# Some Ecological Parameters of the Wood Turtle, Clemmys insculpta, in Southeastern Pennsylvania

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ABSTRACT. - The wood turtle, Clemmys insculpta, was studied in Lancaster County, Pennsylvania, USA, from May 1965 to August 1988. Eighty-eight individuals were captured and marked, and the estimated population size (Shumacher-Eschmeyer) was 159 individuals. Density for the total 240 ha of available habitat was 0.66 turtles/ha, but density for the available riparian habitat where most turtles occurred was 4.42 turtles/ha. Specimens located were 44.3% adult males, 31.8% adult females, and 23.9% juveniles. The sex ratio of 1.39:1 (males:females) was not significantly different from 1:1; the adult to juvenile ratio was 3.19:1. The annual cycle of activity lasted from early March through November. Mating occurred in the spring and fall, and nesting took place in June. Male/ male aggressive behavior was observed throughout the year. Foraging took place from mid-April to early October, and observed feedings were terrestrial and aquatic with similar frequency. Prey taken was entirely animal: earthworms, leeches, lepidopteran caterpillars, fish — probably taken as carrion (Catostomus commersoni, Cyprinus carpio), and tadpoles and adults of the green frog (Rana clamitans). Daily activity was almost entirely diurnal, with only nesting females active into the evening. The period of diel activity shifted from early afternoon toward morning as spring progressed to summer, and then reversed back to afternoon as summer moved to fall. Daily straightline movements were usually less than 100 m, but some foraging females and males moved as far as 410 m and 358 m, respectively. During the spring mating season males traveled greater daily distances than at other times of the year. Some females searching for nest sites moved 900-1000 m. The incidences of algal colonization, leech parasitism, shell abnormalities, and injuries were also recorded.

# KEY WORDS. - Reptilia; Testudines; Emydidae; *Clemmys insculpta*; turtle; ecology; population density; activity; diet; Pennsylvania; USA

The wood turtle, *Clemmys insculpta*, has become a desired species in the pet trade. This, along with habitat alteration and destruction, has resulted in a general decline in populations throughout its range, and has caused most states to list the turtle as threatened or endangered and for it to be placed on CITES Appendix II.

Complete documentation of the local status of wood turtles and formulation of adequate conservation policy will require much further field study. Such information is needed from latitudes throughout the range of the species. The data herein were gathered during a 23-year study (1965-88) of a small wood turtle population in Lancaster County, Pennsylvania. This paper summarizes some aspects of wood turtle ecology and compares them to published data from other populations of C. insculpta and to data published on the spotted turtle, Clemmys guttata, and bog turtle, Clemmys muhlenbergii, from the same Pennsylvania locality (Ernst, 1976, 1977). Data on the thermal ecology and growth of the Pennsylvania wood turtle population have been previously published (Ernst, 1986; Lovich et al., 1990), and reproduction will be addressed in a separate paper (Ernst and Laemmerzahl, in prep.).

#### METHODS

*Clemmys insculpta* was studied from May 1965 until August 1988 in the vicinity of White Oak, Lancaster County, Pennsylvania (see Ernst, 1971, for a description of the study area). Research occurred year round from May 1965 to August 1967, but in later years most study was conducted from the beginning of March to 30 June. Random observations were also made during other months of the year, particularly during July–September. Field study was less intense during the winter months, which coincide with the winter dormancy period for the wood turtle at this site (Table 1).

Wood turtles were found in a variety of aquatic and terrestrial habitats: streams (to 150 cm depth), shallow brooks (10-30 cm deep), shallow marsh waterways (10-25 cm), flood plain pools (to 120 cm), debris-covered flood plains, cattle pastures, cultivated fields, and a small strip of woodland. Most turtles were either collected by hand or with a dip net, but one individual was captured in a baited hoop net. Data recorded from each capture included: date, time, place of capture (recorded on a detailed map of the area), distance to the nearest waterbody, cloacal and environmental temperatures (see Ernst, 1986), sex, age, ectoparasites, carapacial algal colonies, injuries, scute abnormalities, and behavior. Straight-line measurements were taken of the maximum lengths of the carapace, plastron (front to back edge), and abdominal scute, as well as any discernible growth annuli on the abdominal scute and the second right pleural scute (scute terminology from Ernst et al., 1994) to the nearest 0.1 mm with dial calipers. Individuals were sexed using the characters described by Ernst et al. (1994), and aged by the method of Sexton (1959). Distances from water were measured with a metric tape, or taken from a detailed topographic map. The carapacial marginals were notched for future identification using the coding system of Ernst et al. (1974).

## RESULTS AND DISCUSSION

Annual Activity Cycle. — Active wood turtles were found at White Oak in all months except December-February, when individuals were in aquatic winter dormancy (Table 1). Sixteen (66.7%) of 24 records in March also pertained to dormant or semi-dormant individuals. Most active wood turtles (147, 58.3%) were found in April-June. Surface activity continued through the hot months of July and August, although 3 of 53 (5.7%) records were of individuals inactive in the soft bottom of a waterway, and 15 (28.3%) were occupying terrestrial forms. Movements, basking, and foraging continued until November, but with decreasing numbers of individuals (Table 1). Females basked more frequently from late April to early June (Ernst, 1986), perhaps to raise body temperature to enhance egg development. Males basked throughout the year. This annual pattern more closely resembles that of C. muhlenbergii (Ernst, 1977) than that of C. guttata (Ernst, 1976).

The earliest date for a surface active individual (basking) was 11 March, and the latest 28 November (walking in a pasture), a maximum annual activity period of 263 days. Based on the first and last observations of turtles foraging or ingesting prey, feeding first began when cloacal temperatures reached 15°C on 18 April, and ceased after 19 September (cloacal temperature, 19°C). Minimum water and air temperatures of feeding *C. insculpta* were 14.2 and 17.2°C, respectively (Ernst, 1986).

The wood turtle's annual surface activity period reported here for southeastern Pennsylvania is longer than that reported for more northern populations — late April or May to early October in Michigan (Harding, 1991), early March to late November in northeastern New Jersey (Farrell and Graham, 1991) — but not as long as that of *C. insculpta* at the southern extreme of the range in northern Virginia — March to January (Ernst and McBreen, 1991).

Courtship attempts or copulation were observed from 11 March until 31 May, and on 10 October. Nesting was only observed from 4–19 June. Hatchlings only emerged in the fall (14 September – 11 October).

The annual activity period of adult males and females was essentially the same, but active juveniles were not found until May, and 50% of juvenile records were from August– October. This late summer/fall period included the time of hatching, and eight (61.5%) of the 13 juvenile records for this period were of recently emerged hatchlings. No hatchlings were observed to overwinter in the nest and emerge the following spring.

New shell growth was usually noticeable in mid-May as a lighter zone around the border of carapace and plastron scutes about four weeks after feeding commenced in mid-April, and continued until about 1 October. The normal growth period at White Oak was from 15 May to 30 September, or approximately 168 days. Additional data on growth are presented by Lovich et al. (1990).

Daily Activity Cycle. - Wood turtle activity was almost entirely diurnal (Table 1). Although observations at the study site continued after sundown, especially during the June nesting season, only one nesting female was found once darkness had fallen (2130 hrs), and she had begun excavating before dark. The latest diurnal observation was of a male at 1945 hrs on 13 August entering a pre-existing form beneath a pile of driftwood. The earliest morning records were at 0645 hrs on 12 July (a female eating an earthworm) and 0750 hrs on 5 July (a basking female). These records set a minimum daily summer activity period of 12-13 hrs since both females had been active before detection. Table 1 shows that most daily activity occurred in the late morning or early afternoon in the spring. As the year progresses and the environment warms, White Oak wood turtles shift their activity patterns toward the morning hours, and after summer return to a more midday activity pattern (a pattern also followed by C. guttata and C. muhlenbergii at White Oak).

Although a similar shift in the daily activity pattern occurs in Virginia wood turtles (Ernst and McBreen, 1991),

Time (hrs)	J	F	Μ	А	Μ	J	J	A	S	0	Ν	Totals
0700	0	0	0	0	0	0	2	1	0	0	0	3
0800	0	0	0	1	7	8	11	12	0	0	0	39
0900	0	0	1	2	8	11	4	7	1	0	0	34
1000	0	0	0	6	8	17	2	1	3	1	0	38
1100	0	0	1	11	11	6	2	3	3	1	0	38
1200	0	0	6	10	5	8	1	0	2	1	0	33
1300	0	0	8	5	3	3	0	0	2	3	1	25
1400	0	0	5	6	5	1	0	0	4	4	0	25
1500	1	0	1	1	0	0	2	0	0	0	0	5
1600	0	1	2	0	1	2	0	0	0	0	0	6
1700	0	0	0	0	0	0	0	0	0	0	0	Ő
1800	0	0	0	0	0	0	1	0	0	0	0	1
1900	0	0	0	0	0	0	3	1	0	0	0	4
2000	0	0	0	0	0	0	0	0	0	0	Ő	0
2100	0	0	0	0	1	0	0	0	0	Ō	õ	ĩ
Totals	1	1	24	42	48	57	28	25	15	10	1	252



Figure 1. Population structure of Clemmys insculpta (n = 88) at White Oak, Pennsylvania.

this contrasts with that reported for captives in Illinois and the populations in northwestern New Jersey and New Hampshire, where most daily activity occurred between 1000 and 1600 hrs (Meritt, 1980; Farrell and Graham, 1991; Tuttle, 1996). Wood turtles in New Hampshire were most active from 1400–1500 hrs in early afternoon (Tuttle, 1996).

Feeding and movements at White Oak occurred during all active hours when environmental temperatures were suitable (see Ernst, 1986). Basking wood turtles were only found before 1200 hrs (0645-1140). Courting and mating took place in the morning from 0850-1200 hrs at water depths of 10–125 cm. Five of the six observed nestings occurred after 1640 hrs, with one occurring at 1100 hrs.

During the early spring and fall, wood turtles spent nights in the water either partially covered by substrate, sitting on the bottom at a depth greater than 60 cm, or in muskrat burrows. During the summer, wood turtles spent the night in terrestrial forms under driftwood, downed trees, or in leaf litter under brush. From May to September, turtles basked after awakening until sufficiently warmed, and then foraged or made long distance movements. Activity generally ceased and turtles sought refuge once the warmest hours of midday were reached. Most remained in their refuges (usually forms, but in one case a water-filled cow hoofprint) until the next morning.

*Population Dynamics.* — A total of 88 individuals were captured a total of 252 times during the period 1965–88 (Table 1, Fig. 1). The estimated size of the wood turtle population at White Oak was calculated with the "weighted least squares" method of Shumacher and Eschmeyer (1943), recommended by Turner (1977). This method has the advantage of eliminating bias caused by unequal recapture rates, as it is based on a series of collecting periods rather than only on two, as in the Petersen Estimate (Begon, 1979). Data from a series composed of the last 30 collections of *C. insculpta* between 1983 and 1988 were used to calculate the population size at White Oak, and the population size limits were determined by adding and subtracting two standard

errors (95% confidence level) from the population size (Shumacher and Eschmeyer, 1943). The population was estimated to be 159 wood turtles, with a possible range of 103–215 individuals.

The proportion of recaptures to the cumulative number of wood turtles marked did not increase as more turtles were marked (Spearman's coefficient of rank correlation, rs = 0.469, p > 0.05). Sixty-one percent (54) of the 88 *C. insculpta* marked were recaptured at least once. The mean number of captures per recaptured turtle was 4.07. Fifty (92.6%) recaptured turtles were taken 2–6 times: 14 (25.9%) were recaptured twice, 11 (20.4%) three times, 9 (14.8%) four times, 11 (20.4%) five times, and 5 (9.2%) were recaptured six times. Two (3.7%) females were each captured ten times. Two (9.5%) of the 21 wood turtles captured only as juveniles (mostly hatchlings) were recaptured, but only once each. An additional 12 individuals first recorded as hatchlings or juveniles, were later recaptured as adults.

Interval between recaptures gives a rough estimate of survivorship. The 14 turtles first recorded as juveniles averaged 6.93 (1-17) years between first and last capture. One female caught at 8 years of age was last caught 17 years later at age 25. A male first caught at age 9 was last taken 14 years later at age 23, and another female caught as a hatchling was last captured at age 14. Adult longevity, based on recapture interval averaged 6.82 (1-20) years for males and 6.47 (1-17) years for females. A Chi square test revealed no statistical differences between the mean duration between captures of juveniles and those of either adult males or adult females. The oldest male wood turtle was first captured when 22 years old in 1965 and last captured at age 42 in 1985. Other males of known age survived to 39, 36, 35(2), and 31 years, respectively. Known age females survived to ages 37, 29, and 28(2) years, and one female that had at least 30 annuli in 1969, but could not be aged more accurately, was last captured in 1985 at an age of at least 46 years. The age structure of the White Oak wood turtle population is presented in Table 2.

**Table 2.** Age structure of the White Oak population of *Clemmys insculpta* (0 = hatchling).

Age (yrs)	First Capture (%)	Total Captures (%		
0	8 (9.1)	8 (3.2)		
1-5	14 (15.9)	16 (6.3)		
6-10	13 (14.8)	35 (13.9)		
11-15	9 (10.2)	29 (11.5)		
16-20	23 (26.1)	67 (26.6)		
21-25	16(18.2)	49 (19.4)		
26-30	5 (5.7)	25 (9.9)		
31-35	0 (0.0)	18(7.1)		
36+	0 (0.0)	5 (2.0)		
Totals	88	252		

A total of approximately 240 hectares of riparian and other habitats were available to wood turtles at White Oak (as determined from topographic maps), which translates to a density of 0.66 turtles per hectare, based on the estimated population size of 159 individuals. However, almost all turtles were captured in limited riparian habitat measuring only 36 hectares, which translates to a density of 4.42 turtles per hectare. This is much below the estimated density of 39.5–79.1 *C. guttata* per hectare at White Oak (Ernst, 1976). It is also less than the 9.9–12.5 per hectare of New Jersey wood turtles (Harding and Bloomer, 1979; Farrell and Graham, 1991), and 19.1 turtles per hectare recorded in West Virginia by Niederberger and Seidel (1999).

The White Oak wood turtle population, as sampled, was composed of 39 (44.3%) adult males, 28 (31.8%) adult females, and 21 (23.9%) juveniles. The adult male to female ratio was 1.39:1, and not significantly different from 1:1 (Chi square test, 1 d.f.). Farrell and Graham (1991) reported a male to female ratio of 1.6:1 for their New Jersey population, and Kaufmann (1992), Tuttle (1996), and Niederberger and Seidel (1999) found no significance differences in the number of males to females in their respective populations of C. insculpta. However, in large populations individuals identified as females tend to predominate, and Lovich et al. (1990) thought this possibly due to the inclusion of some males, which mature later and at a larger body size than females, in the "female" category. Brooks et al. (1992) reported a female biased sex ratio of 0.38:1 in Ontario, and Harding (1991) recorded a 0.82:1 male to female ratio in his Michigan population.

The White Oak adult to juvenile ratio was 3.19:1. The adult: juvenile ratio in Farrell and Graham's (1991) population was 1.2:1, where 42% of the individuals were 1–8 years old. In West Virginia, 46% of the wood turtles found by Niederberger and Seidel (1999) were juveniles. In addition, both Harding (1991) and Ross et al. (1991) reported their populations in Michigan and Wisconsin, respectively, were composed mainly of adults. The White Oak site is surrounded by agricultural tracts, and Saumure and Bider (1998) found 23% fewer juveniles and shell injuries were more prevalent in adults at an agricultural site compared to an undisturbed site in southern Québec. They concluded that agricultural development reduces growth and recruitment in wood turtle populations (possibly by subsidizing predation), and this may also have been true at White Oak.

Social Interactions. — Adult male C. insculpta are known for their aggression towards each other (Dinkins, 1954; Harding, 1979; Harding and Bloomer, 1979; Brewster and Brewster, 1988; Kaufmann, 1992), and in captivity male wood turtles are often agonistic towards other species (Chrysemys picta, Emydoidea blandingii, Terrapene carolina, Trachemys scripta; pers. obs.). Male:male aggressive behavior was observed 31 times at White Oak. It consisted of one male chasing another, biting the hind quarters, mounting the carapace and holding tight with all four feet, and biting at the head and forelimbs of the turtle beneath. Occasionally the upper male raised up and slammed his plastron down onto the carapace of the lower male. Such behavior has been described in greater detail by Kaufmann (1992). Aggressive behavior was common in the spring (14 observations) and fall (8 observations). Aggressive behavior is usually thought to be associated with reproduction (Farrell and Graham, 1991), and is similar to courtship behavior (Ernst et al., 1994). However, eight aggressive male:male encounters were observed during the summer, and another in December, both times not considered prime mating periods.

Movements. — White Oak C. insculpta usually moved between recaptures (Table 3). Daily straight-line movements were normally less than 100 m; however, foraging females moved up to 410 m and males up to 358 m (straightline distances represent the minimum distance traveled by a wood turtle between captures; time interval 1-415 days). In Michigan, most recaptured wood turtles were found less than 305 m from the original capture point, and only two individuals ever traveled over 800 m from the first capture point (Harding, 1991). Strang (1983) reported a mean daily minimum travel distance of 108 m (139 m on rainy days, 110 m on dry days) in central Pennsylvania. In contrast, a radioequipped male C. insculpta in northern Virginia moved 1.0 km in 24 hours from his hibernaculum to his normal summer home range (Ernst and McBreen, 1991), and Tuttle (1996) recorded movements of over 900 m in one day by New Hampshire C. insculpta.

White Oak wood turtles did not stray far from water; mean distance from a waterway of those individuals captured on land was 15.7 m (range 0.5–250 m), and 95.2% of

Table	3.	Straight-line	distances	(m)	between	captures	of	wood
turtles	(ti	me intervals =	= 1-415 da	iys).		(1921)		

		Distance Between Captures (m				
Cohort	n	Mean	Range 25-154			
Juveniles	2	89.5				
Males	85	83.4	0-358			
Females	85	91.7	0-1000			
	76*	67.5	0-410			
Nesting	9	296.2	10-1000			
All	172	87.6	0-1000			
	163*	76.1	0-410			

\*Excluding nesting excursions.

the captures (excluding those of nesting females) were within 40 m of a waterway. During the mating season, males averaged greater distances moved than before or after mean distance between captures was 121.2 m (range 75.0– 333.0 m). During the nesting season, most females traveled long distances while searching for suitable sites (Table 3); two such excursions by females were 900 and 1000 m, respectively. By midsummer 12 individuals had traveled several hundred meters from their aquatic overwintering sites (mean 312 m, range 5–410 m), but 49.5% of the captures of individuals whose hibernacula were known were within 100 m of that site.

Reported home ranges of wood turtles in other populations are: 1) central Pennsylvania, an average of 5.0 ha for adult males, and 3.3 ha for adult females (Kaufmann, 1995); 2) central Pennsylvania, mean 447 m (Strang, 1983); 3) New Hampshire, 5.8 ha for adult males, 3.9 ha for adult females (Tuttle, 1996; Tuttle and Carroll, 1997); 4) Wisconsin 0.08– 0.41 ha for adult males, 0.27–2.2 ha for adult females (Ross et al., 1991); and 5) Ontario, Canada, mean home range 24.3 ha (range 1–115 ha) (Quinn and Tate, 1991).

Foraging Behavior and Diet. - Observations of actual feeding occurred from 8 April to 13 July. Sixteen wood turtles were found while ingesting prey, eight on land and eight in water. All feeding on land took place at distances of 3-17 m (mean 10.6) from the closest water. Feeding in water occurred at depths of 2-100 cm (mean 28). No plant materials were seen to be ingested, although other researchers have listed plants among foods eaten by the wood turtle (Surface, 1908; Strang, 1983; Farrell and Graham, 1991; Niederberger and Seidel, 1999). Earthworms were eaten during five of the terrestrial observations, with slugs, a caterpillar, and an adult green frog (Rana clamitans) being consumed once each. Prey ingested in aquatic settings included earthworms twice at depths of 2 and 10 cm, respectively; unidentified leeches twice at 10 and 13 cm, respectively; fish three times at 4 cm (unidentified fish remains), 70 cm (Cyprinus carpio), and 100 cm (Catastomus commersoni); and a frog tadpole (Rana clamitans) at 15 cm depth. The fish consumed were probably discovered as carrion. The earthworms may have been initially captured on land and carried into the water. The observation at 2 cm water depth was in a puddle in a cattle pasture, and that at 10 cm was along the shoreline of a brook.

Wood turtles displayed foraging behavior on 25 additional occasions dating from 15 April to 4 October. Hunting turtles walked slowly on land and looked into or poked their heads into sedge tussocks, or along the base of bushes, logs, or piles of driftwood. Similar behavior was exhibited while foraging in water, where the turtles explored algal clumps, the bases of emergent vegetation, or the entrances of muskrat (*Ondatra zibethicus*) bank burrows. In no case was "worm stomping" behavior observed, as has been described from other populations (Harding and Bloomer, 1979; Kaufmann, 1986, 1989; Kaufmann et al., 1989; Tuttle, 1996; Tuttle and Carroll, 1997). Such behavior has also not been observed in the northern Virginia population of *C. insculpta* by CHE or J.F. McBreen who have conducted extensive field studies there. Perhaps worm stomping behavior is more specific to certain northern or highland populations of this species.

Injuries and Scute Abnormalities. — Fifteen (17%) wood turtles had injuries when captured. Injuries included 6 turtles with missing hind limbs (probably predator amputations), and one with a gnawed carapace. Five individuals had bobtails that could have resulted from either winter frostbite or a predatory attack, two had clefts cut into their carapaces (probably by mowers), and a large male had a fishing hook imbedded in its mouth. In addition to turtles with injuries, four were found dead: two winter kills, one predator kill, and one roadkill. The total number of turtles (9, 9.1% of the total population) that definitely experienced predatory injury or mortality is low compared to the 12.5% experienced by *C. guttata* from 1965–76 (Ernst, 1976), and the 17.3% in New Jersey *C. insculpta* reported by Farrell and Graham (1991).

Shell abnormalities were rare. Only four (4.5%) of the wood turtles captured showed scute anomalies: three individuals had vertebral 2 subdivided, one had right pleural 1 subdivided, and one had both vertebrals 4 and 5 subdivided. This compares with the 5.3% of *C. guttata* collected at the same site in 1965–76 with shell abnormalities (Ernst, 1976). Only one old female wood turtle showed plastral pitting.

Algae and Ectoparasites. — Only 15 (17.0%) of the C. insculpta had algae on their shells; 9 adult males and 6 adult females. No juveniles had algae. The algae were tentatively identified as Cladophora kuetzingiana, apparently a new host record. Few patches of algae were attached and these were only on the posterior marginals. Algae were observed on the turtles from March to October, with the peak period from April through July (80% of records), suggesting that algae come and go seasonally. Algae were recorded from 46% of the C. guttata collected at the same site from 1965 to 1976 (Ernst, 1976), and the significantly lower number of colonies on C. insculpta (Chi-square quantile plots; Johnson and Wichern, 1992) is probably due to its more terrestrial habits.

Thirty-four (38.6%) of the C. insculpta captured were infested with the leech Placobdella parasitica; 20 adult males, 13 adult females, and one juvenile. Individual wood turtles had 1-10 (mean 2.03) leeches attached to the skin of the gular region, in the limb sockets, or at the base of the tail. Eleven (32.3%) of the wood turtles with leeches also had algae attached. Individuals with leeches were collected from March to October, with a peak incidence from April to August (79.4%). This matches the period of greatest leech parasitism reported in New York and New Jersey by Koffler et al. (1978), but Hulse and Routman (1982) found that the highest incidence at another Pennsylvania creek was in October, and Brewster and Brewster (1986) noted a drop-off in the incidence of leeches after June in Wisconsin which they attributed to the drying effect of summer terrestrial activity. At White Oak, many wood turtles spent considerable time (as long as three days) soaking in floodplain pools or water-filled cattle tracks during July and August, and this may account for the greater summer prevalence of leeches there than elsewhere.

The incidence of leech infestation was significantly greater than found on the more aquatic *C. guttata* from 1965–76 (12.1%) at the same site. Farrell and Graham (1991) reported an incidence of leech infestation of almost 90% at their New Jersey site with as many as 39 adult and 60 juvenile leeches attached to one wood turtle. Koffler et al. (1978) reported an incidence of 63% in *C. insculpta* from New York and New Jersey, and Niederberger and Seidel (1999) found that over 50% of the West Virginia wood turtles they collected in water were parasitized by *P. parasitica*.

The only other ectoparasites observed on *C. insculpta* was a swarm of at least a dozen mosquitoes on the head and neck of a basking female.

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