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FRED R. CAGLE,  
*DEPARTMENT OF ZOOLOGY, TULANE UNIVERSITY,  
NEW ORLEANS.*



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## TWO NEW SPECIES OF THE GENUS *GRAPTEMYS*

FRED R. CAGLE,

*Department of Zoology, Tulane University,  
New Orleans.*

Two distinctive, undescribed populations of turtles were found in Mississippi and Alabama by the Tulane University field crews of 1952 and 1953. The turtles are abundant at the type localities and are the dominant species of turtles present.

Both species are closely related to *Graptemys oculifera* (Baur) and with this species form a unique complex of three allopatric species ranging from the Pearl River in the west to the Alabama river in the east. The three groups of populations are recognized as species because: (a) the degree of difference between the three groups is much greater than that between the subspecies of related species occurring in the central United States; (b) the degree of difference is as great as that occurring between sympatric species of this and related genera; (c) there are no intermediates. These factors suggest that these populations have been reproductively isolated for a long period. It is not possible to conclude that these three forms would not be capable of interbreeding if they were not spatially isolated.

The following abbreviations are used in the descriptions: Cl., carapace length (not along curve); Cw., carapace width; Pl., plastron length; Pw., plastron width; Hw., head width; Ht., height; Aw., alveolar width. All measurements are maximum. The size of individuals is expressed as plastron length.

UMMZ = University of Michigan Museum of Zoology; CNHM = Chicago Natural History Museum.

The illustrations in color were provided through the cooperation of Roger and Isabelle Hunt Conant who had photographed the turtles for inclusion upon one of the color plates in their forthcoming *Field Guide to the Reptiles and Amphibians*. Mr. George P. Meade generously provided the funds for their publication here. The research was aided by a grant from the National Science Foundation.

The collections essential to these descriptions could not have been made without the enthusiastic field work of graduate students. I am especially grateful to A. H. Chaney, Robert Gordon, Donald Tinkle, Robert Webb, Walter Stone, and Howard Suzuki:

### *GRAPTEMYS FLAVIMACULATA*, sp. nov. Yellow-blotched Sawback

*Holotype*.—Tulane 14798, a juvenile male, collected from the Pascagoula River, 13 miles S.W. of Lucedale, George Co., Mississippi, 18 Aug. 1952 (figs. 3, 5, 7).

*Paratypes*.—Tulane 14752, 14754, 14756-766, 14768, 14772, 14774-776, 14778-785, 14788, 14790, 14795, 14799-802, 14804, 14806-809, 14811-812, 14815, 14818, 14821-822, 14825-827, 14829, 14832-833, 14842, 14845-846, 14850, 14852-854, 14857-858, 14862-863, 14865-

871, 14873-875, 14920-921, 14935, 14938; CNHM 69806-808; UMMZ 108567-571, 36 juveniles, 44 males and 3 females collected at the type locality by a Tulane University field crew.

*Hypodigm.*—A total of 124 preserved specimens, 74 examined by dissection and not retained, and many others observed in the field provided a series of observations for the analysis of variation of this species. The study of these individuals has also provided a basis for determination of some aspects of the behavior and for estimating the population structure.

*Diagnosis.*—*Graptemys flavimaculata* is a member of a narrow-head complex that includes three species occurring only in Louisiana, Mississippi and Alabama, *Graptemys oculifera* in the Pearl River drainage, *Graptemys flavimaculata* in the Pascagoula River and its tributaries, *Graptemys nigrinoda* in the Black Warrior and Alabama Rivers (fig. 9).

*G. flavimaculata* differs from *G. nigrinoda* in that: the postorbital mark is rectangular or triangular, is broader than any of the lateral neck lines entering the orbit, and is usually joined to a longitudinal line; the ventral surface of the jaw is dominated by broad yellow lines much wider than the olive-green interspaces; each costal with a large yellow or orange central blotch or crescent; the vertebral spines are high, narrow, laterally compressed; the edge of the carapace of males and juveniles is much less serrate (Table 1).

*G. flavimaculata* differs from *G. oculifera* in that: the orbital mark is broad and is ordinarily joined to a dorsal longitudinal neck line; the lower jaw is dominated by broad yellow lines; each costal has a large blotch or crescent of yellow.

*Description of holotype.*—Carapace length, 8.05 cm; carapace width at juncture of fourth and fifth marginals, 6.15 cm; carapace width at juncture of seventh and eighth marginals, 6.72 cm; plastron length, 7.43 cm; width of posterior lobe of plastron, 3.63 cm; height (measured in vertical line through spine of second vertebral), 3.70 cm; height at spine of third vertebral, 3.41 cm; head width (measured at anterior edge of tympanum) 1.24 cm; length of symphysis of lower jaw, 0.44 cm; alveolar width of upper jaw, 0.25 cm.

Edge of carapace serrate; each marginal projecting beyond anterior corner of the next posterior one. Each marginal with a wide, yellow bar or semicircle of yellow. Each costal with a broad ring or yellow blotch (figs. 1, 3).

Plane of the plastron 1.40 cm below a plane through the edge of the fifth to the seventh marginals. Yellow color predominant on the plastron, bridge and ventral surface of marginals. Black plastral marks extending along the sutures between each pair of shields (fig. 7).

Neck with 19 longitudinal, yellow lines; those on the ventral surface twice the width of those on the dorsal surface. Longitudinal, interorbital line nearly as wide as widest dorsal neck lines and terminating above postorbital mark. Three yellow lines between the orbits. Two broad, yellow lines entering the orbit below a triangular post-

TABLE 1  
A COMPARISON OF *Graptemys oculifera*, *flavimaculata* and *nigrinoda*

	<i>oculifera</i>	<i>flavimaculata</i>	<i>nigrinoda</i>
Carapace margin of adult ♂	slightly serrate	slightly serrate	very serrate
Vertebral projection	laterally compressed; spine-like	laterally compressed; spine-like	broad, rounded knob-like
Postorbital mark	Ovoid, rectangular or rounded; usually not connected with dorsal, longitudinal line; usually not wider than widest neck line	usually rectangular and joined to a dorsal, longitudinal neck line; usually 2 or 3 times wider than widest neck line	a vertical curved bar not wider than neck lines; connected dorsally by diagonal lines to form a Y shaped mark
Neck lines entering orbit	two broad, yellow lines; width equal to width of black area between them	two to four yellow lines; 2 widest much broader than width of olive-green area between them	usually four yellow lines; 2 widest about twice width of narrower lines
Interorbital line	broad; equal to or greater than width of broadest neck lines	narrower than neck lines	narrower than neck lines
Color background of soft parts	black	olive-green	black
Markings, lower jaw	longitudinal yellow lines as wide as black interspaces; black color predominant	longitudinal yellow lines much wider than olive-green interspaces; yellow color predominant	longitudinal lines as wide as interspaces; black color predominant
Markings, forelegs	lines from 2nd and 4th digits equal in width; no or very narrow lines from base of 3rd digit	lines from base of 2nd and 4th digits very broad; line from base of 3rd digit $\frac{1}{2}$ to $\frac{1}{2}$ width of line from 3rd digit	as in <i>oculifera</i>
Markings, costal shields	yellow or orange circle formed on each costal by a broad line (broader than widest neck line)	large yellow blotch or crescentic mark covering most of the surface	yellow or orange semi-circle or circle formed by a narrow line (much narrower than widest neck line)
Color, plastron	yellow or orange	light cream	yellow often tinted with red

orbital mark (figs. 1, 5).

Horny edges of both upper and lower jaws light in color. Ventral surface of lower jaw with two broad, transverse, yellow bands.

Anterior surface of forelegs with wide, yellow lines; those from the base of second and fourth toes are the broadest.

*Description of paratypes.*—The paratypic series is divided into juveniles, adult males and adult females to insure adequate description.

*Juveniles.*—The juveniles represent individuals in the first to the tenth seasons of growth (figs. 11, 13). The color pattern of the individuals greater than 9 cm in plastron length is basically the same as that of the smaller juveniles but the contrast between the yellow or orange markings and the background is less.

The head pattern in lateral view consists of two wide, yellow lines extending posteriorly from the orbit along the neck, a triangular or vertically elongated postorbital mark, and a broad yellow line extending the length of the lower jaw. The postorbital mark is, in most individuals, joined to a longitudinal line on the dorsal surface of the head (figs. 1, 11, 13).

The head pattern from the dorsal view consists of a wide yellow line between the orbits extending from a point just above the nostrils to above the center of the postorbital mark; two lines from the upper edge of the orbit that, in most individuals, join the postorbital mark and continue posteriorly onto the neck. The latter lines are interrupted in some individuals. The background color is black (figs. 11, 13, 15).

The lower jaw is dominated by wide yellow lines broadly bordered with black. Of the three or four transverse yellow lines, the most posterior ones join longitudinal lines (figs. 11, 13, 15). The neck has 17-20 wide yellow lines around its circumference at the rear of the skull.

The carapace has bright yellow or orange central splotches on each costal. These are extremely variable in shape but usually cover more than one-third the total area of each shield. In some individuals (14795) they are rounded, in others (14788) they are crescent-like. The upper surface of each marginal has a semicircle of yellow enclosing a darker area having a faint indication of two concentric light lines. Each of the vertebral spines is conspicuously colored black.

The plastron has a pattern of black lines tending to extend along the seams. The background is cream or light.

The anterior surface of the forelimbs has fine yellow lines on a black background. Those extending from the base of the second and fourth toes are the wider.

The jaws have a thin, sharp-edged horny covering. That of the upper overlaps the lower to provide a scissor-like action. The alveolar surfaces are not broadened in the larger turtles,  $Hw/Aw = 4.7-5.8$ ; no correlation with size.

The head is narrower in relation to plastron length in the larger juveniles.  $Pl/Hw = 4.1-4.5$  in those 5.0 cm to 5.3 cm in plastron

length; 5.5-6.6 in the larger turtles.

The carapace width decreases in proportion to plastron length in the larger individuals;  $Pl/Cw = 0.91-0.99$  in those 5.0 cm to 5.5 cm in plastron length,  $0.95-1.1$  in the larger ones. The height is reduced in larger turtles;  $Pl/Ht = 1.7-1.9$  in those 5.0 cm to 5.5 cm in plastron length;  $1.8-2.1$  in the larger ones.

The spines of the first four vertebrae are conspicuous in all the juveniles (fig. 11). In those with a plastron length of less than 11 cm the height of the spines of the second vertebral is  $2/3$  to  $3/4$  the length of the seam between the second and third marginal. The elevations on the first and fourth vertebrae are ridge-like, those of the second and third are distinct spines.

*Adult males.*—The adult males in the paratypic series range from 7.10 cm to 9.5 cm in plastron length. The smaller adult males (less than 8 cm in plastron length) have the same color pattern as the juveniles. The larger males (more than 8 cm in plastron length) lose the orange tint in the blotches of the carapace and the lines of the head. The plastral pattern is lightened and poorly defined in the larger individuals.

The spines of the vertebral shields are slightly lower in the large males than in the juveniles and those of the first and third shields are rounded (14850, 14858). The carapace edge of the largest male is less serrate anteriorly than in smaller males; the posterior lateral corners of the fifth and sixth marginals project but slightly beyond the anterior lateral corner of the next posterior marginal (fig. 15).

The height is not reduced with increased length as it is in other species,  $Pl/Ht = 1.9-2.2$ . The carapace is somewhat narrowed as the male increases in length;  $Pl/Cw = 1.0-1.1$ .

The head is slightly narrower in relation to plastron length in larger males,  $Pl/Hw = 5.6-5.8$  in those 7-8 cm in plastron length;  $Pl/Hw = 6.0-6.3$  in those greater than 8 cm in length. There is no consistent broadening of the alveolar surfaces in larger males,  $Hw/Aw = 5.1-6.1$ .

The third claw of the forefoot is slightly longer than the length of the seam between the second and third marginals.

*Adult females.*—The adult females retain the color pattern of the juveniles but the blotches on the carapace and the black lines of the plastron are not as distinct. The largest female (14815) has the black background of the carapace lightened by the development of irregular areas of olive-green. The black borders of the yellow marks on the marginals are indistinct. The only remaining vestige of the black lines of the plastron are present on the gular, humeral and anal shields.

The spines of the vertebral shields are much more reduced than in adult males but remain clearly evident on the first four vertebrae (height of spine of second vertebral =  $1/4-1/3$  length of seam between first and second marginals). The carapace edge is not serrate except between the eighth to the twelfth marginals.

The smallest mature female (14920) in the paratypic series has the following measurements: Pl. 14.0, Cl. 14.9, Cw. 13.0, Ht. 6.5, Hw. 2.1, Aw. 0.43. The largest (14815) has these measurements: Pl. 15.9, Cl. 17.4, Cw. 14.3, Ht. 7.3, Hw. 2.33, Aw. 0.52.

The carapace height is not reduced in comparison with the juveniles and adult males, Pl/Ht = 1.9-2.2. The carapace is slightly broadened in contrast with the adult males, Pl/Cw = 1.1 (in all three individuals).

The head is proportionately broader than in adult males, Pl/Hw = 4.5-4.9 and the alveolar surfaces are wider, Hw/Aw = 4.5-4.9. The third claw of the forefoot is 1/2 to 2/3 the length of the seam between the second and the third marginal.

*Range.*—Specimens are available from three localities; the type locality, the Chickasawhay River and 15 miles from the mouth of the Pascagoula River, Jackson County, Mississippi (AMNH 46774, collected by M. J. Allen, 1930). All specimens have been taken from the Pascagoula River or its tributaries. It is apparent that this species is restricted to this stream system as repeated efforts to collect it from adjacent rivers to the east and west were unsuccessful (fig. 9). Populations undoubtedly occur in all the major tributaries and should be especially abundant in the Escatawpa River.

*Habitat.*—The Pascagoula River basin, comprising 8,900 square miles, has had the greatest concentration of industry in Mississippi. Two of the tributaries, Tallahala and Sowashee Creeks, have been highly polluted by sewage and waste from wood pulp and chemical industries (Anderson, 1950). This pollution has apparently had no tendency to reduce the *Graptemys* populations and has probably, through contributing to the increase of the mollusc populations, improved the general habitat for *G. flavimaculata*.

The river at the type locality has a sand and clay bottom and many sand bars and beaches. Flood-stranded debris is abundant and much of the shoreline has a stand of dense brush. The debris and brush extending into the water provides shelter for turtles. The river is 75 to 250 feet in width and deep pools are separated by long stretches of shallow water. A moderately rapid current maintains a narrow channel through the shallow areas.

These turtles were most abundant about the tangled roots of trees. Often several turtles were observed lying together in such places. The approach of the boat usually caused them to leave the resting site and swim rapidly toward deep water.

The Chickasawhay River is 30-150 feet wide; the banks have exposed areas of limestone in many places and the bottom is generally rock and sand. Deep, quiet pools are connected by fast-flowing stretches of shallow water. Drift wood and rocks are abundant along the shores. No *G. flavimaculata* were taken in the faster current or the static water but they were abundant in the snags in the slower current.

This species occurs with *Graptemys pulchra*, *Pseudemys floridana*

*mobiliensis*, *Pseudemys scripta elegans* and *Sternotherus carinatus*. It is clearly the dominant turtle species in the Pascagoula and Chickasawhay Rivers.

*Bionomics*.—*G. flavimaculata* is a comparatively small, rapidly growing turtle adapted to live in moderate current. The smallest sexually mature male studied had a plastron length of 6.67 cm; the smallest mature female had a plastron length of 13.30 cm.

The males may reach sexual maturity in the second growing season. The smallest mature male was in its second growing season when collected and three others ranging in size from 7.47 cm to 8.00 cm were in the third and fourth seasons. The largest male studied had a plastron length of 10.95 cm.

The age at maturity of females could not be determined as the early growth rings were not evident in any mature individual. None of the females larger than 14 cm in length had measurable growth zones.

#### GRAPTEMYS NIGRINODA, sp. nov.

Black-knobbed Sawback

*Holotype*.—Tulane 14662, a juvenile female, collected from the Black Warrior River, above Lock 9, 17.5 miles SSW of Tuscaloosa, Tuscaloosa County, Alabama (figs. 4, 6, 8).

*Paratypes*.—Tulane 14643, 14647-648, 14652-653, 14655-657, 14659, 14664-665, 14682, 14691, 14694, 14697, 14700, 14706, 14708-710, 14714, 14720, 14723, 14725, 14729; CNHM 69809-811, UMMZ 108572-574, 26 juveniles, 5 adult males.

*Diagnosis*.—*Graptemys nigrinoda* differs from *G. flavimaculata* and *G. oculifera* in that: the yellow postorbital mark is boomerang-shaped and is joined to the mark of the opposite side by a diagonal line; the interorbital line is narrow or indistinct; each costal has a circular or semicircular mark formed by a narrow yellow line; the vertebral spines are flattened, compressed, knob-like; the carapace is very serrate.

*Hypodigm*.—A total of 117 individuals were available for study from two localities and numerous others were observed in the field. The data derived from field observations and a study of the 117 preserved individuals provide the basis for the information presented.

*Description of the holotype*.—Maximum carapace length, 8.02 cm; carapace width at juncture of fourth and fifth marginals 6.54 cm; carapace width at juncture of seventh and eighth marginals 6.91 cm; maximum plastron length 7.52 cm; maximum width of posterior lobe of plastron, 3.87 cm; maximum height (measured in vertical line through spine of second vertebral, 3.42 cm; height at spine of third vertebral 3.30 cm; maximum head width (measured at anterior edge of tympanum) 1.32 cm; length of symphysis of lower jaw 0.57 cm; alveolar width of upper jaw 0.28 cm.

Edge of carapace very serrate (fig. 4). General color of carapace dark olive green. Faintly defined, narrow circular or semicircular mark formed by a thin yellow line on each marginal and costal (figs.



2, 4).

Plane of the plastron 1.23 cm below a plane through the edge of the fifth to the seventh marginals. Yellow color predominant on plastron and ventral surfaces of marginals. Branching, black pattern on plastron (fig. 8).

Neck with 25 longitudinal yellow lines; those on the ventral surface not much wider than those on the dorsal surface. Longitudinal inter-orbital line narrower than lateral neck lines. Fine yellow lines between orbits. Four yellow lines entering the orbit laterally; two of these broader than others. Postorbital mark boomerang-shaped and joined to mark of opposite side by a diagonal line (fig. 2).

Ventral surface of lower jaw with a broad, transverse yellow line (fig. 8).

Anterior surface of forelegs with five yellow lines.

*Description of the paratypes.*—The paratypic series is divided into two groups, juveniles and adult males.

*Juveniles.*—The juveniles are in their first or second season of growth. The background color of the carapace is dark olive green and that of the soft parts intense black.

The head pattern differs from that of juveniles of *flavimaculata* in that the postorbital yellow mark is a vertically elongated, boomerang-shaped line extending posteriorad on the dorsal surface to join the mark of the opposite side to form a Y. The interorbital, longitudinal stripe is narrow and indistinct in many individuals.

The lower jaw has one broad, yellow transverse line sometimes bordered both anteriorly and posteriorly by narrow yellow lines. Two of the wide, longitudinal neck lines join behind the level of the jaw juncture to form another transverse line. The lower surface of the neck is dominated by black on which the yellow lines appear to be superimposed (figs. 10, 12).

The carapace has a complete circle of a narrow yellow line on each costal. The knob-like vertebral spines are intense black. The upper surface of each marginal has a semicircular mark formed by a narrow yellow line. The ventral surface of each marginal may be yellow with an ocellus of black and yellow rings, or the yellow may be reduced to an irregular blotch on the medial side with the remainder of the marginal covered with alternating black and yellow lines (figs. 2, 8).

The plastron is yellow to bright orange with black lines extending along the seams (fig. 8). The anterior surface of the forelimb has two to five yellow lines. When four or five are present, those from the base of the second and fourth digits are much the wider.

The jaws are as described for *flavimaculata*. The alveolar width is contained 4.0-6.0 times in the head width. There is no relative broadening of the alveolar surface in the larger individuals.

The head is narrower in relation to plastron length in the larger turtles than in the smaller,  $Pl/Hw = 4.6-5.6$ . The carapace width decreases in proportion to plastron length with size,  $Pl/Cw = 0.9-1.0$ .



Figures 1-2. **1** (upper), *G. nigrinoda*, sp. nov.; **2** (lower), *G. flavimaculata*, sp. nov. (Photographs and color renderings by Isabelle Hunt Conant).

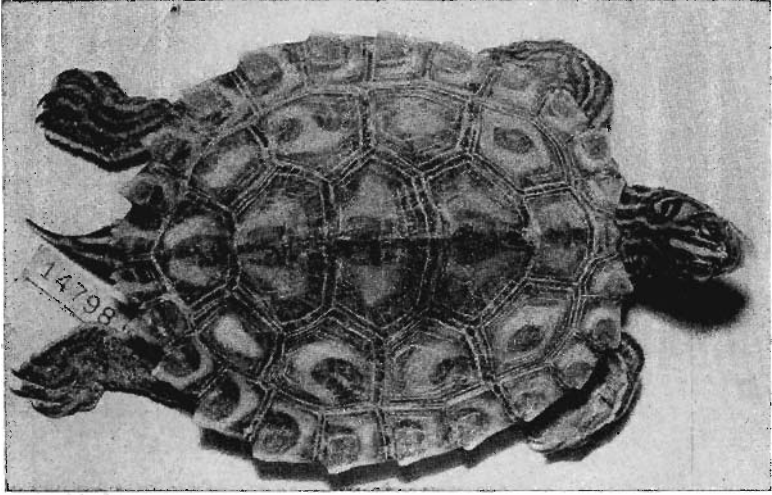


Figure 3. Dorsal view, *G. flavimaculata*, sp. nov. (Photograph by Isabelle Hunt Conant).

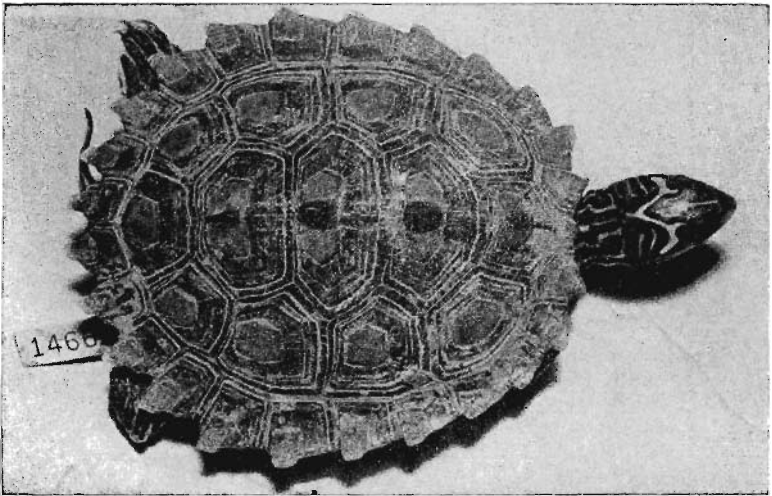


Figure 4. Dorsal view, *G. nigrinoda*, sp. nov. (Photograph by Isabelle Hunt Conant).

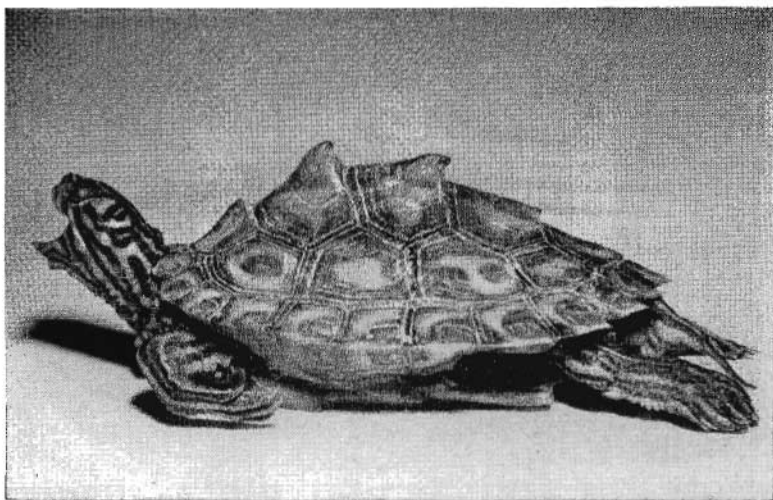


Figure 5. Lateral view, *G. flavimaculata*, sp. nov. (Photograph by Isabelle Hunt Conant).

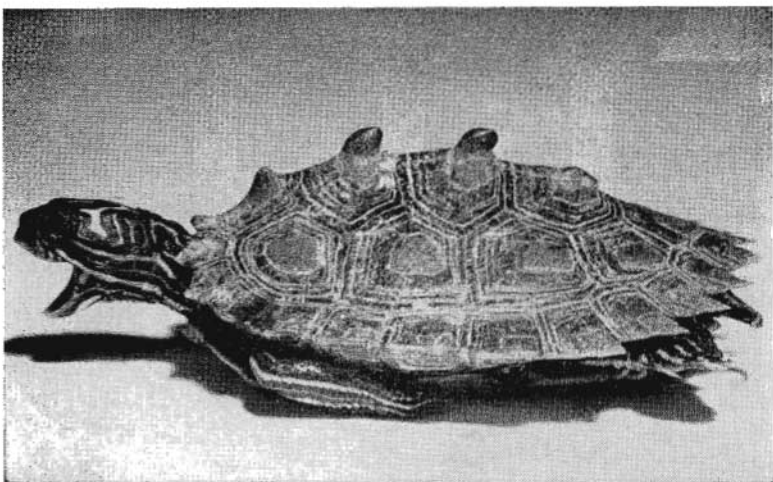


Figure 6. Lateral view, *G. nigrinoda*, sp. nov. (Photograph by Isabelle Hunt Conant).

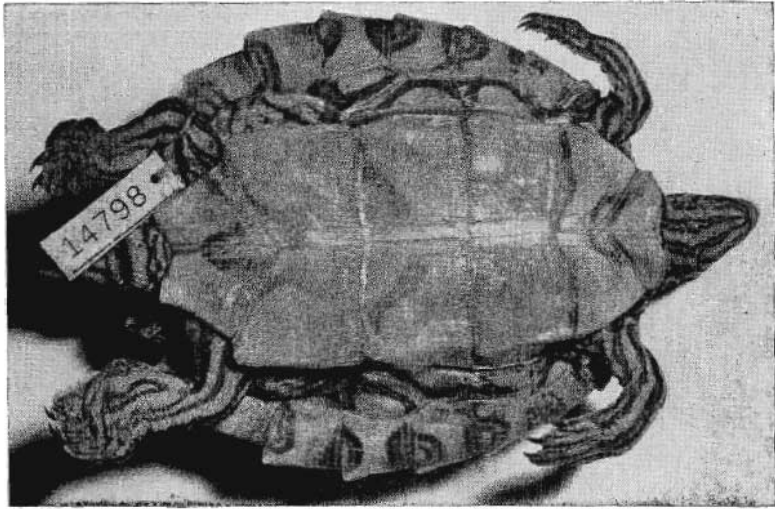


Figure 7. Ventral view, *G. flavimaculata*, sp. nov. (Photograph by Isabelle Hunt Conant).

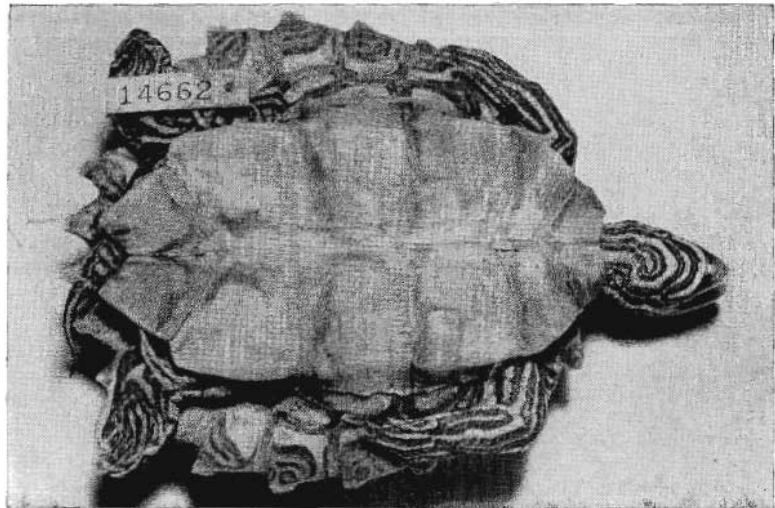


Figure 8. Ventral view, *G. nigrinoda*, sp. nov. (Photograph by Isabelle Hunt Conant).

The height is proportionately reduced in the larger turtles  $Pl/Ht = 1.8-2.2$ .

The spines of the first four vertebrals are high (height of second equals  $2/3$  or more lengths of seam below second and third marginal) and are much broadened and rounded. This is in sharp contrast with *flavimaculata*.

*Adult males*.—The adult males range from 6.80 cm to 8.00 cm in length. They have the same color pattern as the juveniles but the yellow markings of the carapace and the black markings of the plastron are more obscure. The lines of the head in the largest male (14648) are fainter and the black background is lightened.

The spines of the vertebral shields are worn and eroded in the largest specimen and do not have the broadened, rounded appearance of the spines of juveniles. The carapace edge is less serrate than in the four smaller individuals (fig. 14).

The height is reduced in the largest male in relation to plastron length ( $Pl/Ht = 2.0-2.2$  in smaller animals; 2.3 in largest). This is primarily a reflection of the worn spines. The carapace is not narrower in the larger males,  $Pl/Cw = 0.9-1.0$ ; in four smaller ones,  $Pl/Cw = 1.0$  in largest.

The head is slightly narrower in relation to plastron length in the larger males;  $Pl/Hw = 5.3-5.5$  in those 6.0 cm-7.1 cm in plastron length;  $Pl/Hw = 5.5-6.0$  in those greater than 7.5 cm in plastron length. There is a slight broadening of the alveolar surfaces in relation to head width,  $Hw/Aw = 5.8$  in smallest, 4.8 in largest.

The third claw of the forefoot is slightly shorter than the length of the seam between the second and third marginal.

*Adult females*.—No adult females were collected but one was studied with binoculars and a 20 power telescope in the field. This large female retained the distinctive markings of the juveniles. The black background color of the head and the brilliant yellow markings were not reduced.

*Range*.—Specimens were collected from only two localities, the type locality and the Alabama River 5.5 miles east of Gosport, Monroe County, Alabama. Collecting on the Coosa River and the Mulberry Fork of the Black Warrior River did not yield this species. Its absence from these streams poses the problem of what limiting factors have prevented its movement northward. An attempt to approximate the northernmost occurrence in the Black Warrior was made June 18. A count of basking turtles was made from the juncture of Locust Fork and Mulberry Fork to the Barney Coal Mine during the period from dawn until 1 P.M. No *G. nigrinoda* were observed until the river widened approximately three miles above the Barney mine. Basking turtles were common along the entire stretch. There was an apparent correlation between the occurrence of *G. nigrinoda* and the occurrence of *Amyda*. *Graptemys pulchra* is present in Mulberry Fork and Locust Fork.

*Habitat*.—Generally similar to that of *G. oculifera* and *G. flavimaculata*. All individuals were taken from brush or logs in current or

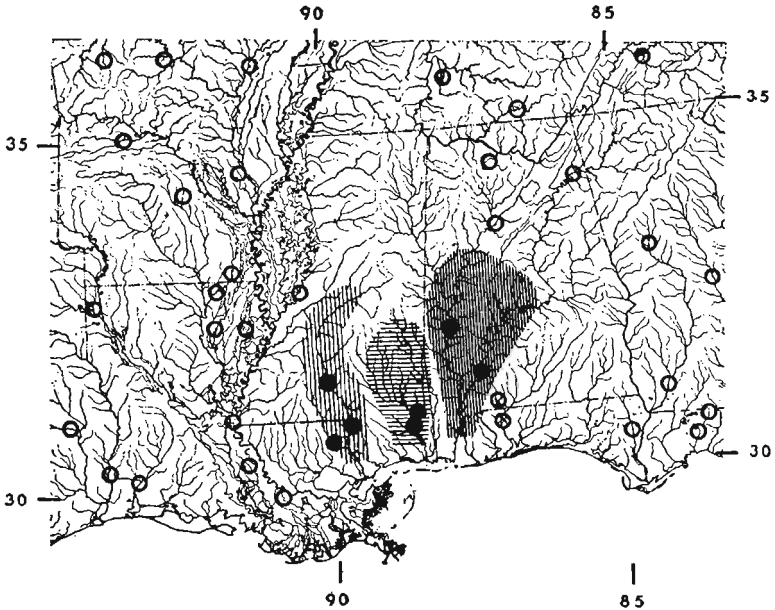


Figure 9. The distribution of *G. oculifera* (narrow vertical lines), *G. flavimaculata* (horizontal lines), and *G. nigrinoda* (wide vertical lines). The black spots indicate collecting sites; the circles indicate localities where intensive collecting has failed to produce members of this complex.

were shot from basking sites above current. Both the Black Warrior and Alabama Rivers are wider, deeper rivers than the Pascagoula or the Pearl Rivers but they also have sand and clay bottoms and moderate current in those areas where *G. nigrinoda* was collected.

This species occurs in association with *G. pulchra*, *Pseudemys floridana mobilensis*, *Pseudemys scripta elegans*, *Sternotherus carinatus*, and *Amyda* sp.

*Bionomics*.—The smallest male has a plastron length of 6.80 cm and is in the third season of growth. The largest male observed was 8.76 cm in length and had no growth zones present. No adult females were collected.

#### DISCUSSION

Other turtle species occurring in the Pearl, Pascagoula and the lower parts of the Tombigbee and Alabama rivers exhibit a gradual coast-wise gradient in most of their characters. The populations of *Pseudemys scripta*, *Pseudemys floridana*, *Kinosternon subrubrum*, *Amyda ferox* and *Graptemys pulchra* of each river system are different in the percent expression of characters but much overlap is evident.

*Graptemys pulchra* occurs in these same stream systems as well as in the Escambia to the east and the upper reaches of the Alabama where *G. nigrinoda* is absent. However, the populations of the upper Alabama are conspicuously different from those of the lower. This

difference in parts of the Alabama is also reflected in the fact that *Graptemys geographica* occurs in the upper reaches but not in the lower.

The restriction of *G. nigrinoda* to that part of the river below the fall line may be suggestive of a rather recent, rapid evolution of this complex since the exposure of the Gulf Coast in Pliocene time. There is a correlation between the northern limit of distribution and the isocryme of 15° C (as reported by Hedgpeth, 1953).

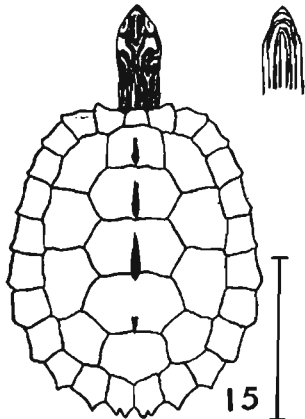
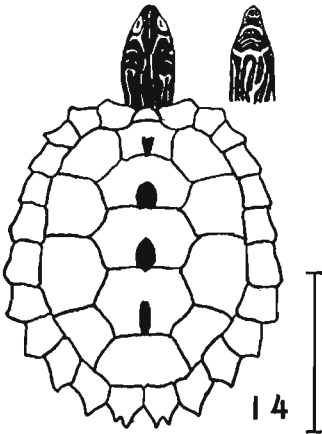
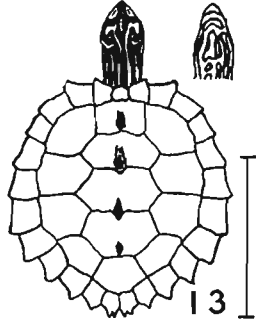
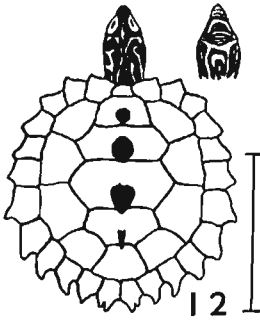
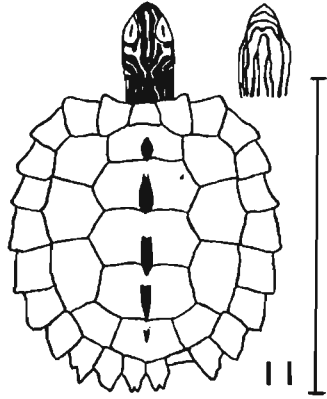
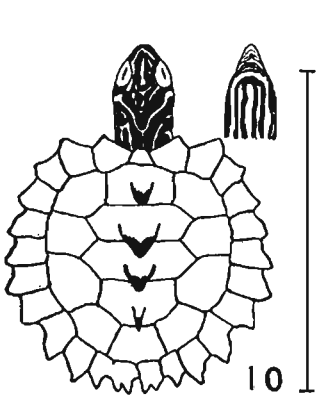
The absence of these three forms in river systems east of the Alabama and west of the Pearl is further evidence that the evolutionary history of this complex is substantially different from that of other turtle species of the Gulf Coast (fig. 9). Unfortunately there is but limited information available on the history of these river systems. The extent of the Alabama and Tombigbee systems as contrasted with the Pearl and Pascagoula is suggestive of greater age. Perhaps in this situation rests the explanation of the greater degree of divergence in *G. nigrinoda*, it perhaps being the older of the three forms. The biologist has no precise knowledge of comparative rates of evolution in the turtles but their long fossil record suggests unusually slow response. The relative youth of the Gulf Coast streams implies that rapid evolution has occurred in this complex.

These current-dwelling turtles do not inhabit the extreme head waters and smaller tributaries as do members of the genera *Amyda*, *Pseudemys* and *Kinosternon*. There are no reports of overland movements although such observations are common for other turtles. Their isolation is thus possibly much more complete than is implied by the proximity of the drainage systems. The cohesiveness of the three groups would suggest the designation of a superspecies. This would serve to emphasize the differences between these and the remainder of the genus. Each of the three groups of populations could be designated a semispecies (Mayr, 1942; Cain, 1953).

Although the three forms are basically similar in their osteology and general configuration, the morphological gap between *G. nigrinoda* and *G. flavimaculata* is much greater than that between *G. flavimaculata* and *G. oculifera* (Cagle, 1953b). Particularly striking is the contrast between the flattened carapace and knob-like projections in *G. nigrinoda* and the elevated carapace and laterally compressed spines of the other two species. An alternative taxonomic arrangement would be the recognition of *G. flavimaculata* as a subspecies of *G. oculifera* while retaining *G. nigrinoda* as a separate entity. Such an arrangement would place emphasis on the differences in degree of divergence between the forms but the evolutionary implications of such a grouping can not be justified.

Related species of this genus do not have such striking differentiation in adjacent stream systems. *Graptemys geographica*, *Graptemys pseudogeographica* and *Graptemys kohni* occupy more extensive ranges without developing such gaps or steepening gradients in variation (Cagle, 1953a).





A TENTATIVE KEY TO THE GENUS *GRAPTEMYS*

This key is presented as an aid to identification of the members of this genus. It is not intended to present those characters that are of fundamental significance in establishing the patterns of speciation.

1. Length of symphysis of lower jaw  $\frac{1}{4}$  longer than minimum distance between the orbits and a small triangular, yellow spot back of orbit separated from orbit by 2 to 3 diagonal yellow lines ..... *Graptemys geographica* (LeSueur)  
(Geographic turtle. Mississippi and St. Lawrence basins. Northern Louisiana north through eastern Oklahoma and Kansas to northern Minnesota; eastward through Missouri, Illinois, Kentucky, Tennessee to Vermont. Northern Mississippi, Alabama.)  
Length of symphysis of lower jaw equal to or less than minimum distance between the orbits; or, if symphysis is longer than minimum distance between orbits, no triangular spot behind eye but a large, irregular-shaped greenish or yellowish post-orbital blotch present ..... 2
2. Each costal with a large yellow-orange blotch, crescentic mark or ring. .... 3  
Costals without markings as described ..... 5
3. Each costal with a large yellow or orange blotch or crescentic mark covering much of the shield. Yellow the dominant color on the ventral surface of jaw and neck ..... *Graptemys flavimaculata* n. sp.  
(Yellow-blotched sawback. Pascagoula River and tributaries, Mississippi.)  
No such markings ..... 4
4. Each costal with one complete circle of yellow or orange formed by a line broader than the widest neck line. A yellow postorbital ovoid, rectangular or rounded spot not connected with a dorsal, longitudinal line. Vertebral spines laterally compressed ..... *Graptemys oculifera* (Baur)

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Figures 10-15. Juveniles and males of *G. nigrinoda* and *G. flavimaculata*; scale line = 5 cm. 10, Hatchling, *G. nigrinoda*; 11, Individual in first season of growth, *G. flavimaculata*; 12, Juvenile male, *G. nigrinoda*; 13, Juvenile male, *G. flavimaculata*; 14, Adult male, *G. nigrinoda*; 15, Adult male, *G. flavimaculata*.

(Ringed sawback. Pearl River and tributaries, Louisiana and Mississippi.)

Each costal with a yellow or orange semicircle or circle formed by a line much narrower than the widest neck line. A yellow, vertical curved post-orbital bar connected by a diagonal line with the postorbital bar of the opposite side. Vertebral spines knob-like ..... *Graptemys nigrinoda* n. sp.

(Black-knobbed sawback. Alabama and Black Warrior River systems.)

5. Females never developing a head as wide as  $\frac{1}{3}$  the carapace width. Post-orbital mark not a large irregular shaped greenish or yellow blotch ..... 6

Females developing a much broadened head as wide as  $\frac{1}{3}$  the carapace width. Postorbital mark an irregular bordered greenish or yellowish blotch or mark absent (see illustrations, Cagle, 1952.) ..... 10

6. Without vertebral spines (each vertebral may be slightly elevated above next posterior one). Maximum plastron length about 16 cm. .... *Graptemys versa* Stejneger

(Texas map turtle. Colorado River System, Texas.)

With distinct vertebral spines (absent in some individuals greater than 16 cm in plastron length.) ..... 7

7. A postorbital vertical line extending from a dorsal longitudinal line to the base of the orbit and anteriorly under the orbit; vertical line frequently interrupted by a longitudinal line or bar ..... *Graptemys kohni* (Baur)

(Mississippi map turtle. Eastern Texas, Oklahoma, Kansas and Nebraska east to Mississippi River and southern Indiana.)

No postorbital vertical line; a comma-shaped, rectangular or ovoid post-orbital mark. A series of longitudinal neck lines entering orbit below postorbital mark. .... 8

8. Postorbital spot, oval or elongate, much smaller than orbit, and surrounded by 2 or 3 concentric lines; 3 or 4 conspicuous longitudinal lines entering orbit; these lines alternating with thinner, less conspicuous lines. A total of 6-7 lines entering orbit; a wide yellow band extending the width of the ventral surface of the jaw; no large yellow spot beneath eye -----  
*Graptemys pseudogeographica sabinensis* Cagle  
 (Sabine map turtle. Sabine River of western Louisiana and eastern Texas.)
- Not as above. ----- 9
9. Postorbital spot not elongate but rectangular; length of rectangle extending dorso-ventrally; maximum of 5 longitudinal lines entering the eye. No wide yellow band extending the width of ventral surface of jaw but a large spot present at symphysis of lower jaw; a large yellow spot beneath eye.  
 -----*Graptemys pseudogeographica ouachitensis* Cagle  
 (Ouachita map turtle. Louisiana northwestward into eastern Oklahoma, Kansas, Nebraska and eastward through southern Wisconsin, Illinois and southern Indiana to northern Alabama. Eastward in the Ohio River System.)
- Postorbital spot comma-shaped; not rectangular; maximum of 5 longitudinal lines entering the eye; no wide yellow band extending the width of the ventral surface of the jaw; no large spot present on symphysis of lower jaw; no large yellow spot beneath the eye.  
 -----*Graptemys pseudogeographica pseudogeographica* (Gray)  
 (False map turtle. Eastern Nebraska, southeastern South Dakota eastward through southern Minnesota and Iowa to eastern Illinois.)
10. An irregular bordered yellow bar extending completely across ventral surface of lower jaw; margins of plastral shields not bordered with black -----*Graptemys barbouri* Carr  
 (Barbour's map turtle. Southwestern Georgia and Panhandle of Florida.)

No bar as described (an elongated blotch or bar may be present); margins of plastral shields bordered with black

----- *Graptemys pulchra* Baur

(Alabama map turtle. Pearl River, Louisiana eastward to Alabama, Coosa and Escambia rivers.)

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