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STUDIES ON THE OCCURRENCE, GROWTH, AND FOOD HABITS OF THE OPOSSUM (DIDELPHIS VIRGINIANA VIRGINIANA) IN MICHIGAN

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Clarence Martin Taube

1942

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by

Clarence Martin Taube

A THESIS

Submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Zoology

1942

THESIS

ACKNOWLEDGEMENTS

Appreciation of assistence received is particularly expressed to Mr. Burton T. Ostenson, of the Michigan State College Zoology Department, who directed this study, and to Dr. H. R. Hurt, Head of the Zoology Department, who read the manuscript and made suggestions.

Acknowledgement is made to Mr. H. D. Ruhl, Head of the Game Division, Michigan Department of Conservation, for permission to incorporate into this paper various data regarding the opossum which were available in the Game Division files. Of particular value were the food analysis data. Most of the specimens which these concern were collected by Mr. Paul Hickie, formerly mammalogist with the Game Division. The analyses were made by Mr. C. S. Williams who at that time was associated with the U. S. Bureau of Biological Survey (now the U. S. Fish and Wildlife Service).

Acknowledgement is also made of help received from individuals who aided in identifying material found in the digestive tracts analyzed by the writer. Mr. Curtis Sabrosky, of the Michigan State College Entomology Department, identified some of the insect remains. Dr. P. I. Tack, of the Zoology Department, verified determinations on fragments of crayfishes. Mr. Charles A. Stahl, Chief Analyst in the Seeds Laboratory of the Michigan State Department of Agriculture, identified some of the fruit seeds. Mr. Philip Hawkins, instructor in Parasitology at Michigan State College, identified the parasites.

Mr. Don Hayne, Research Assistant in Zoology with the Michigan State Experiment Station, kindly contributed all the young opossums and three of the adults which were observed during this investigation.

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Mr. Leo Klever, Superintendent of the College Rodent Laboratory, gave valuable assistance. Appreciation is expressed to Mr. L. R. Schoenmann, Director, Michigan State College Conservation Institute, who permitted examination and use of data. Thanks are expressed to Miss Bernadette McCarthy, of the Zoology Department, for help she gave on numerous occasions.

Mr. W. H. Burt, Curator of Mammals at the Museum of Zoology, University of Michigan, generously guided the writer to sources relating to the early occurrence of the opossum in this state.

Many other persons who lent assistance could be mentioned but it is hardly possible to cite all individually. Various members of the Field Division of the Michigan Department of Conservation were helpful. Staff members of the Game Division gave assistance often and gladly. Fur dealers were cooperative in saving specimens which were examined in this study. Thanks are expressed to a number of correspondents who took a genuine interest in inquiries sent them and who provided helpful information.

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INTRODUCTION

Probably most wild animals have some of their habits "explained" by erroneous information. The North American opossum (Didelphis virginiana virginiana) is an heir to a goodly number of mythical attributes. To name only one aspect of its behavior to which this applies, the breeding habits of the marsupial have been subject to several bizarre and misleading descriptions. Perhaps such legends are bound to arise, yet it is hardly questionable but what a general lack of available scientific information encourages their fabrication. The behavior of many mammals deserves to be investigated more thoroughly than it has been in the past, and the opossum certainly offers no exception. As a laboratory animal the opossum has been studied rather intensively, its embryology, anatomy, and physiology all receiving considerable attention. However, its habits of life and the niche it occupies in relation to other animals are subjects which deserve more research than they have received to date.

This study embodies an attempt to add a little information on the natural history of the opossum. Since the marsupial now occupies a significant place in the fauna of southern Michigan and because it has been the center of much controversy due to a widespread belief that it is detrimental to some of the more highly esteemed species of animals, it seemed desirable that such an investigation should be undertaken.

Data were gathered over a period extending from September, 1941 to August, 1942. This paper is divided into three parts, namely, "Occurrence", "Growth", and "Food Habits". Because of the rather broad separation in relation between these subjects, little rhetorical unity will

be found between the divisions. But in so far that an attempt has been made in each to unearth some information which is hoped will lead to a better understanding of the opossum, perhaps that is unity enough.

The primary purpose of this investigation was to study the food habits of the opossum. Consequently this part of the study received the most attention, and it is believed that the observations made on the foraging habits of the animal produced the most valuable information.

OCCURRENCE

Methods

Data on the occurrence of the opossum in Michigan were collected principally by three means, namely, by referring to published literature on the subject, by examining records which the Game Division of the Michigan Conservation Department has on file, and by sending questionnaires to trappers and fur hunters, fur dealers, and Department of Conservation field men. In addition, interviews with trappers and raw fur buyers produced some information. Field observations made by the writer are also noted.

Early Occurrence

The first records on the occurrence of the opossum in Michigan date back nearly a century and there are a considerable number of other reports available on the presence of the animal here in succeeding years. These facts refute a commonly held belief that the marsupial is a relatively new addition to the fauna of the state. Moreover, it is quite possible that this fur bearer existed in Michigan for a considerable time before these recorded observations were made, but that it may have failed to receive mention because of its small economic importance and also because of the animal's secretive nature which resulted in its being seldom seen.

Wood (1922) notes that an opossum was taken by his father in Lodi Township, Washtenaw County, in 1845. Isaac Lamoex reported that opossums occurred at New Richmond, Allegan County, when he arrived there in 1845 (Wood and Dice, 1924). The last-named authorities present other evidence of the animal's existence in the state during the mid-1800's. They were said to have been 'not uncommon' near Petersburg, Monroe County, about 1850. In the same year John Bassett caught one near Novi in Oakland County. A specimen was reported killed during the fall of 1857 in Atlas Township, Genesee County.

In the first biennial report of the geological survey of Michigan it was reported that an opossum had been taken in Genesee County about 1859 and it was noted that these animals were frequently seen in the more southern parts of the state at that time (Miles, 1861).

A note on file at the Museum of Zoology, University of Michigan,

refers to a publication by H. C. Perry which contains the observation that opossums were numerous in a part of Hillsdale County in 1851. Mr. Lyman Hendrickson, a Lenawee County sportsman living in Adrian, writes that his father had heard of these animals occurring there about 1855 or 1856 (letter, May 19, 1942).

No records were found on the presence of opossums in Michigan from the late 1850's until 1897. Jerome Trombley reported in 1910 that none had been seen in Monroe County since 1865 (Wood and Dice, 1924). The father of Lyman Hendrickson mentioned an exceptionally severe winter which occurred sometime about 1860. This may have killed opossums, perhaps accounting for the long lapse in recorded observations of the animal in this state.

Wood and Dice, (1924) present evidence of the existence of opossums in Wayne County shortly before and after the turn of the last century. In 1898 they were reported there in some numbers. One was trapped near Trenton on December 1, 1900; in 1904 three others were caught in the same locality.

Mr. Marion Wagner, a veteran Berrien County trapper and fur hunter, says that the first opossum he ever saw was one trapped along Yellow Creek in Royalton Township, Berrien County, about 1897 (letter, April 8, 1942). He adds that in 1908 opossums were fairly numerous in a wooded area near the village of Berrien Springs.

Additional evidence of the early occurrence of opossums in Michigan is given by Wood and Dice (1924). It was stated that at one time there was a specimen in the museum of Michigan State College which was caught March 29, 1899, at Holt, Ingham County. The late Professor W. B. Barrows,

formerly head of the Zoology Department at Michigan State College, was reported to have had records of one taken in the summer of 1898 or 1899 at Shepherd, Isabella County, of one from Washington Township, Gratiot County, in 1905, and of another caught in the vicinity of Ottawa, Ottawa County, in 1911. E. R. Hawley said an opossum was caught in Bunker Hill Township, Ingham County, in 1906; he also reported one captured in 1910 in Leslie Township.

There now is an opossum in the museum collection at Michigan State College which was taken in 1903 at Dimondale, Eaton County.

An opossum was killed near Breckenridge, Gratiot County, in 1900. A fur dealer in Alma bought the pelt of another specimen from a trapper of Lakeview, Montcalm County, in 1910 (McCurdy, 1912).

Wood (1922) reports that a trapper caught an opossum near Ann Arbor on February 12, 1912. The same authority notes that another of these animals was taken in Washtenaw County, just south of the Oakland County line, in November, 1921.

Mr. Jed Meade, a trapper and fur buyer of many years experience who lives near Vandalia, Cass County, writes that the first opossum he caught was taken in 1912. He observes that the animals were scarce at that time (letter, June 2, 1942).

Mr. James Norris, a Grand Rapids fur dealer, states that he bought an opossum pelt in 1915 or 1916 near Baroda in Berrien County (letter, June 28, 1942).

In a letter, Mr. F. M. Packer, a fur dealer in Lawton, Van Buren County, writes that a trapper sold an opossum to him in 1915 (letter June 26, 1942).

Dice (1920) reports three opossums seen and one caught in Three Oaks,

Berrien County, during the winter of 1919-20. He further states that a specimen was found outside the village the same winter and that one was shot and another seen in the same vicinity the previous winter.

Evidence tends to show that while opossums were present in Michigan during earlier years, they were nowhere plentiful until about 1927 or 1928. There is a possibility that the animals were fairly numerous in some localities in the 1850's. Several references give this hint, but reliable data are too scarce for drawing any conclusions on the matter.

Recent Occurrence

Opossums began appearing in appreciable numbers in the southern counties about 1927 or 1928. Replies to questionnaires sent to a considerable number of trappers, and statements made by fur buyers in general indicated that was the time the animals first appeared in many localities where they had been long absent or where they had never been known to exist.

The state game laws first mentioned this fur bearer in 1929. In that year it was given protection except for an open season extending from November 1 to December 15.

During the 1928-29 trapping and hunting season, 994 opossum pelts were sold to Michigan fur dealers, according to records on file with the Game Division of the Conservation Department. For that period the greater number of opossums were reported by St. Joseph and Cass County buyers who handled 282 and 241 skins, respectively.

The number of opossums bought by local dealers during the 1929 season increased to 3,422. In 1930 there was a decrease in the take when 2,319 were reported purchased. Another increase was recorded for 1931, however, when 4,668 pelts were handled by Michigan buyers. These figures, of course, do not take into account the skins sold to out-of-state fur houses. Consequently the total catch for those years was greater than is indicated by these records.

During the season of 1928-29 the writer trapped in Benton Township, Berrien County and caught 10 skunks and 5 weasels. The first opossum the writer saw taken in Michigan was a specimen captured by

Jesse Garlanger in this locality in December, 1929. Opossums, in so far as is known, were totally absent from that neighborhood until about the time the animal cited above was taken. In November, 1934 the writer trapped in that locality again. Seven opossums and one weasel were caught. Trapping was also done there over a period of about two weeks in September, 1941 when six opossums were taken, five of which were collected for use in this study.

Beginning with the 1937-38 season and continuing to the present, trappers have been requested to note their catches on a report card provided with each license. These reports are to be sent to the Game Division offices and from them figures are compiled on the take of each species. The resultant data probably give a fairly good index on the status of the fur bearer populations. Since there never is a 100 per cent return of report cards, computations are made from those which are received. The computed kill for each species is attained by calculating on the basis of the reported number of trappers, the reported kill, and the percentage return of cards. For example, in the season of 1939-40, 344 opossums were taken by 54 trappers reporting from Cass County, giving an average of 6.33 per trapper. For that season 57 per cent of the report cards from all licenses sold were returned to the Game Division. On the basis of this, the computed number of trappers was 94. Multiplying this figure by the average catch made by each trapper reporting, the computed kill for that county was 599 opossums.

These compilations for the past five years were utilized in showing the opossum kill in counties south of the North Line of Township 16

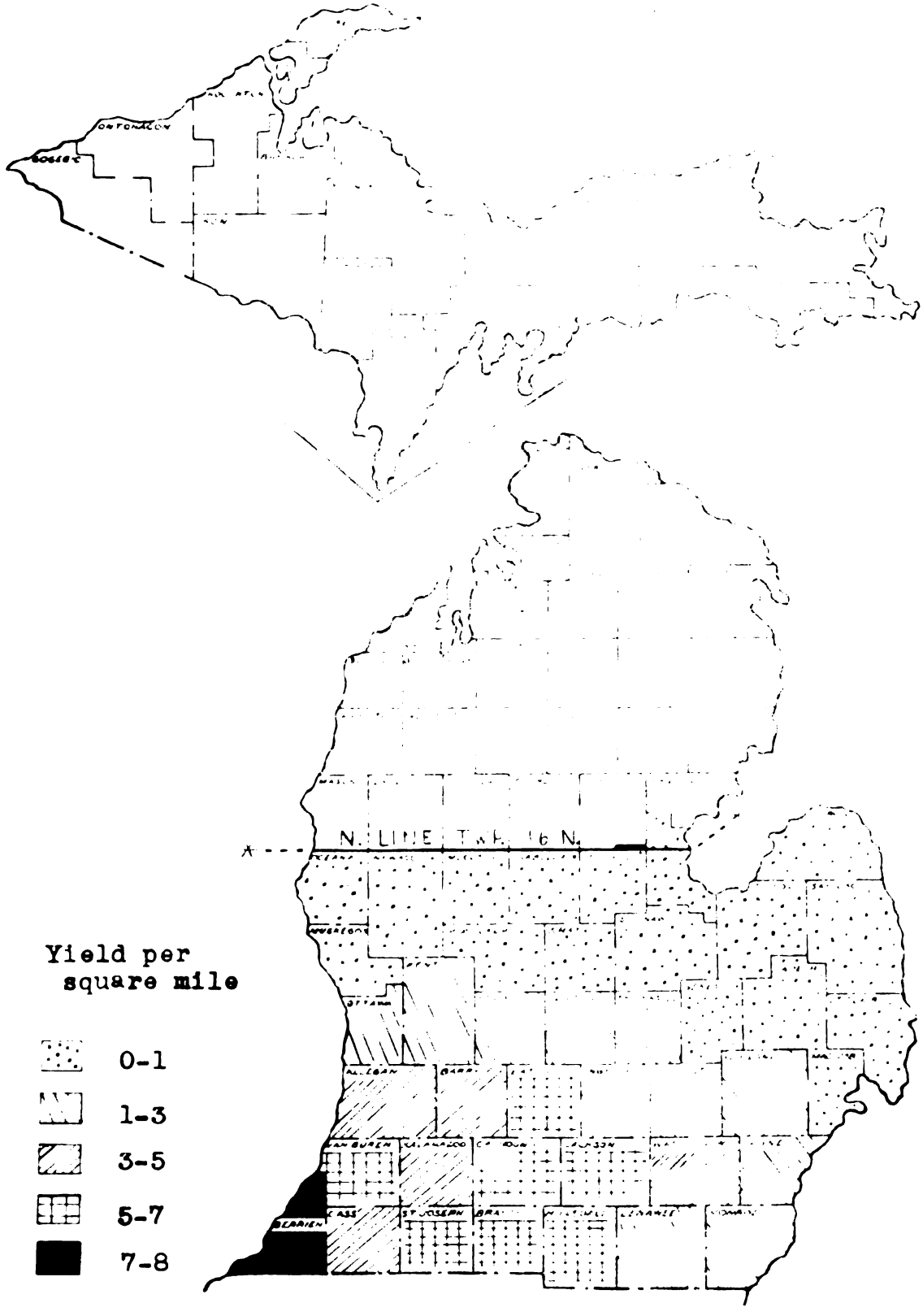
North. The results are shown graphically on Map I. This indicates the computed take per square mile in each county for a total of five seasons. The catch over that period ranged between the extremes of the 7.99 average per square mile in Berrien County to no yield at all in Bay County.

The computed opossum kill in the region lying south of the North Line of Township 16 North for each of the last five seasons was as follows: 1937-38, 13,793; 1938-39, 18,571; 1939-40, 13,189; 1940-41, 8,155; 1941, 10,608.

Opossums have appeared occasionally in the Lower Peninsula north of the North Line of Township 16 North, but records of their occurrence in that section apparently are few. Questionnaires regarding reports of occurrence were sent to the seven district headquarters of the Field Division of the Conservation Department in that region and to most of the Game Area Managers of the same area. Only seven records were produced.

Mr. Robert J. Furlong, Field Division Supervisor of District 8, wrote, "....one opossum was picked up on a county road at the south end of Burt Lake, by Lawrence Waldron, who operates a gas station there, on March 18, 1942. The tail and ears were frozen off." He added that one other specimen had been taken in south Emmet County previously and that he also knew of one found near Leer in northern Alpena County several years ago (letter, May 22, 1942).

Mr. Chester W. Bonney, Field Division Supervisor of District 13, stated that he had seen an opossum on the outskirts of Reed City, Osceola County, about 10 years ago (letter, May 14, 1942).



THE OPOSSUM KILL IN SOUTHERN MICHIGAN COUNTIES FOR A TOTAL OF FIVE SEASONS AS SHOWN BY TRAPPERS' REPORTS IN M 1937 T 1941

Mr. Mert McClure, Supervisor of District 11, gave the information that an opossum was killed by an auto northeast of Kalkaska, Kalkaska County, in 1930 and that another was caught on the west side of Higgins Lake, Roscommon County, in 1939 (letter May 3, 1942).

No particular record was produced by Mr. G. A. Fuehr, Field Division Supervisor of District 14, but he stated, "From personal observation, I have known this animal [opossum] to have been in Arenac County since 1930. He is still there and is occasionally seen by hunters and fishermen," (letter, May 7, 1942).

No reliable report of the opossum existing in the Upper Peninsula was found. Mr. Paul Hickie, until recently mammalogist with the Game Division of the Michigan Department of Conservation and who had been stationed in the Upper Peninsula for several years, informed the writer that he had never known the animal to occur in that part of the stat e (oral communication).

Fig. 1. The sprawling tracks of the opossum are often seen in mud along southern Michigan streams.

Why Has the Opossum Extended its Range?

To discover an explanation for the reappearance and significant increase of the opossum in northern latitudes within recent years presents an intriguing challenge. Questions relating to fluctuations in various animal populations have lately received considerable attention from ecologists, and although some conjectures have been drawn in attempting to explain these phenomena, it seems that little progress has been made to date. Insufficient evidence was found during the course of this investigation for formulating even so much as a tentative explanation of the marked increase of the opossum in southern Michigan in late years, although some facts appear to have a bearing on the question.

Whatever influence accounted for the significant rise in opossum numbers in Michigan about 14 years ago apparently operated in other northern states about the same time. The animals began exhibiting a noticeable increase in Wisconsin in 1927 (letter and unpublished data from W. E. Scott, Wisconsin Conservation Department, 1941). For several years thereafter the opossum became more abundant and extended its range northward in that state. The marsupial occurs in Minnesota and apparently has become more common there in late years (letter from V. E. Joslin, Minnesota Department of Conservation, May 4, 1942). The opossum lately has invaded new territory and increased in Connecticut (Goodwin, 1935).

Appearance of the animal in Vermont has been sporadic but most of the specimens recorded for that commonwealth were taken while the

species was extending its range in other northern regions (Osgood, 1938). Hamilton (1933) has presented evidence showing that the opossum has spread northward and increased in New York State within recent times.

The subject of artificial introduction deserves mention. Some replies to the questionnaires sent trappers suggested that the present establishment of the opossum in Michigan might be explained by importations. Mr. Harold Bordeau of Monroe writes, "I do not know how it /the opossum/ got around but some southern fellows told me they brought some from the south up here for pets and lost them," (letter, June 6, 1942). Remarking about the re-appearance of this fur bearer in Hillsdale County within recent years, Mr. L. C. Spencer of Jonesville says, "They claim that the negroes brought them here about 10 years ago and turned them loose," (letter, May 22, 1942). Several of the Conservation Department field men reporting on the occasional appearance of the animal in the northern part of the Lower Peninsula said that they supposed the opossums which were seen there had been brought up by people from regions farther south.

Mr. Herman Schneider of Benton Township, Berrien County, has informed the writer that he had three opossums sent to him from Arkansas sometime around 1930. They escaped from their pen shortly after they were received. The two sexes were represented by the group and my informant is of the opinion that these animals gave the species a start in that neighborhood (oral communication).

It is quite certain that importations led to the establishment of the opossum in California (Grinnell, Dixon, and Linsdal, 1937).

Physiographic barriers likely were the chief obstacles preventing its occurrence in that state before it was introduced by man.

Observations relating to weather conditions also deserve mention and the answer to the question may be bound up in that rather complicated maze of influences termed "climatic factors". Elton (1939) has said, "If we followed the subject of time-communities to its logical conclusion (which happily we shall not do, since it would involve a consideration of astronomy and the causes of the ice ages, and finally a discussion of the evolution of man), we should have to consider the larger periodic variations in climate from year to year, which undoubtedly exists, even though opinions may differ as to their exact cause and periodicity. For instance, in England there were severe droughts in 1899, 1911, and 1921. In the same way there have been extremely wet years, or very cold winters, all of which have enormous effects upon wild animals. These periodic variations in the climate and weather have chiefly an influence upon the numbers of animals by encouraging their increase, and therefore to some extent their distribution.

"The exact limits of the ranges of a number of animals are constantly shifting backwards and forwards, ebbing and flowing as the outer conditions change, and as the number of each species increase or decrease. We understand at present little about the precise causes of these fluctuations in range; but although the immediate influence at work may often be biotic, many of these changes are no doubt ultimately referable to short-period climatic pulsations, whether regular or irregular. For instance, in certain years there are great influxes

into the British Isles of various animals not normally found there, or only rarely."

Records compiled by U. S. Weather Bureau observers in Michigan were examined during this study but no marked deviations from the normal were found in the various data for years around the time the opossum began appearing here in appreciable numbers. It seems possible, however, that the record system is inadequate in providing applicable information in that it does not note some rather intangible facts which may have a bearing on the increase of the animal in this region. The writer admits that he does not know what these climatic "intangibles" are, yet it does not seem unreasonable, as Elton has suggested, that such factors exist. In this case length of continuous periods of low temperature or high temperature may be influential; snow depth and persistence of snow or the lack of it might have considerable importance. No data on these particular phenomena were contained in the climatic summaries on hand.

The previously mentioned observation that Michigan experienced a particularly severe winter sometime around 1860, together with the apparent lack of evidence showing the opossum existed here during a period of 30-odd years thereafter, suggest that weather conditions may exert considerable influence in determining fluctuations of its abundance in northern latitudes. It is interesting to note that opossums were either absent or else extremely scarce in Wisconsin during a period which very nearly coincides with the one in Michigan when the same condition obtained. A source from that state says, "It seems that opossum has always been with us but was never abundant. In the early days before 1848 it was more

common or as common as the present day, but they became scarce (probably because of severe winter kill) for a period of years between 1850 and 1900 approximately. After 1900 there is indication of increase again," (unpublished data compiled by W. E. Scott, Wisconsin Conservation Department, 1941).

That this animal is sensitive to extremely low temperature is often shown by Michigan specimens which have had their ears and tails frozen. Opossum catches have tended to decrease in this state in seasons following what were generally considered "hard winters". One of the latest studies of the 10-year muskrat cycle in Canada tends to show that some climatic factor controls the various fluctuations in population of cyclic species there (Elton and Nicholson, 1942).

Fig. 2. Michigan winters are not kind to the opposum. This one lost a part of its tail by freezing.

GROWTH

Methods

Data on opossum growth and related phenomena were obtained from specimens collected personally, from unskinned animals observed at fur buying centers, from carcasses which were saved by fur dealers, from trapping records, and from observations made on captive animals. Only little literature relating to the subject was found.

The specimens collected and held over for examination at a later time were preserved in a solution of one part 40% formalin to nine parts of water. A slit was made in the abdominal wall of each animal before immersion so as to insure rapid permeation of the preservative through the tissues. Before weighing, measuring and removal of the digestive tracts, the carcasses were taken from the formalin solution and immersed in water for at least 20 hours. At the end of this or a slightly longer period they were removed from the water, placed in a dissecting pan in such a position as would allow the greatest quantity of liquid to run off, and were drained for two hours. At the end of this time each specimen was weighed and in most instances the sex determined. Then measurements were taken of the total length, tail length, and length of hind foot. After this the digestive tracts were removed and returned to formalin solution to be examined later for food content.

Weights had been noted for 11 skinned specimens of average size before preservation and these were compared with readings taken after draining. No particularly significant difference was observed. Some weights remained constant while others showed a slight gain not exceeding two ounces.

Five specimens were weighed before and after skinning. The pelts registered an average weight amounting to approximately 26 per cent of the weight of the unskinned animals. The extremes of this proportion for the five specimens considered ranged between 23 and 30 per cent.

Measurements were taken on six opossums before skinning for comparison with measurements taken after treatment in preservative. When the skinned carcasses were re-measured at the time of removal from formalin, about two months after immersion, the lengths showed an increase; the body length, the length of tail, and hind foot all were affected. The increase in total length of the six specimens averaged 8.8 per cent. This raises the question as to whether formalin has the effect of distending animal tissues, at least those of the opossum.

Unfortunately, the techniques employed in obtaining the length data at the two different times were not exactly comparable, so it is quite possible that the deviation is at least in part due to error. The animals were measured both times with a cord having a minimum of "stretch" and the exact figures were obtained by transferring the cord to a rule. When the specimens were unskinned the total length was determined by stretching out each animal on its back and extending the cord full-length along the ventral side from the tip of the nose to the tip of the tail. The tail was measured by extending the cord from the upper base to the tip. Foot length was that from the back of the heel to the end of the longest claw.

When measurements were taken on the preserved carcasses it was

found necessary, in obtaining the total and tail lengths, to vary the procedure by establishing successive points with the cord instead of extending it in one continuous length. The distorted shapes the bodies had assumed during storage necessitated the use of such a method. The variation in techniques, then, could have conceivably introduced a source of error. There also is a possibility that the strain which the carcasses are subjected to during skinning may result in an increase of body length, but since the foot and tail measurements likewise showed deviations, this could not have been the only responsible factor.

It seems that the possible distending effect formalin may have on tissues deserves more thorough investigation. At this time there apparently is very little information available which concerns the subject. It has been observed that formalin swells brain tissue (Guyer, 1936). The data relating to the subject which this study revealed are too few and the likelihood of error too great for them to be of much value.

Other sources of information on growth included two litters of captive young which were observed for a period of over two months. Some data on the development of opossums in the wild were made available by live-trapping records compiled by the Conservation Institute of Michigan State College.

Size of Adult Opossums

Relatively little information is recorded on the growth of the opossum. Dr. Carl Hartman perhaps has contributed more knowledge than anyone else on the postnatal development of the species but this concerns mostly young animals. A few size records on adult specimens are available but reliable data are extremely scarce.

The size of opossums is often over-estimated. Reports of specimens caught in Michigan weighing as much as 15 and 20 pounds are frequently heard, but these claims probably are based on guesses rather than actual weights. The largest animal collected during this investigation was a male received from Berrien County. This individual had a skinned weight of 8 pounds, 2 ounces after preservation. If 26 per cent of the original weight is allowed for the pelt, the animal would have registered slightly less than 11 pounds when unskinned. No opossum has ever been seen by the writer which exceeded the size of this specimen, although many killed, unskinned animals were observed at fur buying stations. Indications of the old age of this individual were the unusually large feet and teeth, the latter being considerably worn. Much of the tail had been lost, evidently from freezing. Opossums larger than this specimen may occasionally occur in Michigan, but it appears very doubtful that they grow much larger. The greatest weight attained by any of seven captive adults was 10 pounds. All the animals gained weight while held in captivity.

Allen (1901) was of the opinion that there is virtually no differ-

ence in size between northern and southern animals. He says that the females are somewhat smaller than the males. An attempt was made in this study to learn if there is a size difference between the sexes.

Thirty-one unskinned specimens received from Kalamazoo County were weighed at Marcellus on November 21, 1941. The lot consisted of 21 females and 10 males. The resultant data are presented graphically in Figure 3. These tend to show that males in general are larger than females. Six males, or 60 per cent of the total of this sex, fell in the group including animals which weighed between $6\frac{1}{2}$ and $8\frac{1}{2}$ pounds, while only two females, or 9.5 per cent of this sex came within the same category. Ten females, or 47 per cent of the total, fell within the smaller weight range of $4\frac{1}{2}$ to $5\frac{1}{2}$ pounds.

Data on the body length of preserved specimens were also utilized in this analysis. The variation in measurements which resulted after skinning and preservation probably do not appreciably affect these results since all carcasses were subject to increases in length, and these were fairly constant between individuals.

The sex and measurements were determined on 40 of the preserved opossums. Seventeen were females, 23 were males. The records of these are plotted graphically in Figure 4. In this instance also the larger size groups showed a preponderance of males. Eleven, or 47 per cent, of this sex fell within the grouping between 500 and 549 millimeters. Only two, or 11.7 per cent, of the females were found here. Forty-one per cent of the females are tabulated under the category containing specimens measuring within the limit of 400 to 449 millimeters.

Variation in numbers of the two sexes in such groupings would make a difference and a variation existed in these instances. But it is believed that the value of the combined data has not been reduced by this factor since the predominance of sex was evenly divided in occurrence by group, that is, in one group females predominated in number while in the other males predominated. This condition evidently introduces a stabilizing effect. The total of each sex for both lots was 38 females and 33 males.

The fact that males predominated in the larger size groupings in both tabulations strongly suggests that a size difference does occur between the sexes. The limited number of specimens examined prevents the formulation of more definite conclusions.

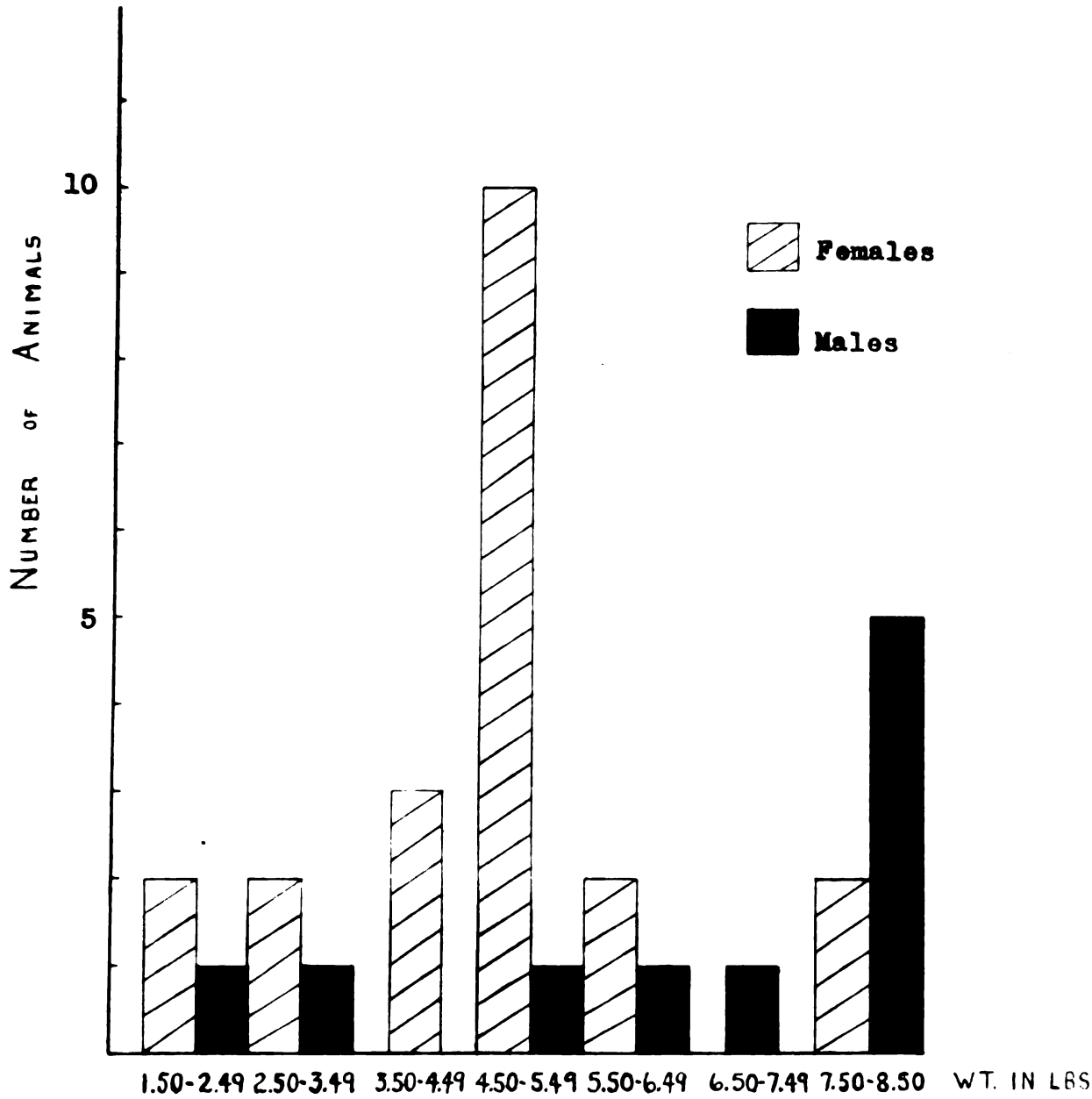
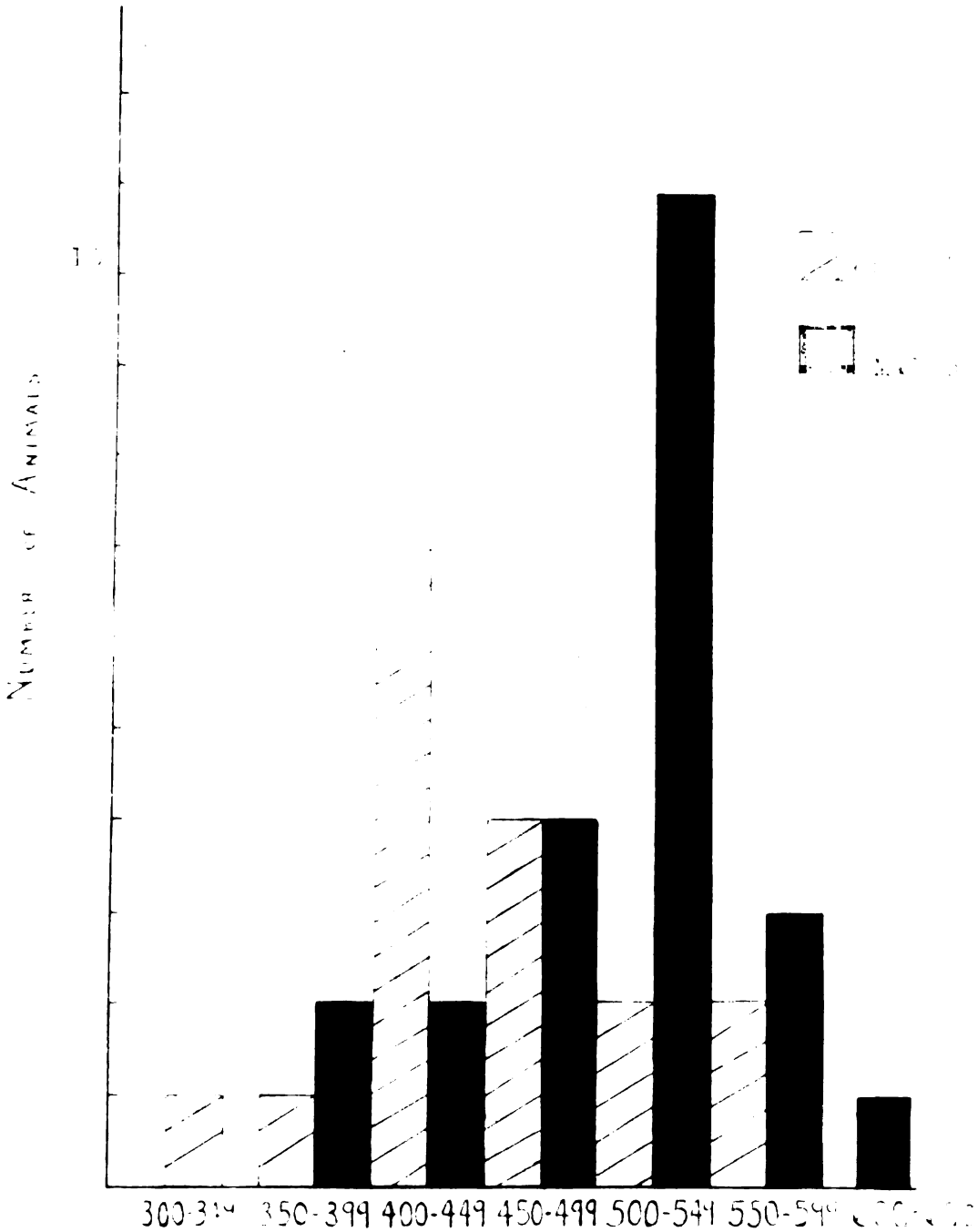


Fig. 3. DISTRIBUTION OF SIZE AMONG 31 OPOSSUMS AS INDICATED BY WEIGHTS


Number of Animals
300-349
350-399
400-449
450-499
500-549

Growth of Young Opossums

Two litters of young opossums were available for this study. A female carrying 12 young in the pouch was found caught in a box trap on May 3, 1942. Another female bearing 11 young was taken from a trap on May 10. Both litters were entirely dependent on the mothers when obtained, the individuals firmly attached to the teats, bodies naked, and the eyes unopened.

Daily observations were made on the young and the time when the eyes first opened was noted. The eyes are said to open sometime between 50 and 60 days after parturition (McCrady, 1938). On the basis of this calculation the litter of 12 was born within a period dating from March 30 to April 9 and was between 24 and 34 days old when received. The family of 11 was estimated to have been born sometime between April 5 and April 15, making it between 25 and 35 days old when acquired. The two groups will henceforth be referred to as Litter No. 1 and Litter No. 2, respectively.

One individual of Litter No. 2 was found dead in the pouch the day following capture. It apparently had not died long before discovery. Calculation placed the age of this animal between 26 and 36 days. Its weight was 7 grams, the total length, 86 millimeters, length of tail, 26 mm., and length of hind foot, 10 mm.

Weight records were kept on three young opossums from Litter No. 2 and on one from Litter No. 1. These specimens were marked for identification either by ear-clipping or toe-clipping and the animals were weighed at weekly intervals. Subsequently measurements of the tail and hind foot were taken at the time of weighing. Weight and measurement data on the four animals are listed in Tables IIIa, IIIb, IIIc, and IIId (Appendix).

Fig. 5. The opossum found dead in the pouch. Its size is shown in contrast with a 6-inch rule.

Fig. 6. The eyes of this 47-57-day-old opossum were still closed but a light coat of hair had appeared on the body.

Fig. 7. Weights were taken on marked individuals at weekly intervals. This specimen weighed 74 grams (2.6 ozs.) when between 60 and 70 days old.

The period of gestation in the opossum has been calculated to average 12 3/4 days (McCrady, 1937). At birth the young average 0.13 gram in weight (Hartman, 1928). The exceptionally small size of newborn opossums has been a subject of frequent comment. Hartman (1928) observes that an average litter might weigh as little as one-thousandth of the body weight of the mother.

Hartman (1928) has constructed a growth curve of the opossum for the first 56 days of its life. It shows a very gradual rise at the beginning, differing in this respect from the postnatal growth curves of most other mammals which start a rather steep climb not long after parturition. Commenting on the course of development shown by the opossum, Hartman says, "It will be seen that the growth curve thus far closely parallels the first part of the growth curve of other mammals and man. In other words, the opossum is still long after birth, to all intents and purposes, an embryo, although leading, as Doctor Meigs has grandiliquently put it, 'a chylopoietic, warm-blooded, oxygenating, innervating, and free-willing life.'" From this observation it is understood that the growth trend of the opossum corresponds with that of other mammals except that the early stage in the postnatal development of the marsupial is comparable to a part of the embryonal stage in most other mammals.

The weights of the four experimental young are plotted in Figure 8 and a growth curve is constructed for the average rate of development of the animals between the ages of 37-47 days and 99-109 days.

As it is to be expected, some variation in weight occurred between individuals of the same litter. These differences were not outstanding,

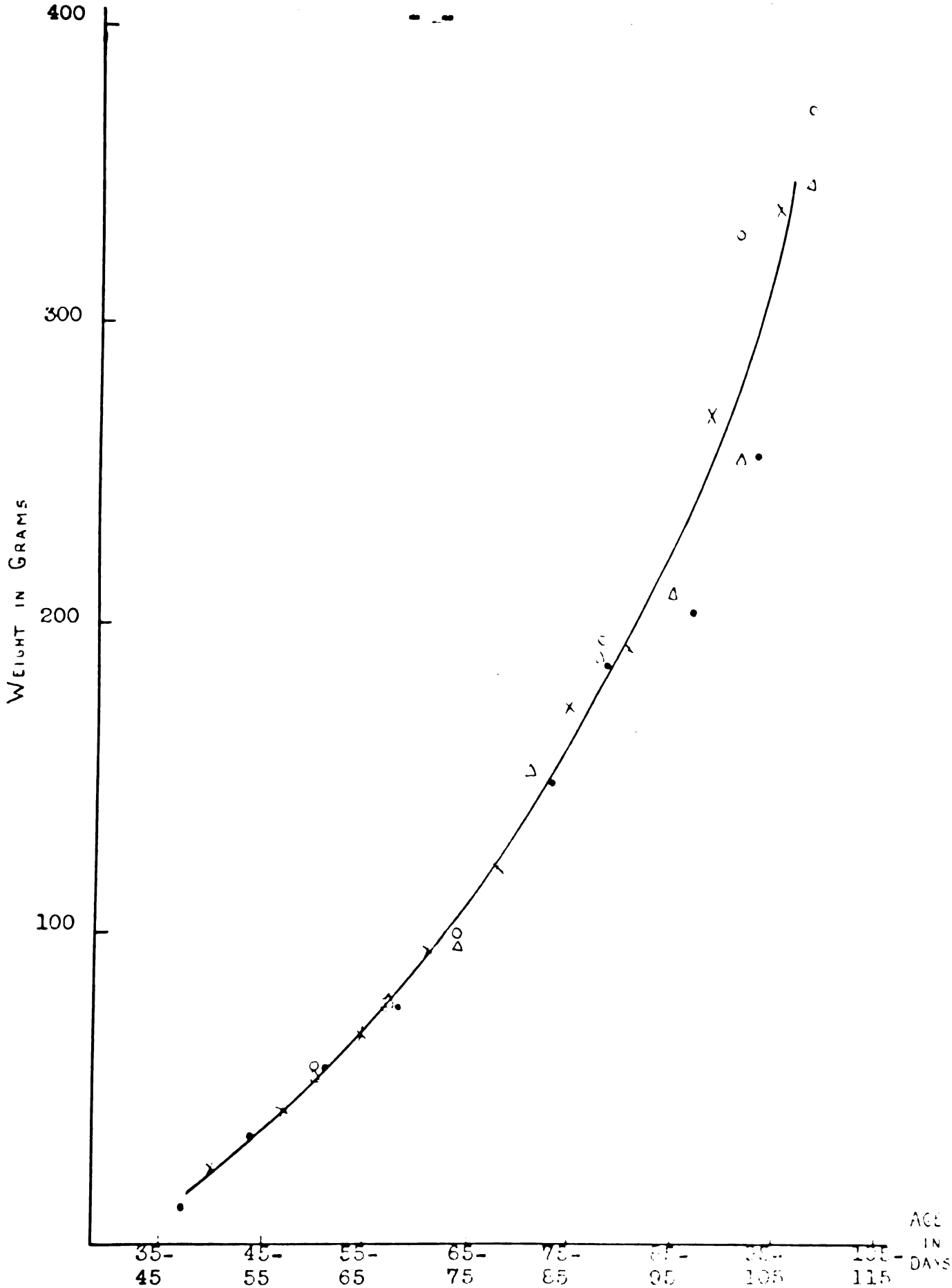


Fig. 8. GROWTH CURVE OF THE OPOSSUM BETWEEN 37-47 AND 99-109 DAYS

although they became greater as the animals grew older. Comparative weight data are listed in Tables IVa, IVb, and IVc (Appendix).

Some information on the later growth of immature opossums in the wild was available from live-trapping records compiled by the Conservation Institute of Michigan State College. These data were collected in 1941 as a result of operations carried on in Baker Woodlot on College land in Ingham County. The records are presented in Table V.

Measurements generally were taken on tail length and hind foot length of the four captive young at the time they were weighed. Length of tail noted was that taken along the dorsal side, beginning with the first caudal vertebra and continuing to the tip; length of hind foot is that from the base of the heel to the end of the extended longest toe. Tail measurements exhibited considerable variation between individuals; foot measurements were much less variable. Consequently it appears, that if measurements are employed in estimating the approximate age of young opossums, the hind foot length would be a better index than length of tail. Furthermore, there is less likelihood of error resulting from the former method since it requires some practice to determine the position of the first caudal vertebra.

Measurement data are included in Tables IIIa, IIIb, IIIc, and IIId (Appendix).

Fig. 9. Baby opossums have protection and find sustenence within the mother's pouch for many weeks after birth.

Fig. 10. A litter of nursing young. These had the eyes open, their age being somewhere between 58 and 68 days.

Sex Ratio

Little literature pertaining to the sex ratio of the opossum was available. No reference was found on the ratio between males and females shortly after birth. A count was made of the two litters of captive young and in both cases males outnumbered females. In the family of 12 juveniles there were 7 males and 5 females; in the family of 11 there were 8 males and 3 females. The two groups combined showed a male-to-female ratio of 1.87 : 1.

Several records were found on the sex ratio of adult opossums. Of 117 specimens live-trapped in Texas on an 86-acre plot over a 21-month period, 66 were males and 51 were females (Lay, 1942). This gives a ratio of 1.29 : 1. Trapping in Mississippi on the same territory during the usual trapping seasons in five successive years produced 65 male opossums and 77 females, (Yeager, 1937). This gives a male-to-female ratio of 0.84 : 1. A male-to female ratio of 1.31 : 1 was revealed by Missouri trappers' reports on 2,185 opossums caught during the season of 1934-35 (Bennitt and Nagel, 1937).

It would seem that trapping of adults cannot produce reasonably accurate data on the relative numbers of the two sexes unless operations are carried on over the same territory for a fairly long period of time. Disparity in degree of activity of male and female opossums at various seasons appears to exist. Audubon and Bachman (1849) observed this phenomenon. The laws of chance also are such that short-term records often give unreliable evidence.

Various trapping data relating to the sex ratio of opossums were gathered during this study. The value of these records is questionable because of the limitations just pointed out, but the observations will be noted here as a matter of record.

The six specimens caught during September, 1941, in Benton Township, Berrien County, were all males. These animals were taken with steel traps set on a plot of ground estimated to comprise four acres.

The lot of 31 unskinned opossums examined at Marcellus in November gave a count of 10 males and 21 females.

The sex was determined on 41 of the 49 specimens in the collection from fur buyers. Twenty-three of these were males and 18 were females.

Records of live-trapping operations conducted by the Conservation Institute of Michigan State College in Baker Woodlot at intervals during the past two years provide additional data on sex ratio. The animals taken were marked for later identification, so duplications were avoided. From August 8, 1940 to August 16, 1940, inclusive, four opossums were trapped and all were females. Over a period extending from July 11, 1941, to November 16, 1941 twelve different opossums were caught and the sex determed on 11. Seven were males and four were females.

Most animals whose secondary sex ratios have been rather extensively studied exhibit an unbalancec condition in the numbers of male and female young produced. In some invertebrantes this condition is quite marked, but in the vertebrates whose sex ratios have been observed this difference is not particularly outstanding (Crew, 1927). Among the mammals there is a general tendency for male births to outnumber female (Crew, 1927, Lush, 1938). On the basis of the more dependable data revealed by this

investigation it would seem that not only does the Virginia opossum produce a greater number of male progeny, but also that the resultant ratio may be greater in this marsupial than in any other mammal in which the phenomenon has been studied up to this time. However, the records are too few to serve as a basis for final conclusions.

Obviously the best method for determining the facts on this point would consist of making observations on large numbers of pouch young. The sexes of opossums can be differentiated by superficial examination beginning when they are between 10 and 14 days old, (Langworthy, 1932). In the case of captive stock, if any mortality resulted before this age was attained, dissection could be resorted to in making determinations.

Color

The matter of fur color is really outside the intended scope of this paper, but since a variation was observed among the captive stock which differed considerably from the usual color of opossums, it was deemed advisable that some attention be given the subject. It was noted that one of the females (the mother of Litter No. 2) had a darker coat of overhair than that generally possessed by Michigan opossums. Five of the young from this animal likewise were dark; the other five had the usual all-white overhairs.

The dark hue of the overhairs of the adult made the animal appear to have an over-coat of dark gray, verging on black. Closer examination of the hair, however, showed the colored distal half to be pigmented with brown. The pigmented and white parts were about of equal length, in some cases one and in some cases the other predominating slightly. The colored section was very dark brown, approaching black, for the greater part of its length, gradually fading out to a light brown toward the white proximal, or basal, end and at the tip.

The overhairs of the dark-colored young also were pigmented with brown. In these the colored part usually was proportionally longer than in the samples removed from the adult. A few white hairs were scattered within the coat. The dark individuals could be easily separated from the normally colored specimens.

Hartman (1922) notes that a black color phase is common in Texas opossums. He describes this type as having overhairs which are black for their entire length. He also says, "Dark gray specimens, for which

Fig. 11. A dark-furred and a normal colored young from Litter No. 2.

Fig. 12. This four-month-old animal became self-sustaining when about three months of age. Its weight was 659 grams (1 lb., 7 ozs.).

Bangs tried to set up a new subspecies (D. virginiana pigra), are often met with in this locality. No analysis of our dark grays has as yet been made, but they, too, are in a different class from the blacks." This authority further observes that he made notes on a Virginia opossum once in his possession which had "individual overhairs partly white and partly black."

Questionnaires sent to fur buyers asked for information on opossum colors. The replies in general indicated slight variations in shading had been observed but that this difference was not outstanding. Mr. L. V. Irwin of Constantine, St. Joseph County, stated he once bought a white opossum (letter, July 1, 1942). Hartman (1921) remarks about the occasional appearance of albinescent individuals in Texas. No report of black specimens caught in Michigan was received. Mr. H. J. Guntzviller, a fur buyer and taxidermist living at Northville, Wayne County, reports having observed some opossums with pelts which were of a "dark blue gray color" (letter, July 3, 1942). These may have been of the same phase as the dark-colored captive animals.

It is concluded that the dark opossums observed during this study may have either belonged to the dark gray color phase which occurs in the deep South or else represented a fluctuation or mutation which has not been previously described.

FOOD HABITS

Methods

Sources of data on the food habits of the opossum included 6 specimens collected personally in Berrien County in September, 1941, and 49 specimens gathered from southern Michigan fur buyers who received them during the hunting and trapping season which extended from November 1 to December 15, 1941. The fur-dealer collection represented the following counties and numbers of opossums from each county: Berrien, 2; Calhoun, 19; Cass, 8; Ingham, 1; Ionia, 3; Kalamazoo, 11; Shiawassee, 3; Van Buren, 2. Both stomach and intestinal contents of these animals were analyzed. Food analysis data from 86 opossums collected in southern Michigan in 1933 and 1934 were found on file at the Game Division offices of the State Department of Conservation. Mr. C. S. Williams, of the U. S. Bureau of Biological Survey, made the determinations. The information contained in these records was organized and is presented in this section of the paper. Few reliable sources concerning the food habits of the opossum were found in the literature.

The procedure adopted in making stomach analyses was as follows: The stomach was severed from the intestinal tract and the latter saved for examination at a later time. The field number and place of collection were noted on paper tags attached to these organs. The stomach was cut open with scissors and the contents emptied into a fine-meshed sieve. With the sieve held over a pan, running water from a faucet washed the material free from dirt, serving to make separation of the various inclusions less difficult. Before emptying the drain water it was carefully

examined to see that no sizeable food particles were discarded with it. Although some finely ground food was lost by washing, the volume sacrificed was never great. Since the same procedure was followed throughout the investigation, about the same percentage of material was lost from each specimen, and therefore it is assumed that no significant differences between specimens was introduced in the final volumetric determinations.

After the stomach contents had been washed, they were emptied into a small dissecting pan having a light colored bottom. Water was put in the pan so as to separate the various particles from one another and to make their identity more discernable. Then in good light the items were picked out with a fine-pointed forceps and each kind placed in a separate watch glass. When the separation had been completed, excess water was removed by squeezing the material between layers of paper towels. The volume of each item in cubic centimeters was obtained by the displacement of water in a graduate. The data were recorded on cards, one or more cards being kept for each specimen examined, and these were filed for future reference. Material which could not be immediately identified was put in glass vials for identification at a later time.

The intestinal contents were handled in much the same way as were those of the stomachs. The only deviation in method consisted of estimating the volumes of the various kinds of foods rather than taking separate volumetric readings. The material was examined in the dissecting pan and the percentage that each item comprised of the total volume was estimated. Then excess water was removed from the mass of material and its volume obtained. The estimated percentages were employed in convert-

ing the volume of each item into cubic centimeters.

While the more intensive methods used when examining stomach contents doubtless gave more accurate results, the extimated volumes of intestinal contents probably are fairly accurate. The majority of the stomachs were handled before the intestines were considered. By that time a facility had been developed for judging the approximate volumes of various items. At any rate, approximation of these volumes was deemed an adequate method of appraising them because digestive action has made volumetric data less significant by the time food material reaches the intestines.

In Tables I and II the findings are listed both as to volume and and as to frequency of occurrence. The volumetric figures are based on the bulk percentage of each item in comparison with the total volume of content from the group of a whole. The frequency figures represent the percentage of times that each item appeared in the specimens of the group.

Remains of mammals were identified mostly through the use of hair keys. Cross-sections were made of some hairs. These and medullary characters were examined under a microscope. Several keys and descriptive articles (Mathiak, 1938, Williams, 1938, Dearborn, 1939) were utilized while making determinations from hair characters.

Some bird remains could be readily identified by superficial inspection of feathers. Identification of domestic fowl usually gave no difficulty. That of wild birds, however, presented a more involved problem and very few determinations on these could be made by the writer. Feather keys have limited value in tracing the identity of specimens and they probably can be used effectively only by one who has had considerable ex-

perience at working with them. An attempt was made to have the bird remains identified by an ornithologist who has had experience in this field, but circumstances were such that he did not have an opportunity to undertake the task.

It was not difficult in most instances to identify the order of the insects, but mastication of this food was too thorough to permit any amount of more detailed identification.

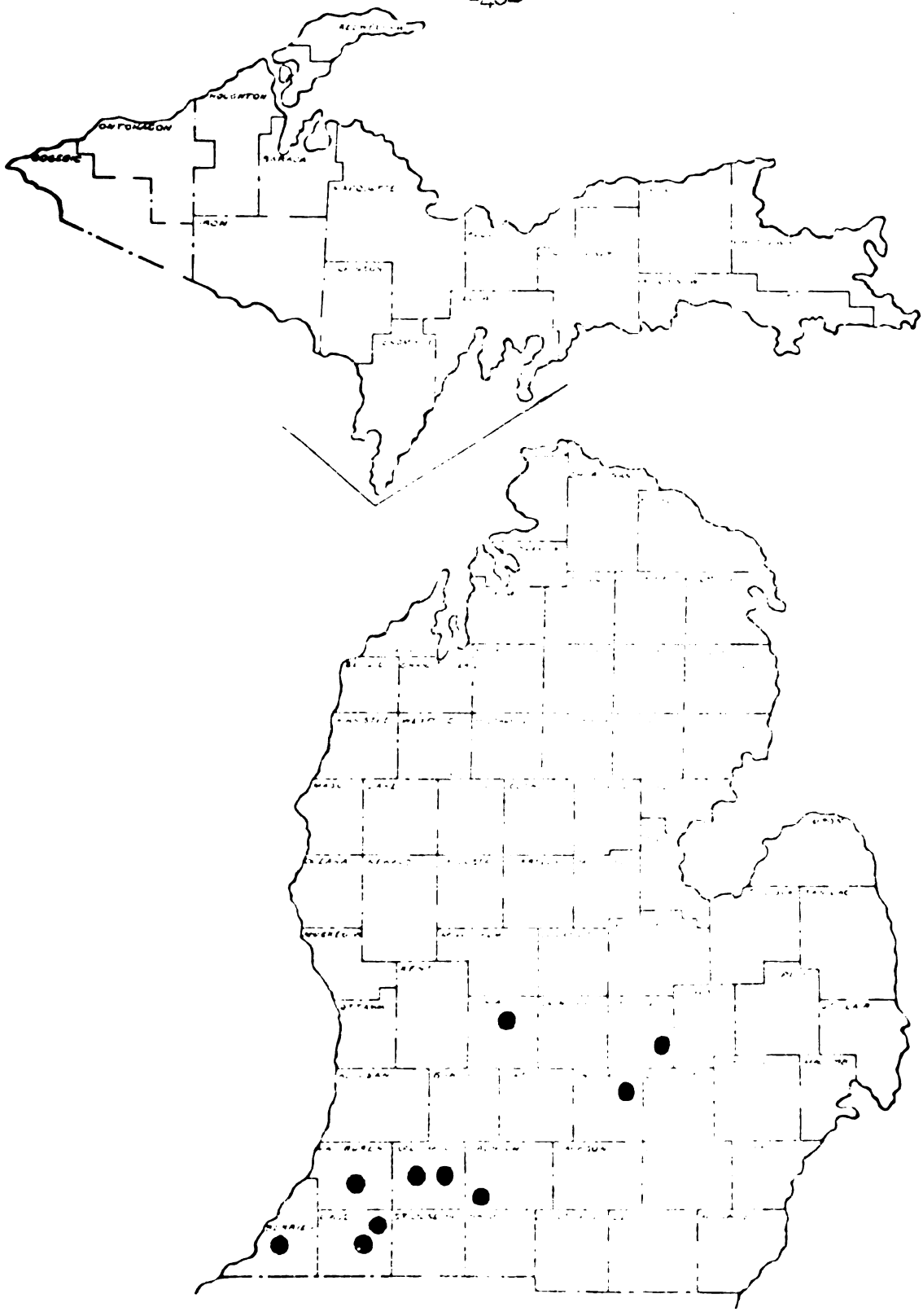
Fruit skins and seeds served as clues for the determination of most of the vegetative foods.

The opossum food analysis data obtained from the Game Division records concerned mostly stomachs, although intestinal contents were included in some cases and these were combined with stomach foods in the compilation. Apparently when these analyses were made the volume of each item was calculated on the basis of an estimated percentage. For this reason the findings of this work and that done by the writer obviously are not exactly comparable, especially in regard to the volumetric indices. The frequency indices of the two groups of data can be more accurately compared. Most of the specimens delt with in the Game Division records were taken during the same season (late fall) that the majority of specimens considered in this study were caught. Likewise the two lots were collected from virtually the same territory. The collection of 1933 was made from Branch, Calhoun, Cass, Kalamazoo, Monroe, St. Joseph, and Van Buren counties, most of them coming from Branch, Cass and St. Joseph counties.

The question may be raised as to what part of the food material dealt with in this study consisted of bait used by trappers. It is believed that

this source had little significance, if it contributed anything at all. The far larger number of opossums collected in 1941 had been killed by night hunters. Moreover, it has been observed by the writer that bait is seldom used by trappers of southern Michigan when making sets for terrestrial fur bearers. Meat is the only effective bait for these forms, and since there is too much chance in this section of catching cats and dogs in baited sets, these sets are not often made.

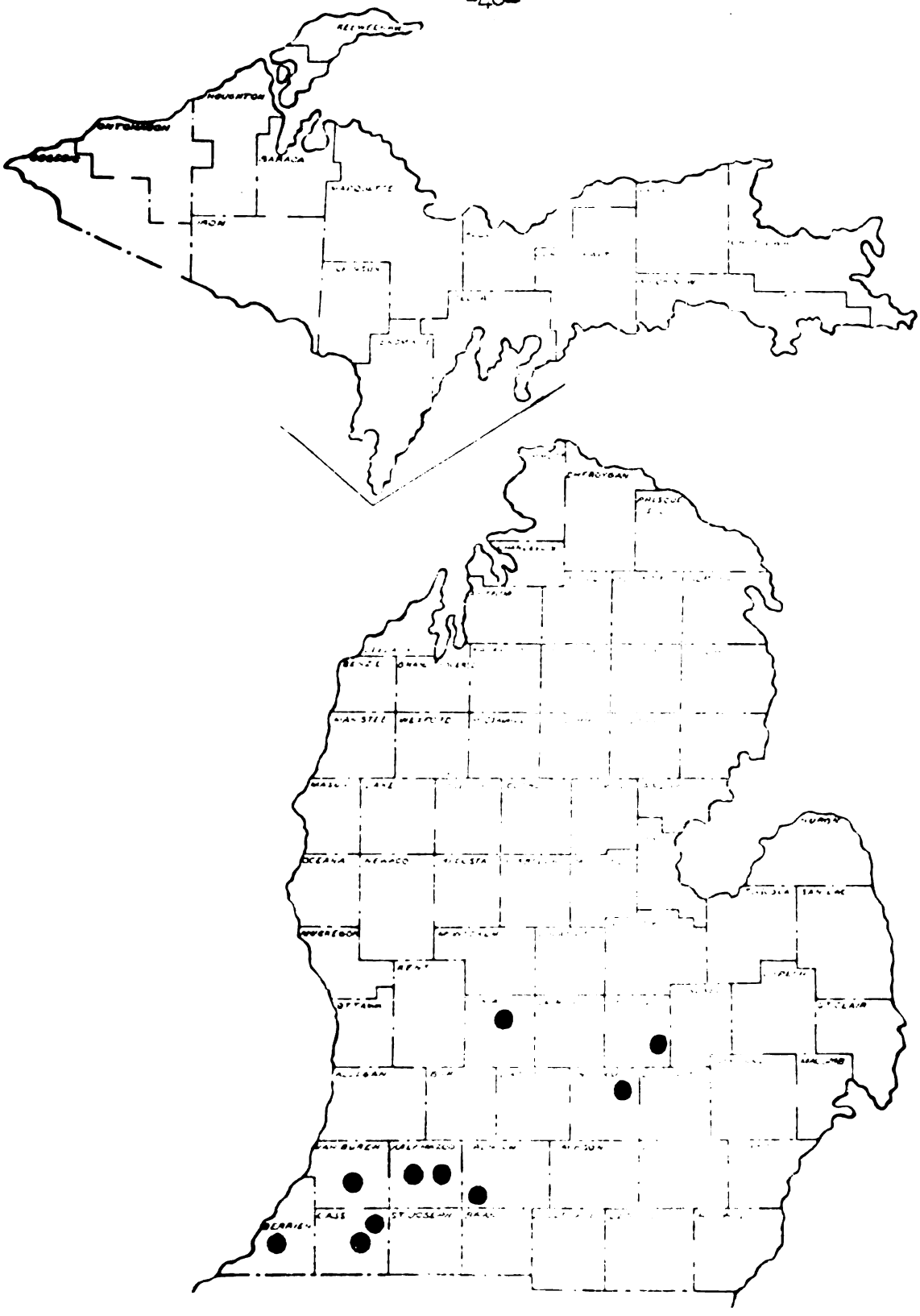
MAP II



POINTS AT WHICH OPOSSUMS WERE COLLECTED

FROM FUR BUYERS IN THE FALL OF 1941

MAP II



POINTS AT WHICH OPOSSUMS WERE COLLECTED

FROM FUR BUYERS IN THE FALL OF 1941

Food Habits of the Opossum

The predatory status of the opossum is a topic of frequent discussion among Michigan sportsmen. The usual contention is that this animal is highly distructive to more desirable species of game animals, especially the pheasant and cottontail rabbit. A small minority of persons has disagreed with this viewpoint, but when all things are considered neither side has had much support for argument because the food habits of the opossum have been given little study. It is generally known that this animal is an omnivorous feeder but a relatively small amount of information has accumulated on such matters as its food preferences and the quantities of the various kinds of foods it eats.

Of what work has been done on this problem over the country as a whole, evidently the greater share of it concerns Michigan opossums. In most instances, however, these investigations have been incidental parts of zoological studies mainly concerned with other objectives. To this category belong such contributions as have been made by Allen (1938), Haugen (1940), and Stuewer (1941) which present some pertinent and valuable data. Dearborn's work (1932) probably constitutes the most intensive investigation previously made on the food habits of the marsupial in this state. Analyses made in the Food Habits Research Laboratories of the U. S. Biological Survey on specimens collected in Michigan in 1933 and 1934 provide a valuable source of information. These findings, in so far as is known, have never been organized into form which would allow the facts to be readily interpreted, and for this reason they were given careful consideration in this study.

Animal Matter

Fifty-five stomachs from fall-caught opossums were examined in this study and of these 52 contained food. The collection represented 6 specimens caught in September and 49 caught in November and December, the greater number having been taken in November.

Of any single specific item, rabbit had the greatest volumetric significance (30.9%) in the 52 stomachs which contained food. Rabbit did not appear especially often (in 10 specimens) but when present it usually made up the bulk of the contents. One stomach, for example, held 72 cc. of this food, this volume exceeding by far the average volume of edible material which was found present in the individual specimens. Rabbit closely followed chicken in the order of greatest volume in the opossums collected in 1933.

Among animal matter, opossum comprised the next greatest volume (9.3%), but in this instance also the volumetric index, if considered alone, gives a distorted impression because these remains appeared in only four stomachs and 40 of 45 cc. were contained in a single animal. Data on the 1933 collection showed that opossum comprised 5.7 per cent of the total volume and occurred in five specimens. Dearborn (1932) notes that two-thirds of the 23.2 per cent mammal remains which were found in the animals considered in his survey consisted of opossum flesh. He interpreted this as having probably come from animals which had been trapped and skinned. However, opossums have been known to resort to cannibalism occasionally (Pray, 1921, Seton, 1929).

Over eight per cent by volume of all food material found in the stomachs consisted of earthworms.

These appeared in 13 different specimens to give an occurrence index of 27.1 per cent. This item comprised 4.6 per cent of the food eaten by the animals collected in 1933 and showed an occurrence index of 21.8 per cent.

Insects apparently have an important place in the diet of opossums. In the analyses made on stomach contents from specimens collected during the fall of 1941, grasshoppers made up 6.2 per cent of the aggregate volume and other insect remains and larvae helped increase the total for this class of food. Insects comprised 6.6 per cent of the food consumed by the animals collected in 1933, and were found in over four-fifths of the digestive tracts.

Apparently insects are eaten more often in summer. Dearborn's findings tend to support this view. These showed that insects constituted 16.7 per cent of the inclusions found in 40 opossums. Fourteen of these specimens were collected in July and August and the data, as noted above, revealed that this food composed a greater proportion of the entire contents of that group than it did in either of the two groups which were considered in this study. Lay (1942) found that 45 per cent of the contents of 16 opossum stomachs collected in Texas during the month of September consisted of insects and worms.

Mice appear occasionally in the diet of opossums. The results of this investigation show that Microtus sp. comprised 2.7 per cent and other mice 3.4 per cent of the total contents. Data on the 1933 collection revealed that mice as a group, including Microtus pennsylvanicus, made up 3.4 per cent of the total volume. Allen (1938) found that in 27 stomachs from Michigan opossums, collected principally in fall and winter, mouse remains

composed 6.4 per cent of the food. Seven of those stomachs contained mice and all the remains were those of Microtus sp. Stuewer (1941) noted the appearance of both Microtus sp. and Peromyscus sp. in opossum stomachs and feces.

Some of these rodents may have been carrion but it seems likely that opossums occasionally kill mice. Although slow afoot, the marsupial can be surprisingly quick in body movement, and since it apparently possesses a keen sense of smell, it may be fairly adept at mouse hunting. Mice were often fed captive animals and this food was ravenously eaten. Audubon and Bachman (1849) believed opossums helped check the increase of cotton rats in the South.

Chicken remains comprised a rather small portion (1.9%) of the total bulk in the stomachs of the fall-caught specimens examined by the writer. This food did appear more frequently and in greater volume in the intestines, though. A single specimen collected in the spring had its stomach gorged with chicken. Of any one specific item, chicken was found to possess the greatest volumetric significance (12.8%) in the 78 animals collected in 1933 by the Game Division; it appeared in 22 digestive tracts. Of eight spring-caught opossums collected by the Game Division in 1934, chicken showed volumetric and occurrence indices of 31.1 per cent and 37.5 per cent. Dearborn notes that domestic fowl composed a significant portion of the food taken by opossums considered in his study, but he states that this flesh consisted mostly of refuse discarded when chickens and other birds were prepared for human consumption.

Wild birds on the whole do not exhibit great importance as food of opossums judging from analyses made to date. In this study remains which

Fig. 13. Some observations on food habits were made with captive opossums. This animal was eating a mouse when the picture was taken.

were determined as belonging to wild birds comprised 4.7 per cent of the total contents of 52 stomachs and pheasant appeared in only one stomach. The category of "miscellaneous birds" in the 1933 collection composed 5 per cent of all foods eaten. This grouping included some domestic fowl other than chicken. No notation regarding pheasants was found in the data. Dearborn found that miscellaneous wild species composed about 8 per cent of the contents he worked with.

Moles are sometimes eaten by opossums. The analyses made in this study revealed moles constituted .8 per cent of the stomach inclusions. They were found in three specimens. These insectivores made up 4.8 per cent of the material in the digestive tracts and appeared in seven animals of the 1933 collection.

Allen (1938) mentions the discovery of shrew remains in an opossum stomach, but apparently these insectivores are seldom eaten. Shrews composed .6 per cent of the stomach contents examined in this investigation and .2 per cent of the food taken by the opossums collected in 1933. Short-tailed shrews were accepted on various occasions by captive animals.

Squirrels also are rather infrequently eaten by opossums. Fox squirrel hair and flesh were found in one of the stomachs considered in this study. Red squirrels and fox squirrels together comprised 2.2 per cent of the food of those animals collected in 1933 in Michigan. Stuewer's investigation (1941) of opossum food habits on the basis of 15 stomachs and 9 scats showed some remains of a red squirrel present.

Opossums eat skunk flesh. The only evidence of skunk found in this study was represented by a trace in one specimen. The animals

gathered in 1933 for the purpose of food analysis contained remains of this mustelid amounting to 3.7 per cent. The flesh appeared in the digestive tracts of five specimens. It is highly probable that skunks eaten by opossums are carrion.

Snakes are accepted as food by opossums, although their volumetric significance in fall-caught animals, at least, is small. Two small snakes were discovered in one of the stomachs examined by the writer and traces of another were found in the intestines of one animal. Only .03 per cent of the food from the opossums of the 1933 group was composed of this item. Dearborn observed that .05 per cent of the remains found in specimens he considered consisted of these reptiles.

Amphibians were represented surprisingly seldom among the things eaten by opossums which have been studied for their habits of foraging. Frogs, toads, and salamanders constituted 1.4 per cent of the inclusions found in the 52 stomachs. Salamanders and frogs comprised 3.5 per cent of the volume of the 1933 collection. Dearborn's compilation shows that frogs made up .3 per cent of the remains present in the specimens he studied. It seems possible that amphibians may be more often eaten in spring and summer when they are more available. Frogs offered captive opossums were avidly accepted.

Crayfishes were represented by traces in the stomachs considered in this study. Traces of these crustaceans were also found in the 1933 lot of specimens. This food comprised 12.6 per cent of the inclusions present in the eight animals collected in the spring of 1934. Crayfishes composed 3.5 per cent of the food matter in opossums analyzed by Dearborn. Lay (1942) found that this food constituted 3.3 per cent of the contents

in animals taken in Texas.

Some evidence of spiders and millipedes was noted in the digestive tracts of the 1933 collection. Neither form was found by the writer in any of the stomachs or intestines examined.

Mollusks in the form of snails and slugs are included in the opossum's diet. These items comprised 2.3 per cent of the inclusions found in the stomachs analyzed during this investigation. Dearborn lists snails as comprising .7 per cent of the volume of all foods discovered through his analysis. Lay found these mollusks made up 0.8 per cent by volume the contents of 16 stomachs.

A trace of fish was observed in one of the specimens of the 1933 collection and a small quantity of fish remains was found in one of the eight spring-caught animals collected by the Game Division in 1934. It seems almost certain that when this food is eaten by opossums it is carrion, although these marsupials have a pronounced liking for fish (Seton, 1929).

Indications are that opossums have a relish for bird eggs (Baile y, 1905, Allen, 1938). The charge is frequently made that the animals raid nests in poultry houses. Determinations on egg remains are among the most difficult to make, for it seems impossible to isolate egg inclusions with any appreciable degree of accuracy. Apparently very little shell is swallowed by opossums when they feed on eggs, which adds to the difficulty.

Small fragments of shell which apparently came from hens' eggs were seen in two stomachs examined during the course of this study. Evidence strongly suggested that in one case the shell was a part of household refuse which had been eaten. Traces of egg were found in the digestive

tracts of three of the 78 animals collected by the Game Division in 1933.

An attempt was made to study the reactions of captive opossums toward eggs. On various occasions pheasant eggs were put with animals and daily observations were made to see what had happened to them. Two specimens which occupied separate cages were the particular subjects involved in this experiment. These cages were situated outdoors, were constructed of woven wire, and were approximately six feed square and eight feet high. The reactions exhibited by each animal will be described in turn.

Four pheasant eggs were placed in a shallow metal pan and the pan set on the floor of the cage in which a single male opossum was kept. The pan was weighted with a stone. At the end of five days all the eggs were still intact and at this time two of them were removed for use in the experiment with another specimen. Two days later one of the two remaining eggs had been broken and the contents apparently eaten. The following day the other egg was broken and the crushed shell empty. Moderate amounts of other foods had been put in the cage during these trials.

A week elapsed before the experiment was continued with this animal. At the end of this period five pheasant eggs were placed in the cage in the manner of the others and some other food was included. By the following day all the shells were crushed and the contents evidently eaten. Four days later five more eggs were put in this cage together with four mice and an apple. The following day all the eggs were broken, the contents gone, and the mice and apple also eaten.

The second animal employed in this experiment was also a male. Two eggs were first put in the cage of this specimen and were placed as those which had been offered the other animal. At the end of the first day the eggs were intact, but 24 hours after that both were broken and the yolks and whites presumably had been eaten. These were replaced with two more which remained unbroken for two days. On the third day one shell was crushed and the other egg was still intact, although out of the pen. Two more eggs were put in this cage, making a total of three. Two of these were consumed, one each during two successive days.

Then five eggs were placed with this specimen and no other food included. Twenth-four hours later three of the five eggs were crushed. Two mice were put in the cage with the two remaining eggs. By the next day both the eggs and mice were eaten. After this five eggs were placed in the cage of this specimen on each of five successive days and all of them each time were consumed within successive 24-hour intervals, including other foods such as mice, apples, and dog food.

The results of these experiments tend to show that the egg-eating habit must be learned by opossums and that it takes some time for it to become well developed. Although eggs were broken and the contents evidently consumed by one of the experimental animals within the second day after the food had been offered, the breakage might have been accidental. This seems the logical explanation when it is considered that eggs put with this specimen following the initial trial were not broken for several days thereafter and also that eggs remained uneaten in the cage of the other animal for five days after they had been introduced. Development of the egg-eating habit would appear to be largely initiated by accident for

any individual opossum. If this be the case, it would seem that opossums cannot be considered a serious menace to eggs of wild birds since such chance breakages probably seldom occur.

Fig. 14. The crushed shells of pheasant eggs after the contents had been eaten by an opossum.

Vegetative Matter

Grape berries appear to be a favorite food of Michigan opossums in autumn. This fruit formed the greatest volume (9.5%) of any particular vegetative item in the stomach contents analyzed in this study. It likewise predominated within the vegetative class in stomachs and intestines of the 78 opossums collected by the Game Division during November and December, 1933. In these the volume comprised 6.8 per cent of the total contents.

Remains of apple were quite frequently found among the various foods eaten by fall-caught animals. This study revealed a considerably greater volume of this fruit present in the intestines than in the stomachs, which may indicate that it passes through the digestive tract more rapidly than many foods which have a more substantial consistency. Pear and peach fruits were occasionally found.

The most common of the wild fruits observed in the stomachs and intestines of the fall-caught opossums were poke berries. Some evidence of ground cherries was seen. Remains of elderberries and nightshade fruits appeared in the digestive tracts of animals collected in September.

Grass shows up frequently in the stomachs of opossums taken in the fall. This investigation revealed that 4.7 per cent of the stomach contents consisted of grass and that it appeared in nearly 70 per cent of the specimens examined. In many of these individuals, however, the quantity present was very small. In some cases grass may have been ingested incidentally, but the significant volumes present in some animals

suggest that it doubtless had been consciously sought by them. Whether this item is consumed mainly for its nutritive value or for other reasons is not known, but it seems more likely that it serves as an "accessory" food. Giles (1940) found that a considerable amount of grass was eaten by raccoons. He concluded that it probably was taken as roughage or as a tonic food.

Other vegetative material such as leaves, dry fruits, and weed seeds were present in the digestive tracts but the total volume of these inclusions was small. It seems probable that a considerable portion of these items were consumed incidentally rather than primarily for food.

TABLE I

Volumetric and Occurrence Indices of Opossum Foods as Shown by 55 Fall-caught Animals Collected in 1941

Food	Stomachs of 52 specimens collected in Sept., Nov., & Dec.		Intestines of 54 specimens collected in Sept., Nov., & Dec.	
	Volumetric indices	Occurrence indices	Volumetric indices	Occurence indices
Rabbit	30.9	19.2	14.6	22.2
Squirrel	1.0	1.9	0.4	1.9
Meadow vole	2.7	11.5	3.6	7.4
Miscellaneous mice	3.5	5.8	3.2	7.4
Skunk	trace	1.9	trace	1.9
Mole	0.8	5.8	1.7	3.7
Shrew	0.6	1.9	2.5	3.7
Opossum	9.3	7.7	4.4	5.6
Chicken	1.9	7.7	3.0	9.3
Miscellaneous birds	4.7	25.0	2.9	22.2
Bird eggs	trace	3.9		
Snake	0.4	1.9	trace	1.9
Salamander	0.6	1.9	trace	1.9
Frog and toad	0.8	3.9	trace	1.9
Grasshoppers	6.2	76.9	5.0	63.0
Bettles	0.1	19.2	trace	11.1
Miscellaneous insects	0.6	21.2	0.2	3.7
Crayfish	trace	3.9	trace	3.7
Snails and slugs	2.5	15.4	2.1	7.4
Earthworms	8.4	27.0	1.3	14.8
Unident. animal matter	6.4	9.6	7.8	16.7
Grapes	9.5	28.9	10.3	40.7
Apple	1.9	21.2	20.9	27.8
Pear	0.1	1.9	4.4	9.3
Peach	0.2	3.9	0.3	3.7
Pokeweed berries	0.5	9.6	5.4	27.8
Elderberries	trace	1.9	0.1	5.6
Ground cherry	trace	5.8	2.5	9.3
Nightshade fruit			0.1	3.7
Wheat and oats	trace	3.9	trace	1.9
Grass	4.7	69.2	1.7	46.3
Miscel. unident. veg.	1.8	11.5	2.1	9.3

TABLE II

Volumetric and Occurrence Indices of Opossum Foods as Shown by 86 Digestive Tracts from Animals Collected in 1933 and 1934

Food	78 species collected in Nov. & Dec.		8 specimens collected in Mar., Apr., May	
	Volumetric indices	Occurrence indices	Volumetric indices	Occurrence indices
Rabbit	12.3	39.7	trace	12.5
Squirrel	2.2	5.1		
Meadow vole	2.6	11.5		
Miscellaneous mice	0.8	6.4	4.3	37.5
Skunk	3.7	6.4		
Mole	4.8	9.0		
Shrew	0.2	2.6		
Opossum	5.7	6.4	10.9	37.5
Sheep	trace	1.3	2.1	12.5
Chicken	12.8	28.2	31.1	37.5
Miscellaneous birds	5.0	42.3	trace	25.0
Bird eggs	trace	3.9		
Snake	trace	9.0	6.4	37.5
Turtle	trace	1.3		
Salamander	0.7	6.4	0.4	12.5
Frog	2.7	12.8	3.9	25.0
Fish	trace	1.3	0.1	12.5
Insects	6.6	83.3	0.9	50.0
Millipedes	trace	11.5		
Spiders	trace	5.1		
Crayfish	trace	5.1	12.6	25.0
Snails	0.8	1.3		
Earthworms	4.6	21.8		
Unident. animal matter	4.2	14.1	18.0	37.5
Grapes	6.8	32.0		
Apple	0.9	29.5	1.0	25.0
Pear	0.6	1.3		
Raspberries	trace	1.3		
Pokeweed berries	0.6	15.4	1.9	12.5
Ground cherry	0.2	11.5		
Nightshade fruit	0.2	20.5		
Acorn	1.4	15.4		
Potato	trace	1.3	0.6	12.5
Wheat and oats	0.7	14.1	0.8	12.5
Corn	1.3	30.8		
Grass	0.1	52.6	0.6	12.5
Spruce needles	0.1	1.3		
Miscel. veg. matter	17.4	79.5	5.1	75.0

Discussion

Apparently animal foods occupy a much more conspicuous place in the diet of opossums than do vegetative foods. Of the 52 stomachs examined in this study, approximately four-fifths (80.9%) of the identified contents was animal matter. Vegetative matter comprised 16.5 per cent, and undetermined items, both animal and plant, made up 2.2 per cent. Intestine content analyses showed these organs held approximately equal portions of animal (52.7%) and plant (47.8%) remains. Differential digestion probably accounted for the rather pronounced difference in composition existing between stomachs and intestines. It appears that relatively more vegetative material resists digestion. On the basis of this observation is seems that stomach content analysis gives a more accurate insight into the food habits of an animal than do analyses of intestinal contents or fecal material.

Data on the foods of the 78 fall-caught opossums collected by the Game Division revealed that 69.5 per cent consisted of animal matter and 30.3 per cent was of plant origin. These figures correspond almost identically with Dearborn's findings (1932) in which the food remains were found to consist of 69.6 per cent animal and 30.4 per cent fruit. These two groups of data show a difference from the results obtained by the writer amounting to approximately 10 per cent by volume of animal foods and 14 per cent by volume of vegetative foods. Since some intestinal contents of the 1933 collection were included when volumetric determinations were made on those animals, and since Dearborn's material apparently included some scats as well as stomachs, these factors might

account for some variance, due to reasons stated above. Of course, variation in methods employed in determining volumes might also be responsible for a difference.

Data on the eight spring-caught opossums of the 1934 collection showed that animal remains comprised about nine-tenths (91%) of the total volume and vegetative matter about one-tenth (9%).

The captive animals showed a definite preference for animal flesh over fruit or other vegetative foods when both were offered at once, even though both were usually consumed within the time elapsing from one feeding to another.

Although the opossum is more carnivorous than herbivorous, it appears likely that any preference it may have for the various kinds of animal flesh is denied fulfillment more often than attained. The marsupial obviously is not equipped for being a proficient predator. It ranks low in the scale of intelligence; the distinctly predaceous mammals possess more than average animal intelligence. It is slow afoot; the predatory carnivores in general are swift afoot.

The opossum apparently more often eats what it can obtain rather than what it would prefer to have, and therefore its foraging habits probably are largely determined by the availability of food which can be easily acquired. Perhaps the great variety of things eaten by the animal indicates its limitations for satisfying preferences. The tables which list analysis data show the highly diversified character of the diet. The opossum truly is an omnivorous animal.

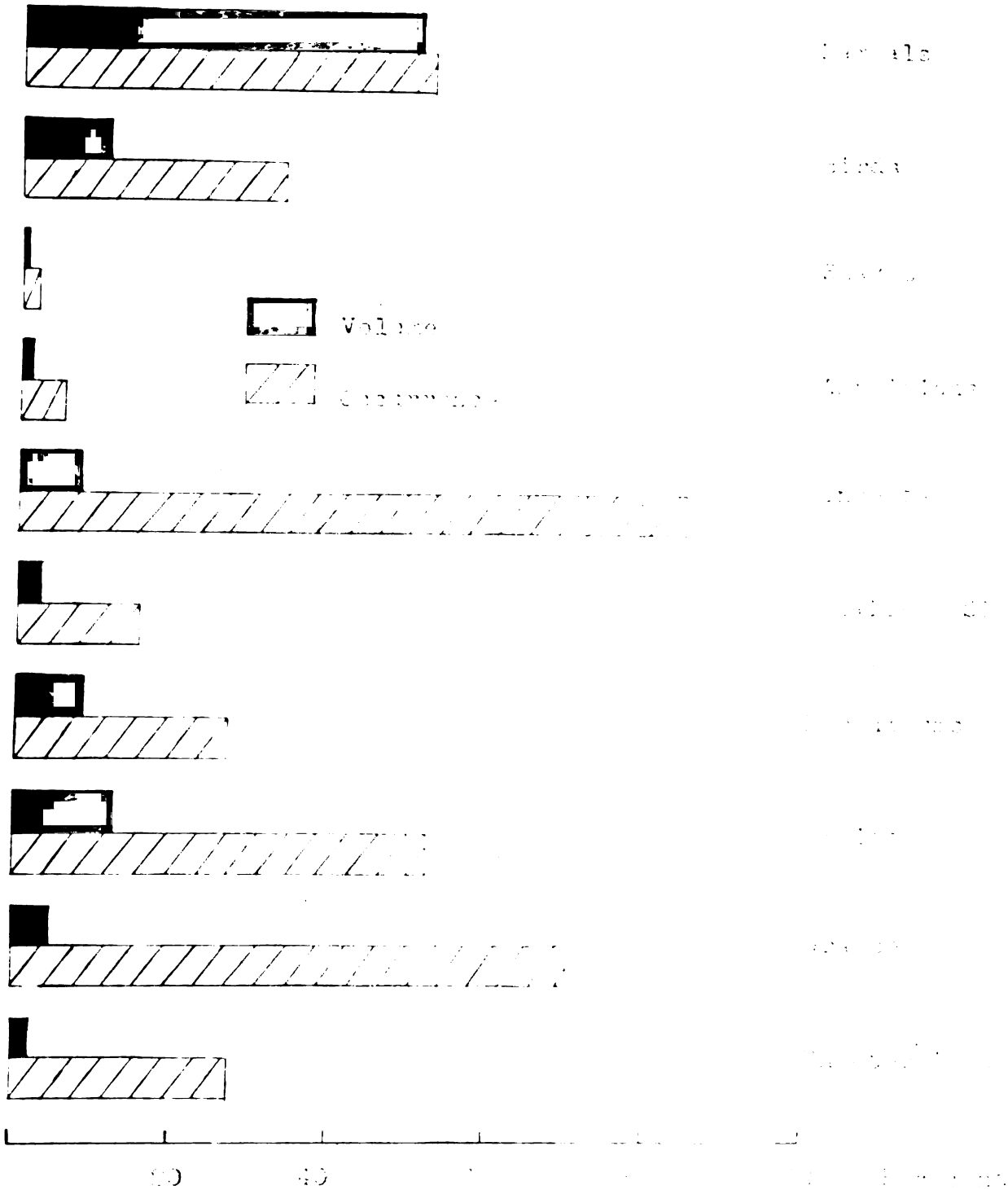


Fig. 15. VOLUMETRIC AND
OF FOOD EATEN

An Annotated List of Foods Eaten by

Michigan Opossums in Autumn

Cottontail Rabbit (Sylvilagus floridanus mearnsii)

Rabbit composed the greatest volume (30.9%) of any food found in the opossum stomachs examined in this study. However, its frequency of occurrence was not high. Flesh and fur were the main constituents present; relatively little bone appeared.

Cottontail rabbits are the most common upland game animals of the southern part of the state. For the section south of the North Line of Township 16 North, there was a computed kill of 2,127,219 rabbits for the 77-day season in 1941. This species is most plentiful in the southwestern and south central counties, where opossums likewise are most prevalent.

It appears likely that some of the rabbit remains found in the stomachs of the fall-caught opossums consisted of carrion. The legal hunting seasons on the two animals overlapped when most of the food habits material was collected for this study. A considerable number of rabbits are killed which are not recovered by hunters. Since opossums feed extensively on carrion, it is reasonable to suppose that these animals are quite often eaten by them. Rabbits frequently are killed by autos on roads, thereby affording another ready source of food. A study of predation on rabbits which was carried out in Michigan several years ago revealed very little positive evidence that opossums prey on cottontails (Haugen, 1940).

Fox Squirrel (Sciurus niger rufiventer)

Squirrel flesh was found in only one of the 52 stomachs analyzed. Fox squirrels are fairly common in many parts of southern Michigan. The computed kill of this species in the southern district of the state during the 21-day 1941 season was 506,332 animals.

Mice (Rodentia)

Mice, including Microtus sp., composed 6.2 per cent of the food in the stomachs examined. The remains of these rodents consisted of flesh, fur, and bones. The bones generally were broken into small pieces. Observations made on captive animals while they were eating mice showed that this food was mostly swallowed whole or in large pieces, but before ingested it was rather thoroughly chewed. Sometimes remains of mice could be grossly identified by superficial examination; at other times it was necessary to resort to hair keys. Specimens of Microtus were usually differentiated from other forms by the somewhat longer fur and by the curliness of the overhairs. No specific determinations were made.

Skunk (Mephitis mephitis nigra)

Skunk remains were represented by a small trace. Skunks formerly were quite numerous in southern Michigan, but within recent years their numbers have decreased considerably, presumably due to disease. There is no evidence showing that opossums will kill skunks. It seems probable that remains of this mustelid which are found in opossum stomachs

have come from animals which died from causes other than natural predation.

Prairie Mole (*Scalopus aquaticus marchrinus*)

Mole flesh and hair made up .8 per cent of the stomach contents analyzed in this study. Guard hair characters served to identify remains of this animal. The apical ends of these hairs possess a bulbous enlargement in which the medulla is almost completely lacking (Williams, 1938). One specimen examined contained a part of the head of a mole.

Shrew (Soricidae)

Shrews were found to have been eaten by two opossums. Hairs largely represented the remains of these animals, although a dentary bone with the teeth intact was also found. One of the two shrews was identified as *Blarina brevicauda*; a definite determination could not be made on the other specimen.

Opossum (*Didelphis v. virginiana*)

Opossum found in the digestive tracts consisted almost entirely of flesh and hair. As in the case of other animals of larger size which had been eaten, few bones were found among the inclusions. When small quantities of hair alone were present these were not regarded as a part of the food contents. Apparently the animals quite often pull fur from their own bodies, since traces of opossum hair were rather frequently seen.

It is known that opossums occasionally kill their own kind. But it seems likely that they more often feed on the flesh of individuals which are killed on highways or by hunters who do not bother to retrieve them.

Domestic Chicken

Chicken represented a rather small portion (1.9%) of the total bulk from the stomachs examined in this study, although other analysis data indicate that this food is taken fairly often by opossums. It was quite evident that some of the chicken remains discovered through analyses made by the writer were carrion.

Ring-necked Pheasant (Phasianus colchicus torquatus)

Pheasant, like chicken, comprised a small portion (1.9%) of the various foods found in the 52 stomachs examined. It was present in a single specimen. The infrequency of occurrence could in part be due to the fact that most of the specimens were collected in neighborhoods where pheasants are not particularly plentiful. Nevertheless, these game birds seem common enough even in those sections so that they should have appeared fairly often in the digestive tracts if they occupy a significant place in the diet of the marsupials.

The hunting season on pheasants extended into the first part of the opossum season in 1941. This fact would seem to increase the possibility of pheasant remains appearing in the stomachs which were analyzed because a number of birds shot by hunters are crippled and

make their escape only to die later, thereby serving as a convenient source of food for carrion eaters like opossums. Figures computed from hunters' report cards showed that 1,254,725 cock birds were taken in Michigan during the 21-day season in 1941.

Miscellaneous Wild Birds

Bird material consisted mainly of flesh. Few bones were seen and not many feathers. Determinations on this food were made chiefly by means of feathers attached to flesh. Bird remains which were thought to have represented wild species composed 4.7 per cent of the stomach contents. This total included the 1.9 per cent pheasant remains. Except for pheasant, no specific determinations were made on this material. Bird remains definitely of uncertain origin comprised 3.9 per cent of the contents.

Snakes (Serpentes)

Two small snakes were found in one of the stomachs of the fall-caught opossums. These were not specifically identified. Snakes are fairly plentiful in Michigan. Sixteen different species have been recorded in various localities of the southern half of the Lower Peninsula (Ruthven, Thompson, and Gaige, 1928).

Frogs, Toads, and Salamanders (Amphibia)

Amphibians comprised only .8 per cent of the total volume of stomach contents from the 52 specimens examined in this study. Frog or toad remains were present in two stomachs. These were masticated

to such an extent that it was only possible to determine that the fragments were those of either frogs or toads. The two salamanders which had been eaten by one opossum were in much better condition for identification and these were identified as Jefferson's salamanders (Ambystoma jeffersonianum).

Perhaps the relatively small volume of amphibian remains is accounted for by the possibility that many of the forms which ordinarily are available to opossums have begun hibernating by November.

Crayfishes (Cambarus spp.)

Crayfishes composed a rather small portion of the food material. Limited data indicate that this food is more often taken during the warmer seasons of the year. Crayfish found in specimens examined in this investigation consisted almost entirely of small fragments of chitinized parts.

Grasshoppers (Acrididae)

Grasshoppers compose a significant part of the food eaten by Michigan opossums. Despite the small size of these insects and considerable loss of volume due to mastication, they comprised 4.1 per cent of the total volume from the stomachs of 46 November and December caught animals. Thirty-two per cent of the remains found in the stomachs of six specimens taken in September consisted of grasshoppers. It is reasonable to suppose that these insects form a greater part of this animal's diet in summer when they are much more plentiful. Perhaps

grasshoppers appeared more frequently in these late-fall-caught opossums than they generally do in animals taken during that season. The exceptionally mild weather which prevailed during the fall of 1941 probably permitted the acridids to remain active for a longer time than ordinarily is possible.

Beetles (Coleoptera)

Beetle remains appeared in 10 of 52 stomachs. Their volumetric significance was low, in most instances apparently only a single specimen having been eaten. The presence of these insects was usually indicated by fragments of wings and legs.

Miscellaneous Insects

Evidence of bugs (Hemiptera, probably Pentatomids) were found in two specimens. Ants were present in two others. Larvae were more numerous, lepidopteran remains being most frequently represented among the immature forms. Besides these, one sawfly larva, two cranefly larvae, and one May beetle larva were seen.

Larval remains in most instances consisted only of the cases and their appendages, the fluid-like contents having been lost. Consequently the volume of these inclusions was small.

Snails and Slugs (Gastropoda)

Snails and slugs comprised 2.5 per cent of the stomach contents of the opossums considered in this study. No attempt was made to

determine the particular identity of the snails since few clues were available. In almost all findings the shells were absent; only the foot and a little flesh of the body comprised the available remains of most specimens. It seems likely that these were land snails rather than aquatic species. A. L. Winslow's "A Revised Check List of Michigan Mollusca" in 1926 noted that 104 native land shells and slugs occurred in the state. (Goodrich, 1932). Slugs had been eaten by one animal.

Earthworms (Annelida)

A considerable number of earthworms were eaten by the opossums observed in this study. The volume consisted of 8.4 per cent of the stomach contents. It would appear that the quantity of this food consumed is considerably influenced by the factor of availability. For example, the fall of 1941 was a particularly wet season in southern Michigan. During October the East Lansing Station of the U. S. Weather Bureau recorded an excess of rainfall above the normal for this month amounting to 4.86 inches. Excessive moisture increases the activity of earthworms above ground. From these facts it may be inferred that the annelids served as a more convenient source of food in the fall of 1941 than they do in seasons when considerably less precipitation occurs.

The pieces of earthworms present in the stomachs were mostly from large species, those which are generally referred to as "nightcrawlers". Two genera of these large forms are known to occur in Michigan, Helodrilus and Lumbricus.

Grapes (Vitis spp.)

Grape berries, both from wild and cultivated varieties, comprised the greatest volume of any fruit found in the opossum stomachs examined. Cultivated varieties were represented more often than was the wild species (Vitis vulpina). Grapes probably are grown in most localities of southern Michigan and in some sections they comprise the main crop. In 1941 Michigan ranked third among the 48 states in the production of this fruit.

Remains of this food consisted chiefly of seeds and skins. Occasionally the "meat" of the berries was found intact but more often it had disintegrated and did not figure in the volumetric determinations.

Apple (Malus spp.)

Apples apparently are quite frequently eaten by opossums, although their volumetric significance in stomachs was small (1.9%). Apple remains comprised the greatest volume estimated for any of the intestinal items, however. They composed over 20 per cent of these contents. Seeds and skin aided in identifying this material.

Apples are available in many localities throughout the fall and even into winter because usually a considerable quantity of the fruit is left unharvested. Michigan ranks high in the production of this crop.

Pear (Pyrus spp.)

Remains of pear fruit were found in the digestive tracts of several opossums but they made up a relatively small percentage of the total content. As in the case of apples, this item was found more consistently

and in greater volume in the intestines than in the stomachs. The skin with "stony" structures adhering to it served as evidence in the identification of pear remains

Peach (Prunus Persica)

Peaches comprised a very small part of the foods examined in this study, being present in the stomachs of two opossums collected in September. It seems possible, however, that this fruit is fairly often taken in season in those sections of the state where it is more commonly grown. The fuzzy outer surface of the skin was a clue leading to the identification of peach remains.

Pokeweed (Phytolacca decandra)

Evidently the fruit of the pokeweed is a favorite food of opossums. The blackish-brown seeds usually are still intact in the intestines, and the seeds served as the means of identifying the fruits from which they came. The volumetric significance of this item is greatly reduced by digestion. Only 0.5 per cent of the stomach contents examined in this study was composed of poke berries, but they made up over five per cent of the intestinal inclusions. The remains consisted almost entirely of seeds.

Elder (Sambucus spp.)

Remains of elderberries were found in the stomachs and intestines of only the opossums collected in September. The presence of this fruit in the alimentary canal at one time of year and its complete absence at

other times is indicative of those fluctuations in diet which are determined by food availability. In late summer and early fall elderberries are abundant and probably are often eaten by the marsupials. By November the productive season of the elders has passed and then something else must take the place of these berries.

Remains of elder fruits were represented by the yellowish white seeds with roughened surfaces.

Ground Cherry (Physalis spp.)

Fruits of the ground cherries are accepted as food by opossums. The pod which encloses the berry served to identify this material and usually represented the only part remaining which had any volumetric significance.

Grass (Gramineae)

Grasses generally occurred among the stomach and intestinal contents in the form of leaves and stems; roots were present much less often. This material showed few effects from digestive action.

ENDOPARASITES

Various endoparasites were found when the opossum digestive tracts were examined. Since the subject of parasitism is rather far removed from the main objectives set for this study, it was not thoroughly considered.

The writer does not know how opossums compare with other mammals in regard to susceptability to endoparasites, but the animals examined in this study seemed rather heavily infested. The more mature specimens generally contained more parasites than did younger individuals. Chandler (1932) observed that a series of opossums caught in the region about Houston, Texas, carried three species of flukes and four species of nematodes.

Nematodes were found in the opossum stomachs examined for food content. Only one specimen in 55 had no round worms in the stomach. A sample of this form was identified as Physaloptera turgida. Chandler (1932) notes that this species is very common in opossums and that it was absent from only one animal of a number examined in the vicinity of Houston, Texas.

Rather thorough counts were made of the nematodes occurring in several stomachs. The numbers found in these specimens ranged from 24 to 311. The animal in which the count of 311 round worms was made had its stomach the most heavily infested of any of the 55 fall-caught opossums. It was the largest animal in the collection. (See section on "Growth" for a description of this individual.) The nematodes observed in the stomach of this animal showed the following distribution in number according to length: 45-35 mm., 25; 35-25 mm., 46; less than

20 mm. long (mostly minute), 240.

Relatively few round worms of large size were found in the majority of the other stomachs. A far greater number might be regarded as minute (approximately 4-2 mm. long). These may have been of the same kind as the larger forms or some of them may have represented other species.

Parasites were observed in every one of the 55 intestinal tracts examined. Tape worms were found in five specimens and all specimens contained round worms. Round worms were in both the small and large intestines and usually were numerous. The caecum generally held an especially large number. A sample from the caecum was identified to the Order Ascaroidea. The tape worms were identified to the Order Cyclophyllidea.

Determinations on the parasites were made by Mr. Philip Hawkins, instructor in Parasitology at Michigan State College.

SUMMARY AND CONCLUSIONS

Occurrence

It is known that the opossum existed in Michigan as far back as 1845 and it is quite possible that it was here previous to that time. During the 1800's and early in the 1900's it apparently was not abundant, although there is some evidence that it may have been fairly plentiful in some localities in the 1850's. About 1860 opossums either became extremely scarce or non-existant in this state, presumably as a result of a severe winter which occurred around that time. No reports were found concerning the appearance of these animals in Michigan for 30-odd years dating from the 1860's. At about the turn of the present century their presence was noted again. Around 1927 and 1,28 this fur bearer showed a decided increase and continued to become more plentiful in succeeding years until today it is recognized as a definite part of the fauna in the southern part of the state.

No explanation has been demonstrated for the marked increase of the opossum in Michigan within recent years. Some people believe artificial introduction may have been a contributing factor. Climatic influences could have played a part. Whatever factors accounted for the phenomenon, they apparently operated in other regions too, because the marsupial extended its range and increased in various northern states during this period.

Perhaps the opossum may some day again become a rarity in Michigan. The suggestion offered by a few records which indicate that this fur bearer was once fairly numerous in the state and then disappeared lends

support to this view. It is evident that the species is vulnerable to extremes of low temperature. A particularly severe winter or a succession of them could conceivably take an immense toll and possibly bring about the animal's extinction in this region.

On the other hand, conditions in the physical environment might be such now that the species could survive such a catastrophe should it occur. Influences created by man may favor its survival and these might counter-balance decimating factors which could otherwise operate. Evidence shows that the opossum thrives amid civilization. The extensive agricultural development of southern Michigan appears to be of advantage to the animal. Improved farming practices favor some small mammals, and horticultural development, such as occurred in many parts of the state within a comparatively recent period, would appear to be of particular benefit to this mammal. If these assumptions have a basis of fact, then the opossum may continue as a persistent and common resident of Michigan.

Growth

Michigan opossums probably do not much exceed a weight of 11 pounds. The majority of the animals do not attain this size, somewhere between five and seven pounds apparently being the average weight. Evidence strongly indicates that males grow larger than females.

At birth the opossum is the least developed of any new-born mammal of those species which occur in the United States. Its weight at birth averages 0.13 gram. As an indication of the extreme immature development at parturition, the postnatal growth rate of the opossum

corresponds with that of the embryonal stage in most other mammals.

Available data tend to show that the secondary sex ratio of this marsupial exhibits a greater preponderance of male progeny than occurs in any other mammal whose sex ratio has been studied to date. However, the evidence at this time is too meager for definite conclusions.

Apparently color varies less among the opossums of this state than among specimens in the South, although slight variations from the usual phase have been observed in Michigan. One female and 5 of 10 young this animal reared had distinctly darker coats of fur than that possessed by most opossums.

Food Habits

Stomach and intestinal content analyses show that the diet of the opossum is varied. Evidently animal flesh is taken in preference to vegetative material. In the stomachs of fall-caught specimens the relative volumetric composition of each class was found to average approximately three-fourths and one-fourth respectively.

This study revealed that remains of mammals comprised over 50 per cent of the stomach contents in 52 specimens. Fruits (12.2%) composed the next largest portion. Then followed birds with 10.5 per cent and earthworms with 8.4 per cent. Predominating volumes of specific items made evident by this study probably can be largely explained either by the large size of certain units of food (as in the case of rabbit) or by accessability (as in the case of earthworms and grapes). On

the whole, the foraging habits of the opossum appear to be greatly influenced by the availability of foods which can be easily obtained.

A first glance at the analysis data might suggest that the opossum preys extensively on the rabbit. But when it is observed that remains of this animal appeared in a relatively small number of stomachs and that the size of the rabbit is such that it can contribute a large volume of flesh at one feeding, a new perspective is gained. To these observations may be added the facts that the marsupial eats carrion and that probably a considerable number of rabbits were available in the form of carrion at the time most of the study specimens were collected.

This paper does not offer a final estimate of the predatory status of the opossum. Such conclusions could be attained only after a year-round investigation had been carried out. In the case of rabbit, opossums collected in winter after the rabbit hunting season has closed and in spring and summer when the young are born could provide data which would go far in interpreting the interrelations of the two species. Yet despite the incompleteness of trustworthy evidence, it seems that the opossum is not nearly so destructive to the rabbit population as is so often maintained.

It is also charged that opossums prey extensively on pheasants. The evidence afforded by fall-caught animals gives almost no support at all to this claim. No reference was found regarding the discovery of pheasant remains in the 86 specimens collected by the Game Division of the Michigan Department of Conservation in 1933 and 1934, and only one animal of 55 examined in this study definitely contained pheasant. While perhaps enlightening, these findings admittedly cannot be considered conclusive. As in the case of the rabbit, here too a long-term

investigation would be required before a final answer could be given. It is possible that pheasant-nest predation is practiced by the opossum. A springtime study of the animal's food habits, including field observations, would determine if this is true and, if true, whether the damage is extensive enough to be significant. The fact that the pheasant population in Michigan showed a steady increase while opossums also were increasing, alone tends to suggest the falsity of the charge that opossums are highly detrimental to these game birds.

Dearborn (1932) noted that popular opinion was against all but three of the predatory fur bearers which occur in Michigan. The exceptions at that time were the raccoon, the badger, and the opossum. These he believed were tolerated because the raccoon is considered mainly a game animal and because the badger and opossum were too scarce then to attract much attention. Since that observation was made the opossum has become more numerous in the southern part of the state and it certainly has received a generous share of criticism.

The opossum has very few friends here now. Most sportsmen consider it a detriment. Some go so far as to suggest that not only should it be unprotected the year round, but a bounty ought to be placed on its scalp. Nevertheless, a few people take a tolerant attitude toward the animal. One hunter has said, "My opinion of the opossum as a fur bearing animal is that the fur is not so valuable but it furnishes some income. I enjoy hunting nights and if it was not for the opossum there would be lots of nights that we would not catch anything. The opossum does very little damage as I can see. I therefore consider them as an asset to Michigan."

Perhaps in time more people will take this attitude as the habits of the opossum become better known.

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APPENDIX

TABLE IIIa

Weights and Measurements of a Dark-furred Female Young from Litter No. 2

Approximate age in days	Weight Grams	Weight Ounces	Tail Length	Hind Foot Length	Remarks
37-47	13	½			Weight first taken May 22.
44-54	22	3/4			
51-61	36	1¼			
58-68	59	2	45 mm.	18 mm.	
66-76	--	--	--	--	Data not taken.
73-83	131	4½	95	28	
80-90	175	6	111	32	
87-97	202	7	136	35	
94-104	235	8¼	155	35	
101-111	268	9½	157	36	
108-118	323	11¼	184	36	Data last taken July 31.

TABLE IIIb

Weights and Measurements of a Dark-furred Male Young from Litter No. 2

Approximate age in days	Weight Grams	Weight Ounces	Tail Length	Hind Foot Length	Remarks
40-50	17	½			Weight first taken May 25.
47-57	27	1			
54-64	47	1½	57 mm.	21 mm.	
61-71	81	3	74	21	
68-78	113	4	85	27	
75-85	154	5½	110	31	
82-92	187	6½	137	34	
89-99	250	8-3/4	149	36	
96-106	325	11½	166	39	
103-113	429	15	193	42	Data last taken July 27.

TABLE IIIc

Weights and Measurements of a Normal-furred Male Young from Litter No. 2

Approximate age in days	Weight Grams	Weight Ounces	Tail length	Hind foot length	Remarks
50-60	36	1¼			Weight first taken June 4.
57-67	61	2	62 mm.	21 mm.	
64-74	93	3¼	73	23	
71-81	134	4-3/4	95	27	
78-88	181	6¼	131	31	
85-95	206	7¼	141	35	
92-102	236	8¼	173	38	
99-109	331	11½	184	41	
106-116	460	16¼	199	42	Data last taken July 30.

TABLE IIId

Weights and Measurements of a Normal-furred Female Young from Litter No. 1

Approximate age in days	Weight Grams	Weight Ounces	Tail length	Hind foot length	Remarks
50-60	37	1¼			Weight first taken May 29.
57-67	60	2	68 mm.	20 mm.	
64-74	100	3½	82	27	
71-81	--	--	--	--	Data not taken.
78-88	130	6¼	130	37	
85-95	--	--	--	--	Data not taken.
92-102	320	11¼	160	39	
99-109	351	12½	162	40	
106-116	449	15-3/4	176	44	
113-123	500	17½	203	44	Data last taken July 31.

TABLE IVa

Weights of Six Young Chosen at Random from Litter No. 1
When Between 60 and 70 Days Old

Sex	Weight	
	Grams	Ounces
Female	76	2.7
Male	74	2.6
Male	72	2.5
Female	72	2.5
Female	71	2.5
Male	66	2.3

TABLE IVb

Weights of Six Young Chosen at Random from Litter No. 1
When Between 99 and 109 Days Old

Sex	Weight	
	Grams	Ounces
Female	380	13.4
Female	351	12.4
Male	344	12.1
Female	331	11.7
Female	318	11.2
Female	314	11.1

TABLE IVc

Weights of the Ten Young from Litter No. 2 When Between 71 and 81 Days Old

Sex	Weight Grams	Weight Ounces	Color
Male	134	4.7	Normal
Male	131	4.6	Dark
Male	130	4.6	Dark
Male	126	4.4	Dark
Female	124	4.4	Normal
Male	124	4.4	Normal
Female	122	4.3	Dark
Female	119	4.1	Dark
Male	116	4.1	Normal
Male	114	4.0	Normal

TABLE V

Growth of Opossums in the Wild as Indicated by Weights of Live-trapped Animals

Sex	Date of 1st capture	Wt. in ounces	Date of 2nd capture	Wt. in ounces	Date of 3rd capture	Wt. in ounces
Male	4/29/41	12½	8/16/41	24		
Male	10/18/41	8	10/27/41	12		
Male	10/19/41	8	11/3/41	13		
Male	10/21/41	11	10/25/41	13	10/27/41	12
Female	10/25/41	11	11/3/41	12	11/16/41	15

TABLE VI

Reactions of Captive Opossums Toward Various Kinds of Foods

Foods accepted	Foods usually rejected, but occasionally eaten	Foods rejected
House mouse	Corn (mature, on cob)	Potato (raw and cooked)
Jumping mouse- (*Zapus h. hudsonius*)	Carrot	Celery
Norway rat		Lettuce
Cottontail rabbit		Red beets
Shrew (*Blarina brevicauda talpoides*)		Honeysuckle berries
English sparrow		
Eggs (pheasant)		
Snake		
Frog		
Pork and beef scraps		
Dog food		
Milk		
Bread		
Cake		
Candy		
Apple		
Pear		
Plum		
Strawberries		
Raspberries		
Orange (peeled)		
Grapefruit (peeled)		

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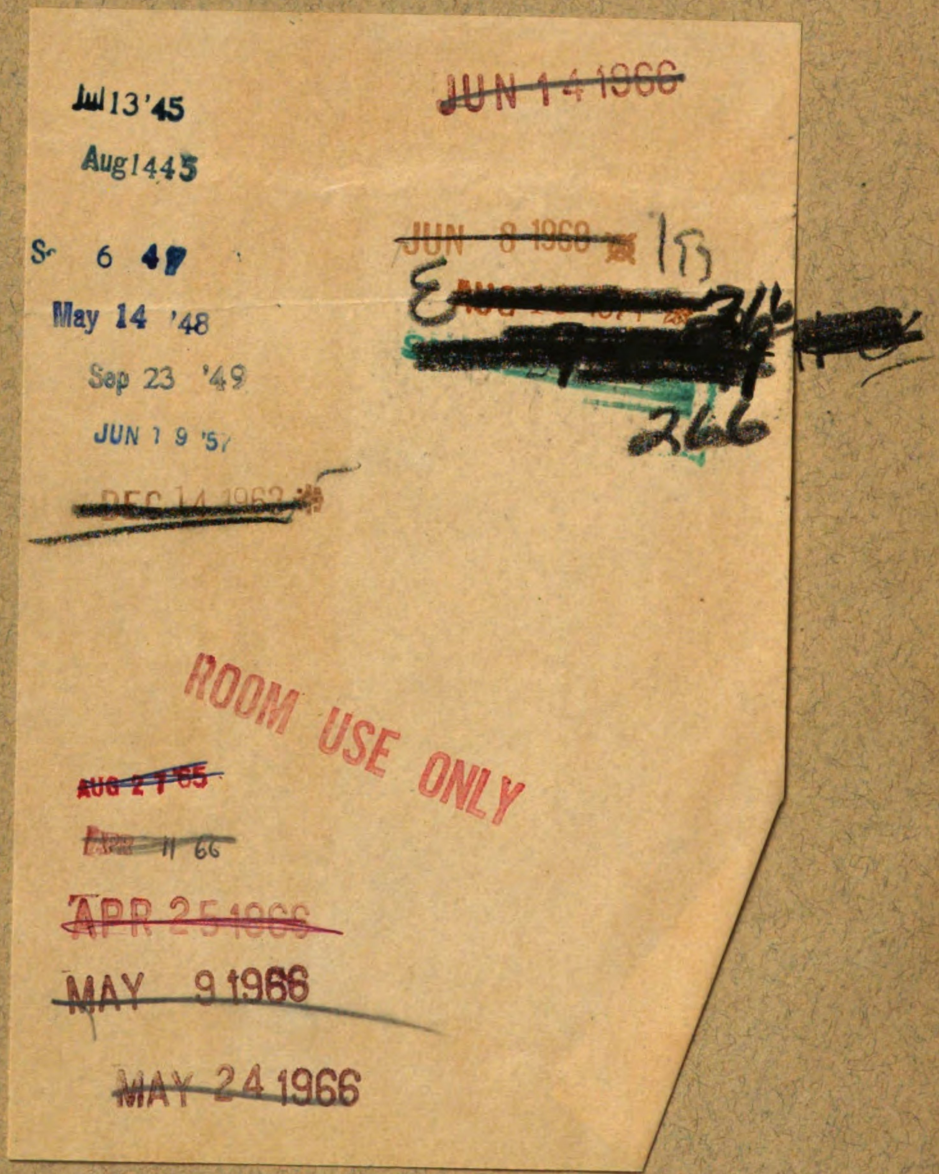

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