LIFE HISTORY AND MANAGEMENT STUDIES OF THE RACCOON (*Procyon lotor lotor*) IN MICHIGAN

By

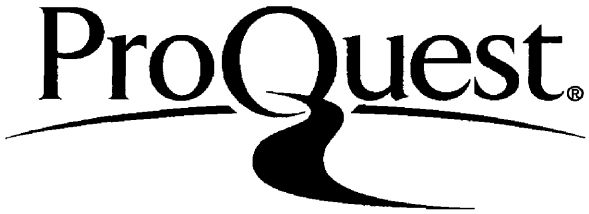
FREDERICK WILLIAM STUEWER

A THESIS

Presented to the Graduate School of Michigan State College of Agriculture and Applied Science in Partial Fulfillment of Requirements for the Degree of Doctor of Philosophy

Department of Zoology

1941



ACKNOWLEDGMENTS

Gratitude is expressed to Mr. H. D. Ruhl, Chief of the Game Division, and to the Michigan Department of Conservation for providing part-time employment which made this study possible. Grateful acknowledgment is made to Professor J. W. Stack, chairman of the graduate committee; to Dr. H. R. Hunt, Head, and Dr. M. D. Pirnie of the Department of Zoology; to Dr. H. T. Darlington, who helped with botanical studies, of the Department of Botany; and to Dean E. A. Bessey of the Graduate School, Michigan State College. Indebtedness is expressed to Mr. R. D. Burroughs, Supervisor of Game Division Pittman-Robertson projects in Michigan; to Dr. D. L. Allen and Dr. Carl Gower, who were in charge of Swan Creek Wildlife Experiment Station in 1939 and 1940 respectively; and to Mr. B. T. Ostenson, Department of Zoology, Michigan State College, for their supervision and many helpful suggestions. Constructive criticism by other members of the Game Division is also appreciated.

Analysis of food habits material was made by Mr. Charles C. Sperry, United States Department of Interior, Fish and Wildlife Service, Dr. H. E. Ewing and Dr. Irving Fox, United States Department of Agriculture, Bureau of Entomology and Plant Quarantine identified the ecto-parasites and Dr. Carl Gower the endo-parasites. Valuable field records were contributed by Mr. A. O. Haugen, Mr. R. D. Montgomery, Mr. P. S. Baumgras, Mr. M. C. Cooley, Mr. R. C. Dunning, Mr. W.T. McConnell, and Mr. J. C. Cameron, who were members of the Swan Creek Wildlife Experiment Station staff at various times during my work. The writer also expresses thanks to Mr. Guy Teed, Allegan, Michigan, who furnished dogs and much enjoyed companionship on numerous nights of 'coon hunting.

TABLE OF CONTENTS

INTRODUCTION

The raccoon is one of Michigan's most important fur-bearers, usually rating about third in annual fur value. Moreover, the species furnishes sport to approximately 10,000 hunters who trail the animals with dogs. According to hunters, trappers, and fur-buyers, there have been declines in raccoon numbers in parts of southern Michigan during the past twenty years. Reports indicate that these scarcities have occurred in areas where drainage, wood cutting and other human activities have altered previously favorable habitats. Any systematic improvement of such conditions must come through constructive management. So little has been known about the habits and habitat requirements of raccoons that it was deemed expedient first to conduct impartial investigations before setting up a state-wide management program.

The only available study of the species in Michigan is that by Dearborn (1932) who analyzed 500 scats. Similar food habits studies have been made by Hamilton (1936 and 1940) in New York, and by Giles (1939 and 1940) in Iowa. The raccoon is a secretive, nocturnal, seldom observed animal, and facts concerning it have been extremely few. There has been, as far as is known, no comprehensive ecological study of the species. Many of the references in the compiled bibliography include only "handed down" nature lore and casual findings.

The present report is the result of a two-year Pittman-Robertson project initiated in February, 1939, and preliminary work done during two summers prior to that time. Under a cooperative arrangement, the writer was employed part-time by the Game Division, Michigan Department

of Conservation, and at the same time enrolled in the graduate school of Michigan State College. Representatives of both agencies gave technical direction for the work.

The Swan Creek Wildlife Experiment Station of the Game Division served as headquarters and furnished laboratory and field equipment besides that purchased with Pittman-Robertson funds specifically for the project. The population of raccoons equalled or excelled the average for the state. Of further advantage was government ownership of the land, which made available about 35,000 acres upon which required modifications and regulations could be set up according to the special needs of the work.

The object of this research was to determine every possible fact concerning the habits and requirements of raccoons as a basis for sound management, and to test proposed measures. An attempt was made to conduct the work along those lines most productive of information applicable to management and to follow various leads as they evolved from the studies.

THE AREA

Intensive studies were conducted on the Swan Creek Wildlife Experiment Station of 5,000 acres in Allegan County, Michigan, and cursory observations were made over much of the surrounding 35,000 acres of government owned land. The Station lies in the approximate center of the county, along the Kalamazoo River which traverses the region in a southeasterly northwesterly direction. Its boundaries include parts or all of Sections 22, 23, 25, 26, and 27, Manlius Township; Sections 30, 31, 32, and 33, Heath Township; and Sections 3, 4, 5, 8, 9, 10, and 17, Valley Township.

Physiography and soils

The topography and soils of the area are the result of glaciation (Riggs, 1938). A pre-glacial Kalamazoo River is believed to have occupied nearly its present position with a deep valley through this region. During glacial times the river was an important outlet for melting ice, discharging into Lake Michigan. The large, almost level tract of sand found here originated as an outwash plain and delta at the mouth of this drainageway. Veatch (1933) rates the soil as third class.

The present Kalamazoo river and its tributary bayous flow in a rather deep valley out through the sandy formation, the floodplain, as much as a mile wide in places, lying about 50 to 100 feet lower than the adjacent sandy plains. There are thus two distinct physiographic types, the uplands and the lowland floodplain. The alluvial clay loam soil of the latter is fertile, but recurring floods make it unsuitable for cultivation. It is the floodplain habitat which is particularly favorable for raccoons.

Recent history

The floodplain in the region formerly supported a heavy stand of ash, elm, and maple, with scattered hemlock. The last of the lumbering operations here took place between 15 and 20 years ago. Only the best timber was removed and many of the larger trees having little value as lumber were left. Reproduction of the same species has since grown up. Because of prohibitive cost little bottomland was cleared for cultivation. Much of the floodplain in which the studies were made was, however, pastured by cattle several years ago.

The sandy upland plain formerly supported a forest of northern white pine with an admixture of white and black oak. About 80 years ago the pine was lumbered off. Succeeding reproduction was largely of white and black oak with a scattering of pine. Repeated fires swept the region during the following years. Within the last two decades some (not over 10%) of the land was cleared for agricultural purposes. Low fertility of the soil soon discouraged the farmers and open waste fields are now the only evidence of their activities. The Federal Government beginning in 1935 purchased about 35,000 acres of the land under the Resettlement Administration in a rehabilitation project, and moved the last remaining settlers out. Since 1937, 5,000 acres in about the center of this large tract have been under the administration of the Game Division, Michigan Department of Conservation as the Swan Creek Wildlife Experiment Station.

Vegetation of the region in general

The vegetation of the region at present is much the same as that of 50 years ago. The sandy uplands support a forest principally of white oak (*Quercus alba*) and black oak (*Quercus velutina*), the trees ranging up

to 16 inches in diameter. Northern white pine (Pinus strobus) occurs in scattered stands throughout the area. Other species of common occurrence are poplars (Populus spp.), black cherry (Prunus serotina), and sassafras (Sassafras officinale), and these three are also invading the openings resulting from former cultivation. Many kinds of weeds and grasses have stabilized most of the open area, but severe wind erosion has resulted in occasional sand "blows".

The floodplain forest corresponds to the black ash-American elm-red maple forest type established by the Society of American Foresters (Forest Cover Types of the Eastern United States, 1932). The three type species predominate over all others occurring here, and throughout the greater part of the region, red maple (Acer rubrum) is the most abundant species. Associates include a moderate amount of basswood (Tilia glabra), some sycamore (Platanus occidentalis), and scattered swamp white oak (Quercus bicolor) and butternut (Juglans cinerea).

Vegetation of the General Study Area

The General Study Area is a 2,464 acre tract upon which most of the intensive raccoon investigations were carried out (fig. 1). Bounded on the north by the Kalamazoo River and on the east by Swan Creek, it includes both floodplain and sandy upland. Of approximately 200 acres of cleared land, about half is sedge meadow and wasteland. The remainder is under cultivation as the Experiment Station farm. A dike prevents flooding here.

The lowland portion of the tract supports principally the typical ash-elm-maple type of forest (fig. 2 and 3) in which red maple predominates. Many of the trees are old specimens left during lumbering

Fig. 1. Aerial map showing the General Study Area outlined in black. A, Lowland Den Study Area.

Fig. 2. Typical black ash-american elm-red maple forest type found on the Kalamazoo River floodplain. Note zone of buttonbush bordering bayou.

Fig. 3. Early spring aspect of the wooded floodplain.

operations and the majority are decayed and hollow. Some measure as much as 50 inches in diameter. Young trees of the various species are coming in. In the Swan Creek bottoms American elm (Ulmus americana) is about equal in abundance to red maple, and butternut is somewhat more plentiful there than on the river floodplain. The second story vegetation is made up of a great variety of species. Poison ivy (Rhus toxicodendron) and wild grape (Vitis vulpina) are abundant. Spice bush (Benzoin aestivale) is the principal shrub in the more shaded locations, while red osier (Cornus stolonifera) and silky dogwood (Cornus amomum) grow in great profusion where there is more light.

The western part of the tract is upland with vegetation as described for the sandy plain in general. The white and black oak are generally interspersed but almost pure stands of each species occur in places. Flowering dogwood (Cornus florida) is the chief shrubby species.

Vegetation of the Lowland Den Study Area

This area, chosen for a quantitative study of dens in the lowland habitat, is situated within the General Study Area, and its vegetation is similar to that already described (fig. 2). The southern portion contains a considerable amount of white pine and some hemlock (Tsuga canadensis). In the open situations herbaceous vegetation, consisting of wood nettles (Laportea canadensis), giant ragweed (Ambrosia trifida), and jewel weed (Impatiens biflora), form an almost impenetrable tangle in summer.

Vegetation of Upland Den Study Area

The upland tract in which a den survey was made is in the northwest corner of the General Study Area. White and black oak are the pre-

Fig. 4. Bulrushes and yellow water lilies are found along the bayous.

Fig. 5. A white oak den tree in the uplands. A remnant from earlier days when oak was only an admixture among the pine.

dominant tree species with a few scattered white pines. There is a fair abundance of large white oaks in the eastern half of the tract, which were left during lumbering operations. Most of these are decadent and hollow and furnish the majority of the dens in the upland habitat (fig. 5). Few of the second growth trees are larger than 12 inches in diameter. The forest canopy is rather dense in this area resulting in very little understory vegetation.

Vegetation of Ottawa Marsh (Controlled Hunting Area)

The so-called Ottawa Marsh consists primarily of floodplain habitat with forest cover of the ash-maple type (fig. 6). The central portion of between two and three-hundred acres is marshland including some open water, sedge meadow, and a considerable zone of shrubs, principally of buttonbush (Cephalanthus occidentalis), and two species of dogwood, (Cornus stolonifera and Cornus amomum) (fig. 7). The latter three species are also found as an understory in the open situations of the forested portion, and constitute what is locally known to the hunters as "knuckle-brush". The Kalamazoo River bounds the area on the north, and Daily Bayou traverses it from east to west. Invariably in spring and often in summer after heavy rains the whole lowland portion is inundated (fig. 8).

About 200 acres at the southern edge of the area is upland supporting a uniform stand of white and black oak. The mast produced here is an attractive food supply for the raccoons living in the adjacent lowlands.

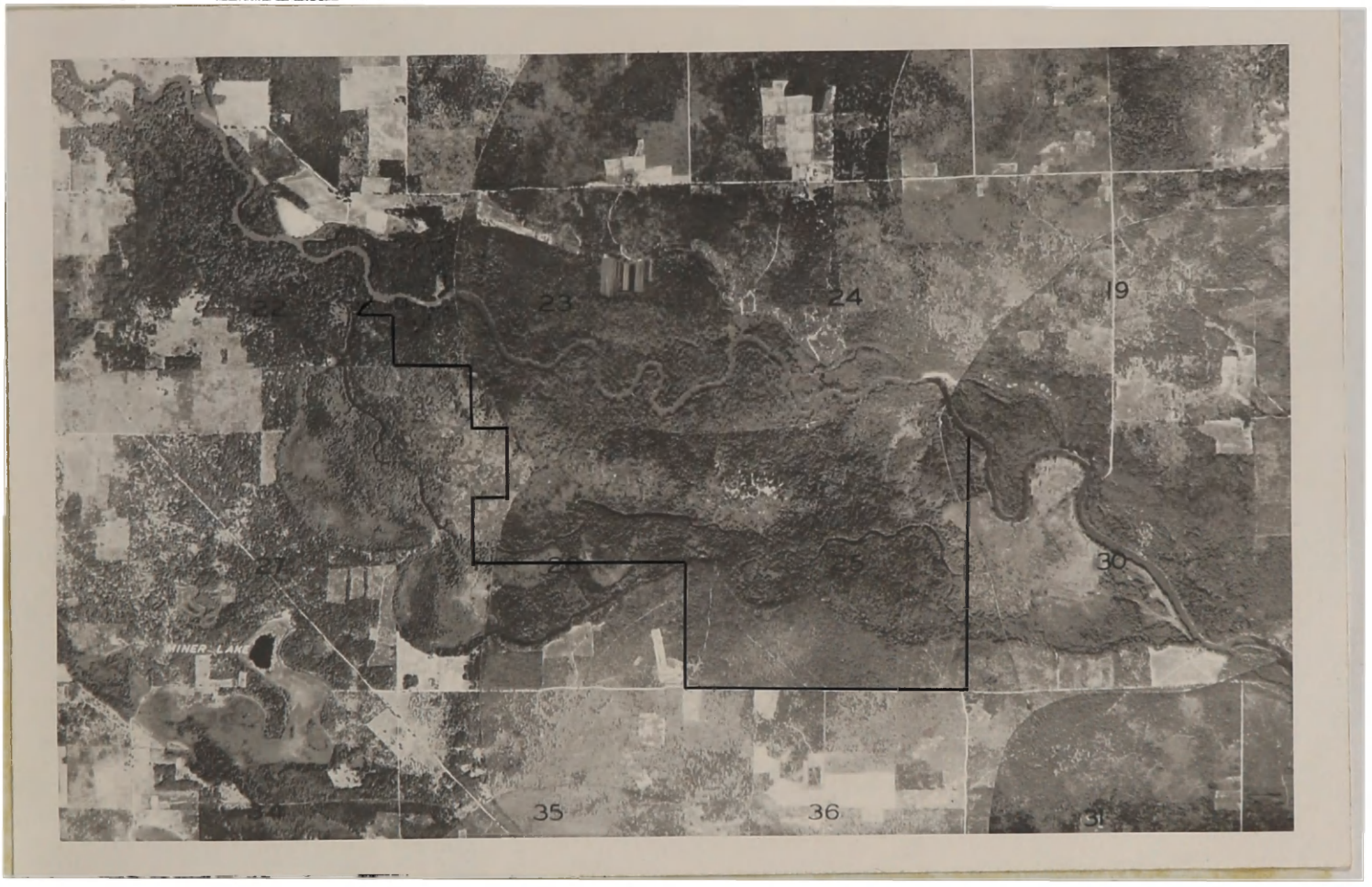


Fig. 6. Aerial photograph of the Ottawa Marsh. The Kalamazoo River forms the northern boundary, and Daily Bayou traverses the tract from east to west.

Fig. 7. Marsh, shrub zone, and ash-elm-maple forest of the Ottawa Marsh tract.

Fig. 8. High water causes flooding of the lowlands invariably in spring and often in summer and fall.

Fig. 9. Vines of poison ivy such as this one, and of wild grape make the woods almost impenetrable in places.

METHODS

The principal methods employed in the investigation will be described here. Other minor procedures will be discussed in the text where it seems appropriate to do so. There have been very few formulated techniques for studying the fur-bearers, and for the raccoon there seem to have been practically none. As this study progressed certain methods evolved which were adapted to getting the desired information.

Live-trapping

Live-trapping was employed rather successfully and resulted in a great deal of information which otherwise would not have been obtainable. Since raccoons are secretive, nocturnal animals, some means of capturing the animals was necessary in order to get any amount of detailed information. Examination of the live raccoons gave many of the data on the breeding habits, sex ratios, weights, incidence of disease and parasitic infestations, clues to possible mortality factors, and general condition of the raccoon population. By marking captured individuals numerous other facts, including breeding age, range, dispersal, mortality and population density were learned. Tagging of juveniles early in the work made it possible to handle some animals of known age throughout the investigations, which aided greatly in getting significant and reliable data. A number of attempts were made to follow lactating females to their young with a dog, but the animals took temporary refuge instead of returning to their regular dens.

Traps: The live-trap used was originally designed after the Evans cat-trap, but since has undergone many modifications (fig. 12). It measures one foot square by two feet long. The framework is made of

1½ inch fir with the 22 inch front uprights grooved (¼ inch wide x 5/8 inch deep) to accommodate the sliding door. The latter is of no. 18 gauge sheet metal. No. 16 gauge, ½ inch-mesh hardware cloth covers the trap, a lighter material often being torn by raccoons and other large mammals. The trigger mechanism is of a simple "figure 4" type, in which a spring holds one wire arm of the trigger against the metal floor treadle when the trap is set, and another wire connected to the upper end of this one extends forward and underneath the door to hold it up. When an animal steps on the treadle, releasing the first wire, the spring pulls the second from beneath the door. A triangular metal lock swings into place above the door after it has dropped preventing raccoons from raising it.

Trapping technique: Best results were obtained by placing the traps along avenues of travel such as rivers, creeks, bayous and ditches (fig. 10). Generally a position next to a tree or fallen log was most effective. Accessibility of the bayous, rivers and creeks to a car governed to a great extent the distance between groups of traps, while suitability of sites for making good sets determined the individual spacing. Each trap location was marked with a numbered metal tag as a permanent station to be used in succeeding years.

Traps were tended once a day, usually in early morning in order not to hold the animals any longer than necessary. Most of the raccoons were surprisingly quiet and did not fight the traps to the extent of injuring themselves seriously. Several times two young individuals were taken together in a trap (fig. 11) and once a juvenile was waiting outside of the trap in which its mother had been caught.

Fig. 10. Ditches made very good trap set locations in spring.

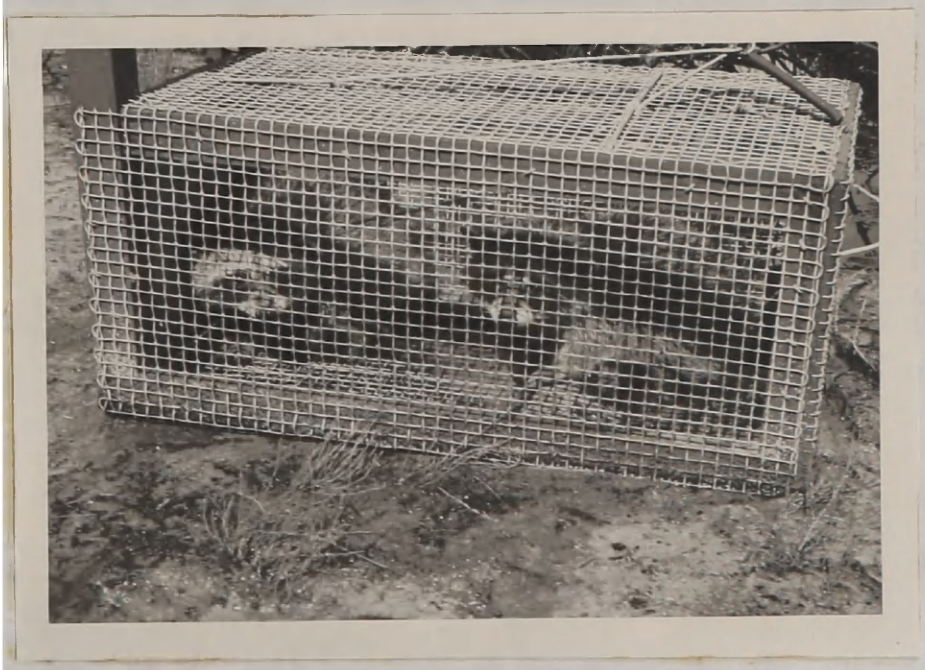


Fig. 11. Two-in-one occurred several times.

Baits: The most satisfactory trap bait proved to be an ear of corn together with some smoked, dried herring. The animals did not seem to eat the herring very readily, but the strong odor probably attracted some individuals to the trap which otherwise would not have been caught. The corn was invariably eaten. A number of other baits including smoked whitefish, fresh carp, chicken, cheese, peanut butter, prepared dog food, and a mixture of honey, fish oil, and anise oil were tried, but they were either ineffective or spoiled too quickly, except the last-mentioned combination, and that had to be renewed too often for best results.

Handling: In order to tag, weigh, and examine the animals thoroughly, they were restrained in a cone made of wire netting. This device consisted of a piece of two-inch mesh, 16-gauge fox-netting fashioned into a cone about two feet long and tapering from nearly a point at one end to approximately 10 inches in diameter at the other. The large end was placed in the open doorway of the trap and the animals would usually run into the "cone" of their own accord as they sought to escape. The equipment and techniques employed are shown in figs. 12 to 15. With a raccoon in this cage, it was not difficult to tag the ears, pull the feet through the mesh for measurement, and examine the animal for pregnancy, lactation, parasites, and other desired information. Large dialed scales accurate to one ounce, and having a capacity of 30 pounds, were used to weigh the animals.

Marking: Marking raccoons for later identification was done in two ways: ear-tagging and toe-clipping. Tagging proved quite satisfactory, since of 256 animals handled only six were known to have lost their tags. Some which were marked near the beginning of the study

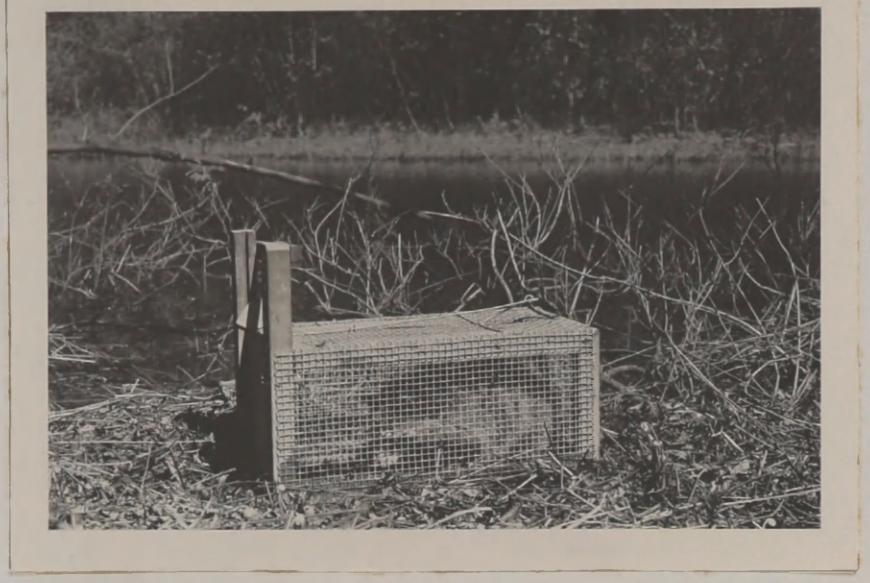


Fig. 12. First step in handling -- the raccoon in the trap.

Fig. 13. The animal would usually enter the "cone" voluntarily when the trap door was opened.

Fig. 14. Dialed scales were used for weighing which had a capacity of 30 lbs. with three revolutions of the pointer. This animal weighed 17 lbs., 1 oz.

Fig. 15. Ears projected through the wire netting of the "cone" allowing convenient and safe tagging. Feet were also measured and general examination of the animals made.

retained their tags two years later. The tag employed most successfully was the #1005 metal tag of the National Band and Tag Company, Newport, Kentucky (fig. 16). This tag is three-sixteenths of an inch wide, with a three-sixteenths inch space between the sides. Pliers made especially for the purpose were used to place the tag in the ear and clinch the ends in one simple operation. To distinguish sex of animals on sight, males were tagged in the right ear and females in the left. This was especially useful in den studies whenever a marked animal escaped before it could be caught. Very young animals of litters found in dens were marked with smaller tags, which were replaced by the larger ones if the individuals were recaptured at a later date.

The main purpose of toe-clipping was to make possible the identification of individuals by means of their tracks. This gave valuable information on range and breeding, and to some extent the numbers using an area. A wire cutter which crushed off the toe rather than severing it cleanly was employed because it caused less bleeding than a sharper instrument. Toes of very young raccoons bled little, if at all, and the injuries healed in a short time. Fig. 17 illustrates the system of numbering used. On the first 20 animals only one toe was clipped. Beyond that two toes, one front and one hind, were removed. Toe number 11 indicated the 20's, number 12 the 30's, etc., while a front toe indicated the digit in each case. Fig. 17 therefore shows the marking of individual number 38. Tracks in sand, mud or snow made by animals marked in this manner could be easily identified (figs. 18 to 20).

Den studies

In investigating dens all trees with hollows, whether occupied or not, were tagged with numbered aluminum tags for future identification,

Fig. 16. The metal ear tag proved to be a good marker.

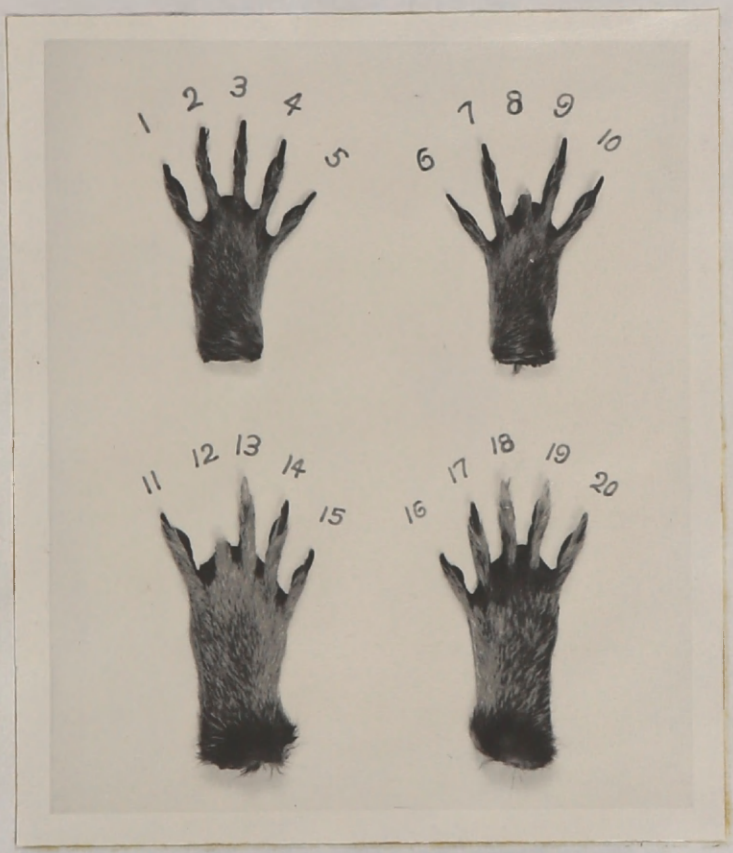


Fig. 17. Showing the system of clipping toes to represent numbers. For 20 and below only one toe was removed. Above 20 a hind toe was clipped to indicate the tens and a front toe to indicate digits, no. 11 indicating 20's, 12 the 30's etc. The above toe-clip was therefore no. 38.

Fig. 18. Tracks in sand road of raccoon toe-clipped number 57.

Fig. 19. Tracks in mud of raccoon toe-clipped number 40.

Fig. 20. Tracks in melting snow were easily identified. This animal was not toe-clipped.

DEN RECORD

Den number____ Date located____ Locality____

County____ Twp.____ R.____ Sec.____ Forest type____

____ Topography____

Den tree: Species____ Height____ Dia.____

Dist. to water____ Dist. to edge of woods____ Den: Height____

Location____ Exposure____ Inside dia.____ Dist. from hole

to nest____ Dia. of hole____ Type entrance____ Nest materials

____ Signs (if not occupied)____

If occupied, Number____ Sex____ Age____

Potential breeding den____ Not____

Additional notes____

____

____

____

By____

Sketch of den

Fig. 21. Card form used for recording den data.

and a form card filled out for each one (fig. 21). All measurements except distances to water and edge of woods, and heights of tree, were taken with flexible steel tapes.

Equipment and handling: In addition to measuring tapes, other equipment was indispensable to the den work. Climbing irons with three-inch spurs were used to gain access to the dens and a safety belt employed to allow freedom while working in the tree. A flashlight with lens at right angles to the case was very useful. Raccoons were taken from the natural den entrance when possible, but often it was necessary to cut an opening at nest level with keyhole and pruning saws. Such "doors" were then hinged into place, making the dens habitable for raccoons, and easily accessible for further examinations. To take a raccoon from a hollow, fox tongs were used by which the animal was transferred to a cone lashed to a tree branch. After descending the tree, the handling procedure was the same as for trapped animals.

To determine whether or not certain dens were used, "combs" were fastened to the den entrances to catch fur and hair. These were made by doubling a small piece of light, $\frac{1}{4}$ inch mesh hardware cloth and twisting the cut wires together by two's along the one edge. These caught hair and fur as evidence of an animal's visit.

Tracking

Track observations were often made while traps were being tended and during other field work, but in order to gain specific information concerning range, food habits, and hibernation, a sand road was mulched with a steel road drag every night during certain periods, and walked the next morning for track counts (fig. 22). This 1.8 miles of road lies

between the oak upland and floodplain habitats, running parallel to a steep bank separating the two. Since the animals were denning in the lowland area on one side, and going to feed in the uplands on the other side, and since toe-clipped animals could be identified, some valuable information was obtained. As many as 17 animals crossed the road in one night (p.90).

Fig. 22. Tracks in a dirt road which was dragged the evening before.

NUMBERS HANDLED

During the present investigations a total of 256 live raccoons were handled, excluding the 70 pen-raised animals released for experimental purposes. Total handlings amounted to 517; 443 from live-traps; 62 from dens; 6 from a poultry house (female and young); 4 by "treeing" with dogs; and 2 by hand capture. In addition 223 observations of toe-clipped tracks were made, making a total of 740 records for the 256 animals.

Table I shows the numbers and sex of the raccoons handled. Ages indicated are those at the original capture of the animals. Thirty-one of the juveniles were recaptured in later years as adults.

TABLE I

Numbers, Sex, and Age of Raccoons Handled (1937-1940)

Sex	Male	Female
Number first handled when a year or more old	41	48
Number first handled as juveniles	92	75
Totals	133	123
Number of the juveniles later handled as adults	15	16

Fig. 23 shows the frequency distribution of trap-nights and trap-catches, and the percentage of traps catching raccoons in each

month. May, July and August were the most profitable trapping periods. After this was learned more traps were operated at those times, which accounts for the high degree of correlation between percentage of efficiency and high numbers of trap-nights. The principal reason for better success during these three months is probably due to the animals feeding more regularly then along the water courses where traps could be set most effectively. Why so few catches were made in June is unknown.

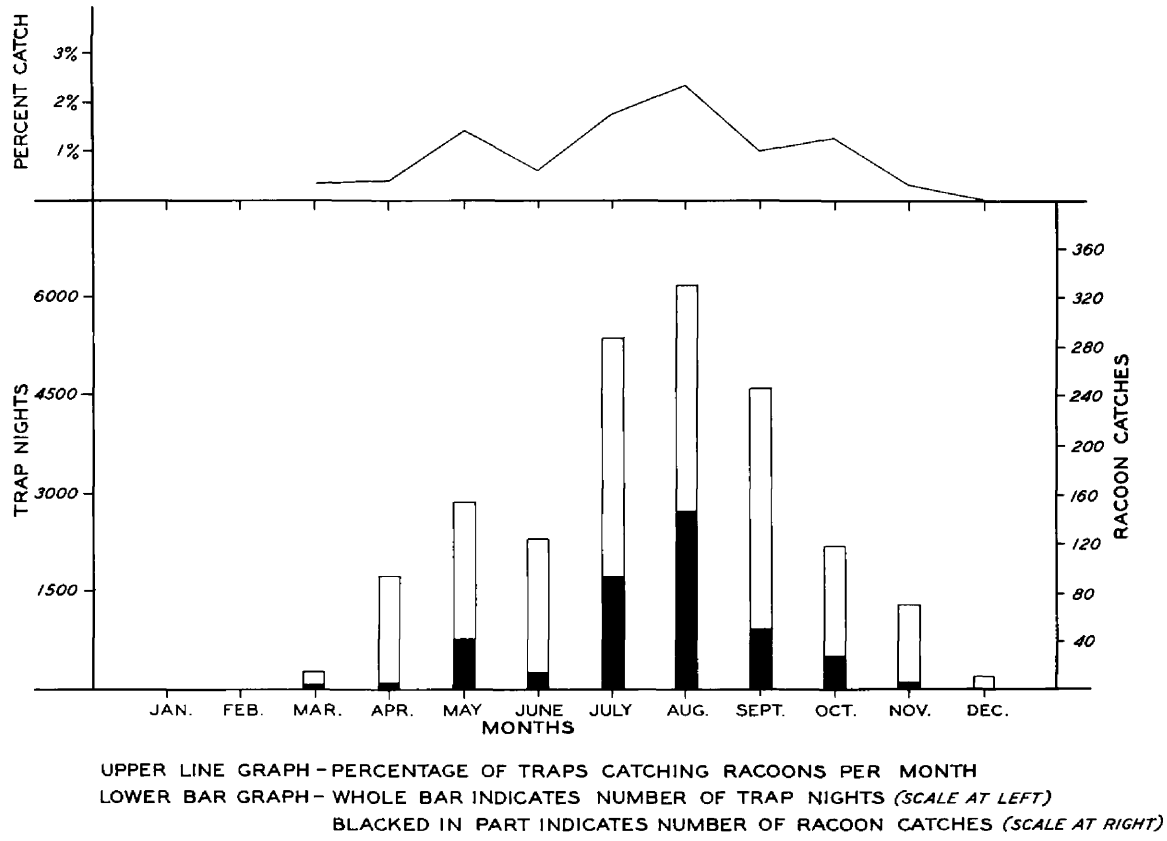


Fig. 23. Graph showing number of trapnights and number of raccoon catches per month from 1937 to 1940.

I. LIFE HISTORY OF THE RACCOON

GENERAL CHARACTERISTICS

Description

The raccoon has been described so often and so well, Anthony (1928), Seton (1929), and others, that no lengthy description is needed here. The distinctive marked face and ringed tail immediately distinguish the animal from any other species in our part of the country. Its cousin, the cacomistle of the southwest, also has these markings, but is smaller and more slender with a longer tail. One of the most unique descriptions of the 'coon is that by Burroughs (1900) who calls him "that brief summary of a bear".

Hunters tell of sometimes taking dark, rangy "swamp 'coons" in contrast to the usual lighter "upland 'coons". There is a variation among the individuals both as to color and bodily build, but it is quite possible that the hunter's "swamp 'coon" may have been travelling in the uplands the night before. From present observations there is no evidence that in Michigan color or other variations within the species are correlated with differences in habitat.

Albinism occurs in raccoons as in many other mammalian species, but it is rare. No albinos were taken during the present study and there are no known records of any from this region. Certain areas apparently have strains with a greater tendency toward color differences. For Washtenaw County, Wood (1922) reported a dozen records of albinos, and half that number of melanistic ones. Many of the animals handled during the present study were rather dark, but probably should not be called melanistic according to the usual meaning of the term. One juvenile, prac-

tically all black, was taken by a hunter, but according to reports a captive "black 'coon" had escaped from captivity in that area the year before, and may have been the parent of this animal.

Physical qualities

The hardiness, physical stamina, and ability of raccoons to defend themselves seem extraordinary. Bailey (1926) says that they are savage fighters and will defend themselves against a dog of equal size. Grinnell, Linsdale and Dixon (1937), quoting a hunter, state that a 'coon will turn on a pursuing dog when the two get in water, and drown it. Several hunters in this region will attest this statement, and from the savagery and strength displayed by a cornered animal, it seems entirely credible.

A raccoon can fall from a considerable height without being injured. Several individuals, both adults and juveniles, were shaken to the ground from heights of 30 to 40 feet and all were immediately on their feet and away at top speed. Whitney (1933) reports an incident in which a pregnant female fell 30 or more feet from a tree, landing on her side; yet later she bore four young.

The ability of raccoons to withstand severe temperatures was indicated by an occurrence at the Experiment Station in the winter of 1940. A yearling animal was kept in an open-wire pen with a den box which later showed the entrance was too small. This animal stayed outside on a foot of snow for 10 days and nights, during which time the temperature went down to 28 degrees Fahrenheit or lower every night, and as low as -9 and -10 degrees on two occasions. Even after such

exposure this individual appeared to suffer no ill effects, and was still healthy more than a year later. Their heavy layer of fat evidently furnishes raccoons considerable insulation and protection from cold (p. 73).

Voice

Various writers have described calls of raccoons, which reportedly can be heard considerable distances. Wood (1922) says it is a "shrill, tremule cry, almost like a whistle"; Evermann and Clark (1911) report hearing a shivery call in spring, not unlike that of a screech owl; and Stone and Cram (1902) say that adults reportedly have varying calls similar to that of screech and barred owls, and at times like a colt's whinnying. The writer has never heard any call similar to these in the wild during the present work,nor have any of the several captives ever been known to utter such cries. However, different calls which carry no great distance have been heard from raccoons at various times.

Penned animals often make a "chittering or twittering" sound when wandering aimlessly back and forth, and females assure their young in the same voice. A variety of crys and growls are uttered by angry 'coons. Trapped animals often growled, and issued a cough-like snarl. Cornered individuals, especially those taken from dens, often give a throaty, tremulous cry, somewhat in the same tempo as the whistle of a woodchuck, but more of a growl and not nearly so loud. Captives, when angry at a passing dog or person, sometimes utter a distinctive whine, accented at the end. The very young when disturbed in the den have a "chittering" cry also, and it was by hearing this that several litters

were located. Somewhat older juveniles, handled by hand from traps, usually uttered such a harsh, screeching cry as to hurt one's ears, although the animals were not being injured.

Sense of smell

The only observation to be pointed out here is one concerning the finding of acorns by the animals. In July, 1940, after a road had been dragged, it was found that raccoons had dug up acorns buried in the loose dirt. By some means they had located these nuts, which were covered over with one to two inches of dry, powdery sand (fig. 45). How this was accomplished is not known but the guess that the animals smelled them is as plausible as any.

Sociability

It appears that adult raccoons usually live singly rather than seeking the company of others of their species. Even during the mating season animals of breeding age were usually found alone in the dens. Excepting females with litters, and one other case in which two of the animals had been disturbed previously in another den, no more than two animals were found denning together. Juveniles show a tendency to stay together during their first winter, but older individuals seem to prefer to be alone. In only one instance was more than one adult raccoon found in a den; a liberated pen-raised male was living with a native male (table XXIV, appendix).

Nocturnalism

Anthony (1928) says that raccoons are strictly nocturnal and never leave their dens during the day except when disturbed. However, practically all other writers agree that although principally nocturnal,

raccoons come out at times during the day to feed and sun themselves. During the investigations at Swan Creek, no undisturbed animals were ever seen out by the writer, but two hunters who returned tags reported shooting the 'coons out of the tree during the day, and a pheasant hunter's dog on the experiment station farm came upon an adult and juvenile along the bayou.

The fact that hunters often have the best success in running 'coons on wet, foggy nights has led many to believe that the animals remain denned except in such weather. However, raccoons are out in all kinds of weather during the spring, summer, and fall and it is probably the difficulty encountered by dogs in following the animals over a dry trail that usually accounts for lack of success on dry nights.

Running

The raccoon's ability to lead hunters and dogs on a long chase is due to its stamina, cunning, and probably mainly to a knowledge of his home territory, rather than running ability. Stephens (1906) says that they cannot run fast and this has been verified by the writer. Unless an animal reaches cover or a tree, a person can outrun and catch it rather easily.

Swimming

Raccoons can, and do, swim of their own accord but are not particularly fond of swimming. Animals caught along the bayous or the river often swam across when released. The Kalamazoo River, which averages about 100 feet in width, is no barrier to them (fig. 25). In one instance a juvenile was live-trapped on both sides during the summer, and tracks of

Fig. 24. An albino and normal colored raccoon.

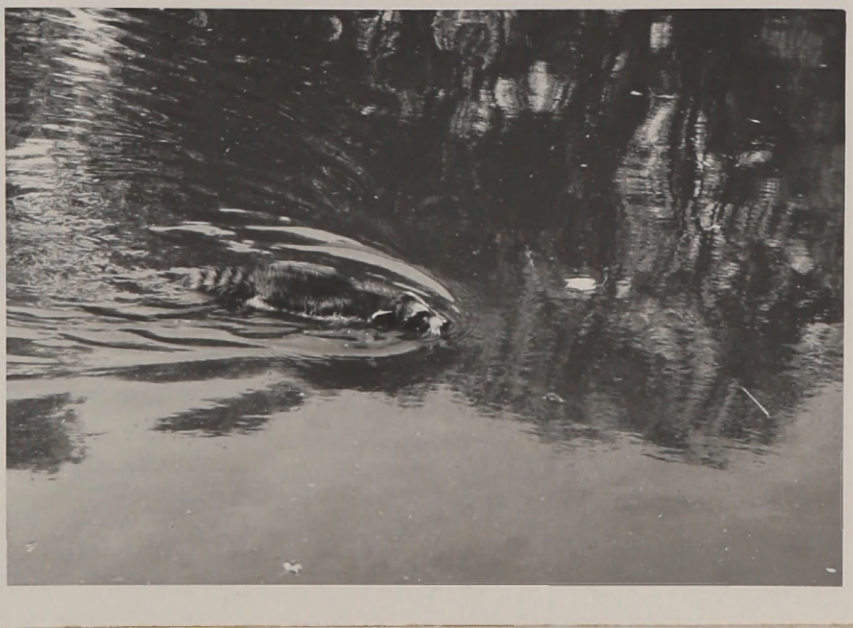


Fig. 25. The Kalamazoo River was no barrier to this juvenile.

some toe-clipped individuals on both sides showed that they often swam across. Reports that a raccoon can drown a dog in midstream also indicates that they are able to handle themselves well in water.

Longevity

The old phrase "for a 'coon's age" implies that this species enjoys a rather long life, but there seems to be little available information on the subject. A hunter acquaintance of the writer, who has a captive male says the animal is eight years old, and that he once had two others which he sold at that age. It is doubtful if many live that long in the wild, since they are so heavily hunted with dogs. Nevertheless, several individuals with badly worn teeth were handled which probably were at least several years old.

Miscellaneous values

Aside from their worth as fur-bearers and sporting game animals, and the accrued benefits to man as a result of their feeding habits, raccoons possess other values. Their flesh is edible, and has been eaten since the early days of frontier settlements. Merriam (1889) mentions seeing carcasses in the market at that time. Alexander Henry, in charge of the Northwest Company's trading post in the Red River Valley, North Dakota, and his men often included roasted 'coon in their diet, according to Bailey (1926), and considered them very good eating. It is interesting to note that earlier, Audubon and Bachman (1851) wrote that the Indians considered the meat rank and no good. At the present day hunters, in Michigan at least, often eat raccoons. The writer can say from personal experience that the flesh of a young, acorn-fattened, well

prepared animal is very palatable. According to Grinnell, Linsdale and Dixon (1937), Chinese buyers regularly buy carcasses in California and sell them to their Chinese customers. They also report gall bladders being in special demand at about 15 cents apiece. In the early days thrifty pioneers converted the fat into a thin oil, which Bailey (1926) says "was the principal oil used for domestic purposes and even for machinery in the frontier settlements". The same was highly prized for use on leather.

REPRODUCTION

Sex Ratio

Sex of raccoons can be readily determined. The os penis of the male is easily demonstrated by palpation, and the external urinary opening is several inches anterior to the anus. On the female the genito-urinary opening is within about one inch of the anus. Though the writer has been assured by an old hunter that he could sex raccoons by a difference in width of the rings on the tail, a method supposedly taught him by the Indians, there seems to be no correlation of color markings with sex, nor any criteria by which males and females can be differentiated without close examination of the animals.

During the present study 250 individuals were handled from traps and dens, and six were taken from a chicken coup. There was a male to female ratio of 1.08 to 1, or 133 males to 123 females. Among 89 adults, 41 were males and 48 females, and of 167 juveniles, 92 were males and 75 females. The only reference to sex ratio of raccoons found in the literature is that by Bennitt and Nagel (1937). They report a ratio of 1.27 males to 1 female, (171 males, 135 females), among 306 raccoons killed in Missouri.

Relationship of sexes

The relationship existing between the sexes in respect to mating has been controversial. Seton (1929) says: "All the evidence there is goes to show that the raccoon is a monogamous animal." However, no evidence is cited as a basis for his statement. Whitney (1933), apparently from observations of captive animals, considers them poly-

gamous. Fur-breeders seem to be generally agreed that a male will mate with more than one female, and this has also been the observation concerning penned animals at the experiment station.

All available evidence during the present study indicates that raccoons in the wild are promiscuous in their breeding. Sexually mature males and females generally den singly, and during the mating season the former travel from one hollow tree to another apparently seeking receptive mates. Wood (1922) mentioned tracking raccoons for miles where they had travelled over the snow visiting other dens. The tracks he saw were very likely those of males active during breeding season. Females have been found to go short distances from their dens at that time, but males were the distance travellers.

Five females in oestrum were examined in 1940, three of them each occupying a den alone. One of the others was an adult denning with two yearling males, but in this case the two yearlings had been disturbed previously in another den, after which they had moved. The situation here should not, therefore, be considered indicative of normal behavior. The other of the five females was a yearling found together with a male of the same age. The fact that upon recapture two months later, she was neither pregnant nor lactating indicates that she and the male were not a mated pair, but were more likely members of the same litter of the previous year. Three more females, two located during breeding season, but not examined, and the third, pregnant in May, were also found alone. In addition, seven females were located in dens with their litters, unaccompanied by males.

Lone mature males have been located in dens at various times of the year, and tracks of toe-clipped individuals are further evidence

of their living alone. During the mating seasons of 1940 and 1941, two toe-clipped males were tracked in the snow. Fig. 26 shows the one and one-half mile trail of adult male #694, who on February 5, 1940, visited several dens and probably mated with at least one female. On February 11, 1940, this individual was in the same territory where his trail was followed for nearly two miles. On the same date female #2037, an adult, was also located in a den, and her tracks followed over the entire circuit she had made the previous night. As seen in fig. 27 these two animals met, possibly mated, and then both continued on their way, she returning almost directly to her den. Fig. 28 shows the activity of another adult male, finally located in a den on February 12, 1941. During wanderings of approximately one mile, he visited eight hollow trees, six of which had been marked previously as potential denning sites. Evidently he was also seeking a mate or mates, although unsuccessful during the length of his observed travels.

Sexual maturity

No information has been found in the literature relative to the age at which raccoons become sexually mature in the wild, and even for animals in captivity records are few. Seton (1929) refers to a pet which gave birth to young when a year old. Bennitt and Nagel (1937) report that on a raccoon farm in Missouri six males observed from birth did not mate until they were two years old, and that twelve females mated at the age of one year. In one instance yearling males are reported to have mated with litters resulting. Bissonnette and Csech (1938) report that of two males and three females from the same litter,

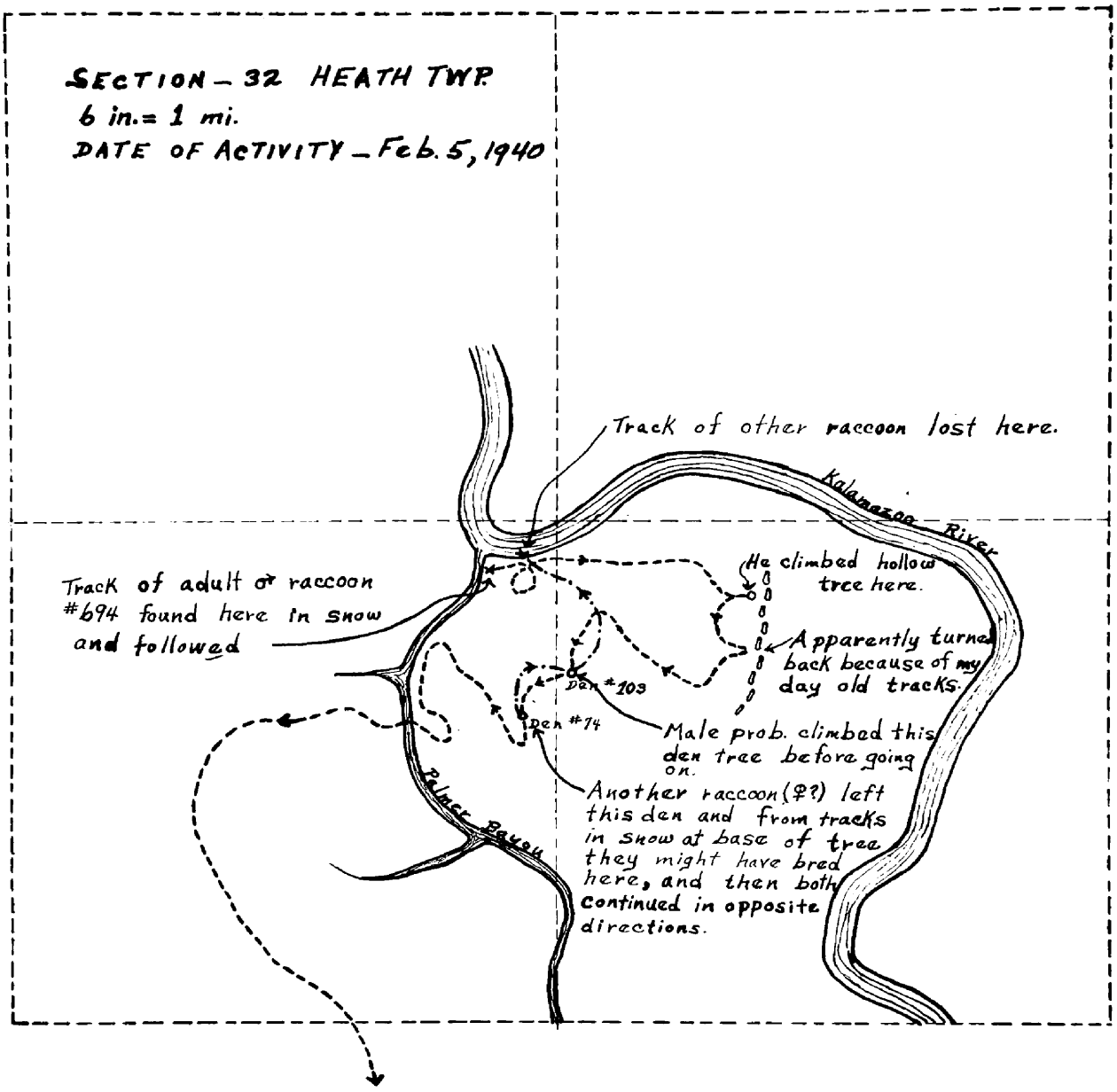


Fig. 26. A night's activity of an adult male during breeding season when he evidently was seeking mates.

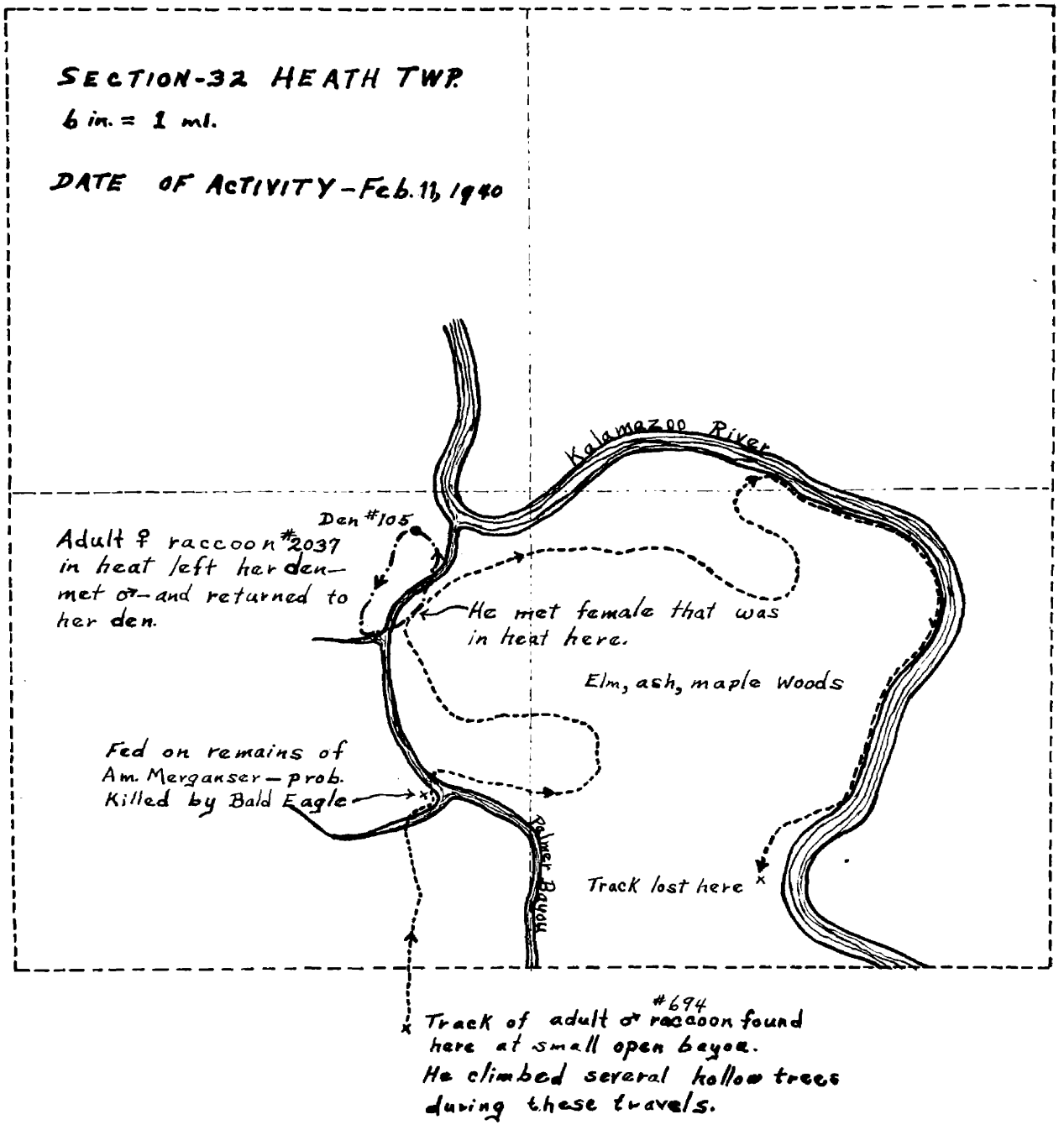


Fig. 27. A night's activity of an adult male and adult female during breeding season.

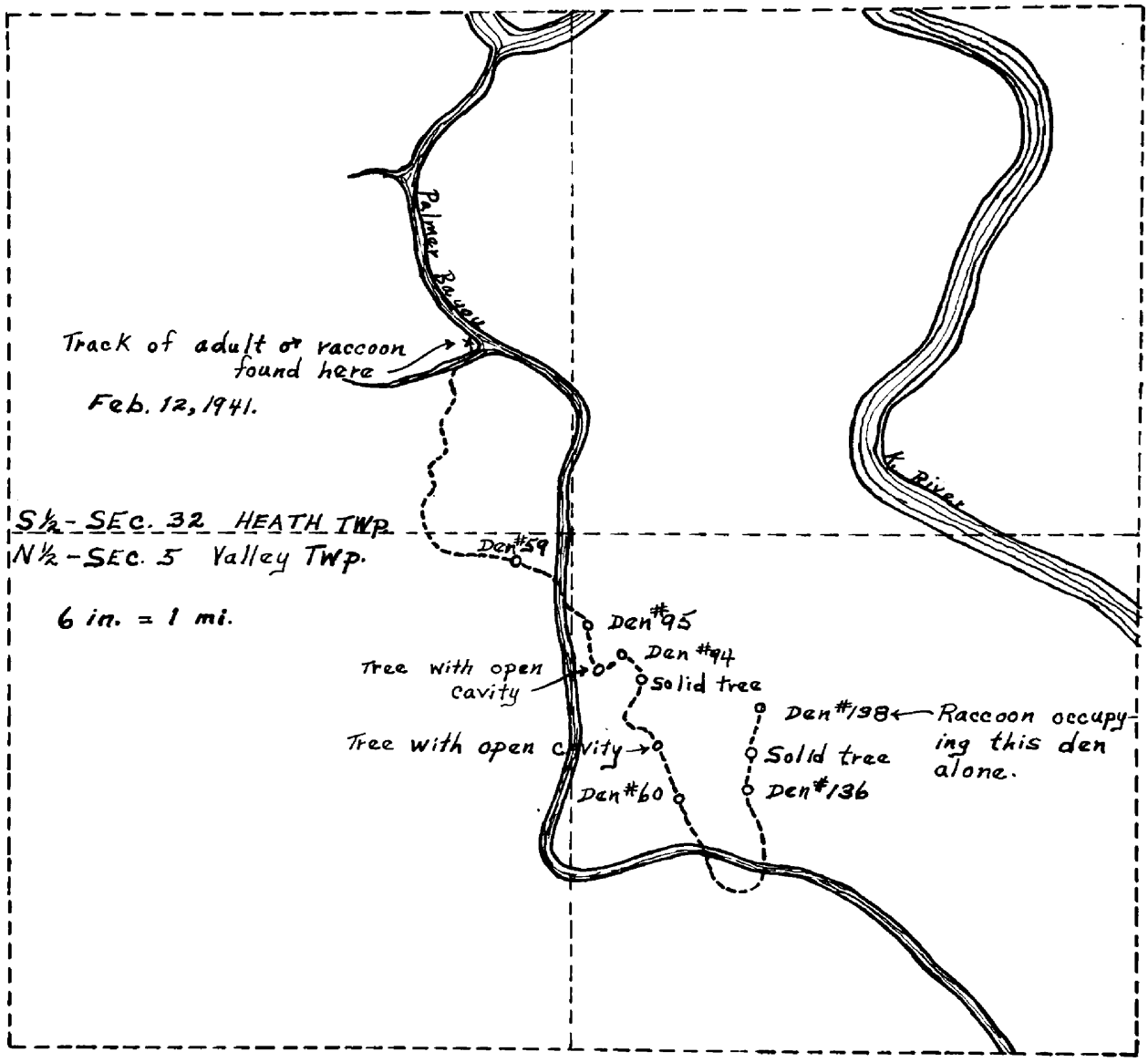


Fig. 28. A night's activity of an adult male during breeding season. He visited eight hollow trees in the search for mates and was found in den #138 at the end of the trail.

two females produced offspring. They stated, however, that "pregnancy in the first winter occurs very rarely ---." Mr. L. Pankrats of the Shady Fur Farm, Springfield, Minnesota, advises that yearling females produce litters but that year old males are not capable of breeding.

Males: Evidence from the present study concerning the age at which male raccoons become sexually mature is meager and circumstantial, since there is no way of knowing whether or not a male has mated. On one occasion a yearling male was found denning with a yearling female, but although the latter was in oestrum she did not produce young that spring. Her failure to conceive may have been due to the male being too young to mate successfully. If this male was in breeding condition it seems that he would have denned alone as adult breeding males did. There is some evidence that the size of testes indicates the capacity of males to breed. Table II shows testes size of juveniles, yearlings, and older animals. Each figure was obtained by measurement of the scrotum of an animal with the testes descended, and is accurate to approximally 5 mm. Since testes of juveniles and yearlings were abdominal in position, it was necessary to force them carefully into the scrotum for measurement. Those of adults were usually descended during the breeding season, and until April and May, but more often in the coelom during the remainder of the year, although the position seemed to be variable. The measurements presented are comparatively few, but show that yearling males tended to have smaller testes than adults until past the mating season (February and March). The gonads of the majority apparently did not attain adult size (approximately 30 mm.) until fall of the raccoons' second year, until which time they were possibly not sexually mature.

TABLE II

Length of Raccoon Testes at Different Times of The Year

Age	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.
Adults		40		20 30 35	20 30 30	30 30	25 25 25 25 30 35	30 30 35	30	30	30	
Yearlings		15 10	15 35	20 20 20	20 25 25 30	30	20			30 30		30
Juveniles							10		10 10 15	10 20		

Measurements in Millimeters and Accurate to approximately 5mm.

Females: Conclusive evidence from the examination of 28 individuals, shows that some females become sexually mature and breed at the age of approximately ten months and bear young when a year old. These animals were captured from dens or in traps when they were either in oestrum, pregnant, lactating, or were with litters of young. Methods of determining the condition of a female are discussed in detail on page 49. The state of pregnancy was most difficult to establish positively. The abdomen was palpated to feel the embryos, but since the abdominal muscles were usually held rigid by the animal, some doubt usually existed as to whether or not a decision was correct. However, the diagnosis for four of five individuals was later proven to be correct when the animals were recaptured, two of them with litters, and two lactating. The other animal was not rehandled.

Fifteen of the 28 yearlings were known to have produced young, since 12 were lactating when examined between May and August and three were found in dens with litters. The ages of nine of these were positively known as they had been marked the previous year as juveniles. The other six were classified as yearlings on the basis of weights, teeth and other characteristics (p. 78). It is possible that three more of the remaining 13 animals also bred, but such information is not available, since they were each handled only once, one not in oestrum on February 3, another in oestrum on February 13, and the other considered pregnant on May 17. That ten did not breed successfully is shown by the fact that they were neither pregnant nor lactating by May or later.

The above data show that at least 15 of 28 or 53.6% of female raccoons produced litters when a year old. It is a matter of conjecture

as to why the 10 individuals failed to reproduce. All except one (apparently in poor health) of 27 adults were known to have mated successfully. It seems unlikely then that there was not an opportunity for all yearlings to mate. The only explanation the writer has to offer, a highly speculative one, is that the presence of a yearling male (probably non-breeding) might deter a breeding male. In one instance, after a yearling female was found denning with a yearling male during her oestral period, later examination showed that she had produced no young.

Several records give indications of fecundity of females from year to year. One, marked as a juvenile in 1938, had a litter in 1939, and another in 1940. Four other animals were handled a sufficient number of times to know that one which did not bear young as a yearling did the second year, and that three adults produced litters in two successive years.

Reproductive cycle

Males: The rather meager information available concerning the age at which male raccoons are capable of breeding has already been presented (p. 45). Apparently ability to mate successfully is not attained until the animals are nearly two years old. The breeding cycle is likewise not well established. If testis size is significant, it appears that the animals are probably capable of breeding at all times of year after reaching maturity. However, table II, p. 46, shows that the testes of four adult males in July measured 25 millimeters, which is smaller than the majority were during mating time and shortly thereafter, and of a captive male, testes measuring 35 millimeters in March were diminished

to 20 millimeters in July. Whether or not the reduction is significant is unknown. From the actions of captives, it appears that males are prepared to mate at any time.

Females: The vulva of a sexually quiescent female is not at all prominent. As the receptive period approaches, it acquires turgidity and becomes larger. When the animal is in oestrum, the vulva is much swollen; the lips protrude and are somewhat divergent. The parts have more reddish hue. After mating, or when the animal is no longer receptive the vulva gradually diminishes to normal size, during which time it is whitish in appearance.

The duration of time from the onset of vulvar enlargement until a female is receptive appears to be between one and two weeks. Swelling was first observed on one captive on February 23. No male was available until March 8, but she was very receptive to him at that time and they copulated. Probably she would not have accepted him for more than a few days previous to the 8th, since another female received a male during only three days. After copulation was observed the male and female were separated. Twenty-one days elapsed before her vulva was down to normal size.

On February 10, 1940, a male was noticed trying unsuccessfully to mount a female. Upon examination her vulva was found to be somewhat swollen. By February 20, ten days later, she was receptive to the male and they were observed to copulate on several occasions during three successive days. The vulva was very turgid and reddish at that time. Gander (1928) also observed a pair to mate over a period of three days. Thirteen days later (March 6) the vulva was approaching normal but was still a bit enlarged.

A third record is for a yearling female that had escaped in December, was caught in a trap on February 14, and was held captive. She appeared to be in heat when caught and the arrival of a litter on April 15 showed that she bred in the wild about February 11. The vulva of this animal was still greatly enlarged and turgid on March 3, or 20 days after copulation. Five days later it was approaching normalcy, but was not down completely until several days later.

From these observations it is apparent that a period of from one to two weeks elapses from the onset of vaginal swelling until the female will receive the male. After the receptive period of about three days, three or four more weeks pass before the vagina is again normal in appearance.

Mating season: The mating period of raccoons seems to vary somewhat with the latitude. In Connecticut and Massachusetts, Whitney (1933) says they breed during the last week in January. Hamilton (1936) states: "In New York mating normally occurs during the first half of February." According to Seton (1929), January or February is the mating season in Ohio (captives). In Oregon where there are differences in seasons and temperatures from high altitudes to the lowlands, Bailey (1936) says that mating appears to be immediately after hibernation, which varies from January to March.

Judging from the present studies most mating in southern Michigan apparently takes place from the first week in February through the first week of March. The date of earliest breeding is based on a litter record in 1939. These young appeared to have been born, judging from their size and development, in the first week of April. The gestation

period being about 63 days, this female must have copulated during the first week of February. There are three records of a similar nature indicating mating as late as the first week in March. Three litters, two to three weeks old, handled on May 23 and 24, must have been born the first or second week of May, which would place the breeding dates of these females in the first week of March. An adult female handled on March 5 appeared to have recently passed the receptive oestral period, which may have occurred as late as March 1.

There is a record of an adult female which undoubtedly bred as late as May, and was parturient in July, probably as the result of a second period of oestrum. When trapped on September 18, she was lactating profusely, and two juveniles, exceptionally young for that time of the year, were taken the next day, one in the same trap and the other in one adjacent to it. All other females had ceased lactating a month before, and the juveniles in the case, whether from this animal or not, were surely born as late as July, because they not only were small (4 lbs. 5 oz.; and 4 lbs. 10 oz.), but still retained their milk teeth in mid-October. Other young animals weighed this much and were shedding their milk teeth in August. Other writers have also observed evidence of a few such late matings. Hamilton (1936) found juveniles in New York weighing less than three pounds in the fall, and believed them to be the result of early summer breeding, due to females failing to conceive during the regular winter breeding season. The same thing was observed by Whitney (1931) in Connecticut. Evidently yearling females do not breed later if they fail to in the winter.

There is one record of a yearling female, which probably bred in late March, since when handled on May 17 she appeared to be pregnant. As pointed out previously, pregnancy was correctly diagnosed for four of five individuals, which should support the validity of this record. This case is not considered indicative of the usual mating time of yearlings, because the majority evidently breed at about the same time as adults.

Table III presents in summarized form breeding data records for 55 females. Calculated copulation dates, records of females in oestrum, and litter records, indicate that most breeding is accomplished in February and early March. One record shows almost the exact date on which a female copulated. Though this animal had been a captive, she had escaped in December, 1938, and having had her freedom for two months before mating time, her breeding activities should have been normal. She was recaptured on February 14, 1939, held in captivity, and gave birth to young on April 15. Copulation therefore took place on February 11, if the gestation was the usual 63 days, and it must have taken place on or before February 14.

Data in table III indicate that there is only one litter of young annually. Such a late breeding record as was discussed on p. 51 indicates that there may be a second oestrum period for adult females which fail to conceive in February or March, but available evidence shows that only one litter is produced. It is interesting to note that Bissonnette and Csech (1938) were able to obtain two litters from captive animals by artificial lighting of the pens, which brought about first matings in December and a second in May or June.

TABLE III

Summary of Reproduction Data For 55 Female Raccoons

	Copulation records calculated from age of litters.		Females in some stage of oestrum		Records of Pregnancy		Parturition records calculated from age of litters			Females lactating		Females in post lact. period	
Dates \ Ages	Unknown	Yrl.	Ad.	Yrl.	Ad.	Yrl.	Unknown	Ad.	Yrl.	Ad.	Yrl.	Ad.	Yrl.
Feb. 1-Feb. 15	4	1	2	2									
Feb. 16-Feb. 28	3												
Mar. 1-Mar. 15	3		1	1									
Mar. 16-Mar. 31						1							
Apr. 1-Apr. 15							4		1*				
Apr. 16-Apr. 30						2	1	2					
May 1-May 15						1		2	1	5	1		
May 16-May 31						2				6	2		
June 1-June 15											1		
June 16-June 30										1			
July 1-July 15										6	1		
July 16-July 31										6	6		
Aug. 1-Aug. 15										1	5	2	3
Aug. 16-Aug. 31										2	1	3	1
Sept. 16-Sept. 30										1**		1	
Oct. 1-Oct 31												1	
Nov. 1-Nov. 30												1	

* Female held captive which bore litter on April 15.

** Female which had unusually late litter (See text, p. 51).

Gestation: The only available record concerning length of the gestation period of a female in the wild is for the escaped animal mentioned previously (p. 52). She was known to be pregnant at least 60 days before parturition. The records of oestrum, pregnancy and parturition presented in table III indicate a span of about two months between mating and birth of young, but give us no definite time limits.

There are several records for the gestation period of captives. One observed by the writer gave birth to young at least 64 days after the last copulation, but it may have been 66 days, since the young were probably two days old when found. Hamilton (1936) and Seton (1929) both give 63 days as the gestation period. Gander (1928) observed a California raccoon (Procyon psora Californicus) which was pregnant for 65 days after the last day of mating. The longest time is cited by Brown (1936) who reported a female becoming parturient 69 days from first coition.

Lactation: There must be a difference in the number of teats possessed by female raccoons, according to the literature. The mastology of a raccoon killed near Toronto, Canada, 1888, as sketched by Seton (1929) includes four pairs. Bailey (1926) in describing raccoons of North Dakota mentions two pectoral and two abdominal pairs; and of Oregon raccoons (1936) he says there are three pairs; one pectoral, one abdominal, and one inguinal. All 126 female raccoons handled in this study had three pairs; one thoracic, one abdominal and one inguinal in position (fig. 29).

The teats of an unbred yearling raccoon remain undeveloped, and measure about one millimeter in length, and are flesh colored. They remain in this condition if the animal does not breed. In advanced

Fig. 29. Showing the mastology of the raccoon. This female was lactating in July and the teats were enlarged.

pregnancy the teats begin to enlarge, become much larger after parturition and suckling, and usually are almost black. The color seems to vary somewhat, as one lactating female had teats mottled in flesh and darker hues. During lactation the teat is from 10 to 15 millimeters long, and the proximal portion appears as a slight elevation between 15 and 20 millimeters wide (fig. 29). When lactation ceases the teats diminish to small nipples approximately 5 millimeters in length, remaining, however, larger than before they were suckled.

During the lactating period, milk could be obtained by gently squeezing and "milking" the teats. For a short time after lactation ceased, a yellowish, or almost clear fluid of syrupy consistency was found, and later there was none at all. Records in table III show that all fecund females lactated through July, and that the majority had stopped by the end of August. Five were found to be "dry" by mid-August. One exceptional animal still suckling a litter on September 18 has already been discussed (p. 51).

Evidently the young are suckled after they have left the den to accompany the mother in seeking food. The milk teeth of juveniles are not yet replaced by the permanent set at that time, the change occurring during August, thus coinciding with the "drying up" of females. This seems to be a favorable adjustment of the development of the young to the lactation cycle, which provides the animals with means of obtaining and utilizing solid foods at the time that they are weaned away from the milk diet.

Litters

There are numerous references in the literature on the number of young in a litter of raccoons and the approximate birth dates (table

IV), but only one concerns records for animals in the wild. For the California raccoon (not P. l. lotor) Grinnell, Linsdale and Dixon (1937) found records (embryo counts and litter observations) in the University of California museum, of from 3 to 7 per litter, and concluded that young are born in April and May.

During the present investigation, ten litters between one to ten weeks of age were examined in dens; and one female autopsied on May 29, 1940, exhibited scars of recent placental attachments. Judging from the age of all of these juveniles they were born during April or the first half of May. Numbers in the ten litters varied from 3 to 7, with an average of four (figs. 30 and 33). There were also four placental scars in the uterus of the autopsied female (fig. 32) making the average for 11 litters of young born in the wild exactly four.

A litter of two, and one of three, were born in captivity at the experiment station, the latter to a female which had escaped captivity and bred in the wild.

Records show that the size of litters by yearling and adult animals are probably the same. Four wild adults are known to have had three and four each, and a captive only two. One wild yearling had three, and a captive three.

The sex ratio existing in eight litters of which all the young were handled, was 1 male to 1.36 females (14 males, 19 females), (table V).

Breeding potential

Data already presented indicate that the sex ratio in this region was close to 50:50; that approximately 50% of the females bore young as yearlings; that one litter per year was produced thereafter; that it was exceptional for an adult female not to

TABLE IV

Dates of Birth of Raccoons and Size of Litters Reported in Literature

Source	Month of birth	Numbers per litter	Records from wild or captive females
Anthony (1928)	April and May	3 to 6	?
Audubon and Bachman (1851)	Early May	4 to 6	?
Cory (1912)	April and May	3 to 6	?
Goodwin (1935)	?	4 to 5 6 sometimes	?
Grinnell, Linsdale and Dixon (1937)	April and May	3 to 7	Wild (Embryos and litters)
Ingersoll (1907)	?	5 or 6	?
Kennicott (1858)	?	3 to 6	?
Martin (1939)	?	litter of 8	Captives
Seton (1929)	April or May	3 to 6 (4 usual)	
Stone and Cram (1902)	April and May	3 to 6	?
Sweeney (1905)	?	2 to 3	?

Fig. 30. A litter of average number (14 to 20 days old on May 23, 1940).

Fig. 31. An exceptionally large litter (10 to 15 days old on April 29, 1940).

TABLE V

Data Concerning 10 Litters of Raccoons Found in Dens

Date handled	Age of female	Number of young				Approx. age in days	Estimated date of birth
		M	F	Unknown	Totals		
4-29-40	?	3	4	0	7	10-15	Apr.-2nd wk.
5-3-39	Ad.	1	3	0	4	21	Apr.-2nd wk.
5-3-40	Ad.	2	2	0	4	7-10	Apr.-4th wk.
5-10-40	?	2	1	0	3	7-14	Apr.-3rd-4th wk.
5-11-39	?	0	5	0	5	14	Apr.-2nd wk.
5-11-39	?	-	1	2	3	21	Apr.-3rd wk.
5-23-40	Ad.	4	0	0	4	14-20	May-1st wk.
5-24-40	Yearl.	1	2	0	3	14	May-2nd wk.
5-28-40	Ad.	1	2	0	3	21-28	May-1st-2nd wk.
6-14-39	?	1	2	1	4	60	Apr.-1st wk.

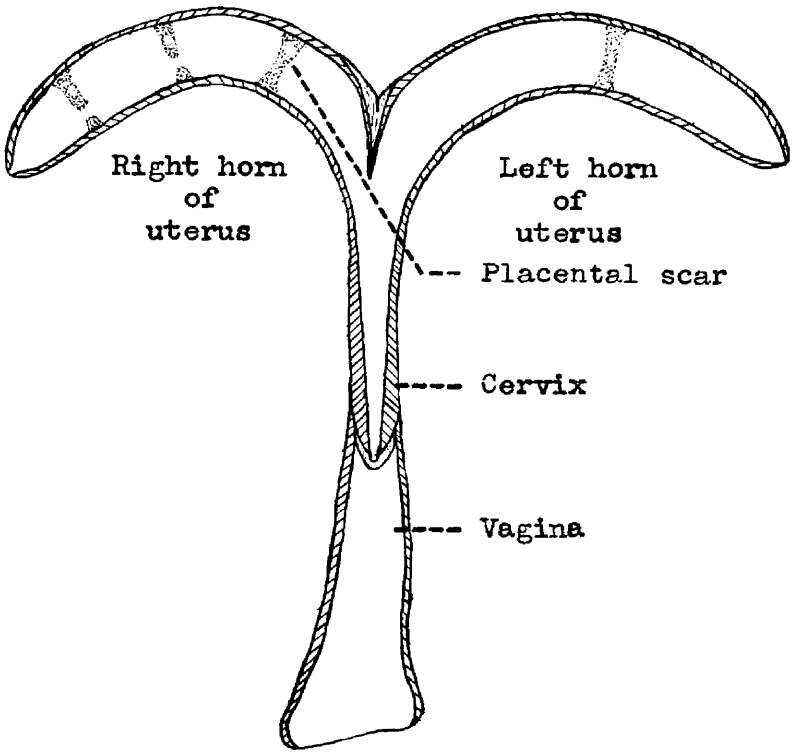


Fig. 32. Diagramatic sketch of dissected genital system of two-year old raccoon, approximately four weeks after parturition. Scars of zonal placentae show that she gave birth to four young.

raise a litter; and that the average litter size was four. If these data are reliable, a definite figure representing the breeding potential of the species can be postulated. It would be in the ratio of 4 to 1 per female or 2 to 1 per adult if all yearlings bred. Since only 50% (actually 53.6%) of the yearlings were found to breed, a correction must be made. This however leads to another unknown to be established first, namely, the relative numbers of yearling and adult breeding females present in a population. Intensive work in one area (trapping, den examinations, and tracking of toe-clipped animals), showed the ratio of breeding yearling females to adult females to be 50:50 (14 yearling females, half or 7 of which theoretically bred, and 7 adult females). Therefore, according to available evidence, the breeding potential is 3 to 1 per female or 1.5 to 1 per adult. On this basis, barring all mortality, fall populations would be 1.5 times greater than the annual breeding reserve.

Bennitt and Nagel (1937) arrived at the same figure (1.5) to represent the actual ratio of increment by any given autumn. They considered the average litter size to be four also, but deducted one to allow for mortality, and assumed that all young females begin to breed at the age of one year. Their deduction of one per litter balanced the allowance made in the present work for only 50% of the yearling females producing, thus giving the same final figure, theirs representing the ratio of <u>actual</u> fall increment and the present one the <u>potential</u> increment disregarding mortality. If raccoons in Missouri show the same tendency for approximately only one-half of the yearlings to breed, their figure would be reduced to 1.12.

Care of young

Most raccoons in Michigan are probably born in tree dens. There are reports that the animals live in ground holes and drains in localities where hollow trees are scarce, but the latter seem to be preferred where a choice is available. All ten litters examined by the writer in the Allegan region where tree sites are plentiful (p. 167) were in that type of home. In Illinois the usual retreat of the raccoon is a hollow tree (Kennicott, 1858). Bergtold (1925) found a litter in Colorado in a magpie nest but considered the site an unusual one. In Iowa, Indiana, and other states, raccoons make their homes in caves and crevices of the rocky outcroppings (Giles, 1940) (McAtee, 1907), and undoubtedly rear young there.

Table VI shows the size of nine dens in which litters were found. The majority of them had small entrances and were relatively deep, affording good protection to the young. Two, however, #75 and #129, were fairly exposed; in each case a long opening in the trunk leading to the nesting cavity, the bottom of which was practically at the level of the opening. It should be noted that the smaller dens must have allowed too little room for the litters, after they had become even one-third grown. Den #63, (12 inches x 11 inches), contained litters of five and seven in successive years. Crowding in such a small cavity must soon force the family to find a new abode. It seems that during the summer months the usual type of winter and spring dens may no longer be utilized, but instead, the animals find refuge and resting sites in trees with open, shelf-like cavities, in crevices among roots of the large bottomland trees, or in the heavy vegetation of marshland. Denning habits will be more fully discussed later (p. 107).

TABLE VI

Size of Rearing Dens Occupied by Litters

Den number	Kind of tree	Height of den in ft.	Diam. hole in in.	Dist. from hole to nest in in.	Inside diam. in in.
63	Red maple	55	6½ x 3	42	12 x 11
66	Red maple	22	6½ x 3¼	36	10 x 10
100A	Red maple	46½	5½ x 3	37	12 x 12
136	Red maple	26	18 x 5	58	12 x 11
138	Red maple	21	5 x 3	42	14 x 12
59	White ash	23	6½ x 5½	20	13 x 10
75	Black oak	23½	50 x 5	0	15 x 12
129	Butternut	38	14 x 10	7	15 x 10
134	Amer. elm	21	57 x 6	34	13 x 13

In keeping with the polygamous habits of the males is the fact that on six occasions when an adult was found accompanying a litter in the den, all were females. Surrounding another den was a perfect track register of mud, and tracks of toe-clipped females were the only ones present. All evidence at hand indicates that males remain entirely by themselves, and that females alone care for their young. Bailey (1905) gives an interesting account of an incident demonstrating the care a female tenders her litter. "From a hollow some thirty feet up in a trunk", one of the young fell to the water below. The mother started down to the rescue, but the little fellow got back to the trunk and began to ascend, the female going back to the den herself. About one-half way up the unfortunate youngster began to cry and stopped climbing. This brought the female down, and "taking a good hold of the back of his neck and placing him between her fore-legs so that he, too, could climb, she marched him up the tree and into the hollow." The writer also made a unique observation in the spring of 1940 pertaining to the care of young. A juvenile, one of a litter tagged in a den with an identified female on May 24, was found on May 28 with the litter of another female in a different den. The adopted animal was approximately a week to ten days younger than the original members of the litter, but he appeared to be healthy and well cared for (fig. 33). It seems possible that the first female, in moving her young (as all females did after being disturbed), inadvertently dropped this one in the den of the other female, and then left it when she found the hollow already occupied. Whenever litters were found, females usually issued a few growled warnings and then, if possible, retreated to a place of safety for themselves. One

left the den and jumped 23 feet to the ground, going away uninjured. She later moved two of the three young, but deserted the third.

Young raccoons are entirely dependent upon the female and apparently get no food other than milk until they begin to accompany her in the search for food. At that time they are approximately ten weeks old. In 1940, when intensive live-trapping and tracking studies were in progress, the first evidence of the young travelling about was the capture of one in a trap on July 12. This animal had been tagged in a den, and was known to be very near 12 weeks of age. Coincidentally, the first juvenile trapped in 1939 was also taken on July 12. From this time until mid-August the young evidently got both solid food and milk for nourishment. Females cease lactating during August (p. 56). How long family companionship continues after the young are weaned is not definitely known, but from present observations it appears that by fall the young go their own way. From November 25 to December 12, 1939, tracks crossing the road track register (p. 24) showed the animals to be travelling singly for the most part, although pairs of juveniles were common. One day after tracks of two juveniles had been seen together, the two were found in a den. During the winter raccoons were usually found alone in the dens, except for a few yearlings. In addition, since many yearling females breed, it seems logical that they would no longer stay with the mother at that time. It appears evident that the raccoons of this region had become independent by winter, and probably sometime during the fall. Nevertheless, some writers, Wood (1922), believe that a family remains together in the home den until the young are a year old. It is entirely

possible that such opinions are based on hunters' reports of "treeing whole families" in hunting season, at which time the young may still be with the female.

Development of young raccoons

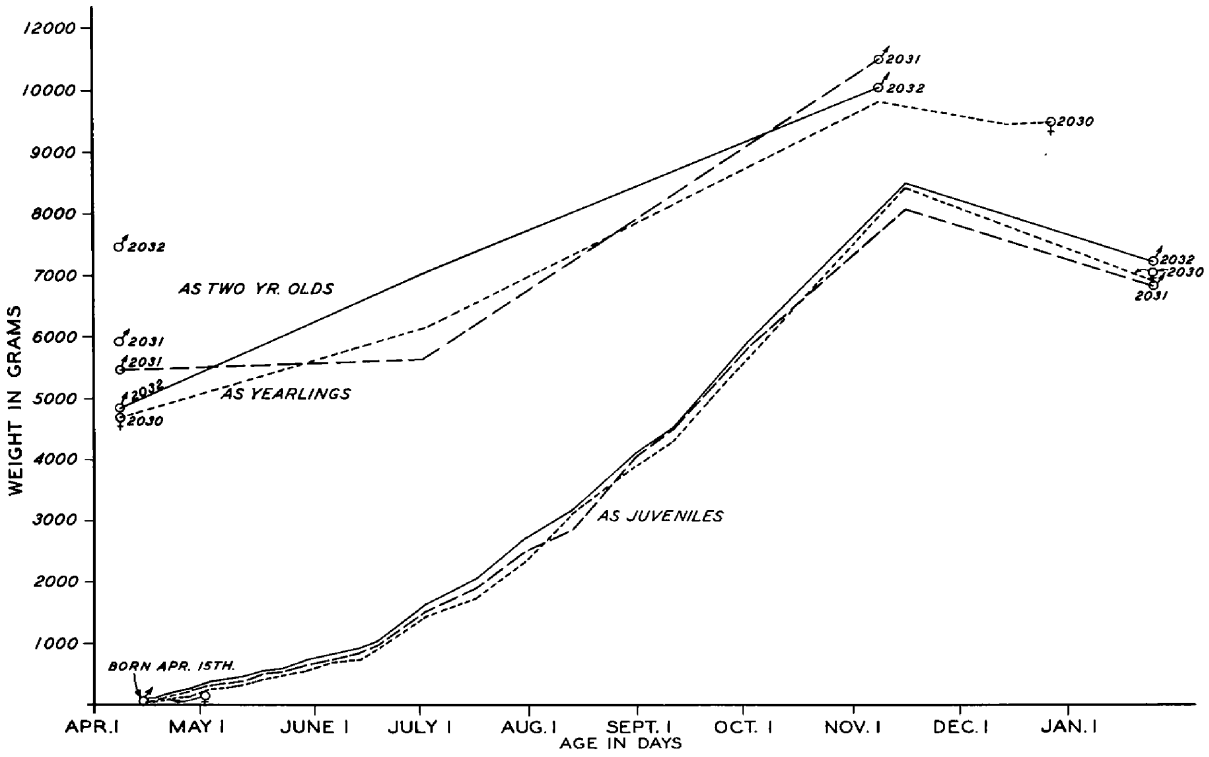
Post-natal development of a litter of captive raccoons until the age of seven weeks has been well described by Hamilton (1936). Therefore little space will be devoted to it here, except to add a few observations made of a captive litter, and to present data obtained on juveniles in the wild.

Raccoons are well furred at birth, dark skinned, have well developed facial vibrissae, but show no rings on the tail. The eyes and ears are closed (fig. 34). Between the 18th and 23rd days the eyes and ears of the captive litter opened. Lower incisors and canine teeth were erupting at about the same time, and upper incisors and other teeth pushed through somewhat later. The rings of the tail, and dark facial mask had also become apparent giving the animals more "coon-like" appearances. From that time on changes were less evident as the animals grew to adult size and acquired adult proportions. Replacement of the milk teeth by the permanent set began when the animals were 16 weeks of age. Wild animals were also observed to be shedding the milk teeth during late August and early September, at which time they were from 16 to 20 weeks old. Incisors and canines were the first to be replaced.

The graph in fig. 35 shows the increase in weight of the captive litter of three during their first year and variations during the second and third years. At birth the average weight was 61.7 grams.

Fig. 33. Female with litter of three and an adopted animal (lightest colored) which belonged to another female.

Fig. 34. A litter of three captive born young on the day of birth.



WEIGHT CURVE OF THREE CAPTIVE RACOONS
FROM
BIRTH UNTIL TWO YEARS OLD

Fig. 35. Graph showing rate of growth of raccoons.

Raccoons grew rather slowly, and it appears that these were not yet fully grown in their second year. That this was also true of wild animals is apparent from fig. 36, which shows graphically 348 monthly weight averages separated according to sex and age of the individuals (also cf. table XXI to XXIII appendix). For those animals handled more than once in a month the average weight was calculated. Numbers of individuals in any one group handled during some months were few, but the weight trend can be clearly seen. Adults, with one exception, were heavier than yearlings for all corresponding periods of the year.

WEIGHTS

Those who have heard hunters report taking raccoons of any weight between 8 and 50 pounds could have been hearing the truth in every case, although about twice the first figure is the average size of a grown Michigan raccoon in fall of the year. Bailey (1926) reports a large fat male in Minnesota which weighed 30½ pounds, but says that one-half that is more nearly their usual weight. Seton (1929) considers 18 pounds as approximately the average size, but also quotes a reliable hunter who took a 49 pound animal in Vermont before 1900. Whitney (1931) tells of a Mr. J. A. Graydon who ran an advertisement for raccoons over 25 pounds to be paid for at the rate of $1.00 per pound. During several months only two were received, which weighed 31 and 26 pounds. These were from Florida and from a western state respectively. The largest raccoon ever taken in Michigan for which an authentic record is available (Wood, 1932) weighed 56 pounds. It was killed in Montcalm County near Edmore in May, 1904.

The heaviest wild individual handled during the present study was an adult male weighing 21 pounds, 10 ounces in August. The largest female weighed 18 pounds, 6 ounces, also in August. Weight records were obtained for 153 adult and yearling raccoons. These were segregated according to sex and age and monthly averages plotted together with juvenile weights in fig. 36, to show the weight increase of animals until they attain full growth. From these data it appears that males tend to be somewhat heavier than females, although the difference is not great. Raccoons do not become full grown before the end of their second year or later.

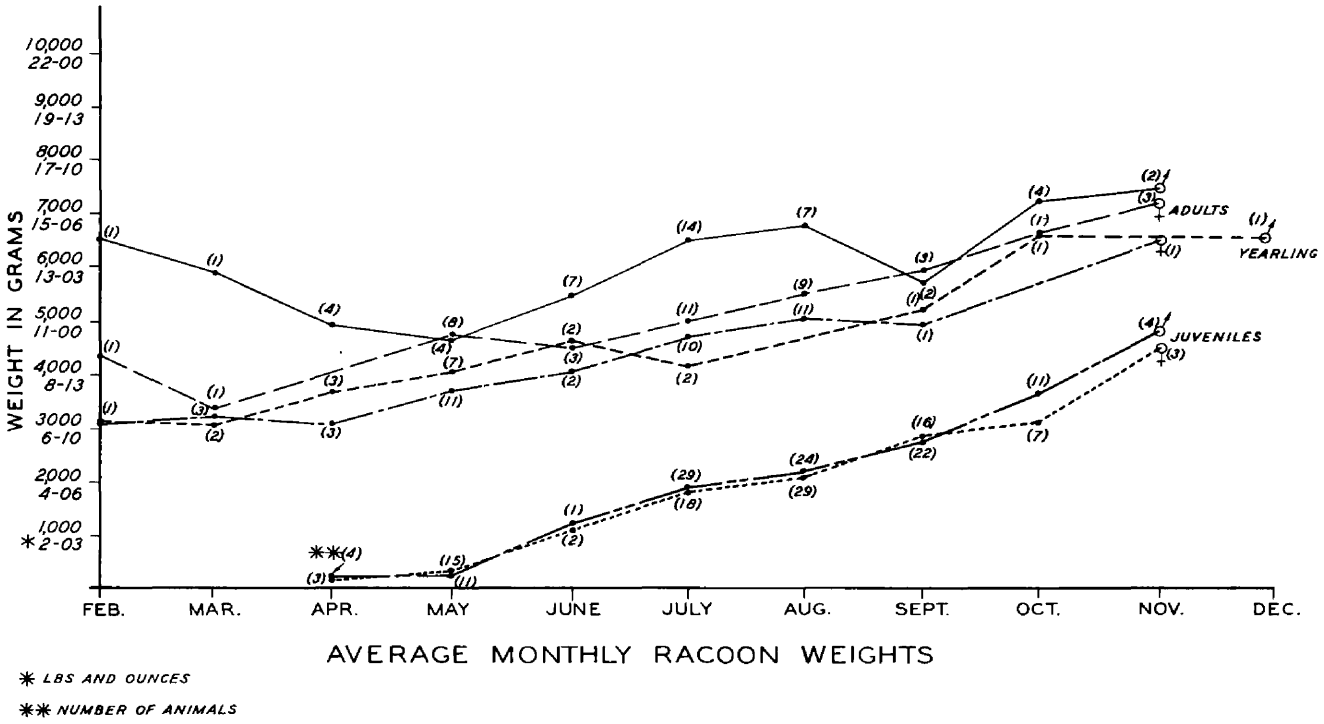


Fig. 36. Graph of the weights of raccoons in three age classes.

Seasonal weights and condition

In fig. 37 the plotted average weights of adults and yearlings were grouped into four periods, considered significant from the standpoint of raccoon activities. During January, February, and part of March, the animals remain denned up most of the time, and during the latter month the majority are at a minimum in weight. They may then weigh only 50 per cent as much as when they ceased feeding regularly and first denned with the coming of snow the preceding fall. Weights of adults in the winter period are few, but indicate that females may be considerably lighter than males at that time. One female known to be a two-year-old, weighed only 7 pounds, 5 ounces, on March 3.

Some animals found in dens in late February or March had drawn faces, a dryish skin, and shrivelled feet, with the appearance of being far below normal in bodily water content. It was such a condition, in addition to the fact that the heavy fall fat reserve had all been utilized, which contributed to minimum weights by the end of the winter denning period. With the renewal of regular feeding, beginning in late March, the animals were found to gain weight and do so steadily, although slowly, until October. At that time, utilizing highly nutritive foods, consisting mainly of acorns in this region, they took on weight rapidly, storing a large surplus of fat.

Wood (1922) found the fatty blanket under the skin of a 30 pound raccoon in November to weigh five pounds. For lack of better terminology we might divide the fat reserve into the "internal" and "external"; the former deposited in the body cavity, surrounding the various organs, and in the mesenteries, and the latter accumulated as a subcutaneous blanket. There are of course smaller fatty deposits in various tissues

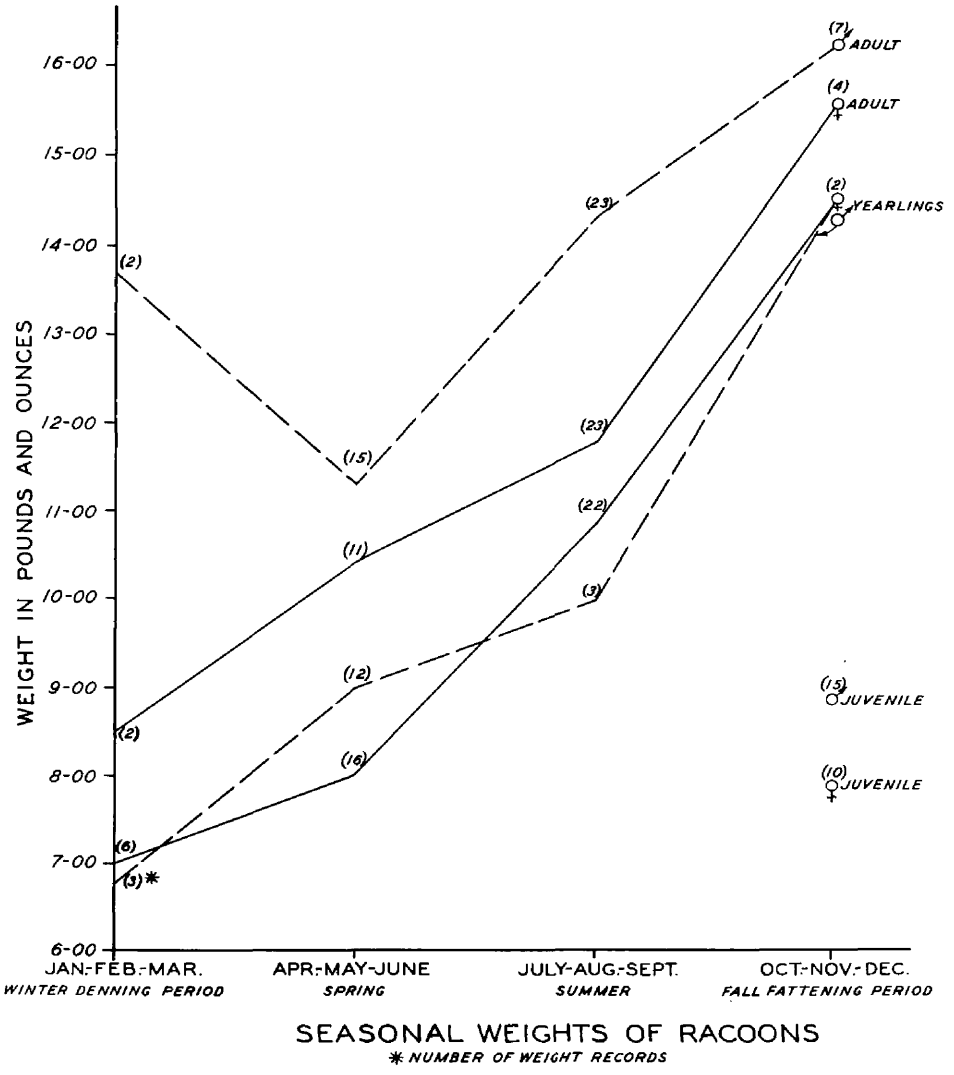


Fig. 37. Average seasonal weights of adult and yearling raccoons.

of the body, presumably of lesser importance as far as bulk is concerned. The "external" constitutes the major deposit, which is distributed principally over the back and rear quarters of the animal. It is thickest over the rump, becoming an inch deep immediately anterior to the base of the tail. This layer becomes thinner as it extends anteriorly, laterally, and down over the thighs (figs. 38 to 40). In this condition, with the greater part of their winter food supply already stored as fat, raccoons are prepared to go into their dens and withstand the fast forced upon them by snow and low temperatures. By the time that they again begin to feed regularly (late March) very little, if any, of the subcutaneous fat layer remains, and the animals are more emaciated than at any other time of year. Burroughs (1900) reports finding young of the previous year starving and helpless in April. The writer never found any in such poor condition during the present study, although animals of this age were found to be thinner than those of other ages. It is logical that yearlings must have the more difficult time of it, for while older raccoons are storing most of the food they take in fall as fat reserve, juveniles are still utilizing much of theirs for growth, and consequently may not be able to acquire so much fat.

Table VII gives the average seasonal weights by sexes of adult and yearling raccoons which are presented graphically in fig. 37.

Fig. 38. Dorsal view.

Fig. 39. Side view.

Fig. 40. Ventral view.

Three views of a raccoon carcass showing the subcutaneous deposit of fat. This animal was killed on November 20, 1940. Arrow in fig. 1 points to 3/4" layer of fat which was transected and turned up to show thickness.

TABLE VII

Average Seasonal Weights of Adult and Yearling Raccoons

Period	Adults				Yearlings			
	Males		Females		Males		Females	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Jan.-Feb.-Mar.	2	13-11	2	8-08	3	6-12	6	7-00
Apr.-May-June	15	11-05	11	10-07	12	9-00	16	8-00
July-Aug.-Sept.	23	14-06	23	11-13	3	10-00	22	10-14
Oct.-Nov.-Dec.	7	16-05	4	15-04	2	14-09	2	14-09
Averages	47	13-10	40	11-10	20	9-06	56	7-13

Weights given in lbs. and ozs.

SEPARATION OF AGE CLASSES

Reliable criteria for separating age classes of raccoons might be of value in analyzing breeding populations, and evaluating the effects of hunting mortality; because apparently only about 50 per cent of yearling females breed. The writer had the opportunity to work with a fairly large number of raccoons of known age, and the information in this section concerning age differences is based entirely on data from such individuals. Seventy individuals had been marked during some preliminary work previous to the beginning of the year round investigations, and in addition 73 more were tagged during the first year of the main project.

The graph in fig. 41 shows that ear and hind foot lengths can be used to determine a raccoon's age for only a short time. The ears seem to have very nearly reached adult size by late summer, or when the animals have become four months old. The foot increases in length until somewhat later than this, but as shown by the graph curve leveling off in November, full length is attained by early fall.

Size and condition of canine teeth offers better possibilities of determining the age group to which a raccoon belongs, although these characters are not entirely objective. The permanent teeth of juveniles begin to erupt in the latter part of August. Measurements have shown that they have not usually reached full size by fall. Excepting a very few cases, it seems safe to consider an animal with upper canines less than 10 mm. long (from gum to tip) as animals of the year. Further, though no methods of comparison are available for exact description, the canine teeth of such a raccoon are less massive than for adults or yearlings, and they show no wear. However, even by fall of an animal's

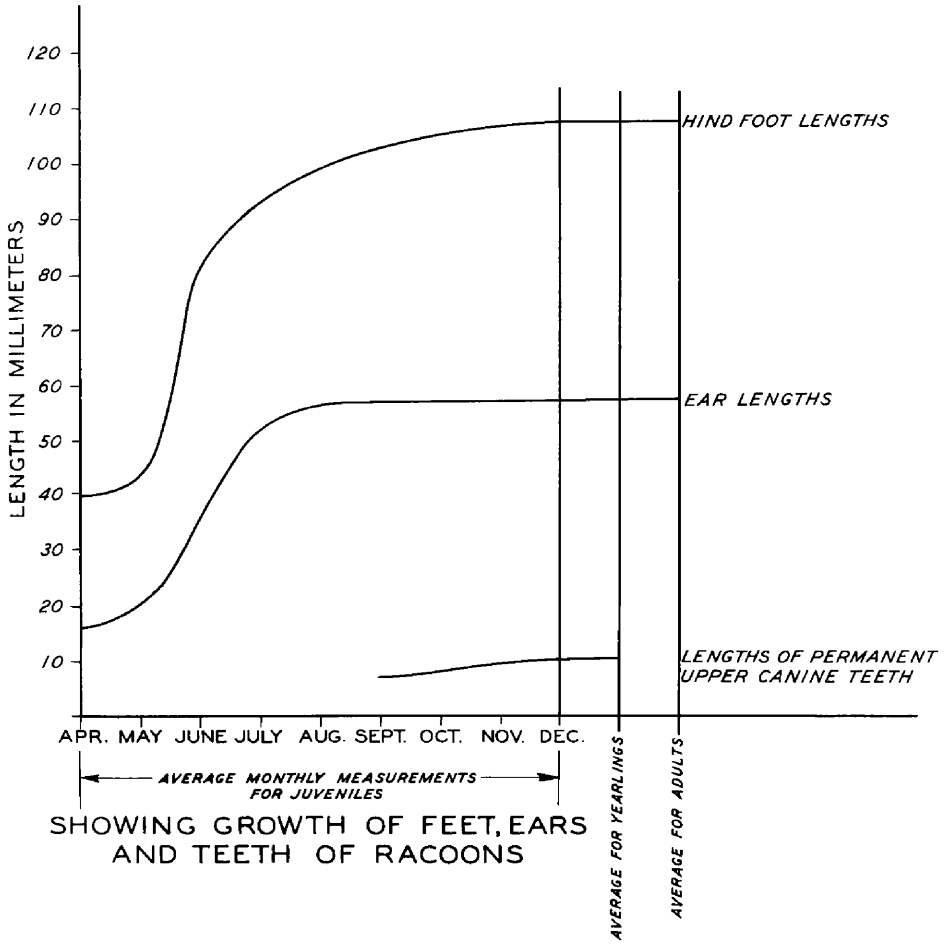


Fig. 41. Growth curve of feet, ears, and canine teeth. Ears measured from notch to tip, and teeth from gums to tip.

second year, wear seems to be negligible. Tooth length is the best criterion for separating the juveniles and yearlings. The upper canines of yearlings are seldom less than 10 mm. by the time they are a full year old, and may be as much as 12 mm. long. It is doubtful if an animal in its second fall could be reliably separated from adults by examination of teeth only, since some adults have a perfect set of unworn canines. But if the teeth, canines and incisors both, are badly worn, there is little doubt but that the raccoon is three or more years old. A few individuals with canines worn down within 6 mm. of the gums were examined, which certainly were several years old. As mentioned previously, the canines of juveniles are less massive than those of yearlings or adults, but this is a relative character for members of the two latter groups, and separations here could not be made with any degree of certainty.

Weights seem to be dependable for separating juvenile raccoons from older animals during the fall, and therefore during the hunting season in Michigan (Nov. 1-Dec. 15). Fig. 37 indicates an average weight of less than 9 pounds for 25 juvenile animals during the Oct.-Nov.-Dec. period, but since these were all taken in the first two months they do not present a true picture. Some juveniles attain a weight of about 14 pounds by December, but few, if any, are heavier than that. The largest juvenile handled in traps in November weighed 13 pounds, 9 ounces, and several weight records from hunters who took tagged animals were all under 13 pounds. One tagged animal taken by a reliable fur-buyer reportedly weighed 22 pounds in its second fall, and, as also shown by other records, it is apparent that in the fall of the year, animals older than juveniles cannot be separated further as to ages.

It appears evident that juveniles can usually be recognized by weights during the winter when they become a full year old. Nine of this age averaged less than seven pounds in winter (Jan.-Mar.) while older animals averaged 11 pounds, 12 ounces. In spring (Apr.-June) 28 which had become a year old averaged between eight and nine pounds, which is lower than the average of approximately 11 pounds for 28 adults, but variations among individuals of both classes at this time makes exact separation impossible.

Size of teats is probably a good criterion for separating yearling and older females in spring. Teats of yearlings remain minute until they have borne young. But since some of this age do not breed, their teats are still smaller than those of animals which have suckled offspring, and therefore an animal with small mammae in fall might be either a juvenile or a non-breeding two-year-old. If in fall a female has teats 6 mm. or more long, usually wrinkled and blackish in color after lactation, she is at least in her second fall.

Observations on age differences can be briefly summarized. Ears and feet attain adult size by the fall of the animal's first year. If upper canines are less than 10 mm. long and unworn, the raccoon is very likely a juvenile, while badly worn teeth indicate an age of at least three years, and probably usually more. In fall, an animal under 14 pounds can be safely considered a juvenile, and in winter, yearlings are still enough lighter in weight than older animals to be distinguished. Juveniles have small teats, about 2 to 3 mm. long, until they have reared young. After that, 6 mm. or longer teats, usually dark and wrinkled, indicate that young have been suckled, and therefore that the animal is at least in its second fall. However, since some yearlings do not produce young they may still have small teats in their second fall.

FOOD HABITS

In reviewing the literature pertaining to the feeding habits and food of raccoons one is impressed with the appropriateness of Nelson's (1916) statement that the diet is "extraordinarily varied". Their aptitude for including in the dietary an almost unlimited variety of foods has been, and still is, of great importance in the remarkable survival and widespread distribution of the species in North America. Like human beings, when necessity demands they will make the best of less palatable matter, but when a variety is available, they are prone to make a choice of preferred items. According to Merriam (1886), captives may even display an aristocratic taste for liquor. Sweeney (1905) says that their fondness for sweets occasionally leads them to destructive forays in the plantations of "sugar cane" in Illinois, and at the same time he points out their utility in forest lands because of the numbers of larvae or injurious and destructive insects they consume. Their love of delicacies is shown by the statement of Kennicott (1858) that they lie in wait while turtles are depositing eggs and then dig them up. Snyder (1931) also reports extensive feeding on turtle eggs in mid-June. Numerous excavated egg deposits were observed along two miles of sandy dike in June during the present study, and in one case predation by raccoons was definitely established (fig. 42). Though skunks were known to be responsible for some of the diggings, this species was not plentiful in this area, it is likely that raccoons were taking many of the eggs.

There have been several food habits studies of raccoons during the past decade for which quantitative and qualitative data have been presented. Hamilton (1936) showed that mast and grains, fruits, small

Fig. 42. Remains of a turtle nest destroyed by a raccoon.

mammals, and insects are important fall and winter foods of the animals in New York State. Further work in summer (Hamilton, 1940) gave wild fruits, including mainly wild cherries, (Prunus virginiana and P. serotina), and berries of silky dogwood, (Cornus amomum), as the important food items. Johnson (1939) examined a small number of stomachs and scats of Maine raccoons, which indicated a preponderance of beechnuts in the fall diet, while sweet corn, insects, and wild cherries were the main items utilized in summer. In Central Iowa, Giles (1939) reported corn, crayfish and hackberries as the three principal foods in fall. Corn was present in 80.60% of 67 scats and comprised 41.05% of all food remains. Further year around work in Iowa (Giles, 1940) showed corn to be used extensively in the post-winter period; grasses and beetles in spring; wild raspberries in early summer; and corn again in late summer and fall. The considerable utilization of corn by Iowa raccoons is not surprising, considering its availability, and the fact that there are few mast bearing trees. Studies at Allegan indicate that acorns are preferred to corn when both are available.

The only known published work concerning the food of Michigan raccoons is that by Dearborn (1932), whose analysis of 500 scats from the southern part of the State indicated that crayfishes are the principal items of the summer diet, with oats and corn, fruit, and insects also important.

During the present investigation the study of food habits was not emphasized, although as the work progressed advantage was taken of every opportunity to obtain information along this line. A total of 121 scats and 10 stomachs were collected over a period of two years.

This number is not large, but since the writer was in the field during the same period making supplementary observations and conducting intensive studies of the species, some significant information was obtained.

The type of country in which the work was done has already been described, but a few more details in connection with the food studies are in order here. The oak uplands adjacent to the lowlands furnished an abundant supply of oak mast in the fall of 1939, but in 1940 the acorn crop was practically a total failure. Scats were collected in the bottomland along the edge of water courses, on fallen logs, in fields, in trees, and from tree cavities. Used dens were found to be kept sanitary, but open hollows and shelf-like cavities of old, decayed trees often contained scats, and some evidently were sites of the reported "'coon latrines" (fig. 43). Nevertheless, Seton's (1929) statement that raccoons are peripatetic defecators seems to hold generally. It was possible in a number of cases to obtain fecal material from animals taken in traps or dens, thereby securing some unique observations for this species. Many scats were collected in the vicinity of the experiment station farm, where corn was available in both years, and other grain crops included buckwheat, wheat, millet, and vetch.

Several bayous, the river, and periodically flooded woodlands furnished suitable habitat for many aquatic species such as crustaceans, fresh water mussels and insects. Along these watercourses, wild grapes, gray, red-osier and silky dogwoods, and buttonbush were plentiful, and bore heavy crops of fruit in late summer and fall.

Analyses of the scat and stomach material were made by Charles C. Sperry of the Wildlife Research Laboratory, U. S. Fish and Wildlife

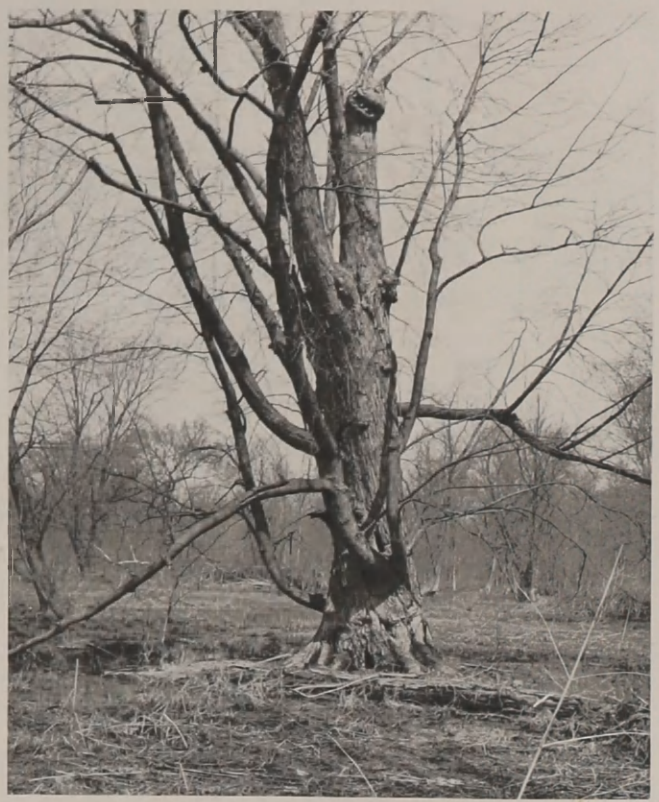


Fig. 43. Hollow tree which served as a refuge site and as a raccoon "latrine".

Fig. 44. One of three ground "latrines" discovered.

Service, Denver, Colorado. In tabulating the fecal material data, the average percentage by volume of each food in the total number of scats was calculated, and also the percentage of occurrence. Figures are represented in Table VIII. Though numbers are small for some periods, the data were grouped into four periods corresponding to those used in presenting weights, both for the sake of correlation and to show a better picture of the food taken at different times of the year. Since there is a change of diet from season to season, such a grouping seems a logical one.

The present work shows again the inadequacy of scat or stomach analyses alone in determining definitely the food habits of a species. The noticeably small part played by frogs in the diet of raccoons in this region seems worthy of mention, especially since several species were very abundant throughout the area, and since most natural history writers include this amphibian in the animal's bill of fare. Hamilton (1940) found the same condition to exist in the Montezuma Marsh of New York, and no one, who has examined either scats or stomachs, has reported frogs being taken in large numbers.

During the winter denning period, when food is taken intermittently in warmer weather, only 11 scats were found, three of which were fresh from animals handled in dens. The high percentage of acorns taken at that time seems almost paradoxical, since there was from six inches to two feet of snow on the ground. But though it is possible that some of the scats had been deposited the previous fall, one scat collected fresh from an animal taken in a den on February 13, when there had been 13 or more inches of snow on the ground for several weeks, was composed

TABLE VIII

Volumetric Indices And Percentage of Occurrence of Raccoon Foods
As Indicated by 121 Scats

Food	Jan.-Feb.-Mar. 11 scats		Apr.-May-June 49 scats		July-Aug.-Sept. 15 scats		Oct.-Nov.-Dec. 46 scats	
	Volumetric indices	% Occur.	Volumetric indices	% Occur.	Volumetric indices	% Occur.	Volumetric indices	% Occur.
Acorns	36.36	45.40	29.49	44.89			9.45	10.87
Corn	18.18	18.18	9.49	18.36			14.46	26.09
Bark, wood & raccoon hair	18.18	18.18						
Earthworms	9.09	18.18	7.14	14.28			1.09	2.17
Snails	9.09	18.18	.94	16.32	1.66	6.66		
Misc. insects	8.18	9.09	2.14	18.36	12.66	40.00	3.15	17.39
Grapes	.90	9.09	.10	2.04	40.66	53.33	63.15	78.26
Crustacea	trace	9.09						
Microtus			26.63	32.65				
Crayfish			14.73	34.69	1.66	13.33	1.52	10.85
Buds (birch?)			4.08	4.08				
Fish			2.45	12.24			.22	4.34
Moths			1.02	2.04				
Cottontail			1.02	2.04				
Frogs			.45	10.20			.43	4.34
Snakes			.20	4.08				
Chicken			.10	4.08				
Caterpillars			trace	2.04	6.66	6.66		
Gallinaceous bird			trace	2.04				
Pheasant			trace	2.04				
Squirrel(Sciurus)			trace	2.04				
Dogwood berries					13.33	13.33		
Sand cherries					13.33	13.33		
Blueberries					6.66	6.66		
Berries (Rubus)					3.33	6.66		
Elderberry (Sambucus)							5.22	10.87
Amphipods							.87	6.52
Ragweed seeds							.43	2.17
Bird (non-game)							trace	2.17

entirely of acorn remains. The other two fresh scats taken from denned animals in February included only dead leaves, wood, bark and raccoon hair, indicating that these animals had taken no nutritive food for some time.

In spring or the post-denning period, acorns were still the most important single food. The crop of these nuts in the fall of 1939 was very large and many were still available in the spring of 1940, when most of the scats for the period were collected. In conjunction with the food and range studies, a road between the uplands and bottoms was dragged intermittently in April, May and June. Tracks there showed that raccoons were going regularly to the highlands to feed on acorns. Apparently these nuts are a preferred food at all seasons. In the aggregate, animal matter constituted 56.84% of the diet in spring, the only season in which it predominated over food of plant origin. The large volume of Microtus (26.63%) found in 32.65% of the scats, indicates the acceptability of such rodents. They were entirely lacking during other periods which may indicate their being less desirable than other foods when a choice is available, inasmuch as these mice were present in waste fields in the bottoms at all times. Crayfish also showed in greater bulk, 14.73%, and in a greater number of remains, 32.65%, than in any other season. Dearborn (1932), however, found them to constitute 58.88% of the summer food in southern Michigan, for which season in this study there was only a small representation in the scats. The recorded 4.04% of buds constituted the entire remains of two scats. This apparently is the first reported indication of such an item being taken by raccoons.

The change to a predominantly fruit diet in summer was very striking, 77.31% of the food being of this origin. Grapes, which seem

to be a favorite food, formed an average of 40.66% of the scats, with dogwood berries, sand cherries, blueberries, and berries of Rubus constituting the remainder of the fruit material. Caterpillar remains filled one scat taken from a juvenile in July. Two others fresh from young animals were composed one of grapes and the other of snails, crayfish and insects.

From analyses alone, it appears that acorns were no longer a part of the summer diet. However, tracks showed that as many as 10 raccoons crossed in one night a two-mile length of dragged road into the oak upland where they were going for mast. The remains of acorn shells at diggings in the road (fig. 45) seemed indicative of their activities throughout the adjacent upland woods. From such observations it appeared that acorns were being taken regularly by certain animals as long as the supply lasted.

In fall, fruits were still predominant in the diet and grapes were still the most important item. It is interesting to note that fresh scat from a male found in a den on December 24, was composed entirely of grapes and earthworms. At that time persistent fruits were noted on grape vines in the vicinity of the den, and since the weather was unusually mild, earthworms were probably available in the wet bottoms. Acorns formed a smaller percentage of remains during this period than in either winter or spring, but here again the inadequacy of analyses alone in furnishing a complete picture is evident. Studies of remains, along with other observations give some interesting information relative to the combined effects of availability and preference by the animals on the fall diet.

Fig. 45. A raccoon sat here and dug out old acorns of the previous year in July. Note imprints of both hind feet to right of acorn shells.

The acorn crop was very large in the fall of 1939, and accordingly, of the six scats collected then, five were made up of 70% or more acorns, and none contained corn. In addition, occurrence of acorns in six stomachs was 100%, while corn was present in only one. In 1940 when there was very little, if any, acorn mast produced, no trace of it was found in 40 scats and four stomachs, while corn was present in 26% of 40 scats and three of four stomachs. All available evidence tends to show that acorns are a highly palatable and favorite food item at all times of year, and evidently are taken in preference to corn when both are available. Field observations showed a noticeable decline from 1939 to 1940 in numbers of animals feeding in the oaks in the fall, while in the farm corn fields, where grain was available in both years, there was little activity in 1939 and considerable feeding in 1940. Further discussion of damage and predation and application in management of the above findings will be discussed under Management, p. 184.

SURVIVAL AND MORTALITY

There is little reference in the literature relative to mortality of raccoons other than that caused by man and his dogs, and all available evidence indicates that hunting and trapping take much the greater part of the annual increment. Burroughs (1900) reports finding young of the previous year starving and helpless in the fields in April, but during the present study no such severe emaciation was noted, though yearlings handled in late spring and winter were usually quite thin, some considerably more so than adults. As far as is known there are no longer any serious predators of raccoons in Michigan. According to Seton (1929), fishers prey upon them, but this species is now entirely absent throughout the important raccoon range in Michigan.

A few raccoons are killed every year by automobiles, but this number is considerably less than for many other game species. Only two were found dead on highways within a radius of 30 miles of the experiment station, during three years. Several times parts of skeletons and skulls were found in the woods, but hunters often pelt their animals as taken and discard the carcass, or at least the heads, which accounted for some of these, and perhaps for all of them. In any case, the total number was few. Never was a dead, entire animal found during the considerable time spent in the field on den investigations and live-trapping. Of 256 animals handled, only one, an adult female, appeared to be in poor health. This individual, live-trapped in August, was thin in flesh, sparsely furred, and seemed weak, but neither the cause of her condition nor whether or not she died was determined. The marked ability of

raccoons to defend themselves, their hardiness and stamina (p. 32) should make them less susceptible to predation, disease, inclement weather and even a reduced food supply, than many other wild species.

A good indication of the survival of juveniles has been obtained by tagging litters in dens. All of 11 so marked (in April and May of 1939) when between the ages of three and ten weeks were accounted for in mid-summer or later. One was live-trapped for the last time in August, while all others were either retrapped or taken by hunters in fall, or were still on the area the next year. In 1940, of 13 juveniles tagged in dens, all except four were rehandled in July or later, or were known to have been killed in fall. The four were marked in an area where little live-trapping was done subsequently, and therefore probably should not be considered one way or another as far as survival is concerned.

In the light of accumulated evidence, it seems that both adult and juvenile losses are low. Yet, according to the breeding potential of raccoons (1.5), if there is no appreciable mortality, either juvenile or adult, it would mean that in a stable population, 3/5 or 60% of the fall number would have to be taken by hunting and trapping. Such a proportion seems large, but in one area where a thorough check on kill was obtained, in the fall of 1939 (p. 147), apparently 47 per cent of the population was taken. Bennitt and Nagel (1937), who judged the average litter size to be four, allowed for a loss of one juvenile per litter in Missouri. They also considered the natural mortality in that state to be 20 per cent of the kill by man and dogs, "according to the consensus of our own and many other opinions", pointing out that no known statistics were available as a basis for their statement. From the

present work it is apparent that in Michigan there is probably no such mortality among juveniles, and considerably less than 20 per cent of the fall kill by hunters (33,442 in 1939) is lost to predation and other natural causes. Further discussion of the annual take by hunters and trappers will be found on p.226.

PARASITES AND DISEASE

The information included in this section is presented as part of the whole picture evolved from the investigations, but by no means reviews the cognate literature, nor pretends to any semblance of completeness. It was not considered expedient to sacrifice animals for autopsies, and therefore only seven carcasses and viscera obtained from hunters, and one animal accidentally drowned in a trap in May were available for studies of internal parasites. Concerning conditions of health and ecto-parasitism, however, the information obtained should be significant since the live animals handled probably constitutes the largest series yet to be examined.

No disease that could be diagnosed from external examination was ever found. All animals (256 handled) excepting the one emaciated female mentioned on p. 93 seemed to be in good health. An infection was found to have destroyed one eye of each of two juveniles which were about one-quarter grown. The entire eye cavities in each case were filled with a purulent discharge (fig. 46). Macroscopically they had the appearance of a Staphylococcus infection, but smear examinations of one of them by Dr. S. C. Whitlock, Game Division Pathologist, showed only pus cells to be present. These raccoons were apparently little handicapped, however, since when caught approximately a month after the infected eyes were first noted, both had gained weight to the same extent as had other animals. One, first taken in August, was "treed" in September by dogs, at which time he weighed 6 pounds, and seemed well and capable of caring for himself.

Fig. 46. Juvenile with one eye destroyed and the cavity filled with a purulent discharge.

Ecto-parasites

Infestation by ecto-parasites was not heavy in any case, and no resultant emaciation or other ill effects were ever apparent. Specimens of each kind of parasite found were collected for identification. Dr. H. E. Ewing of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine identified the ticks and lice, and Dr. Irving Fox of the same bureau identified the flea. Proper names and notes concerning each of these follows.

Ticks, Ixodes sp., both adult and larval forms, were found. They were usually attached on the head of the older raccoons, on the ears, eyelids, or lips, while on many of the very young juveniles in the dens these parasites were fastened to the toes. In the summer of 1940, (June, July and August), 16% of 69 raccoons were noted to be harboring ticks. The one larval form identified was taken from the lower jaw of an adult female in a den on March 5. It is thus easily understood how the juveniles may become infested.

Suricatoecus octomaculatus (Paine), a louse, was found to be present, in some cases in fairly large numbers. These were usually congregated on the back of, and behind, the ears. There seemed to be a much greater incidence of such parasitism during the summer of 1938 than in the next two years, when very few were found.

Fleas identified as Trichopsylla lotoris Stewart could be found by parting the fur on nearly any part of the body of a female taken from her den in March. This was the heaviest ecto-parasitic infestation on any of the animals. Less than half a dozen other raccoons were noted to have fleas.

Endo-parasites

The alimentary tracts of nine animals were examined for macroscopic internal parasites. All, except one taken in May, were obtained from hunters and trappers who killed them in November. Worms found included two kinds of cestodes, one trematode, and one nematode. Identifications of these were made by Dr. Carl Gower of the Experiment Station.

Mesocestoides sp., a tapeworm, was the most common, 10 to 100 or more being collected from each of five animals. It was the only parasite found in the female examined in May. In one case a mass of proglottids, probably of this same species, was protruding from the anus of a juvenile captured in September. Sections of a tapeworm were also once noted in a smear of fecal material found in the field. Two animals each harbored one Diphyllobothrium sp. which could not be further identified to species, since no scoleces were obtained. The fluke, Clinostomum sp., in larval form, of which four specimens were found, was present in only one of the animals. Heaviest infections were of the roundworm, Uncinaria lotoris which were obtained in numbers of over one-hundred, from two raccoons. In three animals no parasites of any kind were found.

There is no definite proof that either internal or external parasites are ever responsible for the death of raccoons. Morgan and Waller (1940) record a case of severe parasitism and lesions in an individual from Iowa, but do not consider that the parasites necessarily caused the animal to die.

PELAGE CHANGES

Little more than passing mention of pelage changes and fur-priming of raccoons was found in the literature. Bissonnette and Csech (1937), who conducted experimental breeding of animals with the addition of artificial light, noted that controls shed their winter fur after birth of litters, while those which bore young earlier than normally due to the lighting, also shed their fur earlier. Bailey (1926) says that in North Dakota an open season from November 15 to March 15 would probably insure prime fur.

However, Gunn (1932a and 1932b) reports findings concerning moulting and priming, principally of muskrats, many of which seem to apply to most fur-bearers. Quoting him (1932b): "It is now clear that the sequence of the growth of new fur, of the priming condition and of the moult is the same, and that the growth of new fur and the moulting proceed synchronously, but the prime phase is separated from these by a definite period of time." This appears to apply to raccoons; moulting and growth of new fur taking place in spring and summer, and priming occurring in fall, but priming seems to proceed in a somewhat different pattern than in muskrats, as will be shown later.

Moulting

The first noted evidence indicating the onset of moulting of raccoons in the wild were the small bunches of fur shed at entrances and in dens examined in late April and May. That shedding begins at about the time young are born was evident upon finding this fur in the dens occupied by females and recently born litters. This was small in amount,

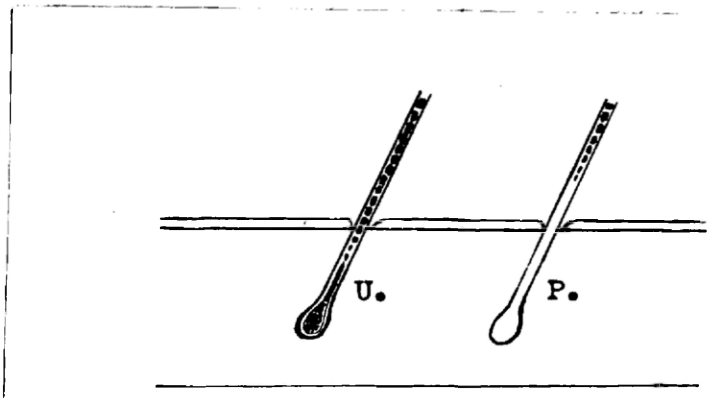
never enough to indicate plucking by the animal to build a nest, as cottontails do, for instance. A good opportunity to observe the progression of the moult presented itself in an albino raccoon held in captivity. The somewhat soiled and discolored old fur and guard hairs were in sufficient contrast with the new, white fur coming in to distinguish the two rather easily. In addition, the matted condition of the coat being discarded caused it to loosen and drop away more or less as a distinct layer above the new fur, the advance and pattern of which could be easily observed.

New white fur made a patchy appearance on the face of the animal in mid-April. The front feet showed a growth of new fur also, and thereafter this growth and moulting proceeded together posteriad until the last patch of old fur dropped from the thighs and rump of the animal in late June. It is believed that the advance was more rapid along the ventral part of the animal than on the dorsal. The pattern of shedding in wild animals was less conspicuous, but the pelage condition was not. The majority of raccoons taken during July and August were rough in appearance, due to moulting and concurrent growth of the new coat. The characteristic condition in early summer was a pelage devoid of many of the guard hairs, with sparse, rough underfur, lacking the luster and sheen of the prime fall pelage. Tails were ragged, with practically all of the guard hairs missing on some individuals (fig. 47). Often the rear dorsum of an animal handled in June was only very sparsely furred, possibly due to the old fur being rubbed off in dens before the incoming hairs had appeared. By late August the new coat was distinctly visible. From that time on, the captured animals had increasingly heavier and longer pelages, with the ultimate in appearance and quality being attained in the prime fur in fall and early winter.

Priming

Priming has been shown by Gunn (1932b) to be a phase in the life cycle of fur and hair, entirely separate in time and processes involved from moulting and new growth. According to his studies (1932a), when a hair primes it migrates outward, devoid of an ampulla, and pulled away from the papilla, which remains in the deeper part of the dermis. All vital connection is not severed, however, because changes stop if the hair is clipped off, whereas they continue in a hair left attached. These changes are manifest in the depigmentation in the medulla of the proximal portion of the hair. The distance above the roots to which a shaft becomes devoid of pigment varies in different animals. Examination of raccoon hairs under the high power (440X) of a microscope by the writer shows this distance to extend somewhat beyond the epidermis (fig. 48). Such a condition is reflected in the raw pelts by the light areas of the underside. Unprime skins are dark on the flesh side due to the heavily pigmented hair roots imbedded in it. According to Gunn (1932a), unprime hairs lie deep in the dermis, at acute angles to the surface of the skin, attached to papillae and pigmented. As the processes of priming already mentioned are taking place, the hairs, as they migrate outward, also straighten more nearly to right angles with the outer surface of the skin. This obviously makes the fur appear longer after priming than it did before. Since each fur-hair of a tuft in a single follicle at the surface, has an epithelial follicle at its base, the fur is not pulled out more easily after priming, as might be supposed due to each hair being loosened from its individual papilla, but instead is wedged more firmly by a pull.

Fig. 47. Adult female with unprime fur on August 8, 1940. The tail was practically devoid of guard hairs.



Showing arrangement of pigment in prime (P) and unprime (U) fur hairs. (After Gunn, 1932)

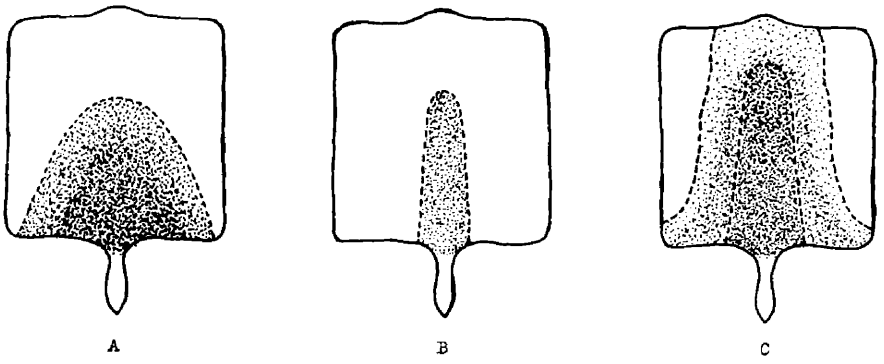
Fig. 48. Diagrammatic sketch of prime and unprime raccoon fur hairs.

The fur evidently is in the final stage of its cycle when prime, and remains so until shed the next spring. However, by late winter, before moulting begins, it no longer has the best appearance, due to having become worn and often somewhat matted from prolonged denning previous to that time.

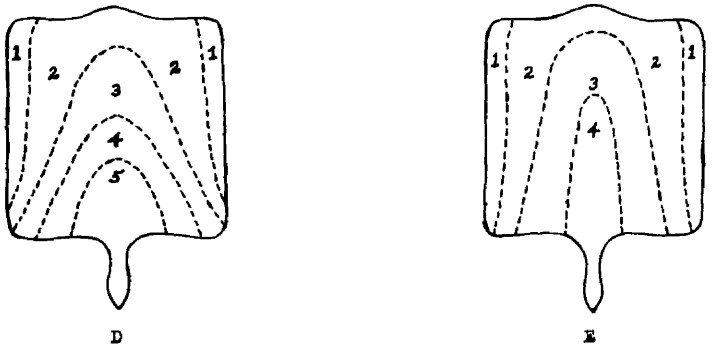
Pattern of priming: It was possible to obtain some information on the progression and pattern followed by the priming process of raccoon fur, by examining pelts in the possession of hunters and fur-buyers. Prime and unprime conditions were differentiated on the basis of light and dark areas respectively of the underside of the skin, due, as has already been explained, to depigmentation of the prime hair bases. From these observations it appears that the pattern is much the same as that of moulting. According to the condition exhibited by a fairly large number of pelts, hypothetical progressions of priming have been postulated, which are shown in fig. 49, D and E. A, B, and C are sketches of three pelts, representing different stages in the phenomenon, which types are the basis for the sketches in D and E. From all pelts examined it seemed evident that priming first begins on the ventral part of the raccoon. The process appears to progress from there towards the dorsal and posterior part of the animal, with either a narrow strip along the back, or a small area immediately anterior to the base of the tail becoming prime last.

All available evidence indicates that the fur of juvenile raccoons remains unprime until later than that of adults. From the best indications, and the consensus of opinion of 12 fur-buyers, one of whom purchases about 5,000 raccoon pelts annually, juvenile pelts

usually are not prime until December, while most adult skins ordinarily are prime by mid-November. Little information is available as to the extent of time from the onset until the completion of the priming process, but it is believed to be at least one and one-half months for raccoons in this latitude. The pelage of many animals was noted to be taking on a gloss and sheen, indicative of primeness, in October, but few become prime apparently before mid-November. A fuller discussion of the condition of pelts taken by hunters and trappers in fall will be presented in the management section, p. 215.



SKETCHES FROM VENTRAL SIDE OF RACCOON PELTS IN DIFFERENT STAGES OF PRIMING. Stippled areas are dark and unprime, white areas light and prime. A, pelt with rear and most of back unprime; B, narrow strip extending along back from base of tail unprime; C, a pelt exhibiting three distinct bands in different stages of primeness.



DIAGRAMS TO SHOW APPROXIMATE PATTERNS OF PRIMING OF RACCOON PELTS. Numbered bands indicate progression of priming from outer edges of pelt, or ventral side of animal, towards the middle and rear, or posterior dorsal part of animal; D, small area immediately anterior to tail primes last in this case; E, narrow strip along back primes last.

Fig. 49. Showing pattern of priming.

DENNING HABITS

The kind of home chosen by a raccoon varies with the region and availability of sites. Being adaptable by nature, the species usually makes the best of a situation, and if the favorite tree type of den is not available, a home is made in a fallen log, a crevice of rocky outcroppings, or in a ground hole. The statement of Beddard (1909) that they den in trees, but carry on their business elsewhere, is a good clue to their usual habits. Practically every writer who describes the species mentions tree cavities as the sort of den most often used. Kennicott (1858) tells us what happens when hollow trees are not present. "Its usual retreat is in a hollow tree, and it never digs for itself, though in the forest as well as on the prairie, it will occupy the deserted burrows of other animals, and even rear its young in such habitations." Stone and Cram (1902) report that "it is said they dig homes in stream banks by preference", but Kennicott's statement that they never dig for themselves seems to hold generally, at least in Michigan.

Some of the states where rocky crevices are most often used are Indiana (McAtee, 1907), Iowa (Giles, 1940), Texas (Bailey, 1905), and California (Grinnell, Linsdale and Dixon, 1937). In reference to Monroe County, Indiana, McAtee (1907) says that every one of the numerous caves in the region had at least one 'coon living in it. In Michigan, where few rocky outcroppings occur within raccoon range, caves are unimportant. Reportedly ground holes are used in those parts of the state where hollow trees are scarce, but where both of these types of den site exist the latter are used by preference, and probably furnish the majority of dens. Certainly in the area at Swan Creek where tree dens are

plentiful they are preferred; in fact, there is no available evidence that any other kinds are used. During the investigations several hundred hollow trees were climbed and examined. One-hundred-forty-three of these were marked as potential denning sites, and the majority were re-examined several times in the course of two years. Thirty-four tree dens were found occupied on at least one occasion and 41 others showed evidence (hair or scats) of having been used. Numerous reports by hunters that the animals are living in ground holes, or cavities amongst tree roots, or even tile drains, undoubtedly are due in many cases to the fact that individuals being pursued or disturbed take to the most accessible cover, which is often one of these kinds of temporary refuge.

Though as pointed out previously, the sandy upland plains are important in furnishing a food supply (mast), the lowlands are preferred for denning. During the most intensive feeding period in late November and early December, immediately before winter denning when the raccoons were feeding regularly on mast in the uplands, they still denned in the bottoms. This was established principally by means of the dragged road observed as a track register. In nearly every case toe-clipped raccoons had gone in both directions across the road. On several occasions, of the large number of tracks seen, some going to the uplands had been made in moist, unfrozen sand, while those returning to the bottoms had been made on a slightly frozen crust. In one instance two toe-clipped juveniles, whose tracks of the previous night were seen leading both ways across the road, were found the same day together in a den in the lowlands. Of the total of 34 occupied dens located, only three were in the oak habitat and they were within 50 yards of the steep bank which

separates the uplands and floodplain. Only six of the 41 dens were in uplands, two of which were a mile from a source of water.

Tree dens

Species of tree probably means little to home hunting raccoons, although the smoothness and hardness of the bark may preclude their use of beech (Fagus grandifolia). Hunters have often asserted that raccoons cannot climb this smooth-barked species. Some verification came when animals were first released in 1939. Several ran to some large beeches, approximately 24 inches in diameter, and tried to climb them. Not one succeeded in getting a footing, and they then went up other nearby trees. They were, of course, pen-raised animals and their poor success may not have been indicative of the abilities of native raccoons.

Table IX shows the species and size of 34 trees with occupied dens and their average distance from water. Over two-thirds of the trees were red maple (Acer rubrum). This species is predominant in the lowland habitat and the majority of the larger individuals are hollow to some extent, which probably accounts for its furnishing the high percentage of dens. Elm, ash, and others are not only fewer in numbers, but are apparently more resistant to decay, thus providing a smaller number of denning sites.

Water from some source within the range of a raccoon seems to be essential (p. 163) and it appears that the animals prefer to den near a permanent supply. All occupied dens were within 300 yards of a creek, bayou, or river, average distance being about 400 feet. Two hollows with hair as evidence of use by raccoons were one mile from the nearest

TABLE IX

Size and Distance From Water of 34 Occupied Raccoon Den Trees

Kind of tree	Number	Ave. distance to water in ft.	Ave. height in ft.	Ave. diameter in inches
Red maple (Acer rubrum)	22	388	52	28
American elm (Ulmus americana)	4	280	74	37
White oak (Quercus alba)	3	800	47	23
Black oak (Quercus velutina)	1	900	65	29
Sugar maple (Acer saccharum)	1	300	60	24
White ash (Fraxinus americana)	1	150	60	26
Butternut (Juglans cinerea)	1	500	50	29
Sycamore (Platanus occidentalis)	1	25	60	27
	Ave.	409	55	28

Distances except tree diameters were estimated.

water. To what extent these dens were used is not known. The available evidence indicates that where denning facilities are abundant, those within one-quarter mile of water are first to be utilized. Where dens are scarce it may be that some at greater distances are of necessity used, but it seems reasonable to assume that in an optimum habitat, dens should be within one-quarter mile from water. This knowledge is significant in making plans for habitat improvement.

The average height and diameter of den trees give an indication of the size, and therefore to some extent of the age, of species which contain suitable hollows. The smallest tree was 16 inches in diameter, the average for each species being shown in Table IX. It is highly probable that none of the trees were under 50-75 years of age. This will be discussed further, as it applies to management, on p. 172.

Many writers state that the usual tree den of a raccoon is high above the ground. Dens found in the present study tend to disprove this. Fig. 50 shows the distribution of heights of occupied dens. Seven of them were from seven to 20 feet up, 11 between 20 and 30 feet, 10 between 30 and 40 feet, and the remaining six between 40 and 65 feet. The histogram shows at a glance that over half (21) were between 20 and 40 feet up, or over three times as many as were above 40 feet. One was as low as 7 feet (fig. 51). The average height of all was 27½ feet.

Suitability of the den cavity itself apparently is dependent mainly upon its size and dryness, the entrance diameter seeming to be of less importance. The average-sized hollow measured 14 x 11½ inches in diameter, with the majority being near the 14 inch mark. One measuring 7 x 7 inches was found occupied by a lone yearling female. Another,

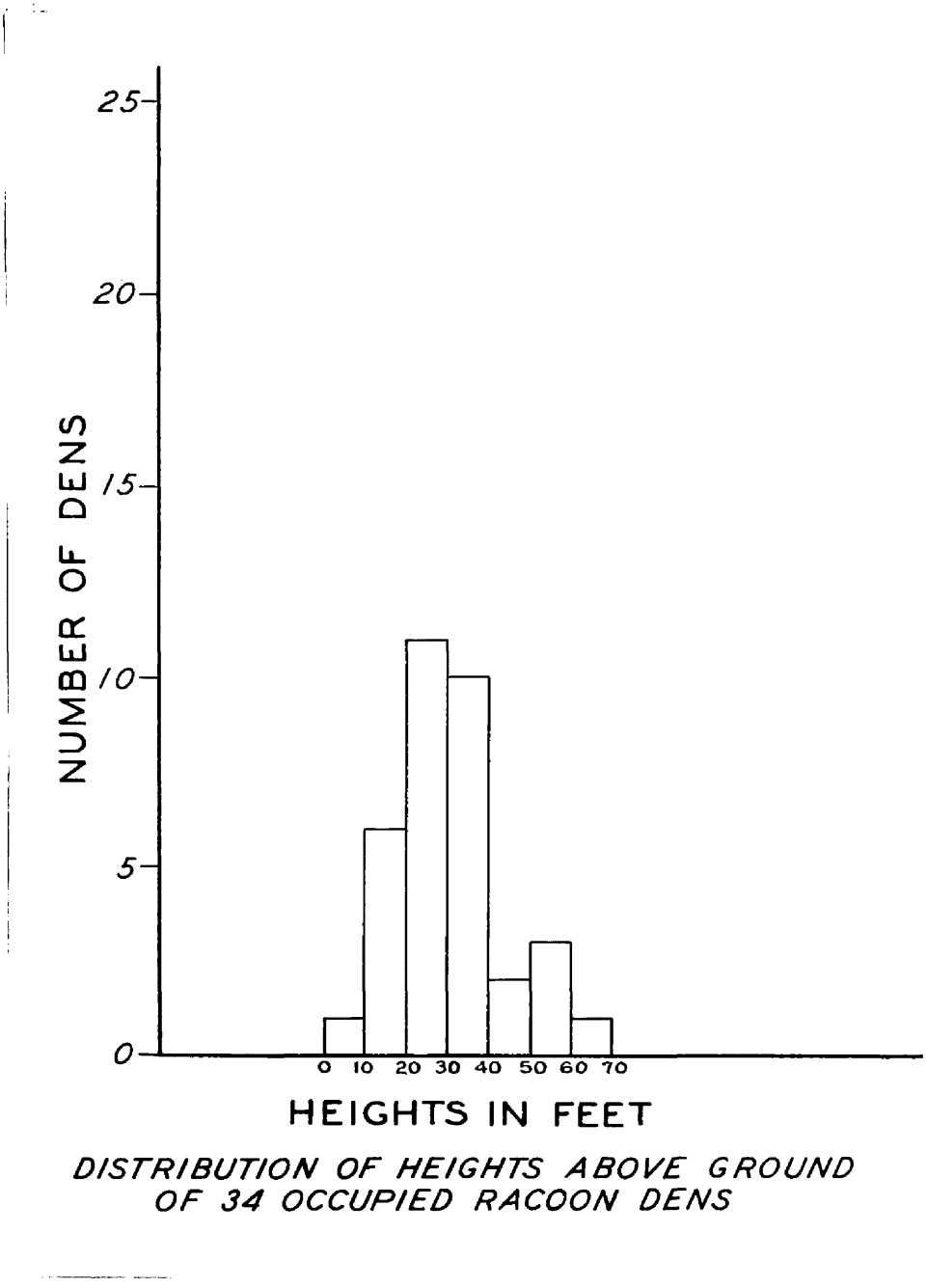


Fig. 50. Histogram of heights of raccoon dens above ground.

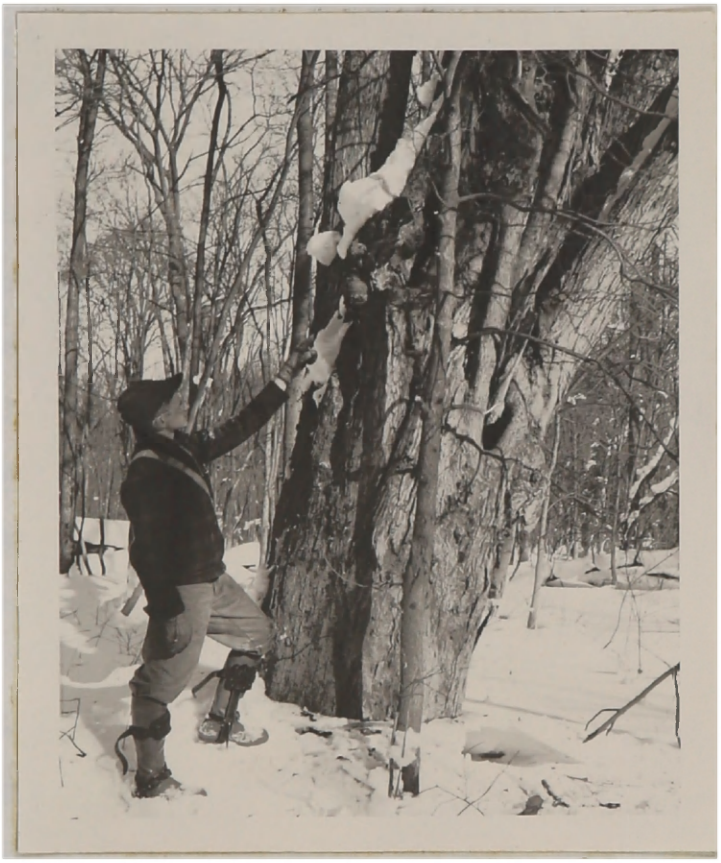


Fig. 51. A low den occupied in winter.

only 10 x 10 inches inside contained a litter of three young a few weeks old, which means that a rather small den can accommodate a female and her young (Table XXIV, appendix).

The dryness of the den often depended upon whether or not it extended to the base of the trunk. Those hollows which reached to the ground were invariably wet and generally avoided by raccoons (fig. 52). Otherwise depth does not seem to be of great importance, since there was a wide variation between the two extremes, from those with the entrance at nest level to one measuring 11 feet deep (fig. 53). The average was 38 inches. Entrances were of various sizes; unless one was so large as to make the cavity little more than an open shelf or too small to allow entrance, any hollow seemed to be acceptable to a raccoon. Dens with holes as small as 5 x 3 inches and $4\frac{1}{4}$ x 4 inches were used in late winter and spring, although it is doubtful if openings so small could be entered by fat animals in fall. Representing the other extreme was a wide trunk opening, which tapered to a V at nest level (fig. 55). The average entrance measured $12\frac{1}{2}$ x 6 inches.

The exposure, or direction to which a den is exposed by the entrance, also appears to matter little. Approximately equal numbers of those examined were facing different directions, and 13 were open from the top, i.e., the entrance was from the top of a broken stub or at a crotch leading into the hollow trunk.

Table XXIV (appendix) gives complete data, including animals found in each, for 34 occupied dens. All measurements except the estimated height of tree, and distance from water, were taken carefully with flexible steel tapes.

Fig. 52. The hollow in this tree which extended to the ground was usually wet and therefore unsuitable as a den. Such trees furnish good refuge sites, however.

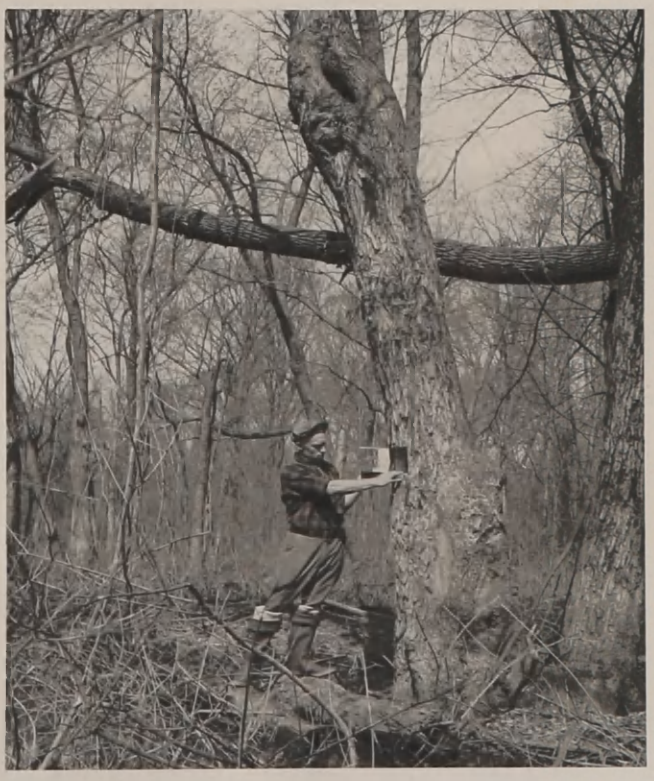


Fig. 53. A very good den which was 11 feet deep. Sawed open to remove raccoon for examination.

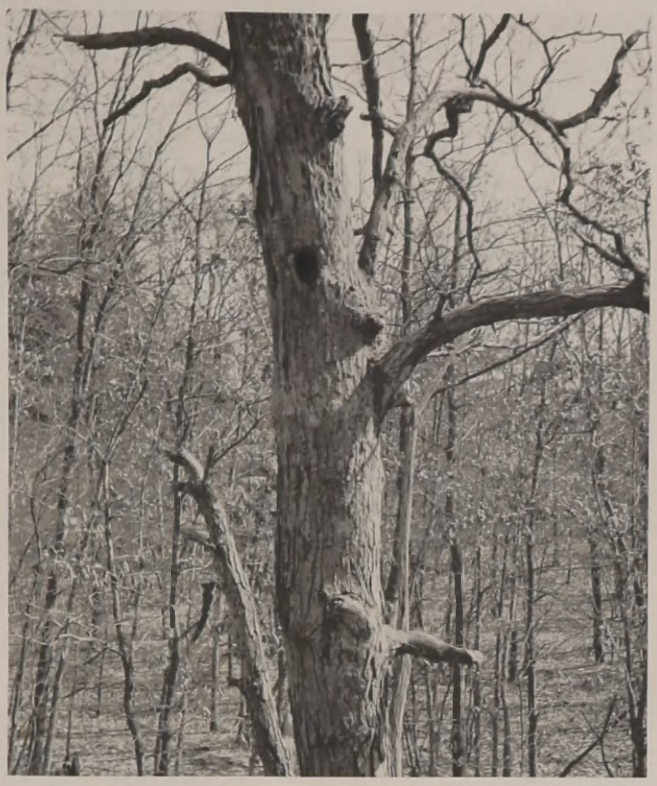


Fig. 54. Den with entrance measuring only 5 x 3¼ inches occupied by yearling male on February 29, 1940. Probably original cavity made by woodpecker.

Fig. 55. Rather exposed den occupied by female and litter. Opening extended about 8 feet above nest.

Raccoons apparently never add any nesting material to their dens. Invariably there was a quantity of decayed and crumbled wood residue, which had accumulated as the cavity formed, sufficient to make a comfortable, dry nest for the animals (fig. 57). Den sanitation was evident, as all were dry and clean. Shelf-like cavities in the trunks and branches of some of the older trees, which were often little more than shells, seemed to be utilized considerably for temporary refuge and resting. It seems probable that raccoons may use such open sites, or perhaps lie out on the larger branches during the summer months, instead of using the better protected dens to any great extent. Data are principally negative in this respect, however, for although a considerable number of hollows were examined in summer, only once was one found occupied, and the two animals there may have taken refuge because my dog was trailing a third raccoon nearby. Reports of animals being found out in trees during the day in summer may be quite indicative of raccoons' usual habits at that time of year.

Adult raccoons apparently prefer to den singly, and the circumstances under which animals have been found indicate that females alone care for their young. In the examination of 10 litters, varying in age from 10 days to 10 weeks, either the young were by themselves in the den or were with a female only. During the oestrus period when females are receptive of breeding males, adults of both sexes were always found denning alone. Yearling females were also found singly at such times, with one exception. One in heat was denning with a year-old male. Several times two yearling males were found together. This and other evidence from tag returns and track observations points to the fact that family

Fig. 56. Examining a den 50 feet up.

Fig. 57. The only nesting material in raccoon dens was the wood residue resulting from decay and insect activity.

groups break up sometime in the fall, the female going her own way and the young often living singly or in groups of two or three.

During the mating period, and coincident with thawing temperatures, raccoons travel, even though there is deep snow. Males seem to be more active at such time, and travel greater distances in the search for females (figs. 26 to 28). In cold weather, even during the mating season, there seemed to be little activity.

Winter denning

Winter denning rather than hibernation will be used in this discussion to denote the protracted inactivity of raccoons in winter. The latter term, used by most writers who have discussed habits of the species, implies a torpid, lethargic state such as is assumed by woodchucks and spermophiles, but which is not characteristic of the winter sleep of raccoons. During the coldest, most severe time of winter, the animals are curled up in their dens asleep, but upon the slightest disturbance are wide awake and, if necessary, ready to defend themselves. This statement is based on observance of 20 raccoons found in dens during the winter months, which were in full command of all the possessed powers of defense. Benedict and Lee (1938) who conducted intensive experiments in marmot physiology say "The facts are that no animal appreciably larger than the hedgehog or marmot has been definitely proved to be in hibernation." The raccoon, although not a great deal larger than the marmot, may be included here, and hibernation in its strictest sense should not be used concerning the species.

The fact that raccoons do not remain in their dens continuously throughout the winter was already noticed many years ago by Kennicott (1858) of Illinois who says that hibernation is not profound—

the animals coming out on mild days. It is generally agreed that the extent of the winter denning period throughout the animal's range varies with the latitude. In the southern states there is no such period at all, while at the northern limit of the range it may be several months long (Anthony, 1928). A good example of the effect of climate in this respect is shown by conditions in Oregon. Bailey (1936) reports that there, in the low country, they probably do not hibernate at all, but do so where deep snow is found. According to Goodwin (1935) they may not hibernate during mild winters in Connecticut, but otherwise den in winter for varying lengths of time depending upon prevailing temperatures. Whitney (1931), who has made observations in both Massachusetts and Connecticut, believes that relative temperatures govern the activities of the animals; i.e., they "hole up" coincident with a drop in temperature and become active with a rise in both fall and winter. For Michigan, Wood (1922) says "---- and when winter comes (the raccoon) curls up in some den tree and sleeps through the winter, sometimes alone and sometimes with others." He mentions also their activities outside in warm spells of late winter.

It was possible to record almost the exact date when raccoons began protracted winter denning in the Allegan region in 1939. The fall was unusually moderate, and mild weather extended to mid-December. On December 13 snow fell and thereafter raccoons appeared to remain in their dens. This information is based principally on track observations on the mulched road (p. 24). Raccoons were feeding regularly on the acorn mast in the uplands and crossed the road each night as they came from dens in the bottoms. Tracks of the same animals were sometimes seen night after night in the same locality. Observations of this kind were made here

from November 25 to December 15. Table X which gives the ground condition, temperatures and number of tracks seen for each day during the period, seems to tell a rather complete story concerning the activities of the raccoons at that time. In late November, lowered temperatures appeared to have caused reduced activity. With warmer weather in December, lasting until the 15th, activity increased and reached a peak on December 7, when 17 different raccoons crossed the road. However, though temperatures did not drop to any great extent, outside activity ceased entirely when snow came on December 13 and on the three following nights not one track was seen in the snow. Evidently the winter denning period had begun abruptly.

In 1940 snow came earlier, and raccoons denned earlier. From November 27 to December 21, there was snow on the ground, and the animals ceased outside activity. However, when the ground became bare, and warmer temperatures prevailed from December 22 to January 3, they were again travelling about and feeding regularly. It snowed again on January 4 after which the animals remained in their dens. It appears that the coming of snow was the deciding factor which induced raccoons to cease outside activities, late one year and earlier the next, rather than temperatures. On the other hand, later in the winter when snow has been on the ground for a month or more, temperatures seem to have more influence. In the winter of 1939-1940 the snow remained after December 13, and later attained a depth of about two feet. No evidence was noted of outside activity on the part of raccoons until the first thaw on February 5, which was coincident with mating activities. Very little feeding was done until about mid-March, or three months after they had first "holed up" in December. In years of mild winters feeding would probably be

TABLE X

Date	Ground conditions	Temperatures Min.	Max.	Number of tracks
Nov. 25	Bare	25	42	1
26	"	10	39	3
27	"	10	43	0
28	"	12	48	1
29	"	14	47	5
30	"	28	50	5
Dec. 1	"	39	44	?
2	"	44	43	?
3	"	35	44	5
4	"	30	38	9
5	"	30	37	4
6	"	32	38	16
7	"	30	45	17
8	"	22	49	13
9	"	22	43	10
10	"	37	49	12
11	"	30	49	11
12	"	27	39	5
13	Snow 1"	30	47	0
14	Snow 1½"	25	33	0
15	Snow ½"	16	36	0

resumed in early March, but snow in the fall often causes denning to begin earlier than it did in 1939, and therefore the usual extent of the winter denning period, during which very little food is taken, is about three months in most of Michigan's raccoon range.

Provision to enable the animals to subsist during such a long fast, is in the form of a large reserve of fat, accumulated in fall (p. 73). It was noted that raccoons asleep in their winter dens consistently assumed a position, which appears to be correlated with the pattern of the layer of insulating fat. As described previously this layer is thickest over the rump and thighs of the animal. The pattern is the same on all raccoons and corresponds closely with those parts of the body exposed to low temperatures when the animal is denning. In the characteristic attitude of a denned raccoon, the head, feet and tail are all drawn closely together underneath the body so that little more than the fat-covered back, thighs and rump remain exposed. Williams (1909) found the subcutaneous layer over the rump and hind quarters of an animal taken in Ohio to weigh one-ninth as much as the entire pelted carcass.

RANGE

The range of raccoons has received little more than passing mention in the available literature. Accumulated information includes only a few casual observations by those who have discussed the species. Audubon and Bachman (1851) mention tracking a pair in snow for a mile circle. The writer has also trailed males one, and one and a half miles in the snow during the breeding season (figs. 26 to 28). In Texas Bailey (1905) says raccoons may go from one-half to one mile from their cliff dens to feed in the streams. Others report the animals travelling greater distances. Whitney (1931) who hunted 'coons in Connecticut reports following families four and five miles, and Grinnell, Linsdale and Dixon (1937) in California found two animals travelling regularly seven miles in a round trip to visit a prune orchard. In the latter case an attractive food supply may have lured the raccoons a greater distance from home than usual. It is possible also that in some cases more than one animal may have been involved when an observer found signs in different places. Seton's (1929) statement concerning the Adirondack and Catskill region, that no man travelled or trapped there for a month without passing within hearing of one hundred 'coons but saw none, certainly holds for the Swan Creek region and probably for other areas of Michigan and various other states as well. There has been, as far as is known, no authenticated information concerning the ranging habits of raccoons in Michigan.

During the present investigations exact records for individuals were obtained by the capture of tagged animals in traps or dens, or by observations of the tracks of those with clipped toes. The data presented

are based on such records obtained during the summer of 1938 and during the two year period beginning in February, 1939. Trapping records were obtained from May to December in 1939, and May to October in 1940. Fig. 58 shows the locations of traps where the majority of catches were made. In addition, traps were in operation along one mile of Swan Creek south of this area, and along two and one-half miles of the Kalamazoo River and bayous north of it. Moreover, for cottontail studies of other workers, numerous traps were stationed in Sections 32, Heath Township, Sections 4, 5, 8, and 9 Valley Township, and in adjoining townships to the west. The majority of these were in the oak upland habitat, where they occasionally caught raccoons which had gone there to feed.

Tracks were observed throughout the year, those of toe-clipped individuals being distinguishable in mud, sand, and snow. Cursory observations were made as the traps were tended and along the various roads shown on the map in fig. 58. The road extending north from the Experiment Station headquarters and diagonally across Section 5, Valley Township was mulched as a track register from November 25 to December 13 in 1939, and at various times during the spring and summer of 1940.

The range data presented are represented by 459 records obtained for 87 animals, comprising 19 adult males, 17 adult females, 27 juvenile males, and 24 juvenile females. Records for any one individual are too few to warrant giving any seasonal ranges. In the case of juveniles only those locations for the animals during their first year are included. For some adults the period during which data were obtained extends over nearly two years. Ranges discussed here should therefore be considered "total apparent range" of animals of the sex and age under

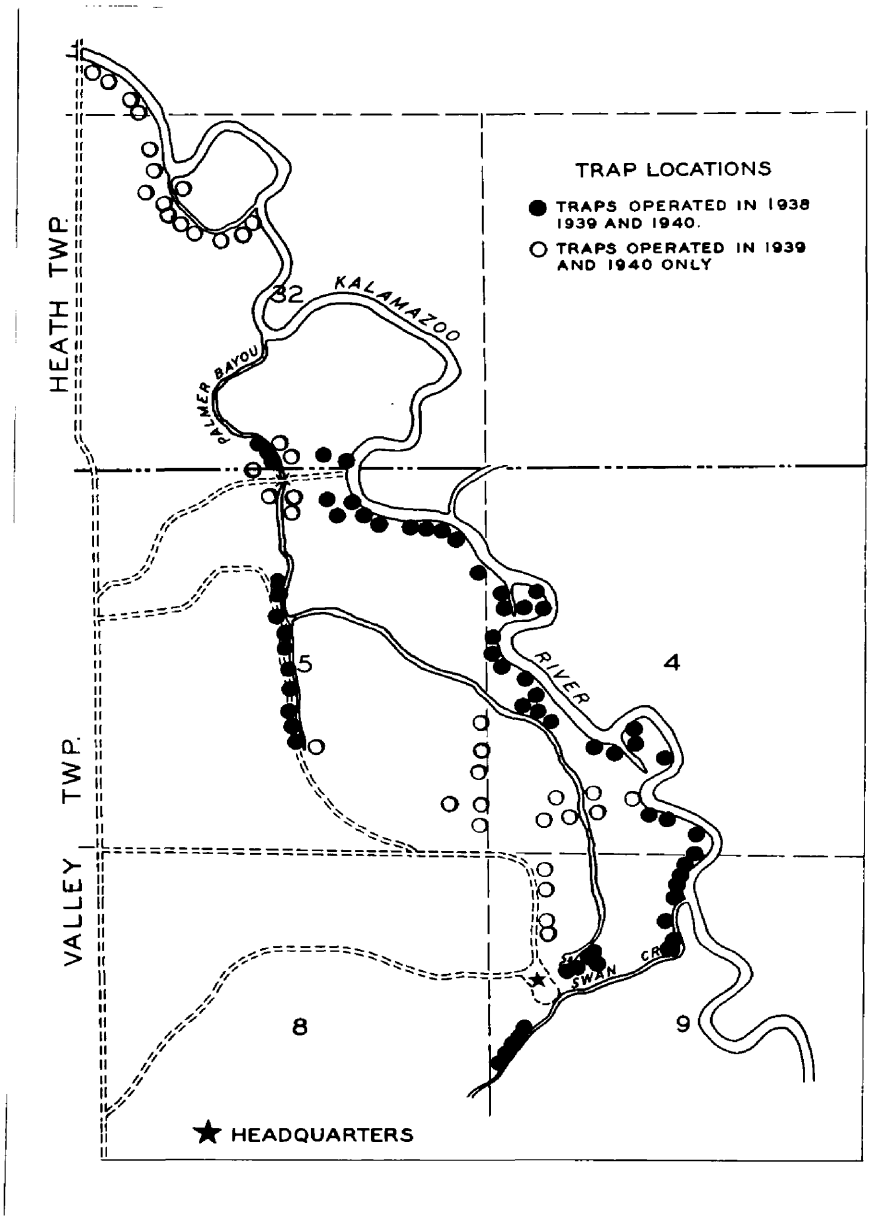


Fig. 58. Traps were also operated in 1939 and 1940 along one mile of Swan Creek south of Section 8, Valley Twp., and along two and one-half miles of the Kalamazoo River and bayous northwest of Section 32, Heath Twp.

consideration. The term range diameter used throughout the discussion refers to the measurement in a straight line between the two most distant recorded points within an animal's determined range.

TABLE XI

Data on Raccoon Ranges*

Age	Sex	No.	Number of Records per Individual			Longest Diam of Known Range in Miles			Calculated Area of Known Range in Acres**		
			Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Adults	Male	19	36	3	7.0	2	.3	1.0	2012	45	503
	Female	17	19	3	7.1	1.4	.2	.7	930	13	268
Juveniles	Male	27	10	2	3.4	1.9	.1	.7	1777	5	268
	Female	24	18	2	4.6	1.3	.1	.5	798	5	111

* Includes records over a period of as much as two years for adults, but only during their first year for juveniles.

** These figures give the areas of circles having diameters equal to longest diameters of the known ranges of the animals.

Table XI presents in summary form the range data for raccoons in each of four classes separated according to age and sex. For each group the maximum, minimum, and average number of records per individual are given and also the range diameters in the same categories. While the diameters have obvious limitations as far as indicating the true ranges of the animals is concerned, they at least show the distances to which the animals travel at times. Perhaps "cruising diameter" would

be a more appropriate term. In order to demonstrate the range of certain other mammals, the uniform spacing of traps throughout quadrats has been used by various workers. Such a method was not applicable to raccoons, since the animals, though they may cover most parts of their range at times, travel more regularly along water courses, and to a certain extent along roads. Therefore, to attain efficiency of catch of a degree sufficient to warrant trapping, it was necessary to locate traps along such avenues of greatest travel. Insofar as the data indicate usual extent of range, their value is enhanced by the fact that trapping operations and concurrent track observations were in progress in 1939 and 1940 along approximately 10 miles of the Kalamazoo River and a tributary creek and bayous, while the greatest range diameter was only two miles. Distribution of the range diameters about the means is shown in fig. 59.

Table XI also indicates maximum, minimum, and average calculated range areas. These figures are presented here for what they may be worth, as indicating the size of an area used by a raccoon. Theoretically the average range of an animal should assume a circular shape. Accordingly the areas were calculated by using the range diameter as the diameter of a circle in each case. During the summer, when much of a raccoon's feeding is near water, the distance between points of capture is probably the more significant, since the animal might occupy only a narrow strip of territory, along a stream for instance. However, in fall when the animals are eating widely scattered mast and fruits, the entire area delimited by a circle would more likely be visited.

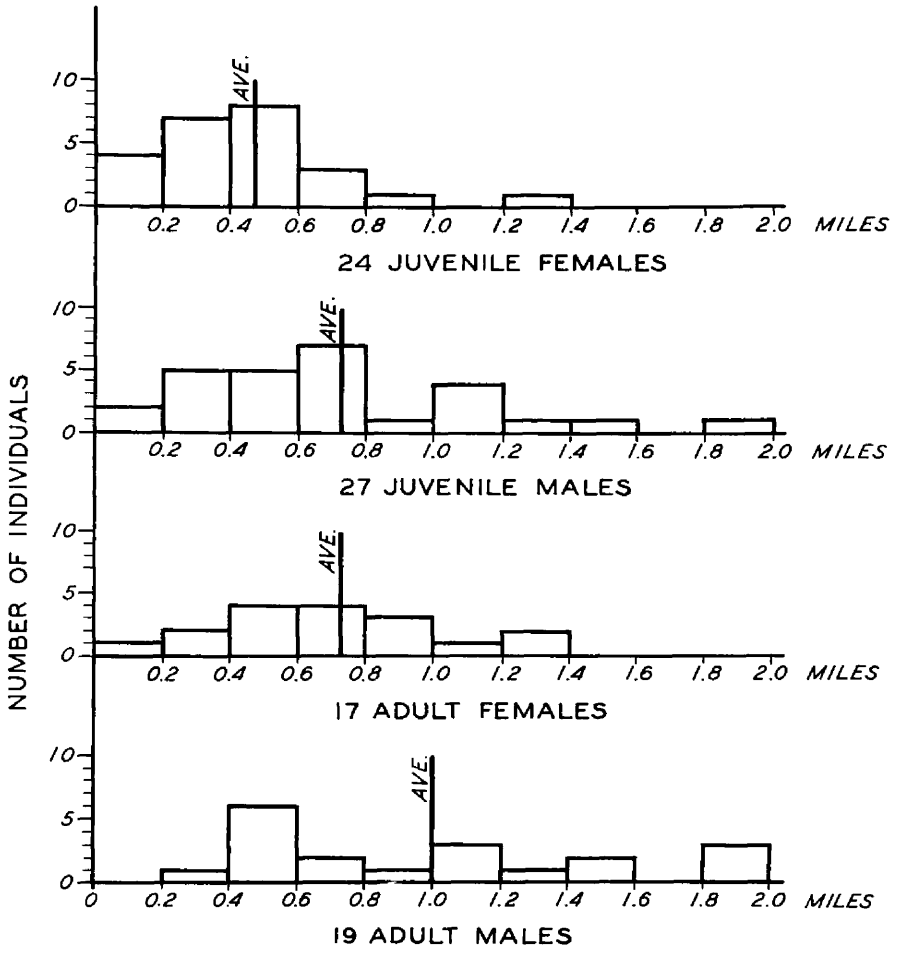


Fig. 59. Histogram showing distribution of range diameters about the means.

Adult males

Range data were obtained for 19 adult male raccoons, with a maximum, minimum, and mean of 36, 3, and 7 records per individual respectively. The known location records for 16 of these animals were plotted on a base map and the outer boundaries connected by straight lines (figs. 60 to 64). Such inclosed areas indicate the known territory utilized by each animal. The plotted range of raccoon #694 (fig. 64) is probably the most significant, for animals of either sex. A total of 11 trap catches and 25 track locations were recorded for this individual. It was known that he visited practically all parts of the range shown on the map, which amounts to approximately one and one-half sections or 960 acres. If he occupied a circular area, he utilized 1850 acres.

Table XI gives the extreme and average range diameters for the 19 adult males. The longest was for one recorded six times. Two other long diameters of 1.9 miles were shown for animals recorded seven and 36 times. The mean was exactly one mile. Using these measurements as diameters to calculate the areas of theoretical circular ranges, there resulted a maximum of 2092 acres, mimimum of 45 acres, and average of 503 acres. The territories of adult male raccoons, as shown by the above data, apparently are larger than those of females or juvenile males. This seems logical when we consider the fact that males have no part in caring for the young, and are free to wander about by themselves during most of the year.

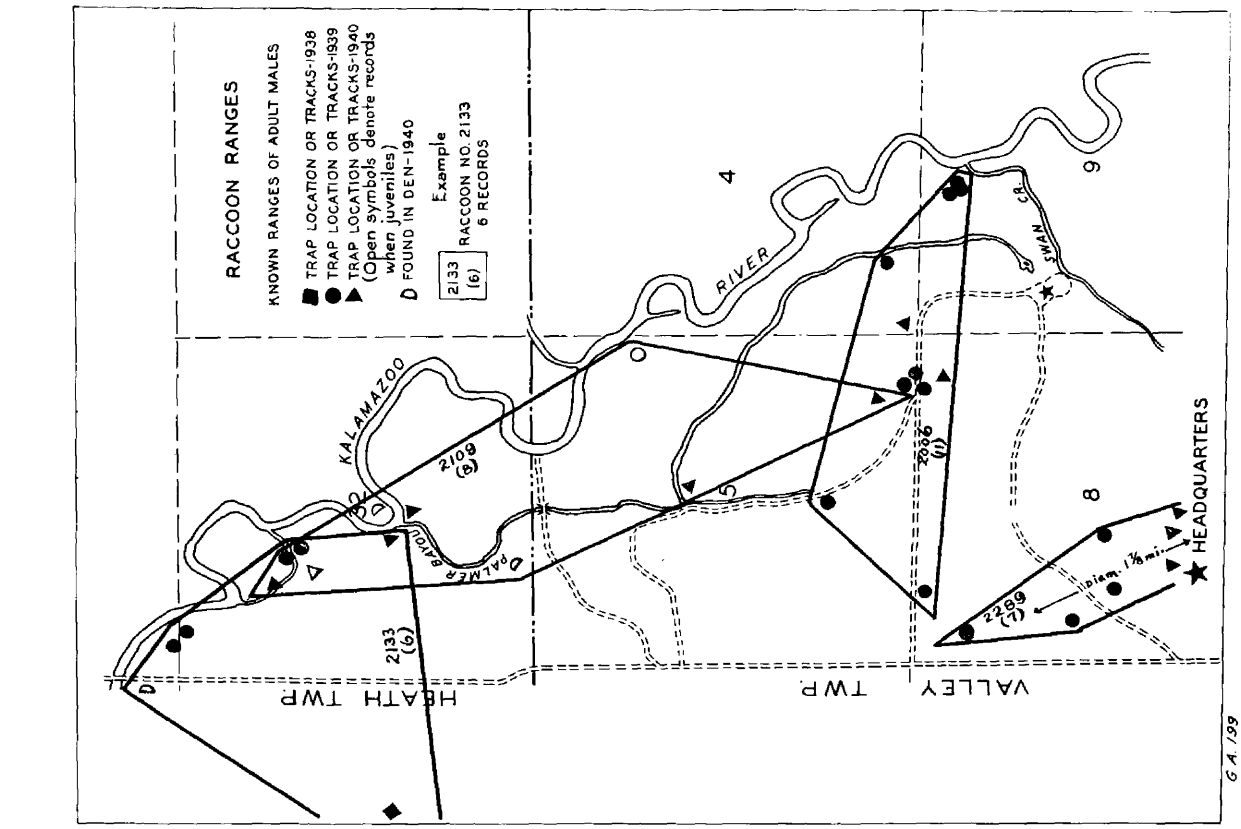

RACCOON RANGES
KNOWN RANGES OF ADULT MALES
TRAP LOCATION OR TRACKS-1938
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
(Open symbols denote records when juveniles)
FOUND IN DEN-1940
Example
2133 (6) RACCOON NO. 2133 6 RECORDS
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
HEATH TWP
VALLEY TWP
HEADQUARTERS
2109 (3)
2133 (6)
2016 (1)
2269 (1)
1 diam. = 1/8 mi.
G.A. '39

Fig. 61.

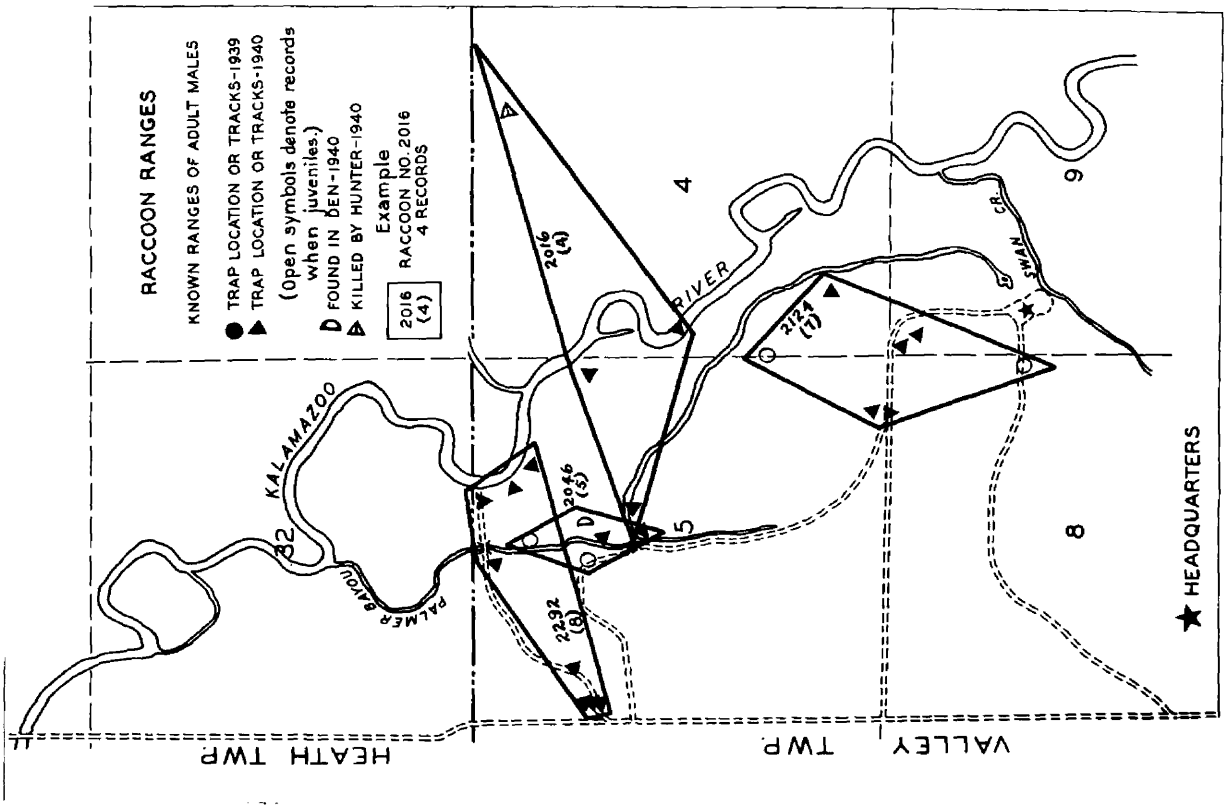

RACCOON RANGES
KNOWN RANGES OF ADULT MALES
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
(Open symbols denote records when juveniles.)
FOUND IN DEN-1940
KILLED BY HUNTER-1940
Example
2016 (4) RACCOON NO. 2016 4 RECORDS
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
HEATH TWP
VALLEY TWP
HEADQUARTERS
2016 (4)
2046 (5)
2292 (8)
2124 (1)

Fig. 60.

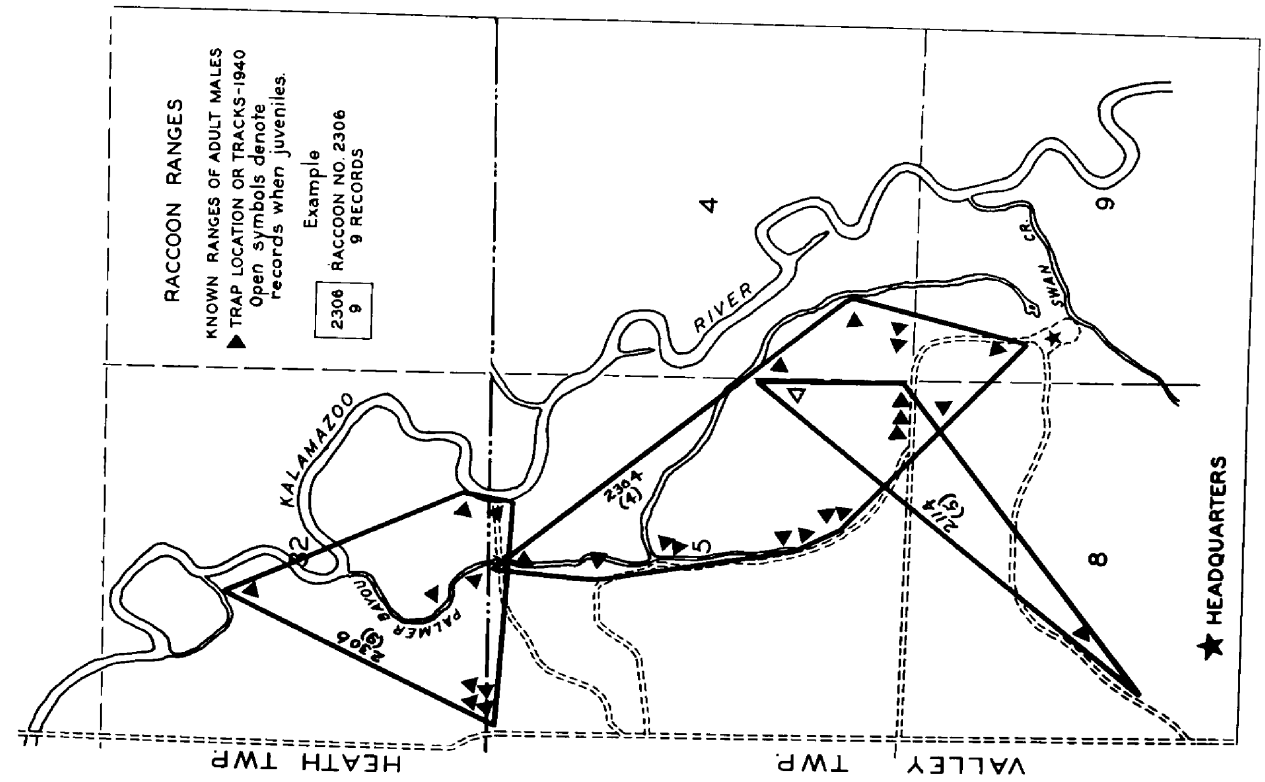

RACCOON RANGES
KNOWN RANGES OF ADULT MALES
TRAP LOCATION OR TRACKS-1940
Open symbols denote records when juveniles.
Example
2306 9
RACCOON NO. 2306
9 RECORDS
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
HEADQUARTERS
HEATH TWP
VALLEY TWP
2394 (4)
2306 (9)
2144 (6)
2 4 5 8 9

Fig. 63

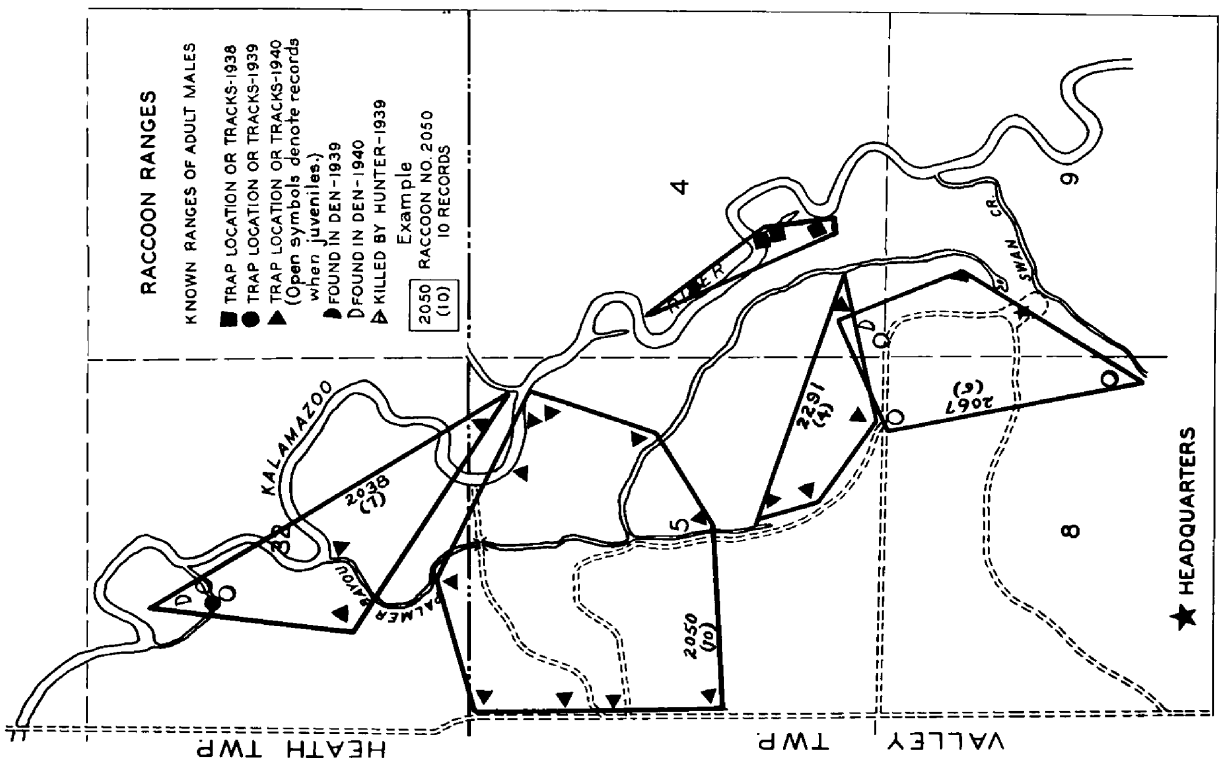

RACCOON RANGES
KNOWN RANGES OF ADULT MALES
TRAP LOCATION OR TRACKS-1938
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
(Open symbols denote records when juveniles.)
FOUND IN DEN-1939
FOUND IN DEN-1940
KILLED BY HUNTER-1939
Example
2050 (10)
RACCOON NO. 2050
10 RECORDS
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
HEADQUARTERS
HEATH TWP
VALLEY TWP
2038 (7)
2050 (10)
2291 (4)
2067 (6)
2 4 5 8 9

Fig. 62

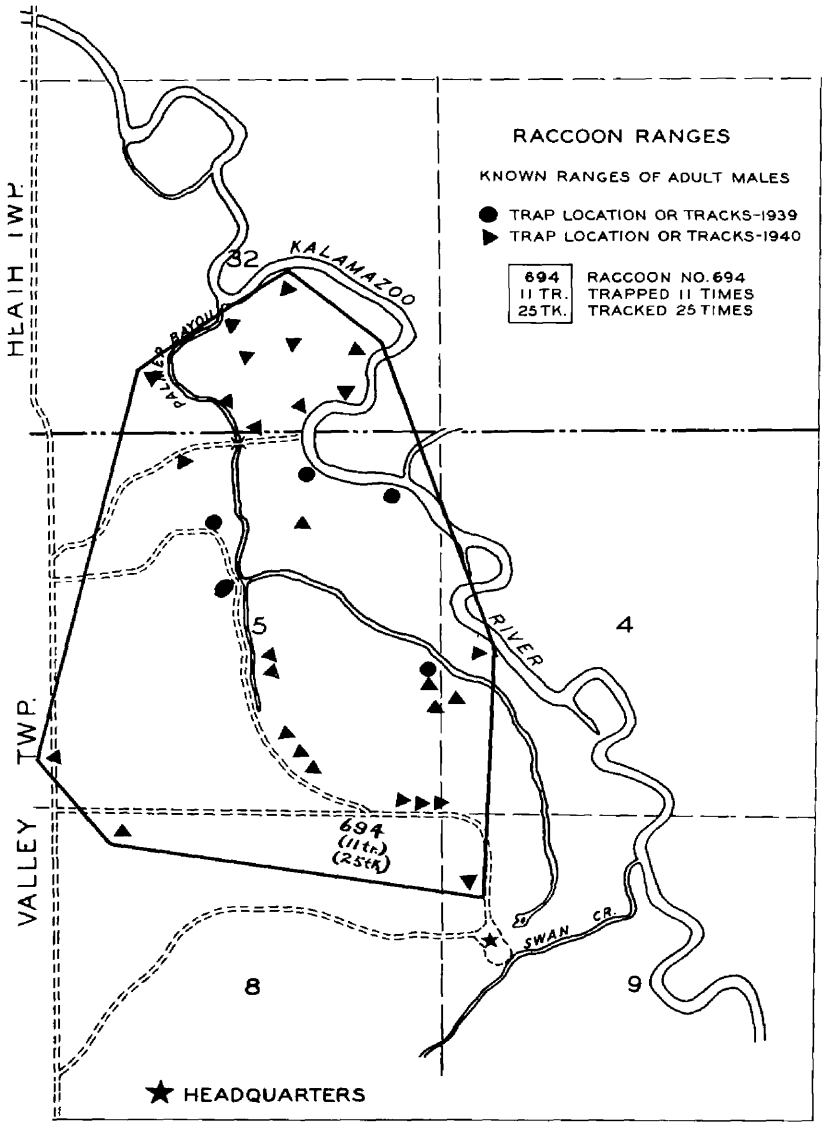

RACCOON RANGES
KNOWN RANGES OF ADULT MALES
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
694
11 TR.
25 TK.
RACCOON NO. 694
TRAPPED 11 TIMES
TRACKED 25 TIMES
HEATH TWP.
VALLEY TWP.
KALAMAZOO
RIVER
SWAN CR.
694
(11 TR.)
(25 TK.)
32
5
4
8
9
HEADQUARTERS

Fig. 64.

Adult females

An average of 7.1 range records were recorded for each of 17 adult females, with extremes of 3 and 19. Available records for seven animals were plotted as shown in figs. 65 and 66. Fig. 67 shows the known ranges of five females both as juveniles in 1939 and as adults, or more exactly as yearlings, in 1940. The maximum, minimum, and mean diameters of 1.4, .2, and .7 miles respectively as shown in table XI, indicate a smaller range than for males. As explained previously, it may be that females are limited in their travels because they have the young to care for. Females of other species, of which the cottontail is one (Haugen, 1940) also exhibit the tendency to range less than the males. Using one-half the determined range diameters as the radii of circular ranges, we find an average area of 268 acres, with greatest and least acreages of 930 and 13 respectively.

Juvenile males

Range data for 27 male juveniles were used, for whom records of from 2 to 10 with a mean of 3.4 per animal were obtained. Maximum, minimum and average diameters of 1.9, .1, and .7 miles respectively were recorded. Theoretical areas were 1777 and 5 acres as the extremes, and the mean 268 acres (table XI). It will be noticed that the average range size was exactly the same as for adult females, which is logical, since the young remain with the mother during their first year, at least until fall. The known ranges of eight animals were plotted in figs. 69 and 70.

Juvenile females

For 24 juvenile females 2 to 18 locations per animal were recorded, with an average of 4.6. The mean range diameter was .5 miles

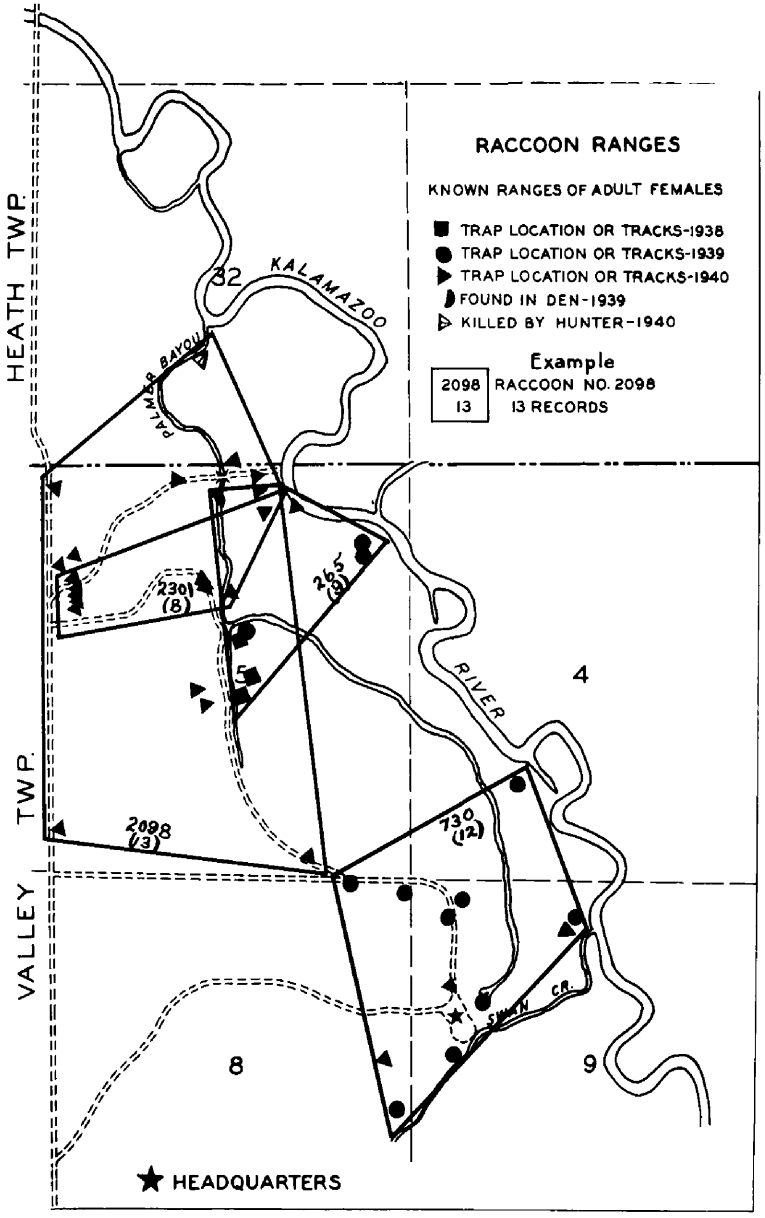

RACCOON RANGES
KNOWN RANGES OF ADULT FEMALES
TRAP LOCATION OR TRACKS-1938
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
FOUND IN DEN-1939
KILLED BY HUNTER-1940
Example
2098
13
RACCOON NO. 2098
13 RECORDS
HEATH TWP.
VALLEY TWP.
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
2301 (8)
265 (8)
2098 (13)
730 (12)
HEADQUARTERS

Fig. 65.

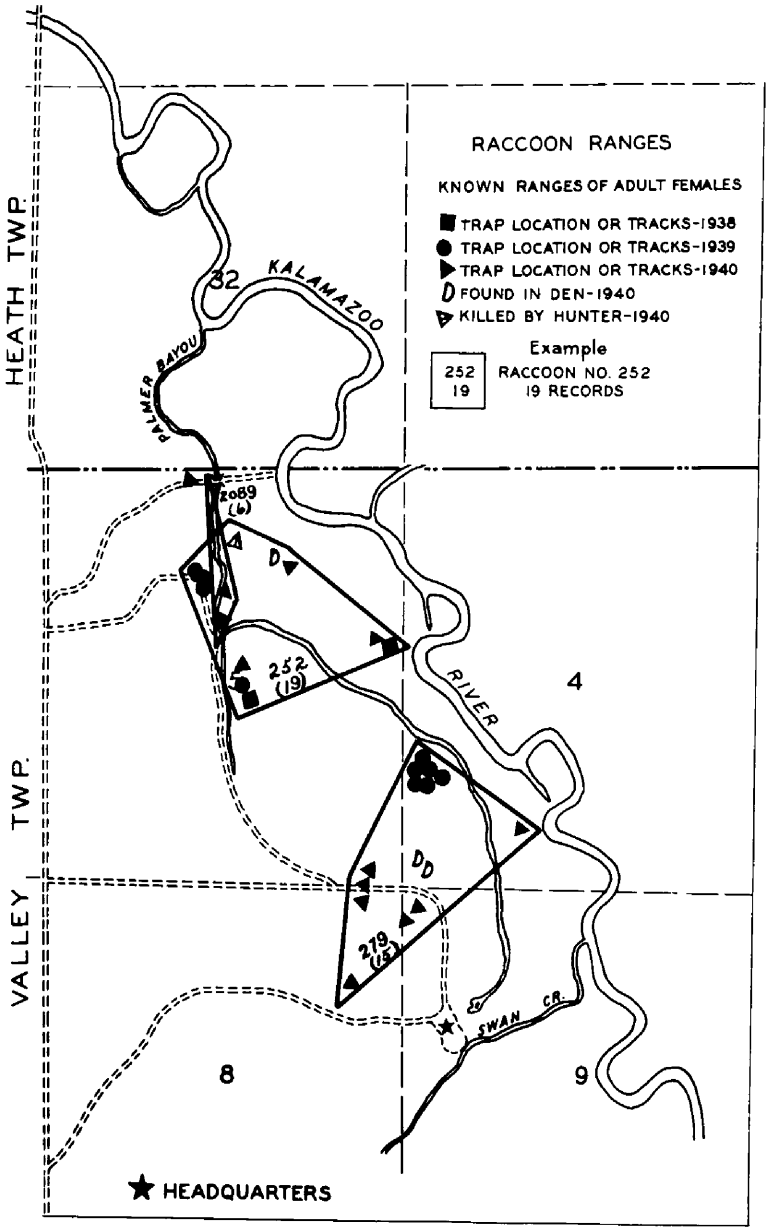

RACCOON RANGES
KNOWN RANGES OF ADULT FEMALES
TRAP LOCATION OR TRACKS-1938
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
D FOUND IN DEN-1940
KILLED BY HUNTER-1940
Example
252
19
RACCOON NO. 252
19 RECORDS
HEATH TWP.
VALLEY TWP.
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
2089 (6)
252 (19)
279 (15)
HEADQUARTERS

Fig. 66.

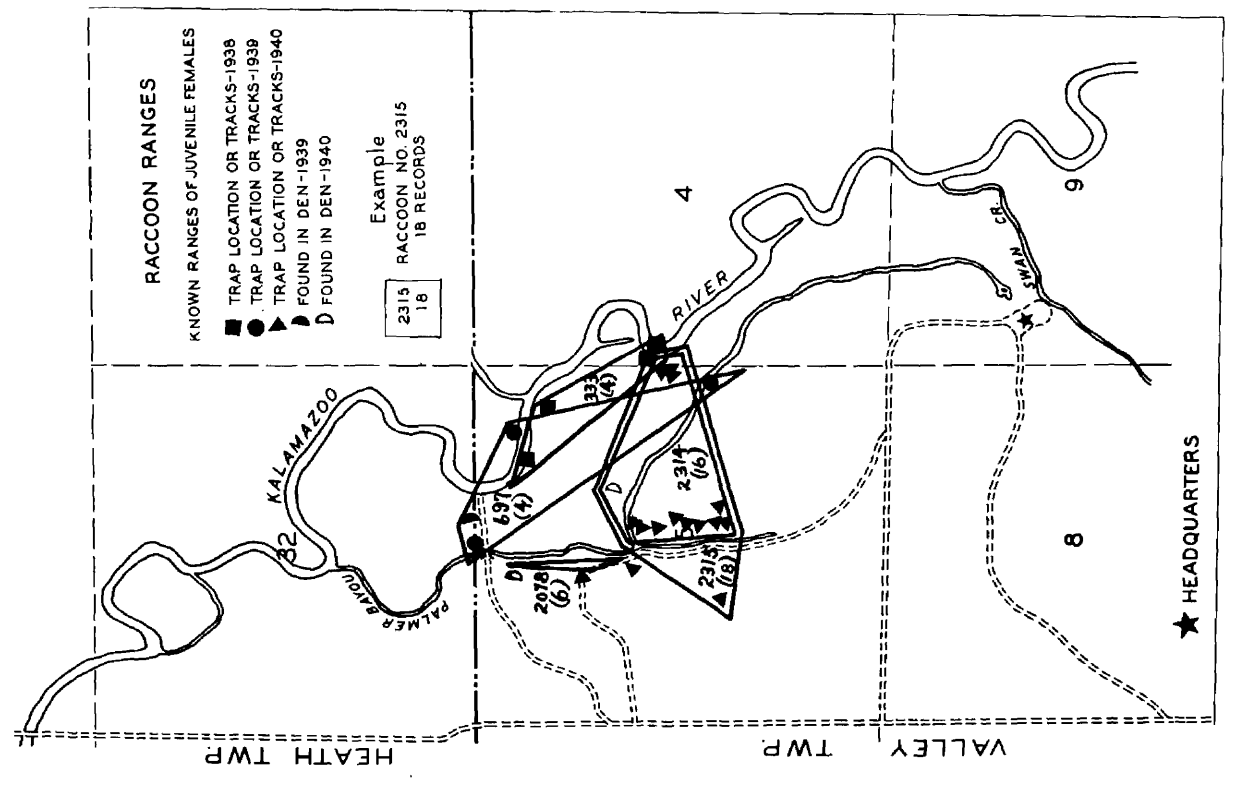

RACCOON RANGES
KNOWN RANGES OF JUVENILE FEMALES
TRAP LOCATION OR TRACKS-1938
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
FOUND IN DEN-1939
FOUND IN DEN-1940
Example
RACCOON NO. 2315
18 RECORDS
2315
18
HEATH TWP
VALLEY TWP
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
HEADQUARTERS
333 (4)
697 (4)
2078 (6)
2314 (16)
2315 (18)

Fig. 68.

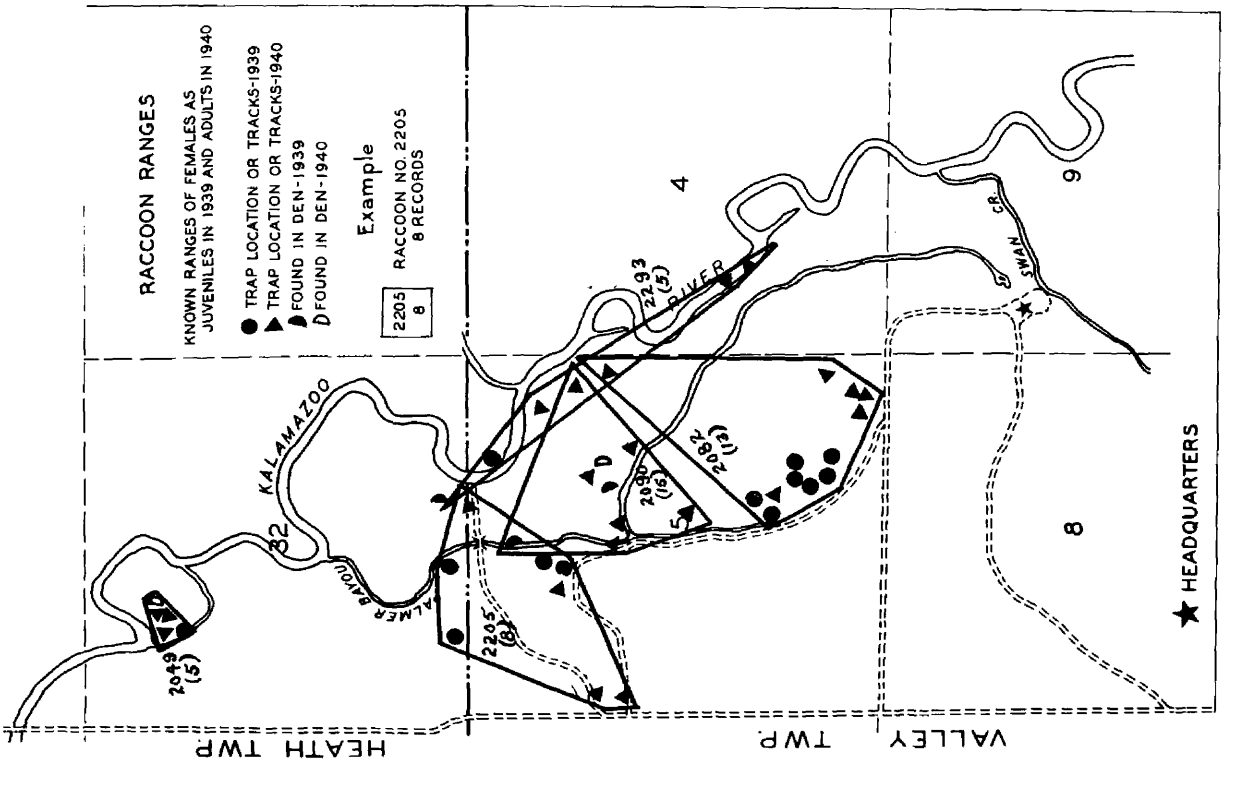

RACCOON RANGES
KNOWN RANGES OF FEMALES AS JUVENILES IN 1939 AND ADULTS IN 1940
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
FOUND IN DEN-1939
FOUND IN DEN-1940
Example
RACCOON NO. 2205
8 RECORDS
2205
8
HEATH TWP
VALLEY TWP
KALAMAZOO
PALMER BAYOU
RIVER
SWAN CR.
HEADQUARTERS
2049 (5)
2205 (8)
2030 (16)
2082 (13)
2293 (5)

Fig. 67.

with extremes of 1.3 and .1 mile. Circular areas were found to be 798 acres as a maximum, 5 acres as a minimum, and 111 acres as the average. The determined mean is smaller than for juvenile males, which is not considered significant, since juveniles of both sexes probably cover areas of equal size. Returns from hunters have shown that some juveniles, both females and males, travel considerable distances in fall, indicating true dispersal, to be discussed later.

Five known ranges of juvenile females are plotted in fig. 68. It is interesting to note the great similarity in size and location of those of females numbered 2314 and 2315 (fig. 68) and male number 2321 (fig. 69), which animals comprised a complete litter. They were often all caught in adjacent traps and sometimes two in one trap, probably remaining for the most part within the territories as plotted, or within an idealized circular area of 147 acres.

Undefended territories

Available data on ranges seem to show without question that raccoons do not defend "territories" as do some other species. This is true of both males and breeding and non-breeding females. The evidence for this statement is the overlapping of known ranges as plotted in figs. 71 and 72. In making these maps only the known locations recorded in one year (1940) were used. For females the majority of records were obtained during the time that young were being reared.

Fig. 71 shows the overlapping ranges of 16 adult males. Tracks of several individuals were often seen on the same days within a short distance, or at the same location. Different animals were sometimes taken in the same traps within the space of a few days. It can be said

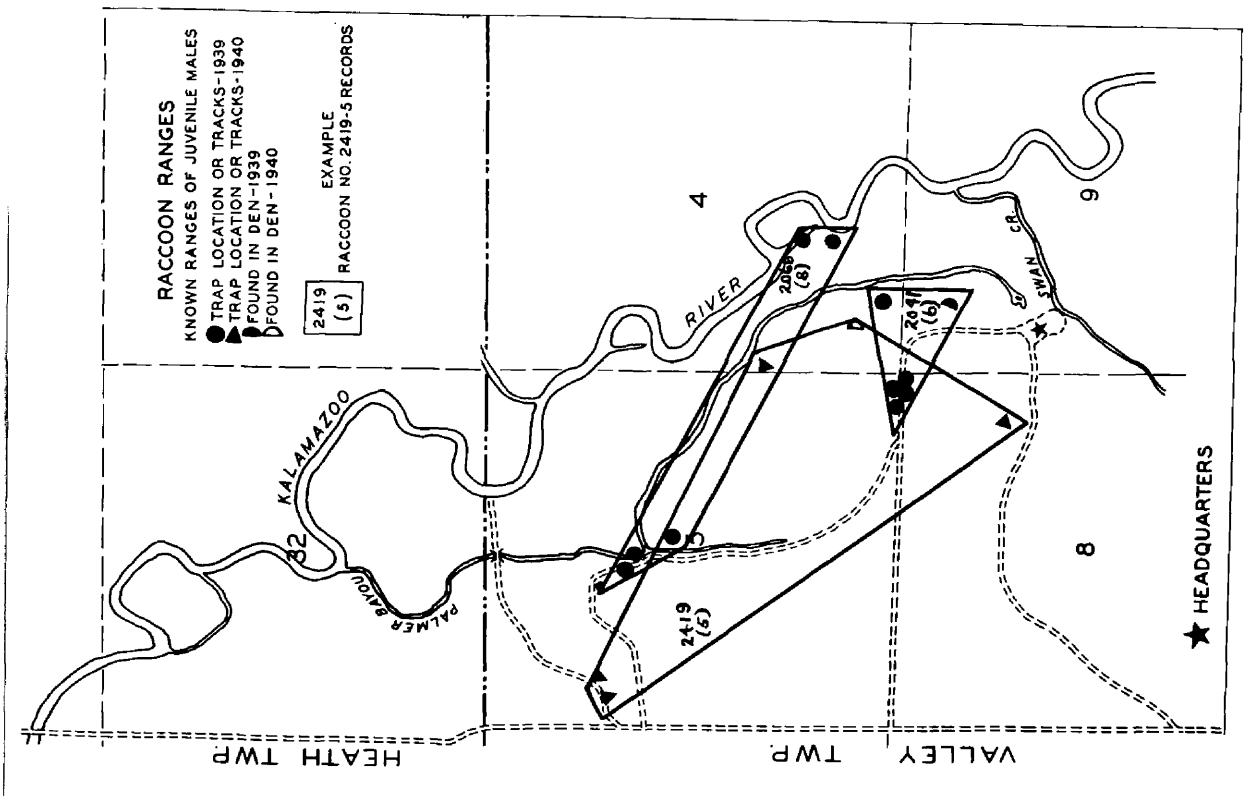

RACCOON RANGES
KNOWN RANGES OF JUVENILE MALES
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
FOUND IN DEN-1939
FOUND IN DEN-1940
2419 (5) EXAMPLE RACCOON NO. 2419-5 RECORDS
HEATH TWP
VALLEY TWP
KALAMAZOO
RIVER
PALMER
SWAN CR.
HEADQUARTERS
2419 (5)
2069 (8)
2041 (6)
32
4
8
9

Fig. 70.

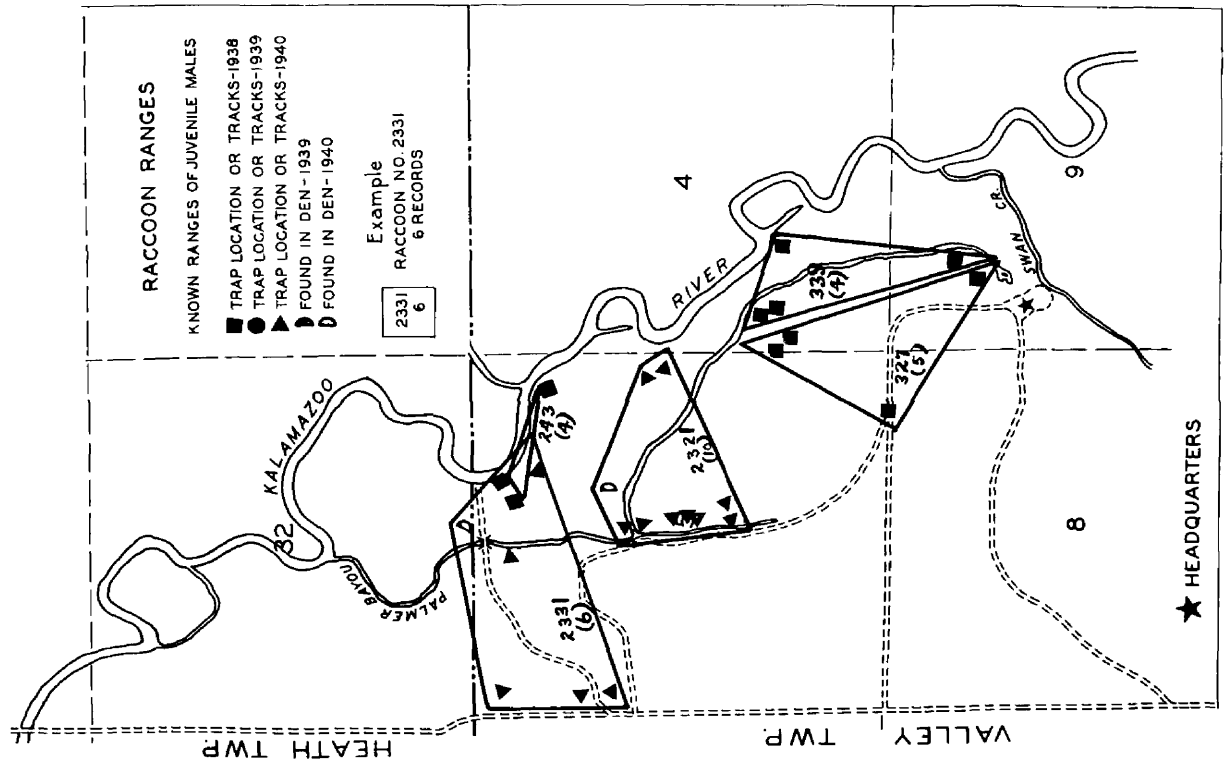

RACCOON RANGES
KNOWN RANGES OF JUVENILE MALES
TRAP LOCATION OR TRACKS-1938
TRAP LOCATION OR TRACKS-1939
TRAP LOCATION OR TRACKS-1940
FOUND IN DEN-1939
FOUND IN DEN-1940
Example 2331 6 RACCOON NO. 2331 6 RECORDS
HEATH TWP
VALLEY TWP
KALAMAZOO
RIVER
PALMER
SWAN CR.
HEADQUARTERS
2331 (6)
243 (4)
2321 (5)
333 (4)
321 (5)
32
4
8
9

Fig. 69.

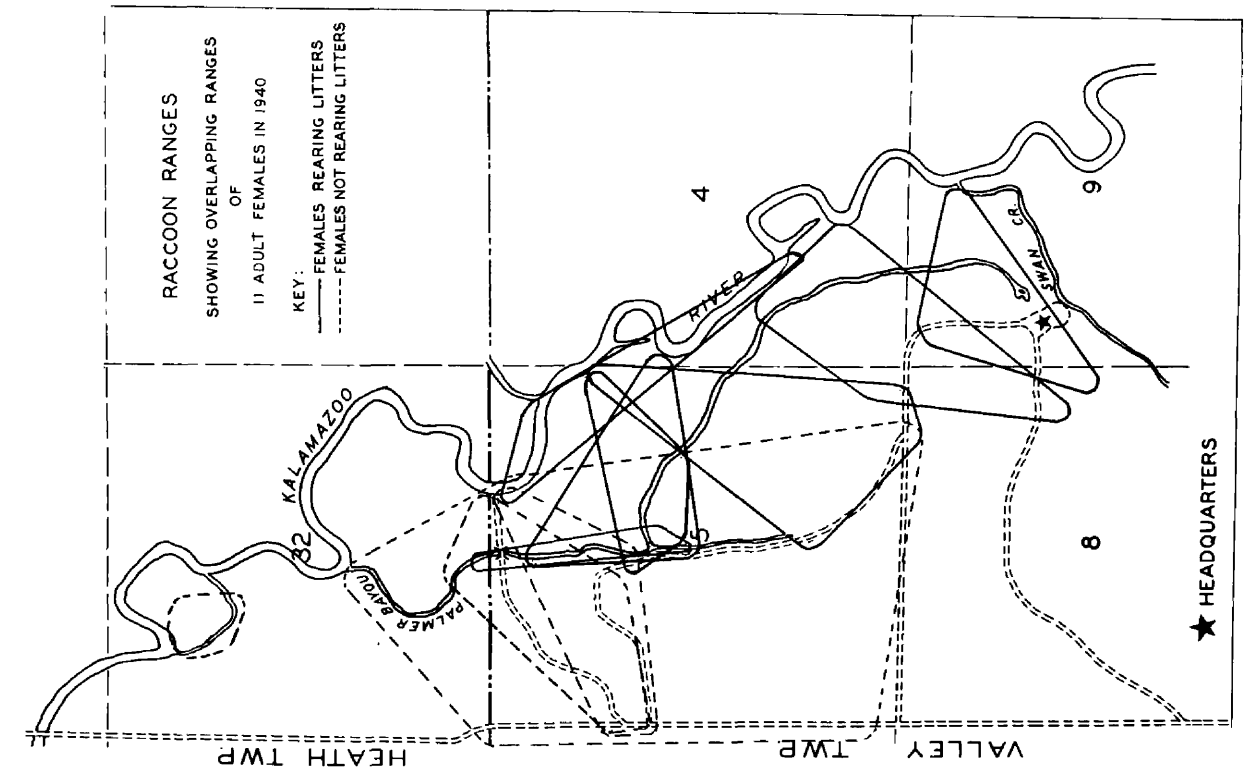

RACCOON RANGES
SHOWING OVERLAPPING RANGES
OF
11 ADULT FEMALES IN 1940
KEY:
FEMALES REARING LITTERS
FEMALES NOT REARING LITTERS
KALAMAZOO
RIVER
PALMER BAYOU
SWAN CR.
HEADQUARTERS
HEATH TWP
VALLEY TWP
4
8
9
32

Fig. 72.

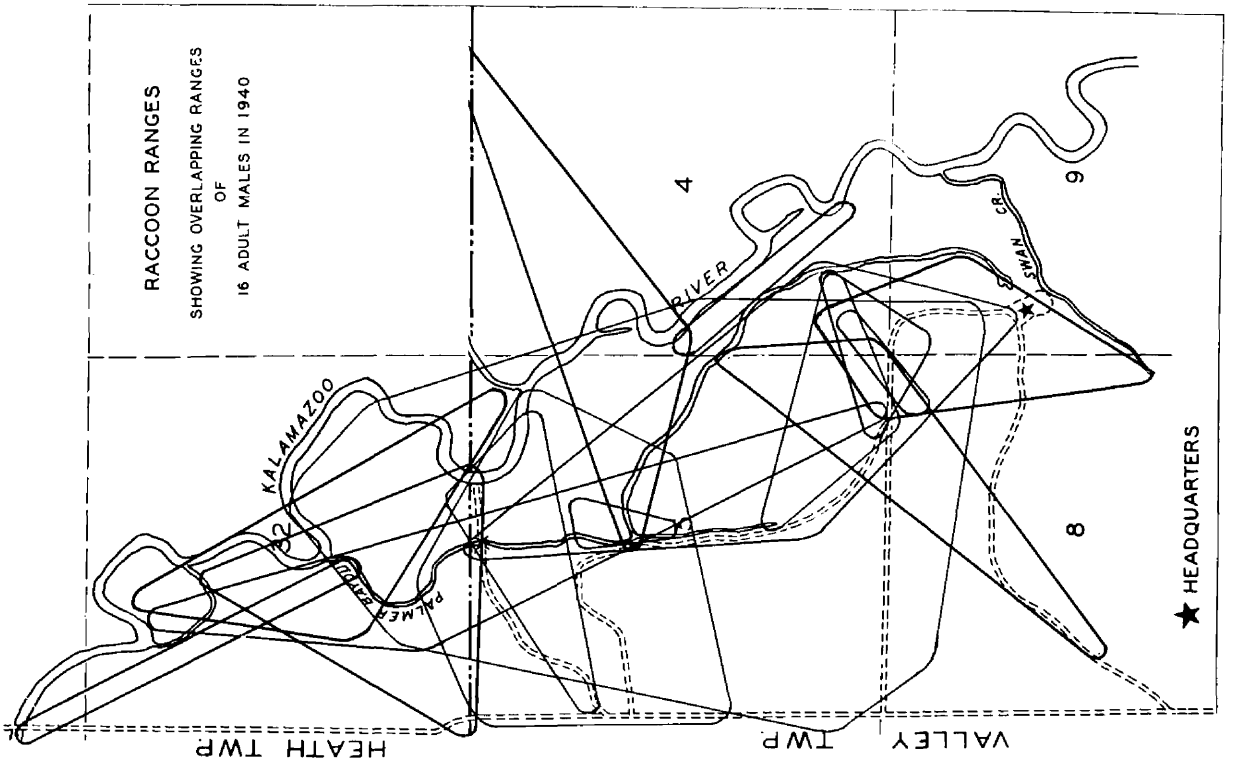

RACCOON RANGES
SHOWING OVERLAPPING RANGES
OF
16 ADULT MALES IN 1940
KALAMAZOO
RIVER
PALMER BAYOU
SWAN CR.
HEADQUARTERS
HEATH TWP
VALLEY TWP
4
8
9
32

Fig. 71.

that within the duration of a year, males will occupy an area which is also occupied by other males, and that the same parts of the area may be visited by several males.

The ranges of 11 females, which in many cases extended over the same area, are shown in fig. 72. The animals included eight individuals known to have reared young and three which did not. As for males, only those records obtained in 1940 were plotted. This map shows clearly that several females may use a certain territory. The relative locations of dens occupied by females and litters are also significant in this same respect. In 1939, three rearing dens were so situated that the middle one was within 600 feet and 900 feet of the two others, which were in opposite directions from it. Certainly the proximity of these dens indicated that the females ranged over the same territory during their search for food and other nightly activities.

Further evidence of a similar nature was obtained in 1940, when two females with litters were located in dens only 600 feet apart. That these two animals not only covered the same territory, but also visited some parts of it in the same night, was shown by the fact that both were caught along a ditch one night in traps only 150 feet apart. They were probably both feeding along the same route. Moreover, a third lactating female had been taken only four days earlier in one of the same traps. It is evident that there is no conflict between females in an area and that no inalienable "home territories" are established.

DISPERSAL

Available evidence indicates that some juvenile raccoons migrate, or disperse, from the territories in which they are born, and probably become established in new localities. Information relative to this point was obtained from the return of tags by hunters who killed marked individuals. Inasmuch as such returns were the last records for the raccoons, it cannot be proven that the animals would not have returned to their original ranges, but the distances to which many travelled made it highly probable that they had migrated permanently to live in new areas.

A total of 62 returns, 20 for adults and 42 for juveniles, were received, with which kill locations were reported. Analysis of these records showed that 14 of the juvenile raccoons travelled 3.5 miles or farther from their respective earlier recorded ranges, with the distances for 13 ranging between 4.5 and 27 miles. Since the maximum summer range diameter of juveniles was never greater than about 2 miles, these 14 animals were considered to have dispersed. The remaining 28 were taken within 2 miles or less of their known ranges. The maximum distance to which any adult, either male or female, was taken from the last recorded location was 2.25 miles, and therefore no adults were considered to have left their former range, since a maximum range diameter of only slightly over 2 miles had been recorded for them by live-trapping and track observations.

Table XII gives the summarized data concerning the movements of 62 raccoons taken by hunters. The reported distances were measured off in straight lines on a map, and are considered accurate to the

nearest one-quarter mile. The kill locations should be reliable, since many hunters reporting were contacted at least once during the work, and were aware of the importance of getting correct information. Whenever any doubt existed as to the place of kill, or when incomplete descriptions were received, the hunter was either interviewed, or sent a letter to obtain the complete data.

The average distance travelled by the 9 dispersing juvenile males was 11.75 miles. A maximum of 27 miles and minimum of 3.5 miles were reported. For the 5 dispersing females extremes of 16 and 4.5 miles were recorded with a mean of 8.25 miles. It is doubtful if the difference here between the averages for the two sexes is significant.

TABLE XII

Data On Movements of Raccoons in Fall
As Indicated By Hunters' Returns of Tags.

	Males				Females			
		Distance*				Distance*		
	Number	Max.	Min.	Ave.	Number	Max.	Min.	Ave.
Dispersing juveniles	9	27.0	3.5	11.75	5	16.0	4.5	8.25
Non-dispersing juveniles	15	2.0	.00	1.00	13	2.00	.25	.75
Adults (All non-dispersing	7	1.5	.25	1.00	13	2.25	.25	.75

* Distances were recorded to nearest .25 of a mile, and averages were corrected to nearest .25 of a mile also.

There were 28 non-dispersing juveniles, of which 15 males travelled maximum, minimum, and mean distances of 2.0, .00, and 1.0 miles respectively, and 13 females travelled 2.00, .25, and .75 miles

respectively. Adults, none of which migrated, were also grouped separately as to sex but the differences in distance were here again probably not significant. Seven males averaged 1.0 mile and 13 females .75 mile.

It appears that the migration of young raccoons usually occurs sometime during fall of their first year. However, records for two males show that one remained in his home territory at least until February after birth, or when approximately 10 months old, and the other at least until May, when he was about one year old. It therefore seems that some may spend the winter near their original homes before moving out.

Since many of the juveniles had not migrated by fall it appeared that they probably would not do so later. That many did not, was definitely shown by records for animals tagged as juveniles and caught the next year. They were known to have remained in the localities in which born, and fig. 67 shows the known ranges of several. One female tagged in a den in 1939 as one of a litter, was found the next year with a litter of her own in a den only one-half mile distant.

These data seem to point rather conclusively to the fact that some juvenile raccoons disperse, but not all of them, and that adults remain in their home areas in fall. The map in fig. 73 shows the locations where the dispersing juveniles were last live-trapped and where they were killed.

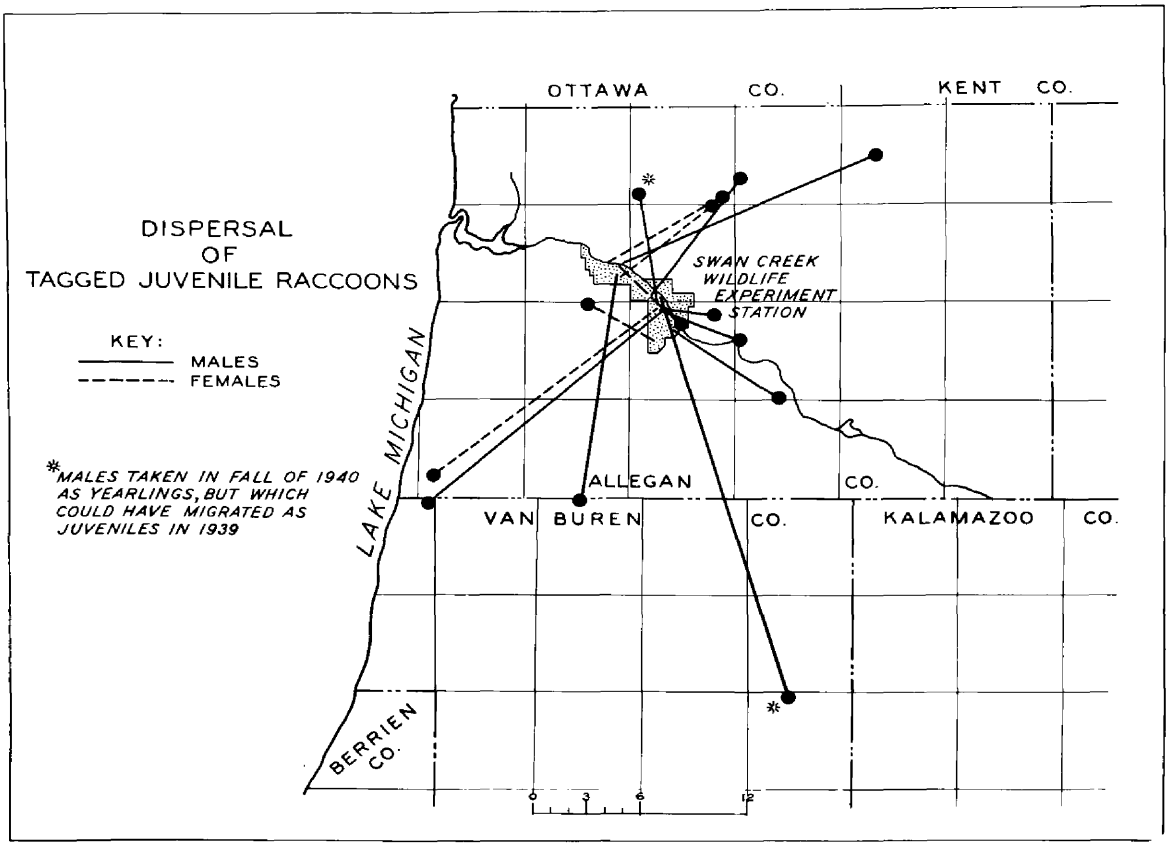


Fig. 73. Map showing dispersal of juvenile raccoons.

POPULATIONS

In line with the dearth of information concerning raccoons in general, there has been little definitely known regarding populations of the species in any type of habitat. In Ohio, Williams (1936), who made an ecological investigation of a beech-maple climax community, estimated 10 to 12 raccoons to be present on a 65 acre tract, which would indicate a density of one raccoon per 5.4 to 6.5 acres. Apparently his figures were based on track observations alone, so they are probably only a rough approximation of actual numbers present. The area was within the North Chagrin Reservation of the Cleveland metropolitan park system, and therefore was undoubtedly closed to hunting and trapping by the public. Lay (1939) obtained some kill figures in eastern Texas, and reported a trapper taking six raccoons in 150 acres or one per 25 acres. In another case, 250 raccoons were trapped from 10,000 acres on Neches River and Piney Creek, representing a kill of one raccoon per 40 acres. Reporting on an ecological study of a 500 acre farm in southwestern Michigan, Allen (1938) said that probably not more than two or three raccoons were present there at any one time in summer.

Fairly good estimates of raccoon populations on two areas were obtained during the present investigations. On the Ottawa Marsh, live-trapping and tagging were employed in conjunction with hunters' returns of tags to obtain a fall census. On the other, known as the General Study Area, intensive box-trapping, den investigations, and track observations gave a good indication of the number of raccoons present in the fall, and also of the composition of the population as to age and sex.

Ottawa Marsh

The Ottawa Marsh is a 1235 acre tract lying along the Kalamazoo River. A description of its vegetation and physiography have already been given on p. 10 (aerial photograph, fig. 6). Briefly the area comprises 1027 acres of floodplain where the ash-elm-maple type of forest predominates, and 208 acres of sandy upland, which supports principally second growth white and black oak. Between two and three hundred acres of the lowland part is marshland, including open water and sedge meadow, with shrubby growth principally of buttonbush, and several species of dogwood interspersed.

Since the fall of 1938, killing of all game on the area has been controlled as part of the Experiment Station's investigations. Hunting and trapping privileges have been given to all individuals who asked for permits, and agreed to file a report on game taken. In 1939 and 1940, this system made available some information concerning raccoons. It was conceivable that a ratio similar to the Lincoln Index (Leopold, 1933) could be employed to calculate the total fall population, even though the numbers involved would be small, if complete records of tagged and untagged raccoons killed on the area could be obtained. Allen (1938) applied a similar technique in making a cottontail census. Logically, the same proportion of untagged as of tagged animals would be killed.

After determining the percentage of tagged raccoons taken and the total kill for the area, the total population can be computed by use of the following equation:

$\frac{A}{B} = \frac{X}{100\%}$, where A = total kill, B = percentage of tagged animals killed, and X = the total population.

Possible errors in this method may arise from mortality prior to the hunting season, or from failure of the hunters to report all animals killed.

However, all available evidence indicates that mortality of raccoons from causes other than hunting and trapping is low, since juvenile survival appears to be high. A number of hunters who obtained permits to hunt on the tract did not return report blanks, but there is evidence that such persons probably either did not hunt, or did not take any animals. Many permittees were under the false impression that they need not report unless they killed an animal. Probably few, if any, unreported kills were made. Perhaps some marked raccoons taken outside the area were not reported, but since every known hunter in Allegan County was sent a questionnaire, the number was probably small.

1939 census: Live-trapping and tagging prior to obtaining the fall census in 1939 was done between July 27 and October 18. Since greatest trap efficiency could be obtained during July and August, trapping was begun in July in order to tag a fairly large number of animals, and 34 raccoons were tagged. Only 42 of 88 hunters, who obtained permits, hunted raccoons on the Ottawa Marsh. These reported a kill of 34 animals. Trappers secured 2 animals making a total kill of 36 raccoons. Of the 34 tagged raccoons, 16, or 47 per cent, were killed. The fact that 6 were taken outside of the Ottawa Marsh can probably be disregarded, because hunting pressure within and without was about the same.

Substituting the figures in the equation we have: $\frac{A}{B} = \frac{X}{100}$ or $\frac{36}{.47} = \frac{X}{1} = 76.5$ raccoons in the total fall population.

According to these calculations there was an average density of one raccoon per 16.2 acres on the 1235 acre tract. Such a figure

would represent a maximum; the minimum occurring in spring, immediately before the young were born. Since 36 of the 76.5 animals were killed, 40, or one per 30.9 acres, remained after hunting season.

1940 census: The 1940 census of the Ottawa Marsh was taken in the same manner as the one of 1939. Thirty-six animals were tagged during the period from July 19 to October 24. The number of hunters who hunted and returned reports was 16, only two permittees, who may or may not have hunted, failing to report. Only 16 raccoons were taken on the tract. This rather low kill (less than one-half that of 1939), was probably due to unfavorable hunting conditions. Though the kill for the area was smaller than in 1939, exactly the same percentage of tagged animals were taken, 17 of 36, or 47 per cent. By substituting the figures in the proposed equation we have: $\frac{A}{B} = \frac{X}{100\%}$ or $\frac{16}{.47} = \frac{X}{1} = 34.0$ raccoons in the total fall population. According to these computations, the fall population thus consisted of 34 individuals, which denoted an average density of one raccoon per 36.3 acres.

Evaluation of the censuses: Using similar census methods in the two years, 1939 and 1940, the calculated fall populations of the Ottawa Marsh was found to be 76.5 and 34.0 raccoons respectively. Inasmuch as the method was the same in both years, the determined numbers should be usable for comparing relative abundance of raccoons. It appears that over twice as many raccoons were present on the tract in 1939 as in 1940. However, certain factors could effect variations in the computations, which should be analyzed. First, the hunting season varied considerably because of weather conditions. In 1940, there were only three of the 45 nights when one could not hunt with some expectancy

of success. Unusually mild weather prevailed into December and conditions were favorable to raccoon hunting until snow came on December 13, to remain for the last three days of the open season. The situation was far different in 1940. Snow, heavy rains, high wind, and subzero temperatures reduced the season by 18 days, leaving only 27 suitable for hunting. Snow and severe temperature caused the animals to den temporarily, and on the nights of high wind and heaviest rain, it was extremely difficult for man or dogs to work even though the animals might have been active. Thus the reduced kill might be due to this factor. But when one considers that the same percentage of tagged animals was killed in 1940 as in 1939, it appears that adverse conditions did not affect the kill. A tenable explanation of this may be found by consideration of ground conditions in the Ottawa Marsh. Due to high water and subsequent inundation in late summer of 1940, much of the tract was still flooded during November, making hunting very difficult. One hunter who took 23 raccoons there in 1939 took only 5 in 1940. He reported that his dogs trailed numerous animals which they were unable to "tree" because of the flooded conditions. Inasmuch as many of the tagged individuals were taken in 1940 outside of the tract where these wet conditions did not prevail, a disparity in percentages of tagged and untagged raccoons killed could be explained. Therefore, by taking these conditions into account, it is possible that the populations did not vary as much from one year to the next as it first appeared. Before hunting season, when approximately equal numbers (34 in 1939 and 36 in 1940) had been tagged in the two years, it was believed that they were nearly the same. Since figures for the 1940 calculations were small, thereby making the final total

subject to considerable variation by only a small difference one way or the other in the number killed, and since hunting conditions were so adverse, it seems likely that the 1939 census was the more accurate. Concerning the number of raccoons in the same region about 10 years prior to 1939, a member of the former Ottawa Hunting Club, which owned the tract at that time, said that one fall their caretaker trapped 65 'coons around the duck shooting ponds where they were preying upon the live decoys. Lack of further records makes it impossible to know how great a percentage of the entire number present were taken off, but the kill of 65 indicates that probably at least as high a population occurred then as in 1939.

General Study Area

The General Study Area is a 2,464 acre tract, chosen as the place for carrying out practically all of the intensive phases of the raccoon life-history investigations. Since the work there was intensive, including extended live-trapping operations, den investigations, and systematic as well as cursory track observations, a large proportion of the raccoons were either handled, or accounted for by track observations.[1]

Physiography and vegetation of the area were described on p. 5. It differs from the Ottawa Marsh chiefly by embracing a considerably larger proportion of the upland, oak-forest habitat. The latter type comprises 1,582 acres, and the floodplain portion, which is very similar to that of the Ottawa Marsh with its elm-ash-maple cover, comprises 882 acres. As shown earlier, raccoons make their homes in the lowlands, but

[1]Clipped toes made it possible to identify some individuals which were not trapped during certain periods in 1940.

the adjacent oak country is an important part of their range, since it furnishes an attractive and substantial supply of food, principally acorn mast. At no point is the upland more than one mile from the bordering bottomland, and inasmuch as some animals were known to have gone that far away from the lowlands, it is probable that at times most of the area was visited by raccoons.

It should be pointed out here that hunting restrictions were in force during the study over a varying extent of the tract. In 1938, only the lowland portion was closed; the next year all of it was closed; and in 1940 all of it was open to hunting. Restrictions were in force for the two-fold purpose of conserving the tagged animals, many of known age for whom it was important to obtain records over as long a period as possible, and to secure information on the efficacy of a sanctuary. It was found in the first year, however, that since most of the raccoons went to the uplands where hunting was allowed, many were killed despite no-hunting regulations on the neighboring territory. This will be discussed further under Sanctuaries, p. 187. In view of this fact, the whole tract was posted against hunting in 1939, to accomplish more effectively the original purpose. Since the active field studies were to be finished by the end of 1940, hunting was allowed on the tract, to gain every possible bit of information concerning the animals, and perhaps also to apply the same methods for calculating the fall population as were employed for the Ottawa Marsh. The latter failed to materialize because, due to a combination of factors, hunters took too few animals to yield significant figures.

Locations of traps operated on the General Study Area are shown in fig. 58. In 1938, during preliminary work prior to the beginning of the two-year study in 1939, the trapline was less extensive than in the following two years. Location of a road mulched as a track register is also indicated.

Numbers in 1938: Known numbers of raccoons on the area in 1938 were determined entirely by the live-trap method. Trapping was carried on from June 28 to September 8 for a total of 2,249 trapnights. The catch included 54 individuals, 12 male and 9 female adults, and 22 male and 11 female juveniles. Some of them repeated in traps, making a total of 99 catches. It may be noted that the adult female to juvenile ratio was 3.5, which would be about normal, inasmuch as an average of four young per litter was determined during subsequent investigations.

It is difficult to judge what percentage of the raccoons living on the area were handled, and also what percentage of the latter were residents. Undoubtedly some of the animals captured along the river, which bounds the area on the north, were borderline residents, whose ranges extended both ways from the boundary. Also there is no doubt that not all of the inhabitants were trapped, since a few untagged ones were being taken near the end of the trapping period, and probably some were too wary to be caught at all. Therefore the known number of 54 should, reasonably, be considered a minimum; i.e., there were at least that many raccoons present, and probably more. It would mean that in fall there was probably no less than an average of one raccoon per 16.3 acres of the lowland in which the animals denned, or one per 45.6 acres of lowland and upland both, the latter of which constituted principally feeding range only.

Numbers in 1939: Live-trapping as a method for obtaining varied information about raccoons in other respects, was again the principal means of determining numbers in 1939, while den investigations furnished some further data. Owing to the fact that toe-clipping was only initiated during this year's work, all of the animals necessarily had to be caught at least once before they could be identified by tracks.

Table XIII gives the 1939 population data for the General Study Area summarized into three periods. Some traps were set in March, previous to the time shown, and numerous dens were examined in both February and March. Only the one yearling female was handled, she from a den during February. Traps were operated between March 14 and December 4, not continuously but for some time during each month.

One can gain a fairly good picture of the known population of the area from the data in table XIII. The upper section of the table shows the number of new animals recorded during each period and, therefore, the total number of individuals taken; below that the number of individuals recorded are given, of which some taken after June were returns from the preceding period or periods; and in the third section the repeats are listed. The first group of figures are most significant, since they constitute census results of the tract, by giving the number of individuals present during the year. The data show that a considerable time is required to "trap out" a raccoon population. Nineteen adults were taken between April 1 and June 30, but five more were taken during the next period. Since juveniles do not become active outside their dens until July, the majority of them were caught between July 1 and September 30, those taken in June comprising litters found in dens. Only one new raccoon, a juvenile, was taken after September. Admittedly

TABLE XIII

Records of Raccoons Known To Be Present On General Study Area In 1939

			Apr.-May-June	July-Aug.-Sept.	Oct.-Nov.-Dec.	Totals
	Kind of record		Trap & den	Trap, den & track	Trap, den & track	
	Number of trapnights		2408	5596	2551	11,555
Number of new individuals recorded for each period	Adults*	M	9	0	0	9
		F	10**	5	0	15
	Juv.	M	2	17	1	20
		F	11	8	0	19
	Totals		32	30	1	63
Total number of individuals recorded	Adults	M	9	4	3	
		F	10**	7	4	
	Juv.	M	2	19	6	
		F	11	16	6	
	Totals		32	46	19	
Repeat records	Adults	M	9	0	8	17
		F	7	3	9	19
	Juv.	M	0	7	13	20
		F	0	13	27	40
	Totals		16	23	57	96

* All animals older than juveniles grouped as adults because not enough data available to be able to distinguish yearlings.

** One of these females found in a den in February.

trapping operations were reduced, and a lesser amount of time was spent at den work from October to December, but inasmuch as only one of 19 animals handled during that time was new, it seems highly probable that a great majority of the residents were accounted for. The variations in numbers recorded from period to period should not be construed as indicative of seasonal population fluctuations but rather as evidence of the raccoons' trap wariness, which appeared to vary throughout the year. It was not possible to trap or otherwise capture all animals each period. Therefore the total number recorded for the year is probably the best estimate of the population. This total for the area was 63 raccoons, 24 adults (9 males and 15 females) and 39 juveniles (20 males and 19 females). During this year's work all of the animals older than juveniles were grouped as adults, because not enough data were available to enable one to distinguish yearlings from older individuals.

It was known that 10 of the females gave birth to young, and that four did not, while the other one may have produced a litter. With an average litter size of four, the breeding females should have produced 40 young, or only one more than the 39 which were handled. The female to juvenile ratio was therefore about normal. With a population of 63 animals on the 2,464 acre tract, there would be an average of one raccoon per 39.1 acres.

Numbers in 1940: Information concerning numbers of raccoons on this same area in 1940 was obtained in much the same way as in 1939. Due to the fact that so many of the animals were handled the previous year, the majority of which were toe-clipped, it was often possible to learn the whereabouts of the animals from their tracks alone. Two

tagged yearlings were never handled in 1940, yet their presence was recorded several times during the year. One was tracked in April, May, July, and October, and was killed on the area by a hunter in fall. Less live-trapping was done than in 1939, but den studies were more productive of data. During February and March, 13 yearlings and adults were located in their dens, and in April and May, six litters of young were found.

The population data are presented in table XIV. Three age groups are shown. Such a classification seemed advisable to present the best picture of the population's make-up since the females at least do not all breed when a year old.

By the end of March, 16 adults and yearlings were recorded for the area; 2 by tracks and 14 from dens. Trapping and systematic track observations were initiated in April after the animals had resumed activity outside their dens, and 53 additional raccoons were tallied by July 1. From then until October 1, only five more, one adult and four juveniles were caught. The total for the year was 74. In view of the fact that no new animals were taken after the first of October, it seemed probable that few unmarked animals remained. But when we examine the data as to ages represented, it seems evident that some unhandled juveniles were present. Whereas at least 13 of the 23 females were known to have produced young, only 27 juveniles were caught, and 24 of those belonged to six litters located in dens. On the basis of four young per litter, there should have been 25 more young produced than were handled (52-27), and the total population should have been 99 raccoons, rather than the known 74. Probably the best estimate of the population would be a figure falling somewhere between 74 and 99.

TABLE XIV

Records of Raccoons Known To Be Present On General Study Area In 1940

	Kind of record		Jan.-Mar. Den & track	Apr.-June Trap, den & track	July-Sept. Trap, den & track	Oct.-Dec. Trap, den & track	Totals Trap, den & track
	Number of trapnights		0	2998	1013	303	4314
Number of new individuals recorded for each period.	*Adults	M	2	5	1	0	8
		F	3	5	0	0	8
	*Yearl.	M	7	9	0	0	16
		F	4	10	1	0	15
	Juv.	M	0	13	2	0	15
		F	0	11	1	0	12
	Totals		16	53	5	0	74
Total number of individuals recorded	Adult	M	2	6	5	1	
		F	3	7	6	3	
	Yearl.	M	7	13	5	1	
		F	4	13	12	1	
	Juv.	M	0	13	5	3	
		F	0	11	6	1	
	Totals		16	61	37	9	
Repeat records	Adult	M	2	19	13	1	35
		F	0	25	4	0	29
	Yearl.	M	0	14	18	0	32
		F	0	14	22	0	36
	Juv.	M	0	1	16	1	18
		F	0	0	30	0	30
	Totals		2	73	103	2	180

* All but 4 adults and 10 yearlings were originally tagged in 1939.

The 74 comprised 16 adults, 8 males and 8 females; 31 yearlings, 16 males and 15 females; and 27 juveniles, 15 males and 12 females. If all were present in fall, the mean density was one per 33.3 acres.

Evaluation of censuses on General Study Area: A brief review of the foregoing discussion on General Study Area censuses is deemed expedient to facilitate a better understanding of the data. Total numbers of raccoons recorded for the area were 54 in 1938; 63 in 1939; and 74 in 1940. These figures cannot be accepted at face value, but must be evaluated according to their probable significance.

Without question the 1938 total is below the real population figure. Trapping was the only method used, and probably was not sufficient to take all the animals, since it was limited to little more than the months of July and August. Results for 1939 and 1940 should be more significant. Trapping operations were greater in scope, and the additional den studies and tracking should have made the censuses for those two years more complete.

Composition of the known 1939 population appeared to be rather well balanced, which should enhance the value of the figures. The proportion of breeding females to juveniles was about normal (10 to 39). Since only one new animal was taken after October 1, the census seemed to be about complete. However, as shown in Table XIV, 14 animals were taken the next year (1940) which had not been tagged. But, here again a further consideration should be made. Only four of the new animals were adults, while 10 were yearlings. Since dispersal by juveniles has been shown to occur (p. 141), it appears entirely possible that some of the 10 yearlings had moved into the area after the census had been taken. Thus we have another of those unknowns about animal populations for which an evaluation

is difficult. It was known from tag returns that some of the marked animals moved from the area. Perhaps dispersal is the manifestation of a general "shuffle" of the juveniles in fall, in which case the number leaving, and the number coming to the area, may have balanced. With the information available, the known figure of 63, with no correction is the best estimate of the population, and is probably not far from the actual number.

The 1940 data, having been determined in a manner similar to that used in 1939, should be usable for comparison of figures between the two years. However, it appears that a correction of the total for 1940 may be warranted. As previously pointed out, at least 13 of the 23 females were known to have produced young, which, considering the average litter size to be four, should have totalled 52. But only 27 were handled, or 25 less than were theoretically present. If we make the correction, the total population estimate for the year was 99 rather than the known 74. Regardless of which of the two figures for 1940 is held to be more nearly correct, the population was, with little question, higher than in 1939. A further discussion of this fact from the standpoint of sanctuary evaluation will be given on p. 187.

It is interesting to compare the numbers of yearlings and older animals found on the area in 1940. The ratio was 1.7 yearlings to 1 adult (27 to 16), which is about normal considering the determined breeding potential of 1.5.

II. MANAGEMENT OF RACCOONS

Treed !

It seems appropriate to point out at this time the position of Michigan within the entire raccoon range, and the bearing of this upon raccoon numbers. This state is practically at the upper limit of raccoon distribution. The northern part, especially the upper peninsula, is not 'coon country. Winters are longer and snow remains longer progressively from south to north. Dearborn (1932) says of the upper peninsula that the winters are too long, and nut trees too few for raccoons. The same applies to some extent to the northern part of the lower peninsula. Raccoons den up in winter, and do not take any appreciable amount of food, subsisting mainly on the fat acquired during the previous summer and fall. There is a limit to the length of time this fat reserve will last. Snow is often on the ground for six months in the upper peninsula. Even in the southern part of the state, the length of winters approaches the limits of toleration. Therefore, Michigan probably can never have raccoons in the numbers found in the more southern states. Weather, as such, is not responsible alone, but also the innumerable factors conditioned by climate. In view of this, the farther north one goes in the state, the fewer raccoons he would expect to find, and hunting records show this to be true (Map I, p. 229). Since raccoons are scarce in the upper peninsula, no hunting is allowed there.

HABITAT

To a considerable degree the success with which any game species can be managed depends upon the game manager's capacity to manipulate the animals' habitat. Granting this to be true, it follows that one of the first and principal requisites of a sound program is a knowledge of what constitutes the optimum habitat. Once this is known, the possibilities of supplying needs can be reviewed more intelligently, and practicable measures determined more expeditiously.

In order to maintain itself a species must be able to find food, have cover in which to take refuge, and must reproduce. For raccoons the essentials of habitat seem to be present in areas with a permanent water supply, tree dens and available food.

Water

Water appears to be essential for raccoons. Grinnell, Linsdale and Dixon (1937) state that ready access to a good supply is necessary, the animals apparently being so adjusted as to make regular visits to a stream, marsh, pond or lake. Undoubtedly some water is taken every night, except during the winter denning period, and the raccoon requires a goodly amount, judging from the habits of captives. Aside from the drinking requirement itself, raccoons find much of their food in or along water, which makes its presence doubly important. If the average range diameter of one mile, as determined in this study, is valid, it is apparent that an optimum habitat for raccoons should be within that distance from a permanent water supply. The greatest distance from water of any occupied den was about 1200 feet. As far as could be determined raccoons make little use of the uplands over a mile from the floodplain, though uplands within a half mile are visited often when mast is available. Whether or

not water within that distance is absolutely necessary, the animals evidently prefer to live near it. As far as management is concerned, there is usually nothing that can be done about providing a water supply, but a knowledge of the matter should be a guide in directing management efforts.

Dens

A second important characteristic of timbered areas favorable for raccoons is the presence of hollow trees for use as dens. In fact the lack of dens--in Michigan tree dens--is probably one of the most important factors limiting raccoon numbers. In the first place, raccoons are almost unique among our native mammals in not building their own homes. Squirrels occupy hollows, but if none are available they build leaf nests; woodchucks sometimes live in tree hollows near the ground, but more often dig their own burrows. Practically all the other mammals can provide their own homes when necessary. The raccoon, though he has proven to be so adaptable in tolerating increased encroachment upon his habitat by man, has not learned the art of home construction, which may some day cause his downfall. In the second place, the hollow tree is the natural home of raccoons. The preference for tree dens has been demonstrated by the animals' apparently exclusive use of this type of den in the Experiment Station region. If conditions are to be optimum it seems imperative that hollow trees be available.

Denning habitat: In this study an attempt was made to determine what constitutes an acceptable raccoon den. This has already been discussed in detail (p. 109). A further point to be made here regards the use of more or less isolated trees as it relates to raccoon habitat.

The Experiment Station region did not lend itself to a study of this, since it is practically a continuous extent of forest. However, some pertinent information was obtained elsewhere. Though the usual concept of raccoon habitat is that of wooded tracts, which probably do constitute some of the best range in the state, still there must be many animals living in small units of woods or even perhaps in fairly open country. Approximately three-fourths of the state kill is in the lower half of the southern peninsula, of which much the greater part is farming country.

Mr. E. E. Moran, president of the Southern Michigan 'Coon Hunters' Association and a hunter of considerable experience reports that many animals live in suitable dens considerable distances from any woodlots. According to him, even roadside trees may often be occupied by unsuspected raccoons. In the spring of 1941, a used den of such a nature was located in Barry County (adjacent to Allegan on the east). This tree was a large chestnut (Castanea dentata) standing in an open field about 300 feet from a road (fig. 74). A small tree-fringed creek flowed past at about 600 feet in another direction, and the nearest woods were about one-quarter mile distant. Such observations indicate that perhaps a great deal of the more open farming country of the state constitutes suitable raccoon range, though it may be less favorable than are the more wooded regions. There is still much to be learned regarding this, and future work should in part be directed towards finding some definite answers on the subject. At present it appears that even the smallest woodlot may be home to a raccoon, if it contains a suitable den.

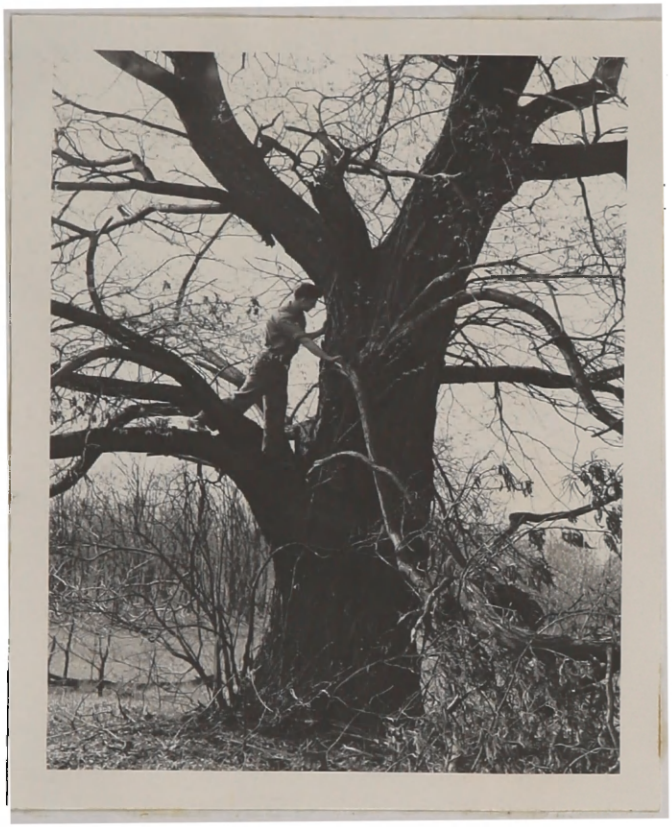


Fig. 74. Large chestnut den tree in open field. Trees in such situations may be providing dens for many of our raccoons.

Quantitative den studies: As a prerequisite to management of habitat for improving denning conditions, a knowledge of what constitutes the optimum number of dens is important. In an attempt to determine this, quantitative den surveys were made on areas representative of the two principal habitat types of the region. The physiography and vegetation of these two areas have already been described.

Lowland habitat

As representative of the floodplain which is fairly uniform throughout the region, a 165 acre tract situated near the center of the General Study Area was chosen (fig. 1). Irregular in outline, the area is more or less a natural unit, being bounded on two sides by a bayou and on another by the steep bank which separates upland and floodplain. A road is the fourth boundary.

During the winter and spring of 1939 and 1940, a thorough investigation was made to locate all available denning sites. This was done by using a compass, and searching the tract by strips. All trees large enough to contain a fairly large cavity were examined from the ground, and those exhibiting any indication of being hollow were climbed. Upon discovery of a cavity large enough for a raccoon, whether used or not, complete measurements and notes were taken. The tree was marked with a numbered tag, and located on a map, so that future examinations could be made. Besides quantitative data, information on denning habits was obtained by the periodical examinations.

Within this area a total of 20 hollows were located. Based on what was learned during the entire investigations about denning, and what constitutes a den, 10 of these were considered to be suitable for

use by raccoons. This indicated a density of one den per 16.5 acres. During the first year only 50 per cent were used by raccoons, but over the period of two years, 80 per cent showed evidence of having been used. Apparently the number here was more than sufficient for the resident raccoon population. For the General Study Area as a whole, within which this quantitative study tract was located, densities of one raccoon per 33, and 39 acres were found for the years 1939 and 1940 respectively. If these figures are valid, there were approximately two dens per animal before the hunting season. After the fall kill, and therefore during breeding season, a still greater number of dens per raccoon was available. It seems evident that in a forest of this type, with about one den per 15 to 20 acres, denning conditions would be favorable for a good raccoon population. At the present time, this is probably the best available measuring stick for den management.

Upland habitat

A 165 acre area situated adjacent to the lowlands was chosen for a quantitative survey in the upland habitat. The same method of locating and designating denning sites was used here as for the lowland survey. The principal forest cover is second growth oak, but larger, decadent trees interspersed throughout the tract furnished the majority of the dens. The average diameter of the den trees was 21 inches.

A total of 28 hollow trees were discovered, 15 of which appeared suitable for raccoon dens, indicating a density of one per 10.1 acres. During the first year, only three were used by raccoons, and in the second two more were found occupied. Thus only 33 per cent were known to have been used during two years. This probably does not indi-

cate a surplus of dens so much as it reflects a preference for the lowland habitat for denning. Lone yearlings but never any litters were found in these dens. Apparently raccoons go to this habitat mainly when food such as mast is available, and at such times use the dens temporarily. In view of these facts, fewer hollows per unit area are needed in this type of cover than in the lowlands where breeding and rearing dens are required. Therefore, where the two types exist, first and greatest efforts toward den management should be expended on lowland areas. Probably in much of the farming country this is not important, since little of such territory exhibits these abrupt habitat differences.

Den formation: A number of factors are responsible for the initiation of tree decay and the eventual development of suitable hollows. The following contingencies appear to have been primarily important in giving bacteria, fungi and other destructive agents the chance to cause deterioration or produce an entrance to an already hollow limb or trunk for 101 dens. Thirty-four of the dens were occupied, 41 showed evidence of use, and 26 were considered suitable but no evidence of use was found.

1. Injuries: Some dens were evidently initiated by injuries to the tree trunk by lightning, wind, or some other element. In the majority of cases the injury allowed decay to begin after which a number of years were required for the den to be formed (fig. 75). However, in some instances a hollow already existed and was made accessible by the breaking of some part of the tree. This group comprised 48 or 47.6% of the dens.

2. Breaking off of dead limbs: Dens which apparently formed after the breaking off of dead limbs numbered 38, or 37.6%. The processes involved in the formation of squirrel dens in a similar manner are described in some detail by Baumgartner (1939). For raccoons it is necessary that the limb be no smaller than four or five inches to provide a large enough entrance. In many cases it was one of several large primary branches from the main trunk which had died, leaving a large opening. Weathering and other factors then allowed decay to produce cavities (fig. 76).

3. Decay with no injury: In this group are dens which apparently had formed due, at least indirectly, to deformity, or shape of the tree. On some trees growth at a crotch produces an opening where weathering and decay can begin (fig. 77). Freezing of water in such cavities, or

Fig. 75. Den in trunk; decay initiated after injury (found occupied).

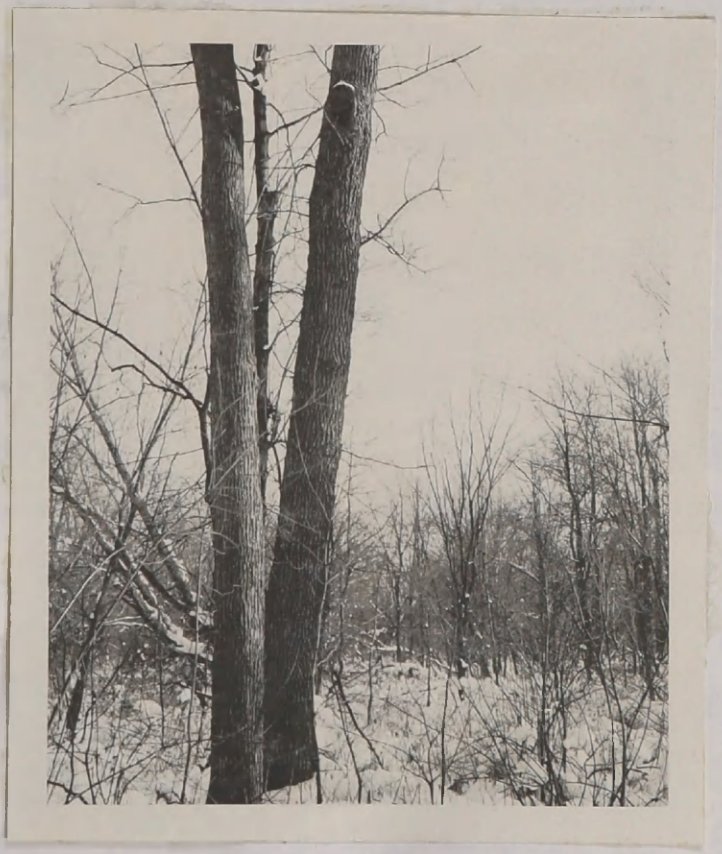


Fig. 76. Den in trunk; decay initiated after breaking off of dead limb (found occupied).

in malformations, probably also sometimes causes a split as a point of entrance for agencies causing deterioration. Only 10 of the dens, or 9.9 per cent, appeared to have been caused in this way.

4. Woodpeckers: There was evidence that woodpeckers had originally made five cavities which later became raccoon dens. Though the number is small, there is significance in the fact that all were occupied dens. The entrances measured in the neighborhood of $3\frac{1}{2}$ x 5 inches, which is larger than most woodpeckers make. The holes and cavities probably became enlarged by decay, and gnawing by various animals (fig. 78).

The length of time required for a den to form is important to evaluating habitat. At present, however, the available data on this allow little more than estimates. According to G. W. Pike of the U. S. Forest Service (1935), as quoted by Bennitt and Nagel (1937), the estimated time for the formation of a hole five feet from end to end, which starts in a trunk higher up than at the base, is about 20 years. At this rate the average raccoon den (about three feet deep) would require about 12 years. He goes on to say that the "action will vary greatly, due to factors such as size of tree when fungus enters, nature and position of scar, and probably climatic conditions or site." Thus it takes a considerable time for a den to form after decay has once begun. If one stops to consider the total time required for a tree to grow large enough to contain a hollow, for decay to set in, and the hollow to form, it is evident that den formation is a very long term process. Very few of the den trees found were under 50 years of age and the majority were probably between 75 and 100 years old.

Logically, the practical application of this knowledge is to conserve the dens present in any area. But as pointed out by Baum-

Fig. 77. Den with entrance in crotch where decay organisms were able to become effective (found occupied).

Fig. 78. Den in which the original cavity was evidently made by woodpecker; inside diameter 11 x 12 inches; entrance $6\frac{1}{2}$ x 3 inches (found occupied by litters in both 1939 and 1940).

gartner (1939), this "can resolve itself into a short-sighted program". Hollow trees continue to decay and eventually are no longer suitable as dens. The length of use may vary considerably, according to the rate of decay conditioned by innumerable factors. Species of tree, site, climate, and location of the hollow in the tree are some of these. As shown previously, there is a wide variation in size of dens used by raccoons. One hollow 11 feet deep was found occupied. Such a den probably was at least 40 years old, but in many cases wind blows the weakened trees over before they have given nearly that much service. Proper management should therefore aim toward a sustained yield of dens, in addition to conserving those already present. Old deformed trees, and those already attacked by organisms of decay, which are potential den trees ought to be left, especially since they have no value as lumber, and little more for firewood.

There is also the possibility of artificially initiating decay. Edminster (1941) recommends girdling at times, to speed up development of hollows, and eliminate dominating foliage. Baumgartner (1939) regards this method less favorably because it is in the young woodlots that dens are usually too few, but where at the same time the trees are too small to produce dens. In older woodlots, if potential den trees are present, the conditions necessary for the initiation of decay are usually also present. Nevertheless, the method may have some practical application in a long term program, especially on government or state-owned land, if in an area supporting a climax forest selective cutting has eliminated all "wolf" trees.

Den destruction: There are a number of agencies causing den destruction, some beyond control and others subject to some measure of control. Some of the more common of those included in the first category are decay beyond the point where a den is suitable, lightning, and wind. One den occupied in 1939 was no longer habitable the next year, after the bottom had fallen out, leaving merely a hollow trunk open at both ends. Two dens were destroyed by wind, and a third tree was shattered by lightning. The accumulated total loss from these causes is of some consequence but there is little to be done about it. To the second category belongs cutting, both by hunters and land owners. The latter have the privilege of handling their property as they wish, but many undoubtedly would be willing to cooperate if approached properly. The hunter-owner could probably be persuaded the more easily to spare hollow and potentially hollow trees, since it would be for his benefit, as well as the other hunters'. As with all farmer-sportsmen relationships, the owner, in abetting any such program, usually must be able to recognize some benefit to himself, either material or otherwise, for which he cannot be blamed. The job in this respect may lie principally with the raccoon hunter. Rather than merely ask permission to hunt in fall, some time could profitably be spent in "talking 'coons". If the farmer knew how important dens are, and perhaps also that raccoons are mousers as well as the more publicized "poultry poachers" he would probably be more inclined to spare the animals' homes.

The hunter himself has also been responsible for den destruction. But it is perhaps not merely wishful thinking to believe that the hunter with saw and axe is becoming more the exception than

the rule. In Michigan at least, the trend is towards hunting this species more for sport than the fur. After "treeing" his quarry, the game hunter may be less reluctant than the fur hunter to leave an animal in its den. Lower pelt prices probably have a favorable influence in this respect also. Moreover, hunting clubs are becoming more common, and these organizations tend to discourage unsportsman-like practices of all kinds, at least within their own memberships.

In any case, destruction of dens, wherever it occurs, is surely a menace to sustained raccoon numbers. This is strikingly pointed out by Bennitt and Nagel (1937) who believe that "next to the actual kill by man, the problem of the destruction of den trees is the most serious of those that must be solved before the raccoon can be restored to Missouri." They further state that "the number of den trees is rightfully regarded as a limiting environmental factor." The latter statement at least also applies in Michigan and probably raccoon management can include nothing more constructive than den conservation and production, both preached and practiced.

Artificial dens: Since raccoons are so dependent upon hollow trees for dens, the possibility of supplying some sort of artificial home is worthy of attention. We should know whether or not artificial dens will be used, the proper specifications for construction and placement, and their practicability as a management measure.

Prior to the beginning of the raccoon project, 50 wood-duck nest boxes had been erected at the Experiment Station, which were checked for raccoon use during the two years' work. In addition, 25 den boxes designed for raccoons, according to average measurements obtained for occupied natural dens, were put up in the summer of 1940.

The wood-duck nesting sites were constructed according to plans by W. T. Cox, formerly of the U. S. Biological Survey. Made of rough, salvaged lumber, they have an inside space 12 inches square and 24 inches high. The round entrance, 4½ inches in diameter and 16 inches above the floor, is on the front (fig. 79). These were erected in the fall of 1938 along approximately three miles of Palmer Bayou which traverses the area where most of the intensive raccoon work was done. They were placed in trees at heights varying from 17 to 40 feet. On the basis of a limited knowledge at the beginning of the raccoon investigations, it seemed that these boxes would be of suitable size and construction for raccoons. They were therefore checked during the study.

In 1939, the boxes were checked in spring, summer, and fall. As far as could be determined only one was used by a raccoon that year. A lone, two-thirds grown juvenile was occupying the box in August. There was evidence that a greater number was used in 1940. Hairs were found in one in April, four in August, and two in September. Whether or not the animals used the sites to any great extent is not known, but they at least entered them. In April, 1941, another box contained feces and hair of a raccoon, and a well-formed bed on an old squirrel nest. Use by more than one species in this way was a common occurrence, wood ducks, squirrels, and white-footed mice successively occupying many of the dens. There has been evidence that raccoons destroy some of the wood duck nests in these boxes. Broken eggs, with raccoon hair in the box and stuck to the shells, seems positive proof in one instance. Somewhat less satisfactory evidence were hairs on the entrance of two boxes containing egg shells. It was not known, however, whether or not these eggs had hatched; and even if they were destroyed, the blame could not definitely be placed.

It is evident from the foregoing observations that these artificial sites were not particularly attractive to raccoons. They were intended for wood ducks, and as shown by later studies did not conform very closely to the measurements of natural raccoon dens. The entrances were only 4½ inches in diameter, which is near the minimum size that raccoons can enter, and it is doubtful that a fat animal can enter one so small. In addition, the holes were on the front of the boxes which would further handicap a raccoon in trying to enter. In the only instance of occupancy, the box was so placed in the tree that a branch extended near the doorway. Moreover, natural hollows, which could be expected to be preferred over an artificial den, are very plentiful in the area.

With information on the wood duck nesting sites, and also data on about 30 occupied raccoon dens available, 25 raccoon den boxes were designed. These were also constructed of rough lumber, and measured 14 inches square by 36 inches in height. The back extends above and below the den proper, to facilitate nailing to the tree. The entrance measuring 5 by 6 inches, is located next to the roof, and to the rear on one side, so that it is easily accessible to a raccoon. Tops were hinged to facilitate examination (fig. 80). Evaluating the lumber used at $10.00 per M. bd. ft., the approximate cost of materials per box, including one hinge and a hook and eye costing 15¢, was 35¢. An additional 90¢ for labor (two man-hours at 45¢ per hour) brought the total cost to $1.25 per box.

These dens were erected in early July, 1940. They were placed at distances varying from 25 to 44 feet from the ground, in several species of tree and with various exposures. Wire "combs" were fastened

Fig. 79. One of the artificial wood duck nest boxes.

Fig. 80. Raccoon den box designed after studies of natural dens.

along one side of the entrances to catch hairs of any entering animals. Ten were spaced at intervals near the wood-duck nest boxes, and 15 were erected in creekbottom habitat where natural dens seemed to be rather few.

TABLE XV

Species Using 25 Raccoon Den Boxes Erected in Early July, 1940

Species	1940						1941	
	No. in August		No. in October		No. in November*		No. in Apr. & May	
	Signs	Occ.	Signs	Occ.	Signs	Occ.	Signs	Occ.
Raccoon	10	0	3	0	0	0	4	0
Fox squirrel	2	0	10	1(dead)	0	4	6	2
Flying squirrel	1	3	2	0	0	2	0	0
White-footed mice	0	1	2	0	0	0	0	0
No evidence of use	8		7		9		13	

* Ten not examined in November.

Table XV shows the extent to which these boxes were used as indicated by three examinations in 1940 and one in 1941. The greater number containing signs of raccoons in August may have been the result of our having released 10 captive animals in the vicinity at the time the boxes were erected. Later in October and November there was less evidence of their being used. Circumstantial evidence in May, 1941, indicated possible predation on fox squirrels in three boxes. In two the remains of squirrels and piles of raccoon scats were found, and in the third were the remains of a partially eaten squirrel. Since a

number of dead squirrels were found in the wood-duck nest boxes at about the same time, which along with other evidence indicated a general die-off of that species in the region, it is possible that the raccoons had found these animals dead. At any rate the squirrels had been eaten by the raccoons since the scats were composed almost entirely of squirrel hair and bones. The fourth den showing use in May, 1941, contained an old squirrel nest with a large form and considerable raccoon hair. It was apparent that the raccoons had lived in these four boxes for some time.

Recommendations: The foregoing information provides a basis for some definite recommendations concerning den management. There are good reasons to believe that tree dens are strictly essential to favorable raccoon habitat, and therefore constructive measures should strive to provide optimum numbers of such dens.

First, den trees already present should be protected, wherever possible. This can be done on Federal and state-owned land by proper selection in cutting. Management of land in private ownership, however, presents a real problem. Apparently the principal solution is education of land-owners. As pointed out previously, the raccoon hunter can be instrumental in establishing a favorable attitude among owners. At the same time it is essential to plan for the future by sparing potential den trees.

Where cutting can be controlled, it is recommended that at least one, and preferably two dens per 15 to 20 acres be left, and probably two or three times that many potential denning sites, or "wolf" trees. It may be advisable to leave greater numbers in the smaller units of denning territory. In much of the range in the state, woodlots of 5 to 40 acres comprise the possible denning territory. It is conceivable that such habitats might serve somewhat as communal denning areas for raccoons which carry out most of their activities in the surrounding open country. Some basis for this assumption is available. Within about 40 acres on the General Study Area, where denning conditions were especially favorable, 8 occupied dens were located in the winter of 1940. Apparently this small portion of the large tract was attractive enough to cause the animals to congregate. Also, evidence indicates no tendencies of raccoons to defend territories (cf. p. 137), which further contributes to the validity of this theory.

Areas to receive first consideration should be those within one-quarter mile of a permanent water supply. Where denning facilities were abundant, greater use was made of those within one-quarter mile of water. This is to be considered especially in placing artificial dens.

It is believed that artificial den boxes may prove attractive to raccoons. They were tested here for too short a time to draw any definite conclusions but the evidence indicated that they are acceptable. They are recommended, not as being definitely practicable, but as worth a trial. The type of box designed during these studies is believed to be of proper construction, but variations could profitably be made to develop the most suitable type of den.

Food

Management of the food of raccoons might include means of controlling destructive habits of the animals, and means of augmenting the food supply. Raccoons, like practically all other wild species, at times display habits which are not in the best interests of man. Baker (1940) reports circumstantial evidence of the complete destruction of eggs in a colony of Roseate Spoonbills in one of the few remaining colonies of this avian species on the Florida Keys. The havoc sometimes wrought to nesting waterfowl in California is indicated by the following statement of Grinnell, Linsdale and Dixon (1937). "The coon is the most destructive of all our fur-bearers to nesting waterfowl as is indicated not only by stomach examinations, but also by field observations." Dixon (1924) also reports serious depredations on nesting wood ducks in California. From observations on 50 artificial nest boxes at the experiment station, one case of predation appeared certain and two other cases were circumstantial. In instances where certain other species may be of primary importance, some method of raccoon control may be quite in order. In the case of the Spoonbill predation in Florida, if raccoons are found to be the real culprits preventing this seriously diminished species from nesting, it seems entirely justifiable to institute control measures even to the extent of killing some of the animals if necessary. Live-trapping and removal might be feasible.

To protect wood-ducks in artificial boxes, smaller entrances might be constructed. One natural hollow with a hole measuring only 4 x $2\frac{1}{4}$ inches was found to contain a wood-duck nest, but it is doubtful if a hole that small could be entered by a grown raccoon. Juveniles are not present until the duck nesting season is over.

In Michigan there appear to be only two grounds on which raccoons are likely to be denounced; their destruction of corn and poultry. It is to be emphasized, however, that such activities seldom appear to be of serious proportions, and few fair-minded individuals would advocate unlimited control. In the present study one instance of poultry predation was brought to the writer's attention. This was by a farmer who finally caught a female and her five young in his chicken coop. The animals had killed several pullets in three successive nights, and probably would have continued their exploits as long as allowed. In similar instances capture of the animals and disposition by a Conservation Officer should suffice, since more often than not it is a single family or animal which finds such a welcome food supply, and makes a habit of utilizing it. Raids of this nature, though happening now and then, are by no means grounds for general condemnation of the species.

Utilization of corn by the animals probably occurs to some extent wherever this crop is grown in raccoon country, but the damage is not great. Damon (1933), who interviewed 76 farmers in Williamston Township, Ingham County, Michigan, received only one complaint of corn damage by this species. Depredations blamed on raccoons may sometimes be the work of squirrels, as could have been the case at the Experiment Station in the fall of 1940. By ascertaining that the principal damage was being done during the day, it was shown that raccoons were taking less corn than might have been supposed had only a cursory examination been made.

From the present studies it is evident that natural foods when available are preferred over corn. In 1939, when a good crop of acorns was produced, there was noticeably less utilization of corn than

the next year when little mast could be found. In the light of this evidence, it seems that cutting of nut-bearing trees, particularly oaks and beech, should be held to a minimum where raccoons are an important consideration. The practical aspect of such a recommendation can probably have greater application on State and Government-owned land, but private owners might also apply it profitably on a smaller scale. The importance of acorns to raccoons has been pointed out by Bailey (1926), who says "In fall they usually fatten on acorns where these are obtainable, and the northern limits of their range are almost coincident with the northern limits of oaks." In view of the fact that so many kinds of birds and mammals, as well as raccoons, utilize oak products, it seems expedient that oaks be encouraged wherever such is compatible with other activities.[1]

For landowners who are interested in raccoons, the recommendation that they leave some corn in the fields in years when the mast crop fails should not be amiss, though this at best can be considered only an emergency measure. Mast is highly nutritive, and aids greatly in conditioning the animals for the wintering period, but when this is not available, corn seems to be one of the best and most often utilized substitutes. A supply of this grain should be a boon to raccoons whenever the crop of mast fails.

---

[1] Van Dersal (1940) reports that from the present accumulated information, 186 different kinds of wild birds and mammals in the United States utilize oak products.

SANCTUARIES

The establishment of sanctuaries is often suggested as a means of promoting increases of various animals. It therefore seems expedient that game managers know to what extent the measure is practicable for raccoons.

As pointed out previously in the discussion of populations, the General Study Area constituted a sanctuary for raccoons. In 1938, the lowland portion of the tract was closed to hunting; the next year all of it was closed; and in 1940 hunting was allowed on all of it. Administration of the tract in this manner made available information on the relative effectiveness of different sizes and types of habitat as sanctuaries.

Data on apparent populations of raccoons have already been presented. By live-trapping, 54 raccoons were tagged on this area in 1938. During the fall, with hunting prohibited only on the lowland habitat, 11 of these animals were killed in the adjacent upland portion of the tract. Three other animals had dispersed, being taken 5 miles or farther outside. It was readily apparent that lack of any upland in this sanctuary rendered it notably ineffective. Raccoons, though denning in the bottoms, were being attracted by acorn mast to the uplands during hunting season. The great majority living on the tract were therefore regularly visiting territory open to legal hunting.[1] In an effort to protect the tagged raccoons, which were invaluable to further

---

[1] In the fall of 1939 as many as 17 raccoons crossed a road between upland and lowland in this area in one night.

studies, and at the same time to test the efficiency of a larger closed area, the whole tract was posted in 1939. In that year, 74 tagged raccoons were recorded by live-trapping and other observations. Among these were only six repeats from 1938, further indicating a considerable kill the previous fall. In the fall of 1939, with no hunting permitted there were, of course, no raccoons killed on the area, but 5 of the 74 tagged animals were reported taken outside. These were all killed a short distance across the river which bounds the tract on the north. However, the next year (1940), 30 of the animals were rehandled, indicating a much better survival than had been attained in 1938, after which only six were retaken the following year.

A comparison of the population figures obtained for this area indicates that protection from hunters was probably instrumental in raising the population level. As pointed out, the censuses in 1939 and 1940 were sufficiently similar in method and completeness to warrant direct comparison of results. In 1940, 74 animals were recorded, an increase of 17.4% over the 1939 figure of 63. Although the time was short for obtaining completely reliable data here, there was an apparent increase in the number of raccoons by 1940.

If sanctuaries are included in a program of raccoon management in a region similar to the one here, greatest effectiveness will result from the inclusion of a generous strip of upland as well as lowland. It is particularly in the fall when the hunting season is open, that raccoons visit the oak country to find food. The best sanctuary would probably be an area transecting a stream valley, and including both the floodplain and some adjacent upland on either side. From the available

data relative to raccoon ranges (average range diameter about one mile), it seems that the smallest sanctuary should embrace at least four sections (four square miles) and these in a square block. An area much smaller than that would include little beyond the range of any resident animal. Inasmuch as dispersal of juvenile raccoons is known to occur, it seems logical that a closed area might be practicable for supplying breeding stock to considerable surrounding territory. However, considering the status of the raccoon population in Michigan, sanctuaries are not recommended at present, though they might be of value in the future.

RACCOON-OPOSSUM RELATIONSHIPS

A better understanding of the habits and requirements, and therefore possibilities of management of any game species will be had through a knowledge of the existing interrelationships with other animals. For one thing, the predator-prey relationships should be known as far as possible. In addition, it would be desirable to know the existing ecological associations of a less direct nature such as competition for the same food, dens, and cover, which might often cause populations of the species to fluctuate. The food habits of raccoons have been discussed (p. 82), and showed that game animals form an insignificant part of the diet. Excepting man and his dogs, enemies of raccoons are few, if any. Therefore, it appears that as far as other animals are concerned, the indirect competitors, those vying for food, dens and cover, are apt to be the most important in influencing raccoon numbers.

In this region, the opossum appeared to be the chief species which might affect the raccoon adversely, since he also is principally nocturnal, prefers much the same type of habitat as raccoons, and builds no home of his own. Moreover, when raccoons seemed to be decreasing in some localities of Michigan, many hunters quickly "diagnosed" the situation and decided that the opossum was guilty on many counts. He was soon accused of usurping raccoon dens, of chasing raccoons out of an area, of killing the young, or even the adult animals, and lastly, as perhaps the main reason for drawing so much condemnation, he was considered an unmitigated nuisance to the hunter whose dogs he deterred from the more prized 'coons. Therefore it was deemed expedient to devote some time during the investigation towards determining the extent, if any, to which numbers of raccoons are affected by opossums.

Fig. 81. Opossum ---- disliked by the 'coon hunter.

Fig. 82. The mother's pouch is home to a young opossum for about two months.

Relative numbers

As the first clue to the compatibility of raccoons and opossums, it seems that relative numbers of the two species in an area should be significant. Box-trapping and other observations gave a good indication of opossum numbers of the General Study Area, for comparison with the estimates for raccoons. The animals were taken in traps used in these studies and also in some used by other workers in the same area.

TABLE XVI

Raccoon And Opossum Numbers Taken On The General Study Area

Year	Species	Number of adults		Number of Juveniles		Totals
		Male	Female	Male	Female	
1938	Raccoon	12	9	22	11	54
	Opossum	4	5	28	17	54
1939	Raccoon	9	15	20	19	63
	Opossum	8	15	62	42	127
1940	Raccoon	24	31	15	12	74
	Opossum	12	4	4	4	24

Table XVI presents the apparent population data for the two species in the General Study Area. At first hand it is evident that fairly "good" populations of both were present, at least in 1938 and 1939. In view of this fact, it seems probable that no extremely serious conflict between the two species exists.

Trapping was less extensive in 1938, and probably not so great a percentage of the population was taken as in 1939. But, without doubt another factor, the weather, was involved. The winter of 1938-'39 was very mild, which gave the prolific opossum an opportunity to increase rapidly. This species is a rather recent addition to Michigan fauna, and since it is not acclimated to the cold weather of the State, has been known to suffer great losses during severe winters. During a mild winter the losses are much lower and the population again builds up. Opossum numbers were on the upswing due to the fairly moderate winter of 1937-'38 and the mild conditions in 1938-'39 were conducive to a continued increase. Therefore the known figure of 127 opossums in 1939, or more than twice as many as in 1938, while due in some measure to a more intensive census, was probably due principally to the moderate winter weather.

The most significant fact about these population figures is the steady upswing of raccoon numbers, as compared with the erratic fluctuation shown by opossums. The raccoon is a hardy species, able to withstand severe temperatures, and go without food for extended periods. In winter they remain "holed up" during the severe weather, utilizing their fat reserve. Apparently in 1939 they responded to closing of this area to hunting by an increase in numbers, opossums notwithstanding. Opossums, in contrast, must feed the year round, despite weather conditions, or suffer malnutrition. Evidence of the effects of winter were manifest in the condition of adult animals in the spring of 1940. All examined had sustained frozen ears and tails, as a result of which the tips had sloughed off (fig. 83). Vertebrae were often exposed at the end of sore, unhealed tails.

Fig. 83. The ears of this animal were reduced to about one-half length by freezing the previous winter.

The reduction from 127 opossums handled in 1939 to only 24 in 1940 is believed significant, in reflecting the winter die-off. Only five of the 127 were retaken the next year. Since the tract was closed to hunting, the decrease evidently meant that a large number of the animals died. The juveniles in particular probably found it difficult to come through the winter. There were two feet or more of snow during three months (January-March), which certainly made it difficult for them to find much food, and what they did get must have been obtained at the expense of exposure to cold temperatures for long periods.

In summary, from the available evidence, it appears that high numbers of opossums did not tend to reduce the populations of raccoons. On the contrary, while the number of the latter appeared to increase from 1939 to 1940, opossum numbers dropped drastically, due, apparently, to a severe winter.

Denning habits

Studies indicate that in this region at least, where both tree dens and ground holes are plentiful, there is no competition for homes. Raccoons were found to use the tree dens exclusively, while the opossums apparently live in ground holes. In the several hundred tree cavities examined, there was no evidence of opossum occupation. When hunted with dogs, opossums often climb trees, but usually go only high enough to be out of reach, often in some sapling. The ability to climb serves them well in escaping enemies, but in this northern edge of their range it appears that the animals may not be as arboreal as is commonly supposed. It seems possible that a difference between temperatures in ground holes and tree dens might be responsible for use of the former.

Testing of various types of artificial home sites at the Experiment Station furnished further information supporting the foregoing conclusions. In addition to experimental raccoon dens, 112 experimental ground burrows were installed in the oak uplands by Haugen (1940) in connection with cottontail management. Although hairs of other species were often found in the boxes placed in trees, there was no evidence that the duck nesting and raccoon denning sites were ever inhabited by opossums, during a period of two years. Nevertheless, individuals were found a number of times in the artificial ground burrows. In one instance a female and her litter of nine were found occupying one of them, and on a number of occasions, single juveniles were located. Of further significance was the fact that the ground burrows were in a part of the Upland Den Study Area, but the tree dens were not used by opossums. The animals apparently preferred the man-made burrows to the natural tree cavities.

Opossums were tracked to a number of ground holes in winter. These were often natural cavities beneath stumps and among the roots of trees. Woodchucks, which are fairly common in the bottomland habitat, probably excavated most of the other burrows available there. A large number of burrows are present in a dike along the Kalamazoo River, many of which opossums were known to use during the winter.

In March, 1940, the writer located a burrow in the oak uplands by tracking a raccoon. Tracks showed that at least two raccoons had recently visited this hole. Upon excavating it, two leaf nests, and patches of opossum fur were found. Opossums had evidently used the burrow at some time, but there were no tracks of this species in the snow around the entrance. Tracks showed that the raccoons had returned to

the lowland after visiting the burrow. This was the only record available of a raccoon entering a ground hole (except some released or pursued), and the full significance in this case is not known.

Predator-prey experiments in pens

Inasmuch as numerous reports had been received from hunters by the Game Division of the Michigan Department of Conservation, and by the writer at the Experiment Station, that opossums could and often did kill raccoons, experiments were conducted to obtain authentic information. These experiments consisted of putting captive raccoons together in pens with captured opossums under various conditions.

During the winter of 1938-'39, an opossum lived in a pen with two raccoons for several weeks. All slept in one den provided for them, and no fighting was ever observed. Later 12 other opossums were put with raccoons. In no instance was a raccoon killed or injured in any way, nor was fighting ever observed. However, the opossums died in every case, three of them apparently being killed within from one to five days. Whatever was the cause of death, the animals were invariably partially eaten, and carcasses left in the pens were largely consumed by the raccoons. In one instance a raccoon killed an opossum the first night, the eviscerated carcass of the latter being found in the pen next morning. For the most part, however, members of the two species were observed to ignore one another, and nine of the opossums were believed to have died as a result of exposure or inability to become adjusted to captivity.

A variety of situations were tried out in the experiments. When a raccoon had been living in a pen, and an opossum was introduced, the latter remained out of the den box even in freezing weather, but if

put in the den, both usually used the box thereafter. Several times two dens were provided, and one animal lived in each. An experiment of this nature was carried out in the winter of 1940. An artificial burrow and a barrel filled with straw were made available in a pen with a dirt floor. A raccoon and opossum lived in the ground hole for five weeks. The raccoon then occupied the barrel and the two lived compatibly in that manner for another month. At the end of that time the opossum was found dead. When an opossum had been living in a den, the introduced raccoon often assumed exclusive rights to the den, or the two animals denned together amicably. One opossum was given no food for 12 days in order to have conditions approximate those wherein hunters claim hungry individuals will dispatch a raccoon on the spot. The raccoon alone survived here, however. In two instances two opossums were made pen-mates of a single raccoon, but after seven and eight days respectively the opossums succumbed, though neither seemed to be injured in any way.

Since the experiments herein described were, of course, conducted under conditions unnatural to the animals, one is probably not justified in drawing final conclusions concerning conditions as they exist in the wild. The results seem to demonstrate, however, that raccoons are capable of caring for themselves in the company of opossums. It is doubtful if predation of either species upon the other occurs in the wild.

Food relationships

It is obvious that there must be competition for food between the opossum and raccoon since both are omnivorous. There seems to be little in the way of animal food that neither will take, and many kinds of berries, grains, and other fruits are also utilized. However, the

opossum tends to be more of a scavenger, taking dead animal matter which is usually not so acceptable to raccoons. The fact that the diet of the latter is extraordinarily varied, the animals being able to turn to so many different kinds of food when the supply of one fails, should render food competition relatively less important than for species more restricted in diet.

Some evidence of a difference in habits of the two species was shown by trapping results in cottontail studies by A. O. Haugen. During 1939, 54 opossums, and only six raccoons were taken in traps in the oak uplands. To some extent, difference in actual numbers present and in trap efficiency for the two species may be responsible for this inequality of catch, but the figures undoubtedly indicate to some extent that the opossum spends more time in the uplands than do raccoons, and may find more of his food there. Analysis of several fresh scats showed that even in mid-winter, with over a foot of snow, opossums were finding acorns to eat.

In all, the contents of 15 stomachs and 9 scats were analyzed. No single food seemed outstanding in quantity or frequency of occurrence. Some of the items found in greatest bulk included: rabbit (probably domestic), shrews (Blarina sp.), mice (Microtus sp. and Peromyscus sp.), chicken, frogs (5 made up the entire contents of one stomach), small slugs, and caterpillars, of an animal nature, and wild grapes (Vitis sp.), corn, buckwheat, and berries (Rubus sp. and Rhus sp.), of plant origin. Other foods of lesser amounts included pheasant, red squirrel (Tamiasciurus hudsonicus loquax), insects of many kinds including larvae, and a few seeds of several kinds. It appears that any-

thing which is edible will be taken by an opossum, in view of the great variety shown by this rather small sample of food habits material.

Recommendations

It has been shown that substantial numbers of both raccoons and opossums concurrently inhabited the Swan Creek region. While the former apparently increased, under protection from hunting, the opossums suffered a considerable reduction in numbers due to an adverse winter. Evidently this recent immigrant, instead of exerting any unfavorable influence on raccoons, has difficulty in coping with Michigan weather, which is unsuited to its best survival, but to which the native raccoon is well adapted.

The data presented on denning habits of both species leads to the conclusion that there is no conflict resulting from den competition. In this region these animals use distinctly different types of denning sites, the raccoons using tree dens, the less arboreal 'possum using ground holes. In several hundred natural tree hollows, and 75 artificial dens erected in trees, there was no evidence of opossum use, neither occupancy nor signs of any other kind being discovered. Raccoons used all these types to some extent. Artificial as well as natural ground holes, however, were occupied by opossums in areas where hollow trees were plentiful. As far as home sites are concerned, relationships between the two species in such an area seem to be entirely compatible. There is some indication that raccoons in parts of Michigan are being forced to resort to burrows, due to destruction of the preferred tree cavities. If such is the case, the artificial boxes erected in trees

may furnish a partial solution. In any case, the raccoon would probably be the winner if competition for any type of den existed. When animals of the two species were placed together in pens, if one remained out of the nest box to suffer exposure, it was the opossum and not the raccoon. As to the possibility of opossums preying upon raccoons, that also seems very unlikely, because while several opossums were killed, the raccoons were never injured. If there is any predation in the wild, the raccoon is more likely to be the predator, and the opossum the prey.

Probably the main reason for the practically unanimous condemnation of opossums by Michigan raccoon hunters is the fact that 'coon dogs will trail either species, while the hunter is intent upon getting raccoons. In the first place a raccoon pelt is worth about 10 times as much as an opossum skin.[1] To some hunters the monetary gain involved is what counts, but even those who hunt for sport would rather "tree" one raccoon than a dozen of the despised opossums. The latter usually give the dog only a short chase, and the hunter feels cheated when his hounds spend time on their trails. Many bona fide 'coon hunters will not even carry opossums home. In years when these marsupials are abundant, such as in 1939, their nuisance value may become quite a problem. A good illustrative example is one hunter's report which, while humorous to the listener, was probably not as much so to him. This fellow went out one night to hunt raccoons with two hounds. Shortly after getting started, one dog set out on the trail of a deer. In the meantime, while the hunter waited about four hours for the deer-chaser to return, his other hound "treed"

---

[1] According to data compiled by Game Division, Michigan Department of Conservation for 1936-'37, average pelt price of raccoons was $4.00, of opossums $ .40.

a total of 26 opossums. The dogs never as much as found a 'coon track all night. Experiences similar to this one have turned the Michigan hunters against opossums. The hunter gets little enjoyment out of tracking them, the pelts are of little value, and the dogs are too often deterred before finding a raccoon trail. The opossum is truly a detriment to the enjoyment of 'coon hunting.

What then constitutes proper management in regards to opossums? If, as is held, their nuisance liability to the hunters is the principal consideration, there seems to be at least two alternatives. The hunters can be informed about the situation as it exists and become reconciled to the fact that the opossum, intruder that he is, is probably here to stay, but held in check by nature through recurring severe winters, or a policy can be adopted whereby this species is discouraged in every possible way. How the latter should be actively carried out is a difficult question to solve. Bounties, with all their inherent failings for dealing with any species, are not the answer. Probably the most expedient policy for handling the situation would be one combining both alternatives mentioned. By giving opossums little, if any, protection their numbers could be controlled to some extent. In a state where there are many more desirable native game species, it seems logical not to encourage this new-comer. Since opossum pelts have so little value, there should be few who would criticize such a policy. Fur-buyers are practically as vehement as are 'coon hunters in condemning them, as there usually is too little profit to be gained compared to the involved labor and risk of taking a loss on a poor market. Moreover, there

seems no reason why periodic adverse weather should not continue to hold the species in check, but if in the future it does not, then more radical measures of control might properly be instituted. Raccoon hunters, if acquainted with the available facts concerning the relationship between their favorite game and opossums, should be less apprehensive for their sport.

We do not yet know enough about opossum and their habits to warrant final conclusions, but at present it appears that opossums are neither enemies nor serious competitors of raccoons, and therefore seemingly constitute no serious menace to raccoon populations in the state.

ARTIFICIAL PROPAGATION

Artificial propagation has been proposed many times as an effective way to increase the number of raccoons. A review of available evidence concerning this proposition indicates such a method to be impracticable. In the first place, the high cost of breeding and rearing or buying the animals would require a prohibitive yearly expenditure. In the second place, there is complete lack of evidence that such a project would materially increase the annual take of raccoons, and some evidence that it would not.

Pen-raised raccoons are expensive. The cost of raising them on fur-farms has been too high to allow a profit. As pointed out by Hamilton (1939), the early attempts at 'coon ranching were unsuccessful because the price commanded by the pelts was too low in comparison to the cost of production. Only the raising of mink and foxes proved to be commercially feasible.

The minimum cost of food and labor for raising a raccoon until he is one year old, according to work in Ohio (Egger, 1939), is $6.40. If allowance is made for overhead expense, cost of housing, maintenance of breeders the year round, and contingent miscellaneous expenses incurred by a raccoon farm, it is likely that double this figure would represent the average cost per raccoon. Even the $6.40 minimum production cost per animal compared to an approximate $3.50 average pelt price paid to hunters and trappers in recent years, shows that production in pens is economically unsound.

In an attempt to justify large expenditures for propagation, it may be contended that a raccoon hunted for sport has greater value

than its fur alone. The fact still remains, however, that it costs at least $6.40 to raise one raccoon, and given a certain amount of money to spend, only a certain number of animals could be raised or purchased for release. There are approximately 10,000 raccoon hunters in Michigan (computed estimates from hunters' reports in 1939 was 10,027). If the entire $10,000 from their license fees were spent for rearing animals, (which cannot fairly be done), the Conservation Department could, at the minimum price produce only about 1,560 raccoons annually. This is based on the presumption of having good success in breeding and rearing. Probably 1,200 animals or less would represent the number which could be liberated annually. Advocates of propagation usually cite the number of offspring which the females would produce after liberation, augmenting the original release. An estimate can be made of what this number could be expected to total. Normally 1,200 released raccoons would include 600 females. Our best evidence shows that about 50 per cent of the females breed their first year, and produce an average of four per litter. Thus, the maximum number of young born, if all the females survived and the expected one-half bred, would be four times 300 or 1,200. This number added to the original stocking, would give a total of 2,400, barring all losses. Reasonably a loss of 400 could probably be expected as the result of deaths from various causes, but it will be ignored here for the sake of presenting the picture as envisioned under the best possible conditions. Comparison of 2,400 with the total kill and population in the state gives us some idea of the significance of such a release plus reproduction. The computed annual kill of raccoons in recent years has been roughly

35,000. Undoubtedly more than twice this figure,[1] or over 70,000 animals constitute the fall population. Probably very few sportsmen would enjoy substantially better hunting if there were 72,400 instead of 70,000 raccoons in Michigan. To be impartial the animals released would have to be distributed proportionately to all counties of the state within suitable raccoon range.

Further, some might point out certain depleted localities and argue that restocking is essential to recovery of the species in such habitats. This contention is not necessarily correct. Studies at Swan Creek indicate that some yearling raccoons disperse from the region in which reared, to establish themselves in new distant territories. Returns from hunters show that this distance may be as great as 27 miles. It is highly probable, therefore, that numbers in depleted areas would be built up as the result of juveniles migrating naturally from better populated territories.

The effect of a closed season on the subsequent take of raccoons should be an indicator of what to expect from releases. From the standpoint of restocking areas, wild animals would probably be worth several times as much as semi-tame pen-reared animals. However, the records indicate that even a closed season, which should have resulted in saving many times as many raccoons as could be reared and released, had little or no effect on subsequent catch (cf. p. 219).

---

[1] Considering a breeding potential of 1.5 and hunting and trapping mortality of 47%, as shown at Swan Creek, it seems that this estimate is not far off.

Stocking experiments at Swan Creek

Experimental releases of raccoons were made as part of the present investigations to obtain some definite information as to the fate of such animals. Seventy pen-raised raccoons were released: 50 in October, 1939; 10 in April, 1940; and 10 in July, 1940. The 50 in 1939 were liberated in the vicinity of four lakes surrounded by oak upland habitat. Acorns were abundant, furnishing a good supply of natural food. The remaining 20 animals were released in Swan Creek bottoms. Neither of the areas was under special hunting restrictions.

The principal source of information concerning the activities and fate of these raccoons was the tag returns by hunters. Of the 50 released in 1939, one was killed by a car three days later. During the hunting season, 21 or 42.8% of the remaining 49 were taken by hunters. This percentage nearly equals that of the native population taken by hunting in the Ottawa Marsh (47%), but for the latter area controlled hunting was in effect requiring a complete report of kill from everyone securing a permit. Returns from the release area were voluntary, and perhaps some tagged raccoons were taken which were not reported. Only 5 of the 28, which so far as was known survived the 1939 hunting season, were accounted for in 1940. One was taken in a den with a native animal in spring, and one was taken in a trap during the summer. The other 3 were killed during the 1940 hunting season. There is little doubt that the release in 1939 furnished considerably better hunting in a localized area for that one season than there would have been otherwise. But was it practical economically to furnish animals at a cost of $5.15[1] each,

---

[1] These animals were purchased from Michigan breeders, the majority of whom were going out of business and who reported that $5.15 was below the cost of rearing.

Fig. 84. Two raccoons released on the shore of Little Tom Lake. Part of a release of 50 in fall of 1939.

whose pelts brought only $3.50? Even though the release was a heavy one (50 animals within a block of four sections or 2,560 acres), there was apparently no greater number of raccoons there in 1940 for the hunters than before.

The distances that these raccoons were taken from release locations varied from less than one-quarter mile (some were taken at almost the exact location where liberated) to about 6 miles. Adults averaged two miles and juveniles three. The juvenile killed by a car had gone six miles within three days. Thus, some of these animals turned out into country strange to them tended to wander about, which would not only indicate their inability to become adjusted, but also would be conducive to mortality. Of the 20 raccoons released in April and July, 1940, 30 per cent were reported taken by hunters the following fall, indicating a probable good survival.

Information relative to breeding of liberated animals was obtained for one individual. This female had been used in experimental work and was allowed to pass her heat period in February without being bred, and then turned out in April. In August she returned to a farm house for food. Upon capture and examination she proved to be lactating heavily, apparently suckling a very recent litter. She therefore had become receptive a second time, and bred in the wild.

The above mentioned female was the only reported animal of the 70 which tended to remain domesticated. However, the region is only sparsely settled and the animals had little opportunity to return to domestic life had they any desire to do so. On the other hand, one of nine animals which the Kalamazoo 'Coon Hunters' Association released

soon returned to a farm house, and another was still tame when taken in fall. A third animal of theirs was killed by a car one month after release, and the others were not reported. Another Conservation Club at Cadillac reported a pen-raised 'coon coming back to domesticated life after liberation. An animal released by the Kellogg Bird Sanctuary, Augusta, Michigan, was found some time later hungry and weak, and after being fed for several days and turned loose a second time, it raided a chicken coop in the neighborhood until captured. Evidently releases in farm country have not been generally successful.

In summary:

1. The minimum cost, according to available records, of raising a raccoon is approximately $6.40. At this price the greatest number of animals the Conservation Department could annually release by expending all receipts from 'coon hunters' licenses would be about 1,200. Compared to a native population of about 70,000 or over, this number appears insignificant.
2. Populations of depleted areas can be expected to be built up naturally by juveniles dispersed from better stocked territories. In one known instance dispersal was as far as 27 miles.
3. A closed season for two years (1927 and 1928), which should have saved many times the number of raccoons which could be released annually, apparently failed to effect a substantial and sustained increase in the subsequent take.
4. Even the large release at Swan Creek in 1939 apparently produced no greater number of raccoons there for the hunters in 1940.

5. Ten pen-raised animals liberated in farming districts, which comprises most of the best raccoon range in the state, showed more of a tendency to remain tame than those liberated in the sparsely settled area at the Experiment Station, and survival was undoubtedly lower also.

6. The cost of purchased animals (average price of $5.15, which the majority of breeders from whom the 50 were bought for release purposes reported was far below the cost of rearing, and which was considerably below that demanded by those who were not going out of business) was too high to make acquisition of animals in this manner feasible for large scale propagation.

ESTIMATING ABUNDANCE

From the inception of game management to the present, game censusing has been one of the most difficult problems confronting field workers. In discussing methods for certain species, Dice (1938) points out the difficulty of obtaining accurate censuses of any kind of mammal even on a small area. As a basis for recommending proper hunting seasons it is imperative to have some knowledge of abundance of the species under consideration. Of chief consequence in designating hunting seasons is relative abundance from year to year rather than absolute population figures. At present, various indices furnish the best indication of relative abundance of most game animals.

The live-trapping method of determining raccoon numbers as used in this study has been discussed in the presentation of population data. Such a method is not applicable to a rapid appraisal of conditions throughout the state, however. It would be too time consuming, and entail too great expense. Preferably some method is desirable whereby various field men can survey their territories in a short time, and arrive at fairly reliable estimates of numbers in comparison to past years. For raccoons this is very difficult. The species is nocturnal, and their dens are found only by diligent search. Signs of the animals' presence (principally tracks) therefore seem to constitute the best source of information. For any index of abundance to be usable as a basis for drawing up fall hunting regulations, it must be available in any year by early summer at least, and therefore any knowledge concerning the young of the year is eliminated, since juveniles do not leave

the dens until July. The time for appraising raccoon abundance is thus limited. Probably the best possibilities lie in taking track counts in winter, during the breeding season, and in late spring.

Raccoons breed in February and March, when there usually is snow on the ground. They are most active on mild nights, most often during a thaw when their tracks register plainly. It therefore seems that some good information could be obtained at such a time. In this work it would be necessary that suitable days be chosen for making a survey, namely, when ground and weather conditions had been conducive to raccoon activity the preceding night.

It probably would be best to conduct spring surveys in late May or June. By that time raccoons are visiting streams regularly, and tracks can be found along their margins. Inasmuch as one raccoon often travels a considerable distance along a water course, it would be desirable that a number of locations along a stream be visited to make the observations, and as much as a mile or more traversed at each. Considerable territory could be covered in such a manner in one day.

Another method used in the present studies might also prove feasible in spring. This is track observation along roads in oak country which is near lowland denning habitat. In years when an abundant crop of acorns had been produced the previous fall, raccoons would often still be finding mast in oak uplands in early spring. This was known to be true at the Experiment Station in 1940, after a large crop of acorns in 1939. In fact the animals were going to the oaks regularly as late as mid-summer. Thus, in limited areas where roads are favorably situated, such a method might profitably be used. Tracks registered

well in dirt or sand roads, and mulching would not be necessary, although it would perhaps facilitate a better count. In one area at Swan Creek where the breeding population was considered good (about 1 raccoon per 50 acres), as many as 10 animals often crossed a road 1.8 miles long in a single night. The road lies in oak upland near the adjacent lowland. These data might serve somewhat as a measuring stick for similar situations.

HARVESTING RACCOONS

Proper season

The raccoon is important as a fur-bearer, but is regarded more highly as a game animal by many hunters with dogs, and the present trend seems to be towards hunting them for sport, rather than taking the fur. The low price commanded by pelts in recent years (about $3.50 average) probably has been instrumental in causing this change in attitude. Nevertheless, there are trappers in the state who take the animals for the fur alone, and it thus is difficult to establish satisfactory regulations because of conflicting interests. To the hunters whose enjoyment is chiefly derived from the chase, primeness of fur is of secondary importance, while to the trapper it is of primary importance.

The present season in Michigan, as has been pointed out (Michigan Conservation, September, 1939, p. 3), is a compromise for the raccoon hunter and the trapper. Hunting is allowed during 45 days from November 1 to December 15 inclusive. Trapping season in the northern part of the southern peninsula, Zone 2, extends from November 15 to December 15 inclusive and in the southern part, Zone 3, from December 15. The trapping seasons coincide with those for muskrats, except that in Zone 3 it closes two weeks earlier, which is important from the administrative and law enforcement angles. This season has been in effect for six years, since 1935, and seems to be satisfactory.

Primeness of pelts: In the fall of 1940 some information was obtained as to the condition of pelts taken during the season as it now stands. It is expedient that we know what proportion of raccoon pelts taken are unprime, as a basis for continuing or modifying the present

season. To the extent that it is compatible with other interests, the season should be at such a time as to insure taking pelts when the greatest number will be prime.

All fur-buyers in Allegan County (10) were interviewed and figures were obtained from the Kalamazoo Hide and Fur Company, one of the largest buyers in the state. The former were almost unanimous in reporting that pelts of juvenile raccoons usually do not become prime until near the end of the season, or in December, but that the majority of adult pelts are prime early in the season or by mid-November. These data are supported by the writer's observations of pelts examined at buyers' establishments as the season progressed. Estimates by the buyers of the numbers of unprime juvenile pelts taken each season varied from 30 per cent to "most of them", while all but one agreed that fewer unprime adult pelts were taken. That these figures are not very far wrong is shown by data obtained at the Kalamazoo Hide and Fur Company, whose 1,081 medium and small pelts (presumably the majority juveniles), numbered 57.64% prime and 42.36% unprime.

Table XVII shows the frequency and percentage distribution in classes of size and primeness, of 5,214 raccoon pelts purchased by the Kalamazoo Company in 1940. Part of these pelts were purchased from Indiana, but according to the company buyer, there is little difference in pelts from that state and Michigan. This seems logical since, although the state is somewhat farther south, which might cause priming to be later, Indiana's hunting season opens 15 days later than the season in Michigan.

Pelts were graded as to size into four classes: extra-large; large; medium; and small. Each of these were divided into prime and

unprime lots. The buyer reports that all extra-large and most large pelts are from adult animals. Mediums probably include a few adults with the majority juveniles, and small pelts are all from juveniles.

Only 25.16% of the extra-large and large furs were classed as unprime, while 42.36% of the medium and small furs went into this class. This is further evidence that juveniles furnish a considerably greater proportion of unprime pelts than do adults.

TABLE XVII

	Prime		Unprime		Totals	
	No.	%	No.	%	No.	%
Extra-large	1275	85.81	211	14.19	1486	28.50
Large	1818	68.69	829	31.31	2647	50.77
Medium	539	58.72	379	41.28	918	17.61
Small	84	51.54	79	48.46	163	3.12
Totals	3716	71.27	1498	28.73	5214	100.00

Frequency and percentage distribution in classes of size and primeness of 5,214 raccoon pelts purchased and graded by the Kalamazoo Hide and Fur Company in 1940.

Referring to table XVII, a positive correlation can be noted between size and primeness of pelts. The percentages of prime pelts diminish through the classes from 85.81% of extra-large furs to 51.54% of the small furs. Grouping all skins together, 71.27% were prime and 28.73% unprime. Fig. 85 shows the percentages in the various groups graphically.

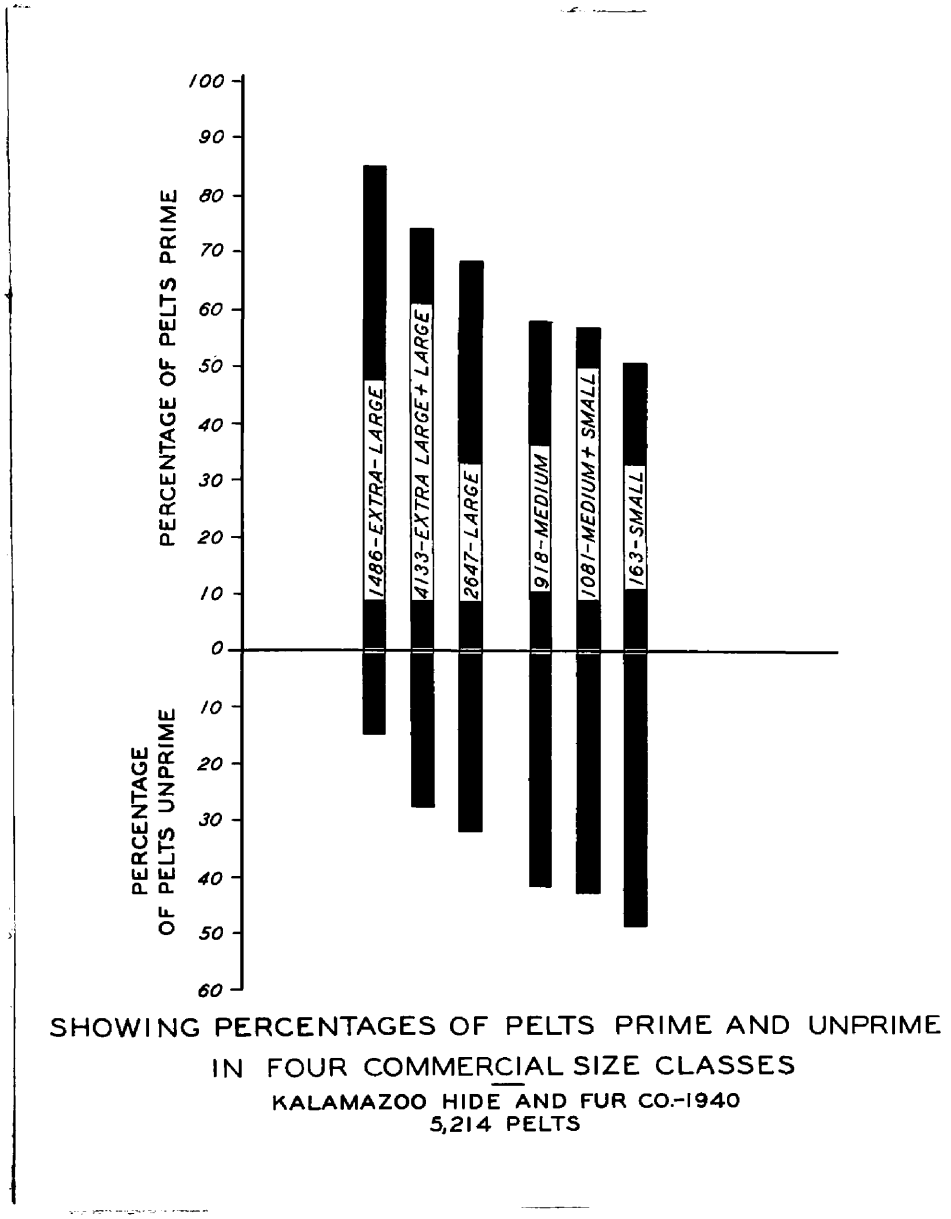


Fig. 85. Primeness of pelts taken in fall is in direct correlation with size, because fur of juveniles primes later than that of adults.

The facts and figures which have been presented indicate that solely from the standpoint of primeness, the present season is too early. To take only prime furs, hunting and trapping would have to be done later, beginning probably not before December 15. However, since raccoons are hunted for sport as well as fur, the condition of pelts is not to be considered alone. Inasmuch as animals "den up" with the coming of snow, and the number of sport hunters outnumber the fur hunters and trappers, it is not advisable to designate a later season. Nevertheless, primeness should not be disregarded altogether, and for that reason the season should not begin earlier than it does at present.

Closed seasons

There are those who recommend closing the season on raccoons for a year or more whenever there seems to be a decline in abundance. From the available evidence such action would probably not bring about the desired results. Some information in this respect can be derived from records of pelts sold to licensed fur-dealers after a closed season in 1927 and 1928. The data are summarized in table XVIII.

Unfortunately, there are no available records of pelts sold in years prior to the closed seasons, but the numbers reported during the subsequent eight years seems significant. During the first year (1929), about 16,000 raccoons were taken in a hunting season of 30 days and trapping season of 30 and 15 days. The next year in a shorter season, 22,000 or about 6,000 more were killed, which at the time may have been considered indicative of substantially increasing numbers, However, during seasons of varying length after that time the take was again as low as 15,000, and varied between that figure and 21,000.

TABLE XVIII

Pelts Actually Sold to Licensed Michigan Fur-dealers -- 1929-1936

Year	Length of season	Number of pelts sold*
1929	30** 30-15***	16,172
1930	15 15-15	22,079
1931	15 15-15	16,062
1932	15 15-15	14,899
1933	30 30-15	15,117
1934	30 30-15	20,162
1935	45 30-15	18,417
1936	45 30-15	21,051

* Records are taken from fur-dealers reports and do not show the total catch made in the state, as shipments to out-of-state mail order houses, fur used in garments etc. are not recorded.

** Hunting season (in lower peninsula only).

***First figure indicates length of trapping season in lower peninsula north of townline 16, and the second south of townline 16. All seasons between November 1 and December 15.

Since the number of raccoon pelts sold in 1929, after a closed season of two years, was less than the average for the succeeding seven years, it appears that closing the season would be ineffective in raising the population of raccoons above the present level. Surely the monetary loss during 1927 and 1928, when 30,000 or more animals could probably have been taken, was not compensated for in the following years.

Training season for dogs

A period for training 'coon dogs has occasioned considerable controversy. At the present time the Michigan law provides for a training period of 60 days preceding the open season, on species which may legally be hunted with dogs, but only during the hours from sunrise to sunset. This practically eliminates training on the nocturnal raccoons. Many hunters believe they should be allowed to train their dogs at night, and that no harm would result to the 'coons.

In 1938, a pair of well-trained hounds were used at the Experiment Station during the last week of August and first week of September. Three juvenile 'coons were captured, one on August 29, and two on September 6. The first one was started in the floodplain habitat, and "treed" 30 minutes later. The other two, in the oak uplands, where conditions favored the dogs, ran only about 10 minutes. Two more juveniles were "treed" on September 11, 1939. In all instances these immature raccoons stayed away from the dogs, and, except for one that fell out of a tree as it was being captured, none were injured. It was surprising to note the rapidity with which one was able to regain his equilibrium after falling a considerable distance. The animal, taken in September, 1938, was "treed" three times before being captured, twice falling about

30 feet. Each time he was able to lead the dogs on a several hundred yard chase before taking to a tree again and seemed none the worse for his experiences.

Though these observations indicate that by early September juvenile raccoons are capable of caring for themselves against dogs, there are further considerations. In the area here, trees which the animals could climb were available at all times. In farming country where this is not true, it is doubtful if the 'coons would have done so well. Some people maintain that too many would be killed, especially by "silent trailers", which the animals could not hear before being cornered, often in an open field. There are further angles to the problem. One is in regard to the possible indirect harm to young raccoons during too early a training season. Juveniles are still dependent upon the adult females for care and aid in finding food during the summer months. If dogs were in the field at that time, they might often break up family groups and thereby indirectly cause some losses. However, in early fall the breaking up of families before hunting might even be beneficial, by reducing the chances of hunters taking a whole family from one tree, as sometimes happens, according to reports. Another consideration is law enforcement. It would be very difficult to apprehend the hunter who might be inclined to kill the raccoons he trails before the legal season. Those opposed to training believe that poaching in this manner would be common enough to constitute a serious problem.

Considering solely the welfare of the raccoons, it would undoubtedly be best that no dogs be allowed in the field before September 1, and perhaps even before October 1. As a compromise, September 15 might be recommended, if a training season is to be allowed.

Hunting practices

There are certain practices employed by raccoon hunters to be considered in any program devoted to the betterment of raccoon hunting.

Destructive: Destructive practices which are forbidden by law but which are still used by some hunters, include the cutting of den trees and climbing of trees to take raccoons which have "holed up". These methods are probably employed for the most part by the fellow who takes raccoons for the pecuniary return. Apprehension of such violators at night is very difficult, and improvement of the situation lies almost wholly in education, and appealing to the hunters' sense of fair play.

Climbing of trees, while a law violation, is not as detrimental as tree cutting. The climber takes only the animals while in the latter case, a good den is sometimes destroyed as well, thereby reducing the carrying capacity of the habitat. Fig. 86 shows the method by which one hunter secured his quarry. A small sapling was wedged into the crotch of the larger tree and thus served as a means of gaining access to the hollow. The seriousness of tree cutting is somewhat lessened by the fact that 'coons often take refuge in trees which do not contain good dens. Many such trees are those with trunks hollow from the ground up in which the animals can gain protection from the dogs. Rather than cut the tree, the hunter need only chop a hole in the trunk to dislodge the 'coon. This practice, of course, results in the destruction of refuge sites but not dens. In the floodplain of the General Study Area, approximately 900 acres, eight trees showed evidence of such cutting and two dens were destroyed within the past few years. Only one violation had apparently been committed on this area in the past year.

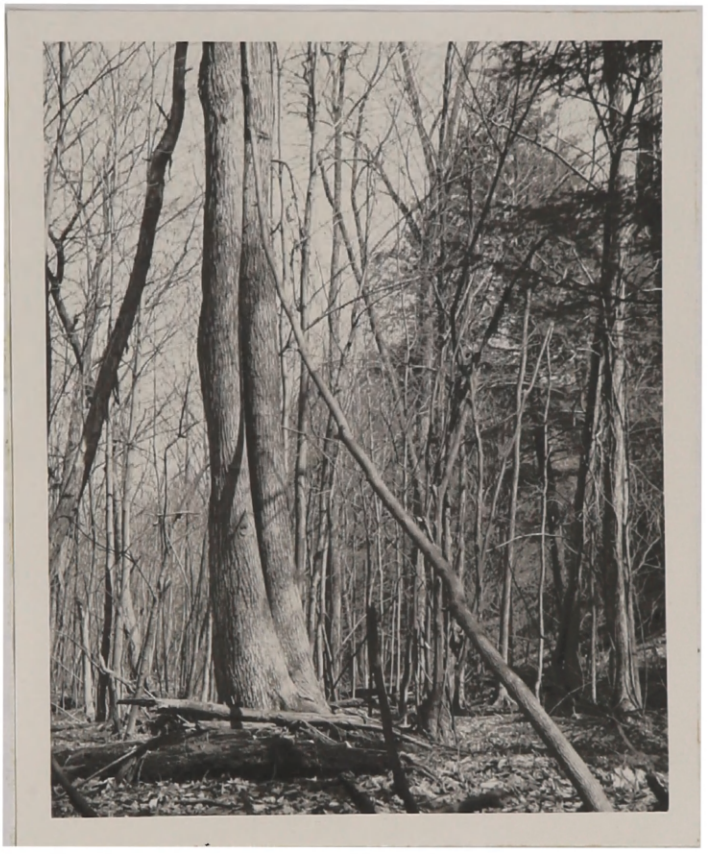


Fig. 86. Some hunters do not need climbers in order to raid a den. Disturbance of raccoons in dens is a law violation in Michigan.

While damage of this nature is probably not as prevalent as formerly, the Conservation Department could wisely emphasize the harmful results of such practices through its regular educational channels.

Constructive: A method advocated by some hunters, which undoubtedly will have beneficial results to raccoons, and which commands attention, is that of taking the animals alive and holding them for release after the hunting season is over. Within the past year such a policy has been adopted by a 'coon hunters' club in Kalamazoo County. These men, organized because of a common interest, hunt raccoons primarily for the enjoyment derived from the chase. In an attempt to improve their sport they capture at least a part of the animals alive each year, hold them for protection against further hunting, and liberate them at the end of the season. This particular club reimburses anyone who brings them an uninjured raccoon, at a rate approximating the current price commanded by pelts.

The Conservation Department probably should encourage such activities for several reasons. In the first place, promotion of the conception of raccoons as game animals, rather than merely fur bearers, is probably desirable. It should result in fewer violations, less den destruction, and probably better breeding reserves. In the second place, hunters would be encouraged to take an active interest in improving their own sport. Active local interest and management by hunters of any species, based on the particular needs in a locality, are important. Furnishing tags to clubs for marking their captured animals has value in fostering healthy relations with the hunters. By being able to identify their 'coons, the hunters might learn something about the habits of the species, which would give them a fuller understanding of the problems of

management. One club, at least, seems to be relinquishing the idea that propagation would be effective. Whereas the members had regularly reared a few animals to be turned out, they now place more reliance in the practice of retaining wild animals for release.

Annual kill

The system in Michigan of requiring all hunters and trappers receiving licenses to file kill reports, makes possible reliable estimates of the annual kill of raccoons. Such figures, for comparison from year to year, are invaluable to wise management of the species.

TABLE XIX

Annual Kill of Raccoons in Michigan

By whom taken	1938			1939			1940		
	No. of licens-ees.	Kill		No. of licens-ees	Kill		No. of licens-ees	Kill	
		Total	Ave. per licensee		Total	Ave. per licensee		Total	Ave. per licensee
Hunters	10,068	33,442	3.32	10,745	35,287	3.28	8,825	30,202	3.42
Trappers	2,653	6,501	2.45	3,318	8,449	2.55	1,665	4,443	2.67
Totals	12,721	39,943	3.14	14,063	43,736	3.12	10,490	34,645	3.30

Figures computed on basis of 19.4%, 36.6%, and 20% respectively of total hunting license sales and 58.9%, 57%, and 14.9% respectively of total trapping license sales.

According to figures in table XIX, raccoon numbers apparently have remained fairly stable from 1938 to 1940. Previous to this time fur-dealer's reports of purchases were the only records of kill in the state (table XVII). Inasmuch as many of the pelts were sold out-of-state,

used in garments, or for some other reason did not reach Michigan buyers, those figures were much lower, and cannot be compared directly with hunters' reports for the past three years.

It is evident that hunters not only outnumber trappers by about 3 to 1, but take roughly 80 per cent of the total kill. Actually the differences between the numbers of bona fide raccoon hunters and bona fide raccoon trappers and their kills are still greater than indicated. Whereas a considerable number of trappers who are seeking primarily to catch muskrats or other species catch a few raccoons, very few hunters who are not out for the specific purpose of hunting raccoons ever kill one. In making these calculations, however, every trapper reporting a raccoon was considered a raccoon trapper.

Length of seasons: The estimates of kill for 1939 and 1940 appear significant in indicating the effect of longer or shorter seasons. The legal seasons were the same in both years (45 days), but while weather conditions were such as to eliminate only three nights in 1939, 18 were not suitable for hunting in 1940 (p. 148). Nevertheless, hunters took an average of 3.42 raccoons each during only 27 days in 1940, or slightly more than the 3.28 average taken during 42 nights in 1939. The weather observations were made at the Experiment Station, but hunting was probably similarly affected throughout the state, since snow which caused the raccoons to den up seemed to be widespread in occurrence. In Allegan County, a total of 1,114 raccoons (an average of 3.27 per hunter) was reported for 1939, and 1,244 (an average of 2.6 per hunter) for 1940. According to these observations and figures it appears that other things being equal nearly as many 'coons would be killed in a season of only one month as are taken now in one and one-half months.

Distribution of kill: Map I shows the distribution of the 1940 kill throughout the state. As pointed out previously, inasmuch as Michigan is at the northern edge of raccoon distribution, the southern part of the state furnishes the most favorable raccoon habitat, with fewer raccoons being found northward. Much the greater share of the total take is in Zone 3, or the southern half of the lower peninsula. In 1940 hunters took over three times as many in Zone 3 as in Zone 2 (23,232 and 6,970), and trappers about one and one-half times as many. Much the same distribution has held since kill records have been available.

The annual crop: Records already presented indicate an annual kill of between 30,000 and 40,000 raccoons in Michigan in recent years. It would be of considerable value to know what percentage of the population this kill represents, or what percentage of the total fall population can be killed and adequate breeding stocks maintained.

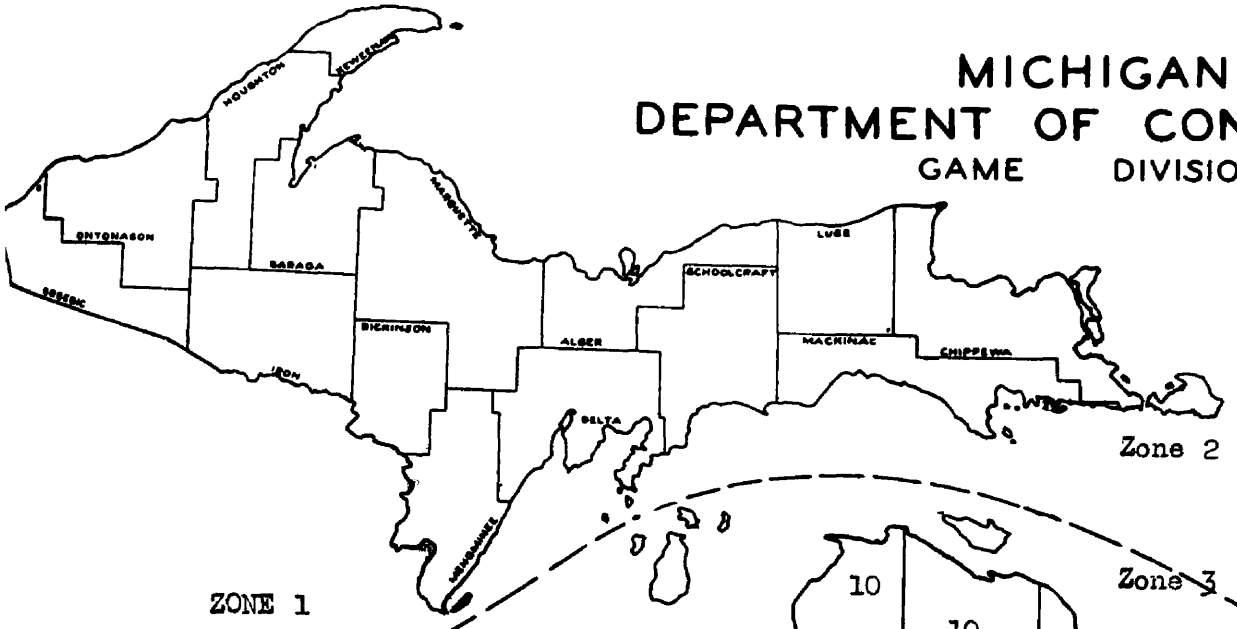
It has been shown by apparently reliable data that the breeding potential of raccoons is about 1.5. That is, the breeding reserve of the species is potentially capable of producing an annual increment 1.5 times as large as itself. On this basis the breeding reserve would comprise two-fifths and the increment three-fifths of the summer population. If the species is to remain stable in numbers from year to year, three-fifths of the total number existing immediately after reproduction occurs must be eliminated annually. The problem is to determine what proportion is taken by mortality factors other than hunting and what proportion, therefore, can safely be taken by hunting without exceeding the allowable three-fifths.

The annual loss of raccoons from all causes other than hunting is apparently rather small. Predators on the species seem unimportant;

MICHIGAN
DEPARTMENT OF CONSERVATION
GAME DIVISION

MAP I

DISTRIBUTION
of
RACCOON KILL
1940



By hunters: 6,970
By trappers: 1,841

By hunters: 23,232
By trappers: 2,602

Totals: 34,645

Upper no.:
Taken by trap

Lower no.:
Taken by hunt

			10 293 EMMET	10 19 CHEBOYGAN	29 73 PRESQUE ISLE	
			10 220 CHARLEVOIX			
		19 530 LEELANAU	0 183 ANTRIM	19 37 OTSEGO	10 110 MONTMORENCY	29 91 ALPENA
		29 54 BENZIE	39 330 GRAND TRAVERSE	19 110 KALKASKA	39 19 CRAWFORD	58 110 OSCODA	19 933 ALCONA
		39 274 MANISTEE	29 293 WEXFORD	19 37 MISSAUKEE	10 147 ROSCOMMON	39 878 OGEMAW	50 731 IOSCO
ZONE 2	87 164 MASON	10 731 LAKE	50 54 OSCEOLA	29 201 CLARE	0 37 GLADWIN	10 311 ARENAC	
ZONE 3	19 586 OCEANA	10 220 NEWAYGO	19 146 MECOSTA	0 19 ISABELLA	0 19 MIDLAND	0 0 BAY	0 146 HURON
	29 274 MUSKEGON		19 91 MONTCALM	10 183 GRATIOT	10 146 SAGINAW	10 201 TUSCOLA	10 1,390 SANILAC
	10 19 OTTAWA	68 1,043 KENT	19 787 IONIA	19 438 CLINTON	10 421 SHIAWASSEE	10 1,152 GENESEE	0 548 LAPEER
							10 384 ST. CLAIR
							MACOMB 29 330
	29 1,244 ALLEGAN	10 604 BARRY	49 1,061 EATON	39 621 INGHAM	29 1,701 LIVINGSTON	19 768 OAKLAND	
	10 841 VAN BUREN	49 805 KALAMAZOO	29 1,134 CALHOUN	49 421 JACKSON	10 677 WASHTENAW	19 421 WAYNE	
68 1,061 BERRIEN	68 164 CASS	39 897 ST. JOSEPH	10 421 BRANCH	49 823 HILLSDALE	39 897 LENAWEE	29 128 MONROE	

this study has shown evidence of high juvenile survival; and parasites and disease probably cause few deaths either directly or indirectly. Apparently hunting and trapping take most of the annual toll. Returning to figures, it seems reasonable to assume that the maximum natural loss is not over one-fifth of the animals. If this assumption is tenable, it means that there remain two-fifths to be preserved as a breeding stock for the next year and two-fifths that can be allowed to hunters and trappers. Since nearly all the natural loss probably occurs in summer, approximately one-half of the fall population can be killed, and an adequate breeding reserve maintained. Such a statement should not be made without reservations, but seems to be essentially sound.

Further information relative to this point is available in the reported kill of tagged animals at the Experiment Station. In 1939 and 1940, 34 and 36 raccoons respectively were tagged on the Ottawa Marsh tract. During the hunting seasons of each year 47 per cent of these animals were reported taken. A few more unreported animals may have been killed but the number, if any, was believed to be low. The exact duplication of kill (47%) in both years must be considered coincidental, especially since numbers were small, but similarity of the figures seem indicative that they approach the actual kill. In any event, the data constitute further evidence for establishing hunting mortality. Inasmuch as the kill on the Ottawa Marsh was so near 50%, it supports the more theoretically determined percentage of that amount. Since the figures are conservative in each case, it seems likely that at least 50 per cent of the fall population is killed annually. The present hunting pressure can, apparently, be tolerated since raccoons seem to be holding their own.

SUMMARY AND CONCLUSIONS

Purpose

The purpose of this study was to determine the habits and requirements of raccoons in Michigan as a basis for formulating a constructive management program, and to test proposed management measures.

Area

Intensive investigations were made on the 5,000 acre Swan Creek Wildlife Experiment Station of the Game Division, Michigan Department of Conservation in Allegan County. Two principal physiographic types exist on the area, the sandy upland of glacial outwash plain origin and the fertile floodplain valley of the Kalamazoo River which has dissected it.

In general the upland is covered by a forest of second growth white and black oak, with interspersed open waste fields marking the sites of abandoned farms. The floodplain supports a black ash-American elm-red maple type of forest.

Methods

The principal field methods employed included live-trapping, ear tagging, intensive den investigations, collection of food habits material, tracking, and hunting with dogs. Field observations were made at all times of the year.

A total of 256 live raccoons were handled 517 times. These comprised 41 males and 48 females which were a year or more old, and 92 male and 75 female juveniles. Thirty-one of the juveniles were rehandled when one or two years old.

Life-history of the raccoon

The sex ratio among the 256 animals was 1.08 males to 1 female, or 133 males to 123 females. According to accumulated evidence, raccoons are promiscuous breeders, the males probably mating with more than one female in a season. Circumstantial evidence indicates that some males may not be sexually mature by the first breeding season after their birth. Fifteen of 28 yearling females were known to have produced offspring and 10 were known to have produced none their first year.

The main breeding season in Michigan occurs from the first week in February through the first week in March. A few adult females breed as late as May, evidently because of failure to conceive during the winter. Young are born approximately 63 days after copulation, and the majority of litters arrive in April and May. Only one litter per female is borne annually. Lactation extends over a period of about three months after parturition, though the young leave the den at approximately 10 weeks of age. The average number of young in 11 litters was four. Females alone were found to care for the young. If, as was determined here, only about 50 per cent of yearling females conceive, the breeding potential is 1.5 per adult.

Juvenile raccoons averaged between 10 and 11 pounds in November, though some attained a weight of nearly 14 pounds by that time. Full growth apparently is not attained until at least the second autumn of an animal's life, or when it is about 19 months old. In spring female raccoons averaged only about one-half as heavy as in fall. Males were also lighter in spring, but the difference was proportionately less. It appears that raccoons can be separated as to age by weight differences

only until they become approximately one and one-half years old. Undeveloped nipples serve as a distinguishing character of juvenile females until they bear young.

The most striking fact recorded concerning food habits was the preference exhibited by raccoons for acorn mast whenever it was available. Animal matter predominated in the spring diet, while fleshy fruits and seeds were predominant in spring and fall.

The only noted cause of mortality, other than from hunting and trapping, was accidental death on highways, and losses from this source were few. Juvenile survival is apparently high. Deaths in the wild due to parasites and disease are evidently negligible.

Moulting and growth of new fur proceed synchronously, and in this region take place from mid-April to late June, though growth of fur probably continues throughout the summer. Priming is a separate process, appearing to begin in late October and requiring about six weeks for completion. Fur of juveniles becomes prime later than that of older individuals.

In this region tree dens are used exclusively as homes. The average distance of 34 occupied den trees from water was 409 feet, although those within a distance of one mile from water showed evidence of some use. Dens averaged 27½ feet above ground, 14 x 12½ inches in inside diameter, and had an average sized entrance of 12½ x 6 inches. The latter measurement varied widely, holes as small as 4½ x 4, and 5 x 3 inches being entered. Adults were found to den singly, and young of the previous spring were found singly, and by two's. Raccoons do not hibernate in the strict sense of the word, and become active upon the slightest disturbance,

or coincident with mild temperatures in mid-winter. Snow seems to be the principal factor causing the onset of prolonged winter denning. In 1939, outside activity ceased abruptly on December 13, with the coming of snow. In 1940, the animals denned from December 21, when there was snow, but were active thereafter while the snow was gone until January 3.

The determined average range diameter of adult males was one mile, and of adult females .7 mile. Juvenile males and females had average range diameters of .7 and .5 mile respectively. Probably the most significant known range was that of 1.2 mile exhibited by an adult male for whom 11 trap catches, and 25 track locations were recorded. From all available evidence, neither sex displays territorialism, at least not beyond the den tree.

From 62 tag returns by hunters it was shown that some of the young raccoons of an area disperse to other areas. Nine dispersing males averaged 11.75 miles, and five females, 8.25 miles. No adults moved from their earlier recorded ranges.

On the Ottawa Marsh tract of 1,235 acres, a fall population of 76.5 animals, or 1 per 16.2 acres was calculated on the basis of percentage of tagged animals killed. On the same basis, the fall population of 1940 was determined to be 34.0 raccoons. Because of adverse weather conditions in 1940, the figure for that year is believed to be less indicative of true numbers than the one for 1939. For the General Study Area of 2,464 acres (1,582 acres of upland and 882 acres of floodplain), a live-trap census gave a total count of 54 raccoons in 1938. In 1939 and 1940, by live-trapping, den examinations, and tracking, 63 and 74 individuals respectively were recorded. Figures for the last two years are

considered to be the most significant and the increase from 1939 to 1940 was apparently due to closure of the area to hunters.

Management

The principal essentials of an optimum raccoon habitat appear to be a permanent water supply, tree dens, and food. Management of habitat should be aimed towards conserving or providing dens in well-watered areas. Artificial feeding is not advised, though provision of corn might be of value when mast crops fail entirely.

Quantitative studies showed a density in the Swan Creek area of one den per 16.5 acres in the floodplain habitat, and one per 10.1 acres in the upland. The animals apparently prefer to den in the former habitat and select their rearing dens there. It is recommended that first management efforts be expended in lowland habitats.

Tree injury, loss of dead limbs, tree deformities, and woodpeckers are the chief agencies inducing decay, and the formation of hollows suitable for raccoon dens. Wind, lightning, and decay beyond the point where a den is suitable, are the chief natural destructive agencies. Hunters still cut some trees, but this destructive practice is undoubtedly not as prevalent in Michigan as formerly. Many trees which are cut in order to take raccoons are only refuge sites, and not good dens. Where cutting can be controlled, it is recommended that at least one, and possibly two dens per 15 to 20 acres be left, and about two or three times that many potential denning sites.

More extensive provision of artificial den boxes on an experimental basis, of a design similar to those tested during the present work, seems warranted. Ten of 25 erected for 10 months showed some evidence of use.

Damage caused by raccoons is usually negligible. In a few instances local control may be necessary, for which capture and transfer of the animals should usually suffice.

Closure of the General Study Area appeared to be mainly responsible for a noted 17% increase in population from 1939 to 1940. However, sanctuaries are not deemed generally necessary in Michigan at present, though they might be of value for rehabilitating the stock in depleted areas.

From all available evidence, opossums are neither enemies nor serious competitors of raccoons and therefore seemingly constitute no serious menace to raccoon populations in the state. They are, however, a detriment to the enjoyment of 'coon hunting, and their fur has little value. It is recommended that the species be given no protection insofar as such a policy is feasible in protecting other species.

Artificial propagation is an ineffective, economically unsound method for attempting to increase raccoon numbers. The release of 50 animals in the fall of 1939 furnished local hunters with more animals to hunt that year, but apparently effected no increase in numbers the following year. In farming country, raccoons showed less ability to become adapted to the wild, and also had poorer survival than at Swan Creek.

For an appraisal of raccoon numbers throughout the state preliminary to designating hunting seasons, track observations during the winter breeding season, and in May or June, seem to be most practicable. The live-trap method of censusing is too time-consuming for state-wide application.

The present open season on raccoons which is a compromise for the hunter and trapper, seems to be satisfactory. Analysis of data on 5,214 pelts purchased by a Michigan buyer showed 28.73 per cent to be unprime, but since the raccoon is regarded as a game animal as well as a fur-bearer, primeness of pelts is only one of several necessary considerations.

Complete protection of raccoons in the state during 1927 and 1928 seemed to have little effect on kill in subsequent years. Closed seasons are at present deemed neither necessary for the sake of maintaining raccoon numbers nor expedient if best use is to be made of the fur resource. It would undoubtedly be best to set the starting date of a dog training season no earlier than about September 15.

Within the past year or two some hunting clubs have adopted the policy of capturing "treed" 'coons alive, and releasing them after the hunting season. Such an active interest in the management of a species by hunters is desirable.

Estimates calculated from hunters' and trappers' report cards indicate a state kill of between 35,000 and 45,000 raccoons annually since 1938, of which about three-fourths were taken in the southern portion of the lower peninsula (Zone 3). Hunters take roughly 80 per cent of the total. There is some evidence that nearly as many animals would be killed in a season of one month, as in the present season of one and one-half months. It appears that about one-half of the fall population is killed annually by hunters and trappers, and that such a mortality can be tolerated since raccoons seem to be holding their own.

BIBLIOGRAPHY

Allen, D. L. 1938. Ecological studies on the vertebrate fauna of a 500-acre farm in Kalamazoo County, Michigan. Ecol. Monogr. 8:347-436.

Anon. 1932. Forest cover types of the eastern United States. Report of Committee on Forest Types, Society of American Foresters. Jour. Forestry 30:1-48.

Anon. 1938. Closed seasons fail to increase 'coons. Michigan Conservation 8:3.

Anthony, H. E. 1928. Field book of North American mammals. G. P. Putnam's Sons, New York.

1937. Animals of America. Garden City Publ. Company, Garden City, New York.

Audubon, J. J. and J. Bachman. 1851. The quadrupeds of North America. New York.

Bailey, Vernon. 1905. A biological survey of Texas. U. S. Dept. Agr., Bur. Biol. Survey, North American Fauna 25:1-222.

1923. Mammals of the District of Columbia. Proc. Biol. Soc. Wash. 36:103-108.

1926. A biological survey of North Dakota. U. S. Dept. Agr., Bur. Biol. Survey, North American Fauna 49:1-226.

1936. The mammals and life zones of Oregon. U. S. Dept. Agr., Bur. Biol. Survey, North American Fauna 55:1-416.

Baker, J. H. 1940. The director reports to you. Bird Lore 43:183-192.

Baumgartner, L. L. 1939. Fox squirrel dens. Jour. Mamm. 20:456-465.

Beddard, F. C. 1909. Mammalia. Macmillan and Company, London.

Bell, W. B. 1937. Methods in wildlife censuses. Jour. Amer. Statistical Assoc. 32:537-542.

Benedict, F. C. and R. C. Lee. 1938. Hibernation and marmot physiology. Carnegie Inst. Wash. Publ. no. 497:1-239.

Bennitt, R. and W. O. Nagel. 1937. A survey of the resident game and fur-bearers of Missouri. Univ. Missouri Studies 12:1-215.

Bergtold, W. H. 1925. Unusual nesting of a raccoon. Jour. Mamm. 6:280-281.

Bierens de Haan, J. A. 1932. Ueber das so-genannte "Waschen" des Waschbären (Procyon lotor), nebst einigen Bemerkungen ueber die Formen und die Bedeutung der tierischen Spiele. Biol. Zbl., Leipzig. 52:329-343.

Bissonnette, T. H. 1938. Experimental control of sexual periodicity in animals and possible applications to wildlife management. Jour. Wildlife Management 2:104-118.

Bissonnette, T. H. and A. G. Csech. 1937. Fertile matings of raccoons in December instead of February induced by increasing daily periods of light. Proc. Royal Soc. London, ser. B 122:246-254.

1938. Sexual photoperiodicity of raccoons on low protein diet and second litters in the same season. Jour. Mamm. 19:342-348.

Brown, E. C. 1936. Rearing wild animals in captivity and gestation periods. Jour. Mamm. 17:10-13.

Bryant, H. C. 1914. A survey of the breeding grounds of ducks in California in 1914. Condor 16:217-234.

Burroughs, John. 1900. Squirrels and other fur-bearers. Houghton Mifflin Co., New York.

Cole, L. W. 1907. Concerning the intelligence of raccoons. Jour. Compar. Neur. Psychol. 17:211-261.

1912. Observations of the senses and instincts of the raccoon. Jour. Animal Behavior. 2:299-309.

1915. The Chicago experiments with raccoons. Jour. Animal Behavior. 5:158-173.

Cory, C. B. 1912. The mammals of Illinois and Wisconsin. Field Mus. Nat. Hist. Publ. 153, Zool. Ser. 11:1-505.

Damon, David. 1933. A study of crop damage by wild birds and mammals in the southern peninsula of Michigan. Michigan State College, Dept. Zool. Unpubl. Thesis.

Davis, H. B. 1907. The raccoon: a study in animal intelligence. Amer. Jour. Psych. 18:447-489.

Dearborn, Ned. 1932. Foods of some predatory fur-bearing animals in Michigan. Univ. Mich. School of Forestry and Conservation Bull. 1:1-52.

Dice, L. R. 1925. A survey of the mammals of Charlevoix County, Michigan, and vicinity. Univ. Mich. Mus. Zool. Occ. Papers. 159:1-33.

1927. A manual of the recent wild mammals of Michigan. Univ. Mich. Publ. Handbook Ser. 2:1-62.

1931. Methods of indicating the abundance of mammals. Jour. Mamm. 12:376-381.

1938. Some census methods for mammals. Jour. Wildlife Management. 2:119-130.

Dixon, Joseph. 1924. Nesting of the wood duck in California. Condor 26:41-66.

1925. Food predilection of some predatory and fur-bearing mammals. Jour. Mamm. 6:34-46.

Edminster, F. C. 1941. Wildlife management through soil conservation on farms in the northeast. U. S. Dept. Agr. Farmer's Bull. 1868:1-53.

Egger, Charles. 1939. Ohio Conservation Bull. 3:12-13.

Enders, R. K. 1938. Fur animal reproductive cycles and their relation to management. Trans. Third North Amer. Wildlife Conf. 515-517.

Eulenburg, K. Graf zu. 1934. Vom Waschbär (Procyon). Kleintier u. Pelztier, Leipzig. 10:21-24.

Evermann, B. W. and H. W. Clark. 1911. Notes on the mammals of the Lake Maxinkuckee region. Proc. Wash. Acad. Sci. 13:1-34.

Gander, F. F. 1928. Period of gestation in some American mammals. Jour. Mamm. 9:75.

Giles, L. W. 1939. Fall food habits of the raccoon in central Iowa. Jour. Mamm. 20:68-70.

1940. Food habits of the raccoon in eastern Iowa. Jour. Wildlife Management 4:375-382.

Goodwin, G. G. 1935. The mammals of Connecticut. State Geol. and Nat. Hist. Survey Bull. 53:1-221.

Grinnell, Joseph, J. S. Dixon and J. M. Linsdale. 1937. Fur-bearing mammals of California. Univ. Calif. Press.

Gunn, C. K. 1932a. Phenomena of primeness. Canad. Jour. Research 6:387-397.

1932b. Color and primeness in variable mammals. Amer. Nat. 66:546-559.

Hamilton, W. J. Jr. 1936. The food and breeding habits of the raccoon. Ohio Jour. Sci. 36:131-140.

1939. American mammals. McGraw-Hill Book Co., New York.

1940. The summer food of minks and raccoons on the Montezuma Marsh, New York. Jour. Wildlife Management 4:80-84.

Haugen, A. O. 1940. Life history and management studies of the cottontail in southwestern Michigan. Univ. Mich., Mus. Zool. Unpubl. Thesis.

Herrick, C. L. 1892. Mammals of Minnesota. Minn. Geol. and Nat. Hist. Survey Bull. 7:1-299.

Howell, A. H. 1921. A biological survey of Alabama. U. S. Dept. Agr., Bur. Biol. Survey, North American Fauna 45:1-88.

Ingersoll, Ernest. 1907. The life of animals. The Macmillan Co., New York.

Johnson, R. H. 1939. Life history and management studies of raccoons in Maine. Univ. Maine School of Wildlife Conservation. Unpubl. Thesis.

Kennicott, Robert. 1858. Quadrupeds of Illinois injurious and beneficial to the farmers. Ex. Doc. 105, 35th Congress, 2nd Session; Rept. Commissioner Patents 1858, Agriculture. Washington, 1859. 241-256.

Lay, D. W. 1939. Fur resources of eastern Texas. Texas Game, Fish and Oyster Comm., Austin, Texas. Bull. 15:1-7.

Leopold, Aldo. 1933. Game Management. Charles Scribner's Sons, New York.

Martin, E. D. 1939. Raccoon management and propagation. Ohio Conservation Bull. 3:4-5.

McAtee, W. L. 1907. A list of the mammals, reptiles and batrachians of Monroe County, Indiana. Proc. Biol. Soc. Wash. 20:1-16.

Merriam, C. H. 1886. The mammals of the Adirondack region. New York.

Morgan, B. B. and E. F. Waller. 1940. Severe parasitism in a raccoon (Procyon lotor lotor, Linnaeus). Trans. Amer. Microscop. Soc. 59:523-527.

Nelson, E. W. 1916. The larger North American mammals. Nat. Geog. Mag. 30:385-472.

Nelson, E. W. and E. A. Goldman. 1930. Six new raccoons of the Procyon lotor group. Jour. Mamm. 11:453-459.

Neseni, Von Raimund. 1938. Beitrag zur Ernährung und Verdauung des Waschbären. Zeitschrift fur Säugetierkunde. 13:77-113.

Petersen, Marcus. 1914. The fur traders and fur-bearing animals. Buffalo, New York.

Riggs, C. H. 1938. Geology of Allegan County. Mich. Dept. Conservation, Geol. Survey Div. Progress Rept. 4:1-29

Seton, E. T. 1909. Life-histories of northern animals. Charles Scribner's Sons, New York. 2 vols.

1929. Lives of game animals. Doubleday Doran and Co., Garden City, New York. 4 vols.

Shelford, V. E. 1913. Animal communities in temperate America. Geog. Soc. of Chicago, Univ. Chicago Press.

Snyder, L. L. 1931. A faunal investigation of Long Point and vicinity, Norfolk county, Ontario. II The mammals of Long Point and vicinity. Trans. Royal Canad. Inst. 18-127-138.

Stephens, Frank. 1906. California mammals. West Coast Publ. Co., San Diego, California.

Stock, C. 1929. A census of the Pleistocene mammals of the Rancho La Brea, based on the collections of the Los Angeles Museum. Jour. Mamm. 10:281-289.

Stone, Witmer and W. E. Cram. 1902. American animals. Doubleday Doran and Co., New York.

Stuber, James W. 1932. 'Coon propagation in Ohio. Trans. 19th Amer. Game Conf. 328-333.

Sweeney, Z. D. 1905. Biennial report of the Commissioner of Fisheries and Game for Indiana, Dept. of Game. 399-642.

Van Dersal, W. R. 1940. Utilization of oaks by birds and mammals. Jour. Wildlife Management 4:404-428.

Whitney, L. F. 1931. The raccoon and its hunting. Jour. Mamm. 12:29-38.

1933. The raccoon--some mental attributes. Jour. Mamm. 14:108-144.

Williams, S. R. 1909. On hibernation in the raccoon. The Ohio Nat. 9:495-496.

Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. Scientific Publ. Cleveland Mus. Nat. Hist. 6:1-92.

Wimmer, H. 1930. Die Zucht der Waschbären (Procyon lotor). Pelztier-Zucht, Leipzig. 6:1-46.

Wood, Norman A. 1922. The mammals of Washtenaw County, Michigan. Univ. Mich. Mus. Zool. Occ. Papers 123:1-23.

APPENDIX

TABLE XX

Summary of Breeding Data Obtained For 28 Female Raccoons

Individual	Date	Age	How caught and condition
252	7-26-38	Juv.	Trap
	5-18-39	Yearling	Trap- Not lact. or preg.
	5-9-40	Ad.	Trap- Lact.
	5-16-40	"	Trap- Lact.
	5-19-40	"	Trap- Lact.
	5-28-40	"	Den- Lact., with litter.
257	7-29-38	Juv.	Trap
	2-14-39	Yearling	Trap- In oestrum; held captive.
	3-29-39	"	Pen- Pregnant; embryos first felt.
	4-15-39	"	Pen- Gave birth to young.
264	8-11-37	Juv.	Trap
	7-12-38	Yearling	Trap- Lact.
	7-30-38	"	Trap- Lact.
	8-11-38	"	Trap- Lact.
	8-31-38	"	Trap- Not lact.; clear fluid from teats.
279	8-6-38	Juv.	Trap
	5-8-39	Yearling	Trap- Pregnant.
	5-16-39	"	Trap- Pregnant.
	6-6-39	"	Trap- Lact.
	3-5-40	Ad.	Den- In one stage of oestrum.
	5-3-40	"	Den- With litter.
292	8-12-38	Juv.	Trap
	5-12-39	Yearling	Trap- Lact.
746	6-14-39	Juv.	Den- One of a litter.
	5-30-40	Yearling	Trap- Lact.
750	5-17-39	Yearling	Trap- Not preg. or lact.
	7-8-39	"	Trap- Not lact.; teats undeveloped.
	9-6-39	"	Trap- Not lact.; teats undeveloped.
	5-28-40	Ad.	Trap- Lact.
	8-8-40	"	Trap- Not lact.; clear fluid from teats.
986	5-15-39	Yearling	Trap- Not lact.; not preg.
	7-6-39	"	Trap- Not lact.; not preg.
2049	7-15-39	Juv.	Trap
	3-2-40	Yearling	Den- In one stage of oestrum.
	4-29-40	"	Den- Not preg.; not lact.

TABLE XX (Cont'd)

Individual	Date	Age	How caught and condition
2082	8-7-40	Juv.	Trap
	7-24-40	Yearling	Trap- Lact.
2089	8-12-39	Juv.	Trap
	8-6-40	Yearling	Trap- Lact., but very little.
2090	5-3-39	Juv.	Den- One of a litter.
	5-19-40	Yearling	Trap- Lact.
	5-23-40	"	Trap- Lact.
	5-24-40	"	Den- With litter.
	7-31-40	"	Trap- Lact.
	8-8-40	"	Trap- Not lact.
2293	5-12-39	Juv.	Den- One of a litter.
	4-29-40	Yearling	Trap- Believed to be preg.
	7-23-40	"	Trap- Lact.
2022	6-21-39	Yearling	Trap- Not preg. or lact., teats (undeveloped.
2138	2-3-40	Yearling	Den- Not in oestrum.
2141	2-13-40	Yearling	Den- In one stage of oestrum.
2290	4-24-40	Yearling	Den- Believed to be preg.
	7-16-40	"	Trap- Lact.
2296	5-8-40	Yearling	Trap- Not preg. or lact.
	7-25-40	"	Trap- Not preg. or lact.
	8-3-40	"	Trap- Teats undeveloped.
2299	5-11-40	Yearling	Den- Not preg. or lact., teats (undeveloped.
2301	5-17-40	Yearling	Trap- May be preg.
2335	7-30-40	Yearling	Trap- Lact.
	8-9-40	"	Trap- Not lact.
	8-15-40	"	Trap- Not lact.
2345	7-31-40	Yearling	Trap- Teats undeveloped.
2401	8-2-40	Yearling	Trap- Teats undeveloped.
2404	8-3-40	Yearling	Trap- Lact.
2408	8-4-40	Yearling	Trap- Lact.
2411	8-8-40	Yearling	Trap- Lact.
2412	8-8-40	Yearling	Trap- Not lact.; teats undeveloped.
2417	8-9-40	Yearling	Trap- Lact.

TABLE XXI

Weight Records Obtained For Juvenile Raccoons

April		May		June		July		August		September		October		November	
M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
0-06	0-06	0-04	0-05	2-11	2-04	2-08	2-14	3-06	2-09	3-06	4-12	4-05	4-12	6-10	9-00
0-07	0-07	0-05	0-05		2-04	2-13	3-01	3-08	3-03	3-07	5-01	4-10	5-12	10-08	10-07
0-08	0-08	0-05	0-06			2-14	3-04	3-12	3-04	4-12	5-07	6-00	5-14	12-00	13-00
0-09		0-06	0-08			2-15	3-05	3-14	3-06	5-02	5-08	7-04	6-11	13-09	
		0-08	0-08			3-04	3-06	4-04	3-07	5-03	5-08	7-07	6-12		
		0-09	0-09			3-05	3-07	4-07	3-10	5-03	5-14	8-10	8-14		
		0-09	0-10			3-07	3-07	4-08	3-11	5-03	6-04	8-14	9-12		
		0-09	0-11			3-08	3-08	4-08	3-12	5-04	6-08	10-00			
		0-09	0-14			3-09	3-13	4-09	4-00	5-06	6-10	10-02			
		0-10	0-15			3-09	4-01	4-09	4-05	5-08	6-13	11-00			
		0-14	0-15			3-11	4-03	4-10	4-07	5-10	7-01	11-08			
			0-15			3-14	4-06	4-11	4-07	5-12	7-03				
			0-16			3-14	4-08	4-13	4-07	6-00	7-05				
			0-16			3-15	4-11	4-14	4-08	6-02	7-05				
			0-16			4-00	4-14	4-14	4-09	7-00	7-06				
						4-01	4-15	4-14	4-10	7-02	7-09				
						4-02	5-04	4-14	4-12	7-08					
						4-05	6-02	5-00	4-12	7-11					
						4-06		5-07	4-13	7-12					
						4-08		5-07	4-13	8-04					
						4-09		5-08	4-14	8-12					
						4-11		6-09	4-14	8-14					
						4-12		6-13	4-15						
						4-12		7-01	5-00						
						5-00			5-05						
						5-04			6-02						
						5-06			6-05						
						5-07			6-08						
						7-02			7-02						
Average:															
0-07	0-07	0-08	0-11	2-11	2-04	4-02	4-01	4-14	4-10	6-02	6-06	8-03	6-15	10-11	10-01

Weights in Lbs. and Ozs.

TABLE XXII

Weight Records Obtained For Yearling Raccoons.

February		March		April		May		June		July		August		September		October		November		December	
M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
6-15	6-12	6-06	6-15	6-12	5-11	7-04	6-15	9-11	7-12	7-13	7-00		9-00	11-09	11-00	14-09			14-00	14-08	
	6-13	7-00	7-04	8-10	6-14	8-06	7-00	10-12	10-04	10-12	9-04		9-06						15-00		
	7-00		7-04	9-00	7-06	9-02	7-08				9-10		9-15								
						9-02	7-11				9-15		10-00								
						9-04	8-02				9-15		10-15								
						9-15	8-10				10-07		10-15								
						10-01	8-10				11-10		11-12								
							8-11				11-10		12-00								
							8-14				12-05		12-00								
							8-15				14-03		13-01								
							9-06						13-09								
Average:																					
6-15	6-14	6-11	7-02	8-02	6-11	9-00	8-03	10-04	9-00	9-04	10-09		11-02	11-09	11-00	14-09			14-08	14-08	

Weights are given in lbs. and ozs.

TABLE XXIII

Weight Records Obtained For Adult Raccoons.

February		March		April		May		June		July		August		September		October		November		December	
M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
14-05	9-11	13-00	7-05	8-15		8-14	8-15	10-08	9-07	10-12	9-03	12-12	8-08	11-06	12-00	13-02	14-10	14-10	15-00		
				10-04		9-00	9-02	10-08	9-08	10-14	9-08	13-00	9-14	14-00	12-10	14-00		17-00	16-00		
				11-05		9-08	10-00	11-08	11-00	11-00	9-08	13-08	10-00		14-14	17-06		18-10	16-14		
				12-14		9-10	10-03	11-12		12-03	10-04	13-10	11-08			19-09					
						12-03	10-08	12-08		12-13	10-06	15-00	11-14								
						12-10	10-10	13-04		13-02	10-09	15-10	12-06								
							11-07	14-12		13-09	11-08	21-10	13-08								
							13-12			14-10	11-13		14-00								
										14-12	13-00		18-06								
										15-00	13-00										
										17-03	13-03										
										18-00											
										18-02											
										19-02											
Average:																					
14-05	9-11	13-00	7-05	10-14		10-05	10-09	12-02	10-00	14-06	11-01	15-00	12-04	12-10	13-03	16-00	14-10	16-12	16-00		

Weights are given in lbs. and ozs.

TABLE XXIV

Data for 34 Occupied Raccoon Dens

Tree						Dens						Raccoons
Tree no.	Date Occupied	Kind of Tree	Distance to Water	Height In Ft.	Diameter In Inches	Height In Ft.	Diam. hole In Inches	Distance From Hole To Nest	Inside Diameter In Inches	Exposure	Type Entrance	Numbers, Age And Sex
94	1-15-40	Red maple	300	60	27	36	9 x 9	55	14 x 14	N	Top	2 yearling ♂.
99	2-2-40	Amer. elm	600	70	39	47	8 x 4	37	20 x 16	W	Side	2 ?.
35A	2-3-40	Red maple	800	50	40	7	19 x 4½	19	23 x 14½	S	Side	1 yearl. ♀; 1 ?.
102	2-7-40	Red maple	25	50	28	12	8 x 6	6	14 x 12	SW	Side	1 ? ♀.
105	2-12-40	Red maple	100	50	26	32	12 x 11	31	14 x 11	S	Top	1 adult ♀.
106	2-12-40	Red maple	300	40	22	14½	6½ x 4½	14	12 x 9	W	Side	1 yearl. ♂.
107	2-12-40	Red maple	1200	55	23	38½	5 x 3	9	10 x 10	N	Side	1 adult ♀.
108	2-12-40	Red maple	300	50	27	15½	10 x 8	37	14 x 12	S	Side	1 yearl. ♀.
109	2-12-40	Red maple	300	30	22	11	10 x 4	54	14 x 14	SE	Top	1 ?.
111	2-14-40	Red maple	500	45	36	31	15 x 7	15	22 x 12	S	Top	1 yearl.♂ ; 1 ?.
1	2-21-39	White oak	600	45	30	27½	7½ x 4	16	9½ x 9½	SW	Top	1 yearl. ♀; 1 ?.
114	2-28-40	Red maple	200	60	18	32	7 x 4½	132	14 x 12	N	Top	1 yearl. ♂; 1 yearl. ♀.
115	3-5-40	Red maple	100	29½	26	29½	9 x 6½	74	17 x 14	Top	Top	2 yearl. ♂; 1 adult ♀.
19	4-5-40	White oak	1300	55	23	35	4½ x 4	72	7½ x 7	W	Side	1 yearl. ♂.
26	4-5-40	White oak	500	40	16	22½	5 x 3¼	48	9 x 8	W	Side	1 yearl. ♂.
119	4-22-40	Amer. elm	300	65	23	23½	17 x 13½	46	15 x 12	NW	Side	*2 adult ♂.
52A	4-24-39	Amer. elm	200	85	54	65	16 x 6	6	16 x 12	E	Top	1 ? ♂.
121	4-24-40	Red maple	50	65	27	51½	11 x 9	10	11 x 9	E	Side	1 yearl. ♀.
125	4-25-40	Red maple	300	50	22	13	12 x 5½	120	12 x 12	E	Side	1 yearl. ♀.
59	5-3-40 1-8-40	White ash	150	60	26	23	6½ x 5½	20	13 x 10	NW	Side	1 adult ♀ & litter of 4, 1 yearl. ♂.
129	5-3-40	Butternut	500	50	29	38	14 x 10	7	15 x 10	E	Top	1 adult ♀ & litter of 4.
100A	5-10-40	Red maple	50	60	38	46½	5½ x 3	37	12 x 12	NE	Side	Litter of 3.
63	5-11-39 4-29-40	Red maple	300	75	42	55	6½ x 3	42	12 x 11	E	Side	Litter of 5. Litter of 7.
66	5-11-39	Red maple	500	40	23	22	6½ x 3¼	36	10 x 10	W	Side	Litter of 3.
130	5-11-40	Red maple	900	70	33	38½	9 x 3½	54	14 x 14	Top	Top	1 yearl. ♀.
68	5-17-40	Red maple	600	50	28	26½	15 x 15	120	15 x 15	S	Top	1 adult ♀ & litter of 5.
134	5-23-40	Amer. elm	20	75	31	21	57 x 6	34	13 x 13	N	Side	1 adult ♀ & litter of 4.
136	5-24-40	Red maple	300	60	25	26	18 x 5	58	12 x 11	E	Side	1 adult ♀ & litter of 3.
137	5-27-40	Sycamore	25	60	27	36½	7 x 5	6	17 x 12	NE	Side	1 adult ♂.
138	5-28-40	Red maple	900	50	24	21	5 x 3	42	14 x 12	SW	Side	1 adult ♀ & litter of 4.
75	6-14-39	Black oak	900	65	29	23½	50 x 5	0	15 x 12	E	Side	1 adult ♀ & litter of 4.
74	7-7-39	Red maple	300	40	23	14 ½	14 x 10	29	14 x 10	S	Top	1 adult ♀ & 1 juv.♂.
51	12-8-39	Red maple	200	70	33	56	7 x 4½	10	15 x 15	N	Top	2 juvenile ♂.
139	12-23-40	Sugar maple	300	60	24	37	9½ x 4	9	12 x 12	NE	Side	1 adult ♂.
		Averages:	409	55	25	27½	12½ x 6	38	14 x 11½			

* One of these two males had been released from captivity three miles away the previous October.