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(TESTUDINATA, CHELYDRIDAE)

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THE SYSTEMATICS AND ECOLOGY OF THE *STERNOTHAERUS CARINATUS* COMPLEX

(TESTUDINATA, CHELYDRIDAE)

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Department of Biology, Texas Technological College, Lubbock, Texas

CONTENTS

Fresh water turtles of the northern coast of the Gulf of Mexico are excellent materials for a study of speciation. Populations of species of several genera occupy approximately the same geographic areas and may have been exposed to the same modifications in drainage systems and geological changes in the Gulf coast.

Turtles of the genus *Sternothaerus* are restricted to the United States and southern Canada. Three species (four forms) are found in the Gulf coastal plain and some adjacent areas, and presumably have undergone the major part of their evolution there. These four forms constitute the *Sternothaerus carinatus* complex. Because of its geographic position, a study of this complex utilizing a field approach with a laboratory analysis was feasible.

Analysis of selected morphological characters as a means of evaluating relationships within the *Sternothaerus carinatus* complex was the first objective. The populations of each major drainage system were considered separately in order to gain a better understanding of geographic variation.

The second objective, to obtain information on behavior, habits and ecology of these turtles, was accomplished primarily in the field, but a few laboratory experiments and observations were made.

The third objective was to correlate the differentiation of the *Sternothaerus carinatus* complex with changes in river systems, stream capture, and changes in coastline elevation. This objective was difficult to attain because the geological history of the Gulf coast is inadequately known.

The last objective was to compare the speciation pattern of the *Sternothaerus carinatus* complex with that discernible in the turtle genera *Pseudemys*, *Graptemys* and *Trionyx* that occur in the same area. The details of speciation in the last three groups have been worked out by other investigators, and the writer has had considerable field experience with many representatives of these genera.

II. Methodology

Collection of samples.—Collections were made in most Gulf Coast rivers from central Texas to Florida and north into Arkansas and Tennessee (fig. 1). Most collections were made during the summer because this was the only time available for the extensive trips required for this type of study. Supplementary collections were made at other seasons in a few localities.

Traps made of three-quarter inch seine netting yielded the greatest number of specimens. These traps were approximately 30 inches long, 12 to 14 inches in diameter with an open throat at each end. The traps were placed near stumps and brush in shallow, generally quiet-water areas of rivers. Trapping was the most reliable means of obtaining *Sternothaerus*.

A second means of sampling was from brushpiles at night, using the method of Chaney and Smith (1950). This method, the best known for obtaining emydid turtles, is less effective for collecting *Sternothaerus*.

A third method was successfully employed on two occasions. In the Suwannee River near Fannin Springs, Gilchrist County, Florida, *Sternothaerus m. minor* was obtained by backing a 7.5 horsepower outboard motor up to the bank near tangled cypress roots and accelerating the motor to stir up the water. This action attracted the turtles or washed them out of sleeping places under the bank. On June 7 to 8, 1953, 20 *S. m. minor* were taken by this method in about two hours. In the Wacissa River of northern Florida on June 5, 1953, Mr. Robert Webb and I swirled a boat in and out of weed beds in shallow water at night, and collected 34 *Sternothaerus* that came up beside the boat during a three-hour period. Whether the water current from the motor stirred the turtles to the surface or whether they were attracted by the sound of the engine could not be determined. In August 1954, the locality was revisited, the swirling technique employed, but no turtles were seen. Diving in the same area during the day produced 21 *Sternothaerus odoratus* in approximately four hours.

Chaney and Smith (1950) obtained 382 specimens of *Graptemys barbouri* in 13 hours in the Chipola River of Florida by a similar swirling method on July 12 to 14, 1950. A field crew from Tulane University revisited the same locality on June 4, 1953, but collected only two *Graptemys* and saw less than 20. Perhaps faulty technique was partly responsible for the smaller

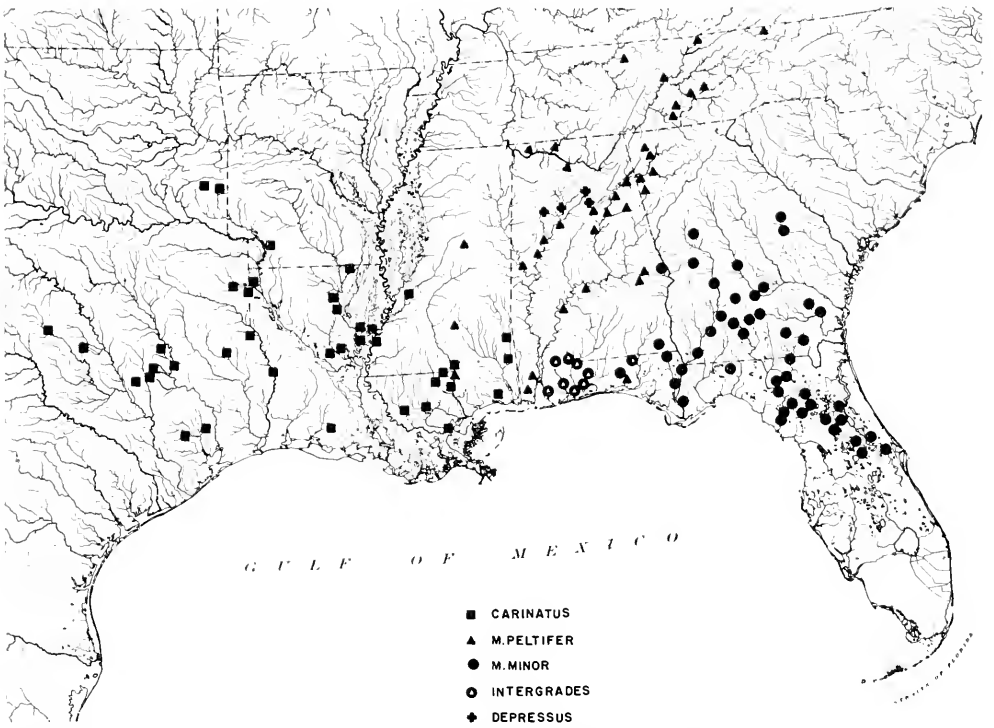


Figure 1. Distribution of members of the *Sternothaerus carinatus* complex. Symbols represent localities from which material has been examined.

catch, but pitch of the motor or seasonal differences in the excitability of turtles may have been influential in this instance and in the Wacissa River. The possibility exists that the *Graptemys* population in this portion of the Chipola River was severely decimated by the collection of 1950 that contained mostly adults.

III. Taxonomic Considerations of Species

The turtles of the genus *Sternothaerus* were placed by Williams (1950) in the subfamily Kinosterninae (*Kinosternon* and *Sternothaerus*) of the family Chelydridae.

Synonymy. — *Testudo* Latreille, 1801; *Testudo* Daudin, 1802; *Terrapene* Merrem, 1820; *Cistuda* Fleming, 1822; *Kinosternon* Spix, 1824; *Cistudo* Say, 1825; *Sternotherus* Gray, 1825; *Sternothaerus* Bell, 1826; *Cinosternon* Wagler, 1830; *Kinosternon* Gray, 1831; *Clemmys* Fitzinger, 1835; *Staurotypus* Duméril and Bibron, 1835; *Kinosternon* LeConte, 1854; *Aromochelys* Gray, 1855; *Cinosternum* Agassiz, 1857; *Ozotheca* Agassiz, 1857; *Goniochelys* Agassiz, 1857; *Kinosternon* Siebenrock, 1907; *Sternothaerus* Lindholm, 1929.

The current spelling of the generic name is incorrect. *Sternothaerus* is the correct transliteration (according to the nomenclatural rules) for the Greek words composing the name, a fact pointed out by Strauch (1862). This was the spelling used by Bell (1826) in his description of the genus, but he was antedated a few weeks by Gray (1825) who described the genus *Sternotherus* with the following notation (p. 211): "3. *Sternotherus*, Bell, MSS - - -". Gray obviously meant to give Bell credit for the generic description. Perhaps Gray had seen Bell's manuscript and had received Bell's permission to include the new genus in his (Gray's) checklist of the genera of reptiles and amphibians.

According to the Copenhagen (Fourteenth International Congress on Zoological Nomenclature) decisions on modifications

of the *Regles Internationales de la Nomenclature Zoologique*, page 45: "An invalid original spelling is to be corrected wherever it occurs, the corrected spelling (*i.e.*, the valid emendation) replacing the invalid original spelling in all respects, including authorship and date." The description of the genus, therefore, should be credited to Bell (in Gray), 1825.

Most authors have followed Gray's spelling and given him credit for the generic description, but some have not. Wright and Funkhouser (1915) listed "*Sternothaerus carinatus* (Gray)" from the Okefinokee Swamp, and Lindholm (1929) gave Bell credit for describing the genus and correctly spelling the generic name.

The genus *Sternothaerus* of Bell also contained pelomedusid turtles and was accordingly associated with the sideneck turtles by later authors. In 1831 Gray placed *Sternothaerus* in the family Chelydae and placed the only musk turtle known at the time (*odoratus*) in the genus *Kinosternon*. Neither Boulenger (1858) nor Siebenrock (1907, 1909) recognized the musk turtles as a separate group, but retained them in the genus *Kinosternon*. Gray (1855) erected the name *Aromochelys*, removed *odoratus* from *Kinosternon*, and placed it (*odoratus*) in the newly created genus. Agassiz (1857) described *Aromochelys carinatus* and placed *odoratus* in the same genus. He also described the genera *Goniochelys* and *Ozotheca*, but later in the same work synonymized them with Gray's *Aromochelys*. Strauch (1862) accepted the name *Aromochelys* for the musk turtles, but pointed out that the name *Sternothaerus* of Bell was earlier and available since the side-neck turtles originally included in it were placed in a different genus by Wagler (1830). The process by which the currently used generic name of the musk turtles became available with *odoratus* as the type species is explained by Stejneger (1902).

If the musk turtles are considered as a group distinct from *Kinosternon* then the spelling must be *ae* in keeping with the rules of nomenclature and the credit for the description should go to Bell, albeit in Gray's publication.

The genus *Sternothaerus* as presently understood contains four species and five forms (Tinkle and Webb, 1955). *Sternothaerus odoratus* is the only species with an extensive range, occurring in "eastern and southern United States from Quebec, Ontario, Michigan, Wisconsin and Minnesota through the tier of states west of the Mississippi to eastern and southern Texas, and southeast to Florida" (Schmidt, 1953). This species is sympatric with the other three in the genus, the taxonomic arrangement of which is that of Tinkle and Webb (1955). The range of the *Sternothaerus carinatus* complex lies almost entirely within the Austroriparian and Texan biotic provinces (Dice, 1943) of the Gulf coastal plain. More exact definition of ranges may be obtained from the distribution map (fig. 1) or from the list of material examined.

The following discussion of species contains primarily new information relative to relationship, distribution and characterization.

Sternothaerus carinatus (Gray), 1855

Synonymy.—*Aromochelys carinatus* Gray, 1855; *Goniochelys triquetra* Agassiz, 1857; *Cinosternum carinatum* Boulenger, 1858; *Sternotherus carinatus* Stejneger, 1923; *Sternotherus carinatus carinatus* Carr, 1952; *Sternotherus carinatus* Tinkle and Webb, 1955.

Type locality.—Louisiana, restricted to vicinity of New Orleans. Cotypes, Museum of Comparative Zoology, Harvard University.

This species is characterized by a high carapace with distinct mid-vertebral keel, by the absence of a gular scute and by presence of a head pattern of dark spots on a light background.

Sternothaerus carinatus extends from the Balcones Escarpment of central Texas (Smith and Buechner, 1947; Brown, 1950), northward through southeastern Oklahoma (Ortenburger, 1927), southern Arkansas, and southward and eastward through all the major rivers of Louisiana and Mississippi. The exact northward limits have not been determined, but this form apparently does not occur far up through the rivers of the alluvial Mississippi Embayment. There is a record from Illinois (Davis and Rice, 1883), but Cahn (1937), in his review of the turtles of Illinois, reported no additional specimens and suggested that this record was based upon a misidentification.

Sternothaerus carinatus and *odoratus* were the only generally recognized species in the genus until 1923, so the following reports were correct considering the taxonomic knowledge available at the time of publication.

Brimley (1910) reported *carinatus* from Mimsville, Georgia, in the Apalachicola River drainage, as did Siebenrock (1907). Mimsville might have been a shipping point for this species, but it is more likely that the specimens were actually *S. m. minor.*

The specimen mentioned by Rhoads (1895) from the Emory River at Harriman, Rhoane County, Tennessee, has elicited much discussion and speculation. Stejneger (1923) examined the specimen and called it *S. minor,* but Smith and Glass (1947) suggested that it was *"S. peltifer"* on the basis of Rhoads' mention of dark stripes on the head. I have seen several specimens from Tennessee and have read Rhoads' description and am in agreement with the allocation of Smith and Glass. Neither *S. carinatus* nor *S. m. minor* is known from Tennessee.

The report of *carinatus* from Arizona by Yarrow (1875) is obviously in error. Loding (1922) reported *carinatus* from Tuscaloosa and Talladega counties, from Sepulga River between Butler and Conecuh counties, and from Saraland, Mobile County, Alabama. These specimens were almost surely *Sternothaerus minor peltifer.*

DeSola and Adams (1933) and Wright and Funkhouser (1915) reported *S. carinatus* from the Okefinokee Swamp of Georgia. The description given by Wright and Funkhouser prove them to be *m. minor.*

The easternmost records are from the Chickasawhay (upper Pascagoula) River of Mississippi. No specimens were seen from the Escatawpa River, but should be interesting as this river, generally speaking, is intermediate between the known ranges of *S. carinatus* and *S. m. peltifer.*

Sternothaerus depressus Tinkle and Webb, 1955

Type locality.—Black Warrior River, 1 mile east of Jasper, Walker County, Alabama. Holotype, Tulane University collections.

This species has a low, flattened carapace without distinct vertebral keel except in young. There is one gular scute and a head pattern of thin, dark reticulae on a greenish-yellow background.

Since the publication of the original description, one juvenile female paratype (TU 16062.2) has been sent to the Museum of Comparative Zoology of Harvard University, and a topotype (TU 16631.4) deposited in the Senchkenberg Museum, Frankfurt, Germany.

This species, the least known of the complex, has been found only in the Mulberry and Locust forks of the Black Warrior River above the Fall Line in Alabama. In this northern area of Alabama, the Tennessee River closely approaches the smaller tributaries of the Black Warrior River. Because of this, Webb and I suggested that further collecting would demonstrate the existence of this species in the Tennessee River. However, all specimens that I have seen from the Tennessee River are *S. m. peltifer,* although some of these approach *depressus* in carapace shape and in color pattern of the head (figs. 2, 3). There is no similar situation of such restricted range among North American turtles with the possible exception of *Kinosternon flavescens spooneri* (Smith, 1951). However, further collecting in western Tennessee may reveal this form and extend its known range farther north and west.

The original description of *S. depressus* was based upon a series containing only one adult. Since then several adults have been secured. The following color description of these was made without reference to a color guide.

Adult female.—Top of head with reticulated pattern of dark lines on a light olive-green background (cream green in some adults). Head with irregular blotches posteriorly which become smaller anteriorly where they are replaced by lines forming the reticulated pattern. The mask reaches midway back on the orbit and is a greenish yellow, distinct from the darker color of the rest of the head. The barbels are red-tinted, and adjoining areas of the chin have a faint tinge of red or orange. Carapace greenish brown or olive drab with numerous dark brown spots and streaks which are particularly prominent on the vertebral shields. No other species of *Sternothaerus* normally has as many or as distinct carapace

markings as *depressus*. Plastron immaculate, yellow-cream in color with light pink cartilage between the scutes. This color description is applicable to other living adults; the color of preserved specimens is like that of living animals except that the light green color of the head is lost and there is a general darkening of the carapace.

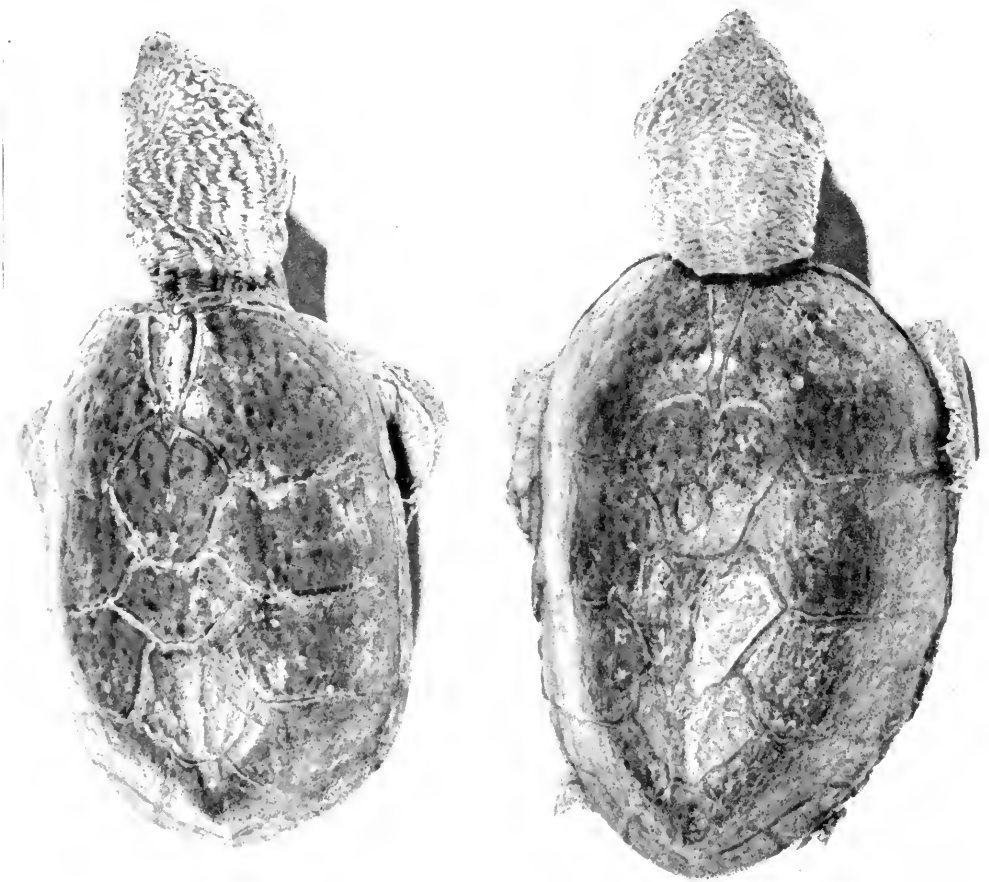
The carapace of adults in outline is a broad oval, made slightly asymmetrical anteriorly by the truncated end. The flattening of the carapace dorsally is characteristic and becomes most pronounced with increasing size, as shown by four specimens at hand. The carapace lengths of these are 91, 99, 100 and 106 mm, and the widths of the flat portion of the carapace are 13, 22, 24 and 30 mm respectively.

Color of juveniles.—Dorsum of head with dark brown to black reticulae on a yellow-green ground color. The yellow-green ground color of the head is unique and diagnostic of living juvenile *S. depressus*. Chin barbels and portions of marginal shields orange-tinted. Plastron an immaculate pinkish-orange color. Carapace light brown to olive drab with dark brown streaks.

Sternothaerus minor peltifer Smith and Glass, 1947

Synonymy.—*Sternotherus peltifer* Smith and Glass, 1947; *Sternotherus carinatus peltifer* Carr, 1952; *Sternotherus minor peltifer* Tinkle and Webb, 1955.

Type locality.—Bassfield, Jefferson Davis County, Mississippi. Holotype, Texas Co-



Figures 2-3. *Sternothaerus m. peltifer*. Both specimens from 5 miles southeast of Cumberland Gap, Tennessee.

operative Wildlife Collection, A & M College of Texas.

This form has a distinct vertebral keel as a juvenile that is lost in the adult. One gular scute is present and the head pattern is primarily one of dark stripes on a light background.

The range of this race embraces most of Alabama, the northwest corner of Georgia, the western tip of Florida, at least the eastern half of Tennessee and an undetermined area in Mississippi and extreme eastern Louisiana.

The holotype is from the Pascagoula River drainage of central Mississippi. I have seen one additional specimen from Mississippi, and one other from the Pearl River boundary of Louisiana and Mississippi. The remaining records are east of the Pascagoula drainage. Both the Pearl and Pascagoula rivers in which *S. carinatus* is common have been extensively investigated so *S. m. peltifer* is almost surely a rarity in these rivers. Perhaps it is expanding its range westward into that of *carinatus*.

Three records in the literature deserve comment. The specimen reported by Rhoads (1895) from the Rhoane River at Harriman, Tennessee was probably *m peltifer*. *Sternothaerus m. peltifer* reported by Neill (1948) from near the Fall Line in Georgia was actually *S. odoratus* (Tinkle and Webb,

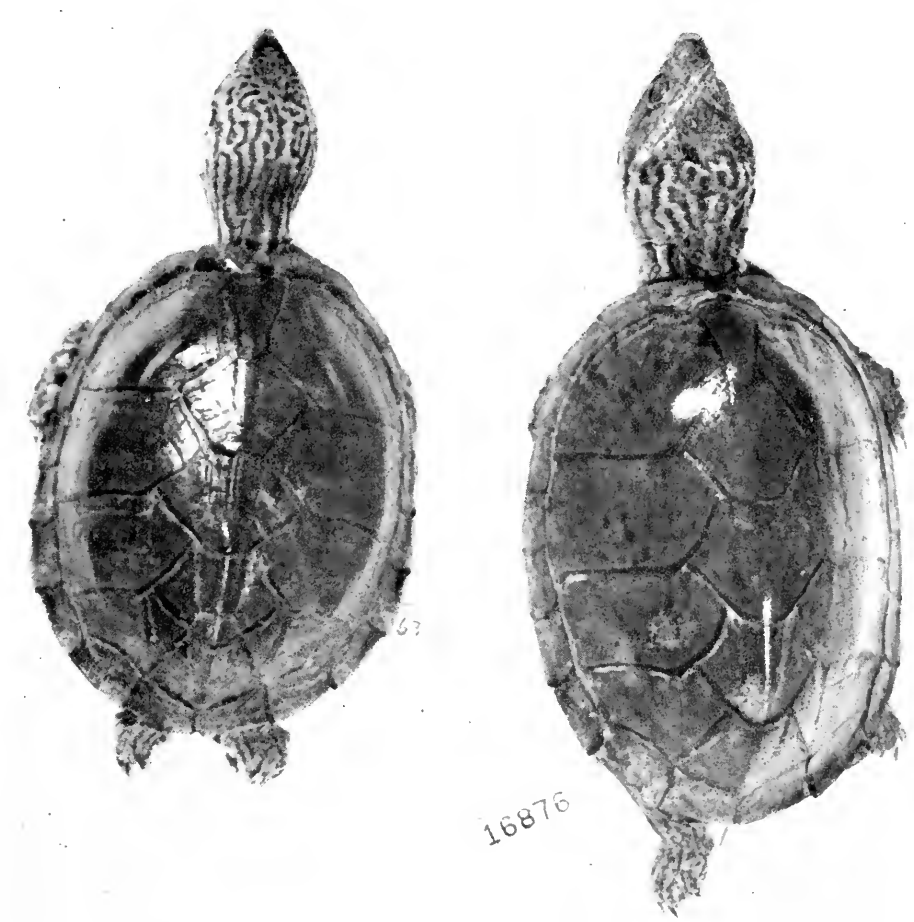


Figure 4. *Sternothaerus m. peltifer*. (Left) specimen from Coosa River, 6 miles east of Pell City, Talladega County, Alabama (No. 16863.7). (Right) specimen from Black Warrior River, 3 miles east of Eutaw, Greene County, Alabama (No. 16876).

1955). King (1939) reported specimens from the Great Smoky Moutain National Park which I have examined and found belong to *m. peltifer*.

Considerable variation exists in this race in different river systems. The specimens from the Tombigbee and Alabama rivers on the coastal plain are most like the holotype. In the Coosa River of northern Alabama, *m. peltifer* develops a rounder carapace with reduced elevation (fig. 4). This same tendency prevails in the Tennessee River drainage where *m. peltifer* specimens are quite flat and the head stripe-spot pattern becomes more diffuse or reticulated (figs. 2, 3).

Since nothing has been published on the coloration of living *m. peltifer*, the following notes on a Coosa River juvenile are pertinent. Plastron dull orange; carapace light to dark brown. Underside of neck reddish, becoming brownish-orange on the lower jaw and cream brown on the upper jaw. Dorsum of head light brown to a point two millimeters posterior to eyes; there this color blends gradually with the yellow-orange ground color of the neck. Dark brown to black stripes pass from the eyes and jaws across the yellow-orange neck. These stripes are also present dorsally, but they break up into spots as they meet the brown ground color.

The plastron of an adult from the same locality is orange-tinted, but the color is not as intense as in the juvenile. Carapace brown. Underside of neck brown to olive. Dorsum of head greenish brown with some yellow; no orange on head. The green and yellow become more obvious posteriorly. Dark brown stripes present as in juveniles, but traversing a brownish-green ground color.

Sternothaerus minor minor (Agassiz), 1857

Synonymy.—*Goniochelys minor* Agassiz, 1857; *Sternotherus minor* Stejneger, 1923; *Sternotherus carinatus minor* Carr, 1952; *Sternotherus minor minor* Tinkle and Webb, 1955.

Type locality.—Restricted to Columbus, Georgia. Cotypes Museum of Comparative

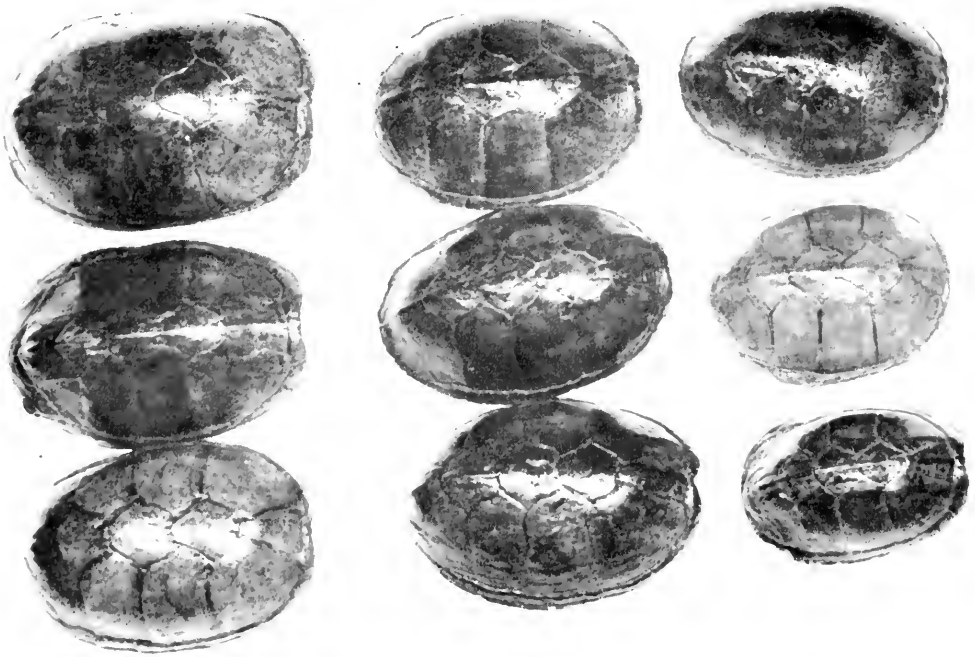


Figure 5. Shells of *Sternothaerus odoratus* from the Savannah River near Price Island, Georgia, showing variation in shape.

Zoology and Museum of Zoology of the University of Michigan.

Juveniles of this race have a mid-vertebral keel as well as a lateral ridge that is absent in other forms except *S. odoratus*. The mid-vertebral keel and lateral ridges are lost in most adults which have a rounded, arched carapace. There is one gular. The head pattern of dark spots on a light background is like that of *S. carinatus*.

I have examined four cotypes. Only one of these is *S. m. minor* (UMMZ 63520) and the locality data on this one (New Orleans, Louisiana) is obviously in error. Two of the cotypes are *S. odoratus* (MCZ 1572 and MCZ 1573) and one is *S. m. peltifer* (MCZ 1570). This mixture of species in the type series calls into question the original description of *m. minor*. However, Agassiz (1857) in his description of *Goniochelys minor* calls attention to the absence of head stripes in that species, stripes which are generally prominent on *odoratus* and *m. peltifer*.

Sternothaerus minor minor extends from Florida (at least as far south as Seminole County) through Georgia at least to Burke County (Neill, 1948b) near the Fall Line which is generally the northern limit of distribution. Westward *m. minor* occurs along the coast as far as the Escambia River drainage in Florida. It occurs in extreme eastern Alabama in the drainages of the Chattahoochee and Choctawhatchee rivers. There are no records of *m. minor* from South Carolina and Albert Schwartz informed me by letter that *m. minor*, to his knowledge, does not occur in that state. Carr (1940) reported it common in north and north central Florida. I did not find *m. minor* in Lithia Springs, Hillsborough County, Florida, although the habitat appeared suitable. The specimens reported as *S. carinatus* from Baker County, Georgia by Siebenrock (1907) and Brimley (1910) were doubtless *S. m. minor*. Wright (1926) described *m. minor* as common in the Okefinokee Swamp.

Although I have not seen *S. m. minor* from further north than the Ogeechee Riv-

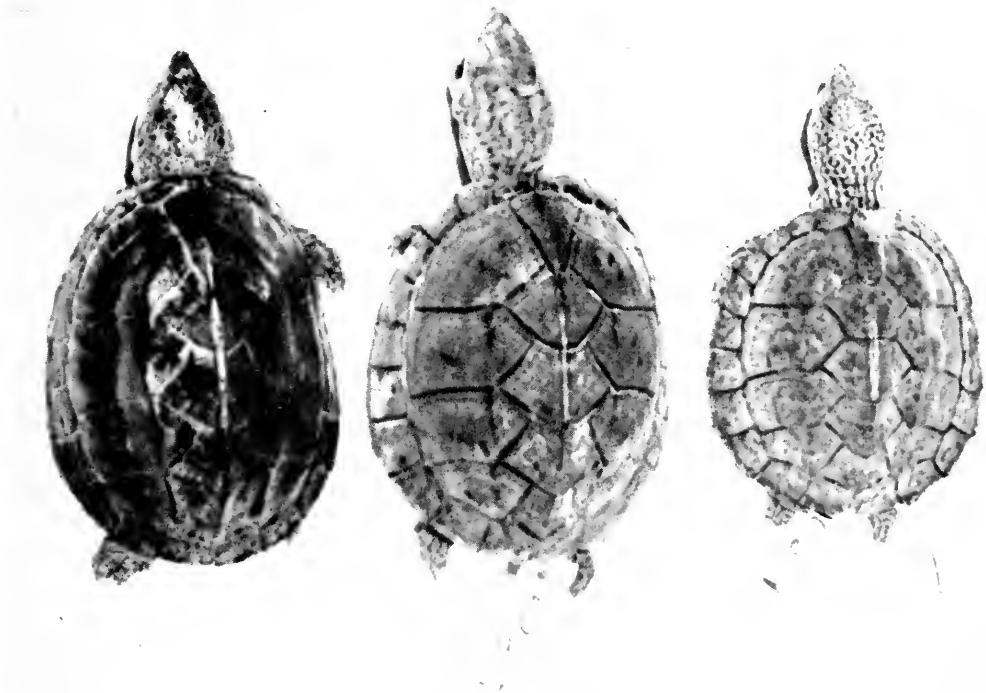


Figure 6. Comparison (left to right) of *Sternothaerus m. minor*, a presumed intergrade between *m. minor* and *m. peltifer*, and a juvenile of *S. m. peltifer*.

er drainage of Georgia, it may occur in the Savannah River. Hayes and Campbell (1900) and Johnson (1907) believed that part of the upper Chattahoochee was directed into the Savannah River. If *S. m. minor* were in the Chattahoochee at the time of this diversion, it could have invaded the Savannah drainage.

I have examined 47 specimens from the Savannah that are represented only by shells and skulls, making specific identification difficult particularly because the series exhibits great individual variation. Most specimens appear to be *S. odoratus*. None has the carapace shape of *S. m. minor*, but some resemble that of *S. m. peltifer* which could also occur in the Savannah River (fig. 5).

The following characters differentiate the turtles in the Savannah River sample from *S. m. peltifer:* 1) first vertebral very wide; the seam between it and the first costal shield contacts the first marginal shield at a point posterior to the midpoint of the marginal; 2) inguinal very wide; 3) keel of carapace greatly reduced; 4) gular large; and 5) shell narrow.

The Savannah River sample was compared with *peltifer* from the Coosa and Tennessee rivers. The turtles from the Savannah River that are most like *m. peltifer* in carapace shape are like *odoratus* in other characters. Twenty-one specimens are shaped like *odoratus*, while 26 have a keeled carapace reminiscent of *m. peltifer*. In *m. peltifer*, the first vertebral overlaps the second, whereas in the Savannah River sample (and generally in *S. odoratus*) this is not so.

Although the characters discussed are somewhat subjective, all specimens were examined at one sitting so that the same relative standards were utilized. The entire series is referable to *odoratus*, but the possibility remains that *m. minor* or *m. peltifer* occurs in the Savannah River (Table 1).

The turtles in the Escambia River and areas immediately east and west appear to be intergrades between *m. minor* and *m. peltifer*. Figure 6 shows a juvenile of *m. peltifer*, *m. minor* and a specimen from the Escambia River. Note the absence of head stripes in the specimen from the Escambia (*m. minor* character) and the absence of lateral ridges (*m. peltifer*) character. The differences are more pronounced in juveniles; the adults may be compared in figures 4, 7 and 8.

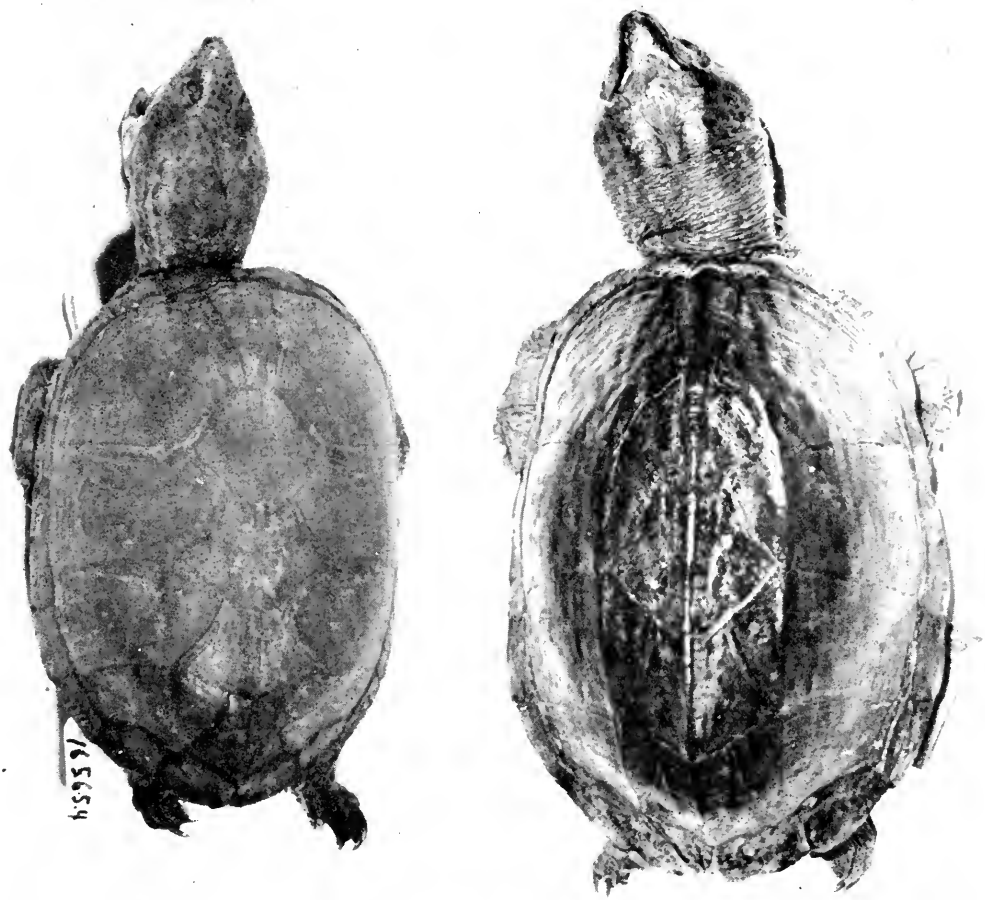
Critical Areas for Collecting

Investigation in the following localities is likely to add significant knowledge concerning the natural ranges of the species.

Sternothaerus carinatus.—The Ouachita, Arkansas and White rivers of Arkansas. I have investigated the White River at Clarendon, Arkansas, and the Ouachita west of Crossett with negative results. The Mississippi River drainage of western Tennes-

TABLE 1. *Distribution of specimens of S. m. peltifer, S. odoratus, and Savannah River material with respect to selected characters*

Character	USNM *peltifer*-like		*odoratus*-like		Tulane *odoratus*		Tulane and PMJ *peltifer*	
Contact of 1st vertebral seam with 1st marginal								
m-1 ($<\frac{1}{2}$)	5	19%	4	19%	8	36%	22	92%
m-1 ($\frac{1}{2}$)	1	4%	3	14%	1	5%	1	4%
m-1 ($>\frac{1}{2}$)	20	76%	14	67%	13	59%	1	4%
Size of inguinal								
wide	16	61%	14	67%	12	54%	4	17%
narrow	10	38%	7	34%	10	45%	20	84%
Size of gular								
large	22	84%	15	72%	17	77%	4	17%
small	4	15%	6	29%	5	23%	20	84%
Shell shape								
long compared with width	21	80%	8	38%	13	59%	9	38%
not so	5	19%	13	62%	9	41%	15	63%



Figures 7-8. **7** (left): adult *Sternothaerus m. minor* X *m. peltifer* intergrade from the Escambia River. **8** (right): typical adult *S. m. minor* from Eureka, Florida.

see. The Escatawpa River in extreme eastern Mississippi.

Sternothaerus minor peltifer.—The western half of Tennessee. Several localities in this area which may be critical also for *carinatus* and *depressus* have been visited but no specimens were obtained.

Sternothaerus depressus.—Further collecting in the upper Black Warrior River and in the Tennessee River is needed.

Sternothaerus minor minor.—The spring runs of southern and southwestern Florida; the Choctawhatchee River; and, the Atlantic coast drainages of Georgia and South Carolina.

IV. Variation

Characters typically used as diagnostic of species are of little value in showing the slight differences between populations of different river systems. Only samples from major rivers are considered in the section on geographic variation. Samples of *S. carinatus* were available from the Pascagoula, Pearl and Tensas Rivers; of *S. depressus* from the Black Warrior River; of *S. m. peltifer* from the Alabama, Tombigbee and Tennessee Rivers; and, of *S. m. minor* from the St. Johns, Suwannee, Apalachicola and Escambia Rivers.

Graphic presentation of data follows the method of Hubbs and Hubbs (1953) and comparable tables were used to assign levels of significance to differences between means. Means were considered significantly different at the one percent level of con-

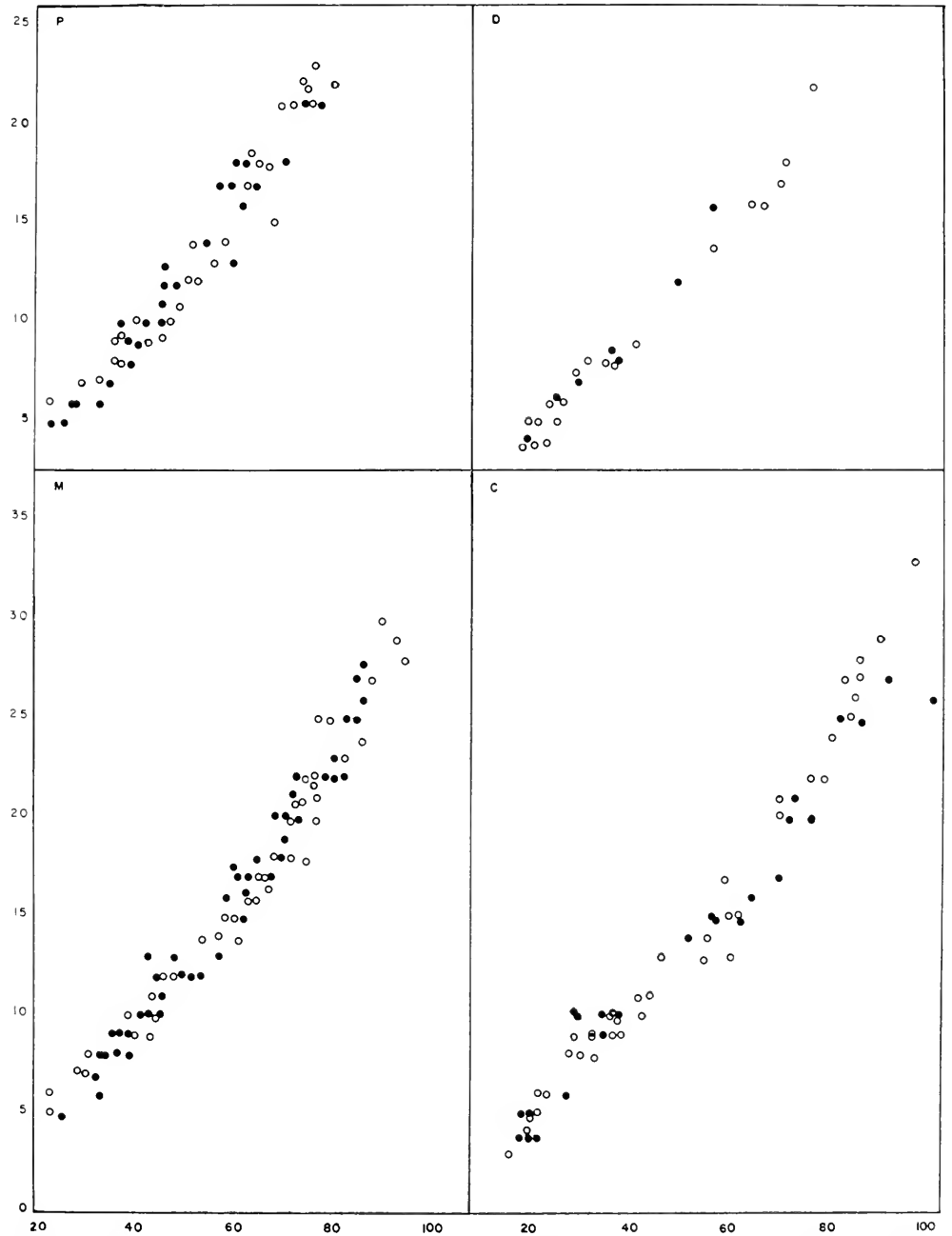
fidence, and were considered marginally significantly different between the one and five percent levels.

The following measurements (to the nearest millimeters) or analyses of characters were used. *Carapace length:* maximum straight line measurement from anterior end of nuchal shield to the seam between the eleventh marginal shields of each side; *carapace width:* at juncture of sixth and seventh marginals; *carapace height:* measured from plastral bridge to juncture of the second and third vertebrals; *carapace angle:* measured at juncture of second and third vertebrals with wire; the angle of the wire when outlined on paper and measured with a protractor actually expresses the acuteness or obtuseness of the angle of the vertebral shield; the general method was developed by Mosimann (1955), and the inherent errors and estimation of them have been discussed previously (Tinkle and Webb, 1955); *plastron length:* measured along the mid-plastral seam; *interhumeral seam:* maximum length; *interpectoral seam:* maximum length; *interabdominal seam:* maximum length; *interfemoral seam:* maximum length; *interanal seam:* maximum length; *length of bridge:* measured from anterior to posterior margin at narrowest point: *length of inguinal:* maximum length from seam to seam; in some instances encroachment of tissue obscured portions, or all of this scute, but the original seams often could be located and accurate measurements obtained; *width of inguinal:* the same pertinent remarks are applicable to this measurement; *head length:* measured from posterior tip of supraoccipital to tip of snout; *head width:* measured across tympanic region; this may or may not be the widest point of the head; *length of dentary symphysis:* measured in a straight line from tip of lower jaw to angle between dentary bones; *length of mask:* in all species there is an ontogenetic development of a cartilaginous or bony mask over the nasal bones, produced apparently by co-ossification of skin and underlying tissues; this mask covers the head anterior to the eyes and sends wing-like projections back to or beyond the eyes; length was measured in the midline and the posterior extent of the wings noted; *tail length:* the tail was straightened as much as possible and then measured from the posterior tip of the plastron to the tip of the tail; *preanal length:* measured from posterior tip of plastron to anterior edge of anus; *number of gular scutes; number of annuli:* only those lines were counted that appeared to be true annual rings; several smaller, sometimes incomplete rings, were usually not included; there is error in this procedure, but no other rapid means of age identification is known; *relative length and width of vertebrals:* ten measurements were made on each turtle; I noted for each of the five vertebrals whether the length and width were equal or one dimension was greater than the other; *seam contacts:* each intercostal seam was lettered anterior to posterior and each of the right marginals was numbered clockwise, then the contact of each costal seam with a marginal or with the seam between marginals was designated; for example, B-m5 (½) signifies that the second intercostal seam contacts the fifth marginal at the midpoint of the latter; *lateral keels:* details of procedure for this measurement are explained in the section on lateral keels (costal ridges) possessed by *Sternothaerus m. minor.*

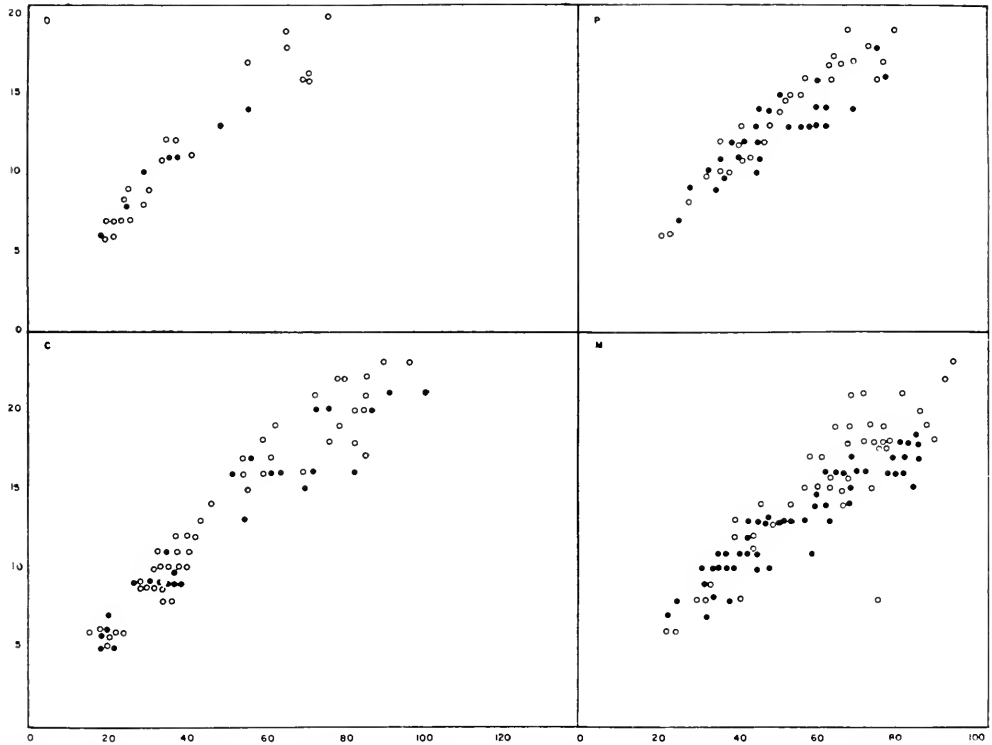
Treatment of measurements.—The following ratios were developed from the measurements and used throughout the study of variation. Reference to these ratios will be made by the abbreviations within the parentheses: Carapace length/carapace width (CL/CW); carapace length/plastron length (CL/PL); carapace angle/carapace height (CA/CH); plastron length/length of bridge (PL/BL); plastron length/length of interhumeral seam (PL/Ih); plastron length/length of interpectoral seam (PL/Ip); plastron length/length of interabdominal seam (PL/Ib); plastron length/length of interfemoral seam (PL/If); plastron length/length of interanal seam (PL/Ian); inguinal length/inguinal width (IL/IW); head length/head width (HL/HW); head length/length of dentary smyphysis (HL/DS); tail length/preanal tail length (TL/PL); preanal tail length/plastron length (PL/PL).

A. *Sexual Dimorphism*

Sex was determined by dissection when possible, by tail length when necessary. The following characters show little or no sexual dimorphism: HL/HW, PL/Iab, HL/DS, CA/CH, PL/Ip, PL/If, PL/Ih, IL/IW,



Figures 9-12. Plastron length (abscissa) plotted against length of interabdominal seam (ordinate). Dots = males, circles = females. Each point may represent one or more specimens. **P.** = *m. peltifer*, **D** = *depressus*, **M** = *m. minor*, **C** = *carinatus*.



Figures 13-16. Plastron length (abscissa) plotted against length of interanal seam (ordinate). Symbols as in figs. 9-12.

CL/CW, vertebral formulae, and seam contacts. The remaining ratios show slight sexual difference in some forms and these will be discussed further.

PL/Ian (figs. 13-16).—The difference between the sexes is most distinct in *S. m. minor* and becomes noticeable at a plastron length of 60 mm which is near the size at sexual maturity. After this point, the increase in length of the interanal does not keep pace with increasing plastron length in males. In females there is almost perfect correlation between the two measurements at all sizes. The same situation exists in *m. peltifer,* although it is less marked. The trend seems to be developing in the graph of *depressus,* but in *carinatus* there is no sexual difference except possibly in very large turtles.

The statistical relationships of this ratio may be seen in figure 17. The differences between the means of males and females were significant in all *m. minor* except those from the Apalachicola and Escambia rivers. The differences in the means of males and females from the Apalachicola are marginally different. The degree of sexual difference diminishes as samples approach the range of *m. peltifer* in which form the mean differences of the sexes are insignificant.

PL/BL (figs. 18-21). — There is no marked divergence of the sexes at a particular size, but, there is an indication, most evident in *m. minor,* that the bridge of the female continues to increase in length after the plastron has reached a definite growth plateau.

CL/PL (figs. 22-25).—The dimorphism in this character begins approximately at sexual maturity and is strongest in *S. m. peltifer.* Apparently the plastron increases at a faster rate than the carapace; a slowing of growth rate of the carapace is not evident. The dimorphism is present in *S. m. minor,* indicated in *depressus,* but absent or weak in *carinatus.* That the differences are not statistically significant may be seen in figure 26.

Risley (1930) found that the plastron

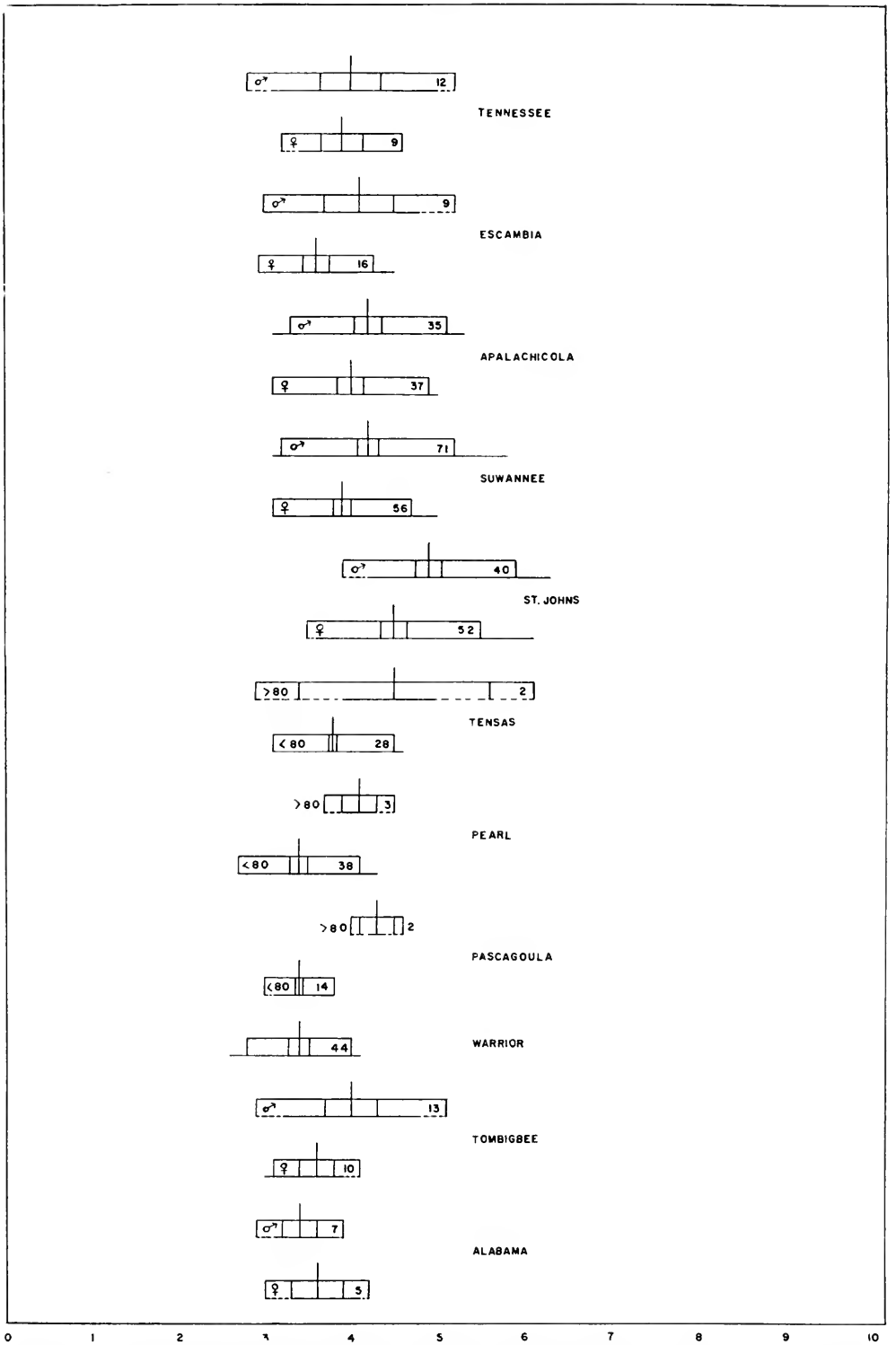
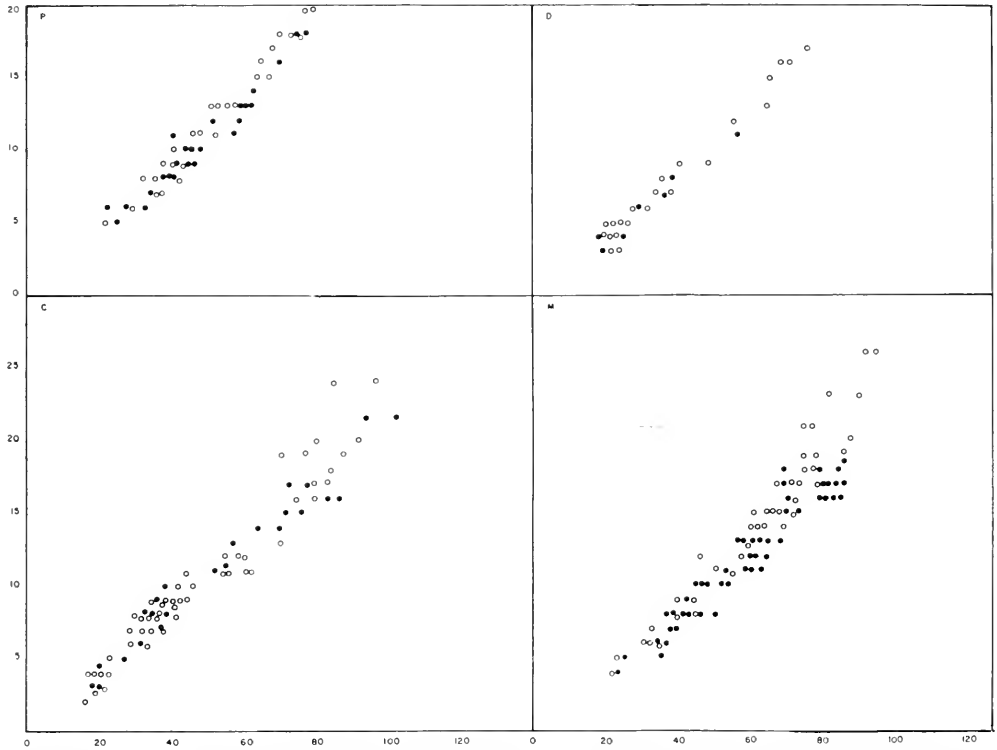


Figure 17. Ratio of plastron length to length of interanal seam. Each bar shows range, two standard errors and two standard deviations of the mean.



Figures 18-21. Plastron length (abscissa) plotted against length of bridge (ordinate). Symbols as in figs. 9-12.

length in female *Sternothaerus odoratus* is greater than that in males. This is true in both races of *Sternothaerus minor*.

TL PL (figs. 27-30).—In many turtle species, the length of the tail of the male is greater than that of the female. Figures 27 to 30 show that the relative length of the preanal region to the total tail length is approximately the same in both sexes, but the tail of the male in all forms is longer. Thus, in *S. carinatus* the tail of the females did not exceed 34 mm, but in the males a length of 45 mm was attained. In adult or near-adult individuals the length of the tail is 100 percent diagnostic of sex.

Risley (1930) found that the average tail length of male *S. odoratus* is 33.72 mm, that of females 22.31 mm. The average preanal lengths are 16.42 and 10.76 for males and females, respectively. Thus, the ratio of tail length to preanal length of 2:1 is the same for both sexes.

PL PL (figs. 31-34).—This ratio shows an early separation of males and females and continuing divergence with increasing size of the individual. In *S. m. peltifer* and *m. minor* there is an obvious early differential rate of growth of the preanal tail length in males. Later the rate slows and the growth curves for the two sexes become more parallel. The divergence in *m. peltifer* and *m. minor* takes place at a plastron length of 30 to 35 mm, considerably in advance of attainment of sexual maturity. In *carinatus* the divergence takes place at a plastron length of 40 to 50 mm and is not as marked as in *m. minor*. In *depressus* the dimorphism exists, but the few large specimens available preclude comparisons with the other forms.

B. *Ontogenetic Variation*

Ontogenetic variation was considered to determine whether lumping individuals of different size in comparing various characters in the populations of each river was justified. No regression coefficients were calculated as there was no apparent necessity for doing so. Unless there was a significant change in ratio (as determined by inspection of the graphs), samples were lumped

in further consideration of geographic variation.

There is little change in the following ratios: CL/CW, CL/PL, HL/HW, PL/Ip, PL/If, PL/Ih, IL/IW, CA/CH, and in seam contacts.

The correlation of carapace angle to height is not as close as that of most other ratios, probably because of the greater error involved in measuring the angle. There is little change, however, in the ratio of angle to height with increasing height or widening angle.

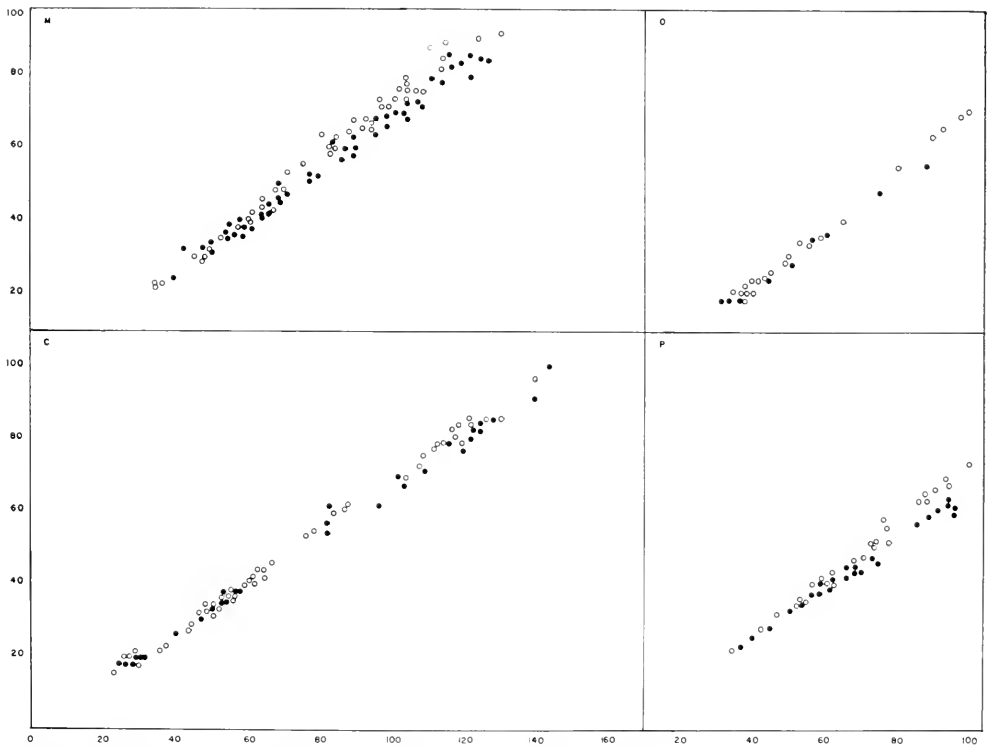
There are few specimens of *S. m. minor* and *m. peltifer* less than 20 mm in carapace height. *Sternothaerus depressus* and *S. carinatus* are represented by many specimens smaller than this, which exhibit a decided difference in the ratio of carapace angle to height. This may be due to a real difference in this ratio in small turtles or to error in obtaining accurate angle measurements of these small turtles because of the thickness of the aluminum wire used and the flexibility of the carapace. Most readings of the angle in turtles less than 20 mm in carapace height are greater than the actual vertebral angle itself.

In *S. depressus, S. m. peltifer* and *S. m. minor* the carapace becomes progressively flatter with increasing size. At a certain point in this flattening process, the carapace angle becomes so wide that it is extremely difficult to measure. Any specimen in which the vertebral angle was 165 degrees or greater was generally considered flat. This explains the absence in the figures of individuals with nearly straight carapace angles.

The following characters or ratios show some ontogenetic changes.

PL/Iab (figs. 9-12).—A slight change in this ratio, particularly evident in *S. m. minor*, appears due to failure of the plastron to continue a rate of growth equal to that of the abdominal scute.

PL/Ian (figs. 13-16).—A change in this ratio is almost non-existent in *S. m. minor*, but is indicated more strongly in males than in females. The change in the ratio, evi-



Figures 22-25. Carapace length (abscissa) plotted against plastron length (ordinate). Symbols as in figs. 9-12.

dent in *S. m. peltifer* is at least indicated in *depressus*. In *S. carinatus* the change is most clearly seen and only in the latter does it require consideration when samples are lumped for study of geographic variation.

PL BL (figs. 18-21).—There is a change in this ratio, negligible for most purposes, due to failure of the plastron to increase in length at the same rate as the bridge. This change, evident in *m. minor* and *m. peltifer*, is shown more strongly by females than by males and occurs near the size of attainment of sexual maturity.

Vertebral dimensions.— An ontogenetic change in the length/width relationship of the vertebrals occurs only in *carinatus*. Generally, all vertebrals except the first are wider than long in all forms; however, this is generally true only of adults of *carinatus*. Only 13 percent of 124 *carinatus* have all vertebrals longer than wide and only 28 percent have four longer than wide (Table 15).

Length of mask.—The development of the mask begins just posterior to the tip of the snout and proceeds posteriorly as the turtle grows larger. In some old individuals most of the dorsal surface of the head is ossified, but characteristically the mask consists of a basal portion mostly anterior to the orbit with two wings curving backward to a point slightly posterior to the orbit.

The ontogenetic posterior extension of the mask is shown in all forms (Table 2). The mask in the smallest size group of turtles is absent or represented by a rudiment wholly anterior to the orbit in 70 percent of *m. minor*, 96 percent of *m. peltifer*, 100 percent of *depressus*, and 100 percent of *carinatus*. In the 51 to 80 mm size group, the mask reaches the middle of the orbit in 64 percent of *m. minor* and 50 percent of *m. peltifer*. In *depressus* and *carinatus* it reaches mid-orbit in only 20 and 9 percent, respectively, of specimens in the 51 to 80 mm size group. In the 81 to 110 mm size group the mask extends at least to the posterior margin of the orbit in 90 percent of *m. minor*, 67 percent of *m. peltifer*, 50 percent of *depressus* and 67 percent of *carinatus*. The mask in the largest size group of all forms always extends to a point posterior to the orbit.

The fact that the mask in *carinatus* reaches mid-orbit at a carapace length greater than in *m. peltifer* and *m. minor* makes the character of some diagnostic value, and is an additional indication of the uniqueness of *S. carinatus*.

C. *Geographic Variation*

Because the characters must be treated statistically to reveal small differences, I felt obliged to reduce the total number of characters to be analyzed. For the purposes of comparison of the four forms of the *Sternothaerus carinatus* complex, the following ratios were chosen: CL/CW; CA/CH; CL/PL; IL/IW; PL/lh; PL/lf; PL/lan.

In addition to these ratios, geographic variation in seam contacts and in expression

TABLE 2. *Length of mask*

Species	Size groups (mm)	N	Absent	Anterior to orbit	To less than mid-orbit	To mid-orbit	To post-orbit
minor (N=285)	21-50	60	30-50%	12-20%	2-3%	15-25%	1-2%
	51-80	101	0—	4-4%	9-9%	56-55%	32-32%
	81-110	100	0—	0—	1-1%	9-9%	90-90%
	111-140	24	0—	0—	0—	0—	24-100%
peltifer (N=81)	21-50	29	23-79%	5-17%	0—	0—	1-3%
	51-80	32	0—	7-22%	0—	16-50%	9-28%
	81-110	18	0—	0—	0—	6-33%	12-67%
	111-140	2	0—	0—	0—	0—	2-100%
depressus (N=44)	21-50	28	21-75%	7-25%	0—	0—	0—
	51-80	10	1-10%	7-70%	1-10%	1-10%	0—
	81-110	6	0—	0—	1-17%	2-33%	3-50%
carinatus (N=104)	21-50	42	25-60%	17-40%	0—	0—	0—
	51-80	34	2-6%	29-85%	1-3%	2-6%	0—
	81-110	6	0—	1-17%	0—	1-17%	4-67%
	111-140	22	0—	0—	0—	0—	22-100%

TABLE 3. *Treatment of sex and size groups in each species with respect to seven ratios. X's, dashes or explanation under each category show disposition of ratios in calculations*

Character	Lump sexes	Lump sizes	Treat sex separately	Treat sizes separately	Size groups to use	Exceptions
c.l./c.w.	x	x	–	–	–	–
c.h./c.angle	x	x	–	–	–	–
c.l./p.l.	–	x	x	–	–	Lump sexes in *carinatus*
inguinal l./w.	x	x	–	–	–	–
p.l./i.h.	x	x	–	–	–	–
p.l./i.f.	x	x	–	–	–	–
p.l./i.an.	–	–	x in *minor* & *peltifer*	x *carinatus* only	p.l.>80mm p.l.<80mm	–

of the lateral keels of *S. m. minor* are discussed; these latter two characters first.

On the basis of the study of ontogenetic and sexual variation in seven ratios, the statistics for each species were treated as shown in Table 3. In the following discussion, reference may be made to the tables showing the sex ratio of each form (Tables 19-20) and to table 4 which shows the percentage of individuals of each form in various size groups. These tables will help in the interpretations of differences between populations in various river systems.

The fact that the bulk of individuals of *S. depressus* are in the two smallest size groups may tend to exaggerate small ontogenetic differences. The size distributions of *S. m. minor* and *m. peltifer* are comparable. In *S. carinatus* the large percentage of small specimens is balanced by a high percentage of large individuals.

TABLE 4. *Percentage of specimens of each form in four size groups*

carapace length (mm)	21-50	51-80	81-110	111-140
minor	7	36	49	8
peltifer	13	55	29	3
depressus	62	24	14	—
carinatus	33	29	11	25

Seam contacts.—Data pertinent to this discussion are shown in Tables 5 through 7. The modal formula shown is based upon the most frequent points of contact between costal seams and marginal scutes or seams.

In *S. m. minor* of the St. Johns and Suwannee rivers the modal formula is the one most often represented in the populations, but in specimens from the Escambia and Apalachicola rivers other formulae have a greater frequency of occurrence than the modal formula. In the Apalachicola the modal formula occurs second-most, but in the Escambia it is not one of the three most common formulae. The seam contact formula most frequently encountered is dif-

TABLE 5. *Point of contact of costal seams with marginals or marginal seams: S. depressus and S. carinatus*

Contact		*depressus* Warrior (41)	*carinatus* Pascagoula (16)	Pearl (41)	Tensas (30)	Total (87)
m1(<½)	N	26	9	30	14	53
	♂	63♂	56♂	73♂	47♂	61♂
m1(½)	N	13	2	6	9	17
	♂	32♂	13♂	15♂	30♂	20♂
m1(>½)	N	2	5	5	7	17
	♂	5♂	31♂	12♂	23♂	20♂
m5(<½)	N	5	7	15	2	24
	♂	12♂	44♂	37♂	7♂	28♂
m5(½)	N	14	5	18	4	27
	♂	34♂	31♂	44♂	13♂	31♂
m5(>½)	N	22	4	8	24	36
	♂	54♂	25♂	20♂	80♂	41♂
s5	N	0	0	0	0	0
	♂	0♂	0♂	0♂	0♂	0♂
m7(<½)	N	2	2	5	0	7
	♂	5♂	13♂	12♂	0♂	8♂
s8	N	0	0	0	0	0
	♂	0♂	0♂	0♂	0♂	0♂
m7(½)	N	8	2	15	3	20
	♂	20♂	13♂	37♂	10♂	23♂
m7(>½)	N	31	12	21	27	60
	♂	76♂	75♂	51♂	90♂	69♂
m8(>½)	N	10	0	0	0	0
	♂	24♂	0♂	0♂	0♂	0♂
m9(½)	N	0	0	1	0	1
	♂	0♂	0♂	2♂	0♂	1♂
m9(>½)	N	0	0	1	0	1
	♂	0♂	0♂	2♂	0♂	1♂
s9	N	22	1	5	0	6
	♂	54♂	6♂	12♂	0♂	7♂
m9(<½)	N	9	15	34	30	79
	♂	22♂	94♂	83♂	100♂	91♂
s11	N	25	4	8	0	12
	♂	61♂	25♂	20♂	0♂	14♂
m10(>½)	N	2	0	0	0	0
	♂	5♂	0♂	0♂	0♂	0♂
m11(<½)	N	14	12	32	30	74
	♂	34♂	75♂	79♂	100♂	85♂
m11(½)	N	0	0	1	0	1
	♂	0♂	0♂	2♂	0♂	1♂

TABLE 6. *Point of contact of costal seams with marginals or marginal seams: S. m. minor*

Contacts		St. Johns (101)	Suwannee (120)	Apalachicola (83)	Escambia (42)	Total (346)
m1(<½)	N	69	62	42	21	194
	%	68%	52%	51%	50%	56%
m1(½)	N	16	33	24	7	80
	%	16%	28%	29%	17%	23%
m1(>½)	N	16	25	17	14	72
	%	16%	21%	20%	33%	21%
m5(<½)	N	63	83	36	21	203
	%	62%	69%	43%	50%	59%
m5(½)	N	14	24	26	9	73
	%	14%	20%	31%	21%	21%
m5(>½)	N	24	12	21	12	69
	%	24%	10%	25%	29%	20%
s5	N	0	1	0	0	1
	%	0%	1%	0%	0%	0%
m7(<½)	N	0	0	1	3	4
	%	0%	0%	1%	7%	1%
s8	N	3	2	2	0	7
	%	3%	2%	2%	0%	2%
m7(½)	N	3	2	6	2	13
	%	3%	2%	7%	5%	4%
m7(>½)	N	95	116	73	37	321
	%	94%	97%	88%	88%	93%
m8(>½)	N	3	2	1	0	6
	%	3%	2%	1%	0%	2%
m9(½)	N	0	0	0	0	0
	%	0%	0%	0%	0%	0%
m9(>½)	N	1	0	0	0	1
	%	1%	0%	0%	0%	0%
s9	N	23	53	28	11	115
	%	23%	44%	34%	26%	33%
m9(<½)	N	74	65	54	31	224
	%	73%	54%	65%	74%	64%
s11	N	48	79	65	19	211
	%	48%	66%	78%	45%	61%
m10(>½)	N	2	0	0	0	2
	%	2%	0%	0%	0%	1%
m11(<½)	N	51	41	18	23	133
	%	50%	34%	22%	55%	39%
m11(½)	N	0	0	0	0	0
	%	0%	0%	0%	0%	0%

ferent for the samples of *m. minor* from each of four rivers. The situation in *S. m. peltifer* is similar to that in *m. minor,* except that *m. peltifer* in the Alabama and Tennessee rivers have the same formula with the greatest frequency of occurrence. *Sternothaerus depressus* shows extreme variability with 24 different formulae among 41 specimens.

Sternothaerus carinatus shows a definite east to west trend involving a posterior shifting of the point of contact of the second costal seam with the fifth marginal. The formulae most commonly encountered are similar in the Pearl, Pascagoula and Tensas rivers. The specimens from the Tensas River show only nine different formulae, all of which are shared with turtles in either the Pearl or Pascagoula.

Most rivers contain populations showing less than 30 percent unique formulae, *i.e.* formulae not shared with a turtle from any other river system containing turtles of the same form. However, *S. m. peltifer* in the Tennessee River exhibited 65 percent unique formulae, and *S. carinatus* in the Pearl River had 52 percent not shared with turtles in the Pascagoula or Tensas.

In most rivers, the three most common formulae account for less than 35 percent of the total sample from that river. However, *S. m. peltifer* in the Alabama and Tennessee rivers had three formulae accounting for 70 and 64 percent of the specimens, respectively. Seventy percent of the *S. carinatus* from the Tensas River have one of the three most common formulae.

The percentages of contact between the seams and shields show tremendous variation (Table 5-7). The percentages reveal either no trends, east to west trends or un-

TABLE 7. *Point of contact of costal seams with marginals or marginal seams: S. m. peltifer*

Contacts		Alabama (Above Fall Line) (29)	Tennessee (25)	Tombigbee (Below Fall Line) (22)	Total (76)
m1(<½)	N	25	24	17	66
	%	86%	96%	77%	87%
m1(½)	N	4	1	3	8
	%	14%	4%	14%	11%
m1(>½)	N	0	0	2	2
	%	0%	0%	9%	3%
m5(<½)	N	17	23	14	54
	%	59%	92%	64%	71%
m5(½)	N	5	1	4	10
	%	17%	4%	18%	13%
m5(>½)	N	7	1	4	12
	%	24%	4%	18%	16%
s5	N	0	0	0	0
	%	0%	0%	0%	0%
m7(<½)	N	0	1	3	4
	%	0%	4%	14%	5%
s8	N	0	0	0	0
	%	0%	0%	0%	0%
m7(½)	N	0	3	4	7
	%	0%	12%	18%	9%
m7(>½)	N	29	21	15	65
	%	100%	84%	68%	86%
m8(>½)	N	0	1	1	2
	%	0%	4%	5%	3%
m9(½)	N	0	0	0	0
	%	0%	0%	0%	0%
m9(>½)	N	0	0	0	0
	%	0%	0%	0%	0%
s9	N	3	5	9	17
	%	10%	20%	41%	22%
m9(<½)	N	26	19	12	57
	%	90%	76%	55%	75%
s11	N	11	8	11	33
	%	38%	32%	64%	43%
m10(>½)	N	0	0	1	1
	%	0%	0%	5%	1%
m11(<½)	N	17	17	7	41
	%	59%	68%	32%	54%
m11(½)	N	1	0	0	1
	%	3%	0%	0%	1%

correlated variability depending upon which seam contact is considered. The variation in percentages of various seam contacts in each river system makes the mean percentage for each form of little diagnostic value (Table 8). In *S. m. peltifer* and *S. depressus* the frequency of contacts between the first costal seam and the posterior half of the first marginal is low. In *S. depressus* the second costal seam comes in contact with the fifth marginal in 12 percent of the specimens, while this contact occurs in 71 percent of *S. m. peltifer*. Several other instances of this nature could be detailed, but none is diagnostic of a particular form.

TABLE 8. *Percentages of contacts between costal seams and each marginal or marginal seams: summary*

Contact	*m. minor* (346)	*m. peltifer* (76)	*depressus* (41)	*carinatus* (87)
	%	%	%	%
m1 (<½)	56	87	63	61
m1 (½)	23	11	32	20
m1 (>½)	21	3	5	20
m5 (<½)	59	71	12	28
m5 (½)	21	13	34	31
m5 (>½)	20	16	54	41
s5	0	0	0	0
m7 (<½)	1	5	5	8
s8	2	0	0	0
m7 (½)	4	9	20	23
m7 (>½)	93	86	76	69
m8 (>½)	2	3	24	0
m9 (½)	0	0	0	1
m9 (>½)	0	0	0	1
s9	33	22	54	7
m9 (<½)	64	75	22	91
s11	61	43	61	14
m10 (>½)	1	1	5	0
m11 (<½)	39	54	34	85
m11 (½)	0	1	0	1

These formulae and positions of contact between seams and marginal shields (Tables 9-12) serve as additional indicators of divergence of the populations in different rivers. If these contacts are genetically determined, they may serve as useful characters in future studies on transmission of traits in turtles.

Lateral keels of Sternothaerus minor minor.—One distinctive characteristic of *S. m. minor* is the presence of two lateral ridges in addition to the vertebral keel. This character is found elsewhere only in juveniles of *Sternothaerus odoratus*.

These lateral ridges are most distinct in *m. minor* from streams of the Atlantic coast drainage and disappear in specimens from the Escambia River, due probably to gene exchange with *m. peltifer*, a detail for later discussion. Within most drainages in which *m. minor* occurs, there is variability in the degree of expression of the lateral ridges (Table 13). The determination of the relative size of the ridges is subjective, but all examinations were made at the same time without reference to the geographic origin of the turtles.

CL/CW (fig. 35).—The means of *S. m. minor* are the same in the St. Johns, Suwannee and Apalachicola rivers, but there

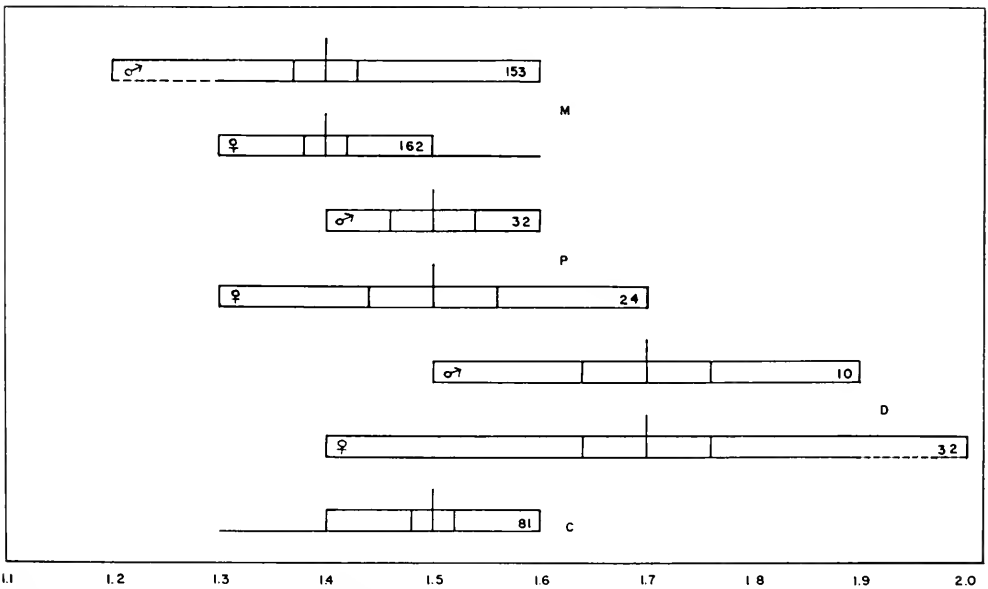


Figure 26. Ratio of carapace length to plastron length. Symbols as in fig. 17.

TABLE 9. *Seam formulae of Sternothaerus m. minor*

		St. Johns	Suwannee	Apalachicola	Escambia
No. of Specimens		101	120	80	42
No. of formulae		34	37	33	26
Spec. per formula		3.4	3.2	2.4	1.6
% shared		71	76	73	85
% unique		29	24	27	15
Modal form		m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)
% occurrence		18	13	8	2
Most common formulae	1	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) s9 s11	m1(<½) m5(>½) m7(>½) m9(<½) s11
	2	m1(<½) m5(>½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) s9 s11	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(>½) m5(>½) m7(>½) m9(<½) m11(<½)
	3	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) s9 m11(½)	m1(>½) m5(>½) m7(>½) m9(<½) s11	m1(>½) m5(<½) m7(>½) m9(<½) s11
Percent occurrence	1	18	13	10	10
	2	10	12	8	10
	3	7	8	8	7

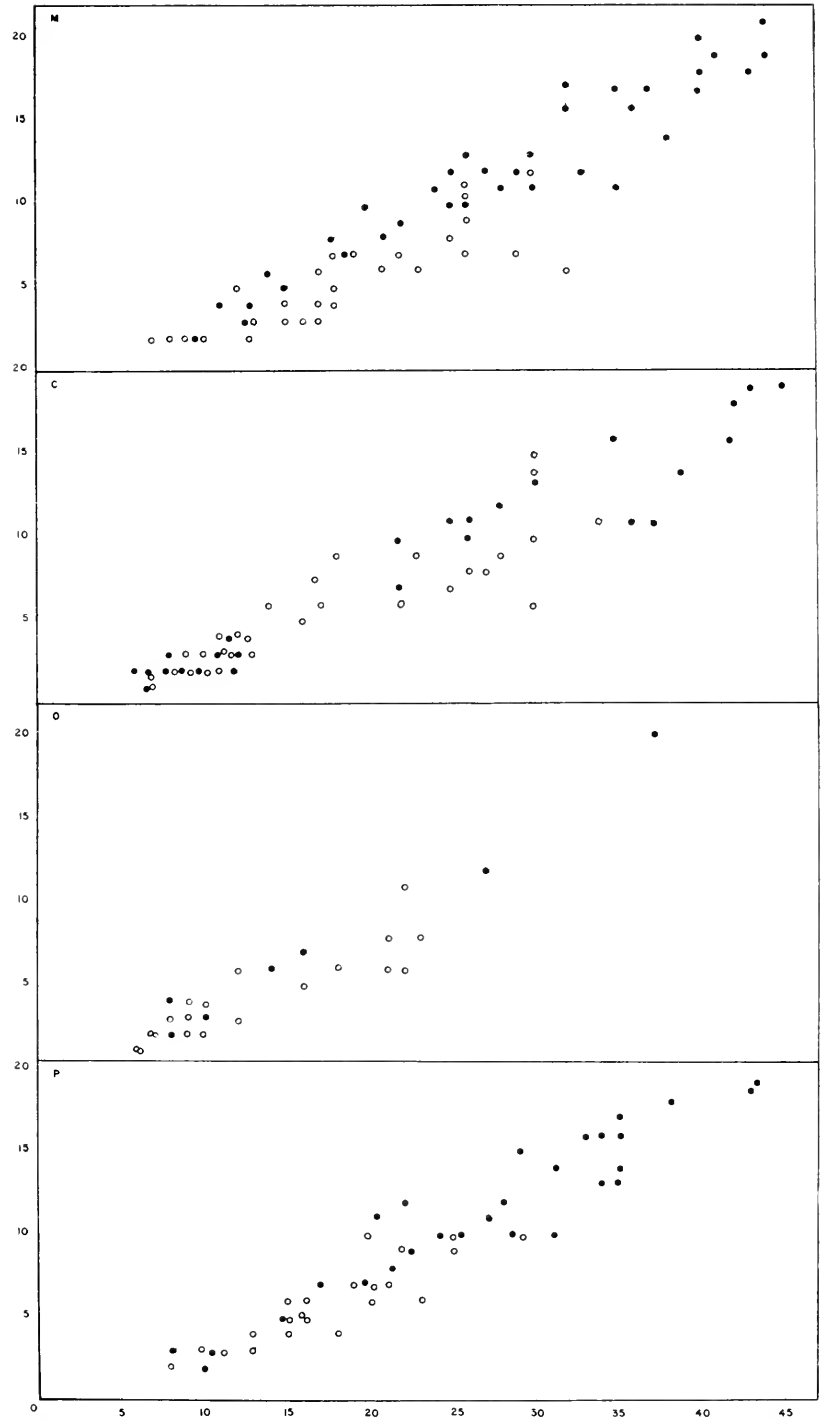
is a significant shift in Escambia River specimens toward the mean of *m. peltifer*. The means of *m. peltifer* are approximately the same in all rivers, and are significantly different from those of *m. minor*. The mean of *depressus* is significantly different from that of the *Sternothaerus* from every other river except that of *S. carinatus* from the Pearl. Because the samples from the Warrior and Pearl rivers contain mostly juvenile individuals, small differences between size groups are accentuated. The means of *carinatus* are significantly different in the Pearl, Pascagoula and Tensas rivers, but little consequence is attached to this because of the difference in proportions of the size groups represented in samples from each river.

CA/CH (fig. 36).—The ratio of carapace angle to carapace height shows a definite longitudinal trend in *S. m. minor*. The mean of the populations in the St. Johns River is significantly different from that of Escambia River samples. In *S. m. peltifer* there is also a longitudinal trend, but the trend is toward a decrease in the ratio of angle to height, whereas in *m. minor* it is toward an increase. The mean of *S. depressus* is significantly different from that of samples from all other rivers, but particularly from the means of *S. carinatus*. The mean differences of *S. carinatus* from different rivers are significant and, generally significantly different from the means of turtles from any other river. The mean of specimens from the Pearl is probably shifted toward a high ratio because of the disproportionate number of young in the sample.

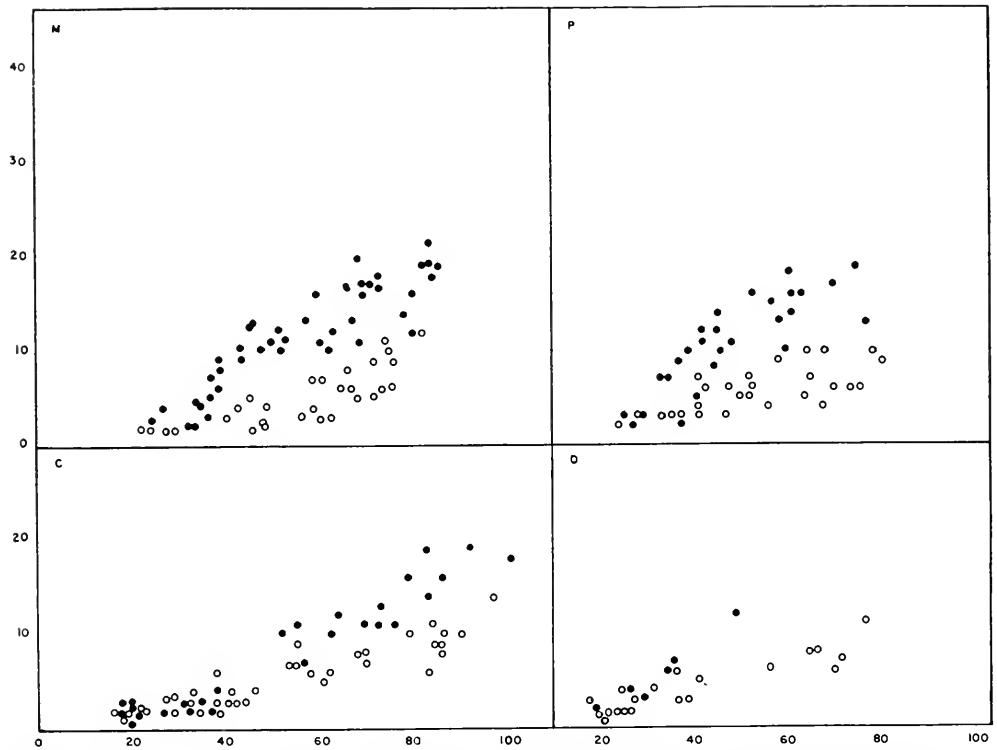
CL/PL (fig. 37).—*Sternothaerus m. minor* shows greater expression of sexual dimorphism in this ratio in the western part of its range. The males and females show little difference in the St. Johns and Suwannee rivers. In the Apalachicola and Escambia rivers the mean of the females remains the same, but the males show a higher mean ratio than do those in the St. Johns or Suwannee rivers. The means of *m. peltifer* are generally slightly different from those of *m. minor*. *Sternothaerus depressus* exhibits the most significant deviation with respect to this ratio. The small plastron size of *depressus* is accentuated by the flared marginal and rounded carapace. The means of *S. carinatus* are significantly different from those of most forms, but similar to *S. m. peltifer* due to convergence in the shape of the carapace and relative size of plastron and carapace.

TABLE 10. *Seam formulae of Sternothaerus m. peltifer*

		Alabama	Tennessee	Tombigbee
No. of specimens		29	25	22
No. of formulae		11	12	17
Spec. per formula		2.6	2.1	1.3
% Shared		64	67	35
% Unique		36	33	5
Modal formula		m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) m9(<½) s11
% Occurrence		28	20	11
Most common formulae	1	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) m9(<½) s11
	2	m1(<½) m5(>½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)
	3	m1(<½) m5(<½) m7(>½) m9(<½) s11	m1(<½) m5(<½) m7(>½) s9 m11(<½)	m1(<½) m5(<½) m7(½) s9 s11
Percent occurrence	1	28	36	11
	2	21	20	9
	3	21	8	9



Figures 27-30. Tail length (abscissa) plotted against preanal tail length (ordinate). Symbols as in figs. 9-12.



Figures 31-34. Plastron length (abscissa) plotted against preanal tail length (ordinate). Symbols as in figs. 9-12.

IL/IW (fig. 38).—The ratio of samples of *S. m. minor* from the St. Johns and Apalachicola rivers are similar and their means significantly different from those of samples from the Escambia and Suwannee rivers. *Sternothaerus m. peltifer* displays a longitudinal trend toward a nearer equality between the length and width of the inguinal scute, a trend which is carried through *S. carinatus* with slight mean differences in three rivers. *Sternothaerus carinatus* displays the greatest differences in the ratio. The means of samples from the Pearl, Pascagoula and Tensas rivers are significantly different from those of other rivers. The greatest similarity is in the mean of the sample from the Tensas to the mean of *depressus* from the Warrior.

The size of the axillary and inguinal scutes was used by Smith and Glass (1947) to differentiate "*S. peltifer*" from *S. carinatus*. My data show that the ratio between the length and width of the inguinal would separate approximately 50 percent of those individuals.

TABLE 11. *Seam formulae of Sternothaerus depressus*

		Black Warrior
No. of specimens		41
No. of formulae		29
Spec. per formula		1.4
% Shared		—
% Unique		—
Modal Formula		m1(<½) m5(>½) m7(>½) s9 s11
% Occurrence		7
Most common formulae		m1(<½) m5(>½)
	1	m7(>½) s9 s11
	2	m1(½) m5(>½) m7(>½) s9 s11
	3	m1(½) m5(½) m7(>½) m9(<½) s11
Percent occurrence	1	7
	2	7
	3	7

PL/Ih (fig. 39).—The St. Johns River sample of *S. m. Minor* has a significantly greater mean ratio than those of samples from the Suwannee and Apalachicola rivers. However, the mean of the St. Johns sample is approached by that of specimens from the Escambia River. The Tennessee River sample of *m. peltifer* shows the widest divergence in this ratio, with a shift of the majority of individuals toward a higher ratio, *i.e.* toward a shorter interhumeral seam. The mean of the Tennessee River samples is significantly different from that of samples from all other rivers. The means of Alabama and Tombigbee river samples are similar to those of *m. minor*. *Sternothaerus carinatus* shows low variability for this character, and the means are all significantly different from those of the *minor* group. The mean of *S. depressus* is approximately intermediate between that of *m. peltifer* and *carinatus*, and is generally different from the means of any of the river samples of these two latter forms.

PL/If (fig. 40).—The mean of the *m. minor* samples from the Suwannee River is

TABLE 12. *Seam formulae of Sternothaerus carinatus*

		Pascagoula	Pearl	Tensas
No. of specimens		16	11	30
No. of formulae		14	25	9
Spec. per formula		1.1	1.6	3.3
% Shared		71	48	100
% Unique		29	52	0
Modal formula		m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(>½) m7(>½) m9(<½) m11(<½)
% Occurrence		0	22	10
Most common formulae	1	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(<½) m7(>½) m9(<½) m11(<½)	m1(<½) m5(>½) m7(>½) m9(<½) m11(<½)
	2	(only 1 specimen)	m1(<½) m5(<½) m7(<½) m9(<½) m11(<½)	m1(>½) m5(>½) m7(>½) m9(<½) m11(<½)
	3	(only 1 specimen)	m1(<½) m5(<½) m7(<½) 89 m11(<½)	m1(<½) m5(>½) m7(>½) m9(<½) m11(<½)
Percent occurrence	1	19	22	27
	2	—	7	23
	3	—	7	20

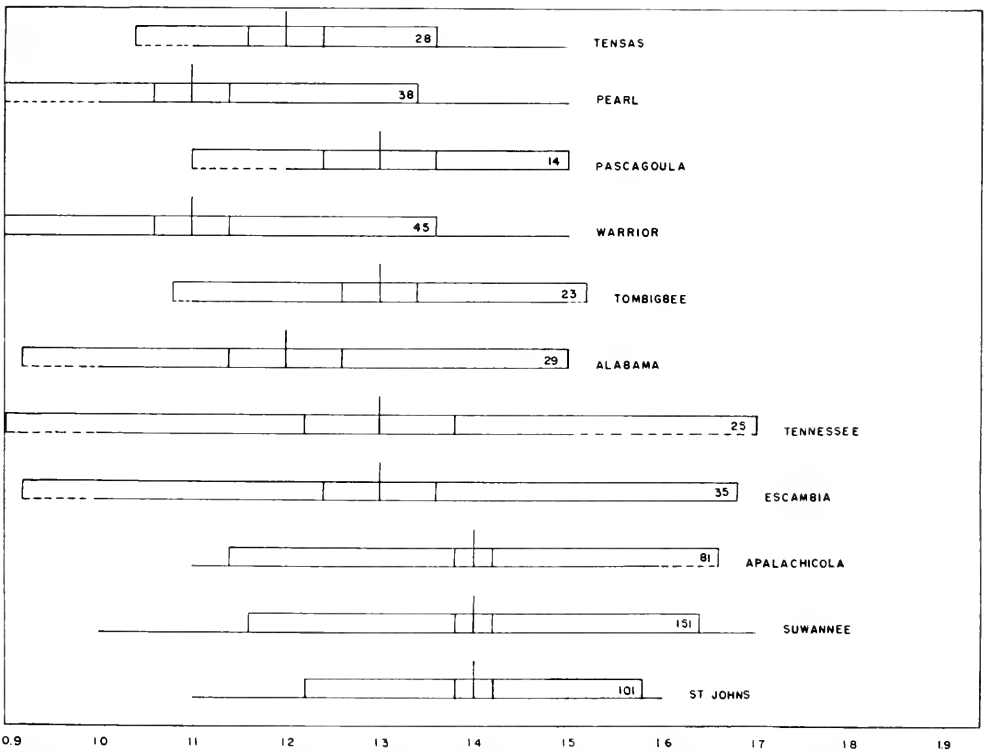


Figure 35. Ratio of carapace length to carapace width. Symbols as in fig. 17.

significantly different from that of the other samples of this race. This difference is more significant because of the narrow range of variation in this ratio in the Suwannee River specimens. The mean of the St. Johns sample is significantly different from that of samples from the Apalachicola and Escambia rivers, but the difference is slight and the ranges of variation overlap considerably. The Apalachicola and Escambia samples have the same mean. The sample of *S. m. peltifer* from the Tennessee River shows tremendous divergence from the samples from the Alabama and Tombigbee rivers. In fact, the extremes of the ratio in the Tennessee River do not overlap the extremes of those from the Alabama and Tombigbee rivers. The means of *S. m. peltifer* from the Alabama and Tombigbee rivers are similar to those of *S. depressus* and *carinatus*, although the Tensas River samples of the latter show a slightly smaller mean ratio than do other samples of this species.

PL lan (fig. 17).—The variability in this ratio is less than that encountered in any other. This may reflect the importance to the turtle of having anal plates that do not extend too far posteriorly and interfere with egg deposition or coitus. In general there is a gradual decrease in this ratio from that of *S. m. minor* in the St. Johns River to that of *S. carinatus* in the Pearl River. Small differences exist between the mean ratios of samples from each river system.

D. *Statistical Treatment of Pooled Samples*

The data for each species were combined to facilitate comparison. The figures to be discussed were derived from the data presented in figures 17 and 35 through 40. The mean of means, mean of standard deviation and mean of standard error were calculated by standard procedure.

CL CW (fig. 41).—The means of all forms are significantly different, but ranges overlap considerably and little significance

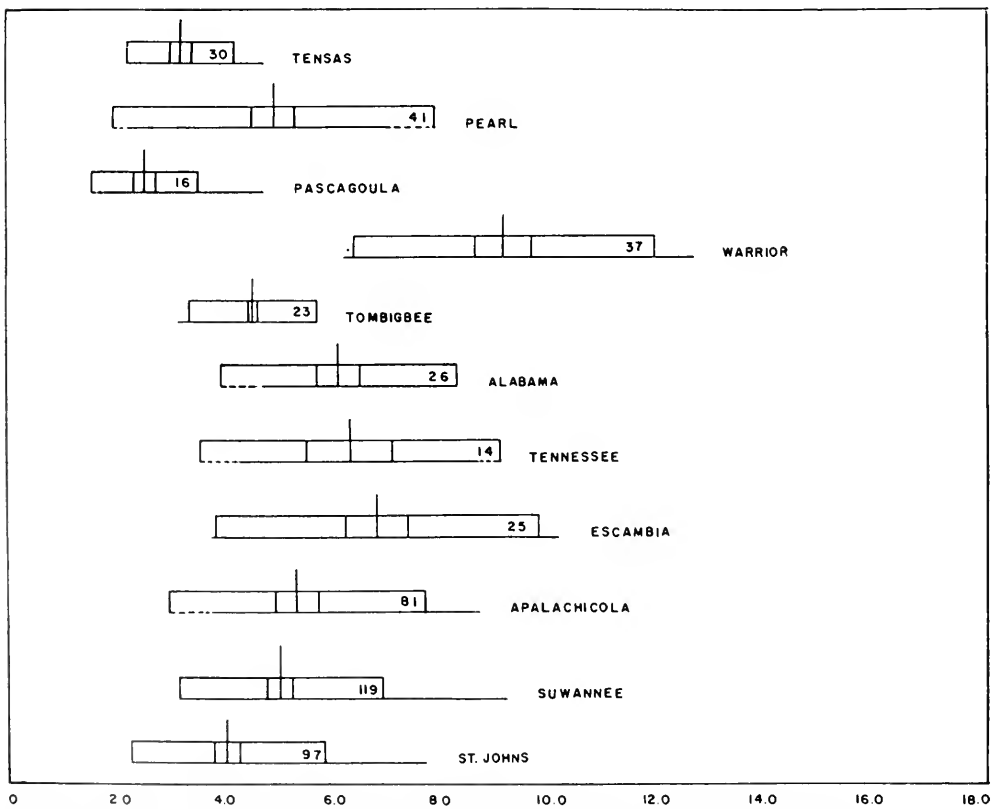


Figure 36. Ratio of carapace angle to carapace height. Symbols as in fig. 17.

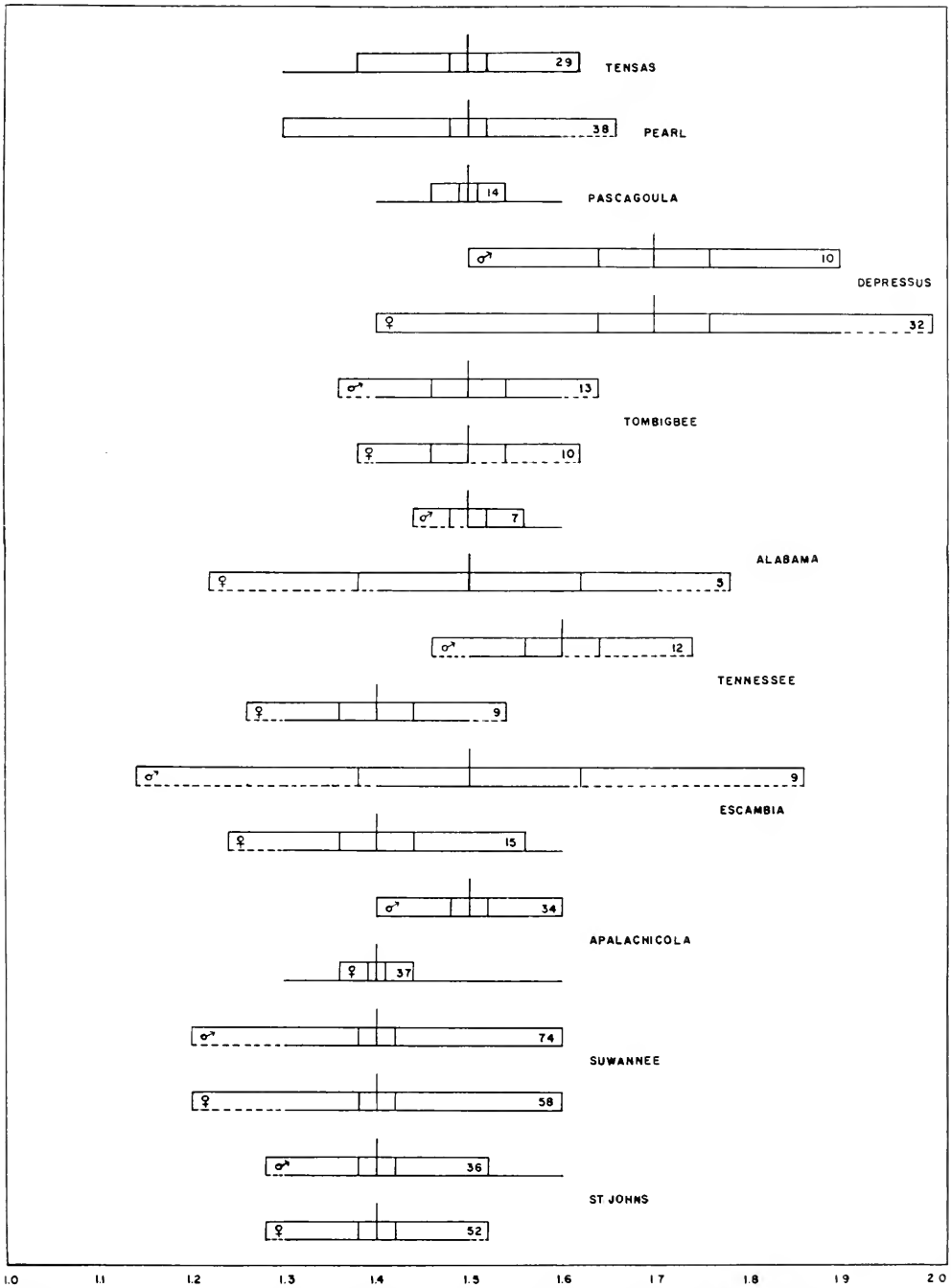


Figure 37. Ratio of carapace length to plastron length. Symbols as in fig. 17.

can be attached to the differences. The carapace shape of *Sternothaerus depressus* is considerably different from that of the other forms. The large numbers of juveniles in the samples of *S. carinatus* shift the mean slightly to a smaller ratio than would a more balanced sample.

CL PL (fig. 26).—*Sternothaerus depressus* shows the most marked difference in this ratio, but displays considerable overlap with the other forms. *Sternothaerus carinatus* and *S. m. peltifer* are similar, while the mean of *S. m. minor* is significantly different from that of the other three forms.

CA CH (fig. 42).—The means of the four forms are significantly different from one another, but *Sternothaerus m. peltifer* and *S. m. minor* show close similarity. *Sternothaerus carinatus* shows a significantly smaller ratio because of the acuteness of the vertebral angle, and *Sternothaerus depressus* shows the most significant difference. The ranges of variation of *depressus* and *carinatus* overlap slightly. The standard deviations of the means of *depressus* and *S. m. peltifer* overlap slightly. The majority of individuals of *S. depressus* may be distinguished from all other forms by a high (greater than eight) ratio of carapace angle to height.

IL IW (fig. 43).—*Sternothaerus carinatus* and *S. depressus* show nearer equality between the length and width of the inguinals than do *S. m. minor* and *m. peltifer.*

TABLE 13. *Geographic trends in expression of lateral keels of S. m. minor*

River	Not Keeled	Faintly Keeled	Fairly Distinct	Prominent	Very Distinct
Altamaha					
Satilla	0	0	1	1	3
Ogeechee					
St. Johns	3	14	26	8	1
Suwannee	1	8	30	5	6
Chipola					
Apalachicola	3	10	7	1	0
Choctawhatchee					
Escambia					
Yellow	27	1	0	0	0

Sternothaerus m. peltifer and *m. minor* show close similarity in this ratio. This character has some diagnostic value for differentiating *S. carinatus* from *S. minor.*

PL Ih (fig. 44).—*Sternothaerus m. peltifer* shows significant divergence from the other three forms in this character. The means of *carinatus* and *depressus* are similar, while the mean of *S. m. minor* is intermediate between theirs and that of *m. peltifer,* but significantly different from the mean of all three.

PL IF (fig. 45).—The means of *Sternothaerus carinatus, S. m. peltifer,* and *S. depressus* are strikingly similar, but *S. m. minor* diverges markedly from these three. However, the degree of overlap of the ranges of variation demonstrates the relative uselessness of this character in distinguishing between the members of the complex.

PL Ian (fig. 46).—The geographic trend from the smaller interanal seam of eastern *minor* to the larger one of western *carinatus*

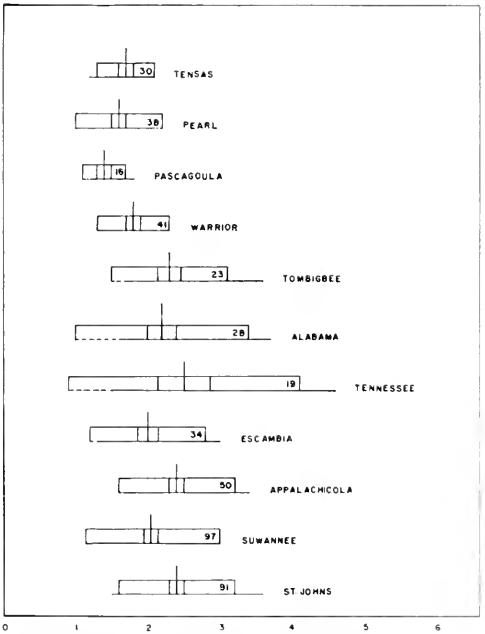


Figure 38. Ratio of inguinal length to inguinal width. Symbols as in fig. 17.

is clearly evident. *Sternothaerus depressus* is significantly different from most of the other forms. There is considerable overlap in the range of variation of *depressus* and that of the other forms, but the ratio differences indicate species divergence. There is a significant ontogenetic shift in the mean ratio of *S. carinatus* in which specimens less than 80 mm in plastron length are similar to *depressus* and different from the other forms.

E. *Uncorrelated Variation*

Vertebrals (Tables 14-16).—The first vertebral is always longer than wide in each form. The second vertebral of *S. m. minor, m. peltifer* and *S. depressus* is wider than long in 90, 98 and 100 percent of the individuals, respectively. In *S. carinatus* the width of the second vertebral is greater than length in only 32 percent of individuals. The width of the third vertebral is greater than the length in 45 percent of *carinatus*, but width is greater than length in 100 percent of individuals of the other three forms. The width of the fourth vertebral is greater than length in 95 percent of *m. minor*, 99 percent of *m. peltifer*, in 100 percent of *depressus*, but in only 28 percent of *carinatus*. The fifth vertebral is wider than long in 69 percent of *m. minor*, 76 percent of *m. peltifer*, 98 percent of *depressus*, and 17 percent of *carinatus*.

TABLE 14. *Relationship between the length and width of each vertebral in each form in the Sternothaerus carinatus complex*

	Vertebrals									
	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
	minor									
L=W	0	—	24	8	1	—	11	4	65	22
L>W	290	100	6	2	0	—	4	1	25	9
L<W	0	—	260	90	289	100	275	95	200	69
	peltifer									
L=W	0	—	1	1	0	—	0	—	17	20
L>W	84	100	1	1	0	—	1	1	3	4
L<W	0	—	82	98	84	100	83	99	64	76
	depressus									
L=W	0	—	0	—	0	—	0	—	1	2
L>W	43	100	0	—	0	—	0	—	0	—
L<W	0	—	43	100	43	100	43	100	42	98
	carinatus									
L=W	0	—	25	20	26	20	35	28	66	52
L>W	127	100	61	48	44	35	57	45	39	31
L<W	0	—	41	32	57	45	35	28	22	17

These data show the tendency for *carinatus* to have all vertebrals longer than wide and the opposing tendency in the other forms to have all vertebrals (except the first) wider than long. Because there is an ontogenetic tendency in *carinatus* for the vertebrals to become longer than wide, we may safely distinguish adults of *carinatus* from the other three forms on the basis of their possession of three or more vertebrals longer than wide.

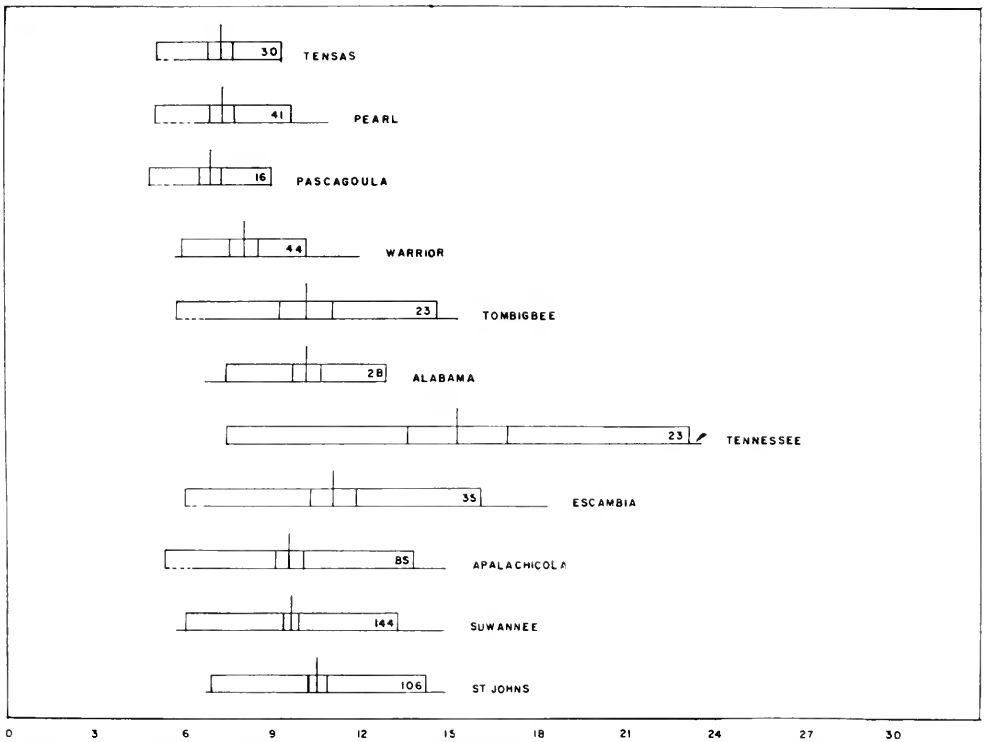


Figure 39. Ratio of plastron length to length of interhumeral seam. Symbols as in fig. 17.

Three or more vertebrals longer than wide are shown by 51 percent of *carinatus*, by one percent of *m. minor* and by no individuals of *m. peltifer* and *depressus*. Two or more vertebrals longer than wide occur in 10 percent of *m. minor*, six percent of *m. peltifer*, in no *depressus*, but in 67 percent of *carinatus*.

Considering another point of view, 89 percent of *m. minor*, 94 percent of *m. peltifer* and 100 percent of *depressus* have only one vertebral in which the length is greater than width, whereas this is true in only 31 percent of *carinatus*.

Smith and Glass (1947) distinguished *peltifer* from *carinatus* on the basis of the second, third and fourth vertebrals of the former being wider than long. This is a good distinguishing feature if juveniles of *carinatus* are excluded.

TABLE 15. *Percent of specimens of each form having 1, 2, 3, 4, or 5 vertebrals longer than wide*

	Number of Vertebrals Longer than Wide									
	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
minor	259	89	27	9	4	1	0	—	0	—
peltifer	79	94	5	6	0	—	0	—	0	—
depressus	13	100	0	—	0	—	0	—	0	—
carinatus	40	31	20	16	29	23	19	15	16	13

Number of gular scutes. — *Sternothaerus m. minor, m. peltifer* and *depressus* usually have one gular scute; *S. carinatus* has none. Of 387 *S. m. minor* examined, 384 had a single gular; one had two, and two had none. One of those without a gular is an embryo in which the scute may not yet have developed. The other specimen appears to have lost the gular scute by wear. Of 87 specimens of *S. m. peltifer*, 85 had one gular and one had none. The two gulars in one specimen resulted from an obvious

TABLE 16. *Percent of specimens of each form having 1, 2, 3, 4, or 5 vertebrals wider than long*

	Number of Vertebrals Wider than Long									
	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
minor	1	—	17	6	100	34	172	59	0	—
peltifer	0	—	1	1	21	25	62	74	0	—
depressus	0	—	0	—	1	2	42	98	0	—
carinatus	28	22	28	22	19	15	2	2	0	—

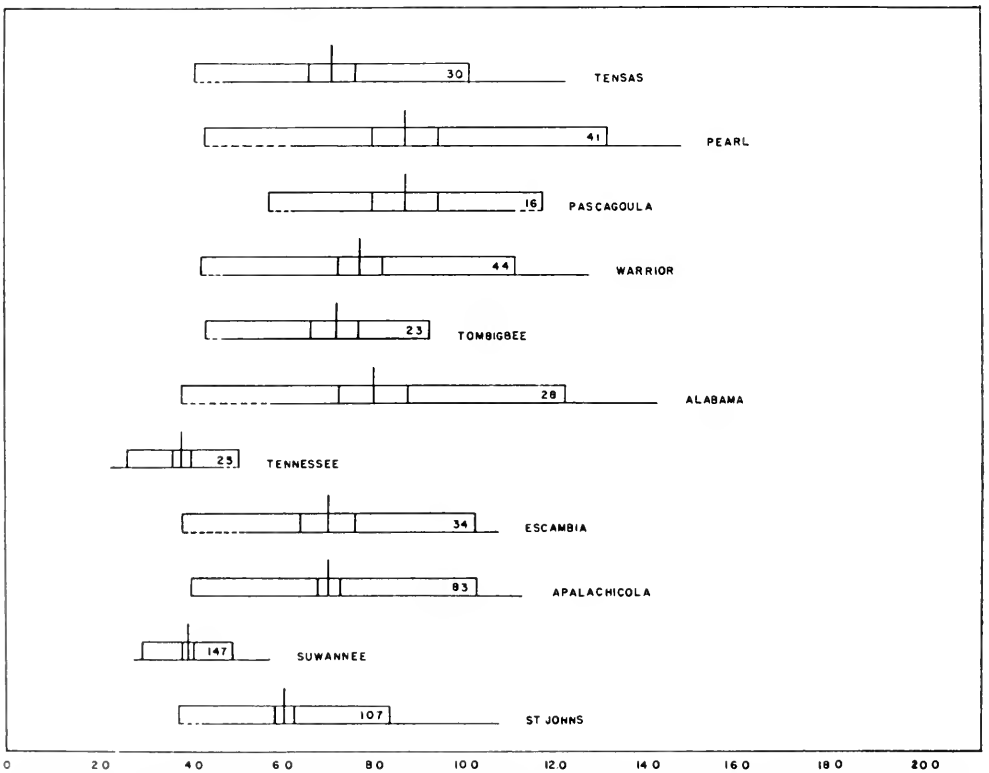


Figure 40. Ratio of plastron length to length of interfemoral seam. Symbols as in fig. 17.

split in a single scute. The 44 specimens of *S. depressus* have one gular. *Sternothaerus carinatus* is usually described as having no gular scute, or an occasional one. Of 135 specimens one had a gular and this one was a cotype (MCZ 15086). Presumably this specimen has been the reason for emphasizing the occasional presence of a gular scute.

Abnormalities. — Abnormalities in the number or arrangement of shields or scutes is uncommon. Three percent of 360 *S. m. minor*, seven percent of 86 *S. m. peltifer*, seven percent of 45 *depressus* and two percent of 123 *carinatus* displayed abnormalities.

The following abnormalities were found in *S. m. minor:* 12 marginals; 12 marginals plus six vertebrals; 12 marginals plus seven vertebrals; six vertebrals plus five pairs of costals; seven vertebrals plus five pairs of costals; two of five vertebrals irregularly divided into four; no seam between abdominal and femoral scutes; no interpectoral seam; split humeral; extra scute between humerals; and a transversely divided anal scute.

Sternothaerus m. peltifer displayed the following abnormalities: supernumerary vertebrals plus an extra costal; split fifth vertebral; 12 marginals; gular in contact with anterior edge of interhumeral beam (2 specimens).

In *Sternothaerus depressus* the following abnormalities were found: seven vertebrals plus five pairs of costals; split fourth vertebral; split tenth marginal.

In *Sternothaerus carinatus* there were two instances of a split first marginal and one of split femoral shields.

Discounting obviously split scutes or shields, there were seven instances of increase in the number of shields or scutes, six of which were accompanied by abnormalities in some other set of shields or scutes. Abnormal development of seams

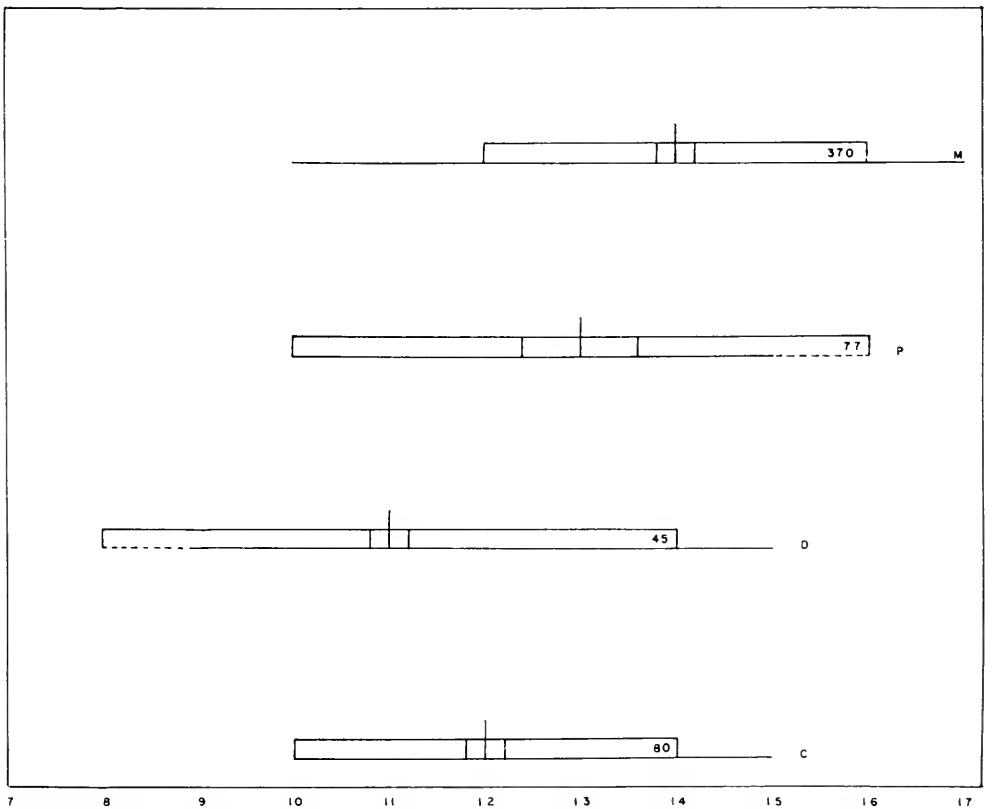


Figure 41. Ratio of carapace length to carapace width. Symbols as in fig. 17.

during early ontogeny in one area of the carapace or plastron may force readjustment and consequent abnormalities in another area.

In *Sternothaerus carinatus*, particularly in the eastern part of its range, some unknown substance erodes the marginal shields and underlying plates, particularly the posterior ones. Many specimens are found in which the posterior marginals and peripheral plates of bone have been eroded completely away. Occasionally lateral marginals have the same fate. Carr (1952) reported a similar observation and said that the "disease" was seen only in Louisiana specimens. I have noticed it most strikingly in specimens from the Pascagoula River drainage of Mississippi.

F. *Intergradation*

Intergradation is definitely indicated between *S. m. minor* and *S. m. peltifer* from the eastern rim of Mobile Bay to the drainage of the Choctawhatchee River. The juveniles in these populations differ from *m. minor* in lacking lateral ridges and from *m. peltifer* by the absence of head stripes. A comparison between juveniles of *m. minor*, *m. peltifer* and a presumed intergrade is shown in figure 6. The adults may be compared in figures 4, 7 and 8.

The area in which intergradation occurs

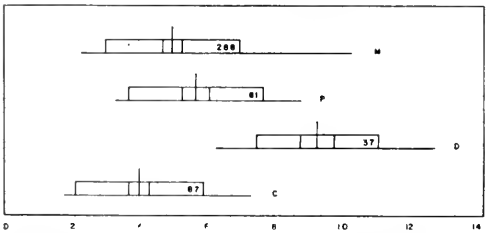


Figure 42. Ratio of carapace angle to carapace height. Symbols as in fig. 17.

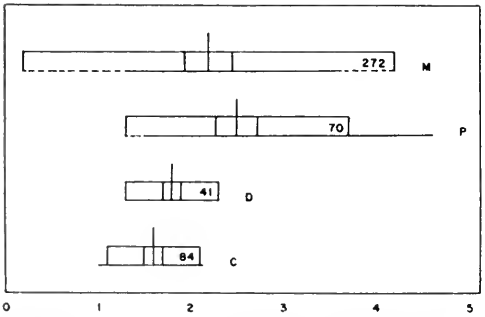


Figure 43. Ratio of inguinal length to inguinal width. Symbols as in fig. 17.

is one of the youngest on the Gulf coast and the overlap of the ranges of *m. minor* and *m. peltifer* may be recent. Most characters studied exhibit intermediacy between these two races in the Escambia River.

V. Key to Species of Sternothaerus

1. Fleshy protuberances on neck in addition to chin barbels; head with light stripes on a dark background; three dorsal keels in juveniles, none in adults; ground color of head dark ..... *odoratus*
   No fleshy protuberances other than chin barbels; stripes, if present, are dark; number of keels variable; ground color of head light ..... *carinatus* complex 2
2. Gular scute absent; lateral ridges never present; carapace high and steep; generally with three or more vertebrals longer than wide (except in many juveniles) ..... *carinatus*
   Gular scute present; lateral ridges present or absent; carapace not high nor steep (except in juveniles of *peltifer*); three or more vertebrals wider than long 3
3. Head with reticulated pattern of narrow lines on a light background; ratio of carapace angle to height greater than eight; adults or near-adults with an extremely low carapace, flat on top; juveniles with flattened carapace and blunt middorsal keel; no distinct lateral ridges ..... *depressus*
   Head with spots, with spots and stripes, or with spots and reticulations on posterior portion of head and neck; ratio of carapace angle to height less than eight; adults with carapace somewhat semicircular in cross-section, seldom completely flat on top; juveniles with pronounced middorsal keel; lateral ridges present or absent 4
4. Dark stripes on sides of head and neck; juveniles and adults without lateral ridges; spots present on dorsum of head in anterior one-half, replaced by stripes or reticulations in posterior region of head ..... *minor peltifer*
   Without dark head stripes (except in occasional juveniles near range of *peltifer*); spots on entire dorsal surface of head; juveniles and some adults with distinct lateral ridge on the carapace ..... *minor minor*

VI. Comparative Skull Osteology

A detailed study of skull structure was not made, but eight skulls of different size of each form were compared and several measurements taken.

The following measurements were taken to the nearest millimeter with dividers. The relationship of these measurements with increasing size of the skull are shown in table 17: 1.) tip to snout to tip of supraoccipital (maximum length); 2.) maximum width; 3) depth of jugal; 4.) anterior edge of prootic to posterior edge of opisthotic; 5.) maximum length of supraoccipital; 6.) maximum depth of supraoccipital; 7.) breadth at waist of pterygoids, *i.e.* at narrowest point; 8.) maximum length of alveolar cartilage in midline; 9.) tip of snout to juncture of parietals and supraoccipitals measured in midline; 10.) width of skull dorsally across the posterior tips of the squamosal bones.

The general appearance of the skulls of adults of each form may be seen in figure 47. The depth of the supraoccipital and the breadth of the skull make *m. minor* outstanding and the low, level skull of *depressus* is also distinctive.

A. *Description of Skulls of Adults*

The skull of *S. m. minor* is short, broad and massive with structural adaptation for accommodation of the powerful jaw musculature. The supraoccipital is deep with broad area for muscle attachment The upper ridge of the parietal is overhanging.

The skull of *S. carinatus* is longer, narrower and lighter than that of *m. minor.* The low, shallow supraoccipital has a strongly developed ridge on the ventrolateral surface. The area for muscle attachment on the supraoccipitals, parietals, quadrates, prootics and paraoccipitals is reduced compared with *m. minor,* but the processes on the basioccipital are more strongly developed than in *m. minor.*

The skull of *S. depressus* is low, neither elongated nor broadened, and similar to *m. minor* in general appearance except that it lacks the auxiliary ridges and excrescences of *m. minor.* One striking feature is the

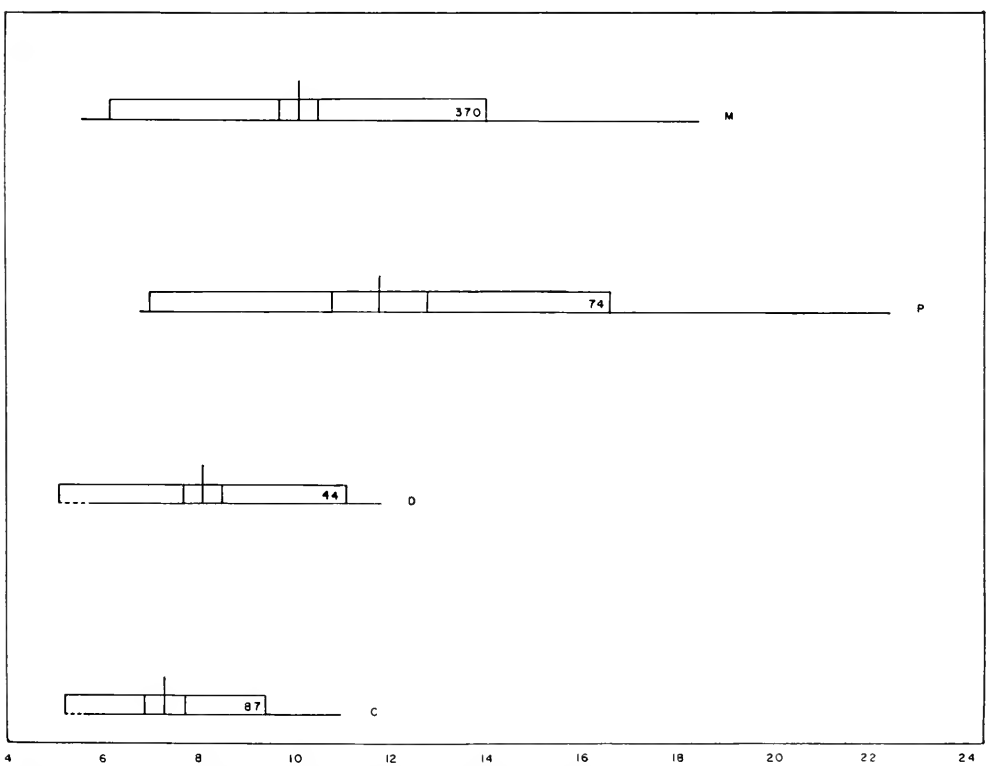


Figure 44. Ratio of plastron length to length of interhumeral seam. Symbols as in fig. 17.

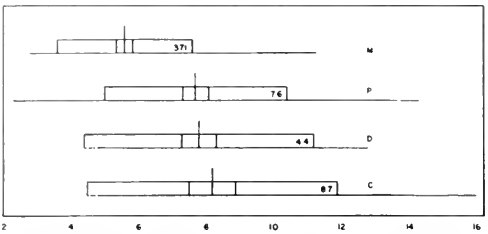


Figure 45. Ratio of plastron length to length of interfemoral seam. Symbols as in fig. 17.

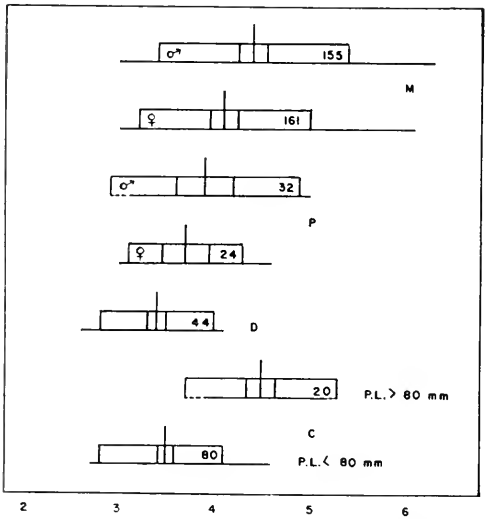


Figure 46. Ratio of plastron length to length of interanal seam. Symbols as in fig. 17.

horizontal slope of the head from the anterior tip of the prefrontal to the posterior tip of the supraoccipital. This condition contrasts with the rather abrupt upward curve in this same region of the skull in *carinatus* and *m. minor*. Another distinctive feature is the trench in the lower surface of the projecting portion of the supraoccipital. The waist of the pterygoid is broad like that of *m. minor* and in contrast to that of *carinatus* and *m. peltifer*.

The skull of *Sternothaerus minor peltifer* is not as broadened, and the supraoccipital is shallower and more elongate than that of *m. minor*. The skull of *m. peltifer* is most like that of *carinatus*. A smooth, rounded ridge along the lateral edge of the pterygoids from the base of the quadrate to the alveolar cartilage is most evident in *m. peltifer*. This ridge is also present in *m. minor*, but extends only about one-half the distance from quadrate to alveolar cartilage.

B. *Possible Diagnostic Characters for Skulls*

The spinous process from the middle of the pterygoid is an ontogenetic development most prominent in adults of *carinatus* in which its size is diagnostic. It is prominent in *m. minor* and *m. peltifer*, but much reduced in *depressus*. In *m. peltifer*, *carinatus*, *depressus* and young *m. minor* this process may be seen from a direct dorsal view of the skull, but in adults of *m. minor* this process is obscured from dorsal view by the overthrust of the prootic shelf.

The ventrolateral ridge of the supraoccipital is prominent in adult or near adult turtles. It is distinct in all forms except *m. minor* in which its absence or reduction is diagnostic.

The forward projection of the prootic and parietal develops ontogenetically and is shown by large individuals of all forms except *m. minor* in which its absence is diagnostic.

There is a roughened projection in the anterior temporal fossa which is presumably for muscle attachment. It is absent or scarcely developed in all skulls except those of *m. minor* in which it is diagnostic.

Knob-like projections from the basioccipital are prominent in *carinatus* and *m. minor*, but weak in *m. peltifer* and *depressus*. The skulls of juveniles do not exhibit this characteristic.

A boss on the underside of the squamosal becomes prominent and diagnostic in the skulls of adult *S. carinatus*. In *m. minor* there is a faint elevation, but this feature is absent in *m. peltifer* and *depressus*.

The supraoccipitals (lateral view) in juveniles of all forms taper to a point, but in adults the end of this bone becomes rounded or slightly truncated except in *S. carinatus* in which the tapering point is diagnostic.

The extent of a trench in the ventral surface of the supraoccipital is diagnostic of *depressus* in which this trench is 75 to 100 percent of the length of the projecting portion of that bone. The percentage in *m. peltifer* is always less (highest, 55 percent). In *carinatus* and *m. minor* only the two

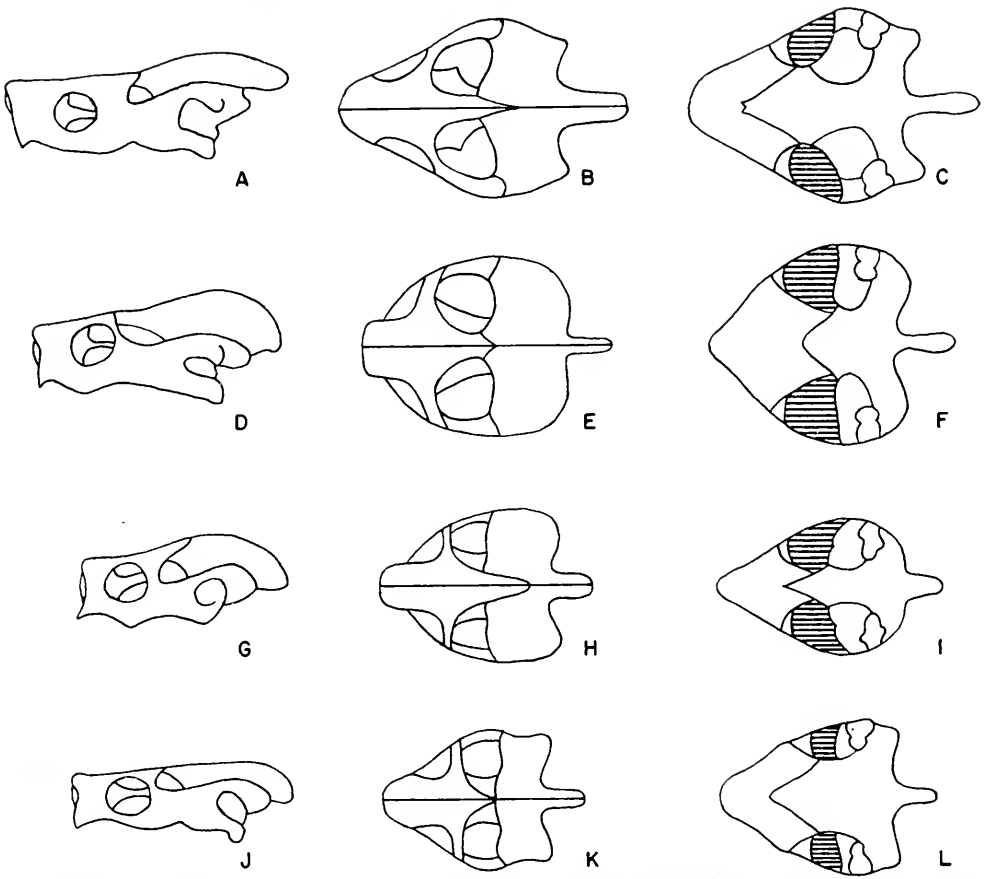


Figure 47. Comparison of skulls of the members of the *Sternothaerus carinatus* complex. Left to right, lateral, dorsal and ventral aspects. **A-C:** *carinatus;* **D-F:** *m. minor;* **G-I:** *m. peltifer;* **J-L:** *depressus.*

smallest skulls examined show any overlap with *depressus* in this characteristic. The percentage of the length of the trench to that of the projecting part of the supraoccipital may be generally stated as follows: *carinatus,* 50 percent; *m. peltifer,* 50 percent or less; *m. minor,* 50-70 percent; *depressus,* 75 to 100 percent.

C. *Discussion of Measurements and Ratios*

The greatest ratio of head length to carapace length is that of *m. minor,* the least that of *depressus.* In *m. minor* there is an abrupt increase in the ratio, indicating continuing growth of the head after cessation of growth in the carapace or a wide differential in rate of increase of head and carapace. The same phenomenon occurs less strikingly in *m. peltifer* and *depressus. Sternothaerus carinatus* shows no abrupt change.

The remaining percentages, all ratios between head measurements, fall into four categories: (a) *no allometry.*—while head length increases, length, etc., of another part increases in proportion; (b) *positive allometry.*—while head length increases, ratio of head length to length, etc., of another part increases; (c) *negative allometry.*—while head length increases, ratio of head length to length, etc., of another part decreases; (d) *no correlation.*—the ratio between two measurements fluctuates.

The distribution of the various measurements with respect to these four categories is shown in table 17.

Only *Sternothaerus m. minor* and *S. carinatus* exhibit definite positive and negative allometry. In *m. minor* this allometry is associated with the disproportionate increase in length of the prootic-opisthotic shelf and

TABLE 17. *Distribution of ratios of skull measurements. Numbers refer to measurements on page 35.*

Species	No Allometry	Positive Allometry	Negative Allometry	No Correlation
carinatus	5	7	2,4,8	3,6,9,10
peltifer			3,9	2,4,5,7,8,10
	(5,6 show weak positive allometry at sexual maturity)			
	(7 exhibits weak and variable negative allometry) except			
minor	4(15915,3) except 6(15915)		3	5,7,9,10
	(2,8 show sudden positive allometry at sexual maturity)			
depressus			2,3,4	7,8,9,10
	(5,6 show weak positive allometry near sexual maturity)			

in depth of the supraoccipital for the head and jaw musculature. The reason for the positive allometry in *S. carinatus* is not clear.

Some characters show rather sudden positive allometry near the size of sexual maturity. The width of the head and the length of the alveolar cartilage of the upper jaw in *m. minor* are examples. In *S. depressus* and *S. m. peltifer*, the length and depth of the supraoccipitals show weak positive allometry near sexual maturity.

Negative allometry is shown clearly only by the breadth of the pterygoid waist in *S. carinatus*. The width of the pterygoid bones increases so little ontogenetically that it does not keep pace with the elongation of the skull. Negative allometry is weakly indicated by the same character in *S. m. peltifer*. The width of the skull across the posterior tips of the squamosal shows negative allometry approximately until sexual maturity, and then positive allometry in all forms except *S. carinatus*.

The difference between no allometry and no correlation is arbitrary and these two categories may be considered as a single one.

The important skull characteristics of *Sternothaerus carinatus* are a prominent pterygoid spinous process in adults; prominent projections from the basioccipital in adults; prominent boss on ventral surface of the squamosal in adults; pointed and tapering supraoccipital in adults; and a long and narrow skull.

The important skull characteristics of *Sternothaerus minor minor* are a spinous pterygoid process that cannot be seen in adults from a direct dorsal view; a weak or absent ventrolateral ridge on the supraoccipital; no forward projection of the prootic or parietal in adults; prominent projections from the parietal in the anterior part of the temporal fossa; and prominent projections from the basioccipital in adults.

The important skull characteristics of *Sternothaerus minor peltifer* are no prominent projections from the basioccipital in adults; a well developed ridge along the lateral surface of the pterygoid bones which extends to the posterior edge of the alveolar cartilage in adults. This is a weak character for diagnostic purposes.

The important skull characteristics of *Sternothaerus depressus* are a small spinous process of the pterygoid; no prominent projections from the basioccipital in adults; length of trench in ventral surface of the supraoccipital is 75 percent or more of the length of the projecting portion of that bone; no overthrust of the parietal in adults; skull level dorsally from a lateral view.

D. *Key to Species Based on Skulls*

1. Supraoccipital pointed and tapering (lateral view); prominent boss on underside of squamosal; prominent projections from basioccipital; prominent spinous process on pterygoids ..... *carinatus*
   Supraoccipital blunt and rounded; boss on underside of squamosal absent or weak; articular projections from basioccipital weak or prominent; spinous process of pterygoids weak or distinct 2
2. Length of trench in ventral surface of supraoccipital 70 percent or more of the length of the projecting portion of the supraoccipital; no overthrust of the dorsal edge of the parietal; spinous process on pterygoid small; no prominent projections from basioccipital; skull low and level from lateral view ..... *depressus*
   Length of trench less than 70 percent (except in some specimens less than 55 mm in carapace length) of length of the projecting portion of the supraoccipital; dorsal edge of parietal overhanging temporal fossa; spinous process of pterygoids larger; size of projections from basioccipital variable 3

3. Ventrolateral ridge of supraoccipital reduced or absent; prominent projections from parietal in anterior part of temporal fossa; spinous process of pterygoid not visible from direct dorsal view of the skull in adults; articular projections from basioccipital prominent; no forward projection of prootic and parietal ..... *minor minor*

Ventrolateral ridge of the supraoccipital distinct; no prominent projection from the parietal (this projection weakly indicated in some skulls); spinous process of pterygoid visible from direct dorsal view of skull; projections from the basioccipital weak; prootic and parietal bones project forward ... *minor peltifer*

VII. Speciation and Phylogeny

Most of the range of the *Sternothaerus carinatus* complex lies within the Gulf coastal plain. In contrast, *Sternothaerus odoratus* is widely distributed over the United States east of the Rocky Mountains. *Sternothaerus odoratus* may have achieved its present distribution since the Pleistocene or it may have survived farther north during this period than members of the *S. carinatus* group. *Sternothaerus odoratus* may be more cold-resistant than most members of the *S. carinatus* complex. The only data available on thermoregulation are the quite inconclusive ones of Edgren and Edgren (1955) on *S. odoratus*.

The relationship between three members of the *Sternothaerus carinatus* complex is clear. *Sternothaerus m. peltifer* is subspecifically related to *S. m. minor*, although the two races are well-differentiated. *Sternothaerus depressus* is obviously related to, and probably derived from the progenitor of *peltifer*. *Sternothaerus carinatus* is distinct and its exact relationship with other members of the complex is not clear, but morphologically it is most like *S. m. peltifer*.

The origin of *Sternothaerus* is not clear. Dunn (1931) said the Kinosternidae were descended from the Central American family Dermatemydidae. Simpson (1943) said the distribution of the Kinosternidae "suggests origin in southern North America or in the ancient part of Central America..."

The only fossils (*i.e.*, Kinosterninae) available are of the genus *Kinosternon* from the Pliocene and Pleistocene of Kansas (Galbreath, 1948) and from the Pleistocene of Arizona (Gilmore, 1922). These fossil species were similar to living ones.

Of all members of the *S. carinatus* complex, the one most closely related to *S. odoratus* is *S. m. minor*. In both species, the juveniles have lateral carapace ridges that are lost completely in older *odoratus* and greatly reduced or lost by most *S. m. minor*. *Sternothaerus odoratus* is possibly the most primitive existing species in the genus. The time or place of origin of *S. m. minor* from *odoratus* is a matter for conjecture, but it seems likely that the differentiation of *m. minor* took place on the Gulf coastal plain in Georgia or Florida. In the clear, calcareous springs of central Florida *m. minor* reaches its greatest abundance.

There is little reason for looking beyond the Pleistocene or Pliocene to explain speciation in the *S. carinatus* complex. The climate of the Pleistocene exerted enough influence to force many species of animals southward (Deevey, 1949, 1950; Richards, 1939). This may have been true especially of river dwelling animals with little means of temperature regulation. The progenitor of *m. minor* was forced into Florida and separated from its western populations by the encroaching Pleistocene sea or by some physiographic rift. Cooke (1939) and Mossom show the sea covering most of Florida during the early Pleistocene.

Sternothaerus carinatus is more differentiated from *S. m. minor* and *S. m. peltifer* than the latter two are from one another. The shape of *carinatus* is approached by *m. peltifer* and little imagination is required to convert *m. peltifer* into *carinatus* by steepening the carapace, eliminating the gular scute and the head stripes of *m. peltifer*.

Therefore, I believe that *carinatus* arose from *m. peltifer* stock just prior to or during the Pleistocene. The separation of the populations in the central Gulf coast was probably caused by the rather sudden entrance of the great mass of water carried by a river in the vicinity of the present Mississippi River (Fisk, 1944) or earlier by encroachment of the sea (Shaw, 1918; Stephenson, 1928). Hobbs (1949) stated that the channel of the Mississippi River south of Cairo, Illinois was tremendously enlarged during the Pleistocene by great

volumes of meltwater during the summers. The range of *carinatus* lies, for the most part, west of the Mississippi embayment, and this species has in comparatively recent times extended its range east of the Mississippi River. *Sternothaerus m. peltifer* has extended its range westward into that of *carinatus*, but only a few specimens have been taken west of the Tombigbee River drainage. There is no evidence of intergradation of these forms, so separation may have been of sufficient duration to allow isolating mechanisms to develop.

The range of *m. peltifer* to the north crosses the Fall Line in the Alabama River and extends into the Tennessee River drainage. The distribution of this form suggests the possibility that this distribution is further evidence of the former connection of the Tennessee and Alabama rivers by way of the Coosa River. This might explain the absence of *m. peltifer* above the Fall Line in the Tombigbee River. The biological evidence for a former connection is good (Simpson, 1900; Van der Schalie, 1938, 1939, 1945; Adams, 1901), but the geological evidence indicates that the Tennessee River has held its present course since Cretaceous time (Johnson, 1905, 1939, 1941). The assumption of a past connection in the present case would require a great amount of geological time which is unnecessary in view of the similarity of *m. peltifer* to *m. minor* and their indicated gene exchange in western Florida. It is more likely that *m. peltifer* migrated into the Tennessee River relatively recently, a supposition borne out by the absence of this form in the Mississippi River drainage. Why *m. peltifer* has been able to cross the Fall Line in the Alabama River, but not in the Tombigbee River is not known. Although the Fall Line is no longer a strong physiographic feature, many costal plain rivers that cross it are interrupted by riffles or rapids that might be a deterrent to upstream movements of turtles. The passage of *m. peltifer* into the Tennessee River may have been facilitated by stream capture, an explanation suggested by Ortmann (1913) to explain the distribution of freshwater molluscs.

The range of *S. m. minor* in Florida occupies primarily the central and western highlands, but not the young (geologically) formations. In Georgia its range, almost entirely south of the Fall Line, indicates the youthfulness of the rivers, recent expansion of the range of *m. minor*, or both.

The work of Campbell (1940) makes it unlikely that *S. m. minor* was in Florida prior to the Pliocene. This is additional evidence for the relatively recent differentiation of *m. minor* in that state. The intergradation between *S. m. minor* and *m. peltifer* is in an area recently reclaimed from the sea (Mac Neil, 1950; Cooke and Mossom, 1939).

The distribution and isolation of *Sternothaerus depressus* is remarkable. Its range and obvious affinities with *m. peltifer* indicate that *depressus* was derived from the

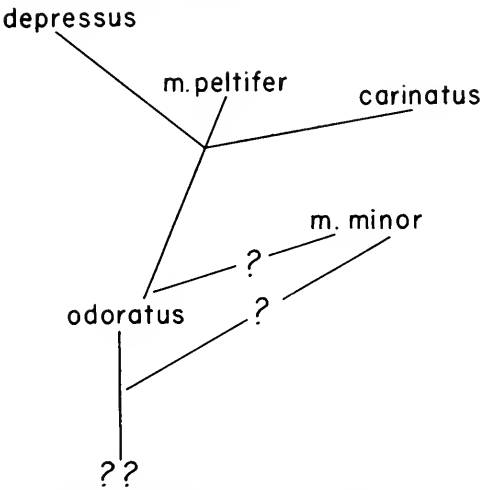
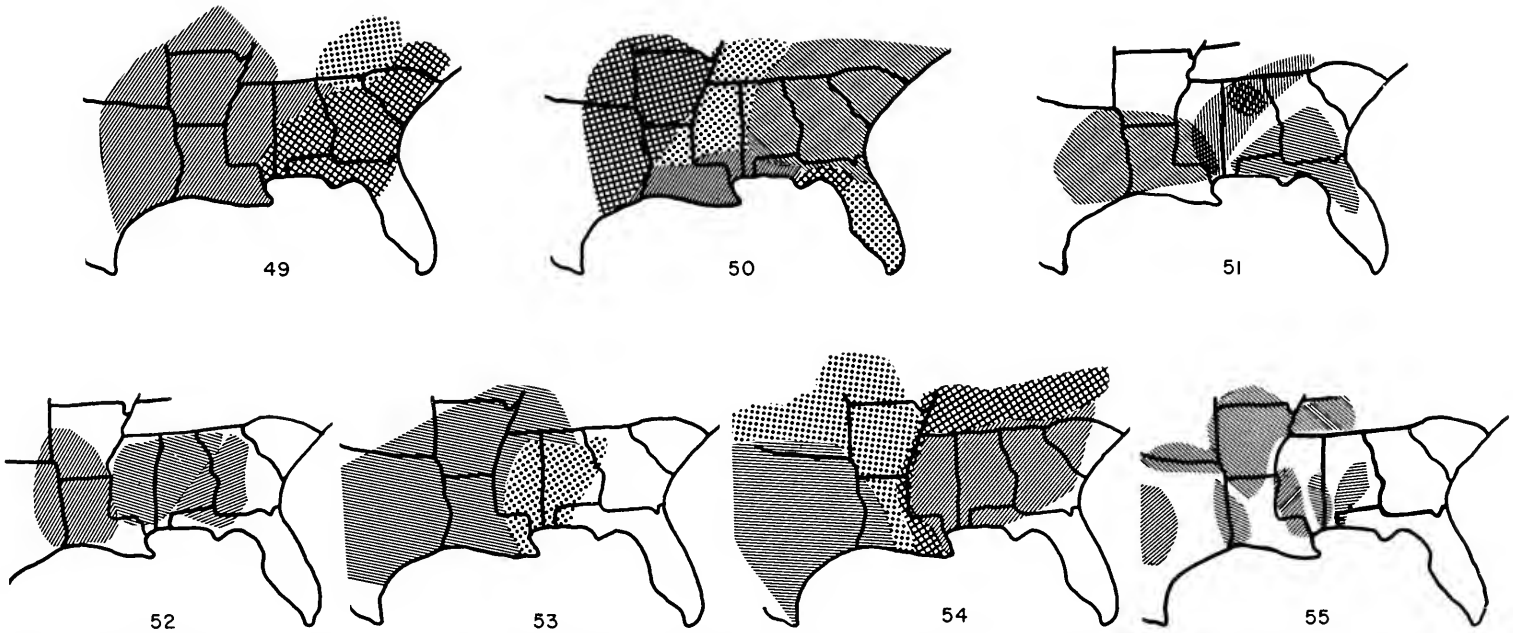


Figure 48. Diagram illustrating phylogeny of *Sternothaerus*.

stock that produced *m. peltifer*, perhaps entering the upper reaches of the Warrior River from the Tennessee River drainage. Its extreme isolation may indicate that it is becoming extinct. Certainly it has not been successful at extending its range as the other members of the complex have done.

Graphically, the phylogeny of the genus *Sternothaerus* appears as shown in figure 48.

The structure of the skull supports this proposed scheme. The external morphology, also in agreement, shows a closer relationship of *carinatus* to *m. peltifer* and *m. minor* than to *depressus*, a close relationship between *m. minor* and *m. peltifer*, and a general similarity of *depressus* to individuals from certain populations of *m. peltifer*.



Figures 49-55. Distribution of races, forms or species of turtles; each pattern represents a different race, form or species. **49.** *Pseudemys scripta* (after Carr, 1952; and Cagle, 1950). **50.** *Pseudemys floridana* (after Carr, 1952). **51.** *Sternothaerus carinatus* complex. **52.** *Graptemys kohni, pulchra* and *barbouri* (after Cagle, 1952, 1953). **53.** *Trionyx muticus* (after Webb, unpublished). **54.** *Trionyx spinifera* (after Crenshaw and Hopkins, 1955; Schwartz, 1956; and Carr, 1952). **55.** Narrow-headed *Graptemys*: *G. versa, pseudogeographica* and *oculifera* (after Cagle, 1954, and unpublished data).

VIII. Patterns of Speciation in Gulf Coast Turtles

Figures 49 to 55 show the distributions of the members of four genera of turtles on the Gulf coastal plain. The data for *Sternothaerus, Graptemys* and *Trionyx* are most reliable. Some distributional data on *Trionyx* were supplied by Mr. Robert Webb from his unpublished records. The distribution of the races of *Pseudemys scripta* is based upon the work of Cagle (1950) and Carr (1952). The distribution and taxonomic status of the races of *Pseudemys floridana* are poorly known, but chiefly I have followed Carr (1952). Dr. John Crenshaw of the University of Missouri is currently investigating the *floridana* group and has furnished me some information on species distribution. I have had considerable field experience with most of the forms of *Graptemys, Pseudemys* and *Sternothaerus.* In the genus *Sternothaerus* I have considered only the *carinatus* complex.

In *Sternothaerus, Pseudemys* and *Trionyx* the patterns are different in detail, but generally similar. These three genera display a pattern of differentiation into several geographic races. This trend is least developed in *Pseudemys scripta,* possibly because its migratory habit and wide range of habitat tolerance facilitates gene exchange. Most other turtles considered show some preference for running water or, at least, for bodies of water associated with lotic situations.

The members of the *Sternothaerus carinatus* complex seem more differentiated than do members of the *Trionyx* and *Pseudemys* groups, but in none of these are great spans of time needed to explain their differentiation. We might conclude that the rates of evolution in these three genera of turtles are essentially the same, assuming that each has had a similar time interval for speciation in the rivers of the Gulf coast.

The genus *Graptemys* exhibits two patterns of speciation. *Graptemys kohni, G. pulchra* and *G. barbouri* (the broad-headed group) form a group displaying slight geographic variation, much like the situation in *Sternothaerus.* An obviously different pattern exists in some narrow-headed *Graptemys: G. oculifera* in the Pearl River, *G. flavimaculata* in the Pascagoula River and *G. nigrinoda* in the Tombigbee-Alabama River are obviously related, but distinct. Yet *Graptemys oculifera* and *flavimaculata* occupy exclusively two of the youngest (geologically) rivers on the Gulf coast, and it is difficult to escape the conclusion that the rate of differentiation in this group has been faster than in the other genera in these same rivers in which no detectable differentiation has occurred. There are no close relatives of the narrow-headed *Graptemys* to the north of their known range, and I conclude that they have differentiated in situ. Cagle's conclusions (1954) concerning speciation in the narrow-headed *Graptemys* are similar to mine.

> "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—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 divergence in *G. nigrinoda,* it perhaps being the older of the three forms—the relative youth of the Gulf coast streams implies that rapid evolution has occurred in this complex."

The headwaters of the Pearl, Pascagoula and Tombigbee rivers are quite close at present and accelerated stream piracy may soon accomplish or speed the mingling of the narrow-headed *Graptemys.* All three species of the *oculifera* group may have had a common origin from the Tennessee or Tombigbee river systems during the early Pleistocene.

A major difficulty in discussing differences in rates of evolution or in patterns of speciation is that subspecies or species recognized in one genus are not, obviously, at the same level of differentiation as those in another group. For example, the many recognized races of *Pseudemys floridana* are, at best, poorly differentiated with great overlap in most characters. For this reason, the numerous races of *P. floridana* may not have the same significance in terms of evolutionary patterns as the well-differentiated members of the genus *Graptemys.* With this major handicap in mind, plus the knowledge that I have had to rely heavily upon the judgment of other workers, I will attempt further comparisons of the patterns of speciation.

Pseudemys scripta and *Pseudemys floridana* exhibit similar patterns, although fewer races of the former are recognized. *Pseudemys floridana* is more of a river-dwelling turtle than *scripta*, and this may explain its apparent greater raciation. *Pseudemys scripta* shows clearly a correlation of differentiation with the disruption of its range by the Mississippi delta. The wide range of intergradation between *scripta scripta* and *scripta elegans* on recent sediments is a result of the recent expansion of the range of one race into that of the other. *Pseudemys scripta troosti* probably differentiated in the Tennessee River (figs. 49, 50).

The *Sternothaerus carinatus* complex, the broad-headed *Graptemys*, and the *Trionyx muticus* groups show similar patterns of differentiation (figs. 51-53), distinguishable chiefly by the peculiar distribution of *Sternothaerus depressus*. These patterns suggest that similar processes have shaped the course of speciation, and that similar time intervals were involved. The pattern in *Trionyx spinifera* is somewhat different, but is generally similar if allowance is made for the development of two races in an area north of the coastal plain. Considering the coastal plain races, the pattern is similar to the others described (fig. 54).

The pattern of evolution in the narrow-headed *Graptemys*, particularly in the *oculifera* complex, is different. *Graptemys versa* is different from all other members of the genus. *Graptemys pseudogeographica sabinensis* and *G. p. ouachitensis* are related, but well-differentiated. *Graptemys oculifera* is closely related to, but different from *G. flavimaculata* and these two are, in turn, very different from the related *G. nigrinoda*. The conclusion seems inescapable that evolution in the narrow-headed *Graptemys* has been more rapid than that of the genera *Sternothaerus, Pseudemys, Trionyx,* or the broad-headed group of *Graptemys*. In none of the genera, apparently, has the differentiation of recent forms required great expanses of time. The relative youth of Gulf coast rivers inveighs against assumption of antiquity.

IX. Comparative Ecology

A. *Growth*

The rings in the plastral and carapacial shields of some turtles yield accurate age and growth information up to a certain size or age of individual. These rings are seldom as clear in *Sternothaerus* as they are in the emydid turtles, and whether they may be utilized for accurate age determination in the musk turtles has not been established. Risley (1933) used these rings in age and growth studies of *Sternothaerus odoratus*, but pointed out that accurate counts could not be made on turtles more than ten years old, *i.e.*, with more than ten "annuli". This is the age at which counts become difficult or impossible to make in most members of the *S. carinatus* complex.

Counts of rings were made in 205 *S. m. minor*, 82 *S. carinatus*, 63 *S. m. peltifer*, and 30 *S. depressus*. The mean carapace length of the turtles at each age was calculated, and these means used to construct growth curves (fig. 56). The most reliable data are those of *m. minor* because no fewer than three individuals are present in each

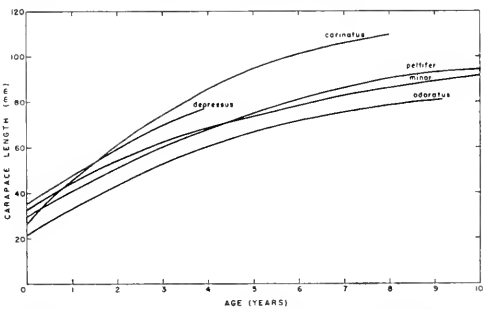


Figure 56. Comparative growth curves of *Sternothaerus*. Ages are based on counts of rings in scutes and shields.

age group and usually 10 or more. In the other forms, plot points represented by a single count which obviously deflected the growth curve in the wrong direction were omitted.

Sternothaerus m. peltifer and *S. m. minor* display almost congruous growth curves, and *S. depressus* may be similar, but specimens of the latter in older age classes are not available. The curves of all forms are similar until three or four years of age is attained and then the rate of growth of *m. minor* and *m. peltifer* declines, while that of *carinatus* continues at the same rate. The growth curve of *S. odoratus* was redrawn from that of Risley (1933). This species differs from the members of the *S. carinatus* complex in exhibiting smaller mean size at each successive age, but the rate in change

of size is similar to that of most other species of *Sternothaerus*.

B. *Size and age at sexual maturity*

The collections lack individuals from some seasons of the year. Most specimens were taken in June, July and August, but a few were available from April and September. Approximately 100 individuals were examined for signs of sexual maturity. Testes were macerated on slides and examined microscopically. Ovaries were removed when necessary for proper examination.

A single large male of *depressus* was available, with a carapace length of 75 mm and with four or five annuli. The testes were enlarged and a few small, possibly immature spermatazoa were present in the smear. The individual was probably subadult. Four large females were available, one a juvenile, the other three at least subadult.

Males may mature at a carapace length of 75 mm and an age of four years; females at a carapace length of 90 to 100 mm and an age exceeding four years.

Twenty large specimens of *S carinatus* were available for dissection. Spermatazoa were not found in any of the smears; the testes of adults were collapsed and obviously out of season. The complete absence of spermatazoa was unusual, as a few generally may be found even in out of season males of other forms. The size of the testes indicates that sexual maturity occurs at a carapace length of 100 to 120 mm and at an age of five to six years. One specimen was apparently a gynandromorph. It possessed the elongate tail of the male, but lacked testes. There were two tubular structures in the body cavity which resembled rudimentary oviducts, but no ovaries were present. Females of *S. carinatus* reach sexual maturity at approximately 100 mm carapace length and at an age of four to five years.

Twenty-five large specimens of *S. m. minor* were examined. Males mature at a carapace length of approximately 80 mm. The age at sexual maturity cannot be accurately stated, but is probably between four and seven years. Females also mature at a carapace length of 80 mm. The youngest sexually mature female had six annuli, another had seven. The age at attainment of sexual maturity is probably five or six years.

Twenty large specimens of *S. m. peltifer* were available for study. Spermatazoa were consistently present in the testes. Sexual maturity in the males is reached at a carapace length of 60 to 70 mm and at an age of three to four years. The data for large females are inadequate. One specimen with a carapace length of 78 mm had ovocytes that were beginning to enlarge and may have been adult or subadult. Two others (C.L. 92 and 95 mm) were subadult, one (C.L. 104 mm) was adult. Sexual maturity in females is reached at a size between 90 and 100 mm and at an age of six to eight years.

TABLE 18. *Summary of sizes and ages at sexual maturity in the four members of the Sternothaerus carinatus complex*

Species	Size		Age	
	Females	Males	Females	Males
carinatus	100 mm	100-120 mm	4-5 years	5-6 years
depressus	90-100	75	>4	4
peltifer	90-100	60-70	6-8	3-4
minor	80	80	5-6	4-7

The data on size and age at maturity are summarized in Table 18. The ages of males and females at sexual maturity are about the same in all forms except in *S. m. peltifer*, in which females are older and males younger than the respective sexes in the other forms. Risley (1933) estimated age at maturity of *Sternothaerus odoratus* as three to four years in males and nine to eleven years in females. The age for females is high compared with females of the other species of *Sternothaerus*.

The sizes at sexual maturity are approximately the same in most forms, but *m. minor* attains sexual maturity at a smaller size than do the other races, although at nearly the same age. The males of *Sternothaerus carinatus* reach sexual maturity at a greater size than any of the other forms. This species, incidentally, reaches the greatest size, *i.e.*, there is a greater percentage of individuals in the largest size class. The time required to reach sexual maturity is approximately the same in *carinatus* as in the other forms. In *carinatus* and *m. minor* the sexes are approximately the same size at attainment of maturity, but in *m. peltifer* and *depressus* the males are smaller than females. Size dimorphism is never so evident as in

TABLE 19. *Sex ratios and percentages of each sex in five arbitrary size groups. Carapace lengths in mm.*

	21-50		51-80		81-110		111-140		141-170	
	Males N %	Females N %	Males N %	Females N %	Males N %	Females N %	Males N %	Females N %	Males N %	Females N %
minor	9 39% N=23	14 61%	70 56% N=126	76 44%	76 45% N=170	94 55%	14 50% N=28	14 50%	0 0% N=0	
peltifer	4 50% N=8	4 50%	18 53% N=34	16 47%	8 44% N=18	10 56%	2 100% N=2	0 0%	0 0% N=0	
depressus	6 23% N=26	20 77%	3 30% N=10	7 70%	1 17% N=6	5 83%	0 0% N=0	0 0%	0 0% N=0	
carinatus	20 49% N=41	21 51%	8 22% N=36	28 78%	8 57% N=14	6 43%	3 42% N=31	18 58%	1 100% N=1	

some other turtles (*e.g., Graptemys* and *Trionyx*).

C. *Sex ratios*

The specimens were divided into four arbitrary size groups and the number and percentage of individuals in each group noted (Table 19). This method is not entirely satisfactory because samples taken at different periods of the year at widely scattered localities were combined. However, ratios of pooled samples were compared with those in large samples from a single locality.

The grouped data on sex ratios are shown in Table 20. The differences in *m. minor* and *m. peltifer* are not marked, and the totals show a near 50-50 ratio. In *carinatus* the ratios are approximately 50-50 in the smallest size groups, but fluctuate generally in favor of females in the other groups. The total ratio in *carinatus* differs significantly from a 50-50 one ($X^2 = 4.3$). In *depressus* the female comprises a greater percentage than the male in all size groups. This may be significant since all the specimens are from the same locality, albeit they were not collected at the same time. The differences in *carinatus* and *depressus* may reflect a differential sex ratio, but I am reluctant to attribute differences in the ratios to anything more than chance selection of individuals.

TABLE 20. *Sex ratio obtained from pooled samples of each form in the Sternothaerus carinatus complex*

Species	N	Males		Females	
		N	%	N	%
minor	347	169	49%	178	51%
peltifer	62	32	52%	30	48%
depressus	42	10	24%	32	76%
carinatus	123	50	41%	73	59%

The ratios of sexes in samples from various periods of the year show little consistency in which sex is predominant (Table 21). Likely the distribution and ease with which the two sexes are captured varies with season.

TABLE 21. *Sex ratios in selected samples of each form in the Sternothaerus carinatus complex*

Species	Date	Males N	%	Females N	%
minor	6-7 June 1953	9	50	9	50
	6-10 Aug. 1954	7	41	10	59
peltifer	13-15 Aug. 1955	6	67	3	33
	17-20 Aug. 1955	7	87	1	13
depressus	17 June 1953	4	33	8	67
	11-12 Aug. 1953	1	9	10	91
	9-12 Aug. 1955	1	13	7	87
carinatus	17-18 Aug. 1952	4	40	6	60
	14-21 Apr. 1950	13	57	10	43

Risley (1933) found that the sex ratio in 255 specimens of *Sternothaerus odoratus* was 77 males to 178 females, a ratio similar to that observed in *S. depressus*.

D. *Reproductive potentials*

A small number of specimens was available for estimating reproductive potentials. There were few gravid females, so estimates were based chiefly upon counts of large ovarian follicles.

In *carinatus* the mean number of potentially ovulatory follicles (those in the two largest size groups) is 3.3, if one individual that contained 17 is omitted. This extreme individual affects the mean considerably. The mode is three, and this figure may be the best estimate. The mean for *depressus* is 5.5, that for *m. peltifer* 7.0, but the small size of the sample of these two forms precludes accurate estimate. The largest size group of follicles in *m. minor* does not correspond to the largest in *carinatus*, so the groups used to estimate potential differ.

The mean in six females of *m. minor* is 2.7.

In both *carinatus* and *m. minor,* the probability that there may be two broods during one year is evident, and the same may be true of *m. peltifer* and *depressus.* Both specimens of *carinatus* with oviducal eggs have large follicles approximately equal in number to the oviducal eggs. These large follicles are nearly the same size as the yolk in the oviducal egg and presumably near ovulation. A female with five corpora lutea (the term corpus luteum as used herein neither assumes nor denies an endocrine function of this structure) had four follicles near ovulatory size. One of the females with oviducal eggs had three large lutea obviously representing a recent ovulation and four smaller structures which appear to be old lutea from an earlier ovulation. One female with oviducal eggs was taken in early April, the other in early June. One specimen of *S. m. minor* captured in early June had five corpora lutea and several follicles of ovulatory size.

Corpora lutea should be included in the estimate of potential, but they are not always distinct. Assuming two broods per year, the means given earlier may simply be doubled. However, this procedure introduces error because the original estimate of potential may have been high due to inclusion of follicles that would not contribute to the reproductive pool of the same season. The best estimate is obtained by adding the corpora lutea to the number of potentially ovulatory follicles. The mean number of lutea plus ovulatory follicles in *carinatus* is 7.3. This is more than twice the mean potential calculated previously. The presence of one turtle with 17 enlarged follicles indicates a higher fecundity in some individuals.

The mean number of corpora lutea plus follicles in *S. m. minor* is 6.3. The data indicate that *carinatus* and *m. minor* have approximately the same mean annual reproductive potential. The differences in the size of the largest follicles in *carinatus* and *m. minor* suggest a difference in the size of the eggs at ovulation.

Few data are available on clutch size. Carr (1952) reported finding eggs of *m. minor* in April laid singly or in two's or three's. He also states that eggs "almost certainly of this species", have been found in May and June. Neill (1948a) reported finding two eggs of *S. m. minor* unearthed by a plow in Georgia. I have seen a clutch of two eggs of *carinatus* found half-way up a steep bank on the Pearl River east of Varnado, Louisiana. Data on egg production in relation to potential are needed on all species of *Sternothaerus.*

Risley (1933) reported a variation of two to seven in clutch size of *Sternothaerus odoratus.* The usual number was three to five.

E. *Feeding habits*

General habits.—The stomach and or intestines of 159 *Sternothaerus* were examined, of which 95 were empty. Gut contents were taken when the stomach was empty, but often no food remains were found in the digestive tract. Few specimens were preserved in the field immediately after capture. Most were retained alive for 18 to 36 hours, and many kept indefinitely for laboratory observation.

Samples from the digestive tract of 23 *carinatus,* 7 *depressus,* 17 *m. minor* and 17 *m. peltifer* were examined and the major food categories tabulated (Tables 22-24). The major items in the diet were insects, snails and clams.

There is a clear shift (except in *depressus* from which a sufficient sample is lacking) with increasing size from an insectivorous habit in young turtles to a molluscivorous one in adults.

Sternothaerus m. minor develops heavy musculature associated with the lower jaw and a greatly expanded crushing surface in both jaws. This parallels the development of the crushing apparatus found in *Graptemys pulchra* and *G. barbouri,* and appears to be an adaptation for mollusc eating. *Sternothaerus m. peltifer* also develops a partially expanded, crushing jaw surface, but not to the extent common in *m. minor.* However, *S. m. peltifer* shows the same change in diet to mollusc feeding as does *m. minor. Sternothaerus carinatus* develops the mollusc feeding habit at a smaller size than *m. peltifer* or *m. minor,* but never develops the crushing jaws or hypertrophied head musculature. *Sternothaerus m. minor* may, by virtue of its crushing jaws, have access to larger prey than the other forms. The differences in feeding habits between old and young turtles may reduce compe-

tition and allow for larger populations in a given area.

There is no evidence of a sexual difference in feeding habits and only one instance of a geographic difference. In the Escambia River, most turtle stomachs and intestines examined in large specimens were filled with bottom detritus which was composed chiefly of leaves, seeds, algae and other plant material. It seems unlikely that all of this material was accidentally swallowed by turtles seeking animal food.

Specific items of food.— Adult insects were more commonly encountered than larvae. Coleoptera were the most prevalent with Trichoptera second. Spiders, the most common arachnids, were found in only a few stomachs. The clams encountered were always small and usually represented by fragments. Snails seldom exceeded one-half inch in length.

TABLE 22. *Food items of Sternothaerus m. peltifer and depressus of various sizes*

C.L.	Insecta	Arachnida	Isopoda	Decapoda	Clams	Fish
			peltifer			
40	X					X
43	X			X		
51	X					
						X
					X	
					X	
						X
				X		
				X		
					X	
	X				X	
					X	
	X					
	X				X	
	X					
101	X				X	
111					X	
			depressus			
35	X					
	X	X				
	X					
	X	X	X			
	X					
46	X			X		
50	X	X			X	

In *S. depressus* haliplid beetles were prevalent in the stomachs. This prevalence of shore beetles is correlated with this turtle's habit of frequenting brush and masses of twigs very close to shore. All items in the stomachs and intestines of *depressus* indicate inshore feeding.

Feeding time.—Trapping of *Sternothaerus* is non-selective of sex or size groups and yields information on population density. By analyzing trap records, the time at which turtles feed or are most active may be determined.

Sternothaerus carinatus is difficult to trap. I have had little success at trapping this turtle in the Pearl, Sabine or Pascagoula rivers even though traps were set in areas where basking *carinatus* were abundant. Mr. Paul Anderson obtained only about 12 specimens in several months of trapping in the Pearl River. Cagle and Chaney (1950) reported that *S. carinatus* was reluctant to enter traps or was not attracted by the bait. They captured one specimen in an area where numbers were seen basking.

TABLE 23. *Food items of Sternothaerus carinatus of various sizes*

C.L.	Insecta	Decapoda	Snails	Clams	Plants
					X
	X				
	X				
	X				
	X	X			
	X				
	X				
	X				
	X		X	X	
	X		X	X	
	X			X	
			X	X	
	X			X	
			X		
			X		
			X	X	
116	X				X
128	X				
140			X		
140	X			X	X
144			X	X	

I have attempted to trap *Sternothaerus m. minor* in the Escambia River (intergrades with *peltifer*) and in the Ichtucknee Spring run (Suwannee River drainage) in Florida. *Sternothaerus m. minor* is abundant in the spring run and can be observed easily in the clear water, but no specimens were taken in traps. The clear water may be the factor responsible for trapping failure. At 1330 hours on August 9, 1954, 10 traps were set in quiet eddies out of the main channel of the Escambia River. Six specimens were taken in the traps at 1930 hours, none at 0830, August 10, and three at 2000 hours, August 10. The data are too meager for positive conclusion, but they indicate that these turtles fed in the evening or early night, not during the morning.

More conclusive data are available for *S. m. peltifer*. On August 13, 1955, eight traps were set in shallow water near shore along a 350 yard stretch of the east bank of the Coosa River, six miles east of Pell City, Alabama; five additional traps were set along 150 yards of the west bank. Traps were baited with whiting fish, the most effective bait used throughout the study. From 1930 hours, August 13, until 0600 hours on August 16, 42 *Pseudemys s. scripta*, 19 *Sternothaerus odoratus* and 14 *Sternothaerus minor peltifer* were taken in the 13 traps.

The traps were rebaited each day; when the fish develop a strong odor, turtles avoid them. Traps without bait were used unsuccessfully. At 1200 hours, August 15, the two traps which had been most productive were left unbaited. These traps had accounted for 25 turtles, but yielded none during the next two days.

TABLE 24. *Food items of Sternothaerus m. minor of various sizes*

C.L.	Insecta	Diplopoda	Snails	Clams	Fish	Plants
32	X					
34	X					
35	X					
38	X					
49	X					
69	X					
72				X		X
80					X	
83						X
90				X		X
91				X		
93	X					X
95			X	X	X	
97		X	X	X		
103						X
105			X			
113	X					X

There was a gradual decrease and, finally, a cessation of yield from the traps on the east side of the river. If this indicates that all turtles within feeding range were captured, then the trapping data yield information on relative population density. Continual disturbance of the trapped area causing a decrease in trap efficiency and movement of individuals from outside of the trapped area may produce errors in the census figures. With certain assumptions, the number of individuals of each species in a one-quarter mile stretch of river may be estimated (Table 25).

The traps on the west side of the river were run for two days only, during which time no evidence of decreasing yield was noted. The west bank was shaded for a greater part of the day than the east bank.

TABLE 25. *Numbers of three species of turtles trapped in a one-quarter mile length of the Coosa River during four days*

Species	Aug. 13 E	Aug. 13 W	Aug. 14 E	Aug. 14 W	Aug. 15 E	Aug. 15 W	Aug. 16 E	Aug. 16 W	Total E	Total W
Pseudemys s. scripta	13	—	16	—	8	2	0	3	37	5
Sternothaerus odoratus	5	—	6	—	3	3	0	2	14	5
Sternothaerus m. peltifer	1	—	7	—	1	2	0	3	9	5
					Grand Totals				60	15

Traps were examined at the same time on successive days. The pooled data for different periods of the day reveal patterns of feeding activity which differ in the three species (Table 26). Most *Pseudemys* feed early in the morning and at dusk, but not at night; few are taken during the late afternoon and morning. *Sternothaerus odoratus* is most abundant in the traps early in the morning and later at night than *Pseudemys*. As the traps were not examined throughout the night, it is not clear whether the bulk of individuals taken from the nets in the morning were trapped the previous night or early that morning. In *Pseudemys*, which was not taken at night, it is clear that those in the traps in the morning had most likely been caught that morning. The situation with *Sternothaerus odoratus* is not this clear.

TABLE 26. *Numbers of three species of turtles trapped at five periods of the day during four days of trapping in the Coosa River*

Hours	800	1200	1600	1900	2100
Pseudemys scripta	15	5	6	16	0
Sternothaerus odoratus	7	0	1	3	8
Sternothaerus m. peltifer	6	0	1	7	0
No. of times nets checked	3	2	2	3	3

Sternothaerus m. peltifer displays a morning peak, but none was trapped at night. It is similar to *Pseudemys* in feeding time. The data demonstrate that *Sternothaerus* is inactive during the day, but trapping records from more periods of the night are needed.

Seven traps were set August 17 to 19,

1955, in the Black Warrior River, three miles east of Eutaw, Alabama, covering a combined distance of 200 yards on both sides of the river.

Two *Pseudemys s. scripta* and 12 *Sternothaerus m. peltifer* were collected. The traps were examined at about the same time as those in the Coosa River, and *m. peltifer* shows the same peaks of feeding activity as in the Coosa River. Six *Sternothaerus* were taken during the 0800 hour check and six at 1900. All musk turtles were taken on August 17 and 18, none on the 19th, indicating that most turtles in the area had been trapped. If this is true, the density here was one turtle per 17 linear yards of river bank compared with one per 25 yards in the Coosa River.

TABLE 27. *Numbers of Sternotherus depressus taken during six trapping periods on several visits to the Black Warrior River*

Hours	0500–0600	0700–0800	0900–1000	1500–1600	1800–1900	2100–2200
No. of times nets checked	2	1	1	3	2	2
No. of turtles	7	2	1	0	0	4

Sternothaerus depressus is not so easily trapped as *m. peltifer*, and hand collecting from a boat along the shore at night is as effective as trapping, except that adults are not collected by this method. Table 27 shows during what hours trapping was most successful at the type locality of *depressus* during August, 1954 and 1955. *Sternothaerus depressus* is most active late at night and during the early morning. The exact time of peak activity cannot be determined until trapping experiments are conducted throughout the night.

F. *Basking*

The function of basking in turtles is not clear, but it appears to be thermoregulatory, a means for drying the body, and for disposing of algal, fungal and bacterial growths, or animal parasites.

This habit is poorly developed in *Sternothaerus*. I have never observed basking individuals of *m. minor*, *m. peltifer* or *depressus*. Occasional instances of basking by specimens of *m. minor* have been reported, but observers who have watched this form for long periods in the field do not find the habit developed in most individuals. In contrast with these forms, individuals of *S. carinatus* habitually bask.

G. *Nocturnal behavior*

Observations around stumps and inshore brushpiles at night often reveal individuals coming to the surface to breathe, or at least extending their snouts to the surface. This habit partly explains the concentrations of turtles around brushpiles where they have immediate access to deep water for rapid escape, but are able by remaining at a shallow level to obtain air during the night with little expenditure of energy.

H. *Habitat preference*

Sternothaerus m. minor, *S. m. peltifer* and *S. carinatus* are associated with running water or with permanent bodies of water connected with running water, such as oxbow lakes. I have not seen *S. depressus* from enough localities to ascertain its preference. The only habitat from which I have collected this species is sluggish water, but creation of this habitat at the type locality was due to recent damming of the Black Warrior River.

Sternothaerus odoratus is seldom found in equal abundance with any member of the *S. carinatus* complex. *Sternothaerus odoratus* is most abundant in ponds, lakes and other lentic situations and has a habit of overland migration (Cagle, 1944) which in part accounts for its wider range and absence of clear-cut geographic races. The absence of the members of the *S. carinatus* group in most ponds or lakes removed from lotic environments indicates no migration.

In the Coosa River near Pell City, Alabama, *S. odoratus* and *S. m. peltifer* occur in equal abundance. This, I believe, is a secondary phenomenon associated with damming of the river and creation of favorable habitat for *odoratus*. *Sternothaerus m. peltifer* is common below the Fall Line on the Black Warrior River near Eutaw, Alabama, but I have never collected *S. odoratus* there even though the current is slow.

Lake Concordia, Louisiana, from which I have seen cotypes of *S. carinatus*, is an oxbow lake of the Mississippi River. Extensive collecting and observations in this lake in 1954 revealed no *S. carinatus*, but 25 *S. odoratus* were taken in two days of trapping.

The Wacissa River in Jefferson County, Florida, is an exception to the rule of *odoratus* in quiet water. However, the current there is slow and the clear water channel is bounded by dense lily pads in a mucky bot-

tom, which supports dense weeds in many places. *Sternothaerus odoratus* is common among these plants and the cypress roots near shore. In two trips to this locality, 53 *S. odoratus* and three *S. m. minor* were taken.

Sternothaerus is most abundant around brushpiles, stumps, roots or rocky crevices in quiet areas of rivers, particularly in the inlets behind sand spits. Traps set far from brush or in deep water generally produce no turtles.

I. *Associated Species*

On most trips several techniques were employed to obtain samples of as many turtle species as possible. The emydid turtles are easiest to sample; comparable samples of *Chelydra, Trionyx, Macroclemys* and *Kinosternon* were not obtained. A list of species taken at several localities is of qualitative interest though it sheds little light on relative abundance (Table 28).

X. Behavior of Captive Sternothaerus

A. *Reaction to Light*

Sternothaerus depressus is especially sensitive to light and attempts to burrow in the aquarium when a bright light is turned on. The other forms show a preliminary annoyance with, and movement away from light. When a light is turned on an aquarium in which turtles are quiet, there is a burst of activity as though darker situations were being sought. Most become inactive a short while after the light is removed. Several turtles in a lighted aquarium will generally be at the side away from the highest light intensity. In their behavior, contact with some part of the aquarium or with another turtle appears important.

B. *Reaction to Heat*

Heating coils over a two-gallon aquarium containing juveniles of *Sternothaerus* have a marked effect on activity. At a water

Table 28. *Relative numbers of turtles taken in Gulf Coast rivers. The numbers in parentheses following names of rivers indicate the number of visits to the river. Black Warrior[a] is below the Fall Line, Black Warrior[b] above the Fall Line*

	Escambia (2)	Suwannee	Wacissa (2)	Flint (2)	Coosa (3)	Pascagoula (2)	Tombigbee	Black Warrior[a] (3)	Black Warrior[b] (4)	Pearl (3)	Tensas	Sabine
S. carinatus						7				8	6	3
S. depressus									48			
S. m. minor	18	21	3	1								
S. m. peltifer					17		6	28				
S. odoratus			53		28				2	2	5	
C. s. serpentina			1						1			
M. temminckii				4								
G. pulchra	78				4	15	13	17	7	57		
G. kohni											30	3
G. barbouri				29								
G. p. ouachitensis											10	
G. p. sabinensis												36
G. oculifera										30		
G. geographica									3			
G. nigrinoda							5	175				
G. flavimaculata						21						
T. f. aspera	4											
T. f. emoryi												3
T. f. ssp.				7	1		1		1			
P. s. scripta	10			7	48	3		26	1			
P. s. elegans										3	23	1
P. f. suwanniensis		3										
P. f. floridana			13	59								
P. f. ssp.	18						1	12	50	12	8	

temperature of 29.5°C, most turtles become active. Repeated efforts were made by two individuals of *S. m. peltifer* to swim to the surface, but they always retreated when about one-half way up, apparently because of the high surface temperature (30°C). The turtles appeared hesitant to extend their heads into this thermal level, and flinched repeatedly when encountering the higher temperature. The juvenile *S. m. minor* remained on the bottom in the sand. When the water surface temperature reached 30° to 31°C, this turtle became active and made one or two attempts to surface, but was repulsed by the high temperature. It returned to the bottom and began to kick up sand in what appeared to be an attempt to cover its body.

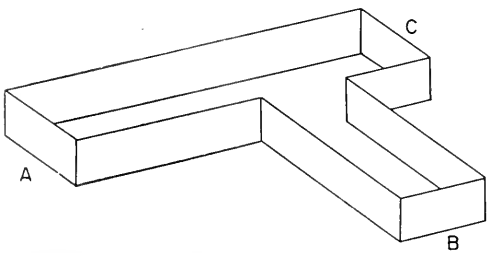


Figure 57. Diagram of trough used in experiments on reaction to current.

C. *Reaction to Current*

Several individuals of each form were placed in a trough shown in figure 57.

Strong currents of water were admitted at A or C, while the water in B remained quiet. Repeated experiments showed that there was little avoidance of the current during movement, but resting places were always chosen out of the main sweep of the current. Only *S. m. minor* avoided the current, moving always into the eddy at B or to the end of the trough opposite the current source.

When the trough was drained, the turtles showed no reaction until the amount of water remaining was insufficient to supply buoyancy to their bodies, at which time there was a sudden scrambling behavior that soon abated. Then the turtles became motionless and partly or wholly withdrew the head and limbs into the shell.

XI. Summary

1. Trapping and hand collecting from a boat are the best means of obtaining *Sternothaerus.*

2. The generic name *Sternotherus* of Gray (1825) is a misspelling and should be replaced by the valid spelling *Sternothaerus* of Bell (in Gray, 1825).

3. The total range of the *Sternothaerus carinatus* complex lies within the Austroriparian and Texan biotic provinces, and almost wholly within the Gulf coastal plain. Several critical areas must be studied before exact range delineation can be made, particularly in the northern limits of distribution.

4. *Sternothaerus minor minor* and *minor peltifer* intergrade in the area between Mobile Bay and the Choctawhatchee River drainage. The other forms show no definite signs of gene exchange.

5. Sexual dimorphism is shown in measurable degree in some forms in the ratios of plastron length/length of bridge, plastron length/length of interanal scute, carapace length/plastron length, and plastron length/preanal tail length. Most characters show no sexual differences.

6. Ontogenetic changes in relative sizes of various structures are shown by the ratios of plastron length/length of interabdominal scute, plastron length/length of interanal scute, and plastron length/length of bridge. In *Sternothaerus carinatus* there is an ontogenetic change in the relationship between the length and width of some of the vertebral shields.

7. Geographic variation occurs in most characters and small differences between populations of the same form in different rivers are apparent. In general, *Sternothaerus depressus* and *carinatus,* which represent the extremes in body shape, show the most striking differences from the other forms.

8. Abnormalities in shields or scutes are rare, averaging five percent in all forms. Abnormalities in one set of shields or scutes is commonly accompanied by abnormalities in another set.

9. The skulls of *Sternothaerus m. minor* and *depressus* are unusual. The former is distinguished by massiveness associated with development of musculature for the crushing jaws, the latter by its nearly level slope from the nasal to the tip of the supraoccipital.

10. The origin and fossil history of *Sternothaerus* is unknown. *Sternothaerus odor-*

atus is possibly the most primitive species in the genus, and is the one most closely related to *S. m. minor.* The differentiation of *m. minor* from *odoratus* or a common stock presumably took place on the coastal plain and probably in Florida, the present area of greatest abundance of *m. minor.*

11. The remarkable isolation of *Sternothaerus depressus* in the upper drainage of the Black Warrior is inexplicable at present, but may indicate imminent extinction. This species is most closely related to *S. m. peltifer* and may have arisen from *m. peltifer* stock, perhaps in the Tennessee River drainage where *depressus* does not now occur.

12. With allowances for small differences, the patterns of race or species differentiation in the *Sternothaerus carinatus* complex, in *Pseudemys, Trionyx* and the broad-headed *Graptemys* group are similar, and apparently the rate of evolution in these groups is nearly the same.

13. The pattern of speciation in the *Graptemys oculifera* complex is different because three well-differentiated species have developed in some of the youngest rivers on the Gulf coast in which turtles of other genera show little or no differences.

14. The growth curves of *Sternothaerus depressus, S. m. peltifer* and *S. m. minor* are almost congruous, and similar in form to that of *S. odoratus.* The growth curve of *carinatus* shows a more rapid rate of growth.

15. Males and females reach sexual maturity at about the same size except in *S. m. peltifer* in which males are smaller than females at sexual maturity. All species reach sexual maturity at about the same size, except females of *m. minor* which are smaller at sexual maturity than the other forms, and in *carinatus,* in which the males are larger.

16. The age at sexual maturity is not very different in males and females, nor between the various forms, except that in *S. m. peltifer* females are generally older at maturity than those of other forms. The age at sexual maturity given in the literature for *S. odoratus* females is twice that of the males at maturity.

17. *Sternothaerus depressus* displays a marked divergence in sex ratio, with females outnumbering males three to one. This ratio is approximately the same as that reported in *S. odoratus.* The sex ratio of other members of the complex is not exactly 50:50, but the divergence is slight.

18. The reproductive potential of all forms in the complex averages between five and seven eggs per female per season. *Sternothaerus carinatus* and *S. m. minor* show potentialities for two broods per year. No data are available on realized egg production.

19. The food habits are similar in all forms. There is a change in food habits from an insectivorous juvenile to molluscivorous adults. *Sternothaerus m. minor* develops hypertrophied jaw musculature and crushing alveolar jaw surface correlated with mollusc-feeding. This is true to a lesser extent in *m. peltifer,* but is not true in *carinatus* and *depressus,* which also become mollusc feeders.

20. Trapping data indicate that *Sternothaerus* is not active during the day. Peak activity, and presumably feeding, occurs in the morning and evening in *m. peltifer* and in the morning and late at night in *depressus,* and probably *m. minor.* Insufficient data are available on *carinatus.* In one locality obvious differences existed in the feeding times of *S. m. peltifer* and *S. odoratus.*

21. The habit of basking is well-developed only in individuals of *S. carinatus,* but basking individuals of *S. m. minor* have been reported.

22. *Sternotherus carinatus, m. minor* and *m. peltifer* are seldom taken outside of rivers, streams or bodies of water connected with lotic environments. Little can be said of *S. depressus* because it has been taken in few localities. *Sternothaerus odoratus* is most abundant in lentic situations. Overland migration, a common habit in *S. odoratus,* has not been observed in other *Sternothaerus.*

23. *Graptemys, Pseudemys* or *Trionyx,* often all three, are generally abundant in the areas where *Sternothaerus* abound.

24. Water current is not shunned during movement (except by *m. minor*) by turtles, but stationary positions are never assumed in the direct sweep of the current.

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ABSTRACT

The *Sternothaerus carinatus* complex of three species (four forms) is limited primarily to the Gulf coastal plain and has presumably speciated in this area. The present study compares the external morphology, the skull and the ecology of these species to establish the relationships within the group. The pattern of species distribution is compared with that in other turtle genera on the Gulf coast. Samples of *Sternothaerus* were collected from most major rivers of the Gulf coast, and were supplemented by material in many museum collections. The samples from each river

drainage were treated separately to show small differences between populations.

The spelling of the generic name is incorrect and should be changed to *Sternothaerus*.

Geographic, sexual, ontogenetic, or uncorrelated variability exist in each species. Significant differences in certain characters are apparent between populations of the same species in different rivers. Some characters show clear longitudinal trends, while others display the same or fluctuating means between populations in different rivers. Some characters used by previous authors to distinguish between species are not diagnostic and other characters are suggested for use in differentiating species in this complex.

Variability exists in the skulls, but study of these reinforces the ideas of relationship obtained from external characters. The suggested phylogeny within the genus places *S. odoratus* as the oldest form, with *m. minor and m. peltifer* evolving from the same progenitor. *Sternothaerus carinatus* arose from pre-*peltifer* stock. *Sternothaerus depressus* is most closely related to *m. peltifer*, but the path of its differentiation is not clear, nor is the reason for its extreme isolation in northern Alabama. The youth of most Gulf coast rivers and the obvious similarities between members of the *S. carinatus* complex suggests that most of their evolution occurred during the late Pliocene and Pleistocene.

The patterns of speciation in the *Sternothaerus carinatus* complex, in the *Trionyx spinifera* and *T. muticus* groups and in the broad-headed *Graptemys* are grossly similar and may indicate similar rates of evolution. The pattern in the *Graptemys oculifera* complex is one of extreme differentiation in youthful rivers, indicating a more rapid rate of evolution.

The growth curves of all *Sternothaerus* species are similar; growth rate is fastest in *S. carinatus*.

Sex ratios are not markedly divergent from 50:50 except in *S. depressus*, but in this species chance selection of individuals might account for the difference. Generally sexual maturity is reached by individuals of each species at a size of 75 - 100 mm (carapace length) and at four to six years of age. The sexes and species show slight differences in size and/or age at sexual maturity.

The average annual egg production per female is five to seven, but some individuals have a higher potential and may deliver more than one brood per year.

The juveniles in the *S. carinatus* complex are mainly insectivorous, but older individuals and adults become predominantly molluscivorous. Feeding habits vary little geographically or sexually. Feeding takes place in the early morning, late evening or at night; turtles are inactive during the day.

All members of the group are associated with streams, rivers, or bodies of water associated with these lotic environments. In these areas, they occur most abundantly with *Trionyx*, *Pseudemys* and *Graptemys*.

The habit of basking has been reported in several *Sternothaerus*, but is apparently well-developed as a habit only in individuals of *S. carinatus*.

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Volume 6, Number 2 June 6, 1958

THE BUTTERFLIES OF MISSISSIPPI

BRYANT MATHER
and
KATHARINE MATHER,
JACKSON, MISSISSIPPI

TULANE UNIVERSITY
NEW ORLEANS

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KATHARINE MATHER,
Jackson, Mississippi

CONTENTS

I. Introduction

We propose to summarize the data on the butterflies of Mississippi. Previous work, supplemented by our studies, begun in 1946, has yielded records from 189 localities representing all of Mississippi's 82 counties. Records are given of the occurrence of 122 species of butterflies, 45 of which were not included in either of the two previously published lists. We also present our reasons for believing that 41 other species are of probable or possible occurrence in Mississippi. We believe that approximately 160 species will be found and we hope that additional collecting will increase the number that are known. We have taken specimens of 109 of the 122 species listed as known. Flight-period information is given for 121 species in Mississippi. Specimens of ten species have been taken in all months of the year. Of ten species, only one Mississippi specimen is known; and of one species (*Phoebis philea*), no specimen from Mississippi is known.

We believe that one principal value of this summary to lepidopterists not directly concerned with Mississippi butterflies, will be in clarifying the significance of some of the numerous vague statements found in the literature regarding the range of the species listed here. Particularly unsatisfactory, for the purpose of deciding whether or not it was the author's intention to indicate that a given species did or did not occur in Mississippi, are such statements of range as: "Florida, Texas"; "Florida and Texas", "Florida to Texas"; "Florida, Gulf States, Texas"; "Gulf States"; "Gulf Coast"; or "Gulf Strip." We are cognizant of the virtual absence from the data here summarized of information on food plant preferences or on life histories. We hope that future work by us and others will help to remedy these deficiencies. No photographs are included in this report. Readers who wish to consult illustrations for aid in identification of specimens are referred to *A Field Guide to the Butterflies* (Klots, 1951). Taxonomists working on revisionary studies will find typical examples of Mississippi butterflies from our collection, in a number of other collections or they may write to us. We will be happy to lend material for such studies. In preparing this report we have tried to follow the advice and suggestions given by Clench (1949) in his discussion of regional lists.

II. Literature and Collections

The scientific study of the butterflies of Mississippi was begun by Howard Evarts Weed in 1891, continued by Frank Morton Jones in 1910 and 1921, by Ross E. Hutchins from 1929 to 1933, by Harold I. O'Byrne in 1940, and by us since 1946. Two lists have been published: Weed (1894) listed 53 species from Oktibbeha County; Hutchins (1933) listed 73 species based principally on collecting in the vicinity of Mississippi State College, Oktibbeha County, and on specimens in the State College collection. The results of the work by Jones and O'Byrne have not been published. The greater part of the Jones collection is now in the Peabody Museum of Natural History at Yale University. The O'Byrne collection is at the University of Missouri. Dr. Jones kindly furnished us with a detailed summary of his results, and data on 14 Mississippi specimens from the Jones collection were kindly provided by Prof. C. L. Remington. Data on Mississippi specimens in the O'Byrne collection were compiled by one of us (K.M.) in October 1953. Data on Mississippi specimens in the collection of the American Museum of Natural History were compiled in April 1956 and kindly furnished to us by Mr. Kilian Roever; additional data were supplied by Mr. Cyril F. dos Passos. Martin and Truxal (1955) reported Mississippi specimens of two species in the collection of the Los Angeles County Museum; Mr. Martin kindly supplied us with additional data on these. We examined the collection at Mississippi State College in March 1953, and one of us (B.M.) examined the collection at Purdue University, Lafayette, Ind. in October 1953.

No species, subspecies, or form of butterfly has been described from specimens taken in Mississippi. The state of Mississippi is not mentioned in either edition of *The Butterfly Book* (Holland, 1898, 1931), and but three times in *A Field Guide to the Butterflies* (Klots, 1951). Williams (1938) and Williams, et al (1942) mentioned observations of fall movement of *Phoebis sennae eubule* at Biloxi by R. S. Smith and at Bay St. Louis by C. Lyle, and of *Danaus plexippus* at Bay St. Louis by Lyle. Urquhart (1955) mentioned observations of

fall movement of *D. plexippus* at Minter City by Miss Carrie Avent. Jones (1943) reported observations of migration of *P. sennae eubule* near Oxford. Forket (1900) reported observations at Ocean Springs. Preliminary reports of some of our work have been published (Mather, 1952a, 1952b, 1953, 1954a, 1954b, 1955a, 1955b, 1956b).

III. Area Studied

A. *Geography*

The state of Mississippi has an area of about 47,000 sq. mi., an extreme width of about 180 mi., an extreme length of about 330 mi., and a maximum elevation of 806 ft. above sea level. It is bounded by Tennessee, Alabama, Louisiana, Arkansas, and the Gulf of Mexico.

B. *Physiography*

Mississippi lies entirely in the Gulf Coastal Plain province, extending to the inern boundary of the province in its northeastern corner where the boundary of the state and the province is the Tennessee River (Fenneman, 1938). Portions of two major divisions are included: the east Gulf Coastal Plain and the Mississippi Alluvial Plain. The state has been subdivided into regions based on geological formations, topography, soils, forest types, land use, and similar criteria. Pre-Cretaceous, Paleozoic, rocks reach the surface only in small areas in the tributaries of the Tennessee River in the extreme northeastern corner of the state. The soils belong to four major groups (U.S. Dept. of Agriculture, 1938). We believe that differentiation of the following five regions is sufficient for our purposes; the approximate boundaries of each are shown on the locality maps (figs. 2-6).

Delta.—The major part of the alluvial plain of the Mississippi River included in the state is the Yazoo River basin and is known as "The Delta." This is an area of lowlands extending south along the Mississippi River from the Tennessee line for about 200 mi., reaching a maximum width of 60 mi. It has a rich alluvial soil and is characterised by hardwoods.

Tennessee River Hills.—This region includes the highest elevation in the state and constitutes a rather narrow belt along the northern one third of the eastern boundary.

Black Prairie.—The black prairie or black belt, is a narrow zone bordering the Tennessee River Hills, underlain by chalk. The soils are classified as Rendzina.

Coastal Meadows.—This is a narrow belt, 5 to 15 mi. wide, bordering the Gulf of Mexico, rising 20 to 30 ft. above sea level, characterised by poor drainage and soils of the Weisenboden-, Ground- Water Podzol, Half-Bog Group.

Central Hills, Plateau, and Prairie.—This subdivision includes the major part of the state. It is underlain by a sequence of sedimentary formations and, together with the Tennessee River Hills, is characterised by soils of the red-yellow podzol group. The hills bordering the delta are capped with brown loam or loess. The hills north of the coastal meadows are the "piney woods" or southern pine hills area.

C. *Life Zones*

The map given in Klots (1951) indicated that Mississippi is entirely in the Lower Austral Life zone. Lowe (1921) wrote "All of Mississippi is embraced within the Austroriparian Area of the Lower Austral Zone, though a number of species, which probably belong in the Carolinian Area, reach this state in its extreme northeast corner." Lambremont (1954) stated that Louisiana was entirely within the Austroriparian life zone; the northern portion in the Carolinian area, and the southern portion in a semi-tropical region called the Gulf Strip. Prof. R. L. Chermock called our attention to the paper by Rehn and Hebard (1916) in which the Sabalian life zone was proposed for the area along the Gulf and stated that his studies in Alabama indicated that this zone includes the southern tier of counties and extends some distance up the rivers. He also noted that recent studies of the biology of Tishomingo County in extreme northeast Mississippi and of adjacent areas in Alabama indicated an upper Austral outlier in that region. Prof. Klots wrote us that he believes many species get deep down into Mississippi that are not merely Upper Austral but Transition; that while Mississippi is essentially all Lower Austral, this does not mean that all species found there are Lower Austral. It contains some tropical species: that is, species that certainly originated in truly tropical regions and have extended their ranges so that they occur naturally in the Lower Austral life zone, not as strays.

Figure 1. Division of Mississippi into regions.

It also contains similar Upper Austral and Transition zone elements.

D. *Climate*

The average temperature is 65°F, the average frost-free season is 200 days in the north and 250 days in the south, and the average rainfall is 50 inches in the north and 60 inches in the south. The average rainfall by months for the period 1888-1955 varied from 2.5 inches for October to 5.9 inches for March. The records of average monthly temperature and total precipitation for Jackson, Hinds Co., for the 10-year period, 1946-1955 were examined. Only once, January 1948, was there a month with an average temperature below 40°F, and there were three winters, 1948-49, 1949-50, and 1951-52, during which no month had an average temperature below 50°F. The annual rainfall ranged from 32 inches in 1952 to 61 inches in 1946. No precipitation at all was recorded in three of the 120 months: November 1949, May 1951, and October 1952. More than 15 inches was recorded in November 1948, and more than 12 inches in January 1947 and July 1955.

IV. Localities

The 189 Mississippi localities from which we have records are circled on the five regional maps (figs. 2-6). The division of the state into these five regions (fig. 1) is arbitrary and only for convenience of indicating localities. The counties in each region are: (1) *Southeast:* Covington, Forrest, George, Greene, Hancock, Harrison, Jackson, Jefferson Davis, Jones, Lamar, Marion, Pearl River, Perry, Stone, and Wayne Counties. (2) *Southwest:* Adams, Amite, Claiborne, Copiah, Franklin, Hinds, Issaquena, Jefferson, Lawrence, Lincoln, Madison, Pike, Rankin, Sharkey, Simpson, Walthall, Warren, Wilkinson, and Yazoo Counties. (3) *East Central:* Attala, Clarke, Jasper, Kemper, Lauderdale, Leake, Neshoba, Newton, Noxubee, Scott, Smith, and Winston Counties. (4) *Northwest ("Delta"):* Bolivar, Carroll, Coahoma, De Soto, Grenada, Holmes, Humphreys, Leflore, Panola, Quitman, Sunflower, Tallahatchie, Tate, Tunica, Washington, and Yalobusha Counties. (5) *Northeast:* Alcorn, Benton, Calhoun, Chickasaw, Choctaw, Clay, Itawamba, Lafayette, Lee, Lowndes, Marshall, Monroe, Montgomery, Oktibbeha, Pontotoc, Prentiss, Tippah, Tishomingo, Union, and Webster Counties.

The boundaries of the five natural regions defined previously in this report are indicated on the locality maps. (1) The Delta occupies the greater portion of the northwest region and extends into the southwest section. All or a major part of twelve counties is included in this region. (2) The Tennessee River Hills lies in the northeast region and includes all of Tishomingo County, most of Itawamba County, and the eastern parts of Alcorn, Prentiss, Monroe, and Lowndes Counties. (3) The Black Prairie occupies a belt to the west of the Tennessee River Hills, is shown on the maps of the northeast and east central regions. (4) The Coastal Meadows, bordering the Gulf Coast, is shown on the map of the southeast region, and occupies the southern parts of Hancock, Harrison, and Jackson Counties. (5) The remainder of the state comprises the central hills, plateau, and prairie.

V. Comparison with Other Regions

Louisiana.—The recently published Louisiana list (Lambremont, 1954) includes 137 names, eight of which are, according to our views, duplications. In seven of these cases two subspecies are listed: *C. p. pegala* and *C. p. alope*, *D. p. plexippus* and *D. p. melanippe*, *A. c. celtis* and *A. c. alicia*, *A. c. clyton* and *A. c. flora*, *S. o. ontario* and *S. o. autolycus*, *P. t. troilus* and *P. t. ilioneus*, and *P. s. sennae* and *P. s. eubule;* in an additional case material that we regard as conspecific is assigned to two species: *A. dion* and *A. alabamae*. Of the 129 remaining distinct species mentioned, 93 are listed as known, 36 as probable. All of these are among the species discussed in this report. The 35 species included here that were not mentioned by Lambremont include 14 that are known from Mississippi: *S. diana*, *P. comma*, *I. augustinus*, *I. henrici*, *L. thoë*, *A. maerula*, *A. cellus*, *P. syrichtus*, *P. zabulon*, *A. arpa*, *A. palatka*, *A. loammi*, *A. hegon*, and *A. carolina*. Nine species listed as known from Louisiana have not yet been recorded from Mississippi: *D. julia*, *S. cybele*, *I. irus*, *B. polydamas*, *P. agarithe*, *C. nessus*, *H. leonardus*, *P. viator*, and *A. dukesi*. Of the 36 species listed as probable for Louisiana, 25 are reported here as known from Mississippi. Two additions may be made to the list

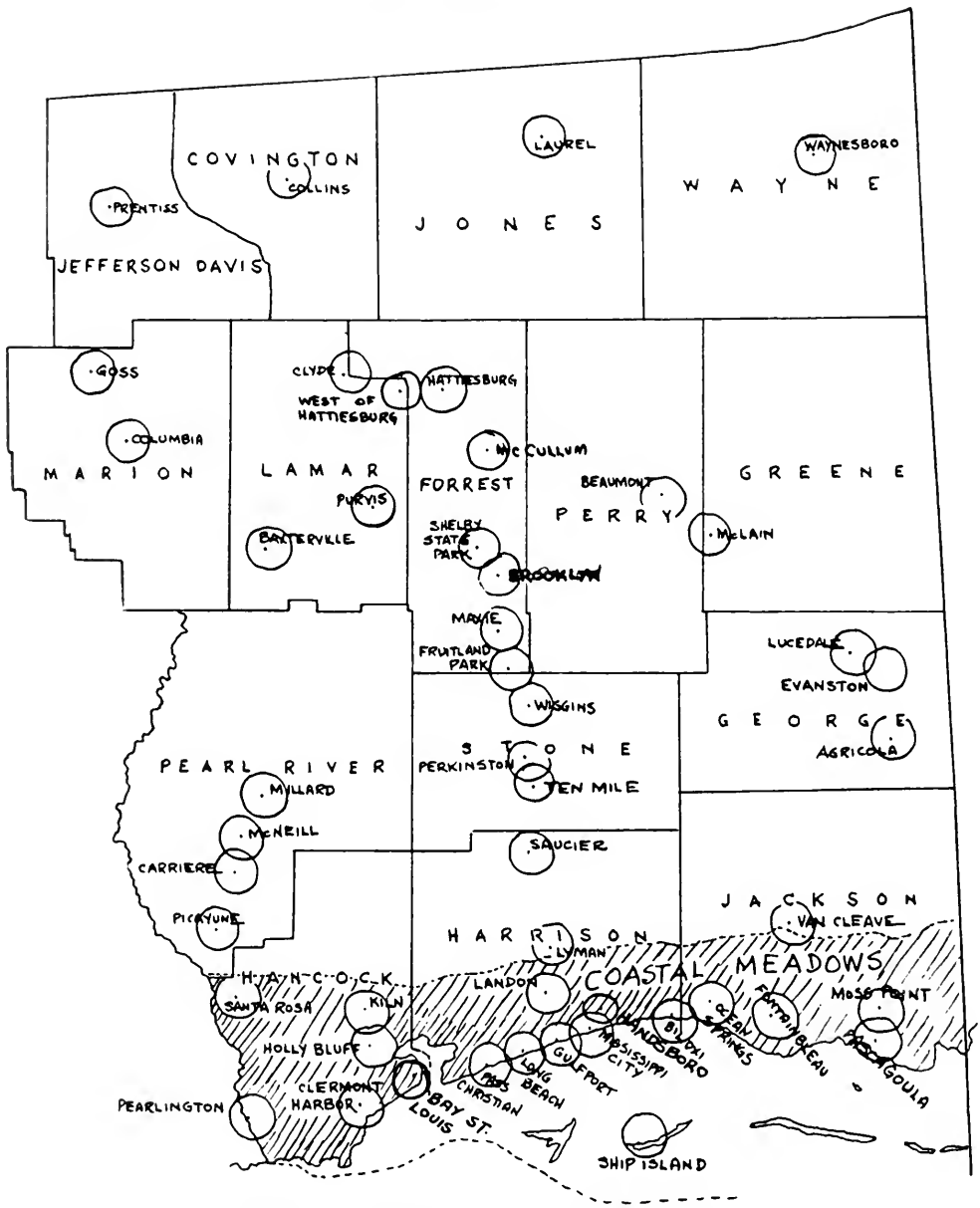

Figure 2. Localities in southeast Mississippi.

of species known from Louisiana: *L. creola* and *S. diana.* The basis for these additions is given in the annotated list.

Virginia and Georgia.—A total of 143 species were recorded from Virginia by the Clarks (1951). Harris (1950) recorded 144 species from Georgia. Only three species listed as known from both Virginia and Georgia are not known or expected from Mississippi: *Polygonia faunus, Speyeria aphrodite,* and *Poanes aaroni.* Three others are listed as known from Georgia but not listed as probable or possible for Mississippi: *Strymon calanus, Polites baracoa,* and *Problema bulenta.*

Kentucky.—Of the 67 species listed as recorded or expected for Jefferson County, Kentucky by Merritt (1948), all but two

(*Speyeria aphrodite* and *Nymphalis j-album*) are listed here.

Texas.—Of the 62 species listed as known from the vicinity of Waco, Texas by Gooch and Strecker (1924), all but three (*Melitaea harrisi, Chlosyne lacinia* and *Mestra amymone*) are listed here. Notations from Freeman's study (1951c) of the Hesperioidea of Texas are given in the annotated list.

Tennessee.—Of the 72 species listed as known from the Nashville region by Osborn (1895) all but one (*Speyeria aphrodite*) are listed here. Considerable information from the unpublished studies of Mr. Kilian Roever of Jackson, Tennessee is included in the annotated list with his kind permission.

Alabama.—There is no published list of the butterflies of Alabama. A considerable number of records kindly provided by Prof. Ralph L. Chermock have been mentioned, with his permission, in the annotated list.

Arkansas.—We know of no published general list of the butterflies of Arkansas. Comment on certain species reported from Arkansas by Freeman (1945, 1951a) is included in the annotated list.

Southeastern.—Of the 104 species listed by Richards (1931), all but three (*Speyeria aphrodite, Polygonia faunus,* and *Strymon calanus*) are included in our annotated list.

VI. Check List

A. *Species Known to Occur in Mississippi*

SUPERFAMILY PAPILIONOIDEA

FAMILY SATYRIDAE

1. *Lethe portlandia portlandia* (Fabricius)
*2. *Lethe creola* (Skinner)[1]
3. *Euptychia cymela cymela* (Cramer)
4. *Euptychia hermes sosybia* (Fabricius)
*5. *Euptychia areolata areolata* (J. E. Smith)
6. *Euptychia gemma gemma* (Huebner)
7. *Cercyonis pegala pegala* (Fabricius)

FAMILY DANAIDAE

*8. *Danaus gilippus berenice* (Cramer)
9. *Danaus plexippus plexippus* (Linnaeus)

FAMILY HELICONIIDAE

*10. *Heliconius charitonius tuegeri* Comstock and Brown
11. *Agraulis vanillae nigrior* Michener

FAMILY NYMPHALIDAE

12. *Euptoieta claudia* (Cramer)
*13. *Speyeria diana* (Cramer)
*14. *Melitaea gorgone gorgone* (Huebner)
*15. *Melitaea nycteis nycteis* Doubleday
16. *Phyciodes phaon* Edwards
17. *Phyciodes tharos tharos* (Drury)
*18. *Phyciodes texana seminole* (Skinner)
19. *Polygonia interrogationis* (Fabricius)
20. *Polygonia comma* (Harris)
21. *Nymphalis antiopa* (Linnaeus)
22. *Vanessa atalanta* (Linnaeus)
23. *Vanessa cardui* (Linnaeus)
24. *Vanessa virginiensis* (Drury)
25. *Precis lavinia coenia* (Huebner)
26. *Limenitis arthemis astyanax* (Fabricius)
27. *Limenitis archippus watsoni* (dos Passos)
28. *Anaea andria* (Scudder)
29. *Asterocampa clyton clyton* (Boisduval and LeConte)
30. *Asterocampa celtis alicia* (Edwards)

FAMILY LIBYTHEIDAE

31. *Libytheana bachmanii bachmanii* (Kirtland)

FAMILY RIODINIDAE

32. *Lephelisca virginiensis* (Guérin)

FAMILY LYCAENIDAE

33. *Atlides halesus halesus* (Cramer)
*34. *Strymon m-album* (Boisduval and LeConte)
35. *Strymon cecrops* (Fabricius)
36. *Strymon melinus melinus* (Huebner)
*37. *Strymon favonius* (J. E. Smith)
*38. *Strymon ontario ontario* (Edwards)
39. *Strymon falacer* (Godart)
40. *Strymon liparops strigosus* (Harris)
41. *Mitoura gryneus gryneus* (Huebner)
*42. *Incisalia augustinus croesioides* Scudder
43. *Incisalia henrici turneri* Clench
*44. *Incisalia niphon niphon* (Huebner)
*45. *Feniseca tarquinius tarquinius* (Fabricius)
*46. *Lycaena thoë* (Guérin)
*47. *Hemiargus ceraunus antibubastus* Huebner
*48. *Echinargus isola alce* (Edwards)
49. *Everes comyntas comyntas* (Godart)

[1] Species marked by an asterisk were not included in either of the previously published lists of Mississippi butterflies (Weed, 1894; Hutchins, 1933).

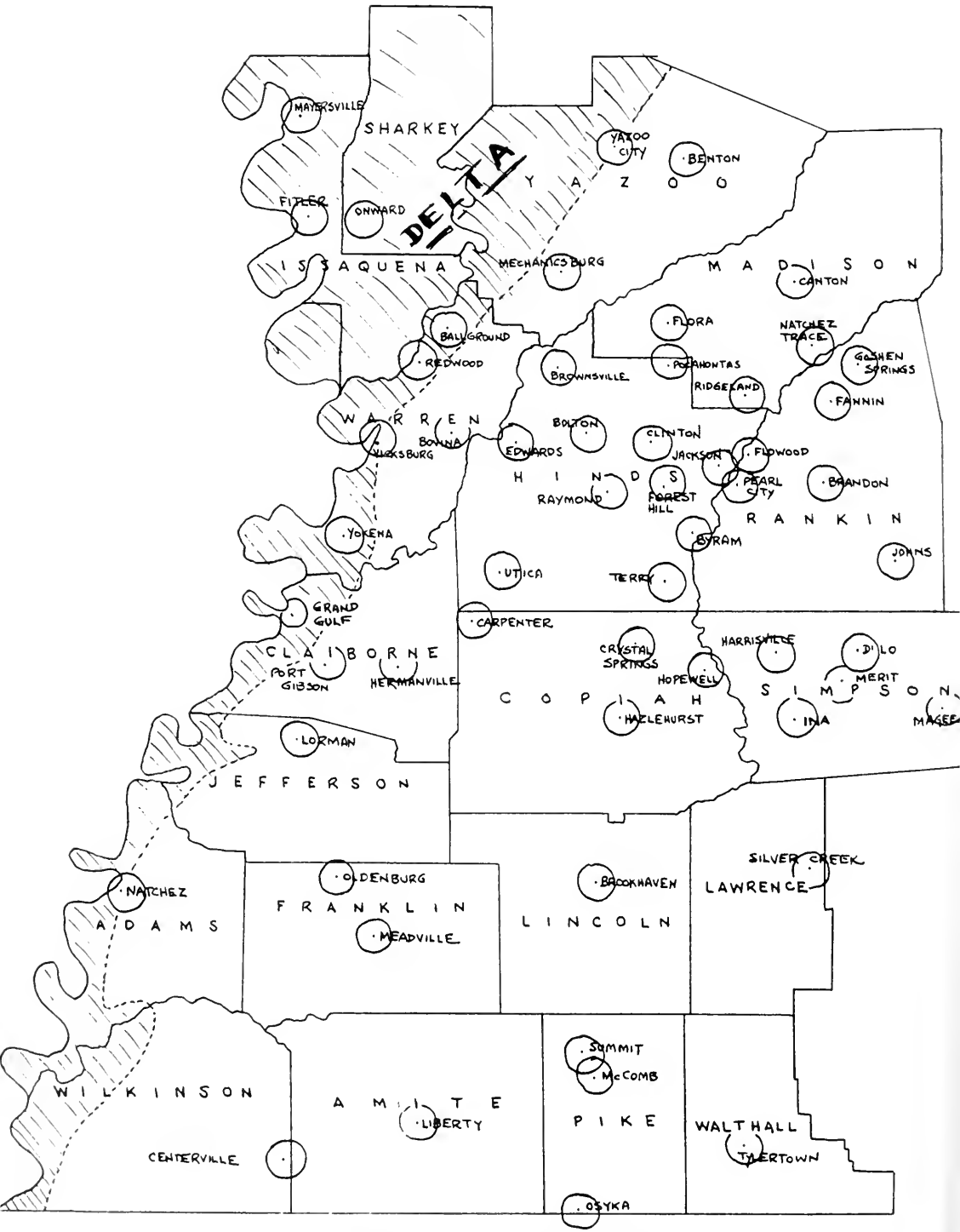

Figure 3. Localities in southwest Mississippi.

50. *Lycaenopsis argiolus pseudargiolus* (Boisduval and LeConte)

FAMILY PAPILIONIDAE

51. *Papilio polyxenes asterius* (Stoll)
52. *Papilio cresphontes cresphontes* (Cramer)
53. *Papilio glaucus glaucus* (Linnaeus)
54. *Papilio troilus ilioneus* J. E. Smith
55. *Papilio palamedes palamedes* (Drury)
56. *Graphium marcellus marcellus* (Cramer)
57. *Battus philenor* (Linnaeus)

FAMILY PIERIDAE

58. *Anthocaris genutia* (Fabricius)
59. *Colias eurytheme* Boisduval
60. *Colias philodice* Godart
61. *Zerene cesonia* (Stoll)
*62. *Anteos maerula lacordairei* (Boisduval)
63. *Phoebis sennae eubule* (Linnaeus)
64. *Phoebis philea* (Linnaeus)
65. *Eurema daira daira* (Latreille)
*66. *Eurema mexicana* (Boisduval)
67. *Eurema nicippe* (Cramer)
68. *Eurema lisa lisa* (Boisduval and LeConte)
69. *Nathalis iole* (Boisduval)
70. *Pieris rapae* (Linnaeus)
71. *Pieris protodice protodice* (Boisduval and LeConte)
72. *Ascia monuste phileta* (Fabricius)

SUPERFAMILY HESPERIOIDEA

FAMILY HESPERIIDAE

73. *Epargyreus clarus clarus* (Cramer)
74. *Urbanus proteus* (Linnaeus)
75. *Achalarus lyciades* (Geyer)
*76. *Autochton cellus* (Boisduval and LeConte)
77. *Thorybes bathyllus* (J. E. Smith)
78. *Thorybes pylades* (Scudder)
*79. *Thorbyes confusis* Bell
80. *Pyrgus communis communis* (Grote)
*81. *Pyrgus syrichtus* (Fabricius)
82. *Pholisora catullus* (Fabricius)
*83. *Pholisora hayburstii* (Edwards)
84. *Erynnis brizo brizo* (Boisduval and LeConte)
85. *Erynnis martialis* (Scudder)
86. *Erynnis horatius* (Scudder and Burgess)
87. *Erynnis juvenalis* (Fabricius)
*88. *Erynnis baptisiae* (Forbes)
*89. *Erynnis zarucco* (Lucas)
90. *Ancyloxypha numitor* (Fabricius)
*91. *Copaeodes minima* (Edwards)
*92. *Hesperia metea metea* Scudder
*93. *Hesperia attalus* (Edwards)
94. *Hylephila phyleus* (Drury)
95. *Atalopedes campestris* (Boisduval)
*96. *Polites verna sequoyah* H. A. Freeman
97. *Polites manataaqua* (Scudder)
98. *Polites themistocles* (Latreille)
99. *Polites vibex vibrex* (Geyer)
100. *Wallengrenia otho otho* (J. E. Smith)
*101. *Poanes zabulon* (Boisduval and LeConte)
*102. *Poanes yehl* (Skinner)
*103. *Atrytone arogos arogos* (Boisduval and LeConte)
*104. *Atrytone arpa* (Boisduval and LeConte)
*105. *Atrytone dion alabamae* (Lindsey)
*106. *Atrytone palatka* (Edwards)
*107. *Atrytone ruricola metacomet* (Harris)
*108. *Atrytonopsis loammi* (Whitney)
*109. *Atrytonopsis hianna* (Scudder)
110. *Oligoria maculata* (Edwards)
111. *Lerema accius* (J. E. Smith)
*112. *Amblyscirtes vialis* (Edwards)
*113. *Amblyscirtes hegon* (Scudder)
*114. *Amblyscirtes carolina* (Skinner)
*115. *Amblyscirtes textor* (Huebner)
*116. *Amblyscirtes alternata* (Grote and Robinson)
*117. *Amblyscirtes belli* H. A. Freeman
118. *Lerodea l'herminieri* (Latreille)
119. *Lerodea eufala* (Edwards)
120. *Calpodes ethlius* (Stoll)
*121. *Panoquina panoquin* (Scudder)
122. *Panoquina ocola* (Edwards)

B. *Species of Probable or Possible Occurrence in Mississippi*

SUPERFAMILY PAPILIONOIDEA

FAMILY SATYRIDAE

123. *Lethe eurydice appalachia* R. L. Chermock

FAMILY HELICONIIDAE

124. *Dryas julia delila* (Fabricius)

FAMILY NYMPHALIDAE

125. *Speyeria idalia* (Drury)
126. *Speyeria cybele cybele* (Fabricius)
127. *Euphydryas phaeton phaeton* (Drury)

FAMILY LYCAENIDAE

128. *Strymon titus mopsus* (Huebner)
129. *Strymon edwardsii* (Grote and Robinson)
130. *Strymon kingi* Klots and Clench

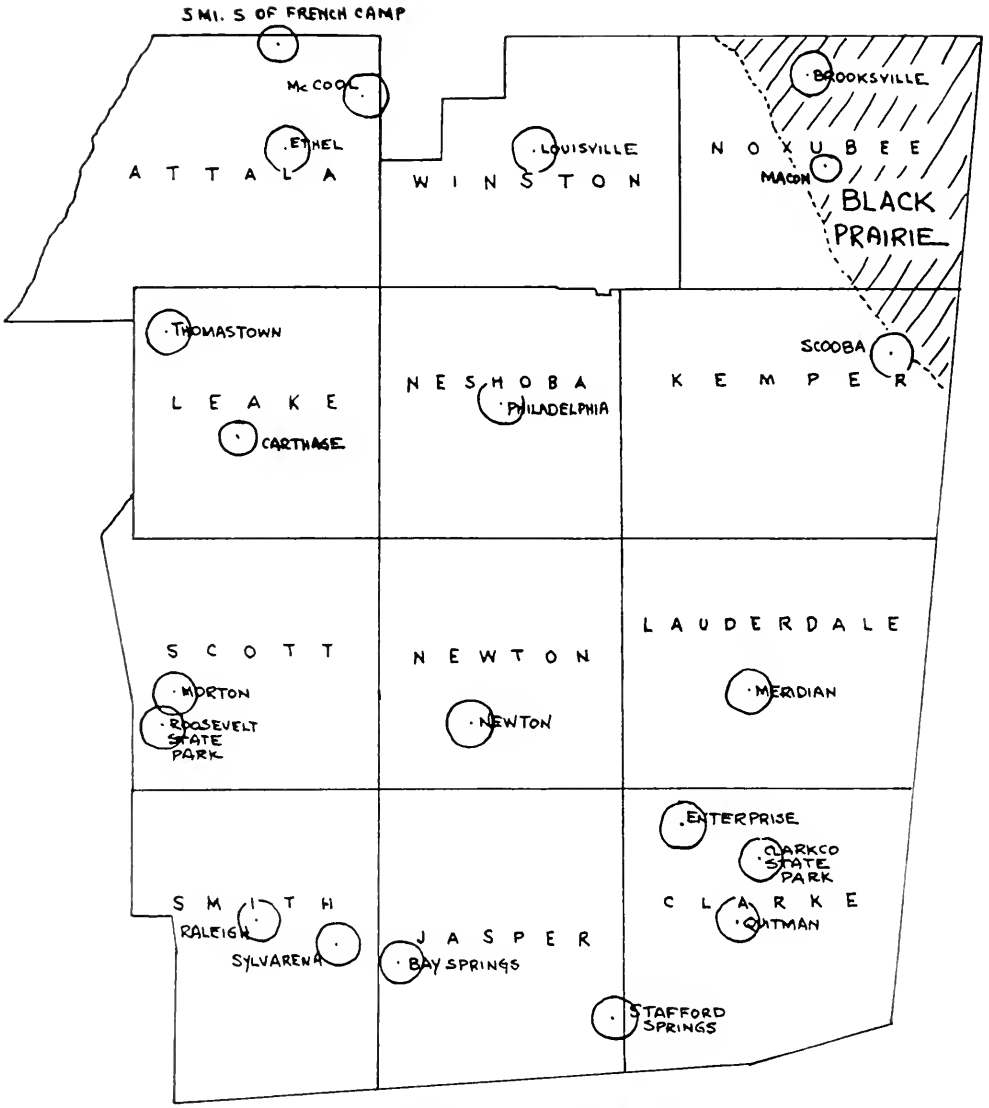

Figure 4. Localities in east central Mississippi.

131. *Strymon columella modesta* (Maynard)
132. *Mitoura hesseli* Rawson and Ziegler
133. *Incisalia irus irus* (Godart)
134. *Lycaena phlaeas americana* Harris
135. *Leptotes cassius theonus* (Lucas)
136. *Brephidium pseudofea* (Morrison)
137. *Glaucopsyche lygdamus lygdamus* (Doubleday)

FAMILY PAPILIONIDAE

138. *Battus polydamas lucayus* (Rothschild and Jordan)

FAMILY PIERIDAE

139. *Anteos clorinde nivifera* (Fruhstorfer)
140. *Phoebis agarithe maxima* (Neumoegen)
141. *Pieris virginiensis* Edwards

SUPERFAMILY HESPERIOIDEA

FAMILY HESPERIIDAE

142. *Celotes nessus* (Edwards)
143. *Erynnis icelus* (Scudder and Burgess)
144. *Erynnis persius* (Scudder)
145. *Erynnis lucilius* (Scudder and Burgess)

146. *Erynnis funeralis* (Scudder and Burgess)
147. *Copaeodes aurantiaca* (Hewitson)
148. *Hesperia leonardus stallingsi* H. A. Freeman
149. *Hesperia sassacus sassacus* Harris
150. *Hesperia meskei* (Edwards)
151. *Polites peckius* (Kirby)
152. *Poanes viator* (Edwards)
153. *Poanes hobomok hobomok* (Harris)
154. *Problema byssus* (Edwards)
155. *Atrytone logan logan* (Edwards)
156. *Atrytone berryi* Bell
157. *Atrytone dukesi* Lindsey
158. *Atrytone bimacula* (Grote and Robinson)
159. *Amblyscirtes linda* H. A. Freeman
160. *Lerodea neamathla* Skinner and Williams

FAMILY MEGATHYMIDAE

161. *Megathymus yuccae yuccae* (Boisduval and LeConte)
162. *Megathymus cofaqui* (Strecker)
163. *Megathymus harrisi* H. A. Freeman

VII. Annotated List of the Butterflies of Mississippi

A total of 163 species are discussed; part A lists the 122 that are known to occur; part B the 41 that we regard as probable or possible. The arrangement and, in general, the nomenclature follow that of the most recent published check list applicable to this region (Klots, 1951: 308-328). In some cases we have had difficulty in making an unequivocal determination as to what named population the Mississippi representatives of a given species should be assigned; such cases are discussed. There may be cases in which the Mississippi representatives of a given species represent more than one population; if so, we do not believe that we as yet have adequate data to support such a conclusion. "No two subspecies are permanent residents in the same locality" (Remington, 1951). We therefore do not assign to different subspecies, individual specimens, or groups of specimens apparently possessing the diagnostic characteristics of these different subspecies when the indications are that the specimens come from a single resident population in the same locality.

A published request (Mather, 1950b) for information on specimens, records, or references produced no response. Information not credited to others was obtained by us; information credited to others for which no publication reference is given, was obtained orally or by letter.

A. *Species Known to Occur*

SUPERFAMILY PAPILIONOIDEA

FAMILY SATYRIDAE

1. *Lethe portlandia portlandia* (Fabricius). Fifty-eight specimens are known from localities in four counties. One female taken at Vicksburg, Warren Co., by George Dorner in September 1908, is in the United States National Museum and was mentioned by Clark (1936a: 254). Brown (1949) indicated that it was known from one county in Mississippi. A series of 22 was examined in 1954 by Mr. William D. Field at the USNM. Of the 17 males, eight showed some transitional tendencies toward *L. portlandia anthedon* A. H. Clark, nine did not. The five females showed a yellowish suffusion within the ocelli below that is also shown by the USNM specimen from Vicksburg and by another USNM specimen from Mobile, Ala. *L. p. portlandia* was found by Mr. Field to have the antennal club above and below orange, while *L. p. anthedon* has this club behind the tip completely ringed with black. In the USNM series there is but a single exception to this in 102 specimens of *L. p. portlandia*, and but two in 124 specimens of *L. p. anthedon*. Mr. C. F. dos Passos wrote that this character seems to hold in his series. One Mississippi specimen, a male from Yazoo City, has this *anthedon* character. Prof. Chermock expressed the belief that *L. p. anthedon* might well be expected in the northeast corner of Mississippi. Specimens have been taken from 6 April to 5 November, except in May. The best localities we have found are along the Pearl River in Hinds and Madison Counties and near the Big Black River in northwestern Hinds County where giant cane, *Arundinaria gigantea*, is found. Specific localities and dates are: *Hinds Co.*—Brownsville: 19 July 1953, 25 July 1953 (4), 1 June 1954, 6 April 1957 (3), 8 June 1957 (M. & E. Roshore), 4 July 1957 (M. & E. Roshore), 24 August 1957, 22 September 1957 (M. & E. Roshore), 20 October 1957 (2) (1 M. & E. Roshore), 3 November 1957 (4) (M. & E. Roshore); Clinton: 2 July 1947, 16 August 1953, 23 August 1953 (3); Jackson (waterworks): 5 November 1955 (3). *Madison Co.*—

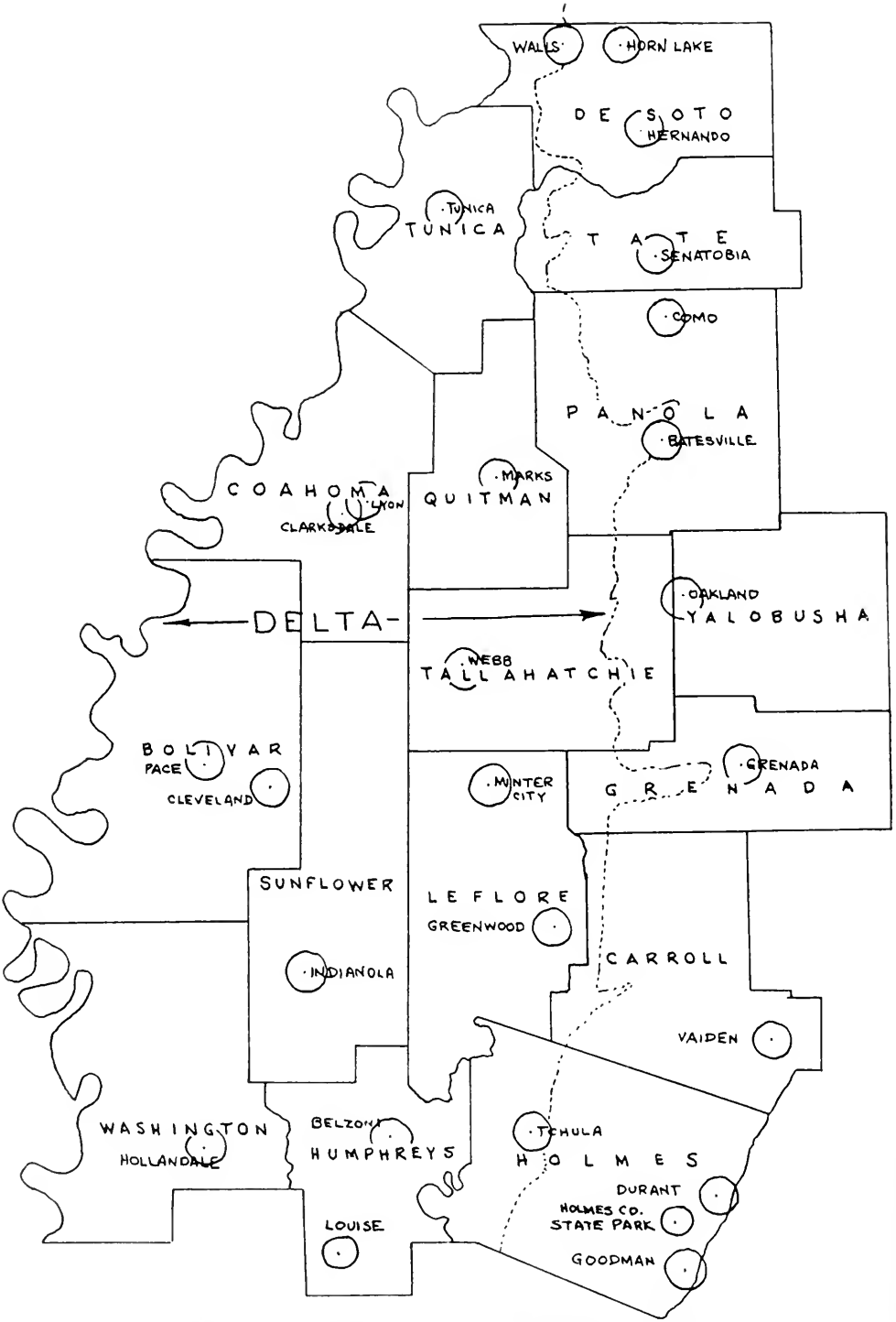

Figure 5. Localities in northwest Mississippi ("Delta")

Natchez Trace Cypress Swamp: 31 August 1952, 26 April 1953 (4), 29 August 1953 (4), 17 October 1953, 9 April 1954 (2), 6 June 1954, 6 September 1956, 7 September 1957 (14); Pearl River near Goshen Springs: 17 October 1953. *Warren Co.*—Vicksburg: September 1908 (George Dorner). *Yazoo Co.*—Yazoo City: 27 April 1951.

2. *Lethe creola* (Skinner). Nine specimens are known: *Hinds Co.*—Clinton: ♂ ♂: 30 July 1950, 8 July 1956, ♀: 11 September 1949; Brownsville: ♂: 17 July 1956 (John L. Daniel), ♀: 19 July 1953. *Madison Co.*—Natchez Trace Cypress Swamp: ♂ ♂: 31 August 1952 (2), 26 April 1953, 7 September 1957. Five of these were examined by Mr. Field and compared with the series in the U.S. National Museum. They agree with that series and with the original description (Skinner, 1897) based on specimens from Opelousas, La. Mr. A. H. Clark wrote to us on 10 December 1953: "In Skinner's original description of *Debis creola* the female is not *creola* but *L. p. portlandia.* I have a photograph of the underside that is unmistakable." A previous letter (12 November 1953) from Mr. Clark to Mr. E. N. Lambremont suggested that *L. p. portlandia* be added to Lambremont's manuscript on the butterflies of Louisiana on the basis of the true identity of the female mentioned above. This was done, but *L. creola* was deleted from the list. The type of *creola* is a male and is in the collection of the Academy of Natural Sciences in Philadelphia. Through the courtesy of Dr. H. J. Grant, one of us (B. M.) was permitted to examine the series of *creola* in the Philadelphia Academy of Natural Sciences on 11 July 1957. The type specimen (Type No. 7039), a male, is labelled Opelousas, La. 3 July 1897. The associated female, labelled Opelousas, La. 9 July 1897, carries the following label: "This specimen is actually a female *L. portlandia* and is thus incorrectly designated the allotype of *creola.* Paul R. Ehrlich X-9-51." *L. creola* should therefore be included among the butterflies known from Louisiana.

3. *Euptychia cymela cymela* (Cramer). This subspecies appears to occur generally over the state from March through September, except August. It was taken by Weed in northeast Mississippi in 1891-93 and by Jones on the Gulf Coast in 1910. It is most abundant in May.

4. *Euptychia hermes sosybia* (Fabricius). This subspecies appears to occur generally over the state from March through November. It was taken in northeast Mississippi in 1891-93 by Weed and in 1920 by Benjamin, on the coast in 1910 by Jones and in 1940 by O'Byrne. It is the most common member of this family in Mississippi. Brown (1949) indicated that it was known from three counties in Mississippi.

5. *Euptychia areolata areolata* (J. E. Smith). This and other names credited to "Abbot and Smith" in Klots' check list (1951) are credited in this report to "J. E. Smith" in accordance with the discussion of the question by Remington (1948) and Meiners (1948). Eighteen specimens are known, from eight localities in six counties, five southeastern and one northeastern; April through October, except May and July. Brown (1949) indicated that it was known from one county in Mississippi. Specific localities and dates are: *Tishomingo Co.*—Burnsville: 28 August 1955. *Forrest Co.*—Mississippi Southern College campus, Hattiesburg: 16 April 1955 (B. J. Miller) (ex coll. B. D. Valentine). *Marion Co.*—Goss: 15 June 1952. *Wayne Co.*—Waynesboro: 20 September 1953. *Jackson Co.*—Ocean Springs (Van Cleave Road): 13 June 1952 (7), 3 October 1953. *Harrison Co.*—Biloxi: 10 April 1921 (F. M. Jones); Gulfport: 4 September 1940 (4) (H. I. O'Byrne), 23 September 1951. The locality in Tishomingo County is within 12 miles of the Tennessee line and appears to constitute a significant extension of the known range of the species.

6. *Euptychia gemma gemma* (Huebner). This subspecies appears to occur generally throughout the state from March through November. It is less abundant than *E. hermes sosybia* and is found slightly earlier in the spring. It is less common in the south than elsewhere in the state.

7. *Cercyonis pegala pegala* (Fabricius). Four records, involving eight specimens, are known: *Forrest Co.*—Maxie: 22 Angust 1940, ♀, (H. I. O'Byrne); Shelby State Park: 24-25 July 1956 (5) (John L. Daniel). *Harrison Co.*—Gulfport: 4 September 1940, ♂, (H. I. O'Byrne). *Jackson Co.*—Fontainbleau: 3 October 1953, ♀. *Oktibbe-*

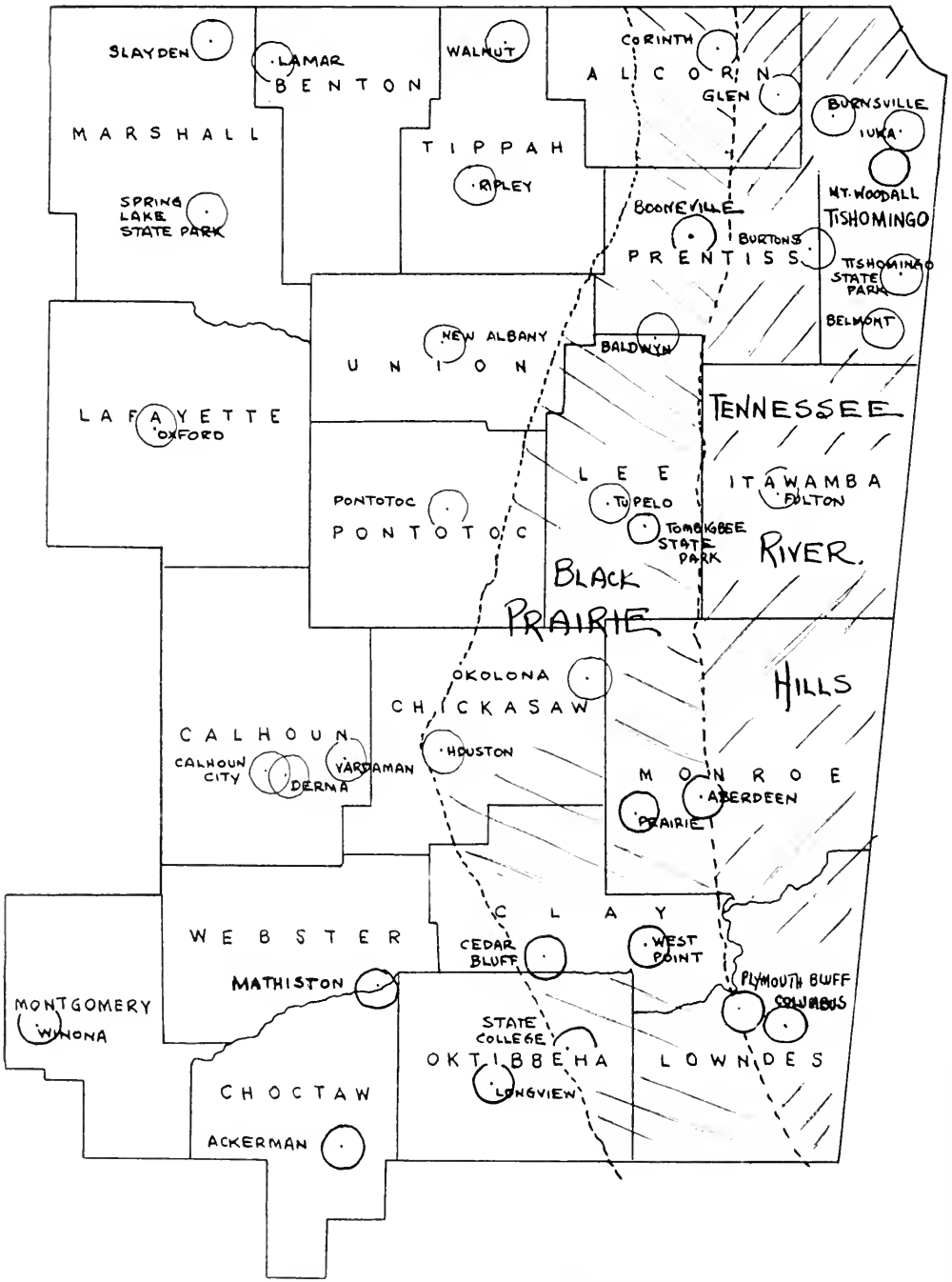

Figure 6. Localities in northeast Mississippi.

ha Co.—1891-93 "not common" (Weed, 1894); "Doubtful occurrence. Specimen in State College collection with no label" (Hutchins, 1933).

FAMILY DANAIDAE

8. *Danaus gilippus berenice* (Cramer). Nine records, each involving a single individual, are known: *Harrison Co.*—Long Beach: August 1916 (W. J. Frederich) (State College Coll.); Gulfport: September 1916 (C. C. Greer) (State College Coll.), 18 August 1940 (H. I. O'Byrne), 9 August 1953, ♂, forewing length 45 mm; Biloxi: 1910 (F. M. Jones), 8 August 1953 (sight record). *Jackson Co.*—Ocean Springs: 1891-94 (H. E. Weed) (State College Coll.); Moss Point: 12 May 1952 (sight record) (Lucien Harris, Jr.). *Hancock Co.*—Bay St. Louis: 14 August 1957 (M. & E. Roshore), ♀, forewing length 42 mm. All of these localities are on the Gulf Coast. These and other data through 1955 were discussed by Mather (1955a.)

9. *Danaus plexippus plexippus* (Linnaeus). Mississippi records through 1954 were discussed recently (Mather, 1955b). Adults have been observed by us in every five-day period from 5-10 March through 20-25 November in one or more of the nine years, 1946-1955. We have observed no winter hibernation and are thus unable to confirm Urquhart's suggestion (1955) that they overwinter in Mississippi. The earliest arrival we have noted was 8 March 1952, the latest departure 25 November 1953. We can supply some evidence as desired by Williams et al (1942) regarding the northward extension of the zone of complete absence in the summer. If such a zone exists in Mississippi, it does not extend very far to the north. We observed larvae on milkweed on 12 May 1957 and on 29 June 1947. Thomas E. Kennedy collected a number of larvae on milkweed on 27 April 1956 from which he reared a series of adults that emerged early in May. We observed freshly emerged adults on 26 May 1951 and 3 June 1949. Large congregations are frequently seen late in September and early in October, moving south. The annual flight in central Mississippi seems to occupy the period between the last killing frost in the spring and the first in the fall, which occur, on the average, on 19 March and 8 November, respectively. Our specimens range in forewing length from 41 to 57 mm.

Prof. A. B. Klots examined a series of 65 Mississippi *D. p. plexippus* from our collection (40 ♂♂, 25 ♀♀). He wrote: "The occasional specimen that resembles the tropical subspecies is probably just an individual variant; I don't think that there are enough of them to warrant even a guess that there may actually be a representation of the nonmigratory tropical subspecies. . . . The peculiar female from Clinton, 3 June 1951, is a fairly close match of a female I took in Florida in July, just very recently emerged. Of all your specimens, it could well be a member of a tropical stock."

FAMILY HELICONIIDAE

10. *Heliconius charitonius tuckeri* Comstock and Brown. On 23 April 1956, in the woods near the Shearwater Pottery, Ocean Springs, Jackson Co., Kilian Roever took four specimens. The only Alabama record (Chermock, 1950) was from Fairhope, Baldwin Co. on 22 November 1950. The Louisiana records (Lambremont, 1954) were in August and October. The Mississippi record thus appears to be the only one for it or adjacent states in the spring.

11. *Agraulis vanillae nigrior* Michener. This subspecies appears to occur generally over the state from July through November. It seems to be more abundant and to be found earlier in the season in central Mississippi in those summers preceded by a mild winter. Mississippi specimens are assigned to *A. v. nigrior* following Remington (1948), although many show tendencies toward *A. v. incarnata* and the northwestern part of the state is closer to localities in Arkansas from which examples of *A. v. incarnata* are known (Michener, 1942) than to localities in Alabama from which examples of *A. v. nigrior* are known; no specimens from Mississippi were among those listed by Michener.

FAMILY NYMPHALIDAE

12. *Euptoieta claudia* (Cramer). This species appears to occur generally over the state from February to November. We have reared specimens from larvae on *Passiflora incarnata* at Clinton, Hinds Co. (larvae collected by Tom and R. V. Tye). February specimens are characteristically very small.

13. *Speyeria diana* (Cramer). A female, taken at Gayoso Farm, Horn Lake, De Soto Co., by C. H. Crabill, is in the collection at

State College, where we have examined it. Mr. J. R. Jones, Jr. of Jackson, Miss., told us on 21 June 1953, that in about September 1932 he saw one in Tupelo, Lee Co. Mr. P. A. Glick wrote us on 14 January 1953, that he saw a female at Tallulah, La. near Vicksburg, Warren Co. *S. diana* should therefore be included among the butterflies known from Louisiana.

14. *Melitaea gorgone gorgone* (Huebner). This species is known only from Tishomingo Co. in the Tennessee River Hills. A female, taken in Tishomingo State Park, by Kilian Roever on 20 April 1952, determined by Mr. A. H. Clark as *"M. ismeria ismeria"*, was presented to us by Mr. Roever. Roever took additional specimens on 20-21 April 1956 at the same locality and at Mt. Woodall, the highest point in Mississippi, elevation 806 ft. One of us (B.M.) joined him at Mt. Woodall on 21 April 1956 and took a series of six specimens; and on 20 April 1957 and took three more. We have a series of specimens taken by Mr. Lucien Harris, Jr. at Stone Mountain, Ga. and a series taken by Mr. Raymond J. Jae at Red Rocks, Colo. These two series and the specimens from Mississippi were examined by Mr. C. F. dos Passos, on whose advice the Mississippi population is assigned to *M. g. gorgone*. Mr. dos Passos regards *M. g. carlota* as a population occurring in Colorado, Texas, Arkansas, Montana, Washington, Manitoba, Saskatchewan, and elsewhere in the northwest. We were unable to detect consistent differences among our Mississippi specimens, those from Georgia, and those from Colorado. The figure of *M. g. carlota* given by Klots (1951) differs from that of *M. ismeria* given by the Clarks (1951), but some Georgia specimens have the features mentioned by Klots for *carlota*, and some Colorado specimens have the *ismeria* features. Harris (1950) used the name *Phyciodes gorgone* for the species here designated as *P. phaon* and *P. ismeria* for the species here designated as *M. gorgone*. Of the specimens of *ismeria* from Georgia, he wrote that they had been examined by Mr. A. H. Clark who had said that they agreed with others from the west, from Texas to southern Canada. Mr. dos Passos stated that, in series, the difference between eastern *M. gorgone gorgone* and western *gorgone carlota* is quite pronounced, *carlota* being much duller on the upper side.

15. *Melitaea nycteis nycteis* Doubleday. This subspecies is quite abundant from time to time in a large number of rather restricted localities. Lambremont (1954) noted that one of the two Louisiana localities was from the Pearl River area near Mississippi. Our records are from Carroll, Hinds, Rankin, and Warren Counties, from April through August. We have taken about 60 specimens.

16. *Phyciodes phaon* Edwards. Thirty specimens are known; March through November. Specific localities and dates are: *Leflore Co.*—Greenwood: July 1955 (John Carr). *Madison Co.*—Pearl River near Goshen Springs: 17 October 1953 (3). *Warren Co.*—Vicksburg: 17 May 1952, 15 November 1952 (4). *Hinds Co.*—Jackson (waterworks): 15 October 1955, 5 November 1955 (3). Brownsville: 8 June 1957 (M. & E. Roshore), Bolton: 1 September 1957. *Amite Co.*—Liberty: 17 September 1955. *Wayne Co.*—Waynesboro: 20 September 1953 (7). *Harrison Co.*—Biloxi: 10 March 1910 (F. M. Jones), 5 April 1910 (F. M. J.), 11 May 1921 (F. M. J.); Long Beach: 2 August 1940 (H. I. O'Byrne); Gulfport: 21 March 1954. *Jackson Co.*—Ocean Springs: 14 June 1952; Fontainbleau: 3 October 1953.

17. *Phyciodes tharos tharos* (Drury). This is of the most common butterflies of Mississippi, found in all months of the year apparently in all localities. It is subject to considerable variation in size and in markings.

18. *Phyciodes texana seminole* (Skinner). One specimen is known, a female, found dead but still relaxed in an open longleaf pine-oak woods, in Lamar County, three miles west of Hattiesburg, on 3 November 1956 by Prof. and Mrs. Barry D. Valentine. The identification of this specimen was confirmed by Mr. William D. Field.

19. *Polygonia interrogationis* (Fabricius). Weed (1894) reported *P. interrogationis* as quite common on the State College campus and stated that the larvae fed on the cross vine (*Bignonia capreolata*). We have taken specimens in all months of the year. The light "winter" form ("fabricii") has been taken as early as 28 August and as late as 6 April; the dark "summer" form ("umbrosa") has been taken as early as 17 April and as late as 17 September. It is fairly

common and appears to be generally distributed over the state. It is most easily taken in numbers when attracted to the sap of wounded trees; we have taken it on willow and oak sap.

20. *Polygonia comma* (Harris). This species was not included in Weed's list (1894), but was included in Hutchins' list (1933) presumably on the basis of a specimen taken by Weed at State College, determined by F. H. Benjamin, and now in the collection there. Seventeen additional specimens are known, 15 representing the light "winter" form. Specific localities and dates are: Light form: *Warren Co.*—Vicksburg: 12 February 1952 (2), 3 April 1954. *Hinds Co.*—Brownsville: 13 March 1955, 4 March 1956, 18 March 1956 (2), 25 March 1956, 9 February 1957 (2, one by Thomas E. Kennedy), 3 November 1957 (M. & E Roshore); Clinton: 13 November 1955, 4 March 1956 (John L. Daniel), 24 March 1957, 5 October 1957 (M. & E. Roshore). Dark form: *Hinds Co.*—Clinton: 12 May 1957; Jackson: 21 May 1957.

21. *Nymphalis antiopa* (Linnaeus). Apparently this species occurs generally over the state. It was taken by Jones at Biloxi, Harrison Co. on the Gulf Coast, by Thomas E. Kennedy in Holmes Co., and by us in Hinds, Warren, Madison, and Tishomingo Counties. Only three specimens with yellow edges are known; we took these in May. Other specimens taken in October, January, February, March, and April, all have white edges. Two specimens with yellow edges were observed at Port Gibson, Claiborne Co. on 22 February 1957 by Warren Grabau.

22. *Vanessa atalanta* (Linnaeus). This species appears generally distributed over the state, but not numerous. It was taken by Jones at Biloxi, Harrison Co. There is a specimen from Oktibbeha Co. in the State College collection. We have taken specimens in all months except January, September, and October at localities in Hinds, Warren, Scott, Claiborne, Madison, and Harrison Counties.

23. *Vanessa cardui* (Linnaeus). Specimens have been taken in February, March, April, July, August, September, October and November. Dates for the spring flights are from 3 February to 7 May; specimens taken between these dates have a median forewing length of 27 mm (range 25-29 mm). The summer and fall specimens have been seen between 4 July and 21 December and have a median forewing length of 32 mm (range 31-35 mm). It was recorded by Weed (1894) and by Hutchins (1933). It appears to occur generally over the state; records are available from Alcorn, Harrison, Hinds, Holmes, Jefferson Davis, Lee, Montgomery, Oktibbeha, and Warren Counties. We found it present but very rare in 1947 and 1948, rather common in 1949, apparently absent in 1950 and 1951, abundant in 1952, rather scarce in 1953 and 1954, apparently absent in 1955 and 1956, and present in 1957. The size difference between spring and summer forms was reported by Field (1940); the alternation of periods of scarcity and abundance has been noted by Klots (1951), Clark (1932), and others.

24. *Vanessa virginiensis* (Drury). Common throughout the state and throughout the year. We have records for every month. It seems to be attracted to a wide variety of flowers.

25. *Precis lavinia coenia* (Huebner). Common throughout the state and throughout the year. We have records for every month. The variation in color of the hind wings beneath, from buff to purple, is found among specimens in our collection but we have not been able to associate it with a "dry" and "wet" habitat; specimens with both kinds of coloration often are found flying together. We have one specimen, taken at Clinton, Hinds Co. on 10 September 1949, that is very much like the specimen of *P. l. zonalis* (Felder) figured by Klots (1951, Plate 14, fig. 13).

26. *Limenitis arthemis astyanax* (Fabricius). Apparently rather common throughout the state, April through November. Most frequently seen alighting on leaves of tree branches overhanging woods roads at elevations from 10 to 20 feet above the ground. Dr. C. L. Remington, after examining a series of 25 Mississippi specimens, noted that they represent pure *astyanax* very far from any hybridization zone with *arthemis*.

27. *Limenitis archippus watsoni* (dos Passos). The Mississippi population is referred to *L. a. watsoni* (dos Passos, 1938) on the advice of Mr. dos Passos who wrote "the majority of your specimens approach

watsoni." One specimen in the O'Byrne collection (Box #130, University of Missouri), taken on 30 August 1940 at Saucier, Harrison Co., was determined by him as *L. a. floridensis*. A male, taken on 14 July 1933 at Iuka, Tishomingo Co., is in the collection of the Los Angeles County Museum (Martin and Truxal, 1955) and was determined as *L. a. archippus* by John A. Comstock. After examining a series of 34 Mississippi specimens (22 males, 12 females), Dr. C. L. Remington wrote: "The males are relatively uniform and are intermediate between our New Orleans series (*watsoni*) and the northeastern population, although closer to the New Orleans form. One male comes near the lightest southern Florida males, and one is of the northern type. The females are much more varied than the males. One taken at Johns, Rankin Co. on 12 August 1956, appears to be identical to New Orleans material, a second is similar, nine are like the males, and one taken at Clinton, Hinds Co. on 29 September 1951 matches many Connecticut specimens." Klots (1951) stated that *watsoni* is an intermediate, blend-zone form; it appears to us that the Mississippi population is an intermediate, blend-zone population. The species appears to be generally distributed over the state. We have records for all months from April through November.

28. *Anaea andria* (Scudder). This species appears to be common and widely distributed over the state. It flies rapidly and is rather difficult to take. We have records for all months. Specimens taken from April into September tend to have less strongly produced forewings and less reddish ground color. Forket (1900) reported taking *Anaea portia* at Ocean Springs, Jackson Co., in April 1899 and seeing one in March 1900. We believe that this report must refer to *A. andria*.

29. *Asterocampa clyton clyton* (Boisduval and LeConte). Klots (1951) stated that *A. c. flora* (Edwards) is found in the Coastal Plain, Georgia, south through Florida and Gulf States. The Mississippi population is assigned to *A. c. clyton* on the advice of Mr. dos Passos, who stated: "I believe that *flora* should be restricted to the Florida subspecies." All of our specimens came from Hinds Co. and were taken on dates in all months from May through October. Weed (1894) reported it from Oktibbeha Co.; seven Oktibbeha Co. specimens are in the State College collection.

30. *Asterocampa celtis alicia* (Edwards). After examining a series from Mississippi, Mr. dos Passos wrote: "These specimens do resemble *A. c. celtis*, but I feel we must apply the name of the southern population, *alicia*." We have found it common in the vicinity of hackberry trees (*Celtis laevigata*) from April through October. We have noted that it is apparently strongly, and equally, attracted to fresh manure and to us. Individuals have ridden for periods up to ten minutes on our shoulders or on the net handle.

FAMILY LIBYTHEIDAE

31. *Libytheana bachmanii bachmanii* (Kirtland). Apparently this subspecies is common and generally distributed over the state. We have records for all months. It is associated with hackberry, as are the two preceding species. We have observed a group that appeared to regard the hackberry tree in our yard as its territory. We use the spelling *bachmanii* rather than *bachmannii* as used by Klots (1951) on the advice of Mr. Field and Mr. dos Passos.

FAMILY RIODINIDAE

32. *Lephelisca virginiensis* (Guérin). This species is apparently widely distributed and probably more common than it appears to be. We have records for all months from March through October. Found in open fields on a wide variety of flowers, especially bitterweed (*Helenium tenuifolium*.) Specific localities and dates are: *Oktibbeha Co.*—State College: 25 August 1931 (R. E. Hutchins). *Hinds Co.*—Clinton: 16 October 1947, 12 August 1951, 29 September 1951, 30 September 1951, 8 June 1952, 27 July 1954, 24 July 1954, 7 August 1954, 26 July 1954, 1 August 1954, 18 April 1954, 18 October 1953, 24 July 1953, 22 October 1955, 24 June 1956, 1 September 1956, 30 September 1956, 20 October 1956, 7 June 1957, 26 June 1957; Edwards: 8 April 1954. *Madison Co.*—Natchez Trace: 14 October 1956. *Rankin Co.*—Johns: 12 August 1956. *Wayne Co.*—Waynesboro: 19, 20 September 1953. *George Co.*—Lucedale: 4 October 1953. *Forrest Co.*—Hattiesburg: 30, 31 March 1955 (B. & B. Valentine), 3 April 1955 (B. & B. Valentine), 25 May 1955 (B. J. Miller). *Jackson Co.*—

Ocean Springs: 13 June 1952; Van Cleave: 3 October 1953; Fontainbleau: 3 October 1953. *Harrison Co.*—Biloxi: 12 March, 5, 7, 11 April 1910 (F. M. Jones); Long Beach: 2 August 1940 (H. I. O'Byrne); Gulfport: 2 September 1940 (H. I. O'Byrne).

FAMILY LYCAENIDAE

33. *Atlides halesus halesus* (Cramer). After examining a series of specimens, Mr. H. K. Clench suggested that the Mississippi population is intermediate between *A. h. halesus* and *A. h. estesi* Clench, but from somewhat east of the middle of the transition zone. We have taken about 40 specimens on dates in February, March, April, June, September, October, and November. It appears to be widely distributed. Weed and Hutchins report it from Oktibbeha Co. Jones and we have found it on the Gulf Coast. Most of our specimens come from Hinds, Madison, and Warren Counties. We took eight males and four females on wild plum blossoms near Vicksburg, Warren Co. on 3 March 1955. Jung (1950) reported one taken on 30 May 1936 at New Orleans, La.

34. *Strymon m-album* (Boisduval and LeConte). Eight specimens are known: *Jackson Co.*—Moss Point: 9 August 1940 (H. I. O'Byrne). *Hinds Co.*—Clinton: 14 February 1951, 22 February 1957, 29 July 1951, 8 July 1956; Jackson: 3 March 1956. *Warren Co.*—Vicksburg: 3 March 1955. *Tishomingo Co.*—SW of Iuka: 28 March 1953.

Twenty-four additional specimens were taken in Hinds Co. in March 1958: Clinton: 28 March; Raymond: 20 March, 28 March (6), 30 March (5); Brownsville: 16 March (5), 22 March (6) (M. & E. Roshore).

35. *Strymon cecrops* (Fabricius). This is the commonest Mississippi *Strymon*, apparently occurring generally over the state. We have taken it in all months from February through October. In the early spring it is very abundant on fruit tree blossoms and on cedar and young oak leaves; in August and September it is very abundant on flowers such as goldenrod (*Solidago* sp.)

36. *Strymon melinus melinus* (Huebner). This is the second most abundant Mississippi *Strymon* and apparently occurs throughout the state. We have found it from February through October. Hutchins (1933) wrote: "This is the cotton square borer which often does considerable damage to cotton in the south." We have not found it in very large numbers at any one time and place. Clench, after examining a pair from Mississippi, wrote: "They are probably transitional between typical *melinus* (Fla., and the SE) and *S. m. franki* Field (Kans., Okla., Tex., eastern Colo., etc.)." We assume that the species listed by Weed (1894) as "*T. acadica*" is properly assigned here; no specimen labelled *acadica* is now in the collection at State College.

37. *Strymon favonius* (J. E. Smith). Kilian Roever wrote that he and A. B. Klots examined a specimen in the collection of the American Museum of Natural History in April 1956, taken by F. M. Jones at Biloxi, Harrison Co., on 12 May 1921. This was not included in the summary Dr. Jones provided to us since that summary was based on a list of specimens he collected in 1910 plus additions from pin-label data on specimens he collected in 1921 that were still in his collection. He was in Bixoli from 9 to 12 May 1921. Presumably this specimen was placed in the AMNM collection prior to the preparation of the summary in 1953.

38. *Strymon ontario ontario* (Edwards). Seventeen specimens are known, all taken at Clinton, Hinds Co.: 8 May 1948 (male), 21 May 1950 (female), 25 April 1953 (five males, three females), 2 May 1953 (female), 6 May 1953 (male), 29 April 1954 (two males, one female), 4 May 1957 (female), 11 May 1957 (male). The two specimens taken in 1948 and 1950 were examined by Mr. dos Passos who wrote: "they appear to be *ontario* and not *autolycus*." A pair taken in 1953 and 1954 was examined by Mr. Clench who wrote: "they are very different from true *ontario*, and I think probably constitute a nameable subspecies." A series, six males and two females, was examined by Mr. H. A. Freeman who wrote: "they look like my specimens from Arkansas, appear to be rather typical *ontario* and are not like the ones from Georgia." Most of our specimens were taken on blossoms of the farkleberry (*Vaccinium arboreum*). Most of the specimens have some orange on the forewing above, but not as much as the specimen shown on Fig. 13, Plate XXIX, of Holland (1947),

more like Fig. 22. Below, they are like Fig. 4, Plate 16, of Klots (1951) not like Fig. 3. Field (1940: 145) stated that *S. o. ontario* never has more than a slight amount of orange on the upper side in a few specimens. Freeman (1951a) stated that Arkansas specimens characteristically have no brown on the forewing above; some however integrade with *S. o. autolycus*. Kilian Roever said that our Mississippi specimens look more like *S. o. ontario* than his from western Tennessee. As noted by Freeman, they are more like *S. o. ontario* than those from Georgia.

39. *Strymon falacer* (Godart). Weed (1894) and Hutchins (1933) listed *S. edwardsii* as known from Mississippi, based on a specimen in the State College collection labelled: "Ag Coll Miss, May 1893, H. E. Weed." We borrowed this specimen and sent it to Mr. Clench for determination; he wrote: "a male, unquestionably *S. falacer*, looks very like our widespread typical *falacer*." We have taken three specimens at Clinton, Hinds Co., two on 21 May 1950 and one on 4 June 1950, on blossoms of New Jersey tea (*Ceanothus americana*). These were examined by A. B. Klots who wrote: "they show the type of variation that characterizes the deep south, clear-cut, slightly bluish marks beneath; in all a darker background and a bolder pattern." Two others were taken, one at Brownsville, Hinds Co., on 19 May 1957; and one at Clinton, Hinds Co., on 9 June 1957, by Mr. and Mrs. E. C. Roshore.

40. *Strymon liparops strigosus* (Harris). Hutchins (1933) stated, "Doubtful occurrence. One badly mutilated specimen in State College collection." We have examined this specimen; it has no wings; the pin labels read: "*Liparops*, June 1896, Ag Coll Miss, H. E. Weed; *Th. strigosa*; *S. liparops*." We took a female on 30 April 1955 at Raleigh, Smith Co. This specimen has been examined by W. D. Field, Lucien Harris, Jr., Kilian Roever, and John Symmes and determined as *S. liparops strigosus*. Our specimen is assigned to *S. l. strigosus* because it entirely lacks orange brown patches on the wings above. Klots and Clench (1952) stated that *S. l. liparops* consistently has a large fulvous patch on each forewing. The pattern of the markings on the hindwings of our specimen more nearly resembles that of the specimen of *S. l. liparops* (fig. 3C) than that of the specimen of *S. l. strigosus* (fig. 3D) illustrated by these authors. Since *S. l. liparops* was described from Georgia and has been recorded from Louisiana (Lambremont, 1954) and *S. l. liparops* was recorded from Arkansas and Tennessee (Klots, 1951), it is not unlikely that the Mississippi population is actually transitional between the two subspecies. Lambremont (1954) stated that the one specimen of *S. l. liparops* known from Louisiana, was taken on 12 June 1950.

41. *Mitoura gryneus gryneus* (Huebner). We have taken about 75 specimens, mostly of the spring brood (February, March, April). "Fall" brood specimens have been taken on 21 July 1956, 1 August 1954, 11 August 1951, and 12 August 1951. A series of 36 Mississippi specimens (four fall, thirty-two spring) was examined by Dr. J. Benjamin Ziegler, who wrote: "They seem to be by and large consubspecific with northeastern *gryneus*. There are perhaps some slight indications of clinal trends towards *castalis* on the one hand and toward *sweadneri* on the other, but individual variation is considerable and it seems that no actual separation is warranted." A series of five (one fall, four spring) was examined by Mr. Clench, who wrote: "They are *not* eastern *gryneus;* nor are they Florida *sweadneri*." Our specimens have all been taken on or near redcedar (*Juniperus virginiana*), many on white flowers, accompanied by *Strymon cecrops* and, in the spring in some localities, by *Incisalia henrici*.

42. *Incisalia augustinus croesioides* Scudder. One male was taken by Killian Roever on 28 March 1953 at Tishomingo State Park, Tishomingo Co. and was presented by him to us. It was examined by Mr. Clench, who wrote: "very likely represents the southern subspecies *croesioides* Scudder, much paler below than specimens I have seen from Alabama."

43. *Incisalia henrici turneri* Clench. Thirty-two specimens are known: *Tishomingo Co.*—SW of Iuka: 28 March 1953; Tishomingo State Park: 28 March 1953. *Hinds Co.*—Clinton: 1 April 1951; Brownsville: 13 March 1955 (5), 4 March 1956 (2), 18 March 1956 (6), 17 March 1957 (8), 6 April 1957. *Warren Co.*—Vicksburg: 3 March 1955. *Forrest Co.*—Camp

Shelby near Hattiesburg: 17 February 1944 (male) (C. D. Michener, in coll. C. F. dos Passos), 29 February 1944 (2) (C. D. Michener, in coll. AMNH). *Jackson Co.*—Van Cleave: 20 March 1954. *Hancock Co.*—Holly Bluff: 21 March 1954 (2). The Michener specimens in the AMNH are labelled *"Incisalia henrici margaretae"*. they were examined on 5 December 1956 by Mr. dos Passos who wrote: "They are one male and one female. In my opinion they are not typical, but one should really have a series from Camp Shelby and the type locality to be positive. Thus far too few of these things have been seen." He also wrote: "I doubt that *Incisalia henrici margaretae* occurs outside of Florida." Three of our specimens were examined by Mr. W. D. Field and determined as *I. henrici henrici* trans *margaretae*. Mr. Field regarded *turneri* as a synonym of *h. henrici,* noted that no specimens of *h. margaretae* from the type locality were in the collection of the USNM, compared our three with two from Southern Pines, N.C., found that they had somewhat longer tails than typical *henrici* and somewhat less contrasting limbal and basal areas below. dos Passos (1943) stated that specimens from Southern Pines, N.C. suggested that a link between *I. h. henrici* and *I. h. margaretae* might exist. A series of six of our specimens, including the three previously seen by Mr. Field, was examined by Mr. Harry K. Clench, who wrote: "They have little to do with the Florida subspecies *margaretae,* they seem nearly identical to subspecies *turneri* Clench, described from Kansas and occurring from there perhaps south into Texas, eastward at least to southern Ohio. Redbud (*Cercis canadensis*) seems to be the foodplant of *turneri.*" Raymond J. Jae of Denver, Colo. wrote regarding one of our specimens, that it checked with topotypes of *I. h. turneri.* A series of 16 of our specimens, including one from the Gulf Coast, two from the Tennessee River hills, and 13 from Hinds Co., was examined by Mr. dos Passos, who wrote: "The sexes do not appear to differ in coloring as they do in New Jersey and superficially all look alike except for size, however, some of your largest specimens are undoubtedly males. I should call them *I. h. turneri;* they are not *I. h. margaretae* nor *I. h. henrici,* so the nearest population which they resemble would be the proper name to apply. However they do not match *I. h. turneri* exactly either and if a study were made it might develop that a new name is warranted for Texas and Mississippi specimens." Our specimens were taken on cedar, oak, redbud, and wild plum blossoms.

Fifty additional specimens were taken at Brownsville and Raymond, Hinds Co., in March and April 1958.

44. *Incisalia niphon niphon* (Huebner). We have four specimens taken on 28-29 March 1953, SW of Iuka, Tishomingo Co. Kilian Roever took three at the same time, and on 21 April 1956 he took a female ovipositing on pine in Tishomingo State Park.

We took a series of forty-four, 40 ♂♂ and 4 ♀♀, south of Raymond, Hinds Co., on plum blossoms on 15, 22, 28, and 30 March 1958.

45. *Feniseca tarquinius tarquinius* (Fabricius). Fifteen specimens are known: *Hinds Co.*—Clinton: 23 July 1950; Brownsville: 19 July 1953 (3), 25 July 1953 (2), 1 July 1956 (3), 17 March 1957, 8 June 1957 (M. & E. Roshore), 30 May 1957, 6 July 1957 (2). *Jackson Co.*—Van Cleave: 20 March 1954. In a note (Mather, 1952b) on the specimen from Clinton, mention was made that it was taken in the vicinity of hawthorn (*Crataegus*); the Brownsville specimens were taken in the vicinity of beech (*Fagus grandifolia*).

Six additional specimens were taken at Brownsville on 30 March, 4 and 6 April 1958 by M. & E. Roshore.

46. *Lycaena thoë* (Guérin). The single known specimen from Mississippi, a female, was taken by us at Pace, Bolivar Co., on 27 April 1951 at 1 p.m. on pink clover at the side of State Highway No. 8. Mr. Clench wrote that it seems to be typical although the hind wing underside is a bit whiter than usual. A note of this occurrence was published (Mather, 1954a).

47. *Hemiargus ceraunus antibubastus* Huebner. Three specimens are known. One, a male, was taken by us at Lucedale, George Co. on 4 October 1953; another was taken by Kilian Roever at Ocean Springs, Jackson Co. on 23 April 1956; the third was taken at Clinton, Hinds Co. on 6 July 1957 by Mrs. E. C. Roshore.

48. *Echinargus isola alce* (Edwards). We took one specimen at Jackson, Hinds Co. on 25 June 1955. It was examined by Mr. Field and assigned by him to subspecies *alce* Edwards on the basis of considerations previously reviewed by him (Field, 1942). The name used differs from that given by Klots (1951) on the advice of Professor Nabokov (1953) who pointed out that *isola* is not a Latin adjective and thus cannot be rendered *isolus* to agree in gender with the generic name. Other writers have questioned the generic status of *Echinargus*, regarding it as no more than a weak subgenus of *Hemiargus*. Nabokov (1953) noted that *isola* and the two other species he included in *Echinargus* constitute a neotropical group. He regarded *isola* as less securely established in the Nearctic than representatives of other neotropical groups such as *G. marcellus*, *S. melinus*, *P. communis*, and *E. clarus*. He also wrote to us: "There is no such subspecies as *alce* (which is an inconsistent form and thus merely a synonym of *isola*)." Since but one specimen is known from Mississippi there is no basis for assignment of the Mississippi population to a subspecies on the basis of its typical characteristics. The assignment to *alce* serves to provide a convenient citation to a description of the specimen that is at hand. Lambremont (1954) recorded five specimens from Louisiana, all taken in June 1950 at localities 12 to 17 miles west of the Mississippi River. Klots (1951) stated that the range is almost entirely west of the Mississippi River.

49. *Everes comyntas comyntas* (Godart). Common throughout the state and throughout the year except in December and January. Subject to considerable variation in color and size. It is the most abundant member of the family in Mississippi.

50. *Lycaenopsis argiolus pseudargiolus* (Boisduval and LeConte). Apparently generally distributed over the state. We have taken specimens in all months except July, October, November, December, and January. Most frequent in March and April. Hutchins (1933) reported that he had only taken two specimens in Mississippi. The State College collection includes a specimen taken by H. E. Weed at State College, Oktibbeha Co., in May 1893. F. M. Jones took it at Biloxi, Harrison Co., on 7 March and 24 April 1910. Two specimens, taken and determined by F. H. Benjamin, are in the State College collection: 27 June 1920, Longview, Oktibbeha Co., "f. transneglecta", and 7 August 1921, Cedar Bluff, Clay Co., "f. neglecta". A pair taken at Clinton, Hinds Co. on 8 March 1953 (male) and 6 May 1951 (female) was examined by Mr. H. K. Clench, who wrote of the male: "This spring form is very like the common form I took in the spring in Michigan, and it is not either "marginata" or (obviously) "lucia". There is a difference between northern and southern Michigan in the spring forms—in the north you get "marginata" and "lucia" . . . in southern Michigan you get the form like this one from Mississippi, which also occurs in Pittsburgh." Of the May female, he wrote: "Looks like the common summer form, which I cannot distinguish from anywhere in the eastern half of the continent."

We have examined a series of 59 specimens (46 ♂♂, 13 ♀♀) representing dates in the months February through June and August. The variation by sex and month follows. *Males*. February (4): Ground color beneath is pale brownish gray with quite heavy brown spots. March (17): Sixteen are like the March group, one (Van Cleave, Jackson Co., 20 March 1954) has the underside ground color paler and more grayish and has smaller spots. April (8): Beneath all resemble the March specimen from Van Cleave, above four show a tendency to development of a whitish discal area in the hindwing. May (9): Five are quite pale gray beneath with most of the spots smaller and paler but with a few of the spots quite distinct, three are still grayer beneath with the spots even more reduced in size and darkness, one is indeterminate. In six the whitish discal area in the hindwing above is present. June (4): Beneath they are like the group of five from May, two show the whitish discal area in the hindwing above. August (4): The ground color beneath is a little darker than the June group and has a brownish cast, there are a few quite distinct black spots near the anal margin of the hindwing beneath and a few other scattered small but distinct black spots whose location is not constant. All have the whitish discal area on the hindwing above. *Females*. February (1) and March (3): Pale grayish brown beneath,

darker and browner than the February males, with fairly large brown spots. Ground color above is uniformly blue. April (2): Pale gray below with the spots smaller and lighter. Beginning to show white in the discal area of the forewings above. Hindwings above are pale gray with the blue much reduced and concentrated along the veins. May (3): Like the April group except beginning to show sharp dark spots near the anal margin of the hindwing below. June (2): Like May specimens except that the dark spots near the anal margin of the hindwing below are more pronounced. August (2): Like June except that the ground color beneath is beginning to be brownish and the spots are beginning to darken and enlarge.

FAMILY PAPILIONIDAE

51. *Papilio polyxenes asterius* (Stoll). Moderately abundant and apparently generally distributed over the state. We have taken specimens in all months except November through January. It is a pest on our parsley patch. Listed by Weed (1892) from Mayersville, Issaquena Co.

52. *Papilio cresphontes cresphontes* (Cramer). Moderately abundant and apparently generally distributed over the state; March through September. Specimens show considerable variation in size and markings. Apparently associated with hercules club (*Zanthoxylum clava-herculis*). A series of 30 specimens (16 ♂♂, 14 ♀♀) showed a forewing length distribution as follows: 54-59 mm: 6 ♂♂; 60-64 mm: 7 ♂♂, 3 ♀♀; 65-69 mm: 3 ♂♂, 5 ♀♀, 70-74 mm: 6 ♀♀. Individual data on these specimens are: *Hinds Co.*—Clinton: 20 May 1956 ♂ 59 mm, 25 June 1949 ♀ 67 mm, 6 July 1952 ♂ 61 mm, 10 July 1955 ♀ 74 mm, 17 July 1947 ♂ 66 mm, 24 July 1954 ♀ 69 mm, 26 July 1952 ♀ 72 mm, 28 July 1956 ♀ 65 mm, 30 July 1955 ♂ 65 mm, 3 August 1953 ♀ 64 mm, 8 August 1954 ♀ 69 mm, 16 August 1952 ♀ 71 mm, 18 August 1952 ♂ 63 mm; Jackson: 26 March 1949 ♂ 54 mm; Brownsville: 8 April 1956 ♂ 59 mm, 1 July 1956 ♂ 59 mm, ♂ 62 mm, 19 July 1953 ♂ 59 mm, ♂ 61 mm. *Warren Co.*—Bovina: 31 July 1955 ♂♂ 61, 63, 64 mm, ♀♀ 71, 73 mm, 2 August 1956 ♀ 62 mm, 7 August 1955 ♀ 64 mm. Ballground: 16 August 1952 ♂ 55 mm, ♀ 70 mm. *Jackson Co.*—Moss Point: 14 June 1952 ♂ 69 mm. *Harrison Co.*—Biloxi: 14 June 1952 ♀ 69 mm.

53. *Papilio glaucus glaucus* (Linnaeus). Moderately abundant and apparently generally distributed over the state; March through October. All females so far found by us have been dark, although one shows a dusting of yellow scales. Prof. Ralph Chermock wrote us that "In south Alabama the specimens are referable to *P. glaucus australis*, northern examples are *P. g. glaucus*, with a cline between." Prof. Barry Valentine wrote that he took a yellow female together with three males on 13 August 1950 at Akron, Hale Co., Alabama, a locality within 35 miles of the Mississippi line and 180 miles north of the Gulf of Mexico. Dr. Lincoln P. Brower wrote that there is a yellow female from Biloxi, Harrison Co. in the collection of Mr. C. F. dos Passos. Early spring specimens tend to be quite small; a male taken at Clinton, Hinds Co. on 8 March 1953 had a forewing length of 36 mm. Fall specimens are quite large; a female taken at Hattiesburg, Forrest Co. on 23 Septembre 1951 had a forewing length of 68 mm. These data were discussed by Mather (1954b).

54. *Papilio troilus ilioneus* J. E. Smith. This is the most abundant swallowtail in Mississippi; apparently generally distributed over the state; February through October. The Mississippi population is assigned to *P. t. ilioneus* on the advice of Mr. dos Passos who examined a series of seven Mississippi specimens, five males and two females.

55. *Papilio palamedes palamedes* (Drury). Apparently fairly common in the southern part of the state, rare in central and northern Mississippi. One specimen taken by A. J. Laoner at State College, Oktibbeha Co. on 1 April 1950 is in the collection there. We took specimens at Clinton, Hinds Co. on 27 June 1948 and 19 July 1952; all other records are from the southern counties; March through October.

56. *Graphium marcellus marcellus* (Cramer). Apparently generally distributed and locally rather abundant; February through August. The spring form, with shorter tails, is found from February through April; the summer form, with longer tails, May through August. The earliest record that we have is of a specimen taken at Ball-

ground, Warren Co. on 9 February 1957 by Mrs. E. C. Roshore.

57. *Battus philenor* (Linnaeus). Weed (1894) reported *philenor* as much rarer in northeastern Mississippi than *P. troilus* which he said was very common. Hutchins (1933) reported *philenor* as common about with honeysuckle bushes in the spring. Our records indicate it to be second in abundance in Mississippi only to *troilus* among the swallowtails. We have records from 22 localities in 15 counties located in all sections of the state. We have examined a series of 74 specimens taken on dates in all months except November, December, and January. Our earliest specimen was taken on 9 February 1952 at Jackson, Hinds Co., our latest on 17 October 1953 on the Pearl River, Madison Co. The series of 74 specimens included 62 males and 12 females. The mean forewing length of the series is 45.40 mm and the standard deviation is 5.90 mm. The greatest forewing length is 59 mm, a female from Jackson, Hinds Co., taken on 18 August 1956; the least is 32 mm, a male from Brownsville, Hinds Co., taken on 13 March 1955. The largest males have a forewing length of 56 mm and were taken at Crystal Springs, Copiah Co., 21 August 1955 and at Clinton, Hinds Co., 30 August 1952. The smallest female has a forewing length of 38 mm and was taken at Mt. Woodall, Tishomingo Co., 20 April 1957. One specimen, a male taken at Clinton on 11 May 1952, having a forewing length of 44 mm, has very short tails. A few males are distinctly greenish, a few are royal blue. The mean forewing length of the males is 45.34 mm; that of the females is 45.75 mm. The observed range, 32 to 59 mm, is approximately ± 2.3 times the standard deviation. Only 2 of the 74 specimens have forewing lengths outside the range of plus and minus two standard deviations from the mean. Brown (1951) noted that, on the average, in a perfectly random sample of 100 specimens from a homogeneous population, five specimens will differ from the mean by more than two standard deviations. The tendency for size to increase through the year from spring to fall was reported by the Clarks (1951) who said that, in Virginia, the early spring individuals appearing shortly after the middle of April had forewings about 40 mm long, while summer individuals had forewings 50 to 55 mm long in males and 50 to 60 mm long in females. Field (1940) stated that the spring form had forewings "never more than 40 mm in length" and the typical form had forewings between 45 and 55 mm in length. The disproportionate sex ratio does not seem to have been commented on previously although it is suggested by Lambremont (1954) whose series from Louisiana included 13 males and four females. His earliest date was 1 February 1949 and his latest 16 October 1940. Five of the specimens in our series were taken by Wilbur I. Luke and one each by Olivette C. P. McGough and Thomas E. Kennedy.

FAMILY PIERIDAE

58. *Anthocaris genutia* (Fabricius) Apparently widespread but local. We have taken 54 specimens (45 ♂♂, 9 ♀♀). Specific localities and dates are: *Tishomingo Co.*—Tishomingo State Park: 20 April 1952 (2 ♂♂) (Kilian Roever), 28 March 1953 (♂). *Marshall Co.*—Spring Lake State Park: 20 April 1952 (3 ♂♂, 2 ♀♀). *Oktibbeha Co.*—State College: 1 April 1917 (3 ♂♂) (collector not known), 19 April 1950 (♂) (C. Blackwell). *Clay Co.*—West Point: 11 April 1954 (♀). *Hinds Co.*—Clinton: 6 April 1947 (♂), 17 April 1949 (♂, ♀), 18 March 1950 (3 ♂♂), 3 March 1951 (2 ♂♂), 10 March 1951 (♂), 25 March 1951 (4 ♂♂), 31 March 1951 (♂), 1 April 1951 (2 ♂♂), 29 March 1952 (♂), 7 April 1952 (2 ♂♂), 19 April 1952 (♀), 8 March 1953 (3 ♂♂), 15 March 1953 (5 ♂♂), 21 March 1953 (2 ♂♂), 5 April 1953 (2 ♂♂), 26 March 1954 (2 ♂♂), 30 March 1954 (♀), 1 April 1954 (♀), 4 April 1954 (♀), 20 March 1955 (2 ♂♂), 17 March 1956 (♀) (John L. Daniel), 1 April 1956 (♂, ♀), 16 March 1957 (2 ♂♂), 24 March 1957 (♂). Brownsville: 13 March 1955 (♂). Bolton: 5 April 1953 (2 ♂♂). From these data it will be apparent that we have no data from the southern counties and no evidence of a second brood. It is also apparent that the males emerge earlier than the females.

59. *Colias eurytheme* Boisduval. We have more than 600 records of the occurrence of *C. eurytheme* in Mississippi. These records involve 74 localities in 47 counties distributed throughout the state, including

all physiographic regions; and dates in all months of the year. Weed (1894) reported *C. eurytheme* as very abundant throughout the year. Hutchins (1933) reported it as very common. A series of 227 specimens in our collection included 118 males and 109 females (45 orange, 64 white) taken at localities in 14 counties and on dates in all months. A study of time distribution of the records and of the data on the series of 227 specimens suggests that there are periods of spring and fall abundance separated by periods of summer and winter scarcity. The period of spring abundance begins about the first of February when the average temperature has risen to about 50°F and continues until about mid-June when it reaches about 80°F. The period of fall abundance begins about mid-October when the average temperature has fallen to about 60°F and continues until about the first of December when it falls to about 50°F. We have no indication that adults are ever completely absent during either period of scarcity. There have been three Januaries in the 10-year period, 1947-57, in which we have observed no adults flying, but there have been days in almost every year on which they have been seen in spite of freezing weather earlier the same day. Hovanitz (1951) reported that *C. eurytheme* was found in northern Florida only during February, March, and early April, and in October or November. He stated that it does not seem to maintain itself for a longer period in the consistently warm and humid summer climate. He wrote (1953): " . . . in the Gulf Coast, the hot, humid weather appears to destroy the populations completely." Our records for the Mississippi counties along the Gulf Coast are not numerous but they include not only March, April, and October, but also May, June, and August; specifically: *Harrison Co.*—Gulfport: 4 May 1952, 12 June 1952. *Jackson Co.*—Pascagoula: 14 June 1952, Moss Point: 14 June 1952, Ocean Springs: 8 August 1953.

Hovanitz (1950b) indicated that the percentage of white females of *C. eurytheme* to be expected in this region would be in the range of 20-25 percent. Our data do not permit accurate verification of this range because of our bias in collecting. Of 109 females in our collection, 64 are white. This reflects, in part, our tendency to collect white females preferentially. It is our impression that of the order of 30 percent of the females are white. Of the females in our collection, we have more white than orange for all months for which we have more than seven females, except for February. Of nineteen February females, 7 are white, 12 are orange. We believe that this ratio is close to that for the population, since our February collecting has been less selective than at other times of the year. We doubt that we could, using normal manual collecting techniques, collect a random sample from an abundant population containing varieties that are recognizable at a distance and present in significantly different proportions. Gerould (1946) found in 1943 that when he and non-technical assistants both collected *C. eurytheme* and *C. philodice* in New Hampshire, *C. eurytheme* made up 11.8 per cent of the 762 specimens he collected and only 7.4 percent of the 1090 collected by others. Although he tried to collect at random he was unable to avoid preferentially collecting the rarer variety.

Our data refer to a *C. eurytheme* population for which alfalfa (*Medicago sativa*) is not an important food plant. Alfalfa is grown on less than 0.1 percent of Mississippi farm land and over 60 percent of the alfalfa acreage is in four northwestern counties along the Mississippi River (Bolivar, Coahoma, Tunica, and Washington) from which we have no specimens. The majority of our specimens came from Hinds Co. in which in 1949, there were but 36 out of 440,000 acres of farm land in alfalfa (U. S. Bureau of the Census, 1952). We understand that less and less alfalfa has been grown in Hinds Co. in the years since 1949. We have virtually no data on plant preferences, most of our specimens having been taken in fields that had not been seeded to any given crop. We have taken specimens on white clover, red clover, crimson clover, and white sweetclover. We have seen a female oviposit on a low yellow-flowering legume locally known as lespedeza. Hovanitz (1948) stated that *C. eurytheme* does not find red clover (*Trifolium pratense*) a suitable food; Clark (1932) reported that he had found females of *C. eurytheme* ovipositing on red clover. Hovanitz (1943a) stated that in California *C. eurytheme* does not have definite broods. Our observations

tend to suggest that this is likewise the case in Mississippi.

The variation of size, wing shape, color, and pattern of *C. eurytheme* has been described by many authors. The Mississippi population shows most of the types of variation described in detail by the Clarks (1951). Small pale males are found from November to April and have forewing lengths in the range 17 to 23 mm, with a mean of 20 mm. Large dark males are found throughout the year, mostly from April until November, with forewing lengths from 22 to 30 mm, with a mean of 25 mm. The females have forewing lengths from 18 to 32 mm. The white females do not appear to have a significantly different forewing length distribution from that of the orange females. The smallest and largest specimens in our series are: *Males*. 17 mm Clinton, Hinds Co. 20 February 1949; 30 mm Clinton, Hinds Co. 31 May 1948; *Orange females*. 18 mm Clinton, Hinds Co. 8 February 1953; 31 mm Clinton, Hinds Co. 5 October 1952, 21 October 1951, 23 November 1950, Natchez Trace, Madison Co. 17 October 1953; *White females*. 19 mm Jackson, Hinds Co. 13 February 1954, Clinton, Hinds Co. 22 February 1949, 30 May 1951; 32 mm Vicksburg, Warren Co. 15 November 1952. The hindwing lengths of the specimens in the series range from 13 to 25 mm. The forewing lengths average 1.3 times the hindwing lengths. We took one orange female on 5 June 1949 at Clinton, Hinds Co. that had its left forewing reduced to about one half the area of the right forewing, left forewing length 16 mm, right forewing length 28 mm.

Females show greater variation in color and pattern than males, white females show greater variation than orange females. The discal spot on the hindwing above is orange in all of the 118 males and in all of the 45 orange females, becoming red in some dark November individuals. Among the 64 white females it is orange in 45, yellow in 18, and straw colored in one taken at Clinton, Hinds Co. on 6 May 1953 having a forewing length of 26 mm. Remington (1954) noted that the color of this spot is not a good species recognition character. The width of the marginal black band in the forewing above in the females and the degree to which it borders the included orange, yellow, or white spots inwardly, have been suggested as characters for separating *C. eurytheme* and *C. philodice*. Among the 45 orange females, eight February specimens and one March specimen have the narrower border that characterizes typical *C. philodice*. The 64 white females show greater variation. One October specimen has very wide black borders with no white spot between veins Cu_1 and Cu_2 and only very small white spots anywhere within it. One May specimen has the white spots so enlarged that they occupy nearly half the area of the black border but are still well bordered inwardly by black. One specimen each taken in March, May, November, and December, and three taken in April have the inner black boundary of the white marginal spot between Cu_1 and Cu_2 obsolescent as in typical *C. philodice*.

Among the 64 white females there are three that have a distinctly cream color: *Jackson Co.*—Pascagoula: 14 June 1952, forewing length 30 mm; *Harrison Co.*—Biloxi: 4 October 1953, 31 mm; *Hinds Co.*—Clinton: 15 November 1953, 29 mm. The first two taken on the Gulf Coast, have the hindwing discal spot above orange, in the third, this spot is yellow.

The distribution of data on month of capture and forewing length by major classes for the 227 measured specimens is given in Table 1.

60. *Colias philodice* Godart. We credit this name to Godart rather than to Latreille on the advice of Mr. dos Passos. Klots (1951) apparently followed the conclusions reached by Brown (1941) on this question. On the basis of additional information, Mr. dos Passos reached a different conclusion. We assign to this species the specimens of the *C. eurytheme - C. philodice* complex, the ground color of which is completely yellow; no orange. Such specimens are rare in Mississippi; there are four in the State College collection; we have taken five others, all but one of our specimens were taken while they were flying in company with *C. eurytheme*. Weed (1894) reported *C. philodice* as quite abundant, but not so much as *C. eurytheme*. Hutchins (1933) reported *C. philodice* as common. Lambremont (1954) found it rare in Louisiana, only one specimen being known. Hovanitz (1950a) indicated the southern limit of the distribu-

TABLE 1. *Collection data and forewing lengths for Colias eurytheme.*

	small	large					grand
	——MALES——			——FEMALES——			
month	pale	dark	total	orange	white	total	total
Jan.	3	0	3	0	0	0	3
Feb.	77	1	78	12	7	19	97
Mar.	8	0	8	6	8	14	22
Apr.	1	8	9	3	13	16	25
May	0	6	6	6	10	16	22
June	0	2	2	4	3	7	9
July	0	0	0	0	1	1	1
Aug.	0	1	1	1	0	1	2
Sep.	0	0	0	2	0	2	2
Oct.	0	1	1	6	14	20	21
Nov.	2	3	5	5	8	13	18
Dec.	4	1	5	0	0	0	5
total:	95	23	118	45	64	109	227
length mm							
17	1	0	1	0	0	0	1
18	5	0	5	1	0	1	6
19	26	0	26	0	3	3	29
20	29	0	29	4	5	9	38
21	18	0	18	3	2	5	23
22	12	3	15	3	1	4	19
23	1	4	5	8	8	16	21
24	0	4	4	3	4	7	11
25	0	4	4	3	8	11	15
26	0	3	3	4	5	9	12
27	0	4	4	3	4	7	11
28	0	2	2	3	10	13	15
29	0	1	1	4	3	7	8
30	0	1	1	2	5	7	8
31	0	0	0	4	4	8	8
32	0	0	0	0	2	2	2

tion of *C. philodice* by an east-west line crossing central Mississippi. Specific localities and dates are: *Oktibbeha Co.*—State College: May 1893 (H. E. Weed) (4). *Lowndes Co.*—Plymouth Bluff: 13 October 1950, male. *Tippah Co.*—Ripley: 14 October 1950 (sight record). *Hinds Co.*—Clinton: 23 January 1949, male, determined by A. H. Clark; 13 October 1953, female; 25 October 1952, female; Raymond: 22 August 1957, female. Some of the white females assigned to *C. eurytheme* may belong to *C. philodice.* These records include localities only in the northern half of the state and only the months of January, March, May, August, and October. The January male closely resembles a large number of small pale *C. eurytheme* males except that it lacks orange coloration. It has a forewing length of 18 mm. The October male has a forewing length of 23 mm; the only October *C. eurytheme* male in our series has a forewing length of 27 mm. The two October females have forewing lengths of 26 and 27 mm. We have two white October females with 26-mm forewings and two orange October females with 27-mm forewings. The 25 October 1952 female has the large yellow spot in the black margin of the forewing above, between veins Cu_1 and Cu_2, separated from the yellow ground color inwardly, by only a very faint dark line: the 18 October 1953 and 22 August 1957 females have this spot as fully surrounded by black as is characteristic of most *C. eurytheme.* Three of our five specimens have the discal spot on the hindwing above yellow, it is orange in the 25 October 1952 and 22 August 1957 females. Four of our specimens were examined by Dr. William Hovanitz who confirmed their determination as *C. philodice:* he commented that the two October females were "typical summer *philodice.*"

We have four specimens, all males, that have been determined as definite or probable *eurytheme* x *philodice* hybrids. All of these were taken at Clinton, Hinds Co. One, taken on 3 March 1951, was determined by Mr. A. H. Clark. Dr. Hovanitz commented on this specimen as follows: "may be an F_1 hybrid or even more *eurytheme* than seems apparent . . . since the cold reduces the orange pigment in the forewings of *eurytheme* to an area on the lower basal part of the wings, it is difficult to analyze the hybrid products when confused by temperature effects." Among 263 specimens of *C. eurytheme* taken by us in Mississippi, Dr. Hovanitz noted no signs of hybridization among the 51 orange females and commented that while there might be one or two *philodice* females among the 67 white specimens, he could not detect any. Of the 145 males he commented on three: (1) 16 January 1955: "probably a hybrid as it shows no orange flush at all on the forewing—this is not certain though." (2) 6 February 1957: "may be a hybrid or segregation product, showing little orange." (3) 29 May 1950: "is certainly a *philodice-eurytheme* intermediate, Grade 3 orange according to my scale. Most likely not an F_1 but rather an F_2 or backcross to *philodice.*"

61. *Zerene cesonia* (Stoll). Apparently generally distributed over the state but found only in very restricted localities. We have records for all months except November, January, and February. All of our specimens have been taken at five localities, three of which have yielded only a single specimen each: *Tishomingo Co.*—Burnsville: 28 August 1955 (1). *Lowndes Co.*—Plymouth Bluff: 13 October 1950 (1). *Harrison Co.*—Gulfport: 23 September

1951 (1). *Hinds Co.*—Clinton: 15, 21, 24 March, 23 29 April, 2, 8, 12, 14, 27, 31 May, 1, 5, 13 June, 19 July, 1 August, 27, 29 September, 1, 5, 17, 18, 19 October, and 12 December; Jackson: 3 April; 4, 18 May; 1, 30 June; and 6 July. Additional records are: *Harrison Co.*—Biloxi: 26 March 1910 (F. M. Jones). *Tishomingo Co.*—Tishomingo State Park: 20 April 1952 (Kilian Roever). *Oktibbeha Co.*—State College: 1950 (State College collection).

We have examined a series of 36 Mississippi specimens representing dates from 15 March through 19 October. There were two problems that we encountered in attempting to discuss the variation displayed by this group. First, we had difficulty in being positive about the assignment of certain specimens to the proper sex. Holland (1931) noted that "the sexes are much alike," but he figures one of each. His figure of the female is the only one that we found. Macy and Shepard (1941) wrote: "In the male the outer margin of the hind wing has a heavy black border that is nearly absent in the female." Klots (1951), alone among the authors whose work was available to us, noted that: "The male has a conspicuous sex patch near the base of the costa of the HW." We have six specimens that possess an oval orange or yellow patch at this location, that is partially opaque when the specimen is viewed in transmitted light, that we would otherwise have classed as females, since the black border of the hindwing above is very much reduced, is discontinuous, and where present extends inward as narrow rays along veins. Second, we had difficulty deciding whether we could properly employ the form name "rosa" McNeill for any of our material. It was not clear from the literature available to us whether this name applied to a population or to individuals. Mr. dos Passos wrote us that form "rosa" was described from specimens taken at Moline, Illinois on 16 September that were the third, or at least the fall, brood there, and that the females were very distinct in that the yellow on the underside of the secondaries is entirely replaced by pink. He also noted that Mississippi specimens that we had taken in April and December that showed a pink flush were not fall-brood specimens. Field (1940) wrote: "Typical *caesonia* [sic] is the summer form. It lacks any and all pink coloration that may be found on the underside of the wings . . . the fall form is "rosa" McNeill. It differs from typical *caesonia* in having a pink flush or pink markings on the underside of the hind wings." Of the 36 specimens we examined, 25 have no pink beneath except for a very narrow pink border along the outer edge of the forewing in a few, while 11 have considerable pink. Those with considerable pink were taken between 27 September and 23 April and include all but four of the specimens taken in that period. All the specimens that show considerable pink beneath have discontinuous black margins of the hindwing above, however, five have the yellow or orange semi-opaque basal patch. The four specimens with the greatest development of pink are: 27 September 1949 (♀, 32 mm), 5 October 1953 (♂, 31 mm), 18 October 1952 (♀, 28 mm), and 21 March 1953 (♀, 30 mm). Forbes (1949) noted that form "rosa" occurs in males as well as in females but that there is less of the rose tint in males than in females. He also stated: "It is not a sharply defined seasonal form, but essentially statistical."

Many authors call attention to the pointed apices of the forewings. We note, among our specimens, considerable variation in the degree of development of pointedness, ranging from individuals where the apex is only slightly more acute than a right angle to others in which it is distinctly prolonged and arcuate. The tendency to be arcuate seems more likely to be developed in fall and spring specimens than in summer individuals.

Seven of the ten females in our series have indistinct yellow patches within the apical black area of the forewing above.

The forewing lengths of the series of 36 specimens range from 23 to 33 mm. Except for one 23-mm male (Clinton, Hinds Co. 2 May 1954) and one 33-mm male (Burnsville, Tishomingo Co. 28 August 1955), the males have forewing lengths in the range 26 to 31 mm and the females in the range 28 to 33 mm. There does not seem to be any general tendency for forewing length to change with date of capture.

62. *Anteos maerula lacordairei* (Boisduval). Prof. and Mrs. Barry D. Valentine showed us a specimen, a male, taken on the

campus of Mississippi Southern College, Hattiesburg, Forrest Co. in August 1955, by Miss Laurie Segars. It was taken feeding on blossoms of *Abelia grandiflora*. The date on which it was taken was approximately one week after a tropical storm.

63. *Phoebis sennae eubule* (Linnaeus). Generally distributed over the state, the commonest member of the family, found in all months. Listed by Weed (1892) from Mayersville, Issaquena Co. Migrations have been reported near Oxford, Lafayette Co. (Jones, 1943), at Biloxi, Harrison Co. and at Bay St. Louis, Hancock Co. (Williams, 1938; Williams et al, 1942). We observed movement from left to right (northwest to southeast) while driving northeast on the Natchez Trace Parkway from Ridgeland, Madison Co. to Kosciusko, Attala Co. on 31 August 1952 and on 29 August 1953. Of the 300 to 400 individuals observed on each occasion, all but 4 or 5 were moving in the same direction. Hutchins (1956) reported that the direction of autumn movement is southeasterly in Mississippi. Hutchins (1953) reported that a "yellow sulfur butterfly" was able to hold its position in a wind tunnel against a 7 m.p.h. wind. We assume that the specimen was a *P. s. eubule* taken at State College, Oktibbeha Co.

We have examined a series of 46 specimens in our collection (27♂♂, 19 ♀♀) representing dates in all months and localities in seven counties. This series includes one female (Clinton, Hinds Co., 8 July 1952) that is very pale yellowish white and several that are noticeably paler than the rest of the group. Five of the females, taken in July and August, and eight of the males taken on dates from 30 May to 6 October, have the dark markings beneath greatly reduced and presumably represent the form "drya" Fabricius. We have no specimens that show a tendency to orange coloration. We have taken seven specimens because they were noticeably smaller than average; data and forewing lengths of these are: Clinton, Hinds Co., 6 October 1953, ♂, 23 mm; Jackson, Hinds Co., 25 July 1953, ♀, 24 mm; Clinton, 28 July 1947, ♀, 24 mm; Bovina, Warren Co., 31 July 1955, ♂, 26 mm; Clinton, 2 December 1956, ♂, 27 mm; Jackson, 28 January 1956, ♂, 28 mm; and Clinton, 12 October 1952, ♂, 28 mm. The remaining 39 specimens have forewing lengths in the range 30 to 37 mm, the median length for the males is 34 mm, that for the females is 33 mm.

Mr. F. Martin Brown examined a series of 62 specimens (35 ♂♂, 27 ♀♀) from our collection. Although he regarded it as possible that *P. s. sennae* exists as discrete colonies in southern Louisiana, where the climate is more tropical than temperate, he concluded that all of our Mississippi specimens should be determined as *P. s. eubule*. The most heavily marked of our specimens approach *P. s. sennae* in appearance, but should not be so designated. He found no indication of the tropical mainland form, *P. s. marcellina*, that strays as far as Colorado. He noted that we could use the form name "drya" Fabricius, for the late summer broods with the least markings beneath; and the form name "browni" Field, for the whitish females; but he doubted the desirability of so doing.

64. *Phoebis philea* (Linnaeus). Hutchins (1933) wrote: "Rather common in southern sections, but rare in northern part." Hutchins' observations were made between 1929 and 1933. Specimens of *P. philea* taken in New Orleans, La. in 1932 are reported by Lambremont (1954). Tietz (1952) reported that *P. philea* was taken at State College, Pa. and in Wisconsin in 1930. We believe that *P. philea* was found in Mississippi during the period in which Hutchins was working and that it may be expected to be found again. We therefore include it among the list of those regarded as known from the state even though no specific record or specimen is known to us. It is the only species so listed for which we have no specific record.

65. *Eurema daira daira* (Latreille). We follow Klots (1951) in including here, as forms, the material sometimes assigned to two species *E. jucunda* and *E. delia* (or *E. daira*). Generally distributed over the state, locally abundant, February through December. It was mentioned by Klots (1951) as found in Mississippi. We have taken the summer form ("jucunda") from 7 April to 13 October, transitional forms ("delioides") from 28 September to 25 October, and the winter form ("daira" or "delia") from 16 September to 21 March. We have taken specimens of two or of all three forms fly-

ing together at Biloxi, Harrison Co. on 23 September 1951, at Ocean Springs, Jackson Co. on 3 October 1953, at Waynesboro, Wayne Co. on 19 September 1953, at Clinton, Hinds Co. on 1 October 1950 and 5 October 1952, at Plymouth Bluff, Lowndes Co. on 13 October 1950, and at Hattiesburg, Forrest Co. on 16 September 1955. The transition from one form to the other seems to coincide approximately with the time during which the average temperature is changing from greater than to less than the mean annual temperature or vice versa. Klots (1948) commented on work reported by Haskin in 1933 that it "strongly suggests the likelihood of *jucunda* being a hot-season form and *daira* a cold-season form of the same species." The average forewing length of a series of 40 Mississippi "daira" is 17.3 mm (range 16-19) and of 46 "jucunda" is 16.2 mm (range 14-18). Holland (1931) indicated that *jucunda* was larger than *daira* and that there was no overlap in size; such does not seem to be the case with the Mississippi population (Mather, 1956b).

66. *Eurema mexicana* (Boisduval). One specimen is known. It is in the State College collection and is labelled "Agri Coll Miss. IX-13-1917, J. A. Thomas." We have examined this specimen, as has Mr. dos Passos who confirmed the determination.

67. *Eurema nicippe* (Cramer). Apparently generally distributed over the state; frequent but not often numerous. We have examined a series of 50 specimens, 29 males and 21 females, representing dates in all months and 14 localities in nine counties (Amite, Covington, Harrison, Hinds, Jefferson, Rankin, Walthall, Wayne, and Wilkinson). The average forewing length was 22 mm; the range from 16 to 25 mm. Males had an average forewing length of 21.8 and a range of from 18 to 25, females averaged 21.6 and ranged from 16 to 25 mm. A majority of the specimens (33) were taken in the four months August through November. Twenty-one specimens (10 ♂♂, 11 ♀♀) had the hindwings beneath brown or tan, without yellow; these included all specimens taken in December, January, February, and April plus three of four taken in March, seven of nine taken in November, three of six taken in October, and one of ten taken in September. The remaining 29 had yellow on the hindwings beneath, varying from clear yellow to yellow with brown or tan markings or mottling; these included all specimens taken in May, June, July, and August. These data suggests that size does not vary with sex or season and that the color of the hindwing beneath varies with season but not with sex.

68. *Eurema lisa lisa* (Boisduval and LeConte). Generally distributed, often common, May through December and January. Females with very light yellow to white ground color are fairly frequent. We have no records of migratory activity in Mississippi.

Prof. A. B. Klots examined a series of 71 Mississippi *E. lisa lisa* from our collection (29 ♂♂, 42 ♀♀). He wrote that they looked quite normal for North American material and that they fit in quite well with the rest of the South. He concluded that a male, taken at Vicksburg, Warren Co., 13 October 1956, could be called form "clappi."

69. *Nathalis iole* (Boisduval). Apparently generally distributed, sometimes locally abundant, June through November, most common September to November.

70. *Pieris rapae* (Linnaeus). Generally distributed, sometimes common, found in all months.

71. *Pieris protodice protodice* (Boisduval and LeConte). Apparently generally distributed over the state, much less common than *P. rapae*, found in all months except January.

72. *Ascia monuste phileta* (Fabricius). Five occurrences are known: on 20 October 1922 A. McIntosh took three specimens, all white, at Summit, Pike Co. (they are in the State College collection); on 14 May 1950 we took one white male at Clinton, Hinds Co.; between 13 and 15 June 1952 we observed an eastward migration along the Gulf Coast in Jackson, Harrison, and Hancock Counties. We took 19 specimens: eight males, eleven females (one white, ten gray). Additional details of this occurrence are given in a paper (Mather, 1953). A specimen of the gray form was seen but not taken at Jackson, Hinds Co. on 7 July 1957. Mr. and Mrs. E. C. Roshore took a series of seven specimens (3 ♂♂; 4 ♀♀; one white, three gray), at localities in Harrison and Hancock Counties on 12, 13, and 14 August 1957. These specimens were taken feeding

or at rest and showed no tendency to migrate. Chermock (1950) reported an eastward migration in 1950 on Dauphin Island and the Fort Morgan Peninsula, Mobile Bay, Ala. Jung (1950) stated that it is: "the most common of the white pierids in residential New Orleans."

SUPERFAMILY HESPERIOIDEA
FAMILY HESPERIIDAE

73. *Epargyreus clarus clarus* (Cramer). Apparently generally distributed over the state, rather common, February through October.

74. *Urbanus proteus* (Linnaeus). Reported by Jones from Biloxi, Harrison Co. on 3, 11, and 21 March 1910. We have taken it in southern and central Mississippi from July through November. We have no records of its occurrence north of Hinds Co. and in some years it apparently does not get that far north. It seems to arrive in central Mississippi about the same time as *Agraulis vanillae*. Additional specific dates and localities are: *Hinds Co.*—Clinton: 14 July 1948, 1, 3, and 22 October 1950, 28 October 1951, 12 October 1952, 27, 28 September 1953, 18 October 1953, 4 November 1953, 18 November 1956, 6 October 1957; Edwards: 22 August 1957; Brownsville: 20 October 1957 (M. & E. Roshore); Jackson: 25 August 1956; Utica: 21 August 1955. *Harrison Co.*—Gulfport: 23 September 1951, 13 August 1957 (M. & E. Roshore); Biloxi: 8 August 1953. *Jackson Co.*—Moss Point: 3 October 1953. *Hancock Co.*—Bay St. Louis: 12 August 1957 (M. & E. Roshore).

75. *Achalarus lyciades* (Geyer). Apparently generally distributed over the state, often associated with, but less common than, *Epargyreus clarus*. Records are available for dates from April through October.

76. *Autochton cellus* (Boisduval and LeConte). Clark (1936b) reviewed the known distribution in detail, citing records from Tennessee, Kentucky, Georgia, Florida, Missouri, and Texas but not from Mississippi, Alabama, or Louisiana. This was presumably the basis for Klots' statement (1951) "apparently absent from Gulf States." We have seen *A. cellus* four times and have taken three specimens at a locality three miles southwest of Clinton, Hinds Co.; the dates were: 13 and 20 May 1951, 19 August 1951, and 3 May 1953. We took one specimen in Riverside Park, Jackson, Hinds Co., on 11 May 1957. Mr. and Mrs. E. C. Roshore reported seeing one at Brownsville, Hinds Co., on 4 July 1957. Professor Chermock has taken it at two localities in Alabama.

77. *Thorybes bathyllus* (J. E. Smith). Generally distributed over the state, often common, March through September.

78. *Thorybes pylades* (Scudder.) Apparently generally distributed, less common than *T. bathyllus*, April through September.

79. *Thorybes confusis* Bell. We have found it difficult to distinguish specimens of *T. confusis* from those of *T. pylades*. Ten of our specimens (7 ♂♂, 3 ♀♀) were determined by C. F. dos Passos and fifteen (13 ♂♂, 2 ♀♀) by H. A. Freeman; one taken by Kilian Roever was determined by A. H. Clark; and one was listed by F. M. Jones. On the basis of the records provided by these determinations, *T. confusis* has been taken in Harrison, Pearl River, Clarke, Hinds, Benton, and Tishomingo Counties in April, May, July, and August.

80. *Pyrgus communis communis* (Grote). Generally distributed, often common, found in all months except January. In a series of 25 males and 16 females representing all months from March through November and localities in twelve counties (Franklin, Harrison, Hinds, Jackson, Jefferson, Jones, Leflore, Panola, Stone, Walthall, Warren, and Wayne) the females all have more dark than white above, the males usually have more white than dark above; and the dark areas in the females are consistently darker (blackish brown) than the dark areas in the males (brownish gray). We see no tendency for the pattern or relative darkness in specimens of either sex to change with seasons of the year.

81. *Pyrgus syrichtus* (Fabricius). One specimen is known, a male, taken on 12 August 1957 at Bay St. Louis, Hancock Co., by Mr. and Mrs. E. C. Roshore. Klots (1951) and previous authors have stated that it occurs in southern Florida and southern Texas. Freeman (1945) reported a female taken on 10 September 1929 on the Arkansas River at North Little Rock, Arkansas. He also reported (1951c) its occurrence at Dallas, Texas in September and October. The Mississippi specimen, now in our collection, has the markings on the hind-

wing beneath almost precisely as figured by Brown (1956b: 266).

82. *Pholisora catullus* (Fabricius). Generally distributed, however in most cases only one or two specimens are found at a time; March through September. One specimen in the State College collection is labelled "23 Jun 1927, Yokena, Warren Co., ex larva from corn, O. M. Chance." It was reported by Forket (1900) from Ocean Springs, Jackson Co. Specific localities and dates include: *Oktibbeha Co.*—State College: 25 March 1907, April 1916, 26 August 1921 (F. H. Benjamin, det. A. W. Lindsey), 27 April 1950 (J. L. Horton)—all in State College collection. *Monroe Co.*—Aberdeen: 15 August 1955 (K. Roever). *Clay Co.*—West Point: 11 April 1954. *Kemper Co.*—Scooba: 27 April 1957. *Noxubee Co.*—Brooksville: 11 April 1954; Macon: 27 April 1957. *Bolivar Co.*—Pace: 27 April 1951. *Leflore Co.*—Greenwood: 30 July 1955 (John Carr). *Warren Co.*—Yokena: 23 June 1927 (O. M. Chance, State College collection); Bovina: 24 July 1955, 31 July 1955. *Hinds Co.*—Jackson: 25 August 1956, 26 April 1952, 1 September 1956, 29 May 1954, 7 April 1956; Clinton: 30 March 1951, 8 April 1951, 6 August 1953, 16 May 1954, 1 May 1955, 3 July 1955, 17 July 1954; Bolton: 1 June 1957 (M. & E. Roshore), 1 September 1957; Brownsville: 2 September 1956, 24 August 1957. *Lincoln Co.*—Brookhaven: 3 July 1954. *Harrison Co.*—Biloxi: 1910 (F. M. Jones).

83. *Pholisora hayhurstii* (Edwards). Not as common as *P. catullus*. We have records for all months from April through September; none from localities in the southern part of the state. Specific localities and dates include: *Benton Co.*—Lamar: 28 August 1955. *Calhoun Co.*—Derma: 11 September 1954. *Leflore Co.*—Greenwood: 22 June 1955. *Panola Co.*—Batesville: 5 August 1956. *Hinds Co.*—Brownsville: 24 August 1957 (M. & E. Roshore); Clinton: 4 July 1952, 4 April 1953, 2 April 1954, 4 April 1954, 17 July 1954, 16 May 1954, 5 April 1955, 14 September 1956, 13 August 1956, 1 July 1956, 12 May 1957, and 1, 2, 3, 5, 7, 9, and 23 August 1957 (M. & E. Roshore). *Warren Co.*—Bovina: 7 August 1955; Vicksburg: 15 June 1957 (M. & E. Roshore); Redwood: 4 July 1957.

84. *Erynnis brizo brizo* (Boisduval and LeConte). One specimen, in poor condition, in the State College collection, is labelled: "26 Sep. 1928, Utica, Hinds Co., F. Lewis, feeding on *Daubentonia longifolia*, det'd as *Thanaos brizo somnus* by H. G. Dyar." The specimen is not now determinable. We have taken about 40 specimens, all in February, March, or April; at localities in Alcorn, Attala, Hinds, and Tishomingo Counties. We have no records from the southern part of the state.

85. *Erynnis martialis* (Scudder). One specimen, determined by A. W. Lindsey, was taken at Longview, Oktibbeha Co. on 26-27 June 1920; it is in the State College collection. One taken by Kilian Roever in Tishomingo State Park on 20 April 1952 is now in our collection. Additional specific dates and localities include: *Tishomingo Co.*—SW of Iuka: 28-29 March 1953, 21 April 1956; Mt. Woodall: 20 April 1957; Tishomingo State Park: 21 April 1956. *Lee Co.*—Tombigbee State Park: 21 April 1957. *Jefferson Davis Co.*—Prentiss: 4 May 1952. *Hinds Co.*—Clinton: 15 March 1953, 16 May 1954, 23 June 1956. *Forrest Co.*—Hattiesburg: 4 March 1956 (B. and B. Valentine).

86. *Erynnis horatius* (Scudder and Burgess). Generally distributed through the state, February through October. It is the commonest species in this genus. We have taken about 200 specimens, more in March than in any other month.

87. *Erynnis juvenalis* (Fabricius). Probably generally distributed but not as common as *E. horatius*. February through August, except May; we have taken about 100 specimens, almost all in March and April.

88. *Erynnis baptisiae* (Forbes). All of the specimens that we have hoped would be *E. baptisiae* have turned out not to be, except for two females taken at Clinton, Hinds Co., on 8 and 9 June 1951, determined by C. F. dos Passos and E. L. Bell.

89. *Erynnis zarucco* (Lucas). Apparently generally distributed, February through October. We have taken about 70, about equally as many in the period July through September and in March and April. Its occurrence in Mississippi was mentioned by Lindsey, Bell, and Williams (1931) and by Klots (1951).

90. *Ancyloxypha numitor* (Fabricius). Apparently rather generally distributed, but not common. It is usually found near the water's edge on the bank of a stream. Specific localities and dates include: *Panola Co.*—Batesville: 5 August 1956 (sight record). *Calhoun Co.*—Calhoun City: 11 September 1954. *Oktibbeha Co.*—State College: 1891-93 (H. E. Weed, State College collection). *Clarke Co.*—Clarkco State Park: 30 April 1955. *Simpson Co.*—D'Lo: 10 October 1954. *Copiah Co.*—Crystal Springs: 2 June 1957. *Hinds Co.*—Clinton: 19 July 1953, 7 June 1956; Jackson: 2 October 1954, 17 August 1957. *Harrison Co.*—Biloxi: 21 April 1910 (F. M. Jones); Gulfport: 4 September 1940 (H. I. O'Byrne). We use the spelling *Ancyloxypha* rather than *Ancyloxipha* as used by Klots (1951) on the advice of Mr. Field and Mr. dos Passos.

91. *Copaeodes minima* (Edwards). Generally distributed, rather abundant, April through November. Although this is our smallest butterfly, it is not as hard to see as some others since it characteristically is found in open fields in bright sunlight and usually rests on the tops of grass stalks or flower heads.

92. *Hesperia metea metea* Scudder. Thirty-six specimens are known from Mississippi; a pair taken on 20 April 1952 by Kilian Roever at Tishomingo State Park were determined by A. H. Clark. The other 34 were taken by us on 29 March 1953, 10 April 1954, 21 April 1956, and 20 April 1957 in Tishomingo and Alcorn Counties. Two were examined by C. F. dos Passos, eight were examined by W. D. Field. They are assigned to *H. m. metea* since the white markings beneath are usually not obscure or absent as in *H. m. licinus* (Edwards) although a number of Mississippi females show a strong tendency toward *licinus*. Freeman (1948) stated that specimens from Georgia appear to be intermediate between typical *metea* from the northeastern United States and *licinus* from Texas, but that no typical *metea* were known from Texas or any of the adjoining states, and that two females from Arkansas were known that were not quite as dark and immaculate as the specimens from Texas originally described as *H. m. belfragei* by Freeman in 1944.

93. *Hesperia attalus* (Edwards). Two specimens are known, both taken by H. I. O'Byrne: a female taken on 20 August 1940 at Carriere, Pearl River Co., and a male taken on 4 September 1940 at Gulfport, Harrison Co. Both are in the O'Byrne collection at the University of Missouri where they were examined by one of us (K. M.). The range is given by Klots (1951) as "Florida and Texas . . . ", by Lindsey, Bell, and Williams (1931) as "Florida, Alabama, and Texas . . . " It was listed as expected for Louisiana by Lambremont (1954).

94. *Hylephila phyleus* (Drury). Generally distributed through the state, common, taken in all months except January and February. As noted by Klots (1951) the females vary more in darkness and lightness than do the males.

95. *Atalopedes campestris* (Boisduval). Generally distributed through the state, common, the only skipper commoner than *H. phyleus*, taken in all months except January and February.

96. *Polites vema sequoyah* H. A. Freeman. Eight taken by us were determined by Mr. H. A. Freeman who commented that they were the first he had seen from Mississippi. Twelve others were determined for us by Mr. C. F. dos Passos. These specimens were taken at localities in Hinds, Madison, Rankin, Warren, and Smith Countis in April, May, July, and August.

97. *Polites manataaqua* (Scudder). Generally distributed through the state, rather common, May through October. Taken by F. M. Jones and by us on the Gulf Coast, by us in central Mississippi and north into Calhoun Co.

98. *Polites themistocles* (Latreille). Generally distributed over the state, rather common, April through October. Taken by Jones, O'Byrne, and us on the Gulf Coast, by us in central Mississippi, and by H. E. Weed in Oktibbeha Co. Weed wrote (1926): "It is apparently absent . . . along the Gulf Coast except in Florida."

99. *Polites vibex vibex* (Geyer). Generally distributed over the state, quite common, March through October.

100. *Wallengrenia otho otho* (J. E. Smith). Generally distributed through the state, frequent, April through November. Freeman (1950) stated: "Typical *otho* oc-

curs from Florida, through Georgia, Alabama, Mississippi, Arkansas, parts of Oklahoma, and into Texas as far south as San Antonio . . . subspecies *egeremet*, characterized by its indistinct maculation and dull coloration, occurs over the most of southern Canada and in the United States west to the Rocky Mountains. It occurs rarely in the same localities as typical *otho*, especially near Dallas, Texas during June." Mr. dos Passos, after examining a series taken by us, remarked that Mississippi was the only state from which he had specimens of both forms. Mr. Freeman examined a group of our Mississippi specimens and determined some as *W. o. otho* and others as *W. o. egeremet*. The Clarks (1951) reported both forms from Virginia, noting that *W. o. otho* was first found there in 1940. Harris (1950) reported both forms from Georgia. Knudsen (1954) found both forms on the Oglethorpe University campus. Freeman (1951c), commenting on the co-occurrence of the two forms, wrote: "*Egeremet* occurs around the Dallas area as a form of *otho* instead of a subspecies, as both fly together at the same time of the year." A male taken at Biloxi, Harrison Co. on 17 August 1943 by Frederick H. Rindge and determined by him as *W. o. egeremet* is in the Los Angeles County Museum and was referred to by Martin and Truxal (1955). A series of 67 Mississippi specimens taken by us includes 38 *otho otho* (23 ♂♂, 15 ♀♀) and 29 *otho egeremet* (17 ♂♂, 12 ♀♀). The typical specimens were taken in all months April through October; the *egeremet* specimens in April, May, June, August, and September. Specimens of both forms have been taken in Hinds, Madison, Rankin, Smith, and Wilkinson Counties; *o. otho* also in Clarke, Harrison, Jackson, Jefferson, and Warren Counties; *o. egeremet* also in Forrest and Jasper Counties. The *o. otho* specimens from Mississippi correspond more closely with the description of that form and show fewer traces of a transitional tendency than the Mississippi specimens of *o. egeremet* do to the description of it. We therefore assign the Mississippi population to *W. o. otho*. We assume that the reference by Weed (1894) to *P. pontiac* was to material we would include here.

101. *Poanes zabulon* (Boisduval and LeConte). Twenty-two specimens are known (18 ♂♂, 4 ♀♀). Three of the females were taken between 1 and 3 April, the fourth on 25 August, at Clinton, Hinds Co., the males were taken in March (2), April (8), June (2), July (2), August (2), and September (2) at localities in Hinds, Warren, and Carroll Counties.

102. *Poanes yehl* (Skinner). Twenty-seven specimens are known (18 ♂♂, 8 ♀♀, one sex not known). A light male taken by George Dorner at Vicksburg, Warren Co. is in the Barnes Collection at the U. S. National Museum and is probably the basis for the reference to Mississippi in the range of this species as given by Lindsey, Bell, and Williams (1931) and Klots (1951). One was taken at Jackson, Hinds Co. on 5 June 1938 by Lucien Harris, Jr. and is in his collection. The remaining 25 were taken at localities all relatively near the Pearl River in Hinds and Madison Counties except for three taken at Brownsville, Hinds Co., one taken at Bovina, Warren Co., near the Big Black River; and one taken at Calhoun City, Calhoun Co. near the Yalobusha River. Two of the Brownsville specimens were taken by M. & E. Roshore. There appear to be two broods, one flying at least between 30 May and 16 June, another between 22 August and 14 October. Forewing-length distribution of 23 specimens is given in Table 2.

TABLE 2. *Forewing lengths for Poanes yehl.*

Forewing length, mm.	Number of specimens			
	May - June		August	October
	♂♂	♀♀	♂♂	♀♀
14	1			
15	1		3	
16	1		3	
17	1	1	1	2
18	2	1		
19		1		2

The Clarks (1951) referred to two quite distinct forms connected by a complete series of intergrades. In one form the hindwings beneath are cinnamon with the light spots clearly defined and conspicuous. Their figured specimen of this form is a female taken at Nashville, Tenn., on 23 August 1895. In the other form the hindwings beneath are yellow with the spots vaguely and indefinitely outlined and scarcely contrasting with the background. Their figured specimen of this form was taken at New Bohemia, Va. on 19 July 1941. They also describe a variation in the males in which the dark border is scarcely half the

usual width, the ground color is light and rather bright yellow, and the stigma are yellow with narrow black edges. Of this they figure a specimen taken at New Bohemia on 19 July 1941. The specimen figured by Klots (1951) is a male from Suffolk, Va. having a forewing pattern including the yellow stigma with narrow black edges; the hindwing beneath is yellow with indefinitely outlined spots. As indicated in the size-distribution table, the series that we have at hand includes 23 specimens (16 ♂♂, 7 ♀♀): 12 taken in May-June (9 ♂♂, 3 ♀♀), 11 taken in August-October (7 ♂♂, 4 ♀♀). Among the males, we have none with the stigmas yellow with narrow black borders. The August-October males appear to have slightly darker stigmas than those taken in May and June. The undersides of the hindwings of the May-June males are yellow (pumpkin yellow) in all but two that are only slightly darker. In four the spots are vague and fade into the background; in three they are slightly more distinct; in two they are fairly distinct—these are the two with slightly darker background. Of the seven August-October males, in three the brown of the outer margin of the hindwing beneath becomes darker and grayer outward from the zone of the spots; in the other four, the ground color does not darken outwardly from the zone of the spots. The background of these is darker than in the May-June group on the hindwing beneath. In three the spots are vague and fade into the background; in two they are slightly more distinct; and in two they are fairly distinct—these are not the two with the darker borders of the hindwing beneath. The females are darker above than the males. The three May-June females have yellowish brown hindwings beneath, the color being intermediate between that of the earlier and later males and duller than either. The spots in one are vague and fade into the background; in the other two they are slightly more distinct. Of the four August-October females, two have the hindwings beneath brown with sharply defined cream-colored spots. These are the only two of the series of 23 specimens that have spots of comparable clarity of definition and conspicuousness to those in the figure of this form given by the Clarks. The other two are only slightly browner on the hindwing beneath than the earlier females but they have materially more distinct spots. The conclusion indicated by these data would seem to be that the later specimens tend to be darker than earlier ones and that the form with dark cinnamon hindwings beneath with clearly defined light spots is more likely to occur in females. The two most widely separated localities from which we have specimens are a little more than 130 miles apart. No geographic differences were indicated.

103. *Atrytone arogos arogos* (Boisduval and LeConte). Eighteen specimens are known (8 ♂♂, 10 ♀♀), two from Clinton, Hinds Co., the remainder from south Mississippi: *Forrest Co.* (Maxie), *Harrison Co.* (Gulfport), and *Jackson Co.* (Ocean Springs). Six were taken in August and September 1940 by H. I. O'Byrne, the remainder by us. Our first specimen, taken at Clinton, Hinds Co. on 5 June 1951, was determined as *A. arogos iowa* (Scudder) by Mr. C. F. dos Passos. A series of four taken by us on the Gulf Coast on 13 June 1952 were determined by him as *A. arogos arogos*. In 1955 a series of eight was examined by Mr. W. D. Field, compared with those in the U. S. National Museum, and determined as *A. arogos arogos*. Lambremont (1954) reported that one specimen was known from Louisiana, a male taken on 6 September 1950.

104. *Atrytone arpa* (Boisduval and LeConte). Only one occurrence is known: H. I. O'Byrne took nine specimens (5 ♂♂, 4 ♀♀) on 4 September 1940 at Gulfport, Harrison Co.; they are in the collection of the University of Missouri where they were examined by one of us (K. M.).

105. *Atrytone dion alabamae* Lindsey. Two specimens are known, both males, one taken at Gulfport, Harrison Co. on 4 September 1940 by H. I. O'Byrne; the other taken at Burnsville, Tishomingo Co. on 28 August 1955 by us. The determination of our specimen was confirmed by Mr. W. D. Field. Two specimens from Alabama were known to Lindsey, Bell, and Williams (1931): the type, a male from Mobile Co. taken by W. C. Dukes on 25 June 1922; and a female from Chickasaw taken by Bell on 1 September 1925. Freeman (1941) reported taking three at North Little Rock, Ark. in June and July 1930. Kilian Roever

took it at Jackson, Tenn. on 12 September 1953. It was not reported by Lambremont (1954) as known from Louisiana.

106. *Atrytone palatka* (Edwards). Two specimens are known: one, a female, taken by H. E. Weed at State College, Oktibbeha Co. in June 1896, determined by F. H. Benjamin and A. W. Lindsey; the other, a male, taken by us at Moss Point, Jackson Co. on 14 June 1952, determined by C. F. dos Passos.

107. *Atrytone ruricola metacomet* (Harris). Apparently generally distributed over the state, rather common, April through October. A study of frequency of capture through the season, based on a series of 60 specimens, indicates a higher peak in late April and early May and a lower peak in early August.

108. *Atrytonopsis loammi* (Whitney). Four specimens are known, all were taken by Prof. and Mrs. Barry D. Valentine, three on 17 March 1956 eleven miles south of Hattiesburg, Forrest Co.; the fourth on 31 March 1955 at Hattiesburg. A discussion of the determination of these specimens is given under the next species.

109. *Atrytonopsis hianna* (Scudder). Four specimens are known, three from Mt. Woodall, Tishomingo Co., two taken on 21 April 1956, one by Kilian Roever, and one taken on 20 April 1957. The fourth was taken at Van Cleave, Jackson Co. on 28 March 1954. The Van Cleave specimen was studied in 1955 by Mr. William D. Field and determined as *A. hianna*, female. The four Hattiesburg specimens, listed above under *A. loammi*, were determined as such by us and were so referred to by Proctor (1957). Later in 1957 the entire series of eight was examined by Prof. R. L. Chermock who suggested the probability that they were conspecific and assignable to *A. hianna*. In October 1957, the entire series was studied by Mr. Field at the USNM. He found that the four from Hattiesburg closely resembled the series of *A. loammi* from Florida in the U.S. National Museum while the four listed here under *A. hianna* did not. The two males from Mt. Woodall have the features of typical *hianna:* the two females have traces of the spots on the hindwings beneath that suggest a trend toward *loammi*. Klots (1951) and Lindsey, Bell, and Williams (1931) indicated that *A. loammi* may always be distinguished by the white, opaque spots on the hindwing beneath. Our Hattiesburg specimens have such spots well developed. The male genitalia as figured by Lindsey, Bell, and Williams (1931, plate XXIX, figs. 21, 22) do not show striking differences. The range of *A. loammi* is given as Florida and North Carolina. *A. hianna* has been reported from Georgia (Harris, 1950) and was listed as probable for Louisiana by Lambremont (1954). On the basis of current criteria it appears that these specimens are properly assigned as here indicated, but we suggest that the relations of the populations to which they have been assigned should be re-examined to confirm or disprove their specific distinctness.

110. *Oligoria maculata* (Edwards). Apparently this species occurs only along the Gulf Coast where it has been taken in April and May and in August and September by F. M. Jones, H. I. O'Byrne, R. P. Barnhart (State College collection, specimens determined by A. W. Lindsey), and by us. We have taken only two specimens: *Harrison Co.*—Gulfport: 4 May 1952; Biloxi: 8 August 1953. Mr. and Mrs. E. C. Roshore took one at Bay St. Louis, Hancock Co. on 12 August 1957.

111. *Lerema accius* (J. E. Smith). Apparently generally distributed over the state, February through November, most common in September and October.

112. *Amblyscirtes vialis* (Edwards). Fourteen specimens are known, all taken in Tishomingo Co. in March and April; one by Kilian Roever, the other thirteen by us.

113. *Amblyscirtes hegon* (Scudder). Two specimens are known, both taken by us; one, a male, was taken southwest of Iuka, Tishomingo Co., on 10 April 1954, and was determined by Mr. W. D. Field; the other was taken in Tishomingo State Park on 20 April 1957.

114. *Amblyscirtes carolina* (Skinner). One specimen is known. It was taken on ironweed (*Vernonia* sp.) together with *A. textor* on 2 September 1957, west of Brownsville, Hinds Co. by Mr. and Mrs. E. C. Roshore. This occurrence appears to constitute a significant extension of the known range of the species as given by Klots (1951) as Georgia to Virginia. Har-

ris (1950) indicated that only two specimens were known from Georgia. The Mississippi specimen, now in our collection, is of the typical form as figured by Klots (1951, plate 35, fig. 12; and plate 38, fig. 2) and by the Clarks (1951, plate 30, fig. a). It has fewer spots on the forewing above than the specimen figured by the Clarks on Plate 28, fig. p or the one figured by Klots on Plate 38, fig. 2; but like that figured by Klots on Plate 38, fig. 2, it has fewer spots on the hindwing above than that figured by the Clarks in Plate 28, fig. p. The determination was confirmed by Mr. William D. Field.

115. *Amblyscirtes textor* (Huebner). Apparently rather generally distributed. A specimen from Clay Co. is in the collection of the American Museum of Natural History. We have taken specimens in Lee, Wayne, Hinds, and Madison Counties in March, April, May, July, August, and September. We have found this species in localities similar to those in which *L. portlandia portlandia* is found.

116. *Amblyscirtes alternata* (Grote and Robinson). Seven specimens are known. One taken by F. M. Jones at Biloxi, Harrison Co., on 21 March 1910, is now in our collection. Three, taken by H. I. O'Byrne at Gulfport, Harrison Co., and at Maxie, Forrest Co., in August 1940 are now at the University of Missouri. We took one at Fannin, Rankin Co., on 4 July 1956. Prof. and Mrs. Barry D. Valentine took one each on 30 and 31 March 1955 at Hattiesburg, Forrest Co. The determination of Dr. Jones' specimen was checked by Mr. dos Passos, that of ours by Mr. H. A. Freeman, and that of those taken by the Valentines by Prof. Ralph L. Chermock.

117. *Amblyscirtes belli* H. A. Freeman. One specimen is known from Mississippi, taken at Vaiden, Carroll Co., on 22 April 1956 by Kilian Roever and presented by him to us. It was determined by Mr. H. A. Freeman.

118. *Lerodea l'herminieri* (Latreille). Apparently generally distributed over the state, but not common; April through July and September through October. It was taken at State College, Oktibbeha Co., by Weed (1894), in southeast Mississippi by F. M. Jones, F. H. Benjamin, H. I. O'Byrne, and by us; in southwest Mississippi by us.

119. *Lerodea eufala* (Edwards). Apparently generally distributed over the state and quite common; April through December.

120. *Calpodes ethlius* (Stoll). Apparently occurs throughout the state in some years. Specimens are in the State College collection from Harrison, Pike, and Oktibbeha Counties. We took two at Jackson, Hinds Co., on 22 August 1953. We reared six from larvae collected at Biloxi, Harrison Co., on 9 August 1953, that emerged on 18-21 August; and another from a larva collected at Jackson on 23 June 1956; emerged 4 July 1956. Found only near cannas (*Canna generalis*). Jung (1950) stated: "larvae may be collected in great numbers from cannas in the gardens of New Orleans."

121. *Panoquina panoquin* (Scudder). This species is known only from coastal salt marshes. Specific dates and localities are: *Harrison Co.*—Biloxi: 5 April 1910 (F. M. Jones). *Jackson Co.*—Ocean Springs: 13, June 1952, 14 June 1952, 6 October 1956 (B. J. Collins, ex coll. B. D. Valentine); Pascagoula: 14 June 1952.

122. *Panoquina ocola* (Edwards). Taken at Biloxi, Harrison Co. on 12 April 1921 by F. M. Jones. We have taken it only from July through October. We have found it most abundant along the Gulf Coast in October, but have also found it in Central Mississippi and in some years in the north. We took it at Memphis, Shelby Co., Tenn. on 24 October 1954. On 3 October 1953 we saw very large numbers at several localities in Jackson Co. Penn (1955) described a mass flight seen on the southeastern shore of Lake Pontchartrain in Orleans Parish, La. on 15 October 1950.

B. *Species of Probable or Possible Occurrence*

SUPERFAMILY PAPILIONOIDEA

FAMILY SATYRIDAE

123. *Lethe eurydice appalachia* R. L. Chermock. Chermock (1948) reported finding it in numbers in Moody Swamp near Tuscaloosa, Alabama (about 40 miles from Mississippi); Roever reported finding it at Jackson, Tenn. (also about 40 miles from Mississippi). We expect that it oc-

curs in northeast Mississippi. Lambremont (1954) listed it as expected to occur in Louisiana.

FAMILY HELICONIIDAE

124. *Dryas julia delila* (Fabricius). Hutchins (1933) wrote: "Doubtful occurrence. Specimen in State College collection with no label." Lambremont (1954) reported one male from Lafayette, La. taken on 5 November 1941, in the collection of Southwestern Louisiana Institute. This locality is about 60 miles from Mississippi.

FAMILY NYMPHALIDAE

125. *Speyeria idalia* (Drury). This species was reported to occur in Arkansas (Klots, 1951).

126. *Speyeria cybele cybele* (Fabricius). Lambremont (1954) reported one male taken at Lafayette, La. on 2 October 1931, in the collection of Southwestern Louisiana Institute. H. A. Freeman (1951b) reported it as usually rather scarce in Arkansas. Roever has taken it in southwestern Tennessee. We regard it as probable for Mississippi. It was listed from Tennessee, Illinois, Arkansas, Oklahoma, but not Louisiana, by dos Passos and Grey (1947).

127. *Euphydryas phaëton phaëton* (Drury). Chermock (1951, 1953) reported its occurrence at Tuscaloosa, Ala. Roever has taken it in Perry Co. in middle Tennessee. We expect that it occurs in northeast Mississippi.

FAMILY LYCAENIDAE

128. *Strymon titus mopsus* (Huebner). Roever has taken it at Jackson, Tenn. Chermock (1953) reported it from Tuscaloosa, Ala. Freeman (1951a) reported it common in central Arkansas. Klots (1951) included "Gulf States" in his statement of its range. Lambremont (1954) listed it as expected to occur in Louisiana. We expect that it occurs in Mississippi. It is possible that the reference by Weed (1894) to *"T. acadica"* refers to this species.

129. *Strymon edwardsii* (Grote and Robinson). As noted under the discussion of *S. falacer* (No. 39), *S. edwardsii* was included, in error, in both previous lists of Mississippi butterflies (Weed, 1894; Hutchins, 1933). Klots (1951) gave the range ". . . s to Georgia and Kansas." Freeman (1951a) reported it evenly distributed over Arkansas, chiefly in May. Michener and dos Passos (1942) stated that it ranges from Ontario to Florida and thence far beyond the Mississippi River. Roever has taken it at Jackson, Tenn. We expect that it occurs in Mississippi.

130. *Strymon kingi* Klots and Clench. Klots and Clench (1952) reported a specimen taken by R. L. Chermock at Sipsey, Walker Co., Alabama (65 miles from Mississippi) on 10 July 1949.

131. *Strymon columella modesta* (Maynard). Klots (1951) gave the range of this species as "Florida n. into Gulf States."

132. *Mitoura hesseli* Rawson and Ziegler. Rawson and Ziegler (1950) suggested that its range might extend throughout the range of the white cedar (*Chamaecyparis thyoides*) to southeast Mississippi. Ziegler stated that it has been found as far south as North Carolina. We were directed by Prof. James D. Ray to a stand of *C. thyoides* on Bluff Creek at Van Cleave, Jackson Co. We have visited this locality several times but we have not yet taken *M. hesseli*.

133. *Incisalia irus irus* (Godart). Freeman (1951a) reported a male taken near Conway, Ark. in late March 1929 by Paul McHenry. Lambremont (1954) listed it as known from Louisiana based on the report by Skinner (1907). Chermock has taken it around Tuscaloosa, Ala. and Roever has taken it near Jackson, Tenn.

134. *Lycaena phlaeas americana* Harris. Hutchins (1933) wrote: "Doubtful occurrence. One specimen in State College collection with no label." Klots (1951) gave the range as ". . s to Georgia, Gulf States, and Arkansas." Holland (1931), on the other hand, said: "Abundant everywhere, except in the Gulf States."

135. *Leptotes cassius theonus* (Lucas). Holland (1931) and Field (1940) gave "Gulf States" in their statements of the range of this species.

136. *Brephidium pseudofea* (Morrison). Klots (1951) wrote: "Georgia, Florida, and supposedly Gulf States. There is one record from Galveston, Texas, perhaps of a stray." Holland (1931) and Field (1940) said "Gulf States." It was listed by Lambremont (1954) as expected to occur in Louisiana. Chermock found it common on Dauphin Island, Ala., within 20 miles of Mississippi.

137. *Glaucopsyche lygdamus lygdamus* (Doubleday). The late Mr. A. H. Clark wrote to us on 12 February 1951: ". . . the typical form of *G. lygdamus* might occur in your area. . . . In your region it should fly in early March." We understand that Hans Epstein took it near Rockford, Alabama. A male taken on 5 April 1932 at Hot Springs, Arkansas, by L. I. Hewes and determined by him is in the collection of the Los Angeles County Museum and was mentioned by Martin and Truxal (1955).

FAMILY PAPILIONIDAE

138. *Battus polydamas lucayus* (Rothschild and Jordan). Klots (1951) gave the range of this species as: "Florida, Georgia, Gulf States, southward into Mexico." It was reported from New Orleans, La. by von Reizenstein (1863).

FAMILY PIERIDAE

139. *Anteos clorinde nivifera* (Fruhstorfer). Brown (1956a) lists this species and *A. maerula lacordairei* as essentially equally to be expected in Colorado. Field (1940) reports the occurrence of *A. clorinde* in Kansas and *A. maerula* in Nebraska. Klots (1951) reported that they have essentially the same range and both occur as breeding residents in southern Texas north to Dallas. Since *A. maerula lacordairei* has been found in Mississippi, we expect that *A. clorinde nivifera* may also be found.

140. *Phoebis agarithe maxima* (Neumoegen). Lambremont (1954) cited four records from Lafayette and Orleans Parishes, La. Klots (1951) gave the range as: "Florida, Gulf Coast, Texas, s. into Mexico, strays n. to Illinois, Arkansas, and Kansas." We expect that it occurs in Mississippi.

141. *Pieris virginiensis* Edwards: Holland (1931) gave the range as ". . . to the northern limits of the Gulf States." Gooch and Strecker (1924) stated that specimens from Waco, Texas, where it was "rather common", were identified by W. J. Holland as *Pieris napi*. Prof. C. L. Remington wrote us that *P. virginiensis* is locally common in Tennessee. We regard it as unlikely that this species will be found in Mississippi.

SUPERFAMILY HESPERIOIDEA

FAMILY HESPERIIDAE

142. *Celotes nessus* (Edwards). Reported by Glick (1939) as having been taken at an altitude of 20 feet, between August 1926 and October 1931, at Tallulah, Madison Parish, La. (less than 10 miles from Mississippi).

143. *Erynnis icelus* (Scudder and Burgess). Reported by Freeman (1945) from Pinnacle Springs, Faulkner Co., Ark., 7 July 1944 (two males); taken by Chermock at Tuscaloosa, Ala.; and taken by Roever near Jackson, Tenn. Roever's specimens were determined by A. H. Clark. Klots (1951) gave the range of this species as: "Quebec w. to Manitoba and Vancouver, s. to North Carolina and New Mexico but not in Great Plains, or states bordering them." Lindsey, Bell, and Williams (1931) gave the range as: "Northern United States and Canada, extending south to North Carolina in the east, and to New Mexico in the west. Apparently the species does not enter the plains region in the central United States." Macy and Shepard (1941) wrote: ". . . . throughout the Northern United States and Canada from Nova Scotia to Florida and westward to California . . . it is found in Illinois and Indiana."

144. *Erynnis persius persius* (Scudder). Forbes (1936) reported a specimen from Eagle, Alabama. Roever has taken it at Jackson, Tenn. Freeman (1945) reported it from Faulkner Co., Ark., and (1943) gave the range as "Florida, westward to Arkansas." We expect that it occurs in Mississippi.

145. *Erynnis lucilius* (Scudder and Burgess). Klots (1951) gave the range as ". . . w. to North Dakota, and Nebraska, s. to Georgia." Lindsey, Bell, and Williams (1931) gave the range as: ". . northeastern United States." Macy and Shepard (1941) suggested that the range may be much the same as that of the foodplant, *Aquilegia canadensis*. Although *A. canadensis* was not reported from Mississippi by Lowe (1921), Prof. James D. Ray informed us that reliable distribution records indicate its presence. He also noted that it would not be expected in abundance but should be sporadic in areas such as the river bluffs and the northeast highlands. A closely related form, *A. vulgaris*, is in cultivation as a garden ornamental.

146. *Erynnis funeralis* (Scudder and Burgess). This species was reported by Watson (Grossbeck, 1917) from Pensacola, Fla. (60 miles from Mississippi) and by

Freeman (1945) from Osage, Ark. We expect that it occurs in Mississippi.

147. *Copaeodes aurantiaca* (Hewitson). Reported by Freeman (1945) from the Arkansas River at North Little Rock, Ark. (85 miles from Mississippi) in October 1931.

148. *Hesperia leonardus stallingsi* H. A. Freeman. Reported by Glick (1939) from Tallulah, Madison Parish, La. (less than 10 miles from Mississippi); by Freeman (1945) from Rogers, Ark.; taken by Chermock at Tuscaloosa, Ala.

149. *Hesperia sassacus sassacus* Harris. Taken by Roever at Chickasaw State Park and at Jackson, Tenn. in April and May. Listed by Lambremont (1954) as expected to occur in Louisiana.

150. *Hesperia meskei* (Edwards). Reported by Freeman (1942) from North Little Rock and from Faulkner Co., Ark.; taken by Chermock at Tuscaloosa, Ala.; and listed by Lambremont (1954) as expected to occur in Louisiana.

151. *Polites peckius* (Kirby). The range of this species has been given as: "Canada to Florida and Kansas" (Field, 1940); "Maritime Provinces westward, s. to Georgia and Texas" (Klots, 1951); "Atlantic Coast to Texas and Arizona" (Lindsey, Bell, and Williams, 1931). Listed by Lambremont (1954) as expected to occur in Louisiana. Brown (1956b) gives the range as: "The Maritime Provinces of Canada south to Georgia and westward to Montana and Arizona." The species is not mentioned by Freeman (1951c) in his study of the skippers of Texas. Prof. Chermock advised us that he doubted that this species occurs in Mississippi. If it does not occur in Mississippi and Texas, there would appear to be some revisions needed in the description of its range.

152. *Poanes viator* (Edwards). Klots (1951) gave the range as: ". . . s. to Alabama and Texas." Holland (1931) described it as: ". . . not uncommon in the Gulf States." Reported by Lambremont (1954) from Norco, St. Charles Parish, La. and by Scudder (1889) from Orleans Parish, La. It was taken by Roever in August 1955 near Mobile Bay, Ala. We expect that it occurs in Mississippi.

153. *Poanes hobomok hobomok* (Harris). Taken by Roever at Chickasaw State Park and at Jackson, Tenn.; by Chermock at Tuscaloosa and in Walker Co., Ala.; and reported by Freeman (1945) from Mt. Sequoyah, near Fayetteville, Ark. Klots (1951) gave the range as: " . . . s. to Georgia, Alabama, Arkansas, and Kansas."

154. *Problema byssus* (Edwards). Range given by Klots (1951) as: "Florida to Texas and n. to Kansas and Iowa." Field (1940) gave it as: "southern United States from Florida to Texas." Remington (1955) reported it from Elsah, Illinois and wondered whether its occurrence there was discontinuous or connected to regions to the south from which it is known. Listed by Lambremont (1954) as expected to occur in Louisiana.

155. *Atrytone logan logan* (Edwards). Stated by Klots (1951) to occur in the "Gulf States." Stated by Lindsey, Bell, and Williams (1931) to occur from "Florida to Arkansas." It has been taken by Roever at Jackson, Tenn. It was described by Freeman (1945) as common over Arkansas. A male taken at Linden, Alabama on 17 May 1930, determined by Lloyd M. Martin, is in the Los Angeles County Museum and was referred to by Martin and Truxal (1955). It was listed by Lambremont (1954) as expected to occur in Louisiana.

156. *Atrytone berryi* Bell. This species has been taken at Pensacola, Fla. (60 miles from Mississippi) by S. S. Nicolay (Chermock, 1953); it was described from Monticello, Florida in 1941.

157. *Atrytone dukesi* Lindsey. The type locality is the vicinity of Mobile Bay, Ala. Lambremont (1954) reported a male taken 11.5 miles west of Oak Grove, West Carroll Parish, La. We expect that it occurs in Mississippi.

158. *Atrytone bimacula* (Grote and Robinson). Klots (1951) stated that old records far to the south of Virginia are based on misidentifications. Kilian Roever told us that a specimen taken at Mobile, Alabama and determined by Lindsey has recently been re-determined and confirmed.

159. *Amblyscirtes linda* H. A. Freeman. Klotz (1951) referred to this species as "of the lower Mississippi Valley." It was described from Arkansas and was reported by Freeman (1945) to have been taken at three

localities in that state. One, taken by Roever at Jackson, Tenn., was determined by Mr. dos Passos.

160. *Lerodea neamathla* Skinner and Williams. Klots (1951) wrote: "The recent description of *julia* from Texas makes it doubtful whether old records of *neamathla* from the Gulf States, Texas, and north to Missouri refer to it or to *julia*. Range.—Florida, probably Georgia, perhaps Gulf States and Texas." Mr. Freeman wrote to us: "I have never seen specimens of *julia* from farther north than San Marcos" (200 miles southwest of Dallas, 160 miles west of Houston, Texas). A male taken at Chickasaw, Ala. in September and determined by E. L. Bell is in the Los Angeles County Museum and was referred to by Martin and Truxal (1955).

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161. *Megathymus yuccae yuccae* (Boisduval and LeConte). This species was redescribed by Freeman (1952) to include material previously known as *M. y. alabamae* (Freeman, 1943), the type locality of which was Anniston, Alabama; from specimens from South Carolina, Georgia, Alabama, and Buffalo, Leon Co., Texas. It has been taken at Tuscaloosa, Ala. (Chermock, 1951). We expect that it occurs in Mississippi.

162. *Megathymus cofaqui* (Strecker). This species was described from Georgia. Freeman (1955) stated that it feeds on *Yucca aloifolia* which occurs in Louisiana (Brown, 1945), and also in Mississippi. Lambremont (1954) listed both *M. yuccae* and *M. cofaqui* as expected to occur in Louisiana.

163. *Megathymus harrisi* H. A. Freeman. Kilian Roever told us that in the fall of 1956 he found tubes adjacent to yucca plants in west Tennessee that were indicative of the presence of this species. Harris (1954) and Freeman (1955) note that it feeds on *Yucca filamentosa*, *Yucca filamentosa* (*sensu strictu*) may not occur in Mississippi. Brown (1957) lists *Yucca aloifolia* L., *Y. gloriosa* L., and *Y. smalliana* Fern. as native to Louisiana. In a letter, he explained that *Y. filamentosa* L. has leaves with a short, concave, rigid, partly hooded tip while *Y. smalliana* has leaves with a flat, long, attenuated apex. He finds that native Louisiana yuccas with filaments on the sides of their leaves meet the description of *Y. smalliana*. The material we have seen in Mississippi appears to be this species also. We do not know whether *M. harrisi* feeds on *Y. smalliana* as well as on *Y. filamentosa*.

VIII. Flight Period

We have date and locality records for 121 of the 122 species that we have listed as known to occur in Mississippi; no specific record is known for *Phoebis philea*. Of ten species there is but a single record and a single specimen: *Phyciodes texana seminole, Strymon favonius, Incisalia augustinus croesioides, Lycaena thoë, Echinargus isola alce, Anteos maerula lacordairei, Eurema mexicana, Pyrgus syrichtus, Amblyscirtes belli, Amblyscirtes carolina.*

We have records of the occurrence of ten species in all months of the year: *Phyciodes tharos tharos, Polygonia interrogationis, Vanessa virginiensis, Precis lavinia coenia, Anaea andria, Libytheana bachmanii bachmanii, Colias eurytheme, Phoebis sennae eubule, Eurema nicippe, Pieris rapae.*

Available flight-period data for the 121 species are summarized in Table 3 by months.

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TABLE 3. *Flight-period data for Mississippi butterflies.*

	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
1. *L. p. portlandia*				x		x	x	x	x	x	x	
2. *L. creola*				x			x	x	x			
3. *E. c. cymela*			x	x	x	x	x		x			
4. *E. hermes sosybia*			x	x	x	x	x	x	x	x	x	
5. *E. a. areolata*				x		x		x	x	x		
6. *E. g. gemma*			x	x	x	x	x	x	x	x	x	
7. *C. p. pegala*							x	x	x	x		
8. *D. gilippus berenice*					x			x	x			
9. *D. p. plexippus*			x	x	x	x	x	x	x	x	x	
10. *H. charitonius tuckeri*				x								
11. *A. vanillae nigrior*		x					x	x	x	x	x	x
12. *E. claudia*		x	x	x	x	x	x	x	x	x	x	x
13. *S. diana*									x			
14. *M. g. gorgone*				x								
15. *M. n. nycteis*				x	x	x	x	x	x			
16. *P. phaon*			x	x	x	x	x	x	x	x	x	
17. *P. t. tharos*	x	x	x	x	x	x	x	x	x	x	x	x
18. *P. texana seminole*											x	
19. *P. interrogationis*	x	x	x	x	x	x	x	x	x	x	x	x
20. *P. comma*		x	x	x	x					x	x	
21. *N. antiopa*	x	x	x	x	x					x		
22. *V. atalanta*		x	x	x	x	x	x	x	x	x	x	x
23. *V. cardui*		x	x	x	x		x	x	x	x	x	x
24. *V. virginiensis*	x	x	x	x	x	x	x	x	x	x	x	x
25. *P. lavinia coenia*	x	x	x	x	x	x	x	x	x	x	x	x
26. *L. arthemis astyanax*			x	x	x	x	x	x	x	x	x	
27. *L. archippus watsoni*				x	x	x	x	x	x	x	x	
28. *A. andria*	x	x	x	x	x	x	x	x	x	x	x	x
29. *A. c. clyton*					x	x	x	x	x	x		
30. *A. celtis alicia*				x	x	x	x	x	x	x		
31. *L. b. bachmanii*	x	x	x	x	x	x	x	x	x	x	x	x
32. *L. virginiensis*			x	x	x	x	x	x	x	x		
33. *A. h. halesus*		x	x	x		x			x	x	x	
34. *S. m-album*		x	x				x	x				
35. *S. cecrops*		x	x	x	x	x	x	x	x	x		
36. *S. m. melinus*		x	x	x	x	x	x	x	x	x		
37. *S. favonius*					x							
38. *S. o. ontario*				x	x							
39. *S. falacer*					x	x						
40. *S. liparops strigosus*				x		x						
41. *M. g. gryneus*		x	x	x	x		x	x				
42. *I. augustinus crocsioides*			x									
43. *I. henrici turneri*			x	x								
44. *I. n. niphon*			x	x								
45. *F. t. turquinius*			x	x	x	x	x					
46. *L. thoë*				x								
47. *H. ceraunus antibubastus*				x			x			x		
48. *E. isola alce*						x						
49. *E. c. comyntas*		x	x	x	x	x	x	x	x	x	x	
50. *L. argiolus pseudargiolus*		x	x	x	x	x		x	x			
51. *P. polyxenes asterius*	x	x	x	x	x	x	x	x	x	x		
52. *P. c. cresphontes*			x	x	x	x	x	x	x			
53. *P. g. glaucus*			x	x	x	x	x	x	x	x		
54. *P. troilus ilioneus*		x	x	x	x	x	x	x	x	x		
55. *P. p. palamedes*			x	x	x	x	x	x	x	x		
56. *G. m. marcellus*		x	x	x	x	x	x	x				
57. *B. philenor*		x	x	x	x	x	x	x	x	x		
58. *A. genutia*			x	x								
59. *C. curytheme*	x	x	x	x	x	x	x	x	x	x	x	x
60. *C. philodice*	x		x		x			x		x		
61. *Z. cesonia*	x		x	x	x	x	x	x	x	x		x
62. *A. maerula lacordairei*								x				
63. *P. sennae cubule*	x	x	x	x	x	x	x	x	x	x	x	x
64. *P. philea*												
65. *E. d. daira*		x	x	x	x	x	x	x	x	x	x	x
66. *E. mexicana*									x			

TABLE 3. — Continued. *Flight-period data for Mississippi butterflies.*

	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
67. *E. nicippe*	x	x	x	x	x	x	x	x	x	x	x	x
68. *E. l. lisa*	x				x	x	x	x	x	x	x	x
69. *N. iole*						x	x	x	x	x	x	
70. *P. rapae*	x	x	x	x	x	x	x	x	x	x	x	x
71. *P. p. protodice*		x	x	x	x	x	x	x	x	x	x	x
72. *A. monuste phileta*					x	x	x	x		x		
73. *E. c. clarus*		x	x	x	x	x	x	x	x	x		
74. *U. proteus*			x				x	x	x	x	x	
75. *A. lyciades*				x	x	x	x	x	x	x		
76. *A. cellus*					x		x	x				
77. *T. bathyllus*			x	x	x	x	x	x	x			
78. *T. pylades*				x	x	x	x	x	x			
79. *T. confusis*				x	x		x	x				
80. *P. c. communis*		x	x	x	x	x	x	x	x	x	x	x
81. *P. syrichtus*								x				
82. *P. catullus*			x	x	x	x	x	x	x			
83. *P. hayhurstii*				x	x	x	x	x	x			
84. *E. b. brizo*		x	x	x					x			
85. *E. martialis*			x	x	x	x						
86. *E. horatius*		x	x	x	x	x	x	x	x	x		
87. *E. juvenalis*		x	x	x		x	x	x				
88. *E. baptisiae*						x						
89. *E. zarucco*		x	x	x	x	x	x	x	x	x		
90. *A. numitor*				x		x	x	x	x	x		
91. *C. minima*				x	x	x	x	x	x	x	x	
92. *H. m. metea*			x	x								
93. *H. attalus*								x	x			
94. *H. phyleus*			x	x	x	x	x	x	x	x	x	x
95. *A. campestris*			x	x	x	x	x	x	x	x	x	x
96. *P. verna sequoyah*				x	x		x	x				
97. *P. manataaqua*					x	x	x	x	x	x		
98. *P. themistocles*				x	x	x	x	x	x	x		
99. *P. v. vibex*			x	x	x	x	x	x	x	x		
100. *W. o. otho*				x	x	x	x	x	x	x	x	
101. *P. zabulon*			x	x		x	x	x	x			
102. *P. yehl*					x	x		x	x	x		
103. *A. a. arogos*						x		x	x			
104. *A. arpa*									x			
105. *A. dion alabamae*								x	x			
106. *A. palatka*						x						
107. *A. ruricola metacomet*				x	x	x	x	x	x	x		
108. *A. loammi*			x									
109. *A. hianna*			x	x								
110. *O. maculata*				x	x			x	x			
111. *L. accius*		x	x	x	x	x	x	x	x	x	x	
112. *A. vialis*			x	x								
113. *A. hegon*				x								
114. *A. carolina*									x			
115. *A. textor*			x	x	x		x	x	x			
116. *A. alternata*			x				x	x				
117. *A. belli*				x								
118. *L. l'herminieri*				x	x	x	x	x	x	x		
119. *L. eufala*				x	x	x	x	x	x	x	x	x
120. *C. ethlius*					x		x	x				
121. *P. panoquin*				x		x				x		
122. *P. ocola*				x			x	x	x	x		

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ABSTRACT

Published and unpublished previous work by H. E. Weed beginning in 1891, F. M. Jones, R. E. Hutchins, H. I. O'Byrne, and others is reviewed. Previous lists published by Weed (1894) and Hutchins (1933) recorded the occurrence of 77 species. The annotated list summarizes all available data on the known, probable or possible occurrence of 163 species. Records of the following 45 species, not included in either of the two previously published lists, are given: *Lethe creola, Euptychia areolata, Danaus gilippus berenice, Heliconius charitonius, Speyeria diana, Melitaea gorgone, M. nycteis, Phyciodes texana seminole, Strymon m-album, S. favonius, S. ontario, Incisalia augustinus, I. niphon, Feniseca, tarquinius, Lycaena thoë, Hemiargus ceraunus antibubastus, Echinargus isola, Anteos maerula lacordairei, Eurema mexicana, Antochton cellus, Thorybes confusis, Pyrgus syriehtus, Pholisora hayhurstii, Erynnis baptisiae, E. zarucco, Copaeodes minima, Hesperia metea, H. attalus, Polites verna sequoyah, Poanes zabulon, P. yehl, Atrytone arogos, A. arpa, A. dion alabamae, A. palatka, A. ruricola metacomet, Atrytonopsis loammi, A. hianna, Amblyscirtes vialis, A. hegon, A. carolina, A. textor, A. alternata, A. belli,* and *Panoquina panoquin.* Records of occurrence at 189 localities (shown on maps) representing all of Mississippi's 82 counties are abstracted. Flight-period data by months are given for each of the 122 species listed as known from Mississippi. Of ten species, there is but a single Mississippi record and specimen: *P. texana seminole, S. favonius, I. augustinus, L. thoë, E. isola, A. maerula, E. mexicana, P. syriehtus, A. carolina,* and *A. belli.* Of ten other species, records are available of the occurrence of adults in Mississippi in all months of the year: *Phyciodes tharos, Polygonia interrogationis, Vanessa virginiensis, Precis lavinia coenia, Anaea, andria, Lybytheana bachmanii, Colias eurytheme, Phoebis sennae eubule, Eurema nicippe,* and *Pieris rapae.* Reasons are given for believing that 41 other species are of probable or possible occurrence in Mississippi. Comparisons are made with lists for other states and regions.

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AQUATIC AND SEMIAQUATIC HEMIPTERA OF MISSISSIPPI

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AQUATIC AND SEMIAQUATIC HEMIPTERA OF MISSISSIPPI

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CONTENTS

I. Introduction

This investigation was undertaken to obtain information on the distribution and biology of the families of aquatic and semiaquatic Hemiptera that occur in Mississippi. Since no previous studies, other than a few brief lists of species, are reported in the literature, special effort was made to collect specimens from as wide a range of habitats as possible. The major portion of the collecting was done during the spring and fall months, and part of one summer was spent on the Gulf Coast where opportunity for the study of aquatic and semiaquatic Hemiptera was provided by the Gulf Coast Research Laboratory.

The project consisted primarily of collection, preservation, mounting and identification of specimens along with observations on habitat preferences, associations of species, mating habits, food habits and other biological data. This work includes data on 132 species in 13 families.

II. Review of the Literature

There have been no comprehensive studies dealing specifically with the aquatic and semiaquatic Hemiptera of Mississippi. Various checklists have included records of species from Mississippi and these papers are noted in the distributional data. Drake (1922) described a new species of *Plea* from the state and listed 17 other species of aquatic and semiaquatic Hemiptera that he collected in one pond. A list of 17 species, collected in Marshall and Lafayette counties, Mississippi, was published by Penn and Ellis (1949).

This literature review will be limited to a brief survey of selected publications that contain information useful to students of the Mississippi fauna.

A number of species of aquatic Hemiptera was described by Say (1832) in his series of works on the insects of North Amercia. Although his descriptions of species were brief, they provided a basis for future taxonomists to build on. Useful lists of species with notes on habitats were published by Uhler (1876, 1877, 1878). A number of the species he reported were collected by early explorers of the United States west of the Mississippi River. Since it represents some early collecting in a neighboring state, Townsend's (1886) report of three species of aquatic Hemiptera collected in Louisiana is of interest. A short list of aquatic Hemiptera found in the Mississippi River bottoms near Quincy, Illinois was published by Garman (1890). Summers (1891b) did considerable collecting in Tennessee and published a bulletin giving keys to 10 families and a few common genera. However, he did not include any locality data in this publication.

Bueno in a long series of papers issued from 1905 to 1942 added greatly to our knowledge of the general occurrence and distribution of many American species. Bueno made contributions to the taxonomy of several families of aquatic and semiaquatic Hemiptera, which will be reviewed under the appropriate family headings below. Bueno and Brimley (1907) listed a few aquatic Hemiptera from North Carolina.

Barber (1913b) published a short paper on aquatic Hemiptera which was a popular, general account of the habits of this group of insects. The following year a list of the known species of the aquatic Hemiptera of Florida appeared (Barber, 1914). Riley (1918) wrote a general account on the food and feeding habits of aquatic Hemiptera. The handy and widely used catalogue of the Hemiptera of America North of Mexico by Van Duzee became available in 1917. This work treats the synonymy and distribution of all species of Hemiptera known at that time. The classic and extremely useful work on the biology and ecology of aquatic and semiaquatic Hemiptera was the next comprehensive, general publication that became available (Hungerford, 1920). Hungerford has published a number of other detailed works on specific families which will be reviewed under the appropriate headings below. A paper by Hussey (1919) covering the so-called "waterbugs" of the Douglas Lake region of Michigan (even though far removed from Mississippi ecologically) is of interest since it contains useful keys.

Britton et al (1923), published the Hemiptera of Connecticut, a useful work that included many southern species. Parshley's (1925) bibliography of the American Hemiptera-Heteroptera provides a convenient, fairly complete listing of references arranged alphabetically by author. The following year a work covering the Heteroptera or true bugs of eastern North America was pub-

lished and filled the need for a convenient manual for the identification of all Hemiptera (Blatchley, 1926). It still remains a most valuable aid to the general student of the Hemiptera.

Usinger et al (1948, 1956) published excellent papers on the aquatic insects of California. They are complete with keys to families, genera and species and available biological data.

Ellis (1952) listed forty species, exclusive of Corixidae and Saldidae from southeastern Louisiana. He included locality and ecological data for twenty-eight species, ten species of which were not previously reported from Louisiana. A series of papers by Herring (1950a, 1950b, 1951a, 1951b) includes locality records, biological data and keys to the aquatic and semiaquatic Hemiptera of northern Florida.

III. Techniques and Procedures

Accurate identification of a number of species made examination of the genitalia necessary. Essentially, the technique followed was that described by Hungerford (1933a). The genitalia must be placed on the pins with the specimens from which they came; thus, they are readily available for study and are not likely to be lost or confused with other specimens.

All measurements were made with an eyepiece micrometer using either 20 or 40 magnifications, and are reported in millimeters or fractions of a millimeter. Unless indicated otherwise, all lengths of insects were measured from the tip of the clypeus to the apex of the abdomen and all widths were across the widest part of the pronotum. Where the wings exceeded the tip of the abdomen, the length included this extension.

Abbreviations are used as follows: J.T.P. = J. T. Polhemus, C.A.W. = the writer, M.S.C. = Mississippi State College collections. All other collectors names are given in the locality data sections. For brevity, localities only are listed where 10 or more records are available for a species.

Specimens collected in the state and used as the basis for this study are in the personal collection of the writer, indicated by (C.A.W.) or in the collections of other workers as indicated in parentheses after locality records. Also, duplicate specimens of most species have been deposited in the collections of the Department of Zoology and Entomology at Mississippi State College.

IV. Ecological Considerations

This study was concerned with aquatic habitats of many kinds, widely scattered over the state, therefore some general statements relative to the various soil areas or types might be pertinent. The state has been divided into the following soil areas by soil scientists.

Northeast Highlands.—In this region are found some of the steepest hills in the state, and these have been cut up by erosion to form deep gullies in many places. Pine and oak stands cover much of the area providing protection to the soil by reducing the rapid run-off of water. Stock ponds, small streams and borrow pits comprise common collecting habitats encountered in the area. The soils were formed mostly from coastal plain deposits of gravel, clay and sand. The soils are quite sandy in texture generally, and drainage is good.

Northeast and Central Prairies.—The topography of this region is flat to gently rolling with heavily sodded areas limited primarily to river bottoms. Some post oak and hickory stands occur in parts, however. Stock ponds, sink holes, artificial lakes and small streams are common collecting habitats noted. The soils of this area were developed primarily from chalky limestone and clays which are coastal plain deposits. Due to the nature of the parent material, the soils possess textures of the clay and heavy clay classes. The soils are characteristically dark in color, or where heavy sheet erosion has occurred, chalky-white in color.

Pontotoc Ridge.—The topography of this region varies from rolling to rough and rugged, with much of the area bisected by deep gullies. Pine stands, oak groves and fruit orchards are common. Ponds, small upland streams, small rivers and roadside ditches are typical habitats. The soils were derived from marine deposits of sands and reddish clays. Soil texture varies from clay to sandy loam, and has suffered greatly from erosion due to the texture and the topography of the land.

Flatwoods.—This region is level to gently rolling and in general heavily covered with trees such as pine, oak and hickory. Internal drainage of the soil is poor and this provides

many aquatic collecting habitats. Stock ponds, woodland pools and streams abound. The soils were derived from a marine deposit of sour unstratified clay, commonly called "soap stone". The texture of the soils varies from silt loam to fine sandy loam and the color varies from grey to pale yellow.

Sand-Clay Hills.—The topography varies from very hilly to gently rolling and in many places erosion has made considerable progress forming large, steep-banked gullies. A wide variety of collecting habitats occur in the area due to the variability of the topography. Typical forest trees include extensive stands of pine, oak, hickory and other hardwoods in the uplands, with various species of gum and willow common in the swamps. The soils of the area were derived from intermixed coastal plain deposits of sands, clays, shales and lignite. Soil texture varies from light sandy loams to heavy clays. Drainage is generally good. Predominating soil colors are red and yellow.

Brown Loam.—Topography varies from gently rolling to steeply rolling with bluffs and steep banks in many places. Collecting habitats are limited mostly to streams and roadside ditches. Hay crops and livestock are common. The forests consist mostly of miscellaneous hardwoods. Soils of the area were derived from windblown deposits high in silt content and rich in lime and other bases. Texture of the soils varies from silt loams to silty clay loams with the color predominantly brown to buff. Drainage is generally very good.

Mississippi Delta. — The topography is very flat with the main problem being drainage. Aquatic habitats are numerous and all types were present. Many swamps and river bottoms containing heavy growths of mixed hardwoods are scattered throughout the delta. The soils of the region were formed from alluvial deposits transported by the Mississippi river and other smaller streams. The soils of this region are the most recent deposits in the state. Drainage varies from very good to very poor and the soil texture from light sand to heavy clay.

Longleaf Pine. — The topography varies from hilly to almost level. Habitats for aquatic insects are restricted mostly to streams, marshes and seepage areas since ponds and lakes are quite rare. The predominant tree is the longleaf pine with mixed hardwoods common in the swamplands. Soils developed primarily from relatively young marine deposits of sands, clays and gravel. Drainage is generally good because of the coarse sandy texture of the soils.

Gulf Coast.—Topography is very flat and there are a few streams. Also, there are numerous tidal marshes, a few ponds and some seepage areas suitable for aquatic collecting. Many interesting brackish areas were found. Soils are mostly sand and tidal marsh lands from recent marine deposits that have not developed very far. Internal drainage is good due to the sandy nature of the soil.

A study of the locality data on all species indicates that faunal areas may be present to some extent in the state, although they are not clearly defined. In the families Belostomatidae, Hydrometridae, Hebridae, Ochteridae and Naucoridae certain species were taken only in the Gulf Coastal region of the state. Study of collection data from the other families reveals no clear-cut faunal areas.

V. Key to Mississippi Families of Aquatic and Semiaquatic Hemiptera

The arrangement of Van Duzee (1917) has been followed for the general taxonomic treatment of families, with modifications within certain families as treated by more recent workers. The families where arrangements of authors other than Van Duzee (1917) have been followed include: Belostomatidae, De Carlo (1938); Corixidae, Hungerford (1948); Gerridae, Drake and Harris (1934); Hebridae, Porter (1950); Hydrometridae, Hungerford (1934); Nepidae, Hungerford (1922); Notonectidae, Hungerford (1933); Saldidae, Drake and Hoberlandt (1951).

1. Antennae shorter than head 2
   Antennae as long as or longer than head 8
2. Ocelli present; semiaquatic 3
   Ocelli absent; aquatic 4
3. Antennae exposed; front and middle legs similar; eyes not protuberant; beak reaching to or beyond the hind coxae ..... PELOGONIIDAE Leach
   Antennae concealed; front legs formed for catching prey; eyes protuberant; beak very short, hidden by front femora ..... GELASTOCORIDAE Kirkaldy

4. Hind tarsi with indistinct setiform claws except in *Plea* (which is less than 3 mm long) 5
   Hind tarsi with distinct claws 6
5. Head overlapping thorax dorsally; front tarsi one-segmented, shovel-shaped ..... CORIXIDAE Leach
   Head inserted into thorax; front tarsi two-segmented except in a few males ..... NOTONECTIDAE Leach
6. Membrane of hemelytra net-veined 7
   Membrane of hemelytra without veins ..... NAUCORIDAE Fallen
7. Terminal appendages of abdomen as long as, or almost as long as abdomen; tarsi one-segmented ..... NEPIDAE Latreille
   Terminal appendages of abdomen flat and much shorter than abdomen; tarsi two-segmented ..... BELOSTOMATIDAE Leach
8. Head as long as or longer than thorax ..... HYDROMETRIDAE Billberg
   Head shorter than thorax plus scutellum 9
9. Claws of at least the front tarsi distinctly anteapical, with terminal tarsal segment more or less cleft 10
   Claws all apical, last segment entire 11
10. Tip of hind femur extending much beyond apex of abdomen; intermediate and hind pairs of legs approximated, very distant from front pair; beak four-segmented ..... GERRIDAE Amyot and Serville
    Tip of hind femur subequally reaching apex of abdomen; intermediate pair of legs about equidistant from front and hind pairs except in *Rhagovelia;* beak three-segmented ..... VELIIDAE Amyot and Serville
11. Tarsi two-segmented ..... HEBRIDAE Amyot and Serville
    Tarsi three-segmented 12
12. Membrane without veins; clavus and membrane of similar structure; corium thicker than clavus; apterous forms slender in shape generally ..... MESOVELIIDAE Douglas and Scott
    Membrane with veins; clavus and membrane unlike in structure; corium and clavus similar in structure ..... SALIDAE Amyot and Serville

VI. Annotated List

A. *Family HEBRIDAE Amyot and Serville, 1843*

Review of the literature.—Porter (1950) studied the ecology of the Hebridae in Kansas and Michigan. He concluded that the type of soil has very little influence on their choice of habitats. However, the insects do require moist cover to hide in. Light is not important in their choice of habitat. Porter found that plant species in a habitat do not limit hebrid species, and that mites parasitize these insects. Predaceous larvae were observed feeding on hebrids.

This family of small, difficult-to-collect insects has been studied by relatively few taxonomists in previous years. One of the early papers was by Drake (1917) on the North American species of *Merragata.* Following Drake's paper, Hungerford (1918b) published brief notes on the oviposition habits of *Hebrus.* Descriptions of new species of Hebridae in the Hungarian National Museum by Horvath (1929a) included some American forms. Harris (1942a) established the priority of the family name Hebridae over Naeogeidae which had been used interchangeably with Hebridae by taxonomists before 1942. Also, he established that *Hebrus* Curtis takes precedence over *Naeogeus* Laporte. Drake and Harris (1943) published keys, descriptions, synonymy and distributional data on western hemisphere Hebridae. A list of the Hebridae of Missouri by Froeschner (1949) includes two genera and six species from that state. The taxonomy and natural history of the American Hebridae were investigated by Porter (1950), and this work served as a guide to the writer in his collection and study of Mississippi Hebridae.

Key to the Mississippi Genera of *HEBRIDAE* Amyot and Serville

Antenna with apparently four segments, but actually five ..... *MERRAGATA* White
Antenna with five distinct segments ..... *HEBRUS* Curtis

Key to the Mississippi Species of *HEBRUS* Curtis

1. Median longitudinal sulcus of the pronotum wide and shallow, ending anteriorly in two well defined pits ..... *consolidus* Uhler

Median longitudinal sulcus of the pronotum narrow, not or scarcely wider than deep anteriorly 2

2. Median longitudinal sulcus of vertex deep
buenoi Drake and Harris

Median longitudinal sulcus of vertex absent 3

3. Inner vein of hemelytron rounded or angulate at the distal end
burmeisteri Lethierry and Severin

Angle of the inner vein of the hemelytron produced at the distal end 4

4. Male genital capsule, when viewed from the posterior, smaller (0.20-0.22 mm wide), and more rounded; hook of paramere shorter than wide
concinnus Uhler

Male genital capsule, when viewed from the posterior, larger (0.25-0.33 mm wide), and half-moon shaped; hook of paramere as long as wide
sobrinus Uhler

Hebrus buenoi Drake and Harris, 1943

Biological notes.—Porter (1950) reared this insect in the laboratory and observed its life stages from egg to adult. He obtained eggs on moss leaves where they were glued with a gelatinous mass secreted by the female. The time required for hatching varied from 10 to 22 days, the first stadium, 5 to 9 days; the second stadium, 4 to 9 days; the third stadium, 5 to 9 days; the fourth stadium, 5 to 7 days and the fifth stadium, 5 to 6 days. The total development time from egg to adult varied from 34 to 62 days. Molting activities were similar in all instars.

Locality data.—Previously recorded from Wiggins by Drake and Harris (1943). The writer has not taken it in Mississippi.

Hebrus burmeisteri Lethierry and Severin, 1835

Biological notes. — The writer collected this insect at only one locality in the state. This was on the bank of a pond near overhanging vegetation where the water had receded. The specimen was taken in late November which may indicate that it spends the winter in the adult stage in Mississippi.

Hungerford (1920) made a rather thorough study of this insect at Ithaca, New York where he collected it upon the moist earth on the bank of an upland meadow-pool. He observed mating and found that the male mounts the female and that they remain in copula for varying periods of time. In the laboratory, oviposition was obtained by placing sprigs of moss in a petri dish partially filled with moist sand. The eggs were placed between the leaves and stems of the moss and took about one week for incubation. In the laboratory the bugs fed on plant lice, midges and mosquitoes that were dropped upon the sand of the petri dish.

Porter (1950) reared it in the laboratory. Eggs were placed in the axils of moss leaves and enclosed in a sticky gelatinous mass. The time required for development varied as follows: first stadium, 3 to 5 days; second stadium, 6 to 8 days; third stadium, 6 to 13 days; fourth stadium, 6 to 13 days and fifth stadium, 5 to 9 days. The total developmental period varied from 26 to 48 days.

Locality data.—This speices has not been recorded previously from Mississippi. Specimens have been seen as follows: Ocean Springs, May, 1 specimen (J.T.P.); Saltillo, Nov., 1 ♂ (C.A.W.).

Hebrus concinnus Uhler, 1894

Biological notes. — This insect frequents the banks of sluggish streams, ponds and shallow drainage ditches, where there is overhanging vegetation present. It is the most common species of the genus in the state. It is quite generalized in its habitat preferences, but as with other small insects the collector must work carefully and diligently to avoid overlooking it. Dousing the overhanging vegetation with water and dipping the specimens off the water surface proved to be the most fruitful method of collecting for the writer.

Uhler (1894) reported finding them on muddy soil and among the roots of grasses near pools of water. Winged specimens were noted swimming on the surface of quiet water.

Bueno (1908d) collected it at White Plains, New York on the muddy bottom of a temporaty pool.

Blatchley (1926) records it as occurring in muck, beneath boards and in masses of weeds near ponds. Also, he noted specimens on the surface of ponds and adjacent mud flats.

Locality data. — Previously recorded from the state by Drake and Harris (1943) and Porter (1950). Specimens have been seen

at follows: Biloxi, April, 6 specimens (J.T.P.); Fearn Springs, Sept.-Oct., 1 ♂, 2 ♀♀ (C.A.W.); Fulton, Oct., 2 ♂♂ (C.A.W.); Handsboro, June, 1 specimen (J.T.P.); State College, Sept.-Oct., 2 ♂♂, 6 ♀♀ (C.A.W.); Vancleave, Sept., 6 specimens (J.T.P.).

Hebrus consolidus Uhler, 1898

Biological notes.—Specimens of this species were collected only in the Gulf coastal region by sweeping grasses growing in the water of a shallow freshwater pond fed by the overflow from a deep well on the property of the Gulf Coast Research Laboratory. A dense growth of algae covered the surface of the pond.

Uhler (1894) collected it on muddy soil and among the roots of grasses near pools of water. Hungerford and Beamer (1925) took specimens on the margins of a small pool. Blatchley (1926) indicates that it may be collected by sweeping low herbage along the margins of ponds.

Locality data.—Previously recorded from the state by Drake and Harris (1943) and Porter (1950). Specimens have been seen as follows: Biloxi, April-May, 5 specimens (J.T.P.); Charleston (H. M. Harris); Handsboro, June, 2 specimens (J.T.P.); Laurel (H. M. Harris); Ocean Springs, Aug., 1 ♂, 1 ♀ (C.A.W.).

Hebrus sobrinus Uhler, 1877

Biological notes.—Specimens were collected in two localities in Mississippi, both in the hilly northeastern part. One of the habitats was a large, flat-bottomed drainage ditch partially covered with vegetation and with shallow pot-holes of water in the bottom of the ditch. Also, specimens were taken by sweeping the vegetation in the ditch with a net. The other locality was on the bank of a small, sandy-bottomed stream with clear water and very little vegetation.

Porter (1950) studied its life history in the laboratory at Lawrence, Kansas. Females laid their eggs in the axils of moss leaves in the laboratory and the incubation period varied from 9 to 12 days. The length of time required for the various stadia to be completed was as follows: first stadium, 4 to 6 days; second stadium, 5 to 9 days; third stadium, 6 to 11 days; fourth stadium, 6 to 7 days; and fifth stadium, 9 to 20 days. Time for complete development varied from 39 to 62 days. Activities of individuals of all instars were similar.

Locality data.—Previously recorded from Lucedale by Porter (1950). Specimens have been seen as follows: Fulton, Oct., 1 ♂ (C.A.W.); Pontotoc, Oct., 1 ♂ (C.A.W.).

Key to the Mississippi Species of *MERRAGATA* White

1. Apical segment of the antenna elongate ..... *brevis* Champion
   Apical segment of the antenna fusiform 2
2. Apex of the scutellum rounded; membrane white ..... *brunnea* Drake
   Apex of the scutellum truncate or slightly concave; membrane with four white spots on dark background ..... *hebroides* White

Merragata brevis Champion, 1898

Biological notes.—No information on the biology of this species is available.

Locality data.—This insect has not been recorded previously from the state. Specimens have been seen as follows: Biloxi, April, 4 specimens (J.T.P.); Handsboro, June, 10 specimens (J.T.P.); Meridian, April, 1 ♂ (J. A. Roe).

Merragata brunnea Drake, 1917

Biological notes.—In Mississippi the writer found this to be the second most abundant species in the family. It was most frequently collected on the surface of ponds and sloughs that either were covered with aquatic vegetation or had vegetation hanging into the water from the banks. A long series was collected from a shallow area of a large spring-fed pond which had the surface completely covered with a heavy growth of the sweet-scented pond lily, *Castalia odorata* (Ait.). This bug was taken in association with *Mesovelia mulsanti* White, *Mesovelia amoena* Uhler, *Hebrus concinnus* Uhler and *Merragata hebroides* White. The most abundant was *Mesovelia mulsanti* White, with *Merragata brunnea* Drake second. Another habitat where it was collected was a shady, shallow slough which had the surface densely covered with a mat of *Lemna*. Nymphs were collected in the state as late as November.

Drake (1917) described the habitat preferences of *Merragata brunnea* as being on the secluded coves of ponds, lakes and swampy pools where there is a dense growth of aquatic plants and the water is shallow.

He indicates that he has rarely seen them on the banks and that they usually are found running around on the surface of the water where *Lemna, Nymphaea* and other floating aquatic plants are growing. They also can stand submergence in water for approximately half an hour and still come to the surface by their own power.

Blatchley (1926) took numerous specimens from masses of water shield, *Brasenia purpurea* (Michx.), in small ponds.

Porter (1950) observed the details of its life history. Oviposition was obtained on moss leaves and under algae in the laboratory, and incubation time varied from 8 to 12 days. He determined the time required for various stadia as follows: first stadium, 3 to 6 days; second stadium, 3 to 4 days; third stadium, 3 to 4 days; fourth stadium, 5 to 6 days; and fifth stadium, 5 to 6 days. Thus, the total developmental period varied from 31 to 38 days.

Locality data.—Previously recorded from the state by Drake and Harris (1943) and Porter (1950). Specimens have been seen as follows: Charleston, July-Sept., 2 specimens (H. M. Harris); Fearn Springs, Sept., 57 specimens (C.A.W.); Marks, Oct., 1 ♂ (C.A.W.); Minter City, Oct., 1 ♂ (C.A.W.); Ocean Springs, May, 1 specimen (J.T.P.); State College, Sept., 1 ♂, 2 ♀♀ (C.A.W.).

Merragata hebroides White, 1877

Biological notes.—Four years collecting in the state by the writer has revealed that this is the most abundant of the Hebridae. It was found commonly on ponds and lakes that were filled with algal mats. They were observed moving slowly over the surface provided by the thick mats of algae. Some were living in a saline tidal pool at Ocean Springs. At the time the collection was made salinity was 6.6 ‰. The banks and shallow water were filled with grasses and sedges. Clear ponds with overhanging vegetation along the banks proved to be another favorite habitat.

Drake (1917) noted that the habitat preferences of *Merragata hebroides* seemed to be the secluded coves of ponds, lakes and swampy pools where there was a dense growth of aquatic plants and where the water was shallow. He rarely saw them on the banks and they usually were found running around on the surface of the water where *Lemna, Nymphae* and other floating aquatic plants were growing.

Blatchley (1926) reported that he swept two specimens from low herbage along the side of a ditch.

Porter (1950) observed the life history in the laboratory where eggs were laid on moss leaves. He also found eggs in nature under filaments of algae growing on stones and deposited in small holes which were in the surface of the stones. The incubation period in the laboratory varied from 9 to 12 days. Instar developmental times were as follows: first stadium, 2 to 4 days; second stadium, 3 to 4 days; third stadium, 2 to 3 days; fourth stadium, 3 to 7 days; and fifth stadium, 3 to 6 days. Total developmental time varied from 20 to 36 days.

Locality data.—Previously recorded from the state by Drake and Harris (1943) and Porter (1950). Specimens have been seen as follows: Biloxi, March-April, 95 specimens (C.A.W. and J.T.P.); Fearn Springs, Sept., 1 ♂, 1 ♀ (C.A.W.); Handsboro, June, 3 specimens (J.T.P.); Ocean Springs, May-Aug., 57 specimens (C.A.W. and J.T.P.); Ramsey Springs, Oct., 1 specimen (J.T.P.); State College, May-July, 52 specimens (C. A.W.).

B. *Family MESOVELIIDAE Douglas and Scott, 1867*

Review of the literature.—The species in this family are abundant, easily seen and collected and therefore have received considerable attention from taxonomists. A monograph of the family, including considerable data on American species, was written by Horvath (1915). Also, a second paper on the family was published as a fascicle of the general catalogue of the Hemiptera (Horvath, 1929b). Further studies on the life history and habits of *Mesovelia mulsanti* White were carried out by Hungerford (1917a). The original description of *Mesovelia cryptophila*, from Michigan, along with notes regarding its life history were published by Hungerford (1924a). Jaczewski (1930) published a revisionary work on *Mesovelia mulsanti bisignata* Jaczewski. Rather detailed studies of *Mesovelia mulsanti* White and *Mesovelia cryptophila* Hungerford in Michigan and Kansas were published by Hoffman (1932b). Harris and Drake (1941) recorded *Meso-*

velia amoena Uhler from Mississippi for the first time. Further work on the distribution and variation of *Mesovelia mulsanti* White was published by Usinger (1942a). A check list of the Mesoveliidae of the western hemisphere (Drake and Harris, 1946) was useful to the writer in this study. Froeschner (1949) recorded locality data on two species of *Mesovelia* from Missouri.

Key to the Mississippi Species of *MESOVELIA* Mulsant and Rey

1. Size larger, length, 2.87 to 3.80 mm; front and middle femora each with a row of spines on lower hind margin ..... *mulsanti bisignata* Jaczewski
   Size smaller, 2.8 mm or less; front and middle femora not spined on lower hind margin 2
2. Beak almost reaching apex of hind coxae; slender in shape; length 2.1 to 2.8 mm ..... *cryptophila* Hungerford
   Beak reaching between the middle coxae; robust in shape; length 2.00 to 2.38 mm ..... *amoena* Uhler

Mesovelia mulsanti bisignata Jaczewski, 1930

Biological notes.—Widely distributed in Mississippi and most abundant on ponds, borrow-pits and slow moving streams, this insect was especially abundant on floating vegetation in ponds. The writer usually found the ratio of this species to *Mesovelia amoena* Uhler to be about eight of the former to one of the latter, and they were frequently collected together. Four years observation in Mississippi has shown that it reaches maximum numbers in September. Nymphs were collected as early as March and as late as November at State College, and wingless adults were always more numerous than winged specimens.

Three collecting trips during July, 1951 to Deer Island, about one mile off the coast from Biloxi, revealed specimens in fair numbers in a tidal pool on the east end of the island. They were predominantly in the nymphal stage at this time of year. The water in the pool was brackish as determined by taste. It was also collected in brackish tidal pools on both Horn and Cat Islands.

Hungerford (1917a) studied the life history of this insect at Ithaca, New York. He collected it commonly around the margins of pools upon floating vegetation where it fed upon small organisms that came to the surface from below or that fell upon the surface. It probably passes the winter in the adult stage at Ithaca, and starts ovipositing in the stems of plants or the spongy wood of floating logs. There was a succession of generations throughout the season, each complete cycle requiring about 24 days. The insect flies from pool to pool.

Hoffman (1932b) studied its biology in Kansas and Michigan and his data agree fairly well with Hungerford's. The average time for development of the first instar was 3.4 days; second instar, 3.2 days; third instar, 3.5 days; fourth instar, 4.4 days; and fifth instar, 5.4 days. Average time to maturity from the egg was approximately 20 days, and there was no difference in the length of the developmental period of the sexes. Hoffman reared the insect in the laboratory on houseflies and fruitflies.

Locality data.—Previously recorded from Fayette by Drake (1922) and from Oxford by Penn and Ellis (1949). Specimens have been seen as follows: Beulah; Biloxi; Cat Island; Deer Island; Fearn Springs; Fountainbleau; Glen Allen; Handsboro; Horn Island; Iuka; Jackson; Natchez; Ocean Springs; Okolona; Oxford; Prairie; Ramsey Springs; Saltillo; Saratoga; State College; Terry; Tupelo; Vancleave.

Mesovelia cryptophila Hungerford, 1924

Biological notes.—The habitat in which this bug was collected was a spring-fed, clear pool about thirty feet in diameter and three to five feet deep. It had a gravel bottom and was covered with a mat of dead leaves. The insect was collected from this mat of leaves near the bank of the pool in a densely shaded spot. The water in the pool was very cold.

Harris (1943b) noted that he collected it in stagnant backwater of a stream near Clinton, Iowa. His collecting also revealed it in shady spots near the base of trees in the water. He again collected it in a small pond near Bedford, Iowa along the shady sides of adjacent logs. This series of specimens was taken with *Mesovelia mulsanti bisignata* Jaczewski, *Hydrometra martini* Kirkaldy, and *Microvelia hinei* Drake.

Hoffman (1932b) studied its life history in Michigan and found the average duration

of life as follows: first instar, 3.5 days; second instar, 3.6 days; third instar, 4.2 days; fourth instar, 5.8 days. The total life cycle was 17.6 days.

Hungerford (1924a) collected this insect in Michigan and described it as a new species. He noted that it was taken in an upland pond in a dense growth of chamaedaphne a short distance back from the open water margin. Hungerford suggested that the retiring habits of the insect accounts for it being unknown so long.

Locality data.—Previously recorded from McComb by Drake and Harris (1928c), from McComb by Harris (1943a) and from Mississippi by Froeschner (1949). Specimens have been seen as follows: Saratoga, Aug., 1 ♂ (C.A.W.).

Mesovelia amoena Uhler, 1894

Biological notes.—This species was associated with *Mesovelia mulsanti bisignata* Jaczewski in every collection taken in the state. Since very little information is available in the literature relative to habitat preference of this insect, the various locations where it was taken will be discussed briefly. At Brookhaven it was collected from along the edge of a ten acre pond which was densely covered with water chinquapin, *Nelumbo lutea* (Willd.). The specimens were taken in shallow water by sweeping with a net among the leaves at water level. The collection at Fearn Springs was near the bank of a small river that was clear of vegetation and had a small amount of floating debris on the surface. The location was densely wooded and thus quite shady. At Ocean Springs it was taken along the edge of a brackish, tidal pool rather heavily covered with emergent vegetation. The salinity of this pool was 6.6 ‰ at the time the insects were collected. The Okolona collection was made in a shallow borrow-pit heavily covered with emergent vegetation. The collection at Prairie was made in a small ditch with overhanging vegetation around the edges; the water was not flowing but had dried up into puddles. It was collected in three habitats at State College, namely a flowing stream filled with algae, along the edge of a shallow pond, and at the base of willow trees in a deep, clear pond.

Uhler (1894) in the original description noted that it was collected in British West Indies on the surface of a stream and on a pool among grass and weeds. Blatchley (1926) collected a single specimen in Florida on floating mats of duckweed, *Riccia fluitans*, on the surface of sinkhole ponds and from algal mats of a nymphaea marsh.

Locality data.—Previously recorded from Laurel by Harris and Drake (1941). Specimens have been seen as follows: Brookhaven, Nov., 1 ♀ (C.A.W.); Fearn Springs, Sept., 1 ♂, 2 ♀♀ (C.A.W.); Handsboro, June, 3 specimens (J.T.P.); Harrison County, Oct., 1 specimen (J.T.P.); Ocean Springs, July-Aug., 4 ♂♂, 2 ♀♀ (C.A.W.); Okolona, Oct., 1 ♂ (C.A.W.); Prairie, Oct., 3 ♂♂, 4 ♀♀ (C.A.W.); State College, Sept.-Nov., 3 ♂♂, 3 ♀♀ (C.A.W.).

C. *Family HYDROMETRIDAE Billberg, 1820*

Review of the literature.—A preliminary study of the life history of *Hydrometra martini* Kirkaldy in the vicinity of Ithaca, New York was made by Martin (1900). He included a drawing of the egg and presented some observations on mating. Further work on the biology of *Hydrometra martini* at Staten Island, New York was done by Bueno (1905a), where he determined the length of the life cycle in that locality. Hungerford's (1923b) paper contains keys to the species found in America north of Mexico with the description of one new species. Bueno (1926a) published a paper on the Hydrometridae of the Western Hemisphere, containing keys, descriptions and a few biological notes on some of the species. Bueno's work was followed a few years later by an extensive monograph of the Hydrometridae of the world (Hungerford and Evans, 1934) containing keys to the species of both the Eastern and Western Hemispheres, descriptions, synonymy and locality data. Many of the key characters are illustrated by drawings. One of the more recent works on this family (Herring, 1948), concerns the Hydrometridae of Florida. Six species are included and detailed locality records are given for the state. Drake and Hottes (1952a) published notes on eleven species of North American *Hydrometra*, including the description of two new species from Mexico. They made *Hydrometra myrae* Bueno a synonymn of *Hydrometra australis* Say.

Key to the Mississippi Species of *HYDROMETRA* Lamarck

1. Pits on pro- and meso-acetabula four or more 2
   Pits on pro- and meso-acetabula normally two ..... *martini* Kirkaldy
2. Pits on pro- and meso-acetabula normally four; tylus bluntly jointed as viewed from above 3
   Pits on pro- and meso-acetabula usually eight to ten; tylus broadly rounded as viewed from above ..... *wileyae* Hungerford
3. Male processes on last venter transversely linear; anteocular distance two and one-half times postocular distance; metanotum two-thirds length of pronotum ..... *australis* Say
   Male processes on last venter spine-like; anteocular distance slightly less twice postocular distance; metanotum one-half length of pronotum ..... *hungerfordi* Bueno

Hydrometra martini Kirkaldy, 1900

Biological notes.—Collections have been made in all sections of Mississippi. The writer was surprised to find it so abundant since literature records indicated that it was much less plentiful than *Hydrometra australis* Say in the southern states. It was collected most commonly in clear, shady streams, ponds covered with emergent vegetation, shallow drainage canals, roadside borrow-pits covered with vegetation, and shady *Lemna*-covered sloughs in swamps.

Hungerford (1920) gave a rather complete account of the biology of *Hydrometra martini.* He found it in habitats in Kansas and New York very similar to those it frequents in Mississippi. The eggs were placed on aquatic plants slightly above the surface of the water. As many as 11 eggs were laid in a single day and the average time for incubation was 7 days, with a range of 4 to 22 days. A female may lay 175 eggs in a season. Each of the five nymphal instars required about 2 days, and the complete life cycle under favorable conditions approximately 15 days. Hungerford found that the main food supply consisted of mosquito larvae, ostracods and emerging midges.

Martin (1900) made observations on its biology at Ithaca, New York. He observed egg-laying and found that the female backs up to grass stems extending above the water to deposit eggs which are glued singly by a gummy, gelatinous substance. The sticky mass hardens very quickly and the egg is fastened in place before it has left the body. Martin states that they feed mostly on the juices of insects trapped on the surface of the water.

Sprague (1956) published a detailed study of the morphology of all stages and complete biological studies of habitats, collecting and rearing methods, behavior, development and dimorphism.

Locality data.— Previously recorded from Fayette by Drake (1922), Agricultural College, Charleston, McComb, Port Gibson and Woodville, Drake and Harris, (1928c), Hungerford and Evans (1934), and Oxford and Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Batesville; Beulah; Biloxi, Brookhaven, Columbus; Fearn Springs; Fulton; Hattiesburg; Mississippi City; Ocean Springs; Okolona; Ramsey Springs; Saltillo; Saratoga; State College.

Hydrometra australis Say, 1832

Biological notes.—The Mississippi specimens were collected in a variety of habitats similar to those for *Hydrometra martini.* However, they did seem to be more common near the edge of ponds with heavily vegetated banks. It is common in Mississippi and was collected somewhat more frequently than *H. martini* Kirkaldy.

Herring (1951b) collected it in Florida from streams, springs, swamp-and-bog streams, and flatwoods ponds. No data is available on the life cycle. However, it is probably quite similar to that of *H. martini.*

Locality data.—Previously recorded from Fayette by Drake (1922) and from Oxford and Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Anguilla; Biloxi; Brooklyn; Charleston; Fayette; Fearn Springs; Handsboro; Hattiesburg; Laurel; McComb; Ocean Springs; Port Gibson; Ramsey Springs; Saratoga; Saucier; State College; West Point; Wiggins; Woodville; Wortham.

Hydrometra wileyae Hungerford, 1923

Biological notes.—The writer has not collected it in Mississippi and thus has had no opportunity to observe its habits.

Herring (1951b) collected specimens in Florida only from calcareous streams, which are characterized by clear, cold water derived

from huge springs of a calcareous nature.

Locality data.—Previously recorded from the state by Drake and Hottes (1952a).

Hydrometra hungerfordi Beuno, 1926

Biological notes.—The writer made collections generally in cool, clear, shady streams and ponds. It was also taken commonly in shady, clear, spring-fed seepage areas at the base of hills. Collections were made most easily by quietly observing the surface of the water until the insects were seen, and then capturing them with a small, fine-mesh tea strainer.

Locality data.—Previously recorded from the state by Hungerford and Evans (1934), and Drake and Hottes (1952a). Specimens have been seen as follows: Biloxi, April, 11 specimens (J.T.P.); Brooklyn, Feb., 5 specimens (J.T.P.); Hattiesburg, Feb., 8 specimens (J.T.P.); Ocean Springs, July, 2 ♂♂, 1 ♀ (C.A.W.); Ramsey Springs, Aug.-Oct., 2 ♂♂, 6 ♀♀ (C.A.W. and J.T.P.); Saratoga, Aug., 1 ♂ (C.A.W.); Summit, Sept., 1 specimen (H. M. Harris); Vancleave, Aug., 4 ♂♂, 5 ♀♀ (C.A.W.).

D. *Family GERRIDAE Amyot and Serville, 1843*

Review of the literature.—This family has received considerable attention from taxonomists throughout the world and there are many publications available for use in the study of the water striders. Only the more significant publications will be reviewed here and other references are in the "references" section of this paper.

An early contributor to the United States literature on Gerridae was Riley (1918, 1919, 1920, 1921a, 1921b, 1922a, 1922b) who published considerable information on the food habits, migration and tropistic responses of water striders. A number of United States records of Halobatinae are included in the paper by Esaki (1926a). Drake and Harris (1927) published notes on *Rhagovelia*, along with descriptions of six new species. A monograph of *Rhagovelia* of the Western Hemisphere, Gould (1931), is especially useful since original descriptions gleaned from many sources are included. Schroeder (1931) published keys to the males of *Rheumatobates* plus original descriptions of species, biological notes and locality records. A monograph of *Metrobates* (Anderson, 1932a), contains keys to the North American genera of Gerridae, synonymy of the species of *Metrobates* and copies of the oirginal descriptions of the species. Another paper on *Metrobates* appeared the same year (Drake and Harris, 1932a). A publication on the species of *Trepobates* (Drake and Harris, 1932b), includes keys to species, descriptions and redescriptions and information on the location of type specimens. The valuable work by Drake and Harris (1934a) on the Gerrinae of the Western Hemisphere contains keys, descriptions and excellent illustrations that make it very useful for the identification of specimens in this subfamily. Keys to the Indiana subfamilies, genera and species of Gerridae along with county distributional data and brief biological notes are included in the paper by Deay and Gould (1936a). Kuitert (1942), in a paper on Gerrinae, recorded three species from Mississippi. The paper was written after a study was made of the Gerrinae in the Snow collections of the University of Kansas.

Key to the Mississippi Subfamilies of *GERRIDAE* Amyot and Serville

1. Inner margin of eyes not sinuate, either convexly rounded or straight and oblique behind middle. Body comparatively short and stout, abdomen often very short 2

   Inner margin of eyes concavely sinuate behind middle. Body usually comparatively long and slender ..... *GERRINAE* Bianchi

2. Vertex without an impressed median line. Head produced before the antennae; genae not embracing base of beak ..... *HALOBATINAE* Bianchi

   Vertex with an impressed median line. Head wide and short, not produced before antennae; genae, as rounded disks, embracing base of beak ..... *RHAGADOTARSINAE* Lundblad

Key to the Mississippi Genera of *GERRINAE* Bianchi

1. Body dull. Tarsal segments of fore leg subequal in length. Antennae moderately long, scarcely reaching beyond hind margin of thorax ..... *GERRIS* Fabricius

   Body shiny. First tarsal segment of fore leg short, much shorter than second ..... *LIMNOGONUS* Stål

Key to Mississippi Species of
♂ *GERRIS* Fabricius

1. Venter simply emarginate at apex. Connexival spines very long, reaching to or slightly beyond the middle of the last genital segment 2
   Venter doubly emarginate behind, the second emargination forming a more or less distinct notch at the middle. Connexival spines much shorter or wanting 5
2. Antennal segment I subequal to or distinctly longer than II and III conjoined. Color very dark 3
   Antennal segment I shorter than II and III conjoined. Body reddish brown or marked with reddish brown 4
3. Antennal segment I longer than II and III conjoined. Last segment of venter without distinct median depression ..... *conformis* (Uhler)
   Antennal segment I subequal to II and III conjoined. Last segment of venter with a prominent, deep, broad, depressed median furrow ..... *nebularis* Drake and Hottes
4. Smaller, 8 to 11 mm. First genital segment with median keel at base ..... *canaliculatus* Say
   Larger, 12 to 20 mm. First genital segment without keel at base ..... *dissortis* Drake and Harris
5. Large, robust (11 mm or more). Connexival spines rather long and conical. First genital segment with a very strongly elevated, prominent keel ..... *remigis* Say
   Smaller species (less than 11 mm). Connexival spines shorter, angular. First genital segment with keel only moderately prominent or absent 6
6. Antero-lateral stripe of pronotum silvery ..... *argenticollis* Parshley
   Antero-lateral margins of pronotum without silvery stripes 7
7. First genital segment plump, scarcely impressed on each side ..... *insperatus* Drake and Hottes
   First genital segment strongly impressed on each side ..... *marginatus* Say

Key to Mississippi Species of
♀ *GERRIS* Fabricius

1. Larger species, length 12 mm or more 2
   Smaller species, length 11 mm or less 5
2. Antennal segment I equal to or longer than II and III combined 3
   Antennal segment I shorter than II and III combined ..... *dissortis* Drake and Harris
3. Antennal segment I subequal to segments II and III united 4
   Antennal segment I distinctly longer than II and III combined ..... *conformis* (Uhler)
4. Connexival spines long, slender, curved in and upward, as long as genital segments ..... *nebularis* Drake and Hottes
   Connexival spines short, as long as first genital segment ..... *remigis* Say
5. Pronotum without silvery or yellow stripes on anterior side margins 7
   Pronotum with stripes on anterior side margins 6
6. Anterior lateral stripes extending to basal margins of pronotum ..... *argenticollis* Parshley
   Anterior lateral stripes not extending to basal margins of pronotum ..... *canaliculatus* Say
7. Connexival spines thick, not extending to apex of first genital segment ..... *insperatus* Drake and Hottes
   Connexival spines moderately thick, extending to apex of first genital segment ..... *marginatus* Say

Gerris conformis (Uhler), 1878

Biological notes. — Osborn and Drake (1915a and b) noted that in Ohio it occurs in both lakes and flowing streams. It spends the winter as an adult and mating starts in the early spring. Eggs are laid on material just beneath the surface of the water, and incubation is about 11 days. The time for development is about 34 days.

Locality data. — Has not been recorded from the state previously. Specimens have been seen as follows: Houlka, 1 specimen (M.S.C.); State College, June, 1 specimen (M.S.C.); Sturgis, April, 1 specimen (M. S.C.).

Gerris nebularis Drake and Hottes, 1925

Biological notes.—This large, swift gerrid inhabits the flowing smaller streams and rivers of Mississippi. It prefers open water and treads water quite swiftly, alternately resting and then moving short distances. When approached it will retreat to the cen-

ter of a stream. Mating was observed as early as mid-April in the central part of Mississippi. It was observed feeding upon small insects on the water surface on several occasions.

Herring (1950a) collected adults in Florida throughout most of the year. He took nymphs along the more secluded areas of streams in February, April and May. Deer flies killed and thrown upon the surface of the water were eaten.

Locality data.—Previously recorded from A. & M. College and Charleston by Drake and Harris (1928c, 1934a) and Kuitert (1942). Specimens have been seen as follows: Charleston, Sept., 2 specimens (M. S.C.); Fearn Springs, April-Sept., 4 ♂♂, 5 ♀♀ (C.A.W.); State College, July, 1 ♂, 1 ♀ (C.A.W.); Vancleave, May, 7 ♂♂, 4 ♀♀ (J.T.P.).

Gerris canaliculatus Say, 1832

Biological notes.—Adults have been collected in Mississippi every month of the year. Nymphs were taken as late as mid-October in the northern part of the state. This is the most common water strider in the state, and was collected in a wide range of habitats. It was taken in small streams, springs, rivers, lakes, ponds, drainage ditches, borrow-pits, sloughs and bayous.

Penn and Goldsmith (1950) studied the life history of this insect in Louisiana. They were able to rear the nymphs to maturity on a diet of freshly killed small insects dropped on the water surface each morning. The adults were kept alive quite successfully when fed adult mosquitoes. The life cycle from egg-laying to emergence of adults was completed in an average of 27 to 28 days, with a minimum of 24 days and a maximum of 32 days. The incubation period for eggs averaged 7 days and the length of time required for the instars was as follows: first instar, 3.7 days; second instar, 3.4 days; third instar, 4.4 days; fourth instar, 5 days and fifth instar, 5.4 days.

Herring (1950a) reared specimens in Florida on a diet of coccinellid beetle larvae. They preferred beetle larvae, and would eat adult mosquitoes only when no beetles were available for long periods of time. Herring determined that the length of time required for hatching of the eggs was a little less than 6 days, and that the total time from egg to adult was 30. Breeding was observed in Florida throughout most of the year.

Locality data.—Previously recorded from Fayette by Drake (1922), Agricultural College, Charleston, McComb, Port Gibson and Woodville (Drake and Harris, 1928c), Kuitert (1942) and from Oxford and Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Batesville; Biloxi; Bovina; Brookhaven, Brooklyn; Burnsville; Charleston; Cleveland; Columbus; Crowder; Fearn Springs; Fulton; Glen; Glen Allen; Greenwood; Hattiesburg; Iuka; Jackson; Lorman; Louise; Lucedale; McComb; Marks; Mississippi City; Natchez; Ocean Springs; Oxford; Pass Christian; Port Gibson; Prairie; Ramsey Springs; Saratoga; Saucier; Schlater; State College; Stewart; Sturgis; Vancleave; Vicksburg; Webb; Wiggins.

Gerris dissortis Drake and Harris, 1930

Biological notes.—This insect is commoner in the northern part of the United States, and the writer has not had the opportunity to observe it. Blatchley (1926) indicates that it ranges from New England and Quebec west to British Columbia and California and southwest to North Carolina. It occurs in ponds, lakes and ditches, especially those particular bodies of water located in the mountainous regions. Eggs are laid on the floating leaves of aquatic plants just below the surface. Occasionally they are deposited on small sticks and other objects in the water.

Bueno (1913c) indicated that it is Palearctic in origin and that it has migrated 15,000 miles to establish colonies throughout the North Temperate zone of the world. He records it as predaceous.

Locality data. — Has not been recorded from Mississippi and the writer has not collected it in the state. However, it is included since Drake and Harris (1934a) report it from Indiana and Missouri.

Gerris remigis Say, 1832

Biological notes.—Essenberg (1915) observed its life history at Berkeley, California. In that locality it winters in the adult stage, hibernating under rubbish, rocks, and logs. Egg laying starts in the early spring, and they are deposited on grasses just beneath the water surface. The eggs hatch in about 3 weeks. The food supply consists primarily

of living and dead insects found upon the surface of the water. Essenberg observed that it was cannibalistic.

Bueno (1917b) found breeding and oviposition as early as February in New York, and mating as early as April. Nymphs were found from late May to the middle of October. The eggs were laid end to end along the edges of grasses and other vegetation growing in the water. Laboratory observations by Bueno showed that the eggs develop in approximately 10 days or 2 weeks; the first instar, 4 to 7 days; the second instar, 4 to 6 days; the third instar, 5 to 10 days; the fourth instar, 5 to 10 days and the fifth instar about 15 days. Thus, the complete life cycle from egg to adult extended over a period of from 43 to 60 days.

Riley (1919, 1920, 1921a, 1921b) published notes indicating that they are cannibalistic, positively phototactic and positively thigmotactic.

Hungerford (1920) studied this insect in Kansas and noted that it was found most commonly on running water, or pools connected with running water. It was observed to winter as an adult under brush and logs near water. The incubation period for the egg stage was about two weeks. There are five instars, each lasting about one week. The food consisted largely of midges, notonectid nymphs, jassids and other insects cast upon the water. On one occasion he noted them feeding upon snails left in a dried-up pond.

Deay and Gould (1936a) collected specimens most commonly on ponds and lakes in Indiana, where schools of the insect were seen in late fall and again in early spring. It hibernates as an adult in Indiana.

Locality data.—Previously recorded from the state by Drake and Harris (1934). One specimen has been seen from Tupelo, April, 1 ♂ (H.C.R.).

Gerris insperatus Drake and Hottes, 1925

Biological notes.—Specimens were collected in quiet pools of shady, upland streams. It seems to prefer streams that are spring-fed and once it was taken in a small spring in a hilly region of the state. Adults were taken from February to November and nymphs were collected as late as Sepember. Only macropterous specimens were taken.

No literature references were noted on the biology of this species.

Locality data.—Previously recorded from the state by Kuitert (1942). Specimens have been seen as follows: Brooklyn, Feb., 15 specimens (J.T.P.); Enterprise, June, 6 specimens (M.H. Brunson); Fearn Springs, May, 1 ♂ (C.A.W.); Hattiesburg, Feb., 22 specimens (J.T.P.); Ramsey Springs, Aug., 9 ♂♂, 9 ♀♀ (C.A.W.); Wiggins, Nov., 1 specimen (J.T.P.).

Gerris marginatus Say, 1832

Biological notes. — This gerrid is quite common in Mississippi, although it was not collected as commonly or in as wide range of habitats as *Gerris canaliculatus*. Based on collection data, it seems to prefer large, shady ponds, larger streams and large springs. Specimens were taken every month from February through August. It is very active and moves over the water surface at a rapid rate. Occasionally it spends considerable time remaining stationary on the water surface. It feeds upon small insects on the water surface, capturing them with the armed front legs. The mating process lasts for several hours. On several occasions mating pairs were captured in a net, then released, and they remained attached. The female swims about with the male on her back.

Bueno (1917c) on Long Island found that it preferred quiet pools rather than open waters. The eggs hatch in about 10 days or two weeks; the insect has five molts, reaching the adult stage in about five or six weeks.

Hungerford (1920) noted that the eggs are laid as by *Gerris remigis,* and that there are five instars, each requiring from 3 days to one week for completion.

Locality data.—Previously recorded from Charleston by Drake and Harris (1928c, 1934a). Specimens have been seen as follows: Crowder, Sept., 1 ♂ (M.S.C.); Fearn Springs, May-Aug., 4 ♂♂, 3 ♀♀ (C.A.W.); Hattiesburg, Feb.-April, 2 ♂♂, 2 ♀♀ (C.A.W. and J.T.P.); Perkinston, April, 1 ♂ (C.A.W.); Rienzi, Sept., 1 ♂ (M.S.C.); State College, May-Aug., 14 ♂♂, 6 ♀♀ (C.A.W.).

Gerris argenticollis Parshley, 1916

Biological notes.—Habitats in Mississippi in which this water strider was taken included small ponds, streams and shady sloughs. It was found with about equal frequency in all of the habitats mentioned.

Nothing has been published on the biology of this insect. Specimens were successfully reared in the laboratory at Mississippi State College at a constant temperature of 60° F on a diet of houseflies or freshly killed corixids.

The insects were isolated in pairs in 10 cm petri dishes. A block of wood ¼ by ¼ by 1 inch was placed in each dish for the females to oviposit on. Mating occurred within minutes after isolation of the pairs in every case. The male circled the female popping the water with his abdomen, then very rapidly mounted the female to complete the act. Time required for mating averaged 30 seconds, and usually four or five matings were performed in succession. Five days after mating, eggs were found on the blocks of wood. They were pearly-white in color, 1.5 mm long by 0.5 mm wide, and were attached flatly to the wood. Within 24 hours there appeared down each side of the egg two rows of brown dots and by the third day red eye spots were clearly visible. After this the egg became dark yellowish-brown and on the six day the molting line appeared. Hatching was noted on the seventh day. Table 1 gives the average length and width of specimens and the duration of each instar for the 17 specimens reared.

TABLE 1.
Life history data for Gerris argenticollis

Instar	Length mm	Width mm	Duration in days
First	2.00	1.25	2
Second	3.20	1.80	5
Third	3.50	2.20	6
Fourth	5.50	2.20	4
Fifth	6.60	2.40	5

Locality data.—Previously recorded from the state by Drake (1920b) and Blatchley (1926) and from Agricultural College by Drake and Harris (1928c). Specimens have been seen as follows: Biloxi, Feb., 1 specimen (J.T.P.); Brooklyn, Feb.-April, 3 ♂♂, 8 ♀♀ (C.A.W.); Fearn Springs, April-May, 1 ♂, 2 ♀♀ (C.A.W.); Hattiesburg, Feb., 5 specimens (J.T.P.); State College, May, 1 ♂ (C.A.W.).

Limnogonus hesione (Kirkaldy), 1902

Biological notes.—Four years of collecting in Mississippi has shown this to be one of the most abundant water striders in the state. Collections were made in a wide variety of habitats including ponds, streams, lakes, borrow-pits, sloughs, springs, seepage areas, and others. Specimens frequently were found in association with other water striders, especially *Gerris canaliculatus*. In central Mississippi nymphs were taken as early as April 1st, and as late as November 15th, and mating was observed as late as November 15th. Thus, breeding is continuous over a good part of the year in the state. The ratio of winged to wingless individuals in the collections made in the state averaged about one winged to twenty wingless. Specimens feed on insects that fall into the water.

Osborn and Drake (1915a and b) observed that the long-winged form is quite rare in Ohio. Pairs were found *in coitu* for several days at a time. Eggs are laid on the underside of sticks and leaves just below the water surface. The eggs are enlarged at one end and are approximately three times as long as wide. They are dirty greenish yellow in color when laid and become somewhat darker with age. The nymph passes through five instars, and the time required for nymphal development was approximately 50 days in Ohio.

Herring (1950a) collected this species in Florida from quiet lakes and ponds. Also, it was taken frequently from *Nymphaea* marshes, sinkholes and vegetation-filled, roadside ditches. Herring noted that macropterous individuals were taken commonly in Florida.

Locality data.—Previously recorded from Fayette by Drake (1922); from Charleston, Fayette, McComb, Summit and Vicksburg by Drake and Harris (1928c, 1934a); and from Oxford and Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Batesville; Beulah; Biloxi; Brookhaven; Brooklyn; Charleston; Cleveland; Columbus; Corinth; Fearn Springs; Fulton; Greenwood; Hattiesburg; Iuka; Jackson; Laurel; Louise; Marks; Minter City; Ocean Springs; Perkinston; Port Gibson; Ramsey Springs; Saucier; Starkville; State College; Terry; Tutwiler; Vancleave; Webb.

Key to the Mississippi Genera of *HALOBATINAE* Bianchi

1. Tibia and first tarsal segment of middle leg with a fringe of long hairs ..... *HALOBATES* Esch.
   Tibia and first tarsal segment of middle leg without a fringe of long hairs 2

2. Antennal segment I subequal in length to other three united, distinctly longer than II and III ..... *METROBATES* Uhler

   Antennal segment I much shorter than other three united, sometimes shorter than II and III 3

3. Abdomen as long as remainder of body, pointed at apex, antennal segment IV subequal to III in length ..... *RHEUMATOBATES* Bergroth

   Abdomen much shorter than remainder of body; antennal segment IV slightly longer than III ..... *TREPOBATES* Uhler

Metrobates hesperius Uhler, 1871

Biological notes.—The preferred habitat in the state was flowing streams relatively free of vegetation. On one occasion several schools of specimens were observed in a large sandy-bottomed river in southern Mississippi. They avoided the swiftly flowing parts of the stream except when feeding. They feed on small insects in the water, which they capture by "treading water" in the faster flowing areas. Nymphs were collected in large numbers as late as October in the southern part of the state, and frequently in assoication with other waterstriders, especially *Rheumatobates rileyi palosi, Rheumatobates tennipes,* and occasionally *Gerris canaliculatus.*

Summers (1890) collected winged specimens in Tennessee.

Parshley (1917a) recorded an unusual case on Long Island where he encountered large numbers of individuals with fully developed wings. By actual count of a random collection he found 269 winged and 234 wingless specimens. A drawing of a winged adult male is included in the paper.

Drake and Harris (1932a) noted that it is common in the eastern part of North America and frequently is found in association with species of *Trepobates* and *Rheumatobates* and occasionally with *Tenagogonus, Gerris,* and *Rhagovelia.*

Locality data.—Previously recorded from the state by Anderson (1932a) and Drake and Harris (1932a). Specimens have been seen as follows: Biloxi, Oct., 57 specimens (J.T.P.); Cleveland, Oct., 26 ♂♂, 29 ♀♀ (C.A.W.); Harrison County, Oct., 7 specimens (J.T.P.); McComb, Sept., 1 ♂ (M. S.C.); Ramsey Springs, Aug., 2 ♂♂ (C.A. W.); Schlater, Oct., 23 ♂♂, 5 ♀♀ (C.A. W.); Vancleave, Aug., 1 ♂ (C.A.W.).

Metrobates alacris Drake, 1955

Biological notes.—Nothing is known of the life history.

Locality data.—The type locality is Tallulah, Louisiana. It has not been collected in Mississippi.

Key to the Mississippi Species of ♂ *TREPOBATES* Uhler

1. Intermediate legs with femora and basal portion of tibiae clothed within with a fringe of hairs whose lengths are subequally as great as the diameter of the segment at the point where they arise 2

   Intermediate femora and tibiae clothed on their inner margins with much shorter setose hairs, these never longer than half the diameter of segments where they arise ..... *pictus* (Herrich-Schäffer)

2. Antennal segment III clothed within a row of long hairs, these often closely appressed to the segment; first genital segment rather thickly clothed beneath with moderately long, erect, pale hairs ..... *knighti* (Drake and Harris)

   Antennal segment III without long hairs; the first genital segment not noticeably hairy beneath 3

3. Second genital segment thickly pilose beneath; antennal segment II shorter than III ..... *inermis* Esaki

   Second genital segment without long hairs beneath; II and III antennals subequal ..... *subnitidus* Esaki

Key to the Mississippi Species of ♀ *TREPOBATES* Uhler

1. Connexivum produced outward and upward at apex into long, curved spines ..... *knighti* (Drake and Harris)

   Apices of connexivum not strongly produced 2

2. Metanotum produced posteriorly into a blunt spine; apical margin of last segment of venter clothed with long hairs ..... *pictus* (Herrich-Schäffer)

   Metanotum not produced posteriorly into a blunt spine; last segment of venter not ciliate at apex 3

3. Segments II and III of antennae subequal ..... *subnitidus* Esaki
   Segment II of antennae distinctly shorter than segment III ..... *inermis* Esaki

Trepobates knighti (Drake and Harris, 1928)

Biological notes. — This insect has not been collected in Mississippi and no references to its life history were found in the literature.

Locality data.—It has been recorded from Arkansas and Missouri (Drake and Harris, 1928c, 1932b), and therefore is included here.

Trepobates subnitidus Esaki, 1926

Biological notes.—This is one of the common species in the state. It was usually taken in association with other *Trepobates* and several species of *Gerris*. The habitats in which it was most frequently encountered included bayous, sloughs, ponds, brooks and flowing streams. Algal filled ponds seemed to be a favorite habitat. The insects were found extremely abundant on ponds in the vicinity of State College and the writer observed their activities on many occasions. Mating was observed from May until October, and the latest in the season that an adult was collected, at State College, was November 29th. They were noted feeding on small insects on the water surface. The winged form, previously unknown, was collected by the writer at State College on June 25, 1951.

Locality data.—Previously recorded from Summit by Drake and Harris (1932a). Specimens have been seen as follows: Beulah; Charleston; Cleveland; Escatawpa; Eupora; Glen Allen; Greenwood; Itta Bena; Ramsey Springs; Scott; Starkville; State College; Stoneville; Vancleave; Wortham.

Trepobates inermis Esaki, 1926

Biological notes.—It was usually collected along with *Trepobates subnitidus* in the state. Extensive observation showed that it is quite similar to *Trepobates subnitidus* in biological habits. A considerable number of winged specimens were collected, especially during May and June.

Locality data.—Previously recorded from the state by Drake and Harris (1928c, 1932b). Specimens have been seen as follows: Beulah; Biloxi; Carthage; Charleston; Cleveland; Escatawpa; Eupora; Fayette; Greenwood; Grenada County; Heidelburg; Laurel; Mathiston; Natchez; Ramsey Springs; Schlater; State College; Stoneville; Vancleave; Vicksburg; Washington; Wiggins.

Trepobates pictus (Herrich-Schäffer, 1848)

Biological notes. — In Mississippi it is found only in running streams, springs and clear borrow-pits. Also, the species definitely seems to be limited to the hill sections and coastal areas of the state, since long series of specimens were taken there and not one was taken in the Mississippi Delta. It occurs in schools and feeds on small insects that fall on the water surface. Adults and nymphs were collected in Mississippi from early April until early November. Apparently it winters in the adult stage in Mississippi.

Hungerford (1920) was able to obtain oviposition in the laboratory, and he also found egg masses on the underside of leaves and sticks in a pond. There were 3 to 10 eggs in a mass and they hatched in the laboratory in five days.

Locality data.—Previously recorded from the state by Drake (1922), and Drake and Harris (1928c, 1932b), all three records being the same collection from Fayette. Specimens have been seen as follows: Bude; Columbus; Eupora; Fearn Springs; Harrison County; Hazelhurst; Jackson; Lorman; Ocean Springs; Ramsey Springs; Saratoga; State College; Stewart; Sturgis; Toccopola; Union; Vancleave; Winona.

Trepobates citatus Drake and Chapman, 1953

Locality data.—Recorded from Pascagoula by Drake and Chapman (1953).

Key to the Mississippi Species of ♂ *RHEUMATOBATES* Bergroth

1. Hind legs slender, straight; tibiae of the middle legs straight ..... *tennipes* Meinert
   Hind legs thickened, curved 2
2. Hind femora without long hairs on basal third of posterior margin ..... *trulliger* Bergroth
   Hind femora with long hairs on the basal third of the posterior margin 3
3. Spur on terminal antennal segment beyond the middle ..... *rileyi rileyi* Bergroth

Spur on terminal antennal segment before the middle ..... *rileyi palosi* Blatchley

Key to the Mississippi Species of ♀ *RHEUMATOBATES* Bergroth

1. Mesonotum and metanotum with yellow triangular shaped spot; ovipositor as viewed from above more blunt shaped ..... *rileyi palosi* Blatchley

Mesonotum and metanotum with yellow rectangular spot, or spot entirely absent; ovipositor as viewed from above more tapering ..... *tenuipes* Meinert

Rheumatobates rileyi rileyi Bergroth, 1892

Locality data.—Reported from the state by Hungerford (1954).

Rheumatobates rileyi palosi Blatchley, 1926

Biological notes.—Studies on this insect made in the state indicate that it prefers ponds and lakes or the quiet pools of larger streams and rivers. The writer observed their activities on many occasions and the food consisted of small insects encountered in the water. Winged specimens of both males and females were collected on several ponds in the vicinity of State College in May. Mating takes place on the water surface, and numerous females with the wings broken off in the typical manner were noted in collections made during May.

Specimens were reared successfully in the laboratory at Mississippi State College at a constant temperature of 60° F during June and July, starting with stock cultures collected from nearby ponds. The 60° F temperature was necessary to prevent the formation of a scum on the water surface. If the scum was allowed to form, the hairs on the legs quickly became matted and the insects would sink and die.

The insects were isolated in pairs and placed in 10 cm petri dishes with a small piece of Johnson grass leaf. After a lapse of several days mating was observed. The male would dart around the female, pounce on her, lock his antennae around her head just back of the eyes and clasp her around the abdomen with his hind femora. The female would then flex her abdomen upward to complete the mating act. The total time required for the process was about 15 seconds. Mating was usually repeated three times in a period of five minutes. Egg laying occurred 3 days after mating.

The eggs were pearly white with a brownish-red stripe on each side when they were deposited. In 3 days the red eye spot became prominent; on the sixth day a bubble formed dorsad to the eyes and a white line appeared between the eyes and extended to the metathorax. On the seventh day hatching occurred in the usual manner. Table 2 gives the average length and width of specimens and the duration of each instar for a total of 52 specimens which were reared.

TABLE 2.
Life history data for Rheumatobates rileyi palosi

Instar	Length mm	Width mm	Duration in days
First	0.60	0.35	2
Second	1.20	0.70	5
Third	1.60	0.75	7
Fourth	2.20	1.00	4
Fifth	2.60	1.30	3

The insects are cannibalistic. One case was noted where a first instar nymph attacked a full grown male, inserting its beak at the base of the adult's head.

One sexually dimorphic winged female was observed in a large collection of winged males taken at State College.

In Kansas, Hungerford (1920), noted that they live on quiet waters. He suggested that the nature of the ovipositor indicated that the eggs are hidden in the tissues of plants.

Herring (1950a) fed *Rheumatobates rileyi* on a diet of small moths, ants and psychodid moths in the laboratory.

Locality data.—This insect has not been recorded previously from the state. Specimens have been seen as follows: Batesville; Beulah; Bovina; Charleston; Columbus; Escatawpa; Fearn Springs; Greenwood; Prairie; Ramsey Springs; State College; Wiggins; Grenada County; Laurel; McComb.

Rheumatobates tenuipes Meinert, 1895

Biological notes.—Collections in Mississippi indicate that the open water of creeks, rivers, ponds and bayous is preferred. On two occasions collections were made from tidal brackish pools near the Gulf of Mexico in Jackson County. Salinity of the water in one of the pools was 6.6 ‰ at the time of the collection. Larger numbers were observed where the collections were made and they were found in association with other species of *Rheumatobates* and *Trepobates.* Since this insect is a very active swimmer,

swift action with the net was necessary to capture it. Food consists of small insects on the surface of the water.

Herring (1950a) made collections from the deeper pools of calcareous and sand-bottomed creeks in Florida. He observed that it preferred the sluggish portions of the stream. The eggs were placed in the stems and leaves of aquatic plants.

Locality data.—Recorded previously from Charleston by Drake and Harris (1928c) and from the state by Hungerford (1954). Specimens have been seen as follows: Beulah; Biloxi; Cleveland; Columbus; Escatawpa; Greenwood; Grenada; Ocean Springs; Schlater; Vancleave; Wiggins.

Rheumatobates trulliger Bergroth, 1915

Biological notes.—This species was encountered only once by the writer. It was collected in a clear, gently flowing stream in Pearl River swamp, which contained no vegetation. Only 4 specimens were collected and they were in association with large numbers of *Rheumatobates rileyi palosi* and *Trepobates pictus*. All were wingless.

Locality data.—Previously reported from Charleston and Shipman by Drake and Harris (1928c) and from the state by Hungerford (1954). Specimens have been seen as follows: Carthage, Aug., 4 specimens (H. G. Johnston); Charleston, Aug.-Sept., 2 specimens (H. M. Harris); Fearn Springs, Sept., 3 ♂♂ (C.A.W.); Laurel, Sept., (H. M. Harris).

E. *Family VELIIDAE Amyot and Serville, 1843*

Review of the Literature.—Taxonomic keys to three genera and nine species of Veliidae were included in a paper by Bueno (1916a). Parshley (1921b) published a brief monograph on the genus *Microvelia* Westwood. A survey of the species of *Microvelia* of the Western Hemisphere with keys to the species (Bueno, 1924a) was followed the same year by a similar type of taxonomic treatment of the nearctic *Rhagovelia* (Bueno, 1924b). Drake and Harris (1927) described six new species of *Rhagovelia* and published distributional notes on the genus. Further notes on the genus *Rhagovelia* were recorded by Drake and Harris (1931). That same year, Gould (1931), published a monograph on the genus *Rhagovelia* of the Western Hemisphere. Bueno (1924a) wrote a survey of the species of the genus *Microvelia* of the western world, including new species from the southern United States. Drake (1951a, 1951b, 1951c, 1951d, 1952b) described a number of new species of Veliidae from the Americas and recorded data on distribution for some of the species. Drake and Hussey (1955) published a check-list of American forms with descriptions of two new species.

Key to Mississippi Genera of VELIIDAE (Amyot and Serville)

1. Middle tarsi deeply cleft, with leaflike claws and plumose hairs arising from base of cleft 2
   Middle tarsi not deeply cleft and without plumose hairs arising from base of cleft 3
2. Posterior tarsi 2-segmented, the basal segment very short; apterous, marine ..... *TROCHOPUS* Carpenter
   Posterior tarsi 3-segmented, the basal segment very short; apterous or macropterous ..... *RHAGOVELIA* Mayr
3. Tarsal formula 3:3:3. First segment of antennae distinctly longer than the others ..... *VELIA* Latreille
   Tarsal formula 1:2:2. First segment of antennae subequal to others ..... *MICROVELIA* Westwood

Key to the Mississippi Species of *MICROVELIA* Westwood

1. Antennae subequal to or shorter than head and thorax united; abdomen of wingless form without silvery pubescence 2
   Antennae longer than head and thorax combined; abdomen of wingless form often with silvery pubescence 6
2. Length: macropterous form, 2.4 mm; apterous form, 2.5 mm ..... *pulchella* Westwood
   Length not greater than 2.0 mm 3
3. Antennae shorter than head and thorax united; hind tibiae curved in male; pronotum, wingless form, with a transverse linear impression before the middle; male elongate, fusiform; female orbicular ..... *borealis* Bueno
   Antennae subequal in length to head and thorax united; hind tibiae straight in both sexes; pronotum without the linear impression; sexes quite similar in form 4

4. Color sooty-black; wingless form with pronotum produced backward to second dorsal segment and minute white elytral pads present; length 1.6-2.0 mm ..... *atrata* Bueno

   Color pale to dark-brown; wingless form with pronotum not produced backward, reaching at most the base of first dorsal segment and elytra wholly absent 5

5. Antennal segment IV slightly longer than width of interocular area, approximately two and one-fourth times as long as II ..... *hinei* Drake

   Antennal segment IV a little less than the width of interocular area, and about one-fourth longer than segment II ..... *austrina* Bueno

6. Segment I of antennae shorter than III, IV subequal to II and III united; hemelytra with several white spots; wingless form shining, almost smooth; length: brachypterous form, 2.13-2.50 mm; apterous form, 2.1-2.3 mm ..... *albonotata* Champion

   Segments I and III of antennae subequal in length; wingless form pubescent, opaque 7

7. Segment IV of antennae slightly longer than II and III united; abdomen and connexivum of wingless form with conspicuous tufts of silvery pubescence; length 1.7-2.0 mm ..... *buenoi* Drake

   Segment IV of antennae shorter than II and III united; length 2.0-3.3 mm 8

8. Dorsum of abdomen with patches of fine bluish-gray pubescence on base and apex; wingless form with mesonotum concealed by pronotum; winged form unknown ..... *fontinalis* Bueno

   Dorsum of abdomen with patches of silvery-white pubescence; wingless form with mesonotum visible 9

9. Wingless form predominantly light brown dorsally; winged form with hemelytra light brown and usually unicolorous ..... *americana* (Uhler)

   Wingless form predominantly black, covered with patches of silvery pubescence; hemelytra of winged form smoky-gray colored; posterior-lateral margins of scutellum lemon-yellow in color ..... *paludicola* Champion

Microvelia albonotata Champion, 1898

Biological notes.—This interesting species seems to prefer the shady, cool, quiet surfaces of spring-fed marshes in Mississippi. On one occasion it was taken from the surface of a farm pond that was spring-fed and contained an abundant supply of algae and some emergent vegetation. Adults were collected as late as mid-November in central Mississippi. The apterous form was predominant in all collections made.

Herring (1950b) collected it in Florida from a sand-bottomed lake.

Locality data.—This species has not been previously recorded from the state. Specimens have been seen as follows: Biloxi, Jan.-March, 17 specimens (C.A.W. and J.T.P.); Brooklyn, Feb., 1 specimen (J.T.P.); Crystal Springs, Nov., 3 ♂♂, 2 ♀♀ (C.A.W.); Fearn Springs, Sept., 1 ♂, 1 ♀ (C.A.W.); Glen, Nov., 2 ♂♂, 4 ♀♀ (C.A.W.); Mississippi City, March, 1 ♂, 1 ♀ (C.A.W.); Ocean Springs, July, 7 ♂♂, 4 ♀♀ (C.A.W.); Ramsey Springs, Aug., 13 specimens; Vancleave, Aug., 17 specimens (C.A.W.); Wiggins, Nov., 1 specimen (J.T.P.).

Microvelia americana (Uhler), 1884

Biological notes.—This species was collected from the surface of sluggish streams, springs, ponds and similar habitats in the state. Specimens moved over the surface of the water swiftly and the collector had to work rather quickly to capture them. These were collected from water that contained abundant vegetation as well as from areas without vegetation.

Bueno (1910) studied the life history in New York and New Jersey. In that region it could be found on the banks of any body of water. They live both on the bank and on the water surface, moving out away from shore when disturbed. The eggs are laid singly or in clusters on pebbles or stones and are glued in place by a transparent gelatinous material. The egg stage lasts for two or three weeks. There are five instars, each requiring 2 to 10 days for completion with the fifth stadium the longest. Food consists of water-fleas, small insects and ostracods on the water surface. They ate living flies avidly when fed in the laboratory.

Locality data.—It has not been recorded previously from the state. Specimens have been seen as follows: Charleston; Crowder;

Enterprise; Fearn Springs; Hattiesburg; Hazelhurst; Longview; Macon; McComb; Oxford.

Microvelia atrata Bueno, 1916

Biological notes.—The writer has not collected this species in the state and has had no opportunity to observe its natural history. Blatchley (1926) reported that it was collected at the base of dense clumps of a tall wire-grass growing in the pine-barrens of Florida about one-fourth mile from water.

Locality data.—It has not been recorded from Mississippi, however, it has been reported from Georgia by Van Duzee (1917) and Hungerford (1920), from Georgia and Florida by Blatchley (1926), from Georgia, Florida and Louisiana by Drake and Hussey (1955); and Louisiana by Ellis (1952).

Microvelia austrina Bueno, 1924

Biological notes.—The writer collected specimens once, in the hilly section of extreme northeastern Mississippi, in a small, clear, shallow woodland pool with a mat of oak leaves on the surface.

Locality data.—This species has been reported previously from Charleston by Drake and Harris (1928c) and from Mississippi by Drake and Hussey (1955). Specimens have been seen as follows: Charleston, Sept., 1 specimen (H. M. Harris); Tishomingo, Nov., 1 ♂ (C.A.W.).

Microvelia pulchella incerta (Kirby), 1890

Biological notes.—The habitat preferences in Mississippi include the surfaces of quiet streams, ponds and sloughs. Collections indicate there are several generations in a season, and nymphs were taken as late as mid-November in central Mississippi. It was collected at only three localities indicating that it is not common.

Bueno (1917a) observed the life history in New York. He found eggs on the underside of duck weed leaves, with the anterior end pointed toward the edge of the leaf. Incubation time was seven to twenty-three days and there were four instars.

Hungerford (1917d) reared it and observed its life history in Kansas. He collected it in pools filled with cat-tail, on floating mats of algae, and on dead *Typha* stems. Egg laying in nature is on stones, pebbles, and other plants above the water surface where the female glues the egg with a gelatinous material. Time for incubation in the laboratory was about 6 days, and each female laid about 5 eggs per day. From 10 to 20 days are required for the insect to reach the adult stage. The bugs ate plant-lice, house flies and ostracods when they were offered in the laboratory. Hungerford found more than four instars in some specimens he reared.

Herring (1950b) found this the most abundant *Microvelia* in Florida. He collected it from roadside ditches, fluctuating ponds, sand-bottomed creeks, calcareous streams and marshes.

Locality data.—This species has been reported previously from Charleston, Crowder, Port Gibson, Vicksburg and Woodville by Drake and Harris (1928c). Specimens have been seen as follows: Charleston, Aug.-Sept., 4 specimens (H. M. Harris); Jackson, Nov., 1 ♂ (C.A.W.); Laurel, Aug., 4 specimens (H. M. Harris); Saratoga, Aug., 1 ♂ (C.A.W.); State College, June, 1 ♂, 2 ♀♀ (C.A.W.); Vicksburg, July, 1 specimen (C. J. Drake).

Microvelia buenoi Drake, 1920

Biological notes.—This is a northern United States species and the author was quite surprised to obtain it in one locality in the northern part of Mississippi. It was collected along with numerous specimens of *Microvelia hinei* and Mesoveliidae from a quiet stream which had overhanging vegetation around the edges.

Drake (1920b) indicated that it lives in small, secluded coves near the shore, usually under the shelter of overhanging vegetation or among plants in the water. He also took a few specimens from moist soil near the edge of the water.

Herring (1950b) caught one male from a mat of sphagnum moss along the shore of a swampy stream in Alachua County, Florida.

Locality data.—It has not been recorded previously from the state. One specimen has been seen as follows: Prairie, Oct., 1 ♂ (C.A.W.).

Microvelia fontinalis Bueno, 1916

Biological notes.—Specimens have been taken from the surface of a small spring-fed stream which contained overhanging vegetation along the banks. The clear, cool water contained no floating vegetation or algae.

Bueno (1916a) collected it in Westchester County, New York from a spring in a marshy woodland, where it clung to the mosses growing in the water or was on the water surface a short distance from the rocks.

Blatchley (1926) collected specimens in Indiana from pools below a spring along a hillside.

Locality data.—Recorded from the state by Drake and Hussey (1955). Specimens have been seen as follows: Charleston, July, 22 specimens (H. M. Harris); Sturgis, Oct., 6 ♂♂, 3 ♀♀ (C.A.W.).

Microvelia hinei Drake, 1920

Biological notes.—This is the most abundant *Microvelia* in the state. It prefers quiet waters covered with vegetation, but it has been collected on some occasions where vegetation was absent. Favorite habitats include sloughs, drainage ditches, stagnant lakes, turbid ponds, spring-fed streams, spring-fed ponds, quiet pools in rivers, and brackish pools along the Gulf coast. The writer on one occasion observed specimens on a heavily vegetated pond at Fearn Springs in such numbers that thousands could be captured in the net with a few sweeps over the surface of the water. This was in September, which seems to be the peak month of abundance. It feeds on small insects in the water, and is extremely active on the surface when disturbed.

Drake (1920b) notes that in Ohio it lives in small ponds, stagnant pools and small lakes.

Blatchley (1926) reported collecting specimens in Florida from small pools, ditches, the margins of lakes and decaying weeds in a slough.

Herring (1950b) found it on mats of sphagnum moss in acid swamps and bog streams in Florida.

Locality data.—Previously recorded from Fayette by Drake (1922) and Blatchley (1926), and from Charleston, Crowder, Fayette, McComb, Ocean Springs and Woodville by Drake and Harris (1928c). Specimens have been seen as follows: Batesville; Biloxi; Cat Island; Charleston; Edwards; Fearn Springs; Fountainbleau; Fulton; Hattiesburg; Iuka; Laurel; Lorman; Marks; McComb; Minter City; Mississippi City; Ocean Springs; Okolona; Oxford; Ramsey Springs; Saltillo; Saratoga; State College; Sturgis; Toccopola; Tutwiler; Webb.

Microvelia paludicola Champion, 1898

Biological notes.—This species seems to be a dweller in sluggish streams in the state. It was collected frequently in pot-holes bounded by overhanging vegetation and occasionally in ponds. The apterous form was more common, and of several hundred specimens that the writer mounted, only about ten were winged.

Locality data.—Recorded from the state by Drake and Hussey (1955). Specimens have been seen as follows: Bude; Fearn Springs; Jackson; Longview; Natchez; Ocean Springs; Oxford; Pontotoc; Prairie; State College; Sturgis; Toccopola; Tupelo.

Microvelia pulchella Westwood, 1834

Biological notes.—Specimens were collected at two localities in the state. The habitats were a turbid roadside puddle and a rather muddy cow-pond free of vegetation.

Locality data.—Reported from the state by Drake and Hussey (1955). Specimens have been seen as follows: Ocean Springs, July, 1 ♂ (C.A.W.); Saltillo, Nov., 1 ♀ (C.A.W.).

Key to the Mississippi Species of *RHAGOVELIA* Mayr

Meso- and metanota broadly exposed behind the pronotum; first segment of connexivum of female with a tuft of long matted hairs arising from its hind angle; front trochanters of males with a stout, black spine on outer face ..... *obesa* Uhler

Mesonotum wholly and metanotum in great part, concealed beneath pronotum; first segment of female connexivum without tuft of hairs; front trochanters of males unarmed ..... *choreutes* Hussey

Rhagovelia obesa Uhler, 1871

Biological notes.—Only the apterous form of this insect was collected in Mississippi. It was taken in two types of habitats, a swiftly flowing spring-fed stream with a sandy bottom and a deep pond free of vegetation. It is an extremely fast swimmer and difficult to capture in a net. These insects dive under water for a considerable distance when chased.

Bueno (1907a) observed that mating oc-

curs in June and July, when the schools are composed almost completely of mating pairs *in copula.*

Gould (1931) wrote that *Rhagovelia* are gregarious, and that they are predators and feed on insects which the current brings to them.

Locality data.—It has not been recorded previously from the state. Specimens have been seen as follows: Columbus, Oct., 4 ♂♂, 2 ♀♀ (C.A.W.); Oxford, Oct., 1 ♂ (C.A.W.).

Rhagovelia choreutes Hussey, 1925

Biological notes.—This insect was collected on the waters of inlets of rivers near the Gulf coast of Mississippi from April through October.

Gould (1931) reports that this species was collected in the Arbuckle Mountains, Davis, Oklahoma and from Eddy County, New Mexico, but he gives no data on the type of habitats yielding the specimens.

Herring (1950b) collected this insect from calcareous streams and swiftly flowing sand-bottomed creeks in Florida. He indicated that specimens were collected abundantly along the shore, beneath bridges, or in the shade of trees where they congregate in schools. They zig-zag in a circular fashion over the surface and return to the same spot time after time, even when disturbed with the collecting net. Whole colonies can be collected easily due to this habit of returning to the same area.

Locality data.—Reported from Mississippi by Bacon (1956). Specimens have been seen as follows: Biloxi, April-Oct., 151 specimens (J.T.P.); Brooklyn, Feb., 2 specimens (J.T.P.); Harrison County, Oct., 5 specimens (J.T.P.).

Trochopus plumbea (Uhler), 1894

Biological notes.—The writer has not collected this species in the state; however, it is included here because it has been reported from the salt water bays of Florida by Gould (1931) and others.

Uhler (1894) reported collecting it on the surface of the sea in the Bay of St. George's, Grenada, B.W.I. where it was observed mating. He also noted that it is gregarious in habit, with fifty to sixty captured together.

Locality data.—Has not been collected in Mississippi.

Key to the Mississippi Species of *VELIA* Latreille

1. Intermediate tarsi, with second segment longer than third; antennae, with segment I one-half longer than II; legs rather short ..... *brachialis* Stål
   Intermediate tarsi, with segments II and III subequal; legs slender 2
2. Hind margin of pronotum (brachypterous form) without a fringe of long hairs; tubercles on sides of pronotum scarcely evident ..... *stagnalis* Burmeister
   Hind margin of pronotum with a fringe of long hairs; tubercles on sides of pronotum distinct 3
3. Genital segment short, usually about 0.28 mm; pronotal horns very evident; width across fifth abdominal segment about 1.12 mm ..... *watsoni* Drake
   Genital segment long, usually about 0.52 mm; pronotal horns less distinct than above; width across fifth abdominal segment about 0.75 mm ..... *paulinae* Wilson

Velia stagnalis Burmeister, 1835

Biological notes.—This species was collected infrequently in the state. The writer took it from the surface of shady *Lemna*-covered sloughs at two localities in Mississippi. At both stations the water was quite clear and fairly shallow. It was in association with large numbers of *Microvelia, Mesovelia* and *Merragata.*

Davis (1911) reported sifting specimens from old leaves in the District of Columbia.

Blatchley (1926) took one specimen from a tuft of weed roots on the margin of a lake at Dunedin, Florida.

Locality data.—It has not been recorded previously from the state. Specimens have been seen as follows: Marks, Oct., 1 ♂, 1 ♀ (C.A.W.); Webb, Oct., 1 ♂ (C.A.W.).

Velia brachialis Stål, 1860

Biological notes.—This species is quite abundant in the state although it never seems to occur in large numbers. Typically, it was collected by sweeping overhanging vegetation along the banks of ponds. Specimens will swim on the water surface, but prefer vegetation or damp soil near the water edge. Specimens were taken from the following types of habitats: shallow borrow-

pits densely covered with vegetation; along the banks of small ponds with overhanging vegetation; large ponds with overhanging vegetation, sloughs densely covered with *Lemna* and large lakes with vegetation along the edges.

In a pond near State College the writer observed the biology of this insect. There are several generations in a season with the peak of abundance in September. Nymphs were found at late as October 19th. Winged forms were more common in May and June, but were collected as late as September 17th.

Nine specimens were successfully reared in the laboratory at Mississippi State College at a constant temperature of 60° F on a diet of housefly larvae and adults.

Specimens were isolated in pairs in 10 cm petri dishes with stems and leaves of *Lemna*. The insects are shy and mating did not occur immediately after isolation. The female mounted the male to initiate mating. After the female mounted the male, she worked her hind tibiae forward and backward on the male's abdomen, then the male organ was forced out and up and the female settled upon it, flexing her abdomen and rubbing it with her tibiae. Duration of mating averaged about 15 minutes, after which the female lunged free and retreated quickly. The day after mating eggs were found deposited in and on the stems of *Lemna*. The eggs were greenish-yellow when deposited and averaged 1.6 mm in length by 0.6 mm in width. The eye spots were brown on the fifth day, becoming dark red by the ninth day. Incubation period in the laboratory averaged eleven days. Table 3 gives the average length and width of specimens and the duration of each instar for 9 specimens reared to maturity.

TABLE 3.
Life history data for Velia brachialis

Instar	Length mm	Width mm	Duration in days
First	2.00	1.00	7
Second	2.50	1.20	5
Third	3.20	1.80	5
Fourth	4.00	1.80	5
Fifth	4.70	2.00	5

Herring (1950b) collected this species in Florida most often from crevices in logs or upon rocks or stumps along the edge of the water, and beneath the cover of short vegetation. Specimens were seldom collected from the open surface film.

Locality data.—Previously recorded from Fayette by Drake (1922). Specimens have been seen as follows: Anguilla; Bixoli; Brookhaven; Charleston, Fearn Springs; Handsboro; Laurel; Marks; Okolona; Oxford; Port Gibson; State College.

Velia watsoni Drake, 1919

Biological notes.—Drake (1919) indicated that the eggs are deposited just beneath the surface on floating sticks and floating aquatic plants.

Hoffman (1925a) observed its life history in Kansas. The insects were obtained from stagnant pools in the bed of a small stream. They were reared in the laboratory in tin boxes containing damp vegetation. They were both predaceous and cannibalistic, hence no more than one nymph could be reared in a jar, even if ample food was provided. The food used was either living, crippled or dead insects; these included cockroaches, flies, cicadellids, cercopids, mirids, grasshopper nymphs, adult *Tribolium, Bruchus, Dermestes* and others. In an aquarium the eggs were laid on the sides of the glass and on rocks and floating objects in the water. The incubation period at room temperature was about twelve days. The length of the five nymphal instars varied as follows: first instar, 3 to 10 days; second instar, 2 to 8 days; third instar, 2 to 8 days; fourth instar, 4 to 8 days; fifth instar, 5 to 10 days. Thus, the total developmental period from egg to adult varied from 32 to 46 days.

Herring (1950b) stated that in Florida the insect prefers the emergent vegetation along the shore line, and that they ran upon the surface film only when molested. Other habitats where it was collected were a swamp, bog stream, and rafts of leaf debris in a small cove.

Locality data.—Previously recorded from the state by Drake (1951b). The writer has not collected it in Mississippi.

Velia paulineae Wilson, 1953

Biological notes.—One specimen was collected from damp soil along the edge of a small, temporary upland ditch. The water was about two inches deep and contained some vegetation.

Locality data.—Fearn Springs, Sept. 11,

1949, 1 ♂ (C.A.W.). This is the type locality for the species.

F. *Family SALDIDAE Amyot and Serville, 1843*

Review of the Literature.—The literature on this family is quite scattered and no thorough monographs are available to taxonomists. However, some of the more general publications that are available on this family include a paper by Osborn (1901) which is of special interest since it concerns two interesting little saldids that he collected in Florida and named as new species. Slosson (1901, 1908) published notes on her collecting experiences with this insect on a Florida beach. She described in some detail the difficulty encountered in capturing specimens. Reuter (1912) separated the family into thirteen genera and established taxonomic characters for these genera. Usinger (1945) recorded the range of *Saldoida* as far north as Georgia and Virginia, and also included a key to the species. Several new species of Saldidae from the Western Hemisphere were described by Hodgen (1949). Drake (1949a, 1950) published descriptions of new species from North America and included some distributional data. He recorded *Pentacora hirta* (Say) and *Pentacora sphacelata* (Uhler) from Mississippi. A catalogue of all known generic and specific names of Saldidae of the world along with general distributional notes on the species was issued by Drake and Hoberlandt (1950a). In a series of papers, Drake and Hottes (1950a, 1950b, 1951a), described a number of new species of Saldidae from the Americas. A paper on the stridulatory organs in certain species of Saldidae (Drake and Hottes, 1951b) includes photomicrographs and drawings of the structures in some of the species studied.

Key to the Mississippi Genera of *SALDIDAE* Amyot and Serville

1. Five complete areoles on membrane ..... *PENTACORA* Reuter
   Membrane with four areoles, with the subexternal areole shorter than the others, third and fifth areoles more or less contiguous toward the apices 2
2. Membrane with its inner basal area prolonged two-fifths or one-half beyond the base of the next area; elytra often punctuate, without silky patches; embolium completely black ..... *SALDA* Fabricius
   Membrane with its inner basal area prolonged slightly or not more than one-third of its length beyond the next area; embolium not completely black 3
3. Two entirely distinct veins present on corium, the inner one branched near apex, the branches touching the suture of the membrane; apex of first or inner cell extending to or almost to apex of second cell ..... *SALDULA* Van Duzee
   Corium with indistinct veins; apex of first or inner cell of membrane distinctly beyond the apex of the second cell ..... *MICRACANTHIA* Reuter

Key to the Mississippi Species of *PENTACORA* Reuter

1. Upper surface dull, varicolored, with appressed pubescence 2
   Upper surface shining, black and yellow, with numerous long, erect hairs ..... *hirta* (Say)
2. Lateral margins of pronotum and elytra with a row of very short erect setae; segment II of antennae much longer than segments III and IV combined; length, 6.5-8.0 mm ..... *signoreti* (Guerin)
   Lateral margins of pronotum and elytra without setae; segment II of antennae equal to or shorter than segments III and IV combined; length, 5.0-6.0 mm 3
3. Dorsal color mostly black; costal area narrowly yellow with edge black; elytra with numerous short suberect hairs ..... *ligata* (Say)
   Dorsal color mostly dull-yellow; costal area con-colorous; elytra with very short inclined bristle-like hairs ..... *sphacelata* (Uhler)

Genus *PENTACORA* Reuter 1912

Biological notes.—The writer collected specimens of this genus on the sandy banks of pools, both brackish and fresh water. They were more numerous where short grasses and weeds were growing along the banks. Specimens were found running around on the sand between the clumps of vegetation and would fly a short distance when approached. Quick movement was required to capture them.

Hungerford (1920) in Maryland observed *Pentacora signoreti* Guerin moving swiftly over a sand beach in association with *Ci-*

cindela dorsalis, and inserting their beaks into dead flies and other insects.

Drake and Hottes (1951b) reported the presence of a series of "spine-like" or "peg-like" organs on each side of the second visible connexival segment of the males. They assumed that these organs were stridulatory in function. A drawing and a photograph of the subbasal hemelytron notch in *Pentacora signoreti* (Guerin) are included in the paper.

Pentacora signoreti (Guerin), 1857

Locality data.—It has not been collected in Mississippi, but is included here because it has been reported from North Carolina, Georgia, Florida and Texas by Van Duzee (1917); from Florida and Texas by Hungerford (1920) and Blatchley (1926).

Pentacora hirta (Say), 1832

Locality data.—Previously recorded from the state by Drake (1949a). Specimens have been seen as follows: Bixoli, May-Aug., 13 specimens (J.T.P. and H. M. Harris); Deer Island, July, 3 ♂♂, 1 ♀ (C.A. W.); Pascagoula, Aug., 1 specimen (C. J. Drake).

Pentacora ligata (Say), 1832

Locality data.—This species has not been collected in Mississippi. It is included here because it has been reported from North Carolina by Van Duzee (1917), Blatchley (1926), and Hungerford (1920). Dr. H. M. Harris has 12 specimens from Baton Rouge, Louisiana, collected Aug. 27, 1930.

Pentacora sphacelata (Uhler), 1877

Locality data.—Previously recorded from the state by Drake (1949a). Specimens have been seen as follows: Biloxi, Feb.-Aug., 42 specimens (H. M. Harris and J.T.P.); Cat Island, Aug., 3 ♀♀ (C.A.W.); Deer Island, July, 2 ♂♂, 8 ♀♀ (C.A.W.); Fountainbleau, March, 4 specimens (J.T.P.); Ocean Springs, Feb., 1 specimen (J.T.P.); Pascagoula, Aug., 1 specimen (C. J. Drake); Pass Christian, March, 3 specimens (J.T.P.).

Genus *SALDA* Fabricius 1803

Biological notes.—Hungerford (1920) indicated that these insects live commonly on damp soils about pools, on the shores of fresh and salt waters and along the margins of ponds. He observed some biological habits of *Salda authracina* Uhler near Ithaca, New York. Last instar nymphs were brought into the laboratory and within 4 to 8 days all were in the adult stage. They were fed various dead insects. Mating occurred and eggs were found about 10 days later. The eggs were laid, usually singly, beneath sheaths of shore grasses or between leaflets of moss.

Brimley (1934) collected *Salda littoralis* Linnaeus at Cley, England on salt marshes and took them into the laboratory for rearing. Mating was observed, and 4 days later one female deposited 8 eggs in the wet mud.

Drake and Hottes (1951b) reported the presence of a series of "peg-like" or "spine-like" organs on each side of the second visible connexival segment of the males. These organs are assumed to be stridulatory in function.

Salda bouchervillei (Provancher), 1872

Locality data.—This species has not been collected in Mississippi. It is included here since it has been reported as occurring in Tennessee by Drake and Hottes (1950a).

Genus *SALDULA* Van Duzee 1914

Biological notes.—Species in this genus were collected from small upland ponds with sandy loam banks and with vegetation hanging over the banks and extending down near the water's edge. Another common habitat was on the sandy banks of beaches along the Gulf of Mexico. The beaches along the mainland and the beaches of the islands visited in Mississippi Sound were favorite habitats.

Very little has been written about the biology of the genus. Drake and Hottes (1951b) reported the presence of a series of "spine-like" or "peg-like" organs on each side of the second visible connexival segment of the males. These organs are assumed to be stridulatory in function.

Key to the Mississippi Species of *SALDULA* Van Duzee

1. Pronotum with lateral margins yellowish; dorsal surface without erect hairs; corium and membrane pale, cells of membrane with dark spots; length, 3 mm ..... *coxalis* (Stål)

   Pronotum with lateral margins black; dorsal surface with erect hairs present or absent; length, more than 3.0 mm 2

2. Corium with costal area almost completely black; dorsal surface black with a few pale spots; length, 6-8 mm ..... *lugubris* (Say)

Corium with costal area white or yellowish, usually spotted with darker spots; length variable, 5 mm or less 3

3. Dorsal surface of body with long, erect hairs ... *orbiculata* (Uhler)

Dorsal surface of body without long, erect hairs ... *pallipes* (Fabricius)

Saldula lugubris (Say), 1832

Locality data.—This species has not been collected in Mississippi. It is included here since it has been reported from Missouri and Texas by Drake and Hottes (1950a).

Saldula orbiculata (Uhler), 1877

Locality data.—Has not been collected in Mississippi. It is included here since it has been reported from Texas and Illinois by Uhler (1877) and Van Duzee (1917), and from Texas by Hungerford (1920) and Blatchley (1926).

Saldula pallipes (Fabricius), 1794

Locality data. — Has not been recorded previously from the state. Specimens have been seen as follows: Deer Island, July, 1 ♂ (C.A.W.); State College, Oct., 2 ♀♀ (C.A.W.).

Saldula coxalis (Stål), 1873

Locality data.—This species has not been collected in Mississippi. It is included since it has been reported from New Jersey to Florida by Van Duzee (1917).

Genus *MICRACANTHIA* Reuter 1912

Biological notes.—The writer found that in Mississippi the species in this genus preferred the leaves of floating aquatic plants. Pools containing an abundance of floating vegetation therefore proved to be the best areas for collecting. *Micracanthia husseyi* Drake and Chapman was taken in large numbers from the floating leaves of the sweet-scented pond lily, *Castalia odorata* (Ait.). The water was deep and clear but had a dense growth of vegetation. At another location they were collected from a shallow pool filled with a heavy growth of vegetation.

There is little information in the literature on the biology of this genus.

Key to the Mississippi Species of *MICRACANTHIA* Reuter

1. Two transverse light-yellow spots on costal area of corium ... *quadrimaculata* (Champion)

Entire costal area of corium light yellow 2

2. Size larger; length, 3.00-3.70 mm; shape oval ... *humilis* (Say)

Size smaller; length, 2.95 mm or less; shape more elongate 3

3. Antennal segment II one-third longer than I ... *husseyi* Drake and Chapman

Antennal segment II twice as long as I ... *pumpila* Blatchley

Micracanthia humilis (Say), 1832

Locality data.—Previously recorded from Fayette by Drake (1922). Specimens have been seen as follows: State College, Sept., 4 ♂♂, 8 ♀♀ (C.A.W. and M.S.C.).

Micracanthia husseyi Drake and Chapman, 1952

Locality data.—Previously recorded from Pascagoula by Drake and Chapman (1952). Specimens have been seen as follows: Cat Island, Aug., 4 ♂♂, 6 ♀♀ (C.A.W.); Ocean Springs, Aug., 6 ♂♂, 3 ♀♀ (C.A.W.); Vancleave, Aug., 2 ♂♂ (C.A.W.).

Micracanthia pumpila Blatchley, 1928

Locality data.—Previously recorded from the state by Drake and Hoberlandt (1950a).

Micracanthia quadrimaculata (Champion), 1900

Locality data.—Previously recorded from the state by Drake and Hoberlandt (1950).

Micracanthia floridana Drake and Chapman, 1954

Locality data.—Reported from Vicksburg (1 specimen) by Drake and Chapman (1954).

Genus *SALDOIDA* Reuter 1901

Biological notes.—These rare insects are collected very infrequently and therefore little is known about their biology. Both *Saldoida slossoni* Osborn and *Saldoida cornuta* Osborn have been collected in Mississippi. They were taken along the Gulf coast by Mr. J. T. Polhemus and the writer is grateful to him for supplying these brief biological notes. The specimens were collected beside a stream supplied from an artesian well. The stream ran through a pasture into a small pond. The soil where they were collected was packed with old cattle hoof marks and was damp from seepage water. The specimens were taken from the damp ground around the hoof marks but never on wet ground. An aspirator was used to capture them. The insects were constantly on the move, their conspicuous an-

tennae continually waving. The area where they were collected was covered with grasses and broken sticks and similar debris. The *Saldoida* collected in Mississippi were taken in association with ants, which agrees with Mrs. Slosson's observation in connection with her collection of the type specimens of *Saldoida cornuta* Osborn and *Saldoida slossoni* Osborn in Florida.

Slosson (1908) recorded her search for *Saldoida* Osborn near Dunedin, Florida. She indicated that they move swiftly about waving their antennae from side to side. She found them most commonly in damp, grassy places where sun-dew, *Drosera*, was growing. They were difficult to capture, but the best method found was to "drive" the specimens into an insect net.

Key to the Mississippi Species of *SALDOIDA* Osborn

Anterior lobe of pronotum and spines black, clothed with appressed white pubescence. Humeri more or less strongly produced into elevated, subacute spines. Scutellum black with appressed pubescence, the disk only slightly elevated apically ..... *cornuta* Osborn

Anterior lobe of pronotum and spines ochraceous to fulvous or even darker, but with the spines glabrous except for a few stiff black hairs. Humeri scarcely produced, rounded. Disk of scutellum strongly inflated apically ..... *slossoni* Osborn

Saldoida slossoni Osborn, 1901

Locality data.—Previously recorded from the state by Drake and Hoberlandt (1950a). The writer has not collected this species in Mississippi.

Saldoida cornuta Osborn, 1901

Locality data.—This species has not been recorded previously from Mississippi. Specimens have been seen as follows: Ocean Springs, May 25, 1950; July 7, 1950 and Sept. 4, 1950 (J.T.P.).

G. *Family NOTONECTIDAE Leach, 1815*

Review of the literature.—Bare (1926) obtained data on the life histories of several species of Notonectidae in Kansas. A very prolific worker on this family has been Hungerford (1933a), whose monograph of the *Notonecta* of the world includes keys, descriptions, synonymy, biological notes and locality data on all the known species. The paper contains colored plates of a number of species plus drawings of the male genital capsules. Rice (1942) published notes on the biology of eight notonectids observed at Reelfoot Lake, Tennessee. Information was presented on food preferences, oviposition habits and metamorphosis for the eight species.

Key to the Mississippi Genera of NOTONECTIDAE Leach

Hemelytral commissure without definite hair-lined pit at anterior end ..... *NOTONECTA* Linnaeus

Hemelytral commissure with definite hair-lined pit at anterior end ..... *BUENOA* Kirkaldy

Key to Mississippi Species of *NOTONECTA* Linnaeus

1. Last abdominal sternite of female large but strongly constricted just before the tip; male with digitate prolongation on genital capsule ..... *irrorata* Uhler

   Last abdominal sternite of female not large nor strongly constricted just before the tip; male without digitate prolongation on the genital capsule 2

2. Mesotrochanter plainly angulate or produced into a tooth or stout spinelike process 3

   Mesotrochanter rounded or nearly so 4

3. Synthlipsis very narrow, not more than one-sixth the anterior margin of the vertex as seen from above; hemelytra brick-red to orange with black blotch on corium ..... *uhleri* Kirkaldy

   Synthlipsis usually broader than above, about one-fourth width of eye; hemelytra not red or orange ..... *raleighi* Bueno

4. Anterior margin of vertex (seen from above) straight and width less than length of vertex; anterior trochanter of male with a stout conspicuous hook; male clasper broad, shallowly incised at tip. Last abdominal sternite of female with apical notch broader than deep if present; color variable from broad black band to no band across distal end of hemelytra ..... *indica* Linnaeus

Anterior margin of vertex rounded and width subequal to length of vertex; anterior trochanter of male with a medium-sized hook; male clasper deeply incised. Last abdominal sternite of female with apical notch deeper than broad; typical color with narrow undulate band across hemelytra ..... *undulata* Say

Notonecta irrorata Uhler, 1879

Biological notes.—The writer took specimens from sluggish streams, pot-holes in ditches, borrow-pits covered with vegetation, cold, clear spring-fed streams, muddy, shallow ponds, shady sloughs in the Delta, and cool, clear springs. Thus, in the state this insect has a wide range of habitats and is usually one of the easiest of all aquatic insects to locate and collect. It frequently stings swimmers and occurs commonly.

Hungerford (1933a) notes that it lives in open ponds or in shady situations near banks with overhanging vegetation. At Ithaca, New York the winters are spent in deeper ponds and it flies to shallower waters for breeding. Specimens were observed swimming under ice in early February. Mating was observed as early as April, and eggs were deposited in the tissues of plants. The egg stage extended for about two or three weeks and there were five nymphal instars.

Rice (1942) found the average length of the complete life cycle was about 60 days at Reelfoot Lake, Tennessee. She also confirmed Hungerford's observations that eggs are deposited in plant tissues.

Locality data.—Previously recorded from Fayette by Drake (1922), from Mississippi by Blatchley (1926), from Agricultural College, Charleston, Crowder, Hamilton, Iuka, Scooba and Smithville by Hungerford (1933a), and from Oxford by Penn and Ellis (1949). Specimens have been seen as follows: Anguilla; Batesville; Beulah; Biggersville; Biloxi; Booneville; Charleston; Columbus; Crowder; Edwards; Escatawpa; Fearn Springs; Glen; Hazelhurst; Houlka; Iuka; Longview; Maben; McComb; Okolona; Picayune; Prairie; Ramsey Springs; Saltillo; Saratoga; State College; Sturgis; Toccopola; Vancleave.

Notonecta uhleri Kirkaldy, 1897

Biological notes.—This species is encountered infrequently and therefore little is known about its biology. The writer collected a series of specimens in October at Anguilla in a shallow roadside borrow-pit. This habitat contained no appreciable amount of vegetation. Another collection was made in August at Escatawpa in a cool, shady, deep stream which contained no vegetation.

Rice (1942) at Reelfoot Lake, Tennessee found nymphs abundant in shallow pools in the saw grass and smart weed zones whereas the adults migrated to the deeper bayous.

Locality data.—Previously recorded from Leland by Hungerford (1933a). Specimens have been seen as follows: Anguilla, Oct., 1 ♂, 2 ♀♀ (C.A.W.); Biloxi, Nov., 1 specimen (J.T.P.); Escatawpa, Aug., 1 ♂ (C.A.W.); Charleston, Aug.-Sept., 6 specimens (H. M. Harris).

Notonecta undulata Say, 1832

Biological notes. — This insect has not been collected in Mississippi nor in any of the southeastern states. Hungerford records it from St. Louis, Missouri and northwestern Arkansas.

Bare (1926) reared the species to maturity in 40 to 52 days, using mosquito larvae as food.

The life history has been observed by Hungerford (1917f) in Kansas and New York. The elongate white egg is attached to submerged objects in the water. There are five nymphal instars. Food of the early instars consists largely of ostracods and similar organisms. The winter is passed in the adult stage, and two broods are reared in a season in Kansas.

Locality data.—This species seems to be supplanted in the state by *Notonecta indica* Linnaeus, which is a very common species.

Notonecta indica Linnaeus, 1771

Biological notes.—Next to *Notonecta irrorata* Uhler, this is the most common notonectid in Mississippi. It occurs commonly in ponds, borrow-pits and small streams. Large series were collected from various parts of the state and an extremely wide variation in the color markings was noted.

Rice (1942) observed this insect at Reelfoot Lake, Tennessee and found that the eggs were glued to the surface of weed stems, grass, and sticks present in the water. The developmental period was about 8 to 10 days for eggs and 40 to 60 days for nymphs depending upon various ecological factors.

Locality data.—Previously recorded from Fayette by Drake (1922), from Agricultural College, Fayette and Natchez by Hungerford (1933a), from Oxford by Penn and Ellis (1949). Specimens have been seen as follows: Anguilla; Biggersville; Biloxi; Booneville; Cleveland; DeLisle; Edwards; Fountainbleau; Handsboro; Marks; Natchez; Pontotoc; State College; Charleston.

Notonecta raleighi Bueno, 1907

Biological notes.—Specimens were collected fairly commonly by the writer. Adults were taken as late as November, whereas no nymphs were found late in the season. It lives in a wide variety of habitats including large, artificial lakes, sloughs, bayous, ponds, and spring-fed marshes. It was not encountered in running streams or borrow-pits. Most of the habitats in which it was collected were filled with vegetation.

Rice (1942) made a study of its life history at Reelfoot Lake, Tennessee and illustrated the life stages. Eggs were laid on stems and leaf surfaces in the water; they hatched in 8 to 10 days and completed all instars in 40 days. Nymphs appeared in greatest numbers in June, while a scattering of nymphs was found all summer.

Locality data.—Previously recorded from Oxford and Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Brookhaven; Columbus; Corinth; Greenwood; Itta Bena; Iuka; Midnight; Scott; Charleston; Fayette.

Key to Mississippi Species of *BUENOA* Kirkaldy

1. Rostral prong longer than third rostral segment ..... *artafrons* Truxal
   Rostral prong equal to or shorter than third rostral segment 2
2. Small species, less than 6 mm long; scutellum reduced, narrow and not as long as pronotum ..... *confusa* Truxal
   Larger species, more than 6 mm long; scutellum broad, as long as or longer than pronotum 3
3. Stridular area on inner lateral face of front femora of males small, oval, with not more than 15 cross ridges; body smaller and more slender; femoral spines spaced approximately twice their diameters apart; length 6.7 to 8.1 mm ..... *margaritacea* Bueno
   Stridular area on inner lateral face of front femora of males sword-shaped, with 30 or more cross ridges; pronotum in both sexes with very feeble or no depressions; femoral spines spaced approximately their diameters apart; length 6.5 to 7.5 mm ..... *scimitra* Bare

Buenoa margaritacea Bueno, 1908

Biological notes. — Hungerford (1920) studied the biology of this insect in Kansas. Collections were made most commonly in ponds, and eggs were oviposited mainly in smartweed stems and cattail leaves. The female slits the tissues and inserts the eggs singly, leaving a small amount of the egg showing. He found five nymphal instars, and adults were collected from early spring to late fall. The anterior legs are adapted for catching pray, and the food consists mostly of small entomostracan Crustacea.

Rice (1942) found that it preferred stock ponds and roadside pools in the vicinity of Reelfoot Lake, Tennessee.

Locality data.—Reported from Fulton and State College by Truxal (1953).

Buenoa scimitra Bare, 1925

Biological notes.—Extensive collecting has shown this to be the most abundant *Buenoa* in Mississippi. It has a preference for sparsely vegetated, muddy, roadside puddles, streams, small ponds, and borrow-pits. Adults were taken from March to December.

Bare (1926) made some observations on the life history in Kansas. The total period of development from egg to adult varied from 58 to 77 days. Eggs were laid in the laboratory in the stems of *Ceratophyllum.* Two broods per season seems to be the rule in Kansas. Nymphs and adults grew well in the laboratory on a diet of mosquito larvae or Entomostraca. Hibernating adults were found in the deeper and more permanent ponds in the winter in Kansas.

Locality data. — Truxal (1953) reported it from Vicksburg and Woodville. Specimens have been seen as follows: Biggersville; Biloxi; Booneville; Charleston; Edwards; Handsboro; Natchez; Ramsey Springs; Schlater; State College; Toccopola.

Buenoa confusa Truxal, 1953

Biological notes. — The writer collected this pretty little species at the edge of a large brackish pool on Cat Island. The pool was

filled with a heavy growth of cattail (*Typha angustifolia* Linnaeus), and the sepcimens were taken from the bottom within approximately three feet of the bank. They were not very abundant and repeated sweepings with the net produced only a few specimens.

Bare (1926) made observations on its life history in Kansas, and was able to rear it in the laboratory on a diet of mosquito larvae. Eggs were found in the stems of grasses and sedges in a pond where adults were collected. Mating and egg laying were observed throughout the summer—when the females were ovipositing the males swam about them in an excited fashion. Developmental time from egg to adult varied from 42 to 52 days. The feeding habits were about the same as the other species of the genus, except they were more cannibalistic.

Rice (1942) found this species rare in Tennessee. The Tennessee specimens were taken in clear water containing considerable plant growth.

Locality data.—Truxal (1953) reported it from Shuqualak and Bay St. Louis. Specimens have been seen as follows: Biloxi, Sept., 2 specimens (J.T.P.); Cat Island, Aug., 1 ♂, 1 ♀ (C.A.W.); Charleston, Sept., 30 specimens (H. M. Harris).

Buenoa artafrons Truxal, 1953

Locality data.—Has not been collected in Mississippi, however Truxal (1953) reported it from Florida and Georgia.

H. *Family PLEIDAE Fieber, 1851*

Review of the Literature.—The description of *Plea harnedi* from Mississippi was published by Drake (1922). Ellis (1950), after studying a large series of specimens from Louisiana, placed *P. harnedi* Drake in synonymy with *P. striola* Fieber. He stated that *P. harnedi* was a color variation of *P. striola.* Drake and Chapman (1953) published a report on the Pleidae of the Americas in which *P. harnedi* was restored as a species based on size of reticulations and relative size of the species. After studying specimens from Mississippi the writer believes *P. harnedi* to be a mere color variant of *P. striola,* and thus Ellis (1950) was correct in placing *P. harnedi* in synonymy with *P. striola.* However, in this paper I am following Drake and Chapman (1953) since their paper is the most recent treatment of the *Plea* complex.

Plea are most commonly collected in Mississippi from alongside banks of ponds, lakes and sluggish streams from beneath overhanging vegetation or from exposed tree roots (especially willow) extending into the water.

Plea puella Barber, 1923

Locality data.—Previously recorded from Mississippi by Drake and Chapman (1953). The writer collected two specimens at Ocean Springs in August.

Plea striola Fieber, 1844

Biological notes.—The writer found this insect throughout the summer at State College in masses of willow roots floating near the surface of a pond. Nymphs and adults were collected in considerable numbers from May to October. Other habitats included a shady slough in the delta and a cool, clear, heavily vegetated pond along the Gulf coast.

Bare (1926) observed mating in a pond in Kansas. A single female lays approximately 30 eggs, and the period of development from egg to adult was slightly over two months. He reared them successfully on a diet of ostracods and mosquito larvae.

Clark (1925) collected specimens in Manitoba, Canada among the tangles of *Chara, Elodea, Myriophyllum* and other aquatic plants.

Hungerford (1920) determined that this species eats ostracods and other small Crustacea. Frequently several specimens were eaten one after another by a single insect. He was able to obtain eggs by placing the insects in an aquarium with *Elodea* and *Chara.* The eggs were inserted into the tissues of the plants.

Rice (1942) found that the length of time required for egg development in the laboratory was from 8 to 21 days. Specimens were collected most commonly in Reelfoot Lake from *Elodea* and coon-tail beds, and in the heavy vegetation of the bayou. She observed that this insect appears to be an important item of food for two top minnows, *Fundulus dispar* and *Fundulus chrysotus.*

Locality data.—Previously recorded from Fayette by Drake (1922) and Blatchley (1926). Specimens have been seen as follows: Batesville, Oct., 2 specimens (C.A. W.); Charleston, Aug.-Sept., 65 specimens

(H. M. Harris); Ocean Springs, Aug., 3 specimens (C.A.W.); State College, May-Oct., 46 specimens (C.A.W.).

Plea harnedi Drake, 1922

Locality *data.*—Previously recorded from Mississippi by Drake (1922) and Drake and Chapman (1953).

Plea notana Drake and Chapman, 1953

Locality *data.*—Previously recorded from Mississippi by Drake and Chapman (1953).

Plea apopkana Drake and Chapman, 1953

Locality *data.*—Previously recorded from Mississippi by Drake and Chapman (1953).

I. *Family NAUCORIDAE Fallen, 1814*

Review of the literature.—This family is represented in Mississippi by only one genus, *Pelocoris* Stål. Bueno (1903) published brief notes on the habits and life history of *Pelocoris femoratus* (Palisot de Beauvois). The biology of *Pelocoris femoratus* was studied by Hungerford (1927a) who recorded information on its food, oviposition habits and habitat preferences. Probably the most energetic workers on this group of insects have been Usinger and LaRivers. They have published keys, descriptions of new species and biological data on a number of species from the areas mentioned above, (Usinger, 1938, 1941, 1942b, 1944, 1946a, 1947; LaRivers, 1948a, 1948b, 1950, 1951).

Key to Mississippi Species of *PELOCORIS* Stål

Sixth ventral abdominal segment of female not or only weakly cleft; male dorsal aedeagal plate emarginate at tip; pronotum greenish in color ... *femoratus* (Palisot de Beauvois)

Sixth ventral abdominal segment of female with a narrow, but deep V-shaped cleft at mid line, the notch two to three times as deep as wide; male dorsal aedeagal plate abruptly truncate at tip; pronotum light brown in color ..... *carolinensis* Bueno

Pelocoris femoratus (Palisot de Beauvois), 1805

Biological notes.—The writer collected a long series of specimens in March from a shallow borrow-pit filled with aquatic vegetation. The water was muddy and the insects were clinging to the vegetation. They prefer these shallow heavily vegetated borrow-pits or similar areas in the state.

Bueno (1903) made a study of its life history in New York. The eggs were oviposited on the surface of submerged plants and hatched in approximately 24 days. The length of time required for the instars varied as follows: first instar, 8 days; second instar, 6 to 9 days; third instar, 8 days; fourth instar, 10 to 12 days; fifth instar, 16 days. The total length of time for development was found to be about 77 days.

Hungerford (1927a) reared this species in the laboratory and made observations on the egg laying, hatching and nymphal development. He fed the insects a diet of mosquito larvae, *Chironomus* larvae, corixids and entomostracans but had difficulty in keeping them alive. The eggs were glued to the stems and leaflets of *Nitella* and other aquatic plants with an adhesive which the bug secreted. There were five nymphal instars. Time required for hatching was approximately 40 days and for total nymphal development, 50 to 62 days.

Locality data.—Previously recorded from the state by Hungerford (1920), from Fayette by Drake (1922), from Charleston by LaRivers (1948a) and from Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Biloxi, Feb.-May, 6 ♂♂, 10 ♀♀ (C.A.W. and J.T.P.); Charleston, Sept., 10 specimens (H. M. Harris); Handsboro, June, 4 specimens (J.T.P.); Laurel, Aug., 30 specimens (H. M. Harris); Wiggins, Aug., 15 specimens (H. M. Harris).

Pelocoris carolinensis Bueno, 1907

Biological notes.—In Mississippi specimens were collected exclusively in clear streams or pools containing abundant vegetation. The writer was stung on the right thumb while removing a specimen from the net. The pain was rather sharp, and severe, smarting, pulsating pain continued for approximately five minutes. Then the pain gradually diminished and had disappeared in approximately fifteen minutes.

Locality data.—Previously recorded from Saucier by Penn (1951). Specimens have been seen as follows: Big Point, June, 6 specimens (G. H. Penn); Biloxi, Jan.-Oct., 78 specimens (J.T.P.); Ocean Springs, July, 1 ♂, 1 ♀ (C.A.W.); Saucier, April, 6 ♂♂, 8 ♀♀ (C.A.W.).

J. *Family NEPIDAE Latreille, 1802*

Review of the literature.—Several interesting papers on the physiology of various species in the genus *Ranatra* were published by Holmes (1904, 1906, 1907, 1912). Bueno (1905c) gave a few preliminary taxonomic notes on three species of *Ranatra* from the northeastern United States. A monograph of the Nepidae of America north of Mexico (Hungerford, 1922a) contains keys to genera and species, descriptions, synonymy and locality data. The paper treats eleven species. Hoffman (1927, 1930, 1933) made detailed studies of the life histories of several Chinese species of Nepidae; these papers are noted because they contain information on rearing techniques that might prove useful. Kuitert (1948, 1949) described several new species of Nepidae from the Americas.

Key to the Mississippi Genera of NEPIDAE Latreille

1. Body broadly oval and flat ... *NEPA* Linnaeus
   Body elongate ... 2
2. Prothorax a little broader than head; body elongate-oval ... *CURICTA* Stål
   Prothorax narrower than head; Body elongate ... *RANATRA* Fabricius

Nepa apiculata Uhler, 1862

Biological notes.—Kirkaldy (1906) noted that food consists of *Daphnia, Cyclops,* fish eggs, small fish and tadpoles.

Severin and Severin (1911a) studied its behavior. They noted the predatory habits in captivity. It would not run in order to overtake its prey, but when houseflies or dragon flies were placed near the insect it would grasp them securely with its front legs and insert its beak and feed.

Hungerford (1920) indicated that it is a mud-loving species and usually may be collected in mud and trash near the edge of the water. At Ithaca, New York it spends the winter as an adult. The eggs bear eleven filaments, and are inserted into the tissues of decaying plants. Two insects were placed in a deep aquarium without vegetation and the smaller one killed the larger one.

Locality data.—This species has not been collected in Mississippi. It has been reported from Georgia by Van Duzee (1917) and Blatchley (1926).

Curicta drakei Hungerford, 1922

Biological notes.—Wiley (1922b) studied the biology of this insect in Texas. Both nymphs and adults were collected in rotten pieces of wood and in tangled plant roots along the banks. Eggs were discovered in the tissues of dead plant stems in nature after careful search. The nymphs were found to be quite agreeable, and did not feed on others of their kind. The nymphs were fond of small notonectids, corixids, small carabids, fresh water shrimp and mosquito larvae, but failed to eat small minnows. The egg is elongate-oval with a rosette of fifteen long filaments. Twelve days after mating one female laid seven eggs on wet sand in an aquarium. The following day three more eggs were discovered, and after three more days six additional eggs were found hidden among the roots of water plants and in the crotch of a dead twig. The insects were reared to maturity and had five instars.

Wiley (1924) reported further on its biology. She collected specimens in Texas and transported them alive to Minnesota where they were reared for two years. For egg deposition it prefers mud over rotten wood, decayed vegetation, or live water plants. The female lays five to ten eggs in a group by placing the ventral surface of her abdomen close to the mud. Only the crown of the filaments remain visible after the eggs are laid. The incubation period varies from 12 to 13 days. Five nymphal instars were observed, with the average duration of each as follows: first instar, 14 days; second instar, 22½ days; third instar, 23½ days; fourth instar, 23½ days; fifth instar, 46 days. Thus, the total time required for development from egg to adult was approximately 142 days. Drawings of all five nymphal stages and the adult are given in the paper.

Locality data.—The writer has not collected this insect in Mississippi. The species is included here since it has been reported from southeastern Louisiana by Hungerford (1922a) and Ellis (1952).

Genus *RANATRA* Fabricius, 1790

Biological notes.—Since all the species in this genus apparently are quite similar in habits, the biology will be discussed here.

This genus is well represented in the Mississippi fauna. Specimens were collected

most commonly from muddy, stagnant or polluted quiet waters. Ponds, borrow-pits, muddy lakes and roadside puddles are typical habitats. The richest single find was a large borrow-pit that had been used for several years as a dumping place for tin cans. The bottom was silted in about one foot deep with mud and there was practically no vegetation. Numerous specimens could be taken with a single sweep of the net, and four species were found here living together. The four were *Ranatra australis* Hungerford, *R. buenoi* Hungerford, *R. drakei* Hungerford and *R. nigra* Herrich-Schäffer. Species in this genus do not necessarily always occur in muddy and polluted habitats. At Port Gibson the writer collected specimens of *R. buenoi* Hungerford, *R. nigra.* H.-S. and *R. fusca,* P. de B., from a five acre artificial lake that contained clear, clean water. The specimens could be seen swimming under the water before they were collected. The lake contained no aquatic plants but the bottom was filled near the edge with several inches of mud, and the place where the insects were collected was densely shaded by willow trees.

Enock (1900) observed the process of oviposition. The female grasped a floating leaf of *Alisma* with the middle and hind legs, and inserted the ovipositor into the leaf to make a hole, then withdrew the ovipositor partially and placed an egg in the hole. The process was repeated after the female moved about one-fourth of an inch. In addition to the leaves, eggs were laid in half decayed stems and occasionally in green stems.

Marshall and Severin (1904) found these insects buried in mud in creeks or pools during the winter.

Bueno (1905b) made a rather thorough study of *Ranatra quadridentata* Stål. He indicated that it lives in deep water where it hangs on to the stems of grasses and rushes. It was found wintering as an adult and sometimes frozen in ponds. The mating process according to Bueno "is rather unorthodox in that the male is below and to one side of the female". The incubation period varied from two to three weeks. Bueno reared the insect through five instars and found the time required for each instar varied as follows: first instar, 8 to 14 days; second instar, 9 days; third instar, 7 days; fourth instar, 8 days; fifth instar, 8 days. Thus, about 61 days elapse between the egg and the adult stage.

Hungerford (1920) added some notes on the biology of these insects. He collected them in weedy pools and on floating debris. The mating process was quite prolonged, and incubation covered a period of about one month.

Herring (1951a) collected them in Florida from all habitats where leaf debris and silt were found on the bottom of protected coves and bays. Eggs were collected along the edge of streams from grass stems.

Key to the Mississippi Species of *RANATRA* Fabricius

1. Antennae simple, distal end of next to last segment without lateral prolongation; front femora broad and stout and not narrowed near middle ..... *kirkaldyi* Bueno

   Antennae with distal end of next to last segment with a lateral prolongation; front femora somewhat narrowed in their middle section 2

2. Lateral prolongation of next to last segment of antennae not greater than one-half the length of the ultimate segment 3

   Lateral prolongation of next to last segment of antennae greater than one-half the length of the ultimate segment 4

3. Prosternum with a single wide, deep longitudinal trough; eyes very prominent ..... *buenoi* Hungerford

   Prosternum without the deep trough, but possessing two longitudinal depressed lines characteristic of most species of *Ranatra* ..... *nigra* Herrich-Schäffer

4. Front femur broad and without apical tooth ..... *australis* Hungerford

   Front femur with apical tooth 5

5. Anterior portion of prothorax fully twice as long as thickened posterior portion; eyes large, plainly greater than interocular space; jugae of head prominent; front femur long and slender; hind femur surpassing middle of next to last abdominal segment; caudal filaments as long as body ..... *drakei* Hungerford

Anterior portion of prothorax shorter than above; eyes not much, if any, greater than interocular space; jugae not so prominent; front femur fairly stout; middle and hind femora short, not attaining middle of next to last abdominal segment ..... *fusca* Palisot de Beauvois

Ranatra kirkaldyi Bueno, 1905

Locality data.—Previously recorded from Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Vancleave, Sept., 6 specimens (J.T.P.).

Ranatra buenoi Hungerford, 1922

Locality data.—Previously recorded from Aberdeen and Leland by Hungerford (1922a) and from Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Beulah; Biloxi; Charleston; Columbus; Crowder; Greenwood; Louise; Okolona; Port Gibson; Scott; State College; Vancleave; Wiggins.

Ranatra nigra Herrich-Schäffer, 1853

Locality data.—This species has not been recorded previously from Mississippi. Specimens have been seen as follows: Biloxi, Jan., 1 specimen (J.T.P.); Marks, Oct., 1 ♂ (C.A.W.); Port Gibson, Nov., 1 ♂, 1 ♀ (C.A.W.); State College, July, 2 ♂♂ (C.A.W.).

Ranatra fusca Palisot de Beauvois, 1805

Locality data.—Previously recorded from Fayette by Drake (1922) and from Oxford and Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Edwards, Nov., 2 ♂♂, 7 ♀♀ (C.A.W.); Handsboro, May, 2 ♀♀ (J.T.P.); Port Gibson, Nov., 1 ♂, 1 ♀ (C.A.W.); State College, Oct., 25 specimens (M.S.C.).

Ranatra australis Hungerford, 1922

Locality data.—Previously recorded from Fayette and McComb by Hungerford (1922a) and from Spring Lake by Penn and Ellis (1949). Specimens have been seen as follows: Biloxi, Oct., 7 specimens (J.T.P.); Edwards, Nov., 3 specimens (C.A.W.); Lyman, Oct., 1 specimen (J.T.P.); Port Gibson, Nov., 2 specimens (C.A.W.); Charleston, Sept., 6 specimens (H. M. Harris).

Ranatra drakei Hungerford, 1922

Locality data.—This species has not been recorded previously from Mississippi. Specimens have been seen as follows: Biloxi, Oct., 2 specimens (J.T.P.); Edwards, Nov., 1 ♀ (C.A.W.).

K. *Family BELOSTOMATIDAE Leach, 1815*

Review of the literature.—The literature on this family is extensive, but only the more comprehensive works will be reviewed here. Notes on the biology of *Lethocerus americanus* (Leidy) were published by Hoffman (1924b). Additional notes on the life cycle of this same species appeared a year later (Hungerford, 1925). Cummings (1933) wrote a paper on the American Belostomatidae complete with keys, description, synonymy and distributional data. The genus *Abedus* Stål was studied by Hidalgo (1935) who gave keys to the four American genera and to nine species of the genus *Abedus*. The publication contains synonymy, descriptions of species and locality data. *Lethocerus americanus* (Leidy) was again the subject of a life history study by Rankin (1935). A most active worker in this family is De Carlo, who has published several useful revisions and monographs. Three papers (De Carlo, 1932, 1935, 1938b) were concerned with the description of new species. A monograph of the Belostomatidae of the Americas (De Carlo, 1938a), includes descriptions, synonymy and locality data on all North and South American species that were known at that time. Craik (1948) revised the family for the Western Hemisphere, but the work was never published. Therefore, the writer has followed the works of De Carlo in studying this family. The excellent revision of the genus *Abedus* (De Carlo, 1948), contains keys, descriptions and synonymy of the known species for both of the Americas. A plate of photographs of common species is appended.

Key to the Mississippi Genera of BELOSTOMATIDAE Leach

1. Membrane of hemelytra reduced ..... *ABEDUS* Stål

   Membrane of hemelytra not reduced 2

2. Fore femora not grooved for reception of tibia; length 50 mm or more ..... *BENACUS* Stål

   Fore femora grooved for reception of tibia, length less than 50 mm 3

3. Elongate - oval; genae meeting in front of tylus; beak elongate - conical or awl - shaped, its first segment shorter than second; length 40 mm or more ..... *LETHOCERUS* Mayr

Broadly-oval; genae not meeting in front of tylus; beak sub-cylindrical, acute, its first segment longer than second; length less than 30 mm ..... *BELOSTOMA* Latreille

Benacus griseus (Say), 1832

Biological notes.—This large insect is collected in Mississippi in ponds, streams and borrow-pits throughout the warm season. It is readily attracted to lights at night. Several references were found in the literature relative to this species killing small fish. Its food consists primarily of fish and other small pond-inhabiting animals.

Needham (1907) made observations on its egg laying and hatching. Egg masses are laid on sticks and other rubbish at the margin of ponds. The egg clusters are two to three inches long, and each mass contains 75 to 100 large eggs. Accurate information on the incubation period was not obtained but it seemed to be about 10 days. Hungerford (1925) observed the hatching process and noted that the cap at the cephalic end was forced up by a bubble confined by a delicate transparent membrane. Then the insect emerged, head first into the space delimited by the membrane of the bubble which then burst and rumpled up about the opening of the chorion.

Locality data.—Previously recorded from Fayette (Drake, 1922), and from Oxford (Penn and Ellis, 1949). Specimens have been seen as follows: Columbus, 2 specimens (M.S.C.); Lake, 1 specimen (M.S.C.); State College, April-Sept., 6 ♂♂, 9 ♀♀ (C.A.W.).

Key to the Mississippi Species of *LETHOCERUS* Mayr

Interocular space not narrower than width of an eye. Sides of elytra obviously, but feebly, curved; middle and hind legs vaguely if at all annulate; length 40 to 60 mm ..... *americanus* (Leidy)

Interocular space narrower than width of an eye. Sides of elytra straight and subparallel from base to apical third; middle and hind legs distinctly annulate; length 45 to 55 mm ..... *uhleri* (Montandon)

Lethocerus americanus (Leidy), 1847

Biological notes.—Rankin (1935) in observing the life history of this insect noted that it places its egg clusters on reeds above the water surface. There are five nymphal instars. Using tadpoles as food, he found that the average developmental period from egg to adult for field reared specimens was 33.4 days, and for laboratory reared specimens 58.9 days. Tadpoles and small frogs proved to be the best food. He noted that of the seven pairs of abdominal spiracles functional in the nymph only the last pair was functional in the adult. These are located near the base of the retractile caudal filaments.

Hoffman (1924b) made a rather thorough study of the biology of this insect in Minnesota. The specimens were found in December hibernating in a stream. Some were buried about six inches deep in the bottom muck and others were at the edge among *Typha* roots. Nymphs were successfully reared on grasshoppers, tadpoles, young frogs, fish, flies, beefsteak and other similar foods. Nymphs and adults would kill food only when they were hungry enough to eat what they killed. Time for complete development was not given; however, the fifth instar was of fifteen or more days duration.

Hungerford (1925) found an egg mass on a dried cat-tail stalk near St. Paul Minnesota. The stalk was inclined a few degrees from perpendicular and the egg mass was on the lower side about six inches above the water surface. There were 119 eggs arranged in six longitudinal rows.

Locality data.—Has not been collected in Mississippi, however, it is included since it has been recorded from Florida (Blatchley, 1926), Tennessee and Texas (Van Duzee, 1917), and southeastern Louisiana (Townsend, 1886).

Lethocerus uhleri (Montandon), 1896

Biological notes.—This species is common in Mississippi, and is collected frequently at lights. Specimens are active during the winter; they were collected at lights on February 8, 1950 at Starkville. The fish-killing habits of this insect are well known and the writer has on several occasions received complaints from minnow pond operators in Mississippi who were losing large numbers of fish to this insect.

On October 9, 1950 while on a collecting

trip near Columbus, Mississippi the writer observed this insect in the act of killing a banded water snake, *Natrix sipedon fasciata* (Linnaeus). The observation was made in a concrete pool filled with about six inches of water. The insect had its beak inserted into the snake near the middle portion of the snake's body. The snake was about twelve inches long, and was almost completely immobolized at the time the observation was made. The snake died after it was brought into the laboratory for observation.

Hungerford (1920) obtained egg clusters in an aquarium and there were 7, 7, 6 and 3 respectively in the clusters. The egg clusters were held together by irregular globose masses of gelatinous material.

Locality data.—Has not been recorded previously from the state. Specimens have been seen as follows: Biloxi; Columbus; Ellisville; Fenton; Kosciusko; Magnolia; Ocean Springs; Scott; State College; Starkville.

Key to the Mississippi Species of *BELOSTOMA* Latrielle

1. Length, 20 to 26 mm 2
   Length, 16 to 18 mm *testaceum* (Leidy)
2. Silken stripe on sides of abdomen narrow, confined to the middle of the side pieces of the ventrals; shape of elytra broadly oval, strongly tapering posteriorly ..... *lutarium* (Stål)
   Silken stripe on sides of abdomen wider, covering side pieces completely and impinging upon median plates of the ventrals; shape of elytra more elongate, not strongly tapering posteriorly ..... *flumineum* Say

Belostoma flumineum Say, 1832

Biological notes. — Its biology has been studied by Hungerford (1920). He found in Kansas that it lives in the trash of stagnant waters. Mating takes place in the water and frequently lasts for several hours. Hungerford observed that the eggs are glued to the back of the male in systematic rows. From 65 to 158 eggs are deposited on the back of the male where they remain until they hatch in one or two weeks. The average length of time required for a complete generation is six or seven weeks. In Kansas the winter is spent in the adult stage in mud and trash in pools.

Locality data.—Previously recorded from Fayette (Drake, 1922). One male has been seen from Columbus (M.S.C.).

Belostoma lutarium (Stål), 1855

Biological notes.—This is a very common insect in Mississippi. Adults were collected from March to November and nymphs from June to November. Males carrying eggs on their backs were collected as early as March 29 at Biloxi, in the extreme southern part of the state.

The author collected specimens August 3, 1951 on Cat Island, approximately sixteen miles off the Gulf coast from Gulfport. The collection was made in a shallow inland brackish pool, which contained a heavy growth of cat-tail, *Typha angustifolia* Linnaeus, and had a coarse, sandy bottom.

In the vicinity of State College it was collected most frequently in shallow stock ponds filled with submerged and emergent vegetation. Considerable variation in color of specimens from various sections of the state was noted. Specimens from the Gulf coastal region are noticeably darker, due apparently to the dark brown or almost black waters encountered in that section of the state.

Locality data.—Previously recorded from Fayette (Drake, 1922) and from Oxford and Spring Lake (Penn and Ellis, 1949). Specimens have been seen as follows: Anguilla; Biloxi; Brookhaven; Edwards; Fulton; Handsboro; Itta Bena; McComb; Natchez; Okolona; State College; West Point.

Belostoma testaceum (Leidy), 1847

Biological notes.—The one specimen collected by the writer was taken from a shallow, shaded pool in a dense swamp. The bottom of the pool was filled with leaves and was soft and spongy and the water murky.

Blatchley (1926) in studying specimens from North Carolina and Florida noted that the Florida specimens were all much darker, and theorized that this was due to the coffee-colored surface waters of the Florida region.

Locality data. — Has not been recorded previously from the state. One male has been seen from Columbus, Sept. (C.A.W.).

Abedus (*Microabedus*) *immaculatus* (Say), 1832

Biological notes.—The Mississippi specimens were collected about 15 miles north

of Biloxi in a temporary pond. Hussey and Herring (1950a) collected it in shallow "flatwoods" ponds in north-central Florida, a permanent stream forming the outlet from Kissengen Springs near Bartow, Florida, and from a shallow cypress swamp near Lakeland, Florida.

Locality data. — Has not been recorded previously from the state. Specimens have been seen as follows: Biloxi, Sept., 5 specimens (J.T.P.).

L. *Family GELASTOCORIDAE Kirkaldy, 1897*

Review of the literature. — *Gelastocoris oculatus* (Fabricius), was first described and placed in the family Naucoridae by Fabricius (1798). Since that time other authors have placed *Gelastocoris oculatus* and other new species under the family names Galgulidae, Mononychidae and Gelastocoridae. Hungerford (1920) suggested that the male genitalia might be of value in helping to distinguish between the species in this family. Hungerford (1922b) gave information on the laboratory rearing of a number of pairs of *Gelastocoris oculatus,* including techniques for rearing, observations on habitats, mating, oviposition, hatching and molting. A study of characters of specific taxonomic value in the genus *Gelastocoris* was made by Martin (1928) who reached the following conclusions after the investigation.

> "The genitalia of the male supply certain stable characters, as do also the lateral margins of the prothorax of both male and female, and the ventrocaudal segments of the abdomen of the male, with due regard for the range of variation of each specific character. The combination of the structural features mentioned above may be relied upon to differentiate the species in this exceedingly difficult genus."

Key to Mississippi Genera of GELASTOCORIDAE Kirkaldy

Forewings free ..... *GELASTOCORIS* Kirkaldy

Forewings fused together ..... *NERTHRA* Say

Gelastocoris oculatus oculatus (Fabricius), 1798

Biological notes.—The writer observed the mating habits of this species at State College. On June 13, 1951, at a pond on the campus, numerous mating pairs were noted on the bank. The mating pairs moved around constantly. A mating pair was placed on a dish of damp sand in the laboratory June 13th and observed. Matings were frequent and on some days quite extended in time. On June 13th mating extended for aproximately four hours; June 14, five hours; June 15, six hours; June 16, one hour; June 17, no mating observed and on June 18, both insects died. Observation at the pond on June 19 and again on June 29 revealed large numbers of mating pairs on the sandy bank. The mating pairs were observed on both dates on damp sand at about noon in bright sunlight. The male clings to the lateral margins of the wings of the female with his middle pair of legs, while the female moves around constantly during copulation. The male rests at an angle of about 30° above the longitudinal axis of the female, maintaining this position for several hours at a time without releasing his hold. Attempts were made to disengage mating pairs by striking them with a small stick, but the male in every case refused to release his hold.

Hungerford (1922b) studied the life history of *Gelastocoris oculatus oculatus* in Kansas and wrote a rather complete report on its life cycle there. He observed that the insect oviposits in the sand and the eggs hatch in approximately 12 days. There are five nymphal instars, the first averaging 15 days in length, second instar 16 days, third instar 15 days, fourth instar 15½ days, and fifth instar, 22 days. The average total time for development from hatching to emergence was 70½ days. A female was found to deposit as many as 12 eggs in a day with the average being from 2 to 6 per day. Nymphs were predaceous and were similar to the adult in other habits also.

Locality data.—Previously recorded from Fayette by Drake (1922) and from Oxford by Penn and Ellis (1949) and from the state by Todd (1955). Specimens have been seen as follows: Batesville; Belmont; Cleveland; Crystal Springs; Eupora; Fearn Springs; Glen Allen; Greenwood; Itta Bena; Maben; Natchez; Ocean Springs; Ramsey Springs; Ruleville; Schlater; State College; Stewart; Vancleave.

Nerthra stygica Say, 1832

Locality data.—This rare species has been reported from Georgia by Say (1832), and from Georgia and Florida by Blatchley

(1926), Hungerford (1920) and Van Duzee (1917). The species has not been collected by the writer in Mississippi.

M. *Family PELOGONIIDAE Leach, 1815*

Review of the literature.—The original description of *Ochterus americanus* Uhler, the first species in this family discovered in the United States, was published about 75 years ago (Uhler, 1876). Another paper by the same writer, Uhler (1884), described briefly the biology and known distribution of this species in North America. Champion (1897) published keys, descriptions and locality data on four American species. The second United States species, *Ochterus banksi* Barber, was described and a list of the known North American species published by Barber (1913a). Brief notes were published by Hungerford (1927a). Schell (1943) published a paper on the Pelegoniidae of the Western Hemisphere including keys to genera and species, descriptions of new species and distributional notes. A recent paper by Drake (1952a) contains a list of American species; two species, *Ochterus americanus* (Uhler) and *Ochterus banksi* Barber, are recorded from Mississippi. Bobb (1951) published detailed drawings and descriptions of life stages of *Ochterus banksi.*

Key to the Mississippi Species of *OCHTERUS* Latreille

Scutellum from one-half to two-thirds as long as wide, not transversely furrowed; lateral margins of pronotum with a pale spot anteriorly *americanus* (Uhler)

Scutellum approximately as long as wide, transversely furrowed; entire lateral pronotal margins usually broadly pale *banksi* Barber

Ochterus americanus (Uhler), 1876

Biological notes.—The writer collected specimens in a drainage ditch containing water about two inches deep. There was some vegetation growing in the ditch and the insect was swept off the vegetation from above the water.

Drake (1952a) indicated that the typical habitat is along the borders of sandy streams and ponds. Their mobility and ability to survive submergence makes these insects fairly independent of wave action, flash floods and seasonal variations in shore line. During rainy days the adults often travel some distance from shore in search of food. Due to the protective coloration, selective habitats, and the jumping and leaping habits they are usually poorly represented in collections.

Schell (1943) reported that the reduction in size of the ovipositor suggests that eggs are deposited on the surface of objects rather than inserted into plant tissues. She says that the eggs are deposited on the surface of grains of sand, plant detritus, and other similar materials. The insect is predacious and feeds on the larvae of horseflies and other insects present.

Locality data.—Previously recorded from Aberdeen by Schell (1943) and Drake (1952a). Specimens have been seen as follows: Fulton, Oct., 1 ♂ (C.A.W.); Ocean Springs, May, 5 specimens (J.T.P.).

Ochterus banksi Barber, 1913

Biological notes.—According to Schell (1943) it resembles *Ochterus americanus* (Uhler) in habits. Both species occur in similar types of breeding areas.

Locality data.—Previously recorded from the state by Drake (1952a). One specimen has been seen from Biloxi, April (J.T.P.).

N. *Family CORIXIDAE Leach, 1815*

Review of the literature.—This family has received the attention of many taxonomists through the years. Fieber (1851) wrote a review of the literature up to that time and treated all of the Corixidae except the extremely small species with a distinct scutellum which were assigned to *Sigara.* Fieber's *Corisa* contained 51 species known to him, plus 20 others he had not seen but one of which he renamed. Abbott (1912-1923) studied North American Corixidae and in a series of papers described 17 species, 6 of which are now synonyms. Walley (1936) described several new species of Corixidae and recorded *Arctocorixa hubbelli* Hungerford from Natchez, Mississippi. Millspaugh (1940) made an interesting report on the ecology of nine species of Iowa Corixidae. A very thorough investigation of the life history, environment and structure of *Ramphocorixa acuminata* (Uhler) was conducted by Griffith (1945). The monumental monograph of the Corixidae of the Western Hemisphere (Hungerford, 1948) is copiously illustrated with figures of taxonomic characters, and contains keys, descriptions of all known species, locality records and much

biological data. Leading up to this extensive monograph, Hungerford published a number of shorter papers (Hungerford, 1917a, 1917b, 1920, 1923a, 1926c, 1926d, 1928e, 1929c, 1939, 1942a, 1942b, 1944, 1947).

Key to the Mississippi Genera of *CORIXIDAE* Leach

1. Small insects, less than 5.6 mm in length; male asymmetry sinistral, the fore tibia produced apically over the short, triangular pala; female with apex of clavus not reaching beyond a horizontal line extending through the costal margins of the hemelytra at the nodal furrows ..... *TRICHOCORIXA* Kirkaldy

   Insects longer than 5.6 mm (except some *CORISELLA*); male asymmetry dextral, the fore tibia not produced apically over the pala; female with apex of clavus reaching to or beyond a horizontal line extending through the costal margins of hemelytra at the nodal furrows 2

2. Width of an eye much greater than interocular space; head sharply curved along rear margin, embracing a very short pronotum; hook-like projection present on dorsal median lobe of seventh abdominal segment; body surface rugulose ..... *PALMACORIXA* Abbott

   Width of an eye subequal to, slightly greater than or less than interocular space; head variable, not as above; hook-like projection absent on dorsal median lobe of seventh abdominal segment; body surface not or only faintly rugulose 3

3. Usually smooth and shining, never more than vaguely rugulose; prothoracic lateral lobe typically with sides tapering to a narrowly rounded apex; pala of male triangular, subequal in length to tibia, and with peg row located near dorsal margin and in or near the upper palmar row of bristles ..... *CORISELLA* Lundblad

   Usually rastrate, rugulose or effaced; prothoracic lateral lobe with sides not tapering to a narrowly rounded apex; pala of male rectangular, and with peg row centrally located on lateral surface of the pala 4

4. Pala of male with dorsal surface deeply incised; vertex of male tapering to a point; palar claw serrate at base in both sexes; pattern of hemelytra usually indistinct ..... *RAMPHOCORIXA* Abbott

   Pala of male with dorsal surface not deeply incised; vertex of male not pointed; palar claw not serrate at base; pattern on hemelytra usually quite distinct 5

5. Pruinose area along claval suture very short; pronotum rastrate (except in *H. laevigata*); hemelytra either rastrate or with one or two stout pegs on dorsal surface of hind femur; hemelytral pattern not reticulate (except in *H. laevigata*); length 7 mm or more ..... *HESPEROCORIXA* Kirkaldy

   Pruinose area along claval suture longer than above; pronotum not rastrate; hemelytra reticulate; length less than 7 mm ..... *SIGARA* Fabricius

Palmocorixa buenoi Abbott, 1913

Biological notes. — Specimens of this interesting little species were collected at two localities in Mississippi by the writer. One locality was a large, shallow, spring-fed pond with sandy banks. The insects were collected by dredging algae out of the water and examining it for them. There was an extremely heavy growth of the algae in the pond, as well as other types of aquatic vegetation. The other habitat where specimens were collected was a large, deep, clear pond fed by seepage. The insects were taken near the edge of the water from floating willow roots. They were tangled in the masses of roots and had to be extracted one at a time. The water where the specimens were collected was approximately three feet deep. Thus, this species seems to prefer permanent ponds filled with matted vegetation.

Hungerford (1920) observed its life history at Ithaca, New York. He discovered that the species winters as a fourth instar nymph in that area. In nature it reaches the adult stage around June 1st and begins oviposition eight days after reaching maturity. This generation reaches the adult stage in late August and produces the generation that spends the winter as fourth instar nymphs. It can live in very large numbers in a small pond and consumes large amount

of filaments of *Spirogyra* and other lower plant organisms. This herbivorous habit is probably the cause of their successful survival in large numbers in a small pond. Nymphs have been found in the stomachs of fishes. The egg and all five nymphal instars are described in detail.

Hungerford (1948) indicated that adult specimens were collected in Alabama in March which probably indicated that the winter was spent in the adult stage. He indicated that the species seems to be associated with streams of more or less permanent waters.

Locality data.—This species has not been recorded previously from Mississippi. Specimens have been seen as follows: Fearn Springs, Sept., 1 specimen (C.A.W.); State College, Oct., 2 specimens (C.A.W.).

Corisella edulis (Champion), 1901

Biological notes. — The writer collected this species from a muddy cow-pond in the northeast prairie section near State College.

Locality data.—Previously recorded from Fulton and State College by Hungerford (1948). Specimens have been seen as follows: State College, May, 1 specimen (C.A.W.); State College, Aug., 1 specimen (M.S.C.)

Key to the Mississippi Species of the Genus *TRICHOCORIXA* Kirkaldy

1. Nodal furrow located at apex of embolar groove or apparently absent 2
   Pruinose area of embolar groove divided into apical and basal portions by the nodal furrow 4
2. Pronotal disk approximately one-fourth as long as wide ..... *macroceps* (Kirkaldy)
   Pronotal disk one-third or more as long as wide 3
3. Pronotum with the black transverse bands separated by not more than five yellow lines; hemelytra with costal margins slightly emarginate anterior to nodal furrows ..... *minima* (Abbott)
   Pronotum with the black transverse bands separated by six or more yellow lines (occasionally broken); hemelytra with costal margins deeply emarginate anterior to nodal furrows ..... *naias* (Kirkaldy)
4. Synthlipsis width exceeding the width of an eye as seen from above along its posterior margin ..... *reticulata* (Guerin-Meneville)
   Synthlipsis width usually less than the width of an eye as seen from above along its posterior margin 5
5. Males 6
   Females 8
6. The apices of clavi not reaching a line produced through the costal margins of the hemelytra at the nodal furrows 7
   The apices of clavi extending to or beyond a line produced through the margins of the hemelytra at the nodal furrows 11
7. Pronotum with the black transverse bands separated by not more than five yellow lines; pala with peg row almost straight and parallel to the inner margin of palm ..... *minima* (Abbott)
   Pronotum with the black transverse bands separated by six or more yellow lines; pala with peg row distinctly curved near apex and oblique ..... *naias* (Kirkaldy)
8. Apices of clavi with conspicuous tufts of hairs ..... *louisianae* Jaczewski
   Apices of clavi without conspicous tufts of hairs, or with two or three setae 9
9. Polished area along costal margin of hemelytra anterior to nodal furrow equal to or less than length of middle tibia ..... *verticalis* (Fieber)
   Polished area along costal margin of hemelytra anterior to nodal furrow greater than length of middle tibia 10
10. Hemelytra with margins of polished prenodal area parallel to apex, and the costal margin suddenly emarginate; two or more patches of bristlelike setae on venter of seventh segment located on right side in region of spiracle ..... *kanza* Sailer
    Hemelytra with margins of polished prenodal area not parallel to apex, and the costal margin gradually emarginate anteriorly; only slightly longer pubescence on venter of seventh segment ..... *calva* (Say)

11. Left posterior lobe of abdomen with the lateral anterior angle produced to form a lobe, causing the lateral margin to appear concave at some region along the distance to apex ..... *verticalis* (Fieber)
    Left posterior lobe of abdomen with the lateral margin convex, frequently expanded from anterior lateral angle to apex 12
12. Strigil seemingly little more than a heavy dark line along lateral margin of the left tergal lobe of sixth segment of abdomen, and usually sharply curved upward at the medial apex ..... *calva* (Say)
    Strigil of normal shape, with distinct comblike rows of teeth 13
13. Strigil with posterior and anterior margins parallel or almost so; dorsal margin of pala angulate, with pegs arranged in the shape of an inverted "V" ..... *kanza* Sailer
    Strigil with posterior and anterior margins not parallel, and with one part noticeably thicker than the rest; lateral half of strigil (relative to dorsum) distinctly widened; vertex rounded anterior to eyes, not projecting one-third the length of an eye along inner margin as seen from above ..... *louisianae* Jaczewski

Genus *TRICHOCORIXA* Kirkaldy 1908

Biological notes.—The writer found the species in the genus common and widely distributed in the state. These insects choose a wide range of habitats, although they seem to prefer small ponds or similar types of water devoid of vegetation and with muddy bottoms. Habitats frequented in Mississippi include sluggish streams, large artificial lakes, cow-ponds, spring-fed ponds, spring-fed streams, sloughs, small puddles and potholes in ditches, borrow-pits and roadside water-holes. Two species, *Trichocorixa louisianae* Jaczewski and *Trichocorixa verticalis verticalis* (Fieber), were collected from saline water near the Gulf of Mexico at Mississippi City and Biloxi.

Sailer (1948) indicated that almost every species in this genus may become adapted to life in either fresh or salt water. Little is known concerning the life histories and food habits. However, it seems that all of them overwinter as adults.

Trichocorixa calva (Say), 1832

Biological notes.—Sailer (1948) collected this species from beneath ice in midwinter in Kansas. They were brought into the laboratory and fed on algae diatoms and the flocculent bottom ooze provided. They were also observed frequently feeding on spirogyra. This feeding was accomplished by a curious movement of the anterior legs which were used to clasp the filaments until the contents of each cell was withdrawn. In the aquarium they fed on their own eggs, but it is not known whether or not this occurs in nature.

Locality data.—Previously recorded from Beaumont, Columbus, Fayette, Fulton, Hamilton, Ireland, Lauderdale, Leland, Lucedale, Port Gibson and Waveland by Sailer (1948). Specimens have been seen as follows: Batesville; Biggersville; Booneville; Burnsville; Charleston; Corinth; Crowder; Fearn Springs; Itta Bena; Longview; Lorman; Marks; Okolona; Pickwick Lake; Prairie; State College.

Trichocorixa kanza Sailer, 1948

Biological notes.—Sailer (1948) collected this species from beneath ice in midwinter in Kansas. They were brought into the laboratory and fed on algae, diatoms and the flocculent bottom ooze provided. The females laid eggs on eel grass and stems, attaching them with a sucker-like disk. Feeding was accomplished by a curious movement of the anterior legs which were used to clasp the filaments until the contents of each cell was withdrawn. In the aquarium they fed on their own eggs, but it is not known whether or not this occurs in nature.

Locality data.—Previously recorded from Ireland, Ocean Springs, Port Gibson, Vicksburg and Woodville by Sailer (1948). Specimens have been seen as follows: Anguilla; Fearn Springs; Itta Bena; Iuka; Marks; Oxford; Pickwick Lake; State College; Stoneville; Toccopola; Tutwiler.

Trichocorixa louisianae Jaczewski, 1931

Biological notes.—Sailer (1948) noted that this species lives by preference in more or less saline water.

Locality data.—Previously recorded from Bay St. Louis, Beaumont and Ocean Springs by Sailer (1948). Specimens have been seen as follows: Biloxi, March, 4 specimens (C.A.W.); Mississippi City, March, 3 specimens (C.A.W.).

Trichocorixa macroceps (Kirkaldy), 1908

Locality data.—Previously recorded from Columbia and Lucedale by Sailer (1948). Specimens have been seen as follows: Fearn Springs, Sept., 23 specimens (C.A.W.); Lucedale, April, 5 specimens (C.A.W.).

Trichocorixa minima (Abbott), 1913

Locality data.—This species has not been recorded from Mississippi. However, the writer is including it here since it has been reported from Georgia and Florida by Sailer (1948).

Trichocorixa naias (Kirkaldy), 1908

Locality data.—Previously recorded from Ireland and Bay St. Louis, by Sailer (1948). The writer has not collected this species in Mississippi.

Trichocorixa reticulata (Guerin-Meneville), 1857

Biological notes.—Sailer (1948) noted that this species lives by preference in more or less saline water. He also reported that it was collected in the desert regions of Nevada and southern California which strongly suggests ability to live in alkaline water.

Locality data.—This species has not been recorded from Mississippi. However, the writer is including it here since it has been reported from Florida and Texas by Sailer (1948).

Trichocorixa verticalis verticalis (Fieber), 1851

Biological notes.—Specimens apparently winter as adults in Mississippi, since full grown specimens were taken as early as March.

Hutchinson (1931) collected two living males in Delaware Bay associated with typical marine planktonic organisms, whereas no living specimens of any other insects were taken. This was noted by Hutchinson as good substantiating evidence for ocean current dispersal.

Pearse (1932) observed the biology of *Trichocorixa verticalis verticalis* especially with reference to its ability to thrive in salt water. His observations were as follows:

"Tortugas, Fla. June 7, 1931; pond 2, Bush Key, salinity 2.46."

"Tortugas, Fla. June 24, 1931; pond 1, Long Key, salinity 2.34."

"Tortugas, Fla. June 8, 1931; Garden Key, salinity 1.98."

Sailer (1948) noted that it lives by preference in more or less saline water.

Locality data.—Previously recorded from Bay St. Louis, Ocean Springs and Waveland by Sailer (1948). Specimens have been seen as follows: Biloxi, March, 1 specimen (C.A.W.); Gulfport, May, 16 specimens (M.S.C.); Itta Bena, Oct., 23 specimens (C.A.W.); Scott, Oct., 35 specimens (C.A.W.); Stoneville, Oct., 32 specimens (C.A.W.).

Ramphocorixa acuminata (Uhler), 1897

Biological notes.—The writer collected this insect in a muddy, shallow pond which contained practically no vegetation and was approximately ten feet square.

A considerable amount of information is available in the literature on its biology.

Forbes (1878) was apparently the first worker to report the interesting fact that the eggs of the corixids are attached in large numbers to a crayfish (*Orconectes immunis*). The collection was made in a stagnant pond in midsummer in central Illinois.

Forbes (1878) again reported taking corixid eggs on two species of crayfish and mollusc shells from ponds in central Illinois. The crayfish were *Orconectes immunis* and *Procambarus blandingi acutus*.

Abbott (1912a) collected them from a small pond near Columbia, Missouri and reared them in a large zinc-lined tank with a soft mud bottom. Five nymphal instars occurred. The approximate duration of each instar was as follows: first instar, 8 days; second instar, 8 days; third instar, 7 days; fourth instar, 4 days and the fifth instar, 7 days. He also collected crayfish with the corixid eggs attached.

Abbott (1912c) again noted the collection of the crayfish *Orconectes immunis* with corixid eggs attached in Texas, Missouri and Illinois. He suggested that the distribution of the corixid might be conditioned by the association with the crayfish, and that the eggs, with adherent debris, might camouflage the crayfish, while receiving protection from egg predators.

Hungerford (1920) reviewed some work he did on its biology in Kansas. It typically inhabits muddy, stagnant ponds and probably hibernates as an adult. Eggs occasionally were attached to sticks and floating plants. The positions of eggs on the crayfish were tabulated, and preference was noted for the

regions most affected by the currents from the gill chambers. He theorized that these oviposition sites insured aeration. Specimens were successfully reared to the adult stage in a balanced aquarium.

Hungerford (1923a) again made note of the selective deposition of corixid eggs on crayfish for the aerative benefits of gill currents.

Other workers who have published notes on the curious egg-laying habits include Comstock (1924), Wellhouse (1926), Blatchley (1926), Jaczewski (1931) and China (1931).

Griffith (1945) published a very thorough report on a study of the environment, life history and structure of the species as it was observed in Kansas. The three published theories on the corixid—crayfish association are: (1) protection of eggs from drought by the migratory habit of the crayfish; (2) protection of eggs from enemies by the pugnacious nature of the crayfish, and a theory of symbiosis; and (3) aeration of the eggs, largely through activity of the gills of the crayfish. The latter theory is the one most generally accepted now. The corixid deposited eggs most frequently on *Orconectes immunis*, probably due to its common occurrence in ponds inhabited by the bugs. It winters in the adult stage in ponds in Kansas. There are marked periods of oviposition in the late spring and early fall, indicating a two-generation cycle in that state. The corixid was carried through the five nymphal instars in an aquarium and the time required for the various stadia varied as follows: first stadium, 7 days; second stadium, 6 days; third stadium, 7 days; fourth stadium, 6 days and the fifth stadium, 9 days.

Locality data.—Previously recorded from Lauderdale, Ocean Springs, Scooba, Vicksburg and Woodville (Hungerford, 1948). Specimens have been seen as follows: Booneville, Nov., 1 specimen (C.A.W.); State College, 2 specimens (M.S.C.).

Genus *HESPEROCORIXA* Kirkaldy 1908

Biological notes.— In Mississippi species in this genus occurred most commonly in upland muddy streams, woodland pools, borrow-pits, sloughs, lakes and marshy seepage areas.

Other than general biological notes on corixids as noted above under the discussion of the family, no references were found in the literature on the biology of this genus.

Key to the Mississippi Species of *HESPEROCORIXA* Kirkaldy

1. Prothoracic lateral lobe less than or subequal to width of the mesoepimeron at level of the scent gland osteole 2
   Prothoracic lateral lobe distinctly wider than the mesoepimeron at level of the scent gland osteole 3
2. Length 7.5 mm or less ..... *semilucida* (Walley)
   Length 8.00 mm or more ..... *brimleyi* (Kirkaldy)
3. Prothoracic lateral lobe narrow, distinctly longer than wide; length less than 8 mm ..... *minor* (Abbott)
   Prothoracic lateral lobe broader; length more than 8 mm 4
4. Color pattern on dorsal surface normal 5
   Color pattern in part indistinct, at least on corium ..... *lucida* (Abbott)
5. Hemelytral pattern reticulate; pronotal surface not rastrate ..... *laevigata* (Uhler)
   Hemelytral pattern not reticulate; pronotal surface faintly to strongly rastrate 6
6. Corium with pale bands beyond hemelytral suture forming slender transverse series; corium not distinctly separated from the membrane ..... *vulgaris* (Hungerford)
   Corium with pale bands beyond hemelytral suture not forming slender transverse series; or, if so, then corium distinctly separated from the membrane 7
7. With a row of approximately 10 spines located ventrally on distal part of rear margin of hind femur ..... *nitida* (Fieber)
   With a row of approximately 6 spines located ventrally on distal part of rear margin of hind femur 8
8. Species more than one-third as wide as long, and short and stout, heavily rastrate hemelytra; stout and spinose middle femora ..... *martini* (Hungerford)
   Species approximately one-third as wide as long; lightly rastrate hemelytra; middle femora not spinose and stout 9

9. Corium and membrane distinctly separated, frequently by a pale line; pala of male with upper distral angle not acutely, obliquely produced *interrupta* (Say)

Corium and membrane not distinctly separated; pala of male with upper distal angle acutely, obliquely produced *obliqua* (Hungerford)

Hesperocorixa scmilucida (Walley), 1930

Locality data.—This species has not been collected in Mississippi. It is listed here since it has been reported from Louisiana, Tennessee, North Carolina and Florida by Hungerford (1948).

Hesperocorixa brimleyi (Kirkaldy), 1908

Locality data.—This species has not been recorded previously from Mississippi. Specimens have been seen as follows: Burnsville, Nov., 2 specimens (C.A.W.).

Hesperocorixa minor (Abbott), 1913

Locality data.—Previously recorded from Lauderdale by Hungerford (1948). Specimens have been seen as follows: Iuka, Nov., 4 specimens (C.A.W.); Lucedale, April, 4 specimens (C.A.W.); Tishomingo, Nov., 6 specimens (C.A.W.).

Hesperocorixa lucida (Abbott), 1916

Locality data.—This species has not been collected in Mississippi. It is listed here since it has been reported from Arkansas, Florida, Georgia and Texas by Hungerford (1948).

Hesperocorixa laevigata (Uhler), 1893

Locality data.—Previously recorded from State College by Hungerford (1948). The writer has not collected this species in Mississippi.

Hesperocorixa vulgaris (Hungerford), 1925

Locality data.—Previously recorded from Agricultural College by Hungerford (1948). Specimens have been seen as follows: State College, 8 specimens (M.S.C.).

Hesperocorixa nitida (Fieber), 1851

Locality data.—Previously recorded from Beaumont, Hamilton, Iuka, Lauderdale and Vicksburg by Hungerford (1948). Specimens have been seen as follows: Anguilla; Beulah; Biggersville; Booneville; Burnsville; Crowder; Edwards; Greenwood; Itta Bena; Iuka; Louise; Marks; Perkinston; Sallis; State College; Toccopola; Tutwiler.

Hesperocorixa martini (Hungerford), 1928

Locality data.—This species has not been recorded from Mississippi; however, it is included here since it has been reported from Georgia and Florida by Hungerford (1948).

Hesperocorixa obliqua (Hungerford), 1925

Locality data.—Previously recorded from the state by Hungerford (1948). One specimen has been seen from State College (M.S.C.).

Hesperocorixa interrupta (Say), 1825

Locality data.—This species has not been previously recorded from the state. The writer has seen specimens as follows: Dossville, 1 specimen (M.S.C.); State College, 10 specimens (M.S.C.).

Genus *SIGARA* Fabricius 1775

Biological notes.—In Mississippi they live in a very wide range of habitats: sloughs, muddy pools, upland streams, pot-holes in ditches, borrow-pits and large ponds. The species of *Sigara* evidently spend the winter in the adult stage in Mississippi, since adults were collected as early as March and as late as November.

Key to the Mississippi Species of *SIGARA* Fabricius

1. Insects 6.3 mm long, or more *S. (Vermicorixa) alternata* (Say)

Insects less than 6.3 mm long (except *saileri* Wilson) 2

2. Median longitudinal pale line evident on pronotal disk 3

Median longitudinal pale line on pronotal disk absent or only faintly visible 4

3. Moderately rastrate; clavus and corium with pale figures on distal half arranged longitudinally in more or less connected series; membranal pattern distinct *S. (Phaeosigara) mississippiensis* (Hungerford)

Strongly rastrate; distal half of clavus and usually the corium with transverse pale figures; membranal pattern indistinct or effaced *S. (Phaeosigara) compressoidea* (Hungerford)

4. Corium either solid black or with scattered, small, irregular pale punctuations only 5

Corium not as above 6

5. Clavus and corium solid black; pronotum black, with three or four transverse pale lines *S. (Pediosigara) hydatotrephes* (Kirkaldy)

Clavus, corium and membrane solid black except for scattered, small irregular pale colored punctuations; pronotum with five or six transverse pale lines ..... *S. (Pediosigara) saileri* Wilson

6. Metaxyphus longer than broad 7
   Metaxyphus not longer than broad 8

7. Lateral lobe of the prothorax subequal in width to the mesoepimeron at the level of the scent gland osteole ..... *S. (Phaeosigara) macrocepsoidea* (Hungerford)
   Lateral lobe of the prothorax much narrower than the mesoepimeron at the level of the scent gland osteole ..... *S. (Phaeosigara) signata* (Fieber)

8. Scent gland osteole located closer to the lateral bend of the mesoepimeron than to its tip ..... *S. (Vermicorixa) modesta* (Abbott)
   Scent gland osteole located closer to the tip than to the lateral bend of the mesoepimeron 9

9. Lineations on clavi slightly forked or more or less entire 10
   Lineations on clavi broken into many fragments 15

10. Pattern on corium in more or less definite series 11
    Pattern on corium not in definite series 12

11. Dorsal surface of hind femur with 4 to 6 pegs; disk of pronotum reduced laterally ..... *S. (Vermicorixa) hubbelli* (Hungerford)
    Dorsal surface of hind femur with at least 12 pegs; disk of pronotum not reduced laterally ..... *S. (Vermicorixa) defecta* (Hungerford)

12. Peg row on pala of male located nearer the dorsal margin than the palm 13
    Peg row on pala of male located nearer the palm than the dorsal margin; pala with a dorsal hump ..... *S. (Vermicorixa) pectenata* (Abbott)

13. Pala of male with from 20 to 26 pegs 14
    Pala of male with more than 30 pegs ..... *S. (Vermicorixa) virginiensis* (Hungerford)

14. Disk of pronotum heart-shaped and laterally reduced ..... *S. (Vermicorixa) scabra* (Abbott)
    Disk of pronotum not heart-shaped nor laterally reduced ..... *S. (Phaeosigara) macropala* (Hungerford)

15. Interocular space subequal to the width of an eye; postocular space quite broad; a sheath present on distal portion of right clasper of male ..... *S. (Phaeosigara) paludata* (Hungerford)
    Interocular space distinctly narrower than the width of an eye; postocular space not broad; sheath not present on distal portion of right clasper of male 16

16. Length less than 4 mm; 7th abdominal segment of male without a lateral projection on right margin; pala of female not depressed ..... *S. (Phaeosigara) bradleyi* (Abbott)
    Length more than 4 mm; 7th abdominal segment of male with a lateral projection on right margin; pala of female depressed dorsally near apex 17

17. Length 4.1 to 4.5 mm; hind femur with a row of short spines on dorsal surface and pubescent ventrally for only slightly more than one-half its length ..... *S. (Phaeosigara) sigmoidea* (Abbott)
    Length 4.5 to 5 mm; hind femur with two or three spines or none on dorsal surface and pubescent ventrally for two-thirds its length ..... *S. (Phaeosigara) zimmermanni* (Fieber)

Sigara (Pediosigara) hydatotrephes (Kirkaldy), 1908

Locality data.—This species has not been recorded previously from Mississippi. Specimens have been seen as follows: Burnsville, Nov., 10 specimens (C.A.W.); Fearn Springs, May, 1 specimen (C.A.W.).

Sigara (Pediosigara) saileri Wilson, 1953

Locality data.—The type locality for this species is Burnsville. The author has the following specimens in his collection from the type locality: Burnsville, Nov., 6 ♂♂ and 16 ♀♀ (C.A.W.).

Sigara (Vermicorixa) alternata (Say), 1825

Biological notes.—Hungerford (1917b) wrote a very interesting account of the

successful rearing of this corixid in close quarters at Ithaca, N. Y. It was reared in small glass petri dishes using sediment from the bottom of ponds as food. Fresh pond ooze was obtained daily. Eggs were laid on bits of cottonwood leaves placed in the containers. In the field eggs were found on the stems and dead leaves of plants lodged in the water. Other objects selected for oviposition included tin cans, boards, the shells of living snails and the bodies of crayfishes. At Ithaca the species apparently winters in the adult stage. The time required for development from egg to adult in the laboratory varied from 43 to 53 days.

Locality data.—This species has not been recorded previously from the state. Specimens have been seen as follows: Beulah, Oct., 1 specimen (C.A.W.); Biggersville, Nov., 1 specimen (C.A.W.); Charleston (H. M. Harris).

Sigara (Vermicorixa) modesta (Abbott), 1916

Locality data.—Previously recorded from Agricultural College, Iuka and Smithville by Hungerford (1948). Specimens have been seen as follows: Charleston, Sept., 1 specimen (H. M. Harris); Okolona, Oct., 3 specimens (C.A.W.); Pontotoc, Oct., 6 specimens (C.A.W.); Prairie, Oct., 9 specimens (C.A.W.); State College, Sept., 1 specimen (C.A.W.); Tupelo, Oct., 8 specimens (C.A.W.).

Sigara (Vermicorixa) virginiensis Hungerford, 1948

Locality data.—This species has not been recorded previously from the state. Specimens have been seen as follows: Charleston, Aug.-Sept., 4 specimens (H. M. Harris); Corinth, Nov., 1 specimen (C.A.W.); Glen, Nov., 12 specimens (C.A.W.); Iuka, Nov., 2 specimens (C.A.W.); State College, Sept., 1 specimen (C.A.W.); Sturgis, Oct., 2 specimens (C.A.W.); Toccopola, Oct., 4 specimens (C.A.W.); Wiggins, Aug., 1 specimen (H. M. Harris).

Sigara (Vermicorixa) hubbelli (Hungerford), 1928

Locality data.—Previously recorded from Lauderdale, Vicksburg and Woodville by Hungerford (1948). Specimens have been seen as follows: Booneville, Nov., 3 specimens (C.A.W.); Edwards, Nov., 1 specimen (C.A.W.); Toccopola, Oct., 1 specimen (C.A.W.).

Sigara (Vermicorixa) pectenata (Abbott), 1913

Locality data.—Previously recorded from Beaumont, Columbus and Lauderdale by Hungerford (1948). Specimens have been seen as follows: Biggersville, Nov., 2 specimens (C.A.W.); Booneville, Nov., 10 specimens (C.A.W.); Cornith, Nov., 1 specimen (C.A.W.); Oxford, Oct., 1 specimen (C.A.W.); Toccopola, Oct., 2 specimens (C.A.W.).

Sigara (Vermicorixa) scabra (Abbott), 1913

Locality data.—Previously recorded from Green Springs by Hungerford (1948). The writer has not collected it in Mississippi.

Sigara (Phaeosigara) bradleyi (Abbott), 1913

Locality data.—Previously recorded from Fulton and Waveland by Hungerford (1948). It has not been collected in the state by the writer.

Sigara (Phaeosigara) sigmoidea (Abbott), 1913

Biological notes.—This species was taken in March from a brackish pool near the Gulf of Mexico at Biloxi.

Locality data.—This species has not been recorded previously from the state. Specimens have been seen as follows: Biloxi, March, 2 specimens (C.A.W.)

Sigara (Phaeosigara) zimmermanni (Fieber), 1851

Locality data.—Previously recorded from Beaumont by Hungerford (1948). The writer has not collected it in the state.

Sigara (Phaeosigara) compressoidea (Hungerford), 1928

Locality data.—This species has not been recorded from Mississippi. However, it is included here since it has been reported from North Carolina and South Carolina by Hungerford (1948).

Sigara (Phaeosigara) mississippiensis Hungerford, 1942

Locality data.—Previously recorded from Lauderdale by Hungerford (1942b and 1948). The writer has not collected it in Mississippi.

Sigara (Phaeosigara) macropala (Hungerford), 1926

Locality data.—This species has not been recorded from the state. However, it is included here since it has been reported from northern Florida by Hungerford (1948).

Sigara (*Phaeosigara*) *berneri* Hungerford and Hussey, 1957

Locality data.—This species has not been reported from Mississippi. However, it is included here since it has been reported from southern Georgia (type locality) by Hungerford and Hussey (1957).

Sigara (*Phaeosigara*) *signata* (Fieber), 1851

Locality data.—It has not been recorded from Mississippi. However, it is included here since it has been reported from Georgia, North Carolina and South Carolina by Hungerford (1948).

Sigara (*Phaeosigara*) *paludata* Hungerford, 1942

Locality data.—Previously recorded from Nealy by Hungerford (1942b and 1948). The writer has not collected it in Mississippi.

Sigara (*Phaeosigara*) *macrocepsoidea* Hungerford, 1942

Locality data.—Has not been recorded from Mississippi. However, it is included here since it has been reported from Georgia and Texas by Hungerford (1948).

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ABSTRACT

This paper contains data on distribution, habitat preferences, mating habits, food habits and other observed biological data for 132 species of aquatic and semiaquatic Hemiptera collected in Mississippi. Included are keys to families, genera and species for all 13 families. Detailed locality data for each species is given along with the numbers of each sex taken, where available. Under each species the writer has reviewed the more important notes on biology obtained from the literature. A general review of the more pertinent literature on aquatic and semiaquatic Hemiptera along with a brief discussion of ecological conditions encountered in the various soil areas of Mississippi is given.

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ONTOGENY OF THE FIRST AND SECOND PLEOPODS OF THE MALE CRAWFISH *ORCONECTES CLYPEATUS* (HAY) (DECAPODA, ASTACIDAE)

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THE COPEPOD GENUS *HALICYCLOPS* IN NORTH AMERICA, WITH DESCRIPTION OF A NEW SPECIES FROM LAKE PONTCHARTRAIN, LOUISIANA, AND THE TEXAS COAST

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A new species of the brackish and freshwater cyclopoid copepod genus *Halicyclops* has been found in plankton collections made in Lake Pontchartrain, Louisiana, during the course of a biological survey conducted by Tulane University and the State of Louisiana. Lake Pontchartrain is a large, brackish water lake in southeastern Louisiana, indirectly connected with the Gulf of Mexico through tidal channels and Lake Borgne. The new species is not endemic to Lake Pontchartrain, having also been found in a Texas collection. The specimens from the two localities vary from one another, and are described separately.

I am indebted to Dr. R. M. Darnell, Marquette University, for the collections of the new species, and for the opportunity to study the interesting copepods of Lake Pontchartrain. Grateful acknowledgment is also expressed to Dr. K. Lindberg, Lund, Sweden, who kindly assisted in a preliminary check list of species and with literature.

Halicyclops in North America

The few American records of *Halicyclops* show that the genus occurs on both the Atlantic and Pacific coasts of North America, in coastal water bodies of the Gulf of Mexico, and of the northern and eastern coasts of South America. Its presence in the Caribbean area is known through two south Haitian species (*H. exiguus* Kiefer, 1934; *H. similis* Kiefer, 1935), and one from the Venezuelan coast of South America (*H. venezuelaensis* Lindberg, 1954). Another species has been described from the Brazilian coast (*H. crassicornis* Herbst, 1955).

North American continental records of *Halicyclops* are listed under either *aequoreus* or *magniceps*, names of geographically separated European forms that have been much confused in literature. Because of this, the species records are questionable. *Kiefer* (1936) and Lindberg (1949) consider *aequoreus* (Fischer), 1860, from the Madeira Islands, as an inadequately known species not presently identifiable with the [illegible] known north European form to which Sars (1913) and Lindberg (1949) have restored the name *magniceps* (Lilljeborg), 1853. Lindberg has reexamined the literature and presented seemingly valid evidence for the preference of the name *magniceps* over *christianensis* (Boeck), 1873, as suggested by Kiefer (1936). In the light of growing knowledge of the broad distribution and diverse structure within the genus, it seems reasonable to me that the species *aequoreus* should be considered in need of redefinition from topotypic material and comparison with the north European form before coidentity can be established.

The first notice of *Halicyclops* in North America is, interestingly, from Lake Pontchartrain where it was reportedly found by Edward Foster, whose publication (1904) is one of the pioneer studies on Gulf of Mexico copepods. No reference was made to *Halicyclops* in Foster's paper, nor in his manuscript records published by Penn (1947). The Lake Pontchartrain record first appeared in Marsh (1910) under the name *Cyclops aequoreus*. In this and other papers, Marsh included several of Foster's Louisiana records, communicated to him either personally or through correspondence. Apparently, he never examined any of Foster's specimens. At the time of writing his 1910 revision of *Cyclops*, Marsh had not found *Halicyclops* in any of his American collections, but stated (p. 1106), "Mr. E. Foster tells me that he has collected it in Lake Pontchartrain and connecting waters." Since only one species has been found in the survey of Lake Pontchartrain, Foster's specimens may well have been the species described herein and named for him.

Marsh's statement (1910) that *Halicyclops* (as represented by the name *Cyclops aequoreus*) "was first recognized in our fauna by Herrick" is erroneous. In Herrick's two summaries (1884, 1895) the species is listed without reference to any North American occurrence. Herrick included diagnoses of many European species which he anticipated might be found on this Conti-

nent, and this has led at times to the interpretation that he was reporting a known occurrence of the species. In 1884 he commented in regard to *Cyclops aequoreus* that "those who have the opportunity to search the brackish pools along our coast would do science a service by looking for this interesting species." This indication that he had not found the species was omitted from the 1895 revision, in which he included a brief diagnosis and a habitus figure labeled "after Brady," and so presumably of an English form. Marsh (1913) again mentioned Herrick's reference as an established record stating that "Herrick found it in waters connected with the Gulf of Mexico," giving as reference Herrick, 1895, p. 122, and adding "in Mississippi Sound." There is no mention of such Gulf of Mexico records in Herrick's 1895 paper. Neither the Appendix of his 1884 paper in which he first listed Gulf species nor of his later enlarged study (1887) contain any reference to *Cyclops aequoreus*. These references of Marsh and his further statement (1918) as to the occurrence of the species "in waters connected with the Gulf of Mexico" are therefore valid only in so far as Foster's communication to him can be accepted.

Marsh's own record (1913) from the Pacific coast of Panama is actually the first substantiation of *Halicyclops* from the Continent. The figure labeled *Cyclops aequoreus* in his 1918 key was made from these Panama specimens. This has been unfortunate since these specimens were not referable to either the European species *aequoreus* or *magniceps*, as has been recognized by others. Gurney (1933) has incorrectly called them *aequoreus propinquus;* Kiefer (1936) and Lindberg (1957) have questioningly referred them to the Haitian species *similis*. Marsh's figure of the fourth leg shows that the Panama species was not the new species described herein, though some characters of the urosome and fifth leg are similar. The Panama material will have to be restudied to determine the identity.

There are two records of *Halicyclops* from Mexico. Whether the specimens in either of these Mexican collections were accurately assigned to the species listed cannot be judged from the brief accounts given. One, based on a single female from a saline pond at Progreso on the Yucatan Peninsula, was identified as *H. magniceps* by C. B. Wilson (1936); general comments on its occurrence and ecology are included in Pearse (1936). Lindberg (1955) considers this a questionable record. Another Mexican record is that of Comita (1951), who listed *H. aequoreus propinquus* from a brackish lagoon near Acapulco on the Pacific coast. Comita's identification is apparently based on Gurney's misapplication of the name *propinquus* given by Sars (1905) to specimens from the Chatham Islands, and should also be considered a questionable record.

H. magniceps has been reported from the Woods Hole, Massachusetts area by C. B. Wilson (1932) and Deevey (1948). Wilson's identification is apparently based on Sars's (1913) redescription of *magniceps,* and since it is stated that the caudal rami are longer than wide, at least some of the specimens may have been referable to this north European species. There is, however, some confusion in the account, particularly in that of the male, which is recorded as much smaller than the female, and as lacking the innermost seta on the fifth leg. This latter point suggests that Wilson may have either misidentified his material or may have had two species in his collections.

Both *H. exiguus* and *similis* were more completely described by Kiefer (1936). This paper gives a good basic revision of the genus, with illustrations of all the nine species recognized at that time. Growth of knowledge of the genus is illustrated by the fact that a key by Lindberg (1949) included seventeen species and subspecies, and a recent revision of the key (Lindberg, 1957) includes thirty-one. This key seems to refer to all named forms except *H. japonicus* Ito (1956) and *H. higoensis* Ito (1957). With inclusion of the new Gulf of Mexico species, the number is now increased to thirty-four.

In Lindberg's keys, the species names are given without author and date, or any other reference to the literature where descriptions may be found. This information has an obviously useful application and it would be well if authors and editors would always consider it an essential part of a key. A check list of named species and subspecies, following the categories recognized in Lindberg's key, with references to the original

and additional descriptions in the literature, is given here as a supplement to the key and Kiefer's (1936) revision. No attempt has been made to evaluate, and no implication is intended regarding the taxonomic status of any of these names.

CHECK LIST OF HALICYCLOPS SPECIES KNOWN TO JANUARY 1958

H. magniceps (Lilljeborg), 1853; Sars, 1913; Gurney, 1933 (as *aequoreus*); Kiefer, 1936 (as *christianensis*); Schafer, 1936 (as *christianensis*); Plesa, 1956 (as *christianensis*).
H. propinquus Sars, 1905.
H. tenuispina Sewell, 1924; Kiefer, 1936.
H. sinensis Kiefer, 1928, 1936; Burckhardt, 1913 (as *aequoreus?*).
H. thermophilus Kiefer, 1929, 1936; Heberer and Kiefer, 1932; Lindberg, 1941 (as *t. spinifer*), 1952b.
H. spinifer Kiefer, 1935 and 1936 (as *thermophilus spinifer*).
H. neglectus septentrionalis Kiefer, 1935 and 1933 (as *aequoreus propinquus*); Margalef, 1951, 1953; Plesa, 1956 (as *rotundipes*).
H. neglectus septentrionalis Kiefer, 1935 and 1936 (as *thermophilus septentrionalis*).
H. rotundipes Kiefer, 1935, 1936, 1938a and b; Petkovski, 1955 (as *neglectus rotundipes*).
H. rotundipes putealis Kiefer, 1938b.
H. exiguus Kiefer, 1934, 1936.
H. similis Kiefer, 1935, 1936; ? Marsh, 1913, 1918 (as *Cyclops aequoreus*).
H. sarsi Akatova, 1935; Hemsen, 1952.
H. canui Lindberg, 1941.
H. electus Lindberg, 1943.
H. caridophilus Humes, 1947.
H. pilifer Lindberg, 1949.
H. konkanensis Lindberg, 1949.
H. setifer Lindberg, 1949 (in key), 1950, 1951.
H. robustus Lindberg, 1951.
H. oblongus Lindberg, 1951.
H. blachei Lindberg, 1952a.
H. korodiensis Onabamiro, 1952.
H. brevispinosus Herbst, 1952.
H. brevispinosus meridionalis Herbst, 1953.
H. venezuelaensis Lindberg, 1954.
H. pusillus Kiefer, 1954a.
H. [illegible]lodytes Kiefer, 1954b; Lindberg, 1956.
H. [illegible]atinus Petkovski, 1955.
H. [illegible]ensis Herbst, 1955.
H. [illegible] Ito, 1956.
H. oraeeburnensis Lindberg, 1957.
H. higoensis Ito, 1957.

COPEPODA, CYCLOPOIDA
Family CYCLOPIDAE
HALICYCLOPS Norman, 1903
HALICYCLOPS **FOSTERI**, sp. nov.
(Figures 1-20)

? Cyclops aequoreus, Marsh, 1910, p. 1106 (Lake Pontchartrain record).

Type lot.—96 females (61 ovigerous), 30 males; Lake Pontchartrain, Louisiana, August 6, 1953, R. M. Darnell, collector. Holotype ♀, United States National Museum catalog number 99413; allotype ♂, number 99414.

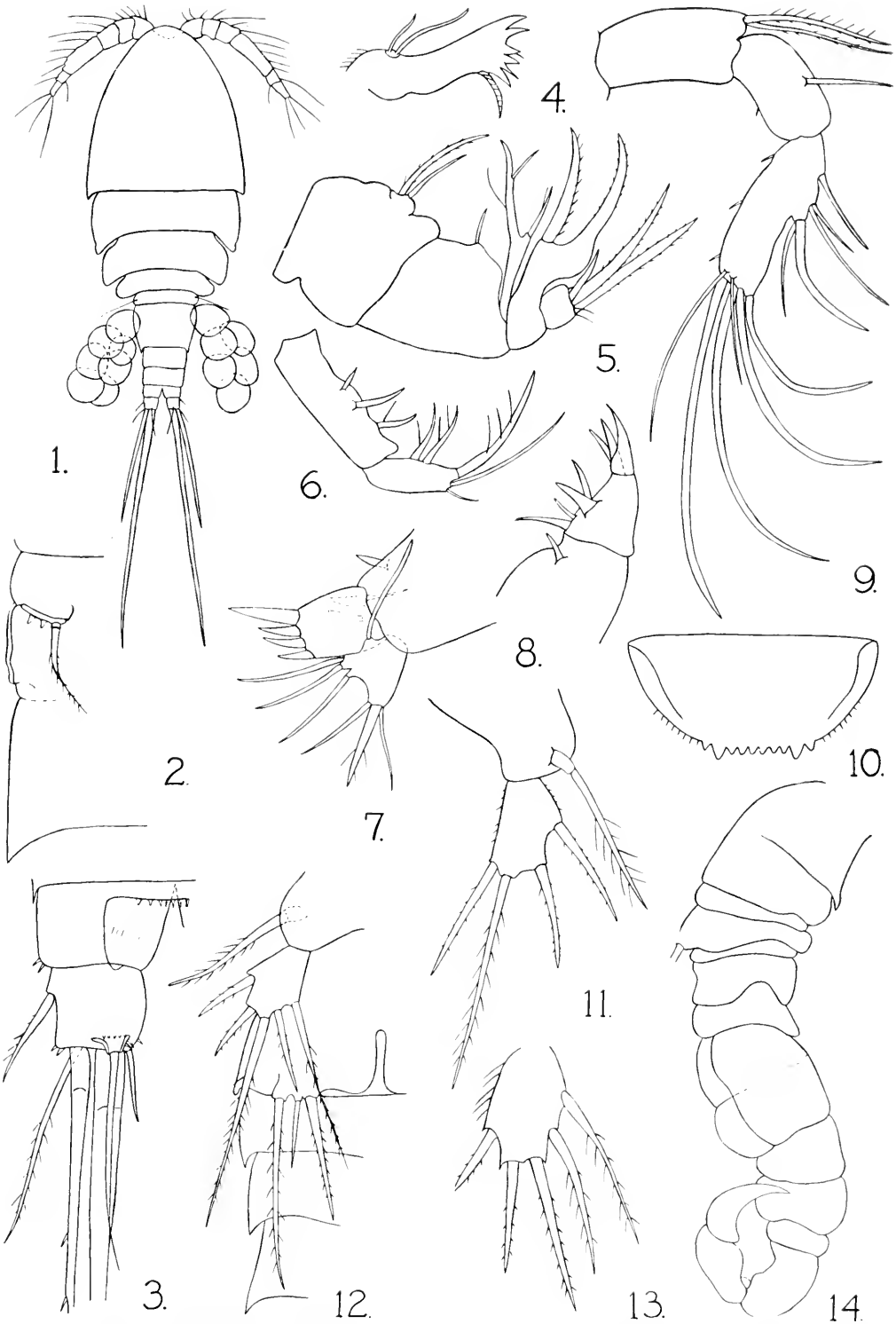
Diagnosis.—Genital segment female proximally with lateral protrusions armed with membranous flange, variously produced but not spiniform; urosomal segments, except anal, without ornamentation; area of anal operculum with minute serrations or denticles. Caudal rami about as long as broad; all apical setae present, the outer lateral seta placed marginally. Leg 4, exopod segment 3 with two spines in both sexes, between proximal and apical spines a somewhat eccentrically placed seta; endopod segment 3 lacking inner setae in female, with two setae in male. Leg 5 female, segment 2 with slender spines, their length subequal to or longer than that of segment; the inner spine the longest; the seta subequal to or longer than inner spine. Leg 5 male, segment 2 with three spines and two elongate setae.

DESCRIPTION OF LAKE PONTCHARTRAIN SPECIMENS

Complete dissections made of 10 females and 5 males. Habitus measurements based on 20 females and 10 males. Antenna examined in dissected and in 20 additional whole specimens. All undissected specimens of type lot examined individually for detection of noticeable variation in habitus characters and spines of legs.

Female

Total length, mid-dorsal line, 0.42-0.52 mm (Mean 0.47). Length of metasome about 2.25 times that of urosome (including somite of leg 5). Length of cephalic segment greater than width (range from 1.1-1.25 : 1); the greatest width in distal portion.



Figures 1-14. *Halicyclops fosteri*, sp. nov. (from Lake Pontchartrain specimens). FEMALE: **1.** Habitus, dorsal aspect; **2.** Lateral portion of genital segment, dorsal aspect, showing lateral flange and leg 6 (from little expanded specimen from which ovisacs were removed); **3.** Anal segment and caudal ramus, dorsal aspect; **4.** Mandible; **5.** Maxilla; **6.** Maxilliped; **7.** Maxillule (with palp); **8.** Profile view of maxillule (without palp); **9.** Antenna; **10.** Labrum; **11.** Leg. 5. MALE: **12.** Legs 5 and 6, *in situ*, ventral aspect; **13.** Leg 4, endopod segment 3; **14.** Antennule, dorsal outline (without setae). (All appendages except fig. 13 drawn to same scale).

Genital segment with variable lateral protrusions in proximal portion, the protrusions armed outwardly with a narrow, seemingly stiff, membranous (or sclerotized?) flange with laterally rounded margin (fig. 2); width of segment below protrusions equal to or a little less than length at midline (range 0.9-1.0 : 1), width of proximal area, including lateral protrusions, subequal to or greater than length (range 1.1-1.25 : 1); genital openings dorso-laterally placed, dorsal armature (leg 6) consisting of a narrow sclerotization armed with an inner plumose seta and two outer, much reduced spinelike points (fig. 2); ovisacs with 6-9 large ova (fig. 1). Urosomal segments posterior to genital decreasing regularly in length; only anal segment with ornamentation, consisting of small spinous serrations on edge of operculum, dorsal rows of medially placed hairs (fig. 3), and minute spinules overlying bases of caudal rami on ventral side. Medial incision of anal segment reaching to or nearly to distal margin of preceding segment.

Caudal rami appearing parallel to one another or slightly divergent as in figure 1; their length subequal to their width (measured just below insertion of lateral seta) and a little less or subequal to that of anal segment; ventrally, minute spinulose scales overlying bases of apical setae. All caudal setae usually found in genus present (fig. 3). Lateral seta plumose; set marginally at about proximal fourth of ramus and reaching beyond the apex; its length usually a little less than twice that of ramus (about 1.72 : 1). Dorsal seta about 3 times length of ramus, arising from enlarged surface papilla ornamented basally and inwardly with minute spinules. Second and third apical setae stout, both jointed basally; second sparsely spinulose on outer edge; third much stouter throughout than second, its proximal third naked, the middle third spinulose on both edges, the distal third thickly plumose. Second seta subequal to or a little longer than urosome and at least one-half of length of third seta; ratio of length of second to third seta, 1 : 2.02-2.27. Ratio of length of third seta to total body length, about 1 : 1.5-1.7. Innermost seta about as long as ramus, nonplumose. Pattern of comparative setal lengths determined from measurement of 10 specimens, and cursory examination of others. Very little range of variation was found except that between the two longest apical setae, as given above. Average ratio of setae and caudal ramus to outer apical seta expressed as 1 (as in Herbst, 1955):

Caudal ramus	Lateral seta	Dorsal seta	Apical setae (outer to inner)			
0.33	0.57	1.03	1	3.5	7.3	0.3

Antennule (fig. 20) 6-segmented, reaching to near or beyond middle of cephalic segment, its actual total length a little more than half that of segment (midline). Length of segment 4 from 2 to 2.25 times its greatest width. Relative length of segments (midline) and number of setae (s), spines (sp), and aesthetes (a):

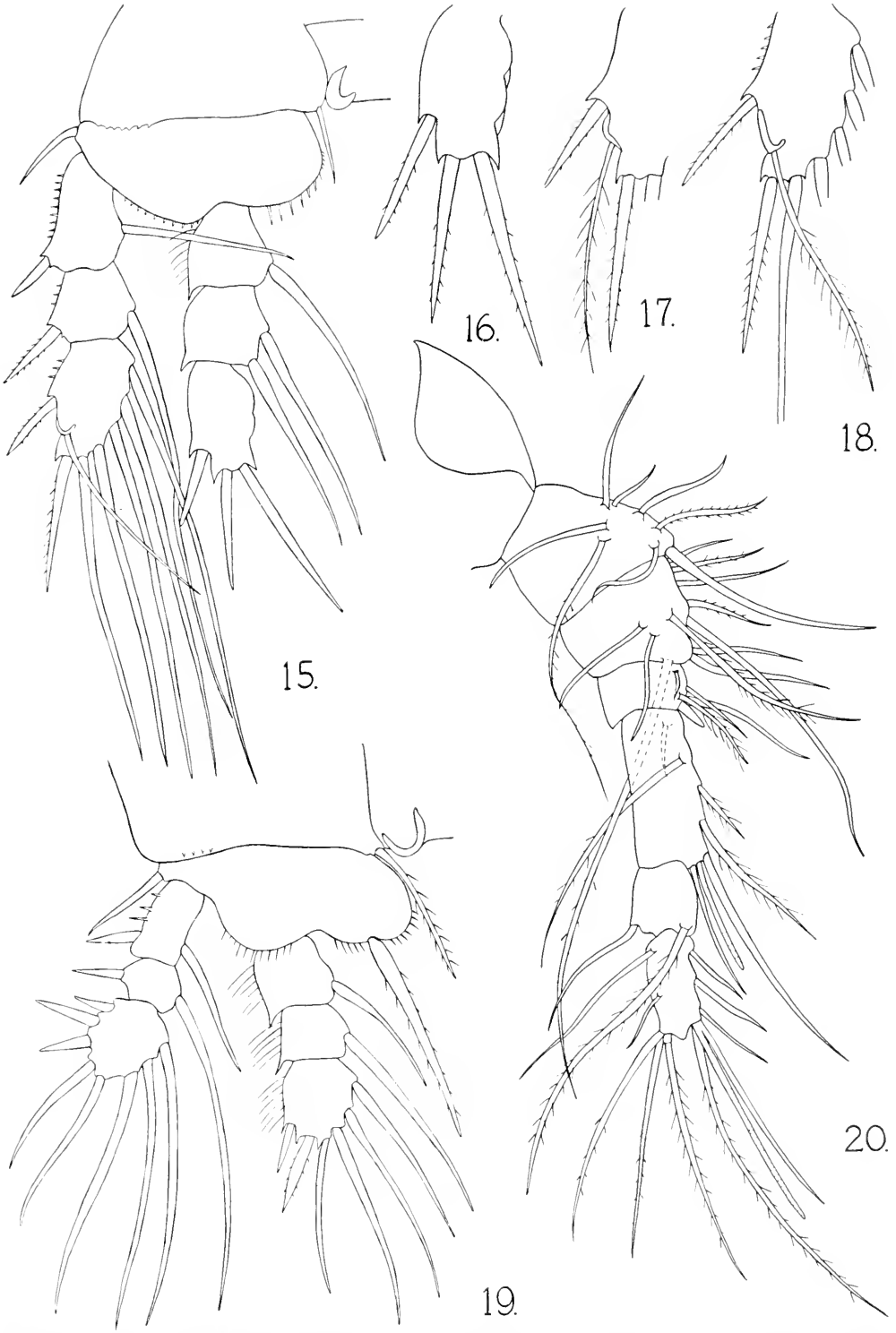
Segment	1	2	3	4	5	6
Length	20	15	10	31	14	20 μ
Armature	8s	11s	4s sp	6s a	2s	10s a

As shown in figure 20, a few of the setae inconspicuously plumose and their lengths ranging from considerably less than that of the segment to considerably more; the longest attached apically on segment 2, reaching to end of antennule or beyond.

Antenna (fig. 9) 3-segmented. Segment 1 with two apically placed setae on inner side, lacking the usual seta on outer side. Segment 2 with one seta. Segment 3 with five lateral setae; of these, the distal two borne on produced part of midportion of segment and one exceptionally stout and clawlike; apical group consisting of four stout and two slender, subterminally placed setae.

Labrum (fig. 10) broader than long; mid-posterior edge toothed as illustrated. Mandibular palp (fig. 4) consisting of two very unequal setae arising from depression in blade.

Maxillule (fig. 7) with broad basal segment to which is attached a slightly shorter apical segment and an unsegmented palp. Apical segment, viewed ventrally *in situ* and in dissection, little longer than broad; armed terminally with four stout clawlike spines of which the anterior is nearly twice as long as the others, and dorsally with a group of setae of irregular size (fig. 8). Setae of palp arranged in three groups; the anterior group consisting of a single seta attached on lateral side; the other two groups terminal in position and each composed of



Figures 15-20. *Halicyclops fosteri*, sp. nov. (from Lake Pontchartrain specimens). FEMALE: **15**. Leg 4; **16**. Leg 4, endopod segment 3; **17-18**. Leg 4, exopod segment 3, two different aspects; **19**. Leg 1; **20**. Antennule. (Note: plumose ornamentation omitted from setae in figs. 15 and 19.)

three setae borne on a slightly produced lobe.

Maxilla (fig. 5) largest of oral appendages, composed of two expanded and nearly equal basal segments and a modified, 2-segmented apical portion. First segment with indistinctly separated lobe bearing two setae; segment 2 with single medial seta. An attenuated lacinia intercalated between narrowed apex of segment 2 and apical portion, armed with a lateral branch bearing a seta and an apical portion drawn out to nearly same point as succeeding segment. Segment 3 modified, expanded and produced distally into stout inner claw and an articulated outer claw. Apical segment not produced, armed apically with a reduced spine, two hairlike setae and two long claws reaching to about the distal third of the claws of the expanded third segment.

Maxilliped (fig. 6) much reduced in size, its two segments together about as long as the two basal segments of the maxilla but exceedingly slender; basal not quite twice length of apical segment. Basal segment with three setae placed near the middle. Second segment with two stout clawlike setae at midpoint and apically with a stout, anteriorly placed claw longer than the segment, and two very slender, posteriorly placed setae of unequal length.

Legs 1-4: First basal segment of all legs with inner seta, and second segment with outer seta. Inner seta of second basal segment present only on leg 1; this seta exceptionally long, reaching at least to apex of endopod (fig. 19). Exopod segments 1 and 2 of all legs with outer spine and inner seta. Endopod segment 1 with one inner seta; segment 2 with one inner seta on leg 1, with two setae on legs 2-4. Exopod segment 3 with spinal formula, 3,4,4,2, and setal formula, 5,5,5,5. Endopod segment 3 with two spines and four setae on leg 1 (fig 19); with three spines and three setae on leg 2 and 3.

Leg 4 (figs. 15-18): Exopod segment 3 with an exceedingly slender, plumose seta somewhat eccentrically placed on a marginal sclerotization between outer marginal and apical spines; seta longer than apical spine. In most of the specimens observed, whether the appendage was still attached or dissected from the body, this seta was directed crosswise of the apical and inner setae as shown in figs. 15 and 18, thus emphasizing its eccentric placement; in appendages turned a little laterad, the seta appeared marginal as in figure 17. Endopod segment 3 not quite twice as long as broad, ratio of length to width about 1.8 : 1; inner margin without setae but with cuticular expansions at the points of attachment of the two setae normally present in the genus, these expansions not resembling the marginal indentations or depressions of usual setal attachments (fig. 16); the outer and two apical spines normal, the apical longer than segment; average ratio of length of segment (expressed as 1) and spines (from outer to inner), 1 : 0.77 : 1.1 : 1.5.

Leg 5 (fig. 11): Segment 1 coalesced with thoracic segment, its lateral seta arising dorsally on stout basal joint. Length of segment 2 varying from 2 to 2.25 times its width; its inner margin straight and armed with inconspicuous, irregularly placed short hairs. First outer lateral spine set just above middle of segment; inner spine subterminal, being placed just above the slight apical production bearing the terminal seta. All three spines exceedingly slender, barely stouter than basal portion of apical seta; their edges minutely denticulate. The seta much longer than spines; inconspicuously plumose. The spines varying slightly in actual length from specimen to specimen, and from left to right side of an individual, but not departing from a pattern of relative length: inner spine always the longest, first outer spine a little longer than the second, and both of these spines as long as or longer than the segment; the shortest spine (second outer) a little shorter to a little longer than segment; the seta more than twice the length of segment, twice or more the length of second spine and less than twice the length of inner spine. This pattern determined from measurement of five pairs of legs from which no spines had been broken (Table 1).

Male

Total length, midline, 0.355-0.37 mm. Metasome more slender than that of female. Urosome lacking dorsal ornamentation except on anal segment as in female. Caudal rami and setae as in female.

Antennule (fig. 14) of fourteen segments; separation incomplete between segments 1 and 2, and between 8 and 9. Setae arising largely on ventral side; proximal

TABLE 1.

Length of segments, spines, and setae found in five pairs of fifth legs of the female of Halicyclops fosteri.

Segment (Length : width)	Outer spine 1	Outer spine 2	Seta	Inner spine
27.2 : 13.6	34	27.2	71.4	40.8 μ
27.2 : 17	37.4	30.6	68	40.8 μ
27.2 : 13.6	34	30.6	68	37.4
27.2 : 13.6	34	27.2	68	37.4
27.2 : 13.6	27.2	23.8	71.4	37.4
27.2 : 13.6	34	27.2	68	37.4
27.2 : 13.6	34	27.2	68	37.4
27.2 : 15.3	30.6	23.8	68	37.4
30.6 : 13.6	37.4	34	68	40.8
30.6 : 13.6	34	30.6	68	40.8

four segments with numerous, closely set setae of which one on segment 3 and one on segment 4 are exceptionally long, reaching to near end of antennule; the rest of antennule with few, short setae or aesthetes. Apical segment curved and somewhat clawlike, its proximal half with numerous setae. (Note: Fig. 14 erroneously shows fifteen segments in the antennule. The fourth segment from the apex is an artifact that appeared in the appendages from which the outline drawing was made. Inadvertently, this faulty drawing was inked and mounted rather than the corrected one, and the error unfortunately was not detected until the galley proof of the paper was seen. Study of several appendages shows that the antennule agrees closely with the superior figures of Gurney (1933). There are five segments beyond the somewhat swollen middle portion (segments 8 + 9); of these, three precede and two follow the point of geniculation which thus occurs between segments 12 and 13.) Other cephalic appendages as in female.

Legs 1-3 and exopod of leg 4 as in female. Endopod segment 3 of leg 4 differing from that of female in having two setae on the inner margin (fig. 13); these setae reaching to near end of apical spine.

Leg 5 (fig. 12) with the usual dorsally placed seta on thoracic segment. Segment 2 with two outer marginal spines shorter than segment; a long, apically placed seta more than twice the length of segment; an inner spine subequal to the segment and a longer seta; all spines very slender and minutely denticulate as in female.

Leg 6 (fig. 12) with outer seta nearly as long as apical seta of leg 5, and longer than its own middle seta and inner spine.

DESCRIPTION OF TEXAS SPECIMENS

Occurrence.—2 ovigerous females; Harbor Island (a tidal delta), Aransas Bay, Texas, March 24, 1948, J. W. Hedgpeth, collector; United States National Museum accession number 179561; occurring with brackish water harpacticoid copepods.

Description.—Total length, midline, 0.635 and 0.65 mm. Color dark brown. Cuticle and appendages stouter than Lake Pontchartrain specimens, but habitus outline and proportions of cephalic segment the same. Genital segment a little longer than broad (1.2 : 1), with pronounced lateral membranous flanges. Ovisac with 9-10 large ova. Urosome without ornamentation except as in Pontchartrain specimens. Length of caudal ramus subequal to width and to that of anal segment. Lateral seta placed marginally near middle of ramus, its length only a little more than that of ramus. Average ratio of length of setae and caudal ramus to outer caudal seta expressed as 1:

Caudal ramus	Lateral seta	Dorsal seta	Apical setae (outer to inner)		
0.5	0.7	1.2	1	5.7	12.7	0.4

Antennule reaching just beyond middle of cephalic segment. Relative segmental length and armature as in Pontchartrain specimens. Antenna differing from Pontchartrain specimens in the presence of the usual outer seta of first segment. Mandibular palp as in Pontchartrain specimens.

Legs 1-4: Armature of exopods differing in part from that of Pontchartrain specimens, and not entirely alike in the two

specimens; that of endopods alike. Leg 1, inner seta of basal segment 2 spiniform, short, barely reaching end of endopod segment 2. Exopod segment 3 with five setae on all legs, but the number of spines of legs 1-3 different in the two specimens, as follows:

	Specimen 1	Specimen 2
Leg 1	2	3
Leg 2	3	4
Leg 3	3	3

Large spines of all legs with narrow, serrate marginal membranes.

Leg 4: Exopod segment 3 like that of Pontchartrain specimens except that the seta between the two outer spines is much shorter, not reaching end of apical spine; the placement not so eccentric, arising from distal part of sclerotized lobe that is entirely marginal. Endopod segment 3, length to width as in Pontchartrain specimens (1.8 : 1); small protrusions at normal point of attachment of inner setae; average ratio of length of segment (expressed as 1) and spines (from outer to inner), 1 : 0.77 : 1.07 : 1.46.

Leg 5 like that of Pontchartrain specimens except that the seta is hardly longer than the inner spine. This observation is based on incomplete data since the spines and setae of the two specimens were variously missing or broken.

COMPARISON OF LAKE PONTCHARTRAIN AND TEXAS SPECIMENS

The two lots of specimens differ in the following points:

Size.—The Texas specimens are longer (0.64 as apposed to 0.47 mm) and more robust than the Pontchartrain.

Habitus.—Lateral flanges of genital segment of female more produced in Texas than in Pontchartrain specimens. Lateral seta of caudal ramus longer and placed more proximally in Lake Pontchartrain specimens.

Antenna.—The usual outer seta of the first segment present in Texas, absent in Pontchartrain specimens.

Spines of exopod segment 3, legs 1-3.—Number varying from one another in the two Texas specimens; no variation found in dissections of ten females and five males of Lake Pontchartrain material, nor noted in examination of whole specimens of the latter lot. A comparative summary of the differences between the two lots of specimens shows that only the third legs of the two Texas specimens were like one another, and differ entirely from the Pontchartrain material:

	Texas	Pontchartrain
Leg 1	2 or 3	3
Leg 2	3 or 4	4
Leg 3	3	4

The close similarity of the fourth leg of the two lots of specimens, in both the distinctive structural modifications and quantitative characters, makes it imperative in light of present knowledge that they be regarded as the same species. Some of the differing characters, such as those found in the antenna and in the spinal formula of legs 1-3, point to the possible existence of two closely allied species, or of local races of a single species, as seem to exist in other *Halicyclops*. Herbst (1952, 1953) has interpreted populations with different spinal formulas as subspecies of *H. brevispinosus*, and has recorded (1955) differences between geographically separated populations of *H. crassicornis* in Brazil. *H. fosteri* may be represented by local races in the Gulf of Mexico area, and if so, the study of its distribution and variation might give insight into geographic speciation in both the genus and coastal brackish water copepods. The presently available material can only suggest the existence of the problem. No interpretation is valid that does not include both sexes and a larger number of individuals than was present in the Texas sample.

TAXONOMY

The most strikingly distinctive character of *H. fosteri* is the combination of the modified spinal pattern of the third exopod segment of the fourth leg, and the dimorphism of its endopod as exemplified by the presence of inner marginal setae in the male and their absence in the adult female. There are three spines on exopod 3 of leg 4 in most of the described species of *Halicyclops*, of which two are on the outer margin and one on the outer apex. *H. fosteri* is not unique in the absence of the second outer marginal spine. Lindberg states that this spine is replaced by a seta in *setifer* from the Caspian Sea and *bluchei* from India. In his illustrations, a seta similar in length to the first spine is shown in the usual place of the second spine. There is a question in

my mind as to whether the seta of *fosteri* can be interpreted as a modified spine. It is exceedingly slender, (much longer than the spine in the type lot), and is distally placed on a marginal sclerotization which does not correspond to the usual indentation in which the spines or other setae are normally placed. *H. fosteri* thus appears to differ from the other two species in the length and placement of this seta which may perhaps be more accurately interpreted as an accessory seta. In addition, *fosteri* and *setifer* differ from *blachei* in having normal spines on exopod 3 of the third leg. In *blachei*, the third or distal outer spine on this leg is also replaced by a seta, and Lindberg has expressed the spinal formula as 3,4,3,2. Following this mode, the formula of *setifer* and of typical *fosteri* is 3,4,4,2.

The absence of inner setae on endopod segment 3 of the fourth leg has been reported otherwise only in the Nigerian species, *korodiensis* Onabamiro. Exopod segment 3 of *korodiensis* differs from that of *fosteri* in having the normal number of spines. The endopod of *korodiensis* is described as having a "small papilla" in place of the proximal seta in contrast to the two areas of cuticular outgrowth in *fosteri*. The male of *korodiensis* has not been described, so whether the sexual dimorphism of *fosteri* is also characteristic of the other species is unknown.

The modifications of the fourth leg do not by themselves indicate close relationship of these four species. That there is no correlation between modification of exopod and endopod is indicated by *korodiensis* which lacks the inner endopod setae, but has normal spination of the exopod. Although any of the four species having modified fourth legs may be more closely related to species in which there is no modification, it is nevertheless apropos to compare their characters with one another and with the new American species. Table 2 gives a summary of the modifications of legs 3 and 4.

The armature of legs 1 and 2 of these four species does not differ. They all have slender, elongate spines on leg 5; where known, the males have the common armature for the genus (3 spines, 2 setae). In none are there spiniform processes on or conspicuous protrusion of the female genital segment. *H. setifer* differs strikingly from the others in its slender habitus and the greater length of the caudal rami.

In Lindberg's 1957 key, the females of both the Pontchartrain and Texas forms of *fosteri* can be placed in the first part by omitting from couplet 1 a statement of the complete spinal formula and including only a reference to leg 4. The species is then separable from *setifer* and *blachei* by the lack of inner setae on the third segment of the endopod, thus:

1. Leg 4, exopod segment 3 with total of two outer spines, between which is a marginally or eccentrically placed seta ... 2
   Leg 4, exopod segment 3 with three outer spines and no outer seta ... 4
2. Leg 4, endopod segment 3 without inner marginal setae. ... *H. fosteri* sp. nov.
   Leg 4, endopod segment 3 with inner marginal setae ... 3
3. Leg 3, exopod segment 3 with three outer spines and distal outer seta. *H. blachei* Lindberg, 1952
   Leg 3, exopod segment 3 with four outer spines. ... *H. setifer* Lindberg, 1949

TABLE 2.

Modified armature of outer margin of exopod segment 3 and inner of endopod segment 3 in some species of Halicyclops.
(s = seta; sp = spine; exo = exopod; endo = endopod).

Species	Leg 3, exo 3	Leg 4, exo 3	Leg 4, endo 3
H. korodiensis	4 sp	3 sp	inner setae absent ♀, unknown ♂
H. setifer	4 sp	2 sp, s	inner setae present ♀, ♂
H. fosteri	4 (3) sp	2 sp, s	inner setae absent ♀, present ♂
H. blachei	3 sp, s	2 sp, s	inner setae present ♀, unknown ♂

Lists of taxonomic characters to be used in studying *Halicyclops* have been given by Kiefer (1936) and Lindberg (1949). It appears to me, however, after reviewing the literature that there is still much to be learned about the structural characters, modifications and variations of the forms within the genus before any adequate evaluation of characters can be made, and relationships of species considered critically. Moreover, in order to achieve this, it is evident that taxonomists must present more complete descriptions of their material. In the study of *Halicyclops*, both the species and the specimens will always be widely scattered geographically, and comparative and revisionary work will depend much upon the literature. Only comprehensive knowledge of the species can lead to adequate and usable taxonomy, and to an understanding of the interrelationships of the species. Unfortunately, complete descriptions are available for only a few of the thirty-four species and subspecies that have been proposed in the genus. Of these, many appear to be indistinctly separated, and may be merely based upon variations or local races. It is comparatively easy to deal with species having distinctive modifications such as occur in *fosteri*, but I have found it impossible to arrive at any satisfactory conclusion as to the specific identity of some other available North American specimens. These show only minor quantitative or slight structural differences, such as variation in the marginal armature of spines, from forms that have been described in the literature under more than one specific name.

There are many structural characters of the genus that can be utilized in its taxonomy in addition to those commonly employed, and often in preference to less significant or overlapping quantitative differences. It is apparent, for instance, that the antennule of the female may have considerable taxonomic value for some species or groups. The extremely shortened antennule of *H. sinensis* Kiefer (1928, 1936) first drew attention to specific differences in the length of the antennule and in the relative lengths of its segments. Since then, authors have usually given relative proportions of the segments to one another and figured the outline. Measurements, however, are difficult to interpret. Some appear to refer to the midline, others to the margin. The total relative length is usually ignored and an unusually short antennule merely called "short" instead of being compared to some standard such as the cephalic segment, antenna, or total body length, so that the description has no comparative value. Very few figures of the antennule illustrate the armature or give details in the text. It is evident, however, from several examples such as the striking condition of *H. pilifer* Lindberg (1949) in which a stout spine occurs on the first segment and most of the setae are densely plumose, that the armature may be distinctive in individual or groups of species. In the description of *blachei*, Lindberg (1952) speaks of the segments as being armed with strongly ciliated setae, but gives no details. There may also be modifications of the aesthetes (apparently normally found on segments 4 and 6) as shown by Humes (1947) for *caridophilus*. Whether the number and distribution of the setae, spines and aesthetes follow a pattern or patterns within the genus is not known. The setation given here for *fosteri* agrees numerically with that given by Gurney (1933 : 20) for *"H. aequoreus"* and shown in the figure of *caridophilus* by Humes. In comparing *fosteri* with the few other illustrations in the literature, the agreement was not so close, or could not be judged with certainty because the figures are much too small to show such detail. It is suggested that a comparative study of the details of the antennules of several species, including those of distinctive form such as *pilifer* and *blachei*, might well give a basis for needed standards in description.

Attention should also be given to the antenna. That of *fosteri* agrees very well with the setation shown in the few figures given in the literature, except that the seta usually present on the distal outer edge of the first segment was lacking in specimens examined from Lake Pontchartrain and present in the two Texas specimens. This seta is usually present in gnathostome cyclopoids, so that its absence may have taxonomic significance. It is not shown in the figures given for *H. propinquus* (Sars, 1905), and *H. tennispina* (Sewell, 1924).

There may also be specific differences in the mandible, but this appendage is rarely mentioned in descriptions. Sars (1905,

1913) and Gurney (1933) show the palp with three setae arising from a minute papilla. Such a papilla is absent in *fosteri*, the setae arising from an indentation in the blade. The number of setae may be presumed to be a specific character since only two setae occur in *fosteri*, and the number is reduced to one in *caridophilus*.

In *fosteri*, a group of short setae or spines is present on the dorsal face of the apical segment of the maxillule (figs. 7 and 8). Of the few illustrations of this appendage in literature, comparable armature is shown only by Humes (1947) and suggested in Sars's (1913) figure. The presence or absence of such setae in this position should be noted for species of *Halicyclops* because they are invariably present in other Cyclopidae, and their absence from even some species would constitute an important divergence. I suspect, though, that they will probably be found to be present in all species of *Halicyclops* upon critical examination.

Differences in the inner seta of the second basal segment of the first leg, as shown in figures in the literature, suggest that the length and stoutness of this seta should be noted in descriptions.

In addition to the need for complete description of species, there is need for studies of variation within populations. Most subspecies in this genus have been proposed without knowledge or analysis of such variation, or even of comparison with the nominate form—an unfortunate and invalid practice throughout much modern copepod literature. The continued publication of names for species, subspecies and forms, based upon incomplete investigation, inadequate numbers of specimens, unevaluated and indefinite characters, is rapidly placing the genus *Halicyclops* in a state of confusion. Investigators having access to adequate numbers of specimens and collections of several species or geographic races would advance our knowledge, and perhaps erase some of the difficulties of evaluation and identification, by presenting comprehensive, comparative studies of such material.

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Abstract

American records of the cyclopoid copepod genus *Halicyclops* are reviewed. Records of four species from West Indies and South America are considered valid, but all those from North America are questionable because they have been referred to European forms that have been confused in literature. Revisions and keys by Kiefer and Lindberg are evaluated and supplemented by a check list of species and forms known for the world to January, 1958, with appropriate bibliographic references.

A new species, *H. fosteri*, is described from the brackish waters of Lake Pontchartrain, Louisiana, and compared with females collected on the coast of Texas. The latter are referable to this species because of the distinctive modifications of both rami of the fourth leg. Differences in specimens from the two localities suggest the possible existence of local races of the species in the Gulf of Mexico area, but more material and both sexes of the Texas form are necessary for a valid interpretation.

Species with structural modifications, such as found in *H. fosteri*, are relatively easy to distinguish, but most species and subspecies proposed in the genus are based on minor quantitative and slight structural differences so that identification of species in the genus is often difficult and unsatisfactory. The need for complete descriptions and comparative morphological studies is emphasized, and taxonomic characters of appendages usually not considered in descriptions are indicated.

ONTOGENY OF THE FIRST AND SECOND PLEOPODS OF THE MALE CRAWFISH *ORCONECTES CLYPEATUS* (HAY) (DECAPODA, ASTACIDAE)

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In all crawfishes of the family Astacidae, the appendages of the first and second abdominal segments of the male are modified for use as organs of sperm conduction from the deferent ducts of the male to the annulus ventralis (=seminal receptacle) of the female. Of these appendages, the first pair are the more highly modified showing a variety of forms which bear little resemblance to the generalized biramous condition found in the other abdominal appendages.

Although the gonopods of the male crawfish, and particularly the first pleopod, are of paramount importance in the taxonomy of the group, little is known of their growth and development. Andrews (1906) made an excellent study of the ontogeny of the annulus ventralis of the female but did not include information on the ontogeny of the gonopods of the male. Again, Andrews (1907) made a study of the young of the crawfishes *Pacifastacus leniusculus* and *Orconectes limosus* with emphasis upon their development immediately before and after hatching; however, this study did not include specific information on the development of the first and second pleopods of the male. Later, Andrews (1910, 1911) also made excellent studies of the anatomy, both internal and external, of the first and second pleopods of the crawfish *O. limosus* and gave an ontogenetic description of these appendages. He also noted that the sexes may be distinguished from one another in *O. limosus* after the third molt. Penn (1943) briefly described the development of the first pair of pleopods of *Procambarus clarki* (Girard) stating that "they appear as very small . . . 'knoblike' processes on the ventral transverse ridge of the first abdominal somite when the crawfishes are 4.5 mm cephalothorax length". He concluded that the first pair of pleopods of the very small males develop into the mature form by gradual growth and differentiation. Hobbs (1940, 1945) in his studies of the first pleopod of male Cambarinae, proposed a nomenclature to be followed in all taxonomic descriptions of crawfishes. Hart (1952, 1953) made excellent studies of the exokeleton, musculature, and serial homologies of the first three pairs of abdominal appendages of male *Cambarus longulus longulus* Girard and *Cambaroides japonicus* (DeHann). Suko (1953) made detailed studies on the development of secondary sexual characters in appendages of *Procambarus clarki*. He included notes on the development of the first and second pleopods of the male from their first appearance at a total body length of 4.7 mm to full development, and compared them with corresponding stages of the first and second pleopods of the female. Also included are drawings of the first and second pleopods of both male and female at critical stages in their development. Suko stated that the first pleopod made its first appearance on 4.7 mm individuals as a process from the epimeron lying between the pleuron and the sternum growing along the central bar of the sternum, and attained its full growth at the eleventh molt. The second pleopod appeared at the third instar and was completely formed at the eleventh instar. Finally, Hart (1956) gave a summary of the important changes in the first pleopod of *Cambarus l. longulus* from its appearance in the third instar to its mature form. He assumed that sexual maturity is attained when the crawfish has a cephalothorax length of between 14.0 and 17.5 mm. He also stated that at no time in the development of the first pleopod does it show any tendency toward a biramous condition so typical of the other pleopods.

Adult male crawfishes of the subfamily Cambarinae are peculiar in the possession of two distinct forms of the male sexual appendage. Those males capable of mating are designated as first form; those which are not capable of mating are designated as second form. First form males are distinguished from second form males by the presence of well-defined and corneous terminal processes of the first pleopods; the processes of the second form are poorly defined, blunt and never corneous. Also, the first form male possesses well-developed hooks on the ischiopodites of certain of the pereiopods, usually on the third or fourth

pair, which are not present (or present but less developed) in the second form males. These distinguishing features of the two forms of the adult male crawfish were discussed at length by Hagen (1870), and more recently by Creaser (1933a), Hobbs (1942) and Hobbs and Marchand (1943).

Objectives of the Study

The objectives were threefold. First, to determine a growth increment for *Orconectes clypeatus*. This would make the determination of the instar of any individual possible and would permit the use of previously collected and preserved material in studying the ontogeny of the first and second pleopods of the male.

Second, to study the ontogeny of the first and second pleopods of the male from the earliest instar in which sexual dimorphism is apparent.

Third, to determine if the suture which was present between the basipodite and the endopodite of the first pleopod in juvenile males is recovered when the first form males return to the non-breeding condition after the close of the breeding season. The results of this study should show whether the second form is a seasonal condition or a developmental stage.

Materials and Methods

All or the specimens used were collected from a pineland ditch 2.4 miles south of Hickory, and a roadside ditch 2.5 miles south of Talisheek, St. Tammany Parish, Louisiana. During periods of drought when the ditches completely dried up, the crawfish were recovered from their burrows one to four inches below the surface of the ground as described previously by Smith (1953). At other times the crawfish were collected by means of a dipnet.

Growth increment.—The specimens which were used to determine the growth increment for each molt were kept individually in small, round, glass bowls 10 cm in diameter and 4 cm in depth. They were fed primarily on lettuce and the water was changed weekly. This crawfish survives well under laboratory conditions.

Some writers, notably Creaser (1933a) and Van Deventer (1937) questioned the validity of growth data gathered from laboratory raised animals; both writers preferred to collect large numbers of specimens at one place at stated time intervals throughout the year.

Any attempt to obtain growth data on particular individuals while allowing them to remain in their natural habitat is difficult because of the important part played by molting in the growth of crawfishes. This prevented the possibility of studying and measuring certain individuals, tagging them and releasing them in their natural habitat in the hope of recovering them at a later date for restudy and remeasurement. However, future workers should consider the method recently devised by Slack (1955) which apparently does not injure the crawfishes or alter their behavior, and which is not lost during the process of molting. The method involves injecting black numbering machine ink just beneath the exoskeleton.

In any study of growth, a measurement must be chosen which will show the true growth of the individual throughout the study. Total length is not considered a particularly valid measurement by most students of crawfish, although it has been used in some morphological studies such as those by Andrews (1907) and by Suko (1953). Andrews chose this measurement because of the extremely small size of the newly hatched individuals.

The length of the cephalothorax from the anterior tip of the acumen to the posterior edge of the carapace was chosen as the measurement which best fitted all requirements. Many writers, including Creaser (1933a), Van Deventer (1937), Tack (1941), Penn (1943) and Smith (1953), have used the length of the cephalothorax as a measurement of growth. This measurement has at once the advantage of being easily translated into terms of approximate total body length throughout the life span after the young become independent of the mother. Furthermore, it is not easily affected by the movement of the animal during the process of measurement since the exoskeleton of the cephalothorax is a rigid unit.

The animals after being brought to the laboratory from the field were measured and placed in glass bowls. Such data as cephalothorax length, sex, and date of collection were kept for each specimen. Measurements were taken by means of a vernier caliper and were recorded to the nearest

0.1 mm. Approximately twenty-four hours after each molt, the newly molted crawfish was remeasured. The time interval between molting and remeasurement was necessary to allow the exoskeleton to harden. Juveniles and adults of both sexes were used in the increment determination.

Ontogeny.—To show clearly the expected allometric growth of the first and second pleopods, the animals to be studied were divided into size groups, measurements made of significant characters and such measurements treated statistically. The animals were separated first according to whether they were first form or second form. They were further arranged in groups with a cephalothorax length range of 0.4 mm, since this had been found to be the average increase in cephalothorax length per molt. For example, the males measuring 5.3 mm in cephalothorax length were arbitrarily assigned to the size group 5.0 to 5.4 mm. Ten specimens for each size group were selected randomly from the preserved material for study. This number was selected as being small enough to be convenient yet large enough to handle statistically with fair accuracy. In some cases where more than ten specimens in one size group were accidentally studied, all were included to eliminate personal bias. Lack of sufficient material prevented the inclusion of size groups of first form males below 11.5 mm in cephalothorax length and above 17.4 mm (Table 1). Likewise, 5.0 mm and 17.9

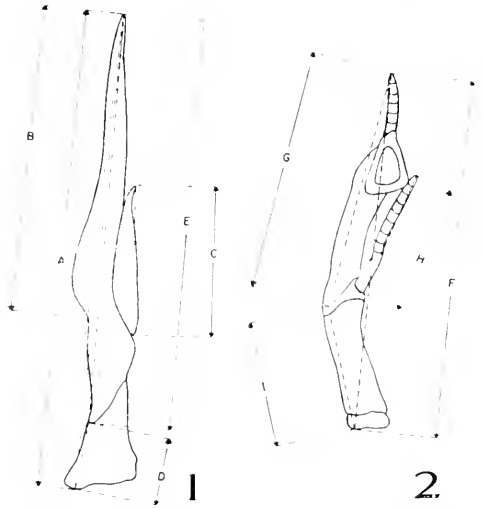
TABLE 1.
First form males used in ontogeny study

No. of Specimens	Cephalothorax Length Range	Mean
12	11.5-11.9	11.73
12	12.0-12.4	12.21
12	12.5-12.9	12.66
13	13.0-13.4	13.10
13	13.5-13.9	13.58
11	14.0-14.4	14.08
10	14.5-14.9	14.57
10	15.0-15.4	15.08
10	15.5-15.9	15.68
10	16.0-16.4	16.20
11	16.5-16.9	16.65
10	17.0-17.4	17.35

mm cephalothorax length represent the minimum and the maximum sizes of second form males studied (Table 2). All measurements, with the exception of the cephalothorax length, were made with an ocular micrometer calibrated for an American Optical Company's stereoscopic microscope and were recorded to the nearest 0.1 mm. In each case the right pleopod was removed for measurement except when injured. The measurements chosen for study on the first pleopod (fig. 1) were (A) total length, (B) length of the central projection, (C) length of the mesial process, (D) length of the basipodite, and (E) length of the endopodite. In first form males the latter two measurements were omitted because of the obliteration of the suture between the basipodite and the endopodite. The measurements on the second pleopod (fig. 2) were (F) total length, (G) length of the endopodite, (H) length of the exopodite, and (I) length of the protopodite. To better compare the growth rates of the various organs, the measurements were all expressed as ratios of the measurements to the length of the cephalothorax, unless otherwise stated, rather than as absolute measurements. Standard deviation and standard error of the mean were computed without grouping according to the method outlined by Cazier and Bacon (1949).

TABLE 2.
Second form males used in ontogeny study

No. of Specimens	Cephalothorax Length Range	Mean
11	5.0- 5.4	5.39
10	5.5- 5.9	5.81
11	6.0- 6.4	6.21
11	6.5- 6.9	6.70
10	7.0- 7.4	7.21
11	7.5- 7.9	7.58
10	8.0- 8.4	8.20
11	8.5- 8.9	8.69
10	9.0- 9.4	9.10
10	9.5- 9.9	9.81
13	10.0-10.4	10.22
11	10.5-10.9	10.75
10	11.0-11.4	11.28
10	11.5-11.9	11.70
10	12.0-12.4	12.20
10	12.5-12.9	12.64
10	13.0-13.4	13.13
12	13.5-13.9	13.60
10	14.0-14.4	14.12
12	14.5-14.9	14.63
10	15.0-15.4	15.21
10	15.5-15.9	15.56
11	16.0-16.4	16.10
10	16.5-16.9	16.58
10	17.0-17.4	17.21
11	17.5-17.9	17.75



Figures 1-2. Illustrations of measurements used in the ontogeny study. **1**, Mesial view of first pleopod of second form male: (A) length of pleopod, (B) length of central projection, (C) length of mesial process, (D) length of basipodite, (E) length of endopodite. **2**, Mesial view of second pleopod of second form male: (F) length of pleopod, (G) length of endopodite, (H) length of exopodite, (I) length of protopodite.

Growth Increment

Between January 24, 1956 and June 18, 1957, 153 molts from 132 specimens were recorded. These showed an average increment of 0.41 mm. Standard deviation and standard error of the mean were ± 0.1821 and ± 0.1288 respectively. Several increment averages were taken during this period and none varied more than 0.02 mm from this final figure after the first fifty molts were recorded. The scatter diagrams, showing correlation between increment and cephalothorax length (figs. 3-6) indicate that there is very little correlation between the growth increment per molt and cephalothorax length. The regression lines show that the second form males that molted and remained second form (fig. 3) tended to increase in cephalothorax length slightly more per molt with increased size (positive correlation), whereas, the second form males that molted to second form (fig. 6), the first form males that molted to second form (fig. 5), and the females (fig. 4) tended to increase in cephalothorax length slightly less per molt with increased size (negative correlation). However, these positive and negative correlations are not considered significant. Thus *O. clypeatus* tends to increase in cephalothorax length approximately the same amount per molt regardless of sex or size.

The smallest recorded sexually mature *O. clypeatus* (first form) measured 10.8 mm in cephalothorax length (Smith, 1953). With an average increase of 0.4 mm cephalothorax length, and using a modified version of Van Deventer's (1937) formula, the approximate number of molts for any individual may be calculated.

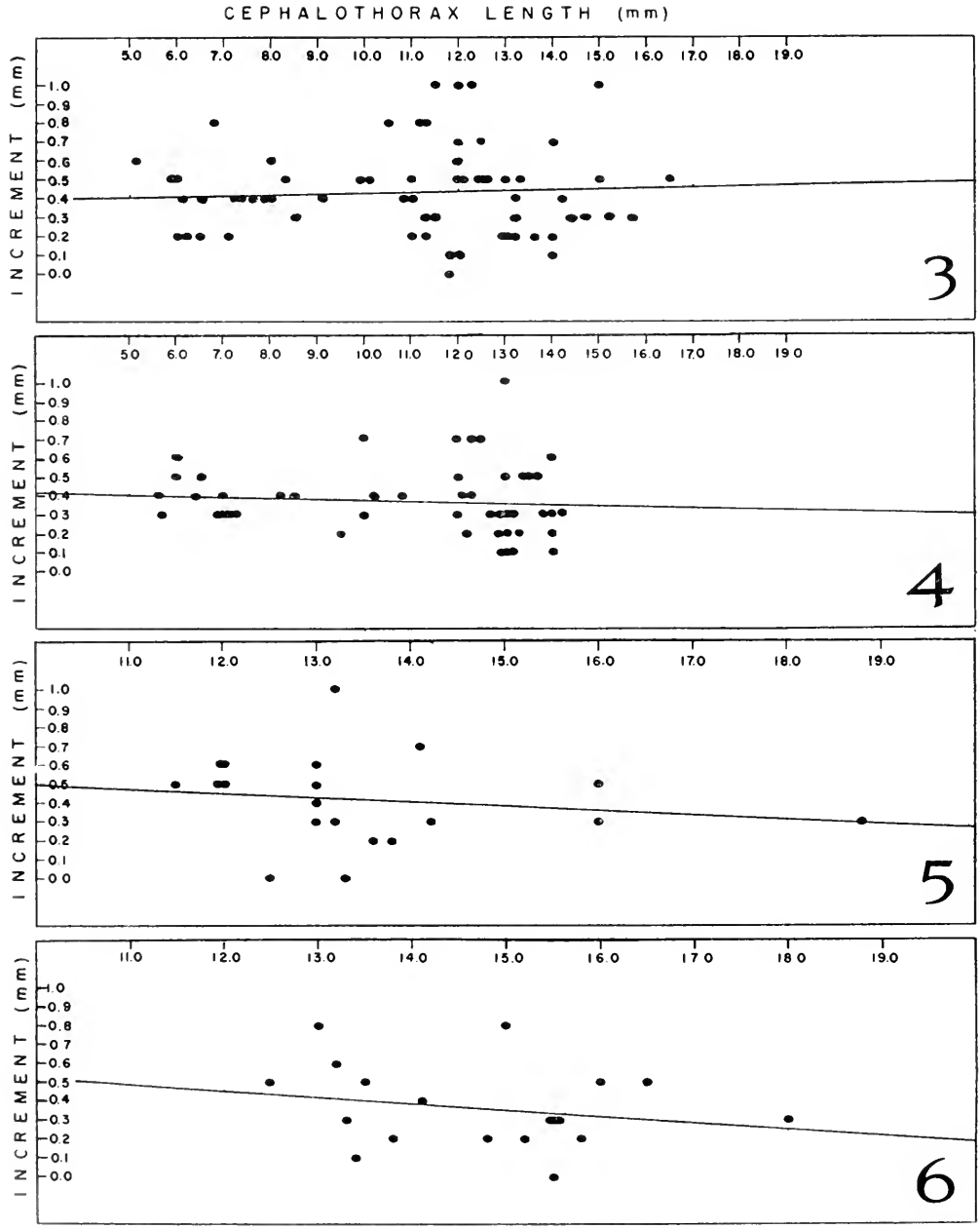
$$\frac{x - y}{0.41} + 2 = z$$

Where:

- x = cephalothorax length of individual
- y = average cephalothorax length of juvenile crawfish when it first becomes free-living (i.e., 2.5 mm according to Smith)
- 0.41 = average growth increment at each molt
- 2 = number of molts undergone by crawfish before it becomes free-living
- z = total number of molts undergone

Hence, *O. clypeatus* requires approximately twenty-two molts before reaching the minimum size for sexual maturity. Van Deventer (1937) stated that a cephalothorax length of 20.0 mm marked the boundary of sexual maturity in males of *Orconectes p. propinquus* (Girard), and that approximately eight to nine molts were required by *O. p. propinquus* males before reaching sexual maturity. Based upon fifty-nine actual molt increments, Penn (1943) found that the average increase in cephalothorax length of all sizes of *Procambarus clarki* was 2.6 mm per molt. He also stated that males attained sexual maturity at approximately 31.0 mm cephalothorax length, indicating *P. clarki* passes through approximately 12 molts before reaching sexual maturity. Also, Suko (1953) reports a first form male in the eleventh instar. Tack (1941) did not determine an increment for *Orconectes immunis* (Hagen); however, he raised a pair of males in the laboratory which survived the eighth molt and still had juvenile form sexual appendages.

Thus, *O. clypeatus* has a comparatively low average increase in cephalothorax length



Figures 3-6. Scatter diagrams showing correlation between growth increment and cephalothorax length. **3.** Males molting from second form to second form. **4.** Females. **5.** Males molting from first form to second form. **6.** Males molting from second form to first form.

per molt, and also requires a higher number of molts before attaining sexual maturity. Possibly this is due in part to the small size of *O. clypeatus*, and also to unknown environmental and physiological differences, as well as inherent genetic growth factors.

Ontogeny of the First and Second Pleopods

The study of the ontogeny of the first and second pleopods of male *O. clypeatus* was somewhat hampered by the early egg-laying season in the fall of 1956. According to Smith (1953), the egg maturation and embryonic development extends from October through January. However, during the period of the present study several extensive collections produced only two egg-bearing females (collected September 17, 1956) and the eggs were shed and eaten by the females after two days in captivity. In February after rains had refilled the collecting site, hordes of juveniles were collected, but these already ranged from 5.3 to 7.0 mm cephalothorax length. These circumstances prevented the study of the young from the time of their hatching until they were in approximately the twelfth instar. One preserved collection consisting of two females bearing young (range: 1.8 to 2.5 mm cephalothorax length) was of importance in giving an insight into the first appearance of the sexual appendages.

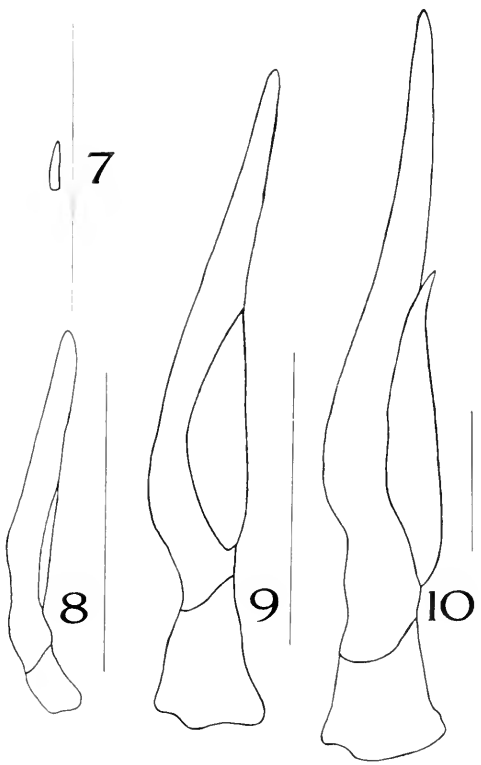
Description of the First and Second Pleopods of a First Form Male

The first pleopod, which reaches the coxopodite of the first pereiopod when in normal position, consists of three fused segments: coxopodite, basipodite, and endopodite. The exopodite is lost. The endopodite bears two conspicuous, terminal rami: the central projection which is very long, slender, subcylindrical and corneous and the mesial process which is considerably shorter (between one-third and one-half the length of the central projection) and also acute and non-corneous. The central projections of the right and left first pleopods are curved mesially and cross each other slightly at the tips when held in a resting position.

The second pleopod consists of four segments: a coxopodite, basipodite, exopodite and endopodite, and overlaps the basal portion of the first pleopod. The exopodite is slender, segmented and slightly offset from the endopodite, while the endopodite bears a terminal segmented process and a triangular-shaped outgrowth on the mesiodorsal side. This process, called the "triangle" by Andrews (1911), and later described by Hart (1953) as the centrocephalic process, is partly sclerotized and partly membranous and fits snugly into the space between the first pleopods.

Significant Stages in the Development of the First and Second Pleopods of the Male

First pleopod.—The first pleopods of the male appear as small papillae, widely separated on the sternum and pointing mesially toward each other when the crawfish are approximately 2.0 mm (second instar) in cephalothorax length (fig. 7). At this stage the rami of the endopodite are undifferen-



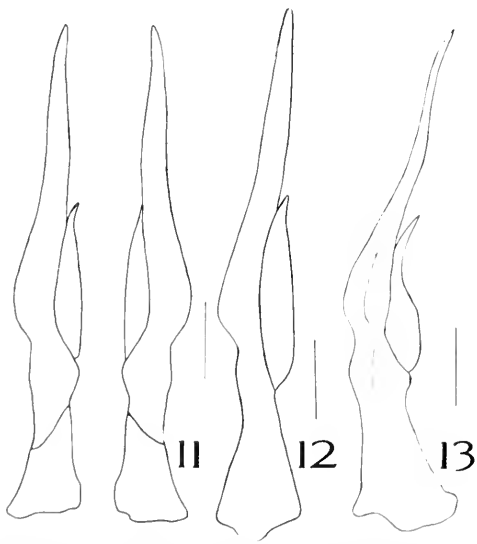
Figures 7-10. Outline drawings of caudal view of first pleopod. Vertical lines = 1.0 mm. **7.** Juvenile, 2.0 mm cephalothorax length. **8.** Juvenile, 5.3 mm cephalothorax length. **9.** Juvenile, 8.7 mm cephalothorax length. **10.** Second form, 13.0 mm cephalothorax length.

tiated. As the crawfish increases in size, the first pleopods tend to be relatively closer together, with the sternal sclerite from which they arise developing into a heavy, calcified, transverse ridge.

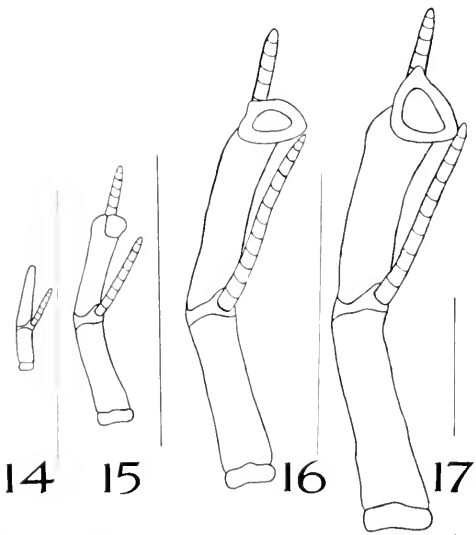
The mesial process is barely visible as a slight groove on the lower portion of the endopodite in approximately the 5.0 mm stage (fig. 8), but not until approximately the 10.0 mm srage (fig. 9) does the mesial process appear as a completely separate process.

After maturity is reached there are no significant changes in the first pleopod (figs. 10-12), other than a gradual increase in size which is approximately proportional to the increase in size of the cephalothorax length with each molt, except those resulting from the change from second form to first form (fig. 13) and from first form to second form. Except for various individual differences, the first pleopod of the second form male which has never undergone the change from second form to first form is identical to the first pleopod of a specimen of the same size which has molted from second form to first form and then returned to the second form condition following the breeding season. This pleopod shows at no time in its development any tendency toward a biramous condition. This agrees with the findings of Hart (1956) in his study on the ontogeny of the first pleopod of *Cambarus l. longulus* Girard.

Second pleopod.—In comparing the development of the second pleopod, one must keep in mind that whereas the first pleopod never at any time closely resembles any of the other pleopods, the second pleopod is present as early and is at first identical to the unspecialized pleopods. It becomes specialized through the course of its development by the addition of an outgrowth and not by the loss of parts. As previously mentioned, no first instar specimens were available to the writer for study; however, Andrews (1911) mentions that the pleopods of the second, third, fourth and fifth somites of both males and females of *Orconectes limosus* are represented at the time of hatching and are remarkably similar. Thus, the writer assumed that the second pleopod of *O. clypeatus*, of the same genus, appears at approximately the same time as the third, fourth and fifth pleopods, since these four pleopods were all of the same size in the smallest observed specimens. The second pleopod appears in the 2.0 mm stage

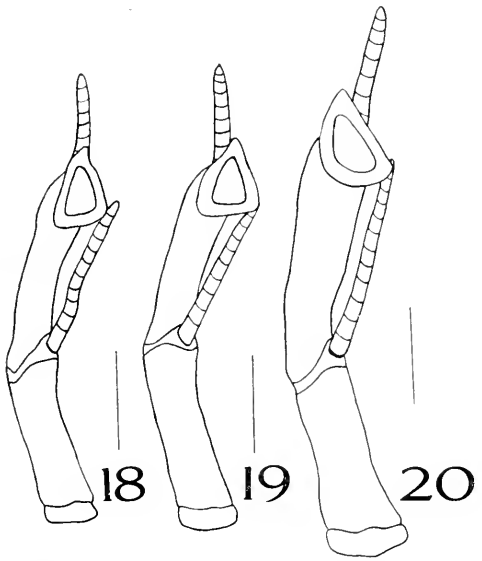


Figures 11-13. Outline drawings of the first pleopod (caudal view unless otherwise indicated). Vertical lines = 1.0 mm. **11.** Cephalic and caudal views, second form, 15.0 mm cephalothorax length, with complete suture. **12.** Second form, 15.0 mm cephalothorax length, without suture. **13.** First form, 16.5 mm cephalothorax length.



Figures 14-17. Outline drawings of mesial view of second pleopod. Vertical lines = 1.0 mm. **14.** Juvenile, 2.0 mm cephalothorax length. **15.** Juvenile, 5.3 mm cephalothorax length. **16.** Juvenile, 8.7 mm cephalothorax length. **17.** Second form, 13.0 mm cephalothorax length.

(second instar) as a flattened, translucent, typically biramous appendage with the endopodite slightly longer than the exopodite (fig. 14). The exopodite shows segmentation, whereas segmentation in the endopodite is absent or, at best, obscure. The distinctive centrocephalic process first appears in the 5.0-5.4 mm size groups (fig. 15) as a small protuberance on the mesial side of the endopodite near the distal end. At this stage the endopodite is prominent with the exopodite decidedly smaller. The exopodite which begins as a short, club-like ramus, becomes relatively narrower and longer with each succeeding molt (figs. 14-20) until the specimen molts into the first form condition. By the time the cephalothorax length of the specimen is 8.7 mm, the centrocephalic process has taken on much of its final appearance (fig. 16). As might be expected, the change from second form to first form does not affect the second pleopod as extensively as it does the first pleopod, the chief difference being that portions of the endopodite, especially the centrocephalic process, are more sclerotized in the first form condition.



Figures 18-20. Outline drawings of mesial view of second pleopod. Vertical lines = 1.0 mm. **18.** Second form, 15.0 mm cephalothorax, with complete suture on first pleopod. **19.** Second form, 15.0 mm cephalothorax length, without suture on first pleopod. **20.** First form, 16.5 mm cephalothorax length.

Ontogenetic Variation

The first and second pleopods of *O. clypeatus* undergo a very rapid growth rate in early life; however, in later life their growth rates tend to parallel that of the cephalothorax. In the second form males all five of the measurements of the first pleopod (length, length of the central projection, length of the mesial process, length of the endopodite and length of the basipodite) show an initial growth rate that closely parallels the growth rate of the cephalothorax. Then between 6.0 and 10.0 mm the growth rates of these parts increase rapidly. On the other hand, all four of the measurements of the second pleopod (length, length of the protopodite, length of the exopodite and length of the endopodite) show a rapid, steady increase in growth rate from the smallest size measured (5.0 mm) to 10.0 mm (fig. 21).

Another character is expressed as a ratio of the length of the central projection to the length of the mesial process, and shows that the proportional growth rates of the two parts are almost identical (figs. 23 and 24). Little change of significance is to be noted throughout the life span.

The growth rate of the first and second pleopods and their component parts in the first form males tend to parallel closely that of the cephalothorax length and may be considered isometric (fig. 21).

Significance of the First Form and Second Form Conditions

The existence of two forms in the mature male crawfishes of the subfamily Cambarinae has aroused much interest and speculation as to the explanation of this phenomenon. Much has been written describing the two forms in various species, but little is known of the actual position of the second form in the life history of any species.

Previous Studies

Hagen (1870), who was the first to publish on the eixstence of the two forms in the male crawfish, gave a detailed description of the two forms and conjectured that the second form was merely a sterile individual. Faxon (1884) conducted a simple experiment in which he kept several first form males and mature females of *Orconectes rusticus* together in the laboratory. After breeding, three of the males molted;

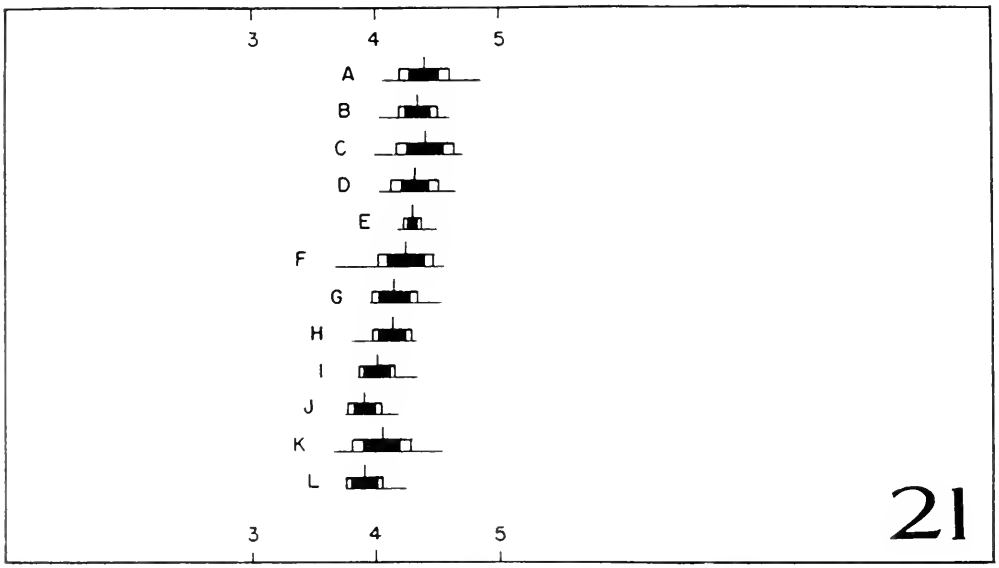


Figure 21. Ontogenetic variation in length of endopodite of second pleopod of first form male. Size groups (cephalothorax length) indicated to left of line as follows: **A** = 11.5-11.9 mm, **B** = 12.0-12.4 mm, **C** = 12.5-12.9 mm, **D** = 13.0-13.4 mm, **E** = 13.5-13.9 mm, **F** = 14.0-14.4 mm, **G** = 14.5-14.9 mm, **H** = 15.0-15.4 mm, **I** = 15.5-15.9 mm, **J** = 16.0-16.4 mm, **K** = 16.5-16.9 mm, **L** = 17.0-17.4 mm.

their exuviae were of the first form whereas the soft-shelled specimens were of the second form. Faxon concluded from this observation that the two forms represented alternating periods in the life of the individual male crawfish; the first form being the form assumed during the breeding season, the second form that assumed during the intervals between.

Steele (1902) drew several conclusions concerning the changes of the first and second forms after various laboratory experiments with *Orconectes nais* (called *Cambarus virilis* by Steele). She pointed out that during the late fall and winter the primary reproductive organs of the second form males were smaller and less developed than the same organs in the first form males. She also noted that males with imperfect or no chelae continue to molt into second form until the chelae have reached a size normal for the size of the animal. This was probably only an sssumption, as pointed out by Creaser (1933a), because several first form males of *O. nais* with imperfectly developed chelae were observed by him in Missouri in September and October.

Harris (1903) considered the two forms of the male in detail. He reviewed the works of Hagen and Faxon and gave the results of his own observations and experiments on *O. nais* and *O. immunis*. He noted that first form males of *O. immunis* collected in the middle of April soon molted into the second form condition. However, contrary to the conclusions of Hagen, Faxon and Steele, Harris reported observing spermatozoa in the same quantity and apparently in the same condition in the testes of both first and second forms, and concluded that the second form males were not sterile. He also mentioned a communication from W. P. Hay who reported seeing second form males in the act of copulation. This report has been the source of controversy in more recent works.

Creaser (1933a) studied a single population of *Orconectes p. propinquus* making collections at stated intervals during the year and noting seasonal changes in the male population. He concluded that the second form of the sexual appendage might be regarded as a developmental rather than a seasonal condition. He further concluded that after breeding, the older crawfishes die and do not, for the most part, if at all, revert to the second form condition. He explained the presence of second form males

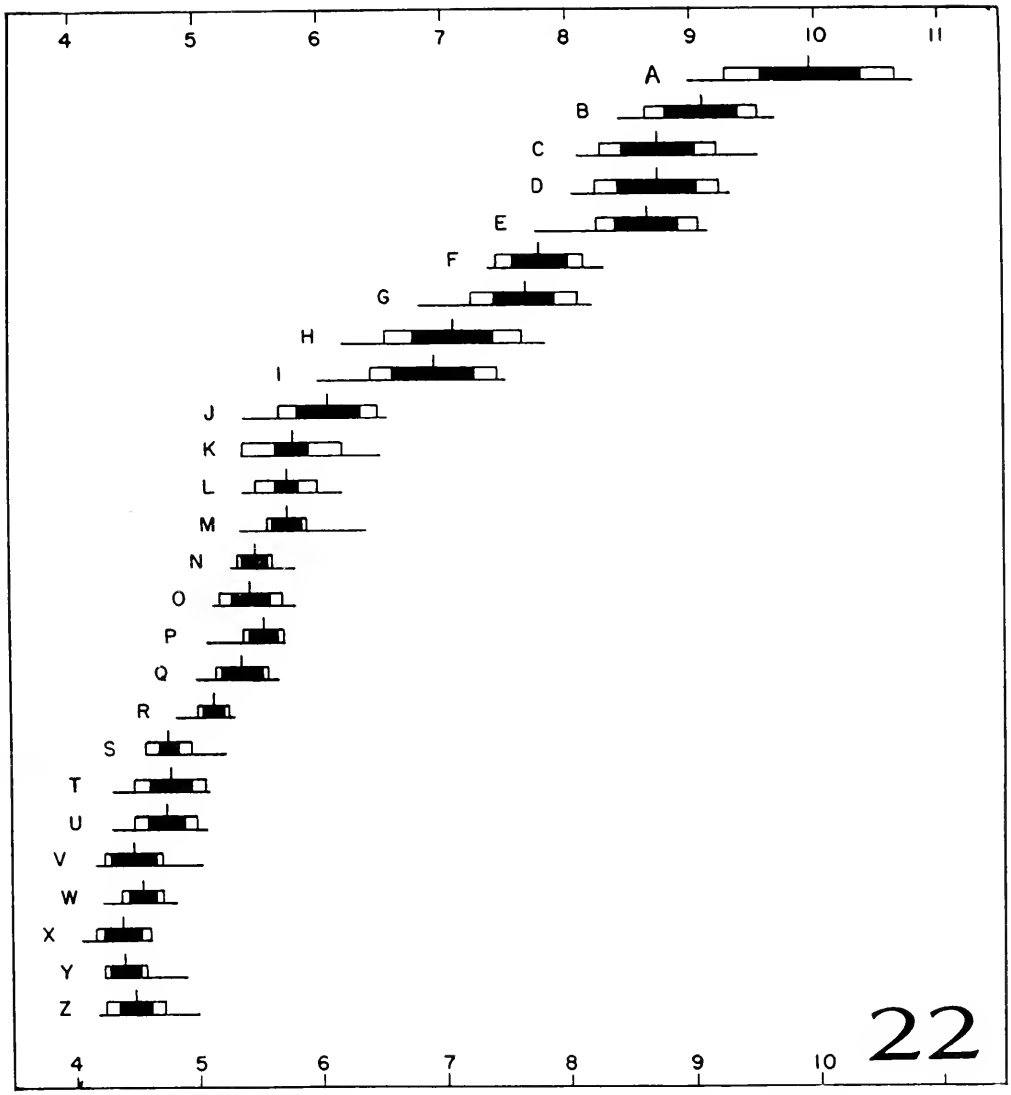


Figure 22. Ontogenetic variation in length of endopodite of second pleopod of second form male. Size groups (cephalothorax length) indicated to left of line as follows: **A** = 5.0-5.4 mm, **B** = 5.5-5.9 mm, **C** = 6.0-6-4 mm, **D** = 6.5-6.9 mm, **E** = 7.0-7.4 mm, **F** = 7.5-7.9 mm, **G** = 8.0-8.4 mm, **H** = 8.5-8.9 mm, **I** = 9.0-9.4 mm, **J** = 9.5-9.9 mm, **K** = 10.0-10.4 mm, **L** = 10.5-10.9 mm, **M** = 11.0-11.4 mm, **N** = 11.5-11.9 mm, **O** = 12.0-12.4 mm, **P** = 12.5-12.9 mm, **Q** = 13.0-13.4 mm, **R** = 13.5-13.9 mm, **S** = 14.0-14.4 mm, **T** = 14.5-14.9 mm, **U** = 15.0-15.4 mm, **V** = 15.5-15.9 mm, **W** = 16.0-16.4 mm, **X** = 16.5-16.9 mm, **Y** = 17.0-17.4 mm, **Z** = 17.5-17.9 mm.

in the population which were larger than some of the first form specimens on the assumption that not all of the young of the first year transform into the first form during the fall breeding season but overwinter in the second form condition.

Hobbs (1942) mentioned that the adult male crawfish exhibits two distinct and usually alternating morphological forms. Moreover, he stated that the first form is the breeding stage and that the two forms are deifnitely associated with the reproductive cycle.

Results

Preserved exuviae of each individual and the molted specimens were eaxmined for

TABLE 3.
Results of the suture study

Condition of Suture Prior to Molting	Complete Suture	Mesial Suture	Complete Suture	Mesial Suture	No Suture	No Suture
Form	II-II	II-II	II-I	II-I	I-I	I-II
Complete Suture Retained	23					
Suture Retained Mesially		6				
Suture Lost			10	5		
Complete Suture regained		1				8
Mesial Suture Regained						5
Suture Not Regained					1	4

the presence or absence of a suture between the basipodite and endopodite of the first pleopod. The writer at first anticipated that, after losing the suture when molting into the first form condition, the specimen would not regain the suture when it molted into the second form condition following the breeding season. Thus, this lack of suture on the first pleopod would clearly delineate the "true" second form male from the larger juveniles.

However, the examination of the exuviae and molted specimens showed immediately that this was not the case (Table 3). Four

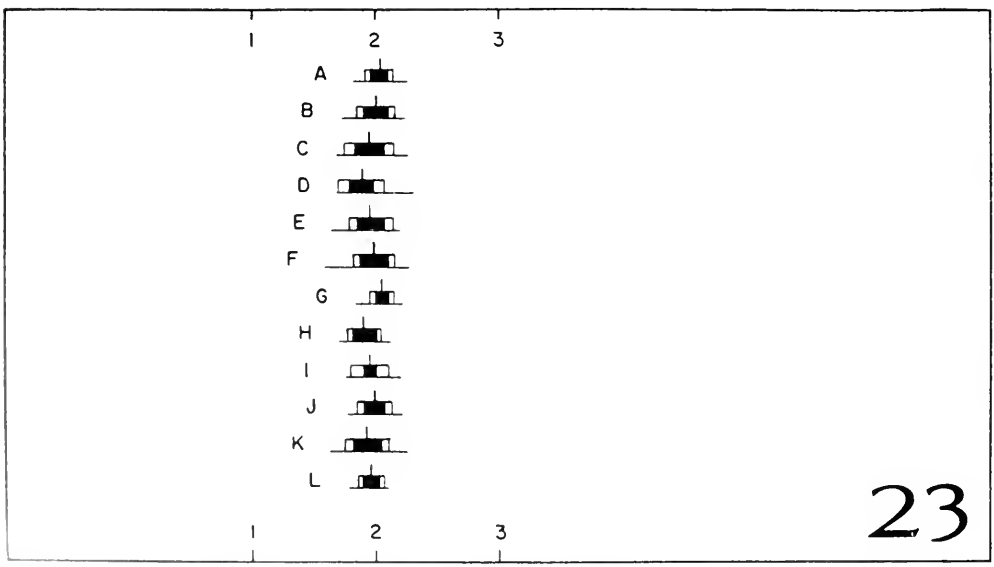


Figure 23. Ontogenetic variation in ratio of central projection/mesial process in [illegible] form male. Abbreviations for size groups as in fig. 21.

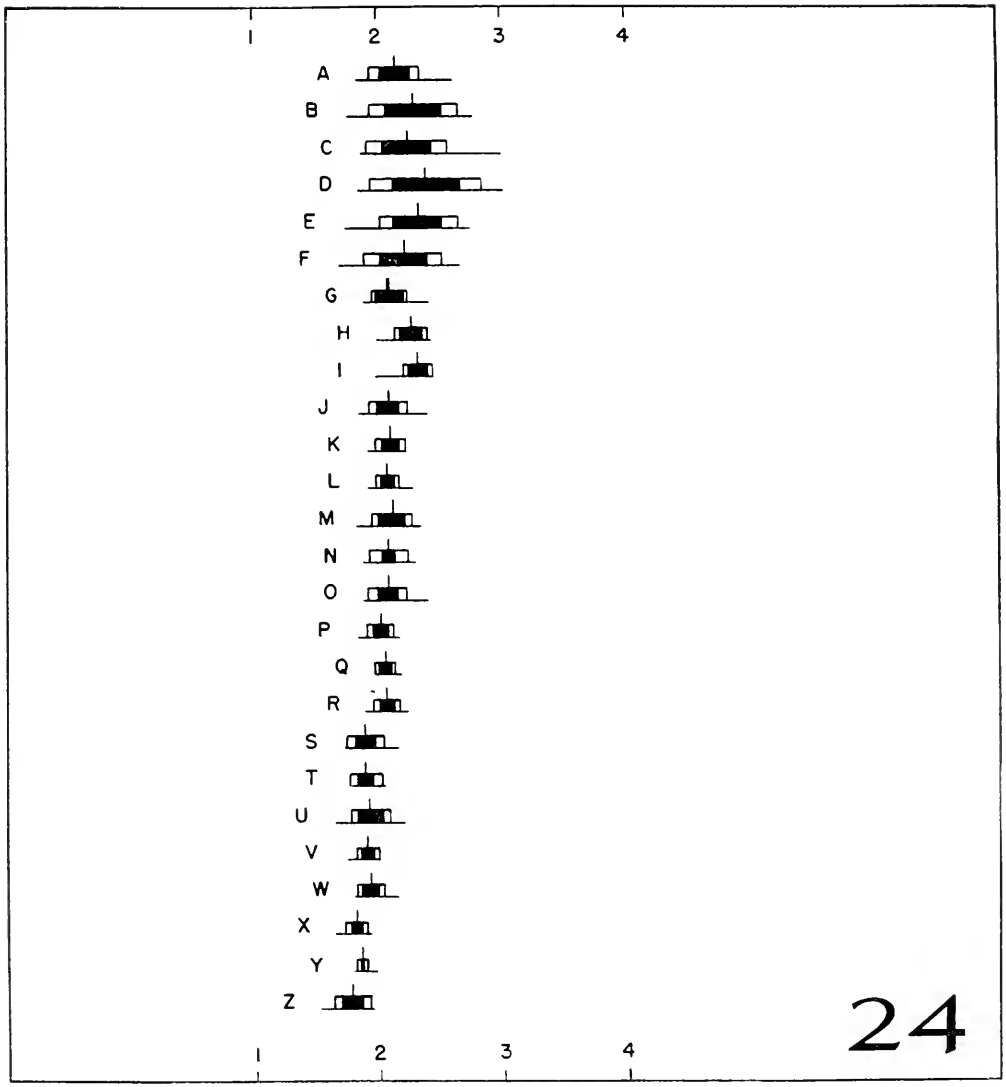


Figure 24. Ontogenetic variation in ratio of central projection/mesial process in second form male. Abbreviations for size groups as in fig. 22.

of the seventeen specimens (23.5%) which molted from first form to second form did not regain the suture between the basipodite and the endopodite of the first pleopod. However, five of the seventeen (29.4%) regained the suture on the mesial side of the pleopod, and eight of the seventeen (47.1%) completely regained the suture. All of the second form males which molted into the first form condition lost the suture completely; the second form males possessing a complete suture without exception retained the complete suture in the next instar; and one specimen which molted from first form to first form failed to regain the suture.

One particular individual is worth mentioning. This specimen when captured was in the second form condition with a suture on the mesial surface of the first pleopod. Following its molt to first form it had lost the suture completely. Later, when it molted

back into second form it had regained the suture mesially. Finally, the complete suture was regained following the next molt which was from second form to second form.

Thus, the results of this study are in line with the general summary presented by Hobbs and Marchand (1943) and clearly demonstrates that in *O. clypeatus* the second form condition cannot be considered to be a developmental rather than a seasonal (reproductive) condition.

Comparison of Results with Previous Studies

The occurrence of second form individuals with only a mesial suture seems to further confuse the problem. Furthermore, as noted above, the majority of individuals molting from first form to second form regained the suture completely. Thus, this method is not a sure means of separating second form males of *O. clypeatus* which have never molted into first form from those which have molted into first form and then returned to the second form. Hagen (1870) mentioned the same phenomenon in his discussion on the second form of males of *Cambarus acutus* (probably *Procambarus blandingi acutus*). He stated that occasionally, both in younger and in full-grown specimens, the articulation between the basipodite and the endopodite was partly gone, but its remains were still visible on the upper margin; and that in most cases the articulation had entirely disappeared.

Several conclusions about *O. clypeatus* may be drawn from the results of this study. First, all the males lose the suture between the basipodite and the endopodite of the first pleopod following the molt into first form regardless of the condition of the suture prior to molting. Second, the majority of the first form males molt into the second form condition following the breeding season, thus disproving the idea that the second form is merely a developmental condition. Third, the presence or absence of a suture between the basipodite and the endopodite of the first pleopod of the second form male is not a sufficiently reliable character to be used as a means of distinguishing second form males which have not been in the first form previously, from those which have been in the first form.

Summary

O. clypeatus was found to have an average growth increment of 0.41 mm cephalothorax length per molt. This increment is constant throughout the life span of the individual.

The length of the carapace of *O. clypeatus* tends to increase approximately the same amount per molt regardless of sex or size.

The first and second pleopods of *O. clypeatus* undergo a very rapid allometric growth rate between the size ranges 5.0 and 10.4 mm cephalothorax length; however, above this size range their growth rates tend to parallel the growth rate of the cephalothorax in both first and second form males.

The growth rate of the first and second pleopods and their component parts tends to parallel closely that of the cephalothorax length in the first form males of all sizes and may be considered isometric.

All the males of *O. clypeatus* lose the suture between the basipodite and the endopodite of the first pleopod following the molt into first form regardless of the condition of the suture prior to molting.

First form males of *O. clypeatus* molt into the second form following the breeding season, thus disproving the idea that the second form is merely a developmental condition.

In *O. clypeatus* the presence or absence of a suture between the basipodite and endopodite of the first pleopod of the second form male is not a sufficiently reliable character to be used as a means of distinguishing second form males which have not been in the first form condition previously from those which have.

Acknowledgements

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Abstract

The crawfish, *Orconectes clypeatus*, was found to have an average growth increment of 0.41 mm cephalothorax length per molt. This increment was established under laboratory conditions and is apparently constant throughout the life span of the individual.

The first and second pleopods undergo a very rapid growth rate in early life exceeding the growth rate of the cephalothorax, however, after maturity the growth rates of the pleopods tend to parallel that of the cephalothorax.

The majority of the first form males kept in the laboratory molted into the second form condition following the breeding season, thus disproving the idea that the second form is merely a developmental condition.

In *O. clypeatus* the presence or absence of a suture between the basipodite and the endopodite of the first pleopod of the second form male is not a sufficiently reliable character to be used as a means of distinguishing second form males which have not been in the first form condition previously from those which have.

INDEX TO AUTHORS AND SCIENTIFIC NAMES

(New species and genera in boldface)

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