The Wood Turtle, *Clemmys Insculpta* . . . A Natural History

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ABSTRACT — The biology of the Wood Turtle, *Clemmys insculpta,* is described based on field studies in Michigan and New Jersey, and observations of captive specimens. Nomenclature, range, and identifying characteristics are treated briefly, followed by discussions of shell and coloration abnormalities, growth patterns and aging, hibitat preferences, daily and seasonal behavior, homing, hibernation, reproductive habits (including detailed descriptions of courtship and nesting behavior), feeding, physical capabilities, enemies, conservation, and captive breeding. Geographical differences in physical characteristics and behavior are highlighted.

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Purpose

This Paper combines data from separate field studies conducted in Michigan and New Jersey to describe the natural history of the Wood Turtle, *Clemmys insculpta*. Wood Turtle populations were studied to augment the knowledge of this species' biology and to determine if the turtles exhibit differing responses to their environment in geographically separated parts of their range. It is also hoped that this paper will illuminate some of the many aspects of Wood Turtle biology that require further definition and study.

The Studies

Harding's data results from field work entirely within the State of Michigan. While informal observations have taken place throughout the Michigan range of *C. insculpta*, intensive study of a population in the State's Upper Peninsula had produced most of the data incorporated into this paper. Beginning in 1969, turtles in this population were marked using a modified version of the method described by Cagle (1939). Each specimen was measured (straight line measurement of carapace and plastron to nearest mm) and sexed, and notes were taken on general physical condition, coloration, external parasites, location, time of day, and weather conditions. A count of the growth rings ("annuli") was also made, when possible, using the right pectoral scute. Generally, the procedure was followed for each subsequent capture. By Fall 1978, nearly 270 specimens have been marked in this population, and nearly 30% have been recaptured at least once. The study area consists of a portion of a river and its tributaries and the surrounding floodplain forest (mostly mixed hardwood-coniferous), swamps, meadows, and agricultural land. Total time spent on data collection varied from year to year; in 1971 and 1976, observations began in May and continued into September. Less total time was committed in other years, but the study area was visited in May, June, August or September, and October during most field seasons. Over 230 hatchlings from eggs collected in the study area and incubated in the laboratory have been marked and released. Observations were also made on several specimens retained and kept in captivity.

Bloomer's data is the result of field work which bagan in 1965 in Passaic County, New Jersey. Observations have been made throughout much of northern New Jersey, southeastern New York State, and eastern Pennsylvania. Two populations of New Jersey *C. insculpta* were subjectd to controlled research. The first of these was located in Passaic County, within the Newark Watershed lands. The second was located in Sussex County, and included Bloomer's Cross Creek Farm. Specimens were marked and photographed for future identification. Day to day observations were made during the months of turtle activity. Data on hibernation was compiled during the Fall and Winter months at three denning sites within New Jersey. In addition, observations of captive specimens were initiated in 1972 and continue to the present.

Taxonomy / Local Names

The Wood Turtle, *Clemmys insculpta* (Le Conte), belongs to a genus of North American turtles which includes three additional species: the Spotted Turtle *(C. guttata)*, the Bog Turtle *(C. muhlenbergi)*, and the Pacific Pond Turtle *(C. marmorata)*. Merkle (1975) suggested that *C. insculpta* may be the most primitive member of its genus, based on a study of blood proteins, and that *C. muhlenbergi, C. guttata,* and *C. marmorata* were more closely related to each other than to *C. insculpta*. This genus belongs to a large family of mostly semi-aquatic turtles, the Emydidae. No subspecies of *C. insculpta* have been described (Ernst and Barbour, 1972).

Throughout its range, the Wood Turtle is known by a number of "local" names, and the following have been encountered by one or both authors: wood tortoise (or terrapin), land turtle, meadow turtle, field turtle, swamp turtle, mud turtle, and red-leg turtle (or red-legger). Surprisingly, many people living in New Jersey recognized this species and called it by its correct name, Wood Turtle. On the other hand, few people encountered in Michigan recognized this species by name; many persons tended to lump all turtles into two general catagories: "mud turtles" and "snappers"!

General Range

Clemmys insculpta ranges from extreme eastern Minnesota and northern Iowa, across Wisconsin and the Upper and northern Lower Peninsulas of Michigan, to parts of southeastern Ontario and southern Quebec, through Maine to Nova Scotia, south through New England, New York, northern

New Jersey and Pennsylvania, to extreme northern Virginia. A recent range map for the species is illustrated in Conant (1975).

During the last glacial period, *C. insculpta* apparently ranged far to the south of its present distribution. Holman (1967) reports a Pleistocene record from Georgia.

The historical range described above will certainly require modification in the future as Wood Turtle populations shrink from the effects of human activities. It has already been greatly reduced or exterminated from some parts of its range (see sections on "Relations with Man" and "Conservation").

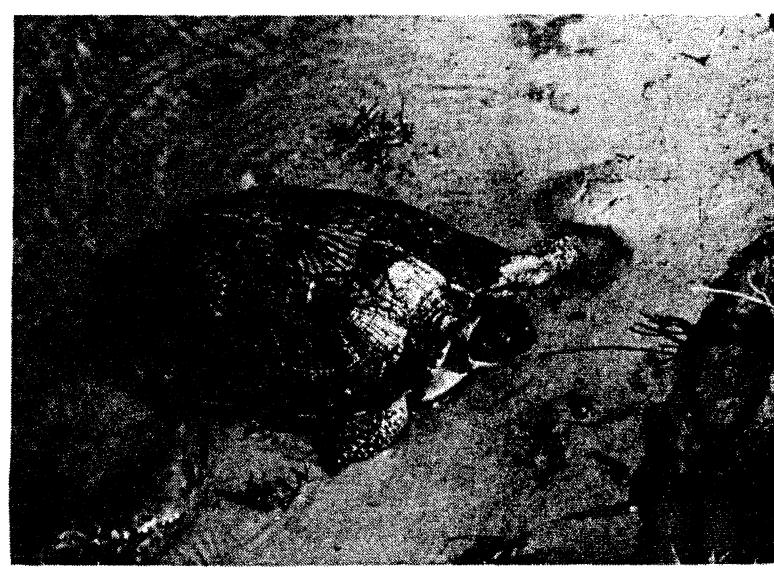
Description

Detailed descriptions of *C. insculpta* have been given previously by Pope (1939), Carr (1952), Ernst and Barbour (1972), and Conant (1975). The following characters are useful for field identification: the carapace is brown, grayish brown, or tan, often with radiating yellowish lines on the vertebral scutes. The well-defined concentric growth rings on each large scute may form a flattened pyramid; the extent of development of this pyramidal structure is highly variable, but the carapace usually has a somewhat "sculptured" look.

The hingeless plastron is yellow, with a dark blotch occupying the posterior outer corner of each scute. The head is black, and the upper parts of the legs and tail are black or brown. The throat, and the lower surfaces of the neck, legs, and tail may be yellowish, orange, or salmon-red, with considerable variation between individuals and, especially, between populations.

There may be certain geographical trends in skin coloration in *C. insculpta,* based on the comments of many students of this species. For example, specimens from Wisconsin and the more westerly parts of the range reportedly tend towards "duller" coloration, such as yellow or yellowish-orange, while certain populations in eastern Pennsylvania and southeastern New York tend to be brighter orange or even reddish in lower skin color. However, more thorough study of the geography of Wood Turtle coloration is needed before definitive statements can be made.

An interesting phenomenon noted in some New Jersey specimens was an apparent seasonal change in the intensity of skin coloration on the lower neck and legs. The orange color appeared to become more vivid during the early Spring, after emergence from hibernation, and in the Fall. This change in color intensity is thought to be correlated with sexual activity in captive specimens, and might conceivably be so correlated in the wild. Most recorded mating behavior occurred in the Spring and Fall (see section on "Mating"). Seasonal color changes are apparently unrecorded for North American Emydid turtles, but are known in certain Asian species such as *Batagur baska* (Moll, 1978).



A female wood turtle approaching nesting area from under water.

Hatchling *C. insculpta* lack the brightly colored underparts and the black heads and dark upper leg surfaces of the adults. From above they appear a monotone light brown or tan, although newly hatched Wood Turtles are usually grayish for the first few days after hatching. In most specimens, the head color nearly matches the carapace color, or may be somewhat darker. The plastron of a new hatchling is usually a dark mottled gray that becomes brownish or black after a few weeks. The carapace may be nearly circular in outline, and the tail is often about as long as the carapace. The young turtles gradually acquire "adult" coloration during the first summer after hatching.

Abnormal Coloration / Shell Abnormalities

An albino specimen was recorded in Sussex County, New Jersey, in 1974. This turtle, a juvenile less than a year old, was a very light, almost white-yellow, cream color that was not interrupted by any other markings or coloration on shell, legs, or any other part of the animal.The eyes, however, were not pink but brown.

Congenital shell abnormalities (those not attributable to previous injury) were frequently recorded for *C. insculpta* in the Michigan study. These were usually in the form of doubled (divided) vertebral scutes or as deviations in the normal number of marginal scutes. Approximately two percent of all specimens studied, including those hatched in the laboratory, showed some deviation from the normal carapacial scute pattern. The affected turtles seem to suffer no observable disadvantage from scute abnormalities, as the growth patterns "compensate" for abnormalities, and the shell remains symmetrical.

One juvenile *C. insculpta* from Michigan exhibited symptoms of mild kyphosis: the carapace was strongly arched, with the highest point at the second vertebral scute. This turtle was 132 mm in carapace length, and had 15 growth rings (annuli). If the ring count is reasonably close to the true age of the specimen, then it appears that the growth was slower than would be expected — possibly due to the shell abnormality (see section on "Age and Growth").

No congenital plastral abnormalities were recorded in either study.

Size

Clemmys insculpta is considered a medium-sized turtle, although it is the largest member of its genus. Conant (1975) gives a range of 140 to 190 mm carapace length for average adults, and a record length of 229 mm (9 inches). For the reasons given below, the authors felt that it was unwise to assign "adult" status to specimens exhibiting "female" characteristics with carapace lengths under 160 mm (6.3 inches). All figures given below reflect this standard; all measurements given are straight-line carapace lengths unless otherwise stated, and are reported to the nearest millimeter.

In the Michigan study, the average length of 86 adult male specimens was 200 mm. The largest measurement for a male (two specimens) was 228 mm. For adult females, the average length of 105 specimens was 182 mm; the largest female was 218 mm in carapace length. Sixty-three marked individuals classed as "juveniles" (those with juvenile or "female" characteristics under 160 mm in length) averaged 127 mm. This latter figure merely indicated the relative difficulty of finding very young specimens — which may or may not reflect a real scarcity of such specimens.

In New Jersey, adult *C. insculpta* averaged considerably smaller than those in Michigan. This might be attributable to the numerous human pressures on the population. In New Jersey, 311 adult males and 464 females were examined. The average adult male carapace length was 178 mm; the largest New Jersey male was 206 mm long. An average female mesured 165 mm, and the largest female was 188 mm long.

The size range of 96 hatchlings from the Michigan study area was 28.0 to 37.8 mm (carapace length to nearest .1 mm); the average length was 34.0 mm. The average width of these specimens was 32.2 mm, which indicates the nearly circular outline of hatchling *C. insculpta*. A smaller sample of New Jersey hatchlings also showed an average carapace length of 34 mm, with a range of 32 to 37 mm.

Sex / Sex Ratio

Fully mature *C. insculpta* normally exhibit well-defined secondary sex characteristics. These are summarized below:

The male Wood Turtle has a longer, thicker tail than the female, with the anal opening well beyond the posterior edge of the carapace. (The anal opening of the female is usually not beyond the posterior edge of the carapace.) The male's head is wider and more "squared" than the female's, and the forelimbs are thicker with heavier scales and claws. The hind legs are also more massive in the male, with heavier, more curved claws. The plastron of the male is concave, that of the female flat or slightly convex. Large male Wood Turtles may develop high "domed" shells; the carapace of the female is flatter and tends to have more flared rear marginals.

Individual expression of these characteristics is highly variable, but a fully mature specimen will usually exhibit sufficient clues to its gender.

An apparent correlation between eye color and sex was noted in New Jersey *C. insculpta*, although no statistical analysis was performed. Males tended to have yellow irises, while the majority of females exhibited uniformly brown eyes. Such a pattern was not observed in Michigan, as the amount of yellow in the eyes of marked specimens was highly variable between individuals of both sexes.

In Michigan, the sex ratio for *C. insculpta* was found to be approximately 1:1. Of 191 mature specimens marked by September 1978, 86 were males and 105 were females. Application of the chi-square test reveals no signifiant deviation from a 1:1 sex ratio ($p < .05$, $\chi^2 = 1.696$).

In New Jersey a sex ratio of approximately 1.5 females to 1 male was found (464 females; 311 males). Gibbons (1970) suggested that published reports of sex ratios in turtles that tended to deviate from a 1:1 ratio were often based on a sampling error, or an error in assigning a minimum size for sexual maturity. In the present study, however, a conservative minimum adult size limit was established (see section on "Age and Growth" below), and the New Jersey data continue to support a 1.5:1 ratio. While an unforeseen sampling bias may yet exist, it seems possible that environmental and/or behavioral factors may be contributing to unequal mortality in the New Jersey Wood Turtles, thus accounting for a skewed sex ratio.

The appearance of secondary sex characteristics may be delayed until the turtles reach a "critical" size, often around 160 mm in length, and then may appear with surprising rapidity. This subject is discussed in the next section.

Age and Growth

In certain species of turtles, the growth rings that form at the edge of the carapacial and plastral scutes may provide a reasonable estimate of a specimen's age (Gibbons, 1976). In other species, the growth rings may be lacking or unreliable, for a number of reasons.

Data from the present Michigan study indicates that the growth rings, or "annuli", are a highly reliable indicator of age in wild specimens under about fifteen years of age, and are probably increasingly less reliable as a specimen grows beyond early maturity. Growth tends to slow as a turtle ages; thus the rings become narrower and more difficult to count. Many specimens of varying sizes were recaptured over the nine years of study, and most had added exactly one ring per year. For example, a female with a carapace length of 164 mm in June 1976 had 15 annuli (pectoral scute). By June 1977, she had grown to 170 mm and had added one additional ring. A male specimen had 12 annuli in June 1972, and had 17 annuli in June 1977.

Despite the inherent difficulties in counting annuli in older specimens, an average age for a series of adult Michigan *C. insculpta* was calculated: For 41 adult male specimens, the average age was 21.46 years. For 50 adult female specimens, the average age was 20.18 years. Based on a knowledge of growth rates, and recaptures made several years after original marking, these figures seem reasonable.

The reliability of growth ring counts was not established for New Jersey specimens. Studies on the related species *C. muhlenbergi* (Bloomer and Holub, 1977) showed ring counts to be poorly correlated with known ages of specimens. This was perhaps due to the turtles going through "growth spurts" followed by periods of insignificant growth during the active season. There may be geographical differences in the reliability of aging techniques for turtles, and additional work is needed. Studies of aging techniques should be done on specimens in the wild or those kept under near-natural conditions. Growth ring formation is greatly affected by conditions of captivity,

especially when specimens are kept active through the winter. A juvenile *C. insculpta* raised in captivity since hatching had twelve very narrow growth rings by the end of its third year!

Oliver (1955) recorded a longevity of 58 years for a captive Wood Turtle. A large male from Michigan with a carapace length of 211 mm had 32 reasonably distinct annuli on the right pectoral scute.

The growth rate of the Wood Turtle follows the "normal" chelonian trend of rapid juvenile growth, slowing at maturity, and practically halting with advanced age. Typifying this trend was a female specimen with the following recapture history and carapace length measurements:

25 June 1971 — 127 mm
9 Sept. 1971 — 133 mm
1 Aug. 1976 — 166 mm
14 June 1977 — 168 mm

This specimen had an annuli count of 18 on the last capture date. Another Michigan female had a carapace length of 190 mm in June 1971; she was recaptured seven years later and had added only one millimeter, at which time she had a minimum annuli count of 28.

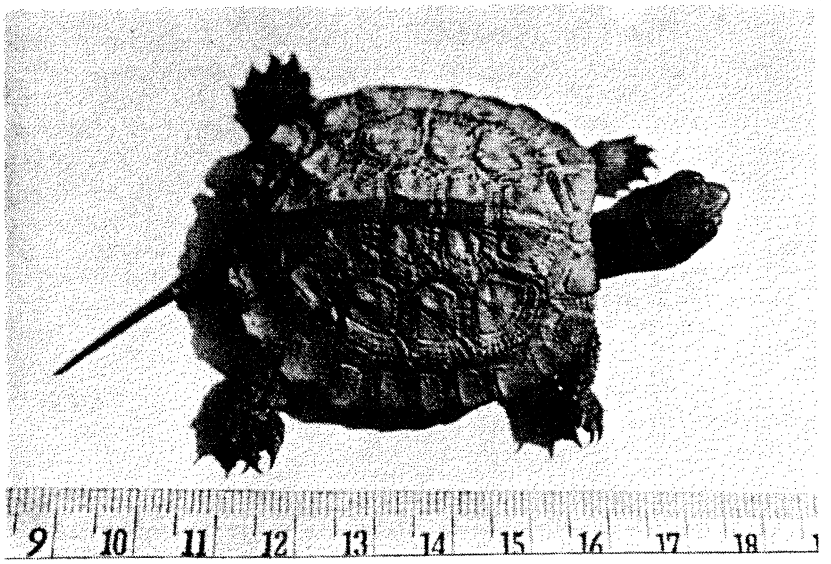
A New Jersey hatchling kept outdoors under semi-natural conditions grew from 34 mm to 56 mm (carapace length) in its first year, and was 71 mm by the end of its second growing season. Another hatchling grew at the following rate:

35 mm — hatching size
54 mm — end of first growing season
69 mm — end of second season
110 mm — end of fourth season
122 mm — end of sixth season
126 mm — end of seventh season (released)

This specimen hibernated naturally, but was provided with food; thus the figures may approximate a natural growth rate under optimal conditions.

The average age of attainment of sexual maturity was not determined, but it appears to vary geographically and beween individuals. Breckenridge (1944) felt that *C. insculpta* in Minnesota matured at carapace lengths between 152-178 mm (6-7 inches). New Jersey hatchlings, which grew from an average hatching size of 34 mm (CL) to around 165 (CL) in seven to eight seasons, were thought to be sexually mature at histime. No specimen under 160 mm was ever seen to exhibit courtship or nesting behavior under natural conditions.

It was felt that more time was needed for the attainment of sexual maturity in Michigan *C. insculpta* than those in New Jersey. The smallest Michigan specimen observed in courtship activity was a female 158 mm long with 12 well-defined annuli. The smallest courting male observed was 192 mm long. The smallest female noted depositing eggs had a carapace length of 185 mm and had 19 annuli. It would be conservative to state that Wood Turtles in this northern Michigan population do not become sexually active until they are at least 10 years old.



A yearling wood turtle (metric scale)

An interesting phenomenon we noted was the rapid attainment of secondary sexual characters by male *C. insculpta* upon reaching a certain "critical" size. Because females essentially retain juvenile characters upon maturity, some specimens captured early in both studies were recorded as females at lengths then thought to be sufficient for sexual maturity. They would later be found to have "changed" into males, causing considerable confusion! It was eventually realized that many male Wood Turtles do not develop "male" sex characteristics until they reach a "critical" size now thought to be between 160 and 170 mm (CL). For example, a Michigan specimen with a length of 163 mm on 8 August 1971 was recorded as a female, based on the characters described above. This specimen was recaptured on 28 June 1978 and was quite obviously a male.

This sexual characteristic change was also noted in captive New Jersey specimens. A supposed "female", over a three month period, gained five millimeters in carapace length and developed the widened head and heavy front legs of a male, followed by the relatively rapid development of plastral concavity. Also noted as part of this masculinization process was a "smoothing off" of the front of the carapace which was seemingly not accounted for by wear alone. No specimens were sacrificed for examination of gonadal development in either study; thus it is uncertain whether there is a close correlation between maturation of spermatozoa and the attainment of secondary sexual characteristics in the male turtles.

We caution researchers working on *C. insculpta* and other species that the age of attainment of sexual maturity and the appearance of secondary sexual characters should be carefully determined before assigning sex to recorded specimens based on size alone.

Habitat

Clemmys insculpta will utilize a wide variety of habitats, both aquatic and terrestrial. These include rivers and streams, swamps, bogs, wet meadows, woods, upland fields, and farmland. This species is sometimes described as being similar to the Box Turtle *(Terrapene carolina)* in having strong terrestrial inclinations (Ernst and Barbour, 1972). However, habitat preferences in the Wood Turtle can vary greatly, both seasonally and geographically.

In New Jersey, *C. insculpta* was generally found in or near waterways from April through early June. In late June, July, and August the turtles assumed a terrestrial existance in woodlands, meadows, and pastures. It was rare to find them in water during the Summer, except during periods of drought. By late August the movement was reversed, and by early September they were again in or near water.

Habitat preferences of Michigan *C. insculpta* were similar to those in New Jersey during the Spring, being found in or near rivers and streams. However, most individuals retained this semi-aquatic habit through the active months; no specimen was taken more than 152 m (500 feet) from water during the course of the study. Individuals were found basking or foraging in woods and open areas bordering the shoreline, but the water appeared to be their "base of operations". Wood Turtles were associated with moving water, and were rarely taken in ponds or sloughs inhabited by other turtle species of the area — *Chrysemys picta belli* × *marginata* and *Chelydra serpentina.*

Comments by several workers suggest that *C. insculpta* from the western parts of its range may be more aquatic than those in the east. Pentecost and Vogt (1976) describe Wisconsin Wood Turtles as "much more aquatic" than members of eastern populations. Ratner and Anderson (1978, unpubl.) studied a Wisconsin population and found nearly all specimens in or near water. While their search efforts were concentrated near the water, it was noted that several specimens had algae growing on their shells — a good indication of aquatic tendencies.

Koffler et. al. (1978) reported that *C. insculpta* from study areas in New York and New Jersey were infested with leeches *(Placobdella parastica)* in April, and in October and November. The turtles had practically no leeches from May through September, and the authors supposed that this finding was due to the turtle's terrestrial activities during these months. In the present Michigan study, individual *C. insculpta* harbored leeches during all months of activity, while in New Jersey the turtles could be found with leeches in early Spring, but such occurrences were exceedingly rare after late May.

Reports of "more aquatic" populations of *C. insculpta* are not restricted to the western parts of its range; Reed (1956) stated that he never found the species in a "truly terrestrial habitat" in Maryland, and invariably found it "in or very near water".

One factor that may contribute to limiting the Michigan population to the vicinity of water could be the nature of the habitat. There the dense floodplain forest surrounding the streams may limit the wanderings of the turtles due to their need to regulate body temperatures by basking. The dense woodland canopy would make thermoregulation and maintenance of optimal body temperature difficult during the frequent cool periods of the northern Summer. There are undoubtedly a number of factors influencing habitat preference in the Wood Turtle, and the subject requires further study.

Hatchling and small juvenile specimens appeared to be preferentially aquatic in both Michigan and New Jersey.

Habits

We found *Clemmys insculpta* to be a diurnal species, with night activity restricted to copulatory and nesting behavior initiated late in the afternoon and ending after dark. In New Jersey, daily activity began within an hour after sunrise and often ended after sunset. Wood Turtles were active at temperatures as low as 14 °C (57 °F), but became inactive on very hot days in Summer. Rain seemed to stimulate activity in New Jersey, but discouraged movement in Michigan where wet weather is often accompanied by rapid drops in temperature. Early morning and late afernoon seemed to be the preferred times for feeding and moving about.

The basking habit is well developed, and accounted for a considerable portion of the daily cycle in Michigan Wood Turtles, especially the late morning and late afternoon hours of sunny days. A few specimens were seen to "bask" even on days with heavy overcast. Favored basking spots were emergent logs over deep stream channels, grassy, sandy, or muddy banks, and woodland openings with low ground cover. A specimen basking on land is quite inconspicuous, and may be even less noticeable because they often bury themselves in shallow pits which conceal the outline of the carapace. In addition, when leaving the water, the turtles almost invariably throw sand or dirt over their shells with a quick alternating flipping motion of the front feet (Holman and Harding, 1977). This behavior is highly stereotyped, and has been noted in specimens held captive for several years — and often occurs in the absence of any loose, "throwable" substrate. Hatchlings only minutes from the egg will exhibit the behavior as they emerge from the nest.

Specimens which choose emergent logs over water as basking sites were more conspicuous; when approached by land or water they would usually drop off and dive to the bottom, then scuttle along the shoreline or head directly to deeper water in the middle of the stream. Adults of both sexes used the emergent logs for basking in Spring, but from the end of June through August the females seemed to prefer terrestrial sites, while the males continued to use the logs. By September, the females are again using the logs for basking. Wood Turtles were found to be solitary creatures and it was rare to find specimens in close proximity; the few exceptions being times of courtship, or females sharing a nesting area.

In captivity where space is limited, *C. insculpta* were observed to form dominance hierarchies. These "pecking orders" were reinforced by aggressive encounters, which were observed to be swift, savage, and decisive. An individual turtle's place in this hierarchy seems to depend largely on size and degree of maturity, though the sex of a specimen may play some part in determining the outcome of an aggressive encounter. Large females can be very aggressive toward smaller males, but an encounter between a male and female of nearly equal size is often decided in favor of the male. Harless (1970) tested sexual dominance in this species and found that males were consistently dominant in aquatic situations, while females often were dominant in non-aquatic tests. It seems noteworthy that most courtship behavior is initiated by the male, and takes place in water. However, conditions of captivity present a number of variables not found in the wild, and caution must be used in translating captive behavior into predictors of behavior in the wild.

Wood Turtles recognize others of their own species; it is uncertain which recognition factors are most important. They may also recognize other species; in New Jersey several specimens exhibited an avoidance reaction to Snapping Turtles *(Chelydra serpentina)* but not to other species. Harding (1979) observed a number of aggressive encounters between a young male *C. insculpta* and an adult male *Terrapene c. carolina* in captivity. Bloomer & Holub (1977) reported that captive *Clemmys muhlenbergi* hesitated to enter a pool inhabited by a juvenile *C. insculpta* of equivalent size. In June 1972, a wild male *C. insculpta* was observed biting at a withdrawn female *C. muhlenbergi* in New Jersey.

Home Range / Homing Ability

Wood Turtles in the Michigan study were fequently recaptured consistently within a small area. These recaptures were often several years apart and provide evidence for a restricted home range in these animals. Of 47 adult *C. insculpta* recaptured at least once after the original capture, 30 (63.8%) were found within 150 meters of the original capture point, and 15 (31.9%) were recovered less than 305 m (1000 feet) from the original point. Only two individuals had travelled over 800 m (a half mile) from the first capture point. Most movement was along a watercourse; no evidence of overland movement of more than 150 meters was found during the study.

Some of these turtles exhibited a remarkable site tenacity. A female specimen was marked on 2 July 1971, and recaptured in May 1972, May 1974, and June 1977. Twice she was captured on the same log as the original capture, and the other time she was on the bank adjacent to "her" log! A large male was marked on 27 May 1972 and recaptured on 6 August 1976 within twenty meters of the original capture point. Another male was marked in July 1971 and recaptured within 100 meters of the first site in September 1971 and August 1976.

The data does not lend itself to an estimate of the area of an average "home range" for these turtles. A more terrestrial population of *C. insculpta* in New Jersey would wander within about a 12 ha (30 acres) area during the Summer months, but individual home ranges were not determined. Ernst (1968) reported an estimated home range of 2.57 ha (6.36 acres) for a Pennsylvania male, based on one recapture. In another limited study, Ratner and Anderson (1978, unpubl.) used a radio-tracking device to follow the movements of two Wisconsin females. One was tracked from 5 June to 1 August and had an estimated home range of .91 ha (2.25 acres). The other, tracked after nesting, from 8 July to 1 August, had an estimated home range of .48 ha (1.19 acres).

This species appears to have a strong homing instinct. One New Jersey male was released about 2.4 km (1.5 miles) from its point of capture and returned to its home area within a five week period. During its return, this specimen had to pass through woodlands, pastures, and corn fields, cross over hills, a small stream, and three roads. This animal, it should be noted, was missing one of is limbs. Another male released a mile from its point of capture was retaken at the same spot three weeks later.

The Michigan study also provided examples of Wood Turtle homing ability. One female marked on 22 June 1971 was released about 8 km (5 miles) downstream from the capture site. On 11 August 1971 the specimen was retaken at the first capture point. Assuming that most of her travel was by water, she had travelled the distance against the stream's current. Another adult female, without a right front leg, was marked on 23 June 1971 and displaced 1.6 km (one mile) downstream. Two days later she had returned to the capture point. She was again displaced 1.6 km downstream, and returned in four days. She was then displaced about 3.2 km (two miles) downstream, and was not retaken again that year. But five years later on 15 June 1976, she was again taken at the original marking point. Since she had fully proven her "homing" abilities, we released her at the point of capture — and in May of the following year found her nearly 2.4 km (1.5 miles) downstream!

Hibernation

Depending on local climatic conditions, Wood Turtles enter hibernation between late September and early November, and emerge between early April and mid-May. New Jersey turtles were generally active later in Fall and earlier in Spring than those in northern Michigan, reflecting the longer winter season in the latter area.

Hibernation may occasionally take place on land (Pope 1939), but this is definitely the exception. Most *C. insculpta* overwinter in aquatic situations. Bloomer (1978) found New Jersey specimens hibernating in beaver and muskrat burrows and in the bottom mud of streams, ditches, and beaver ponds. The turtles often congregated in considerable numbers, and groups of from 5 to 70 were recorded. Some groups of hibernating *C. insculpta* made little attempt at concealment and were found lying dormant, shell to shell, on the bottom of the waterway under the ice. Bloomer feels that this species is a "social hibernator" in New Jersey, and that congregating does not merely reflect a lack of suitable hibernation sites.

Data on hibernation in the Michigan study was limited. No turtle activity was noted after mid-October, and in some years activity ceased by late September. Winter observations were lacking.

While New Jersey Wood Turtles were active by mid-April, the Michigan turtles were often not really active until mid-May. One male was found in late May emerging from between tree roots in a stream bank about two feet above the water-line; its carapace was caked with mud. This could have been a hibernation site, but it is not certain. Other specimens have also been discovered sitting within muskrat burrows and stream bank root systems in May, but again no proof exists that these represent hibernacula, though it is conceivable.

Populations

In northern New Jersey, suitable Wood Turtle habitat, with a proper balance of water, woods, and meadow, can produce an average population density of five adults per .4 ha (acre). However, they do not often distribute themselves evenly through the habitat, tending to concentrate in favored basking areas and places where food is accessible. During times when wild strawberries or other favored foods are available, concentrations of *Clemmys insculpta* may be as high as twenty per .4 ha (acre).

New Jersey populations of these turtles would usually occupy an area of around 40-120 ha (100-300 acres), perhaps due to forced congesting as a result of human land use patterns. However, populations of this size seemed the rule for areas of rural Sussex County, New Jersey, where habitat constraints were not as obvious; in these instances the populations might be considered "colonies", similar to the bogland colonies of *C. muhlenbergi* (Bloomer and Holub 1977), but less restricted due to the broader habitat tolerances of *C. insculpta.*

In Michigan, no estimate of density per ha was determined. The scattered disribution of the turtles and the nature of the terrain made any determination of population density difficult. The numbers of *C. insculpta* in this area would not approach the five per .4 ha (acre) figure determined for New Jersey populations, and it is almost certainly less than one turtle per .4 ha (acre) of habitat. As in New Jersey, the Michigan turtles may concentrate in limited areas at cerain times, such as for nesting in Spring. The number of turtles found in the study area is declining steadily, and some parts of the area where specimens were once common are now nearly devoid of resident turtles. Similar patterns are seen in New Jersey due to human development; the problem is discussed below ("Relations with Man").

In Michigan, *C. insculpta* was rarely seen to associate with other species of turtles, except in Spring when they would share the limited nesting areas. The two sympatric species were *Chrysemys picta belli* × *marginata* and *Chelydra serpentina.* In New Jersey, Wood Turtles seasonally shared their habitat with *Clemmys muhlenbergi, C. guttata, Chrysemys p. picta, Chelydra serpentina,* and *Terrapene c. carolina.*

Mating

Wood Turtles may exhibit mating behavior at any time during the months of activity, but it occurs with greatest frequency in the Spring (April-June) and Fall (September-November). Mating in wild *C. insculpta* was observed on eight occasions in Michigan — four times in the latter half of June, one on 4 August, and the remainder in early September. In New Jersey, mating in wild and captive specimens was noted on 20 occasions — five in April, nine in May, four in September, and one time each in October and November. The two apparent mating seasons may result from hormonal fluctuations, or possibly from the fact that males and females tend to congregate in aquatic habitats in Spring and Fall.

Mating usually takes place in shallow water, often on the submerged sloping edge of a stream or pond. Preliminary courtship may occur on land but terrestrial copulation is rare; a pair of Wood Turtles in New Jersey was observed in copulation about 3 meters from water. A captive pair also mated on dry land, when a large body of water was not available.

Most courtship occurs in the late afternoon. Males usually assume the initiative during mating. However, three instances of New Jersey females initiating courtship was witnessed; such an occurrence was previously reported by Fisher (1945). Both sexes may mate more than once in a season. The following summary of events in Wood Turtle courtship and copulation is based on the above-mentioned observations of wild and captive specimens:

Courtship often begins with the male approaching the female (usually in or near water) and "nosing" her shell, head, legs, and tail. A receptive female may do the same with the male. They then turn and face each other, extend their heads in a "nose-to-nose" position, and "bob" or "jerk" their heads simultaneously, or perhaps swing their heads in a side-to-side movement (see Knowlton, in Carr 1952, p. 122). This phase may last an hour or more, or be skipped altogether. A male confronting a reluctant female will nip the edges of her carapace, and will often try to chase her into the water where she cannot retract indefinitely in her shell. Mounting is accomplished in a short rush; the male anchors his claws under the female's marginals and nips continuously at her head and front legs to keep her from escaping his grasp. Another behavior sometimes observed is the male raising his shell by straightening his front legs and then dropping quickly, hitting the female's carapace with his plastron — often with a sound audible for several meters away. This may occur several times in succession. Ratner and Anderson (1978, unpubl.) watched a Wisconsin male perform a similar behavior after mounting a female; this male also made pulsating movements with the ventral side of his neck. (Note: Harding observed a young captive male "thumping" the ground with its plastron in front of another Wood Turtle, which it attempted to mount soon afterward. This thumping was accomplished by pushing downward with a front leg, raising the front of the body, then dropping suddenly; as with the male described above, this occurred in rapid succession, but with increasing tempo, and the front legs are used alternately, one at a time. This type of behavior may have other uses in *C. insculpta*— see the section on "Food and Feeding".)

A mounted male, after assuring the female's cooperation, will attempt copulation by curling his tail to bring the anal areas in contact and probing with his penis until entry is gained. Any movement by the female will cause the male to nip at her head and legs and tighten his grip on her shell. In deep water, the actions of the male may make it difficult for the female to get a breath; usually she can scuttle up the slope of the bank to shallower water. The turtles may remain in copulation for one to two hours. As this phase nears an end, the female will increase attempts to escape, and even bite at the male's head. Eventually the male will loosen his grip and slide off her carapace, withdrawing his organ.

There is considerable variation in courtship behavior between mating pairs of Wood Turtles. An audible "courting whistle" has been mentioned in the literature (Pope 1939, p. 97) but the authors have never heard a turtle of this species make any noise which could be interpreted as intentional; a specimen with apparent respiratory problems was heard to "whistle" when it exhaled!

Nesting

Most nesting in *Clemmys insculpta* takes place in June; the earliest observed nesting dates were 5 June for New Jersey and 12 June for Michigan. Late nesting dates were 7 July for New Jersey and 29 June in Michigan. The majority of observed nesting took place in the second and third weeks of June. Michigan females would delay nesting if cold, rainy weather intervened in mid-June, but the first sunny afternoon would precipitate a flurry of nesting activity, even with temperatures as low as 15.6° C (60° F).

In both studies, nesting invariably took place in the afternoon and evening hours, and often extended until well after dark. In Michigan, at least a partially sunny day was a prerequisite for nesting. This is possibly due to the female turtle's need to raise her body temperature by basking, in order to sustain activity into the cool evening hours. Pallas (1960) described a nesting of the Wood Turtle which took place in the early morning during a light drizzle. In the experience of the authors, this would represent an unusual circumstance for this species.

Physical requirements for natural nesting sites include (1) ample exposure to direct sunlight; (2) a sand or soil substrate that retains moisture, is well-drained and not subject to flooding; and (3) a reasonably workable substrate free of rocks and thick vegetation. Observed sites included high ground in meadows, elevated railroad beds and unimproved woodland roads, forest openings (due to fire or logging), and high banks bordering streams and rivers. Perhaps due to a lack of suitable nesting sites, female *C. insculpta* often congregate at "favored" nesting areas, and frequently share these areas with other species of turtles as well.

A description of a typical nesting sequence for a Michigan *C. inscupta* (based on 5 complete and a large number of partial nesting sequences observed) follows:

In the study area, thick forest vegetation limits nesting primarily to a few open sandy places — usually high sand banks along waterways. The turtles may have to move considerable distances from their home ranges to find suitable conditions, and often return to the same nesting area year after year.

1800 EST: A female Wood Turtle leaves the water and flips sand over her wet carapace with alternating motions of her front feet. She moves cautiously up to the flattened top of the beach; an area of open sand dotted with clumps of *Equisetum* species. Wandering in a seemingly random manner, she walks with neck extended, appearing to "smell" the sand as she moves. Every few feet she stops, raises her head, and begins digging motions with her hind legs. (This is interpreted as "testing" the substrate for suitable conditions.) The turtle continues this "walking, sniffing, and digging" behavior for over an hour; the resultant maze of tracks and "false starts" may later serve to confuse potential egg predators, although there is no evidence that this is the intention. Several times she seems to settle into digging an actual nest, only to abandon the site and continue wandering.

1930 EST: The turtle has chosen a nest site and is digging steadily with alternate movements of her hind feet, bracing her body with the front legs. At first she throws sand to the sides and rear, gaining depth, as the rear portion of her carapace slowly sinks and the front legs straighten and extend downward. This enables her to dig considerably deeper than the length of her hind legs as measured from the horizontal surface of the substrate. Formation of the egg cavity is accomplished by cupping the hind foot and lifting out "balls" of moist sand and dumping them at the sides of the nest. Each foot scrapes several times at the opposite side of the cavity before retracting with its "load" — then the other foot is inserted and the process is repeated. The final egg cavity is globular in shape with smooth sides.

2040 EST: The turtle stops digging and does not move for several minutes. She then inserts a hind leg into the nest, and simultaneously retracts her head and raises the hind end of her carapace as the first egg is expelled. A hind foot, claws curled inward, moves the egg to one side of the cavity. About two minutes later the second egg is laid, with the same head and shell movements. Again the "knuckles" of a hind foot are used to arrange the egg in the cavity. The process is repeated for each egg, the hind feet alternating in "egg arranging". The ten oval eggs have been carefully manipulated into a very tight globular cluster, and are in varying positions with relation to ground level (i.e. in vertical, horizontal, and diagonal positions).

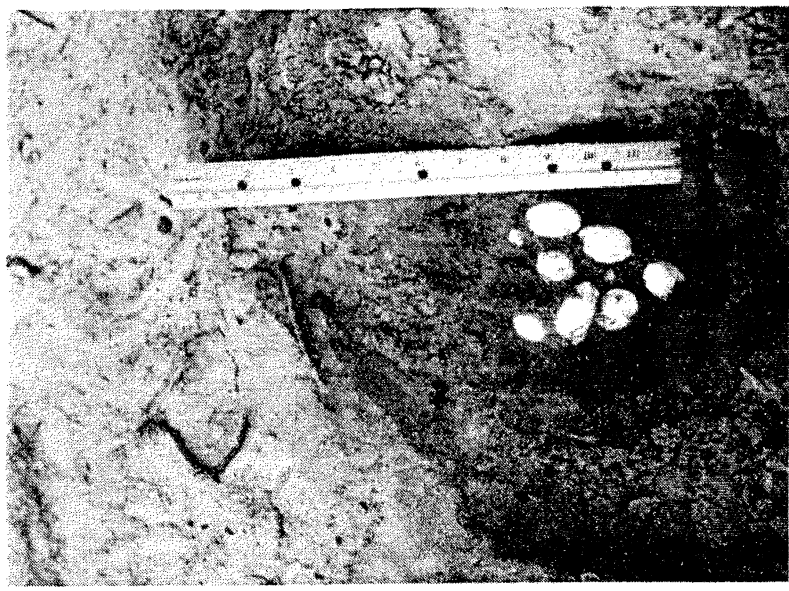
2100 EST: After a brief rest, the female turtle begins filling her nest by first scraping moist sand from the upper part of the egg chamber and packing it tightly around the eggs — in effect collapsing the walls of the cavity inward. (Some female Wood Turtles were observed to moisten the nest excavation with liquid from their bladders.) She then scrapes sand from the "spoil" piles around the nest and packs it down with the "palms" of her feet. The filling process, like the digging process, is accomplished by alternating use of only the hind feet. As the filled nest becomes level with the ground, she begins to change positions and "rocks" the hind part of her plastron over the nest — apparently to aid in smoothing and packing.

2145 EST: The female begins to move in a halting manner towards the water — her hind feet are still alternately scraping the surface of the sand, even though she is now about .5 meters from her completed nest. At 2155 she hesitates for a final moment, then walks over the edge of the bank and slides into the water.

Some nests of *Clemmys insculpta* are extremely well disguised (especially those made on uneven soil) while other nests (particularly those in sand) are fairly obvious until the substrate has been smoothed by the wind or rain. One female had left several small sticks and pieces of vegetation over the nest site — possibly an accidental consequence of the scraping motions of the hind feet.

Female *C. insculpta* apparently nest only once per year. Powell (1967) studied the ovarian cycle of the species in Nova Scotia and concluded that only one clutch of eggs was deposited in a season.

In Michigan, the number of eggs per clutch varied from 5 to 18, with an average of 10.36 eggs per clutch. The one clutch of 18 eggs was probably exceptional (Harding 1977), but clutches of 13 to 14 are common. In New Jersey, a range of 5 to 11 eggs per clutch was found, with the average nest containing 8 eggs. Ratner and Anderson (1978, unpubl.) reported a range of 8 to 17 eggs in a Wisconsin study.



Exposed wood turtle nest in study area (metric scale)

The oval eggs are white with an easily dented shell. They ranged in size from 32.5 mm × 23.5 mm (length × width) to 37.0 mm × 24.0 mm, with an average of 34.0 mm × 23.5 mm. These figures exclude an abnormal egg that was 47 mm long, and two abnormal eggs 30 mm long which all proved to be infertile.

Incubation / Hatching

The incubation period for eggs of *Clemmys insculpta* is variable, being influenced by environmental factors such as temperature. Incubation periods for eggs collected in Michigan and hatched in the laboratory at room temperatures ranged from 47 to 65 days (average 58.9 days). These eggs were buried in moist sand collected at the natural nest sites and kept in covered plastic boxes. Eggs of *C. insculpta* developed at slightly faster rates than eggs of other sympatric species collected from the same nesting areas and incubated under identical conditions; the incubation period for *Chrysemys picta belli* × *marginata* ranged from 48 to 69 days (average 61.8 days) and eggs of *Chelydra serpentina* took from 62 to 71 days to hatch (average 66.6 days). These findings are similar to those of Ewert (1971) who also noted the relatively rapid development of *C. insculpta* eggs.

Vandalism and predation prevented the determination of natural incubation periods for eggs left "in situ" in the Michigan study. A natural nest was discovered in the process of hatching on 4 September 1975 in late afternoon. One hatchling was still in the nest, another was just emerging from the single exit hole, and four others were found under surrounding vegetation and ground litter. Seven empty egg shells were recovered from the nest. Some of the hatchlings already had lost their nose caruncle ("egg tooth"), while others retained it. This may indicate an extended hatching period, since *C. insculpta* hatched in captivity lose their caruncles in from four to eight days after hatching.

In New Jersey, hatchlings appeared from mid-August to early October. Some hatching dates for natural nests were: 19, 27, 29 August; 9, 12, 22 September; and 17 October.

Gibbons and Nelson (1978) showed that hatchlings of many species of turtles practice delayed emergence from the nest; the young overwinter in the nest and emerge the following Spring. In the present Michigan and New Jersey studies, no evidence of delayed emergence in *C. insculpta* was encountered. Observations of hatchling behavior in the wild and in captivity, and the frequent finding of new hatchlings in late Summer and Fall, indicates that it is not the habit of this species to overwinter in the nest. In the Michigan study area, Spring flooding inundates many of the nesting sites, which could have serious implications for any hatchling turtles remaining in the nest. However, hatchling *C. insculpta* were always found in or very near aquatic habitats, and it can be assumed that they hibernate in these situations.

Hatchlings from Michigan had a positive reaction to bright light and a strong basking instinct. At night, they "dig in" under overhanging objects or burrow into sand in shallow water. They feed readily within a day or two after hatching, preferring animal food. Earthworms always initiated a vigorous feeding response. Most refused fruit or other plant food until reaching an age of several weeks or months. The yolk sac is usually fully absorbed before emergence from the nest, or is only a few millimeters in diameter and absorbed within a day or two.

Food and Feeding

Clemmys insculpta can be considered an opportunistic omnivore. They consume a wide variety of plant and animal foods, and are quick to take advantage of seasonal availability of certain foods. Collectively the authors have noted the following items being consumed by *C. insculpta* under natural or semi-natural conditions: blueberries (*Vaccinium* sp.), black and raspberries (*Rubus* sp.), strawberries (*Fragaria* sp.), leaves (including *Salix and Alnus* sp.), grasses, algae, molluscs, insects, earthworms, tadpoles, dead fish, and newborn mice. In New Jersey, evidence was found that Wood Turtles may occasionally eat the eggs or young of low- and ground nesting birds. The same dexterity that permits this species to reach hanging berries would presumably allow them to reach a low bird's nest. Vertebrates are certainly not important food items for *C. insculpta,* but their occasional use serves to illustrate the opportunistic nature of this turtle's feeding habits.

Captive Wood Turtles accept many different foods; a partial list of foods eaten by captive specimens maintained by the authors would include: fruits (bananas, melons, apples, etc.), leafy vegetables (Romaine lettuce, spinach), cooked and raw chicken and beef heart, liver, canned dog food, "pancakes", scrambled and hard-boiled eggs, and canned fish. In addition, more natural foods were supplied when available. Hatchlings prefer animal foods, but begin to accept plant foods during their first year; in captivity their diet should be supplemented with vitamins and a calcium source.

Previously published studies on Wood Turtle diets in nature generally support the above field and laboratory observations. Surface (1908) examined the stomach contents of 26 Pennsylvania specimens. He found that 76% of the turtles had eaten plant foods, and 80% had consumed animal matter, largely invertebrates (insects, snails, worms, etc.). Two of the stomachs contained bird remains, which the author attributed to scavenging of dead material.

Lagler (1943) studied the stomach contents of nine adult specimens from the western Lower Peninsula of Michigan. Plant remains, insects, molluscs, and earthworms predominated in his analysis. Lagler concluded that the Wood Turtle "can be of no concern to fish management".

Clemmys insculpta has largely innocuous feeding habits from the human point of view. In a few areas this species, along with the Box Turtle *(Terrapene carolina),* is sometimes considered a garden pest due to occasional raids on fruit and vegetable crops, and may even be destroyed for this reason. Devising a way to exclude these creatures from a garden should not be difficult, however, and simply collecting and moving them from a problem area would seem to take little more energy than killing them!

Wood Turtles can swallow their food either in or out of water. They make frequent use of the front feet and claws in manipulating food items. Allard (in Pope 1939, p. 99) described the actions of a specimen utilizing its claws to pull down strawberry plants to reach the ripe berries.

Interestingly, a specific behavior used by the turtles during courtship may also be used for feeding. This was the "plastral thumping" (described above under "Mating"), where the front feet alternately lift, then drop the front part of the shell with increasing rapidity. Zeiller (1969) described a captive Wood Turtle which exhibited this behavior while foraging. This turtle's thumping efforts apparently resulted in the appearance of earthworms at the surface of the ground, which were promptly consumed. Zeiller reported that the turtle captured eight worms in twenty minutes with this method. One might think this a curious "quirk" behavior or an isolated incident, except that another observer (B. McClelland, pers. comm.) noted similar occurences in captive *C. insculpta* in an outdoor pen; he noted the behavior both in connection with courtship activity and foraging. One can only speculate whether these turtles have adapted an instinctive courtship behavior to feeding, or vice versa, and whether this behavior is used to any degree by wild turtles. Further behavioral investigations of *C. insculpta* may better clarify this subject.

Physical / Mental Capabilities

In a frequently cited study, Tinklepaugh (1932) decided that *Clemmys insculpta* tested in a laboratory maze exhibited the learning abilities of a rat, which, as Carr (1952) pointed out, is quite good for a turtle. This is perhaps not surprising, since an animal that lives in such a wide variety of habitats, as *C. insculpta* does, must be exposed daily to an equally wide variety of stimuli to which it must successfully respond. Carr (1952) mentions that terrestrial turtles are often described as mentally superior to aquatic species. If so, then a species that performs well in water or on land might have wider capabilities than one primarily confined to a single habitat.

Whether or not the Wood Turtle could be called "intelligent" would depend on one's definition of the word. They are able to quickly adapt to environmental changes. A juvenile, newly captured in an aquatic situation, was placed on a table about one meter high; it promptly walked off the edge and fell to the ground. When again placed on the table, it approached the edge, looked at the ground — then reversed itself and walked in the opposite direction. It refused to go over the edge even when "teased".

Many workers have remarked that specimens of *C. insculpta* have learned the pertinent parts of human daily routine, and could find their way around a house. Bloomer kept a male which learned that the kitchen was the source of food and the bathroom was where it could soak in the tub. Perhaps more impressive was this turtle's ability to negotiate a center hall stairway — in both directions! Wood Turtles are noted for their dexterity; Ernst and Barbour (1972) saw one ascend a chain-link fence.

C. insculpta can swim well, although they are less skillful than more aquatic species. The majority of specimens would quickly dive off a basking log when approached by land or water, though a few specimens tended to hesitate long enough to facilitate capture. Once captured and marked, however, they became far more wary — a fact which undoubtedly prejudices the recapture rate. It is unclear whether these turtles are alerted more by the sense of sight, hearing, or feeling of vibrations. Informal observations indicate that Wood Turtles have good vision, at least for distances up to around two to three meters, and can certainly detect movement at even greater distances. They seem strongly attracted to the color red when feeding, based on observations of captive specimens. Wever and Vernon (1956) found that *C. insculpta* were about as sensitive to sounds as a cat. As in most turtles, this species has a good sense of touch, and as pointed out by Carr (1952), the delicate way a female arranges her unseen eggs in her nest attests to a fine tactile sense.

Natural Enemies

Aside from their most important enemy, Man, Wood Turtles have a host of natural enemies. The eggs and young suffer a high rate of predation. This is confirmed by observations in both study areas. Chief among the egg predators are Raccoons *(Procyon lotor)* and Striped Skunks *(Mephitis mephitis)*, which have an uncanny ability to find and destroy turtle nests. In the Michigan study area, the female turtles are forced to congregate in limited areas for nesting, providing a seasonal bounty for the large Raccoon population. The loss of eggs has approached 100% in some years, other than those collected for artificial incubation. The size of the local Raccoon population has greatly increased in recent years, perhaps due to this animal's known compatability with human activities. Notable, but less important nest predators were Ravens *(Corvus corax)* and Coyotes *(Canis latrans)*.

Predators on hatchlings and juveniles include Raccoons, Skunks, feral cats and dogs, Opossums *(Didelphis marsupialis)*, various birds, Snapping Turtles *(Chelydra serpentina)*, and large fish. The stomach of a Northern Pike *(Esox lucius)* contained a hatchling Snapping Turtle, indicating that young Wood Turtles could also be preyed upon by these fish.

Adult Wood Turtles are not immune to predation. It was noted that 9.7% of Michigan specimens marked were missing at least one limb, and over 2% had two legs missing. Many of these mutilated turtles were undoubtedly the victims of predation. One female was discovered on a stream bank bleeding from the stumps of both front legs; raccoon tracks were found in the immediate vicinity. When attacked, a Wood Turtle will withdraw its head and limbs, using the thickly scaled front legs to protect the head. A narrow-nosed predator like a raccoon would have no trouble in gnawing the turtle's legs. One other possible cause of limb loss in these turtles could be the "leg-hold" traps set for fur-bearing mammals, which are often set in places frequented by *Clemmys insculpta*. No.

direct evidence for this was found in the present studies, but the subject may warrant further examination.

This species is victimized by a number of internal and external parasites, summarized by Ernst and Barbour (1972). The incidence of leeches *(Placobdella parastica)* has been noted above. A newly captured *C. insculpta* in Michigan passed a number if unidentified roundworms in its feces, and a nesting female had many blood-sucking flies biting its head and neck.

Relations with Man

Like many species of wildlife, *Clemmys insculpta* suffers greatly from human activities. In past years considerable numbers were sent to market for food, particularly in the East. More recently, Wood Turtles have been collected for biological supply houses (especially in Wisconsin) and for the pet trade. Both of these activities have reduced turtle populations in certain areas.

In the northern Michigan study area, the Wood Turtle population has been declining over the course of observations, particularly in sections of the area where human activity is concentrated. While the habitat has remained unchanged, the use of the area for recreational purposes has increased, seemingly accompanied by an increase in the raccoon population. One notable and deplorable cause of mortality in adult turtles is the shooting of basking individuals by ignorant or bored persons with rifles, who seem to find a living target "more interesting" than an inanimate object. While some fishermen may mistakingly feel that the turtles are competitors for game fish, most of the shooting is seemingly done for "sport" — although the person who shot a three-legged female on her nest at "point-blank" range could hardly be called a "sportsman". Considering the low reproductive rate of *C. insculpta* any increase in mortality of mature animals by human activities can only result in continued decline.

Habitat loss and degradation are probably the greatest threats to the Wood Turtle. This species was common in many parts of northern New Jersey in the 1950's. Today it is almost totally eradicated from eastern and north-central New Jersey due to urban development, and is declining rapidly in much of northwestern New Jersey, southeastern New York, and eastern Pennsylvania. While able to maintain itself in farming areas and on public lands, this turtle suffers constant losses due to highway fatalities and direct destruction and collecting by people. Large numbers are killed by automobiles every year, often accidentally, but some drivers have been witnessed to intentionally swerve to hit them. In the eastern parts of its range, urbanization, coupled with dredging, damming, and stream channelization, is the most imminent threat to *C. insculpta* populations. In New Jersey, public areas such as the Delaware Water Gap National Recreation Area are keys to the species' survival.

Habitat degradation may be as critical as habitat loss for these animals. *Clemmys insculpta* is rarely found in heavily polluted waters and can be considered a pollution-intolerant species. Little has been published on the sensitivity of turtles to pesticides. Marked decreases were observed in Wood Turtle numbers in parts of New Jersey subjected to heavy spraying of pesticides for Gypsy Moth control (especially in the late 1950's and 1960's) — even where habitats remained essentially unchanged. Although more quantitative studies are needed, observations do suggest a relationship between pesticide usage and reptile population declines. Minton (1972) noted that insectivorous lizards, snakes, and amphibians have decreased in Indiana at a more rapid rate than non-insectivorous species, and that decreases were more marked in areas of heavy pesticide use. Clark et. al. (1971) noted that oviparous species of snakes in a heavily sprayed area of Texas were practically eliminated, while "live-bearing" species fared better. It would come as no surprise to find that highly insectivorous, oviparous turtles are affected by pesticide usage. This problem needs further study and documentation.

Conservation

The Wood Turtle has long been protected by law in New York State. Wisconsin added this species to its list of protected Endangered Species in 1975, while Michigan has listed the species as "Rare", and has initiated a review of its status in the State. New Jersey presently restricts the sale of turtles by the pet industry.

While the authors would recommend that all States and Provinces within the range of *Clemmys insculpta* consider granting legal protection to this turtle, the best hope for the species lies in preservation of unpolluted habitat protected from development and over-use by people. Public education

is needed to sensitize people to the value and ecological role of the Wood Turtle in its environment. Amateur and professional herpetologists can help by sharing their knowledge and providing a good example. It is undoubtedly time to discontinue the collecting of this and other less common species for use as "pets". Serious inroads are still being made on local turtle populations by persons collecting to supply the pet industry. There is a role, however, for those who maintain captive *C. insculpta* for organized research and breeding programs, provided that any necessary collecting be done with care and good judgment.

Clemmys insculpta as a species has certainly declined in recent years, but is still locally common in parts of its range where suitable habitat still exists. We now have the opportunity to take measures to assure the continued existance of the Wood Turtle before the situation becomes as critical as it has for so many other species.

Captive Breeding

Captive breeding can be a useful tool for learning more about Wood Turtle behavior and for providing stock for reintroduction into depleted habitats. A true captive breeding program is a self-perpetuating system, independent of wild sources for eggs or breeding stock after the initial introduction. The facilities used must provide everything needed to keep turtles healthy and stimulated to breed.

Anyone desiring to breed *C. insculpta* should plan on an outdoor facility where turtles will have sufficient room and exposure to seasonal changes in temperature and photoperiod. It may be possible to breed *C. insculpta* indoors, but a large enclosure would be needed, and proper variations in light and temperature would have to be duplicated. Tryon (1978) reported on attempts to breed various aquatic chelonians at the Fort Worth (Texas) Zoo. Although some of the species discussed were of tropical origin, Tryon still felt that variations in temperature and photoperiod were essential in stimulating turtles to breed. For the "cold-adapted" Wood Turtle, it seems probable that captive reproduction may depend on allowing these animals a normal hibernation period. B. McClelland (pers. comm.) kept several healthy adult *C. insculpta* in an indoor enclosure for a number of years; however, they did not breed or lay fertile eggs before being placed in a large outdoor enclosure where they could hibernate over the winter months.

Facilities for Wood Turtle breeding should include basking areas and cover for thermoregulation; open, sunny nesting areas, pools for swimming and mating, and protected areas for hibernation. The pools should have gradually sloping sides. A steep-sided pool is a death trap for females during copulation, since they must be able to creep up the bank for air or they will drown.

Over-crowding should be avoided, and a proper sex-ratio will help avoid aggressive encounters between males. A ratio of one male to three females has proven successful.

It is usually wise to remove all deposited eggs to artificial incubation containers, thus avoiding losses to insects, predators, or other problems. One method of incubation used successfully was described above. Hatchlings can be raised indoors for the first year to afford protection from predators and assure a good "head start". Any young not needed for the breeding program can be released into the wild, preferably near the home area of the parent turtles, to augment natural populations. *C. insculpta* hatchlings are best raised in semi-aquatic tanks with a large, deep (50 to 60 mm depth) swimming area, and a basking area. Use of wide-spectrum fluorescent lighting (such as the "Vita-lite" by Duro-Test Corp.) seems to help stimulate growth. A varied diet supplemented with calcium and a multiple vitamin preparation is advised.

Adults and older juveniles also require a varied diet (see "Food and Feeding"). Food should be offered several times per week. It is foolish to assume that turtles will find sufficient wild food in any enclosed habitat; food should be provided to any captive group of turtles regardless of the size of the enclosure.

Serious efforts at captive propagation will provide valuable knowledge about *Clemmys insculpta* to augment studies of natural populations, and help in efforts to conserve this species. The real future for these animals lies, however, in our determination to preserve their natural habitat, which must be the primary goal for all admirers of the "sculptured turtle".

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Photographs by J. H. Harding

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