. The following insects were taken on passages: Formicidae, several species; Diptera, several species; Onthophagus spp.; Trox spp.; and Aphodius spp. The ants and flies appeared to feed on the mucus coating while the beetles burrowed into the passage. Undetermined mites were also found, and harvestmen (Liobunum sp.) were seen on the passages late in the summer, presumably feeding on the mucus coating.

On two occasions "sign" indicated that small birds had picked seeds out of fox scats. It does not appear unlikely that many of the seeds in scats are eventually utilized as food by birds and small mammals.

FEEDING TRENDS

Data concerning the diet were obtained by investigation of feeding "sign" in the field and by analysis of fecal passages in the laboratory. Fecal analysis furnished the most continuous source of information; feeding evidence from the field mainly served in a supplementary capacity. Used simultaneously, the two methods offered the advantage of providing a means for checking the findings. In this study results from the two methods proved complementary.

In the field only 110 food items for which there was sufficient evidence to permit satisfactory reconstruction of case histories were located. An analysis of these is presented in Table 1 (Appendix). It is obvious that from such observations little can be learned of the invertebrate and plant foods in the diet. Although the method possesses important qualitative values for certain forms of vertebrate prey, it does not lend itself to a suitable quantitative analysis of the foods. The data gathered in this manner mainly are important in demonstrating that the fox exhibits food preferences and that consequently the pressure exerted upon specific prey is not always in agreement with the proportions occurring in the diet.

Trends in the diet were investigated by analysis of fecal passages because the large number of feces available made possible a continuous determination of the relative quantities of foods consumed. During the study 1454 fecal passages were collected and analyzed. Probably three times this number were found and discarded in the field because of an absence of satisfactory "sign" on which to base records. One thousand two hundred and twenty of the fecal passages were not associated with dens in which young foxes were being reared; these are passages of adults and young old enough to have loosened or broken their ties with the dens. No passages were collected at rearing dens in 1938 and in 1939 only 12 were picked up. With 2 families on the area in 1940 it was thought advisable to make careful collections of passages at rearing dens; 222 were collected. On the basis of size the fecal passages of adult foxes can almost always be distinguished from those of the young foxes (Fig. 40) still in rearing dens, particularly during the first few weeks after the pups appear outside the dens. Although 5 adult passages were found outside a rearing den from which young emerged about 1 week later and although single passages were collected on the sites of former and subsequent rearing dens unoccupied by pups, observations on over 50 dens never resulted in the detection of adult passages among the smaller ones of the youngsters during the time of rearing in the dens. Furthermore, it does not seem reasonable that the wide-ranging adults would defecate very often at rearing dens during their usual, brief visits there. Adult passages may contaminate collections of fecal material; however, it must be only occasional in occurrence, and then only after the pups have grown to a size where their larger passages begin to overlap in size with small passages of adults. The 234 passages collected at rearing dens are here considered as those of young foxes.

Identification of scats as those of the red fox and determination

Fig. 40. Fecal passages of red fox cubs about eight or nine weeks of age (right) compared with the passage of an adult (left). Actual size.

of the probable period during which defecation occurred are problems. Thorough knowledge of "sign" and acquaintance with the ecology of the locality reduce the possibilities of error. No passage was collected or analyzed unless it was, to the best judgment of the writer, that of the red fox.

Fecal analysis is uncertain where easily digested foods or those lacking indigestible elements are eaten, and in some instances the utility of the technique may depend on whether the animals studied consume significant amounts of such foods. Observations in the field and on caged foxes did not reveal a tendency to feed extensively on such foods, and experimental feeding of caged animals did not indicate that there was any serious reduction of the identity of the foods eaten through the digestive processes. Some foods certainly remain undetected by the analyst, particularly in a specific way. That is, the species of remains of a mouse may defy identification, but it can readily be recognized as being of undetermined mouse or at least of mammal origin. On the whole, however, it appeared highly unlikely that sufficient food could escape detection as to obscure the principal feeding trends.

Identifying foods as carrion in fecal passages is impracticable, but possibly the value attached to carrion determinations has been unduly emphasized. Such identifications are usually offered as evidence supporting a division of foods into prey killed by the feeding animal and that found dead. Even in the field with fair evidence it is often difficult or impossible to determine whether the feeding animal killed its food or found it dead. Such a segregation of foods is desirable, but too often the evidence on which it is based is fallible. During freezing weather dead animals may remain in a good state of preservation for prolonged periods, and even under milder conditions carcasses are usually found and eaten before they have aged sufficiently to be recognized as carrion. Further, it was learned in this study that prey may be killed by the fox and later eaten as carrion by the same species.

In general, the method of preparing the fecal material for analysis was as follows: Each passage was softened in warm water. The parts of diagnostic significance were separated and cleaned by washing the softened material in a sieve (12 meshes to the inch) over a glass jar; thus, parts that occasionally passed through the sieve were retained for examination. The remaining material was soaked in a glass beaker filled with clear water in which the heavy objects settled out of those that would float. The floating material was then poured portion by portion into petrie dishes where it was mechanically separated and, excepting the hair, removed with a forceps to a paper blotting towel. The hair left in the petrie dishes was caught in a sieve and then removed to the blotting towel as were the heavier parts caught in the glass jar and beaker. Identifications were based on the segregated diagnostic parts.

The relative proportions of the various foods are expressed in percentages of the total number of times each occurred in the collections of fecal passages. By experiment with caged foxes this frequency of occurrence method of analysis was shown to provide a suitable interpretation of the relative quantities of foods consumed (Scott, 1941b). The method is further refined by a progressive group treatment of the food items. The sequence is designed so that no group or item may possess greater potential for scoring occurrences in the same passage than those with which it is contrasted. This treatment is extended to include grouping of undetermined and determined items where foods could not be identified beyond a general group. The various divisions of the foods, from major groups to specific items, may be seen in the tables (Appendix). The percentages are calculated first for the major groups, then for the next largest constituent divisions and so on down to the final items.

Each occurrence should not be thought of as representing an individual animal, nor should similar representation for several foods be construed as meaning that similar numbers of individuals of each were consumed. The number of occurrences resulting from a specific food appears to vary somewhat in direct proportion to the amount eaten. Experiments (Scott, 1941b) with captive animals indicated that on the average one occurrence might be expected for about an ounce of food consumed. Thus, a large mouse, such as Microtus, averages 1 to 2 occurrences whereas a meal of a domestic chicken may result in as many as 15 or more occurrences. A fox must kill as many as 15 large mice to raise the portion of mice eaten to that of a single meal of domestic chicken. It is likely that certain small-sized foods when eaten regularly in small amounts would have a frequency much in excess of the actual volume; this would also tend to improportionately reduce the relative amounts of associated foods commonly taken in larger quantities. This is so prevalent among the invertebrate foods that it was deemed inadvisable to calculate the percentages of total occurrences; only the numbers of occurrences are shown in the tables. In order to demonstrate graphically the trends of the principal invertebrate foods in the diet, percentages were calculated for those items, identified at least to the genus, that occurred over 50 times in the 1220 fecal passages collected away from rearing dens.

An attempt has been made to classify remains of prey as to their probable age in order to learn something of the pressure born by the various age groups. Whenever possible they were classified in three age groups; immature, young and adult. Remains that could be identified as from full-grown animals were listed as adult, remains of half-grown to full-grown animals were indicated as young, and those less than half-grown were noted as immature. Such a classification obviously allows for a certain degree of error particularly in distinguishing between remains that are on the margin between the groups. The separation does, however, permit generalization on the degree of pressure on the various age groups for certain species.

General Feeding Trends

The feeding tendencies of red foxes have been reported upon for Vulpes sp. in southern Wisconsin and Iowa by Errington (1935 and 1937), in Minnesota by Hatfield (1939); for Vulpes fulva in Michigan by Dearborn (1932), on the Edwin S. George Reserve near Pinckney, Michigan, by Murie (1936), in New York and New England by Hamilton (1935), in part of the Harvard Forest, Petersham, Massachusetts by Hamilton, Hosley and MacGregor (1937) and in Virginia by Nelson (1933); for Vulpes vulpes in the U.S.S.R. by Baranovskaia and Kolosov (1935), and in Great Britain by Southern and Watson (1941). The basic feeding tendencies of the red foxes on the Moingona Fox Range did not prove exceptional to the reports of these investigators.

The foxes here were primarily carnivorous with substantial quantities of insect and plant foods being consumed when available. A bar graph (Fig. 41), based on percentages of total occurrences (Tables 2, 3, and 4; Appendix), shows the relative amounts of foods in the major groups for each of the three years of study. Of these major divisions the invertebrate group is almost wholly of insects; there is but a trace of other invertebrate material. The cold-blooded vertebrate segregation (Table 3, Appendix) is not shown in the graph because of its relative unimportance. For convenience in making reference within the text the three years of study are designated as Periods I, II and III.

It is obvious that irrespective of peculiarities of individuals or social groups of feeding animals the foods consumed must first have been available. Further understanding of the relationships between the feeding animal and its food reaches into all the details of the life form, life history, ecology and behavior of the organisms involved. The whole must be examined from an ecological point of view. For this reason determination of the nature of availability is a complex problem attended by many unknowns.

Increased representation of a food in the diet does not necessarily reflect a change in its availability. A conveniently available food may become more prominent in the diet simply because some normally easily available food has become difficult to obtain. Frequency of occurrence then should not be considered an unquestionable expression of degree of avail-

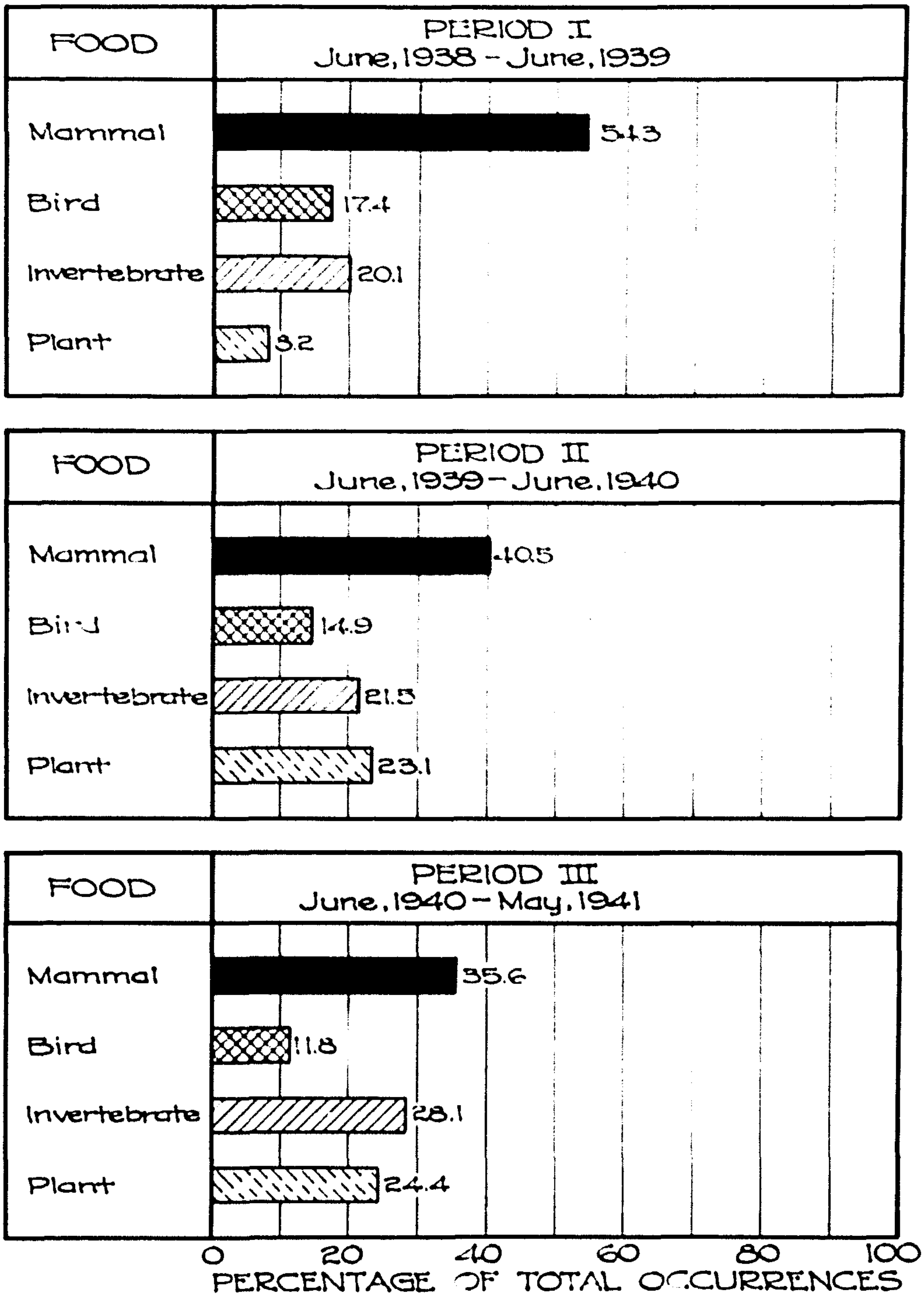

Fig. 41. The annual representations of major food groups in the diet of the red fox.

ability. This emphasizes the importance of investigating definite areas on which it is possible to make continuous intensive observations for correlation with laboratory work.

Availability of foods only occasionally varies so profoundly as to produce a significant modification in the annual pattern of the major food groups. When the annual pattern of the major food groups in Period I is contrasted with Periods II and III (fig. 41), a pronounced increase in plant representation becomes obvious. This reflects the failure of the local crop of wild fleshy fruits during the summer of 1938. Such a difference in plant occurrences was also reported by Dearborn (1932) who found that fruit remains made up 31.5 percent of the total food in 1930 when the fleshy fruit crop, particularly of the service-berry, was enormous; but in 1931 when the crop was light and when more of the scat collections were made when fleshy fruits were not easily available they made up only 3.6 percent of the remains. Errington (1937) who compared the diet of red foxes in Iowa during the "normal" spring and summer of 1933 with the same seasons in 1934 attributed an increase in the occurrence of certain prey, especially insects, in 1934 to the adverse effects of a summer drought in the latter year.

The progression of the seasons is naturally accompanied by modification in availability of foods. The seasonal trends for each of the three years of study are graphically presented in Fig. 42. The representations of mammal foods are lower in summer anf fall than in winter and spring. This does not necessarily reflect a seasonal change in the availability of mammals in general; to a large extent it is probably a

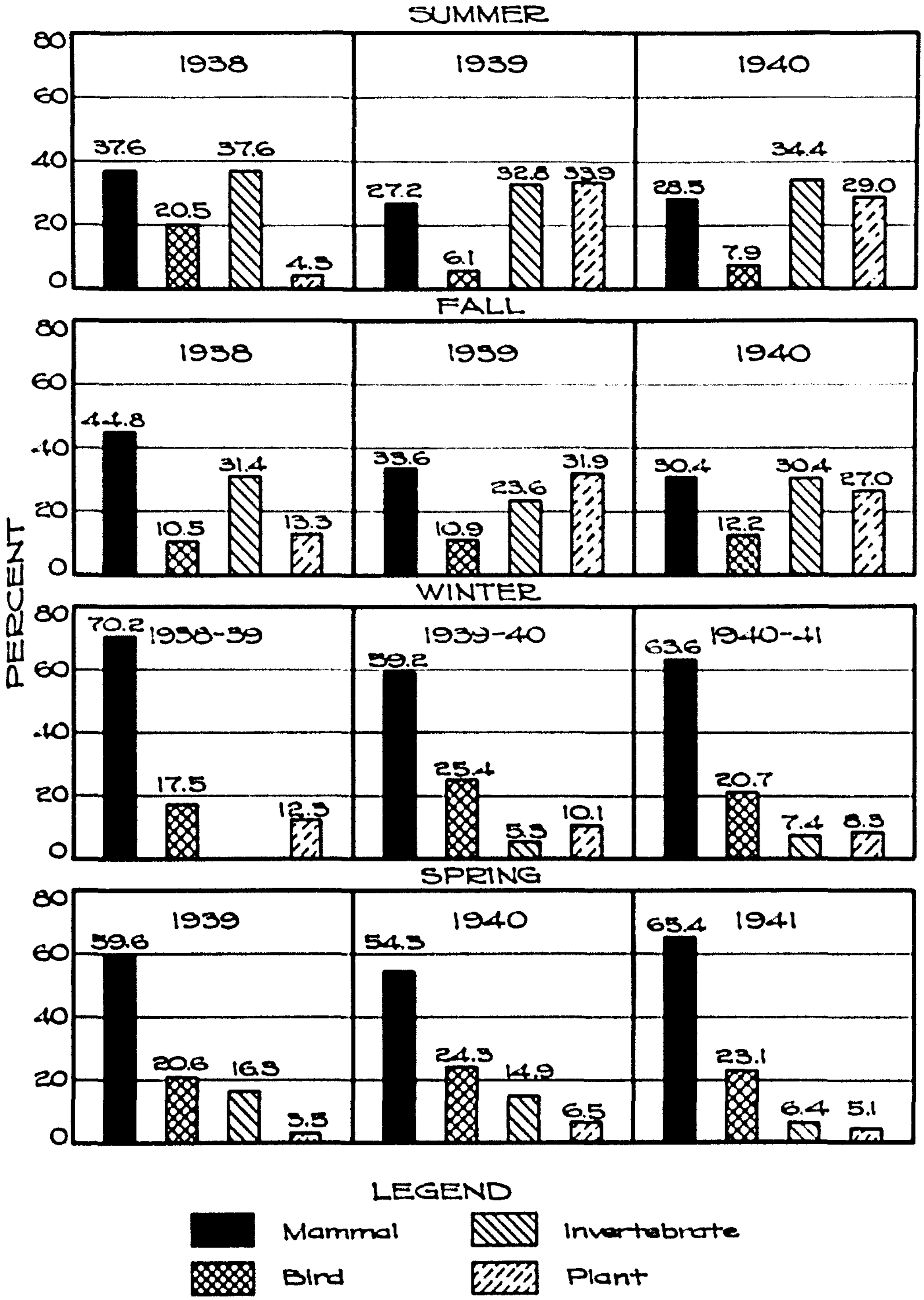

Fig. 42. Seasonal representations of the major food groups in the red fox diet.

compensatory response to the increased seasonal availability of plant and invertebrate foods. Bird is usually more prominent in the winter and spring diet. The high frequency of bird in the summer of 1938 was the result of an unusual increase in the availability of domestic chicken. Invertebrate foods, almost wholly insects, naturally take on largest proportions in the summer and fall while during winter and spring are of little consequence. Plant foods usually are of greatest importance in spring and fall because of the availability of fleshy fruits in those seasons. It is of interest to note that there was somewhat less plant food in the spring diet than the winter. The most striking seasonal trends are spring to summer and fall to winter transitions.

In addition to the seasonal trend a comparison of the dietary pattern of similar seasons in each of the three years is also possible. The conditions that govern the general proportions of these major groups of foods in the summer season seem to continue effective, though somewhat modified, into the fall. This may be seen in the similarity of the graphic patterns of the diet in the summer and fall of each year (Fig. 42). Although less striking than the spring to summer and fall to winter changes there is an obvious variation in the graphic patterns of the winter and spring diets. A comparison of the three winter and three spring seasons reveals a year to year steadiness in the relative positions of the major food groups in the diet. In order, beginning with the group possessing the greatest percentage of total occurrences, the alignment is consistently mammal, bird, plant and invertebrate in the winter season of each year and mammal, bird, insect and plant in the spring of each year.

The month to month trends in the major groups of foods in the diet are presented in Fig. 43. Most of the month to month changes are simply a reflection of seasonal trends. Here are also seen exceptions resulting from emergency circumstances among foods. There are some obvious eruptions and depressions that appear subject to explanation. The abrupt increase in bird consumption in August, 1938, was caused by an unusual availability of domestic chicken. In February, 1939, there is a depression in the proportion of mammal and an increase in bird. During that month a period of extreme cold and snow resulted in the death of many birds. The easily available birds were readily picked up by the foxes and thus bird consumption increased and the relatively less available mammals decreased. The increased consumption of birds in December, 1939, and January, 1941, also appeared to reflect an increased availability of birds through winter-killing. Again in November and December, 1940, an increase in birds in the diet reflects the effect of severe weather on bird life. In November, 1940, an unseasonal blizzard struck the Range. Although wildlife was not so severely affected on the Range as elsewhere (Scott and Baskett, 1941) there was nevertheless a noticeable decimation, particularly among migrant sparrows. The effect of this storm is reflected in an increase in birds in the diet as are severe conditions in the succeeding month, December. Thus it seems that severe weather greatly modifies the availability of birds in the diet, and probably contributes in a large measure to the proportion of birds appearing in winter passages.

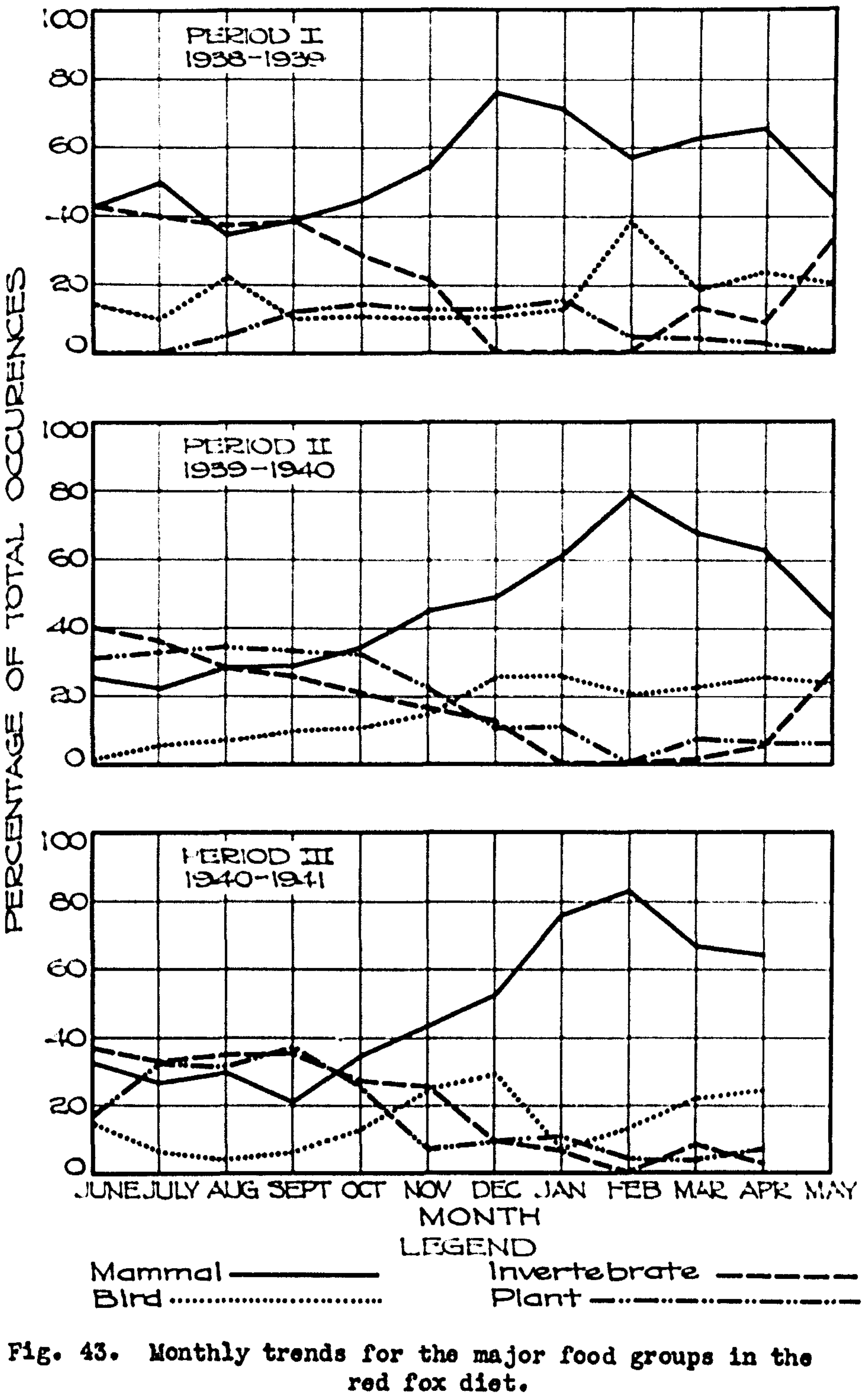

Fig. 43. Monthly trends for the major food groups in the red fox diet.

Food Preferences

Within the broad dietary limits of its primarily carnivorous habit, the red fox seems to show food preferences. The positions of the various foods on the scale of preferences are difficult of evaluation, and the bulk of the foods can be classified only as intermediate between two extremes.

Detailed knowledge of the relative availabilities of potential foods is necessary to the segregation of highly desirable items. This tends to conceal foods that are high on the scale of preferences. Among the foods that appeared to be especially preferred in this study was the meadow mouse and possibly the lemming mouse.

It is easier to discern those foods for which the feeding reaction of the red fox is markedly toward the negative. Insectivores were regularly left uneaten by the hunting red foxes on the Range. Mammalian predators generally seem to find insectivores distasteful (Barrett-Hamilton, 1910-21 and Errington, Hamerstrom and Hamerstrom, 1940). Few remains of insectivores were found in the many fecal passages and stomachs of red foxes examined during the investigations by Dearborn (1932), Nelson (1933), Hamilton (1935),Errington (1935 and 1937), Murie (1936) and others. In Great Britain Southern and Watson (1941) considered the absence of shrews in their study of the red fox noteworthy. Weasels appeared to be even more distasteful to the red fox than insectivores. In Iowa Errington (1937) found that weasels occurred 5 times among 1,010 individual food items from 113 dens in 1933 and 14 times among 2,848 items from 200 dens in 1934 whereas none were recorded in 2,110 fecal passages collected about the same dens. Contemporaneous observations on many areas inhabited by foxes indicated that weasels are commonly killed and discarded. On the Moingona area one weasel was known to have been killed and left uneaten (Fig. 36) while another had been rejected at least in part. In the latter instance the evidence strongly indicated that the fox had discarded the entire animal and that an avian predator had subsequently taken part of it. Mustela was identified 3 times in 57 fecal passages collected in September, 1940; this was, however, very probably mink, and was taken at a time when there appeared a shortage of vertebrate foods on the area. It was also evident that the foxes did not feed on several dog carcasses that were easily available on the Range.

Carrion, too, seems to bear some relationship to food preferences. As here construed, the term "carrion" applies to all animals that were dead when approached by the feeding fox, irrespective of the state of decay. Within the limits of the usual preferences the fox showed no distaste for those carrion foods not noticeably advanced in decay. An extraction of the field data indicates that about 16 percent of all the vertebrate animals upon which the fox fed during the course of the investigation was carrion. The normal economy of nature does not permit much suitable food to reach advanced stages of decay unless it is present in greater quantities than can be consumed by the resident animals. Although carrion that was advanced in decay was visited by foxes, on no occasion did the foxes appear to have eaten from it excepting to take parts little affected. In May, 1940, a young pig died on a nearby farm and was dragged into a gully between Mills Run and Cyclone Creek. The foxes immediately took advantage of this easily available food, but by the time decay was noticeable the "sign" and analysis of fecal passages indicated that they had ceased to feed on the carcass. Eventually all of the soft parts of the animal sloughed away and only the skeleton remained. It was of interest then to trace a fox trail to the skeleton late in December and find that the end of a humerus had been chewed away. Possibly in this some relationship may be seen to the eating of the feet of carrion chickens as described by Errington (1935).

Intelligent as the fox is, however, it simply cannot continually satisfy its hunger from among those foods for which it has the greatest predilection, for the delicacies are not always conveniently available. If the fox found it possible to take the highly preferred foods at will, the diet would consistently follow a fixed pattern which it obviously does not.

Influence of Age on Feeding Trends

It is manifest that the age of the animal influences its feeding trends. In early life it must rely upon the parents for food, (Fig. 44), and then in easy stages it assumes the responsibility of obtaining its own subsistence. It seems logical that young animals should at first begin to take food by sampling everything and rejecting that which proves distasteful or painful (Holmes, 1911).

In the fecal material that was gathered at the den sites in the Moingona area during the first two or three weeks after they began appearing there, little or no evidence of contamination by nonfood material was detected. Thereafter, however, increasing amounts of debris such as leaves, sections of twigs, bark, rotted wood and other nonfood items appeared (Fig. 45). Perhaps a part of this was caused by the feeding of the pups outside the den where there was greater opportunity for contamination with

Fig. 44. Red fox cub estimated to be about five weeks of age.

nonfood debris. On the other hand, it seemed likely that some of this resulted from the tendency of the pups to bite and chew at everything within easy reach of the den entrances.

Analysis of excreta from about the dens of Vulpes vulpes in the U.S.S.R. revealed certain dietary trends that were thought to have been reflections of the growth and development of the cubs (Baranovskaia and Kolosov, 1935). Something of the feeding trends of red foxes in early life may be more clearly understood through comparison of the kinds and frequencies of foods in the fecal material gathered at the dens (Tables 5, 6 and 7; Appendix) with those for droppings collected away from the dens (Tables 15, 24, 27 and 30; Appendix). The data that Murie (1936) assembled concerning the food of the red foxes on the George Reserve showed appreciably greater frequency of mouse in droppings picked up on trails than in those taken at the dens.

Fig. 45. Red fox cub estimated to be about eight weeks of age.

There was also markedly greater cottontail and insect representation in the den material than in that from the trails. This appears in keeping with logic; it may be expected that where cottontails or other large prey are easily available, more of this type of food will be carried to the pups at the dens while such small sized foods as mice are more likely to be eaten in the fields by the adults. It is also reasonable to expect an increase of insects in the diet of pups beginning to feed on easily captured prey.

The marked cottontail-mouse differential that is evident in a comparison of Murie's trail and den findings is absent in a similar comparison of the data from the Moingona Fox area. In fact, there seem to be no appreciable differences or tendencies among the specific food items in the den and trail material collected here. It is likely that Murie's findings would have been more nearly approached on the Moingona Fox area had cottontails been as easily available as they apparently were on the George Reserve.

The Moingona data does, however, reflect the same general tendencies as observed in Murie's work. A comparison of the percentages of total occurrences for the principal groups of foods detected in fecal passages from the trails with those picked up at dens demonstrates this (Table 8).

Table 8

A Comparison of the Percentages of Total Occurrences for the Principal Groups of Foods Detected in Fecal Passages Collected on the Trails (April, 60; May ,58; June, 47) with Similar Percentages for Passages Picked up at Dens (April, 117; May, 89; June, 16) in 1940.

	MAMMAL		BIRD		INVERTEBRATE		PLANT	
	On trails	At dens	On trails	At dens	On trails	At dens	On trails	At dens
April	62.8	72.2	25.5	27.8	5.3	0.0	6.4	0.0
May	42.7	41.4	24.0	17.1	27.1	36.2	6.2	5.2
June	32.5	38.2	14.6	5.9	36.6	44.1	16.3	11.8

In April, when the pups were most dependent upon the adults for food, the remains of mammals and birds were more frequent in the fecal material from the dens than in that gathered away from the dens. At the same time, while limited amounts of invertebrate and plant remains appeared in fecal passages collected on the trails, no evidence of these foods was detected in the fecal passages picked up on the den sites. In May, when the pups were presumably a little less dependent upon the adults, the mammal and bird remains were not so frequent in the den material and more frequent in that from the trails. At the same time the invertebrate representations, almost entirely insects, showed an abrupt increase from no determinations in April to 36.2 percent of the total occurrences in May. This May frequency in the den material is 9.1 percent greater than that for the fecal samples collected away from the den sites. Thus the relative proportion of invertebrate foods in the passages from the trails and dens in April are reversed in May. While plant remains did not occur in the den collections in April, they did occur in May but did not surpass the representation for passages picked up on the trails. In June the relative proportion of mammal in the den collections became greater than that for the trails. The data for the June comparison is based on only 16 passages collected at the dens during the first part of the month and therefore is probably not representative of proportions for the month as a whole. The general trend, however, continues downward for mammal and bird representations whereas the invertebrate and plant representations move upward.

A difference is noted in the frequency with which immature cottontails appeared in the fecal passages from the dens as contrasted with those from the trails. In April when 10.6 percent of all cottontail appearances in the feces from the trails was of immature animals, 19 percent of all cottontail occurrences in fecal material from dens was of the immature age class. In May and June when 20.8 percent and 37.0 percent, respectively, of all cottontail occurrences were of immature animals in the trail scats, 46.3 percent and 45.5 percent of all cottontail occurrences in the den material were represented by immature animals.

Some additional data on the food of the young foxes were obtained. A record was made of all the food items seen at the rearing dens and these are mentioned at appropriate places later in the discussion on the specific food items. In addition, the food contents in the stomach of the young fox found dead on May 31, 1940, in the southern part of the area was analyzed. They were as follows: domestic chicken (Gallus gallus), 75 percent; insects, 15 percent; cottontail, 10 percent. The insects were largely Phyllophaga with some Gryllus assimilis, Scarites, Calosoma scrutator and Calosoma calidum. Two of the fecal passages examined contained deciduous red fox teeth, thus identifying them as from young of the year. One collected in mid-July, 1939, contained remains of immature cottontail and a substantial quantity of the following insects: Gryllus assimilis, Harpalus caliginosus, Scarites, Evarthrus colossus, Bolbocerasoma farctum and Melanoplus. The other tooth-containing dropping was collected in May and contained a large amount of green grass-like leaves together with some pieces of twig, rotted wood and bark.

The Relationship of Home Range and Diet

Although studies of foxes in different regions show the same basic feeding tendencies, differences in the kinds and proportions of specific foods are evident, largely because of regional variation in availability. To a lesser extent the nature of the home range environment may be reflected in the diet. This was detected in the feeding trends of the foxes on the Moingona Fox Range, particularly in 1940 when two families occupied the area. A separate analysis (Tables 9, 10, 11 and 12; Appendix) was made of the fecal passages found in the interpolated home range of each family in order to allow comparison of the diets. Fecal passages collected in the overlapping parts of the two ranges were not included in these analyses. The relative proportions of remains of specific foods in the fecal passages collected at the dens of the two families were also suitable for comparison (Tables 5, 6 and 7; Appendix).

In the material collected away from rearing dens the mammal and invertebrate representations were remarkably similar in the fecal passages on both home ranges while a tendency toward significant differences was apparent in the frequency of plant and bird remains. The den material compared similarly with invertebrates and mammals being detected to about the same extent on both ranges while bird frequencies were more variable.

There were few differences in the frequencies of specific mammal remains in the fecal passages collected on the two ranges away from dens. At the dens, however, in April there were more cottontail occurrences on the north range than on the south range while the reverse was true for meadow mice. In May representations of cottontail were about the same for the findings on both ranges while remains of meadow mice and white-footed mice were somewhat more frequent on the north range.

Bird remains generally seemed more frequent in the material from the south range. Differences in the representations of birds in scats from the two ranges are unreliable beyond the major group because of the difficulties involved in identifying the material. The only quail remains detected were in passages from the south range whereas the only pheasant remains identified were in material from the north range. Quail was somewhat evenly distributed over the area, but pheasants were most common on the northern part. In April bird representations in the fecal passages from the dens of the two families were about the same while a tendency toward greater frequency in scats from the south range was evident in May. As in the trail data pheasant was represented only in the fecal passages from the dens on the north range.

The differences in frequency of occurrences of specific plants in the material from the two ranges were supported by the most definite field data. Gooseberry bushes were evenly distributed over the area while most of the mulberry (Morus rubra) trees accessible to the foxes were on the north range whereas nearly all of the service-berry trees were on the south range. This distribution was almost perfectly reflected by the frequency of occurrences of the fruits of those plants in the fecal analyses for the two home ranges. During the period, June 20 to July 31, when about twice as many droppings were collected on the north range as on the south range mulberry occurred only 17 times on the south range and 83 times on the north range. At the same time remains of the fruits of service-berry occurred 2 times in the fecal passages collected on the south range. These particular differences in the diets of the foxes clearly reveal the feeding limitations imposed upon the animals by their home ranges and to serve to indicate the validity of the home range interpolations.

Although insects as a group were about equally represented on the two ranges there were significant differences in occurrences of specific insects. Crickets were generally more common in material from the north range while there was a tendency for May beetles and stag beetles to be more frequent in the droppings from the south range. The material collected at the dens was remarkably similar except that here, too, crickets were more frequent in the passages from the north range than in those from the south range.

Specific Feeding Trends

The investigation is adapted to study of the interrelationships between the red fox and the specific foods. The many foods, each differing from the other to some extent in life form, life history, ecology and behavior, provide an illuminating background upon which to examine the feeding tendencies of the fox.

MAMMALS, Marsupials.

Opossum. The opossum was represented in only 3 of the 1454 fecal passages (Table 16, Appendix). Because all of these occurred in material collected about the same time in December, 1940, it is likely that only one opossum was involved. Errington (1937) listed a small opossum among the 1010 food items found about 115 red fox dens in 1933; 2 were among 2848 items collected at 200 dens in 1934. Opossum did not appear in any of the 2110 fecal passages collected from about these same dens. Opossum does not seem to have been detected in any reported analysis of the fecal passages or stomachs of red foxes, possibly because most of work has been carried on where the animal is absent or of infrequent occurrence. Opossums were not uncommon on the Moingona area, and because of their apparent vulnerability, a greater representation in the food was expected. Three dead opossums were found on the area as well as several live ones; none of the dead animals had been fed upon by foxes although one had been killed by a fox and its carcass was known to have been visited at least four times. Food on the area seemed unusually scarce during the winter of 1940-41 and the spring of 1941. During this period the remains of several foods not previously identified in the passages appeared. This may have some relationship to the occurrence of opossum.

Insectivores.

Mole. The many mole runways that had been ripped open by foxes with victims occasionally left on the site indicated that the fossorial habit of the mole afforded it little protection when foraging near the soil surface. Of Talpa europaea in Great Britain Barrett-Hamilton (1910-21, p. 41) wrote: "Dogs and foxes occasionally dig it out." Still more vulnerable are those moles which further depart from their range of familiarity and venture out on the surface. Two moles were captured by foxes while out of the soil runways burrowing in snow, one on December 28, 1939, and another on March 6, 1939. The number (10) left uneaten on the trails indicates that moles are distasteful to red foxes. Murie (1936) found 2 prairie moles (Scalopus aquaticus machrinus) and 1 star-nosed mole (Condylura cristata) on fox trails whereas only 1 prairie mole was detected in 768 droppings. Also evidence of distaste are the few remains of moles in investigations of the fox's food (Errington, 1937; Dearborn, 1932; Hamilton, 1935 and Hamilton, Mosley and MacGregor, 1937). Southern and Watson (1941) reported Talpa europaea in 2 of 40 red fox stomachs examined in Great Britain; the 2 stomachs containing mole were from young foxes.

Although moles seem generally distasteful to foxes it was found that they might occur in a relatively high degree of frequency. In this study mole appeared in 32 of 1454 fecal passages examined (Tables 5, 13, 14 and 15; Appendix). In August, 1938, mole appeared in 3 of 28 fecal passages analyzed; this was 2.6 percent of the total food occurrences for the month. With only one occurrence (0.5%) in September and another (1.0%) in December, mole was of little dietary consequence in 1939. In 1940, however, the frequency of mole occurrence was relatively high and somewhat persistent, primarily reflecting an increase of moles on the Range. The trend began in March with 1 occurrence (1.5%) and 2 (1.6%) in April. In May there was 1 occurrence in 49 passages collected at rearing dens of the Cyclone Creek family during the period May 21 to 30; on May 24 a mole was recorded among the food items observed at the dens of this same family. In June there were 2 appearances of mole in 16 passages collected from Den No. 6 of the Second Run family. Among the passages collected away from rearing dens mole was identified 4 times (2.8%) in the 47 passages for June; in 127 passages collected in July mole continued upward with 15 appearances (3.9%). The percentage of total food occurrences for mammal during that month was 26.5 percent, and among the mammal foods mole was exceeded in relative proportion only by cottontail (11.1%). The occurrence of mole declined to 2 (1.6%) in August. Further emphasizing the proportionately high frequency of mole in 1940 is the fact that 5 of the 10 moles left behind by foxes were observed in 1940; 3 were located on July 5, 6 and 22, respectively, and one each on September 10 and November 7. Possibly related to the decline of mole occurrence in August was the unusually heavy precipitation which beginning on July 28 through August amounted to 17.44 inches. June and most of July were dry as was August in 1939 (Fig. 4).

It seems then that despite an apparent distastefulness fox predation on moles generally tended to follow their relative abundance.

Little Short-tailed Shrew. The little short-tailed shrew (Cryptotis parva) appeared 16 times in the 1220 fecal passages collected away from rearing dens (Tables 5, 13, 14 and 15; Appendix). It was not identified in any of the 234 passages collected at the dens. On two occasions it was noted as having been left behind by foxes, once on July 21, 1939, and again on July 6, 1940. Murie (1936) observed 4 individuals left on fox trails and recorded the species only once in 768 passages collected during the period of observation. These data lend further evidence to the general distaste of foxes for insectivores.

Concerning this little short-tailed shrew Lyon (1936, p. 46) wrote: "It is not a common animal and specimens in collections are not numerous." Extensive collecting of small mammals in Iowa shows that the statement need not be further qualified here. During the summer and fall of 1938, however, the species seemed uncommonly numerous on the Moingona area. Several individuals were found dead in the field with no relationship to fox "sign"; considering the usual numbers and small size of the animal these observations seemed reflective of local abundance. Although many traps for small mammals were operated on and off the Range only one specimen of this small shrew was captured in the traps; this one was taken on the Range in the summer of 1938. The frequency of occurrence tended to follow the population. In 5 passages collected in July the little short-tailed shrew appeared once; in August 3 (2.6%) were identified in 28 passages. The trend continued upward in September when the occurrences totaled 6 (6.1%) in 19 passages. None was recorded for October and the trend terminated with 2(4.7%) occurrences for 17 examinations in November. The fox predation on Cryptotis parva here seems to reflect the same response to a relatively high population as that suspected by Davis (1938) for barn owls in Texas.

The little short-tailed shrew did not again occur with unusual frequency. There was a single identification (1.5%) in 32 passages for January, 1939; single occurrences were also recorded for October, 1940, (0.6%), and for January (2.2%) and March (1.4%), 1941.

Large Short-tailed Shrew. Although Murie (1936) located 10 large short-tailed shrews (Blarina brevicauda) along fox trails none was identified in the 768 passages collected during the same period. Of this species Lyon (1936, p. 49) wrote: "When the animals are fully in heat all the sweat gland tubules are secreting. A musky odor is given off which apparently renders the animals more or less distasteful to carnivorous beasts." Dearborn (1932), Hamilton (1935), and Hamilton, Hosley and MacGregor (1937) found but few of these shrews in the passages and stomachs examined.

The results of the present investigation were not exceptional. The large short-tailed shrew occurred only 7 times in the 1220 fecal passages collected away from rearing dens. It appeared once in 49 fecal passages picked up at the dens of the Cyclone Creek family for the period May 21-30, 1940 (Table 5, Appendix). Four individuals were found where they had been left behind by foxes. This shrew never appeared to be particularly common on the Range; of 85 small mammals trapped in 1938 it was taken only once; it made up less than 1 percent of the total number of small mammals trapped on the quadrats in 1939 and in 1940 was not taken at all in the quadrats but made up 1.6 percent of all those trapped off the quadrats.

Carnivores.

The literature bears evidence that carnivores are not commonly eaten by red foxes. This continued true for the foxes on the Moingona Fox Range.

Raccoon. Raccoon was represented twice in 1454 fecal passages, once in December, 1940, and again in April, 1941 (Table 15, Appendix). Several raccoon carcasses were located on the range where they had been left after being pelted by hunters. One of these was left on a section of dry run frequently traveled by foxes; tracks indicated that the foxes had not so much as paused to inspect the animal. On April 27, 1940, the hind quarters of a raccoon were found where a fox had placed it in a cache near the junction of Polly and Bear creeks.

Mustelid. Mustela, probably mink, was detected 3 times in 57 fecal passages for September, 1940 (Table 15, Appendix). On June 22, 1940, an immature mink was found where it had been dropped by a fox on the upper reaches of Mills Run. Errington (1937) recorded one mink among 3858 food items collected about dens in 1933 and 1934.

Striped Skunk. Striped skunk appears to be relatively more tasteful than weasel to the red fox. A few occurrences of this skunk have been reported in the red fox diet (Dearborn, 1932; Hamilton, 1935; Murie, 1936; and Errington, 1937). In this investigation striped skunk was detected once; this was for January, 1941 (Table 15, Appendix). Evidence of this skunk was most common during the last year of study; three individuals were observed during regular work in the field on a single day in April, 1941. It seems reasonable to expect some strife between the red fox and striped skunk resulting from den rights. On several occasions skunks were known to have occupied dens immediately previous to fox inhabitation, and in the fall skunks often moved into dens that had been occupied by foxes during the spring and early summer. Intensive observations of the dens on the area revealed a rather general use of the dens by many animals; the classification of a ground den as that of a specific species could only be temporarily applied because of the dynamic nature of the occupation and in winter the dens were often used by several species at the same time.

Common Badger. The common badger was never known to hold residence long on the Range; however, its remains were identified twice in the material examined (Tables 14 and 15, Appendix), once in December, 1939, and again in October, 1940. Local farmers usually took control measures against the few badgers that wandered into the Range from the adjacent prairie lands. This was done to limit the excavation of dangerous holes in the pastures and hay fields on the comparatively level upland and terraces. The badger would ordinarily appear to be a formidable adversary for the red fox; however, the loss of part of a leg in a steel trap would handicap its defense. A badger in hibernation might also be easily taken.

Canidae. A substantial amount of undetermined Canidae was identified in 1 of the 21 fecal passages collected for the period April 7 to 20-22, 1940, at the natal den of the Second Run family (Table 5, Appendix). So far as was known domestic dog was not available at the time. It is possible that the representation resulted from intra-litter strife terminating in the killing and eating of one of the pups. This does not appear to be uncommon among the litter mates of captive red foxes. The evidence strongly indicated that the dead pup from the Second Run family located on May 31 had been attacked by litter mates, possibly after having been injured by rifle shot.

As a whole carnivore representation in the diet was more frequent during the last eight months of the investigation. Staple vertebrate foods seemed relatively less available during that period than at any other time. Possibly this is reflected in the emphasis on carnivores in the diet.

Rodents(Fig. 46).

Woodchuck. Remains of woodchucks were identified in 7 of the fecal passages examined (Tables 14 and 15, Appendix). There was one occurrence in February, 1940; this must have been for an animal discovered in hibernation. The foxes are actively preparing dens for the young at this time, and a woodchuck might easily be found. Probably all of the dens used by foxes on the Moingona Range were first dug by woodchucks, and these animals

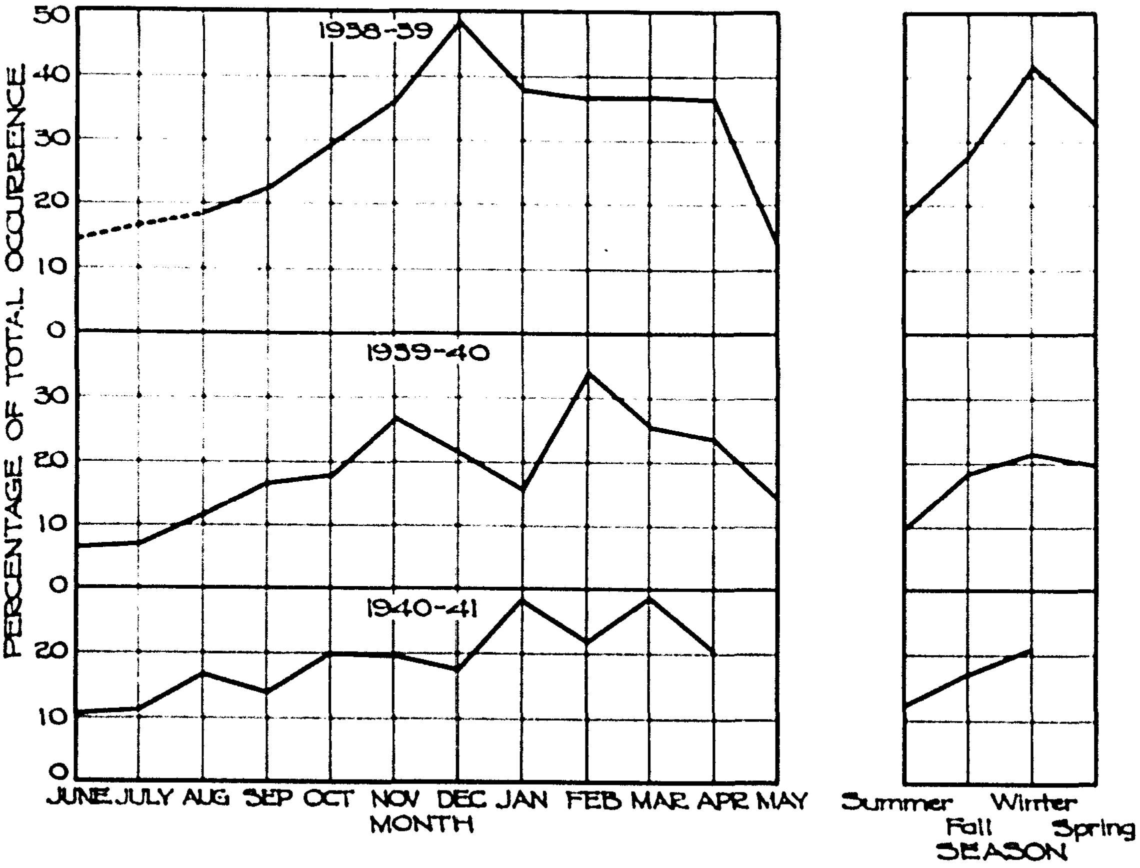

Fig. 46. Monthly trend of rodent representations. A broken lino was used where the number of fecal samples was thought inadequate.

are often seen at dens previously or subsequently used by foxes. The woodchucks on the Range generally appeared to come out of hibernation in March; the earliest sight record was for March 14, 1939. The latter animal was seen at the mouth of a den occupied for a short time the previous year by a family of foxes; it had not yet ventured from the den as was attested by the tracks. The first small woodchucks usually were observed around dens late in May. The remains of an immature (about one-quarter grown) woodchuck were identified in one of the 58 fecal passages collected in May, 1940. It is possible that these remains were from one of two immature animals killed in steel traps on May 21 and 22 by a local farmer undertaking control measures. In June, 1940, woodchuck was identified 3 times in 47 passages; the remains in 1 were of an immature animal while the age of the others could not be determined. Red fox pressure on partly grown woodchucks was emphasized in Errington's (1937) findings at dens in spring and early summer. Of 1010 food items at dens in 1933, 4 were woodchucks, all "young"; the 8 woodchucks among 2848 food items at dens in 1934 also were classified as "young". Further, the single occurrence of woodchuck in 1175 fecal passages collected at dens in 1933 and 5 occurrences in 935 passages for 1934 were also all indicated as "young". Hamilton (1935) reported over 33 woodchucks at 15 red fox dens in New York and New England; this was a greater number of individuals than for any other species listed. The only occurrence of woodchuck in the 768 passages collected by Murie (1936) during his late winter, spring and early summer studies came in May. It occurred twice in 151 late summer passages from New England (Hamilton, Hosley and MacGregor 1937). On the Moingona area woodchuck was identified twice in 30 fecal passages for November, 1940. In New England woodchuck was reported twice in 66 stomachs taken in fall and winter (Hamilton, 1935). Hatfield (1939) found it once in 29 stomachs collected in winter.

All appearances of woodchuck noted in this investigation were for 1940. If the numbers of direct observations on live animals reflect population levels then woodchucks were slightly more numerous during the summer of 1940 than for similar seasons in 1938 or 1939.

Ground Squirrel. The thirteen-striped ground squirrel has become established in the uncultivated clearings on the Moingona Fox Range. So little was seen of Franklin's ground squirrel (Citellus franklini) that nothing can be said of its status except that it is present on the area. It is logical to expect these squirrels to be less frequently taken by red foxes in winter because of their hibernation from about November to April, and the data support this expectation. Errington (1935) found the thirteen-striped ground squirrel in 2 out of 40 red fox stomachs taken in Iowa in winter. In this study there was one occurrence in December, 1938. By far the most of the ground squirrels are captured during the warmer months. Only rabbits and mice exceeded the occurrences of the "ground squirrels" reported in Errington's (1937) spring and early summer studies. It was detected in 7 of 233 den droppings and 3 (2 in April and 1 in May) of 535 trail droppings according to Murie's (1937) Table I analysis. Even then the strictly diurnal activity (Lyon, 1936) of these animals may minimize their vulnerability to fox predation. There is only 1 record of a ground squirrel, the thirteen-striped ground squirrel, for spring on the area; this occurred in 24 fecal passages collected at Den No. 4 of the Cyclone Creek family for the period, May 7-21 (Table 5, Appendix). Franklin's ground squirrel appeared 3 times, once on October, 1938, once in August and once in November, 1940 (Tables 13 and 15, Appendix). The deeply worn molariform teeth of the August representation indicated a very old adult. The thirteen-striped ground squirrel was detected 3 times in September material, twice in 1938 and once in 1939; an undetermined _Citellus_ appeared in September, 1940. This species, _C. tridecemlineatus_, occurred 4 times in 127 passages for July and 2 times in 43 for August, 1940; 1 of the latter could be identified as a young animal.

Chipmunk. The gray Eastern chipmunks on the area were largely established on the wooded slopes. These ground dwelling (Howell, 1929) squirrels rarely climbed trees and usually remained within easy reach of their burrows. They are wholly diurnal with greatest activity in early morning and late afternoon (Burt, 1940. The animals usually disappeared to hibernation late in November and were not known to reappear until March. The earliest spring date on which one was observed on this area was March 26,1941. Howell (1929) reviews data showing that chipmunks in hibernation are not necessarily wholly dormant. At any rate chipmunks seemed to have been free from fox pressure during the less active period of hibernation. Chipmunk remains were not listed in the winter stomachs analyses reported by Hamilton (1935), Hatfield (1939) and Errington (1935). The earliest and latest occurrences of chipmunk remains were 1 in 50 passages for March,1939, and 1 in 17 for November, 1938 (Table 13, Appendix). It was not listed in the spring and early summer studies of Errington (1937). On this area it occurred 2 times in 13 passages gathered about the natal den of the Cyclone Creek family for the period, April 5 to 9-11; during the period, May 7 to 21, 24 passages were collected at Den No. 4 of this family, and chipmunk was detected once in the material (Table 5, Appendix). Even though the Lyster chipmunk (Tamias striatus lysteri) was present on the George Reserve, Murie (1936) did not find it to have been eaten or killed by red foxes during his late winter, spring and early summer observations.

The greatest frequency of chipmunk occurred in passages collected in summer and early fall (Tables 14 and 15, Appendix). Two (0.7%) appearances for August and 3 (1.1%) for September were recorded in 1939. Chipmunk persistently appeared in passages from summer and early fall in 1940. This 1940 chipmunk trend follows: June, 3 (1.7%); July, 5 (1.1%); August, 4 (2.5%); September , 8 (3.7%); and October, 1 (0.4%). According to Burt's (1940) data the movements of the Lyster chipmunk on the George Reserve is confined to young animals and adult males. It seems reasonable to expect these moving animals, particularly the inexperienced youngsters, to be more easily captured than well-established individuals. The chipmunk dispersal is correlated in time with the spring and early fall emphasis on chipmunk remains in the fecal material. The parts in two passages, one in June and another in September, could be identified as belonging to young chipmunks. The molariform teeth in 6 of the chipmunk determinations (2 for August, 3 for September and 1 for October) had been deeply worn. The teeth were like those of very old adults; with so many (6 out of 21) one is inclined to suspect a cause of tooth wear other than that accompanying age. If these were very old adults then a minimum of about .8 percent of the chipmunks taken in the summer and early fall of 1940 was very old adults and young.

Fox squirrel. A tendency for predation to follow population levels was strikingly demonstrated in the predator-prey relationship of the red fox and fox squirrel. Spot counts begun in the summer of 1938 were abandoned because there were so few fox squirrels on the Range that figures could not be obtained on which to base calculations. In the first year of study, Period I, fox squirrel remains were detected but 3 times (0.3%) (Table 13, Appendix). All of these occurred in April, 1939, and possibly represent one individual. Errington (1937) reported 0.5 percent of the 3858 food items about dens in 1933 and 1934 to be fox squirrel, and in 2110 fecal passages from about the same dens this squirrel was identified but once. Also working within the geographic range of the fox squirrel Dearborn (1932) found it but "sparsely represented" in the red fox diet, and Hatfield (1939) detected no evidence of it among the foods. It occurred 3 times in the 768 droppings examined by Murie (1936), and 4 individuals were found on trails where they had been left by foxes.

The findings for Periods II and III on the Moingona area showed an increased frequency of fox squirrel remains in the fecal material (Tables 14 and 15, Appendix). Although no counts were attempted, fox squirrels were obviously more numerous in Period II than they had been in Period I. Reflecting this increase were the 14 (0.7%) occurrences during Period II; the percentage of total food occurrences had more than doubled. The fox squirrel population continued upward and their increased numbers became so noticeable that a spot count was attempted in December, 1940. As a result of the counts the population was estimated to be about one animal to three acres throughout the area. At the same time cottontails showed a population of about one individual to seven acres, a little less than half the estimated fox squirrel density. The increased population level was again reflected in the number of times fox squirrel remains appeared; in Period III there were 24 (1.3%) occurrences. The percentage of total food occurrences, 1.3 percent, had again about doubled that of the previous year of study. It is logical to expect a partially arboreal animal such as the fox squirrel to be less vulnerable to red fox predation than a terrestrial species such as the cottontail, and the data support this logic. The percentages of total food occurrences during the winter of Period III was 2.8 for fox squirrel and 36.9 for cottontail. The percentages of total food occurrences have been shown to respond directly to the amounts of the food consumed (Scott, 1941b). Then the relative amount of cottontail to fox squirrel for this season follows a ratio of about 1:13. It is interesting to note that the percentages of total occurrences for cottontails and fox squirrels (1.3 and 17.1) for all of Period III also show a ratio of about 1:13. Because of the difference in size of the animals about two adult fox squirrels would be required to equal one adult cottontail. Correcting the ratio of relative proportions, 1:13, to numbers of individuals it would become 1 fox squirrel to 6.5 cottontails. If 6.5 cottontails are taken for every fox squirrel when there are twice as many squirrels on the area as cottontails then with equal population levels 13 cottontails might be taken for each fox squirrel if all oth r conditions were the same. For what it is worth then cottontails might have been considered about 13 times as vulnerable as fox squirrels under the kind of circumstances existing on the Moingona Fox Range during Period III.

Flying Squirrel. The flying squirrel (Glaucomys volans) was not expected to appear regularly among the foods of the red fox. In the current investigation it was detected only twice in the fecal passages inspected (Table 14, Appendix). Flying squirrel remains were found in 1 of 11 red fox stomachs taken between December 14, 1931 and February 3, 1932 in Wisconsin (Errington, 1935).

Mice. The systematic trapping of mice showed that they were greatly disturbed by agricultural operations. Such activities as close grazing, burning, plowing, cultivating and mowing largely resulted in disappearnce of the mice inhabiting areas where these practices were undertaken. Often only fence rows grown up to grasses and weeds remained to house the field-dwelling mice. Those farming practices that greatly disturbed the land were most intensively carried out during May, June and July. By August the corn has been "laid by" and the small grains have been harvested; thereafter suitable mouse habitat developed rapidly in fields where these crops had been planted. It appears logical to expect mice that have been evicted from familiar range or caused to occupy a greatly modified habitat could be more easily captured by their enemies. At least it has been found true for muskrats (Errington, 1939). That mice were affected similarly by agricultural operations, however, was not evident in the feeding trends, possibly because of the effect of the seasonably available fruit and insects. Fox pressure on mice was greatest in late fall, winter and early spring despite the fact that mouse habitats at that time seemed generally more stable. This was not only true for mice in general but also for each species.

The data permit an attempt at comparison of the relative proportions of mice taken in traps in the field with the relative proportions of mice in the fecal passages. The records from systematic trapping on the area include the number of individuals of each species taken during definite periods. As the number of occurrences in the fecal passages more accurately reflect size of prey than numbers of individuals (Scott, 1941b) it is necessary to correct the field data for size. With average weights of adults as a basis for calculation, the following correction factors seem to make the necessary allowances: house mouse, 1X; harvest mouse, 1X; white-footed mouse, 1.5X; lemming mouse, 2X; and meadow mouse, 3X. One hundred traps were operated in each of three cover types, fallow field, maple-linden woods and brushy second growth, in October, 1938. Seventy-one white-footed mice, 7 meadow mice and 4 house mice were taken. Corrected for size the proportion of October mice would then be: white-footed mice, 71 X 1.5 or 86; meadow mice, 7 X 3 or 21; and house mice, 4 X 1 or 4. The percentage of the total of the corrected figures may be calculated: white-footed mice, 77 percent; meadow mice, 20 percent; and house mice, 3 percent. By contrast the percentages of total occurrences for mice in the fecal passages were: white-footed mice, 36 percent; meadow mice, 55 percent; and lemming mouse, 9 percent. Similar comparisons have been made for the trapping records and fecal analyses of 1939 and 1940 (Table 16). The differences, even with allowances for error in sampling, are marked and uniform. There is little here that suggests response to population level;

Table 16

A Comparison of the Relative Proportions of Mice Taken in Traps on the Quadrats and at Other Localities on the Area with the Relative Proportions of Mice Occurring in the Fecal Passages in 1939 and 1940

	Reithrodontomys megalotis		Peromyscus		Synaptomys cooperi		Microtus		Mus musculus	
	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940
April	%	%	%	%	%	%	%	%	%	%
In passages	4		30		9		57			
In traps:										
Quadrats	5		95							
May										
In passages		14		32	33	4	67	50		
In traps:										
Grassy fence rows		15		34				51		
Quadrats			100							
June										
In passages			38	33			50	67	12	
In traps:										
General		14		86						
Quadrats		1	89	94				3	11	2
July										
In passages		4	50	34		10	50	52		
In traps:										
General		2		88				8		2
Quadrats		2	100	93				4		1
August										
In passages			24	30	14		62	70		
In traps:										
General				97		2				1
Quadrats			96	94				2	4	4
September										
In passages		5	22	20	3	5	75	70		
In traps:										
Quadrats			96	99					4	1
October										
In passages			24		13		61		2	
In traps:										
Quadrats	4		92				4			

instead specific variation in vulnerability and preferences seem evident.

The trapping records are thought to give a fairly accurate picture of species composition. Extent of habitat alone bears this out. Trapping throughout the area showed that lemming mice and meadow mice were largely restricted to the few undisturbed grassy areas. This also seemed true for the other field-dwelling forms, such as the Baird white-footed mouse and prairie harvest mouse, except that these species appeared to move more readily into fields where farming operations had been terminated for the season. The forest habitat of the Northern white-footed mouse, the most abundant mouse species on the area, was extensive and comparatively undisturbed. In Table 16 the 1940 comparison for May shows remarkable agreement for species composition in the traps and in the fecal passages where all of the trapping was done along a grassy fence row rather than on a bisect through all the representative cover types.

Prairie Harvest Mouse. It seems logical that the prairie harvest mouse would be readily captured by red foxes. For the most part harvest mice (Reithrodontomys spp.) live on the surface of the ground and even construct nests there, occasionally building them above the ground in supporting vegetation (Davis, 1939). They are not as abundant, however, as most mice (Anthony, 1935); this is verified by the infrequency of the prairie harvest mouse in traps (Table 16) on the Moingona area. These mice seemed to occur in groups for where one was taken in the traps several more could be expected. The "waves" in the feeding trend may result from locating and feeding in limited areas where the species was present. The seasonal curve (Fig. 47), showing a gradual rise from a summer low through fall to

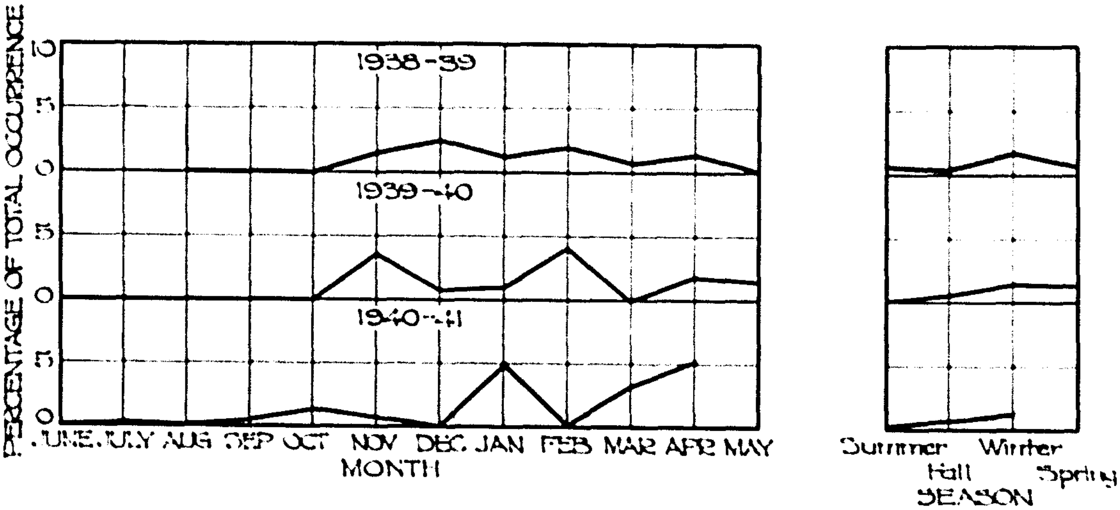

Fig. 47. Monthly trend of prairie harvest mouse representations.

a winter high followed by a spring depression, seems typical for feeding trends on mice generally in this investigation.

White-footed Mice. As previously mentioned, the Northern white-footed mouse and the Baird white-footed mouse are present on the Moingona Fox Range. Mice were trapped on the quadrats from April to October inclusively in 1939; 78 percent of the white-footed mice taken were of the Northern from and 22 percent were of the Baird form. In 4 months, June, July, August and September, 1940, 69 percent of the white-footed mice was Northern white-footed mice and 31 percent was Baird white-footed mice. This relative difference in numbers for the two species is manifestly the result of habitat restrictions. The woods habitat of the Northern white-footed mouse is considerably greater in extent than that of the Baird white-footed mouse. In a discussion of the factors affecting the distribution of these two mice, Dice (1922, p. 30) wrote: "The habitat limitations of these forms is very marked, and, though there is a slight amount of overlapping on the border between the forest and the prairie, the prairie species are not found in the forest nor the forest form on the prairies." This was obvious in the trapping records; only the Northern white-footed mouse was taken in the wooded quadrats, I, II and VII (Fig. 24). On the other quadrats both species were taken, and Baird's form was particularly evident in the open fields of quadrats IV, V and X. Quadrat IX, in a closely grazed pasture, may be excepted, for no mice were taken there at any time.

Unfortunately it was not found advisable to attempt identification of white-footed mouse remains in the fecal material beyond the genus. If the remains could have been identified to the species with accuracy, something might have been learned of the effect of habitat differences on predation by contrasting the results for these two closely related forms of mice.

The trend of white-footed mice in the diet was generally similar to that of the other mice in that there was a summer low with a gradual increase through fall to winter with a decrease in late spring (Fig. 48).

Though proportionately less abundant than white-footed mice as attested by the trapping records, meadow mice nevertheless regularly occurred a greater number of times in the fecal material than did white-footed mice. The occurrence of white-footed mice exceeded that of meadow mice in only 3 months, January, February and October of 1940. A fairly deep and continuous blanket of snow was on the ground during January and February (Fig.25), and this seemed to bear some relationship to the change in the usual position of the two forms as regards number of occurrences in the fecal material. During this period the white-footed mouse appeared more active above the snow than the meadow mouse which remained largely in intricate tunnels beneath the snow. It is possible, too, that the daily rhythm of activity of the white-footed mouse (*Peromyscus leucopus*) might be modified by deep snow (Behney, 1936). Therefore, the white-footed mouse should have been more easily available than the meadow mouse during this period. Although the differences in behavior resulting from deep snow is likely to be more evident in the feeding of an avian predator (Hendrickson and Swan, 1939), it nevertheless seemed not to be without significance to the effectiveness of hunting foxes. The cause of change in relative position for the two species in October could be associated with no specific event.

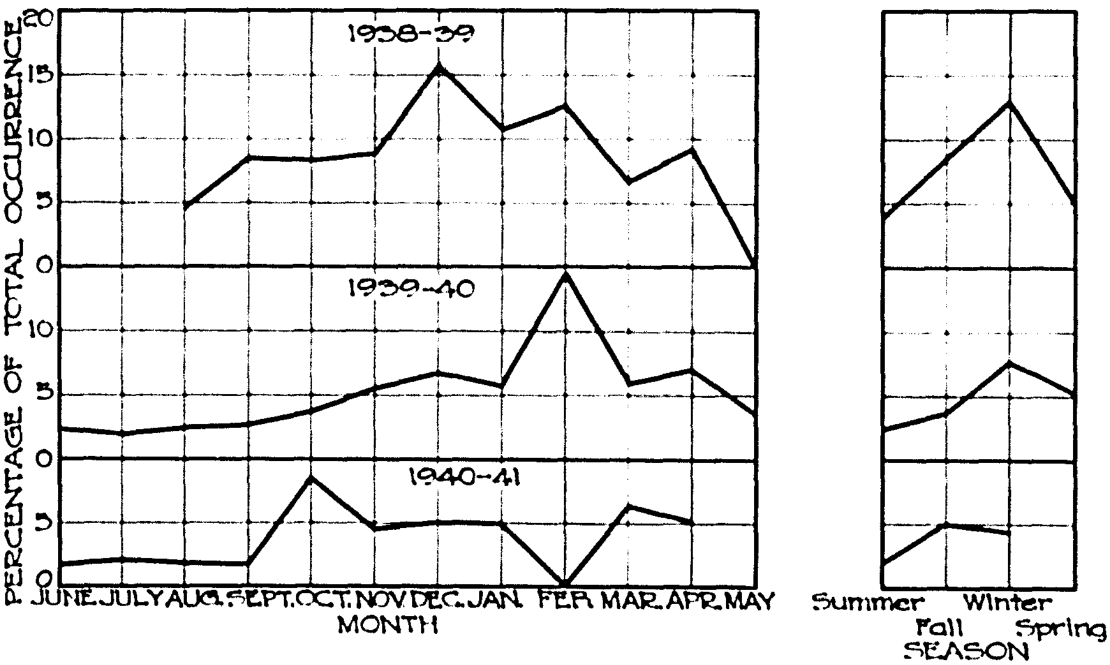

Fig. 48. Monthly trend of white-footed mouse representations.

There were sufficient trapping records for Northern white-footed mice to permit estimation of their numbers to the acre for the quadrats as a whole in 1939 and 1940 (Table 17). For this species the population level in 1940 was markedly above that of 1939; the population of Baird white-footed mice was also higher in 1940. There are, however, no evident responses in the diet of the red fox to these greater numbers.

Table 17

Average Number of Northern White-footed Mice
to the Acre on the Quadrats in 1939 and 1940.

	April	May	June	July	Aug.	Sept.	Oct.
1939[1]	0.26		0.22	0.39	0.78	0.65	1.30
1940[2]			1.66	1.19	2.45	1.23	

A severe warble fly infestation in the Northern white-footed mice on the Moingona Fox Range has been reported by Scott and Snead (1942) for the warm weather months of 1939 and 1940. A certain awkwardness was observed for parasitized mice which might have rendered the animals more subject to predation. Nothing was observed in the feeding trends of the fox to support this; however, some evidence that parasitized Northern white-footed mice were taken by foxes was obtained. In one fecal passage the remains of a

[1]Because of agricultural operations and the nearness of denning foxes only three quadrats were trapped in May; the records were not considered extensive enough to permit estimation of the population.

[2]Quadrats not trapped in April, May and October.

Northern white-footed mouse accompanied a warble fly larva. In an instance on September 26, 1939, an infested Northern white-footed mouse was found where it had been dropped on the dry sand of Polly Creek.

Lemming Mouse. The lemming mouse appeared to be readily taken by red foxes. Murie (1936) reported a high frequency of the remains of the Cooper lemming mouse (*Synaptomys c. cooperi*) in fecal material, 127 in 535 droppings gathered away from dens and 5 in 233 picked up at a den. In this study the Goss lemming mouse (*Synaptomys cooperi gossii*) was represented in 53 of 1220 droppings not on den sites and in 5 of 234 found about the dens (Tables 5, 13, 14 and 15; Appendix). The feeding trend (Fig. 49) appears to take the same direction as those of other mice, being generally lower during the warm weather months and higher in the cold weather months. There was a striking year to year change in relative proportion of lemming mouse in the red fox diet (Fig. 49). The percentage of total occurrences for the 3 years of study were: Period I, 2.6; Period II, 1.0 and Period III, 0.5. Though it is highly probable that this year to year decrease in frequency of occurrences is caused by a lowering of the population levels, the lemming mouse was so scarce in the traps that nothing could be learned of its status.

Meadow Mice. As already brought out in the description of the area the Pennsylvania meadow mouse and the prairie meadow mouse were both present. The former apparently limited itself largely to the bottomland fields and the latter shared the better drained fields of the upland with the Baird white-footed mouse. Meadow mouse remains in the fecal material were identified only to the genus. In 81 fecal samples the molariform teeth were in

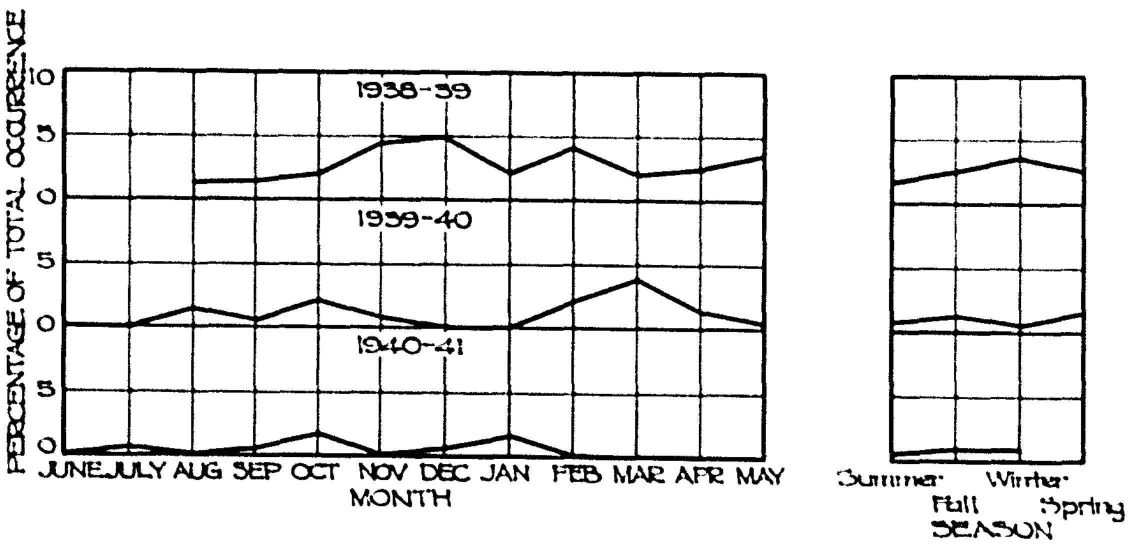

Fig. 49. Monthly trend of lemming mouse representations.

position and in such condition as to allow examination of the characteristic configuration of the enamel; the teeth in 77 were those of the prairie meadow mouse and only 4 were of the Pennsylvania meadow mouse. Here again habitat restrictions are apparent, for well-drained fields are much greater in extent than moist low lying fields on the area.

A general lowering of the population level for meadow mice seemed evident in field "sign" and in the trapping records, few though they may be, for the three years study. Meadow mouse representation in the fecal samples steadily declined during the study as the percentages of total occurrences show: Period I, 15.4; Period, 7.5 and Period III, 5.9. This decrease in frequency is also manifest in a comparison of the seasons showing that the year to year decrease was not brought about by some temporary environmental restriction (Table 18).

Table 18

Seasonal Percentages of Total
Occurrences for Meadow Mice.

	Period I	Period II	Period III
Summer	9.7	4.7	3.5
Fall	12.3	9.9	6.4
Winter	19.7	7.3	10.3
Spring	18.0	7.5	12.7

The winter of Period II was characterized by deeper snow than usual

(Fig. 25). The general downward trend of meadow mouse in the fecal material quickened for that season, probably because of the protective blanket of snow and ice over the runways. Evidence of meadow mice in the fields seemed to be increasing in the spring of 1941.

Meadow mice show a trend (Fig. 50) in the red fox diet like that for the other mice. The occurrences are more frequent during the cold weather months than in the warm weather months. Even during the fruit shortage in the summer of 1938 fewer were taken than at any other season. According to Southern and Watson (1941) Chirkova found that voles (Microtus) were taken most abundantly by the red fox (Vulpes vulpes) in winter, except when especially heavy snow made hunting difficult. Murie's (1936) data also showed that the frequency of meadow mice in the diet of the red fox declined as warm weather approached.

The meadow mouse is thought to be highly vulnerable to foxes (Murie, 1936 and Hamilton, 1935). Its frequent appearance in the diet certainly does nothing to detract from this logic. In this study it was consistently outranked in importance among the mammals only by cottontail. Murie (1936) found it in 109 of 535 droppings picked up away from dens and in 10 out of 233 collected at dens. Errington (1935) identified it in 515 out of 1175 fecal samples collected at dens. It is equally common in the reports of other workers.

At the same dens for which Errington (1935) reported meadow mouse in 515 out of 1175 fecal samples only 6 meadow mice were among the food debris; this, when contrasted with the 55 white-footed mice in the debris and 104 occurrences of this species in the droppings, was interpreted as possible

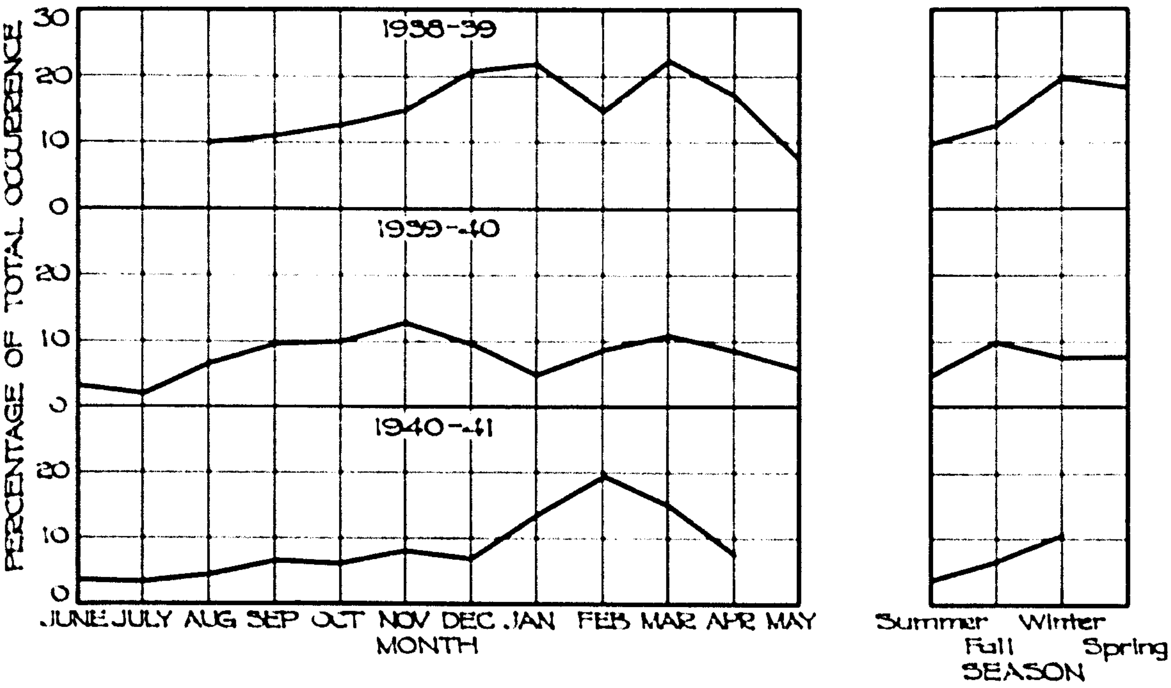

Fig. 50. Monthly trend of meadow mouse representations.

evidence of preference for meadow mice. In this study the ratio of meadow mice to white-footed mice in the diet of the fox was certainly in direct opposition to the relative numbers of these animals taken in traps, possibly this, too, is evidence of preference. Positive evidence of the capture of 11 meadow mice and 9 white-footed mice by red foxes was found during the study. Of these only one meadow mouse was known to have been left uneaten and unretrieved by foxes whereas seven of the white-footed mice were never utilized by foxes.

The complex differential in the interrelationships of the red fox to the meadow mouse and to the white-footed mouse may be explained only after exhaustive research. Contributing to the problem is the difficulty of segregating the species of each form in the fecal material. At least one of the white-footed mice (Peromyscus maniculatus bairdii) occupies habitat similar in life form to that of the more common meadow mouse (Microtus ochrogaster) on the area. In respect to habitat then these two forms appear to be about equally vulnerable. In addition, trapping records showed that this white-footed mouse was generally more numerous than the prairie meadow mouse.

An appreciable difference exists in the rhythmic behavior of white-footed mice and meadow mice. Johnson (1926) demonstrated that Peromyscus maniculatus is normally nocturnal. Hamilton (1937) found Microtus pennsylvanicus to be active at all hours. Hatfield (1940) experimentally demonstrated a 2- to 4-hour rhythm of activity at temperatures of from 0°C. to 28°C. for Microtus pennsylvanicus pennsylvanicus. At 30°C. and above they were active nearly all the time, and at 0°C. the rhythm was maintained but the length of each term of activity was shortened. Perhaps, too, the rhythm of activity is modified somewhat by cover conditions, for the data of Hatfield (1938) indicated that in sparse cover more meadow mice (Microtus) were taken in traps at night than in day whereas the reverse seemed true in dense cover. In the same experiments Peromyscus maniculatus bairdii showed a 24-hour, nocturnal-diurnal rhythm or cycle; they were more active by night than by day. Cold decreased activity and heat produced greater activity but the typical 24-hour cycle was not changed. This marked difference in the rhythmic behavior of the mice together with preference may be of primary importance in bringing about the difference in the relative proportions of white-footed mice and meadow mice in the diet of the red fox.

House Mouse. House mouse (Mus musculus) representation was infrequent in the fecal material. In Period I it did not occur; in Period II it appeared 7 times of which 5 were for winter and early spring; and in Period III it was identified only once. It did not appear in 234 droppings gathered at dens. Murie (1936) found it in only two droppings and other writers did not report it at all.

Muskrat. Pancoast (1937) and Smith (1938) indicated that red fox depredations on muskrats in marshes were occasionally severe. There were 45 occurrences of muskrat in the 768 red fox droppings examined on the George Reserve (Murie, 1936). Murie indicated that a lack of adequate water in the marsh was largely responsible for the vulnerability of these muskrats.

Errington (1939, p. 185) found that "A large proportion of the muskrats resident in drying out habitats tend to stay in familiar home ranges, and, while they may suffer heavy or even anihilative mortality, they are usually more fortunate than the animals that attempt to go elsewhere." In Iowa the drying up of the water in Big Wall Lake during the summer of 1940 exposed the resident muskrats to the attacks of neighboring foxes (Errington and Scott, unpublished). In 79 droppings collected there between June 15 and September 1 muskrat was identified in 70. Late in August heavy rains restored water in the marsh and muskrat abruptly ceased to occur in the fecal passages. Muskrats on the Moingona area are confined to the Des Moines River. Although the water in the river was occasionally very low during the summer months the deeper pools were never dry. In this case the foxes would seem dependent upon catching muskrats wandering out on land. That this was unprofitable is evident in the detection of remains in only 2 (Table 15, Appendix) of the 1454 fecal passages examined. Muskrat was either absent or infrequent in the material investigated by Hamilton (1935), Dearborn (1932), Errington (1935 and 1937), Hatfield (1939) and Nelson (1933). The data show that muskrats living in suitable habitat are not subject to severe red fox predation.

Norway Rat. Norway rat (Rattus norvegicus) appeared 11 times in the 1220 fecal passages collected away from dens, 2 or 0.2 percent of the total occurrences in Period I, 4 or 0.2 percent of the total occurrences in Period II and 5 or 0.3 percent of the total occurrences in Period III. It also occurred in 2 of the 70 passages picked up at dens No. 2 and 3 of the Cyclone Creek family for April 9-11 to 23-30.

Errington (1937) listed it once among 1010 food items at dens in 1933 and 9 times in 2848 items in 1934; it occurred 4 times in 1176 fecal samples from the same dens in 1933 and 5 times in 935 samples in 1934. Hamilton (1935) reported it once in 272 red fox stomachs from New York and New England. In Great Britain Southern and Watson (1941) detected Norway rat in 1 of 40 Vulpes vulpes stomachs examined.

Rabbits

Cottontail. The principal staple food of the red foxes on the Moingona Fox Range was cottontail. It occurred in 920 of the 1454 fecal passages examined (Tables 5, 13, 14, 15 and 21; Appendix), and it was the most frequent food found along the trails (Table 1, Appendix) and around the dens. The findings of Errington (1935 and 1937), Hamilton (1935), Murie (1936) and others show that where cottontails are present they generally make up a substantial portion of the diet. In Great Britain Southern and Watson (1941) identified rabbit (Oryctolagus cuniculus) in 17 of 40 stomachs and in 15 of 18 fecal droppings of the red fox (Vulpes vulpes) collected in spring and summer.

The feeding trend on cottontail (Fig. 51) graphically demonstrates that appreciably more cottontails are taken in the winter and spring months than in summer and fall. The proportion of cottontail shows a general tendency to pass from a winter high gradually downward to a fall low. The data reported by Murie (1936) also reflect a dietary trend on cottontail similar in direction to those found for similar periods in this study. The shifting of the low in the feeding trend on cottontails from summer as it is in mammals generally and mice specifically to a low in fall presents a striking variation. This is particularly well illustrated in the seasonal trends (Fig. 51).

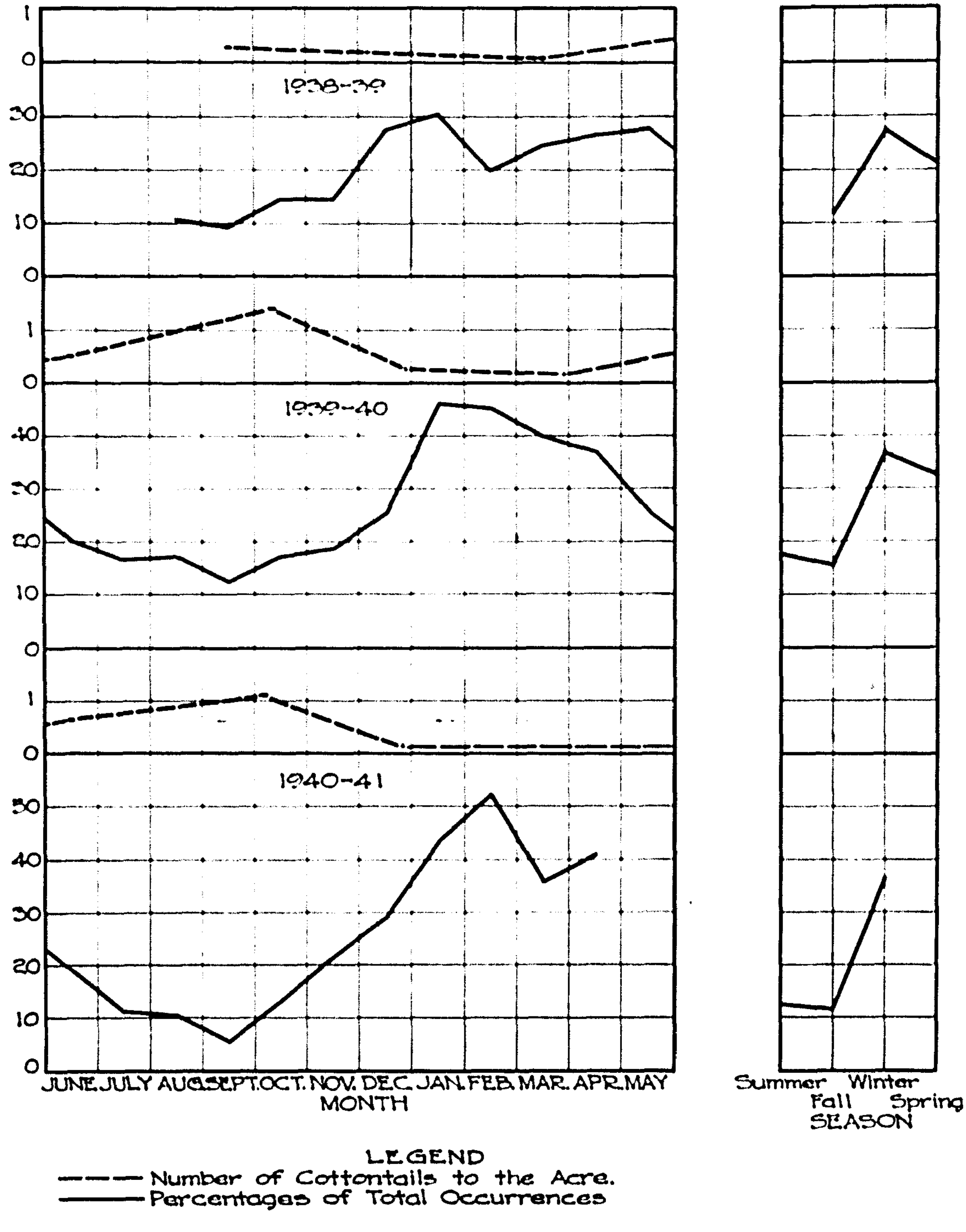

Fig. 51. Monthly trend of cottontail representations in the fecal passages contrasted with seasonal changes in the levels of the cottontail population.

This marked difference in the cottontail trend as compared with mammals in general may be the result of a high availability and possibly preference for immature cottontails in late spring and summer. The detected occurrences of immature and young cottontails are recorded in Table 19 together with total occurrences of cottontail for analytical purposes. In

Table 19

Detected Occurrences of Immature and Young Cottontails Contrasted with Total Occurrences of Cottontail in Fecal Material from the Trails.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Period I												
Total Occurrences	2	3	11	8	5	6	16	20	6	27	14	10
Immature		1									1	3
Young		2	4	3	2	1	1					
Period II												
Total Occurrences	13	15	42	26	32	14	26	41	16	27	47	48
Immature	5	6	6	1							5[1]	10[1]
Young	3	2	10	6	6	2						5
Period III												
Total Occurrences	27	42	13	10	22	24	30	20	19	26	14	
Immature	10[1]	11	2								2	
Young	2	3	2		5	4		1				

[1] Immature cottontail remains were also detected in fecal passages collected at dens during these months. Of 94 occurrences of cottontail in April, 18 were determined as of immature; of 82 in May, 38 were immature; and of 11 in June, 5 were immature.

each year of study immature cottontails first appeared in the food of the foxes in April, were most frequent in May, June and July and terminated their trend in August and September. This agrees directly with the time and intensity of cottontail nesting in the field. The earliest nest of cottontails found on the area was one in which the young were about five days old on April 15, 1940. Some cottontails were born at an earlier date than indicated by the young in this nest, for on April 21, 1941, a cottontail estimated to be four weeks old was found dead on Second Run. The height of the nesting season occurred in May, June and July. Most of the immature cottontails detected in the fecal material seemed to compare well in size with animals just large enough to leave the nest, indicating that the animals might have been particularly vulnerable at that time. The relative number of immature cottontails taken by foxes may be appreciated only when the tendency for occurrences to vary in direct proportion with the size of prey is considered. The differences noted in the frequency of immature cottontails in the fecal passages from the trails and from the dens have been treated in the section on the influence of age on the feeding trends. Those cottontails classified as young were difficult to determine when they approached sub-adult sizes. The results obtained, however, show that the occurrences of this age class lagged somewhat behind that of the immature group both in time and frequency, the latter despite of their larger size. This would indicate that the immature animals were comparatively more vulnerable than the young or that fewer animals reached the young classification because of high mortality in the immature group. In their study of the spring and summer food of the red fox (Vulpes vulpes) in Great

Britain Southern and Watson (1941) found young rabbits (Oryctolagus cuniculus) in 6 of 40 stomachs.

An inventory of cottontails was taken on the quadrats at regular intervals in order to provide some basis for determining the relationship of population levels to dietary proportion. Differences in the cottontail population levels are somewhat accentuated by response of the cottontails to the seasons. The movement of cottontails in and out of wintering quarters and cultivated fields tends to make somewhat more marked changes than actually existed. The population levels are averaged from the counts obtained on all the quadrats and are therefore representative of the area as a whole instead of any one particular cover type.

It seems logical to expect the frequency of cottontail occurrences in the diet to fluctuate directly with population level. It is manifest that the annual fluctuation of the population has little to do with the direction taken by the annual feeding trend (Fig. 51). In fact the annual population curve is directly opposed to the relative proportion of cottontail diet. In other words during the time of year when cottontails are most numerous in the field they make up the smallest proportion of the diet and the reverse. A comparison of the year to year population levels with relative proportion in the diet for similar periods of time is possible (Table 20). A tendency for the relative amount of cottontail in the diet to follow the year to year population level is evident in the fall and spring data. In the winter and summer there was no significant change in the relative proportion of cottontail in the fecal material even though there was some change in population level. Possibly this is because the degree of

Table 20

Comparison of the Average Number of Cottontails to the Acre on the Quadrats with the Percentages of Total Occurrences for Cottontail in the Fecal Material.

	Cottontails to the acre	Percentage of total occurrences
FALL		
September, 1938	.25	9.4
October, 1939	1.40	17.2
October, 1940	1.10	13.3
WINTER		
December, 1938	0.20	27.7
December, 1939	0.29	25.6
December, 1940	0.14	29.0
SPRING		
March, 1939	0.10	24.8
March, 1940	0.17	39.6
March, 1941	no count made	35.8
SUMMER		
June, 1939	0.50	20.1
June, 1940	0.65	19.1

availability of cottontail and other foods is more variable in winter and summer. Hamilton, Hosley and MacGregor (1937) working on the food of the red foxes in the Harvard Forest, Massachusetts, where cottontails were considered sparse in contrast with population levels as known for agricultural sections for New York and the midwest, found only 15 occurrences of cottontails in 131 fecal passages gathered in midsummer.

From the findings as a whole, then, it is apparent that the relative proportion of cottontail in the diet does not respond to the annual population fluctuation resulting from normal life history events but that it may show a tendency to respond to year to year changes in population levels for the same time of year.

Jack Rabbit. This rabbit was never known to occur within the area except in winter when an occasional one appeared on the cleared upland. It was identified in a fecal passage collected in February, 1941; no other occurrences were detected. Many of the localities investigate by Errington (1937) were well within jack rabbit ranges; jack rabbit was recorded 201 times among 3858 food items about dens and it occurred 63 times in 2110 fecal samples collected about the same dens.

Hoofed Mammals.

Domestic Pig. Domestic pig (<u>Sus scrofa</u>) occurred 10 times in the 1220 fecal passages gathered away from dens and 6 times in the 234 passaged picked up on the den sites. No live pigs were reported by farmers to have been lost to any predator and all occurrences of pig in the fecal material could be associated with dead animals discarded by local farmers. Once when seven little pigs killed by the sow were thrown out a farm dog was known to have competed with the foxes in feeding on them. The formidably tusked boar's head that appeared at the fox den on Bear Creek on June 23, 1939, certainly did not indicate fox predation on hogs. One marvels more at the ability of the fox to drag or carry this heavy head from where it had been discarded at a local farmstead to the den.

White-tailed Deer. Remains of an adult deer were found in one of the passages; they appeared in February, 1941. Murie (1936) found remains of three adult deer in the 768 droppings that he examined on the George Reserve, but no evidence that foxes had harmed fawns dropped there in late May and June was obtained.

BIRDS.

Technical limitations make specific determinations of bird remains in fecal passages very difficult. Evidence of this is the large number, 191, of the 470 bird occurrences that could be classified only as undetermined avian remains (Tables 6, 21, 22, 23 and 24; Appendix).

Ten of the undetermined bird occurrences were fragments of egg shells. These were the only records of egg remains in the fecal material except for three of domestic chicken and three of ring-necked pheasant. Five of the egg shell appearances listed as undetermined were qualified as probably domestic chicken and were taken in September and October, leaving only eight occurrences, five undetermined and three of ring-necked pheasant that were detected during the nesting season. Probably all of the ring-necked pheasant egg shell fragments were from one nest, for all were found in the fecal samples from the same den in May, 1940. It is possible that some of the egg shell may have been obtained as a secondary food when the female birds were eaten just prior to egg laying. This would have been possible in the case of one carrion hen located where it had been discarded in the field. No bird nest was known to have been destroyed or disturbed by the foxes. If these records are fair evidence then nest destruction by red foxes must not have been extensive on the Moingona area. Egg shell was listed in only eight droppings collected on the George Reserve (Murie, 1936).

Two hundred seventy-nine of the bird determinations in the fecal material could at least be designated as nongame or game. The percentages of the total number of occurrences for these two categories in droppings from the trails were: Period I, nongame 12.1, game 1.8; Period II, nongame 8.2, game 1.1; and Period III, nongame 4.4, game 1.2 (Tables 22, 23 and 24; Appendix). The ratio of game determinations to nongame determinations in the droppings collected at the dens (Tables 6 and 21, Appendix) were roughly the same as those for the trails.

Nongame Birds.

Domestic Poultry. Domestic chicken proved to be the principal avian food identified in the fecal material. In the trail feces it made up 7.4 percent of the total occurrences in Period I, 3.1 percent in Period II, and 2.1 percent in Period III (Tables 22, 23 and 24; Appendix). It was detected but twice in the 234 scats collected on the den sites. It is generally agreed that a large part of the domestic chicken fed upon by foxes is carrion (Errington, 1935, and Hamilton, 1935). Nearly all of the occurrences of domestic chicken in the fecal material from the Moingona area could be associated with available carrion. A small but almost continuous supply of carrion chicken reached the fields within the ranges of the foxes. On one occasion a large number of dead chickens were thrown out at the edge of River Road in the southeast part of the area, but this supply could not be associated with chicken remains in droppings collected at the time. These chickens were outside the interpolated home range of the resident foxes, and possibly for this reason they were not found, and if found, then only after the material had advanced to such a state of decay as to have been unattractive as food.

As was the experience of Errington (1935), red fox predation may be the source of severe losses to vulnerably situated flocks of domestic poultry. In August of 1938 a substantial 17.6 percent of the total food occurrence was found to be domestic chicken. This resulted from depredations on a flock that had been temporarily forgotten during a domestic emergency at a local farmstead. The exact number of the original flock had not been recorded, but it was estimated to have been about 50; the foxes had taken a toll of nearly one-fourth of the original flock.

In November, 1940, remains of guinea fowl were detected three times, the only occurrences listed. These remains could, almost with certainty, be associated with a dead bird discarded at a local farmstead.

Several of the resident farm families were direct descendants of original settlers in these hills along the Des Moines River. These people, as matter of course, followed the practice of keeping their poultry penned at least from early evening to the following mid-morning. This seemed to have become a somewhat time-honored method of militating against losses to the numerous predators associated with the "river land".

Owls. In October of 1939 a barred owl was shot by hunters and left on upper Polly Creek. Tracks showed that foxes passed within inches of this bird many times, and once a fecal dropping was collected from beside the carcass. Although certainly aware of its existence the foxes did not eat any of the carcass even though it remained in a fair state of preservation for some time. Possibly the foxes first located the bird while it was still heavily associated with scent from human handling.

Remains of owls, however, were twice detected in scats from the trails and three times in those from the den sites. Feather characteristics marked one of the occurences as either Asio or Bubo. The three determinations of owl remains in the fecal samples from the dens were collected at the same time that a barred owl was listed among the food litter there. Errington (1935) reported a juvenile great horned owl and a long-eared owl (Asio wilsonianus) among 1010 food items found at red fox dens.

Woodpeckers. The hairy woodpecker was represented in one of the trail droppings. This was the only positive identification of woodpecker remains. In 11 of the fecal passages the diagnostic parts were definitely determined as being either of woodpecker or perching bird.

Perching Birds. The proportion of perching bird (Passeriformes) identifications to total occurrences in droppings from the trails was 3.8 percent in Period I, 3.7 percent in Period II, and 2.0 percent in Period III (Tables 22, 23 and 24; Appendix). Because of technical difficulties from one-fourth to one-half of the perching bird representations had to be listed as undetermined. About the same proportion of the 35 perching bird representations in the 234 passages picked up at the dens was recorded as undetermined (Tables 6 and 21, Appendix). Of the determined perching bird remains most were of such infrequent occurrence in the fecal material that they seemed to have been taken more by chance than because of any particular species vulnerability. Among these were the blue jay, black-capped chickadee, robin (Turdus migratorius), meadowlark (Sturnella sp.), English sparrow (Passer domesticus), cardinal and goldfinch (Spinus tristis). At the dens a blue jay, a robin, a starling (Sturnus vulgarus), and the feathers of several passerine birds were noted. On January 18, 1939, a red fox dug a crow wing out of the snow but discarded it without eating any of it. A swamp sparrow (Melospiza georgiana), a white-breasted nuthatch and remains of a nighthawk (Chordeiles minor) were found where they had been left by foxes. Of perching birds that were at times importantly represented in the fecal material were fringillids apparently killed or weakened during blizzards and periods of extreme cold. The species principally affected, as identified in the fields and in the passages, were slate-colored juncos (Junco hiemalis) and tree sparrows (Spizella arborea). These were particularly evident following general emergency conditions in February, 1939, and January, 1940, and after the severe unseasonal blizzard of November 11, 1940. The effect of the November 11 blizzard on wildlife has been described (Scott and Baskett, 1940).

Game Birds.

Bob-white. Bob-white remains were identified in only 7 of the 1464 fecal passages examined. Even considering the difficulty of identifying specific avian remains, these records fail to reflect severe fox pressure on bob-whites on the Moingona area. Bob-white was represented only once in 79 red fox stomachs, intestines and complete fecal passages collected in Iowa in winter (Errington, 1937). In Minnesota on the northern edge of bob-white range Hatfield (1939) did not detect its remains in 29 winter stomachs. Quail remains were detected once in 15 red fox stomachs collected in January and February in Virginia (Nelson, 1933).

The extensive research of Errington and Hamerstrom (1936) demonstrated that predation losses to quail in winter were exacted particularly from populations in excess of carrying capacity. Carrying capacity determinations were not made for the covey territories on the Moingona area. However, attempts to make counts of the bob-whites were undertaken. During the winter of 1938-1939 to the best of the writer's knowledge there were near 125 bob-whites or 1 to 16 acres on the area; during the 1939-1940 winter a minimum of about 200 or 1 bird to 10 acres was estimated, and in the 1940-1941 winter the very best count showed only 49 birds or an average of about 1 to 40 acres. The occurrences of bob-white remains in the fecal material are obviously too few to lend much significance to analysis. However, during Period I, but a single determination of bob-white was recorded and that was in March. In Period II there were six identifications, two of which occurred in winter and four in spring. On January 20, 1940, sheared-off quail feathers were found together with tracks, indicating that the foxes had fed on two of these birds. Evidence indicating that these birds had died as a result of deep snow and severe cold was fair. During Period III when the bob-white population was at its lowest remains of these birds were not found in the fecal material.

This low frequency of bob-white remains lends further support to the findings of Errington (1934) who in two to four years of continuous field work found it possible to charge only an occasional loss of quail to foxes. It has been concluded that foxes, compared with great horned owls, are very inefficient winter enemies of bob-white (Errington, 1936).

Ring-necked Pheasant. The ring-necked pheasant was never present in large numbers. There were a few more birds on the area each winter than at any other time as a result of movement into winter concentrations. In winter an average of about 1 bird to 30 acres was considered a reasonable estimate of the population over that part of the area north of Bear Creek.

Although not appreciable there was a slight winter to winter increase in population during the years studied.

Although a few more identifications were made for pheasant than for bob-whites (Tables 22, 23 and 24; Appendix), there were still too few to reveal much of the pheasant-fox relationship. Of the total occurrences in Period I pheasant determinations made up 1.4 percent, in Period II 0.6 percent and in Period III 1.0 percent. Among the 222 droppings collected at rearing dens in 1940, 5, 2 of which were egg shell fragments, were listed as pheasant (Table 6, Appendix). Ring-necked pheasant was located in five places where it had been fed upon by foxes in the field, and it was listed once among the food debris at the den sites.

A comparison of the seasonal frequency of pheasant remains in the fecal material collected on trails indicates a tendency toward greatest relative proportion in winter and spring. It is possible that the winter increase in occurrences may be associated with severe weather and the gregarious tendencies of the birds and in spring with the excitement of courtship and the onset of nesting.

In 79 stomachs, intestines and complete fecal passages collected in Iowa in winter ring-necked pheasant remains were detected 5 times; while in spring and early summer pheasant was represented 173 times in 2110 fecal passages collected about dens (Errington, 1937). Hatfield (1939) found that pheasants made up 4.0 percent of the bulk in 29 red fox stomachs collected in winter and early spring in Minnesota.

Mourning Dove. Mourning doves were scarce on the area throughout most of the year. The only time that they were present in appreciable numbers was in the fall when flocks of them stopped to feed in hemp patches. These flocks of doves usually first became obvious in the hemp about mid-September and were largely gone by November. It is perhaps of significance then that four of the five mourning dove identifications occurred in the fall. By month their occurrences were: August, one; September, one; October, two; and November, one.

COLD-BLOODED VERTEBRATES.

"Lower vertebrates" were represented in 24 of the 2110 fecal passages collected in spring and early summer at dens of red foxes (Errington, 1937).

The remains of a blue racer (Coluber constrictor) were detected in 1 of the 1454 fecal droppings examined. This constituted the only determination of cold-blooded vertebrate in the material studied.

In the field a toad (Bufo americanus) was found where it had been left on the trail; nothing remained but the hind legs and the skin of the back. Possibly the poison glands of the back proved distasteful.

INVERTEBRATES.

Gastropods and diplopods. Undetermined gastropods were detected three times in the fecal passages. Diplopods appeared four times; in two Polydesmus sp. and Julus sp. were identified while two were undetermined. The remaining invertebrate occurrences were insects.

Insects.

Analyses of the fecal material from the Moingona Fox Range showed that insects made up a very substantial proportion of the warm weather diet of the foxes (Tables 7, 21, 25, 26 and 27; Appendix). In this the data of Hamilton (1935), Errington (1937), Dearborn (1932), Murie (1936) and Hamilton, Hosley and MacGregor (1937) agree. The findings of Southern and Watson (1941) and of Baranovskaia and Kolosov (1935) have been interpreted as showing that insects do not form a very large part of the diet of Vulpes vulpes.

Life history events particularly influence the availability of insects because of the accompanying changes in life form. Nearly all of the insects taken were in the adult form; only a few nymphs, larvae and eggs were detected.

Inspection of the data reveals that while over 50 kinds of insects were identified the bulk of the insects in the diet was made up by 7 genera. Those principal insects were: Melanoplus spp., Amblycorypha oblongifolia, Gryllus assimilis, Calosoma spp., Geotrupes, Phyllophaga spp. and Lucanus sp. The trends of these insects are presented in graphs (Figs. 52 and 53). All of these are in two orders, Orthoptera and Coleoptera. In order to simplify the analysis of the insects in the tables, only the seven principal insects, other forms in the same family and major groups are listed; those not listed will be mentioned in the discussion.

Orthoptera. Melanopli grasshoppers were probably taken in greater relative amounts than any other insect. They first appeared in the scats in June or July, reached a peak in fall and continued appearing to a limited extent as late as January (Fig. 52). Those that were detected in the winter months and some that regularly occurred in March were thought to have been

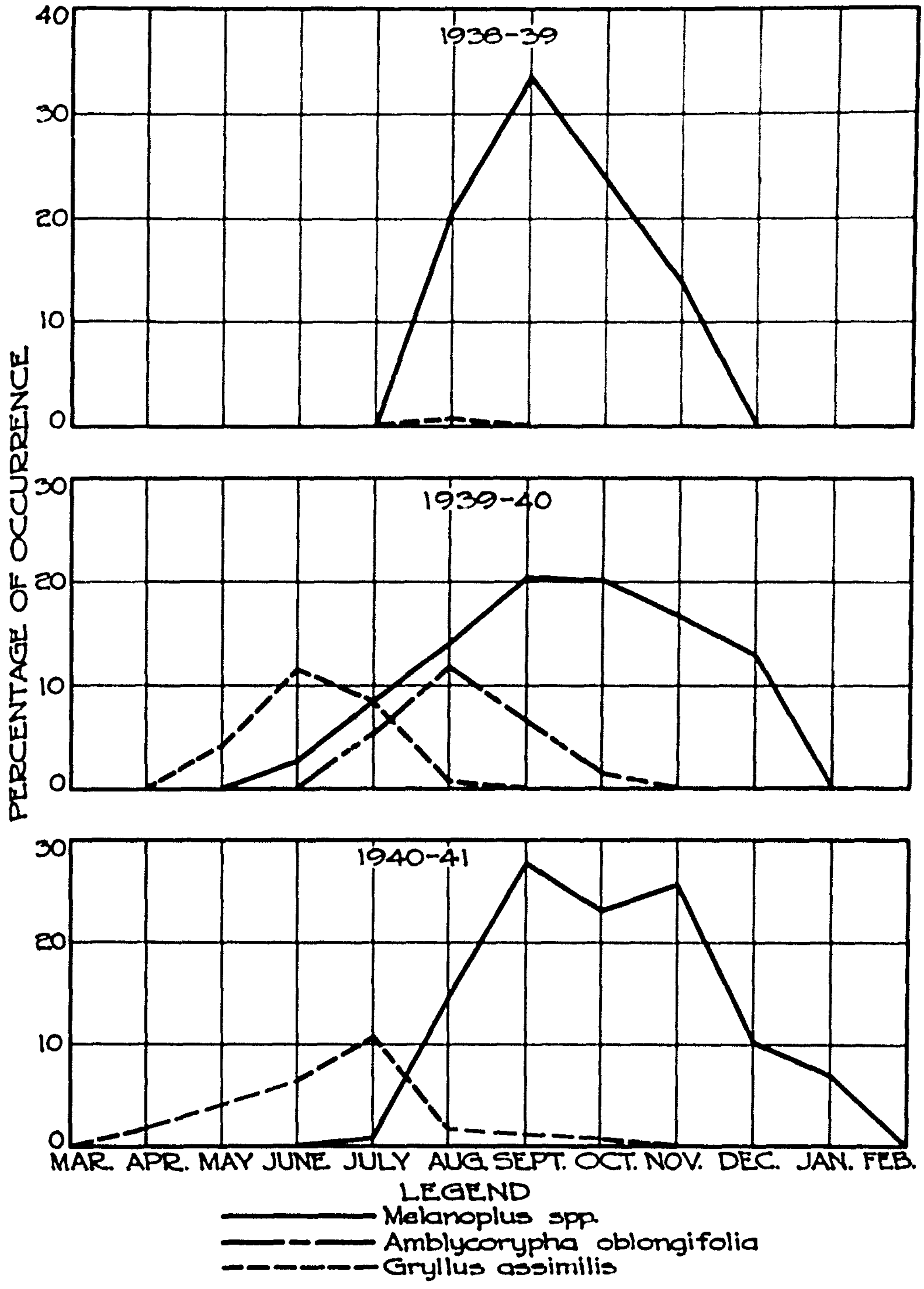

Fig. 52. Monthly trends of the principal Orthoptera in the diet.

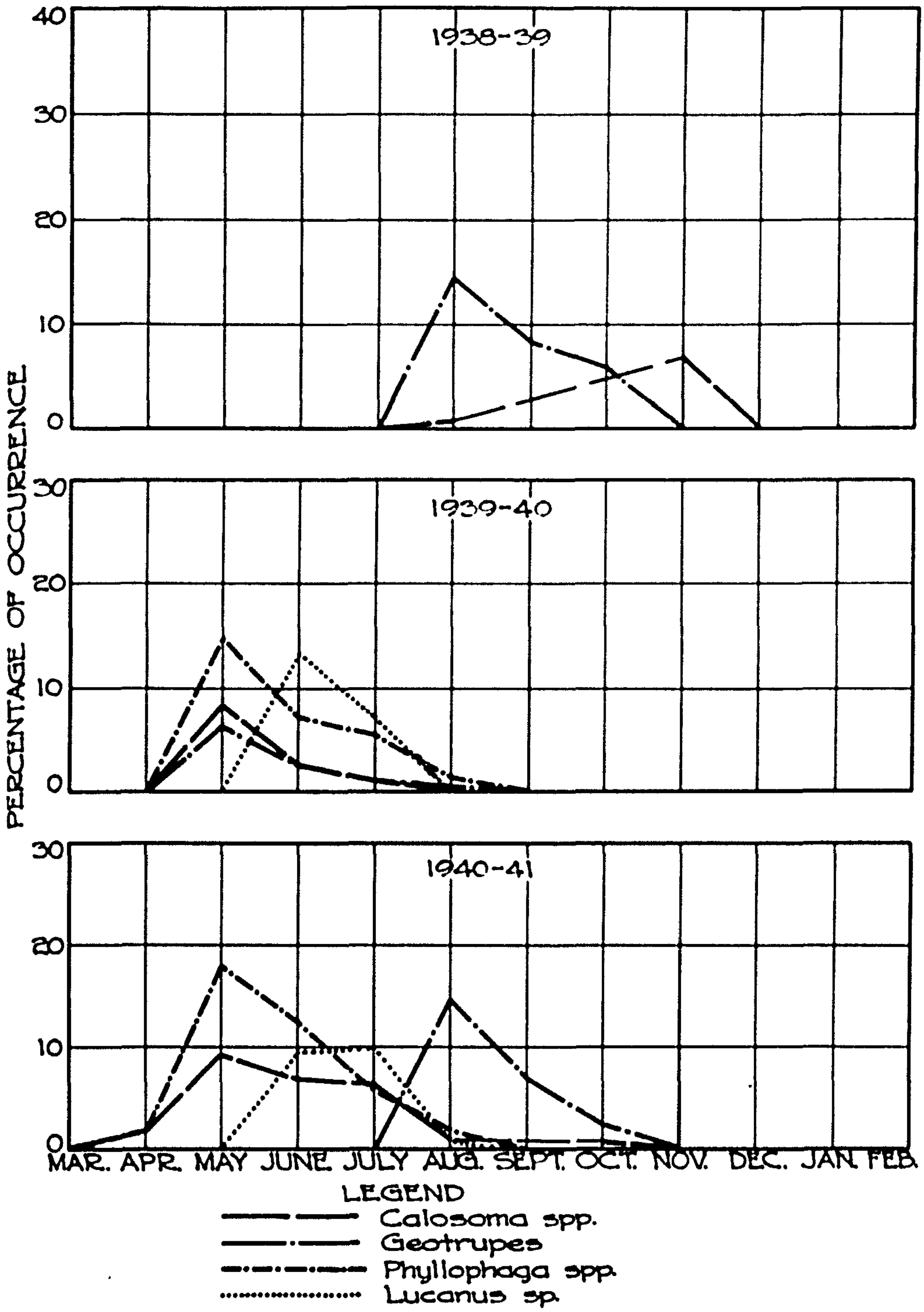

Fig. 53. Monthly trends of the principal Coleoptera in the diet.

adults kept in a state of preservation by the cold. Experience with feeding caged foxes indicated that grasshoppers are relished. Most of these grasshoppers were identified as Melanoplus differentialis and red-legged forms such as M. femur-rubrum. Other Acrididae, occuring in from 1 to 13 of the passages were: Orphulella pelidna, Arphia, Chortophaga sp., Hippiscus rugosus, Pardalophora sp., Dissosteira carolina, Schistocerca, and Trachyrachis kiowa.

Tettigoniidae would have been represented in relatively few samples if it had not been for the large number of Amblycorypha oblongifolia taken during the summer of 1939)Fig. 52); no trace of it was detected at any other time. Eggs were associated with remains of the adults of this species in 31 of its 54 occurrences. The insects were probably taken during oviposition. Seventeen occurrences of Tettigoniidae were undetermined and Microcentrum sp., Conocephalus sp. and Ceuthophilus sp. were each identified once.

Gryllus assimilis, the only representative of the Gryllidae in the fecal material, was among the first live insects in spring to be taken by the foxes (Fig. 52). It appeared 95 times in the droppings collected on the trails, 12 times in 73 scats picked up in May at dens of the Cyclone Creek family, in 4 of 16 fecal samples collected in June at den sites of the Second Run family, and in 1 of the 12 droppings from dens in May, 1939.

Odonata, Homoptera and Hemiptera. An undetermined dragon-fly occurred once. Homoptera was represented by two identifications of Cicadidae. In four appearances of Hemiptera five species were identified as follows: Euschistus variolarius, Clorosternum hilare, Acrosternum sp., Piesma cinerea and Blissus leucopterus. The latter two, the piesmid and the chinch bug, were almost certainly taken by accident.

Lepidoptera and Diptera. Lepidoptera were detected in 7 of the 12 scats from the den in May, 1939, in 12 of 222 droppings picked up at dens in 1940 and in 19 of 1220 collected on the trails. All were larvae except two from the trail material. Geometridae and Phalaenidae each occurred once and of the Noctuidae there were 11 Nephelodes emmedonia and 2 Paipaipema sp. Seven appearances of Nephelodes emmedonia and 1 of Paipaipema sp. were for the 12 passages collected at the den in May, 1939.

Diptera appeared 4 times in 222 passages collected at dens in 1940 and 21 times in the trail passages. Fourteen of the occurrences were for Asilidae, Robber-flies; one was for larval sarcophagids that had no doubt been taken with carrion.

Coleoptera. More species of Coleoptera were identified than any for other order. Eleven of its families were represented.

Cincindela sexguttata was identified once to represent the Cincindelidae.

Carabidae was recorded 201 times in the 1220 passages collected on trails, and 69 times in 234 dens. The many forms in this family make specific determinations difficult, and as a result 96 or about half of occurrences in the trail material and 33 or about half of the occurrences in den scats could not be determined. Calosoma spp. were common in the passages (Fig. 53), occurring 74 times in the trail passages and 52 times in 234 passages from den sits. Of these Calosoma calidum was the most common while C. scrutator and C. externum appeared to a lesser extent. Other determined Carabidae and the number of times each occurred were: Carabus spp. 6, Elaphrus ruscarius 1, Pasimachus elongatus 7, Dicaelus sculptilis 2, Scarites 7, Evarthrus 34, Chlaenius 13, Harpalus caliginosos 46, H. pennsylvanicus 1 and H. pleuriticus 1.

Hydrophylidae was represented once by Hydrous triangularis. Necrophorus was identified four times in five detections of Silphidae. Undetermined Stephylinidae occurred three times and Tenebrionidae appeared once. Of the five records for Elateridae Monocrepidus auritus was identified twice and Melanotus sp. once. For Nitidulidae Glischrochilus fasciatus occurred once. Undetermined Erotylidae was detected once.

Scarabaeidae were recorded 234 times in the trail droppings and 87 times in the 234 fecal samples from den sites. The members of this family were more easily identified than those of Carabidae; only 11 were listed as undetermined. Canthon laevis, Trox sp., Ataenius ovatulus and Ligyrodes relictus each occurred once. There were a few appearances each for Copris anaglypticus, Onthophagus, Aphodius, Bolboceras, Pelidnota punctata, Xyloroytes satyrus and Euphoria. Represented more importantly was Bolbocerasoma farctum with 35 occurrences, Ligyrus with 22, Geotrupes with 73 and Phyllophaga spp. with 205. The trend of Geotrupes and Phyllophaga spp. representations in the fecal material is shown in the graph (Fig. 53). Occurrences of Geotrupes were relatively fewer and ceased earlier in 1939 than in 1938 and 1940.

Lucanidae occurred 92 times in the 1454 passages examined. All were for Lucanus sp., probably dama, except for one occurrence of Dorcus sp. Lucanus sp. was recorded only once in Period I, probably because of the few passages collected in June and July when it ordinarily appeared. In Period II and III it occurred 22 and 69 times respectively with a trend as in the graph (Fig. 53).

Chrysomelidae was represented in two droppings, once by *Typophorus canellus*. Curculionidae was listed by reason of one appearance of *Anametis granulatus*.

Hymenoptera. Hymenoptera occurred 39 times; 2 of these were Andrenidae and the remainder were Formicidae. As the Formicidae were usually represented by one and never more than a few adult individuals it was considered very probable that they were taken incidental to feeding on other foods. It seems likely that if these insects had been taken from a hill greater numbers of individuals as well as larvae and pupae would have been found. The forms identified and the number of occurrences of each were: *Formica* 3, *Myrmica brevinodis* 22, *Ponera* sp. 1, *Aphaenogaster* 8, *Prenolepis imparis* 19, *Lasius* sp. 1, *Tapinoma sessile* 5, *Solenopsis* 5, and *Campanotus pennsylvanicus* 5. The remainder were undetermined.

PLANTS.

Grass-Sedge. Blade-like leaves, typical grasses and sedges, were found in 62 of the scats from the trails and in 3 of the fecal samples collected at the dens. The data show a tendency towards greater frequencies of grass-sedge-like leaves during the cold weather months (Tables 28, 29 and 30; Appendix). Much green "grass" was found in 1 of 40 red fox stomachs taken between December 17, 1932, and June 13, 1933, in Iowa (Errington, 1935). Hamilton (1935) found that "grasses" made up 13.9 percent of the total food in 206 red fox stomachs collected during the fall and winter in New York and New England. "Grass" made up 2.6 percent of the total food bulk in 29 red fox stomachs collected in winter in Minnesota; it made up practically the entire contents of 2 stomachs (Hatfield, 1939). In this study six droppings were collected that were composed entirely of grass-sedge-like leaves; there was sufficient material to allow careful examination of their diagnostic characters. The remains in one were identified as Carex sp. It was of interest to note that in the U.S.S.R. Baranovskaia and Kolosov (1935) found a fecal passage of Vulpes vulpes that was composed entirely of Carex sp. leaves. The contents of two fecal passages were largely Carex sp. with some grass. The contents of another were about 75 percent grass and about 25 percent Carex sp. Grass alone was found in two, probably Muhlenbergia sp. in one case and Poa sp. in the other.

Corn. Fragments of corn kernels occurred 54 times in the fecal material examined. Corn was often accompanied by silk, indicating that it had been chewed directly from the cob. Corn kernels that were not crushed and could be associated with avian remains were not included as food. Most of the fall occurrences were of corn in the "milk stage". As with the grass-sedge leaves there is a tendency for the corn to be most frequent during the cold weather months (Tables 28, 29 and 30; Appendix). This is quite likely a kind of compensatory trend resulting from the usual high availability of fleshy fruits in the warm weather months. Corn made up a greater part of the total occurrences in Period I (3.8%) when the crop of fleshy fruits was very light than in Period II (1.6%) and Period III (1.3%) when fleshy fruit was abundantly available. Corn was recorded five times in the winter, spring and early summer material reported by Murie (1936).

Oats. Oat grains were detected in four of the fecal passages, one in

December, 1939, and three in December, 1940. These occurred in some quantity and were not associated with bird remains. In two of the representations hulls were present, indicating that the grain may have been pulled from shocks forgotten in the field.

Acorns. Murie (1936) listed acorn as from 2 of the 763 fecal passages collected in winter, spring and early summer on the George Reserve. On December 29, 1939 following a light snow, a fox on the Moingona area had worked around beneath some oak trees scratching out acorns; freshly broken fragments indicated that the acorns had been chewed. During Period I acorn remains appeared twice (0.4%), once in January and once in March. In Period II, however, they occurred 48 times (5.1%), 40 of which were detected in passages for September and October. In Period III there was but a single occurrence (0.1%). The mast crop in the fall of 1939 was heavy, but it did not seem to be as proportionately greater than 1938 and 1940 as its occurrences in the passages indicated.

Elm Seeds. There was an extremely heavy yield of elm seeds on the area in May and June of 1940. Elm seeds occurred in substantial amounts in 10 of the 47 fecal passages collected on the trails in June of that year. They appeared in 8 of 89 passages for May and in 4 of 16 passages for June collected at the den sites. The seeds did not seem to have been affected by the digestive processes.

Mulberry. In 1938 the remains of mulberry fruits were not found in the droppings, possibly because of a light crop, few summer fecal samples (36), and the lack of agreement in the location of the territories of the foxes and the location of the trees. Again in 1939 none were recorded, probably because the territories of the foxes did not include the three locations. In 1940 when the territory of at least one family of foxes included most of the tree locations mulberry was detected 110 times as follows: June 4 (3.0%), July 93 (24.3%), August 7 (4.2%) and September 3 (1.6%). These trends are shown in the graph (Fig. 54) for comparison with those of the other fruits.

Gooseberries. Remains of gooseberry fruits were not detected in 1938. In 1939, however, they occurred 33 times as follows: June 1(1.7%), July 24 (26.5%) and August 8 (2.7%); in 1940 there were 31 appearances as follows: July 21 (5.3%), August 9 (5.4%) and September 1 (0.5%)(Fig. 54).

Apple. Apples have been reported among the winter foods of red foxes (Hamilton, 1935). Cultivated apples were not known to have been available to the foxes on the Moingona area, and the remains of those fruits were not detected in the fecal material. Fruits of the red haw and Western crab apple, however, were present and easily available to the foxes. Only one occurrence (Western crab apple), however, was detected in the droppings inspected.

Rose. The seeds and skins of rose hips were detected in one dropping.

Service-berry. The remains of the fruit of the service-berry were detected 33 times in the 1939 and 1940 seasons, mainly in June. The trend is shown in the graph (Fig. 54). In 300 fecal passages collected in 1930, Dearborn (1932) found 31.5 percent of the volume to have been made up by plant remains; of these, remains of the fruit of the service-berry made up 64.8%.

Plum. Fruit remains of the American plum were detected in 64 of the

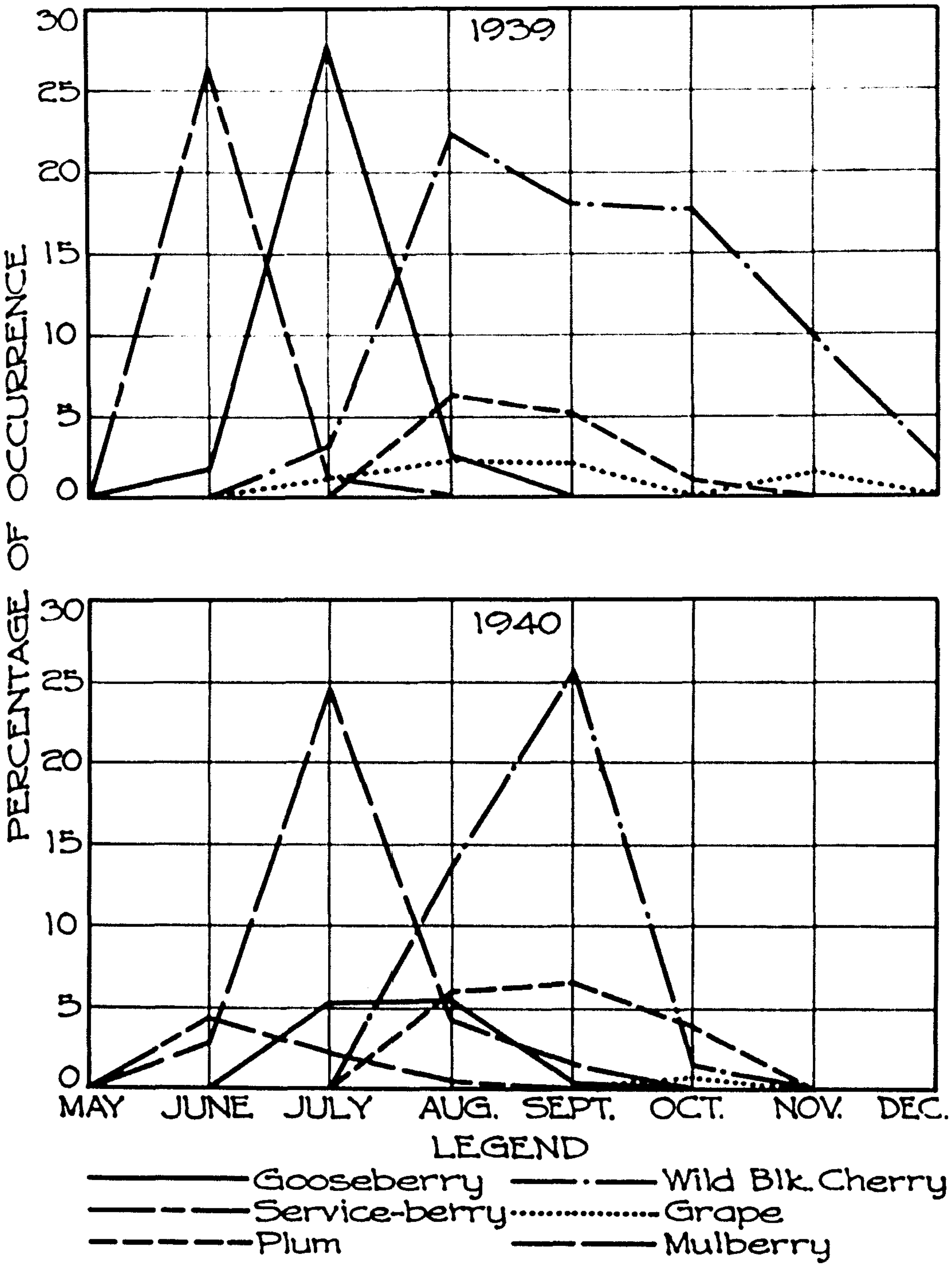

Fig. 54. Monthly trends of fleshy fruit representati^ns.

fecal passages examined. None occurred in 1938, but in 1939 there were 36 appearances as follows: August 19 (6.4%), September 15 (5.2%) and October 2 (1.0%). In 1940 it was detected 28 times as follows: August 10 (6.0%), September 13 (6.8%) and October 5 (4.0%) (Fig. 54).

Cherry. Hamilton, Hosley and MacGregor (1937) found the wild black cherry (Prunus serotina = Padus virginiana) 71 times in 131 mid-summer scats from Massachusetts; it was the most frequent food listed. In this study the fruits of wild black cherry did not occur during the first year. In 1939, however, they occurred 165 times as follows: July 3 (3.4%), August 67 (22.6%), September 52 (18.2%), October 35 (17.8%), November 6 (9.8%) and December 2 (2.1%). It appeared 74 times in 1940 as follows: August 23 (13.8%), September 49 (25.6%) and October 2 (1.6%)(Fig. 54).

Grape. A few occurrences of grape were noted by Murie (1936) and Hamilton, Hosley and MacGregor (1937). In the material from the Moingona area they did not occur in Period I, and in Period III when the grapes did not fruit abundantly there was only one representation. In Period II, however, the remains of the fruit of the grape were identified 15 times as follows: July 1 (1.1%), August 7 (2.4%), September 6 (2.1%) and November 1 (1.6%).

Catmint. The seeds and seed heads of catmint (Nepeta, prob. Cataria) appeared three times in the fecal material examined. Once a seed head of this plant was found along a fox trail in the snow where it had apparently been dropped.

Ground-cherry. The seeds and skins of the ground-cherry (Physalis) were identified in 11 of the fecal passages examined (Tables 28 and 30, Appendix).

Black Nightshade. The seeds and skins of the fruit of the black nightshade (<u>Solanum nigrum</u>) appeared in eight droppings (Tables 28, 29 and 30; Appendix).

Horse-nettle. The seeds and skins of the horse-nettle (<u>Solanum carolinense</u>) were found in three of the scats (Tables 28 and 30, Appendix).

Nonfood and Items of Questionable Dietary Value

Inspection of the food remains in the fecal passages resulted in the detection of many items of questionable or no dietary value. Dirt, sand and gravel were recorded, usually in insignificant amounts. On two occasions, however, over half the passage contents was loam, indicating that this material had probably not been accidentally taken. Sand and gravel appeared with considerable regularity in scats containing mulberries during July, 1940. Observations revealed much fox activity about a mulberry tree, the fruit of which fell on the sand and gravel of a dry run. Several times small amounts of gravel were thought to have been the grit content of avian prey.

The most unexpected item in the fecal passages was a folder of safety matches. A piece of tire tube was also recorded. As both of these items were found in late summer they may represent the feeding of young foxes. Late in the summer of 1939 an old galosh was observed to have been used as an object for play by young foxes. Possibly in the excitement fragments of such items are torn loose and swallowed. Lead shot, about No. 6 size, appeared twice; a single shot was present on each occurrence. One shot was accompanied by cottontail remains and the other by cottontail and pheasant.

Fragments of dead plant material were frequent in the passages. Pieces of rotted wood indicated that fragments might have been swallowed when tearing mouse nests out of rotted logs and stumps. Bits of dead grass or sedge were in many passages. Less common were fragments of weed stem, sections of twigs and rootlets. It was possible to identify one of the twigs as of red cedar and another as of prickly ash. A haselnut catkin appeared once, and fragments of moss were recorded several times. Occasionally unbroken seeds or chewed plant material seemed to be crop or stomach contents of prey. The importance of this source of plant food for the fox is difficult of evaluation.

Some plant debris may enter the digestive tract in play with some item. On three separate occasions the nut of the butternut (Juglans cinerea) was observed to have attracted the attention of foxes. Twice the nut seemed to have served as an object for play, probably by young foxes. Another time the nut was found where it had been dropped in the snow along a fox trail in mid-winter. The trail had been followed for approximately one mile, and it was not considered likely that the fox had obtained the nut in that distance. Possibly these nuts hold some attraction for foxes other than as items of food.

In addition to the seeds of fruits taken as food, there are many that are picked up in an accidental way, either as contained in prey, nipped off the plant by the fox or taken while feeding on food that has been in contact with loose seeds on the ground. A few, such as Lappula echinata, Cenchrus, Bidens, Geum canadense, Meibomia and Sanicula marylandica, are usually eaten along with prey in whose fur they cling or are plucked out of the fur of the fox itself and swallowed. In Tables 31, 32 and 33 (Appendix) a seasonal analysis of the seeds of questionable detary value taken from the 1220 passages collected away from rearing dens is presented. An analysis of the additional 234 passages collected from the rearing dens on the area shows the same low occurence of seeds as is found in the analyses of other passages collected in spring. As might be expected, the seeds occurred in greatest abundance and frequency during the fall. Of most frequent occurrence and abundance were Syntherisma Ischaemum, Syntherisma sanguinale, Chaetochloa glauca and Chaetochloa viridis. These plants were numerous on the area and were commonest in stubble fields where the foxes did much of their hunting. The seeds of these plants are of such a height that a fox might very conveniently nip at the heads or get them in its mouth in capturing prey. Perhaps the dissemination of such seeds as these by the fox bears some importance to bare areas where there is opportunity for establishment of the plants. In agricultural regions there is little to fear from the fox as a disseminator of weeds as may readily be interpreted from the small numbers of noxious weed seeds in the fecal passages. Furthermore such plants must already have been well established in an area before the fox could obtain many of them.

The fox itself contributes from its own body to the nonfood ingesta. In July, 1939, the deciduous molar, dm_3, of a young fox was extracted from the contents of a fecal passage, indicating that it had been swallowed by a young animal losing its first teeth. Another passage from May, 1940, was found to contain two deciduous incisors of a young fox. Wisps of fox fur were taken from among the food remains in 18 of the 1220 passages collected away from dens; in 5 of these cases Lappula echinata seeds accompanied the fur, indicating that the fur had been swallowed following a carding operation. Fox fur occurred eight times in late summer, five times in fall, not at all in winter, and five times in Spring. In the 222 passages examined from about rearing dens in the spring of 1940 for fur occurred twice. It did not occur in 12 such passages examined in the spring of 1939.

Parasitic insects were taken from a number of the passages. These could have been obtained by the fox either through eating parasitized prey or by biting them from its own body. In the 234 passages collected about rearing dens there was only 1 occurrence of parasitic insect. This was an immature bird louse (Goniocotes sp.); it was accompanied by the remains of a ring-necked pheasant, probably its host. In the 1220 passages collected away from dens bird lice occurred 4 times; all were with avian remains. Two were undetermined, and two were identified as Ricinus sp.; both of the latter were associated with the remains of slate-colored juncos.

Siphonaptera was somewhat more frequently represented than Mallophaga. No fleas were found in the scats collected at the rearing dens. In the 1220 passages collected away from the rearing dens, however, 6 species occurred 14 times. Cediopsylla simplex appeared in six passages. In Iowa this species has been reported from Sylvilagus floridanus, Vulpes regalis and Blarina brevicauda (Fox, 1940). Cediopsylla simplex was also collected on the young fox already mentioned as having been found dead on the Range on May 31, 1940. Sylvilagus floridanus remains were present with Cediopsylla simplex on all but one occurrence; it was then accompanied by Microtus and *Peromyscus* remains. *Hoplopsyllus affinis* was identified in six passages. In Iowa this species has been reported on the "house rat", "red fox" and "cottontail" by Fox (1940) and on *Vulpes regalis* by Smith (1941). *Sylvilagus floridanus* remains were included with each *Hoplopsyllus affinis* representation. *Ctenopthalmus pseudagyrtes* appeared once with remains of *Sylvilagus floridanus* and *Microtus* both of which have been indicated as hosts (Fox, 1940). *Opisocrostis bruneri*, commonly on Sciuridae, was found once; it was accompanied by *Sylvilagus floridanus* and *Microtus* sp. remains. There were two occurrences of *Epitedia wenmanni*, once with *Peromyscus* and *Microtus* remains and once with *Sylvilagus floridanus* remains. It has been reported on *Microtus* and *Peromyscus* but not on *Sylvilagus floridanus*. *Megabothris wagneri* was found in one passage; it accompanied remains of *Microtus* sp. and *Citellus tridecemlineatus*.

When the Northern white-footed mice on the area were infested with *Cuterebra*, probably *fontinalis*, (Scott and Snead, 1942), a larva of this warble was found in a passage defecated October 1 or 2, 1940 together with remains of its host.

Analysis of the fecal passages also revealed parasitic arachnids. In August, 1938, a mite, *Machrocheles*, a symbiont on the scarabaeid, *Geotrupes*, was listed twice; *Geotrupes* was present with each appearance. *Ixodes* sp. occurred once. *Ixodes kingi* was collected on the head of a young red fox from Rockwell, Iowa on April 18, 1938. The cottontail tick, *Haemophysalis leporis-palustris* was identified 8 times in the 1220 fecal passages located away from rearing dens. In 1938 there was one occurrence in passages dated for October; in 1939 there were two in June, one in May and three in October;

in 1940 one appeared in May. There was no more than one individual to an occurrence , and each was with remains of Sylvilagus floridanus. In the 12 passages gathered at a rearing den in May, 1939, this tick occurred once. In the 222 passages from rearing dens in the spring of 1940 there was 1 occurrence of an immature Haemophysalis in April; another was recorded in early May. In late May an adult Haemophysalis leporis-palustris appeared in one of the passages. All of these were found in the 156 passages collected about the rearing dens of the Cyclone Creek family. None were found in the 66 passages collected at the rearing dens of the Second Run family.

The common dog tick (Dermacentor variabilis) appeared regularly in spring and summer passages. Table 34 shows the frequency of occurrences of this tick in the passages collected away from rearing dens. Adult and immature forms were not reported for this analysis. The ticks are obviously most available to the fox in late spring and early summer. Perhaps something of the life cycle of this tick is reflected in the degree of occurrences in passages. In the 12 passages picked up at a rearing den in 1939 there was an occurrence of the dog tick and another tick that was probably this species. Of the 73 passages collected about the rearing dens of the Cyclone Creek family in May, 1940, there were 14 occurrences of the dog tick. It did not occur in 83 passages that were collected from the Cyclone Creek family in April. In the 50 passages collected around the rearing dens of the Second Run family in April and May, 1940, no dog ticks were observed. One was found, however, in the 16 passages collected from this family early in June. There is then a generally greater frequency of dog ticks in the passages of the Cyclone Creek family than in those of the Second Run family. This reflects a territorial difference. In May the

Table 34

Monthly Occurrences of the Common Dog Tick
in Passages Collected Away from Rearing Dens.

	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1938									
No. Passages				3	5	28	19	12	17
No. Occurrences						2		1	
1939									
No. Passages	50	22	12	25	33	74	60	47	22
No. Occurrences		3	3	3	4	3		1	
1940									
No. Passages	36	60	58	47	127	43	57	39	30
No. Occurrences		1	6	8	4	2			

Second Creek family occupied dens in closely grazed pasture land with a somewhat open stand of trees and little brushy undergrowth. The Cyclone Creek family occupied dens in brushy second growth. The latter appears to represent good environment for the dog tick. Three specimens of the dog tick were taken from the young fox found dead on the Range on May 31, 1940.

Nematodes were also among the items located in the fecal passages. *Toxascaris leonina* was identified in two passages and *Toxascaris*, probably *leonina*, in one. Smith (1941) found *Toxascaris leonina* to have a greater frequency of occurrence than any other internal parasite of Iowa foxes; of 234 carcasses examined, it appeared in 140. *Physaloptera*, probably *felidis*, was taken from three passages. Smith (1941) identified *Physaloptera felidis* in 80 of 234 fox carcasses. This species ranked next to *Toxascaris leonina* in number of occurrences.

SUMMARY

The Northern Plains red fox was studied as a living organism in a specific area with particular attention for the interrelationships resulting from the fox's feeding. The research was accomplished by field and laboratory methods involving some experimentation with captive animals. The intensive field work was carried out on the Moingona Fox Range in the Des Moines River Valley in Central Iowa while occasional observations were made contemporaneously in other parts of the State. The research extended through the period from June, 1938 to July, 1941.

Observations in the field were most productive when concentrated upon the evidences of "signs" left by the red fox in its life's activity. The techniques employed in locating, recognizing and interpreting these "signs" were discussed in detail. The home range, movements and life history of the red foxes were importantly related to the food interrelationships. Home range and movements reflected in the diet because the animals naturally fed within the limits of their living space. Feeding behavior was examined in an effort to understand something of species vulnerability.

The feeding tendencies were investigated by analysis of fecal passages because the number of samples available made possible a continuous determination of the relative proportions of the foods consumed. During the study 1454 fecal passages were collected and analysed; 234 of these were picked up at dens. The latter were used in evaluations of the effect of early life on the feeding tendencies of red foxes.

The red foxes were found to be primarily carnivorous with substantial quantities of insect and plant foods being consumed when available. Warm-blooded vertebrates were less frequent in the warm weather diet than in the cold weather diet whereas the reverse was true for insects and plant foods. The principal staple foods were cottontails and mice, especially Peromyscus and Microtus.

The red foxes seemed to have food preferences. The meadow mouse was high on the scale of preferences. Insectivores and weasels were regularly left uneaten. Weasels appeared to be particularly unsatisfactory as food. Carrion that was advanced in decay did not seem to be attractive food for the foxes.

Differences were noted in a comparison of the frequency of occurrences of the principal food groups in the fecal passages from the trails and those from the dens. In April, when the pups were most dependent upon the adults for food, the remains of warm-blooded vertebrates were more frequent in the fecal material from the dens than that from the trails. At the same time limited occurrences of invertebrate and plant remains were detected in passages from the trails while neither were found in passages from the dens. In May, when the pups were presumably less dependent on the adults, warm-blooded vertebrates were not so frequent in the den material and were more frequent in that from the trails. Also in May the invertebrate and plant representations markedly increased in the passages found at the dens.

Within the limits of its fundamentally carnivorous nature the red fox was mainly influenced in its feeding by availability. It was obvious that the foods consumed must first have been available. On the whole the proportions of individual food items, however, seemed to respond more to the relative availabilities of all items in the diet than to their specific availabilities. Fluctuations occurred in the frequency of occurrences of some foods for which no appreciable change in availability was evident simply because other foods became relatively more or less available.

There seemed to be no important lack of utilization of suitable foods. The foxes ate carrion not too far advanced in decay and frequently items that they killed and did not eat were readily consumed by animal associates. So far as could be determined these foxes did not exert a dominant influence upon the populations of the prey animals regularly consumed. The direction of seasonal and annual population trends seemed to continued unchanged by the pressure of fox predation.

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APPENDIX

Table 1

Numbers of Individual Food Items Located in the Field

	Period I	Period II	Period III	Totals
Bufo americanus	1			1
Gallus gallus	2	5	2	9
Colinus virginianus		2		2
Phasianus colchicus	2	2	1	5
Zenaidura macroura			1	1
Chordeiles minor			1	1
Corvus brachyhrynchos	1			1
Sitta carolinensis			1	1
FRINGILLIDAE, undetermined			2	2
Spizella arborea		3		3
Melospiza georgiana	1			1
Didelphis virginiana			1	1
Scalopus aquaticus	1	4	5	10
Cryptotis parva		1	1	2
Blarina brevicauda	1	3		4
Procyon lotor		1		1
Mustela frenata		1	1	2
Mustela vison			1	1
Rodent, undetermined	1			1
Peromyscus, spp.	4	3	2	9
Microtus sp.	7	3	1	11
Sylvilagus floridanus	9	20	8	37
Bos taurus	1			1
Sus scrofa		1	1	2
Acorns, *Quercus* sp.		1*		1

*An undetermined number of acorns were scratched out of the snow and eaten. Much "sign" of foxes was also seen about trees bearing fruit that was appearing in the fecal passages, and although there was no question but that the foxes were eating the fruit the "sign" did not show it.

Table 2

Occurrences of General Food Groups in Fecal Passages
from the Trails for Period I

		Mammals		Birds		Invertebrates		Plants	
		Occurrences		Occurrences		Occurrences		Occurrences	
	No. of Passages	No.	Pctg. Tot. No.	No.	Pctg. Tot. No.	No.	Pctg. Tot. No.	No.	Pctg. Tot. No.
June	3	3	42.9	1	14.2	3	42.9	0	0.0
July	5	5	50.0	1	10.0	4	40.0	0	0.0
August	28	27	35.5	17	22.4	28	36.8	4	5.3
Summer	36	35	37.6	19	20.5	35	37.6	4	4.3
September	19	19	38.8	5	10.2	19	38.8	6	12.2
October	12	12	44.5	3	11.1	8	29.6	4	14.8
November	17	16	55.2	3	10.3	6	20.7	4	13.8
Fall	48	47	44.8	11	10.5	33	31.4	14	13.3
December	35	35	76.1	5	10.9	0	0.0	6	13.0
January	32	32	71.1	6	13.3	0	0.0	7	15.6
February	13	13	56.5	9	39.1	0	0.0	1	4.4
Winter	80	80	70.2	20	17.5	0	0.0	14	12.3
March	50	50	62.5	15	18.7	11	13.8	4	5.0
April	22	22	64.7	8	23.5	3	8.8	1	3.0
May	12	12	44.5	6	22.2	9	33.3	0	
Spring	84	84	59.6	29	20.6	23	16.3	5	3.5
Period I	248	246	54.3	79	17.4	91	20.1	37	8.2

Table 3

Occurrences of General Food Groups in Fecal Passages from the Trails for Period II

	No. of Passages	Mammals Occurrences No.	Mammals Pctg. Tot. No.	Birds Occurrences No.	Birds Pctg. Tot. No.	Invertebrates Occurrences No.	Invertebrates Pctg. Tot. No.	Plants Occurrences No.	Plants Pctg. Tot. No.
June	25	15	26.3	1	1.8	23	40.3	18	31.6
July	33	19	23.5	5	6.2	30	37.0	27	33.3
August	74	59	28.9	15	7.4	59	28.9	71	34.8
Summer	132	93	27.2	21	6.1	112	32.8	116	33.9
September	60	50	29.2	17	10.0	46	26.9	58	33.9
October	47	45	34.9	14	10.8	28	21.7	42	32.6
November	22	22	45.8	7	14.6	8	16.7	11	22.9
Fall	129	117	33.6	38	10.9	82	23.6	111	31.9
December	34	34	49.3	18	26.1	9	13.0	8	11.6
January	47	47	61.8	20	26.3	0	0.0	9	11.9
February	19	19	79.2	5	20.8	0	0.0	0	0.0
Winter	100	100	59.2	43	25.4	9	5.3	17	10.1
March	36	36	67.9	12	22.6	1	1.9	4	7.6
April	60	59	62.8	24	25.5	5	5.3	6	6.4
May	58	55	42.7	31	24.0	35	27.1	8	6.2
Spring	154	150	54.3	67	24.3	41	14.9	18	6.5
Period II	515	460	40.5	169	14.9	244	21.5	262	23.1

Table 4

Occurrences of General Food Groups in Fecal Passages
from the Trails for Period III

	No. of Passages	Mammals Occurrences No.	Mammals Occurrences Pctg. Tot. No.	Birds Occurrences No.	Birds Occurrences Pctg. Tot. No.	Invertebrates Occurrences No.	Invertebrates Occurrences Pctg. Tot. No.	Plants Occurrences No.	Plants Occurrences Pctg. Tot. No.
June	47	40	32.5	18	14.6	45	36.6	20	16.3
July[1/]	127	87	26.5	22	6.7	110	33.6	108	32.9
August	43	31	29.8	4	3.9	36	34.6	33	31.7
Summer[1/]	217	158	28.5	44	7.9	191	34.4	161	29.0
September	57	31	21.2	9	6.2	51	34.9	55	37.7
October	39	38	34.5	14	12.7	30	27.3	28	25.5
November	30	30	42.9	17	24.3	18	25.7	5	7.1
Fall	126	99	30.4	40	12.2	99	30.4	88	27.0
December	37	36	52.2	20	29.0	7	10.1	6	8.7
January	23	22	75.9	2	6.9	2	6.9	3	10.3
February	19	19	82.6	3	13.0	0	0.0	1	4.4
Winter	79	77	63.6	25	20.7	9	7.4	10	8.3
March	33	33	66.0	11	22.0	4	8.0	2	4.0
April	20	18	64.3	7	25.0	1	3.6	2	7.1
May									
Spring	53	51	65.4	18	23.1	5	6.4	4	5.1
Period III[1/]	475	385	35.6	127	11.8	304	28.1	263	24.4

[1/] Cold-blooded vertebrate: 0.3 percent in July, 0.2 percent in Summer, and 0.1 for the year.

Table 5

Mammal Remains in Fecal Passages Collected at Rearing Dens in 1940

	APRIL				MAY				JUNE	
	SEC. RUN FAMILY So. Range Dens 1,2,3 April 7 to 30		CYCLONE CR. FAMILY No. Range Dens 1,2,3 April 5 to 28-30		SEC. RUN FAMILY So. Range Dens 4,5 May 1 to 29-31		CYCLONE CR. FAMILY No. Range Dens 3,4 May 7 to 30		SEC. RUN FAMILY So. Range Den 6 June 1 to 8-10	
No. fecal passages	34		83		16		73		16	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
MAMMALS	34	75.6	83	70.9	14	34.1	73	43.2	13	38.2
Undetermined	1	3.6								
Determined	20	72.0								
INSECTIVORES			1	0.6			1	0.4	2	4.8
Scalopus aquaticus			1	0.6					2	4.8
Blarina brevicauda							1	0.4		
CARNIVORES	1	1.6								
CANIDAE	1	1.6								
RODENTS	25	40.0	47	26.1	3	6.4	30	12.8	3	7.2
Undetermined	6	12.0	4	2.2	1	3.2	2	0.9		
Determined	14	28.0	43	23.8	1	3.2	28	12.0		
Citellus tridecemlineatus							1	0.4		
Tamias striatus			2	1.0			1	0.4	1	1.8
Sciurus niger							2	0.8		
Reithrodontomys megalotis	1	1.3	6	3.0						
Peromyscus	4	5.1	13	6.6	1	1.1	15	5.8		
Synaptomys cooperi	1	1.3			1	1.1	2	0.8	1	1.8
Microtus	16	20.4	24	12.2	1	1.1	10	3.9	2	3.6
Rattus norvegicus			2	1.0						
RABBITS	19	30.4	75	41.6	13	27.7	69	29.4	11	26.3
Sylvilagus floridanus	19	30.4	75	41.6	13	27.7	69	29.4	11	26.3
HOOFED MAMMALS			5	2.8			1	0.4		
Sus scrofa			5	2.8			1	0.4		

Table 6

Bird Remains in Fecal Passages Collected at Rearing Dens in 1940

	APRIL				MAY				JUNE	
	SEC. RUN FAMILY So. Range: Dens 1,2,3 April 7 to 30		CYCLONE CR. FAMILY No. Range: Dens 1,2,3 April 5 to 28-30		SEC. RUN: FAMILY So. Range Dens 4,5 May 1 to 29-31		CYCLONE CR. FAMILY No. Range Dens 3, 4 May 7 to 30		SEC. RUN FAMILY So. Range Den 6 June 1 to 8-10	
No. fecal passages	34		83		16		73		16	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
BIRDS	11	24.4	34	29.1	9	22.0	27	16.0	2	5.9
Undetermined	4	8.9	18	15.4			10	5.9		
Determined	7	15.6	16	13.7			17	10.1		
NONGAME	6	13.3	16	13.7			13	7.3		
GALLIFORMES			1	1.0						
Gallus gallus			1	1.0						
STRIGIFORMES			3	2.9						
PASSERIFORMES	6	13.3	10	9.8			13	7.3		
Undetermined	2	8.9					12	5.5		
Determined	1	4.4					4	1.8		
FRINGILLIDAE	1	4.4					4	1.8		
GAME	1	2.2					5	2.8		
GALLIFORMES							5	2.8		
Phasianus colchicus							5	2.8		
COLUMBIFORMES	1	2.2								
Zenaidura macroura	1	2.2								

Table 7

Invertebrate Remains in Fecal Passages Collected at Rearing Dens in 1940

	MAY				JUNE	
	SEC. RUN FAMILY So. Range Dens 4,5 May 1 to 29 - 31		CYCLONE CR. FAMILY, No. Range Dens 3,4 May 7 to 30		SEC. RUN FAMILY So. Range Den 6 June 1 to 8-10	
No. fecal passages	16		73		16	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
INVERTEBRATES	15	36.6	61	36.1	15	44.1
DIPLOPODS			1	0.6		
INSECTS	15	36.6	61	35.5	15	44.1
Undetermined			2	1.5		
Determined			45	34.0		
ORTHOPTERA			12	4.8	4	6.8
ACRIDIDAE					1	1.4
Arphia					1	1.4
GRYLLIDAE			12	4.8	4	5.4
Gryllus assimilis			12	4.8	4	5.4
LEPIDOPTERA	3	4.6	4	1.6	5	8.5
DIPTERA	1	1.5	3	1.2		
COLEOPTERA	15	22.9	58	23.2	15	25.5
CARABIDAE	10	9.2	40	10.1	10	10.2
Undetermined	5	3.5	21	4.2	4	3.4
Determined	8	5.6	29	5.8	8	6.8
Calosoma spp.	13	4.6	26	3.0	10	5.7
Pasimachus elongatus			1	0.1		
Dicaelus sculptilis			2	0.2		
Scarites			1	0.1		
Pterostichus			2	0.2		
Evarthrus	1	0.4	9	1.0	1	0.6
Chlaenius	2	0.7	5	0.6	1	0.6
Harpalus caliginosus			3	0.4		
Harpalus pleuriticus			1	0.1		
SILPHIDAE			1	0.3		
STAPHYLINIDAE			3	0.8		
TENEBRIONIDAE			1	0.3		
SCARABAEIDAE	15	13.7	46	11.6	15	15.3
Undetermined			1	0.3		
Determined			46	11.3		
Copris anaglypticus	2	1.5				
Trox	1	0.8				
Aphodius			1	0.2		
Phyllophaga	15	11.4	46	11.1	15	15.3
CHRYSOMELIDAE			1	0.3		
HYMENOPTERA	5	7.6	8	3.2	2	3.4
FORMICIDAE	5	7.6	8	3.2	1	1.7
ANDRENIDAE					1	1.7

Table 9

Differences in Occurrences of Mammal Remains in Fecal Passages from the Trails on the North and South Ranges, 1940

	April 1 - 23		April 23 - June 20		June 20 - July 31		August		Totals Apr. 1 - Sept 1	
Ranges	S.	N.	S.	N.	S.	N.	S.	N.	S.	N.
No. Fecal Passages	12	21	21	37	50	102	16	20	99	180
MAMMALS	12	21	21	35	33	74	10	16	76	146
Undetermined		2			4				4	2
Determined		20			29				72	145
INSECTIVORES		1	2	1	8	11	1	2	11	15
Scalopus aquaticus			2	1	8	10	1	1	11	12
Blarina brevicauda		1				1		1		3
RODENTS	7	14	9	13	10	40	6	11	32	78
Undetermined	1			1	2	5	3	2	6	8
Determined	6			13	8	35	4	9	27	71
Marmota monax						1				1
Citellus tridecemlineatus					1	3		1	1	4
Citellus franklini								1		1
Tamias striatus				2	2	4		3	2	9
Sciurus niger	1	2	1	2	1	5	2		5	9
Glaucomys volans			1						1	
Reithrodontomys megalotis		3		2		1				6
Peromyscus		7	3	4		11	1	2	4	24
Synaptomys cooperi	1	1	1		1	2			3	3
Microtus	5	6	4	5	4	14	2	4	15	29
Mus musculus		1								1
Rattus norvegicus		1				1	1		1	2
RABBITS	8	17	17	30	14	40	3	8	42	95
Sylvilagus floridanus	8	17	17	30	14	40	3	8	42	95
HOOFED MAMMALS				3						3
Sus scrofa				3						3

Table 10

Differences in Occurrences of Bird Remains in Fecal Passages from the Trails on the North and South Ranges, 1940

	April 1 - 23		April 23 - June 20		June 20 - July 31		August		Totals Apr. 1 - Sept. 1	
Ranges	S.	N.	S.	N.	S.	N.	S.	N.	S.	N.
No. Fecal Passages	12	21	21	37	50	102	16	20	99	180
BIRDS	7	8	9	10	15	16	3	2	34	36
Undetermined	1	4	6	5	12	7	1		20	16
Determined	6	5	3	5	3	9	2		14	19
NONGAME	5	5	3	4	3	7	2	2	13	18
GALLIFORMES	2	2			1	4	2	1	5	7
Gallus gallus	2	2			1	4	2	1	5	7
PASSERIFORMES - PICIFORMES	3								3	
PASSERIFORMES		3	2	3	2	3		1	4	10
Undetermined				1	1				1	1
Determined				2	1				1	2
FRINGILLIDAE				2	1	3			1	5
GAME	2			2		2			2	4
GALLIFORMES	2			2		2			2	4
Colinus virginianus	2								2	
Phasianus colchicus				2		2				4

Table 11

Differences in Occurrences of Invertebrate Remains in Fecal Passages from the Trails on the North and South Ranges, 1940

	April 23- June 20		June 20- July 31		August		Totals[1/] Apr. 1 - Sept. 1	
Ranges	S.	N.	S.	N.	S.	N.	S.	N.
No. fecal passages	21	37	50	102	16	20	99	180
INVERTEBRATES	10	20	45	89	14	17	69	127
DIPLOPODS	1						1	
INSECTS	10	20	45	89	14	17	69	127
ORTHOPTERA	1	3	11	53	10	11	22	68
ACRIDIDAE			1	9	8	10	9	19
TETTIGONIDAE					1		1	
GRYLLIDAE	1	3	11	48		2	12	54
Gryllus assimilis	1	3	11	48		2	12	54
HEMIPTERA	1						1	
HOMOPTERA					1		1	
ODONATA						1		1
LEPIDOPTERA	2						2	
DIPTERA				1		1		2
COLEOPTERA	9	19	44	75	10	14	63	108
Undetermined	1		4	4			5	4
Determined	8		43	75			61	108
CARABIDAE	5	14	13	41	1	3	19	58
Undetermined	2	7	8	15	1	2	11	24
Determined	4	12	8	31		1	12	44
Calosoma spp.	4	11	6	26		1	10	38
Elaphrus ruscarius			1				1	
Pasimachus elongatus	1						1	
Scarites		2		1				3
Evarthrus	1		1	1			2	1
Chlaenius		3						3
Harpalus caliginosus				5				5
HYDROPHILIDAE	1						1	
STAPHYLINIDAE				1				1
ELATERIDAE				2				2
EROTYLIDAE					1		1	
SCARABAEIDAE	5	20	19	30	9	13	33	63
Undetermined		1		2		1		4
Determined		20		28		12	33	60
Copris anaglypticus		1			1		1	1
Aphodius		1						1
Bolbocerasoma farctum	1				5	4	6	4
Geotrupes					7	9	7	9
Phyllophaga	4	19	18	19	1	1	23	39
Pelidnota punctata			1	1			1	1
Ligyrus gibbosus	1	1		7			1	8
Xyloryctes satyrus				2				2
Euphoria inda		1						1
LUCANIDAE	1		35	32	1		37	32
Lucanus	1		35	32	1		37	32
Dorcus			1	1			1	1
HYMENOPTERA	2		5	4		3	7	7
FORMICIDAE	2		5	4		3	7	7

[1/] The one occurrence of *Gryllus assimilis* for the period April 1-23 is included here under the North Range total.

Table 12

Differences in Occurrences of Plant Remains
in Fecal Passages from Trails on the North and South Ranges, 1940

Ranges	April 1 - 23		April 23- June 20		June 20- July 31		August		Totals Apr. 1 - Sept. 1	
	S.	N.	S.	N.	S.	N.	S.	N.	S.	N.
No. Fecal Passages	12	21	21	37	50	102	16	20	99	180
PLANTS		2	2	8	28	90	14	13	44	113
GRAMINEAE-CYPERACEAE		1		4	1	3		1	1	9
Zea mays		1					1		1	1
Quercus				1						1
Ulmus			2	3	2				4	3
Morus rubra					17	83	2	4	19	87
Grossularia spp.					6	15	2	6	8	21
Amelanchier canadensis					13	2	1		14	2
Prunus americana							2	4	2	4
Padus virginiana							10	10	10	10

Table 13

Mammal Remains in Fecal Passages from the Trails, Period I

No. Fecal Passages	June		July		Aug.		Summer		Sept.		Oct.		N[illegible].		[illegible]
	3		5		28		36		19		12		[illegible]		
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	%ot. No.	No.
MAMMALS	3	42.9	5	50.0	27	35.5	35	37.6	19	38.8	12	44.5	16	5.2	47
INSECTIVORES			1	8.3	6	5.9	7	5.8	6	7.1			2	4.8	[illegible]
Undetermined					1	0.8	1	0.7							
Determined					6	5.1	7	5.1							
<u>Scalopus aquaticus</u>					3	2.6	3	2.2							
<u>Cryptotis parva</u>			1	8.3	3	2.6	4	2.9	6	6.1			2	4.8	[illegible]
<u>Blarina brevicauda</u>									1	1.0					1
RODENTS	1	14.3	2	16.6	19	18.7	22	18.4	19	22.3	10	29.7	15	:6.0	4[illegible]
Undetermined					3	2.8	3	2.4			1	2.7	2	4.8	[illegible]
Determined					17	15.9	20	16.0			10	27.0	13	:1.2	4[illegible]
<u>Citellus tridecem-lineatus</u>									2	1.5					[illegible]
<u>Citellus franklini</u>											1	2.1			1
<u>Tamias striatus</u>													1	1.5	1
<u>Sciurus niger</u>															
<u>Reithrodontomys megalotis</u>			1	5.5			1	0.6					1	1.5	1
<u>Peromyscus</u> spp.					7	4.6	7	4.0	11	8.5	4	8.3	6	8.9	2[illegible]
<u>Synaptomys cooperi</u>			1	5.5	2	1.3	3	1.7	2	1.5	1	2.1	3	4.5	[illegible]
<u>Microtus</u> spp.	1	14.3	1	5.5	15	9.9	17	9.7	14	10.8	6	12.5	10	14.9	3[illegible]
<u>Rattus norvegicus</u>											1	2.1			1
RABBITS	2	28.6	3	25.0	11	10.8	16	13.4	8	9.4	5	14.8	6	14.4	1[illegible]
Undetermined															
Determined															
<u>Sylvilagus floridanus</u>	2	28.6	3	25.0	11	10.8	16	13.4	8	9.4	5	14.8	6	14.4	1[illegible]
<u>Lepus townsendii</u>															

, Period I

…er	Sept.		Oct.		[illegible]		Fall		Dec.		Jan.		Feb.		Winter		March		April		May	
	19		12		[illegible]		48		35		32		13		80		50		22		12	
% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% T…
57.6	19	38.8	12	44.5	16	5.2	47	44.8	35	76.1	32	71.1	13	56.5	80	70.2	50	62.5	22	64.7	12	4
5.8	6	7.1			2	4.8	8	5.0			2	3.0			2	1.3			1	1.9		
0.7																						
5.1																						
2.2																						
2.9	6	6.1			2	4.8	8	4.4			1	1.5			1	0.7						
	1	1.0					1	0.6			1	1.5			1	0.7			1	1.9		
18.4	19	22.3	10	29.7	15	6.0	44	27.8	28	48.4	25	37.8	11	36.6	64	41.6	40	36.8	19	36.2	5	1
2.4			1	2.7	2	4.8	3	1.9	2	3.5	1	1.5	1	3.3	4	2.6	5	4.6	1	1.9	1	
16.0			10	27.0	13	1.2	42	25.9	26	44.9	24	36.3	10	33.3	60	39.0	35	32.2	18	34.3	4	1
	2	1.5					2	0.8	1	1.2					1	0.4						
			1	2.1			1	0.4														
					1	1.5	1	0.4									1	0.7				
																			3	4.0		
0.6					1	1.5	1	0.4	2	2.4	1	1.1	1	2.0	4	1.8	1	0.7	1	1.3		
4.0	11	8.5	4	8.3	6	8.9	21	8.6	13	15.8	10	10.7	6	12.5	29	13.0	10	6.7	7	9.2		
1.7	2	1.5	1	2.1	3	4.5	6	2.5	4	4.9	2	2.1	2	4.2	8	3.6	3	2.0	2	2.6	2	
9.7	14	10.8	6	12.5	10	14.9	30	12.3	17	20.6	20	21.4	7	14.6	44	19.7	33	22.1	13	17.1	4	
			1	2.1			1	0.4			1	1.1			1	0.4						
13.4	8	9.4	5	14.8	6	14.4	19	12.0	16	27.7	20	30.3	6	19.9	42	27.3	28	25.7	14	26.6	11	
																					1	
																					10	
13.4	8	9.4	5	14.8	6	14.4	19	12.0	16	27.7	20	30.3	6	19.9	42	27.3	27	24.8	14	26.6	10	
																	1	0.9				

Fall		Dec.		Jan.		Feb.		Winter		March		April		May		Spring		Annual	
48		35		32		13		80		50		22		12		84		248	
No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
47	44.8	35	76.1	32	71.1	13	56.5	80	70.2	50	62.5	22	64.7	12	44.5	84	59.6	246	54.3
8	5.0			2	3.0			2	1.3			1	1.9			1	0.5	18	2.9
																		1	0.2
																		18	2.7
																		3	0.4
8	4.4			1	1.5			1	0.7									13	1.8
1	0.6			1	1.5			1	0.7			1	1.9			1	0.5	3	0.4
44	27.8	28	48.4	25	37.8	11	36.6	64	41.6	40	36.8	19	36.2	5	13.9	64	32.3	194	30.8
3	1.9	2	3.5	1	1.5	1	3.3	4	2.6	5	4.6	1	1.9	1	2.8	7	3.5	17	2.7
42	25.9	26	44.9	24	36.3	10	33.3	60	39.0	35	32.2	18	34.3	4	11.1	57	28.8	179	28.1
2	0.8	1	1.2					1	0.4									3	0.3
1	0.4																	1	0.1
1	0.4									1	0.7					1	0.4	2	0.2
												3	4.0			3	1.1	3	0.3
1	0.4	2	2.4	1	1.1	1	2.0	4	1.8	1	0.7	1	1.3			2	0.7	8	0.9
21	8.6	13	15.8	10	10.7	6	12.5	29	13.0	10	6.7	7	9.2			17	6.1	74	8.1
6	2.5	4	4.9	2	2.1	2	4.2	8	3.6	3	2.0	2	2.6	2	3.7	7	2.5	24	2.6
30	12.3	17	20.6	20	21.4	7	14.6	44	19.7	33	22.1	13	17.1	4	7.4	50	18.0	141	15.4
1	0.4			1	1.1			1	0.4									2	0.2
19	12.0	16	27.7	20	30.3	6	19.9	42	27.3	28	25.7	14	26.6	11	30.6	53	26.8	130	20.6
														1	2.8	1	0.5	1	0.2
														10	27.8	52	26.3	129	20.4
19	12.0	16	27.7	20	30.3	6	19.9	42	27.3	27	24.8	14	26.6	10	27.8	51	25.8	128	20.2
										1	0.9					1	0.5	1	0.2

Table 14

Mammal Remains in Fecal Passages from the Trails, Period II

	June		July		August		Summer		Sept.		Oct.		Nov.		
No. Fecal Passages	25		33		74		132		60		47		22		
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No
MAMMALS	15	26.3	19	23.5	59	28.9	93	27.2	50	29.2	45	34.9	22	45.8	11
Undetermined	1	1.8	1	1.2			2	0.6	1	0.6					
Determined	14	24.5	18	22.2			91	26.6	49	28.6					11
INSECTIVORES									1	0.5					
Scalopus aquaticus									1	0.5					
Blarina brevicauda															
CARNIVORES															
Taxidea taxus															
RODENTS	4	6.2	6	6.7	28	11.6	38	9.6	34	16.3	33	17.7	20	26.9	8
Undetermined			1	1.1	2	0.8	3	0.8	4	1.9	2	1.1	1	1.3	7
Determined			5	5.6	26	10.8	35	8.8	31	14.4	31	16.6	19	25.6	81
Marmota monax															
Citellus tridecemlineatus									1	0.4					1
Tamias striatus					2	0.7	2	0.4	3	1.1					[illegible]
Sciurus niger			2	1.9			2	0.4	2	0.8	1	0.4	1	0.9	1
Glaucomys volans															
Reithrodontomys megalotis													4	3.7	4
Peromyscus spp.	3	2.3	2	1.9	7	2.4	12	2.3	7	2.7	9	3.8	6	5.5	22
Synaptomys cooperi					4	1.4	4	0.8	1	0.4	5	2.1	1	0.9	7
Microtus spp.	4	3.1	2	1.9	18	6.3	24	4.7	24	9.1	23	9.8	14	12.8	61
Mus musculus	1	0.8					1	0.2			1	0.4			1
Rattus norvegicus													2	1.8	2
RABBITS	13	20.1	15	16.8	42	17.3	70	17.6	26	12.4	32	17.2	14	18.9	72
Undetermined															
Determined															
Sylvilagus floridanus	13	20.1	15	16.8	42	17.3	70	17.6	26	12.4	32	17.2	14	18.9	72
HOOFED MAMMALS															
Sus scrofa															

II

Sept.	60	Oct.	47	Nov.	22	Fall	129	Dec.	34	Jan.	47	Feb.	19	Winter	100	March	36	April	60	May	58	S
o.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No
50	29.2	45	34.9	22	45.8	117	33.6	34	49.3	47	61.8	19	79.2	100	59.2	36	67.9	59	62.8	55	42.7	15
1	0.6					1	0.3											2	2.1			
49	28.6					116	33.3											57	60.6			14
1	0.5					1	0.2	1	1.0					1	0.4	1	1.5	3	2.4			
1	0.5					1	0.2	1	1.0					1	0.4	1	1.5	2	1.6			
																		1	0.8			
								1	1.0					1	0.4							
								1	1.0					1	0.4							
34	16.3	33	17.7	20	26.9	87	18.3	22	21.7	14	15.7	12	33.9	48	21.4	17	25.1	30	23.6	27	14.4	7
4	1.9	2	1.1	1	1.3	7	1.5	3	3.0	2	2.2	1	1.8	6	2.7	1	1.5	1	0.8	2	1.1	
31	14.4	31	16.6	19	25.6	81	16.8	19	18.7	12	13.5	11	31.1	42	18.7	16	23.6	29	22.8	25	13.3	7
												1	2.1	1	0.4					1	0.5	
1	0.4					1	0.2															
3	1.1					3	0.5															
2	0.8	1	0.4	1	0.9	4	0.6	1	0.9	1	1.0			2	0.7			3	1.9	3	1.5	
																1	1.0	1	0.6			
				4	3.7	4	0.6	1	0.9	1	1.0	2	4.1	4	1.5			3	1.9	3	1.5	
7	2.7	9	3.8	6	5.5	22	3.6	8	6.8	6	5.8	7	14.5	21	7.7	6	5.9	11	7.0	7	3.6	2
1	0.4	5	2.1	1	0.9	7	1.1					1	2.1	1	0.4	4	3.9	2	1.3	1	0.5	
24	9.1	23	9.8	14	12.8	61	9.9	11	9.4	5	4.8	4	8.3	20	7.3	11	10.8	13	8.2	11	5.6	3
		1	0.4			1	0.2	1	0.9	1	1.0			2	0.7	1	1.0	2	1.3			
				2	1.8	2	0.3									1	1.0	1	0.6			
26	12.4	32	17.2	14	18.9	72	15.1	26	25.6	41	46.1	16	45.3	83	36.9	28	41.3	47	36.9	48	25.6	12
																1	1.5					
																27	39.8					12
26	12.4	32	17.2	14	18.9	72	15.1	26	25.6	41	46.1	16	45.3	83	36.9	27	39.8	47	36.9	48	25.6	12
																				5	2.7	
																				5	2.7	

	Fall		Dec.		Jan.		Feb.		Winter		March		April		May		Spring		Annual	
	129		34		47		19		100		36		60		58		154		515	
% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
5.8	117	33.6	34	49.3	47	61.8	19	79.2	100	59.2	36	67.9	59	62.8	55	42.7	150	54.3	460	40.5
	1	0.3											2	2.1			2	0.7	5	0.4
	116	33.3											57	60.6			148	53.6	455	40.1
	1	0.2	1	1.0					1	0.4	1	1.5	3	2.4			4	1.1	6	0.4
	1	0.2	1	1.0					1	0.4	1	1.5	2	1.6			3	0.8	5	0.3
													1	0.8			1	0.3	1	0.1
			1	1.0					1	0.4									1	0.1
			1	1.0					1	0.4									1	0.1
6.9	87	18.3	22	21.7	14	15.7	12	33.9	48	21.4	17	25.1	30	23.6	27	14.4	74	19.5	247	16.3
1.3	7	1.5	3	3.0	2	2.2	1	1.8	6	2.7	1	1.5	1	0.8	2	1.1	4	1.1	20	1.3
5.6	81	16.8	19	18.7	12	13.5	11	31.1	42	18.7	16	23.6	29	22.8	25	13.3	70	18.4	228	15.0
							1	2.1	1	0.4					1	0.5	1	0.2	2	0.1
	1	0.2																	1	0.1
	3	0.5																	5	0.3
.9	4	0.6	1	0.9	1	1.0			2	0.7			3	1.9	3	1.5	6	1.3	14	0.7
											1	1.0	1	0.6			2	0.4	2	0.1
.7	4	0.6	1	0.9	1	1.0	2	4.1	4	1.5			3	1.9	3	1.5	6	1.3	14	0.7
.5	22	3.6	8	6.8	6	5.8	7	14.5	21	7.7	6	5.9	11	7.0	7	3.6	24	5.1	79	4.1
.9	7	1.1					1	2.1	1	0.4	4	3.9	2	1.3	1	0.5	7	1.5	19	1.0
.8	61	9.9	11	9.4	5	4.8	4	8.3	20	7.3	11	10.8	13	8.2	11	5.6	35	7.5	140	7.3
	1	0.2	1	0.9	1	1.0			2	0.7	1	1.0	2	1.3			3	0.6	7	0.4
1.8	2	0.3									1	1.0	1.	0.6			2	0.4	4	0.2
.9	72	15.1	26	25:6	41	46.1	16	45.3	83	36.9	28	41.3	47	36.9	48	25.6	123	32.4	348	23.0
											1	1.5					1	0.3	1	0.1
											27	39.8					122	32.1	347	22.9
.9	72	15.1	26	25.6	41	46.1	16	45.3	83	36.9	27	39.8	47	36.9	48	25.6	122	32.1	347	22.9
															5	2.7	5	1.3	5	0.3
															5	2.7	5	1.3	5	0.3

Table 15

Mammal Remains in Fecal Passages from the Trails, Period III

No. Fecal Passages	June		July		August		Summer		Sept.		Oct.		Nov.		Fall	
	47		127		43		217		57		39		30		126	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
MAMMALS	40	32.5	87	26.5	31	29.8	158	28.5	31	21.2	38	34.5	30	42.9	99	30.
Undetermined	1	0.8	3	0.9			4	0.7	2	1.4					2	0.
Determined	39	31.7	84	25.6			154	27.8	29	19.8					97	29.
MARSUPIALS																
Didelphis virginiana																
INSECTIVORES	4	2.8	16	4.2	3	2.4	23	3.6			1	0.6			1	0.
Scalopus aquaticus	4	2.8	15	3.9	2	1.6	21	3.3								
Cryptotis parva											1	0.6			1	0.
Blarina brevicauda			1	0.3	1	0.8	2	0.3								
CARNIVORES									3	1.7	1	0.6			4	0.
Procyon lotor																
Mustela									3	1.7					3	0.
Mephitis mephitis																
Taxidea taxus											1	0.6			1	0.
RODENTS	15	10.6	42	11.1	21	16.9	78	12.1	25	13.9	33	20.0	22	19.7	80	17.
Undetermined	3	2.0	6	1.5	5	3.8	14	2.1	1	0.6	1	0.6	2	1.8	4	0.
Determined	13	8.6	37	9.6	17	13.1	67	10.0	24	13.3	32	19.4	20	17.9	76	16.
Marmota monax	3	1.7					3	0.4					2	1.3	2	0.
Citellus sp.									1	0.5					1	0.
Citellus tridecemlineatus			4	0.9	2	1.2	6	0.7								
Citellus franklini					1	0.6	1	0.1					1	0.7	1	0.2
Tamias striatus	3	1.7	5	1.1	4	2.5	12	1.5	8	3.7	1	0.4			9	1.4
Sciurus niger			6	1.3	3	1.9	9	1.1			2	0.9	2	1.3	4	0.6
Reithrodontomys megalotis			1	0.2			1	0.1	1	0.5	3	1.3	1	0.7	5	0.8
Peromyscus spp.	3	1.7	10	2.1	3	1.9	16	2.0	4	1.8	20	8.6	7	4.6	31	5.0
Synaptomys cooperi			3	0.6			3	0.4	1	0.5	4	1.7			5	0.8
Microtus spp.	6	3.4	15	3.2	7	4.4	28	3.5	14	6.4	14	6.0	12	8.0	40	6.4
Ondatra zibethica																
Mus musculus													1	0.7	1	0.2
Rattus norvegicus			1	0.2	1	0.6	2	0.2			1	0.4	1	0.7	2	0.3
RABBITS	27	19.1	42	11.1	13	10.5	82	12.8	10	5.6	22	13.3	24	21.5	56	11.9
Sylvilagus floridanus	27	19.1	42	11.1	13	10.5	82	12.8	10	5.6	22	13.3	24	21.5	56	11.9
HOOFED MAMMALS													2	1.8	2	0.4
Sus scrofa													2	1.8	2	0.4
Odocoileus virginianus																

Oct.		Nov.		Fall		Dec.		Jan.		Feb.		Winter		March		April		Spring		Annual	
39		30		126		37		23		19		79		33		20		53		475	
No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
38	34.5	30	42.9	99	30.4	36	52.2	22	75.9	19	82.6	77	63.6	33	66.0	18	64.3	51	65.4	385	35.6
				2	0.6	1	1.5					1	0.8			1	3.6	1	1.3	8	0.7
				97	29.8	35	50.8					76	62.8			17	60.7	50	64.1	377	34.9
						3	2.9					3	1.6							3	0.2
						3	2.9					3	1.6							3	0.2
1	0.6			1	0.2			1	2.2	1	2.8	2	1.1	1	1.4			1	0.9	27	1.9
																				21	1.5
1	0.6			1	0.2			1	2.2			1	0.6	1	1.4			1	0.9	3	0.2
										1	2.8	1	0.6							3	0.2
1	0.6			4	0.9	1	1.0	1	2.2			2	1.1			1	2.9			7	0.5
						1	1.0					1	0.6			1	2.9			2	0.1
				3	0.7															3	0.2
								1	2.2			1	0.6							1	0.1
1	0.6			1	0.2															1	0.1
33	20.0	22	19.7	80	17.0	18	17.4	13	28.2	8	22.0	39	20.8	21	28.9	7	20.5	28	26.2	225	15.6
1	0.6	2	1.8	4	0.9	1	1.0					1	0.5							19	1.3
32	19.4	20	17.9	76	16.2	17	16.4					38	20.3							209	14.3
		2	1.3	2	0.3															5	0.3
				1	0.2															1	0.1
																				6	0.3
		1	0.7	1	0.2															2	0.1
1	0.4			9	1.4															21	1.1
2	0.9	2	1.3	4	0.6	5	3.2	1	1.7	1	2.8	7	2.8	3	3.2	1	2.6	4	3.0	24	1.3
3	1.3	1	0.7	5	0.8			3	5.0			3	1.2	3	3.2	2	5.1	5	3.7	14	0.7
20	8.6	7	4.6	31	5.0	8	5.0	3	5.0			11	4.4	6	6.4	2	5.1	8	6.0	66	3.5
4	1.7			5	0.8	1	0.6	1	1.7			2	0.8							10	0.5
14	6.0	12	8.0	40	6.4	11	6.9	8	13.3	7	19.3	26	10.3	14	15.0	3	7.7	17	12.7	111	5.9
						1	0.6	1	1.7			2	0.8							2	0.1
		1	0.7	1	0.2															1	0.1
1	0.4	1	0.7	2	0.3									1	1.1			1	0.7	5	0.3
22	13.3	24	21.5	56	11.9	30	29.0	20	43.4	19	52.3	69	36.9	26	35.8	14	40.9	40	37.4	247	17.1
22	13.3	24	21.5	56	11.9	30	29.0	20	43.4	19	52.3	69	36.9	26	35.8	14	40.9	40	37.4	247	17.1
		2	1.8	2	0.4	2	1.9			2	5.5	4	2.1							6	0.4
		2	1.8	2	0.4	2	1.9			1	2.8	3	1.6							5	0.3
										1	2.8	1	0.5							1	0.1

	Fall		Dec.		Jan.		Feb.		Winter		March		April		Spring		Annual	
	126		37		23		19		79		33		20		53		475	
t.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.
o.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
.9	99	30.4	36	52.2	22	75.9	19	82.6	77	63.6	33	66.0	18	64.3	51	65.4	385	35.6
	2	0.6	1	1.5					1	0.8			1	3.6	1	1.3	8	0.7
	97	29.8	35	50.8					76	62.8			17	60.7	50	64.1	377	34.9
			3	2.9					3	1.6							3	0.2
			3	2.9					3	1.6							3	0.2
	1	0.2			1	2.2	1	2.8	2	1.1	1	1.4			1	0.9	27	1.9
																	21	1.5
	1	0.2			1	2.2			1	0.6	1	1.4			1	0.9	3	0.2
							1	2.8	1	0.6							3	0.2
	4	0.9	1	1.0	1	2.2			2	1.1			1	2.9			7	0.5
			1	1.0					1	0.6			1	2.9			2	0.1
	3	0.7															3	0.2
					1	2.2			1	0.6							1	0.1
	1	0.2															1	0.1
.7	80	17.0	18	17.4	13	28.2	8	22.0	39	20.8	21	28.9	7	20.5	28	26.2	225	15.6
.8	4	0.9	1	1.0					1	0.5							19	1.3
.9	76	16.2	17	16.4					38	20.3							209	14.3
.3	2	0.3															5	0.3
	1	0.2															1	0.1
																	6	0.3
.7	1	0.2															2	0.1
	9	1.4															21	1.1
.3	4	0.6	5	3.2	1	1.7	1	2.8	7	2.8	3	3.2	1	2.6	4	3.0	24	1.3
.7	5	0.8			3	5.0			3	1.2	3	3.2	2	5.1	5	3.7	14	0.7
.6	31	5.0	8	5.0	3	5.0			11	4.4	6	6.4	2	5.1	8	6.0	66	3.5
	5	0.8	1	0.6	1	1.7			2	0.8							10	0.5
.0	40	6.4	11	6.9	8	13.3	7	19.3	26	10.3	14	15.0	3	7.7	17	12.7	111	5.9
			1	0.6	1	1.7			2	0.8							2	0.1
.7	1	0.2															1	0.1
.7	2	0.3									1	1.1			1	0.7	5	0.3
.5	56	11.9	30	29.0	20	43.4	19	52.3	69	36.9	26	35.8	14	40.9	40	37.4	247	17.1
.5	56	11.9	30	29.0	20	43.4	19	52.3	69	36.9	26	35.8	14	40.9	40	37.4	247	17.1
.8	2	0.4	2	1.9			2	5.5	4	2.1							6	0.4
.8	2	0.4	2	1.9			1	2.8	3	1.6							5	0.3
							1	2.8	1	0.5							1	0.1

Table 21

Food Remains in 12 Fecal Passages
Collected at a Rearing Den in May, 1939

Occurrences	No.	% Tot. No.
MAMMALS	12	38.7
RODENTS	5	12.1
Undetermined	2	4.8
Determined	3	7.3
Microtus	2	3.6
Peromyscus	2	3.6
RABBITS	11	26.6
Sylvilagus floridanus	11	26.6
BIRDS	8	25.8
Undetermined	2	6.5
Determined	6	19.4
NONGAME	6	19.4
GALLIFORMES	1	3.2
Gallus gallus	1	3.2
PASSERIFORMES - PICIFORMES	1	3.2
PASSERIFORMES	4	12.9
Undetermined	2	6.5
Determined	2	6.5
FRINGILLIDAE	2	6.5
INSECTS	11	35.5
ORTHOPTERA	2	3.6
GRYLLIDAE	2	3.6
Gryllus assimilis	2	3.6
LEPIDOPTERA	7	12.4
COLEOPTERA	11	19.5
CARABIDAE	9	8.8
Undetermined (1 larvae)	3	2.9
Determined	6	5.9
Calosoma calidum	2	1.3
Calosoma scrutator	1	0.7
Evarthrus colosseus	6	3.9
SCARABAEIDAE	11	10.7
Geotrupes	5	3.4
Phyllophaga	11	7.4

Table 22

Bird Remains in Fecal Passages from the Trails, Period I

No. Fecal Passages	June		July		August		Summer		Sept.		Oct.		Nov.		Fall	
	3		5		28		36		19		12		17		48	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% To N
BIRDS	1	14.2	1	10.0	17	22.4	19	20.5	5	10.2	3	11.1	3	10.3	11	10
Undetermined					1	1.3	1	1.1			2	7.4	2	6.9	4	3
Determined			1	10.0	16	21.1	18	19.4	5	10.2	1	3.7	1	3.4	7	6
NONGAME			1	10.0	16	21.1	17	18.3	5	10.2			1	3.4	6	5
Undetermined									1	2.0					1	1.
Determined			1	10.0			17	18.3	4	8.2					5	4.
GALLIFORMES			1	10.0	15	17.6	16	15.4	4	8.2					4	3.
Gallus gallus			1	10.0	15	17.6	16	15.4	4	8.2					4	3.
PASSERIFORMES-PICIFORMES					1	1.2	1	1.0								
PASSERIFORMES					2	2.3	1	1.9					1	3.4	1	1.
Undetermined																
Determined																
FRINGILLIDAE													1	3.4	1	1.
Undetermined																
Determined																
Junco hiemalis																
Spizella arborea																
GAME	1	14.2					1	1.1			1	3.7			1	1.
GALLIFORMES	1	14.2					1	1.1								
Colinus virginus																
Phasianus colchicus torquatus	1	14.2					1	1.1								
COLUMBIFORMES											1	3.7			1	1.
Zenaidura macroura											1	3.7			1	1.

Nov.		Fall		Dec.		Jan.		Feb.		Winter		Mar.		Apr.		May		Spring		Annual	
17		48		35		32		13		80		50		22		12		84		248	
No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
3	10.3	11	10.5	5	10.9	6	13.3	9	39.1	20	17.5	15	18.7	8	23.5	6	22.2	29	20.6	79	17.4
2	6.9	4	3.8			3	6.7	2	8.7	5	4.4	3	3.7	2	5.9	1	3.7	6	4.3	16	3.5
1	3.4	7	6.7			3	6.7	7	30.4	15	13.1	12	15.0	6	17.6	5	18.5	23	16.3	63	13.9
1	3.4	6	5.7	4	8.7	2	4.4	7	30.4	13	11.4	9	11.3	6	17.6	4	14.8	19	13.5	55	12.1
		1	1.0																	1	0.2
		5	4.8																	54	11.9
		4	3.8	3	6.5	2	4.4	1	4.3	6	5.3	7	8.8	1	2.9	1	3.7	9	6.4	35	7.4
		4	3.8	3	6.5	2	4.4	1	4.3	6	5.3	7	8.8	1	2.9	1	3.7	9	6.4	35	7.4
				1	2.2					1	0.9					1	3.7	1	0.7	3	0.6
1	3.4	1	1.0					6	26.1	6	5.3	2	2.5	5	14.7	2	7.4	9	6.4	18	3.8
														2	5.9	1	3.7	3	2.1	5	1.1
														3	8.8	1	3.7	6	4.3	13	2.7
1	3.4	1	1.0					6	26.1	6	5.3	2	2.5	3	8.8	1	3.7	6	4.3	13	2.7
								2	8.7	2	1.8							4	2.9	7	1.5
								4	17.4	4	3.5							2	1.4	6	1.2
								1	4.4	1	0.9	2	2.5					2	1.4	3	0.6
								3	13.1	3	2.6									3	0.6
		1	1.0	1	2.2	1	2.2			2	1.7	3	3.8			1	3.7	4	2.8	8	1.8
				1	2.2	1	2.2			2	1.7	3	3.8			1	3.7	4	2.8	7	1.6
												1	1.3					1	0.7	1	0.2
				1	2.2	1	2.2			2	1.7	2	2.5			1	3.7	3	2.1	6	1.4
		1	1.0																	1	0.2
		1	1.0																	1	0.2

Table 23

Bird Remains in Fecal Passages from the Trails, Period II

No. Fecal Passages	June 25		July 33		August 74		Summer 132		Sept. 60		Oct. 47		Nov. 22		Fall 129	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
BIRDS	1	1.8	5	6.2	15	7.4	21	6.1	17	10.0	14	10.8	7	14.6	38	10.9
Undetermined			1	1.2	7	3.5	9	2.6	5	2.8	4	3.1	1	2.1	10	2.8
Determined			4	5.0	8	3.9	12	3.5	13	7.2	10	7.7	6	12.5	29	8.1
NONGAME			3	3.4	7	3.4	10	2.9	12	6.6	9	7.0	6	12.5	27	7.5
Undetermined					2	1.0	2	0.6			1	0.8			1	0.3
Determined					5	2.4	8	2.3			8	6.2			26	7.2
GALLIFORMES			2	2.5	3	1.4	5	1.4	9	5.0	5	3.1	2	4.2	16	4.1
Gallus gallus			2	2.5	3	1.4	5	1.4	9	5.0	5	3.1	2	4.2	16	4.1
STRIGIFORMES					1	0.5	1	0.3								
Asio or *Bubo*					1	0.5	1	0.3								
PICIFORMES																
Dryobates villosus																
PASSERIFORMES-PICIFORMES									1	0.6	1	0.6	1	2.1	3	0.8
PASSERIFORMES			1	1.3	1	0.5	2	0.6	2	1.1	4	2.5	3	6.2	9	2.3
Undetermined											2	1.3	2	4.2	4	1.0
Determined											2	1.3	1	2.0	5	1.3
CORVIDAE																
Cyanocitta cristata																
TURDIDAE											1	0.6			1	0.3
Turdus migratorius											1	0.6			1	0.3
ICTERIDAE																
Sturnella																
PLOCEIDAE													1	2.0	1	0.3
Passer domesticus													1	2.0	1	0.3
FRINGILLIDAE									2	1.1	1	0.6			3	0.7
Undetermined															1	0.2
Determined															2	0.5
Junco hiemalis																
Spizella arborea																
Spinus tristis									2	1.1					2	0.5
GAME			1	1.3	1	0.5	2	0.6	1	0.6	1	0.7			2	0.6
GALLIFORMES			1	1.3			1	0.3	1	0.6					1	0.3
Colinus virginus																
Phasianus colchicus torquatus			1	1.3			1	0.3	1	0.6					1	0.3
COLUMBIFORMES					1	0.5	1	0.3			1	0.7			1	0.3
Zenaidura macroura					1	0.5	1	0.3			1	0.7			1	0.3

Nov.		Fall		Dec.		Jan.		Feb.		Winter		Mar.		Apr.		May		Spring		Annual	
22		129		34		47		19		100		36		60		58		154		515	
No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
7	14.6	38	10.9	18	26.1	20	26.3	5	20.8	43	25.4	12	22.6	24	25.5	31	24.0	67	24.3	169	14.9
1	2.1	10	2.8	2	2.9	6	7.9	3	12.5	11	6.5	5	9.4	11	11.2	17	12.4	33	11.5	63	5.4
6	12.5	29	8.1	16	23.2	14	18.4	2	8.3	32	18.9	7	13.2	14	14.3	16	11.6	37	12.8	110	9.5
6	12.5	27	7.5	15	21.8	12	15.8	1	4.2	28	16.5	6	11.3	12	11.4	14	9.6	32	10.5	97	8.2
		1	0.3													4	2.7	4	1.3	7	0.6
		26	7.2													10	6.9	28	9.2	90	7.6
2	4.2	16	4.1	8	11.6					8	4.7	4	7.5	5	4.8			9	3.0	38	3.1
2	4.2	16	4.1	8	11.6					8	4.7	4	7.5	5	4.8			9	3.0	38	3.1
																				1	0.1
																				1	0.1
																1	0.7	1	0.3	1	0.1
																1	0.7	1	0.3	1	0.1
1	2.1	3	0.8	1	1.5					1	0.6			3	2.9			3	1.0	7	0.6
3	6.2	9	2.3	6	8.7	12	15.8	1	4.2	19	11.2	2	3.8	4	3.8	9	6.2	15	4.9	45	3.7
2	4.2	4	1.0	5	6.2	2	2.6			7	3.9					6	4.1	12	3.9	25	2.0
1	2.0	5	1.3	2	2.5	10	13.2			13	7.3					3	2.1	3	1.0	21	1.7
								1	4.2	1	0.6									1	0.1
								1	4.2	1	0.6									1	0.1
		1	0.3																	1	0.1
		1	0.3																	1	0.1
																2	1.4	2	0.7	2	0.2
																2	1.4	2	0.7	2	0.2
1	2.0	1	0.3																	1	0.1
1	2.0	1	0.3																	1	0.1
		3	0.7	2	2.5	10	13.2			12	6.7					1	0.7	1	0.3	16	1.3
		1	0.2	1	1.3	4	5.3			5	2.8									7	0.6
		2	0.5	1	1.3	6	7.9			7	3.9									9	0.7
				1	1.3	2	2.6			3	1.7									3	0.2
						4	5.3			4	2.2									4	0.3
		2	0.5																	2	0.2
		2	0.6	1	1.5	2	2.6	1	4.2	4	2.4	1	1.9	3	2.9	3	2.0	7	2.3	15	1.3
		1	0.3	1	1.5	2	2.6	1	4.2	4	2.4	1	1.9	3	2.9	3	2.0	7	2.3	13	1.1
						1	1.3	1	4.2	2	1.2	1	1.9	2	1.9	1	0.7	4	1.3	6	0.5
		1	0.3	1	1.5	1	1.3			2	1.2			1	1.0	2	1.3	3	1.0	7	0.6
		1	0.3																	2	0.2
		1	0.3																	2	0.2

Table 24

Bird Remains in Fecal Passages from the Trails, Period III

No. Fecal Passages	June		July		August		Summer		Sept.		Oct.		Nov.		Fall	
	47		127		43		217		57		39		3[illegible]		126	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
BIRDS	18	14.6	22	6.7	4	3.9	44	7.9	9	6.2	14	12.7	17	[illegible]	40	12.2
Undetermined	17	13.8	11	3.4			28	5.0	6	4.1	5	4.5	6	[illegible]	17	5.2
Determined	1	0.8	11	3.4			16	2.9	3	2.1	9	8.2	11	15.7	23	7.0
NONGAME	1	0.8	9	2.7	4	3.9	14	2.5	2	1.4	8	8.2	11	[illegible]	21	6.4
Undetermined																
Determined																
GALLIFORMES			5	1.5	3	2.9	8	1.4	1	0.7	6	5.5	5	6.5	12	3.5
Gallus gallus			5	1.5	3	2.9	8	1.4	1	0.7	6	5.5	2	2.6	9	2.6
Guinea fowl													3	3.9	3	0.9
STRIGIFORMES											1	0.9			1	0.3
PASSERIFORMES	1	0.8	4	1.2	1	1.0	6	1.1	1	0.7	2	1.8	6	7.9	9	2.6
Undetermined			2	0.6			4	0.7							1	0.3
Determined			2	0.6			2	0.4							8	2.3
CORVIDAE											1	0.9			1	0.3
Cyanocitta cristata											1	0.9			1	0.3
PARIDAE																
Penthestes atricapillus																
FRINGILLIDAE			2	0.6			2	0.4			1	0.9	6	7.9	7	2.0
Undetermined													2	2.6	2	0.6
Determined													4	5.3	5	1.4
Richmondena cardinalis																
Junco hiemalis											1	0.9	4	5.3	5	1.4
GAME			2	0.6			2	0.4	1	0.7			1	1.3	2	0.6
GALLIFORMES			2	0.6			2	0.4								
Phasianus colchicus torquatus			2	0.6			2	0.4								
COLUMBIFORMES									1	0.7			1	1.3	2	0.6
Zenaidura macroura									1	0.7			1	1.3	2	0.6

Oct.		Nov.		Fall		Dec.		Jan.		Feb.		Winter		Mar.		Apr.		Spring		Annual	
39		[illegible]		126		37		23		19		79		33		20		53		475	
No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
14	12.7	17	[illegible]	40	12.2	20	29.0	2	6.9	3	13.0	25	20.7	11	22.0	7	25.0	18	23.1	127	11.8
5	4.5	6	[illegible]	17	5.2	9	13.0			2	8.7	12	9.9	6	12.0	4	14.3	10	12.8	67	6.2
9	8.2	11	15.7	23	7.0	11	16.0			1	4.3	13	10.8	5	10.0	3	10.7	8	10.3	60	5.6
8	8.2	11	[illegible]	21	6.4	4	5.8	1	3.5	1	4.3	6	4.6	5	10.0	2	7.1	7	9.0	48	4.4
												2	1.5							2	0.2
												4	3.1							46	4.2
6	5.5	5	6.5	12	3.5									2	4.0	2	7.1	4	5.1	24	2.1
6	5.5	2	2.6	9	2.6									2	4.0	2	7.1	4	5.1	21	1.8
		3	3.9	3	0.9															3	0.3
1	0.9			1	0.3															1	0.1
2	1.8	6	7.9	9	2.6	4	5.8					4	3.1	3	6.0			3	3.9	22	2.0
				1	0.3															5	0.5
				8	2.3															17	1.5
1	0.9			1	0.3															1	0.1
1	0.9			1	0.3															1	0.1
						1	1.5					1	0.8							1	0.1
						1	1.5					1	0.8							1	0.1
1	0.9	6	7.9	7	2.0	3	4.4					3	2.3	3	6.0			3	3.9	15	1.3
		2	2.6	2	0.6	1	1.5					1	0.8							5	0.5
		4	5.3	5	1.4	2	2.9					2	1.5							7	0.8
						1	1.5					1	0.8							1	0.1
1	0.9	4	5.3	5	1.4	1	1.5					1	0.8							6	0.7
		1	1.3	2	0.6	7	10.2	1	3.5			8	6.2			1	3.6	1	1.3	13	1.2
						7	10.2	1	3.5			8	6.2			1	3.6	1	1.3	11	1.0
						7	10.2	1	3.5			8	6.2			1	3.6	1	1.3	11	1.0
		1	1.3	2	0.6															2	0.2
		1	1.3	2	0.6															2	0.2

Table 25

Occurrences of Invertebrate Remains in Fecal Passages from the Trails, Period I

	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.	Fe
No. Fecal Passages	3	5	28	36	19	12	17	48	35	32	1
INSECTS	3	4	28	35	19	8	6	33		2	
Undetermined											
Determined											
ORTHOPTERA	1	3	26	30	19	8	5	32			
ACRIDIDAE	1	2	26	29	19	8	5	32			
Undetermined											
Determined											
Hippiscus rugosus							1	1			
Dissosteira carolina			1	1	3			3			
Trachyrachis kiowa kiowa						1		1			
Melanoplus	1	2	26	29	18	8	4	30			
TETTIGONIIDAE		2	2	4							
GRYLLIDAE			1	1							
Gryllus assimilis			1	1							
HEMIPTERA						1		1		1	
EPHEMEROPTERA											
LEPIDOPTERA		1	3	4	2			2			
DIPTERA			8	8	3			3			
COLEOPTERA	3	4	21	28	15	3	2	20		1	
Undetermined					2			2			
Determined					15	3	2	20			
CICINDELIDAE		1		1							
CARABIDAE	1	4	6	11	8	2	2	12			
Undetermined		2	3	5	6	1		7			
Determined		3	3	6	5	1	2	8			
Carabus											
Calosoma spp.			1	1			2	2			
Evarthrus		1		1							
Chlaenius		1		1							
Harpalus caliginosus		3	2	5	5	1		6			
SILPHIDAE			1	1	2			2			
ELATERIDAE (larva)										1	
SCARABAEIDAE	3	3	18	24	6	2		8			
Undetermined		2		2	1	1		2			
Determined		3		24	5	2		7			
Aphodius		1		1							
Bolboceras			2	2							
Geotrupes			18	18	5	2		7			
Phyllophaga	3	2		5							
Ligyrodes relictus					1			1			
Ligyrus gibbosus			1	1							
LUCANIDAE			1	1							
Lucanus			1	1							
CHRYSOMELIDAE					1			1			
HYMENOPTERA		2	11	13	4	1		5			

1/ These occurrences were not included in the invertebrate representations because they were obviously of no significance in the diet.

able 25

ns in Fecal Passages from the Trails, Period I

July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.	Feb.	Winter	Mar.	Apr.	May	Spring	Annual
5	28	36	19	12	17	48	35	32	13	80	50	22	12	84	248
4	28	35	19	8	6	33		2		21√	11	3	9	23	91
												1		1	1
												2		22	90
3	26	30	19	8	5	32					3		2	5	67
2	26	29	19	8	5	32					3			3	64
											1			1	1
											2			2	63
					1	1									1
	1	1	3			3									4
				1		1									1
2	26	29	18	8	4	30					2			2	61
2	2	4													4
	1	1											2	2	3
	1	1											2	2	3
				1		1		1		1	1	1		2	4
												1		1	1
1	3	4	2			2							4	4	10
	8	8	3			3									11
4	21	28	15	3	2	20		1		1	7		9	16	65
			2			2					5		1	6	8
			15	3	2	20					2		8	10	59
1		1													1
4	6	11	8	2	2	12					1		5	6	29
2	3	5	6	1		7					1		1	2	14
3	3	6	5	1	2	8							5	5	19
													3	3	3
	1	1			2	2							4	4	7
1		1											5	5	6
1		1													1
3	2	5	5	1		6									11
	1	1	2			2									3
								1							1
3	18	24	6	2		8					1		8	9	41
2		2	1	1		2					1			1	5
3		24	5	2		7								8	39
1		1													1
	2	2													2
	18	18	5	2		7							3	3	28
2		5											7	7	12
			1			1									1
	1	1											1	1	2
	1	1													1
	1	1													1
			1			1									1
2	11	13	4	1		5						1		1	19

uded in the invertebrate representations because
gnificance in the diet.

Table 26

Occurrences of Invertebrate Remains in Fecal Passages from the Trails, Period II

	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.
No. Fecal Passages	25	33	74	132	60	47	22	129	34	47
INVERTEBRATES	23	30	59	112	46	28	8	82	9	
GASTROPODS		1	2	3						
DIPLOPODS					1	1		2		
INSECTS	23	30	59	112	46	28	8	82	9	
ORTHOPTERA	14	17	59	90	43	27	8	78	9	
ACRIDIDAE	3	11	50	64	38	27	8	73	9	
Undetermined		2	5	7		1		1		
Determined		10	45	58		26		72		
Orphulella pelidna		1		1						
Arphia							1	1		
Chortophaga		1		1						
Hippiscus rugosus		1	1	2						
Pardalophora										
Dissosteira carolina			2	2	1			1	1	
Schistocerca		1	2	3	2			2	1	
Melanoplus	3	8	43	54	37	26	8	71	9	
TETTIGONIIDAE		5	36	41	13	2		15		
Undetermined			1	1	1			1		
Determined			35	40	12			14		
Amblycorypha oblongifolia		5	35	40	12			14		
GRYLLIDAE	13	8	2	23						
Gryllus assimilis	13	8	2	23						
HEMIPTERA						1		1		
LEPIDOPTERA	2			2		2		2		
DIPTERA	1		3	4	1			1		
COLEOPTERA	23	24	26	73	13	9		22	)	
Undetermined	1	2		3						
Determined	22	23		71						
CARABIDAE	8	15	19	42	9	8		17		
Undetermined		5	4	9	4	8		12		
Determined		12	15	35	5			5		
Carabus		1	1	2	1			1		
Calosoma	3	1		4						
Pasimachus elongatus	1	2		3						
Scarites		2	1	3						
Evarthrus	4	6	4	14						
Chlaenius		1		1						
Harpalus caliginosus	2	6	12	20	3			3		
Harpalus pennsylvanicus			1	1						
HYDROPHYLIDAE										
SILPHIDAE										
ELATERIDAE	2			2						

ble 26

s in Fecal Passages from the Trails, Period II

July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.	Feb.	Winter	Mar.	Apr.	May	Spring	Annual
33	74	132	60	47	22	129	34	47	19	100	36	60	58	154	515
30	59	112	46	28	8	82	9		1	10	1	5	35	41	245
1	2	3													3
			1	1		2						1		1	3
30	59	112	46	28	8	82	9		1	10	1	5	35	41	245
17	59	90	43	27	8	78	9			9	1	1	1	3	180
11	50	64	38	27	8	73	9			9	1		1	2	148
2	5	7		1		1									8
10	45	58		26		72									141
1		1													1
					1	1							1	1	2
1		1													1
1	1	2													2
													1	1	1
	2	2	1			1	1			1					4
1	2	3	2			2	1			1					6
8	43	54	37	26	8	71	9			9	1			1	135
5	36	41	13	2		15									56
	1	1	1			1									2
	35	40	12			14									54
5	35	40	12			14									54
8	2	23										1		1	24
8	2	23										1		1	24
				1		1						1		1	2
		2		2		2						1		1	5
	3	4	1			1									5
24	26	73	13	9		22	1			1		3	35	38	134
2		3											1	1	4
23		71											34	37	130
15	19	42	9	8		17						1	18	19	78
5	4	9	4	8		12							6	6	27
12	15	35	5			5							14	15	55
1	1	2	1			1									3
1		4										1	15	16	20
2		3											1	1	5
2	1	3											1	1	4
6	4	14											1	1	15
1		1											1	1	2
6	12	20	3			3									23
	1	1													1
												1		1	1
													1	1	1
		2													2

Table 26 (continued)

	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.	F
No. Fecal Passages	25	33	74	132	60	47	22	129	34	47	
SCARABAEIDAE	14	14	13	41	4	1		5			
Undetermined					1			1			
Determined					3			4			
Canthon laevis	1			1							
Copris analglypticus	3			3							
Onthophagus	2			2							
Aphodius femoralis											
Ataenius ovatulus	1			1							
Bolbocerss lazarus		1		1							
Bolbocerasoma farctum	5	7	6	18	1			1			
Geotrupes	3	1	1	5							
Phyllophaga	8	5	4	17		1		1			
Ligyrus	2	1		3	1			1			
Xyloryctes satyrus		2	1	3							
Euphoria	1	2	2	5	1			1			
LUCANIDAE	15	7		22							
Lucanus	15	7		22							
CURCULIONIDAE			1	1							
HYMENOPTERA	3	2	6	11	4	4		8	1		

26 (continued)

ne	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.	Feb.	Winter	Mar.	Apr.	May	Spring	Annual
25	33	74	132	60	47	22	129	34	47	19	100	36	60	58	154	515
14	14	13	41	4	1		5						1	31	32	78
				1			1							1	1	2
				3			4							31	32	77
1			1													1
3			3													3
2			2													2
														1	1	1
1			1													1
	1		1													1
5	7	6	18	1			1									19
3	1	1	5													5
8	5	4	17		1		1						1	29	30	48
2	1		3	1			1							2	2	6
	2	1	3											1	1	4
1	2	2	5	1			1							1	1	7
15	7		22													22
15	7		22													22
		1	1													1
3	2	6	11	4	4		8	1		1	2		1	3	4	25

Table 27

Occurrences of Invertebrate Remains in Fecal Passages from the Trails, Period II

	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Ja	Feb.
No. Fecal Passages	47	127	43	217	57	39	30	126	37	2	19
INVERTEBRATES	45	110	36	191	51	30	18	99	7		
INSECTS	45	110	36	191	51	30	18	99	7		
ORTHOPTERA	15	57	25	97	51	28	18	97	7		
Undetermined					1			1			
Determined					50	28	18	96			
ACRIDIDAE	1	10	23	34	50			96	7	2	
Undetermined		6	7	13	4			4			
Determined		4	19	24	48			94			
Arphia	1		1	2							
Dissosteira carolina			1	1							
Schistocerca			2	2	1	1	2	4			
Melanoplus		4	19	23	48	28	17	93	7		
TETTIGONIIDAE			3	3	11			11			
GRYLLIDAE	14	51	2	67		1		1			
Gryllus assimilis	14	51	2	67		1		1			
ODONATA			1	1							
HOMOPTERA			2	2							
LEPIDOPTERA	2			2			1	1			
DIPTERA		1	2	3	2			2			
COLEOPTERA	45	95	28	168	25	17	4	46			
Undetermined	1	8	1	10	3	4	1	8			
Determined	45	94	27	166	23	13	3	39			
CARABIDAE	19	47	4	70	9	12	3	24			
Undetermined	11	16	3	30	9	12	3	24			
Determined	16	35	1	52	1	1		2			
Calosoma spp.	15	30	1	46		1		1			
Elaphrus ruscarius	1			1							
Pasimachus elongatus	1			1							
Scarites	1	1		2							
Evarthrus		2		2							
Chlaenius	2			2							
Harpalus caliginosus		5		5	1			1			
STAPHYLINIDAE		1		1							
ELATERIDAE	1	1		2							
NITIDULIDAE			1	1							
EROTYLIDAE			1	1							

Table 27

Remains in Fecal Passages from the Trails, Period II

une	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Ja	Feb.	Winter	Mar.	Apr.	Spring	Annual
47	127	43	217	57	39	30	126	37	2	19	79	33	20	53	475
45	110	36	191	51	30	18	99	7			9	4	1	5	304
45	110	36	191	51	30	18	99	7			9	4	1	5	304
15	57	25	97	51	28	18	97	7			9	2		2	205
				1			1								1
				50	28	18	96								204
1	10	23	34	50			96	7			9	2		2	141
	6	7	13	4			4								17
	4	19	24	48			94								129
1		1	2												2
		1	1												1
		2	2	1	1	2	4					1		1	7
	4	19	23	48	28	17	93	7			9	1		1	126
		3	3	11			11								14
14	51	8	67		1		1								68
14	51	8	67		1		1								68
		1	1												1
		2	2												2
2			2			1	1					1		1	4
	1	2	3	2			2								5
45	95	28	168	25	17	4	46						1	1	215
1	8	1	10	3	4	1	8								18
45	94	27	166	23	13	3	39								206
19	47	4	70	9	12	3	24								94
11	16	3	30	9	12	3	24								54
16	35	1	52	1	1		2								54
15	30	1	46		1		1								47
1			1												1
1			1												1
1	1		2												2
	2		2												2
2			2												2
	5		5	1			1								6
	1		1												1
1	1		2												2
		1	1												1
		1	1												1

Table 27 (continued)

No. Fecal Passages	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	Jan.	Feb.
	47	127	43	217	57	39	30	126	37	23	19
SCARABAEIDAE	31	39	24	94	16	4		20			
Undetermined		2	1	3							
Determined	31	37	23	91	16	4		20			
Copris anaglypticus	1		1	2							
Aphodius						1		1			
Bolbocerasoma farctum	1		11	12	4			4			
Geotrupes			19	19	12	3		15			
Phyllophaga	29	27	2	58							
Pelidnota punctata		2		2							
Ligyrus gibbosus	4	7	1	12	1	1		2			
Xyloryctes satyrus	2	2		4							
LUCANIDAE	21	47	1	69							
Lucanus	21	47	1	69							
Dorcus		1		1							
HYMENOPTERA	4	5	3	12	10	7		17			
FORMICIDAE	4	5	3	12	10	7		17			
ANDRENIDAE											

27 (continued)

une	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Dec.	an.	Feb.	Winter	Mar.	Apr.	Spring	Annual
47	127	43	217	57	39	30	126	37	23	19	79	33	20	55	475
31	39	24	94	16	4		20						1	1	115
	2	1	3												3
31	37	23	91	16	4		20						1	1	112
1		1	2												2
					1		1								1
1		11	12	4			4								16
		19	19	12	3		15						1	1	35
29	27	2	58												58
	2		2												2
4	7	1	12	1	1		2								14
2	2		4												4
21	47	1	69												69
21	47	1	69												69
	1		1												1
4	5	3	12	10	7		17					1		1	30
4	5	3	12	10	7		17								29
												1		1	1

Table 28

Plant Remains in Fecal Passages from the Trails, Period I

	June		July		Aug.		Summer		Sept.		Oct.		Nov.		Fall	
No. Fecal Passages	3		5		28		36		19		12		17		48	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
PLANTS					4	5.3	4	4.3	6	12.2	4	14.8	4	13.8	14	13.[illegible]
GRAMINEAE-CYPERACEAE					4	5.3	4	4.3	4	8.1			3	10.4	7	5.[illegible]
Zea mays									2	4.1	2	4.2			4	3.1
Quercus																
Rosa sp.																
Nepeta, prob. *Cataria*																
Physalis											2	4.2			2	1.6
Solanum nigrum											2	4.2	1	3.4	3	2.3
Solanum carolinense											1	2.1			1	0.8

	Nov.		Fall		Dec.		Jan.		Feb.		Winter		March		April		May		Spring		Annual	
	17		48		35		32		13		80		50		22		12		84		248	
t. o.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
.8	4	13.8	14	13.3	6	13.0	7	15.6	1	4.4	14	12.3	4	5.0	1	3.0			5	3.5	37	8.
	3	10.4	7	5.5	4	7.4	4	6.9	1	4.4	9	6.5									20	3.
.2			4	3.1	2	3.7	2	3.5			4	2.9	2	2.5	1	3.0			3	2.1	11	2.
							1	1.7			1	0.7	1	1.3					1	0.7	2	0.
													1	1.3					1	0.7	1	0.
					1	1.9					1	0.7									1	0.
.2			2	1.6			1	1.7			1	0.7									3	0.
.2	1	3.4	3	2.3																	3	0.
.1			1	0.8			1	1.7			1	0.7									2	0.

Table 29

Plant Remains in Fecal Passages from the Trails, Period II

	June		July		Aug.		Summer		Sept.		Oct.		Nov.		Fall	
No. Fecal Passages	25		33		74		132		60		47		22		129	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% To[t. No.]
PLANTS	18	31.6	27	33.3	71	34.8	116	33.9	58	33.9	42	32.6	11	22.9	111	31
GRAMINEAE-CYPERACEAE	1	1.7					1	0.2	3	1.0	3	1.5			6	1
Zea mays	1	1.7			1	0.3	2	0.4	1	0.3	3	1.5	3	4.9	7	1.
Avena sativa																
Quercus									20	7.0	20	10.2	4	6.5	44	8.
Grossularia spp.	1	1.7	24	27.6	8	2.7	33	7.4								
Amelanchier canadensis	16	26.6	1	1.1			17	3.8								
Prunus americana					19	6.4	19	4.3	15	5.2	2	1.0			17	3.
Padus virginiana			3	3.4	67	22.6	70	15.7	52	18.2	35	17.8	6	9.8	93	17.
Vitis vulpina			1	1.1	7	2.4	8	1.8	6	2.1			1	1.6	7	1.
Nepeta, prob. *Cataria*											1	0.5			1	0.
Solanum nigrum					1	0.3	1	0.2								

:	Nov.		Fall		Dec.		Jan.		Feb.		Winter		March		April		May		Spring		Annual	
:	22		129		34		47		19		100		36		60		58		154		515	
		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.		% Tot.
No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
5	11	22.9	111	31.9	8	11.6	9	11.9			17	10.1	4	7.6	6	6.4	8	6.2	18	6.5	262	23.1
5			6	1.1			4	6.0			4	2.1	1	1.9	2	2.1	5	3.4	8	2.7	19	1.2
5	3	4.9	7	1.3	5	5.3	2	3.0			7	3.7	2	3.8	4	4.3	3	2.1	9	3.1	25	1.6
					3	3.2					3	1.6									3	0.2
2	4	6.5	44	8.0			2	3.0			2	1.1	1	1.9			1	0.7	2	0.7	48	3.1
																					33	2.1
																					17	1.1
0			17	3.1																	36	2.3
8	6	9.8	93	17.0	2	2.1					2	1.1									165	10.5
	1	1.6	7	1.3																	15	1.0
5			1	0.2	1	1.0					1	0.5									2	0.1
																					1	0.1

Table 30

Plant Remains in Fecal Passages from the Trails, Period III

No. Fecal Passages	June 47		July 127		Aug. 43		Summer 217		Sept. 57		Oct. 39		Nov. 30		Fall 126	
Occurrences	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
PLANTS	20	16.3	108	32.9	33	31.7	161	29.0	55	37.7	28	25.5	5	7.1	88	27.0
GRAMINEAE-CYPERACEAE	2	1.5	4	1.0	2	1.1	8	1.1	2	1.0	3	2.4	1	1.4	6	1.5
Zea mays					1	0.6	1	0.1	1	0.5	9	7.2	4	5.7	14	3.5
Avena sativa																
Quercus											1	0.8			1	0.2
Ulmus	10	7.4					10	1.4								
Morus rubra	4	3.0	96	24.3	7	4.2	107	15.1	3	1.6					3	0.7
Grossularia spp.			21	5.3	9	5.4	30	4.2	1	0.5					1	0.2
Malus iowensis																
Amelanchier canadensis	6	4.4	9	2.3	1	0.6	16	2.3								
Prunus americana					10	6.0	10	1.4	13	6.8	5	4.0			18	4.4
Padus virginiana					23	13.8	23	3.2	49	25.6	2	1.6			51	12.6
Vitis vulpina											1	0.8			1	0.2
Nepeta, prob. *Cataria*									1	0.5					1	0.2
Physalis											8	6.4			8	2.0
Solanum nigrum									2	1.0	2	1.6			4	1.0
Solanum carolinense											1	0.8			1	0.2

Oct.		Nov.		Fall		Dec.		Jan.		Feb.		Winter		March		April		Spring		Annual	
39		30		126		37		23		19		79		33		20		53		475	
No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.	No.	% Tot. No.
28	25.5	5	7.1	88	27.0	6	8.7	3	10.3	1	4.4	10	8.3	2	4.0	2	7.1	4	5.1	263	24.4
3	2.4	1	1.4	6	1.5	4	5.8	1	3.4			5	4.1	2	4.0	2	7.1	4	5.1	23	1.7
9	7.2	4	5.7	14	3.5			2	6.9	1	4.4	3	2.5							18	1.3
						1	1.4					1	0.8							1	0.1
1	0.8			1	0.2															1	0.1
																				10	0.7
				3	0.7															110	8.2
				1	0.2															31	2.3
						1	1.4					1	0.8							1	0.1
																				16	1.2
5	4.0			18	4.4															28	2.1
2	1.6			51	12.6															74	5.5
1	0.8			1	0.2															1	0.1
				1	0.2															1	0.1
8	6.4			8	2.0															8	0.6
2	1.6			4	1.0															4	0.3
1	0.8			1	0.2															1	0.1

Table 31

Nonfood Seeds for Period I

No. Fecal Passages	Summer 36	Fall 48	Winter 80	Spring 84	Totals 248		
						Individuals	
	No. Occ.	No. Occ.	No. Occ.	No. Occ.	No. Occ.	No.	Pctg. Tot. No.
Zea mays	1	1			2	2	0.5
Syntherisma		3			3	9	2.3
Syntherisma Ischaemum		4	3	1	8	20	5.2
Syntherisma sanguinale	2	7	6	1	16	93	24.1
Echinochloa Crus-galli		4	1	1	6	10	2.6
Panicum capillare		2			2	3	0.8
Chaetochloa glauca	8	16	11	2	37	120	31.1
Chaetochloa viridis	3	2	1	1	7	46	11.9
Avena sativa	1				1	1	0.3
Eragrostis			1		1	1	0.3
Poa Wolfii		1			1	3	0.8
Triticum aestivum	1				1	2	0.5
Carex sp.		1			1	1	0.3
Ostrya virginiana	1				1	1	0.3
Cannabis sativa	1	1			2	3	0.8
Rumex sp.		1			1	1	0.3
Rumex Acetosa			1		1	1	0.3
Persicaria pennsylvanica			1	1	2	4	1.0
Persicaria Persicaria			2		2	2	0.5
Chenopodium album	2	1	2		5	7	1.8
Geum canadense			2		2	2	0.5
Meibomia sp.		1			1	1	0.3
Acer sp.	1				1	1	0.3
Hibiscus Trionum	1				1	4	1.0
Sanicula marylandica		1	1	1	3	4	1.0
Lappula echinata	2	1		1	4	10	2.6
Verbena hastata		2			2	4	1.0
Verbena stricta		1			1	1	0.3
Ambrosia trifida	1	1	1		3	3	0.8
Ambrosia elatior		6	5		11	25	6.5
Bidens		1	1		2	2	0.5

Table 32

Nonfood Seeds for Period II

No. Fecal Passages	Summer 132	Fall 129	Winter 100	Spring 154	Totals 515		
						Individuals	
	No. Occ.	No. Occ.	No. Occ.	No. Occ.	No. Occ.	No.	Pctg. Tot. No.
Juniperus virginiana				1	1	1	0.4
Syntherisma Ischaemum		10	1		11	16	6.6
Syntherisma sanguinale	1	22	11	2	36	48	19.9
Echinochloa Crus-galli			2	3	5	6	2.5
Panicum sp.		1			1	1	0.4
Panicum capillare		1			1	2	0.8
Chaetochloa glauca	1	15	5	8	29	53	22.0
Chaetochloa viridis		5	3	2	10	12	5.0
Cenchrus		1		1	2	2	0.8
Calamagrostis sp.			1		1	1	0.4
Eragrostis		1			1	12	5.0
Poa		1	1		2	6	2.5
CYPERACEAE				1	1	1	0.4
Cyperus sp.			1		1	1	0.4
Eleocharis obtusa		1			1	2	0.8
Carex sp.		1			1	2	0.8
Ostrya virginiana		1			1	6	2.5
Cannabis sativa		4		1	5	9	3.7
Rumex Acetosa	1			1	2	3	1.2
Tovara virginiana			1		1	1	0.4
Persicaria		1			1	1	0.4
Persicaria pennsylvanica	2	1	1		4	4	1.7
Persicaria Persicaria			2		2	2	0.8
Amaranthus retroflexus			1		1	1	0.4
Geum canadense	1	2	3	1	7	7	2.9
Meibomia sp.		1			1	1	0.4
Rhus glabra		1			1	1	0.4
Acer sp.				1	1	1	0.4
Tilia sp.				1	1	1	0.4
Sanicula marylandica		1			1	1	0.4
Lappula echinata	1		7	1	9	9	3.7
Verbena hastata			1		1	1	0.4
Verbena stricta		1			1	1	0.4
Triosteum sp.			1		1	1	0.4
Ambrosia trifida		1			1	1	0.4
Ambrosia elatior		4	1	7	12	20	8.3
Bidens		2			2	3	1.2

Table 33

Nonfood Seeds for Period III

No. Fecal Passages	Summer 217	Fall 126	Winter 79	Spring 53	Totals 475		
						Individuals	
	No. Occ.	No. Occ.	No. Occ.	No. Occ.	No. Occ.	No.	Pctg. Tot. No.
Syntherisma sp.			1		1	1	0.8
Syntherisma Ischaemum		4			4	4	3.2
Syntherisma sanguinale		13	1		14	28	22.4
Echinochloa Crus-galli		1			1	2	1.6
Chaetochloa glauca	4	8	1		13	21	16.8
Chaetochloa viridis		4	1		5	24	19.2
Cenchrus		1	1		2	3	2.4
Poa pratensis	1				1	1	0.8
Cannabis sativa		1			1	2	1.6
Polygonum Convolvulus		1			1	1	0.8
Persicaria			2		2	9	7.2
Persicaria pennsylvanica		3			3	4	3.2
Amaranthus sp.		1			1	1	0.8
Sanicula marylandica			1		1	1	0.8
Lappula echinata		1			1	2	1.6
Verbena sp.			1		1	1	0.8
Ambrosia trifida	1				1	1	0.8
Ambrosia elatior	1	5	1		7	16	12.8
Bidens		2	1		3	3	2.4