ECOLOGICAL STUDIES OF TURTLES IN
MICHIGAN WITH SPECIAL REFERENCE
TO FISH MANAGEMENT
BY
KARL F. LAGLER

Property of

Michigan Conservation Department

Institute for Fisheries Research

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INTRODUCTION

This report on the ecology and economic relations of the turtles native to Michigan is based on a combination of field and laboratory investigations and is one of a series of studies dealing with predation on fish in this state. Many researches have been conducted on physical, chemical, and biological features of fresh-water communities which determine fish yield, but few studies have been made on the role of predation in the dynamic economy of such associations. Although in fish management the control of predatory and so-called "noxious" animal species is widespread, current practices often have little basis or justification in known facts and are for the most part of unknown effect. It is the purpose of this series of investigations on the nature and extent of vertebrate predation on fish to discover the effects of this predation, to learn which, if any, "predators" are retarding the production of fish, to experiment with methods of controlling serious depredations, to establish "a clean bill of health" for the species so deserving, and to inform naturalists, sportsmen, and fish culturists of the ecological relations and economic status of the animals studied.

Feeling that a fundamental relation existed between predation and efforts in the conservation and upbuilding of the game-fish supply, Carl L. Hubbs, Curator of Fishes in the University Museums and then also Director of the Institute for Fisheries Research of the Michigan Department of Conservation, organized an investigation of this problem in 1930. "The services of J. Clark Salyer, II, then a graduate student at the University of Michigan, were obtained. After working on the problem for two years, Salyer withdrew to accept positions elsewhere, and since then he has been able to give but little time to the predator investigations. The information which had been accumulated at much effort and at a considerable investment of funds by the Department of Conservation and the University was consequently not brought to sufficient completeness to warrant its application to the solution of the predator problem.

"Realizing that it might be effective in carrying this research to the point of usefulness, the American Wildlife Institute came to the rescue, after consultation with Salyer and others. Through the financial aid of the Associated Fishing Tackle Manufacturers, a grant was made by the Institute to enable continuation of the work in Michigan. The State University furnished facilities for the work and the Department of Conservation through its Institute for Fisheries Research matched the fund allotted by the Wildlife Institute to further the investigation. This project was made the first to be undertaken under the initial Fish Management Cooperative Unit." (Lagler, 1937: 87)

Since Salyer had studied other suspected predators more thoroughly than the turtles, I chose this group of animals for my own intensive investigation. In addition to sharing the major purposes of the series of predation studies, the work on turtles has the following special aims:

(1) To evaluate various methods for observing and securing turtle specimens for scientific, control, and commercial purposes;

(2) To determine the population by species and individuals for a few sample lakes; and

(3) To develop and refine laboratory techniques for food studies of turtles.

At its inception, as has been indicated, the problem which I have investigated was primarily concerned with determining the effect of turtles on fish yield. As a result, the greater part of the work has been conducted on various phases of the natural history of the more abundant and aquatic species: the musk, snapping, Blanding's, ~~Bell's,~~ western painted, and soft-shelled turtles. Brief consideration has been accorded the less common, though aquatic, spotted turtle, and the more terrestrial wood and box turtles. The species in systematic sequence are as follows:

Musk turtle, *Sternotherus odoratus* (Latreille);
Snapping turtle, *Chelydra serpentina* (Linné);
Spotted turtle, *Clemmys guttata* (Schneider);
Wood turtle, *Clemmys insculpta* (LeConte);
Blanding's turtle, *Emys blandingii* (Holbrook);
Box turtle, *Terrepene carolina* (Linné);
Map turtle, *Graptemys geographica* (LeSueur);
Intergrades between Bell's turtle and western painted turtle, *Chrysemys picta*: *bellii* (Gray) × *marginata* (Agassiz);
Western painted turtle, *Chrysemys picta marginata* (Agassiz);
Soft-shelled turtle, *Amyda s. spinifera* (LeSueur).

The nomenclature followed is that of Stejneger and Barbour (1939) except for the genus *Chrysemys* which is after Bishop and Schmidt (1931), and Hartweg (MS).

The importance of this report is seen in its bearings on the conservation of a natural resource and in the clearer concepts which it brings forth regarding the status of an oft-maligned and persecuted group of animals. Food and feeding habits studies, correlated with determinations of population composition and density, afford an index for the evaluation of the role of turtles in the economy of the fresh waters of the northern states. Refinements in methods for the study of food and feeding habits of fish-eating vertebrates are given and contributions to the knowledge of the distribution of turtles in the area, habitat preferences, and relations with associated plants and animals are made.

Published information on the species of turtles native to Michigan has been freely drawn upon in the accounts of each species. In order to broaden the application of the conclusions, published data on the ecology of each species have been considered, even when based on observations made in other states or Canada.

The field work was conducted in Michigan from April through October in 1937 and from May through September in 1938 in conjunction with investigations on fish-eating birds and snakes. During these two summers, specimens and other materials were collected and subsequently analyzed at the University Museums in the winter of 1937-38 and in the winter and spring of 1938-39.

ACKNOWLEDGMENTS

I acknowledge with sincere gratitude the continued efforts and assistance of Professor Carl L. Hubbs, who initiated this project and the series of fish predator studies of which it is one, who has been largely responsible for the arrangements which make possible the completion of this study, and who has given great and invaluable assistance in the preparation of this report. Particular thanks are also extended Director A. S. Hazzard for help in planning the field work and for privileges granted in the use of equipment and records of the Institute for Fisheries Research.

Helen T. Gaige, who made available the library and collection facilities of the Herpetology Division of the

University of Michigan Museum of Zoology and helped trace uncertain literature references, and the late Frank N. Blanchard, who made several important suggestions during the early part of the investigation, have my gratitude.

I am especially obliged to J. Clark Salyer, II, who contributed the observations and food analyses of turtles which he had made prior to my participation in the studies of fish predation. Advice and ideas of value have been received from Salyer and from other leaders in the wildlife field, particularly from Aldo Leopold, Paul Errington, W. J. Hamilton, Jr., and Miles D. Pirnie.

I greatly appreciate assistance given me by many others. The following members of the staff and field parties of the Institute for Fisheries Research have contributed specimens of turtles and other records: J. W. Leonard, David S. Shetter, R. W. Eschmeyer, W. Fenton Carbine, Walter R. Crowe, William C. Beckman, O. H. Clark, H. Telford, and J. T. Wilkinson.

Specimens or help in securing specimens were given also by W. G. Irwin, M. Lepird, J. Smejkal, E. Bixby, H. Bradley, Anne L. Peacock, and H. Schulz. Employees of the Field Administration and Fish Divisions of the Michigan Department of Conservation collected many specimens and aided in the field work.

Several specimens, as well as instruction in the care and handling of traps and other information, were given me by R. A. Peacock, a professional turtle trapper of White Cloud, Michigan. N. E. Hartweg gave suggestions on methods for collecting specimens and verified the system of nomenclature followed for the turtles in this report.

Director M. D. Pirnie volunteered the use of facilities of the W. K. Kellogg Bird Sanctuary for experiments on food selection and aided in securing specimens. R. M. Stow cooperated in these experiments at the Sanctuary and helped in other ways.

Josselyn Van Tyne, Thomas Hinshaw, and Milton B. Trautman aided in the identification of bird remains. Ruth Marshall determined the water mites and J. W. Leonard most of the aquatic insects and their larvae. Calvin Goodrich and Henry van der Schalie are responsible for the specific determinations on most of the molluscs. Karl E. Goellner identified the amphipods and many of the decapods and I. J. Cantrall, the Orthoptera. C. L. Lundell and M. A. Gleason assisted in the determination of some of the higher aquatic plants and G. W. Prescott identified the algae.

Laura C. Hubbs was very kind in facilitating work in the laboratory by making readily available all materials and equipment needed. William C. Beckman, David Anderson, Frances V. Hubbs, Grace Orton, and Myrtle M. Moffett assisted in the laboratory during parts of the investigation. Help in the preparation of the manuscript was given by Frances V. Hubbs, Katherine Delos, Walter Donnelly, Ralph Hile, Rosalie Lagler, Mary Jane Manchester, Jerome Watts, and Grace Wood who also did the final typing. Vera M. Andres cared for much of the secretarial and administrative detail of the project. Arthur Greenberg and Alice Kornat executed various duties under the auspices of the National Youth Administration.

To these individuals and organizations and to many others, unfortunately too numerous to mention here, I extend my sincere thanks for support and cooperation. Without their help this study could not have reached its present stage of completion.

METHODS

The phases of the ecology of Michigan turtles which I have investigated were largely selected for their value in determining the economic relations of this group of animals. The methods employed were chosen to yield the maximum amount of information pertinent to these relations. Consequently the general methods fall into three major categories: (1) field methods for the study of habits, habitat selection, distribution, kinds and availability of food, and methods of securing specimens for food analyses; (2) laboratory methods for the analysis of food contained in stomachs and intestines; and (3) experimental methods for determining food selection, feeding habits, and population composition and density.

The results of the application of the field and laboratory methods described in this section, as well as the methods and results of feeding experiments, are given in connection with the discussion of the habits and food of the species to which they pertain. The results of the studies on turtle populations are mentioned briefly only in the interpretation of the food of the snapping turtle on natural waters. A detailed report of this aspect of the work is in preparation and will appear elsewhere.

Field Methods

Turtles on land were frequently observed by the naked eye or with the aid of binocular field glasses. Such individuals were, of course, collected by hand.

The more strictly aquatic turtles and the associated flora and fauna were observed during the day with the aid of a glass-bottomed tube and "Polaroid" sun glasses. By these means the perception of submerged objects is greatly enhanced, through the elimination of the interference to vision caused by ripples and surface glare.

At night, observations of turtles were made possible by the use of a modified automobile spot light manipulated by hand and a specially designed, under-water jack light. Both of these lights are superior for this purpose to the ordinary flash light since they furnish not only a more intense light but also a far greater area of illumination. They have a possible disadvantage in that a six-volt storage battery is required for their operation.

The automobile spot light, equipped with a fifty-candlepower bulb, was very useful for identifying and following detailed movements of turtles, their prey, and other organisms.

The under-water jack light, designed and built by H. Hatt of Almena, Michigan, is a distinct improvement over the ordinary types of such lights which were tried. Its distinctive feature lies in the fact that during operation the bulbs and reflector are submerged just beneath the surface of the water. There is therefore no glare from the water's surface to obstruct one's vision, and visibility is good even when there are ripples on the surface.

Specimens of the aquatic turtles were collected for this study by shooting, scapping, gaffing, spearing, "noodling," and trapping.

Although some turtles were shot in the water, shooting is perhaps best suited for obtaining specimens which are sunning themselves on logs, muskrat houses, or other such places. Though larger turtles often remain where hit, smaller ones are frequently knocked from such sunning spots by the impact of the bullet. As recognized by Ruthven (1912), individuals which fall into the water, unless instantly killed by the bullet, are sometimes lost, since they quickly hide themselves in soft bottom material or dense vegetation. In deep rivers, losses were also due to the current. For example, on May 2, 1937, on the St. Joseph River near Mendon, only five map turtles were recovered of twelve which were shot while sunning on logs. Since this method entailed such a consistently large loss of individuals, it was seldom used. Nevertheless, at least a few examples of each of the aquatic species except the musk turtle were collected by this means; Blanding's, map, and painted turtles were shot while they were basking on objects out of the water, and the snapping and soft-shelled turtles while they were floating at some distance from the shore with their heads out of the water.

Scapping with a long-handled dipnet yielded some specimens. This method was used from a rowboat and while wading. Pearse (1923) found this means satisfactory for securing painted turtles from a boat. Only painted, Blanding's, map, and musk turtles, however, may be readily caught with a dipnet. Snapping turtles are usually too large and soft-shelled turtles too agile to rely solely upon this method for their capture. Particularly good results in the collection of musk turtles have been obtained by using a dipnet at night from a boat with illumination from a jack light. I have also scapped a few map and Blanding's turtles.

Gaffing proved more proficient in the capture of the snapping turtle than other species. The gaff used consisted of a sharp-pointed, two-inch hook made on the end of a two-foot piece of three-eighths inch steel rod which was fastened to a pole about six feet long. The opportunity for gaffing was in large part fortuitous, so the gaff was frequently taken along in a boat during other operations. The turtles were gaffed beneath the edge of the carapace. Of more than five hundred snapping turtles which I have handled, only five were captured in this fashion.

The opportunity for spearing, like gaffing, is fortuitous. Furthermore spearing requires considerable skill. In addition, none but a direct blow from a stout spear penetrates the hard shell of most turtles, and the head or neck are difficult objects to hit with a spear. The carapace is particularly thick and protective on the larger snapping turtles. In addition, snappers virtually afforded the only targets which one could successfully spear; the other turtles, with the exception of the soft-shell, were too small and the soft-shell was too swift and too wary. Spearing was no more than tested.

"Noodling" is a term used by professional turtle hunters for seeking out turtles from their places of hibernation. Some hunters "noodle" with their bare hands or feet, groping about under the banks of rivers or in the soft muddy bottoms of creeks or springs where they discharge into lakes or ponds. Other hunters use the blunt end of a steel rod to probe in such places. When a turtle is located, it is hauled out. "Noodling" is particularly effective for the collection of the larger snapping turtles, which are often thus encountered in some numbers. Smaller turtles are infrequently found in this manner.

Trapping was the most efficient means of obtaining representative series of the species in most habitats. The conventional type of turtle trap was employed extensively and three other kinds were tested. These are described below. Still other types of traps for turtles have been suggested by Pirnie (1935) and Surface (1908).

At the suggestion of N. E. Hartweg, and following the directions of Ruthven (1912), I tried a double-throated fyke net. It was found that the amount of time consumed in handling this net was about five times that required in the use of regulation turtle traps. In addition to being more difficult to set and more cumbersome than ordinary turtle traps, the fyke nets showed no advantages in the catches which they made. Their use was therefore abandoned.

Neither of the other two traps tested can be conveniently moved in numbers from one lake to another, which was a desirable feature of both the fyke net and conventional trap. One of these traps, tested at Wolf Lake, Van Buren County, during the summer of 1937, consisted of a four-foot square of two- by four-inch lumber equipped in the following manner. On the inner faces of these timbers, and near the upper edge, there were driven at a slight upward angle four-penny spikes, the heads of which were clipped off. From the lower edge of the timbers, securely nailed all around, was suspended a bag three feet deep made of three quarter-inch poultry netting. Placed in the water, the trap floated with the bag submerged and the spikes just out of water. Turtles clambered up onto the frame to bask in the sun and many, on retiring to the water, were found to go into the enclosure from which they could not escape. Turtles so taken were exclusively the basking species present in the lake — map, painted, and Blanding's; snapping, soft-shelled, and musk turtles, which were also present in the body of water, were not taken.

Modifying the type of trap just described so that it would also take the non-basking species, another was constructed with a funnel-like entrance leading into each of two sides of the underwater bag. Poultry netting replaced the spikes.

(Figure 1). For bait, a punctured tin can of freshly killed fish was kept suspended in the center of the bag. In Whitmore Lake, Washtenaw County, during the summer of 1938 this trap took musk, snapping, and soft-shelled turtles as well as the basking species taken by the trap tried in Wolf Lake.

The most practical and efficient traps for obtaining turtles from lakes, ponds, and streams were those used by the professional turtle hunter. The rudiments of the construction, care, and setting of this type of trap have been given in a mimeographed circular of the Michigan Department of Conservation. This trap has also been described and figured by Pirnie (1935) and has been patented by R. G. Smith of East Killingly, Connecticut.

The traps which I used most and found very satisfactory for scientific collecting were modified from the general types cited above and made up to the following specifications:

Net: One-inch square mesh of No. 24 linen seine twine.

Length: Four feet.

Hoops: Three per trap, each thirty inches in diameter; made of six-gauge steel wire with welded joints.

Throat: Funnel shaped, eighteen inches deep from front hoop to aperture; aperture one inch high by twenty inches wide; corners tied to middle hoop.

Rear end: Closed by pursing string.

Preservative: Asphalt, applied hot to hoops and twine alike.

Stretchers: Nine-gauge steel wire; two for each trap.

Number twenty-four linen thread was selected for use in the traps since experience had shown it to be of sufficient strength to withstand the clawing of large snapping turtles to thirty-five pounds in weight. Contrary to common belief, such turtles did not attempt escape by striking at the mesh with their sharp-edged jaws but tried to tear the twine with their claws. A twenty-two pound turtle was once observed while freeing itself from a trap made of No. 18 twine. The twine was torn by hooking the claws of both front feet in the mesh a short distance apart and pulling simultaneously outward with both feet, much as one would tear a piece of cloth. One-inch mesh was used to assure the capture of smaller individuals.

A minimum of three hoops was deemed essential for each trap. For traps less than five feet in length and which it was necessary to carry from time to time for distances overland, three hoops is considered the proper number. Aluminum hoops, although more costly than steel, would reduce the weight significantly; steel was used, however, since it was more easily bent and since it was sometimes advantageous to flatten the hoops to enable setting a trap in more shallow water and to reduce the chance of its being rolled by a large turtle in it or on it. Thirty inches was selected for the diameter of the hoops in order to increase the efficacy of the trap. Twenty-four inches is the more conventional size employed but experience has demonstrated that the increased size was well-warranted.

A moderately deep throat (about eighteen inches from front hoop to aperture) was found more effective in obtaining and holding specimens than a shallow one (about ten inches deep). An entrance of moderate depth enabled turtles to approach closer to the bait pan and apparently induced more to enter. Once in the trap, turtles were retained more effectively by such a throat since they most frequently crawled to the top of the front of the trap and took air near the upper edge of front hoop while resting on the incline of the throat. Furthermore, escape was usually sought in the lower quarters of the trap; to turtles the angle beneath the throat seemed to suggest greatest opportunity for they have often been seen rooting about there.

A pursing string for closing the rear end of a trap was practically a necessity. Such a string is particularly useful as a speedy and convenient means for freeing numerous or large specimens. Without such a string it is practically impossible to remove a snapping turtle fifteen pounds or more in weight without first collapsing the trap.

Hot roofing asphalt was used as a preservative in preference to tanbark since it lends added strength to the twine, although it almost doubles the weight of the trap. It was superior to ordinary net tar, for our purposes, since it could be used immediately on cooling without soiling hands and equipment. This was particularly important since the traps were being moved frequently from one body of water to another. This preservative not only has prevented the twine from rotting but has retarded the rusting of the steel hoops.

The stretchers which I have used, and which were needed to keep the traps extended, were designed by R. A. Peacock and called "side-wires." Although sticks have been used for stretchers, those of wire offered certain advantages, particularly in transportation.* Sticks were bulky and required more room in a load; wires were compact and took up but little space. Both sticks and wires were slightly longer than the traps and had notches or hooks at both ends. In extending a trap for setting, one stretcher was placed at each side passing through the mesh inside the middle hoop, and the front and rear hoops clipped into the notches.

A few traps were lost, perhaps due to their accidental collapse in the water, to their sinking into soft bottom material, or to their being hidden by movements of vegetation, turbidity of the water, or by waves. In order to insure against losses from such causes, it proved expedient to attach to each trap a small brightly-colored float at the end of a few feet of stout cord.

Before setting a trap, a container filled with bait was suspended in the middle just inside the mouth. Since most of the turtles which I collected were to be used for food studies, it was particularly essential that the container used should not permit the turtles to feed on the bait. Effective containers were discarded tin cans, about three and one-half inches in diameter and five to six inches tall, with covers attached at one edge. These cans were perforated with numerous, small slits to permit exudation of the juices from the bait.

Whether or not the tin of the containers was shiny did not seem to make any difference in their attractiveness to turtles; the nature of the bait which they held appeared to be of greatest importance. Whether shiny, rusty, or discolored, empty tin cans suspended in traps on test sets did not induce turtles to enter.

Several kinds of bait were tried; those which were effective for snapping turtles were apparently equally so for musk, Blandings, painted and soft-shelled turtles. Unspoiled watermelon rind, however, seemed particularly attractive to soft-shells. Map turtles were rather apathetic towards all baits, even crushed molluscs which the contents of their stomachs reveal are an important food for them. Baits of greatest universal value were fresh fish or fresh entrails of fowl. Canned "Balto" (a prepared dog food with a fish base) and canned mackerel or salmon constituted moderately successful lures. Fresh beef, pork, and lamb seemed to be relatively poor baits perhaps due to their comparatively low content of blood or other juices. The freshness of the material used as bait appeared to be an important determinative factor in its value as a lure.

Best results were obtained when traps were set so that the tops of the hoops were just out of water. It seemed that if turtles could obtain air easily, they were less active in their struggles to escape. As a result, it was thought that other turtles seeking to enter the trap would not be frightened away and larger specimens would not be encouraged to tear the twine. When traps were set in water so deep that the turtles could not obtain air, some individuals drowned within twelve hours.

In some waters such as bog lakes or large rivers, it was often impossible to set traps on the bottom since the drop-off was so near the margins and was so steep. To trap these waters, four-inch logs were cut about as long as the trap and tied, one per trap, along the tops of the hoops. A trap so equipped and placed in the water floats with the tops of the hoops near the water's surface. Good catches of turtles have been made by this method. In order to prevent loss by drifting of traps set in this manner, they were anchored to the bottom or shore.

In lakes, ponds, and impounded waters traps were usually set with the entrance away from shore because turtles seeking to escape consistently move along the bottom toward deeper water. In traps such turtles are held particularly well in the angle of twine formed by the bottom of the throat and the bottom of the trap. In rivers, traps set with the entrance downstream gave best results, doubtless due to the fact that it was from this direction that turtles moved up into the scent of the bait which had been carried down to them. A tall stick was driven into the bottom through the rear end of each river-set trap to keep the trap from rolling away with the current.

The traps were tended and the catch removed at twelve-hour intervals. It was generally felt that more frequent visits would needlessly disturb turtles seeking to enter the traps and thus reduce the catch. Amounts of food found in stomachs demonstrated that this interval was entirely satisfactory for obtaining specimens to be studied for food.

It was necessary to practice care in selecting the waters to be trapped. For the most part, waters which had been recently set by commercial trappers were avoided since it was learned that not only have most of the snapping turtles been taken from them, but many of the other turtles have been removed as well. "For the benefit of the sportsmen," it has long been a common practice among turtle trappers to destroy all turtles which they catch, other than snappers and soft-shells.

Another reason for selecting the lakes, ponds, or streams to be trapped is that turtles are not equally abundant in all waters. There appears to be a positive correlation between bottom types and numbers as well as kinds of turtles present. Lakes or parts of lakes with predominantly hard bottoms, for example, were found to have fewer turtles than lakes with extensive areas of soft bottom. Beds of white water lily (Castalia odorata) and yellow pond lily (Nymphaea advena) proved to be prolific trapping grounds for some species. Traps were set in several habitats ranging from those over hard, bare, sandy bottoms through those over muddy bottoms with abundant and various submergents and emergents. From a large series of such sets I have been able to discover the habitat preferences that are exhibited by the various species.

Many specimens of turtles were contributed by several cooperating agencies and individuals, who carried out the following suggestions which were drawn up to ensure good preservation of the material as well as uniform and complete collection data:

(1) As soon as possible after capture, preserve specimen in containers and formalin supplied.

(2) Fill in labels provided completely and attach securely to specimen.

(3) If the specimen is small enough, preserve it entire after making large, deep slits about all four legs.

(4) If the specimen is too large to be preserved whole, remove the stomach and intestines, along with the head, and save only these.

Ten percent formalin was the preservative supplied, sometimes in two-quart, wide-mouth jars and at other times in ten-gallon milk cans. The labels which accompanied these containers on one side requested the following information:

Species .... Exact locality .... Date ....
Time .... Collector ....

On the reverse side, the previously stated suggestions for handling the material were given.

Excepting the larger snappers (more than eight inches in carapace length) all the turtles collected by me for food study were preserved whole. These were usually injected with ten percent formalin by means of a large hypodermic syringe, but were sometimes merely gashed about the legs, and placed in ten-gallon milk cans with liberal amounts of the same preservative. Preservation by injection was superior to that by gashing: of several hundred turtles injected, none were lost;

of a like number gashed, approximately ten percent were lost for food study due to decay. Not infrequently loops of the digestive tract extruded from gashes, forming a plug which retarded the penetration of the formalin. Further, unless the perivisceral fascia was penetrated by the cuts, decay soon spoiled the specimens for food analyses.

Larger snapping turtles received the following treatment in the field. The specimens were weighed and then decapitated. After morphometric and other data had been taken, the digestive system, from esophagus to anus, and the gonads were removed and preserved. Weighing was done on a "Chatillons Improved Spring Balance" with a fifty-pound capacity and accurate to the nearest one-fourth pound. (Figure 2). The hook of the balance was inserted into the open mouth of the turtle to be weighed in such a way that the mandible bore the weight.

Data selected to bring out weight-length relationships, size at maturity, sexual dimorphism, and fecundity for snapping turtles were recorded in the field and laboratory on mimeographed outline blanks a sample of which is given as Figure 3. These blanks were adapted from those used by N. E. Hartweg in assembling data on chelonian systematics.

Body measurements of turtles were made by means of a special caliper (Figure 2) designed by the investigator and constructed by G. Lindenschmidt, Museum craftsman. This caliper consists of eighty centimeters of a standard meter stick with millimeter graduations glued and screwed to a piece of oak one-inch by eleven-sixteenths of an inch. The caliper has one stationary arm and a moveable arm with a copper bearing. The tension on this copper bearing is adjustable by means of a brass set screw. Properly handled, the caliper measures to the nearest millimeter with reasonable accuracy.

In order to furnish a means for evaluating the kinds and amounts of food found in the specimens collected, field notes were taken on the kinds, and relative abundance and availability of animal and vegetable food. Species lists of fishes present were compiled from seine or gill net samples and reports of local anglers. Amphibians, predominantly frogs and toads, were either seined with samples of shore fish or collected by hand among the marginal emergents. Higher aquatic plants, collected by hand or with a grappling hook or rake, and preserved in the standard solution of formalin, acetic acid, and alcohol, were extremely valuable as comparative material for the identification of fragments or masses of partially digested plant materials in the food of the turtles. Preserved wet, the plants were much more usable for this purpose than dried herbarium specimens.

In addition to securing information on the kinds and relative abundance of organisms fed upon by the turtles, some attention was also given to observing and collecting fish-eating birds and snakes. Analyses of the food of these animals have brought to light some interesting data on the natural enemies of turtles which supplement the more commonly recognized list composed of skunks, raccoons, dogs, and cats.

Also recorded, for their value in interpreting food habits data as well as their more general ecological significance were: (1) water color, and turbidity; (2) water and air temperatures; (3) bottom types; (4) extent of shoal areas; (5) nature of shore and environs; (6) depth of capture and methods of capture; (7) number of traps used and for how long; and (8) kind of bait used.

Not all turtles collected were preserved for food analyses. Some were retained alive for: (1) feeding experiments at the W. K. Kellogg Bird Sanctuary (Kalamazoo County); (2) population density and growth studies at Wolf Lake (Van Buren County), Big Twin Lake (Newaygo County), and Wintergreen Lake (Kalamazoo County); and (3) experiments in the artificial propagation of turtles at the Sunset Water Gardens near Holly (Oakland County).

Laboratory Methods

As Cottam (1936) has suggested for wild birds, one of the most important relations that turtles have to man probably comes from their food and feeding habits. For this reason, and because of limits of time, I have chosen to study most exhaustively this aspect of the problem. The broad objective of this phase of the study, as previously stated, is to determine the relationships that various turtle species bear to man particularly as regards aquiculture, waterfowl, and fish.

Although for the most part laboratory studies of food show merely what an animal will eat, certain refinements in laboratory technique and careful correlation of field and laboratory data aid considerably in interpreting the significance of the food items. For example, close scrutiny of organisms in the stomachs has enabled me to determine rather definitely (by means subsequently described) whether or not they were dead or alive when eaten. By comparing fragmentary remains with identical parts of whole individuals, the original size of animals eaten has been estimated. Identification to species of organisms encountered, whenever practicable, has rendered more complete the interpretation of ecological relations, and has contributed facts of value to other fields of biology. Careful counts of the organisms eaten demonstrate the dynamic relations of predator and prey.

In planning and conducting my work I have considered particularly justified and pertinent Shelford's (1930: 236) admonition that: "Papers on food relations should be accompanied by enough quantitative collecting of available food species to indicate the selection made by specimens eating the food. This brings out the interaction of species. Too many papers on stomach contents are mere lists of species found in stomachs collected at various points where the community relations are in doubt or unknown."

The occurrence of items in the food of an animal expresses to a certain degree the availability of these items to the predator. Vulnerability of the prey is more than a question of a presence or absence. Organisms of a certain kind may be abundant in the same environment as an animal and yet may never be eaten by it, because of limits imposed by such factors as size, speed, and protective habits. Whether a given organism is eaten by another depends on a multitude of biological and physical factors, affecting prey, predator, or environment. Integration of field and laboratory data are required for the correct interpretation of these complex relations between predator and prey. Even the most apparent cases of willful selection of food by lower animals may better be interpreted as resulting from the differential availability of the prey.

It was necessary to base the food studies of turtles almost exclusively on materials found in the digestive organs. Opportunities for observing feeding activities and foods were rare indeed. As Cottam (1936) has shown for birds, even if such observations were more common they doubtless could not have been solely relied upon. Analyses of turtle droppings which may sometimes be found on logs are generally unsatisfactory, for turtle scats are not certainly recognizable as to species.

As has been indicated most specimens except larger snapping turtles reached the laboratory as whole individuals which had to be opened for the removal of stomach and intestines. Before the specimens were opened they were measured for greatest horizontal carapace length by means of the caliper earlier described. All species of turtles, except the snappers, were opened by first cutting the bridge of the plastron on each side with ordinary tinner's snips. Snapping turtles were opened easily with a knife by cutting exactly through the suture between the plastron and the carapace, which is much easier than cutting the adjacent bridge of the plastron. After the plastron was cut free from the skin and muscles which hold it in place, it was easy to remove the digestive organs, determine the sex, and estimate the maturity.

In addition to a binocular and compound microscope, I have found almost indispensable the laboratory equipment discussed in the following paragraphs.

In studying the food of turtles (and other omnivores) running hot water was a distinct asset. Where large quantities of flesh were involved, hot water was particularly useful in clearing away adipose tissue to facilitate the discovery and identification of diagnostic remains.

Two types of containers* proved most serviceable in examining stomach or colon contents. For gross inspection, eight- by ten-inch, white-enameled trays, one inch deep were well suited. As an aid to sorting and counting, the bottoms of these trays were ruled into two-inch squares. This ruling was easily done on a dry pan by use of a flexible ruler and a lead pencil. For microscopic analyses, ten-centimeter Petri dishes, one centimeter deep, were most practical.

Vials were used to preserve food organisms or their fragments for more specific determinations, by subsequent reference to comparative materials or by reference to specialists. Workers in many animal or plant groups were pleased to cooperate in the study and detailed identification of the materials found. Some unique systematic and distributional records have materialized.

Parasitic nematodes and trematodes were also vialed, as were samples of the algal flora inhabiting the backs of the musk, snapping, western painted, ~~Bell's,~~ and Blanding's turtles. It is intended that the parasitic worms and the algae be identified, and that these phases of internal and external ecology be recorded. Parasites were preserved in 70 percent alcohol containing 2 percent of glycerine by volume (the glycerine was added to insure against loss of specimens by evaporation of the preservative). The algae were preserved in the standard aqueous solution of formalin, acetic acid, and alcohol.

All stomach or colon contents which could not be completely and absolutely identified were saved. Preservation of this material was found an invaluable aid in increasing the accuracy of the data. It has made it possible for me to correct, verify, or augment earlier determinations on the basis of subsequent knowledge. It is planned that this material shall be saved for some time, in order to furnish actual evidence for much of the unusual food habits data presented in this report.

All volumes of food were measured in moist but not wet condition, by water displacement in graduated cylinders.

Some stomachs and most colons contained amounts of mud, marl, or other fine bottom materials, or of much-digested plant or animal remains which are perhaps best described as "organic ooze." Unless washed from the other contents of the digestive organ, this ooze so obscured the identifiable food items that sorting was hardly possible. The unwashed material often resembled samples of muck bottom taken in limnological investigations. This circumstance suggested the method employed in facilitating the analysis of such materials. The stomach or colon, which had contents of the nature described, was opened onto a No. 20 bottom-fauna screen and repeatedly washed until the washing water was no longer clouded by the debris. As a check, several samples of wash water were permitted to settle out and the settlings were examined for identifiable remains of food items which may have passed through the screen. Discovered in a few samples were fragments of otoliths, small specimens of colonial algae, bits of filamentous algae and occasionally some sand.

To render the identification of food organisms or their fragments more rapid and precise, comparative series of many of the animals and plants concerned were assembled. The various collections of Michigan fauna and flora in the University Museums proved to be a tremendous asset. It was necessary to supplement these collections with a special series of skeletons, otoliths, fish scales, and with a series of aquatic plants preserved wet.

The series of fish skeletons available in the Museum collections has been somewhat more than doubled as a result of our effort to increase number of the species and the size range within species. The skeletons were prepared by placing freshly killed and skinned specimens in the colony of dermestid beetles maintained for this purpose in the Museum. It was later discovered that fish preserved in alcohol and soaked in water for about two weeks were about as well skeletonized by the dermestids. By watching the progress of the feeding activities of the beetles on either fresh or previously preserved materials, it was possible to obtain clean, articulated skeletons in a few days. Specimens became disarticulated if left too long with the beetles. Since disarticulated skeletons offered considerable difficulty in the comparisons, articulated skeletons were chiefly made at the outset.

It was often advantageous, however, to have disarticulated skeletons available for the identification of individual bones. These were obtained in three ways: (1) specimens were left with the dermestids until disarticulation was complete; (2) individuals which had been skeletonized but not disarticulated by the beetles were soaked in water until the bones came apart with ease; or (3) the flesh was digested away from the bones and disarticulation induced by soaking the fish in an alkaline mixture of pancreatin and water held at room temperature for a few days or more depending on the size of the fish.

As demonstrated by Munro and Clemens (1937) in their studies of the piscivorous American Merganser, bones most useful for diagnostic purposes were those of the head, particularly the tooth bearing bones and those of the opercular series, because these bones are not only easily recognizable but also unusually resistant to digestion. For certain families of fishes such as the Salmonidae, Cottidae, and Gasterosteidae, the hypural area is pronouncedly distinctive. A series of otoliths mounted in balsam by Canuto Manuel and preserved in the Museum of Zoology, has also been an aid.

One of the greatest helps in determining the kinds of fish present in the food of turtles, particularly in colons where bones are seldom found owing to their previous digestion, has been my earlier key to the fishes of the Ithaca, New York, region on the basis of scale characters (Lagler, 1936).

In studying the food of predatory animals which may scavenge, it is necessary to distinguish carrion from animals killed and eaten by the predator. In this investigation, it has been possible to make this separation in most instances; the few errors in one direction are doubtless balanced by others in the opposite direction. Carrion fish remains have the following characteristics which make their identity a certainty as material dead when eaten: (1) chromatophores over the whole body are contracted; (2) the blood in the blood vessels is colorless (bleached); and (3) the whole animal mass is often encapsulated in an amorphous, gel-like substance. These characteristics were verified by bait (dead carp) which a few of the turtles had succeeded in obtaining from bait-cans which had been improperly closed.

Some difficulty was encountered in formulating a technique for the analysis of the food contents of the digestive organs of turtles. A review of the literature in economic ornithology and mammalogy as well as for other groups of animals showed a considerable variation in the kinds of data obtained and in the manner in which it was compiled. It soon became evident that it was desirable to perfect a technique particularly suited to the study of the food of turtles. This was done, and in so far as possible the system evolved has been adhered to, except as indicated. Before stating the method employed, I shall discuss briefly a few of the methods which might have been used but which ultimately have each become a part of the composite technique adopted.

It was early discerned that solely to record the numbers of individuals of each food item encountered, as done by some investigators, would not adequately depict the food relations of any animals as omnivorous as the turtles. McAtee (1912) and

Collinge (1927) have objected to this practice. Although this method furnishes important data on how many individuals of various kinds of food organisms or seeds are eaten, it is absolutely of no value when one must account for quantities of filamentous algae or succulent aquatic herbage in various stages of digestion. I feel, however, that the usefulness and value of such figures is somewhat underestimated by McAtee's statement (1912: 464), made for studies on the food of birds, to the effect that "the number of individuals in stomachs have an interest as 'records,' the interest being in direct proportion to the bigness of the number." For numbers of individuals are very important in economic food studies, and form an indispensable tool in determining the economic status of certain animals. This has been shown in many investigations and is also demonstrated in the present study.

It also early became apparent that to adopt a system which alone expressed the relations of food items by their frequency of occurrence was untenable. Such a system tends to submerge the significance of bulky food objects, such as masses of vegetation or flesh, and to overemphasize the role of organisms having persisting hard parts such as insects or crayfish. Since size of fishes taken has much to do with the conclusions to be drawn, it seemed undesirable to rely solely on frequency data. Nevertheless it has been considered important to incorporate frequency figures in the composite system used, for the following reasons: (1) "... frequency of occurrence of food items in ... stomachs may perhaps be taken as rough indices of availability of the food or of relish for it." (McAtee, 1912: 464); (2) percentage frequencies of occurrence aid in interpreting the information obtained both by the volumetric and numerical systems.

To use alone the percentage by estimated bulk or measured volume, as widely done, was deemed to be quite as inadequate as to rely solely upon either of the previous two methods described. The volumetric system has an advantage over the numerical system in that all food items can be comparatively treated, since none are eliminated because the numbers of individuals composing them cannot be counted. This advantage is shared by the percentage frequency system. Calculations of composition by volume are distorted because of the persistence of hard parts, though less significantly than the calculations by percentage frequency. As McAtee (1912) has suggested, comparison of one part of the diet with another or of the food of one species with another is possible with great facility and accuracy when data are based on the volumetric method. Similar comparisons are possible when the data have been interpreted on the basis of frequency of occurrence. Although they provide by no means identical information, both of these methods yield data which graphically depict food habits.

It is generally conceded, by most food habits investigators, that "... bulk or volume percentages have been found more reliable and more rapidly computed than those based on weight." (Wight, 1938: 68). Food substances were not weighed in this investigation.

After reviewing the methods just cited, and others, and evaluating these in terms of the studies on turtles, I have adopted the following system, which appears to be adequate. This system incorporates the best features of the methods of which a brief description has just been offered. These methods were discussed more in detail by McAtee (1912), Collinge (1927), Cottam (1936), and Wight (1938).

Whenever practicable the number of individuals of each food item was determined by actual count. The total volume of food as well as the total volume of the contents were determined for each turtle studied. Data were so organized that percentage frequency of occurrence could be calculated. Interpretations and conclusions of an economic nature are based on a correlation of the data obtained from all three of these laboratory practices, and also from field observations of other workers and myself.

In order to obtain a maximum amount of information from the specimens of the larger turtles (the snapping, Blanding's, and soft-shell turtles), the contents of both the stomachs and large intestines were analyzed. Owing to the limits of time and to the fact that only small amounts of food were found in the small intestine, analyses of intestinal material was limited to that found in the colon, from the anus to the caecum.

A great difference between the contents of the stomachs and intestines was apparent. Materials in the intestines, especially those in the colon, were fragmentary and in advanced stages of digestion (as already described in the discussion of the No. 20 screen used for washing these contents); those in the stomachs were more often whole individuals of food organisms or other undigested or only slightly digested food items and more easily distinguishable. It was also soon noted that the intestines seemed to hold an aggregate of the remains of several "meals." The intestinal contents differed consistently from those of the stomachs, not only in containing more food, but also, as might be expected, in having a greater variety of food items. Very often, however, the items which occurred in the stomach were not found in the intestines, particularly the colon.

Completely in accord with the technique previously described, the methods applied in the analyses of the contents of most stomachs were precise, both quantitatively and qualitatively. These contents were of such a kind that they could be placed directly in water in a dish and sorted; a very few required washing on the No. 20 screen already described. Stomachs of turtles, other than snappers, contained volumes small enough so that they could be sorted from the Petri dishes. Those of the snapping turtles, however, were usually sorted from the white-enameled trays. After the sorting, numbers of individuals, size (for fish), and volumes were ascertained for each food item, and recorded on specially designed cards.

Before analysis the contents of most large intestines were of such a nature that it was desirable to wash them, as already stated. Washed contents were usually examined on enamel trays. Owing to the limits of accuracy imposed by the nature of the colon material, it was impracticable to apply the strictly quantitative and qualitative methods employed in work with the stomachs. Consequently, although for many colons counts of individuals of food items were made, for others estimates of numbers were made after counting samples or merely the relative abundance was noted. In contrast to the method of measuring the volume of each food item as done for stomachs, the food items represented were roughly sorted and estimations of percentage composition were made. Total volumes of food and non-food substances were, of course, taken and recorded. Notwithstanding the variations in the method adopted for obtaining the numerical and volumetric data, care was taken to retain greatest accuracy in discerning and recording the occurrence of items. In considering the food summaries presented, it should be remembered that only the calculations of percentage frequency of occurrence for stomachs and large intestines are strictly comparable; the volumes of food items in stomachs were actually measured, those for intestines, estimated.

It was possible to obtain rather specific identifications of most food items. Sometimes, however, certain food remains could be classified no more definitely than plant or animal, in which case "vegetable debris" was used to designate remains of plants obviously taken as food and "animal debris" for like animal matter. Certain amounts of non-food materials were frequently present, and were classed as "vegetable detritus" (including dead portions of woody stems, dead leaves, etc.), and as "animal detritus" (including an occasional horny scute from a turtle, an exuvium of a snake, etc.). "Inorganic detritus" was used to include sand and gravel.

A uniform blank (Figure 4) for recording food data gathered in the laboratory was found to be a great asset, not only insuring against errors of omission, but also providing a convenient means for noting pertinent information additional to entries of food items. The use of the form increased the speed of the original analyses and was very convenient in summarizing the various data recorded on the cards.

The tabular portion on the front and back of each card provides spaces for recording the names of the food items, and for each item the number of individuals, the length as found in the digestive organ, measured volume in cubic centimeters, and percent of total volume of food. The length of food items as found in the digestive organs, along with the estimated size of the organisms when alive, was recorded for four reasons: (1) since this investigation is concerned with the relations of predators to game fish populations, it is desirable to know what percentage of the fish eaten were legal-sized; (2) to detect size preferences, or vulnerability by size; (3) to obtain data on the rate and extent of the digestion, in the stomach and in the intestine, of the different organs of the species eaten; (4) to enable correlation of the records of time of day and relative fullness of the digestive organs.

In carding food items, plant and animal materials were listed separately. Care was taken to give the correct scientific name or description of the items present.

When the contents of all the available stomachs and colons had been analyzed and carded, the cards for each species were sorted into the major ecological units from which the turtles had been collected. The data were then tabulated for each of these units. Such a tabulation facilitates the summarizing of the food of each species of turtle from a single body of water or from a group of ecologically similar localities. From such tabular arrangement interpretations and conclusions were easily drawn, and summary tables constructed with a minimum of effort.

Details of the numbers and kinds of food organisms, determined as specifically as practicable, are presented in Tables 9, 28, 32, 41, 44, 48, 62, and 66. In Table 67 the summaries of the food of the aquatic species of turtles on natural waters are given together, to facilitate comparison.

RESULTS OF CORRELATED FIELD AND LABORATORY STUDIES

In this section each species of turtle studied is discussed in systematic sequence. In the brief descriptions offered for each, only diagnostic characters are given. More detailed descriptions of adults, eggs, and young may be found in the general works listed under REFERENCES CITED. Of these, Ruthven, Thompson, and Gaige (1928), Cahn (1937), and Conant (1938) furnish excellent details.

Information on general range is taken directly from Stejneger and Barbour (1939), Bishop and Schmidt (1931), and Conant (1938). The general distribution maps of these turtles in the United States, used in the work of Conant, have kindly been loaned me. Distribution in Michigan is compiled from Ruthven, Thompson, and Gaige (1928), the unpublished data of N. E. Hartweg and H. T. Gaige, and from records of collections made by and for me. Maps of the state are given for each species, to show the locations of specimens studied for food.

Sternotherus odoratus (Latreille)

Musk Turtle. Stink-pot.

Description

The musk turtle in Michigan averages less than five inches in carapace length; the largest males and females which I have handled ranged in length from 114 to 121 mm. (4.5 to 4.8 inches). This turtle is characterized by (1) a rigid, domed carapace, predominantly of some shade of brown or black; (2) marginals, including nuchal, usually twenty-three; (3) a small plastron resembling that of the snapping turtle in that it does not fill the opening of the carapace, but with a distinctive emargination behind and predominantly yellowish and brown; and (4) a short tail.

Sexual dimorphism in this species, with special reference to anatomical differences, has been studied extensively by Risley (1930) who concluded that the following characters were absolute: (1) plastron concave in males and flat or slightly convex in females; (2) median side of knee of hind legs of males with two scale patches, absent on females. Risley's material was from Washtenaw County, Michigan. Original examinations of specimens from this county and other areas in the state, as shown in Table 2, are in complete accord with those of Risley.

Range

According to Stejneger and Barbour (1939: 155) the range of this turtle is "Eastern and southern North America from Canada south; west to southeastern Kansas, Oklahoma and southern Texas." In Michigan the musk turtle has not been recorded from waters north of Town Line 16, and it is unknown from several counties to the northeastern part of the state south of that line (Map 1).

Habitat and Habits

Many authors have published data on the habitat of the musk turtle. A selection of the recorded information is given in Table 1, to bring out the variety of conditions from which the species has been reported.

It can be seen (Table 1) that in general the musk turtle is associated with the quiet waters of lakes, ponds, and slow-moving streams in Michigan as well as in other parts of its range. In Michigan I have found the species most common in those portions of lakes, or lagoon-like sections of rivers, where aquatic vegetation grows but not so densely as to impede greatly the movements of turtles on the bottom. Particularly favorable environments were the reedy areas of such lakes as Whitmore (Washtenaw County), Sherman (Kalamazoo County), and Wolf (Van Buren County). Since this turtle is inconspicuous, it is doubtless more abundant in the southern part of the state than commonly assumed. This species is inconspicuous not alone because of the luxurient growth algae (*Basicladia* sp.) which adorns the backs of many individuals, but also because it

TABLE 1. HABITAT OF THE MUSK TURTLE AS GIVEN IN SEVERAL PUBLISHED ACCOUNTS.

Author	Date	Locality	Habitat
Conger, A. C.	1920	Michigan Southern two-thirds of Lower Peninsula	Muddy lakes and ponds
Hankinson, T. L.	1908	Walnut Lake, Oakland County	Most common turtle in the lake
Risley, P. L.	1933	Washtenaw and Livingston Counties	Huron River and lakes
Ruthven, A. G., C. Thompson, and H. Thompson	1912	Range in Michigan	Bottoms of ponds and lakes
Thompson, C.	1911	Cass County	Mud lakes
Atkinson, D. A.	1901	Pennsylvania	Rivers
Burt, C. E.	1935	Kansas	Pools of creek dry to pools
Burt, C. E. and W. L. Hoyle	1934	Kansas	Wooded creek
DeKay, J.	1842	New York	Ponds and ditches
DeSola, C. A.	1931	Northeastern states	Small, sluggish streams and ponds
Ditmars, R. L.	1908	New York	Slow-running streams and ponds
Drowne, F. P.	1905	Rhode Island	Ditches and ponds
Garman, H.	1892	Illinois	Streams and lakes
Hay, O. P.	1887[b]	Indiana	Marshes
Hay, O. P.	1887[a]	Indiana	Quiet streams and ponds
Hay, O. P.	1891	Indiana	Deeper parts of ponds and small lakes

Author	Date	Locality	Habitat
Hay, W. P.	1902	District of Columbia	Marshes
Holbrook, J. E.	1842	Range	Slow moving or muddy waters
Howe, R. H.	1904	Massachusetts	Brook, river
Hurter, J.	1911	Missouri	Slow-running streams, muddy lakes, and sloughs
Mearns, E. A.	1898	New York	Lakes and ponds
Morse, M.	1904	Ohio	Lake Erie
Myers, G. S.	1930	New York	Lakes
Nash, C. W.	1908	Ontario	Lakes Erie and St. Clair
Nelson, J.	1890	New Jersey	Creeks and mill-ponds
Parker, M. V.	1937	Tennessee	Lake, bayous, creek bottoms
Ricketson, O. G.	1911	Massachusetts	River, brooks
Roddy, H. J.	1928	Pennsylvania	Stagnant ponds, mill-dams, slow-flowing streams
Say, T.	1825	Range in limited states	Ditches and other turbid waters
Smith, W. H.	1882	Ohio	Ditches and ponds
Strecker, J. K.	1930	Texas	Creeks
Toner, G. C.	1936	Ontario	Lakes and marshes
True, F. W.	1893	Range in limited states	Placid waters, streams

is predominantly nocturnal and secretive in its habits. Although individuals were seen foraging at all hours of the day, they appeared to be more active at night. Specimens collected by hand at night were usually moving over open bottom. Those taken in the daytime were most often hidden, at least partly, under some sheltering object.

An excellent account of the natural history of this pre-eminently aquatic turtle in the Ann Arbor region has been published by Risley (1933). The reader is referred to this paper for general information on the aquatic propensities, hibernation, sex ratio, breeding habits, nesting, eggs, growth and age, age at maturity, and sexual dimorphism. To this fine study I can make but few additions.

Risley (1933: 708) stated that "mating occurs in the spring between the approximate dates of April 1 and May 15; it may also occur in the fall." Evermann and Clark (1920) recorded having observed copulating pairs of this species in Lake Maxinkuckee on November 1, 1904, and September 13, 1906. I have obtained the following records of fall mating as well as some data on behavior during copulation in captivity, which Risley and previous investigators have not reported. On September 23, 1937, at 8:30 A.M., I found two musk turtles in copulation in four inches of water under a beached boat at Whitmore Lake, Washtenaw County. The lake bottom beneath the boat was sand and gravel. I did not know that the specimens were in coitu until I picked them up and the male was then seen to withdraw his penis from the cloacal aperture of the female. On October 30, of the same year, several musk turtles were seen moving about on the bottom of this lake, frequently in couples which proved on examination to be pairs. These pairs were usually seen in from one to two feet of water but none were observed in copulation on this date.

On two occasions in the fall of 1938, mating pairs were found in traps. The first of these was in Sherman Lake, Kalamazoo County, at 8:00 A.M., on September 17. The second was in Wolf Lake, Van Buren County, on September 20 shortly after 8:00 A.M.

A pair of musk turtles was taken in copulation from a fish rearing pond at Drayton Plains, Oakland County, on October 27, 1938, by W. F. Carbine. In my journal I have recorded the following observations on this pair of turtles:

"Carbine brought the turtles to me about 8 A.M. on October 28, 1938, after they had spent the night out of water in a pail in his car behind the Museum. Temperature over night dropped perhaps to 34° F.

"Placed in an aquarium (small) 8" x 8" x 12" in 4" of water at 68° F. at 9 A.M. At 10 P.M., upon returning to this room, found the male pursuing the female. Each time he would succeed in partially mounting her, she would shake him off and a merry chase would again ensue within the small confines of the container.....

"Once, the female became quiet and in rather an impossible position for the male to mount her. He struck her side of the head with his open mouth and the chase was on again."

In the unsuccessful attempts made by the male to complete the act, the use of two distinct positions was noted. In one, the male mounted the female from behind. He grasped the lower edge of her carapace rather well back on the body with all four feet. Additional support for his body in this position was gained by complete extension of his head and neck, enabling firm apposition of the chin and throat of the male to the anterior, down-curving carapace of the female.

In the second distinct position, the male was observed to approach the female at right angles. Passing behind her body he would entwine her tail between his left hind leg and his tail. At one time this pose was retained for four minutes; the penis was not extruded on this occasion nor on subsequent ones in this position although coitus seemed entirely feasible. It may be that this grasp has no real significance as a mating attitude, but it may actually be one of the positions normally used. That it may be a mating position seems possible for relations where the male is somewhat smaller than the female. Furthermore the attitude, though an unusual form of turtle amplexus, is hardly more unusual than the stance recorded for Terrapene c. carolina by Cahn and Conder (1932).

Continued, but always apparently unsuccessful attempts at mating were observed during the last days of October and the first days of November. The turtles were kept in the aquarium in the laboratory at room temperature and the turtles accepted small amounts of food all winter. During the last week of March the male again made several attempts to mount the female.

Details of the data which I have gathered on the sex ratio of this species, resulting from a sampling of widely separated populations, will be offered in a later report. This subsequent report will include similar material for the snapping, Blanding's, and western painted turtles as well as for the musk turtle.

Food and Feeding Habits

In so far as I have observed, the musk turtle is entirely aquatic and its feeding activities confined to this environment. Other investigators, such as Newman (1906), have found members of this species feeding while on land. Newman observed individuals crawling about in the grass at dusk, eating slugs, and in June saw others crawling about on moss, rooting out insects with their snouts.

After extended observations Newman (1906) considered the members of this species to be scavengers and to be generally indiscriminate in their feeding habits. Evermann and Clark (1920) and Risley (1933) also recognized the scavenger habit of this turtle. On the basis of the lack of response of musk turtles, or of any other Michigan turtle, to putrefying bait in traps, it seems to me that considerations of these animals as scavengers must be tempered. They have been observed to feed readily on freshly dead material but to refuse animal flesh in advanced stages of decay. The word "scavenger," then, as used by me regarding turtles, should be taken to mean feeding on dead, but not putrefying material.

Surface (1908: 138) reported: "Our studies of the food of four specimens of this species have given the following facts:

	No.	Per Cent.
Mollusca,	2	50
Snails,	2	50
Insecta,	3	75
Orthoptera, (Crickets, Grasshoppers),	1	25
Gryllus pennsylvanicus,	1	25
Lepidoptera, (Moths, etc.),	2	50
Larvae,	2	50
Coleoptera, (Beetles),	2	50
Undetermined fragments,	1	25
Carabidae - Undet., (Ground Beetles),	1	25

"It is evident that they feed almost wholly upon mollusks and insects, and thus must be recognized as being decidedly beneficial rather than destructive. It will be noted that no fishes or other vertebrate animals were found in the stomachs thus examined. What may be revealed by further studies remains yet to be seen."

Evermann and Clark (1920: 600) gave the following original observations: "As to food, one [musk turtle] was seen June 6, 1901, in company with a Painted Turtle, swimming along behind a floating dead fish, and nibbling bits out of it. Also, in the late autumn (Oct. 30, 1904), one was seen nibbling at the body of a grass pike 13 inches long that lay in the bottom at the head of the Outlet. This turtle or others stayed near the fish several days, but did not seem to make much progress in disposing of it, perhaps because the cold season was coming on, when they probably eat little or nothing. On September 2, 3 or 4 were seen feeding on fresh cowdung in the edge of Lost Lake. Professor Newman says they often contain <u>Vivipara contectoides</u>."

Morgan (1930: 394) wrote: "They are bottom foragers that crawl over the mud, stretching their necks out very slowly before snapping at their prey—small fish, worms, insects, or tadpoles." Parker (1937) also recognized the bottom-feeding activities of this species.

Risley (1933: 700) reported: "Remains of fish, clams, snails, aquatic insects, and crabs, as well as much vegetable matter, such as buds of Elodea and other unidentified aquatic plants have been found in their stomachs."

Cahn (1937: 55) had original data on food as follows: "The species of fish which have been taken by the writer from the stomaches examined have always been 'minnows': Umbra limi, Notropis whipplii spilopterus, Poecilichthys sp., Notemigonus crysoleucas auratus. Fisherman who practice their art in the shallow, weedy lakes, often catch these turtles on their hooks, particularly if still-fishing with live worms or grubs."

Wild individuals have taken bread which I offered them in from six to ten inches of water in Sherman Lake, Kalamazoo County, in early September, 1938. Specimens in my laboratory, which had been starved for several weeks, readily attacked and partially ate smaller members of the same species placed in the aquarium with them.

Although considered carnivorous by such authors as Babcock (1919), Conger (1920), DeSola (1931), Cahn (1937), Conant (1938) and others, this species is perhaps better classified as an omnivore in accord with my conclusions and those of Newman (1906) and Risley (1933).

My studies of the musk turtle are based on 113 specimens which contained food either in the stomach or colon, or in both. These turtles were collected from the localities and in the numbers given in Table 2.

As can be seen in Table 2, the musk turtles studied for food were obtained from thirteen* lakes, three rivers, and two fish cultural establishments. In the following analyses of the food habits, the specimens from Whitmore and Sherman Lakes are considered separately (Tables 3 and 4) because they each constitute a sizeable series. Individuals from the remaining lakes have been combined into one group (Table 5), those from the rivers into another (Table 6), and those from fish rearing stations into yet another (Table 7). For each of these groups the findings presented are discussed individually. In Table 9 are given details of the numbers of individuals and identity of the food substances taken at all localities. In Table 8 is given material for comparison of the food of this species with that of the other aquatic turtles studied.

Whitmore Lake. Whitmore Lake is a sizeable body of water (estimated 600 acres) of glacial origin lying in the Huron River drainage and has a maximum depth in excess of fifty feet. The bottom is varied; sand, gravel, mud, and marl appear extensively in the shoal areas. Several species of pondweeds of the genus *Potamogeton*, and hornwort (*Ceratophyllum demersum*), dominate the aquatic flora. Game fish reported present are large- and small-mouthed bass, yellow perch, bluegill, pumpkinseed, northern pike and mud pickerel.

TABLE 2. LOCATIONS AND NUMBER OF MUSK TURTLES

WHICH CONTAINED FOOD FROM EACH

Location: Body of Water	County	Number of Individuals	Date of Collection
Whitmore Lake	Washtenaw	34	IX:23-24:37; X:6-8, 23-24, 30:37
Sherman Lake	Kalamazoo	28	VIII:20:37; IX:16-18:38
MISCELLANEOUS LAKES		35	
Robinson Lake	Kalamazoo	1	VIII:30:38
Big Star Lake	Lake	1	VI:26:37
Evans Lake	Lenawee	1	IV:28:37
East Twin Lake	Newaygo	2	VIII:16-17:38
Kimball Lake	Newaygo	6	IX:2-3:37
Nichols Lake	Newaygo	1	VI:23:37
Great Bear Lake	Van Buren	4	IX:10-11:37
Schoolsection Lake	Van Buren	6	IX:9-10:37
Little Cedar Lake	Washtenaw	1	VIII:12-13:37
North Lake	Washtenaw	5	VIII:27-28:37
Silver Lake	Washtenaw	6	VIII:26-27:37
NON-TROUT STREAMS		9	
Muskegon River	Muskegon	1	VIII:31-IX:1:37
Shiawassee River	Oakland	7	IX:21-22:37
Huron River	Washtenaw	1	V:23:31
FISH HATCHERIES		8	
Drayton Plains Hatchery	Oakland	1	VI:24:32
Sunset Water Gardens	Oakland	7	IX:26:37

Associated with these are several species of minnows and other forage fish, gar and bowfin.

The thirty-four musk turtles studied for food from this lake which averaged 95 mm. (3.7 inches) and ranged from 70 to 115 mm. were collected in September and October of 1937. A summary of the results of the examinations of the contents of the stomachs and colons of these individuals are given in Table 3. It should be noted that fifteen of these turtles had no food in their stomachs and that two had empty colons. Several additional individuals collected from this lake in these months had both stomachs and colons empty. Snapping, western painted, and map turtles from Whitmore Lake were also studied for food.

In Table 3, the stomach and colon contents are tabulated separately for the reasons previously given. One should recall that the data for the food in these two organs are not strictly comparable as regards the percentages for composition by volume. Those for stomachs are based on actual measured volume of each item while those for colons are based on estimations of percentage composition of a measured total volume.

In Whitmore Lake, at this time of the year, aquatic insects and their nymphs and larvae, snails, and carrion appear to be the most important food of this turtle. As might be expected, fish carrion is more prominent in volume relationships in the stomachs than in the colons owing to the complete digestion of such material. In contrast, green plants are

TABLE 3. THE FOOD OF THE MUSK TURTLE IN WHITMORE LAKE

Based on nineteen stomachs containing 2.7 cc. of food and thirty-two colons containing 28.0 cc. of food. More specific determinations of food items are given in Table 9.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Carrion	33.3	5.3	9.9	18.8
Crayfish	——	——	3.4	15.6
Insects	25.9	73.7	25.9	81.3
Snails	33.3	31.6	39.0	78.1
Cryptogams and phanerogams	7.4	31.6	7.3	34.4
Vegetable debris	Traces	15.8	14.5	62.5

little affected by digestion until the colon is reached, with the result that they are predominant there.

The aquatic insects most often taken were dragonfly nymphs and leptocerid caddis larvae, frequently Leptocella albida. Terrestrial insects, which had probably fallen upon or near water before being eaten were represented by eleven ants in one stomach, and by a larval lepidopteran in another.

Apparently the strong, broad-surfaced jaws of this little turtle influence its feeding habits. That hard-coated seeds and snails are so abundant in the food seems to be due to the crushing ability of the jaws. For the most part the molluscs and seeds of aquatic plants encountered in the stomachs of this turtle are crushed beyond recognition. In Michigan waters, the musk turtle would seem to run the map turtle a close second in its malacophagous habits.

All fish remains encountered were distinctly carrion, giving concrete evidence of the scavenger habit of this species. Earlier in the season, in July, the species is even more a scavenger. During the more active fishing days of the earlier time of the summer, there are many more game fish which are killed and become carrion. M. B. Trautman has told me that during his many hours of sport fishing on this lake, he has observed musk turtles feeding on fish injured by anglers and also upon dead or dying bait "minnows" dumped from the fisherman's live-bucket.

Sherman Lake. This lake is estimated to be approximately one hundred acres in surface area (Henshaw, 1931), and has fairly extensive shoal areas with a bottom of sand, gravel, muck, and marl. The shores are hilly, partly open meadows and partly wooded with some resort development, and much of the shore line is inaccessible by road. The dominant aquatic vegetation includes several large beds of Nymphaea advena in the sheltered coves and species of Potamogeton in the more open waters. Elodea canadensis, Ceratophyllum demersum, Myriophyllum sp. and Chara sp. are common. Some bulrushes (Scirpus sp.) and cattails (Typha sp.) occur in a few restricted localities. Game fish reported present are large- and small-mouthed bass, rock bass, several species of sunfish, yellow perch, and bullheads. Minnows, darters, and eels (Anguilla bostoniensis) also occur.

TABLE 4. THE FOOD OF THE MUSK TURTLE IN SHERMAN LAKE

Based on twenty-eight stomachs containing 11.7 cc. of food. More specific determinations of food items are given in Table 9.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Yellow perch	9.4	3.6
Carrion	53.0	21.6
Crayfish	5.1	3.6
Insects	10.3	53.6
Molluscs	18.0	57.1
Phanerogams	1.7	14.3
Vegetable debris	1.7	14.3

The presence of an abundant and varied aquatic fauna and flora, the occurrence of an extensive shoal area with soft bottom, the limitation of the resort development on the lake, the presence of sandy banks and open meadows on the shore over considerable area, and the absence of a marginal road favor the turtle population of this lake.

For the series of twenty-eight musk turtles which I collected from this body of water, the contents of the stomachs only were analyzed (Table 4). In length these turtles averaged 95 mm. (3.7 inches) and ranged from 60 to 110 mm. Excepting two individuals collected on August 20, 1937, all were taken from September 16-18, 1938. Regarding time of collection, then, they are quite similar to the material from Whitmore Lake. Snapping, Blanding's, and western painted turtles from Sherman Lake were also studied for food.

Insects, snails, and carrion again appear to be the most important foods of this turtle in a lake habitat. The most common insects taken were leptocerid caddis larvae and the most frequently encountered snails, Helisoma sp. and Amnicola sp. Seeds of aquatic plants appeared, as they did in the food of specimens from Whitmore Lake. Carrion was found to be entirely the remains of fish. The yellow perch eaten was a small individual 1 3/4 inches long, apparently alive when taken.

Miscellaneous lakes. Thirty-five specimens collected at various times throughout the two summers of field work in several lakes in the southern part of the state give a picture (Table 5) which substantiates that for Whitmore and Sherman Lakes. The average length of the thirty-two specimens for which measurements were obtained is 98 mm. (3.9 inches); the range is 79 to 122 mm.

Insects, molluscs, and vegetable matter appear as the principal foods of this species in this random sample from several lakes. The insects most frequently encountered were dragonfly nymphs and the molluscs were predominantly snails of the genera Helisoma and Physa. Crayfish assume greater importance in the food of this series than in that of the lots from the two lakes just discussed.

TABLE 8. THE FOOD OF THE MUSK TURTLE IN MISCELLANEOUS LAKES

Based on twenty-one stomachs containing 2.3 cc. of food and on twenty-seven colons containing 18.7 cc. of food. More specific determinations of food items are given in Table 9.

Food Items*	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Bass or sunfish	——	——	4.0	7.4
Unidentified fish	——	——	Traces	11.1
Crayfish	4.3	4.8	14.9	37.0
Insects	39.1	42.9	16.1	66.7
Molluscs	34.9	52.4	36.4	70.4
Cryptogams and phanerogams	Traces	28.6	5.2	44.4
Vegetable debris	21.7	28.6	23.4	33.3

* One colon contained an hydrachnid which is not included in this table.

TABLE 6. THE FOOD OF THE MUSK TURTLE IN RIVERS

Based on five stomachs containing 1.0 cc. of food and seven colons containing 4.7 cc. of food. More specific determinations of food items are given in Table 9.

Food Item	Stomachs: Composition by Volume (%)	Stomachs: Frequency of Occurrence (%)	Colons: Composition by Volume (%)	Colons: Frequency of Occurrence (%)
Crayfish	40.0	40.0	30.0	42.9
Insects	20.0	60.0	43.2	28.7
Molluscs	20.0	20.0	6.8	28.6
Phanerogams	20.0	40.0	20.0	42.9
Vegetable debris	Traces	40.0	——	——

Again the vegetable matter encountered was very largely composed of the seeds of aquatic plants. The coats of most of these seeds were cracked open, doubtless due in part to the grinding action of the jaws as well as to subsequent digestion.

Rivers. The series of nine specimens available from rivers, notwithstanding the small number of individuals concerned and the different habitats involved, gives results (Table 6) which bear a striking resemblance to those found for lakes. The average length for eight of these specimens was 99 mm. (3.9 inches), the range, 91 to 112 mm.

Crayfish alone, as might be expected, assume greater significance in the food of musk turtles in this type of

TABLE 7. THE FOOD OF THE MUSK TURTLE AT FISH CULTURAL ESTABLISHMENTS

Based on six stomachs containing 3.2 cc. of food and four colons containing 2.0 cc. of food. More specific determinations of food items are given in Table 9.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Bluegill larvae	59.4	16.7	——	——
Leeches	25.0	33.3	——	——
Crayfish	Trace	16.7	Trace	25.0
Insects	Trace	16.7	Traces	75.0
Snails	15.6	50.0	100.0	100.0
Algae	——	——	Trace	25.0

water. The insects eaten are again predominantly dragonfly nymphs, and the hard coated seeds of Nymphaea advena are prominent in the vegetable matter ingested.

Fish cultural establishments. The series of eight specimens available for an appraisal of the status of the musk turtle at fish cultural stations is small. Excepting one specimen taken from a bluegill rearing pond at the Drayton Plains Hatchery on June 24, 1932, the turtles came from an ornamental and forage-fish rearing pond of the Sunset Water Gardens, near Milford on September 26, 1937. The length of seven of these specimens was 89 to 97 mm., averaging 93 mm. (3.7 inches). The results of the food studies of these specimens are given in Table 7.

An estimated thousand and more bluegill larvae were encountered by Salyer in the stomach of the individual which was taken from a bluegill nest at Drayton Plains.

At the Sunset Water Gardens' pond, the food of the turtles hardly differs in any essential respects from what one might expect to encounter on wild waters. The small pond from which the turtles were taken contained several thousand young blunt-nosed minnows (Hyborhynchus notatus), top-minnows (Fundulus diaphanus), and goldfish (Carassius auratus). If one may base any conclusions on data so limited, it would seem that healthy fishes of this nature are in general free from predation by musk turtles, even though they are very crowded and the turtles are possibly more numerous per unit area than in any natural water.

Discussion, Summary, and Conclusions

Material for comparison of the food of the musk turtle with that of the other aquatic turtles studied is given in Tables 8 and 67. The numbers of each food item as determined by actual count and the detailed identifications of the substances taken as food are recorded in Table 9. The numerical dominance of the food by aquatic insects, molluscs, and vegetable debris is apparent and in general corroborates the relations earlier indicated by volumetric and frequency of occurrence calculations as expressed in Tables 3, 4, 5, 6, 7, and 8.

TABLE 8. THE FOOD OF THE MUSK TURTLE ON NATURAL WATERS IN MICHIGAN

Based on seventy-three stomachs containing 17.7 cc. of food and on sixty-six colons containing 51.4 cc. of food. The organs are from 105 turtles collected on thirteen lakes and three non-trout streams. Data on eight specimens from fish hatcheries are not included. More specific determinations of food items are given in Table 9.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	6.2	0.8	1.6	1.1
Unidentified fish	——	——	Traces	1.6
Carrion	40.1	5.8	4.9	3.2
Crayfish	6.2	3.3	10.6	9.7
Insects	16.9	34.2	23.6	26.9
Snails and clams	23.2	28.3	34.7	24.7
Cryptogams and phanerogams	3.4	13.0	7.7	14.0
Vegetable debris	4.0	12.5	16.7	10.8

That the musk turtle is an omnivore is conclusively demonstrated by these data. Stray insects, such as the grasshopper, terrestrial carabid, coccinellid, and rhynchophoran beetles, the lepidopteran larva, and the bee and ants, were doubtless taken after they had fallen into the water and do not alter the picture that this turtle is essentially aquatic in its feeding habits.

TABLE 9. NUMBER AND OCCURRENCE OF EACH ITEM IN THE FOOD OF 115 MUSK TURTLES

Food Item	Locality (and Number of Turtles)					Totals
	Whitmore Lake (34)	Sherman Lake (28)	Miscellaneous Southern Lakes (34)	Rivers (9)	Fish Cultural Stations (8)	(115)
	(16) Stomachs (32) Colons	(28) Stomachs	(21) Stomachs (27) Colons	(6) Stomachs (7) Colons	(6) Stomachs (4) Colons	(76) Stomachs (70) Colons
FISH						
Perca flavescens	..	1	..	..	..	1
Lepomis macrochirus larvae	..	..	..	..	1000+	1000+
Centrarchidae	..	..	2	..	..	2
UNIDENTIFIED FISH	..	..	3	..	..	3
CARRION	X**	X	..	..	..	7
LEECHES (Hirudinea)	..	..	..	..	2	2
CRAYFISH						
Cambarus virilis	..	2	..	.	..	2
Cambarus sp.	5	..	11	5	2	23
WATER MITES (Hydracarina)	..	..	1	..	..	1
INSECTS†						
Caenis sp. nymph	..	..	1	..	..	1
Hexagenia sp. nymphs	..	..	..	2	..	2
Ephemerida nymphs	2	..	1	..	..	3
Melanoplus m. mexicanus	..	1	..	..	..	1
Anax junius nymphs	2	..	..	..	..	2
Aeschna sp. nymph	..	..	1	..	..	1
Leucorrhinia sp. nymph	..	..	1	..	..	1
Celithemis sp. nymph	..	..	1			1
Anisoptera nymphs	16	2	29	10	2	61
Enallagma sp. nymph	..	1	..	..	..	1
Zygoptera nymphs	4	..	..	1	..	5
Ranatra sp.	..	..	1	..	..	1
Belostomatidae	..	..	1	..	..	1
Pelocoris sp.	1	..	..	..	..	1
Carabidae	..	1	..	..	..	1

Food Item	Whitmore Lake	Sherman Lake	Miscellaneous Southern Lakes	Rivers	Fish Cultural Stations	Totals
Dytiscidae	1	..	2	..	..	3
Hydrophilidae	4	1	..	..	..	5
Coccinellidae	..	..	..	..	1	1
Rhynchophora	..	..	1	..	..	1
Coleoptera	..	1	..	..	..	1
Leptocella albida larvae	36	..	..	..	..	36
Leptoceridae larvae	147	12	69	2	2	232
Limnephilidae larva	..	..	1	..	..	1
Trichoptera larvae	26	1	1	1	..	29
Pyralidae larva	1	..	..	..	..	1
Lepidoptera larva	1	..	..	..	..	1
Chironomidae larva	1	..	..	..	..	1
Stratiomyiidae larva	..	..	..	..	1	1
Brachycera larvae	2	..	..	..	..	2
Diptera pupae	..	..	..	..	2	2
Formicidae	11	..	..	..	..	11
Apis mellifera	..	..	1	..	..	1
Hymenoptera	1	..	..	..	..	1
Insecta	X	X	X	..	X	X
SNAILS AND CLAMS						
Helisoma trivolvis	8	..	..	..	5	13
Helisoma antrosum	1	5	6	..	..	12
Helisoma sp.	12	..	2	..	..	14
Physa sayii	6	4	7	..	..	17
Physa sp.	3	..	4	..	..	7
Amnicola sp.	..	36	..	..	..	36
Gastropoda	X	18	X	X	2	X
Pisidium sp.	..	..	..	2	..	2
Pelecypoda	..	..	X	..	..	X
Mollusca	..	..	..	1	..	1
CRYPTOGAMS						
Filamentous algae	X	..	X	..	X	X
Chara sp.	..	..	X	..	..	X
Musci	..	..	X	..	..	X

Food Item	Whitmore Lake	Sherman Lake	Miscellaneous Southern Lakes	Rivers	Fish Cultural Stations	Totals
PHANEROGAMS						
Potamogeton sp.	X	X	X	..	..	X
Najas sp.	..	..	X	..	..	X
Elodea canadensis	..	X	..	..	..	X
Spirodela polyrhiza	X	..	..	..	..	X
Lemna sp.	X	..	..	..	..	X
Ceratophyllum demersum	X	X	X	X	..	X
Nymphaea advena seeds	2	1	26	38	..	6[illegible]
Ranunculus sp.	..	..	..	X	..	X
Castalia odorata seeds	29	..	..	..	..	29
Cornus Amomum	..	..	1	..	..	1
Utricularia	X	..	..	..	..	X
Bidens sp. seeds	1	..	3	..	..	4
VEGETABLE DEBRIS	X	X	X	X	..	X

* The following items were identified as Carrion: *Amia calva, Lepomis gibbosus, Lepomis macrochirus,* Centrarchidae, and the remains of unidentified fish.

** The letter "X" is used to denote the occurrence of food items for which counts of the numbers of individuals present were either impracticable or impossible.

Insects are adults unless otherwise indicated.

Although very few fish were eaten by the musk turtles studied, this "damage" may be more than counterbalanced by the other "enemies" of fish which are also taken. Such insects as the predacious belostomatids and diving beetles, and seeds of the "beggar-tick" (Bidens sp.), may be placed in this category. The latter is so considered as a result of an observation by Leonard (1938), of a goldfish injured by such a burr.

Excepting the effects of predation at hatcheries, it would seem that the principal effect of the musk turtle on game fish is indicated by the numbers of fish-food organisms which this turtle eats. The possible benefits of this turtle may accrue from its scavenger habit, its consumption of molluscs which figure in the life cycle of fish parasites, and possibly from its dissemination of undigested seeds of aquatic plants. The species probably has no significance as a source of meat supply.

Chelydra serpentina (Linné)

Snapping Turtle. Common Snapper.

Description

The snapping turtle attains the greatest size of any of the turtles native to Michigan. The largest specimen which I collected had a carapace 373 mm. (14.7 inches) long and weighed thirty pounds. Specimens up to seventy pounds in weight are reported to have been taken by turtle trappers in the state. Abbott (1884) saw a specimen that weighed sixty pounds in New Jersey and reports having been told of heavier specimens. The snapping turtle is characterized by: (1) a rigid carapace which shares the predominantly dark brown or black color of the upper parts of the head, tail, and limbs; (2) a small, cross-shaped plastron, which is dull yellowish in color like the remaining * ventral regions; (3) a large head and neck; (4) stout, strongly hooked jaws, and (5) a long, distinctive tail, with a prominent crest of horny cuneiform tubercles.

Sexual dimorphism in this species has been recognized by naturalists for a long time. The secondary character generally employed is the location of the anus. As Cahn (1937: 38) wrote, "The anus of the male is nearer to the tip of the tail than it is in the females." Casual observations have suggested that the skull is wider in males than in females, but measurements were not made to demonstrate this difference. I have, however, taken detailed measurements on the tail character in 150 specimens. A report on the findings for this character as well as on the sex ratio will be given at another time.

Range

According to Stejneger and Barbour (1939: 157) the range of the common snapper is: "Eastern North America, except peninsular Florida, from southern Canada and Nova Scotia to the Gulf of Mexico and west to the Rocky Mountains." Conant (1938: 124) reported the distribution as extending ... through Mexico and Central America to Costa Rica." In Michigan the snapping turtle doubtless occurs in every county (Map 2), and is most common to the south.

Habitat and Habits

Many authors, including those listed in Table 10, have published observations on the habitat of the snapper.

As Conant (1938: 126) has written for Ohio, "almost any body of water large enough to keep it wet is a potential home for a snapper," such doubtless also holds for the animal in other parts of its range. In New York I took a large adult from an isolated pool in a small stream which had dried to pools.[1] W. S. Blatchley (1891) found five specimens in a similar, though smaller, "mud-hole" in Indiana. Specimens in Michigan have been collected in streams, rivers, pools, ponds, and lakes of great variety of descriptions and as Holbrook (1842: 144) recognized "... even at a distance from their accustomed element." The types of water areas which yielded greatest returns for effort expended in obtaining turtles from them were as follows: soft-bottomed lakes and ponds in the southern half of the Lower Peninsula; lagoon-like sections of larger rivers such as the St. Joseph near Three Rivers and the Muskegon about seven miles east of the city of Muskegon; and river-mouth lakes such as White and Muskegon Lakes. As has been previously stated, water areas rich in abundance and variety of aquatic vegetation seem to support the larger populations of snapping turtles.

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[1] This small stream 5 1/2 miles west of Newburgh had dried to isolated pools. The pool from which the turtle was taken on August 10, 1936, was eight to fifteen feet wide, about one hundred feet long, and up to about three feet in depth.

TABLE 10. HABITAT OF THE SNAPPING TURTLE IN MICHIGAN AND OTHER PARTS OF ITS RANGE AS GIVEN IN SEVERAL PUBLISHED ACCOUNTS.

Author	Date	Locality	Habitat
Blanchard, F. N.	1928	Michigan Douglas Lake region	Occasionally taken in Douglas and Burt lakes
Conger, A. C.	1920	Throughout the state	Sluggish streams, lakes, and ponds
Ellis, M. M.	1917	Douglas Lake region	In *Scirpus* habitat in lake; in shaded habitat in stream
Hankinson, T. L.	1908	Oakland County	Walnut Lake
Potter, D.	1920	Barry County	Wall Lake
Ruthven, A. G.	1911	Saginaw Bay	Turtle Bay on south shore of Saginaw Bay
Ruthven, A. G., C. Thompson, and H. Thompson	1912	Michigan	Quiet water habitats. Lakes, ponds, and pools of sluggish streams
Ruthven, A. G., C. Thompson, and H. T. Gaige	1928	Michigan	Lakes, ponds, and pools of sluggish streams
Thompson, C.	1915b	Monroe County	Common in River Raisin
Thompson, C. and H. Thompson	1912	Charity Island	Pond
Allen, J. A.	1868	Massachusetts	Ponds and muddy streams
Atkinson, D. A.	1901	Pennsylvania	Rivers, ponds, large creeks
Babcock, H. L.	1919	New England	Stagnant pools, sluggish streams, rivers, soft marshes

TABLE 10 (CONTINUED)

Author	Date	Locality	Habitat
Babcock, H. L.	1938	New England	Ponds and sluggish streams
Blanchard, F. N.	1922	Iowa	Lakes, sloughs, and rivers
Blanchard, F. N.	1926	Kentucky	Cypress woods
Blatchley, W. S.	1891	Indiana	River bottom ponds
Bond, H. D.	1931	West Virginia	Streams and muddy ponds
Boyer, D. A., and A. A. Heinze	1934	Missouri	Ponds
Breder, C. M. and R. B. Breder	1923	North Carolina	Swamp
Brown, J. R.	1928	Ontario	Bay, marsh, and pond
Buckle, C. E.	1925	Illinois	Pond
Burt, C. E.	1927	Kansas	Pools of creek
Burt, C. E.	1933	Kansas	Ponds and streams
Burt, C. E.	1935	Kansas and Oklahoma	Pasture ponds and prairie streams
Burt, C. E. and M. D. Burt	1929	Texas	Prairie pond
Cahn, A. R.	1937	Illinois	Lakes, ponds, rivers, and streams
Cederstrom, J. A.	1931	Minnesota	Lake
Conant, R.	1938	Ohio	Lakes, rivers, ditches, creeks, swamps
DeKay, J.	1842	New York	Clearest and muddiest streams
DeSòlo, C. R.	1931	Northeastern states	Shallow ponds, small streams, and rivers

TABLE 10 (CONTINUED)

Author	Date	Locality	Habitat
Dice, L. R.	1923	Kansas	River
Ditmars, R. L.	1905	New York	Slow-running muddy streams and large ponds
Ditmars, R. L.	1936	Range	Slow-running muddy rivers and streams, ponds, and marshes
Drowne, F. P.	1905	Rhode Island	Ponds and muddy streams
Eckel, E. C. and F. C. Paulmier	1902	New York	Quiet waters
Evermann, B. W. and H. W. Clark	1920	Indiana	Streams, bogs, ponds, and lakes
Force, E. R.	1930	Oklahoma	Ponds, creeks, and bottom lands in sluggish water holes and coal pits
Fowler, H. W.	1906	New Jersey	Creek
Gaige, H. T.	1914	Illinois	Creeks and ponds
Garman, H.	1892	Illinois	Illinois River
Gloyd, H. K.	1928	Kansas	Ponds, creeks, marshes, river
Green, N. B.	1937	West Virginia	Rivers, ponds, and streams
Hahn, W. L.	1908	Indiana	Ponds
Hankinson, T. L.	1917	Illinois	Streams, larger ponds
Hay, O. P.	1887b	Indiana	All waters
Hay, O. P.	1892	Indiana	Streams, lakes, and ponds
Hay, W. P.	1902	Washington, D. C.	Marshes, ponds, shallow waters

TABLE 10 (CONTINUED)

Author	Date	Locality	Habitat
Holbrook, J. E.	1842	North America	Stagnant pools, sluggish streams, rivers
Hughes, E.	1886	Indiana	Sluggish streams and ponds
Hurter, J.	1911	Missouri	Streams and ponds
Jones, J. M.	1865	Nova Scotia	Larger lakes
Leffingwell, D. J.	1926	New York	Stream and pond
Linsdale, J. M.	1927	Kansas	Creek
Mearns, E. A.	1898	New York	Ponds and streams
Myers, G. S.	1930	New York	Lakes
Nelson, J.	1898	New Jersey	Mill ponds, creeks, ditches, brooks
Over, W. H.	1923	South Dakota	Ponds, lakes, muddy creeks
Palmer, E. L.	1922	New York	Sluggish rivers and ponds
Parker, M. V.	1937	Tennessee	Lake, hill streams
Ricketson, O. G.	1911	Massachusetts	Brooks, ponds, and streams
Roddy, H. J.	1928	Pennsylvania	Muddy streams, mill dams, ponds, clear streams
Ruthven, A. G.	1910b	Iowa	Larger streams, bodies of quiet water
Say, T.	1825	United States	Large, muddy ponds, ditches, and other waters of slow current
Schmidt, K. P. and W. L. Necker	1935	Chicago region	Streams and ponds

TABLE 10 (CONTINUED)

Author	Date	Locality	Habitat
Smith, E.	1899	Vicinity of New York City	Soft-bottomed waters or sloughs
Smith, W. H.	1882	Ohio*	Ponds and muddy streams
Storer, D. H.	1839	Massachusetts	Filthy water, pond, pool
Strecker, J. K.	1915	Texas	Lakes, streams, rivers
Strecker, J. K. and W. J. Williams	1927	Texas	River
Surface, H. A.	1908	Pennsylvania	Muddy ponds and clear rivers
Taylor, E. H.	1929		Pool in river
Toner, G. C.	1936	Ontario	Lakes and rivers
Verrill, A. E.	1863	Maine	Ponds and muddy streams
Viosca, P.	1923	Louisiana	Swamp lands

Perhaps contrary to expectation, the few snappers encountered walking with characteristic awkwardness on land were not exclusively females. However, females are probably encountered on land more frequently than males, since nesting activities require that some time be spent thus by them each year. Such a nesting female was encountered in a grassy field on sandy loam about one hundred yards from Pasinski's Pond, Livingston County, about 1.8 miles east of Howell on May 3, 1938, at 6:00 P.M. Another female containing several mature eggs was found dead on the highway (U.S. 31) five miles north of White Cloud, Newaygo County, on May 18, 1937. Cahn (1937: 41) reports having "trailed snappers for more than a half a mile from water during the egg-laying season." A male (ST 155) was picked up by M. B. Trautman while it was walking across a road on July 7, 1938, 1.5 miles north of Ann Arbor, Washtenaw County. Another adult male was taken by R. W. Eschmeyer while it was crossing a road about two miles west of Clyde on May 28, 1938, at about 2:00 P.M.

Although the cause for wanderings of females away from water is usually attributed to the nesting urge this may not necessarily be so. Heape (1931: 326) perhaps knowing of the travels of both sexes of this species wrote that, "the snapping turtle (<u>Chelydra serpentina</u>) may leave the water and travel some distance on land." Baskett and Ditmars (1902: 117) offering an explanation stated that "turtles ... migrate from pond to pond either on account of drought or to hunt new fields for feeding." These authors also suggested that for turtles some migrations may be due to weather conditions for

"... directly after a rain quite a flock of little mud turtles [was seen] half a mile from any body of water." Such travels may be of economic significance in the control of the species and in the natural restocking of waters depleted by commercial turtle hunting.

As is generally known, the snapping turtle has rather a vicious disposition which is displayed very early in life. Although Conant (1938) states that adults may occasionally become tame, specimens retained in the University Museums reptile pit and in large aquaria at the W. K. Kellogg Bird Sanctuary during the summers of 1937 and 1938 did not become noticeably more mildly mannered during their sojourn in captivity. Faced with a potential enemy, this turtle does not ordinarily retreat within its shell or move in the opposite direction as do other Michigan turtles, but at once faces-off and may even move to the attack.

This species is well protected by its strong jaws, which move with remarkable speed, and by its heavy carapace. The common name "moss-back" refers to the luxuriant mat of firmly attached algae, predominantly Basicladia sp., which flourishes on the backs and on the upper parts of the tails of many individuals, rendering them inconspicuous in certain environments. The turtles are thus protected from their enemies and their chance of capturing prey is increased.

I have been in the field and collected specimens only during the months of April through September, inclusive, but occasional records for other months are listed in the Museum of Zoology catalog. Individuals are not infrequently seen moving about under the ice. Evermann and Clark (1920), however, recorded having seen a large specimen just under the ice in Lost Lake, Indiana, on December 18, 1900, which appeared to be too much benumbed to move away, even when a hole was chopped through the ice to effect its capture. E. Krasny, of Whitmore Lake, Washtenaw County, reported obtaining a twenty-pound individual in a like manner from Whitmore Lake early in the winter of 1937-38 just after the first freeze, while the ice was yet clear. In January, 1938, a specimen is reported to have been taken under the ice in a muskrat trap in Evans Lake, Lenawee County.[2] Kilham (1929) found a small, torpid specimen in the mud of an estuary in the Charles River at Cambridge, Massachusetts, during a February thaw. Notwithstanding the occasional discovery of snapping turtles active during the winter months, it appears that this turtle generally hibernates, from early fall (October) to early spring (March). It was Newman's (1906) belief, however, that far fewer individuals hibernate than is commonly supposed.

Snapping turtles usually hibernate in the bottom, sometimes singly and at other times in large aggregations in selected spots such as muskrat burrows, the mouths of tributary streams, in spring inlets, and under logs and banks. Some turtle hunters are aware of these habits and frequently make large hauls from hibernating concentrations. Clark and Southall (1920: 5) recorded "... as much as 5 tons of turtles have been taken from the various muskrat holes [near Muscatine,

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[2] Michigan Department of Conservation Official News Bulletin. January 26, 1938.

Iowa] in one season." E. Bixby, of Berrien Springs, told me that he took five hundred pounds of snappers in the early spring of 1937 from a small channel between two of the Grand Marais Lakes just west of Stevensville (Berrien County). The turtles were buried under from one to two feet of the soft bottom material in this channel and were located and hauled out by the iron rod previously described in this report. Hibernation in similar sites has been reported by Abbott (1884), Newman (1906), Clark and Southall (1920), Cahn (1937), Conant (1938), and others. The time annually consumed for hibernation would seem to reduce by perhaps five months the period in this latitude during which concern may be felt about the feeding activities of this and other turtle species.

That it is not absolutely necessary for snappers to hibernate in water is evidenced by observations on an eight-inch specimen which over-wintered (1938-39) in the reptile pit at the Museum. On November 15, 1938, this turtle was last given food (ground beef) and at about this date the water was drawn from the small pool in the outdoor enclosure. In one end of the pit there was a pile of leaves six inches deep; the remainder of the bottom was largely of bare gravel with one red-osier dogwood and a few small logs. The turtle had "hibernated" under the pile of leaves by December. When uncovered on March 1, 1939, ice was present on its back and the mat of leaves adjacent to its back was frozen. The turtle was alive though very sluggish at this time and had dug itself into the ground to a depth of some four inches. The ground about the turtle was not frozen on March 1. It was alive and active on May 6, 1939.

The snapping turtle has several habits which are almost as characteristic as the one from which its name is derived. Although on land escape from the attack of an enemy is seldom attempted, in water the species flees by swimming as rapidly as possible in its somewhat clumsy manner, almost invariably down the slope of the bottom to deeper water. Not given to basking in the sun on logs, the snapping turtle was frequently found in shallow water, beside logs, stumps, or hummocks, at times lying partly buried in the mud. The depth of water selected was usually not greater than the length of the head and neck extended, for turtles lying in this manner run the head to the surface at regular intervals in order to breathe.

Presumably retaining an extra amount of air in the lungs, snappers are able to float, motionless, at the surface of the water with the eyes and nostrils just exposed. In this position they make a fine target for the rifle and are often shot by natives, an important consideration if conservation of the species is deemed wise. Many times during trapping activities on several lakes I saw turtles floating as described. This habit has been previously recorded by Newman (1906), Evermann and Clark (1920), Cahn (1937), and is widely known among naturalists, sportsmen, and lake-resort dwellers.

The tree-climbing and basking habits of the snapping turtle described by Conant (1938) have never been observed in the wild by me. I have, however, seen captives resting out of water in the sun in the reptile pit at the Museum, during June and July in the summer of 1938.

Perhaps the best account of nesting of this turtle is that given by D. L. Sharp (1911) who related the observations of J. W. P. Jenks. Other accounts of nests or nesting have been given in greater or lesser detail by DeKay (1842), Agassiz (1857), Abbott (1884), Smith (1882), Hay (1892), Garman (1892), Newman (1906), Hankinson (1917), Evermann and Clark (1920), Blanchard (1922), Cahn (1937), and others. Nesting in captivity has been described by Gloyd (1928).

Mating activities of captives have been observed in every month from April through October by Conant (1938). The pairs which I have seen in coitu were in the live boxes of professional turtle trappers near Waterloo, Washtenaw County, in September, 1938, and near Lake Orion, Oakland County, in August, 1939. These turtles had been trapped in nearby lakes during the week previous to the time when I saw them.

Food and Feeding Habits

Reports in the literature are in accord with my own observations that snapping turtles do not swallow food out of water. In the reptile pit at the Museums, ground beef repeatedly placed beside the pool of water was taken into the pool by snappers before it was swallowed. I have suspended a freshly killed carp out of water in a turtle trap and have watched captive snappers come up and secure a mouth full at a time and retire under water to swallow the morsel. One snapper repeated such feeding seven times in twenty minutes, until the supply had been exhausted.

In trapping turtles, it soon became obvious that freshly killed or well-preserved bait insured the best catches. This was contrary to what many observers had reported to me so I drew up a series of simple experiments to learn how freshness determined palatability for this turtle. These experiments, executed for me by R. M. Stow under the superivison of M. D. Pirnie, were conducted in a sizeable aquarium at the W. K. Kellogg Bird Sanctuary in mid-summer. Three adults, 8.1, 10.2, and 10.9 inches long respectively, were placed in the tank which measured about three by four feet and contained water about two feet deep. The turtles were then kept without food for six days. Freshly drawn chicken entrails were secured from a nearby poultry dealer and a small amount of this material, which was kept at room temperature, was offered to the turtles each day until the day on which all three refused to eat. All three turtles ate the allotment of entrails which they were given on the first three days of the experiment. On the fourth day, the small one refused to take the food so the medium-sized turtle ate it. The largest turtle refused the morsel offered it on the fifth day, as did the smallest. On this day, the medium-sized turtle was offered two bits of food; one of which floated while the other sank to the bottom. That which sank was taken first; the floating piece, later. On the sixth day all three turtles refused to take the offerings of entrails, which by this time were largely decomposed and well-covered with maggots.

The same series of experiments was repeated using dead fish as food and employing the medium-sized individual as the subject. This turtle, after being without food for five days, took the fish offered for the first five days of the experiment and then refused to feed on the sixth and seventh days. By the sixth day the fish was in advanced stages of decay and smelled very badly; it had been kept at room temperature.

On another occasion a decaying piece of a fish which had been dead for four days was offered the 10.2-inch snapper. Immediately after the turtle had begun to eat this, a piece of a freshly killed fish was introduced into the opposite side of the tank. In less than one minute the turtle left the decomposing fish and went to the fresh fish and ate it. He then returned to the old fish but ate no more of it; he poked it around for some time with his snout and then left it.

In a general way these experiments confirm original field observations that snapping turtles prefer fresh to decayed animal matter. The tests also refute the rather common concept that the more foul the food, the more tempting it is to the snapper.

Snapping turtles feed in three distinctive ways: (1) "small prey is drawn into the mouth with a sudden gulp, as though it were sucked into a vacuum cleaner" (Conant, 1938: 127); (2) large animals are seized by the jaws and held till they expire, or nearly so, and are then torn by combined action of the jaws and front feet into pieces which may be swallowed; and

(3) vegetable matter and soft bodied animals are bitten into sections which are ingested. These turtles are bottom, free water, and surface feeders. Fish eggs and crawfish are examples of food substances taken off the bottom. Fish of several kinds are taken from free water. Some algae, pond lily leaves, snails, and some insects are taken from the surface.

During bottom feeding activities, snappers often root around the large rhizomes of Nymphaea advena and frequently break off sizeable sections. These sections come to the surface and are taken by professional trappers as a sign that snappers are present. Snapping turtles are also said to "roll" the vegetation during foraging activities. This "rolling" is particularly evident in dense beds of Chara where sizeable areas of the bottom may be bared and the vegetation moved off to one side, usually toward the shore.

The literature contains strikingly few records of original observations on the food of the snapping turtle. From among these few, the more important ones have been selected and are given here.

Hay (1892: 558) wrote: "A large specimen that I dissected had in its large intestine the feathers and partially digested bones of a full grown robin. The wing and tail feathers filled up the intestines. Its excrement contained the remains of a crayfish."

Newman (1906: 150) stated: "Chelydra captures large animals, such as young ducks, by seizing them by the feet and dragging them beneath the surface. I have seen several such tragedies." Hurter (1911) gave one of the few actual records in the literature of a witness to such a "tragedy" who saw a duckling captured by a snapping turtle.

Evermann and Clark (1920: 597) wrote: "Several stomachs examined at the lake [Maxinkuckee] all contained opercula and fragments of <u>Vivipara contectoides</u>, indicating that this mollusk is the principal food of this species of turtle at the lake during certain parts of the year."

Bralliar (1922) recorded for southeastern Iowa a young trumpeter swan having been caught by a large snapping turtle, pulled under water, drowned, and eaten.

Sontag (1924: 211) reported finding, in a snapping turtle stomach in Minnesota, two crushed goose eggs about ready to hatch and the leg and foot of a "white goose."

Buckle (1925: 6) related an unusual occurrence: "On May 29, 1925, on the Ames Plantation, while passing a small pond, a hawk was observed struggling in the water. The head of the hawk was above water and its wings were flapping on the surface. The hawk was killed and when lifted from the water a nine-pound snapping turtle was found holding on to his legs. The hawk was one of the 'Blue-darter' species. The presumption is that the hawk was enjoying a bath in shallow water when the turtle took advantage and seized him by the legs."

Abbott (1884: 269) knew "...quite a small snapper to seize a full-grown musk-rat by a hind leg and drag it into deep water," where he supposed it was "... held until it drowned."

Hatt (1932: 37) observed a snapping turtle feeding on a dead Green Heron which was known to be carrion in a small pond on Long Island, New York.

Cahn's (1937: 43) interesting finds of "bones of dogs, cats, and rabbits in the stomach, as well as pieces of bones of much larger animals showing the saw marks of the butcher" also reflect the scavenger habit of this species. Others of Cahn's comments on the food of the snapping turtle are of such a nature that one cannot know whether or not they are original.

R. Conant has given me permission to include the following observations contained in a letter which he wrote me on June 28, 1939: "In the field I once found a small snapper feeding on a dead water snake at the edge of a small pond. The turtle was in about a foot of water, the time was about an hour after dawn in mid-summer. I watched the turtle take two bites and then an inadvertent movement on my part alarmed the reptile and it turned and headed for deep water so rapidly that I was barely able to capture it. On another occasion I found a large snapper with a fish in its mouth. It escaped to deep water. From the fleeting glance I had of it, the fish looked fresh and as though it had just been caught."

P. L. Errington has given me the following original records of food of the snapping turtle. I quote from his letters to me:

"August 30, 1935 - N. W. of Ames, Iowa. Male snapping turtle with a carapace about 9 inches long was buried in sand at the bottom of a little pool in nearly dry bed of a small creek. Only its head was protruding. Its intestine contained fragments of a large crayfish (Cambarus sp.).

"April 18, 1936 - N. W. of Ames, Iowa. Male snapping turtle with a carapace about 6 inches long was dug out of the mud beside a small creek. Its intestine contained about 60 cc. of remains of a small dytiscid.

"September 8, 1936 - N. W. of Des Moines, Iowa. Female snapping turtle full of egg yolks was caught in shallow water of a small creek. Its stomach contained remains of a small frog (Rana sp.) and a mass of dead leafy and stick debris, perhaps swallowed incidentally. Its intestine, vegetable material only, which it seemed to have eaten primarily, including leaves of willow, Cyperacea, and Poa, hawthorn seeds, and short sections (1/3" × 1/2") green willow stems.

"October 29, 1936 - N. W. of Gilbert, Iowa. Male snapping turtle with a carapace about 9 inches long was taken from shallow water in a small creek. Stomach and intestine contained a few green leaves of Poa.

"September 2, 1937 - N. W. of Ames, Iowa. Snapping turtle fecal passage of unquestionable origin from an animal leaving hole in the mud about 9 inches in width was found in the bed of a small creek that was entirely dry except for a few little puddles. Contents of passage: crayfish exoskeleton fragments and the head of a medium-small bullhead.

"A snapping turtle with a carapace about 9 × 8" was caught on May 25, 1938, near Squaw Creek, N. W. of Ames, Iowa. Contents of stomach and intestine: 3 large Hydrophilus, a medium Dytiscus, and a Phyllophaga. Stomach also contained grassy debris and amorphous jelly-like substance."

A small specimen which I examined from Welch Lake, Dickinson County, in northern Iowa contained the remains of two adult dytiscoids, one Cambarus virilis, and some vegetable debris. The turtle was collected by Carl L. Hubbs and family on August 8, 1932.

The only previous detailed study of the food of the snapping turtle which has been published is that of Surface (1908). As previously suggested, the work of this investigator is unique of its kind for turtles and is unusually complete, although for the snapper only nineteen specimens were studied. It is regrettable, however, that frequency of occurrence only is given for food items and groups of food items. As is generally known, and as has been earlier indicated in this report, food habits data presented in this manner alone do not give a reliable picture (inadequacy of data thus presented is very apparent in the several tables which bring out volumetric as well as frequency relations for food items). Surface (1908: 128-130) summarized his findings as follows:

"Nineteen specimens of Snapping Turtles were found to contain food, of which five contained vegetable matter. In two were found Algae or low forms of aquatic plants, while in two others were found fragments of leaves, and in one seeds were found. Three had fed upon grasses, which were undeterminable, and one had eaten the leaves of the Skunk Cabbage. Another was found to contain apple seeds, indicating that it would feed upon such fruit when available. ....

"A review of the food of the Snapping Turtles shows that this consists chiefly of aquatic creatures, mostly crayfish, and also vertebrates of such species as may be either captured or found dead. The Snapper is a scavenger and will often eat dead material. This may account for some of the unexpected food elements discovered."

Food Chart of Snapping Turtle

	No.	Per Cent
Vegetation, ...	5	26
Algae (low water plants), ...	2	10.5
Seeds, undetermined, ...	1	5.2
Leaves, undetermined, ...	2	10.5
Apple seeds, ...	1	5.2
Skunk Cabbage (Symplocarpus foetida) leaves, .	1	5.2
Grass, ...	3	15.7
Animal Matter, ...	19	100
Mollusca (Snails and Slugs), ...	7	36.8
Snails (Helix), ...	4	21.1
Pond snails, ...	2	10.5
Slugs, ...	1	5.2
Crustacea, Cambarus sp. (Crayfish), . .	12	63.1
Insecta, ...	9	47.3
Undetermined Insects, ...	2	10.5
Hemiptera (Bugs)	1	5.2
Corisidae, Corisa sp., ...	1	5.2
Pentatomidae, (Stink Bugs)	1	5.2
Diptera (Flies), ...	3	15.7
Larvae, ...	2	10.5
Stratiomyiid (Fly) larva, ...	1	5.2
Coleoptera (Beetles), ...	7	36.8
Undetermined, ...	5	26.3
Water Beetle larva, ...	1	5.2
Hydrophilidae, Water Scavengers, .	1	5.2
Dytiscidae, Diving Beetles, ...	1	5.2
Gyrindiae, Whirligig Beetles, . . .	1	5.2
Vertebrata (Vertebrates), ...	7	36.8
Undetermined species (flesh), ...	2	10.5
Pisces (fishes), ...	2	10.5
Undetermined fish, ...	1	5.2
Catostomidae (Suckers), ...	1	5.2
Batrachia (frogs, etc.), Rana sp., . . .	1	5.2
Ophidia (Serpents), ...	2	10.5
Aves (Birds), ...	1	5.2
Mammalia (Mammals), ...	4	21.1
Undetermined, ...	1	5.2
Muridae (Mice), ...	2	10.5
Leporidae (Rabbits), Lepus sp., . .	1	5.2

That the snapping turtle is not wholly carnivorous but rather an omnivore was early suggested by Hay (1887a: 15) when he wrote that this turtle "lives principally on crustaceans, fishes and young ducks, but will also eat vegetable food."

In contrast to most previous published accounts of the food of the snapping turtle,* that of Surface (1908: 128-129) which has just been cited appears to be the first actual record of vegetation in the food of the snapping turtle. Babcock (1916: 90) also found plant material: "On July 9, 1916, I took a Snapping Turtle (carapace 12 inches in length) from a mud hole on the border of a salt marsh at Sagamore Beach, Cape Cod, Massachusetts. The stomach was well-filled with recently eaten marsh grass (Distichlis spicata), the blades being intact, although bent and tangled. There was nothing else in the stomach. The turtle was a male, quite fat and apparently in a healthy condition."

The plant-feeding habit of the snapping turtle was indicated by an unpublished study made in Portage Lake, Washtenaw and Livingston counties, by Lyle S. Hubbard under the direction of Carl L. Hubbs in 1920. A large proportion of the stomachs examined were filled with segments of lily stems. The plant food predominated the animal matter.

The more recent stomach and intestine analyses by Errington, which I have earlier quoted, show an incidence of terrestrial plants in the food of this turtle. The occurrence of land plants, as well as aquatics, in the food of the snapper was mentioned by Cahn (1937) and the suitability of vegetable food by Conant (1938).

Two specimens in my collections which were taken some distance from water gave no evidence of having fed on terrestrial plants or animals. They contained food from the aquatic habitat as follows: (1) ST155. Stomach contained: remains of a large hydrophilid and a trace of Wolffia sp.; colon contained several seeds of Bidens sp., a small amount of Wolffia sp., remains of a snail (Lymnaea sp.) and a beetle, and a Lepidoptera larva. (2) ST222. Stomach contained remains of three Physa sp. and a trace of filamentous algae. The colon had not been saved by the collector. Conant, however, has written to me that a small specimen which he found dead on the road contained the remains of Orthoptera.

In addition to the original specific observations on the food of the snapping turtle which have just been cited, many more general statements have been published. Unfortunately it is impossible to know whether or not several of these statements are based on original discovery or whether they reflect previously published records. In order to demonstrate this difficulty in the interpretation of these accounts, I have arranged, in chronological order, a series of quotations from the writings of previous workers. It is interesting to note, in this series, the failure of writers subsequent to Surface to recognize the role of vegetable matter in the food of this turtle. My findings would seem to indicate that this oversight is distinctly and unfortunately in error. Comments by various investigators on the food of the snapping turtle are as follows:

"... preying on fish, ducklings, etc., etc. ..." (Shaw, 1802: 72)

"In some situations where this species abounds, it is very destructive to young ducks, seizing them by the feet and dragging under water, for the purpose of devouring them." (Say, 1825: 218).

"This species is very voracious in its habits and destroys great quantities of fish." (LeConte, 1829: 129).

"... destroys many fish and waterfowl, ..." (Cuvier, 1831: 15)

"It is exceedingly powerful and voracious, feeding upon fishes and frogs; and the farmers sometimes complain of its depredations among their chickens and ducklings." (Storer, 1839: 212).

"They feed upon frogs and fishes, and snap greedily at ducks in ponds, dragging them under water to be devoured at leisure." (DeKay, 1842: 9).

"They are extremely voracious, feeding on fish, reptiles, or any animal substance that falls their way." (Holbrook, 1842: 144).

"Their [the Chelydridae] food consists entirely of aquatic animals; fishes and young ducks are their ordinary prey." (Agassiz, 1857: 346).

"Fish are not, however, the only food of the snappers, as they do not hesitate to attack anything in the way of beast or bird that they can seize, and if they succeed in drowning the animal that they have caught, they soon make a meal of it. ... Certainly, numbers of young ducks are annually destroyed by these voracious creatures." (Abbott, 1884: 269).

"It is a very strong, fierce and voracious animal, which lives principally on crustaceans, fishes and young ducks, but will also eat vegetable food." (Hay, 1887a: 15).

"The Snapping-turtle is wholly carnivorous and extremely voracious. Their food consists of frogs, fishes, the smaller and younger water fowl, and crayfishes. They do not hesitate to eat any animal substance that presents itself." (Hay, 1892: 558).

"Their food consists of all manner of small animals, such as fishes, frogs, reptiles, and young water birds." (Garman, 1892: 245).

"... prey ... consists of everything of an animal nature within reach. ... It is extremely voracious, and is said to draw ducks and geese under water to devour them at leisure." (Smith, 1899: 15).

"They feed largely upon fish, ..." (Fowler, 1906: 218).

"The turtle is entirely carnivorous." (Ditmars, 1907: 14).

"It feeds upon any living thing it can overpower and is particularly destructive to fish and young waterfowl." (Nash, 1908: 17).

"The snapping turtle is carnivorous and lives wholly on fish, crayfish, frogs, small rodents and small and young water-fowl." (Hurter, 1911: 227).

"This turtle is chiefly carnivorous, its diet consisting of fish, small reptiles and mammals, amphibians, and other aquatic animal life. It is also destructive to young waterfowl, which are seized and pulled under water, to be eaten at leisure." (Babcock, 1919: 357).

"These turtles are carnivorous and very voracious. Their food consists of frogs, fishes, crawfishes, young waterbirds, and such other small animals as they can capture." (Evermann and Clark, 1920: 597).

"The snapper is very voracious, feeding on frogs, fishes, crayfish, young water birds, etc." (Clark and Southall, 1920: 10).

"Feeds on fish, frogs, reptiles, young water-birds, etc." (Conger, 1920: 46).

"They are carnivorous, fish constituting the larger portion of their food; however, young fowls are readily taken and it is likely that these turtles destroy many young of our wild ducks during the breeding season." (Over, 1923: 16).

"Snapping turtles feed mainly on animal life such as slugs, snails, insects, frogs and tadpoles, fish, and even quite good sized snakes, birds and mammals. Young ducks and geese on ponds are often seized from below and drawn under the water and later devoured." (Roddy, 1928: 19).

"The snapping turtle is carnivorous and voracious. Among other things it will pull down swimming ducks and waterfowl." (Eifrig, 1930: 63).

"... it lives on fish, waterfowl, and small mammals, ..." (De Sola, 1931: 156).

"The common snapper is largely a carnivorous species. ... Among the vertebrates, fish, frogs, tadpoles, salamanders, snakes, birds, and mammals are commonly found in the digestive system, while among the invertebrates, snails, insects, insect larvae, and crayfish are predominant. ... Young ducks are often captured, the turtle grabbing them by their submerged legs and dragging them under water, there to drown and be pulled to pieces .... In spite of their preeminently carnivorous habits, occasional individuals are found whose stomach is full of grass, leaves, and other vegetable matter. Sometimes this represents aquatic vegetation, but more often terrestrial plants." (Cahn, 1937: 43-44).

"The diet consists of any kind of animal matter, dead or alive, that can be obtained. This turtle is very destructive to young waterfowl and fishes, ..." (Babcock, 1938: 20).

A few observations on the food of young individuals have been recorded. Surface (1908: 131) "found very young Snapping Turtles feeding upon insects especially beetles, and also upon small fishes, especially suckers, and upon crayfish ... and snails. These were very small specimens, being not over ... two inches in length." Newman (1906: 150) writes: "The young feed upon larvae of insects that are found by burrowing in the mud." This statement is repeated almost verbatim by Cahn (1937: 44). Linsdale (1927: 81) found the "gullet" of a specimen about one and one-half inches long to be filled with the remains of cricket frog. The turtle was collected "in a small puddle of water along a road" in Kansas.

The only small individual which I have examined was collected from the Clinton River at Drayton Plains on July 8, 1937, at 3:00 P.M. The stomach of this young specimen contained a black-nosed shiner, three beetle larvae, a leech, and some filamentous algae. In the colon there was a trace of a crayfish and some vegetable detritus.

In captivity, snapping turtles give additional evidence of their omnivorous feeding habits. They will eat a great variety of animal and vegetable substances. Gloyd (1928: 133) stated that "they fed on crayfish and scrap meat." Brimley (1905) reported that they eat live toads. Conant (1938) found that vegetable as well as animal matter was taken by captives. Captives in my laboratory have fed on ground beef, pieces of beef heart, dead flies and moths, crayfish, earthworms, and fish. In the reptile pit at the Museum, captives eat lettuce and ground beef.

My food studies of the snapping turtle are based on 323 specimens which contained food either in the stomach, colon, or both. These turtles were collected from the localities and in the numbers given in Table 11.

The common snappers studied for food were obtained from seventy-two different lakes, eleven non-trout streams, six trout streams, and eight fish cultural stations (Table 11). In the following analyses of the food habits, the specimens from Silver, Wintergreen, Spring, Sherman, Wolf, First, Ferguson, East Twin, and Mill lakes are treated separately (Tables 12 through 20). Individuals from the remaining lakes have been combined into three groups: (1) those from river-mouth lakes (Table 21); (2) those from southern lakes (Table 22); and (3) those from lakes north of approximately Town Line 16 (Table 23). Additional groups are those from non-trout

TABLE 11. LOCATIONS AND NUMBER OF SNAPPING TURTLES WHICH CONTAINED FOOD FROM EACH

Location		Number of Individuals	Date of Collection
Body of Water	County		
Silver Lake	Washtenaw	13	VI:12-14:37; VIII:26-27:37; V:8-9:38
Wintergreen Lake	Kalamazoo	21	VII:4-24:37; VIII:7, 24:37; VII:5-21:38; VIII:10-12:38
Spring Lake	Kalamazoo	11	VIII:11-12:38
Sherman Lake	Kalamazoo	19	VIII:19-21:37; IX:16-17:38
Wolf Lake	Van Buren	14	VI:26-27:37; VII:7-21:38; VIII:14-15:38
First Lake	Montcalm	21	VIII:23-25:38
Ferguson Lake	Clare	12	VIII:3-6:38
East Twin Lake	Newaygo	25	VII:11-27:38; VIII:16-17:38
Mill Lake	Lake	11	VIII:18-25:37; VIII:1:38
RIVER-MOUTH LAKES		16	
Muskegon Lake	Muskegon	9	IX:1-2:37; VIII:17-20:38
White Lake	Muskegon	7	VIII:19-20:38
MISCELLANEOUS SOUTHERN LAKES		71	
Dumont Lake	Allegan	1	VI:24:38
Yankee Springs Lake	Allegan	1	IX:11:37
Fair Lake	Barry	1	VIII:22:37
Middle Grand Mere Lake	Berrien	5	IX:12-13:37
Brace Lake	Calhoun	3	IX:16-17:37

Birch Lake	Cass	4	VII:8-9:37
Moon Lake	Hillsdale	1	VI:18:31
Lake Lansing	Ingham	2	IX:3:37
Markla Lake	Jackson	1	VIII:25-26:37
Strickland Lake	Jackson	3	VIII:27-29:38
Bonnie Castle Lake	Kalamazoo	3	IX:7-8:37
Gull Lake	Kalamazoo	2	VIII:25:37
Robinson Lake	Kalamazoo	2	VIII:30:38
Dunson Lake	Kent	1	IX:12:37
Pickerel Lake	Kent	1	V:10:37
Reeds Lake	Kent	1	VI:23:37
Half Moon Lake	Muskegon	3	VI:22:37; VII:12:37
Island Lake	Oakland	1	VII:24-29:37
Mitchell Lake	Oakland	2	VII:15-16:37
Richman Lake	Oakland	1	VII:22-23:37
Robinson Lake	Oakland	1	VII:29-30:37
Soft Water Lake	Oakland	1	VII:27-28:37
Lake Huron	St. Clair	1	VIII:6:37
Great Bear Lake	Van Buren	8	IX:10-11:37
Schoolsection Lake	Van Buren	3	IX:9-10:37
Bruin Lake	Washtenaw	2	VIII:27-28:37
Cassidy Lake	Washtenaw	1	VIII:4-5:37
Crooked Lake	Washtenaw	1	VIII:30-31:37
Little Cedar Lake	Washtenaw	1	VIII:12-13:37
Leeke Lake	Washtenaw	1	VIII:28-29:37

Lehman Lake	Washtenaw	1	IX:9-10:37
Loveland Lake	Washtenaw	2	IX:1-2:37
Mirror Lake	Washtenaw	1	VIII:31-IX:1:37
Mud Lake	Washtenaw	2	VIII:4-5:37; VIII:19-20:37
Pierce Lake	Washtenaw	1	VIII:14-15:37
Walsh Lake	Washtenaw	2	VI:4-5:38
Whitmore Lake	Washtenaw	3	IX:23-24:37; V:1-2:38
MISCELLANEOUS NORTHERN LAKES		44	
Lake N. of Mikado	Alcona	1	VII:15:37
Big Platte Lake	Benzie	1	V:23:37
Chicago Lake	Delta	1	VIII:15:37
Swan Lake	Delta	1	VI:17:37
Arbutus Lake	Grand Traverse	1	VII:3:37
Pond in AuSable River	Iosco	1	VII:11-12:37
Van Ettan Lake	Iosco	2	VII:13-14:37
Stevenson Lake	Isabella	2	VIII:4-5:38
Railroad Lake	Lake	1	VIII:23:37
Diamon Lake	Mecosta	7	VIII:6-7:38
Lake S.W. of Atlanta	Montmorency	1	VI:14:37
Fremont Lake	Newaygo	6	VII:26-28:38
Kimball Lake	Newaygo	2	IX:2-3:37
Hart Lake	Oceana	2	VII:2,3:37
Bullhead Lake	Ogemaw	1	VII:5-6:37
Dewey Lake	Ogemaw	1	VI:19-20:37
Horseshoe Lake	Ogemaw	2	VII:11-12:37

Mills Lake	Ogemaw	1	VI:21-22:37
Mud Lake	Ogemaw	2	VI:23-24:37; VII:2-3:37
Nester Lake	Ogemaw	1	VI:23-24:37
O'Connor Lake	Ogemaw	2	VII:3-4:37
Stylus Lake	Ogemaw	1	VII:1-2:37
Sheridan Lake	Osceola	4	VIII:3-4:38
NON-TROUT STREAMS		17	
St. Joseph River	Berrien	1	IX:12:37
Outlet of Pickerel Lake	Emmet	1	VIII:2-3:37
Battle Creek River	Kalamazoo	1	VII:20:38
Thunder Bay River	Montmorency	1	VI:6:37
Muskegon River	Muskegon	1	VIII:31-IX:1:37
Clinton River	Oakland	4	VII:8-23:37
Shiawassee River	Oakland	4	IX:19-28:37
PawPaw River	Berrien	1	VI:15:37
Black River	Sanilac	1	VIII:15:34
Mill Creek	Washtenaw	1	IX:7:38
Stream on Grosse Isle	Wayne	1	VI:19:37
TROUT STREAMS		6	
Stoney Creek	Houghton	1	VI:20:37
Middle Br. Pere Marquette River	Lake	1	VII:30:30
Pere Marquette River	Lake	1	VII:14:31
North Br. Pentwater River	Oceana	1	VII:31:30
Big Creek	Sanilac	1	VIII:7:37

Manistee River	Wexford	1	VII:2:37
FISH HATCHERIES		21	
Benton Harbor	Berrien	1	V:10:37
Silver Creek	Iosco	1	VI:28:36
Comstock Park	Kent	2	VIII:3:38
Baldwin	Lake	6	VII:24:31; VII:1,21:33; VIII:2:31; IX:20:32
Bear Creek	Manistee	1	VIII:11:31
White River	Newaygo	2	V:20:31; VIII:13:32
Sunset Water Gardens	Oakland	1	VII:20-21:37
Wolf Lake	Kalamazoo	7	V:5:30; IX:11:37; VII:21-23:38
	Total	323	

* Lake of unknown name two miles west of Mikado.

** Lake of unknown name four miles southwest of Atlanta.

streams (Table 24), from trout streams (Table 25), and from fish cultural establishments (Table 26). In Table 28 are given details of the numbers and kinds of food items eaten. Material for comparison of the food of this species with that of the other aquatic turtles studied is given in Tables 27 and 67. The groupings which have been made are generally separate ecological units and the food of the snapping turtle is discussed individually for each grouping.

Silver Lake. The following descriptive information on this lake has been largely drawn from the report of the survey made of this body of water in June, 1937, by the Institute for Fisheries Research. The lake lies in hilly, partly wooded country about four miles south of Pinckney. It has a surface area of 217 acres and a maximum depth of forty-seven feet. The shoal area is somewhat restricted, most of the lake being more than twenty feet in depth. Sand, gravel, and marl are the bottom types in the shallower water. More than one half of the shoreline has resort development and has a hard, sandy beach.

Aquatic vegetation in the more shallow water is composed principally of *Scirpus* sp., *Chara* sp., *Nitella* sp., *Pontederia* sp., *Potamogeton* sp., *Utricularia* sp., *Ceratophyllum demersum*, *Utricularia* sp., *Nymphaea advena*, and *Castalia odorata*.

Game fish present are mud pickerel, yellow perch, large- and small-mouthed bass, several species of sunfish, rock and warmouth bass, northern pike, and bullheads. Other fish collected from this lake include minnows, darters, and other forage fishes, long-nosed gar and bowfin.

Turtles associated with the snappers in Silver Lake were musk, Blanding's, map, western painted, and soft-shelled. Nests of the snapping, Blanding's, and western painted turtles were found in the adjacent hilly meadows and plowed fields.

The snappers studied for food were collected as follows: nine on June 12-14, 1937, three on May 8-9, 1938, and one on June 5, 1938. The results of analyses of the contents of the stomachs and colons of these thirteen individuals are given

TABLE 12. THE FOOD OF THE SNAPPING TURTLE IN SILVER LAKE

Based on ten stomachs containing 87.5 cc. of food and on eleven colons containing 334.0 cc. of food and one colon with an unascertained volume. More specific determinations of food items are given in Table 26.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	51.4	20.0	1.3	66.7
Unidentified fish	1.8	20.0	1.2	66.7
Crayfish	——	——	2.3	8.3
Insects	0.1	40.0	8.3	50.0
Molluscs	Trace	10.0	1.7	41.7
Miscellaneous animals*	——	——	1.3	58.3
Cryptogams	28.1	70.0	32.4	83.3
Phanerogams	13.6	40.0	20.9	83.3
Vegetable debris	5.2	40.0	30.8	83.3

* Includes the remains of a bullfrog, a snapping turtle, a feather, a leech, and a few water mites in one colon each.

in Tables 12 and 28. Three of the specimens had empty stomachs and one had a void colon. A few additional snappers taken from this lake at these times contained no food.

The analyses of the stomach contents of this series of snappers indicates that in this lake about one-half of the food (by volume) of this turtle is game fish and the other half, vegetable matter. As regards number, the game fish (twelve) eaten do not quite average one per turtle (thirteen).

Centrarchids, probably mostly sunfish, were almost the sole game fish encountered. Excepting one pumpkinseed, these fish were represented by remains so far digested that it could not be determined whether the individuals were dead or alive when taken. This possibility for error must be kept in mind when interpreting the data in Table 12 and in other tables of a similar nature. For convenience, an indeterminable percid found as a trace in one colon was classified as a game fish although it may have been one of the forage darter species.

In the stomachs, vegetable matter occurred about twice as often as fish, and in the colons there was an even greater preponderance of plant material, doubtless due to the fact that plant tissue is affected little by digestion until it reaches the large intestine. The high incidence and high proportion of the total volume of food constituted by vegetable matter is in sharp contrast to almost all of the findings of the previously cited workers. That this apparently important role of aquatic plants is typical, rather than unusual, for all habitats will be seen as the findings are presented for additional lakes and for other ecological units. Algae, potamogetons, and water lily leaves and petioles constituted by far the greatest portion of the plants present. No land plants were discovered.

The turtles collected on June 12-14, 1937, were taken near the nests of sunfishes, some apparently bluegills and others pumpkinseeds. Fry and eggs were present on these nests and males were on guard. Neither fry nor eggs of these fish were discovered in any of the turtles although records of such in the food of snapping turtles will be found for specimens from Dumont and Wolf lakes.

Wintergreen Lake. That this body of water at the W. K. Kellogg Bird Sanctuary of Michigan State College is characterized by an unusually high productivity is generally conceded by fisheries biologists and limnologists who have spent some time in studying its various features. These individuals are agreed that the increased fertility is at least in part due to the large numbers of waterfowl always present on the lake. Another factor responsible for the productiveness of this lake is its shallowness (although approximately twenty acres in surface area, it is less than ten feet deep over most of its extent). The bottom is chiefly marl with smaller areas of sand and muck. Around one end there are extensive beds of *Nymphaea advena* which, with narrow-leaved potamogetons, dominates the aquatic flora.

Fish are numerous in the lake and comprise several game and forage species. The most abundant game fish is the bluegill. Yellow perch, large-mouthed bass, pumpkinseed, bluegill x pumpkinseed hybrids, mud pickerel, and yellow and brown bullheads are also present in some numbers. Forage fish include four species of minnows, the lake chub sucker, and the Iowa darter. Bowfins also occur.

The series of twenty-one snapping turtles from Wintergreen Lake makes it possible to test the general opinion (see digest of published reports on pp. 78 to 90), that goslings, ducklings, and even adult waterfowl constitute a major part of the food of this turtle. It is only in this lake that I have taken snapping turtles when broods of ducklings, goslings, and cygnets were known to have been present. "Approximately twenty pairs of mallards nest about the lake and swale each year," (Pirnie, 1935: 130) as do some Canada Geese and mute swans.

Inasmuch as some form of snapping turtle control has been in operation on this sanctuary lake since 1927, the thirty-five snappers taken during the summers of 1936 through 1938 constitute a surprisingly high number. In mid-July, 1936, nine individuals averaging about ten inches in length were taken by a professional turtle trapper who used thirteen conventional turtle traps for two nights. From June 26 through September 4, 1937, the catch for 496 trap-nights was eighteen specimens. From July 5 through August 13, 1938, the take on 153 trap-nights was eight snappers averaging about nine inches in length. These trapping operations have reduced the snapping turtle population in the lake, but it seems impossible to eliminate the species entirely (as may be desirable for such waters).

The food studies of snapping turtles from Wintergreen Lake (Table 13) are based on twenty-one specimens containing food

TABLE 13. THE FOOD OF THE SNAPPING TURTLE IN WINTERGREEN LAKE

Based on thirteen stomachs containing 287.5 cc. of food and on seventeen colons containing 604.5 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	10.3	46.2	0.4	52.9
Unidentified fish	Trace	7.7	0.2	29.4
Waterfowl	27.5	15.4	1.0	5.9
Unidentified birds	0.7	15.4	3.4	29.4
Muskrat	——	——	5.6	5.9
Carrion	8.3	7.7	0.3	11.8
Crustaceans	0.4	30.8	0.1	23.5
Water mites	Traces	23.1	Traces	47.1
Insects	0.6	46.2	1.1	88.2
Molluscs	1.7	30.8	0.5	47.1
Cryptogams	46.3	61.5	70.3	88.2
Phanerogams	0.3	38.5	1.8	70.6
Vegetable debris	3.9	38.5	15.4	64.7

in thirteen stomachs and seventeen colons.

Game fish eaten were mostly centrarchids. Generally the remains which occurred in the colons could not be positively identified as carrion or otherwise. Bluegills and a large-mouthed bass were identified as present; other game species taken were mud pickerel, yellow perch and yellow bullhead. In all, the turtles studied had accounted for less than one game fish per individual, during the period of feeding represented by the sample. Even with the assumption that all the game fish taken were alive, which was doubtless not true, such a toll could hardly be a menace to the large fish population of this lake. It is possible that removal of some game fish from this body of water by turtles or otherwise would benefit the remaining individuals, for the fishing pressure by anglers is very light.

Four young mallards had been taken by three turtles—a very low incidence when one considers the general availability of this type of food to turtles in this lake. It could not be ascertained whether any of the birds were alive and healthy when taken. Director Pirnie, of the Sanctuary, has told me that in his seven summers on the grounds he has never seen, nor have any of his men seen, a bird actually being taken by a snapper. Ducklings have disappeared for undiscerned reasons. In spite of the high concentration and availability of avian prey, it appears that the snapping turtles of this lake turn largely to food which is still more available, namely aquatic vegetation, and cannot be blamed for the entire loss of young waterfowl. M. B. Trautman has evidence from elsewhere which suggests that sizeable large-mouthed bass (which are common in this lake) and other predacious fishes may consume ducklings. That bullfrogs are enemies of ducklings is also known.

Feathers alone constituted the unidentified bird remains in one stomach and in two colons. These feathers may have been taken as such from the water's surface or from the bottom of the lake where they were mistaken for food organisms, or they may represent a bird which escaped from the turtle's grasp. No bones or flesh occurred with these feathers. Definite remains of other unidentified birds occurred in four additional turtles. The remains of a starling which occurred in one individual was classed as carrion since several had been shot near the lake during control operations on the day previous to the capture of the turtle.

In Wintergreen Lake, as in many other lakes, the food most available to turtles is aquatic vegetation and this material is by far the most important by bulk and by frequency of occurrence in both the stomachs and colons of the individuals studied. Filamentous algae, almost always present in quantities either on the surface or on the bottom of this lake, constituted the major portion of the vegetable matter taken. Ingested perhaps secondarily, along with the algae, were many miscellaneous invertebrates which constitute but a small proportion of the total volume but which are always associated with these plants and so have a high frequency of occurrence.

Spring Lake. This lake, located in Kalamazoo County about two miles southwest of Yorkville, was formed some years ago by damming a small stream. The surface area is estimated to be approximately ten acres and the maximum depth is perhaps fifteen feet. The bottom is very soft muck except at the dam where it is gravel. The following aquatics are common to abundant in most parts of the lake: Chara sp., Najas sp., Polygonum sp., Elodea canadensis, Myriophyllum sp., Ceratophyllum demersum, Nymphaea advena, Castalia odorata, and Potamogeton sp. The shore is partly wooded and partly open with Typha common in a few restricted areas. There is one small inlet but no outlet. Other small lakes are situated within a half mile of Spring Lake. The game fish of the lake, bluegills, pumpkinseeds, and bullheads, are all very abundant but of small size.

Eleven individuals collected from Spring Lake contained food (Table 14). These turtles were taken in ten traps set for thirteen hours overnight on August 11-12, 1938. The average length of ten specimens for which measurements were obtained was 265 mm. (10.4 inches) and ranged from 225 to 323 mm.

Aquatic plants comprised more than three-fourths of the stomach material and almost all of the colon material. The leaves and petioles of Nymphaea advena and Castalia odorata, with filamentous algae, were the three most important components. Again the turtles gave evidence of having accounted for less than one game fish per individual and since most of these fish occurred as traces, their origin as carrion or otherwise could not be determined.

Sherman Lake. This lake is briefly described in the discussion of the musk turtles studied for food from this

TABLE 14. THE FOOD OF THE SNAPPING TURTLE IN SPRING LAKE

Based on five stomachs containing 17.2 cc. of food and on eleven colons containing 376.0 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	17.4	20.0	0.4	63.6
Forage fish	——	——	0.2	36.4
Unidentified fish	4.6	20.0	0.6	18.2
Water mites	——	——	Traces	54.5
Insects	1.2	20.0	0.2	72.7
Snails	——	——	Traces	27.3
Algae	11.6	20.0	19.3	72.7
Phanerogams	64.5	80.0	69.0	100.0
Vegetable debris	0.6	20.0	10.4	63.6

body of water. A list of the fish and turtle inhabitants is also given in that connection.

Nineteen common snappers containing food (Table 15) were studied from this lake. Seventeen of these were collected on August 19-21, 1937, and two on September 16-17, 1938. The average size of eighteen of these specimens was 274 mm. (10.8 inches), ranging from 208 to 305 mm.

TABLE 15. THE FOOD OF THE SNAPPING TURTLE IN SHERMAN LAKE

Based on fourteen stomachs containing 332.0 cc. of food and eighteen colons containing 1,151.5 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	11.4	28.6	6.2	72.2
Forage fish	0.2	7.1	Traces	16.7
Unidentified fish	0.1	7.1	11.3	50.0
Crayfish	0.5	14.3	Traces	16.7
Miscellaneous invertebrates*	0.1	21.4	2.8	27.8
Cryptogams	53.6	57.1	30.4	83.3
Phanerogams	34.1	50.0	30.7	33.3
Vegetable debris	0.1	28.6	18.7	61.1

* Includes some sponge and a water mite in one stomach each, chironomid largae in each of two stomachs, some sponge in each of two colons, and molluscs, water mites, the remains of an insect, and dragon-fly nymphs in one colon each.

Game fish taken by snappers from Sherman Lake, as for the other lakes studied, were predominantly centrarchids; bullheads and yellow perch were also represented. Fish in the stomachs were clearly not carrion when taken. For those represented in the scanty remains found in the colons, it is again impossible to state the condition of the material when taken. At the most, however, the turtles averaged less than one and one-fourth game fish per individual, during the time of feeding represented by the stomach and colon contents.

Again aquatic vegetation is the predominant food in stomachs and colons and occurs in all colons and in all but one stomach. Filamentous algae constitute the most important single item in both organs, with Castalia odorata next. In addition to the quantities of leaves and petioles of Castalia present in four stomachs and five colons, one of these stomachs and the colon of the same individual contained 11,065 seeds (65 cc.) of this plant. The seeds were apparently mature and very few of the coats were ruptured. It is therefore indicated that the snapping turtle may be a significant agent in the dispersal of the seeds of this and other aquatics.

Wolf Lake. The limnological conditions of this lake are indicated by the survey of this body of water made by the Institute for Fisheries Research in 1931, supplemented by personal observations. It has an area of 26.1 acres and a maximum depth of about forty feet. Shoal areas average about forty feet in width, with a steep slope beyond the drop-off, which lies in five to six feet of water. The bottom is almost entirely marl with a little sand and fibrous peat. There are three soft-bottomed spring inlets.

The vegetation in Wolf Lake is common to abundant on the shoals and slope and is predominantly composed of pondweeds of the genus Potamogeton, and Chara sp., Nymphaea advena, Ceratophyllum demersum, Ranunculus sp., Myriophyllum sp., Scirpus sp., and Typha latifolia. Also present are Elodea canadensis, Najas sp., and Utricularia sp.

Game fishes recorded from the lake are yellow perch, large-mouthed bass, bluegill, pumpkinseed, rock bass, mud pickerel, and brook trout. Lake herring, common suckers, and bowfin occur. Blunt-nosed minnows and common shiners are abundant; rainbow, Johnny, and Iowa darters, and black-nosed dace are present in lesser numbers. Sticklebacks and golden shiners are also known from the lake.

Turtle species associated in Wolf Lake are the musk, snapping, Blanding's, map, western painted, and soft-shelled turtles. Box turtles occur in the adjacent swamps and sandy hills. Factors presumably favorable to the turtle population of this body of water are: (1) the soft-bottomed spring inlets which provide excellent sites for hibernation; (2) the inaccessibility of the lake to the public; (3) two inlets which come from the hatchery waters and carry to the lake a daily supply of fish which have died in the ponds and raceways; and (4) the adjacent low, sandy hills which copiously provide for nesting. Unfavorable to turtles are the narrow shoal areas which restrict the foraging grounds in the lake, and the fact that the lake is used for fish cultural purposes, leading to the removal of some of the turtles.

Fourteen snapping turtles, taken in Wolf Lake in June, July, and August, were preserved for food study (Table 11) and several more which were caught were measured, marked for future recognition, and returned to the lake in a study of growth rate and population composition and density. A summary is given of the findings in the nine stomachs and thirteen colons which contained food (Table 16).

The percentage composition by volume for game fish in stomachs is the highest for any of the series of snappers studied. I do not believe, however, that the figures obtained accurately depict the relations of this turtle to game fish in Wolf Lake for the following reasons: (1) the number of specimens in this series is small; (2) the large percentage by volume is made up by the occurrence of a fair-sized bluegill in each of only two stomachs (and in no others); (3) the game fish average just five-tenths per turtle. It would seem that the importance of fish in the food of the snapping turtles from this lake is less than the data in Table 16 might lead one to believe.

Of considerable interest may be the fact that two specimens taken on June 25-27, 1937, contained 450 and 16,768 fish eggs respectively. These eggs, doubtless centrarchid in origin, had apparently been eaten from the nests. These instances and another for Dumont Lake, Allegan County, are the only actual records which I have of this type of fish predation by snappers.

TABLE 16. THE FOOD OF THE SNAPPING TURTLE IN WOLF LAKE

Based on nine stomachs containing 138.1 cc. of food and on thirteen colons containing 341.5 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	62.5	22.2	3.2	30.8
Forage fish	1.7	11.1	Trace	7.7
Unidentified fish	14.5	11.1	1.5	30.8
Amphibians	0.4	11.1	1.5	15.4
Carrion	——	——	0.9	15.4
Crayfish	5.5	22.2	32.1	53.8
Insects	Traces	11.1	0.8	46.2
Molluscs	——	——	9.3	38.5
Miscellaneous invertebrates*	Traces	33.3	1.3	15.4
Cryptogams	11.7	77.8	23.1	61.5
Phanerogams	3.5	22.2	1.4	61.5
Vegetable debris	0.1	11.1	24.9	46.2

* Includes a scud in one stomach, water mites in two stomachs and two colons, and fresh-water sponge in one colon.

It is rather commonly reported by anglers and others that turtles feed actively on the spawn of bass and sunfish but it is necessary to discredit most of these reports because of lack of concrete evidence. That this aspect of predation on game fish by snapping turtles has any important implications for the management of fishing waters is doubtful. W. Fenton Carbine reports (MS) that the productivity of centrarchid fry is very high for most nests and that fish, including bass and sunfish, are themselves very important predators of such fry. Furthermore, lakes from which thousands of eggs of these fish are removed annually for transportation to rearing ponds do not appear to be adversely affected by this procedure.

Filamentous algae was by far the most important plant material of specific identity found in the stomachs and colons. Although the vegetable matter was predominantly aquatic in origin, terrestrial plants were represented by two leaf-galls of Salix sp., and by two inflorescenses of composites.

First Lake. This lake is one of the Six Lakes, near Six Lakes, Montcalm County. These waters are connected by sizeable channels and comprise a total area of some six hundred acres (Henshaw, 1931). First Lake has an outlet into Flat River of the Grand River system. The bottoms of this lake, its channel inlet, and its outlet are predominantly mud and sand. Principal aquatics present are filamentous algae, Chara sp., Myriophyllum sp., a fine-leafed Potamogeton, Castalia odorata, Nymphaea advena, Peltandra virginica, Ceratophyllum demersum, and Decodon verticillatus. The shore is partly hilly, with open meadows and woods, and partly swampy.

Game fishes present are large-mouthed bass, bluegill, rock bass, yellow perch, northern pike, and bullheads. Several species of minnows and darters and bowfin occur. The most common chelonians, western painted, snapping, and Blanding's turtles were collected in the given order of abundance. Soft-shelled turtles are also reported occasionally seen.

Of the twenty-one snappers collected from this lake on the dates given in Table 11, nineteen averaged 209 mm. (8.2 inches) in length, and ranged from 104 to 282 mm. These twenty-one turtles contained food in ten stomachs and all colons. A summary of the analyses of this food is given in Table 17.

As for specimens from other lakes, the remains of game fish in the colons were completely indeterminable as to origin as carrion or otherwise. In the stomachs, carrion and aquatic vegetation are the outstandingly predominant food substances. The remains of black crappies and other centrarchids composed most of the carrion. The food of these turtles offers little, if any, reason for concern over the relations of the snapper to game fish in this lake.

Filamentous algae and Chara sp. were the aquatics eaten most abundantly. The leaves and seeds of Peltandra virginica ranked next. Terrestrial plants were not represented.

Ferguson Lake. This small, private lake, about four acres in area and with a maximum depth of perhaps fifteen

TABLE 17. THE FOOD OF THE SNAPPING TURTLE IN FIRST LAKE

Based on ten stomachs containing 182.5 cc. of food and on nineteen colons containing 285.1 cc. of food and two colons with an unascertained volume. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	——	——	5.2	28.6
Forage fish	——	——	Traces	14.3
Unidentified fish	0.1	10.0	6.8	23.8
Carrion	56.6	20.0	5.8	9.5
Crustaceans	——	——	12.0	42.9
Watermites	——	——	Traces	4.8
Insects	——	——	1.8	42.9
Molluscs	0.3	10.0	13.3	52.4
Cryptogams	21.9	60.0	28.8	52.4
Phanerogams	21.0	50.0	10.4	52.4
Vegetable debris	0.1	20.0	15.9	66.7

feet, is located in Clare County some three miles north of Farwell. The water in the lake is clear and colorless; the bottom is of soft mud, silt, and detritus; the shore is partly wooded but mostly open and marshy. Fish present were bluegills, pumpkinseeds, large-mouthed bass, bullheads, blunt-nose minnows, mud minnows, Iowa darters, and, in the small outlet, Johnny darters. Other than filamentous algae, the most common aquatics seen were Chara sp., Potamogeton natans, Najas sp., Utricularia sp., Nymphaea advena, and Castalia odorata; marginal vegetation was largely Typha sp. and grasses.

Twelve specimens which averaged 238 mm. (9.4 inches) and ranged from 135 to 332 mm. were available for study; the colons of all contained food but only two had material in their stomachs (Table 18). The high incidence of empty stomachs may be due to the facts that the traps set in this lake were emptied only at intervals of twenty hours or more, and that during the time of collecting the water temperature at the surface probably averaged between 85° and 90° F. at mid-day. Therefore, not only were specimens held unduly long in the absence of food but digestive processes were rapid (the acceleration of digestion by temperature rise for the snapping turtle has been demonstrated by Kenyon, 1925).

Of the two stomachs which contained food, one had a trace of Chara sp. and the other 0.2 cc. of crayfish remains and a trace of vegetable debris.

The apparent importance of crayfish in the food of these specimens is possibly not as great as the figures indicate. In colons, one must remember, organisms with persistent hard parts, such as crayfish or insects, tend to assume an undue magnitude both in terms of percentage composition and of frequency of occurrence. Vegetation, again entirely aquatic, constituted the major portion of the food of these specimens.

TABLE 18. THE FOOD OF THE SNAPPING TURTLE IN FERGUSON LAKE

Based on twelve colons containing 298.9 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	1.7	41.7
Forage fish	0.4	33.3
Unidentified fish	Traces	33.3
Crayfish	16.8	75.0
Insects	0.3	66.7
Molluscs	0.3	75.0
Miscellaneous animals*	0.2	58.3
Cryptogams	50.4	100.0
Phanerogams	5.0	75.0
Vegetable debris	24.9	100.0

* Includes the remains of a frog and a leech in one colon and water mites in six colons.

East Twin Lake. This lake was estimated to have a surface area of forty acres (Henshaw, 1931) and a maximum depth of forty feet. The shoreline is partly hilly and wooded and partly swampy. Bottom types are predominantly muck and marl with a little sand at the inlet, Koolbaugh Creek. The small outlet, Bigelow Creek, flows into Muskegon River. Several cool springs occur in the soft, mucky bottom of the north end of the lake. Shoal areas* are extensive at the north and south ends of this body of water. The principal plants are filamentous algae, Chara sp., mosses, potamogetons, Najas sp., Elodea canadensis, Lemna sp., Spirodela polyrhiza, Ceratophyllum demersum, Ranunculus sp., Myriophyllum sp., Persicaria sp., Decodon verticillatus, Scirpus sp., and Typha sp.

Game fish collected by me from this lake are large-mouthed bass, rock bass, bluegill, and pumpkinseed, yellow perch, and brown bullhead. Common suckers, several species of minnows, Johnny and Iowa darters occur, and muddlers are present at the outlet.

The turtle species found in the association are western painted, snapping, Blanding's, map, and musk (listed in terms of decreasing abundance). Taken to be particularly favorable to the turtle population of this lake are the facts that (1) the lake is private and well-removed from traveled roads; (2) several springs in the soft bottom at one end and a tributary trout stream furnish excellent winter quarters; (3) extensive shoal areas provide for foraging; (4) the lake is seldom fished and thus apparently has a very large fish population.

Twenty-five snappers, available for food study from this lake, were collected on the dates given in Table 11. These turtles averaged 263.8 mm. (10.3 inches) in length, ranging from 180 to 374 mm. A summary of the food of this series of specimens is given in Table 19.

Game fish assume a surprising importance by volume in the stomachs of these snappers. By numbers, however, the average, including both those in the stomachs and in the colons, is less than one and a half such fish per turtle for the feeding period represented by the sample. As in other series, it was impossible to determine whether the fish (predominantly centrarchids) present in the colons were dead or alive when taken. The yellow perch, bluegills, and pumpkinseeds found in the stomachs were apparently alive and healthy when taken.

Filamentous algae was the most important vegetable food, making up 64.7 percent of the contents in the colons and 35 percent of contents in the stomachs.

<u>Mill Lake</u>. A survey of this lake made by the Institute for Fisheries Research in July, 1931, showed it to be a little over fifty-five acres in surface area, and to have fairly wide shoals, and a maximum depth of thirty-nine feet. The bottom is almost entirely marl which supports abundant vegetation largely composed of potamogetons, <u>Ceratophyllum demersum</u>, <u>Vallisneria spiralis</u>, and algae. Minnows and aquatic insects are plentiful and crayfish and pelecypods are present. Of the game fish, bluegill are the most abundant; mud pickerel, large-mouthed bass, pumpkinseed, rock bass, and yellow perch are also present.

TABLE 19. THE FOOD OF THE SNAPPING TURTLE IN EAST TWIN LAKE

Based on nineteen stomachs containing 588.9 cc. of food and twenty-five colons containing 1,140.8 cc. of food. More specific determinations of food items are given in Table 20.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	60.9	47.4	Traces	84.0
Forage fish	——	——	Traces	[illegible].0
Unidentified fish	0.9	21.1	0.3	48.0
Carrion	Trace	5.3	——	——
Crustaceans	0.5	63.1	1.9	60.0
Water mites	Traces	36.8	Traces	48.0
Insects	Traces	26.3	Traces	76.0
Molluscs	0.9	42.1	1.9	96.0
Cryptogams	36.0	84.2	64.7	96.0
Phanerogams	Traces	63.1	11.4	100.0
Vegetable debris	0.5	26.3	19.8	88.0

Blunt-nosed minnows are abundant and other forage fishes occur.

Eleven snappers collected from this lake in August of 1937 and 1938 by V. Pullman contained food (Table 20) in eight stomachs and ten colons.

The percentage composition by volume and the frequency of occurrence are unusually high for game fish in the stomachs of this series of specimens. Concurrently, the amount and

TABLE 20. THE FOOD OF THE SNAPPING TURTLE IN MILL LAKE

Based on eight stomachs containing 437.5 cc. of food and on eight colons containing 188.2 cc. of food and two colons with an unascertained volume. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	83.6	75.0	0.2	80.0
Unidentified fish	———	———	0.1	50.0
Crustaceans	1.7	50.0	42.8	90.0
Insects	Trace	12.5	Traces	70.0
Molluscs	———	———	0.4	50.0
Miscellaneous animals*	1.4	25.0	3.8	30.0
Cryptogams	5.4	12.5	17.3	60.0
Phanerogams	7.9	37.5	17.7	70.0
Vegetable debris	Traces	25.0	17.7	30.0

* Includes the remains of two musk turtles and five water mites in one stomach each and the remains of a frog and a musk turtle and some fur in one colon each.

incidence of vegetable matter is much lower than has appeared thus far in other series. That this may be due to the low number of specimens involved is suggested by the fact that almost three-fourths of the 83.6 percent given for game fish is made up by a fifteen-inch (250.0 cc.) northern pike in one stomach. Other game species taken were bluegills and pumpkin-seeds. Although it was apparent that the game fish represented in the stomachs were alive when taken, the much-digested remains of those in the colons could not be determined one way or the other.

The occurrence of three musk turtles in one of the snappers from this lake provides an interesting note on the inter-relationships of these forms.

<u>River-mouth lakes</u>. Specimens are grouped together from Muskegon and White lakes, which are ecologically very similar bodies of water, situated near Lake Michigan, at the mouths of two large rivers, the Muskegon and the White. The large lakes have extensive areas of marsh, and sand and silt shoals. Considerable expanses are underlain by quantities of water-logged "mill waste" and many "dead-heads." The "mill waste," long strips of bark and wood trimmings dumped irregularly on the bottom, is replete with crevices and provides an unusually favorable habitat for crayfish, snails and other invertebrates, which are particularly abundant. Aquatic vegetation is plentiful in the shallower waters which are not too much exposed to wave action.

Seven snappers from White Lake and nine from Muskegon Lake contained food in thirteen stomachs and in all sixteen

TABLE 21. THE FOOD OF THE SNAPPING TURTLE IN WHITE AND MUSKEGON LAKES

Based on thirteen stomachs containing 146.4 cc. of food and on sixteen colons containing 426.8 cc. of food. More specific determinations of food items are given in Table 25.

Food Item	Stomachs *		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	67.6	46.2	0.7	56.3
Forage fish	0.1	7.7	6.3	6.3
Unidentified fish	Trace	7.7	0.9	31.3
Crayfish	22.3	53.8	35.3	100.0
Insects	0.1	30.8	0.1	50.0
Snails	0.2	23.1	6.4	81.3
Miscellaneous animals*	Traces	18.8	0.8	12.5
Cryptogams	4.8	23.1	9.9	50.0
Phanerogams	4.6	61.5	15.3	87.5
Vegetable debris	0.4	30.8	24.3	75.0

* Includes scuds in each of three stomachs and the remains of a frog and carrion in one colon each.

colons. The specimens from these lakes were collected on the dates given in Table 11. The average length of fourteen individuals for which measurements were obtained is 228 mm. (9.0 inches), ranging from 144 to 321 mm. A summary of the analyses of the food of these individuals is presented in Table 21.

As for Mill Lake (Table 20), the food of the snappers from these river-mouth lakes shows game fish to comprise an unusually high proportion of the food in stomachs. The species taken include bullheads, yellow perch, large-mouthed bass, bluegills and pumpkinseeds. It was impossible to determine the origin, as carrion or otherwise, of the fish in the colons, most of which occurred as traces. Counting all the game fish represented in stomachs and colons the average was a very little more than one per turtle. Owing to the extensive water areas which obtain here, it is doubtful that such an incidence in the food of the snapper offers any occasion for concern to the sport or commercial fisheries.

A seven-inch bluegill with a No. 6 hook firmly lodged in its hyoid region was found in the stomach of one of the turtles collected on September 1; the turtle was 321 mm. (12.6 inches) long. It seems rather probable that the injury suffered by the bluegill was a direct cause of its being taken by the turtle. Though merely a single incident, this occasion merits special citation as an example of what is very probably a frequent occurrence.

As might be expected from the abundance in these lakes, crayfish are represented both in stomachs and colons in larger proportion than anywhere else in my findings. As a result of this incidence of crayfish and of the importance of game fish in the food, aquatic vegetation is present in a lesser amount. The dominant plants found were filamentous algae and the duckweeds, Lemna trisulca and Spirodela polyrhiza.

Miscellaneous southern lakes. The data on the food of snapping turtles from several lakes, as separately tabulated above, is supplemented by the findings on seventy-one specimens from thirty-seven lakes which lie south of Town Line 16 (Table 11). The average size of the thirty-seven specimens for which I have measurements is 244 mm. (9.7 inches) ranging from 109 to 335 mm. The results of food studies on these turtles are presented in Table 22.

The findings for these miscellaneous lakes are almost identical with those for Wintergreen, Spring, Sherman, First, and Ferguson Lakes. They are different, however, from the data for Wolf, East Twin, Mill, and Muskegon and White lakes principally in the greater importance of fish in the food of turtles from these lakes. The great importance of plant materials in the food of the snapping turtle is substantiated. It may be recalled that this picture is hardly that which one would obtain by consulting the papers of previous authors, with the possible exception of Surface (1908) and Babcock (1916).

Miscellaneous northern lakes. Excepting Fremont Lake (Town 12 N.) and Kimball Lake (Town 14 N.) in Newaygo County, and Hart Lake (Town 15 N.) in Oceana County, the twenty-three

TABLE 22. THE FOOD OF THE SNAPPING TURTLE IN MISCELLANEOUS SOUTHERN LAKES

Based on forty-two stomachs containing 994.6 cc. of food and on sixty-two colons containing 2,211.8 cc. of food and four colons containing an unascertained volume. More specific determinations of food items are given in Table 20.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	10.5	30.1	3.5	42.4
Forage fish	0.1	2.4	Traces	6.1
Unidentified fish	0.8	14.3	1.2	21.2
Carrion	15.8	7.1	3.0	3.0
Crustaceans	2.0	11.9	7.7	34.8
Insects	0.2	31.0	4.0	54.5
Molluscs	0.1	19.0	4.8	27.3
Miscellaneous animals*	0.2	7.1	1.5	4.5
Cryptogams	43.4	38.1	8.5	50.0
Phanerogams	19.3	42.9	32.9	61.8
Vegetable debris	7.5	19.0	32.9	63.3

* Includes water mites in two stomachs and two colons, the remains of musk turtles in each of two colons, some unidentified feathers in one stomach and the remains of a Blanding's turtle in one colon.

lakes in this group lie north of Town Line 16. Of the turtles collected in these lakes, forty-four snappers contained food (Table 11). Twenty-five of these specimens for which I have measurements averaged 233 mm. (9.1 inches) in length, ranging from 137 to 344 mm. A summary of the food of the turtles from these lakes is given in Table 23.

In contrast to the food of snappers for miscellaneous southern lakes and most individual southern lakes, those of the northern lake series show a considerable quantity of game fish in the stomachs. The data for this large series bear a striking resemblance to those for East Twin and Mill lakes (Tables 19 and 20) which are also "northern" lakes. The game fish eaten, occurring in small numbers but of large size, averaged only one to every two turtles that contained food in their stomachs. The effects of this predation, then, are probably not as serious as the figures in Table 23 would seem to indicate. The large amount of carrion was contained entirely in only three stomachs and represents the remains of two sizeable yellow perch and one large-mouthed bass.

<u>Non-trout streams</u>. Nineteen turtles containing food were available for study from eleven different non-trout streams (Table 11). Eleven of these specimens for which measurements were available averaged 218 mm. (8.6 inches) in length and ranged from 65 to 317 mm. A summary of the food analyses for this series is given in Table 24.

The entire volume of game fish in the stomachs was made up by a yellow perch and a small-mouthed bass in one turtle.

TABLE 23. THE FOOD OF THE SNAPPING TURTLE IN MISCELLANEOUS NORTHERN LAKES

Based on twenty-four stomachs containing 573.8 cc. of food and on forty colons containing 810.1 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	35.8	45.8	0.4	52.5
Forage fish	0.4	8.3	Traces	7.5
Unidentified fish	0.1	20.8	2.0	47.5
Carrion	52.0	12.5	——	——
Crayfish	3.2	25.0	28.3	62.5
Insects	0.4	29.2	4.3	70.0
Molluscs	0.1	12.5	4.7	40.0
Miscellaneous animals*	Traces	12.5	2.4	20.0
Cryptogams	5.9	29.2	9.8	55.0
Phanerogams	0.5	33.3	22.1	62.5
Vegetable debris	0.5	25.0	26.2	80.0

* Includes water mites in one stomach and two colons, scuds in two stomachs, a tubificid and an oligochaete "earthworm" in another stomach, and remains of a bullfrog, a mudpuppy, a Florida Gallinule, a muskrat and a leech in one colon each.

TABLE 24. THE FOOD OF THE SNAPPING TURTLE IN NON-TROUT STREAMS

Based on twelve stomachs containing 472.9 cc. of food and on fourteen colons containing 337.5 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	19.3	8.3	Traces	35.7
Forage fish	0.1	8.3	Traces	14.3
Unidentified fish	——	——	0.4	21.4
Carrion	53.9	16.7	——	——
Crayfish	11.6	50.0	45.5	71.4
Insects	Trace	8.3	0.5	57.1
Miscellaneous animals*	7.7	16.7	0.8	28.6
Cryptogams	Traces	16.7	8.1	28.6
Phanerogams	7.3	25.0	20.2	64.3
Vegetable debris	0.1	33.3	24.5	85.7

* Includes a bullfrog and a leech in one stomach each and the remains of a musk turtle and a Blue-winged Teal in one colon each and several snails in four colons.

including all the game fish present, even those in the colons which occurred as traces and may have been carrion when taken, only about one out of every three turtles showed evidence of having eaten game fish. Fish composing the carrion were a rock bass and a bluegill. In this series crayfish are of considerable importance, which may be due to a generally greater abundance per unit area in stream than in lake habitats, excepting such river-mouth lakes as previously cited. In this series the contents of the colons seem to give a more accurate picture than do the stomach contents.

<u>Trout</u> <u>streams</u>. It is unfortunate that only six specimens were secured from waters of this ecological type. The snapping turtle population is doubtless lower per unit length of such streams than for warmer, non-trout streams, and little effort was expended in securing specimens from these habitats. The names of the six streams, one turtle from each of which contained food, and the collection dates, are given in Table 11. A summary of the results of the food studies of turtles from these waters is given in Table 25.

Since crayfish are probably the most readily available organisms of attractive size in trout streams, it is not unexpected to find so high a proportion present in the food of these snappers. On the basis of the numbers contained in the stomachs only, the five turtles averaged a little more than four crayfish each. In the one colon (turtle 279 mm. long) which contained crayfish, there were remains of a large,

TABLE 25. THE FOOD OF THE SNAPPING TURTLE IN TROUT STREAMS

Based on five stomachs containing 184.4 cc. of food and on three colons containing 450.4 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of by Volume (%)
Trout	9.8	20.0	——	——
Forage fish	3.1	60.0	——	——
Crayfish	87.0	80.0	33.3	33.3
Insects	0.1	20.0	55.3	66.7
Vegetable matter*	——	——	11.3	66.7

* Includes a trace each of moss and *Potamogeton* sp. and an amount of vegetable debris.

unascertained number with volume of 450.0 cc. Whether or not the nine-inch trout which was found in one stomach was taken as carrion or otherwise was indeterminable.

Fish hatcheries. Twenty-one specimens containing food were available for study from eight hatcheries (Table 11). The average size of twelve of these specimens on which measurements were made is 210 mm. (8.2 inches), ranging from 51 to 294 mm. A summary of the analyses of the contents of the stomachs and colons of these individuals is given in Table 26.

At fish hatcheries and rearing stations, unusually large numbers of fishes are frequently concentrated in ponds and raceways. It is generally assumed that such concentrations create an increased vulnerability of the fish to their predators. Therefore, it is noteworthy that in so far as the figures go, snappers sampled took game fish from rearing waters in no greater amounts than did the turtles collected for Wolf, East Twin, Mill, and the river-mouth lakes. The figures presented for hatchery waters, however, need definite qualification. Almost all of the 54.5 percent given for game fish by volume in stomachs, is made up by forty-three game fish in the stomachs of only two individuals, which were removed from a fyke net set to take the fish from a rearing pond for stocking other waters. Although the data in the table represent the possible damage which these turtles may inflict, they are not representative of average predation in ponds. The remaining sixteen specimens on the average entailed a loss of only one game fish for each three turtles, for the feeding time represented

TABLE 26. THE FOOD OF THE SNAPPING TURTLE AT FISH HATCHERIES

Based on eighteen stomachs containing 1,049.3 cc. of food and on ten colons containing 336.7 cc. of food. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	54.5	27.8	1.1	10.0
Forage fish	26.9	16.7	0.4	30.0
Unidentified fish	3.9	22.2	0.3	20.0
Frogs and toads	1.2	16.7	0.5	40.0
Crayfish	8.0	61.1	41.6	80.0
Insects	1.0	38.9	1.9	80.0
Miscellaneous animals*	0.4	5.6	0.4	40.0
Cryptogams	2.1	27.8	6.1	40.0
Phanerogams	0.4	27.8	10.6	40.0
Vegetable debris	1.6	16.7	37.1	70.0

* Includes remains of a meadow mouse and a muskrat in one stomach and water mites and a scud in one colon and snails in four colons.

by the sample studied. Considering the possible benefit derived from the destruction of the more vulnerable runts and diseased fish, and of numbers of predacious insects (Table 28), there seems to be little occasion for concern over the predation of snapping turtles at hatcheries.

While fish are being removed from hatchery ponds by means of fyke nets, and where fish are extremely crowded in raceways, or where eggs of pond-fishes are placed on trays in rearing ponds, perhaps snapping turtles are intolerable. It seems, however, that the role of this species in limiting the production in fish cultural establishments is less than hitherto supposed.

Discussion, Summary, and Conclusions

In Table 27 is given a summary of the food contained in 173 stomachs and 261 colons of 281 snapping turtles collected from wild or natural (for fish and waterfowl) waters. The data for the twenty-one specimens from Wintergreen Lake (Table 13) are not included here since this lake is abnormal as regards the unusually high waterfowl population. For obvious reasons, the information for the twenty-one specimens from fish hatcheries (Table 26) is also omitted.

Considering only the stomach contents, game fish, carrion, and vegetation appear as the most important foods of this turtle. Summarily stated on the basis of food found in stomachs, about one-third of the food of the snapping turtle in Michigan is composed of game fish and it may be expected that an average

TABLE 27. THE FOOD OF THE SNAPPING TURTLE IN NATURAL WATERS IN MICHIGAN

Based on 173 stomachs containing 4,183 cc. of food and on 261 colons containing more than 8,355 cc. of food. The organs are from 261 turtles collected on seventy-one lakes and eleven non-trout and six trout streams. Data on twenty-one specimens from Wintergreen Lake (W. K. Kellogg Bird Sanctuary) and on twenty-one from fish hatcheries are not included. More specific determinations of food items are given in Table 28.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	34.2	32.4	2.1	31.7
Forage fish	0.3	5.8	0.4	10.3
Unidentified fish	0.9	12.7	2.1	35.2
Other vertebrates	1.1	2.3	1.1	7.2
Carrion	19.6	6.4	1.3	2.7
Invertebrates	7.8	49.7	23.9	62.4
Vegetable matter	36.2	74.6	69.2	93.5

of one out of every three turtles taken in this state will contain this kind of food. Another third is composed of vegetable matter, almost entirely the leaves and petioles of aquatic plants, which three out of every four individuals may be expected to contain. The last third is largely the remains of dead animals but also represents significant quantities of crayfish, snails, and insects.

If one regards the results of the analyses of colon contents only, about one-fourth of the food appears to be composed of invertebrates, principally crayfish, and three-fourths to be composed of aquatic vegetation. The implications which may be drawn from a comparison of the figures for the stomach material with those for the colons have a direct bearing on the validity of food studies based solely on intestinal content, pellet, or dropping analyses. Very apparent misleading features are: (1) persistence of certain hard parts of some animals, such as the exoskeletons of crayfish and insects; (2) differential rate of digestion of various materials ingested; and (3) the postponed, intestinal digestion of cellulose, (in omnivores or carnivores).

In Table 28 are given the numbers of each food item as determined by actual count when feasible; detailed identifications of the substances taken as food are also recorded. In the food of many turtles, however, it was impracticable or impossible to determine the number of individuals composing some of the food items. For these, the letter "X" has been used in the table to denote an undetermined number. Excepting seeds, the plant materials encountered are of necessity recorded in this fashion. For many food items, identifications were made to species, for others, to genus or larger group. Determinations to species were often impossible because of the advanced state in digestion of the material. But frequently determinations were made to larger categories because of the lack of adequate specimens for comparison, the unavailability of consulting specialists, or limits of time.

TABLE 28. NUMBERS AND OCCURRENCE OF EACH ITEM IN THE FOOD OF SNAPPING TURTLES

Food Item	Silver Lake (13) St (10) Co (11)	Wintergreen Lake (21) St (13) Co (17)	Spring Lake (11) St (5) Co (11)	Sherman Lake (19) St (14) Co (18)	Wolf Lake (14) St (19) Co (13)	First Lake (21) St (10) Co (21)	Ferguson Lake (12) St (2) Co (12)	East Twin Lake (25) St (19) Co (25)	Mill Lake (11) St (8) Co (10)	Rivermouth Lakes (16) St (13) Co (16)	Miscellaneous Southern Lakes (71) St (42) Co (66)	Miscellaneous Northern Lakes (46) St (24) Co (40)	Non-trout Streams (17) St (12) Co (14)	Trout Streams (6) St (5) St (3)	Fish Hatcheries (21) St (18) Co (10)	Totals (323)
GAME FISH																
Salvelinus f. fontinalis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Salmonidae	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Ameiurus natalis	..	1	..	..	..	..	..	..	..	..	1	1	..	..	..	3
Ameiurus nebulosus	..	..	..	..	..	..	..	..	..	..	4	1	..	..	..	5
Ameiurus sp.	1	..	..	2	..	..	..	..	..	2	2	2	..	..	..	9
Ameiuridae	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	2
Esox vermiculatus	..	1	..	..	..	..	..	..	..	..	2	1	..	..	..	4
Esox lucius	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Esox sp.	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Perca flavescens	..	2	..	1	..	1	..	4	..	2	3	3	2	..	..	18
Percidae	1	1	..	3	..	..	..	1	..	..	1	5	1	..	..	13
Micropterus d. dolomieu	..	..	..	..	..	..	..	..	..	..	..	1	1	..	3	5
Huro salmoides	..	1	..	..	..	..	..	..	..	1	1	1	..	..	2	6
Micropterinae	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Lepomis macrochirus	..	2	1	2	2	..	3	6	4	1	6	3	..	..	13	43
Lepomis gibbosus	2	..	1	1	..	..	2	5	2	1	..	5	..	..	28	46
Lepomis sp.	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Ambloplites rupestris	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Lepominae	..	..	..	2	..	..	..	..	..	1	1	2	..	..	..	6
Centrarchidae	9	13	6	14	3	6	3	28	5	8	29	25	4	..	..	156
FORAGE FISH																
Catostomidae	..	..	..	..	1	1	..	..	..	1	1	..	..	1	1	6
Notemigonus crysoleucas auratus	..	..	..	..	..	..	..	..	..	..	3	..	..	..	14	17
Notropis cornutus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Notropis heterolepis	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1

Food Item	Silver Lake	Winter- green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Ferg- uson Lake	East Twin Lake	Mill Lake	River- mouth Lakes	Miscell- aneous South- ern Lakes	Miscell- aneous North- ern Lakes	Non- trout Streams	Trout Streams	Fish Hatch- eries	Totals
Cyprinidae	..	..	4	..	..	..	..	1	..	1	3	..	..	..	5	14
Umbra limi	..	..	..	1	1	2	1	..	..	..	1	1	1	..	..	8
Boleosoma nigrum	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	2
Poecilichthys exilis	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	2
Catonotus flabellaris	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
FISH EGGS	..	..	..	..	17,218	..	..	..	..	..	3,302	..	..	..	..	20,520
FISH REMAINS	X*	X	5	X	X	X	4	X	6	X	X	X	3	..	6	X
OTHER VERTEBRATES																
Necturus m. maculosus	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Bufo americanus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Rana catesbiana	1	..	..	..	..	..	..	..	..	..	..	1	1	..	..	3
Rana palustris	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Rana sp.	..	..	..	..	2	..	1	..	1	1	..	..	..	..	3	8
Salientia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2
Amphibia	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Sternotherus odoratus	..	..	..	..	..	..	..	..	3	..	6	..	1	..	..	10
Chelydra serpentina	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Emys blandingii	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Anas platyrhynchos	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	4
Querquedula discors	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Gallinula chloropus	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Waterfowl																
Bird remains	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	4
Feathers	X	X	X	..	..	..	..	..	..	..	X	..	..	..	..	X
Ondatra zibethica	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	2
Microtus p. pennsylvanicus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Fur	..	..	..	..	..	..	..	..	X	..	X	X	..	..	..	X
CARRION*	..	X	..	..	X	X	..	X	..	X	X	X	X	..	..	X
MISCELLANEOUS INVERTEBRATES																
Spongillinae	..	..	..	X	X	..	..	..	..	..	..	X	..	..	..	X
Oligochaeta ("earthworm")	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Tubificidae	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1

Food Item	Silver Lake	Winter-green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Ferg-uson Lake	East Twin Lake	Mill Lake	River-mouth Lakes	Miscell-aneous South-ern Lakes	Miscell-aneous North-ern Lakes	Non-trout Streams	Trout Streams	Fish Hatch-eries	Totals
Hirudinea	1	..	..	..	..	..	1	..	..	..	..	1	1	..	..	4
CRUSTACEANS																
Hyalella knickerbockeri	..	X	..	..	1	8	..	X	..	X	6	32	..	..	..	X
Amphipoda	..	..	..	..	..	..	..	-	-	..	1	..	..	..	X	X
Cambarus virilis	..	..	..	1	5	1	13	1	8	22	14	25	20	X	16	127
Cambarus immunis	..	..	..	..	..	..	..	..	..	..	1	..	..	..	20	21
Cambarus propinquus	..	..	..	1	2	1	1	..	4	8	1	4	21	X	..	X
Cambarus robustus	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1
Cambarus diogenes	..	..	..	..	..	..	..	..	..	4	..	..	?	..	..	6
Cambarus sp.	1	2	..	3	11	0	4	9	3	12	26	21	6	20	21	146
Crustacea	..	X	..	..	..	..	..	..	X	..	X	..	..	..	..	X
WATER MITES																
Diplodontus despiciens	..	4	X	..	..	..	..	..	..	..	..	..	..	..	..	X
Limnesia undulata	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	2
Unionicola crassipes	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Neumania ovata	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Neumania armata	..	..	..	..	..	..	..	2	..	..	..	1	..	..	..	3
Neumania semicircularis	..	3	X	..	..	1	1	3	5	..	..	..	..	..	..	X
Neumania sp.	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Koenikea wolcotti	..	..	..	..	..	..	..	1	..	..	..	..	..	.	..	1
Forelia liliacea	..	..	..	..	..	..	.	..	..	..	..	1	..	..	..	1
Piona reighardi	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	2
Piona pugilis	..	2	..	..	..	..	..	2	..	..	..	1	..	..	..	5
Piona wolcotti	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Piona sp.	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	2
Mideopsis orbicularis	..	..	..	..	..	..	1	.	..	..	..	..	..	..	..	1
Arrenurus infundibularis	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	2
Arrenurus manubriator	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Arrenurus marshallae	..	..	..	..	2	..	..	1	..	..	1	1	..	..	.	5
Arrenurus megalurus	..	..	X	..	..	..	1	..	..	..	2	..	..	..	..	X
Arrenurus megalurus intermedius	..	..	..	..	..	..	..	..	..	..	..	?	..	..	..	2

Food Item	Silver Lake	Winter-green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Ferg-uson Lake	East Twin Lake	Mill Lake	River-mouth Lakes	Miscell-aneous South-ern Lakes	Miscell-aneous North-ern Lakes	Non-trout Streams	Trout Streams	Fish hatch-eries	Totals
Arrenurus wardi	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	2
Arrenurus falcicornis	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	2
Arrenurus sp.	..	..	..	..	..	..	11	10	..	..	6	..	..	..	..	27
Hydracarina	3	X	..	3	13	1	X	X	..	..	X	9	..	..	X	X
INSECTA																
Orthoptera	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Corydalus sp. larva	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Ephemerella bicolor nymphs	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Caenis sp. nymphs	..	X	..	..	..	..	..	..	..	..	1	..	..	..	..	X
Ephemerida nymphs	..	X	1	..	..	..	..	1	..	..	3	..	..	..	..	X
Anax junius nymphs	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Libellula sp. nymph	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Leucorrhinia sp. nymph	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Anisoptera nymphs	..	2	3	2	..	3	1	..	1	6	X	5	X	..	5	X
Enallagma sp. nymphs	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	3
Zygoptera nymphs	..	X	..	..	..	..	..	2	..	..	1	..	..	..	..	X
Odonata nymphs	..	1	..	..	..	..	..	..	..	..	1	1	1	..	..	4
Corixidae	1	1	..	..	1	..	..	..	..	..	1	1	..	..	..	5
Plea striola	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Ranatra sp.	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	2
Lethocerus sp.	..	..	..	..	..	..	..	..	..	..	1	2	..	..	X	6
Benacus sp.	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	2
Belostoma sp.	..	6	..	..	..	..	..	..	1	..	1	1	..	..	1	10
Belostomatidae	6	..	..	..	..	..	..	1	..	2	2	..	1	..	..	12
Gerridae	X	..	..	..	..	..	..	..	..	..	.	..	..	..	..	X
Hemiptera	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Homoptera	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Haliplus sp.	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..	X
Peltodytes sp. larvae	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Haliplidae	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	2
Acilius sp.	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Dytiscidae	1	1	..	..	5	5	5	1	2	5	6	45	6	2	6	90

Food Item	Silver Lake	Winter-green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Ferg-uson Lake	East Twin Lake	Mill Lake	River-south Lakes	Miscell-aneous South-ern Lakes	Miscell-aneous North-ern Lakes	Non-trout Streams	Trout Streams	Fish Hatch-eries	Totals
Gyrinidae	..	..	..	..	..	..	..	1	..	..	..	3	..	..	..	4
Hydrophilidae larvae and adults	1	7	..	..	1	4	..	..	..	..	6	6	5	1	1	32
Elmidae	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Chrysomelidae	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	2
Curculionidae	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Coleoptera larvae and adults	3	7	7	..	X	..	..	X	4	..	8	3	4	..	X	X
Hydroptilidae larvae	..	X	..	..	..	..	X	5	..	3	..	2	3	..	X	11
Phryganea sp. larvae	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	X
Leptoceridae larvae	..	X	..	..	..	1	..	..	..	..	68	..	..	..	..	X
Trichoptera larvae	1	X	..	..	X	1	..	4	..	..	12	5	1	1	..	X
Tipulidae	..	..	2	..	..	..	..	..	..	..	..	6	..	..	..	8
Chironomidae larvae and pupae	6	X	..	4	X	..	..	X	..	1	X	16	..	..	X	X
Ceratopogonidae larvae	1	X	..	..	3	..	X	X	..	1	X	6	..	..	X	X
Stratiomyia sp. larvae	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Diptera larvae and pupae	3	X	4	..	..	..	X	2	1	1	2	2	..	4	..	X
Insecta	1	X	4	1	..	1	..	X	3	3	X	X	1	..	X	X
SNAILS AND CLAMS																
Lymnaea emarginata	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	X
Lymnaea sp.	..	X	..	..	..	3	..	X	..	21	X	X	..	..	X	X
Helisoma trivolvis	..	X	..	..	..	2	..	X	..	X	X	15	..	..	5	X
Helisoma antrosum	1	3	..	..	X	6	X	X	..	8	X	1	2	..	2	X
Helisoma campanulatum																
Helisoma sp.	X	1	1	..	..	X	X	1	X	X	X	X	..	..	X	X
Gyraulus parvus	..	X	..	..	X	..	X	X	X	..	X	..	..	..	..	X
Gyraulus hirsutus	..	..	..	..	..	..	..	..	..	X	..	..	..	..	..	X
Gyraulus sp.	..	X	..	..	..	..	X	..	..	..	X	X	..	..	..	X
Planorbula armigera	..	..	..	..	..	..	..	..	..	X	..	..	..	..	..	X
Planorbula sp.	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1

Food Item	Silver Lake	Winter-green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Fer-guson Lake	East Twin Lake	Mill Lake	River-mouth Lakes	Miscell-aneous South-ern Lakes	Miscell-aneous North-ern Lakes	Non-trout Streams	Trout Streams	Fish Hatch-eries	Totals
Physa sayii	..	X	..	..	..	..	X	X	..	..	..	4	..	..	..	X
Physa elliptica	..	..	..	..	..	..	..	..	..	X	..	..	..	..	..	X
Physa sp.	..	X	..	..	X	1	X	..	..	X	X	1	X	.	..	X
Campeloma sp.	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Valvata tricarinata	..	X	..	..	X	..	X	X	X	..	X	..	..	..	..	X
Valvata sincera	..	3	..	..	..	..	7	..	..	..	..	..	..	..	..	10
Bythinia tentaculata	..	..	..	..	..	..	..	..	..	116	..	..	..	..	..	116
Amnicola limosa	..	4	..	..	X	..	X	X	..	..	X	..	..	..	..	X
Amnicola cincinnatiensis	..	X	..	..	X	..	..	X	..	..	X	..	..	..	..	X
Amnicola lustrica	..	X	..	..	X	..	..	X	..	..	..	..	..	..	..	X
Amnicola sp.	..	X	3	..	..	X	X	16	..	7	X	6	..	..	X	X
Gastropoda	X	X	X	..	X	X	X	X	X	X	X	X	X	..	3	X
Sphaerium striatinum	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Sphaerium sp.	..	X	..	..	X	..	..	..	..	..	..	..	..	..	..	X
Pisidium abditum	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	X
Pisidium sp.	..	X	..	..	X	..	..	..	..	..	..	.	..	..	..	X
Pelecypoda	X	..	..	..	..	3	X	X	X	..	X	3	1	..	..	X
Mollusca	..	X	..	X	X	..	..	..	..	..	1	..	..	..	..	X
CRYPTOGAMS																
Oscillatoria princeps	..	X	..	..	..	..	X	X	X	..	X	..	..	..	..	X
Oscillatoria sp.	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Lyngbya sp.	X	X	..	..	..	..	..	..	..	..	..	..	X	..	..	X
Anabaena sp.	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	X
Nostoc sp.	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Tolypothrix sp.																X
Ulothrix sp.	..	..	X	..	..	..	..	..	..	X	X	..	..	..	..	X
Coleochaete nitellarum	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Cladophora glomerata	..	..	X	..	..	..	..	..	..	X	..	..	..	..	..	X
Cladophora sp.	..	..	X	..	X	..	..	..	..	..	..	..	..	..	..	X
Rhizoclonium hieroglyphicum	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	X
Rhizoclonium sp.	..	..	..	..	..	..	..	..	..	..	X	X	..	..	..	X

Food Item	Silver Lake	Winter-green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Ferg-uson Lake	East Twin Lake	Mill Lake	River-mouth Lakes	Miscell-aneous South-ern Lakes	Miscell-aneous North-ern Lakes	Non-trout Streams	Trout Streams	Fish Hatch-eries	Totals
Pithophora varia	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	X
Oedogonium sp.	..	X	X	X	..	..	..	X	..	X	X	..	..	..	..	X
Hydrodictyon reticulatum	..	X	X	..	..	..	..	..	..	..	X	..	..	..	..	X
Vaucheria sp.	..	X	X	X	..	..	..	X	..	X	X	..	..	..	..	X
Mougeotia sp.	..	X	X	X	..	..	X	..	..	..	X	..	X	..	..	X
Zygnema sp.	..	X	X	X	..	..	X	..	..	X	X	..	X	..	..	X
Scenedesmus acutiformis	..	X	..	..	..	..	..	..	..	X	..	..	..	..	..	X
Spirogyra crassa	X	X	X	X	..	X	X	X	X	X	X	..	..	..	..	X
Spirogyra sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	..	X	X
Algae	X	X	X	X	X	X	X	X		X	X	X	X	..	X	X
Chara sp.	X	..	X	X	X	X	X	X	X	..	X	X	X	..	X	X
Nitella sp.	..	..	..	..	..	..	X	..	..	..	X	..	..	..	X	X
Moss	X	X	..	X	X	X	X	X	..	X	X	X	X	X		X
PHANEROGAMS																
Typha sp.	X	..	..	..	..	..	..	..	..	X	..	..	..	..	..	X
Potamogeton sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	..	X
Najas sp.	..	X	X	X	X	..	X	X	X	X	X	X	..	..	X	X
Elodea canadensis	..	X	X	..	X	X	..	X	X	X	X	..	X	..	X	X
Vallisneria spiralis	..	..	X	..	X	..	..	..	X	X	X	X	..	..	..	X
Gramineae	..	..	..	..	..	X	..	..	..	..	X	..	..	..	X	X
Phragmites communis	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Scirpus sp.	..	..	..	X	..	X	..	..	..	..	X	X	X	..	..	X
Peltandra virginica	..	..	..	..	..	X	..	..	..	..	X	X	X	..	..	X
Spirodela polyrhiza	X	..	..	X	..	..	..	X	..	X	X	X	X	..	..	X
Lemna trisulca	X	..	..	..	..	X	..	..	X	X	X	X	..	..	..	X
Lemna minor	X	..	..	..	..	X	..	X	..	..	X	..	..	..	..	X
Lemna sp.	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	X
Wolffia sp.	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	X
Lemnaceae	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	X
Salix sp.	..	..	..	..	X	..	..	..	..	..	..	..	X	..	X	X
Ceratophyllum demersum	X	..	X	X	X	X	..	X	X	X	X	X	X	..	X	X

Food Item	Silver Lake	Winter-green Lake	Spring Lake	Sherman Lake	Wolf Lake	First Lake	Ferg-uson Lake	East Twin Lake	Mill Lake	River-mouth Lakes	Miscell-aneous South-ern Lakes	Miscell-aneous North-ern Lakes	Non-trout Streams	Trout Streams	Fish Hatch-eries	Totals
Nymphaea advena	X	..	X	X	X	X	..	..	..	X	X	X	..	..	..	X
Castalia odorata	X	..	X	X	..	..	X	..	X	X	X	X	X	..	..	X
Nymphaeaceae	X	X	..	X	..	X	X	..	X	X	X	X	X	..	..	X
Brasenia Schreberi	X	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Ranunculus sp.	..	..	..	X	..	X	..	X	..	..	X	X	..	..	..	X
Rosaceae	..	..	..	..	..	..	..	..	X	..	..	..	..	..	..	X
Acer sp.	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Myriophyllum sp.	X	..	X	X	..	..	X	X	X	X	X	X	X	..	..	X
Cornus Amomum	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Cornus sp.	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
Utricularia sp.	..	..	..	..	..	..	X	X	..	..	..	X	X	..	..	X
Compositae	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	X
Bidens sp.	..	..	X	X	..	..	..	..	..	..	X	..	..	..	..	X
Lycopersicon esculentum	..	..	..	..	..	..	..	..	..	..	X	..	..	..	..	X
VEGETABLE DEBRIS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

* The letter "X" is used to denote the occurrence of food items for which counts of the numbers of individuals present were either impracticable or impossible.

** The following items were identified as carrion: Hyborhynchus notatus, Perca flavescens, Huro salmoides, Ambloplites rupestris, Lepomis macrochirus, Pomoxis nigro-maculatus, Centrarchidae, unidentified fish, Coluber constrictor flaviventris, snake exuvium, snake, Sternotherus odoratus, Sturnus v. vulgaris, unidentified animal flesh.

Assuming that the remains of all of the game fish found in the food of the snappers studied from wild waters (for fish) are from fish which were alive and healthy when taken, 301 turtles may be interpreted as having accounted for 275 fish of this kind, over the period of time represented by the remains in the intestinal tract. That this assumption as stated is somewhat in error has already been indicated, particularly in regard to the remains of centrarchids found in colons. For the most part, these game fish were represented in the colons only by scales and consequently their origin could not be determined as carrion or otherwise. However, permitting the assumption to stand with the maximum number expressed, and interpreting the data for number of fish per turtle studied, minimal significance of this species to game fish populations seems apparent. Although it is not known how long the average food substance remains in the stomach, or how long indigestible materials are retained in the colon of these animals and although no information is available regarding the daily food requirements and periodicity of feeding for this or other turtles, it seems a conservative estimate that on the average not more than one game fish is eaten per day by the snapping turtle. In this interpretation no consideration has been given to the facts that both stomach and colon of all turtles did not contain food or that both organs were not always saved for study.

To interpret in another way, the data on numbers of game fish eaten by snapping turtles on natural waters (for fish), still assuming all fish encountered to have been alive and healthy when taken, it may be stated that the 186 stomachs which contained food averaged approximately five-tenths of a game fish each, whereas the 278 colons with food averaged seven-tenths of a game fish each.

Recalling that the contents of each stomach probably represent a partial "meal," and that each colon probably includes the remains of several feedings, we may assume that the contents of 186 stomachs and of 278 colons (of 302 specimens from wild waters, for fish) approximately represent 454 sample "meals." In this large number of feedings, the game fish average six-tenths of an individual per turtle. It is felt that this interpretation offers the truest picture of predation on game fish by snapping turtles.

Most fish eaten by the snappers were far under legal size, and fish of such size are generally much more abundant than those of legal size. Population studies of snappers in Wolf and East Twin lakes show an average of perhaps two snapping turtles per acre of surface area in these waters. These circumstances minimize the significance of the estimate that each snapper on the average consumes six-tenths of a game fish per feeding. The implications appear to be that there need be little concern over the relations of snapping turtles to game fish populations on wild waters.

The relations of snapping turtles to game fish at hatcheries have already been discussed. In review, the indications are that even at such stations the concern is much less than heretofore commonly supposed. It should be recalled that the large numbers of game fish shown taken at hatcheries are almost entirely made up by those found in two turtles removed from a fyke net set in a rearing pond.

Since forage fish are often more abundant in waters than are game fish, it is surprising to note the low numbers in which they occur in the food of the snappers studied. They averaged about one to every ten of the 462 sample "meals." Consequently, neither does this turtle appear to have a significant role in the current generally perceived decline of forage fish populations, nor does it seem to compete significantly with game fish for this type of food.

It is regrettable that more complete information is not available on the relations of this turtle to nesting game fish. Owing to the low incidence of fish eggs as food, conclusions on this aspect of the problem must await further investigation.

None of the other vertebrates were taken in sufficient numbers to warrant recommendations that snapping turtles be controlled. The vulnerability of waterfowl, young and adult, is hardly more than suggested by the small amount of information gathered during this study. Despite the local concentration of waterfowl the series of twenty-one specimens studied from the W. K. Kellogg Bird Sanctuary at Wintergreen Lake contained the remains of only four young mallards in a total of some thirty "meals." Recalling that it could not be ascertained whether or not these birds were alive and healthy when taken, the slightly damaging nature of this evidence is reduced.

In 434 meals on wild waters (not including sanctuary and fish hatchery waters), feathers were found three times and remains of a Florida Gallinule and a Blue-winged Teal once each. Contrary to the usual claims, which have been based on inadequate data, an extremely low occurrence of birds in the food of the snapping turtle is indicated.

Perhaps the most important invertebrates taken were the crayfish. Insects, molluscs, water mites, and miscellaneous invertebrates, although occurring in large numbers, account for an unimportant proportion of the total food volume. The greatest significance of the feeding habits of the snapping turtle to game fish may be the competition which they offer for food, since game fishes forage upon many of the same organisms.

The consumption of molluscs by this turtle may be of importance in the life-cycles of certain fish parasites and may have an economic bearing. The turtles may be shown to be important final hosts and thus to facilitate the spread of the fish parasites. Such harm, however, is probably more than counterbalanced by the destruction of snails and clams, which are required links in the chains of many fish parasites.

Vegetable matter is clearly the food substance of greatest importance from point of view of proportion of total volume and frequency of occurrence. The extent to which feeding upon aquatic vegetation by snappers may be regarded as harmful or beneficial requires separate consideration for each body of water since, as pointed out by Hubbs and Eschmeyer (1938), it may be desirable to control aquatics in some circumstances and to encourage their growth in others. Obviously this turtle has some habits which tend to destroy water plants and other habits which may spread them. Many plants are destroyed by being fed upon. Others are uprooted by "rolling" while foraging, as previously described. The spread of aquatics is doubtless accomplished by the passage of undigested seeds as earlier suggested. It appears, however, that where large amounts of plant materials are eaten, fewer fish and fish-food organisms find their way into the diet of this turtle and in this manner the effect of feeding on plants, where they are abundant, may be beneficial to the game fish population.

The considerable importance of carrion in the food of the snapping turtle is suggestive of a desirable service rendered to man by this turtle. Doubtless the snappers eat many dead and dying fish which might otherwise form noxious litter on resort beaches and elsewhere.

Much time in the field was spent in studying the importance of the snapper in commerce and as food for man (this aspect of the economic significance of this turtle has been discussed by Clark and Southall, 1920). During the summers of 1937 to 1939 the market demand far exceeded the supply which Michigan trappers could provide. Trappers found a ready market for all the turtles which they could supply, at prices ranging from five to eight cents per pound, live-weight.

These trappers move about from lake to lake with mobile units and obtain snappers mostly by means of the conventional type of trap previously described. Turtles that have been trapped are held and fed in a live-pen until several hundred pounds have accumulated. They are then shipped alive in a barrel or crate to market. The best markets for Michigan turtles apparently are in Chicago and various cities in northern Indiana and Ohio. The greatest demand comes from the restaurant trade, but many turtles are sold to private individuals. Retail prices range from ten to twenty cents per pound live-weight and twenty to thirty cents, dressed weight.

A trapper and helper operating about five dozen traps in Michigan waters have reported that they have cleared more than a thousand dollars (average) for each of the last three summers. Others have told me that revenue derived from this occupation has enabled them to make a living during the recent years of economic depression.

The extensive food habits data here presented have given a limited indication of the harmful effects of snapping turtles in aquatic communities. Considering also the services which they render to man, I suggest that it would probably be best to encourage their conservation, except in waters where they are proven undesirable. Such procedure would materially help to insure a sustained yield of these reptiles to professional trappers. The imposition of restrictions on turtle hunters as to minimum sizes which may be taken and mesh-size to be used in traps might be desirable. It is recommended that six inches be fixed as the minimum size for this purpose. A three inch square mesh in traps would almost automatically establish this limit. An eight-inch turtle is about the smallest which has any real market value, although smaller sizes are often taken indiscriminately and shipped.

Clemmys guttata (Schneider)
Spotted Turtle

Description

Spotted turtles in Michigan average less than 127 mm. (five inches) in carapace length. The species is characterized by having "... the carapace black or dark reddish brown with one to several round, bright orange [or yellow] spots on each scute" (Ruthven, Thompson, and Gaige, 1928: 143). Additional details of description are given by the authors just quoted and by Allard (1909), Babcock (1919), Blake (1921), Cahn (1937), Conant (1938), Holbrook (1842), and others.

Sexual dimorphism in this species has been reported on in detail by Blake (1921) who found the concavity of the plastron, greater length of tail, greater pre-anal length of the tail, and certain pigment characters to be diagnostic for males. Grant (1935) also gives records of chromatic and morphological sex differences.

Range

According to Stejneger and Barbour (1939: 157), the range of the spotted turtle is "Eastern North America from Canada and Maine to northern Florida; in northern part west to Wisconsin and north to southern Michigan and Ontario." Schmidt and Necker

(1935: 74) held that "This species appears to reach the western-most limit of its distribution in the Indiana Dune area." In Michigan the species has not been recorded from the northern half of the Lower Peninsula; the most northerly record is from Lake County.

Habitat and Habits

Many authors have published information on the habitat of the spotted turtle in various parts of its range; abstracts of several of these published accounts are given in Table 29.

The species is considered essentially aquatic by most authors (Table 29) but Allard (1909), Atkinson (1901), Cahn (1937), Hay (1887a; 1892), Morse (1904), Roddy (1928), Smith (1882), and a few others have suggested that the turtle may have definite terrestrial habits at certain seasons of the year (in addition to the time of egg-laying). The spotted turtle is given to basking in the sun on objects out of the water, as are the map, painted and Blanding's turtles, according to Abbott (1884), Babcock (1919), Cahn (1937), DeKay (1842), Ditmars (1936), Eckel and Paulmier (1902), Mearns (1898), Nash (1908), and Roddy (1928).

As can be seen in Table 29, this turtle appears to belong to "small waters." For example, Conant (1938: 130) wrote that in Ohio members of this species "were not seen in rivers or other sizeable bodies of water." The observations cited (Table 29) also seem to indicate that this species is less aquatic in its habits than are the musk, snapping, Blanding's, painted, map, and soft-shelled turtles, with which, however,

TABLE 29. HABITAT OF THE SPOTTED TURTLE IN MICHIGAN AND OTHER PARTS OF ITS RANGE AS GIVEN IN SEVERAL PUBLISHED ACCOUNTS.

Author	Date	Locality	Habitat
Conger, A. C.	1920	Michigan Around East Lansing	Like that of painted turtle
Thompson, C.	1911	Cass County	Ditch
Allard, H. A.	1909	Eastern United States	Wet, swampy grounds
Allen, J. A.	1868	Massachusetts	Ponds, muddy ditches, and sluggish streams
Atkinson, D. A.	1901	Pennsylvania	Small, temporary swamp; pond
Babcock, H. L.	1919	New England	Ponds and streams with muddy bottoms; salt marshes; not uncommonly on land
Babcock, H. L.	1938	New England	Wet woods, meadows near brooks, marshes
Blake, S. F.	1921	Massachusetts	Pool in woods
Cahn, A. R.	1937	Illinois	Swamps, small weedy ponds, and streams
Conant, R.	1938	Ohio	Roadside ditches, small streams, bogs, tamarack, swamps, wet meadows, edges of small ponds and lakes
DeKay, J.	1842	New York	Streams and ponds, preferring those with a deep, muddy bottom
Ditmars, R. L.	1936	Rhode Island	Ponds and sluggish streams
Eckel, E. C. and F. C. Paulmier	1902	New York	Ponds

TABLE 29. (CONTINUED)

Author	Date	Locality	Habitat
Eifrig, C. W. G.	1930	Indiana	Ditches in the sand dunes
Evermann, B. W. and H. W. Clark	1920	Indiana	Small ponds, marshes, and open ditches
Fowler, H. W.	1906	New Jersey	Creek, pools at edge of salt marsh
Grant, C.	1935	Indiana	Small streams and ditches
Hay, O. P.	1887b	Indiana	Marshes
Hay, O. P.	1892	Indiana	Ditches, neighbor-hood of swamps and sluggish streams
Henshaw, S.	1904	New England	Ponds and streams
Holbrook, J. E.	1842	Range	Ponds, brooks, and rivers
Howe, R. H.	1904	Massachusetts	Brooks
Mearns, E. A.	1898	New York	Brooks, ponds, ditches, and Hudson River
Morse, M.	1904	Ohio	Still ponds, streams, or marshy places
Myers, G. S.	1930	New York	Ponds
Nash, C. W.	1908	Ontario	Warm, mud ponds
Nelson, J.	1893	New Jersey	Creeks, swampy land
Netting, M. G.	1936	Pennsylvania	Pymatuning swamp, drainage ditches, or surrounding farms
Palmer, E. L.	1922	Range	Marshes, ponds, and sluggish streams
Ricketson, C. C.	1911	Massachusetts	Brooks, Waterman's pond
Roddy, H. J.	1928	Pennsylvania	Mill dams, ditches, shallow lakes

TABLE 29 (CONTINUED)

Author	Date	Locality	Habitat
Say, T.	1825	Range in United States	Clear, flowing streams
Smith, E.	1899	Vicinity of New York City	Running and stagnant waters, bogs
Smith, W. H.	1882	Ohio	Sluggish streams, ponds, and ditches with muddy bottoms
Storer, D. H.	1839	Massachusetts	Small streams and clear water
True, F. W.	1884	Range	Ponds and running waters
Wright, A. H.	1918	Ontario	Drainage ditches
		New York	Swampy woods, mucky peaty ponds, sphagnum pockets, marly ponds

it may sometimes be associated. The spotted turtle appears to be more aquatic than are the wood and box turtles. Brimley (1905) made the same comparisons of the spotted turtle with the wood and painted turtles. De Sola (1931) considered the spotted turtle to be less aquatic than painted and map turtles.

Extensive field work in the normal haunts of the painted, Blanding's, musk, and snapping turtles failed to yield any specimens of <u>Clemmys guttata</u>. It therefore seems logical to assume that within its range in Michigan, the species is abundant only in restricted localities.

Perhaps the best accounts of the habits of this species are those of Babcock (1919), Cahn (1937), and Conant (1938). In addition to these, others workers have published several details of pertinent information. Dates of copulation have been recorded by Grant (1935), Evermann and Clark (1920), Mearns (1898). Mating on land has been reported by Grant (1935) and in water by Mearns (1898), whose observations were confirmed by Babcock (1919). Numbers of eggs, dates of oviposition or descriptive remarks on nests have been given by Abbott (1884), Agassiz (1857), Babcock (1919), Conger (1920), Hay (1892), Mearns (1898), and Smith (1882).

Food and Feeding Habits

Excepting the work of Surface (1908), no extensive studies of the food of this species appear in the literature. Several investigators have, however, published notes, original or otherwise, on the food habits of this turtle. Abstracts of, or quotations from, several of these follow:

Storer (1839: 207) stated that this species "... feeds upon insects, worms and frogs."

DeKay (1842: 14) reported that "They feed on insects, frogs, and worms ...."

De Sola (1931: 153) recorded that "It feeds on frogs, toads, insects, and dead fish ...."

Holbrook (1842: 83) considered the spotted turtle to feed "... on such animals as it can seize, as tadpoles, young frogs, etc.," and that "It takes to land frequently in search for food, devouring earthworms, crickets, grasshoppers, etc."

Hay (1892: 577) wrote: "Their food is said to consist of tadpoles, young frogs, and other weak animals. On land they devour earthworms, crickets and grasshoppers."

Brimley (1905: 154) has observed this turtle "... to eat apple, pieces of watermelon, sonchus leaves, dead snakes, fish scraps, etc. ...."

Allard (1909: 453) wrote: "There is little doubt but that frogs occasionally enter into its diet. I myself once watched one of these turtles pursue a small frog very actively in a brook at Oxford, Mass. At that time an excellent observer also informed me that he saw one of this same species capture a small frog."

Babcock (1919: 399) stated: "The Spotted Turtle feeds on insects, worms, larvae, small mollusks, tadpoles, etc., and in captivity will eat chopped fish and occasionally vegetable matter. ... I have never seen it eating ... except while under water."

Evermann and Clark (1920: 616) stated: "Their food consists chiefly of crawfish, tadpoles, angleworms, and other weak animals found about the water in the marshes."

Palmer (1922: 263) recorded the food as consisting of "... dead fish, water insects, and plants."

Morgan (1930: 399) observed that "It eats plant stems and leaves as well as insects and crustaceans."

Hatt (1932) found a spotted turtle and two painted turtles in company with several others feeding on a dead Green Heron in a small pond on Long Island, New York.

Ditmars (1936: 421) observed: "The food consists largely of dead fish and the larvae of aquatic insects."

Conant (1938: 131) gave findings which indicate that this turtle is omnivorous: "In the field they were observed to feed upon frogs, earthworms, grubs and the grass growing in a flooded meadow. Captives lived well on a diet of meat, fish, and a small amount of lettuce, and in addition they were seen to devour snails, crayfish, carrot tops, and spinach."

Regarding such statements Surface (1908: 167) wrote: "It is unfortunate that some of our predecessors have been guessing at the food of this and some other species of turtles, and the comparatively recent writers have accepted without quotation marks, the statements made by previous writers on this subject." This quotation would appear to be even more pertinent today than when it was written. Summarizing the findings of authors, however, one finds the following items reported as food of spotted turtles: frogs, tadpoles, insects and their nymphs and larvae, earthworms, molluscs, crickets, grasshoppers, plant stems and leaves, dead fish, and birds.

Surface (1908) studied the contents of twenty-seven stomachs of this species. An abstract of his findings are presented in Table 30.

Of considerable interest is the fact that Surface encountered no vertebrates in the food of this turtle. This finding is a direct contradiction of most of the other published statements just reviewed.

TABLE 30. ABSTRACT OF SURFACE'S (1908: 166-167) FINDINGS IN THE STOMACH CONTENTS OF TWENTY-SEVEN SPOTTED TURTLES

Food Item	Frequency of Occurrence	
	No.	%
Vegetation	3	11.1
Animal matter	27	100.0
Annulata	1	3.7
Mollusca	3	11.1
Crustacea	8	29.6
Myriapoda	1	3.7
Arachnida	2	7.4
Insecta	27	100.0
Ephemerida	2	7.4
Plecoptera	3	11.1
Odonata	9	33.3
Hemiptera	3	11.1
Neuroptera	2	7.4
Lepidoptera	3	11.1
Coleoptera	20	74.0
Diptera	10*	37.0
Hymenoptera	1*	3.7

* Minimum number of stomachs which contained these insects.

Discussion, Summary, and Conclusions

It seems rather clear, from the food and habitat preferences stated by other workers, that the spotted turtle can be of no concern to fish management in Michigan. Furthermore, as has been indicated, the turtle is uncommon in this state and is not known to be even locally abundant on any important fishing waters in this region. Although edible, its small size precludes its having any great potential value as food for man.

Clemmys insculpta (LeConte)

Wood Turtle

Description

The wood turtle in Michigan averages between 178 and 279 mm. (seven and eleven inches) in carapace length and is characterized by a keeled carapace, the scutes of which are sculptured by prominent, roughly concentric grooves. More detailed descriptions of this turtle have been given by Babcock (1919), Ruthven, Thompson, and Gaige (1928), and Cahn (1937).

Sexual dimorphism in the wood turtle has been described by Wright (1918) and Babcock (1919) who found long fore-claws, a concave plastron, and a greater pre-anal length of the tail to be diagnostic for adult males.

Range

Stejneger and Barbour (1939: 158) have given as the range of the wood turtle: "Eastern North America from Nova Scotia to Virginia, west to Michigan, Wisconsin, and Iowa; southwestern Ontario. Not found in Indiana and Illinois," and, according to

Conant (1938), not found in Ohio. The wood turtle was not known from Michigan prior to 1915 (Thompson, 1915a). Since that time it has been recorded from several counties in the northern two-thirds of the Lower Peninsula and in the Upper Peninsula. It remains unknown from the three southern tiers of counties across the state, and from the "Thumb" (Map 3).

<u>Habitat and Habits</u>

Several authors have published accounts of the habitat of the wood turtle; a selection of these writings which include pertinent data on seasonal variation in habitat preferences is given in Table 31.

From Table 31 it can be seen that the wood turtle is most frequently associated with a terrestrial habitat. It would seem that the species occurs typically on land for most of its activities excepting mating, hibernation, and those attendant on mating or hibernation.

The best, though incomplete, accounts of the natural history of this species are those of Wright (1918) and Babcock (1919). Additional facts pertaining to the habits of this turtle are given by many of the authors cited (Table 31). Oviposition and nesting have been described by Gammons (1871). Spring mating has been reported by De Sola (1931) and what may have been fall mating by Wright (1918).

<u>Food and Feeding Habits</u>

Several workers have published notes on the food and feeding habits of this species. The most significant of these are

TABLE 31. HABITAT OF THE WOOD TURTLE IN MICHIGAN AND OTHER PARTS OF ITS RANGE AS GIVEN IN SEVERAL PUBLISHED ACCOUNTS

Author	Date	Locality	Habitat
Gaige, H. T.	1915	Michigan Schoolcraft County	Swales or margin of river
Thompson, C.	1915a	Manistee County	Sand bank of Manistee River
Abbott, C. C.	1884	New Jersey	In water or in the wettest woodlands
Allard, H. A.	1909	Eastern United States	Dry woods and fields in summer
Babcock, H. L.	1916	New England	Woods and pastures in summer; swampy regions or water in spring and fall
Clark, A. H.	1930	Vicinity District of Columbia	River bank in June and August; creek in August; temporary pond in May
DeKay, J.	1842	New York	Woods, river banks, sand beach of river bank
Ditmars, R. L.	1905	Vicinity New York City	In swampy districts
Ditmars, R. L.	1936	Range	Damp woods; in spring, in and about streams
Drowne, F. P.	1905	Rhode Island	Dry fields and woods
Fowler, H. W.	1906	New Jersey	Dry woods; mostly along banks of streams
Henshaw, S.	1904	New England	Ponds and streams; in summer, in dry fields
Holbrook, J. E.	1842	Range	Ponds and rivers; dry places

Author	Date	Locality	Habitat
Jones, J. M.	1865	Nova Scotia	Generally in forests; lakes in winter
Leffingwell, D. J.	1926	New York	Woodlands
Mearns, E. A.	1898	New York	Margins of brooks; beside the Hudson River
Morgan, A. H.	1930	Range	Late spring and summer in pastures, woodlands, and upland fields
Myers, G. S.	1930	New York	Common in woods
Nelson, J.	1898	New Jersey	Generally met with in woodlands
Palmer, E. L.	1922	Range	Damp woods and swamps; sometimes in water
Reed, H. D. and A. H. Wright	1909	New York	Wooded regions along water courses
Ricketson, O. G.	1911	Massachusetts	Common in brooks
Roddy, H. J.	1928	Pennsylvania	During summer in dry fields and woodlands; in spring on soggy soils or near the borders of streams, ponds, and lakes
Smith, E.	1899	Vicinity New York City	Mostly in ponds, sometimes on land
Smith, W. H.	1882	Ohio (?)	Usually in dry fields; in spring, in meadows and along streams
Storer, D. H.	1839	Massachusetts	Ponds; often in woods and pastures
Surface, H. A.	1908	Pennsylvania	Abundant in woods, sometimes all year around
Wright, A. H.	1918	New York	Along stream valleys or in the streams

given here:

Verrill (1863: 196) reported discovering specimens "... feeding on the leaves and scapes of Dandelion (Taraxacum densleonis)."

Smith (1882: 659) reported that they "... feed upon low field blackberry and other vegetables."

Allard (1909: 453) spent an afternoon obtaining the following observations on an individual which he liberated in a pasture: "It fed greedily on any mullein leaves (Verbascum thapsus) in its path, and seemed especially fond of common sorrel (Rumex acetosella). It climbed slowly up the grassy banks bordering the cliffs, and finally gained a spot where grew various weeds and shrubs in the loose soil and rock crevices. When several feet away, its keen eye spied some large, red wild strawberries on a certain bank. It was interesting to see how eagerly and hurriedly it scrambled toward these berries. It spent considerable time among them, reaching up and clawing down the plants in order to reach the berries which it raked off awkwardly, together with the leaves, into its jaws."

Babcock (1919: 406) wrote: "This chelonian is omnivorous, although showing a distinct partiality for vegetable food, especially berries ... during warm weather while living on land. It has been observed to feed on various kinds of vegetation such as leaves, scapes of dandelion ... fruit of the low field blackberry, sorrel, leaves of early potentillas; also insects, and insect larvae. ... A captive of mine ate nine strawberries at one meal. These were held with the forefeet while being bitten and torn apart. The same is done with small fish (horn pout) after they have been killed by biting the head. The turtle apparently cannot see directly ahead, for it always arches its neck and turns its head to one side before striking at food placed in front of it."

Palmer (1922: 363) recorded the food as consisting of "Plants and animal life, many insects."

Morgan (1930: 402) stated: "The food they gather along the way [during terrestrial sojourns] is not very different from that of the ground-feeding birds—blackberries, partridge berries, mushrooms—but in the water they live on the regular turtle diet of small aquatic animals."

Netting (1936: 26) found a specimen which was "... feeding on wild strawberries."

Surface (1908: 162-163) has made the only detailed study of the food of this species. He found that "... that 76 percent of those [26] containing food had eaten vegetable matter ... while 80 percent had eaten animal matter."

Among those that had eaten animal tissue the number that had taken mollusks was rather large, considering that more than one-fourth of all examined was found to contain them, while the number that had eaten insects was still larger, being about 53 percent of all those that contained food. I quote his food table for this turtle:

	No.	Per Cent
Vegetation, ...	20	76.9
Cryptogams, (Flowerless Plants), .	1	....
Fungi		
Basidiomycetes, ...	1	3.8
Toadstools, ...	1	3.8
Bryophyta, (Mosses), ...	1	3.8
Jungermannia, ...	1	3.8
Phanerogams, (Flowering Plants).		
Undetermined flowering plants,. .	13	49.9
Seeds, ...	9	34.8
Asinina triloba, (Papaw fruit), .	1	3.8
Ilex verticillata seeds, (Holly),.	2	7.6
Vitis labrusca, (Fox Grape), . .	1	3.8
Clover, ...	1	3.8
Fragaria sp., (Strawberry, fruit and seeds), . . .	1	3.8
Rubus sp., (Blackberry) seeds, .	1	3.8
Sambucus canadensis fruit (Elder)	1	3.8
Mitchella repens, (Partridge Berry), . .	1	3.8
Solanum sp., (Nightshade berries.	1	3.8
Chelone glabra seeds, (Turtle Head), .	1	3.8
Plantago major, (Plantain), . . .	2	7.6
Betula sp., (Birch),.	1	3.8
Gramineae, grass, ...	9	34.8
Animal matter,.	21	80.7
Annulata, Earthworms, ...	1	3.8
Mollusca, ...	7	26.8
Snails, ...	6	23
Slugs, ...	1	3.8
Crustacea,.	3	11.6
Oniscidae, (Sow Bugs), ...	1	3.8
Cambarus sp., (Crayfish), ...	1	3.8
Gammarus sp., (Fresh Water Shrimp,	1	3.8
Myriapoda, (Millipedes, etc.),. . .	4	15.4
Insects, ...	14	53.7
Undetermined fragments, ...	4	15.4
Hemiptera, Pentatomidae, (Stink Bugs),.	1	3.8
Lepidoptera, (Moths and Butterflies),	2	7.6
Noctuidae, (Cutworms), ...	1	3.8
Heterocerous Macrolepidoptera, (Moth), . . .	1	3.8
Coleoptera, (Beetles).		
Undetermined beetles, ...	5	19.2
Carabidae, (Ground Beetles),. .	1	3.8
Harpalus caliginosus, ...	1	3.8
Chrysomelidae, (Leaf Beetles),.	2	7.6
Undetermined Leaf Beetles,. .	1	3.8
Chrysomela suturalis, ...	1	3.8

	No.	Per Cent
Scarabaeidae, ...	2	7.6
Tenebrionidae, ...	1	3.8
Diptera, (Flies), ...	1	3.8
Hymenoptera, (Ants, etc.), ...	2	7.6
Tenthredinidae, (Sawflies), . . .	1	3.8
Ant, ...	1	3.8
Vertebrata, ...	2	7.6
Undetermined birds, ...	2	7.6

Netting (1927: 4) offered an explanation of the incidence of bird remains in the specimens studied by Surface. He wrote: "The Wood Turtle (*Clemmys insculptus*) is so largely herbivorous and so mild tempered that it seems unlikely that it ever drags down and eats living birds. The bird remains which Surface reports (1908: 192) from the stomach contents of this species may have been those of a bird which the turtle had found floating dead on the water. Furthermore, after the spring mating season the Wood Turtle is largely terrestrial."

The known habitat preferences of the wood turtle, its food habits as related by other workers, and its relative scarcity in Michigan, all have indicated that the species can have little significance from the viewpoint of fish management. Consequently no special effort was made to obtain specimens.

Specimens which have been collected in Michigan by or for me are as follows (one specimen per collection unless otherwise indicated): Cheboygan County, Silver Lake, Black River Ranch, in six inches of water; collected by K. F. Lagler, June 3, 1937. Crawford County, North Branch on Sable River, on bank; collected by I. Bullis, August 15, 1937. Houghton County, Sturgeon River, on a log in mid-stream; collected by W. Hanna and K. F. Lagler, July 24, 1937. Lake County, Pine River on bank; collected by R. P. Bohland about July 15, 1938. Muskegon County, ten miles east of Muskegon, in woods at least 0.5 mile from nearest water; collected by M. D. Pirnie, August 31, 1937. Lake County, Little Manistee River (W. T. 6); collected by J. C. Salyer, II, June 25, 1931. Lake County, Little Manistee River, three specimens (W. T. 7, 8, 10);, collected by J. C. Salyer, II, June 20, 1931. Lake County, near Peacock (W. T. 11); collected by J. C. Salyer, II, June 29, 1931. Lake County, Kinne Creek, in water, two specimens (W. T. 104♀, 103♂); collected by A. S. Hazzard, April 26, 1937. Newaygo County, White River Trout Rearing Station, in raceways, one specimen each (W. T. 101 and 102) on June 1 and 2, 1932.

The five specimens collected in Lake County by Salyer were found by him to contain food as shown in Table 32. The food records for these individuals were given me by Salyer and are presented here with his permission. In Table 32 are also given the food of the two specimens from Kinne Creek, a trout stream, and of the two from the trout rearing station.

Discussion, Summary, and Conclusions

The analysis of the food of nine Michigan specimens (Table 32) confirms the more extensive study by Surface (1908),

TABLE 32. THE FOOD OF NINE WOOD TURTLES IN MICHIGAN

Wood Turtle Number	Organ	Food Item	Number of Individuals for Food Items	Volume in cc.
W. T. 6	Small Intestine	Algae	—	2.5
		Salix sp. leaves	2	0.3
W. T. 7	Stomach	Plant remains, mostly algae	—	7.0
		Black fly larvae	3	Trace
	Small Intestine and Colon	Plant and insect remains	—	4.0
W. T. 8	Stomach and Colon	Mass of green algae containing caddis [larvae] and molluscs	—	60.0
W. T. 10	Stomach	"June beetle"	1	7.0
		Tadpole	1	1.7
		Helisoma sp.	1	1.9
W. T. 11	Stomach	_Lepomis_ _macrochirus_ flesh	—	37.5
	Small Intestine and Colon	Limnephilidae larvae and cases	44	46.5
W. T. 104	Stomach	_Brachycentrus_ sp. larvae	14	1.2
		Limnephilidae larvae and 2 houses	2	0.8
		Gastropoda	1	0.1

		Neuroptera larva	1	0.3
		Leaf fragment	1	Trace
W. T. 103	Stomach	Limnephilidae larvae and houses	6	2.1
		Leaf	1	Trace
W. T. 102	Stomach	Oligochaete "earthworms"	5	1.5
		Hymenoptera adult	1	0.1
		Moss	—	0.5
		Salix sp. leaves	—	0.2
		Gramineae leaves	—	0.5
		Vegetable debris	—	2.0
W. T. 101	Stomach	Salmonidae	1	0.2
		Insect remains	1	0.1
		Vegetable debris including some algae	—	1.5

and the natural expectation from its predominantly terrestrial habits, that this turtle can be of no concern to fish management.

The wood turtle, were it more abundant, might have considerable value as food for man. According to De Sola (1931: 158) "The [wood] terrapin is eaten in many country places [in the northeastern states], the strawberry colored legs supplying the meat for a delicate preparation called 'country turtle'." It was "... in demand for food ..." in New Jersey early in this century (Fowler, 1906: 243) and was considered "... excellent as food ..." by Palmer (1922: 363).

The effects of the demands on this species as food in times earlier than this century has been indicated by Roddy (1928: 24): "This edible turtle was once very abundant from Ontario to Southern Pennsylvania and westward to Eastern Indiana. But when the white man discovered the delicacy of its flesh as food, each succeeding year brought a lessening of its numbers, until now one finds it only in the less populated parts of its range." As a result, "State legislation in New York and New Jersey protect the species from molestation and help to insure its existence" (De Sola, 1931: 152). Article 202 of the Conservation Law of the State of New York reads: "Taking, killing, or exposing for sale of all land turtles or tortoises, including the box turtle and the wood turtle, is hereby prohibited" (Palmer, 1922: 304). Since the species may be terrestrial in its habits for so much of each year, it is very likely to be encountered by man and is thus particularly vulnerable. It might be advisable to enact legislation for the conservation of this species in Michigan as in other parts of its range where though rare it is not yet protected.

<u>Emys blandingii</u> (Holbrook)

Blanding's Turtle.

<u>Description</u>

Blanding's turtle is characterized by its clear yellow chin and throat and by the numerous yellowish flecks on the dark-brown or black, domed carapace. Although individuals may attain a size of 236 mm. (9.3 inches, greatest length through the carapace of an adult male in my collections), 200 mm. (eight inches) is the average size of forty-four adult males and females selected at random from among the specimens which I studied for food. Ruthven (1927) considered 230 mm. as an unusually large size for this species in Michigan. More complete analyses of the characters of this species are given by Holbrook (1842), Babcock (1919), Ruthven, Thompson, and Gaige (1928), Cahn (1937), and Conant (1938).

Cahn (1937) and Conant (1938) gave the greater length of the tail as characteristic of the male. Cahn (1937: 78) wrote: "... in the male the shell is three times the length of the tail, or less, while in the female it is four times the length of the tail." In addition to this, I direct attention to the very pronounced concavity of the plastron which distinguishes adult males of this species from females, in which the plastron is flat or slightly convex. It does not appear to be known how these secondary sex characters vary with age.

Range

Stejneger and Barbour (1939: 158) have stated the range of Blanding's turtle to be: "Northern Illinois, Indiana and Wisconsin, west and north into Iowa, Minnesota, Michigan and southern Canada; east into Pennsylvania, New England and New Jersey; Long Island." In the Lower Peninsula of Michigan, this turtle is known from most counties and probably occurs all over the area. In the Upper Peninsula it has been recorded from only one locality, in Marquette County (Map 4).

Habitat and Habits

Published accounts on the habits and habitat preferences of Blanding's turtle are few, as compared with the information on the other turtles which occur in the state.

The best general account of the natural history of this species which has appeared is that of Conant (1938). Babcock (1919), Ditmars (1936), and Cahn (1937) gave small amounts of original information on life ways. A selection of the habitat notes which have appeared is given in Table 33.

In my field studies of Blanding's turtle in Michigan, no attempt was made to learn of the terrestrial habits which have been mentioned so often for this species by other workers (Table 33). Except for a few females taken along highways not far from water in late spring and early summer during the nesting season, all specimens of this turtle which I have observed or collected in Michigan were in aquatic habitats: lakes, ponds, creeks, rivers, and hatchery ponds. In such places they

TABLE 33. HABITAT OF BLANDING'S TURTLE IN MICHIGAN AND OTHER PARTS OF ITS RANGE AS GIVEN IN SEVERAL PUBLISHED ACCOUNTS

Author	Date	Locality	Habitat
Blanchard, F. N.	1928	Michigan Douglas Lake, Cheboygan County	Among low horsetails and bulrushes in an inch or two of water
Conger, A. C.	1920	Vicinity East Lansing	Along ditches and drains in the marshes during the breeding season
Hankinson, T. L.	1908	Walnut Lake, Oakland County	Shoal
Potter, D.	1920	Barry County	Carpenter's Woods northwest of Wall Lake
Ruthven, A. G.	1911	Vicinity south shore Saginaw Bay	Pine ridges, margin of a pond, and in bay, ponds, and lake
Thompson, C.	1911	Cass County	Mud Lake
Blanchard, F. N.	1922	Iowa	Bayou of Little Sioux River
Burt, C. E. and W. L. Hoyle	1934	Nebraska	Road above a shallow pond
Drowne, F. P.	1905	Rhode Island	Vicinity of ponds and streams
Garman, H.	1892	Illinois	On the prairies
Hankinson, T. L.	1917	Illinois	Prairie pond
Hay, O. P.	1887a	Indiana	In fields
Hay, O. P.	1891	Indiana	Neighborhood of streams and ponds
Henshaw, S.	1904	New England	Vicinity of streams and ponds
Holbrook, J. E.	1842	Range	Meadows and prairies

Howe, R. H.	1911	Massachusetts	Concord River
Hoy, P. R.	1883	Wisconsin	Abundant on prairies
Morse, M.	1904	Ohio	Larger streams flowing into Lake Erie; Ohio River
Schmidt, K. P. and W. L. Necker	1935	Vicinity Chicago	Abundant in sloughs during spring, on land in summer and fall
Storer, D. H.	1839	Illinois	Fox River

are associated with musk, snapping, painted, and map turtles.

Notwithstanding the restriction of my work to the habitats listed, I am inclined to feel that in Michigan, at least, this species is much more aquatic than the literature references cited might lead one to believe. As evidence of the aquatic propensities it may be mentioned that during the months of May through September, in the summers of 1937 and 1938, forty-seven specimens were taken in turtle traps from Wolf Lake, Van Buren County, and fifty-two were collected by this means in East Twin Lake. In addition, they are fairly adept swimmers and are also given to basking on objects out of, though near, the water; they retreat to the water at the slightest disturbance and usually move toward the drop-off. Conant (1938) has observed specimens moving about under the ice in captivity and hibernating in this environment but also records hibernation on land under circumstances similar to those which I have described for the snapping turtle. Babcock (1919: 409) stated: "Individuals vary greatly in regard to their modes of life, some being almost wholly aquatic." Cahn (1937: 80) wrote "... in certain regions it is largely a terrestrial species, while in others it is almost entirely aquatic in its habits." Conant records: "Almost all the Blanding's turtles collected in Ohio were found in shallow water ... it was unusual for one to be more than a hundred yards from the nearest body of water."

Food and Feeding Habits

Ditmars (1936: 438) reported that "Blanding's turtle feeds with equal readiness upon the ground or under water ..." and that "... it prowls through the undergrowth in search of tender shoots, berries, and insect larvae, a character approaching the habits of terrestrial box turtles."

Cahn (1937: 82-83) wrote that "... Blanding's turtle, apparently feeds readily both on land and in the water. On land it eats grasses, leaves, berries, and other succulent vegetation... , and has no difficulty in swallowing food in the absence of water. Insect larvae, grubs, slugs, and earthworms vary the vegetable diet on land, the animal matter composing about 30 per cent of the contents of the only 'terrestrial' stomach available to the writer for study. In their water environment they feed with equal avidity upon frogs, tadpoles, crayfish, minnows, and the larger larvae of aquatic insects. It speaks well for the speed of this turtle to note that it catches these active forms with apparent ease and surety. Also it is interesting to note that this species is able to swallow food both under water and while on land."

Conant (1938: 135) considered this turtle omnivorous but "...the larger portion of their food is apparently of an animal nature. They were seen eating snails, crayfish, earthworms and fish and such items of carrion as dead fish and dead turtles. In captivity they took all of the above plus lettuce, meat and chopped fish."

Specimens in the reptile pit at the University Museums have been observed to take ground beef into the water before swallowing it. They have not been seen to swallow food out of water. Captive specimens in the tanks in the laboratory have soon learned to take ground beef from the hand and have always retired under water before swallowing. Carl L. Hubbs has had live minnows captured by members of this species in small aquaria. Regarding feeding habits, specimens in a large exhibit pool at the State Fish Hatchery near Oden, Emmet County, have been seen rooting about under the detritus on the bottom of the pond in two to three feet of water. Although crayfish and aquatic insect larvae were present in this pond, no captures of these organisms were observed. In this type of foraging activity the head was used to turn over small flat stones on the bottom and the head and claws were employed to enlarge and explore recesses under bulky objects. That they may at least sometimes feed in moderately deep water was shown by an observation of two individuals which were foraging at night in water seven feet deep in Wolf Lake.

My food studies of Blanding's turtle are based on sixty-seven specimens which contained food either in the stomach or colon or in both. The Blanding's turtles studied for food were obtained from seventeen lakes, two non-trout streams, one trout stream and three fish hatcheries (Table 34). Enough specimens with food were obtained in Robinson and East Twin lakes to warrant the separate treatment of the material from each of these waters (Tables 35 and 36). Individuals from the remaining miscellaneous lakes have been combined into one group (Table 37), those from non-trout streams into another (Table 38), and those from fish rearing stations into yet another (Table 39). For each of these groups the findings presented are discussed individually. In Table 41 are given details of the numbers and kinds of the items eaten, and in Table 40, a summary of the food of this turtle for all habitats. The single specimen from the trout reaches of the White River is reported in the discussion of the small group for non-trout streams.

Robinson Lake. This small, shallow lake has an abundance of aquatic vegetation growing from a very soft bottom. The eleven Blanding's turtles studied for food from this lake were collected on August 30, 1938. Their average length is 168 mm. (6.6 inches), ranging from 119 to 190 mm. Four stomachs contained no food but some food was present in each of the eleven colons. A summary of the results of the analyses of the contents of these organs is given in Table 35.

In Robinson Lake, the principal foods of this turtle are very definitely crayfish, aquatic insect larvae, and fish carrion. The dead fish eaten were probably fish of less than legal size which had been returned by anglers to the water.

TABLE 34. LOCATIONS AND NUMBER OF BLANDING'S TURTLES WHICH CONTAINED FOOD FROM EACH

Location		Number of	Date of
Body of Water	County	Individuals	Collection
Robinson Lake	Kalamazoo	11	VIII:30:38
East Twin Lake	Newaygo	13	V:19-20:37; VII:12-13:38; VIII:16-18:38
MISCELLANEOUS LAKES		32	
Jewel Lake	Alcona	1	VII:20:37
Lake*	Alcona	1	VII:16:37
Forked Lake	Cass	2	IX:13-14:37
Ferguson Lake	Clare	2	VIII:3-4:38
Little Portage Lake	Jackson	1	IX:11-12:37
Lake**	Lake	10	VII:22:31
First Lake	Montcalm	2	VIII:23-24:38
Avery Lake	Montmorency	1	V:27:37
Little Joe Lake	Montmorency	1	VI:4-5:37
Fremont Lake	Newaygo	1	VIII:26-27:38
Bass Lake	Ogemaw	1	VI:29-30:37
Mills Lake	Ogemaw	4	VI:20-21:37
Horseshoe Lake	Washtenaw	1	VIII:2-3:38
Silver Lake	Washtenaw	2	VI:13:37; VIII:8-9:38
Sugarloaf Lake	Washtenaw	2	VIII:23-24:37
NON-TROUT STREAMS		4	
Mosquito Creek	Muskegon	2	IX:1:37
Muskegon River	Muskegon	2	IX:1:37

TROUT STREAM		1	
White River	Newaygo	1	V:1:?
FISH HATCHERIES		6	
Sunset Water Gardens	Oakland	1	VII:20-21:37
White River	Newaygo *	3	V:1:?; VI:14:32; VIII:16:32
Wolf Lake	Van Buren	2	VII:22:38

* Lake of unknown name five miles north of Glennie.

** Lake of unknown name near Wingleton.

The food of the specimens studied is very similar to that of two snapping turtles collected from this lake at the same time. The snappers, however, had eaten a little more aquatic vegetation than had the Blanding's turtles. The principal effects of the Blanding's turtles on the game fish of this lake at this time appeared to be in competition for food.

East Twin Lake. A brief description of the biological and physical features of East Twin Lake are given in the discussion of the snapping turtles studied from this lake. Eleven of the Blanding's turtles which contained food for analysis from this body of water were collected on May 19-20, 1937, one on July 12-13, 1938, and another on August 16-17, 1938. These thirteen turtles averaged 212 mm., (8.3 inches) in length, ranging from 181 to 236 mm. Forty-one additional individuals of this species which were trapped in this lake were measured,

TABLE 35. THE FOOD OF BLANDING'S TURTLE IN ROBINSON LAKE

Based on seven stomachs containing 7.7 cc. of food and eleven colons containing 12.9 cc. of food. More specific determinations of food items are given in Table 41.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	——	——	Trace	9.1
Unidentified fish	——	——	Trace	9.1
Carrion	24.7	14.2	——	——
Crayfish	29.9	42.9	43.0	90.9
Insects	35.1	85.7	51.7	90.9
Snails	Trace	14.2	——	——
Algae	Trace	14.2	Trace	9.1
Phanerogams	Trace	42.9	0.4	18.2
Vegetable debris	10.4	85.7	4.9	81.8

marked for future recognition, and returned to the water as a part of the population density and growth-rate studies being conducted here.

In Table 36 is given a summary of the data from the analyses of the food in twelve stomachs and twelve colons. The stomach of one individual and the colon of another were empty.

The two principal food items of the Blanding's turtles from this lake were obviously crayfish and aquatic insect

TABLE 36. THE FOOD OF BLANDING'S TURTLE IN EAST TWIN LAKE

Based on twelve stomachs containing 68.3 cc. of food and twelve colons containing 64.0 cc. of food. More specific determinations of food items are given in Table 41.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	4.7	16.7	Trace	8.3
Forage fish	1.5	8.3	——	——
Fish remains	0.1	8.3	Trace	8.3
Crayfish	52.1	65.3	68.3	91.7
Insects	41.4	77.0	26.5	75.0
Molluscs	Traces	16.4	Trace	8.3
Cryptogams	0.1	41.7	Traces	58.3
Phanerogams	0.1	41.7	Traces	41.7
Vegetable debris	Traces	8.3	4.2	50.0

larvae. No carrion was found, perhaps because most of the turtles were taken before the fishing season opened and before the spawning season for centrarchids was under way. Aquatic vegetation, generally less abundant in this lake than in Robinson Lake, occurred in lesser amounts in the food of these specimens than in those from Robinson. Again the sole possible significance of the food relations to game fish appears to be in competition for food.

TABLE 37. THE FOOD OF BLANDING'S TURTLE IN MISCELLANEOUS LAKES

Based on twenty-nine stomachs containing 101.0 cc. of food, and seventeen colons containing 63.7 cc. of food. More specific determinations of food items are given in Table 41.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	Trace	3.4	Trace	5.8
Fish remains	1.5	10.3	Trace	5.8
Bird remains	——	——	4.4	5.8
Carrion	7.2	6.9	——	——
Leeches	0.2	6.9	——	——
Crustaceans	69.9	72.4	63.1	82.4
Insects	10.6	37.9	20.6	52.9
Molluscs	5.0	20.7	1.2	23.5
Cryptogams	2.2	17.2	Traces	41.2
Phanerogams	0.9	27.6	0.5	29.4
Vegetable debris	2.4	41.4	4.9	29.4

<u>Miscellaneous lakes</u>. The food data for thirty-two specimens from fifteen additional lakes in localities widely distributed over the Lower Peninsula are summarized in Table 37. These specimens were collected during the months of June through September (Table 34). The average length of twenty-eight of these specimens for which measurements were obtained is 199 mm. (7.8 inches), ranging from 110 to 229 mm.

TABLE 38. THE FOOD OF BLANDING'S TURTLE IN NON-TROUT STREAMS

Based on three stomachs containing 18.0 cc. of food. More specific determinations of food items are given in Table 41.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Forage fish	*23.9	66.7
Bird remains	61.1	33.3
Crayfish	13.5	100.0
Caddis fly larvae	1.1	33.3
Vegetable debris	0.6	33.3

The data on the food of Blanding's turtle in lakes as shown by the specimens in this sizeable series (Table 37) substantiates those of the smaller series for Robinson Lake (Table 35) and East Twin Lake (Table 36). The similarity of the data for the two individual lakes with those of this larger series may be taken to indicate an adequacy of the samples. As previously indicated, this turtle is apparently of greater significance to game fish as a competitor for food than as a predator.

Non-trout streams. Although Blanding's turtle is very common in the quiet, marshy areas of several non-trout streams such as the Kalamazoo and Huron rivers, only four specimens were obtained for study from these habitats. Three contained food solely in their stomachs, data on the analyses of which are given in Table 38, and one contained 0.1 cc. of vegetable debris in the colon only.

No trustworthy conslusions can be drawn on data derived from so few specimens. The unidentifiable bird remains encountered in one turtle apparently were not carrion when taken. There is a duck pen near the place where this specimen was taken and it is possible that the remains represent a bird recently killed by some predator. It seems improbable that one of these waterfowl was destroyed by the Blanding's turtle.

In contrast to the food of the three specimens in which no game fish appeared, one eight-inch specimen from the White River in Newaygo County (a trout stream) was found by Salyer to contain in its stomach fifteen brown trout averaging three inches in length with a total volume of 57.9 cc. Also present in the stomach were two Johnny darters (Boleosoma nigrum), two snails, and one crayfish (Cambarus virilis). The colon held traces of trout, caddis-fly larvae, and snail remains. Although this individual was collected in the natural stream, it is possible that it had recently fed in the raceways of the adjacent trout rearing station. This would explain the numbers of trout present. Brown trout of the size taken were being cultured in the raceways at this time.

Fish hatcheries. From fish hatcheries, as from non-trout streams, the series of specimens available for food study is too small to be of very conclusive significance. The six specimens whose food was analyzed were collected during months from June through August (Table 34). A summary of the findings in these analyses is given in Table 39.

TABLE 39. THE FOOD OF BLANDING'S TURTLE IN FISH HATCHERIES

Based on six stomachs containing 33.6 cc. of food. More specific determinations of food items are given in Table 41.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	87.5	33.3
Fish remains	0.3	16.7
Crayfish	6.0	33.3
Insects	0.9	33.3
Molluscs	5.1	33.3

The food in the colon of one specimen, the stomach of which also contained food, was composed of 65 percent insect remains and 35 percent vegetable debris.

Although game-fish made up most of the food by volume for the Blanding's turtles studied, only two of the six specimens contained such fish, six in the stomach of one individual and one in that of another. These two turtles were from the trout raceways of the White River Rearing Station. One other turtle from these raceways contained crayfish only. The remaining three specimens, from bluegill and forage-fish ponds, had apparently not eaten any of these fish. Because of lower concentration fish were probably somewhat less available in these ponds than in trout raceways.

Carl L. Hubbs has demonstrated (unpublished data) the ability of Blanding's turtle to capture and eat several minnows in a short period of time in a forty-gallon aquarium. The conditions of these experiments were very much like the conditions in the narrow confines of raceways. This evidence and that from the food analyses seems to indicate that this turtle should be removed and excluded from fish rearing waters. Means by which this may be accomplished have been described by Lagler (1939).

Discussion, Summary, and Conclusions

In Table 40 is given a summary of the food contained in fifty-one stomachs and forty-one colons of sixty-six Blanding's turtles collected from wild (natural) waters. The food habits data for the six individuals from fish hatcheries are of course not included. Because of the possibility that the specimen taken from the White River had recently fed at the rearing station, it also is omitted here.

Crustaceans, almost entirely crayfish, make up about one-half of the food of Blanding's turtles in Michigan. Crayfish apparently may be expected to make up over one-half of the food of three of every four specimens encountered during the summer months. More than one-fourth of the food of half of the individuals appears to be insects. Miscellaneous invertebrates and vegetable matter compose the remaining fourth of the food of the specimens studied. It may be concluded that this species is omnivorous, similar to the musk and snapping turtles previously discussed.

It is interesting to note how restriction to what may be termed an essentially carcinophagous and insectivorous feeding habit involving hard-bodied food organisms causes a close agreement of figures for stomach and colon contents data (Table 40).

TABLE 40. THE FOOD OF BLANDING'S TURTLE ON NATURAL WATERS IN MICHIGAN

Based on fifty-one stomachs containing 193.8 cc. of food, and forty-one colons containing 140.7 cc. of food. The organs are from 60 turtles collected on seventeen lakes and two non-trout streams. Data on one specimen from a trout stream and on six from fish hatcheries are not included. More specific determinations of food items are given in Table 41.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	1.6	5.9	Traces	7.3
Forage fish	2.7	5.9	——	——
Fish remains	0.7	7.8	Traces	7.3
Bird remains	5.6	2.0	1.8	2.4
Carrion	4.7	5.9	——	——
Leeches	0.1	3.9	——	——
Crustaceans	56.6	74.5	60.1	85.4
Insects	21.4	54.9	30.3	68.3
Molluscs	2.6	17.6	0.5	12.2
Cryptogams	1.2	21.6	Traces	36.6
Phanerogams	0.5	31.4	0.3	29.3
Vegetable debris	2.2	39.2	7.0	51.2

This is in marked contrast to what has been shown for the somewhat more omnivorous snapping turtle, in which the contents of the stomach and colon are markedly different.

In Table 41 are recorded the details as to the numbers and kinds of food organisms encountered in lake and stream habitats

TABLE 41. NUMBERS AND OCCURRENCE OF EACH ITEM IN THE FOOD OF SIXTY-SIX BLANDING'S TURTLES

Food Item	Locality (and Number of Turtles)					
	Robinson Lake (11)	East Twin Lake (13)	Miscellaneous Lakes (32)	Non-trout Streams (4)	Fish Hatcheries (6)	Totals (66)
	(7) Stomachs (11) Colons	(12) Stomachs (12) Colons	(29) Stomachs (17) Colons	(3) Stomachs (1) Colon	(6) Stomachs (1) Colon	(57) Stomachs (42) Colons
GAME FISH						
Salvelinus f. fontinalis	..	..	..	..	7	7
Perca flavescens	1	1	..	..	..	2
Lepominae	..	1	..	..	..	1
Centrarchidae	..	1	2	..	..	3
FORAGE FISH						
Cottus bairdii	..	..	..	6	..	6
Eucalia inconstans	..	1	..	..	..	1
FISH EGGS	..	111	..	..	..	111
FISH REMAINS	1	1	X*	..	2	X
BIRDS	..	..	1	1	..	2
CARRION**	X	..	X	..	..	X
LEECHES (Hirudinea)	..	..	2	..	..	2
CRUSTACEANS						
Gammarus sp.	..	20	..	..	..	20
Cambarus virilis	9	11	16	..	..	36
Cambarus propinquus	..	25	42	..	..	67
Cambarus sp.	11	12	15	3	2	44
INSECTS						
Hexagenia sp. nymph	..	1	..	..	..	1
Anax junius nymphs	..	2	25	..	..	27
Aeschna sp. nymphs	16	..	4	..	..	20
Epicordulia princeps nymphs	..	4	..	..	..	4
Libellula sp. nymphs	..	176	..	..	..	176
Sympetrum sp. nymphs	..	2	2	..	..	4
Leucorrhinia sp. nymphs	..	11	..	..	..	11
Celithemis elisa nymphs	2	..	..	..	..	2
Celithemis sp. nymphs	28	42	10	..	..	80

Food Item	Robinson Lake	East Twin Lake	Miscellaneous Lakes	Non-trout Streams	Fish Hatcheries	Totals
Anisoptera nymphs	82	94	6	..	1	183
Enallagma sp. nymph	..	1	..	..	..	1
Zygoptera nymph	..	1	..	..	..	1
Belostoma sp.	..	..	5	..	..	5
Belostomatidae	..	..	9	..	..	9
Lethocerus sp.	..	..	1	..	1	2
Pelocoris sp.	2	..	..	..	..	2
Haliplus sp.	..	..	1	..	..	1
Dytiscus sp.	..	..	1	..	..	1
Acilius sp.	..	..	1	..	..	1
Dytiscidae larvae and adults	..	3	11	..	..	14
Hydrophilidae	..	..	2	..	1	3
Chrysomelidae	..	..	..	..	1	1
Coleoptera	..	..	1	..	..	1
Neuronia postica larvae	..	2	..	..	..	2
Neuronia sp. larvae	..	..	2	..	..	2
Leptocerinae larvae	..	2	..	..	..	2
Leptoceridae larvae	4	..	X	..	..	X
Limnephilidae larvae	..	..	2	..	..	2
Trichoptera larvae	..	X	..	2	X	X
Pyralidae larva	..	..	1	..	..	1
Lepidoptera larva	..	..	1	..	..	1
Stratiomyiidae larvae	..	..	6	..	..	6
Diptera	..	1	..	..	..	1
Insecta	X	X	..	..	..	X
SNAILS AND CLAMS						
Lymnaea palustris						X
Helisoma trivolvis	..	..	..	..	2	2
Helisoma antrosum	..	..	1	..	..	1
Gyraulus parvus	..	1	..	..	..	1
Physa sayii	..	..	X	..	..	X
Valvata tricarinata	..	1	..	..	..	1
Amnicola sp.	1	1	1	..	..	3
Gastropoda	..	X	X	..	..	X

	Robinson Lake	East Twin Lake	Miscellaneous Lakes	Non-trout Streams	Fish Hatcheries	Totals
Anodonta sp.	..	..	4	..	..	4
Sphaerium sp.	..	..	1	..	..	1
Pisidium sp.	..	..	..	..	3	3
Pelecypoda	..	X	1	..	..	X
Mollusca	..	..	13	..	..	13
CRYPTOGAMS	..	..	X	..	..	X
Algae	..	X	X	..	..	X
Chara sp.	X	X	X	..	..	X
Nitella sp.	..	..	X	..	..	X
Moss	..	X	X	..	..	X
PHANEROGAMS						
Typha sp.	..	..	X	..	..	X
Potamogeton sp.	X	X	..	..	..	X
Najas sp.	..	X	X	..	..	X
Spirodela polyrhiza	..	X	..	..	..	X
Lemna minor	..	X	X	..	..	X
Ceratophyllum demersum	X	X	X	..	..	X
Ranunculus sp.	..	..	X	..	..	X
Myriophyllum sp.	..	X	..	..	..	X
Cornus Amomum seeds	..	..	X	..	..	X
Bidens sp. seeds	..	..	X	..	..	X
VEGETABLE DEBRIS	X	X	X	X	X	X

* The letter "X" is used to denote the occurrence of food items for which counts of the numbers of individuals present were either impracticable or impossible.

** The following items were identified as carrion: Perca flavescens and remains of unidentified fish.

Insects are adults unless otherwise indicated.

and at fish cultural stations. The numerical dominance of the food by crayfish and insects substantiates the findings as seen in Tables 35 through 38. Regarding the food of this turtle, either the volumetric method or the numerical method of food habits study would have given approximately the same picture. By numbers, however, insects dominate whereas by volume, crayfish are most important.

As for the other aquatic turtles studied, it would be desirable to have additional information on the relation of this species to nesting game fish, particularly bass and sunfish. This is suggested by the discovery of 101 fish eggs in the stomach of an individual from East Twin Lake.

On the basis of the specimens studied, it seems that on natural waters the principal significance of Blanding's turtles to fish is reflected in the diet of aquatic invertebrates which they have in common.

This species is edible and of sufficient size and abundance in this region to be a source of meat supply. It might be wise to enact legislation to conserve this form. Field work has conclusively demonstrated that this species, along with the painted and map turtles which also frequently bask in the sun on objects out of the water, is very often the target of thoughtless gunners with small caliber rifles, and that many are thus destroyed.

<u>Terrapene carolina</u> (Linné)

Box Turtle

<u>Description</u>

The box turtle is "a small turtle attaining a carapace length of about six inches" (Conant, 1938: 136). It is characterized by a short, highly domed carapace predominantly yellow and brown or black in color. The plastron is large and divided into two movable lobes. The upper jaw at its tip is extended downward into sort of a beak which overhangs the symphysis of the mandibles. Excellent, detailed descriptions of this species are those of Babcock (1919), Pahn (1937), and Conant (1938).

Range

The distribution of the box turtle has been given as: "Eastern United States from Maine to Georgia, west to Tennessee, southern Illinois, and northwards to southern Wisconsin and central Michigan" (Stejneger and Barbour, 1939: 159). In Michigan it is known only on the Lower Peninsula in scattered counties to the south and west of a line drawn from Detroit to Grand Traverse Bay.

Habits and Habitat

More has been written on the habits and habitat preferences of the box turtle than on any other turtle which occurs in Michigan. This doubtless is due to its attractiveness to amateur herpetologists and to its relative commonness and predominently terrestrial habits, which render it more conspicuous than the species which are characteristically aquatic.

The following workers are in agreement in their statements on its frequent and usual occurrence on land, or report collections from land habitats, in Michigan or other parts of the range:

Abbott (1884), Allen (1868), Atkinson (1901), Babcock (1919, 1938), Blanchard (1925, 1926, 1928), Blatchley (1891, 1899), Bond (1931), Breder (1927), Brimley (1905), Cahn (1937), Conant (1938), Conger (1920), DeKay (1842), De Sola (1931), Ditmars (1936), Dice (1923), Drowne (1905), Eckel and Paulmier (1902), Ellis (1917), Evermann and Clark (1920), Fowler (1906), Frothingham (1936), Garman (1892), Hankinson (1917), Hay, O. P. (1887b, 1892), Hay, W. P. (1902), Holbrook (1842), Higley (1889), Hughes (1886), Mearns (1898), Morse (1904), Myers (1930), Ord (1841), Parker (1937), Potter (1920), Roddy (1928), Ruthven, Thompson, and Thompson (1912), Ruthven, Thompson, and Gaige (1928), Smith (1899), Smith (1882), Storer (1839), Surface (1908), Thompson (1911), and True (1884).

In addition to attributing to the box turtle an essentially terrestrial existence, some of the investigators cited also mentioned its occurrence in or near streams, swamps, and small, woodland pools.

The specimens which I have collected in Michigan were found on land, near water. On May 2, 1937, I took two individuals in a pasture about fifty feet from a small stream on low, moist ground which was covered with close-cropped grass in St. Joseph County near Three Rivers. The species is particularly common in the lower grounds of the sandy hill-country in Van Buren County near Almena in the vicinity of the Wolf Lake State Fish Hatchery. In this region it shares a habitat in which _Heterodon contortrix_ and _Coluber constrictor flaviventris_ are also common.

Several specimens have been encountered on the sand dykes between ponds at the Hatchery by hatchery employees in the course of routine duties.

Food and Feeding Habits

Many of the authors listed and others have published notes on the food of this species in captivity and in nature, as well as on the general natural history of the form. They have given a great variety of plants and animals as suitable food for captives. For wild specimens, the more important observations on the food and feeding habits follow.

Storer (1839: 214) considered that "The principle food of this species is insects."

Ord (1841: 59) stated that "Insects and worms, and the various kinds of tender mushrooms, are its common fare. On strawberries, raspberries, and soft peaches it feeds greedily."

Holbrook (1842) recorded that the food is composed of insects, crickets, and so forth.

DeKay (1842: 25) stated: "It feeds on insects, fruit, and the edible mushrooms."

Allen (1870: 262) wrote: "A few years since I found one [a box turtle] that had just eaten half the pileus of a very large *Agaricus* ..."

Abbott (1884: 252) wrote: "While to a certain extent carnivorous in habit—it devours earth-worms greedily—the box-tortoise is essentially a vegetable feeder, and in summer depends largely upon berries growing upon the ground. Strawberries, dewberries, and, later in the year, windfalls from fruit-trees, form an important portion of their food. Decomposed animal matter, also, is freely eaten."

Blatchley (1899: 550) "... twice surprised adults feeding upon ripe papaws. In one instance more than two thirds of a large-sized one had been devoured." He also has twice observed (1891: 35) individuals "... to feed upon a species of fungus growing upon an oak log."

Lintner (1897: 289) said that "Even the common land turtle [doubtless the box turtle] was tempted to include the [Cicada] pupas in its bill of fare."

Mearns (1898: 329-330) "... found it eating wild strawberries; ..." and stated that "It is also very fond of mushroom fungi."

Morse (1904: 141) considered that "Their food consists of insects mainly, ... "but also includes ... fungi, roots, potatoes, etc."

Hurter (1911: 247) wrote that "The food of the Box Turtle consists largely of vegetable matter and berries, although the larvae of insects are eaten as well as earthworms and slugs."

Latham (1916) found that the species feeds exclusively on _Russula obscura_, a mushroom, which it selects from among several other species of fungi available near Orient on Long Island, New York. Nichols (1917) found an individual which had consumed part of a large _Boletus saber_ near Mastic, Long Island.

Evermann and Clark (1920: 619) gave "... grubs, angleworms and succulent plants and fruits" as chiefly composing the food of this turtle.

De Sola (1931: 156) said that it is "... often found nibbling the edges of umbrella-like mushrooms and sometimes eating slugs and dead fish that have been washed upon the bank of a stream."

Cahn (1937: 95) wrote that vegetable matter predominates in the food of this species and "... consists of a great variety of plants, including the roots, stems, and leaves of a host of species of flowering plants, berries, fruits, and some seeds." He has not found fungi in the food of specimens examined from Illinois.

Box turtles have been observed by Conant (1938: 139) "... to eat earthworms, grubs, crayfish, fish, frogs, salamanders, meat, lettuce, spinach, cabbage, blackberries, blueberries, bananas, tomatoes, several species of fungi, etc., and carrion such as dead birds or amphibians." Apparently this turtle was not seen eating all of these items in the wild.

Brimley recorded observations on feeding habits as well as on food (1905: 154): "The Box Tortoises or Highland Terrapins of the genus Terrapene (Cistudo) which are terrestrial and not aquatic have been seen to eat raw flesh, dead birds, ripe and unripe fruit such as apple, tomato, watermelon, canteloupe, plum and persimmons and also occasionally the leaves of succulent plants. June bugs are also eaten during the period of their abundance. Their usual method of eating is to stretch the head forward towards their food, seize a piece in the jaws, and then jerk or pull the head backward so as to tear or cut the piece away, the forefeet being usually braced against the food or placed on it, while the portion to be swallowed is torn away.

The morsel of food is then crushed sufficiently by the masticating surfaces of the jaws (turtles have no teeth) and swallowed. There is no difference so far as I have been able to observe in the food of the different species of Terrapene, and I have had opportunities for observing T. carolina, T. major, T. triunguis, T. ornata, and T. bauri."

Surface (1908: 177) has made the only detailed laboratory study of the food of the box turtle. He analyzed the food of forty specimens and found that "... 62 per cent of the specimens containing food contained vegetable matter of which berries and seeds were rather conspicuous. Eighty (80) per cent. of those containing food contained animal tissue which means that several individuals contained both animal and vegetable tissue."

The detailed results of Surface are reproduced in the following table quoted from his paper (1908: 175-176). This table was also copied by Ruthven, Thompson, and Thompson (1912).

	No.	Per Cent.
Vegetation,	25	62.5
Cryptogams, (Flowerless Plants),	7	17.5
Fungi.		
Undetermined fungi,	1	2.5
Basidiomycetes,	1	2.5
Mushrooms,	4	10
Bryophyta, Moss,	1	2.5
Phanerogams, (Flowering Plants).		
Undet.,	4	10
Roots,	2	5
Buds,	1	2.5
Leaves,	5	12.5
Berries,	3	7.5
Seeds,	1	2.5
Podophyllum petatum (May Apple),	1	2.5
Vitis labrusca (Grapes),	1	2.5
Prunus sp. (Cherry) seeds,	1	2.5
Rubus sp. (Blackberry),	3	7.5
Pyrus sp. (Apple),	2	5

	No.	Per Cent.
Osmorhiza sp.,	1	2.5
Pyrola rotundifolia,	1	2.5
Physalis sp. (Ground Cherry),	3	7.5
Gramineae, grass,	8	20
Bird's Wheat Moss,	1	2.5
Animal matter,	32	80
Annulata (Earthworms),	2	5
Mollusca (Mollusks),	15	37.5
Snails,	14	35
Slugs,	2	5
Crustacea (Cambarus sp.),	1	2.5
Myriapoda (Millipedes),	8	20
Insecta (Insects),	24	60
Undetermined insects,	7	17.5
Orthoptera (Grasshoppers, etc.),	7	17.5
Acrididae,	1	2.5
Melanoplus femur-rubrum (Red-legged G),	2	5
Gryllidae (Crickets),	1	2.5
Gryllus pennsylvanicus (Cricket),	2	5
Locustidae (Long Horned Grass-hoppers),	1	2.5
Hemiptera Pentatomidae (Stink Bugs),	1	2.5
Lepidoptera (Moths),	9	22.5
Larvae (Caterpillars),	7	17.5
Pupae (Chrysalids),	1	2.5
Notodontidae—Datana ministra,	1	2.5
Noctuidae, larvae (Cut worms),	3	7.5
Diptera (Flies),	1	2.5
Coleoptera (Beetles, etc.),	10	25
Undetermined beetles,	7	17.5
Larvae of Beetles,	2	5
Carabidae (Ground Beetles).		
Undetermined ground beetles,	2	5
Carabus limbatus,	1	2.5
Pterostichus lucublandus,	1	2.5
Harpalus caliginosus,	1	2.5
Hymenoptera (Ants, etc.),	1	2.5
Vertebrata (Back-boned Animals),		
Mammalia, Muridae (Mice),	1	2.5

Discussion, Summary, and Conclusions

It is apparent from the statements on habits and habitats frequented as given in the literature as well as from the remarks on food habits, especially Surface's detailed account, that this omnivorous and essentially terrestrial turtle can be of no concern in fish management. I have no information which would lead to conclusions that it might be a liability in truck or flower gardens although this possibility has been suggested by other workers. The species is reported to be edible and its eggs are said to be a particular delicacy. It seems to me that the species is quite uncommon in its range in this state and that perhaps it should be protected by law as suggested for the wood turtle. The species is thus protected in some eastern states.

Graptemys geographica (LeSueur)

Map Turtle

Description

The map turtle is characterized by having a reticulation of yellowish lines on the dark olive to brown (bright green in young), rigid carapace. The species in Michigan may attain a size as large as ten inches or more. The average length of the specimens studied for food, as indicated by the twenty-one that were measured, is 157 mm. (6.2 inches) ranging from 91 to 229 mm.

Detailed descriptions of this turtle have been published by Babcock (1919), Evermann and Clark (1920), Ruthven, Thompson, and Gaige (1928), Cahn (1937), and Conant (1938). As Cahn (1937) indicated, the sexes of adults may be differentiated by the smaller head, longer tail, and smaller average size of the males.

Range

The range of the map turtle as given by Stejneger and Barbour (1939: 161) follows: "Mississippi Valley north to Iowa, southern Wisconsin, Illinois, southern Michigan, east to Pennsylvania and New York, Canada north to Ottawa River, shores of Lake Ontario, Lake George and Lake Champlain; eastern Tennessee and southwestern Virginia, west to eastern Kansas, southwestern Missouri, eastern Oklahoma, and eastern Texas." The occurrence of this turtle in Michigan is approximately limited to the southern half of the Lower Peninsula although it is unknown from several counties within this area (Map 3).

Habitat and Habits

Many workers have published information on the habitat of the map turtle in various parts of its range. A selection of these contributions is given (Table 42) to demonstrate the variety of conditions under which the species may occur.

I have seen this preëminently aquatic species basking on logs, two and three deep, with western painted turtles, in sloughs and backwaters of the St. Joseph River near Colon. It is a common species in the quiet waters of the Huron River near Ann Arbor, and it inhabits river-mouth lakes such as White and Muskegon lakes where I have obtained specimens in traps. The map turtle was found associated with the musk, snapping, Blanding's, western painted, and soft-shelled turtles in many lakes, large and small, in the southern part of the state.

Phases of the natural history and habits of this turtle have been treated by Newman (1906), Evermann and Clark (1920), Cahn (1937), and Conant (1938). Additional but more limited information has been published by most of the authors cited in Table 42.

TABLE 42. HABITAT OF THE MAP TURTLE IN MICHIGAN AND OTHER PARTS OF ITS RANGE AS GIVEN INSEVERAL PUBLISHED ACCOUNTS

Author	Date	Locality	Habitat
Conger, A. C.	1920	Michigan Range in Michigan	Usually found in lakes
Ruthven, A. G., C. Thompson, and H. Thompson	1912	Range in Michigan	Lakes and rivers, more common in former
Thompson, C.	1915b	Monroe County	Dominant turtle in River Raisin
Cahn, A. R.	1937	Illinois	Lakes, ponds, sloughs, larger rivers
DeSola, C. R.	1931	Northeastern states	Restricted to ponds and lakes
Brown, J. R.	1928	Vicinity Hamilton, Ontario	Common in Hamilton Bay
Conant, R.	1938	Ohio	Larger rivers, Lake Erie
DeKay, J.	1842	New York	Streams flowing into Lake Erie
Eckel, E. C. and F. C. Paulmier	1902	New York	Streams in western part of state
Evermann, B. W. and H. W. Clark	1920	Indiana	Lakes and larger streams
Garman, H.	1892	Illinois	Larger streams and lakes; flood-ground pools
Gloyd, H. K.	1928	Kansas	Lake; river
Hay, O. P.	1892	Indiana	All streams and lakes
Henshaw, S.	1904	Vermont	Lakes and rivers (Lake Champlain drainage)

TABLE 42 (CONTINUED)

Author	Date	Locality	Habitat
Morse, M.	1904	Ohio	Larger rivers flowing into Lake Erie and the Ohio River
Newman, H. H.	1906	Indiana	Lake Maxinkuckee
Strecker, J. K.	1915	Texas	Colorado River and creeks

Food and Feeding Habits

No detailed food studies of the map turtle have heretofore appeared. Several brief statements have, however, been published and are reproduced here in order to bring together the little that is known regarding the food of this species.

In all the specimens examined by Garman (1890: 81) "... the food consisted exclusively of mollusks, in the young turtles consisting of Valvata tricarinata and other thin-shelled species, in the adults of larger and thicker shelled forms."

Morse (1904) considered the food as being largely made up of snails and clams.

Newman (1906: 139-140), who studied the feeding habits as well as the food, reported: "Graptemys feeds exclusively upon the flesh of a species of viviparous gastropod that abounds in Lake Maxinkuckee. The stomachs of all that I have examined (over twenty specimens) contained the bodies and opercula of these molluscs. When kept in aquaria the opercula are very numerous in the excreta. Adult specimens feed on adult molluscs and young specimens on young molluscs.

"Two methods of feeding prevail. The favorite method seems to be to capture the mollusc when the foot and gills are well out of the shell, to bite off the soft parts and leave the hard shell. To do this the final closure of the jaws must be quite sudden. If they fail to secure the body of the snail in this way they adopt the crushing method. The hard shell is easily crushed between the broad flat jaws and the broken pieces of shell are picked out with the aid of the claws. When in search of food they prowl about the bottom, often underneath the dense vegetation. The heavy growth of Chara or Nitella is tunneled in every direction with passageways made by foraging Graptemys.

"It is impossible to induce them to partake of any food other than that mentioned above. Specimens kept nine months in an aquarium never fed, while other species were eager for any kind of animal food."

Surface (1908) found the specimen which he examined to contain only crayfish.

Conger (1920) and De Sola (1931) have stated that this turtle feeds on crayfish and molluscs.

Bishop (1921: 81) confined a captured specimen in a box and it "... disgorged several large and many small fragments of the fresh-water clam, Unio complanatus (Sol), ..."

Roddy (1928: 27) said that the food of this species is chiefly molluscs and crayfish but added that "Water lilies and perhaps other succulent water plants form part of its diet."

Regarding the food of this species, apparently when captive, Ditmars (1936: 409 wrote: "It will eat chopped fish, meat and mealworms, also earthworms and various soft bodied grubs, dragging all its food into the water and devouring it beneath the surface." He had also "... observed it to eat the edges of water-lily pads" but does not express an opinion as to whether the pads were eaten to secure snails.

Cahn (1937: 111-112) wrote: "Snails, and an occasional insect or larva, are the main items of food taken. So badly crushed are molluscan remains that identification is almost impossible." He also repeated Newmans (1906) observation that in captivity this species will eat only snails and clams. Specimens in my laboratory and in the reptile pit at the University Museum take chopped beef-heart, fish, and lettuce as did those reported by Conant (1938: 144). That author recorded the following items in the food: "... crayfish, fish, aquatic insects, carrion, and snails." Specimens in captivity were observed by him to nibble "... upon such greens as lettuce, spinach and beet tops on a few occasions and most of them readily accepted meat. ... They apparently are not averse to eating organic sewage and in certain of the larger rivers which are badly polluted with garbage, etc. they were found in abundance."

Regarding time of feeding, I have seen specimens feeding at most times during daylight hours and at night on a weedless bottom of sand and marl in Wolf Lake (Van Buren County) and East Twin Lake (Newaygo County).

My food studies of the map turtle are based on twenty-seven specimens which contained food either in the stomach or colon or in both. These turtles were collected from four inland lakes,

TABLE 43. LOCATIONS AND NUMBER OF MAP TURTLES
WHICH CONTAINED FOOD FROM EACH

Location		Number of Individuals	Date of Collection
Body of Water	County		
Birch Lake	Cass	2	VII:8,16:37
Gull Lake	Kalamazoo *	7	VII:14,21:37; VII:14,19:38
Grand River	Kent	3	VI:5:37
Pere Marquette River	Lake	1	VII:14:31
White River	Newaygo	1	VII:19:31
Muskegon Lake	Muskegon	1	VIII:19:38
White Lake	Muskegon	1	VIII:19:38
St. Joseph River	St. Joseph	2	V:2:37
Wolf Lake	Van Buren	2	VIII:13:38
Whitmore Lake	Washtenaw	1	IX:23:37
Unknown*		6	

* Owing to the poor quality of the paper used for the labels on these six specimens taken in the state, no collection data are available for them.

two river-mouth lakes, and two trout and two non-trout streams (Table 43). Six additional specimens were from unknown waters in Michigan. Owing to the fact that the series is so small, no ecological grouping of the material has been made. A summary of food analyses of all the specimens is given in Table 44 and details of numbers and kinds of items eaten, in Table 45.

TABLE 44. THE FOOD OF THE MAP TURTLE ON NATURAL WATERS IN MICHIGAN

Based on twelve stomachs containing 38.2 cc. of food and twenty-four colons containing 95.6 cc. of food. The organs are from twenty-seven turtles collected on six lakes, four rivers, and some unknown waters. More specific determinations of food items are given in Table 45.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fish	1.8	8.3	Trace	4.2
Forage fish	11.3	8.3	——	——
Unidentified fish	2.4	8.3	0.6	8.3
Carrion	5.0	8.3	——	——
Crayfish	52.4	8.3	13.0	25.0
Water mites	——	——	Traces	8.3
Insects	8.6	41.7	12.0	50.0
Snails	17.3	83.3	57.7	79.2
Clams	1.3	8.3	12.6	37.5
Plants	——	——	4.2	16.7

Discussion, Summary, and Conclusions

Game fish found in map turtles were represented by the head of a small yellow perch in one stomach and traces of the remains of two centrarchids in one colon. Forage fish found were three northern black-nosed shiners in one stomach. Of these game and forage fish, all those in the stomachs were apparently alive when taken, but this point could not be determined for the remains of centrarchids in the colon.

The data in Table 44 seem to indicate that crayfish as well as molluscs are indeed an important food of this turtle. Snails, clams, and insects are the other invertebrates of significance. As has often been stated, the broad alveolar surfaces of the jaws of these animals are useful in crushing molluscs and other hard-bodied invertebrates. That the jaws are employed for this purpose is evidenced by the crushed condition of the crayfish, beetles, snails, and clams in the stomachs of these turtles.

It is not evident whether the small amounts of plant tissue in four colons had been taken primarily or secondarily. The occurrence of several seeds of Potamogeton sp. in one colon suggests that perhaps hard-coated seeds of this type are definitely taken as food. The coats of these seeds had been broken open by the action of the jaws, digestion, or abrasion from accompanying snail shells.

The data in Table 45 demonstrate a numerical dominance of the food by insects and molluscs. The marl beetles (Elmidae), which appeared in greater numbers than any of the other groups of insects, occurred mostly in one colon which contained 271. These beetles, it will be recalled, are very small and were far from being as volumetrically significant in the food as the numbers would seem to indicate.

Snails were taken in greater numbers and more frequently than clams. Owing to the extremely crushed and partially digested nature of the shells of most molluscs found in the digestive organs, it was impossible to obtain counts of numbers of individuals for much of the material. In order to give some

TABLE 45. NUMBERS AND OCCURRENCE OF EACH ITEM IN THE FOOD OF TWENTY-SEVEN MAP TURTLES

Food Item	Stomachs (12)	Colons (24)	Totals
GAME FISH			
Perca flavescens	1	..	1
Centrarchidae	..	2	2
FORAGE FISH			
Notropis h. heterolepis	3	..	3
FISH REMAINS	X*	X	X
CARRION (Salmonidae)	3	..	3
CRAYFISH			
Cambarus immunis	1	5	6
Cambarus sp.	..	7	7
WATER MITES (Hydracarina)	..	3	3
INSECTS			
Stenonema sp. nymphs	2	..	2
Ephemerida sp. nymphs	2	..	2
Zygoptera nymphs	..	8	8
Hydrophilidae	..	1	1
Elmidae	..	274	274
Scarabeidae	1	7	8
Coleoptera	..	7	7
Leptoceridae larvae	22	46	68
Limnephilidae larvae	56	2	58
Helicophsyche sp. larvae	..	28	28
Trichoptera larvae	62	8	70
Chironomidae larvae	1	3	4
Chironomus sp.	1	..	1
Asilidae	..	1	1
Insecta	1	2	3
SNAILS AND CLAMS			
Lymnaea catiscopium	12	12	24
Lymnaea palustris	..	5	5
Helisoma trivolvis	..	8	8
Helisoma antrosum	Many**	Very Many	Very Many
Helisoma campanulatum	..	3	3
Gyraulus parvus	..	Many	Many
Gyraulus sp.	..	X	X
Planorbula armigera	..	2	2
Physa gyrina	..	4	4
Physa sayii	Many	Many	Many
Physa sp.	..	Several	Several
Valvata tricarinata	..	4	4
Valvata bicarinata perdepressa	..	2	2
Valvata sp.	..	X	X
Amnicola cincinnatiensis	1	4	5
Amnicola limosa	..	Many	Many
Amnicola lustrica	..	Many	Many
Amnicola walkeri	..	5	5
Amnicola sp.	..	X	X

Food Item	Stomachs (12)	Colons (24)	Totals
Bithynia tentaculata	35	Many	Many
Campeloma sp.	13	X	X
Lioplax subcarinatus (?)	..	1	1
Goniobasis livescens	Many	X	X
Goniobasis sp.	..	Many	Many
Gastropoda	Many	Very Many	Very Many
Sphaerium sp.	..	1	1
Pisidium abditum	..	Very Many	Very Many
Pisidium sp.	..	X	X
Lampsilis siliquoidea	X	..	X
Strophitus rugosus	X	X	X
Anodonta grandis	X	..	X
Pelecypoda	X	X	X
Mollusca	X	X	X
PLANTS			
Filamentous algae	..	X	X
Potamogeton sp. seeds	..	Several	Several
Ceratophyllum sp.	..	X	X
VEGETABLE DEBRIS	..	X	X

* The letter "X" is used to denote the occurrence of a food item for which a count of the number of individuals could not be obtained.

** "Many" is used to denote an estimated number between twelve and one hundred; "several," five to twelve; and "very many," more than one hundred.

idea of the numerical relations on such occasions, the approximate numbers were estimated when possible as "several" (5-12), "many" (12-100), or "very many" (more than 100). In organs where it was impossible even to carefully estimate the numbers of individuals for molluscs or other animals present, the letter "X" was used to denote this occurrence.

Identifications of molluscs eaten were made as specific as possible to establish not only the predator-prey relationships of the several forms, but also to provide a tool for the use of parasitologists in working out the life cycles of important fish parasites or human pests such as swimmer's itch, (*Schistosome dermatitis*). It is evident that in destroying many of the molluscan hosts of such parasites, the map turtle may be a distinct economic asset. This may outweigh some of the competition which it offers fish for food.

Ditmars (1936) declared that this turtle is marketable for food. In so far as I am aware none are sold in Michigan or shipped from the state for sale. The young do not appear in sufficient numbers in this state to provide a supply for the pet and souvenir markets.

Chrysemys picta: *bellii* (Gray) × *marginata* (Agassiz)
Intergrades between Bell's Turtle and
Western Painted Turtle

Description and Range

As shown by Hartweg (MS) *Chrysemys picta* is represented on most of the Upper Peninsula in Michigan by intergrades between *bellii* and *marginata*, whereas the western painted turtle (*Chrysemys picta marginata*) is restricted to the Lower Peninsula. The turtles of this genus are the only native forms on the peninsulas which bear bright red markings on the carapace and so are easily distinguished from all others at all ages and sizes. Bishop and Schmidt (1931) summarized and illustrated the characters useful in separating the subspecies; the intergrades are intermediate in most of the subspecific characters. The eight adult intergrades which I studied for food averaged 146.6 mm. (5.7 inches) in length,

TABLE 46. HABITAT OF INTERGRADES BETWEEN BELL'S TURTLE AND WESTERN PAINTED TURTLE IN MICHIGAN

Author	Date	Locality	Habitat
Evans, A. T.	1915	Near Wakefield, Gogebic County	Ponds
Gaige, H. T.	1915	Schoolcraft County	River
Ruthven, A. G.	1904	Ontonagon County	Carp River
Ruthven, A. G.	1910a	Dickinson County	Brown Lake
Thompson, C. and H. Thompson	1912b	Whitefish Point, Chippewa County	Pond

ranging from 126 to 129 mm.; the stomach of one specimen and the colon of another were empty. Four of these turtles were collected from a small pond about nine miles northeast of Engadine, Mackinac County, on July 17, 1937. The other four were taken from Pickerel Lake, near Marquette in Marquette County on July 27-29, 1937.

<u>Food and Feeding Habits</u>

It is unfortunate that so few specimens were obtained for the study of the food of these turtles, but the conclusions drawn from extensive material of <u>C</u>. <u>p</u>. <u>marginata</u> presumably apply also to the intergrades. The results of the analyses of the food of the small series of intergrades are given in Tables 47 and 48.

<u>Discussion, Summary, and Conclusions</u>

Insects and their aquatic larvae, and crustaceans, molluscs, and aquatic plants appear to be the principal foods

TABLE 47. THE FOOD OF INTERGRADES BETWEEN BELL'S TURTLE AND WESTERN PAINTED TURTLE IN MICHIGAN WATERS

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Rana sp.	42.7	14.3	———	———
Feather	Trace	14.3	———	———
Crustaceans	6.0	57.1	6.4	57.1
Insects	15.4	85.7	7.7	57.1
Molluscs	8.5	42.9	0.8	28.6
Cryptogams	Trace	14.3	3.4	28.6
Phanerogams	24.8	57.1	79.9	85.7
Vegetable debris	2.6	57.1	1.9	57.1

of these turtles. The high value for frogs in the "percentage by volume" column is due to the occurrence of the remains of two specimens in one stomach. The numerical relations of the food organisms and details of their identity are given in Table 48.

It is interesting to note the large numbers of hard-coated seeds of the white water lily (Castalia odorata) ingested. These mature seeds, 813 in number, make up most of the volume of the plant materials eaten. They appear no different in the colons than in the stomachs, and probably remain viable in passing through the turtle. This observation, confirming others previously cited, suggests that

TABLE 48. NUMBERS AND OCCURRENCE OF EACH ITEM IN THE FOOD OF EIGHT INTERGRADES BETWEEN BELL'S TURTLE AND WESTERN PAINTED TURTLES

Food Item	Stomachs (7)	Colons (7)	Totals
FROGS (Rana sp.)	2	..	2
CRUSTACEANS			
Cladocera	X*	..	X
Cambarus propinquus	..	1	1
Cambarus diogenes	1	..	1
Cambarus sp.	2	3	5
INSECTS			
Ephemerida nymph	1	..	1
Anax junius nymphs	..	2	2
Libellula sp. adult and nymph	2	..	2
Sympetrum sp. nymph	..	1	1
Anisoptera nymphs	3	..	3
Lestes sp. adult	1	..	1
Ischnura sp. adult	..	1	1
Zygoptera adult	1	..	1
Corixidae adults and nymphs	6	9	15
Belostomatidae adults	1	1	2
Naucoridae adult	..	1	1
Dytiscidae adults and nymph	8	1	9
Hydrophilidae adults	1	1	2
Coleoptera adult	1	..	1
Leptoceridae larvae	11	1	12
Trichoptera larvae	..	1	1
Sphingidae larva	1	..	1
Lepidoptera adults	2	..	2
Chironomidae larvae	..	287	287
Insecta	2	..	2
SNAILS AND CLAMS			
Helisoma trivolvis	1	..	1
Amnicola limosa	..	X	X
Gastropoda	7	X	X
Musculium truncatum	X	..	X
CRYPTOGAMS			
Scenedesmus quadricauda	..	X	X
Mougeotia sp.	..	X	X
Spirogyra sp.	..	X	X
Hyalotheca dissiliens	..	X	X
Filamentous algae	..	X	X
Moss	X	X	X
PHANEROGAMS			
Potamogeton sp.	X	..	X
Sagittaria sp.	..	X	X
Nymphaea advena	X	X	X
VEGETABLE DEBRIS	X	X	X

* The letter "X" is used to denote the occurrence of food items for which counts of the numbers of individuals eaten could not be made.

these animals may be of ecological significance in the dispersal of water lilies.

On the basis of the limited material studied, it appears that intergrades between Bell's turtle and the western painted turtle seem to compete with fish for food, rather than to prey upon them.

Chrysemys picta marginata (Agassiz)

Western Painted Turtle

Description

Like the other forms of the genus the western painted turtle is characterized by red markings on the carapace and in Michigan it is limited to the Lower Peninsula, as it is represented in the Upper Peninsula by intergrades with *C. p. bellii*, as noted above. Details of description and diagnostic characters for the western painted turtle have been given by Bishop and Schmidt (1931). The sexes may be separated by the markedly longer fore-claws and greater pre-anal length of the tail in males.

Range

The range of *C. p. marginata* has been stated by Bishop and Schmidt (1931: 137) as extending "... from eastern New York through western New York and western Pennsylvania, Ohio, Indiana, and the lower peninsula of Michigan and southeastern Illinois..." In the Lower Peninsula it doubtless occurs in all counties (Ruthven, Thompson, and Gaige, 1928) (Map 5).

Habitat and Habits

The western painted turtle is the most common turtle on the Lower Peninsula of Michigan. Notwithstanding the frequency with which the turtle is encountered, very little has been written regarding its habits. In contrast, the life-history and habits of

Chrysemys p. picta have been rather thoroughly described by several investigators in the eastern states. The deficiency of information on *C. p. marginata* may be due to an assumption on the part of most workers that turtles of the genus *Chrysemys* are essentially alike in their life-ways, and to the poor understanding of the systematics of the subspecies. Cahn's statement (1937: 143) doubtless reflects the views of many other workers and accounts somewhat for the paucity of literature strictly pertinent either to *C. p. marginata* or to *C. p. bellii*: "Its [*C. p. bellii*] habits are so similar in detail to those reported for ... [*C. p. marginata*] that it would be largely repetition to print them here ..." The close similarity of food habits of *C. p. picta*, *C. p. bellii*, *C. p. marginata* and intergrades may be seen by comparing the data which I present with those of Surface (1908) for *C. p. picta* (including intergrades with *picta marginata*), and with those of Pearse, Lepovsky, and Hintze (1925) for a series of intergrades between *bellii* and *marginata*.

In Table 49 is given a selection of published materials on the habitats frequented by the western painted turtle. A striking agreement is apparent among these observations and those for the intergrades between *marginata* and *bellii* (Table 48). Similar habitats have been indicated for *C. p. picta* (including *picta* X *marginata* intergrades) by the following authors: Abbott (1884), Allen (1899), Babcock (1919), Ditmars (1905), Fowler (1906), Henshaw (1904), Howe (1904), Jones (1865), Ricketson (1911), and Storer (1839).

TABLE 49. HABITAT OF THE WESTERN PAINTED TURTLE IN MICHIGAN AND OTHER PARTS OF ITS RANGE AS GIVEN IN SEVERAL PUBLISHED ACCOUNTS

Author	Date	Locality	Habitat
Conger, A. C.	1920	Michigan Range in Michigan	Along streams and in lakes and ponds
Ellis, M. M.	1917	Vicinity Douglas Lake, Cheboygan County	Lily ponds, oxbows of Maple River, beach pools
Hankinson, T. L.	1908	Oakland County	Walnut Lake
Potter, D.	1920	Barry County	Wall Lake
Ruthven, A. G.	1911	Vicinity South Shore Saginaw Bay	Lake, bay, river
Ruthven, A. G., C. Thompson, and H. Thompson	1912	Range in Michigan	Along streams or about borders of ponds and lakes
Thompson, C.	1911	Cass County	Lakes, on land
Thompson, C.	1915a	Manistee County	Bayous, streams, lakes, and plains
Thompson, C.	1915b	Monroe County	River Raisin
Atkinson, D. A.	1901	Alleghany County, Pennsylvania	Ponds, deep water in creeks
Brown, J. R.	1928	Vicinity Hamilton, Ontario	Pond, same places as _Chelydra serpentina_
Cahn, A. R.	1937	Illinois	Smaller lakes, ditches, temporary ponds, and sluggish waters preferring shallow, soft-bottomed, weedy bodies of water
Conant, R.	1938	Ohio	Wet meadows, woodland pools, bogs, marshes, brooks, ditches, ponds, lakes, etc.

TABLE 49 (CONTINUED)

Author	Date	Locality	Habitat
Evermann, B. W. and H. W. Clark	1920	Indiana	Lakes, ponds, and streams
Hahn, W. L.	1908	Indiana	Ponds
Hay, O. P.	1892	Indiana	Ponds, pools, sluggish parts of streams
McAtee, W. L.	1907	Indiana	Larger creeks
Newman, H. H.	1906	Lake Maxinkuckee, Indiana	Stagnant lagoons and quiet bays

Judging from the data in Table 49, it would seem that what Conant (1938: 148) wrote for the western painted turtle in Ohio also obtains for this turtle in Michigan as well as in other parts of its range: "Painted turtles are to be found in almost any locality in which there is sufficient permanent water to hide them and to supply them with food." In Michigan I have collected the turtle from all environments listed by Conant (1938) for Ohio as given in Table 49 and in addition from a variety of stream habitats. One of the largest catches of this species which I made in an overnight trap set was forty, which were taken in a bayou of the Muskegon River about seven miles east of Muskegon. The species is very common in the quieter waters of most larger rivers in the state. Specimens have been seen sunning themselves on objects just out of the water on the Huron, St. Joseph, Kalamazoo, Grand, Clinton, and Saginaw Rivers. Individuals have been met with in quiet portions of the Black River, a trout stream in

Montmorency County. They are often taken at trout rearing stations on such trout streams as the White River (Newaygo County), Platte River (Benzie County), and Silver Creek (Iosco County). Artificial ponds, used for pond-fish propagation, such as those of the Wolf Lake and Drayton Plains State Fish Hatcheries, are also frequented by western painted turtles. In all these waters they are most common per unit area where a soft bottom supports a luxuriant, though not over-abundant, aquatic vegetation.

Western painted turtles in Michigan have been collected by me from environments where they are associated with musk, snapping, Blanding's, map, and soft-shelled turtles. In lakes the most common associates of the painted turtles appear to be the snapping and Blanding's turtles, and the musk turtle within the limits of its range. In the larger rivers of the southern part of the Lower Peninsula, its habitat seems to be shared for the most part with the map turtle.

Food and Feeding Habits

In so far as I have observed, the western painted turtle is entirely aquatic in its feeding activities although several investigators claim that the species exhibits certain terrestrial tendencies. Specimens in the wild are active feeders and during summer months have been observed foraging on the bottom in shallow water at night and in the early morning and evening hours. At mid-day they were usually basking.

Morse (1904: 140) made the statement that "Its food consists of mollusks, worms, insects and is indeed omnivorous in its habits."

Newman (1906: 144-145), who studied the actual feeding behavior of this species, reported: "They tear their food to pieces with jaws and the long, sharp claws of the fore-feet and occasionally engage in an exciting tug-of-war over the possession of food. In seizing their food, the head darts out rather speedily but the movement could scarcely be termed 'snapping'." Regarding the food this author wrote: "Chrysemys [picta marginata] is not restricted in its diet, but makes use of any sort of animal food that comes its way. I have observed individuals feeding on dead fish, dead clams, decaying tortoises, worms, meat, and aquatic insects. They even capture the soft and defenseless young of Aspidonectes [Amyda]."

Hankinson (1908: 236-237) reported that the stomach of a specimen collected on July 2 in Walnut Lake, Oakland County, Michigan, "was found distended with the leaves of some small-leaved pond-weed, probably Potomogeton pusillus L. or P. foliosus Raf. C. A. Davis, who identified the leaves, says regarding them, 'It seems as if they had been scooped up from a mass of drift material, such as sometimes accumulates in shallows, rather than bitten off by the animal.' With this material were found water milfoil buds, bunches of filamentous algae, and fruits of the slender Naias."

Surface (1908: 156) apparently did not study the food of any specimens of C. p. marginata but wrote: "... we have little doubt that the food of these turtles is practically the same as that of the closely related Painted Turtle [C. p. picta]."

Conger (1920: 46) stated that the species "... feeds on invertebrates, fish, amphibians and carrion."

Cahn (1937: 137-138) wrote that "these stomachs [of ten specimens collected in southeastern Illinois] showed the remains of aquatic larvae such as Chironomous and other dipterous forms, nymphs of dragonflies, mayflies and stoneflies, aquatic beetles, gastropods, finger-nail shells, small crayfish, tadpoles, ants, flies, and honey bees; only one small, unidentifiable minnow was found. Vegetable matter predominated, being in the form of chewed-up masses of aquatic plants, algae, rootlets, leaves, stems, and grass. Three specimens showed evidence of the scavenger habit; there is no question of the fact that if dead matter is available, this turtle shows well developed scavenger instincts."

Conant (1938: 150) stated: "Painted turtles [C. p. marginata] are omnivorous. They will eat crayfish, earthworms, snails, insects and their larvae, fish, carrion -- including dead birds, mice and turtles -- and a variety of aquatic plants. In captivity they exhibit a fondness for meat and for almost all green vegetables. In all the numerous observations made upon them both in the field and in captivity they swallowed their food under, or at the surface of the water."

Baker (1916: 233) studied the food of fifteen painted turtles from Oneida Lake, New York. These specimens have been examined by S. C. Bishop and by Norman Hartweg, who have assured me that they are C. p. marginata. Baker found the food for three size groups to be as follows:

"Group 1. Infancy, 25 mill. long. 1 specimen examined.

Hirudinea	20 per cent.
Insecta	80 per cent.

"Group 2. Youth, 40-63 mill. long. 8 specimens examined.

Crustacea	65 per cent.
Insecta	27 per cent.
Nematoda	2 per cent.
Mollusca	2 per cent.
Plants	4 per cent.

"Group 3. Adult, 112-154 mill. long. 6 specimens examined.
Insecta . . . . 99 per cent.
Mollusca . . . . 1 per cent.

"The change from crustacean to insect food in groups 2 and 3 is noteworthy. Group 1 is not conclusive as only one specimen was examine."

My food studies of the western painted turtle are based on 413 specimens from various localities, as indicated in Table 50. Since the number of turtles was so large the contents of the stomachs only were analyzed. The total volume of food examined was 423.1 cc.

The 413 western painted turtles studied for food were obtained from fifty-five lakes or ponds, seven non-trout and four trout streams, and five fish cultural establishments (Table 50). These localities are well-spread over the Lower Peninsula (Map 5). The material is doubtless adequate to indicate the food of this turtle, but information on certain special phases of its relation to game fish populations, such as that of predation on eggs and fry, is however, still lacking.

In the following analyses of the food habits, the specimens from Whitmore, Wintergreen, First, Fremont, and East Twin lakes are treated separately for each lake (Tables 51 through 55). This treatment facilitates comparison of the food of this species with that of other turtles which were collected from the same lakes. Individuals from the remaining lakes and ponds have been combined into two groups: (1) those from miscellaneous lakes (Table 57) and (2) those from river-mouth lakes (Table 56). Additional groups are those from: (1) non-trout streams (Table 58),

TABLE 50. LOCATIONS AND NUMBER OF WESTERN PAINTED TURTLES WHICH CONTAINED FOOD FROM EACH

Location: Body of Water	Location: County	Number of Individuals	Date of Collection
Whitmore Lake	Washtenaw	16	IX:23:37; X:6:37; V:1-2:38
Wintergreen Lake	Kalamazoo	21	VII:3-23:37; VII:5-20:38
First Lake	Montcalm	27	VIII:23-24:38
Fremont Lake	Newaygo	77	VIII:26-28:38
East Twin Lake	Newaygo	14	V:19-20:37; VII:12-13:38
RIVER-MOUTH LAKES		32	
Muskegon Lake	Muskegon	14	IX:1-2:37; VIII:17-20:38
White Lake	Muskegon	18	VIII:19-20:38
MISCELLANEOUS LAKES		152	
Clear Lake	Alcona	2	VII:19:37
Jewel Lake	Alcona	4	VII:20-21:37
Long Lake	Alcona	1	VII:22:37
Obrian Lake	Alcona	2	VII:18:37
McDonald Lake	Barry	1	VIII:7:36
Middle Grand Marais Lake	Berrien	16	V:3:37; IX:12-13:37
Brace Lake	Calhoun	1	IX:16-17:37
Forked Lake	Cass	7	IX:13-14:37
Mitchell Lake	Charlevoix	1	V:31:37
Adams Lake	Charlevoix	1	VI:11:37

Silver Lake	Cheboygan	5	VII:4:31; VI:3:37
Ferguson Lake	Clare	9	VIII:3-6:38
Clear Lake	Jackson	1	V:1:37
Little Portage Lake	Jackson	2	IX:11-12:37
Strickland Lake	Jackson	1	VIII:28-29:37
Waterloo Mill Pond	Jackson	2	VIII:18-19:37
Bonnie Castle Lake	Kalamazoo	1	IX:7-8:37
Robinson Lake	Kalamazoo	15	VIII:30:38
Spring Lake	Kalamazoo	4	VIII:11-12:38
Indian Lake	Kent	1	VII:21:37
Mill Lake	Lake	1	VI:18:31
Railroad Lake	Lake	5	VII:22:31
Pere Marquette Pond	Mason	1	VII:21:31
Diamon Lake	Mecosta	1	VIII:6-7:38
Bush Lake	Montmorency	1	VII:4:31
Wildflower Lake	Montmorency	1	VI:4-5:37
Kimball Lake	Newaygo	18	IX:2-3:37
Island Lake	Oakland	1	VII:24-28:37
Softwater Lake	Oakland	1	VII:29:37
Waterford Pond	Oakland	1	VII:31:37
Hewey Lake	Ogemaw	2	VI:20-21:37
Mills Lake	Ogemaw	7	VI:20-24:37
Nester Lake	Ogemaw	1	VI:23:37
Sheriden Lake	Osceola	2	VIII:3-4:38
Sturgeon Lake	St. Joseph	1	V:2:37

Great Bear Lake	Van Buren	1	IX:10-11:37
Saddle Lake	Van Buren	2	VIII:19,23:37
Schoolsection Lake	Van Buren	2	IX:9-10:37
Wolf Lake	Van Buren	5	VII:9:37; VIII:30-31:37; VII:20:38
Cassidy Lake	Washtenaw	1	VIII:4-5:37
Crooked Lake	Washtenaw	1	VIII:10-11:37
Dexter Mill Pond	Washtenaw	2	VIII:24-25:37
Horseshoe Lake	Washtenaw	1	VI:21:38
Loveland Lake	Washtenaw	4	IX:8-9:37
Mud Lake	Washtenaw	3	VIII:19-20:37
Silver Lake	Washtenaw	7	VI:12-14:37; VIII:26-27:37
Welsh Lake	Washtenaw	1	VIII:14-15:37
Meauwataka Lake	Wexford	1	VII:8:37
NON-TROUT STREAMS		50	
Battle Creek River	Calhoun	1	Date?
Kalamazoo River	Kalamazoo	3	VIII:13:37
Ore Creek	Livingston	3	VIII:2:38
Muskegon River	Muskegon	33	VIII:31-IX:1:37
Clinton River	Oakland	3	VII:8:37
Huron River	Oakland and Washtenaw	5	VI:17:38; VII:7:38; VIII:2:38
Shiawassee River	Oakland	2	VII:19-20:37; IX:21:37

TROUT STREAMS		5	
Baldwin Creek	Lake	1	VII:23:31
Little Manistee River	Lake	1	VI:25:31
Pere Marquette River	Lake and Mason	2	VII:4:31; VII:14:31
Hunt Creek	Montmorency	1	Date?
FISH HATCHERIES		19	
Drayton Plains	Oakland	4	VII:28:31; VII:19-21:37
Sunset Water Gardens	Oakland	10	IX:26:37
Pentwater	Oceana	1	Date?
Wolf Lake	Van Buren	3	V:30:36; V:29:37; VI:25:37
Northville	Wayne	1	VII:14:32

(2) trout streams (Table 59), and (3) fish cultural stations (Table 60). These groupings have been made, as for the other species studied, on the basis of the separate ecological units represented. In Tables 61 and 67 data are given for a comparison of the food of this turtle with that of other aquatic species studied. In Table 62 are presented details of the numbers and kinds of food eaten.

Whitmore Lake. Some of the outstanding physical and biological features of Whitmore Lake have been given in the discussion of the food of the series of musk turtles studied from this body of water. Of the sixteen specimens (Table 50) containing food, the thirteen which were measured averaged 121 mm. (4.8 inches) and ranged from 102 to 143 mm. in length. A summary of the food of the series from this lake is given in Table 51.

TABLE 51. THE FOOD OF THE WESTERN PAINTED TURTLE
IN WHITMORE LAKE

Based on sixteen stomachs containing 18.2 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Crayfish	Trace	6.3
Insects	5.5	37.5
Snails	1.1	12.5
Algae	12.6	68.5
Phanerogams	79.1	43.8
Vegetable debris	1.6	62.5

The principal foods of the western painted turtle in Whitmore lake are insects and aquatic vegetation. The insects taken in greatest numbers were larvae of hydroptilid caddis flies and midge larvae. A large moth, which probably fell upon the water, was also eaten. Filamentous algae and *Elodea canadensis* were the chief plant materials consumed. Although found in only six stomachs, the *Elodea* (14.4 cc.) was ingested in an amount about six times that of the algae (2.3 cc.), which was in ten of the stomachs.

Wintergreen Lake. A description of several physical and biological features of Wintergreen Lake has been given in the account of the food of the snapping turtles studied from this body of water. Twenty-one western painted turtles (Table 30)

TABLE 52. THE FOOD OF THE WESTERN PAINTED TURTLE IN WINTERGREEN LAKE

Based on twenty-one stomachs containing 43.5 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrency (%)
Game fish	2.4	4.8
Unidentified fish	Trace	4.8
Insects	21.1	100.0
Miscellaneous invertebrates*	0.2	19.0
Cryptogams	71.0	81.0
Phanerogams	4.4	38.1
Vegetable debris	0.9	33.3

* Includes the remains of a crayfish in one stomach and six water mites in three stomachs.

from this lake contained food. The ten specimens on which measurements were taken, from this series, ranged in carapace length from 94 to 142 mm., averaging 127 mm. (5.0 inches). A summary of the analyses of the stomach contents of the individuals in this series is given in Table 52. Details as to numbers and kinds of food organisms consumed are presented in Table 62.

The item for game fish shown in Table 52 is made up by a small large-mouthed bass taken by one turtle. This fish was apparently not carrion when eaten.

Insects and aquatic vegetation appear again as the most important food of this turtle. Of the insects, 1387 caddis fly larvae, 919 haliplid beetle larvae of the genus Peltodytes, and more than 190 mayfly nymphs were the most important. Filamentous algae comprised by far the dominant plant material ingested. In three stomachs there were forty-seven wheat grains doubtless derived from food scattered along the shores for waterfowl. Some of the grains were in a very much softened condition in the stomachs, indicating they were perhaps undergoing digestion.

First Lake. A description of the habitat and associates of turtles in First Lake has been given in the account of the food of snapping turtles from this lake. The twenty-seven specimens of the western painted turtle which contained food from this body of water were collected on August 23-24, 1938. The average size of these individuals is 126 mm. (5.0 inches)

TABLE 53. THE FOOD OF THE WESTERN PAINTED TURTLE

IN FIRST LAKE

Based on twenty-seven stomachs containing 23.2 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Unidentified fish	0.7	3.7
Insects	32.4	77.8
Miscellaneous invertebrates*	2.5	29.6
Algae	48.4	70.4
Phanerogams	13.2	29.6
Vegetable debris	2.8	51.9

ranging from 98 to 148 mm. A summary of the food found in the stomachs of the turtles from this lake is given in Table 53. Numbers and more specific identity of food items are given in Table 62.

Insects and aquatic vegetation appear yet again as the most important food of this turtle. The predominant insects are dragon-fly and damsel-fly nymphs and adults, caddis-fly larvae, and soldier-fly larvae. The Odonata taken as adults are mostly females, which were probably captured while they were laying eggs. Filamentous algae were the only cryptogams taken and composed more than three-fourths of the vegetable matter ingested.

Fifty-four seeds of the white water lily were found in one stomach.

Fremont Lake. This large body of water, reported to be 1 3/4 miles in greatest length and one mile in greatest width, has a maximum depth of 102 feet according to the survey made by the Institute for Fisheries Research in 1926. It has a few spring inlets* in addition to the main tributary, Tannery Creek. The outlet in Brooks Creek, of the Muskegon River system. Bottom types recorded for the lake are sand, mud, and marl, with sand as the chief type in the shoal areas. *Chara* sp. is the predominant plant in the open water along with some potamogetons. Marginal vegetation consists largely of spatterdock, pickerel weed, cat-tails and loosestrife. Bass, sunfish, perch, and pike are present as are several species of forage fish. Crayfish, molluscs, and aquatic insects and their larvae are common.

Commercial turtle trappers have reported excellent catches of snapping turtles from this lake in recent years. Only a few snappers were collected by me, but the largest series (108 individuals) of western painted turtles which I have from any one lake was obtained during two days and nights of trapping on the north and east shore of this lake, on a bottom of hard sand overlain in a few restricted areas by soft marl. Seventy-seven of the specimens contained food for analysis and averaged 121 mm. (4.8 inches) in length ranging from 88 to 153 mm. A summary of the food which they contained is given in Table 54. Additional details of numbers and kinds of food items eaten are given in Table 62.

TABLE 54. THE FOOD OF THE WESTERN PAINTED TURTLE

IN FREMONT LAKE

Based on seventy-seven stomachs containing 66.3 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrency (%)
Game fish	2.4	2.6
Forage fish	2.1	7.8
Unidentified fish	0.2	1.3
Carrion	1.8	1.3
Insects	7.4	41.6
Miscellaneous animals*	1.2	10.4
Cryptogams	22.5	58.4
Phanerogams	57.8	64.9
Vegetable debris	4.7	31.2

* Includes the remains of an oligochaete "earthworm" in one and two amphipods, a water mite, and a spider in one stomach each and the remains of a crayfish in each of two stomachs.

The game fish taken by these turtles were a small black crappie and a small yellow perch. Forage fish identified were bottom-dwelling darters. Adult beetles, terrestrial and aquatic, and soldier-fly and crane-fly larvae composed the most significant portion of the insects eaten. An adult mosquito in one stomach suggests a possible role of this turtle in the control of this insect pest (1570 mosquito pupae were found in one of the specimens from a fish hatchery pond). The leaves, growing portions, and seeds of potamogetons appeared to be about twice as important as food of the painted turtles in this lake as did filamentous algae. In four stomachs there were ninety-eight seeds of the white water lily.

The striking manner in which the food data on this large group of specimens corroborates those of the smaller series for other individual lakes indicates the adequacy of data in the smaller series on which to base conclusions.

East Twin Lake. A brief description of some of the physical and biological features of East Twin Lake has been given in the account of the snapping turtles studied from this body of water. The fourteen specimens which contained food for analysis from this lake were collected on the dates given in Table 50. The average size for eleven of these turtles for which measurements were obtained is 132 mm. (5.2 inches) ranging from 105 to 156 mm. Sixty-two additional individuals which were trapped in this lake during the summer

TABLE 55. THE FOOD OF THE WESTERN PAINTED TURTLE IN EAST TWIN LAKE

Based on fourteen stomachs containing 9.3 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume * (%)	Frequency of Occurrence (%)
Game fish	16.1	7.1
Water mites	Trace	7.1
Insects	28.0	64.3
Snails	9.7	42.9
Algae	39.8	71.4
Phanerogams	2.2	28.6
Vegetable debris	4.3	28.6

of 1938 were measured, marked for future recognition, and returned to the water as a part of the population density and growth rate investigations being conducted on turtles in this body of water. A summary of the analyses of the food in the stomachs of the series examined from this lake is given in Table 55. Additional details of the numbers and kinds of food items eaten are given in Table 62.

The unusually large percentage composition by volume shown for game fish in Table 55 is constituted by one young pumpkinseed and is therefore probably not a true index of the food

TABLE 58. THE FOOD OF THE WESTERN PAINTED TURTLE

IN RIVER-MOUTH LAKES

Based on thirty-two stomachs containing 33.7 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Oligochaete "earthworms"	1.2	15.6
Crustaceans	3.0	50.0
Insects	37.1	56.3
Snails	3.9	18.8
Algae	25.8	75.0
Phanerogams	24.3	68.8
Vegetable debris	4.7	18.8

relations. Insects found were almost entirely nymphs of Odonata and caddis-fly larvae. Aquatic vegetation, especially filamentous algae, is the most important component of the food of almost all of the individuals. Insects rank next in significance.

River-mouth lakes. The two river-mouth lakes from which I have obtained western painted turtles for food study are Muskegon and White lakes. The general nature of these waters was described in the discussion of the data on the food of sixteen snapping turtles from these lakes. The thirty-two painted turtles which contained food were collected on the same dates (Table 50) as those given for the snappers; fourteen were obtained from Muskegon Lake and eighteen from White Lake. The average length of these individuals is 124 mm. (4.9 inches) ranging from 32 to 154 mm. A summary of the findings on the food in the stomachs of this series of turtles is given in Table 56.

As for inland lakes, the food of the western painted turtle in these river-mouth lakes is dominated by insects and aquatic plants. The insects encountered in greatest volume, numbers, and frequency were larvae of hydroptilid caddis-flies and aquatic pyralids. The pyralid larvae averaged forty-three per stomach for each of ten turtles in which they were found. Most of them were in houses made of _Lemna trisulca_ which, in itself, is often taken as food by the painted turtle in this and other waters. Filamentous algae and _Elodea canadensis_ made up most of the aquatic vegetation found.

Miscellaneous lakes. As for the musk, snapping, and Blanding's turtles, specimens of the western painted turtle from several different lakes have been placed in a group named "miscellaneous lakes." The names of the forty-eight lakes in this group, the number of specimens from each, and the dates of collection are given in Table 50. These bodies of water are ecologically diverse, but the 152 turtles studied for food from them have been assembled to demonstrate the average nature of the food consumed by a wide-spread and random sample of the total population in the state.

The average length of 136 specimens in this series for which I have measurements is 122 mm. (4.8 inches) ranging

TABLE 57. THE FOOD OF THE WESTERN PAINTED TURTLE IN MISCELLANEOUS LAKES

Based on 152 stomachs containing 152.7 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Carrion	5.9	3.3
Water mites	Traces	2.0
Leeches and oligochaete "earthworms"	Traces	4.0
Crustaceans	8.3	13.2
Insects	15.1	54.6
Molluscs	11.7	19.7
Cryptogams	25.7	50.0
Phanerogams	27.9	41.4
Vegetable debris	5.4	42.8

from 49 to 185 mm. A summary of the analyses of the food in the stomachs of 152 individuals is given in Table 57. Additional details as to numbers and kinds of food organisms consumed are given in Table 62.

In the predominance of insects and aquatic vegetation the food of this large series resembles that of the specimens from lakes reported individually. Crustaceans, including amphipods, isopods, and crayfish, and molluscs assume a slightly greater role than heretofore.

TABLE 58. THE FOOD OF THE WESTERN PAINTED TURTLE

IN NON-TROUT STREAMS

Based on fifty stomachs containing 38.2 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Leeches	1.8	4.0
Crustaceans	11.5	28.0
Insects	9.9	46.0
Snails	3.9	16.0
Cryptogams	28.3	58.0
Phanerogams	43.2	54.0
Vegetable debris	1.3	20.0

Non-trout streams. The western painted turtles available for food study from non-trout streams were mostly obtained from the larger rivers in the southern part of the state (Table 50). Of the fifty specimens in this series, thirty-three were from Price's Bayou on the Muskegon River about seven miles upstream from Muskegon. As has been indicated, painted turtles are generally very common in the quiet-water portions of such streams and little difficulty was encountered in obtaining the sample for study.

The average size of forty-five of the specimens studied for food from these waters on which measurements were obtained is 123 mm. (4.8 inches) ranging from 63 to 159 mm. A compilation of the food found in the fifty specimens composing this series is given in Table 58. Additional details of the numbers and kinds of the food items eaten are given in Table 62.

The increase in the amount of crustaceans in these stomachs over those of previous series may be due to the greater numbers of these organisms commonly thought to exist in lotic than in lentic environments. Insects, mostly aquatic nymphs and larvae, retain a position of some importance. Both by volume and by frequency of occurrence, aquatic vegetation is again exhibited as the most important food.

Trout streams. Although only five western painted turtles were available for food-habits study from trout streams, the data on the food which they contained are presented as a separate category. Opportunity is thus provided for a comparison of kinds and amounts of items eaten by this turtle with those of the snapping and Blanding's turtles from waters of this ecological entity. Indications from the data in Table 59 on the food of five specimens seems to be that aquatic insects and their nymphs and larvae are the most important food of the turtle in this type of habitat.

Fish hatcheries. Nineteen specimens collected at fish hatcheries contained food (Table 60). Fifteen of those individuals for which measurements were obtained ranged from 105 to 153 mm., averaging 127 mm. (5.0 inches).

Ten of the turtles in this series were taken at the Sunset Water Gardens, from one of the fish rearing ponds while it was being drained. This pond was being used for the propagation

TABLE 59. THE FOOD OF THE WESTERN PAINTED TURTLE IN TROUT STREAMS

Based on five stomachs containing 16.5 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Frog	9.1	20.0
Crayfish	10.9	40.0
Insects	80.0	60.0
Snail	Trace	20.0
Algae	Trace	20.0
Phanerogams	Trace	20.0

of bait and forage minnows and goldfish. At the time, the turtles were concentrated with very many young fish near the outlet, in a small pool of water with a surface area less than one-tenth that of the bottom of the pond. The remaining nine specimens were from the bluegill and bass rearing waters at the Wolf Lake Hatchery, bluegill or forage fish rearing ponds at the Drayton Plains Hatchery, and a trout raceway at the Pentwater Rearing Station. In spite of the fact that all these rearing enclosures are shallow over their entire area and that they contain abnormally high concentrations of small fish, only one small blunt-nosed minnow represented the propagated species in one stomach.

TABLE 60. THE FOOD OF THE WESTERN PAINTED TURTLE

AT FISH HATCHERIES

Based on nineteen stomachs containing 29.1 cc. of food. More specific determinations of food items are given in Table 62.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Forage fish	1.4	10.5
Unidentified fish	0.3	5.3
Carrion	34.4	5.3
Insects	29.9	57.9
Miscellaneous invertebrates	11.0	21.1
Cryptogams	1.0	36.8
Phanerogams	21.3	31.6
Vegetable debris	0.7	31.6

The carrion, appearing as a food item of some importance in Table 60, was entirely composed of the remains of a large bluegill in the stomach of one individual, which was shot while feeding on the dead fish.

Insects taken included some forms, such as may-fly and dragon-fly nymphs and caddis-fly larvae, which are important as food for the fish being cultured in these waters. To counterbalance this possible liability as a competitor for food, the consumption of predacious beetles and 1570 mosquito pupae must be recognized as an asset.

Discussion, Summary, and Conclusions

In Table 61 is given a summary of the food contained in 394 stomachs of western painted turtles collected from wild or natural waters in Michigan. The data for Tables 51 through 59, on inland lakes and ponds, river-mouth lakes, and trout and non-trout streams, have been combined in the preparation of this summary account. For obvious reasons the material for fish hatcheries (Table 60) is not included here.

The data in Table 61 and in my previous food summaries for this species, as well as the observations of earlier investigators on the food of the western painted turtle, demonstrate conclusively that the species is omnivorous. Insects and other aquatic invertebrates, and aquatic plants, compose the bulk of the food of almost all of the individuals studied.

In Table 62 are given counts of the numbers of animals in the food of the turtles studied. These counts were made whenever practicable. The counts and detailed determinations were made to bring out the ecological inter-relations of predator and prey and to facilitate evaluation of the data from an economic point of view.

The data in Table 62 again demonstrate the omnivorous nature of the western painted turtle. Although the great importance of the many kinds of insects in the food is evidenced by the numbers in which they are consumed, the even greater importance of aquatic vegetation is somewhat submerged in this tabulation. It is interesting to note, for the plant materials, the considerable number of species involved. Additional species