NATURAL HISTORY OF THE MAP TURTLES *GRAPTEMYS PSEUDOGEOGRAPHICA* AND *G. OUACHITENSIS* IN WISCONSIN

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ABSTRACT

Natural history data were collected from populations of *Graptemys ouachitensis* and *G. pseudogeographica* on the Mississippi River, Vernon County, Wisconsin, from 1972-1978. Clutches of eggs were incubated in the laboratory and field under various temperature regimens. Hatchlings were maintained in the laboratory for six years to study growth rates, size at reproductive maturity and sex ratio within clutches.

Examination of reproductive tracts of 50 females suggest that they lay two clutches of eggs annually. The average clutch size for *G. pseudogeographica* was 14.1 and for *G. ouachitensis*, 19.2. The courtship displays of male *G. ouachitensis* and *G. pseudogeographica* involve the drumming of the foreclaws against the ocular regions of the female. The two species differed in the number of contacts per "titillation" bout.

Nesting was observed from 18 May to 26 July. Nest temperatures were monitored continuously for one month in 1972. Incubation temperatures in the laboratory were shown to affect hatching success, number of scute anomalies, size of yellow head blotches, and sex determination in both species. A skewed sex ratio of five females per male was calculated from trapping results.

Stomach contents of adult females suggested that the food resources are being partitioned. Females do not begin feeding until after laying their first clutch of eggs for the season.

The primary function of basking is thermoregulatory, no aggressive interactions were observed between basking *Graptemys*. Grackles, *Quiscalus quiscala*, were observed removing leeches, *Placobdella parasitica*, from basking *Graptemys*. Nest predation by red fox, raccoon, and otter was observed.

INTRODUCTION

The false map turtle complex, *Graptemys p. pseudogeographica, G. o. ouachitensis, G. o. sabinensis* and *G. p. kohni* has perplexed taxonomists and confused ecologists since the time of the original descriptions (Vogt, in press). Ecological data involving *Graptemys* have often been based on populations that were inaccurately identified. I realized this problem while attempting to determine which species of this group occurred in Wisconsin. Specimens collected from the Mississippi River near Stoddard, Vernon County, indicated that all taxa listed above occur sympatrically in Wisconsin. In 1971 at the same locality I collected 26 clutches of eggs from unknown females. Laboratory incubation yielded hatchlings with morphological characteristics of each, suggesting that *pseudogeographica, kohni, ouachitensis* and *sabinensis* have been described from individuals of a single highly polymorphic species. Smith (1961: 150-151) suggested this as one hypothesis, having been confronted with the same problem with false map turtles in Illinois.

These species and subspecies have been defined primarily on differences in head markings (e.g. Cagle, 1953; Ernst and Barbour, 1972); using these criteria

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all "forms" were found to have emerged from the 26 clutches of eggs, in some cases more than one "species" or "subspecies" from a single clutch. Study of this taxonomic perplexity was begun in 1972 at the Stoddard site where the population of *Graptemys* is large, and accessible. Between June and August of that year a mark and recapture study was begun. Subsequent trips were made intermittently between April and November of 1972-1978. Although I was concerned primarily with systematics of the *G. pseudogeographica* complex, various aspects of the natural history of *Graptemys* were observed. The field study was complemented by a five year laboratory study wherein eggs were incubated and young raised. Courtship behavior, reproductive potential and growth rates were studied in both the field and laboratory. This paper deals primarily with the natural history of *G. ouachitensis* and *G. pseudogeographica*. Detailed analysis of the systematics, courtship behavior and resource partitioning are presented elsewhere (Vogt, 1978).

SYSTEMATIC RELATIONSHIPS AND DISTRIBUTION

Graptemys pseudogeographica was described by Gray (1831) from the Wabash River at New Harmony, Indiana. *Graptemys pseudogeographica* is found primarily in large stream systems of the Mississippi drainage and occurs from the St. Croix and Wisconsin rivers in northern and central Wisconsin and the upper Mississippi River in Minnesota southward through Louisiana and eastern Texas (Vogt, Bull. Carnegie Museum, in press).

Cagle (1953) described two new subspecies of *Graptemys pseudogeographica* from the southern United States: *ouachitensis* from the Ouachita River of Louisiana and *sabinensis* from the Sabine River on the Louisiana-Texas border. My studies (Vogt, 1978) show that these two subspecies constitute a separate species, *G. ouachitensis*, which occurs from the Mississippi and St. Croix rivers in Wisconsin and Minnesota, south through the Mississippi River basin into Louisiana, west to Lake Texoma, Oklahoma and east into Indiana and West Virginia.

THE STUDY AREA

My study area, referred to as Mississippi River Pool 8, extends 37.5 river km north of a dam at Genoa, Vernon County, Wisconsin, to a point north of La-Crosse (43°40' N latitude, 93°13' W longitude). The Root and Lawrence rivers are the main tributaries of this impoundment. Before construction of the lock and dam in 1930, the main river channel comprised the bulk of the water surface area: 12,597 ha of channel, 2,764 ha of slough, 4,606 ha of marsh and 1,383 ha of pond. Since the dam was closed in 1937, water in the channel rose 3.5 m creating 27,481 ha of open pool and 2,873 ha of feeder channels; the marshland was increased to 9,435 ha (Claflin, 1973). Much of the pool area was taken from what previously had been river bottom forest (Curtis, 1959), stumps of which still remain provide excellent basking site for the turtles and attachment sites for invertebrates. Timber-meadow in the study area was 56,810 ha in 1930, but in 1970 only 25,396 ha remained (Claflin, 1973).

Within this general area, study was concentrated on 230 ha within the perimeter defined by the intersection of Crosby Slough and the main channel to the north, Crosby Slough and Cook Slough to the south and the main channel to the west. Most nesting observations were made on two islands which border the main channel (Fig. 1).

The islands are characterized by expanses of open sand surrounded by trees

[*Populus deltoides* Marsh., *Fraxinus pennsylvanica* var. *subintegerrima* (Vahl) Fern., *Acer negundo* L., *A. saccarinum* L., *Betula nigra* L. and *Ulmus americana* L.] and shrubs [*Salix* sp., *Amorpha fruticosa* L., *Parthenocissus inserta* (Kerner) K. Fritsch, *Vitis riparia* Michx. and *Cornus obliqua* Raf.]. The trees and shrubs are essential in maintaining the integrity of the island by limiting wind and water erosion.

Open sand is sparsely covered with a variety of herbs, the most common in the open sand being *Sporobolus cryptandrus* (Torr.) Gray, *Carex* sp., *Bromus tectorum* L., *Tradescantia ohiensis* Raf., *Verbascum thapsus* L., *Oenothera biennis* L., and *Lepidium densiflorum* Schrad. *Graptemys* frequently dig nests adjacent to these plants. Along the border of the sand and edge of the woods *Asclepias syriaca* L., *Barbarea vulgaris* R. Br., *Saponaria officinalis* L., *Mollugo verticillata* L. and *Cycloloma atriplicifolium* (Spreng.) Coult. were common. Some plants occur primarily in the woods but were found at the open sand-woods interface: *Rhus radicans* L., *Laportea canadensis* (L.) Wedd., *Urtica dioica* L., *Solanum dulcamera* L., *Lynchnis alba* Mill., *Polygonum convolvulus* L., *Erigeron annuus* (L.) Pers., *Equisetum arvense* L. and *Galium obtusum* Bigel. *Phalaris arundinacea* L. occurs along the edge of the water.

The shrubs and trees along the periphery of the islands as well as the herbaceous plants on the open sand help prevent the wind from eroding the sand and exposing nests, and provide cover for hatchling turtles as they move to the water.

The turtles feed on and in the common marsh aquatic plants found in shallow water. Near the nesting islands these are *Scirpus validus* Vahl, *S. fluviatilis* (Torr.), *Sagittaria latifolia* Willd., *Zizania aquatica* L., *Phalaris arundinacea* L., *Phragmites communis* Trin., *Sparganium americanum* Nutt. and *Carex* sp. In deeper water near the islands and in the feeding areas near the stumps *Potamogeton nodosus* Poir., *P. crispus* L., *P. americanus* C. & S., *P. foliosus* Far., *Heteranthera dubia* (Jacqu.) MacM., *Vallisneria americana* Michx., *Elodea* sp., *Nymphaea tuberosa* Paine, *Nelumbo lutea* (Willd.), *Spirodela polyrhiza* (L.), *Lem-*

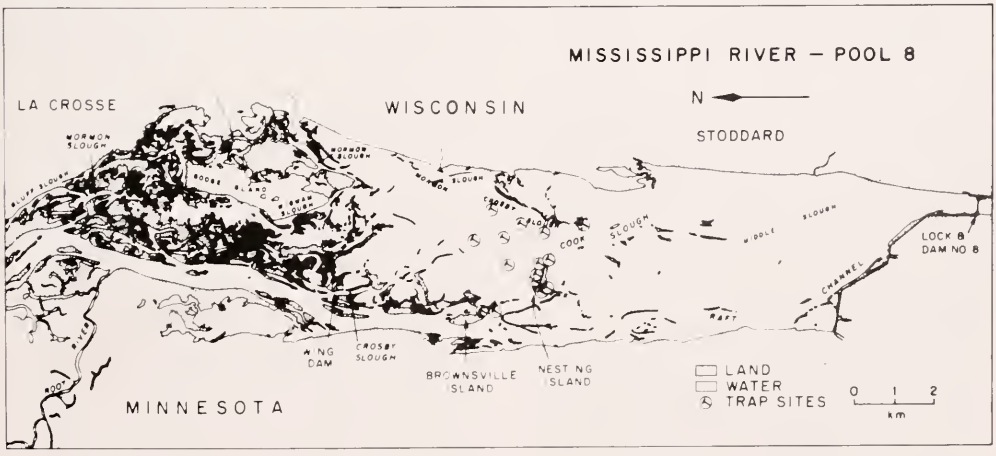

Figure 1. Topographic map of study area showing location of trap sites.

na minor L., *Wolffia columbiana* Karst., *Ceratophyllum* sp. and *Myriophyllum* sp. provide both food and shelter.

MATERIALS AND METHODS

Turtles were collected in fyke nets with leads, gill nets, and trammel nets and by hand capture (Vogt, Copeia, in press). Fyke nets varying in diameter from 61 cm to 90 cm and in mesh size from 2.54 cm to 5.08 cm were set in 1-1.5 m of water with the leads parallel to the shorelines of nesting beaches, between feeding grounds and deep water, or between basking logs and deep water. *Graptemys* was not attracted to bait, therefore fyke nets were baited with fresh dead carp only when turtles other than *Graptemys* were desired.

Local commercial fishermen, when setting gill nets in the study area, saved *Graptemys* that became entangled in the 12.5-17.5 cm mesh gill nets. Many of these were freshly drowned specimens from which eggs could be removed and incubated. These dead specimens were also used for stomach content analysis and skeletal preparation.

Trammel nets (5.08 cm mesh, 17.8 cm outer walling) were used primarily near basking logs or wing dams during hibernation periods (October, November, April). Turtles were driven into the nets by the use of a "carphorn" (Vogt, 1978).

Female turtles were hand captured on nesting beaches and by snorkeling while they were feeding. Hatchlings were collected in shallow water by hand and dipnet. Seining with a 60 m, 2.54 cm mesh bag seine proved to be ineffectual for obtaining young or adults.

During the first summer of study (1972) clutches of eggs from known females of *G. ouachitensis* and *G. pseudogeographica* were collected for taxonomic study. All six nesting beaches on the island were monitored each morning from 0500-0830 hrs (Central Standard Time) to obtain females and their recently laid egg clutches. Eggs from known females were measured by use of dial calipers accurate to 0.1 mm and incubated in the laboratory at 28°C. Each clutch was labeled and kept in a separate glass bowl containing moist spaghnum moss; and the entire bowl was enclosed in a clear plastic bag to prevent desiccation.

Following morning surveillance of nesting beaches, the 12 to 18 fyke nets, set at various localities within the study area, were checked (Fig. 1). All *G. pseudogeographica* and *G. ouachitensis* were brought back to camp for marking, and recording of data.

Each turtle was weighed, measured, photographed and marked; notes were made on shell injuries, abnormalities, color patterns and location of capture. Females were palpated for the presence of shelled eggs. Weight was determined to the nearest gram. The turtles were weighed under field conditions; upon handling *Graptemys* usually void their bladder. Injection of pilocarpin (Dorando, 1979) to induce voiding of all bladder water was not feasible or desirable since the inherent error was shown to be only 2.43% and any lasting effects on physiology or behavior of the turtle have not been studied. Maximum straight line carapace length, width and height were measured to the mm by use of a turtle measuring board (Cagle, 1946). Plastral measurements were taken either with dial calipers accurate to 0.1 mm or with a flexible ruler (nearest mm). Plastron width was taken at the suture between the axillary and pectoral scutes where it meets the 5th and 6th marginals. Straight line plastron length was taken from the farthest extension of the gular and anal scutes. During the summer of 1972 only carapace length and width were recorded. Both sides, dorsum, and venter of the head of each

turtle were photographed. Each turtle was individually marked with colored plastic plugs inserted with a "Dennison Buttoneer" through a 2 mm hole drilled through the center of one of the 7th-12th marginals on each side of the carapace. The marked turtles were then released at the site of capture the following day. Females were sacrified from April-November to obtain eggs and fresh reproductive tracts for determining reproductive condition. Notes were made concerning the number of growth rings on an abdominal scute when discernible. A ring was measured from the edge of the areola to the first deep groove in the scute. In agreement with Moll and Legler (1971) the term annulus is not used since it implies yearly rings and no proof exists to show if rings actually represent only one year.

Eggs were obtained by induction of oviposition by oxytocin injections (Ewert and Legler, 1978) during May and June of 1976 and 1977. If shelled eggs could be discerned by palpation, the females were taken back to the laboratory and injected intramuscularly with 10 units of oxytocin, then placed in a container of clean water, 25 cm deep at 28°-32°C and kept under bright lights with minimal disturbance. If eggs were not laid within one hr an additional injection of 10 units was given. Weights were taken before and after egg laying. The eggs were then weighed, measured and placed in moist vermiculite in incubators set at 25°, 30°, or 35°C or placed in a laboratory room where temperature was maintained at 32°C with a 14 hr light cycle. In 1977, individual eggs of seventeen clutches were incubated at these different temperatures.

Young from the 1972 year class have been reared in the laboratory to October 1978 (48 surviving) on a prepared diet of agar, gelatin, trout pellets, bone meal, oyster shells, cod liver oil, and multiple vitamins. This was done to compare growth rates between males and females and to determine if any changes in head color patterns occurred. They have been kept on a 14 hour light cycle at 32°. "Vitalities" (Durotest) were used to provide ultraviolet light. Blocks of plaster of Paris and copper tubing were kept in each tank to assist shell development. All the young hatched in 1972 were measured, weighed, marked and photographed in a manner similar to that used with adults. In addition, photographs were taken of the carapace and plastron. Measurements were repeated at least once a year. After the second year of growth, when external sex characteristics became apparent, males and females were placed in separate containers.

Analysis of feeding preference was made by examination of the stomach contents of freshly sacrificed or drowned individuals. Stomach flushing (Legler, 1977) was used during the 1977 season. Stomach contents from females were sorted and the components identified. Volume of the sorted contents was then determined by water displacement (Vogt, 1978). Feeding behavior of females was observed through a 30X spotting scope, or by snorkeling in their feeding areas.

Nest and body temperatures were taken with a Schultheis quick reading thermometer. An Easterline-Angus six-channel recorder with six thermistors was used for continuous recording of the temperature in four nests and the sand and air surface from July 16, 1972 through August 17, 1972.

All turtles sacrificed or drowned in the nets of commercial fishermen were either fixed in 10% formalin or skeletonized by dermestid beetles and deposited in the University of Wisconsin Zoological Museum, Madison. Hatchlings from 1971, 1972, 1976 and 1977 were also preserved and deposited there.

Table 1 = Measurements (cm) of carapace length (CL), carapace width (CW), carapace height (CH), and weight (g) of male and female *Graptemys* from Stoddard. (Range above; mean below)

Species	Sex	n	CL	CW	CH	WT (g)
G. ouachitensis	♂	68	10.9-13.7 (12.3)	8.7-10.3 (9.3)	4.0-5.2 (4.5)	161-309 (211)
G. psueodgeographica	♂	68	11.1-15.1 (13.3)	8.7-11.0 (10.0)	4.0-5.3 (4.7)	143-364 (251)
G. geographica	♂	45	9.3-13.6 (11.5)	7.6-11.1 (8.9)	3.4-4.6 (3.9)	165-350 (205)
G. ouachitensis	♀	265	16.3-24.2 (20.5)	12.7-19.1 (15.8)	6.5-10.2 (8.5)	557-2300 (1136)
G. pseudogeographica	♀	109	19.3-27.4 (22.5)	15.1-20.4 (17.3)	7.3-11.2 (8.8)	857-2502 (1477)
G. geographica	♀	15	20.1-25.8 (22.6)	14.9-18.7 (16.9)	7.5-9.4 (8.7)	761-1700 (1138)

REPRODUCTION

Sexual dimorphism

Sexual dimorphism is pronounced in all species of *Graptemys*. Males are much smaller in carapace length, width and height (Table 1). The male tail is comparatively much longer than that of the female, the distance from plastron to cloaca being greater in the male to facilitate intromission of the penis during copulation. The 2nd and 3rd foreclaws of male *G. ouachitensis* and *G. pseudogeographica* are disproportionately elongated. This characteristic has probably evolved along with their characteristic courtship display wherein the male drums his foreclaws over the ocular and otic regions of the female. The foreclaws of *G. geographica* males are not elongated and their courtship display does not involve foreclaw drumming.

Such a marked sexual dimorphism (males averaging 20% the mass of females) has many advantages. Most importantly it allows for intraspecific partitioning of food resources. Males feed on small, energy-rich insect larvae and mollusks, while the adult females are omnivores that feed on invertebrates and vegetation. Small size may allow males to put their energy into searching for females, precopulatory display and sperm production, rather than into growth. Laboratory studies show that reproductive maturity is reached in males at a smaller size allowing for a lower minimum age of reproduction (see section on laboratory growth, below).

Females, on the other hand, have an advantage in being large. The larger the female the greater the number of eggs she produces in a single clutch (Figs. 2 and 3). Warm spring temperatures allow oviducal application of the shell of the first clutch of eggs starting the last 10 days of May; then 10 days to 3 weeks to apply shell material to the second clutch, and an additional 10 days to three weeks for a possible third clutch. This is the maximum number of clutches since temperature becomes too low for incubation to be completed by the onset of winter. A larg-

er female provides a higher than average reproductive input into the population. In addition the larger size of the females may afford greater protection from avian and mammalian predators when they venture ashore to nest.

Reproductive cycles

Females begin the reproductive cycle from late June to mid-July after laying their last clutch of eggs for the year. From then until early September females feed and bask, converting the energy obtained into enlarged ovarian follicles. They enter hibernation with the coelomic cavity encroached upon by enlarged ovarian follicles. They do not feed in the spring until the first clutch has been laid. Mating probably takes place either in October or April while the turtles are congregated at

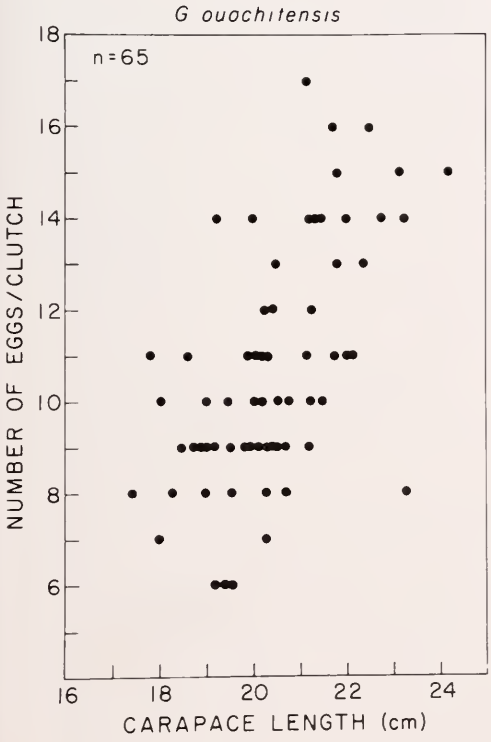

Figure 2. Relationship between carapace length of female and number of eggs per clutch in *G. ouachitensis.*

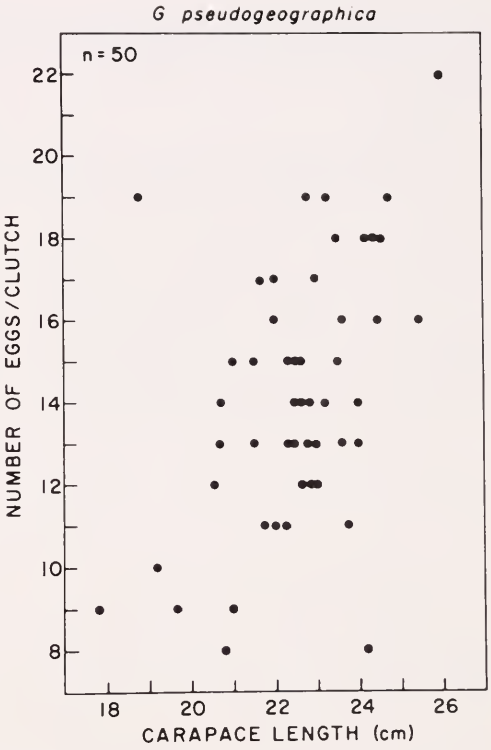

Figure 3. Relationship between carapace length of female and number of eggs per clutch in *G. pseudogeographica.*

hibernacula. After leaving the hibernacula in April the females move toward the nesting beaches and spend approximately six weeks basking and applying shell to ovarian follicles, and egg laying continues until late June to mid-July. This appears to be the typical pattern for North American emydines (Risley, 1938; Atland, 1951; Miller, 1959; Moll and Legler, 1971; Christiansen and Moll, 1973; Moll, 1973; Shealy, 1976). Testis size was noted to be greatest in the fall and smaller in the summer. Shealy (1976) found active sperm present in the epididymis of mature male *G. pulchra* throughout the year, suggesting that mating could occur throughout the year in Alabama. Mating is potential in Wisconsin in both fall and spring. Males of all three species cap-

tured in October, November and April courted and attempted copulation when returned to an outside enclosure at the laboratory.

Courtship by laboratory raised males and males caught in the wild was observed in the laboratory (Vogt, 1978), and high speed motion pictures were made to analyze differences among the three species. Males identify conspecific females by both visual and olfactory cues. Specific odors appear to be associated with the cloacal region of females since a male, after placing his nostrils in close proximity of the cloaca of a conspecific females, often swims rapidly to her head and begins courting; however, evidence for long distance pheromones has not been substantiated (Vogt, 1979).

Courtship in *G. ouachitensis* and *G. pseudogeographica* also seems to be initiated by visual cues. Males have been observed to court conspecific females and often other males after orienting towards the head without initial cloacal contact.

Once a turtle is suspected to be a conspecific female, males may immediately try to mount or they may begin courtship. The courtship displays of the three species differ significantly and are probably responsible for maintaining genetic isolation between species pairs.

The aquatic displays of *G. ouachitensis* and *G. pseudogeographica* are remarkably similar. The male approaches the female anteriorly with his forelimbs raised above his head and arched laterally. Only the hindlimbs are used to bring him into position. When nose to nose contact is nearly made, (within 3 mm) the forelimbs are brought down, the venters of the forefeet are rotated laterally and the foreclaws are simultaneously drummed against the ocular region of the female head. The duration of the drumming does not differ significantly between the two species but the frequency does. Jackson and Davis (1972) described this as the "titillation" phase of the courtship behavior in *Pseudemys scripta*. The length of the titillation phase was highly variable in both species of *Graptemys* ranging from 280-750 ms (mean 454) in 23 *G. ouachitensis* and 344-834 ms (mean 470) in 13 *G. pseudogeographica*. The mean number of contacts per bout, however, was different for the two species. The mean number of contacts for *G. pseudogeographica*, 10.3, was nearly twice that of *G. ouachitensis*, 5.2.

In addition *G. pseudogeographica* differs by bobbing its head up and down while *G. ouachitensis* holds its head stationary and vibrates the foreclaws. Mounting is attempted whenever the female is almost motionless and does not seem to be dependent on the number of courtship bouts.

Courtship in *G. geographica* differs in that no vibration of the forelimbs has ever been observed. The male may attempt to mount after cloacal contact. Or, after cloacal contact, the male has been observed swimming to the head of the female and, after making snout to snout contact, bobbing his head rapidly in the vertical plane. This is similar to the courtship behavior of *G. pulchra* (Shealy, 1976).

Mounting is facilitated in all three species by the male hooking the tip of his tail around that of the female to maintain balance and to pull her cloaca into position to allow intromission. Once intromission is achieved the pairs have been observed in coitus from 15 sec to over four hrs. During this time the male remains in a passive state floating at approximately a 45^{o} angle upon the carapace of the female. His forelimbs are usually arched above his head and held motionless.

Reproductive potential

Detailed reproductive data were only

Table 2. Relationship of both carapace length (CL) and average number of eggs per clutch (n = # of clutches measured) and how they relate to size and weight of eggs in *Graptemys pseudogeographica*.

CL	Ave. no. of eggs (n)	Ave. egg length (cm)	Ave. no. eggs (n)	Ave. egg width (cm)	Ave. no. eggs (n)	Ave. clutch wt. (g)	Ave. egg wt. (g)	Ave. no. eggs (n)
17-18	9 (1)	2.78	9 (1)	1.79	9 (1)	53	5.89	9 (1)
18-19	– – –	– – –	– – –	– – –	– – –	– – –	– – –	19 (1)
19-20	9 (1)	3.67	– – –	– – –	– – –	– – –	– – –	9.5 (2)
20-21	12.4 (5)	3.24	11.3 (3)	2.14	12 (1)	117	9.75	11.8 (4)
21-22	14 (2)	3.38	– – –	– – –	17 (1)	147	8.65	13.3 (6)
22-23	14.9 (11)	3.31	14.8 (6)	2.24	12.8 (5)	134	10.5	14.0 (16)
23-24	15.8 (6)	3.45	16 (5)	2.32	13.6 (5)	135 (5)	9.90	14.8 (10)
24-25	14.5 (6)	3.48	14.2 (4)	2.33	14.7 (3)	147 (3)	9.98	15.5 (8)
25-26	16 (1)	3.88	16 (1)	2.47	– – –	– – –	– – –	16 (1)
26-27	22 (1)	3.50	– – –	– – –	– – –	– – –	– – –	22 (1)

Mean 14.1 eggs/clutch

taken from female *G. ouachitensis* and *G. pseudogeographica*. Examination of re- June and July 1972 suggests that females ordinarily lay two clutches of eggs per season. This was determined by presence of two sets of corpora lutea, two sets of corpora lutea and shelled eggs, or one set of corpora lutea and a set of enlarged follicles. However, there was evidence to suggest the possibility of three clutches in eight individuals.

The average clutch size of 50 *G. pseudogeographica* was 14.1 giving an annual reproductive potential of 28.2. Clutches of 65 *G. ouachitensis* averaged 10.5 eggs for an annual reproductive potential of 21. These figures compare with those for *G. pulchra*, 29 (Shealy, 1976) and *G. barbouri*, 17 (Cagle, 1952), both of which are slightly larger in carapace length. As in *G. pulchra* (Shealy, 1976) there was a direct correlation between clutch size and carapace length (Figs. 2 and 3); the longer the female, the greater the number of eggs per clutch. Tables 2 and 3 show the relationship between mean number of eggs and mean egg length, mean egg width, mean egg weight and mean clutch weight at specific carapace lengths for both *G. ouachitensis* and *G. pseudogeographica*. The mean clutch weight and mean egg length increase most noticeably with increase in both female carapace size and clutch size. Average egg weight and egg width are not so strongly correlated. Tables 4 and 5 show the relationship between clutch size and egg weight, length and width. No direct trends or correlations are obvious.

The method of estimating reproductive potential by counting corpora lutea, enlarged ovarian follicles and oviducal eggs has been used in many turtle studies (Cagle, 1952; Moll and Legler, 1971; Christiansen and Moll, 1973; Moll, 1973; Shealy, 1976). Legler (1960) describes the structures in detail. Although this method appears to be realistic, it may lead to overestimation or underestimation of annual reproductive potential. The presence of enlarged follicles toward the end of the laying season must be interpreted with caution. These follicles could represent clutches to be laid the following year, particularly if the individual had nested early the same year.

Table 3. Relationship of both carapace length (CL) and number of eggs per clutch (n = number of clutches measured) and how they relate to size and weight of eggs in *Graptemys ouachitensis*.

CL	Ave. no. of eggs (n)	Ave. egg length (cm)	Ave. no. eggs (n)	Ave. egg width (cm)	Ave. no. eggs (n)	Ave. clutch wt. (g)	Ave. egg wt. (g)	Ave. no. eggs (n)
17-18	11 (1)	3.02	– – –	– – –	8 (1)	74	9.25	9.5 (2)
18-19	9.3 (6)	3.28	9.2 (4)	2.18	8.6 (5)	82	9.54	9.3 (7)
19-20	8.64 (11)	3.46	9.2 (7)	2.16	8.7 (9)	81.8	9.4	8.5 (14)
20-21	10.22 (9)	3.43	9.8 (6)	2.16	9.7 (14)	99.6	10.3	10.1 (19)
21-22	13.4 (9)	3.36	12.6 (8)	2.19	12 (10)	129.2	10.8	12.8 (13)
22-23	12 (2)	3.44	12 (2)	2.24	13.3 (4)	143.8	10.8	13.2 (6)
23-24	11 (2)	3.47	11 (2)	2.12	14.5 (2)	153	10.5	12.3 (3)
24-25	15 (1)	3.59	15 (1)	2.95	– – –	– – –	– – –	15 (1)

Mean 10.5 eggs/clutch

Eight females collected between 8-15 July contained old corpora lutea, oviducal eggs and enlarged follicles. The latest date *Graptemys* was found with oviducal eggs was 28 July, so these enlarged follicles possibly could have ovulated later that same season. One *G. ouachitensis* collected 8 July 1972, contained 12 new corpora lutea, 25 old corpora lutea and enlarged ovarian follicles. Because the average clutch size of *G. ouachitensis* is 10.5 and the record number of eggs per clutch is 17, the 25 old corpora lutea very probably represent two clutches. This female laid three clutches with the potential of laying a fourth.

Between 6 June 1972, and 13 August 1972, 641 mature *G. ouachitensis* and *G. pseudogeographica* were individually marked and released. No turtles were found to contain shelled eggs after they were known to have laid one clutch, but

Table 4. Relationship of clutch size to egg weight, length and width regardless of the carapace size in *G. ouachitensis* (n = number of clutches measured).

Clutch size	Ave. wt./ eggs (g)	n	Ave. length/ eggs (cm)	n	Ave. width/ eggs (cm)	n
6	9.17	3	3.34	2	2.11	2
7	10.00	2	– –	– –	– –	– –
8	9.07	6	3.25	4	2.10	4
9	9.62	11	3.52	14	2.16	11
10	10.77	7	3.08	2	– –	– –
11	12.18	6	3.33	8	2.15	8
13	13.43	3	3.46	1	2.22	1
14	10.64	3	3.40	5	2.21	5
15	9.73	1	3.28	1	2.95	1
16	11.63	2	3.70	1	2.26	1
	479 eggs	47 clutches		39 clutches		34 clutches

since trapping did not start until 6 June, many of the turtles could already have laid their first clutch.

Eggs were obtained from 16 *G. pseudogeographica* and *G. ouachitensis* females which were injected with oxytocin and released between 23 May and 2 June 1977. None of these was recovered during a five day trapping period, 9-14 June 1977 in an attempt to document the laying of more than one clutch in a season. However, two *G. ouachitensis* were observed to have double clutched in 1978.

Twenty-four adult females collected on 15 October 1976, and maintained in the laboratory at 13°C were found to have atretic ovarian follicles upon dissection in January. The livers were distinctly marked with yellow suggesting eggs were being reabsorbed. Atresia has not been observed in freshly caught *Graptemys* during any season. Atresia of small or medium-sized follicles in *Pseudemys scripta* in Panama was reported by Moll and Legler (1971) and by Webb (1961) in Oklahoma. Occurrence of atretic follicles is also known from several other species: *Chrysemys picta* (Powell, 1967), *Terrapene ornata* (Legler, 1960) and *Terrapene carolina* (Atland, 1951). The magnitude of atresia occurring in the 24 *Graptemys* maintained in the laboratory suggests that they are capable of complete atresia of all enlarged follicles if they are under environmental stress.

NESTING

Females emerge from hibernation and begin basking in early- to mid-April. The warmer the temperatures in April and May, the higher the metabolic rate of the turtles; thus the shell may be laid around the eggs more rapidly, allowing the clutch to be laid earlier. This was demonstrated by a female *G. geographica* collected at the Crosby Slough hibernaculum on 5 November and brought into the laboratory and artificially hibernated at 3°-5°C until 10 January. She was gradually brought to 32°C over a 24 hr period. Within 10 days shelled oviducal eggs were present. She was stimulated to oviposi-

Table 5. Relationship of clutch size to egg weight, length and width regardless of the carapace size in *G. pseudogeographica* (n = number of clutches measured).

Clutch size	Ave. wt./ eggs (g)	n	Ave. length/ eggs (cm)	n	Ave. width/ eggs (cm)	n
8	10.0	1	3.47	2	2.24	2
9	5.89	1	3.62	2	1.79	1
10	--	--	--	--	--	--
11	10.0	3	3.24	1	2.09	1
12	10.67	2	3.33	1	2.20	1
13	11.16	2	3.48	6	2.29	2
14	9.64	1	3.33	5	2.20	4
15	9.87	1	3.43	5	2.37	1
16	--	--	3.74	2	2.47	1
17	8.65	1	3.24	1	2.16	1
18	10.0	2	3.44	3	2.28	3
19	9.36	2	3.23	2	2.20	2
	183 eggs	16 clutches		30 clutches		19 clutches

tion by oxytocin injection on 25 January. After 2 months incubation at 25°C the eggs hatched. The onset of nesting appears to be determined by spring temperatures. During the seven years of this study, the earliest first nesting observed was 18 May and the latest 10 June: the last known nesting occurred on 11 July.

Females with shelled oviducal eggs have been found as late as 26 July (1972). Nesting was not observed in 1972 until 9 June, and 95% of the females caught after 10 July did not contain oviducal eggs. This corresponds roughly with the length of laying period in 1977 when the earliest nest was recorded 18 May and laying was nearly finished by 14 June. Temperatures in April and May, 1977, were higher than in the same period in 1972, and may account for the earlier onset of egg laying in 1977 than in 1972 (Table 6). Although the 1977 turtles conceivably could have laid a third clutch in late June or early July, none appeared to have done so since all eggs in the 128 nests examined on 19 August had hatched and only six had young remaining in the cavity.

Map turtles have been found constructing nests from 0545-2030 CST under various weather conditions. The majority of nestings occurred between 0630 and 1000. Later in the day, air and sand temperatures and sun intensity became too great for turtles to leave the water. During overcast days nesting occurred throughout the day. Cool nocturnal air temperatures may also inhibit females from leaving the water to nest. Sixteen females were found on an overcast day at 1400 on Brownsville Island, South Beach in various stages from searching for digging sites to completion of nests. A rain shower at 1430 stopped these activities, and all but one, which was covering her eggs with sand, began moving toward the water. She finished laying before returning to the water. Seven abandoned the nest cavities they had dug.

Table 6

Temperature data (°C) from LaCrosse Weather Bureau (approximately 16 km north of study area)

Month	April		May		June	
Year	1972	1977	1972	1977	1972	1977
Ave. Max.	11.7	19.0	24.6	26.1	26.2	26.0
Ave. Min.	0.6	6.2	10.3	13.2	11.9	14.0
Ave. Temp.	6.1	12.6	17.5	19.7	19.2	20.0

Cloacal temperatures of turtles observed nesting ranged from 24.6°C to 28.2°C; air temperatures ranged from 21.1°C to 32.0°C. During June, from 0430 to 1000 up to 75 females could be seen floating at the surface of the water 3 to 15 m from the shore of nesting beaches. These turtles were apparently waiting for the right combination of environmental cues before emerging. Once a female reached the beach she would wander from 5 to 150 m before attempting to dig a cavity. Nests were located in a variety of settings from the low shrubs surrounding the beach to the open sand area. Usually nests were dug adjacent to clumps of *Carex* or other herbs.

The nest cavities were dug entirely by alternate use of the hind limbs; no body pit such as that I have observed to be prepared by *Chrysemys picta* and *Trionyx spiniferus*, in this area, was dug. The nest cavity is flask-shaped and 10 to 16 cm deep; the neck broadens between four and eight cm beneath the surface. The eggs are positioned and packed into the hole with one of the hind feet. As an egg is being laid the turtle's neck is outstretched fully and the head bobs slightly in the vertical plane. After the last egg is laid, the hole is filled by scraping and packing sand and nearby debris into the hole with the hindlimbs. Once the cavity is filled, the female continues to pack down the nest by alternately raising each hind limb 5 cm above the surface and then

slapping the sand with it.

The female leaves the nesting beach and returns to the water usually through the same break in the vegetation that was used in coming from the water. Fresh nests can be readily distinguished by the striking difference in sand particle size between the nest and the surrounding sand surface. The surrounding sand has a coarse mosaic of small pebbles created by wind erosion of the lighter sand while the nest has a rather uniform small-grained appearance. If found within an hour of nesting, the nest area is moist due to voiding of bladder water and thus darker than the surrounding sand. Nests remain obvious for a week or longer depending on rain and wind erosion. Settling of sand between recently laid eggs and after the eggs hatch forms a shallow crater making the nest even more easily distinguishable. Some of the nesting beaches are so crowded that nests may overlap.

Areas where dredge spoil has been dumped in the last four years are not used for nesting. No plants grow on those sand piles and the water table is too low for the turtles to reach moist sand. Many attempts to excavate nests in dredge spoil banks were noted; digging was apparently abandoned when the cavity failed to hold its form. Abandoned holes were also observed on other nesting areas. Other authorities (Legler, 1960; Shealy, 1976) refer to these as "test holes," implying that the turtle is testing the substrate before laying. This may be the case in some instances, but it is also just as probable that the turtles were disturbed by weather conditions before egg laying commenced, and abandoned the nest. Turtles did not return to complete or lay in these abandoned cavities.

Nest temperatures were monitored continuously from 16 July to 17 August 1972 (Table 7). Thermistors were placed in the center of four nests. Two (a) were 10 cm beneath the surface and two (b) were 14 cm beneath the surface. Two additional thermistors were placed outside of nests: one 1 cm below the sand surface (c), the other 10 cm above the surface in a slatted wooden container shaded by a tree (*Betula*) (d). Daily temperature fluctuations ranged from 2.2 to 12.2°C in the nests. The average daily fluctuations for two nests for 28 days was 6.7°C. The incubation period in nature ranged from 60-75 days (14 nests). Hatching success in nature was approximately 95% in 285 nests, (1972-77) that were excavated after hatching. Hatchlings usually remain in the nest until the yolk is completely absorbed.

Table 7. Nest, substrate and air mean temperatures (°C) from 16 July 1972 to 17 August 1972.

	a Nest, 10 cm below surface	b Nest, 14 cm below surface	c Sand, 1 cm below surface	d Air in shade, 10 cm above surface	e Air, LaCrosse Weather Bureau
Highest high	34.4	31.3	48.9	43.9	35.6
Lowest low	14.4	13.3	8.9	8.9	7.2
Average high	26.1	24.4	36.6	35.0	26.6
Average low	18.8	18.3	14.4	14.4	16.1
Daily mean	22.5	21.4	25.5	24.7	21.4
Daily fluctuations:					
Largest 12.2°C		Lowest 2.2°C			Average 6.7°C

No positive evidence of hatchling overwintering in the nest has been documented for any of the species at this site. Over 500 nests have been examined from mid-September through November without finding young which might yet overwinter before emergence. On 9 June 1972, one hatchling was found crawling across the center of nesting beach no. 5 at 0930 hours. The umbilical scar was dry and crusted and appeared as if the hatchling had not spent the winter underwater. This early sighting is the only evidence suggesting the possibility of occasional overwintering. Overwintering in the nest has been observed for other species *Pseudemys scripta* (Cagle, 1944), *Chrysemys picta* (Hartweg, 1946; Sexton, 1957; Ream, 1967; Vogt, 1978), and *Graptemys* spp (Newman, 1906).

The head and limbs of the hatchlings of all three species are marked similar to those of the adults, but the carapace and plastron tend to be lighter and more boldly marked than in adult. Ontogenetic differentiation and pattern variation among species is discussed elsewhere (Vogt, 1978).

Laboratory incubation

One to two days prior to hatching in the laboratory, droplets of liquid condense on the surface of the egg. The egg by this time has expanded greatly in width and is reduced in length. Within 48 hours one or two longitudinal slits 5 to 20 mm in length appear. Presumably these are cut by the caruncle. These slits increase in length over the next few hours and the hatchling will force its head through the opening. In the laboratory hatchlings will often pull themselves out of the egg with their forelimbs and bury themselves in the substrate. Usually, however, the hatchling will remain in the egg shell for 3-6 days until the yolk sac is nearly absorbed. The caruncle is shed or absorbed within three weeks of hatching.

The temperature at which the eggs are incubated has a dramatic effect on head patterns, scute anomalies, and sex determination. Each of 11 clutches of *G. ouachitensis* and six clutches *G. pseudogeographica* were divided equally between incubators set at 25° and 35°C. Sixty-six eggs were incubated at 25°C, 54 hatched in 66-70 days, six died during development and six did not develop. Seventy eggs were incubated at 35°C, 17 hatched in 49-54 days, 24 died during late stages of development and 29 failed to show any development. The low success at 35°C can be attributed both to temperature and insufficient humidity. The eggs incubated at 35°C often became dented before water was added to the substrate. Five percent of the 60 that developed at 25°C had scute anomalies while 29% of the 41 that incubated at 35°C had them.

Another effect of incubation temperature was the size of the yellow blotches on the head of both *G. pseudogeographica* and *G. ouachitensis*. Ewert (pers comm) noted that postorbital yellow "crescents" were formed in *G. ouachitensis* hatchlings when eggs were incubated at low temperatures (25°C), but not at high temperatures (30°C). He did not notice this effect in *G. pseudogeographica* from Wisconsin. Measurement of the individual area of 13 of the yellow head blotches on hatchlings of both *G. pseudogeographica* and *G. ouachitensis* showed significant differences between eggs of the same clutch incubated at 25°C and 35°C (Vogt, 1978). A greater percentage of larger yellow blotches were formed at the lower temperatures.

Besides the phenotypic effects of incubation temperature, the sex of the hatchling seems to be influenced by incubation temperature. All of those that hatched at

25°C were male and all that hatched at 35°C were female. The probability that 54 of the 66 incubated at 25°C being male as a result of random sampling is very small (< .05 probability in Chi^2 test). Bull and Vogt (1979) showed that sex is environmentally determined under both field and laboratory conditions. Yntema (1976) and Pieau (1971, 1972, 1973) suggested a similar phenomenon for *Chelydra serpentina* and *Emys orbicularis*.

The likelihood of the environmental determination of sex may help to explain the ratio of 5 females per male in the population. The collecting techniques used were sexually unbiased (Vogt, Copeia, in press). Such skewed sex ratios have been reported for other populations of *G. pseudogeographica* (Timken, 1968). He found a 4:1 sex ratio in favor of females in the Missouri River in South Dakota. Hildebrand (1929) found a sex ratio of 4.4 females per male for captive raised *Malaclemys terrapin*. Most other turtle studies have found sex ratios which do not differ significantly from 1:1 (Gibbons, 1970). My observations and collections made of *Graptemys ouachitensis* and *G.p. kohni* in the White River, DeVall's Bluff, Arkansas from 1975-1977 show the opposite trend. About four times as many males as females are seen and caught. Tinkle (pers comm) found the same to be true in Louisiana populations of these species.

The shorter testes can be distinguished at hatchling from the ovaries by the absence of oviducts. Ovaries also have small white spots on the surface. The sex of a turtle apparently is determined prior to hatching, since no sex reversals have been noted from 30 hatchlings maintained in the laboratory for nine months. Hatchlings that were maintained in the laboratory for 5.5 years showed no tendency toward sex reversal once secondary sexual characters became apparent.

Growth in laboratory reared hatchlings

So few yearling and immature turtles were discovered in the study area that hatchlings had to be reared under artificial conditions to answer several questions concerning growth and demographic phenomena, such as: What is the sex ratio at hatching? Is the differential sex ratio in the adult population an index of the sex ratio at hatching or is differential mortality occurring? Do male turtles grow more slowly than females and thus are they more susceptible to predation for a longer period of time, or do male and female turtles grow at equal rates initially, following which males slow in growth upon reaching a specific size (sexual maturity)? When do the external sexually dimorphic characters appear? When is sexual maturity reached?

A total of 197 hatchlings consisting of 65 *G. ouachitensis* from 17 clutches and 132 *G. pseudogeographica* from 19 clutches were reared in the laboratory. At hatching both species were of similar size (Table 8).

Growth of 86 turtles was measured through 10 March 1975, but 47 of these died in the fall of 1975 due to a virulent infection of the bacteria *Citrobacter freundii*. The 39 that survived after treatment with chloromycetin were maintained through 25 October 1978.

During the first three years males and females increased in mass and shell proportions at nearly the same rate (Figs. 4-9). Male growth began tapering off between March 1975 and June 1976, at 3-4 years of age. Females, however, continued growing up to the present.

Table 9 summarizes the change in the mean monthly increment of growth for males and females in 1975 and 1978 and the effect these differences had on total mass and shell measurements. Monthly increase in carapace length of males and

Table 8. Measurements of hatchling *G. ouachitensis* and *G. pseudogeographica* incubated in the laboratory in 1972. (mean above; range below)

Species	*G. ouachitensis*	*G. pseudogeographica*
# of clutches	16	10
# of hatchlings	116	99
Ave. wt. (g)	4.4 g	4.99 g
	(1.5-6.2)	(1.8-6.6)
Carapace length (cm)	3.07	3.04
	(2.71-3.44)	(2.50-3.30)
Carapace width (cm)	3.01	3.04
	(2.65-3.40)	(2.66-3.37)
Plastron length (cm)	2.85	2.84
	(2.53-3.18)	(2.38-3.16)
Plastron width (cm)	1.97	1.96
	(1.75-2.65)	(1.55-2.12)

females was similar through March 1975, 0.50 mm and 0.43 mm respectively. But from March 1977, to April 1978, the average growth per month differed dramatically, 0.56 mm for males and 1.6 mm for females. The average monthly increase in carapace length from November 1972, through March 1975, (27.5 months) was similar to males and females (1.27 mm and 1.38 mm). However, females grew at over twice the rate of males for the next 37 months (March 1975, through April 1978). Carapace length increased an average of 1.06 mm per month in females, but only 0.52 mm per month in males. Reduction in growth rate of males coincided with the onset of sexual maturity. When the males were four years of age they were considered sexually mature on the basis of extensive development of the external secondary sexual characters (elongated 2nd, 3rd, and 4th foreclaws, elongation and thickening of the tail, and courtship and copulation behavior).

By April 1978, none of the 1972 hatchling females had yet reached sexual maturity. This was evident by their being smaller than the smallest mature female found in the wild and possession of no palpable shelled eggs. At least two of the

Table 9. Growth (cm) rates of 1972 hatchlings. *Graptemys pseudogeographica* and *G. ouachitensis* are combined – growth rates were the same.

	10 March 1975				*15 April 1978*			
	Average		Monthly Growth		Average		Monthly Growth	
	53 ♂	33 ♀	53 ♂	33 ♀	20 ♂	19 ♀	20 ♂	19 ♀
CL	6.30	6.87	.50	.43	8.46	11.73	.56	1.6
CW	5.71	6.01			7.04	9.52		
CH	2.68	2.79			3.37	4.87		
PL	5.61	5.80			7.34	10.50		
PW	4.10	4.20			5.12	7.07		
Wt.	35.5	44.5	.96	2.52	85.0	268.4	1.07	7.69

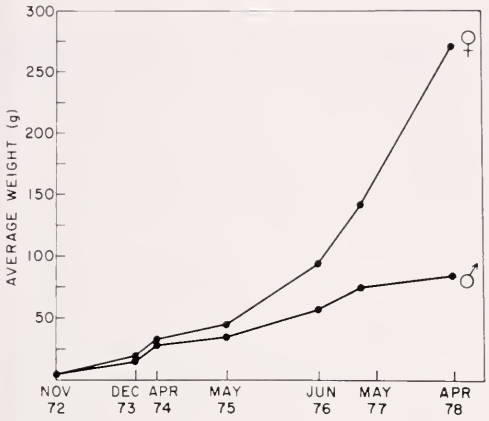

Figure 4. Weight changes in 197 captive raised hatchlings. (65 *G. ouachitensis*; 132 *G. pseudogeographica*).

G. pseudogeographica females will reach reproductive size by spring 1980 if present growth rate continues. Because of the continuous warm temperatures and high intensity light regime under which the turtles were raised and continuous

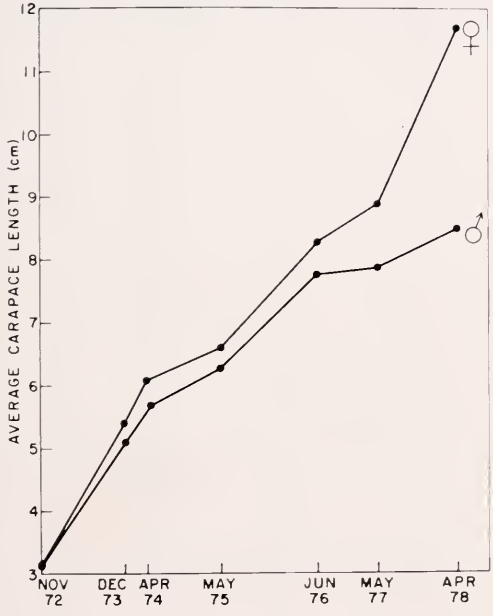

Figure 5. Carapace length changes in captive raised hatchlings.

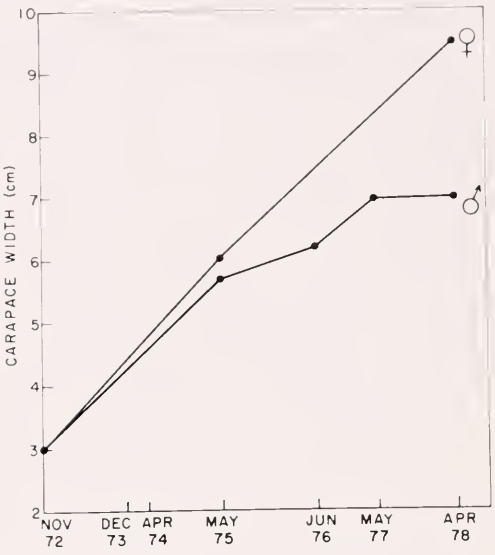

Figure 6. Carapace width changes in captive raised hatchlings.

feeding, these laboratory populations cannot be compared directly to natural ones. However, females did become less active and ate less from January through March each winter when ambient external temperatures reduced the interior vivarium temperatures approximately 7°C.

Growth rings

The use of growth rings to estimate the age of turtles has been reported by nu-

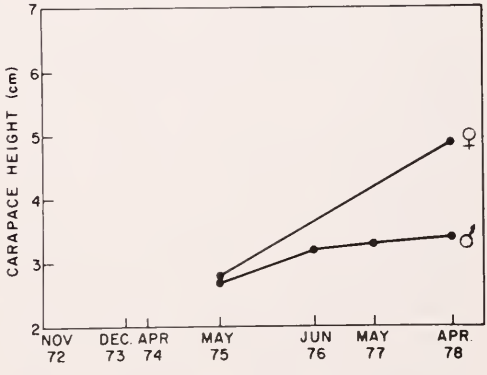

Figure 7. Carapace height changes in captive raised hatchlings.

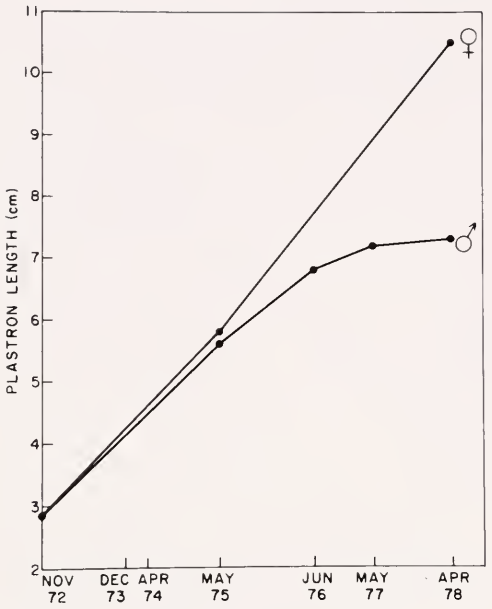

Figure 8. Plastron length changes in captive raised hatchlings.

merous authors (*Graptemys pulchra*, Shealy, 1976; *Terrapene ornata*, Legler, 1960; *Pseudemys scripta*, Cagle, 1946; 1950; Moll and Legler, 1971; *Chrysemys picta*, Sexton, 1959; Gibbons, 1967; Ernst, 1971; *G. ouachitensis*, Webb, 1961; *Pseudemys rubriventris*, Graham, 1971; *Gopherus agassizi*, Patterson and Brattstrom, 1972).

Counting of growth rings gives a rough estimate of the age of the turtle, but can be used reliably only if the areola (hatchling scute) is present. In the Stoddard population of *Graptemys* (all 3 species) the maximum number of rings observed is six in males and up to twelve in females (Table 10). After that time earlier rings become worn off, and growth is so limited that new rings are difficult to distinguish. As the turtles continue to shed epidermal scutes the rings become less and less visible, until the shell is relatively smooth. Thus reliable estimate of the ages of most males over 6 and females over 12 years was impossible. A *Graptemys pseudogeographica* survived 32 years captivity (Bowler, 1977). Cagle (1950) suggested that *Pseudemys scripta elegans* were reproductively active for 40 to 50 years, and that natural longevity extended from 50 to 75 years. Moll and Legler (1971), however, were more conservative, estimating 30 years longevity for tropical *Pseudemys scripta* under natural conditions. Gibbons (1968) estimated some Michigan *Chrysemys picta* to be nearly 40 years old. Judging from the size and age structure of the Stoddard population, and the degree to which shells of some individuals are worn, 30-50 years seems a reasonable estimate for the present age of many individuals.

Natural Growth

The smallest sexually mature male *G. ouachitensis* caught in the wild was 7.48 cm in carapace length. Wild caught *G. geographica*, *G. ouachitensis* and *G. pseudogeographica* males were not reproductively mature in their 3rd year, but did mature in four to six years.

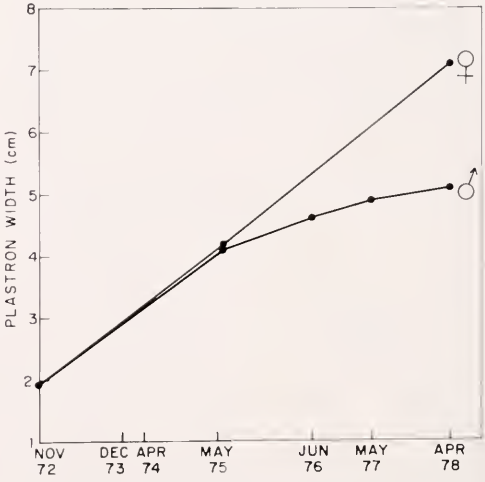

Figure 9. Plastron width changes in captive raised hatchlings.

The youngest mature female *G. ouachitensis* and *G. pseudogeographica*, as evidenced by the presence of shelled eggs, were in their eighth year. Female *G. geographica* that were in their tenth and twelfth years had not yet matured (based on a lack of enlarged ovarian follicles).

Figures 10 and 11 and Table 10 show the relationships between the number of growth rings and the weight and carapace length respectively for *G. ouachitensis* females from the wild. The growth rate pattern of wild females is similar to that shown for captive raised hatchlings (Figs. 4 and 5). The curve (Fig. 10) shows a trend in which carapace length levels off and growth slows. Like the males, females appear to level off in carapace growth once reproductive maturity is reached.

Recapture of nine *G. pseudogeographica* and six *G. ouachitensis* adult females between one and five years after first marking showed very little increase in carapace length, 1.1 mm per year (Table 11). Two individuals decreased slightly in length, which could be due to carapace wear or original measurement error or shrinkage. Ream (1967) also reported loss in carapace length in *Chrysemys picta*. Although increase of the carapace length slows after maturity, 13 individuals exhibited an increase in body weight. The average change in weight for the 15 females (both species) was +49.2 g/yr. Laboratory raised females gained nearly twice as much in body weight in their fifth year of growth, 96.06 g/yr. Changes in carapace cross section to accommodate more eggs continue after ma-

Table 10. Number of growth rings and size of wild caught *G. ouachitensis* ♀ s.

Age	Wt. (g)	CL (cm)	CW (cm)	CH (cm)	PL (cm)	PW (cm)	Maturity
0	4.4	3.1	3.0	1.4	2.9	2.0	hatchling
2	53	7.6	6.5	3.2	6.7	4.5	juv.
3	64	7.8	7.0	3.5	7.3	5.4	juv.
4	170	10.9	9.4	4.6	10.2	6.8	juv.
5	261	12.5	10.2	5.2	11.8	7.5	juv.
6	515	16.6	12.8	6.8	15.8	9.5	juv.
7	441	15.7	12.2	6.2	14.4	9.3	juv.
8	572	16.6	12.6	6.7	15.7	9.4	
8	605	16.5	13.4	6.7	16.2	10.7	
8	767	18.3	14.2	7.4	17.2	11.0	
8	564	16.3	12.8	6.7	15.2	9.3	
8	560	17.2	13.2	6.5	15.4	9.7	
8	557	16.7	13.1	6.2	15.6	9.3	
9	983	20.3	16.1	8.1	19.3	12.2	
9	748	17.8	13.6	7.6	16.6	10.2	eggs
?	1000	16.3					eggs
?	682	17.4					immature
?	555	16.0					immature
10	1031	20.0	15.3	8.0	18.2	11.3	
10	815	19.1	14.1	7.4	17.7	11.1	
11	714	17.4	13.8	7.2	16.1	12.4	eggs
11	1048	21.1	16.5	8.5	19.3	12.0	eggs
12	1032	20.0	15.7	8.4	18.8	11.7	

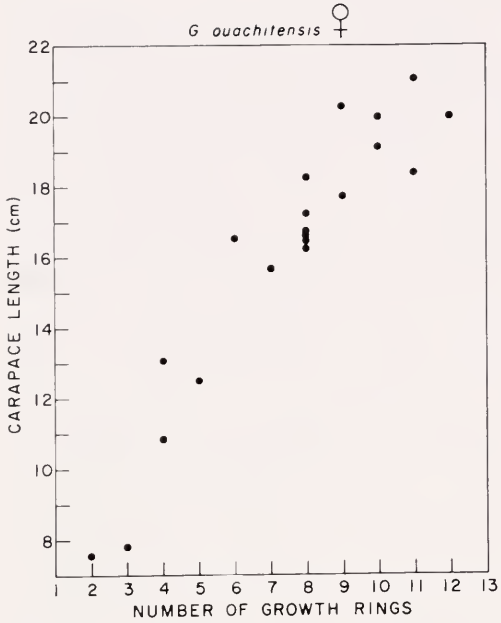

Figure 10. Relationship between carapace length and number of growth rings in wild caught female *G. ouachitensis*.

turity and probably are responsible for the increase in weight. Males show little change in carapace length or shape following maturity.

POPULATION COMPOSITION

Frequencies of size classes of carapace length and weight are shown in Figures 12-15. Definite peaks in both weight and carapace length depict the larger average size of *G. pseudogeographica* females; 82% of the *G. pseudogeographica* females range between 21-25 cm while 85% of the *G. ouachitensis* females range between 19-23 cm. *G. ouachitensis* also weigh less than *G. pseudogeographica* females: 85% of the *G. ouachitensis* were between 800-1400 g while 79% of the *G. pseudogeographica* were in the 1100-1800 g categories. The peak carapace length reached in females probably represents the size at which growth rate decreases at the onset of reproductive maturity. The broader distribution for weight may be due to bias introduced by weighing turtles with full or empty bladders, or with or without mature eggs.

Males of both species are extremely uniform in weight and body size. This reflects the early age of maturity and the slowing of growth after maturity, as was shown in the laboratory population.

POPULATION DYNAMICS

The size of the study area and the mobility of the turtles did not allow a reasonable estimate of population density through traditional mark and recapture techniques. Individual turtles were found to move over 4 km up and down stream within the course of a year, so the use of

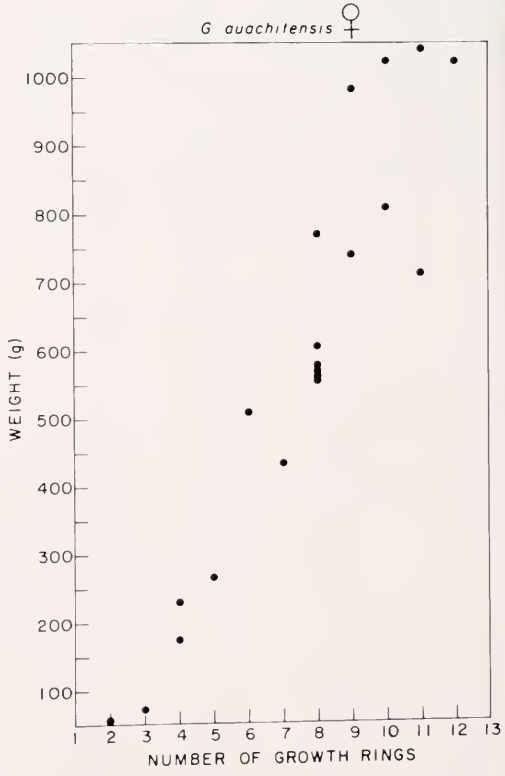

Figure 11. Relationship between weight and number of growth rings in wild caught male *G. ouachitensis*.

traditional mark and recapture index would tend grossly to overestimate the number of turtles actually present. Even in the fall when they are at the overwintering site turtles are moving to different locations (Table 12). This was evidenced by the capture and release of 131 *Graptemys* on 13 October 1977 at the "hibernaculum" in Crosby Slough. On 11 November 1977, 113 *Graptemys* were caught at the same site, but only two of these were turtles that were marked on 13 October.

From 3 June through 13 August 1972, stationary fyke nets were set, and usually checked daily, at 15 localities at Stoddard (Fig. 1). During that period, 326 *G. pseudogeographica* (299 females and 27 males) and 168 *G. ouachitensis* (167 females and one male) were captured.

The highly skewed sex ratio apparent in these totals was biased by extensive trapping adjacent to nesting beaches where females were usually abundant. Traps adjacent to the beaches caught 257 females and only two males. Traps set away from beaches and sloughs, in shallow weedy areas caught 196 females (156 *G. pseudogeographica,* 40 *G. ouachitensis*) and 26 males (25 *G. pseudogeographica,* one *G. ouachitensis*). This was still an overestimate of females since male *G. ouachitensis* were found primarily along the sloughs in moving water. Female *G. ouachitensis* were found primarily in the backwater areas adjacent to islands and

Table 11. Growth of marked turtles in the wild.

#	CL (cm)	△ CL (cm)	△ Wt. (g)	Time after marking
Female *G. pseudogeographica*				
256	22	.9 (.225)	158 (39.5)	4 yr.
342	23.1	.2 (.047)	613 (144.2)	4 yr., 3 mo.
441	23.8	.1 (.044)	152 (67.5)	2 yr., 3 mo.
57	23.1	.4 (.092)	215 (49.88)	4 yr., 4 mo.
59	24.8	2.0 (.4)	412 (82.4)	5 yr.
204	21.0	0	102 (19.4)	5 yr., 4 mo.
331	22.9	.2 (-.041)	425 (86.7)	4 yr., 11 mo.
418	23.1	.7 (.143)	180 (36.7)	4 yr., 11 mo.
594	22.8	1.0 (.02)	58 (11.8)	4 yr., 11 mo.
Male *G. pseudogeographica*				
595			-11	4 yr., 11 mo.
598	15.1	.6 (.12)	+23	5 yr.
602	13.4	.1	+6	4 yr., 11 mo.
Female *G. ouachitensis*				
214	21.8	.8 (.2)	297 (74.25)	4 yr.
685	20.9	.1 (.1)	53 (53)	1 yr.
714	19.2	0	43 (-43)	1 yr.
496	22.1	.3 (.071)	- 15 (-3.53)	4 yr., 3 mo.
47	20.8	1.8 (.45)	250 (62.5)	4 yr.
377	20.6	(-.1)(-.044)	128 (56.8)	2 yr., 3 mo.

CL = carapace length at last capture; △CL = change in carapace length since first capture with average yearly change in parenthesis; △Wt. = change in weight since last capture with average yearly gain in parenthesis

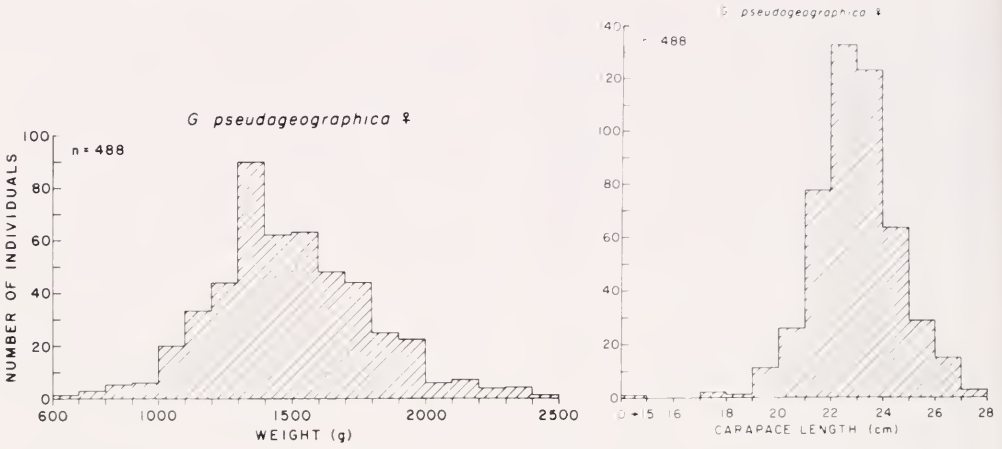

Figure 12. Weight and carapace length classes of *G. pseudogeographica* females captured.

sloughs and were less abundant in shallows away from islands or in moving water.

Gill nets set by commercial fishermen adjacent to the nesting beaches of the main island caught nearly equal numbers of female *G. ouachitensis* (44) and *G. pseudogeographica* (45), but more female *G. pseudogeographica* (142) than *G. ouachitensis* (115) were caught in fyke nets adjacent to the nesting beaches. Female and male *Graptemys ouachitensis* outnumbered *G. pseudogeographica* when trammel nets were set in the sloughs near overwintering sites. In the fall of 1976 and again in 1977, 239 *G. ouachitensis* (191 females and 48 males) and 67 *G. pseudogeographica* (45 females and 22 males) were captured. Since males of both species are found primarily in the

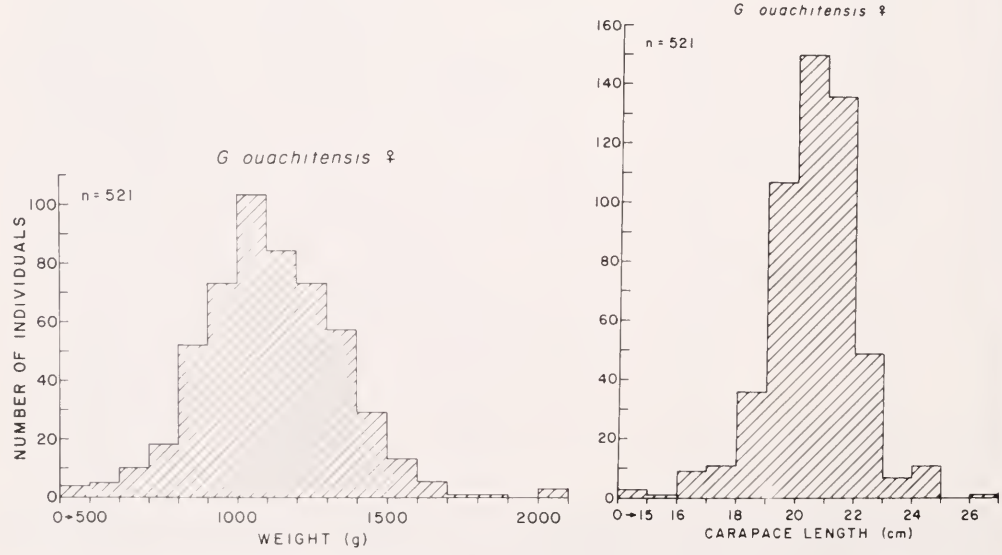

Figure 13. Weight and carapace length classes of *G. ouachitensis* females captured.

Table 12. Turtles caught at Crosby Wing Dam overwintering site.

Date	*G. geographica*			*G. ouachitensis*			*G. pseudogeographica*			Total
	♂	♀	Juv.	♂	♀	Juv.	♂	♀	Juv.	
Oct. 1, 1976	0	4	0	7	49	0	6	19	0	85
Oct. 13, 1977	3	0	0	30	67	1	14	13	1	131
Nov. 11, 1977	9	5	1	11	70	4	1	11	1	113
	12	9	1	48	186	5	22	43	2	329

sloughs and female *G. pseudogeographica* occur primarily in the backwaters, male *G. pseudogeographica* are over-represented in this sample. The ratio of male to female *G. ouachitensis*, 1:4 is fairly realistic but may be an overestimate of the males.

In 1972 a total of 802 *G. ouachitensis* and *G. pseudogeographica* was captured. The sex ratio of 12.6 females per male was biased due to trapping near nesting beaches and use of gill nets. An additional 315 (236 females and 79 males) were captured at intermittent trapping intervals in 1975 and 1977. *Graptemys ouachitensis* and *G. pseudogeographica* make up nearly equal numbers of the 1,117 turtles sampled, 573 and 544 respectively. *Graptemys geographica* were not marked in 1972, but were less abundant, making up less than 10% of the total number of *Graptemys* captured. In 1976 and 1977 this species made up only 7% of the total number caught at the hibernaculum.

Trapping results from 3 June through 13 August 1972 ranged from a daily catch of 106 on bright, warm, sunny days during the height of the nesting season to none on cold, rainy days. Fyke nets were used a total of 45 days, capturing an average of 11 new individuals per day.

Only 48 turtles were recaptured one or more times during the course of the study. Any turtle recaptured the day after

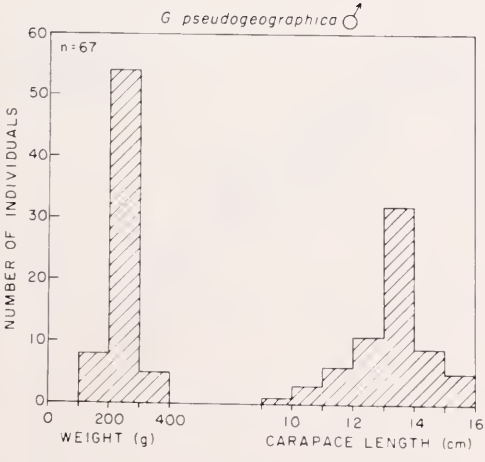

Figure 14. Weight and carapace length classes of *G. pseudogeographica* males.

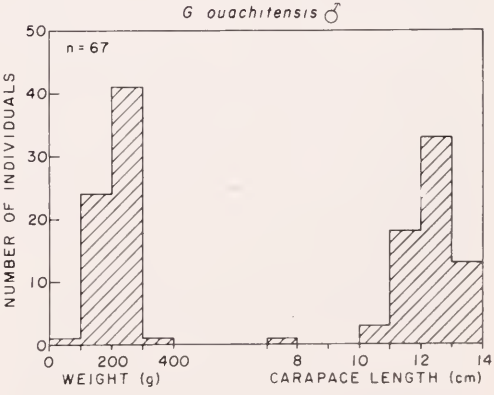

Figure 15. Weight and carapace length classes of *G. ouachitensis* males.

release was not recorded since release was made near the trap site increasing the probability of it being caught in the same trap as it attempted to escape.

MOVEMENTS

During 1972 marked turtles moved distances as far as 4 km. Recapture intervals for females adjacent to nesting beaches ranged from three to 11 days. Since all of these had shelled oviducal eggs upon first capture I assumed that they stayed near the beaches in preparation for laying. Turtles which were caught near the beaches without shelled eggs were never recaptured in the same area in 1972. Twelve were recaptured between 0.4 km and and 1.6 km north of the island from three to 41 days later. Once a female had laid her eggs she vacated the area adjacent to the island and moved into a regular feeding area. Sixteen turtles were recaptured in the same backwater feeding areas 4 to 35 days apart suggesting a regular home range. One female *G. pseudogeographica* first caught after nesting was recaptured three days later 1.6 km north of the island.

Three gravid females caught near the island in 1972 were recaptured near the same beaches in May, 1977. This suggests that an individual turtle may return to the same area to nest year after year. Two females marked near the nesting beaches in June, 1972, were found in October of the same year 4 km north in Crosby Slough in a communal hibernaculum. Nine more recaptures from 1972 were made there in 1976 and 1977. Two turtles hibernating in Crosby Slough in 1976 were recaptured there in fall 1977.

A female *G. pseudogeographica* found on the nesting island 14 June 1976, was released at the boat landing at Stoddard, 15 June 1976. She was recaptured at the Crosby Slough hibernaculum 13 October 1977. This is approximately 8 km from her point of release. Shealy (1976) showed that female *G. pulchra* were capable of homing up to 15 km both up and downstream from points of release to points of original capture, but displaced males tended to be recaptured near the release point. He suggested that this could be because only males have a defined home range. A male *G. pseudogeographica* caught at Crosby Slough wing dam 14 October 1972, was recaptured at the same place 13 October 1977. It had been released at the Stoddard landing in May, 1973, so, like females, males possess homing ability; however, if males regularly travel long distances is not known. The long distances regularly moved by the females from overwintering areas, to nesting grounds, to feeding areas and back to overwintering areas suggests that females have a large irregular activity area defined by the pool itself.

FOOD AND FEEDING

Detailed analysis of food partitioning and feeding behavior is reported in Vogt (1978). The stomach contents taken during June, July, and August from 21 female *G. geographica*, 54 female *G. ouachitensis* and 35 female *G. pseudogeographica* were quantitatively analyzed by volume. Female *Graptemys geographica* were shown to be mollusk specialists, mollusks made up 66% by volume of all their food. Insect larvae and fish carrion comprised most of the remainder. Mollusks were also important in the diet of female *G. pseudogeographica* (19% by volume). In *G. ouachitensis*, however, mollusks made up only 2.8% of the volume.

Vegetation comprised only 3.9% of the volume of material consumed by *G. geographica*, whereas *G. ouachitensis* and *G. pseudogeographica* consumed 31.5% and 42.4% respectively. Algae, *Potamogeton*, *Lemna* and *Vallisneria* were the

plants most frequently eaten.

Insects (caddisfly cases, mayfly larvae, damselfly larvae) comprised 51% by volume of foods eaten by *G. ouachitensis* females; while only 21.9% and 15.3% in *G. pseudogeographica* and *G. geographica* respectively.

No differences in food habits among the males of the three species could be determined. Mayfly larvae, damselfly larvae, caddisfly cases, beetles, flies, other insect larvae, mollusks and fish carrion were eaten by males of all three species but only trace amounts of vegetation were found to have been eaten.

ACTIVITY

Seasonal

Map turtles become active in western Wisconsin in April when they begin dispersing from their overwintering sites while the water temperature is still 4-7°C (Fig. 16). Mating presumably takes place while the turtles are still concentrated around the hibernaculum, but due to water opacity, courtship has never been observed in the wild. I have observed species such as *Emydoidea blandingi*, *Chrysemys picta* and *Chelydra serpentina* mating and courting at this time both north and south of this site in Wisconsin, thus water temperatures are not too cold to allow turtles to breed at this time.

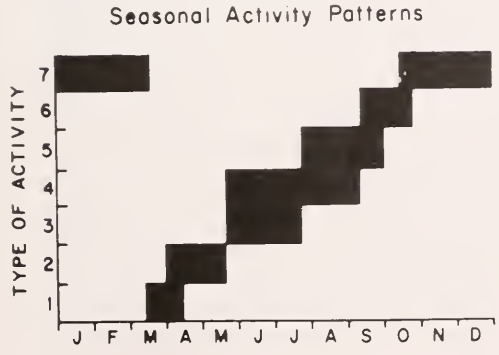

Figure 16. Generalized seasonal activity patterns of *G. ouachitensis* and *G. pseudogeographica*. 1. Emergence from overwintering sites. 2. Dispersal from overwintering sites and basking. 3. Egg laying. 4. Feeding. 5. Hatchling emergence. 6. Backing and movements to overwintering sites. 7. Aggregating at overwintering sites.

During May females move out of the channels and toward the nesting islands. They concentrate to bask by the dozens on the few available emergent logs near the nesting beaches. Male *G. ouachitensis* remain along the channels and sloughs, but during the summer many male *G. geographica* and most male *G. pseudogeographica* move into the quiet backwaters to forage. This is evidenced by the summer fyke net catches in 1972, in which 27 male *G. pseudogeographica* and two male *G. ouachitensis* were captured in the shallow, weedy area, 0.4 - 2.4 km north of the island. Many male *G. geographica* were also caught in this area, but were not marked.

Earliest documented feeding by females occurred on 26 May. There are several possibilities why feeding does not commence until this time: (1) there is not enough room in the body cavity for the stomach or the intestine to expand with food until the first clutch of eggs is laid; (2) the aquatic vegetation and insect larvae on which they feed have not grown to harvestable quantities; or (3) temperatures are not high enough to allow efficient digestion.

All of these ideas are plausible for females of both *G. ouachitensis* and *G. pseudogeographica*, but females of *G. geographica* feed nearly exclusively on mollusks which are abundant throughout the year. They do not consume as large a volume of food as do the other two species, so do not have as great a problem with limited gut space. The earliest *G. geographica* with food in its stomach was located 26 May, only 4 days before the first *G. pseudogeographica* and *G. ouachitensis*. Why feeding is postponed until

such a late date is unclear.

In late May or early June (23 May-10 June) the turtles lay their first clutch of eggs and then move away from the nesting islands to feed for two to three weeks while shell is being deposited around the second clutch of enlarged ovarian follicles. *Graptemys geographica* and *G. pseudogeographica* move far into the backwaters where there are patches of *Potamogeton* and *Vallisneria* and many stumps available for basking. Though some females of *G. ouachitensis* also move into the backwater areas, many stay near the nesting islands to feed and bask or move to the vegetation patches immediately adjacent to the river channel.

After laying their second clutch of eggs the females return to the feeding grounds. Most female *G. ouachitensis* then move away from the nesting islands to the vegetation patches adjacent to the sloughs or channels.

Feeding continues until the first week of September. The turtles then spend the next two months basking, during which time their guts are evacuated presumably so that they can enter hibernation with an empty gut cavity. Turtles which were not allowed to clear the gut cavity before they were artificially hibernated in the laboratory died in 1-2 months, whereas those that were allowed to, lived until Spring.

By October map turtles begin moving to the wing dams along the sloughs and channels. Here they are able to lodge themselves within the rock piles, so not to be carried away by the current and are supplied with a constant flow of well-oxygenated water. They are not totally dormant throughout the winter as commercial fishermen occasionally catch them in their nets while gill netting under the ice. The seasonal activity patterns of *G. ouachitensis* and *G. pseudogeographica* are generalized graphically in Figure 16.

Basking activity

The functions of basking behavior in turtles have been discussed at length by other investigators (Cagle, 1950; Boyer, 1965; Moll and Legler, 1971; Auth, 1975; Shealy, 1976). The primary function of basking is thermoregulatory in nature.

On 14 June 1977, between 1545 and 1550 hours, six female *G. ouachitensis* and one male *G. ouachitensis* were chased from a basking log into a trammel net. The air temperature (sky partially overcast) was 21.5°C and the water, 22.5°C. Cloacal temperatures of the six females ranged from 23.8°C to 27°C (mean 25.8°C); the male was the same temperature as the water – 22.5°C. No other data were obtained on internal temperatures of basking turtles. Since they bask for hours even at ambient temperatures above 35°C, on sunny days their body temperatures must reach considerably higher. Moll and Legler (1971) reported voluntary core temperatures in basking *Pseudemys scripta* as high as 35.7°C. As temperatures approach the critical thermal maximum, basking turtles begin gaping (Moll and Legler, 1971). Male *Graptemys* were observed gaping more frequently than females.

Basking activity was observed between 0900 and 1800. Throughout the day a turtle would alternate between basking, feeding or other activity in the water. Basking sites were at a premium in the study area. Turtles used partially emerged logs, stumps, rock piles, muskrat houses, and sand bars as basking sites. Logs or stumps that were not adjacent to a shoreline were used more frequently than any other type of basking site. Many, particularly males, would often climb onto the highest limbs of a basking log, often 2 m above the water. As turtles climbed onto basking logs they would usually become oriented in an anterior to posterior or posterior to posterior direc-

tion with respect to nearest neighbor. Not only would this reduce the possibility of aggressive interactions by avoiding head to head contact, but also allowed for closer packing on the log by allowing a turtle to crawl partially upon the carapace of another turtle. I did not observe any turtles basking with the plastrons resting over the anterior end of the carapace of another turtle. Up to 47 adult *Graptemys* were observed basking simultaneously on a 6 m log with no aggressive interactions. *Chrysemys picta belli, Trionyx muticus* and *T. spiniferus* were also observed using the same basking logs as the *Graptemys*. Male *T. spiniferus* were observed biting male *Graptemys* that moved into the proximity of the head region on two occasions.

Basking turtles were more prone to disturbance by passing boats within the first 5 min of emergence. The diving of one turtle into the water often triggered the entire log of turtles to slip in. After looking in several directions the turtles would all resume basking within 5 to 10 min. Individuals were noted to remain on a basking log for over 100 min before being disturbed. They occasionally lost their balance and fell into the water, precipitating sudden evacuation of the entire log.

Throughout the time *Graptemys* are basking they are extremely alert to and wary of the slightest disturbance. Approach within 30 meters without disturbing them is difficult unless the observer is snorkeling in the water. Communal basking may be advantageous for the sighting of potential predators and also attracting grackles.

Once a turtle became stationary on a basking log it would stretch out the hindlegs to their fullest extent and spread the webbing between the toes. The neck and forelimbs would also be extended. Presumably this position functions to dry out the skin and increase the surface area exposed to solar radiation. But it also has another purpose; to expose the areas under the limbs where leeches attach. Common grackles (*Quiscalus quiscula*) were observed on 10 June and 14 June removing leeches (*Placobdella parasitica*) from the leg and neck cavities of basking *Graptemys* (Vogt, 1979). The grackles moved along the basking log inspecting each turtle, often walking around inspecting all leg cavities of an individual turtle. The turtles seemed to be oblivious of the grackle, even when the turtle was rocked back and forth on the log by the bird pulling at a particularly tenacious leech. Both male and female turtles allowed grackles to hunt for leeches on their bodies. The only two instances of grackle grooming were on basking logs containing over 20 adult turtles. At what size turtles no longer view the grackle as a potential predator and allow cleaning would be interesting to learn.

Predation

No predation upon basking turtles was noted. Nests and eggs were destroyed by red fox (*Vulpes fulva*), raccoon (*Procyon lotor*), and otter (*Lutra canadensis*). Most (90%) of the nests on beaches 2 and 3 were destroyed within 24 hours after laying. If the nest was not raided within 48 hours it was usually not bothered. During 1977 raccoon predation was responsible for the destruction of over 90% of the nests on both ends of Brownsville Island. No nest predation was observed on the main nesting island in 1976 or 1977. Otters excavated nests and consumed eggs during June, July, and August. Adult map turtles appear to have few potential predators in the study area.

In August, when the hatchlings move to the water, flocks of ring-billed gulls (*Larus delawarensis*), crows (*Corvus brachyrhynchos*), grackles, and red-winged blackbirds (*Agelaius phoenice-*

us), have been observed covering the beaches. On one occasion crows were found excavating a nest where hatchlings were emerging. Redwinged blackbirds and grackles were observed eviscerating hatchlings, leaving only the shells on the beach. Great blue herons (*Ardea herodias*) were also seen walking on the nesting beaches from 0600-0700, when hatchlings were leaving the nest, but no predation was observed. Many turtles are found with the carapace gashed, presumably by outboard motors. Individuals missing one forelimb, two forelimbs, or one hindlimb seemed to be able to function adequately, and were found laying eggs. An adult female *G. ouachitensis* collected in 1972 had recently suffered severe injury to the anterior part of the carapace and had lost half of the mandible. She was recaptured in 1976 still able to function with only half the mandible, and her shell was not completely healed after four years.

SUMMARY

Detailed analysis of the systematics of the false map turtle complex indicates that *Graptemys ouachitensis* and *Graptemys pseudogeographica* are separate species (Vogt, 1978). Natural history data were gathered from populations on the Mississippi River, Vernon County, Wisconsin from 1972 through 1978. Turtles were collected in a 230 hectare area by using fyke nets with leads, gill nets, trammel nets and hand captures. Clutches of eggs were collected from females and incubated in the laboratory under various temperature regimes. Hatchlings were maintained in the laboratory for six years to study differential growth rates of males and females, and to determine the time at reproductive maturity and the sex ratios at hatching.

Examination of reproductive tracts of 50 females suggests that they annually lay two clutches of eggs. Eight females perhaps laid three clutches. The average clutch size of 40 *G. pseudogeographica* was 14.1 and for 65 *G. ouachitensis* was 10.2. There is a direct correlation between clutch size and female carapace length. The mean clutch weight and mean egg length increase with an increase in female carapace length and also the clutch size.

Females begin developing enlarged ovarian follicles in mid-July and enter hibernation with the body cavity packed with enlarged follicles in October (Fig. 16 shows the occurrence of major seasonal activity patterns). Mating probably occurs either in October or April while the turtles are congregated around hibernacula.

The courtship displays of male *G. ouachitensis* and *G. pseudogeographica* involve drumming of the foreclaws against the ocular region of the female. There was a mean of 10.3 (n = 26) contacts per "titillation" bout for *G. pseudogeographica* and only 5.2 (n = 24) for *G. ouachitensis*. *Graptemys pseudogeographica* also differs by bobbing its head in a vertical plane while *G. ouachitensis* holds its head stationary while vibrating the foreclaws.

Fresh nests were found from 18 May to 11 July, but females with shelled oviducal eggs were found as late as 26 July. However, 95% of females captured after 10 July lacked oviducal eggs.

Nest temperatures, monitored continuously from 16 July to 17 August 1972, fluctuated from 2.2°C to 12.2°C daily. The mean daily fluctuation for two nests for 28 days was 6.7°C. Natural incubation periods ranged from 60-75 days. Hatching success is approximately 95% in both laboratory and nature.

Incubation temperature in the laboratory was shown to affect hatching success, number of scute anomalies, size of yellow blotches on the head, and sex determina-

tion in both *G. ouachitensis* and *G. pseudogeographica*. More scute anomalies occurred at 35°C than 25°C. The yellow blotches on the head were larger on siblings incubated at 25°C than on those at 35°C. All eggs that hatched at 25°C (54 of 66) were male. All eggs that hatched at 35°C (n = 17) were female. These results strongly suggest that, at least in the laboratory, sex can be determined by early developmental temperatures. A sex ratio of 5 females per male was calculated from trapping results. Sex determination by developmental temperature may help to explain the skewed sex ratio in both *G. ouachitensis* and *G. pseudogeographica*.

Sixty-five *G. ouachitensis* and 132 *G. pseudogeographica* hatchlings from 1972 were raised in the laboratory. During the first three years male and females (n = 86) increased at nearly the same rate in mass and shell proportions. Male growth slowed between March 1975 and June 1976 while females continued to grow at the initial rate. Males attained sexual maturity in their fourth year, as evidenced by secondary sexual characteristics, and the slowing of their growth rate is apparently correlated with this. Wild male *Graptemys* of all three species were mature when four to six years old.

No females had matured sexually by April 1978. The youngest wild-caught mature female *G. ouachitensis* and *G. pseudogeographica* were in their eighth year. Growth rings were used reliably to estimate age only during the first six years in males and up to 12 years in females. Mature male and female *G. pseudogeographica* and *G. ouachitensis* recaptured after one to five years showed little increase in carapace length (less than 1.1 mm per year).

In 1972 a total of 802 *G. ouachitensis* and *G. pseudogeographica* were captured. Both male and female *G. pseudogeographica* are able to return to their site of original capture after being displaced downstream as far as 8 km. The long distances regularly moved by females from hibernating sites to nesting grounds, to feeding areas and back to hibernating sites precludes the use of the term home range.

Stomach contents of 21 *G. geographica*, 54 *G. ouachitensis* and 35 *G. pseudogeographica* females were quantitatively analyzed by both volume and frequency of occurrence. *Graptemys geographica* is a mollusk specialist, mollusks composed 66% of the volume of food consumed. Mollusks are also important in the diet of *G. pseudogeographica* females (19% by volume), but they make up only 2.8% of the diet of *G. ouachitensis*. Vegetation makes up a large proportion of the diet of *G. ouachitensis* (31.5%) and *G. pseudogeographica* (42.4%). Insects composed 51% of the volume of food eaten by *G. ouachitensis* while only 21.9% and 15.3% in *G. pseudogeographica* and *G. geographica* respectively.

No differences in food habits were noted among the males of the three species. All consumed insect larvae, mollusks and fish carrion. Female *G. ouachitensis* were observed to be primarily surface feeders. *Graptemys geographica* and *G. pseudogeographica* feed mostly underwater. Map turtles become active in April and begin dispersing from the hibernacula while water temperatures are 4°-7°C. During May females move out of the channels toward nesting beaches where they congregate to bask, but have not been observed feeding until 26 May; presumably they do not feed until after laying their first clutch of the year.

In late May or early June map turtles lay their first clutch of eggs and then move away from the nesting islands to feed for two or three weeks while shells are being deposited around their second clutch of eggs. Feeding continues until

the first week of September. By October all three species are moving toward communal overwintering sites. Up to 131 *Graptemys* have been caught in 30 minutes behind a wing dam in October.

Basking activity was observed primarily between 0900 and 1800 hrs. Throughout the day turtles alternate between basking, feeding or other activity in the water. Basking sites are used communally. Up to 47 adult *Graptemys* were observed basking simultaneously on a 6 m log. No aggressive interactions were observed between basking *Graptemys*. On two different occasions a common grackle *Quiscalus quiscula* removed leeches (*Placobdella parasitica*) from basking *Graptemys*.

Nest predation by red fox, raccoon and otter was observed. Hatchlings were consumed as they emerged from the nest by ring-billed gulls, crows, grackles and red-winged blackbirds. Outside of man, adult map turtles have few potential predators in the study area.

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