

# THE HABITS OF CERTAIN TORTOISES.

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(Contributions from the Zoölogical Laboratory of the University of Michigan, No. 104.)

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## INTRODUCTORY REMARKS.

*Methods of Study.*—In order to understand an animal one must live with it, must spend long hours, quiet days, in thoughtful observation of it, as it pursues its daily round of occupations. This I have had an opportunity of doing, and I now feel that I have a really personal acquaintance with at least five species of tortoises. I believe that I am able to diagnose their dispositions and comparative intelligence—their character.

Not only is there a species character but a sex character and even an individual character. For example, males are, as a rule, more timid than females, and specimens of the same sex and age often show marked individual differences in disposition.

Studies of this sort should, I believe, precede experimental studies, for sometimes shyness or wariness might be mistaken for stupidity, and sullenness for sluggishness in reaction. As a rule the more highly organized and alert species of tortoises display, when in captivity, the greatest degree of sullenness and hence their actions in confinement very poorly represent their true character. The species, on the other hand, that are less highly organized are the species that act more nearly normally when in captivity; but these naturally stupid forms furnish the

less interesting psychologic data. Captivity inhibits normal activity in nearly all tortoises; consequently I abandoned at an early stage of my work the observation of specimens in confinement and devoted myself to long-continued, and at times tedious, observation of the various species as they live in their native environment.

*Description of the Environment of Species Studied.*—The work was done at Lake Maxinkuckee in northern Indiana. This lake is nearly circular and measures 2.7 miles at its greatest diameter. Its depth is on the average not great, at no point more than eighty-four feet. The shores are low and, as a rule, slope gradually. The bottom is for the most part muddy and rather soft except in regions that are covered with stones. The water supply of the lake is mainly artesian and is very rich in all the mineral salts necessary for animal and plant life. The lake bottom is almost everywhere covered with a dense forest-like growth of vegetation, that affords a retreat for mollusca, crustacea and fish of all sorts, and a hunting and browsing ground for the various species of tortoises. On the northeastern shore of the lake there are several artificial lagoons that are freely connected with the main body of water. These lagoons furnish unusual facilities for observation as the water is always quiet.

*List of Species Studied and their Relative Abundance.*—When I first visited Lake Maxinkuckee in the fall of 1900, I was immediately struck by the abundance and the variety of species of tortoises there, but not until nearly two years afterward did I begin a systematic study of their habits.

The species that occur in the lake are as follows:<sup>1</sup>

1. *Aspidonectes spinifer.*
2. *Chelydra serpentina.*
3. *Aromochelys odorata.*
4. *Graptemys geographica.*
5. *Chrysemys marginata.*
6. *Nannemys guttata.*
7. *Terrapene carolina.*

The most characteristic and abundant species is *Graptemys geographica*, outnumbering many times any other species found in the lake. The other species occur in abundance in the follow-

<sup>1</sup>The nomenclature and order is that found in JORDAN's Manual of the Vertebrates.

ing order: *Chrysemys marginata*, *Aspionectes spinifer*, *Chelydra serpentina*, *Aromochelys odorata*, *Nannemys guttata*, and *Terrapene carolina*. The first five species were sufficiently abundant for purposes of habit study and it is with these only that I deal in this paper. The first on the list, *Aspionectes spinifer*, was found to be the most interesting and instructive, and its habits are here described as fully as observations permit. The other species studied will be dealt with more briefly, attention being directed chiefly to the differences in behavior displayed by the various forms. In brief, the treatment will be comparative.

#### CLASSIFIED ACTIVITIES.

##### 1. *Aspionectes spinifer* (the Common Soft-Shelled Tortoise of our Lakes and Rivers).

This species is, in many respects, the most highly organized and specialized of our tortoises. In point of intelligence, alertness, swiftness on land and in the water, and in general capability it ranks first of the species studied. A classified account of the activities of this species will serve to lead up to a general conception of its disposition and character.

*Seasonal Activities.*—These tortoises are first seen early in April and seem to be in a very weak condition after their winter's dormancy. I have frequently picked them up from the sandy beaches where they lay with head, neck and legs extended to the full, apparently stupified by their first exposure to the sun's warmth. At these times it is an easy matter to walk up and capture them, for when seized they make only a feeble effort to escape. A coating of mud on limbs and carapace is circumstantial evidence that they have wintered in the mud on the lake bottom. It is possible that only much weakened specimens find it necessary to crawl out on shore for a preliminary warming up. After the first few warm days in April they are no longer to be seen basking on the sand, but seem to devote themselves to very active feeding. Mating must take place during April or May but I have not had an opportunity to observe it.

*Aspionectes* nests rather later than the other species, as a rule not earlier than the middle of June. Nesting continues until the middle of July, and in rare cases considerably later.

As the water becomes colder in late fall they are less often seen

swimming about on the surface, but spend much of their time resting half-buried in the mud. I had an excellent opportunity of observing this preparation for the winter in the case of two large females that were confined within a lattice enclosure in a lagoon. They buried themselves in a peculiar way—by rocking the body from side to side and throwing the mud up in such a way that it settled on the carapace and covered them quickly from sight. By continuing this movement they sunk deeper and deeper, leaving only the snout protruding from the mud.

A few days later the water of the lagoon froze over and I could still see the snouts of the tortoises, but when the ice extended to the very bottom they must have withdrawn deeper into the mud. It was a matter of some surprise to find both of these animals alive when the ice thawed out. After a day or two, however, they died and examination showed that they had suffered from frost. This, then, could not be considered as a normal case, as under natural conditions the animals would be able to bury themselves below the frost line. The observation shows, however, that they are capable of living through the winter without the use of air or water for respiration.

*Resting and Basking.*—Under ordinary conditions *Aspionectes* basks in the open air less frequently than do other species. Occasionally I have seen isolated specimens basking in company with a number of *Graptemys* on floating objects at a safe distance from shore. On my approach they have invariably been the first to slide off into the water.

This quickness to escape is facilitated by a characteristic habit of turning around so as to face the water, whenever they climb out upon a floating object or upon the shore. Thus no time is lost in turning around when danger approaches. The same trait I have observed in other parts of the country—notably in the rivers of northern Illinois. Here the animals basking on the somewhat precipitous river banks had their heads down so that they could swim away without loss of time or equilibrium.

Their favorite method of warming up—a process that seems to be a physiologic necessity for reptiles in general—is to lie in very shallow water. When seen under these conditions they are always rather thinly coated with mud which they throw up by the use of the rocking or careening movement previously described. Sometimes the snout is protruded above the surface of the water

but more often the head is withdrawn into the carapace and only occasionally extended to the surface.

This method of warming up is practicable only in regions where the banks slope gradually and afford shallow water. Where the banks are steep and no shallows are available they come out upon logs, and even upon the shores and bask in the regular chelonian fashion, but they are extremely alert and cannot be taken unawares while out of the water.

*Methods of Locomotion.*—Aspidonectes is exceptionally swift, whether on land or in the water. It is almost impossible to overtake them in boat or canoe, while other species are easily captured in this way. When pursued, they immediately head for deep water, swimming with powerful and rapid strokes.

On land they move in a manner that belies their name "tortoise." I have seen them scramble down a bank and into the water faster than I could follow, while on a level piece of road they can move nearly as fast for a short distance. Although essentially aquatic they climb steep railway embankments with considerable ease, in order to reach a sand pit some fifty yards from the water.

*Methods of Self-Defense.*—Although their ability to elude pursuit furnishes them with a most efficient method of defense, they are not limited to this alone. Their bite is vicious in the extreme. When captured they hiss violently and thrust out the head, snapping vigorously with a sudden precise darting movement. Their aim is accurate and if the objective point is within reach they seldom miss. One learns to grasp them by the tail, as this is about the only part of their body that is beyond the reach of their fierce jaws.

Unlike other species they keep the eyes uppermost when snapping at objects back of them. They refuse also to retire into the carapace when captured, but continue to struggle violently for some time. After an exhausting struggle, however, they seem to become discouraged and lie quietly as long as they are watched. If confined in a room they never wander around, but remain in some dark corner, watching one's actions with an alertness quite characteristic.

When first captured there exudes from the inguinal glands a thick yellow semi-fluid excretion resembling in appearance the yolk of an egg. This substance has no perceptible odor, but is

undoubtedly homologous with the emission of the inguinal glands of the musk and snapping tortoises, that has such a nauseating odor. Of course it is problematical that even this malodorous excretion serves a protective function, but it at least tends to disgust a captor.

*Feeding Habits.*—*Aspionectes* is voracious and carnivorous, feeding principally upon crayfish and the larvæ of large insects. From the vantage ground of a high bank it was possible on still days to observe individuals as they captured their prey. They crawl or swim along the bottom, thrusting their snouts under stones and into masses of aquatic vegetation, occasionally snapping up a crayfish or larva that they have succeeded in dislodging. They do not tear up their food, but swallow it whole, using the fore-feet to assist in forcing it down.

The stomachs of three specimens, opened during the latter part of June, contained the following:

1. A large female contained nine medium-sized crayfish, only slightly digested.
2. A medium-sized female contained four crayfish and twenty-two dragon-fly larvæ.
3. A large male contained nine dragon-fly larvæ and a few plant buds, probably taken by accident when snapping up the larvæ.

The professional fishermen of Lake Maxinkuckee claim that where "soft-shells" are seen swimming about, large-mouth black bass are not far away. The reason for this became apparent as I watched a group of *Aspionectes* feeding. Two large specimens were seen prowling about in a somewhat random fashion, while three large bass accompanied them. Occasionally a fish darted after some object near the tortoises, and once I saw both fish and tortoise aim at the same object. Although I could not distinguish the objects of their search I concluded that the bass were accompanying the tortoises in order to profit by the fact that the latter dislodged many animals that they were unable to capture. The stomach contents of both fish and tortoises are identical and this is further evidence of the reality of their habitual association.

Professor JACOB REIGHARD has noticed minnows of various sorts following soft-shelled tortoises and picking up food, and suggests that the bass might be feeding upon them rather than

upon crayfish. The matter might be settled definitely by the examination of a large number of stomachs.

*Breeding Habits.*—*Aspidonectes* begins to lay as early as June 10, somewhat later than other species. The females are very wary in their choice of times and places for laying. At one place near the lake shore men are accustomed to harvest hay early in July or late in June. The shore near the hay fields is sandy and sloping and affords an ideal nesting ground for "soft-shells." They will not approach the shore, however, until the men leave for the noon-day meal. Then they crawl out cautiously, dig their nests and deposit their eggs before the return of the harvesters.

They also frequent a sandy road that runs for nearly a mile along the water's edge. A new road has been made farther back from the shore, leaving the "old road" almost without traffic. This abandoned road affords a sequestered retreat for the female "soft-shells," and they nest there in large numbers. So many use this place for nesting that regular run-ways are worn through the tall grass that occupies the strip of land between the road and the shore. One can sometimes detect the presence of tortoises by the waving of the grass and this is often a useful signal for the observer to seek concealment and watch developments.

One soon learns to expect the females to seek a nesting place during the warmest part of the day, as they seem to avoid leaving the water in the cool of the morning or evening.

The female "soft-shells" come to the surface many yards from shore and seem carefully to reconnoiter before coming ashore. They then swim shoreward beneath the surface, coming up at intervals to see if the coast is clear. On reaching the shore they crawl out upon the sand and, before proceeding further, they extend the head to its full height and remain motionless for some time, the very embodiment of alertness. At this time the slightest movement or sound of a suspicious character alarms them and they dash back into the water. If undisturbed, however, they proceed slowly and cautiously to the nesting ground and begin operations without delay, working more rapidly than other species.

The following was jotted down in my field note book as I watched one specimen nesting:

June 22, 1903, 11.10 A. M.—A warm sun-shiny day. Place: the "old road" about ten feet from the water's edge and concealed from view on one side by tall grass. A large female *Aspidonectes* has just emerged from the grass and is commencing to make a nest. No time is lost in selecting a spot.

She scratches out footholds for the fore-feet and begins to excavate with the hind-feet, using right and left feet alternately with a circular gouging movement. At intervals she pushes aside the accumulated earth with the hind-feet. As the hole becomes deeper it is necessary for her to raise the anterior part of the body to its full height in order to give a more nearly perpendicular thrust with the hind-feet.

In less than forty minutes the nest is completed and she has commenced to lay her eggs, letting the tail down into the narrow hole as far as possible. After depositing several eggs she arranges them with the hind-feet and then rakes in some earth previously wet up with water from the accessory bladders. The earth is gently packed in before any more eggs are laid. The remainder of the eggs are deposited and the hole is filled up with earth and tramped down quite firmly with the knuckles of the hind-feet, right and left feet being used alternately. This treading movement continues for some minutes and seems to be quite thorough. Although not in any way disturbed, the tortoise left without attempting to cover up the traces of scratching feet, and anyone who is familiar with the appearance of a tortoise nest would have no difficulty in detecting this one. At 12.25 she turned and started for the water but was captured with a landing net. The nest was examined and found to be flask-shaped with a narrow neck only an inch and a half in diameter. The depth of the nest was a trifle over six inches and the diameter at the bottom about three inches.

The nest contained eighteen rather large spherical eggs of a delicate pink color and with a very thin brittle shell.

The above account is typical and differs only in minor details from the other cases observed.

Considering their high order of intelligence, they show little or no judgment in the selection of nesting places. The character of the soil seems to be immaterial so long as it is near the water's edge. Nests were found in clay so hard packed that one could scarcely break it with the fingers. One nest was made in a rock pile, the eggs being dropped into crevices between rocks, and sand packed around them. Several nests were made among the smaller roots of a tree growing on the sandy beach, the eggs being deposited between and under the roots in a very irregular fashion. The majority of nests, however, were found in soft beach sand not over six feet from the water.

AGASSIZ says that tortoises while laying or making their nests cannot be frightened away. This statement does not seem to apply to *Aspidonectes*. Whether or not they leave their task seems to depend somewhat upon the degree of completion of the nest. My observations lead me to believe that they will leave on the first sign of danger if surprised before the actual laying process begins, but will wait to cover up the eggs more or less completely if surprised after laying or during the process.

The suddenness of their dash for the water seems to depend on whether or not they feel that they have been exposed to view. I have frequently passed within a few feet of tortoises that lay



hidden in the grass without causing them to take alarm. Had these been in the open they would almost certainly have hastened to make their escape. On one occasion as I was returning after walking to the southern end of the "old road" in search of nesting tortoises I caught sight of a huge female almost hidden in the grass. As soon as she caught my eye she made a dash for the water and escaped. From the fact that she had almost completed her nest I knew that she must have been in the same place when I passed a few minutes before, but was aware that she had escaped detection.

On another occasion I discovered a large female lying very flat on a narrow shelf-like ledge of railway embankment. She evidently saw me immediately as she stretched up her head in the usual alert fashion. For a few moments she remained perfectly still eyeing me closely, and, as I made no hostile move, she continued her work, which proved to be the filling in of a nest. After the completion of this task she remained motionless for some time. Then, as I turned my head slightly to look at an approaching boat, she turned quickly and scrambled down the embankment and into the lake before I could overtake her.

That females may abandon their nests even when engaged in laying is shown by the fact that on one occasion I found a nest of large size containing only seven large eggs that were not covered up. From the fact that the nest was within a few feet of the railway track, I concluded that the tortoise had been unable to control its fright at the sight of a rapidly approaching train and had beaten a hasty and ignominious retreat.

A discussion of breeding habits would not be complete without some account of the character and number of eggs laid, about which there has been a considerable diversity of statement. Some observers claim that as many as sixty, others as many as forty, are laid by one female at one time. This I believe to be an error due to two incorrect observations. One source of error is the counting of ovarian eggs not in the oviducts. It is well known that these are destined for the following two or three seasons. Only the eggs actually in the oviducts are destined for the current season. The other source of error arises from considering all the eggs in one nest as the deposit of one female. Frequently in small sandy areas such large numbers of tortoises lay their eggs that nests are in contact or overlap. I have found as many as forty eggs together

but have been able to distinguish the eggs of one nest from those of another by the size, shape and stage of development of the different sets.

By counting the eggs in many isolated nests and in the oviducts of many females caught before nesting or while excavating their nests, I have been able to determine that the number of eggs laid at one time varies from nine to about twenty-four, averaging about eighteen.

On one occasion I found on the "old road" a nest containing nine small ellipsoidal eggs and contiguous with these twenty-three large spherical eggs of much fresher color and evidently more recently laid. This nest was unquestionably a double one made by a very large specimen over or overlapping that of a very small specimen. It is interesting to note that the youngest females lay the fewest and smallest eggs, and that such eggs have a tendency to be ellipsoidal in shape. Another interesting fact is that the eggs are so delicately oriented that they fail to develop if turned over after they are laid.

*Behavior in Captivity.*—Extreme sullenness characterizes the behavior of *Aspidonectes* while in confinement. If kept in a room they hide behind the furniture and remain motionless for hours and almost days. When put in aquatic enclosures they immediately bury themselves in the mud and seem to remain there for months. Nothing will induce them to eat or to take any interest in their surroundings. If caught while making their nest, they are sometimes forced to lay the eggs, but never make a nest in confinement. The eggs are simply dropped about on land or in the water and are usually crushed when found. None of their normal characteristics are in evidence and it would be a waste of time to attempt to draw conclusions about their disposition or intelligence from their actions in captivity.

*Behavior of the Young.*—In many respects the behavior of young and half-grown specimens shows marked differences from that of the adults. They are not likely to display when captured the fierce and sullen traits so characteristic of adults. On two occasions I succeeded in taming specimens four or five inches in carapace length so that they would allow their heads to be scratched without snapping. They will also lie quietly in the hand, apparently enjoying its warmth.

On several occasions I found recently hatched young lying in

water an inch or less in depth and partially covered with sand or mud. Their protective coloration was so perfect that only the keenest scrutiny could detect their presence. This protective measure is quite a necessary one, as a young *Aspidonectes* would furnish a tender morsel for fish or other tortoises, if it were at all conspicuous. This I found to my dismay when I tried to keep several young *Aspidonectes* in an aquarium with adult *Armo-chelys* and *Chrysemys*.

*Summary.*—The following brief diagnosis of the character or disposition of *Aspidonectes* may now be attempted:

The adults are characterized by remarkable swiftness, alertness, wariness and fearlessness when in natural conditions.

In captivity they are sullen in the extreme and show marked depression of spirit.

The young acquire gradually the characteristics of the adult.

## 2. *Graptemys geographica* (the Map Tortoise).

Of the three species of the family Emydidæ, that occur in Lake Maxinkuckee, *Graptemys geographica* is the most markedly aquatic, never wandering about on land except during the nesting season. Owing to the abundance of this species and its easily observed activities it seems best to introduce a study of its habits in this place instead of following the order of systematic affinities.

*Seasonal Activities.*—*Graptemys* appears earlier in the season than any of the other species studied, a few specimens coming to view as early as the tenth of April. They are first seen basking on the banks of the lagoons, where the water warms up many days earlier than in the open lake. On first emerging from the water they are so thickly coated with mud that they are apt to be mistaken for stones.

At this time they are less wary than usual and may be captured with a dip-net, if a cautious approach be made. A week or so later, however, they become so sensitive to terrestrial vibrations that, even if one takes every precaution to remain in concealment, it is almost impossible to approach nearer than some fifty feet, without causing them to take alarm.

During the month of April they spend all the sunny portion of the day basking in the sun, but on the approach of warm weather they leave the lagoons in large numbers, presumably in search of

their particular food, which is far from abundant in the muddy waters of the lagoons. From the middle to the end of May the lagoons are almost free of *Graptemys*, large specimens being especially scarce there.

Nesting takes place throughout almost the entire month of June, but it is at its height from the sixth to the twentieth of that month.

After the nesting season they resume their regular vegetative activities, swimming, feeding and basking. Even as late as the last week in November I have seen them swimming about near the surface and occasionally resting on shore. Frequently young specimens, while basking on shore at this season of the year, become benumbed with the cold and, in consequence of their inability to return to the water, are left stranded on the shores after the ice has formed. One can easily pick up dozens that have met such a fate.

*Graptemys* displays a decided reluctance to retire into the mud for the winter. It is a familiar sight to observe individuals swimming about or resting openly on the bottom even after the lake has frozen over for the first time. On one occasion, after a sudden severe frost, a large pile of *Graptemys* of all sizes was observed on the lake bottom in about six feet of water. They lay perfectly dormant, showing no signs of life. It occurred to me that they had huddled up in that fashion for warmth, instead of burying themselves in the mud; or had been taken unawares by the suddenness of the cold spell and were too benumbed with cold to dig their way into the sand of the lake bottom. Very large numbers of *Graptemys* winter in the soft mud of the lagoons, which afford ideal conditions for them.

*Resting and Basking.*—These tortoises are in evidence during the summer months to a greater extent than other native species. Basking seems to be their principal occupation. On warm days they literally line the shores of the lake at certain favorable places. Scarcely a floating board or pier lacks its quota of occupants. In some places where the trees overhang the water or have fallen in from lack of support, the smaller specimens of *Graptemys* mount among the branches to heights of six or seven feet.

When basking they are decidedly gregarious, collecting in such numbers on certain sheltered ledges that it becomes necessary for them to pile up two or even three layers deep, the smaller ones

perching high on the backs of the larger ones. Every member of these groups is on the alert and, at the slightest indication of danger, there is a general scramble for the water. The imitative instinct seems to be highly developed. If one animal scents danger and topples over into the water his neighbors quickly follow suit. I have seen all the tortoises within a hundred yards of shore line follow the lead of one that had become alarmed. So acute is their sense of danger that almost any slight divergence from normal conditions serves to give the alarm. A startled bird flying from the grass along the shore or a frog jumping into the water is sufficient cause for a general commotion among the basking tortoises.

By concealing myself in the long grass across the lagoon from a favorite basking place, I was able to note their behavior. After the initial alarm caused by my approach, they regained confidence and cautiously came to the surface. After reconnoitering carefully and seeing nothing suspicious, they proceeded to crawl out upon the narrow ledge where they habitually congregated. One after another they crawled out, the last ones, for lack of room, upon the backs of the first occupants, until, on a ledge scarcely twenty feet long and averaging less than two feet in width, there were crowded over sixty tortoises. In a few minutes one of them took alarm at something that escaped my observation and slid precipitately into the water. All the others, with one exception, followed the lead and in about four seconds the ledge was in possession of one unusually large female, that, for some reason or other, whether from superior experience or unusual sluggishness, refused to leave the vantage ground.<sup>1</sup> In a few minutes the ledge was again crowded and the previous performance was repeated. During the first forty-five minutes of observation the ledge was vacated seven times.

As they lay basking they were continually snapping at passing insects and wriggling their feet, upon which flies and mosquitos were crawling, their actions reminding one of those of a dog tormented by flies. When undisturbed by pests, however, they stretch themselves out to the fullest extent, the hind legs being extended backward so that the soles of the feet are in contact.

<sup>1</sup>I have repeatedly noticed such cases of marked individuality among tortoises of several species and am inclined to believe that one must admit that there is as marked a degree of individuality in character in this order of reptiles as is acknowledged for much higher animals.

This love for warmth and relaxation seems to be one of the most pronounced traits of *Graptemys* and must be considered as one of the potent factors governing its behavior. Other species show the same traits to a less marked degree.

*Methods of Locomotion and Defense.*—*Graptemys*, as its large, strongly-webbed feet would indicate, is a good swimmer; but not nearly so swift as *Aspionectes*, since the stroke is less rapid and the lines of the body less well adapted for speed.

On land *Graptemys* is not a good traveler. Its movements are slow but not especially laborious. During its search for a suitable nesting place it sometimes goes as much as a quarter of a mile inland, and to do this it must needs be a fairly good walker.

Apart from the possession of a very efficient armor, *Graptemys* seems to be defenseless, unless a very complete protective coloration be considered in this category. This coloration, however, is clear and distinct only in very young specimens and becomes more and more vague with advancing age. It is most in evidence when most needed.

When captured they hiss and struggle, but very quickly quiet down and retire into the shell. If one thrusts a finger very close to the beak they attempt to bite but they never advance the head or snap. Their head and neck movement is always slow and deliberate and they seize an object firmly but without haste. This slowness of movement may be due to the fact that they do not capture active prey.

*Graptemys*, more than any other species with which I am acquainted, seeks concealment amidst the vegetation of the lake bottom. If individuals are pursued in boat or canoe they immediately seek out some burrow or tunnel in the thick masses of water weeds. If one approaches a shore where dozens of *Graptemys* are basking he may search in vain for any trace of tortoises among the weeds, so quickly do they find concealment.

When in the open, however, they depend entirely upon their speed to escape pursuit. But they are easily captured from boats or canoes with the aid of a long-handled dip-net. As a rule, they give one a brief but exciting chase and then stop and retire into the shell, either through exhaustion or in reliance upon the efficiency of their armor.

*Feeding Habits.*—*Graptemys* feeds exclusively upon the flesh of a species of viviparous gastropod that abounds in Lake Maxin-

kuckee.<sup>1</sup> 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.

*Breeding Habits.*—*Graptemys* begins to lay very early in June, somewhat earlier than other species observed. The females are apt to wander some distance from the water for nesting, seeming to prefer soft plowed soil or clear dry sand away from the beaches. They wander about for hours in search of a suitable place for nesting. One specimen started five nests before she was satisfied with the condition of the soil. Two were rejected on account of the presence of stones and one because the sand caved in too readily. The other two appeared to me to be suitable in every way and I was unable to explain why she abandoned them.

If one expects to see the first stages of nest-making it behooves him to be astir before sunrise. Over half of the females found nesting were encountered before eight o'clock. They work slowly and seem to prefer the quiet hours of the day, probably because they are less likely to be disturbed.

Apart from the slowness and deliberateness of their movements, they work much after the fashion adopted by *Aspidonectes*, except that they never work the fore-feet so as to secure a foothold.

<sup>1</sup>This species has been identified for me as *Paludina vivipara*.

The nests are of somewhat smaller dimensions and the flask-shaped expansion is more symmetrically placed, scarcely more bulged on one side than on the other. Two layers of eggs are deposited in the flasklike expansion but the last two or three eggs are placed in the narrow neck, the uppermost egg being sometimes only about two inches from the surface.

It is difficult to frighten them away after they have once decided upon a nesting place. When surprised they stop work but soon resume it and continue it to the end, even while the observer is in plain view. The nest of *Graptemys* is a finished product, all traces of nest-making being obliterated. This is accomplished by dragging the smooth plastron back and forth across the small area that had been disturbed by nesting.

The eggs are ellipsoidal in shape, of a dull white color, and have a rather soft, easily indented shell. The number laid by one female at one time varies from eleven to fourteen.

The eggs hatch, as a rule, late in August or early in September, the young burrowing to the surface through the sand. When they emerge they are covered with sand that adheres for some time. Their instinct directs them unerringly toward the water and they frequently have to travel almost incredible distances before reaching the lake or a tributary stream. On two occasions I have found recently hatched *Graptemys*, at a distance of about a quarter of a mile from the water, traveling steadily and in an approximately correct direction toward the lake. At the observed rate of progress they would reach the lake in about two days.

For some time I was greatly puzzled by the frequent discovery of newly-hatched *Graptemys* during the months of May and June. Farmers in the vicinity frequently plowed up nests of eggs that were nearly ready to hatch.

These facts have been explained by the observation of occasional specimens nesting during the latter part of July. Eggs laid at that time would have only about five or six weeks of steadily warm weather in which to develop, and would be retarded by the chilling of the ground in October. Thus the well advanced embryos must pass the winter in a condition of dormancy analogous to that observed in hibernating adults.

On no occasion have I caught a female nesting whose carapace length was less than nineteen centimeters and whose age was less



than fourteen years—according to the age record afforded by the annual growth rings on the scutes.

*Graptemys* refuses to mate in captivity and I have been unable to obtain any data as to mating in nature.

*Behavior in Captivity.*—When confined in aquatic enclosures with access to land, they spend most of their time wandering about seeking a way of escape. Deep paths are worn along the edges of the enclosures by this continual patrol. They do not become accustomed to their captivity within a year, but will invariably seek the water on the approach of a human being.

Owing to the fact that they will not feed in captivity, it is impossible to keep them longer than about sixteen months, since they become weakened by disease and slowly lose vitality. When near death they seem to commit suicide by filling the lungs with water and breathing it until life is extinct. I have occasionally attempted to rescue them from drowning by putting them on floating boards, but, even if too weak to crawl off they usually manage to immerse the head so as to continue the respiration of water. This apparent suicide is probably brought about by extreme weakness and the consequent inability to come to the surface for air. When once the lungs become filled with water it would be impossible for them to breathe air and the inhibition of respiration caused by removing them from water no doubt stimulates their failing energies to the resumption of water breathing.

*Behavior of the Young.*—The young bask in more exposed places than the adults and in many ways show a decided lack of wariness. They are less disturbed by capture and retire less readily into the shell. They are also found in shallower water and less frequently swim about on the surface than do the adults. In other respects there is no marked difference in behavior between young and old specimens.

*Difference in Disposition of the Sexes.*—The males are much smaller and weaker than the females and are much more timid and less fierce when captured, showing a decided gentleness when handled. They are also more retiring and are consequently found in smaller numbers. The disposition of the male *Graptemys* is much like that of the species *Nannemys guttata*.

*Summary.*—*Graptemys geographica* is a very typical water tortoise. Its disposition or character is not extreme in any

particular except that it has become highly specialized in its food. It is neither remarkably timid nor aggressively courageous. It is very fond of basking, but cannot be accused of marked sluggishness. It is active in the water and a fair traveler on land, but in neither element does it equal *Aspionectes*. *Graptemys* might be chosen as a norm to which other species could be referred for comparison.

3. *Chrysemys marginata* (the *Western Painted Tortoise*).

This species closely resembles the well-known *Chrysemys picta*, described at some length by AGASSIZ. The family Emydidae, to which *Graptemys*, *Chrysemys*, *Nannemys*, etc., belong, shows a gradual advance from a purely aquatic to an almost exclusively terrestrial mode of life. *Graptemys* is thoroughly aquatic, *Chrysemys* less so. The other members of the family will not be considered in this account. It will be of interest, however, to note the tendency toward a terrestrial life displayed by *Chrysemys*.

*Chrysemys* appears a little later in the spring and hibernates a little earlier in the fall than *Graptemys*.

The two species are found closely associated during all of the warm months, but *Chrysemys* is very much in the minority, being only about one-tenth as numerous in Lake Maxinkuckee as *Graptemys*. In other bodies of water in the vicinity the proportion is reversed or in some cases *Graptemys* is entirely absent.

The nesting season of *Chrysemys* corresponds closely to that of *Graptemys* and the methods of hibernation, so far as I have been able to observe, are identical.

They prefer the stagnant lagoons and quiet bays to the waters of the open lake and consequently are to be found basking only in these places. They are often seen in company with *Graptemys* on the ledges bordering the lagoons. It is characteristic of *Chrysemys* to bask with the posterior portion of the carapace submerged. It is not uncommon to see them basking high and dry on the shores and ledges, but the other habit is more frequent. This trait results in a curious growth of algæ on the posterior rim of the carapace in very many specimens. Those that spend long periods entirely out of the water seldom show growths of algæ. Here we have another interesting case of individuality in habit.

It seems that certain specimens habitually bask in one way, while others adopt the other method exclusively. They also are frequently found resting among masses of floating vegetation, such as pond scums, lily pads, etc., by which they are buoyed up and at the same time afforded an effective concealment.

As swimmers they compare favorably with *Graptemys*, no marked difference in speed being evident. They spend much more time wandering about on land than any species thus far described, traveling even further for nesting purposes than *Graptemys*. This tendency to terrestrial life is, however, not restricted to nesting females. I have found young and middle-aged specimens of both sexes traveling about on land, either between the railway tracks or on the open roads. On some occasions I have picked them up at a distance of from a quarter to half a mile from water.

It was a common experience to find small specimens of both sexes huddled up against the hot steel rails of the railway. This intense love of warmth seems to be a marked trait in tortoises. GADOW describes a similar state of affairs in connection with *Clemmys leprosa*. Speaking of their behavior in captivity, he says: "They showed an irresistible love for the hot-water pipes, huddling together by the dozens, so that the pipes had to be screened off to prevent the creatures getting burnt. Until this precaution was taken they heated themselves so much that the shields and even the bones of the plastron were injured." I have observed that *Chrysemys* when kept in a steam-heated room will invariably congregate under the radiator and will lie as nearly in contact with the hot steam pipes as possible.

When captured, *Chrysemys* is less fierce and sullen than *Graptemys*, but is more apt to attempt to bite. The bite however, is not at all severe, since the jaws are comparatively weak. If irritated, they retire into the shell and remain quiet for some time.

*Chrysemys* 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*.

They tear their food to pieces with the 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."

The method of nest-making is essentially like that described for *Graptemys*, but the flasklike enlargement is much less pronounced. This may be due to the much smaller number of eggs laid and the consequent economy of space. The nesting season is about the same as for *Graptemys* and the choice of nesting places about the same. They lay only four to eight eggs that are strikingly like those of *Graptemys* in color, shape and character of shell. In size, however, they are somewhat smaller.

Like *Graptemys*, the broods are sometimes belated in hatching, so that a forced hibernation of embryos results. Many just-hatched young were found during the months of May and June.

Unlike *Graptemys*, *Chrysemys* is capable of domestication, feeding greedily after a few days of captivity and remaining active and reasonably contented in an aquarium for years. After some months of confinement my specimens fed from the fingers without any show of alarm.

I have noticed no marked differences in behavior between young and adult specimens, except that the young tend to be less wary and more timid.

*Summary.*—*Chrysemys* is a bright, intelligent little tortoise, showing, when captured, little of the sullenness displayed by other species thus far studied. They are not so wary or suspicious of danger as *Graptemys* and in consequence are more easily captured. It is a curious fact that, with an increasing tendency toward a terrestrial life, the various genera of *Emydidæ* exhibit a decreasing wariness and sullenness in captivity.

For experimental work *Chrysemys* is the best form I know, because it is almost perfectly normal in captivity after a lapse of a few weeks.

#### 4. *Aromochelys odorata* (the Musk Tortoise).

This is the smallest, most sluggish and least intelligent tortoise I have studied, but in many respects the most interesting. Although very decidedly aquatic, preferring the deeper and cooler waters, it by no means refrains from excursions on land. Its general structure—domelike carapace, hinged plastron, small, poorly-webbed feet, etc.—seem to point to a terrestrial ancestry,

while its large head, its body covered with papillæ instead of scales, its dull color, combined with striped neck, and its love for cold water relate it directly to an aquatic environment. I am inclined to believe that *Aromochelys* is secondarily aquatic, having been driven, through competition, to seek its food in the water.

During the latter part of April they are seen in large numbers resting amidst the algæ at the bottom of the lagoon. They are very inconspicuous when at rest, partly because of their immobility and partly because of their dull color. One learns to detect them by the yellow stripe on the sides of the head and neck.

Later in the season they come to the surface on warm days and float among the pond scums, remaining for hours in apparent stupor.

When the water of the lagoons warms up in May, they seek the deeper and cooler portions of the lake and are not seen in the lagoons again until late in the fall, when they return in large numbers to hibernate in the soft mud.

The nesting season begins early in June and lasts nearly the entire month.

Adult *Aromochelys* never, so far as my observations go, bask openly out of the water. The nearest approach to true basking is seen when they float on the surface supported and protected from view by pond scums. Even in captivity they never crawl out on objects above the water, except when seeking to escape from an enclosure. The young, however, frequently bask on stones and boards after the manner of other tortoises.

*Aromochelys* is a slow, weak swimmer, seldom attempting to swim free from the bottom, but as a rule adopting a compromise between crawling and swimming. The heavy, compact body is evidently a decided hindrance to rapid aquatic locomotion. If startled while at the surface, they drop suddenly to the bottom and use their best efforts to escape. Although their gait on land is unsteady and clumsy in the extreme, they are addicted to more or less extensive journeys on shore. I have caught them at dusk, crawling about in the grass and have seen them catching and eating slugs. On one occasion during a heavy rain I picked up seven full grown *Aromochelys* along the railway tracks, of which four were males. They were wandering along between the rails, apparently unable to escape. On many other occasions I have caught *Aromochelys* of all sizes on the roads and between the tracks.

In certain mossy woods near the southern end of the lake it is possible during the month of June to find specimens wandering about over the moss, rooting it up with their snouts and capturing the insects that abound there. They spend so long periods wandering about in this way that the skin of neck and legs becomes dry and wrinkled and the weight of the body is greatly reduced. They seem to be able to endure a greater degree of desiccation than other species studied.

When first captured they emit a very strong musky odor that is extremely nauseating. This odor proceeds from an exudation of the inguinal glands and probably serves as an efficient protection. Their inconspicuous color, heightened by the dense growth of algæ on the carapace, may also serve a protective function. If seized, they hiss and open the jaws widely giving an impression of fierceness that a further acquaintance belies, for they will seldom bite if given the opportunity. Even when they do bite, they do little damage.

As an additional threatening measure they stretch the head back over the carapace somewhat after the fashion adopted by *Aspidonectes*, but the eyes are directed down instead of up. When the head is stretched backward in this way one can readily seize them by the jaws and hold the head extended from the body. The open mouth and fierce attitude what might very readily deceive one unless he had become acquainted with their truly inoffensive and non-pugnacious character.

They are the scavengers of the lake, feeding on all sorts of material, from dead molluscs to kitchen refuse. They refuse nothing that could be construed as edible. If food is placed in the midst of a group, they fight over it like so many puppies over a rag, pulling and jerking to the best of their ability.

Their appetite is insatiable and indiscriminate. On one occasion I put a living rat in an aquarium containing several musk tortoises. Almost immediately three of them seized it by the feet and pulled it under, thus drowning it. Before it had ceased to struggle they proceeded to disembowel it and succeeded in making a fairly good skeleton of it in a few hours.

On only one occasion did I have the good fortune to observe *Aromochelys* in the process of nesting. When I first encountered the little tortoise she was digging in some soft soil, using all four feet and her snout. On my approach she abandoned her work

and wandered about for fully an hour trying different places. Finally she selected for nesting a decayed stump that had rotted down level with the ground. She dug with fore-feet and hind-feet a shallow hole about two inches wide and of about the same depth, and deposited two eggs therein. After covering these eggs with the excavated débris, she went her way. The form and workmanship of this little nest were of an inferior order as compared with those of other species of tortoises I have observed.

Specimens were captured on land with eggs in the oviducts, ready to be laid, on the following dates: June 11, 16, 20, 22, 23 and 25. In no case did I find more than three eggs in the oviducts. These were elliptical in form and nearly as large as the eggs of *Chrysemys*. The shell is hard and of a china-like consistency, brittle but capable of withstanding considerable pressure.

AGASSIZ states positively that tortoises do not mate in confinement, but this phenomenon is not uncommon in the case of *Aromochelys*. They mate even when large numbers are crowded together in limited space and when people are moving about in plain view. I have been able to observe the process of mating in no other species.<sup>1</sup>

Confinement seems to have little inhibiting effect on the normal activities of *Aromochelys*. They feed and mate quite normally. But when captured with eggs in the oviducts they do not make nests, being satisfied to drop the eggs at random.

When kept in aquaria they frequently stand for long periods on the hind legs, protruding the snout above the surface of the water. In no case have I observed them leaving the water in order to bask on the bricks and boards provided for this purpose. They soon learn to swim toward the person who feeds them and will take food from the fingers.

The young do not differ materially from the adults in general behavior, except that they are often seen basking on shore during the first two or three seasons. They assume the same threatening attitude, when captured, as do the adults, their mock fierceness giving them a decidedly ludicrous appearance.

*Summary.*—*Aromochelys* possesses a shy and retiring disposition, living during a large part of its life on the dark weedy lake bottom, rather than in the warmer and shallower waters. These

<sup>1</sup>Professor JACOB REIGHARD informs me that he has seen *Chelydra* mating in a small box.

tortoises combine in a peculiar way the traits of aquatic and terrestrial forms. Their mock fierceness may be the relic of a fierce ancestry. After the first attempts to escape they become quite docile and cease to resent their captivity. The species presents an odd mixture of traits that could probably be reconciled by a more complete knowledge of its phylogenetic history.

5. *Chelydra serpentina* (the Snapping Tortoise).

The habits of this species are quite generally known and have been referred to in a more or less fragmentary way by several authors. My observations on the subject are less complete than those given for the preceding species, yet for the sake of comparison it seems advisable to set down in systematic form the available facts.

*Chelydra* seems to appear and disappear along with *Graptemys* and it is certain that hibernation takes place in the mud of the pools, swamps and streams of the neighborhood. I am informed on reliable authority that it is possible at almost any time in the winter to secure "snappers" from the mud of the stream bottoms by breaking the ice and grappling in the mud with sharp hooks attached to stout poles.

During the early spring "snappers" frequent the land, leaving the pools probably in search of food. Later in the season, however, they seem to remain constantly in the water, either floating near the surface with the tip of the snout protruded or buried in the mud at the bottom.

Their nesting season corresponds closely with that of *Graptemys*.

*Chelydra* basks occasionally in the open, but is much more apt to resort to warm shallow waters, where it buries itself in the mud, leaving only the head free. The head is very inconspicuous on account of its dull gray color and rough warty appearance. The young are not so careful about concealing the body with mud. In shallow pools at the margins of swamps they may be seen in considerable numbers, lying exposed to full view.

*Chelydra* is a slow and clumsy swimmer, progress through the water being aided as a rule by walking along the bottom. On land they walk slowly, with a peculiarly elephantine gait, yet succeed in covering considerable distances, often going from one



body of water to another. I have found both males and females on land at least half a mile from water.

If brought to bay on land large specimens will make a bold advance to the attack. Seldom will they retreat as do other species. When one approaches close enough they lunge forward with a movement that might almost be termed a leap, snapping savagely at the offender. Their lunge frequently results in a loss of equilibrium and gives them an aspect of impotent fury. When seized by the tail they snap blindly without any apparent objective point. This aimless snapping seems to be an expression of something akin to anger. Like *Aromochelys*, they reach back over the carapace with eyes directed downward.

Like *Aromochelys*, too, they emit a musky secretion from the inguinal glands that, although not so nauseating as the emission of the musk tortoise, is decidedly unpleasant. Their habit of burying the body in the mud and the general inconspicuousness of carapace, head and limbs, might be cited as factors in their equipment for self defense.

*Chelydra* either stalks its prey or lies in wait for it. In the former case it approaches a resting tadpole or frog with movements so slow as to be almost imperceptible. The head is thrust out stiff and is kept very steady and when within easy reach of its prey the fierce jaws are suddenly opened and closed with a snap that leaves no hope of escape for the victim. In the latter case it lies buried in the mud at the bottom, allowing only the head to protrude. The long wormlike tongue is thrust out, probably as a lure for unwary fish. When the prey comes within reach it is suddenly snapped up.

*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. Whole strings of fish, left hanging over the side of the boat by inexperienced fishermen have been stolen by voracious "snappers." It is not uncommon for fishermen to lose their tackle when a "snapper" takes their bated hook. Their weight and strength are too much for any but the heaviest tackle. The young feed upon the larvæ of insects that are found by burrowing in the mud.

Only in one instance have I observed the female *Chelydra* during the nesting process. On this occasion the nest was more than half completed when I first caught sight of her. Although

she stopped work and showed signs of preparing for a retreat, she concluded the filling-in process in a somewhat slovenly manner and then retreated. The filling-in process was the same as that observed for *Graptemys* and *Aspionectes*.

The nest was in gravelly sand on the side of a railway embankment, separating the lake from a swamp. An examination of the nest revealed a broad funnel-shaped depression, about a foot in diameter, at the apex of which a tunnel, about four inches in diameter, led diagonally into a wider expansion of irregular shape and about a foot beneath the general ground surface. The tunnel was obstructed by a stout stick and was consequently turned somewhat to one side. In the expansion and communicating tunnel were thirty-three eggs scattered irregularly in a double layer. On the whole it was a decidedly untidy and primitive sort of nest.

At about the same time of the month (June 15) several half-finished nests were found in the same railway embankment and all had the same general characteristics as the one described. I am told by the engineers on the railroad that the females are often seen at work and that they leave precipitately on the approach of the early morning train.

The eggs are spherical with one hemisphere white and the other pinkish. The shell is very tough, so that the eggs, if thrown on hard ground, will rebound several inches without breaking. The eggs laid on June fifteenth hatched during the last week in August.

Large specimens captured on land and put into aquatic enclosures immediately buried themselves deep in the mud and were not seen again until dug out with a hoe months afterward.

One large specimen, weighing nearly fifteen pounds was tethered out in a lagoon by means of a long dog-chain attached to the carapace. It went the full length of the chain and then buried itself at least a foot deep. It is difficult to do anything with beasts so sullen as *Chelydra*. When kept in captivity on land they are extremely ill-natured, snapping at and injuring one another if they happen to meet. I have never observed a tendency to combativeness in other species.

If kept for some months even the largest specimens of *Chelydra* accept food eagerly.

If eggs that are near hatching are opened, the young *Chelydra* snap in a characteristic, though somewhat feeble, manner. Snapping with them seems to be a sort of reflex and may be more or less

so in adults. Young specimens lack the fierceness and sullenness of adults, being capable of domestication. They will feed from the hand and seem to enjoy being scratched under the jaws.

*Summary.*—Chelydra possesses a very “ugly” disposition. It is vicious and intractable, displaying a blind impotent rage when brought to bay. In temperament it is extremely slow and sluggish, preferring to lie in wait for its prey rather than actively to search for it. Sometimes, however, it summons sufficient energy to stalk the prey.

#### GENERAL SUMMARY.

It will be noted that certain traits and habits are common to all of the species studied and, since the principal groups of tortoises are represented, these may well be considered as chelonian characters. Certain traits stand out more prominently than others and these should be emphasized.

1. The love of warmth and repose seems to be one of the few dominant factors in tortoise life. In some cases they seek warmth to their injury. On the other hand, lack of heat is more apt to cause death than any other factor.

2. Extreme wariness when basking is noticeable in all species that habitually bask.

3. There is a marked variation in the degree of fierceness or timidity exhibited by different species. These characters seem to run parallel with an aquatic or a terrestrial habitat, aquatic species being fiercer than those with a tendency toward a terrestrial life.

4. Naturally enough, it is possible to domesticate the less fierce and less sullen species, while captivity inhibits normal activities in the fiercer and more sullen species.

No general summary of vegetative or reproductive activities is necessary here. The writer, conscious of the incompleteness of his data concerning certain activities, intended to devote another season to the work, but as it seems advisable to publish the facts now as they stand, he hopes to supplement and interpret them on another occasion.