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A new species of *Semotilus* (Pisces: Cyprinidae) from the Carolinas

Franklin F. Snelson, Jr.
Department of Biological Sciences, Florida Technological University, Orlando, FL 32816

and

Royal D. Suttkus
Museum of Natural History, Tulane University, Belle Chasse, LA 70037

ABSTRACT: Snelson, Franklin F., Jr. and Royal D. Suttkus, A new species of *Semotilus* (Pisces: Cyprinidae) from the Carolinas. Bulletin Alabama Museum of Natural History, Number 3, 11 pages, 2 figures, 6 tables, 1977. A new species of chub, *Semotilus lumbee*, is described. It is endemic to the Sandhills region of North and South Carolina where it is known from the Cape Fear, Lumber (Little Peedee), and Yadkin (Peedee) river systems. On the basis of tuberculation, habitat, and distribution, we regard *S. atromaculatus* as the closest relative to *S. lumbee*. Although they are superficially similar, these two species differ trenchantly. The most important diagnostic characters of the new species are (1) dorsal fin rays nine, (2) pigment spot at origin of dorsal fin weak or absent, (3) different body form and morphometrics, (4) larger scales, and (5) a reduced number of cephalic lateral line pores.

The two species are distributionally segregated by the Fall Line. *S. atromaculatus* is absent from the Lumber River, where *S. lumbee* is most abundant, but occurs widely in Piedmont sections of the adjacent Cape Fear and Yadkin river systems. *S. lumbee* occurs in Coastal Plain streams immediately below the Fall Line. They occur in closely adjacent sections of the same stream systems in the Cape Fear and Yadkin drainages and have been collected together at the same site on two occasions in a Yadkin River tributary near the Fall Line.

The conservation status of the new species is a matter of concern. Peripheral populations appear to be too small and disjunct to be of importance in assuring long-term survival. The conservation of the species is dependent, therefore, upon the maintenance of suitable conditions in the center of abundance. Ongoing and planned development in a significant part of the Lumber River headwaters threatens continued stability of these central populations.

Introduction

During the late 1940's and early 1950's Cornell University ichthyology students celebrated spring rites by organizing collecting expeditions south through the central and south Atlantic states. These trips resulted in the discovery of several new species and subspecies and otherwise greatly extended the knowledge of eastern United States fishes. In addition, many now-distinguished scientists reflect upon these annual excursions as among the most influential events in their careers as graduate students.

On 30 March 1949, Edward C. Raney and a group of his students (including the second author) worked in a poorly studied area in the North Carolina Coastal Plain and collected three series of a chub resembling *Semotilus atromaculatus* (Mitchill). Raney recognized the fish as being atypical, especially in aspects of coloration and body shape. Later, detailed laboratory examination confirmed the distinctiveness of the new form. A second collecting expedition in 1951 yielded supplemental material. Over the succeeding years some data were assembled and additional collections accumulated, but the study was postponed by more urgent priorities. Consequently, the status of the fish has never been assessed in the literature (E. C. Raney, pers. comm.).

In 1974, Raney urged the first author to assume the study of this minnow and to follow it to completion. Almost thirty years after its original discovery, we herein describe the new species, *Semotilus lumbee*. We recognize

Editorial committee for this paper:

Dr. Carter Gilbert, Florida State Museum (University of Florida), Gainesville, FL 32601
Dr. Robert Jenkins, Department of Biology, Virginia Commonwealth University, Richmond, VA 23284

that an analysis of variation in *Semotilus atromaculatus* throughout its extensive range would be a desirable corollary study. Fortunately, such a time-consuming project is not required to establish the status of the new chub. This unusually distinctive species is clearly differentiated from all congeners and occurs sympatrically with its presumed closest relative, *S. atromaculatus*, in one area.

Counting and measuring procedures follow Hubbs and Lagler (1958) except as modified or supplemented by Snelson (1972).

Acknowledgements

Walter R. Courtenay, Jr. made X-ray facilities available. The FTU Computer Center provided computer support, and Thomas J. Barnes and Thomas O. Peeples assisted in data analysis. Donald G. Cloutman and Harold A. Loyacano provided information on South Carolina populations, and J. H. Carter, III, provided up-to-date reports on the potential environmental problems in the Aberdeen Creek-Drowning Creek area. Jeanne E. Suttkus assisted with specimen photography; Carter R. Gilbert and Robert E. Jenkins critically reviewed the manuscript. Our sincere appreciation to all these individuals. The institutions listed in Materials Examined and their curators and staffs have been most helpful in arranging specimen loans. We especially thank W. M. Palmer and the North Carolina State Museum staff for assistance and support in numerous ways and for allowing us to transfer specimens from their collection to other institutions. Finally, we are grateful to E. C. Raney for allowing us to describe this fish.

Semotilus lumbee new species
Sandhills Chub

Figure 1 a and b

HOLOTYPE.—TU 101095 (formerly NCSM 7090). Peedee (Lumber) drainage; North Carolina, Moore County, trib. of Aberdeen Creek at culvert on U. S. Hwy #1, 0.5 airmi SW jct Hwys #1 and #15 in center of Aberdeen; 8 May 1975; W. M. Palmer, A. L. Braswell, and J. E. Cooper (WMP 75-2).

The holotype is a tuberculate adult male 151.2 mm standard length with the following counts and measurements (expressed as percent of SL): lateral line scales 47; body circumferential scales 18+2+15 = 35; predorsal scales 28; anterior dorsolateral scale rows 24; caudal peduncle circumferential scales 9+2+7 = 18; dorsal fin rays 9; anal fin rays 8; pectoral fin rays 16; pelvic fin rays 8; predorsal length 50.7; postdorsal length 52.1; prepelvic length 46.4; preanal length 65.3; body depth 25.0; body width 19.1; caudal peduncle length 25.2; caudal peduncle depth 11.6; head length 25.3; head depth 18.1; fleshy interorbital width 12.1; postorbital head length 11.5; snout length 9.7; eye length 4.4; gape width 9.3; jaw length 9.7; dorsal fin length 24.5; anal fin length 21.8; pectoral fin length 16.6; pelvic fin length 15.2.

PARATYPES.—TU 101096, 10 specimens 52.4-78.6 mm SL; collected with the holotype. TU 97877, 13 specimens 53.3-139.1 mm SL; locality same as holotype, 12 May 1976; R. D. Suttkus *et al.* (RDS 6148). CU 55029, 15 specimens 27.8-124.4 mm SL; UF 23220, 15 specimens 28.4-118.8 mm SL; UMMZ 200201, 15 specimens 27.4-133.7 mm SL; and USNM 216715, 14 specimens 28.1-121.0 mm SL; the last four series together constitute the former NCSM 4139; Peedee (Lumber) drainage; North Carolina, Moore County, trib. of Aberdeen Creek at culvert on U. S. Hwy #1 at NE town limit of Pine Bluff; 6 July 1967; W. M. Palmer *et al.* (WMP 67-19).

Other specimens examined are not designated as paratypes and are listed at the end of the paper.

DIAGNOSIS.—Distinguished from all congeners and most other North American cyprinids in having nine rather than eight principal dorsal rays. From its closest relative, *Semotilus atromaculatus*, it differs in having larger scales (Table 1), fewer head canal pores (Table 2), and in numerous morphometric characters (Table 4). In addition, the anterior basidorsal spot usually characteristic of *S. atromaculatus* is typically diffuse or absent in *S. lumbee*. Table 6 summarizes the most important diagnostic features and other differences are noted under Comparisons.

DESCRIPTION.—Scale counts are presented in Table 1. Fin ray and gill raker counts are presented in Table 2 and vertebral counts are presented in Table 3. Other counts follow: anal fin rays 7 (in 3 specimens), 8 (48), and 9 (4), $\overline{X} = 8.0$; pelvic fin rays 8 (in 54 specimens) and 9 (1), $\overline{X} = 8.0$; pharyngeal teeth 2,5–4,2 (in 12 specimens), 2,5–4,1 (1), and 2,5–3,2 (1). Pore counts for the cephalic lateral line are given in Table 2. Preoperculomandibular (POM) canal usually interrupted between preopercle and mandible. Supratemporal (ST) canal usually complete but interrupted at dorsal midline in 18 of 52 specimens. Supraorbital (SO) and infraorbital (IO) canals always complete. Lateral line on body complete. Body fully scaled.

Subterminal maxillary barbel small, triangular, one present on each side; barbel located in groove between upper lip and preorbital; barbel well developed, protruding from groove when mouth is closed. Upper lip notably thicker at midline than at corners of mouth. Intestine short, with one S-shaped flexure; peritoneum silvery with melanophores scattered and few.

MORPHOMETRICS.—General body form is shown in Figure 1a, b. Table 4 summarizes morphometric data for *S. atromaculatus* and *S. lumbee* from Atlantic coast drainages in the Carolinas. Specimens between 80 and 115 mm SL were measured and compared with conspecifics of the opposite sex and heterospecifics of the same sex. Since males spanned a much broader size range, specimens over 115 mm SL were analyzed as a separate group and compared with heterospecific males in the same size category and conspecific males in the smaller size class.

Sexual dimorphism is apparent for a number of characters. Males of *Semotilus lumbee* differ significantly

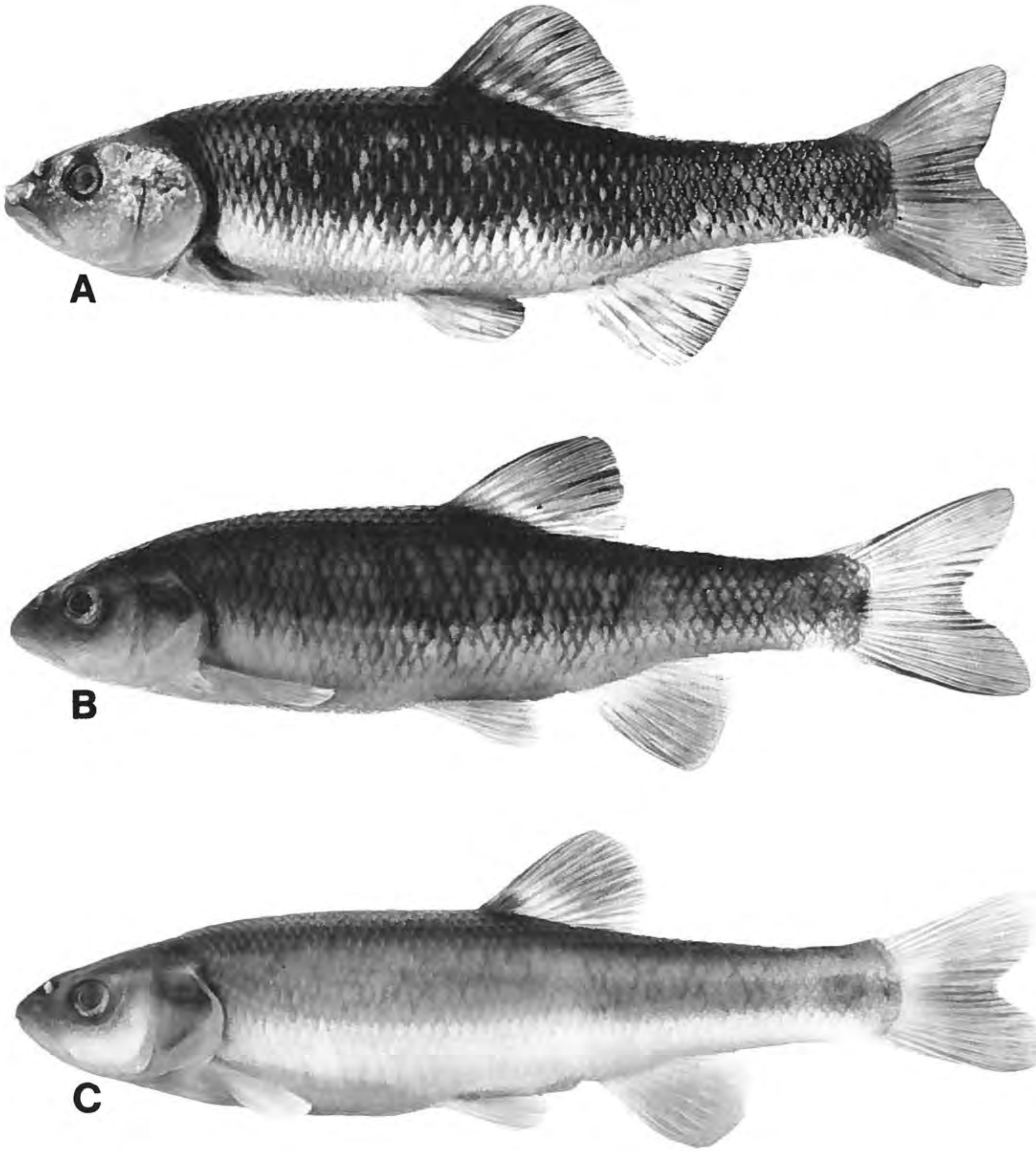

Fig. 1. Lateral view of two species of *Semotilus*. A. *S. lumbee* holotype, TU 101095, breeding adult male 151 mm SL. B. *S. lumbee* paratype, UMMZ 200201, adult female 103 mm SL. C. *S. atromaculatus*, TU 101726, adult female 106 mm SL.

($p < 0.01$) from females in having greater caudal peduncle depth and interorbital width and longer anal and pectoral fins. *S. atromaculatus* is more strongly sexually dimorphic. It shows significant differences in the same four characters as *S. lumbee*. In addition, values for males are significantly higher than those for females for head length, head depth, postorbital head length, snout length, jaw length, dorsal fin length, and pelvic fin length (Table 4).

Ontogenetic changes in many measurements are apparent, and they are indicated in Table 4 where small and large males of a species show significant mean differences. Table 5 summarizes the statistics for those measurements showing significant ontogenetic change as indicated by linear regression analysis. Males of *S. lumbee* show significant allometry in many characters, but the specimens measured covered a much greater size range than in other groups. Both sexes of both species show strong negative allometry in eye size.

COLORATION.—Adult pigment pattern is shown in Fig. 1a, b. Young and small juveniles with broad, dark, midlateral stripe extending along side of body from caudal base across head, terminating on preorbital. Stripe uniform in width along body, expanded slightly just anterior to caudal base, and bordered above by light (sparsely pigmented) stripe of approximately same width. Upper sides and back dusky to olive-brown. Dark triangular or subrectangular spot at base of caudal rays separate from or weakly joined to lateral stripe. Dark lateral stripe and other features of juvenile coloration fade with growth, and most specimens in excess of 70 mm SL show typical adult pigmentation.

In adults, dorsal and dorsolateral scales moderately to strongly outlined by pigment concentrated along scale borders. A variable number of differentially darker scales present on sides of body, producing scattered, crescent-shaped marks. Area over cleithrum heavily pigmented, resulting in dark band bordering posterior edge of operculum. Dorsal fin usually without circular pigment spot at its origin; when pigment is present in this area, it is dusky and diffuse (Fig. 1b). Dorsal fin pigmentation most highly developed in large, breeding males. In such specimens, entire fin dusky but base usually somewhat darker than other parts; dark basal area often broader and more pronounced anteriorly, producing poorly defined spot (Fig. 1a).

In life, most large specimens exhibit faint pink or orange tinges in all fins, at least in the spring and early summer. In large males, the fins, especially the dorsal and caudal, become suffused with melanin and the pink color is masked. In breeding males, the suborbital, preopercle, subopercle, upper branchiostegal rays and lower part of the opercle are pink or orange. The ventral and ventrolateral surfaces of the body from the cleithrum to the vent are pale pink, as is the chin. Scales on the dorsolateral surface of the body are golden. The pectoral, pelvic, and anal fins of nuptial males range from pink to bright orange.

TUBERCULATION.—Females are nontuberculate. Eleven tuberculate males range from 112-192 mm SL, with only three specimens less than 130 mm. Collection dates range from 29 March to 12 May for the ten most strongly tuberculate specimens. A male collected 30 June is distinctly postnuptial and retains primarily scars and cores of tubercles. The smallest specimen is weakly tuberculate and the testes are only moderately enlarged.

Large, stout tubercles, usually with curved, pointed, horn-like tips, project laterally from three areas on head: the postorbital tubercle immediately behind posterior-dorsal margin of eye, the preorbital tubercle immediately in front of anterior-dorsal margin of eye, and the snout tubercles on side of snout between external nare and upper lip.

Postorbital tubercle always largest, most prominent head tubercle; always single, with large, robust base tapering to pointed tip curving posteriorly and ventrally. Preorbital tubercle much smaller than postorbital, more variable in development, completely absent from one or both sides in three specimens 112, 128, and 132 mm SL; present on both sides but very small in a specimen 128 mm SL; when present, always single; shape usually bluntly conical, without curved, horn-like tip. Snout always with multiple tubercles, either two (6 specimens) or three (4 specimens) per side; these appearing as separate tubercles in smaller specimens but as one large, coalesced tubercle with multiple tips in larger specimens; anterior-most snout tubercle(s) (or tips) usually smaller than more posterior one(s); posterior-most snout tubercle only slightly smaller than postorbital tubercle; snout tubercles usually with elongate, pointed, horn-like tips curving posteriorly and slightly dorsally or ventrally. Supernumerary tubercles present in two males; one specimen with very small tubercles laterally on lip (one on left side) and snout tip (one on both sides); other specimen with one small tubercle in suborbital area on right side only. Head devoid of tubercles elsewhere.

Large tuberculate males with thickened, cornified integument covering all lateral areas of head, but thickest and most strongly cornified in areas immediately behind eye (below postorbital tubercle, and across upper parts of preopercle and opercle), below eye (over circumorbital bones) and in front of eye (below preorbital tubercle or between it and nare). Cornified integument weak or absent in smaller tuberculate males.

Body devoid of tubercles except on caudal peduncle; 5-10, usually 7-10, tubercles line posterior margin of body scales; tips of these tubercles distinctly retrorse and occasionally bifid; tubercles begin on midlateral scales in area above middle of anal fin base, spreading dorsally and ventrally to cover all lateral scales of caudal peduncle posteriorly to caudal fin base; tubercles weaker and more variable, occasionally absent, in dorsal and ventral midlines of caudal peduncle.

Dorsal and pelvic fins nontuberculate; anal fin nontuberculate (8 specimens) or with a few small tubercles scattered over rays 2-7 (3 specimens). Pectoral fin with first ray nontuberculate; rays 2-7 or 9 with erect to retrorse tubercles on dorsal surfaces; these tubercles moderately large, uniserial from near ray base to bifurcation where series divides, with uniserial row continuing along each ray branch; distal third or fourth of rays nontuberculate. Caudal fin with middle rays always tuberculate; numerous small, erect tubercles arranged irregularly, rarely uniserially, over proximal half to three-quarters of central 7-10 rays; upper and lower rays of fin lobes usually with a few small, widely scattered tubercles, more consistent dorsally than ventrally; upper procurrent rays often with a few, slightly enlarged tubercles; lower procurrent caudal rays usually nontuberculate.

ETYMOLOGY.—The name Lumbee is in reference to Indians of unknown, perhaps mixed, origin that inhabited the area along the Lumber River, primarily in Robeson County, North Carolina. The Lumbee have been variously stated to be of Croatan, Catawba, or Cherokee ancestry and were at one time thought to be descendants of the Lost Colony of Sir Walter Raleigh's expedition (McPherson, 1915; Rights, 1947). The name Lumbee is apparently of rather recent origin and may not be of Indian derivation (J. L. Coe, pers. comm.).

Comparisons

Table 6 summarizes major diagnostic differences between *S. lumbee* and *S. atromaculatus.* Tables 1-4 reveal that the species differ significantly but less dramatically in many other meristic and morphometric characters not noted in Table 6.

S. lumbee differs most trenchantly from *S. atromaculatus,* other congeners, and most North American cyprinids in the possession of nine principal dorsal rays. In addition to the counts presented in Table 2, dorsal fin rays were counted in another 95 specimens of *S. lumbee* in confirmation of identification and distributional records. Of these, dorsal rays were 8 in 3 specimens and 9 in 92. In addition to Carolina populations analyzed in Table 2, selected samples of *S. atromaculatus* from throughout its broad range were examined; dorsal rays were 7 (in 2 specimens), 8 (733), and 9 (15). It seems likely that no population of *S. atromaculatus* is characterized by 9 dorsal rays.

Semotilus atromaculatus is known to exhibit geographic variation in many characters, especially certain scale counts. Our preliminary data show that some Gulf coast drainage populations (the nominal form *thoreauianus* Jordan) have scale counts approaching those of *S. lumbee.* Bailey, Winn, and Smith (1954) stated that scale size in *S. atromaculatus* increases clinally from north to south, but they gave no data. Although characterized by relatively large scales, Gulf coast populations have 8 dorsal rays, (usually) a distinctive anterior basidorsal spot, typical *S. atromaculatus* body form, and are clearly distinct from *S. lumbee.*

In comparing *S. lumbee* and Carolina populations of *S. atromaculatus,* many subtle differences are apparent. In breeding male *S. atromaculatus,* the three major head tubercles are more nearly the same size, with more prominently pointed and retrorse tips. The snout tubercle is usually single, occasionally double or with double tips. Body tubercles in *S. atromaculatus* extend farther forward on the side of the caudal peduncle and tubercles are absent from the caudal fin. The more elongated appearance of *S. atromaculatus* is due primarily to the positioning of the fins farther posteriorly, lesser body depth, smaller fins, and longer head. Fin position is related to vertebral characters; *S. atromaculatus* has, on the average, one more precaudal and one less caudal vertebra than *S. lumbee,* and the dorsal fin is positioned farther posteriorly in relation to the vertebrae (Table 3). The head and snout of *S. lumbee* are more triangular and pointed, both in lateral and dorsal view, and the mouth is less oblique and smaller than that of *S. atromaculatus.* The barbel of *S. atromaculatus* is highly variable, but usually bluntly triangular. The barbel of *S. lumbee* has a more elongated, tapering tip. Finally *S. lumbee* appears to attain a larger adult size than most populations of *S. atromaculatus* along the central Atlantic coast.

S. lumbee shares certain features in common with *S. corporalis* (Mitchill), most notably rather large scale size and a more anterior dorsal fin position. Of course, it differs trenchantly from *S. corporalis* in possessing nine dorsal rays and in many aspects of coloration, morphometry, and size. In addition, breeding males of *S. corporalis* possess numerous, small tubercles scattered over the head, in sharp contrast to the few large head tubercles in *S. lumbee.* The distributional hiatus between *S. corporalis* (south on Atlantic slope through James River drainage, Virginia) and *S. lumbee* and the preferred habitat of the former species (large creeks and rivers) suggest that these two fish are not intimately related. In our view, distribution pattern, habitat preference, and especially the close similarity in the highly distinctive pattern of tuberculation, all confirm a close relationship between *S. lumbee* and *S. atromaculatus.*

Distribution and Habitat

The vast majority of the records of *S. lumbee* are from the Drowning Creek system in the headwaters of the Lumber River (Little Peedee system of the Peedee drainage) in southeastern Moore County and extreme northeastern Richmond County, North Carolina (Fig. 2). Within this very limited area, there are multiple records from two localities on Drowning Creek and from five of its small tributaries. The species also occurs in the immediately adjacent Big Mountain Creek system, which is a westward-flowing tributary of the Peedee (Yadkin) River in Richmond County. In addition, it inhabits the Cape Fear drainage, where it occupies streams adjacent to the Lumber system on the northeast in Cumberland, Hoke, and Moore counties (five localities in two major stream systems). Finally, the species has been collected once at each of two somewhat disjunct Peedee River tributaries in Chesterfield and Kershaw counties, South Carolina. These latter localities are about 80 kilometers southwest of the center of the species' distribution in North Carolina.

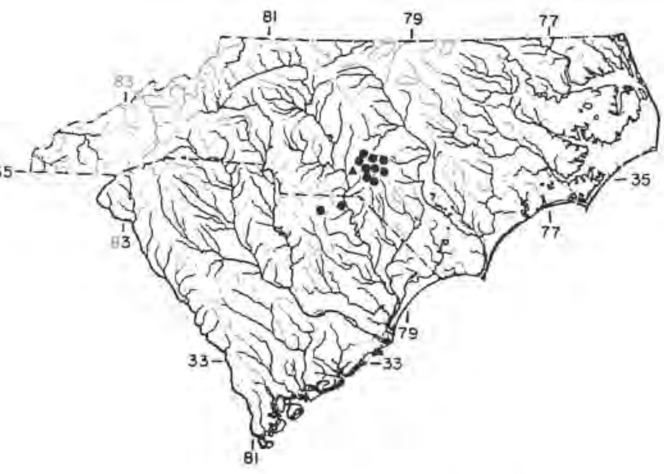

Fig. 2. Distribution of *Semotilus lumbee* in North and South Carolina (circles). Syntopic collections of *S. lumbee* and *S. atromaculatus* are designated by a triangle. Broadly overlapping symbols and imprecise localities are not plotted.

The range of *S. lumbee* lies immediately below the Fall Line, and all known localities are within or on the fringes of an unusual geological area referred to as the Carolina Sandhills. The Carolina Sandhills is a segment of the Fall Line hills, a discontinuous belt of low, rolling terrain that borders the seaward edge of the Fall Line and extends from central North Carolina through central Alabama. The Carolina Sandhills is best developed in Hoke, Moore, Richmond, and Scotland counties, North Carolina; and it extends into Chesterfield County, South Carolina. Remnants of the Carolina Sandhills persist further south and southwest in South Carolina; but the characteristic features become progressively less distinctive, and there is a change in soil type at the Santee River Valley (Heron, 1958; Duke, 1961).

Topographically, the Carolina Sandhills is an area of gently rolling hills from 60 to 150 m above sea level. The hills are blanketed with loose sand and typical vegetation is pine-turkey oak and scrub oak associations (Duke, 1961). The area is well drained and headwater tributaries are in a youthful stage of development with well-marked, though flat, drainage divides. The soil type is classified as Norfolk (Duke, 1961; Bartlett, 1967).

The subsurface geology of the Carolina Sandhills is fairly well known. Underlying strata are mostly of Cretaceous origin and the boundary of the Sandhills coincides approximately with the Middendorf (Tuscaloosa) formation. The eastern edge coincides roughly with the Orangeburg (Citronelle) escarpment, a probable Miocene shoreline (Heron, 1958; Bartlett, 1967; Swift and Heron, 1969; Cooley, 1970).

The origin of the loose surficial sands of the area has been a matter of controversy for over one hundred years (see Cooley, 1970, for literature review). In general, most early authors postulated marine submergence as the source; whereas, most recent accounts document fluvial origin. The Pinehurst Formation, the most widespread formation in the Carolina Sandhills, is composed of nonfossiliferous sands apparently weathered from the underlying Middendorf formation and shaped into dune-like hills by eolian and fluvial influences. Considerable evidence now suggests that most of the Carolina Sandhills have not been inundated by the ocean since late Eocene times (Duke, 1961; Bartlett, 1967; Cooley, 1970).

Streams inhabited by *S. lumbee* are typically small to moderate size creeks (2-4 m wide) carrying clear water that may be darkly stained. Bottom materials are usually sand, with gravel or rubble in some areas. Silt deposits cover the bottom in pools and protected areas. Current in these streams is moderate, noticeably faster than most other Coastal Plain streams. Pools range to about 1.5 m deep and alternate with shallow stream sections. The only record of this species from a relatively large stream is a single young taken in the Lynches River in South Carolina. This individual may have been a waif from a tributary population.

Semotilus lumbee and its close relative *S. atromaculatus* are only rarely sympatric. In general, *S. lumbee* is restricted to the Sandhills formation and is found only at or below the Fall Line. *S. atromaculatus*, in contrast, is rare or absent in the Sandhills and usually occurs above the Fall Line in Piedmont streams, at least in this part of its range.

Semotilus atromaculatus does not occur in the Lumber River system where *S. lumbee* is most abundant. However *S. atromaculatus* is abundant and widespread in Piedmont portions of adjacent drainages, the Peedee (Yadkin) on the southwest and the Cape Fear on the northeast. *S. lumbee* and *S. atromaculatus* have been collected together on two occasions in the Big Mountain Creek system, a tributary of the Peedee River, in Richmond County, North Carolina. *S. atromaculatus* alone is known to occupy other nearby tributaries of the Peedee. In the Cape Fear drainage, the two species have not yet been taken together, although they occupy streams in relatively close proximity. For example, both are known from streams in the Little River system in Moore County, North Carolina. In the South Carolina Sandhills, *S. lumbee* is rare and *S. atromaculatus* absent in well-collected areas around the Carolina Sandhills National Wildlife Refuge in Chesterfield County (D. G. Cloutman, pers. comm.). Both species are present in the Lynches River system. *S. lumbee* is represented by a single young individual collected in the River immediately below the Fall Line; *S. atromaculatus* is known from at least four collections in headwaters of Lynches River above the Fall Line (H. A. Loyacano, pers. comm.).

The distribution of *S. lumbee* coincides almost exactly with that of another Carolina endemic, *Etheostoma mariae* (Fowler). This darter is also limited to the Sandhills area in the Lumber and Peedee river systems. Unlike *S. lumbee*, it has not been discovered in the Cape Fear drainage (Richards, 1963).

Conservation Status

Like all other species with severely restricted distributions, the long-term survival of *S. lumbee* is in jeopardy. It is generally distributed and common only in the headwaters of the Lumber River system. Outside this system, collection localities are rather scattered and samples are small, suggesting a pattern of small, disjunct populations around the periphery of the range. In general, the distribution suggests a species that was once widespread throughout Carolina Sandhills streams but has retracted its range in recent years, leaving small peripheral populations isolated in favorable habitats. Alternatively, this species always may have been rare and scattered throughout its range, but may have encountered unusually favorable conditions in headwaters of the Lumber River. In either case, it appears that the conservation of this species is dependent on the maintenance of suitable conditions in the upper Lumber River system. Populations outside this area seem to be too small and scattered to be of importance in assuring the long-term survival of *S. lumbee*.

Aberdeen Creek, the type locality stream and near the center of abundance for the species, appears to have deteriorated in recent years. The expansion of the towns of Aberdeen, Pinehurst, Pine Bluff, and Southern Pines and concomitant construction have altered many parts of the Aberdeen Creek system. General collecting data suggest that populations of *S. lumbee* at certain sites have been reduced or at least have become highly variable in recent years.

A sewer interceptor line is currently under construction along the full length of Aberdeen Creek; and a second line, which would cross the Creek at two points, is under consideration. A sewage treatment plant is being built at Addor and its outfall will enter Aberdeen Creek just upstream from the Drowning Creek confluence. It will have an initial treatment capacity of 6.7 million gallons per day (MGD). Construction of a regional water treatment plant, drawing water from Drowning Creek, is proposed; but construction has been at least temporarily averted.

During periods of natural low flow, Drowning Creek may virtually dry up. In the fall of 1968, a severe drought lasted over six weeks. Drowning Creek at U.S. Hwy #1 bridge had a seven-day low flow of 15.7 MGD, about ten percent of average flow; and most upstream tributaries were nearly dry. Heavy water utilization would certainly compound the stress caused by such natural drought conditions. In addition, future expansion of the water-using utilities might require the construction of a large impoundment to ensure adequate supply. There has been no comprehensive review of the environmental impact of these projects. Under certain realistic circumstances, it would appear that the entire aquatic biota of the upper Lumber River could be in serious jeopardy (J. H. Carter, III, pers. comm.).

The states of North and South Carolina have recently convened conferences to consider the status of their rare and endangered biota. North Carolina will treat *Semotilus lumbee* under the category "special concern" (W. M. Palmer, pers. comm.). South Carolina will list the species as "threatened" in the state (H. A. Loyacano, pers. comm.). Current developments in the Lumber River headwaters suggest that this species should be closely monitored.

Material Examined

The following institutional abbreviations are used in recording material examined: CU (Cornell University), DU (Duke University), NCSM (North Carolina State Museum), TU (Tulane University), UF (University of Florida, Florida State Museum), UMMZ (University of Michigan Museum of Zoology), UNCC (University of North Carolina at Charlotte), and USNM (U.S. National Museum of Natural History).

Semotilus lumbee

Forty collections containing 566 specimens have been examined. None of the following material is designated as paratypes.

Cape Fear River drainage. **North Carolina:** CUMBERLAND COUNTY: DU F-342,343 (2) small creek 0.6 mi W Manchester on N.C. Hwy 87, 27 March 1962. HOKE COUNTY: CU 15276 (3) small stream 6 mi S Fayetteville fish hatchery, 18 June 1946; NCSM 2678 (1) Beaver Creek 4 mi NE Raeford off N.C. Hwy 401, 9 July 1962. MOORE COUNTY: CU 35339 (12) trib. crossing N.C. Hwy 211 7.5 mi W jct. with U.S. Hwy 1 in Pinehurst, 1 April 1960; NCSM 7063 (6) Mill Creek, trib. to James Creek, in Weymouth Woods Sandhills Nature Preserve off county Rd 2033 2 airmi SE center Southern Pines, 1 July 1976.

Peedee River drainage (Little Peedee=Lumber River system). **North Carolina:** MOORE COUNTY: CU 15489 (50) trib. to outlet of Aberdeen Lake 0.2 mi S city limit Aberdeen on U.S. Hwy 1, 30 March 1949; CU 16905 (2) Ray Mill Brook at Aberdeen, 30 March 1949; CU 19470 (5) trib. of Aberdeen Creek 0.2 mi S Aberdeen on U.S. Hwy 1, 29 March 1951; CU 19762 (40) Drowning Creek on Moore-Montgomery county line, 3 mi W Jackson Springs, 29 March 1951; CU 26013 (1) trib. of Drowning Creek at S city limits Pine Bluff on U.S. Hwy 1, 2 April 1954; CU 26044 (3) trib. of Drowning Creek 1 mi SW Aberdeen on U.S. Hwy 1, 2 April 1954; CU 32689 (3) culvert draining from pond along U.S. Hwy 1 just N Pine Bluff city limits, 2.1 mi SW Aberdeen, 3 April 1959; CU 32694 (14) culvert on U.S. Hwy 1 about 0.5 mi N Pine Bluff, 1.5 mi SW Aberdeen, 3 April 1959; CU 32704 (12) culvert at S city limits Aberdeen on U.S. Hwy 1, 3 April 1959; CU 35307 (32) outlet from beaver pond 4.4 mi NE Drowning Creek on U.S. Hwy 1, 1 April 1960; CU 35854 (3) stream 1.9 mi W jct. U.S. Hwy 1 and N.C. Hwy 211 on 211, 1 April 1960; CU 43534 (12) between Aberdeen and Pine Bluff on U.S. Hwy 1, 8 September 1962; DU F-337-340 (4) Horse Creek 2 mi NW Pine Bluff on county Rd 1112, 6 May 1970; DU F-341 (1) Deep Creek 5 mi WNW Pine Bluff on county Rd 1112, 6 May 1970; NCSM 1250 (2) Horse Creek, trib. of Drowning Creek, 1 mi E Roseland on Aberdeen Rd, 1 July 1960; NCSM 2370 (14) Meadow Creek near Jackson Springs, below Jackson Pond off N.C. Hwy 73, 29 June 1960; NCSM 6395 (6) Sandy Run at county Rd 1122 culvert 3.3 airmi WSW center Pinehurst, 8 May 1975; TU 97887 (33) Sandy Run at county Rd 1122 bridge 8.6 mi NW Aberdeen, 12 May 1976; UF 17895 (20) small creek at NW city limits Pine Bluff on U.S. Hwy 1, 27 April 1971; UF 23301 (12) trib. on U.S. Hwy 1 at NE city limit Pine Bluff, 2.3 airmi SW center Aberdeen, 30 June 1974; UF 23302 (40) Sandy Run at culvert on county Rd 1122, 3.3 airmi WSW center Pinehurst, 30 June 1974; UNCC 69-96-1 (1) Deep Creek 6.5 mi W Aberdeen at county Rd 1113, 27 June 1968; RICHMOND COUNTY: DU F-334-336 (3) outlet to Broad Acres Lake 1 mi S Hoffman, 2 April 1964; NCSM 5508 (15) trib. of Naked Creek 0.5 mi W Derby on county Rd 1458, 27 June 1969; UNCC 69-94-3 (9) Naked Creek 1.5 mi WSW Derby on county Rd 1458, 27 June 1969; UNCC 69-95-1 (41) trib. of Naked Creek 0.5 mi W Derby on county Rd 1458, 27 June 1969.

Peedee River drainage (Yadkin River system). **North Carolina:** MONTGOMERY COUNTY: NCSM 3698 (3) trib. of Mountain Creek 2 mi W Norman, 7 July 1960. RICHMOND COUNTY: CU 35231 (6) trib. Big

Mountain Creek 2.3 mi NE jct. U.S. Hwy 220 and N.C. Hwy 73 on Hwy 73, 2 April 1960; NCSM 7134 (1) trib. Mountain Creek at culvert on county Rd 1153 3.7 rdmi W jct. N.C. Hwy 220 in Norman, Richmond-Montgomery county line, 30 June 1974. **South Carolina:** CHESTERFIELD COUNTY: CU 43529 (8) stream on U.S. Hwy 1 2.2 mi NE jct. Hwy 102 at Patrick, 8 September 1962; UF 23303 (1) Lynches River at Hwy 903 about 12 airmi ENE Kershaw, Chesterfield-Kershaw county line, 17 September 1976.

Semotilus atromaculatus

Several hundred series of *S. atromaculatus* have been examined in cursory fashion. Two hundred and fifty-one collections from the mid-Atlantic states have been examined in more detail for information on variation, distribution, and comparison. Only those series used in generating counts and measurements presented in Tables 1-4 are noted here by drainage and museum number.

Neuse drainage. CU 9691, CU 19843, NCSM 1915, NCSM 1951.

Cape Fear drainage. CU 34554, NCSM 2958, NCSM 5556. NCSM 6171.

Peedee drainage. CU 9282, CU 11422, CU 11993, CU 25104, CU 30038, CU 30057, NCSM 3697, NCSM 5903, NCSM 5914.

Santee drainage. CU 17073, CU 17720, NCSM 2292, USNM 216804, USNM 216805, USNM 216806, USNM 216807.

Savannah drainage. USNM 162362, USNM 216808, USNM 216809, USNM 216810.

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Table 1. Scale counts for two species of *Semotilus* from Atlantic coast drainages of the Carolinas.

Predorsal Scales

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	N	$\bar{X}$
lumbee	3	3	10	4	6	7	9	4	2	1			1												50	31.3
atromaculatus			1		1	1	4	6	3	5	6	4	7	8	11	4	7	2	4	1	1	2	2	1	81	39.6

Lateral Line Scales

	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	N	$\bar{X}$
lumbee	1		1	4	15	15	8	6	4		1							55	47.1
atromaculatus						2	8	9	19	21	19	15	7	2			2	104	51.2

Circumference Scales Above Lateral Line

	17	18	19	20	21	22	23	N	$\bar{X}$
lumbee	3	25	27					55	18.4
atromaculatus			6	24	58	14	2	104	20.8

Circumference Scales Below Lateral Line

	13	14	15	16	17	18	19	20	21	N	$\bar{X}$
lumbee	1	15	36	2						54	14.7
atromaculatus			1	9	22	29	21	19	3	104	18.2

Total Circumference Scales

	33	34	35	36	37	38	39	40	41	42	43	44	45	N	$\bar{X}$
lumbee	2	10	22	18	2									54	35.1
atromaculatus				1		4	17	16	23	22	9	8	3	103	41.1

Anterior Dorsolateral Scale Rows

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	N	$\bar{X}$
lumbee	1	3	10	17	12	10	1								54	24.3
atromaculatus						7	17	21	24	23	7	4		1	104	28.8

Caudal Peduncle Scales Above L.L.

	8	9	10	11	N	$\bar{X}$
lumbee	3	48	2	1	54	9.0
atromaculatus	3	84	15	1	103	9.1

Caudal Peduncle Scales Below L.L.

	6	7	8	9	10	N	$\bar{X}$
lumbee	1	47	6			54	7.1
atromaculatus		9	27	63	4	103	8.6

Total Caudal Peduncle Scales

	16	17	18	19	20	21	22	N	$\bar{X}$
lumbee	1	2	43	7		1		54	18.1
atromarulatus		1	10	22	55	10	4	102	19.7

Table 2. Cephalic lateral line pore, fin ray, and gill raker counts for two species of *Semotilus* from Atlantic coast drainages of the Carolinas.

	POM Canal Pores																								
	11	12	13	14	4+5	5+4	5+5	4+6	5+6	6+6	5+7	6+7	7+6	5+8	7+7	6+8	7+8	8+7	6+9	8+8	7+9	8+9	10+10	N	% Inter-rupted
lumbee	1				5	3	23	4	19	1														56	98.2
atromaculatus	3	2	6	4						15	1	17	9	1	14	14	9	2	1	2	3	1	1	105	85.7

	ST Canal Pores																	
	5	6	7	8	2+2	2+3	3+2	3+3	2+4	3+4	4+3	4+4	5+3	3+5	4+5	5+4	N	% Interrupted
lumbee	4	13	8	9			1	6		1	3	7					52	34.6
atromaculatus		1			11	10	6	35	2	13	8	11	1	1	3	1	103	99.0

	SO Canal Pores								
	5	6	7	8	9	10	11	N	X̄
lumbee	1	1	17	35	4			58	7.7
atromaculatus			6	32	42	23	1	104	8.8

	IO Canal Pores											
	11	12	13	14	15	16	17	18	19	20	N	X̄
lumbee	1	2	13	19	12	7	2	1			57	14.3
atromaculatus			2	14	27	24	19	10	3	3	102	16.0

	Dorsal Fin Rays					
	7	8	9	10	N	X̄
lumbee		2	58	1	61	9.0
atromaculatus	1	106			107	8.0

	Pectoral Fin Rays							
	15	16	17	18	19	20	N	X̄
lumbee	1	23	27	5			56	16.6
atromaculatus	2	15	39	39	4	1	100	17.3

	Lower Limb Gill Rakers							
	3	4	5	6	7	8	N	X̄
lumbee	4	25	19	3			51	4.4
atromaculatus	2	9	26	26	25	5	93	5.8

Table 3. Vertebral counts for two species of *Semotilus* from Atlantic coast drainages of the Carolinas. The position of the first pterygiophore of the dorsal fin is recorded in relation to the neural spine of the vertebrae between which it inserts.

	Precaudal Vertebrae					
	21	22	23	24	N	X̄
lumbee	4	26	4		34	22.0
atromaculatus		4	41	10	55	23.1

	CaudalVertebrae					
	18	19	20	21	N	X̄
lumbee	1	16	16	1	34	19.5
atromaculatus	21	32	2		55	18.7

	Total Vertebrae					
	40	41	42	43	N	X̄
lumbee	1	16	16	1	34	41.5
atromaculatus	1	16	33	5	55	41.8

	First Dorsal Pterygiophore Position					
	13-14	14-15	15-16	16-17	17-18	N
lumbee	15	19				34
atromaculatus		3	46	5	1	55

Table 4. Summary of morphometric data for two species of *Semotilus* from Atlantic coast drainages of the Carolinas. Standard length is given in millimeters; all other characters are converted to thousandths of standard length. For each character the range is given first followed in parentheses by the mean. A mean in bold type is significantly different from the mean of that character for the other species, same sex and size group. A mean followed by an asterisk is significantly different from the mean of the other sex, same species and size group. A mean followed by a plus sign is significantly different from the mean of the other size group, same species and sex. T-test was used to compare means and the significance level was 0.01.

	lumbee small males N=11	*lumbee* large males N=13	*lumbee* small females N=20	*atromaculatus* small males N=25	*atromaculatus* large males N=10	*atromaculatus* small females N=14
Standard Length	81.3-110.2 (98.0)	115.8-191.5 (146.8)	81.0-109.9 (94.5)	80.7-112.9 (97.0)	115.8-143.8 (125.6)	84.6-114.3 (95.5)
Predorsal Length	520 - 543 (532)+	507 - 528 (521)+	519 - 549 (536)	552 - 589 (567)	553 - 571 (561)	549 - 577 (561)
Postdorsal Length	491 - 505 (499)+	493 - 530 (510)+	488 - 517 (500)	438 - 491 (464)	446 - 479 (466)	446 - 489 (463)
Prepelvic Length	481 - 504 (492)+	464 - 493 (481)+	475 - 509 (494)	477 - 530 (503)	486 - 521 (502)	490 - 522 (505)
Preanal Length	663 - 689 (677)+	646 - 681 (664)+	665 - 694 (682)	665 - 711 (688)	665 - 705 (683)	676 - 704 (691)
Body Depth	254 - 276 (264)	243 - 274 (259)	241 - 297 (265)	233 - 270 (252)	237 - 266 (251)	232 - 291 (254)
Body Width	148 - 180 (167)	151 - 191 (169)	152 - 192 (173)	156 - 196 (175)	164 - 188 (174)	157 - 215 (181)
Peduncle Length	222 - 250 (238)	230 - 259 (244)	224 - 243 (234)	204 - 252 (229)	211 - 237 (228)	218 - 244 (231)
Peduncle Depth	115 - 124 (120)*	104 - 125 (115)	105 - 123 (115)*	109 - 126 (119)*	105 - 124 (116)	108 - 120 (114)*
Head Length	239 - 258 (252)	242 - 256 (249)	238 - 262 (250)	254 - 288 (273)*	258 - 283 (272)	251 - 272 (262)*
Head Depth	177 - 190 (184)	176 - 193 (183)	176 - 194 (185)	175 - 194 (188)*	183 - 197 (190)	171 - 188 (179)*
Interorbital Width	112 - 119 (116)*	112 - 124 (117)	104 - 117 (111)*	112 - 129 (121)*	114 - 127 (120)	104 - 119 (111)*
Postorbital Head Length	109 - 117 (114)*	103 - 118 (112)	102 - 118 (110)*	124 - 147 (135)*	127 - 142 (136)	118 - 131 (125)*
Snout Length	81 - 87 (83)+	83 - 97 (90)+	71 - 89 (82)	77 - 91 (85)*	82 - 92 (88)	77 - 87 (82)*
Orbit Length	50 - 61 (55)+	41 - 53 (46)+	53 - 64 (58)	51 - 62 (55)+	45 - 53 (49)+	52 - 59 (55)
Gape Width	75 - 85 (81)+	78 - 105 (88)+	73 - 86 (79)	83 - 104 (97)	85 - 119 (100)	77 - 104 (91)
Jaw Length	88 - 100 (95)	94 - 101 (97)	82 - 102 (95)	98 - 119 (109)*	103 - 122 (110)	94 - 111 (102)*
Dorsal Fin Length	225 - 252 (239)	236 - 256 (245)	223 - 245 (232)	206 - 227 (215)*+	209 - 234 (221)+	199 - 215 (208)*
Anal Fin Length	197 - 219 (207)*	200 - 229 (214)	191 - 212 (199)*	175 - 206 (188)*+	189 - 205 (195)+	170 - 190 (180)*
Pectoral Fin Length	181 - 202 (188)*+	166 - 184 (176)+	164 - 188 (179)*	160 - 194 (172)*	161 - 181 (173)	155 - 174 (164)*
Pelvic Fin Length	158 - 183 (168)+	152 - 167 (160)+	151 - 173 (163)	136 - 166 (147)*	144 - 153 (148)	132 - 148 (141)*

Table 5. Summary of allometric measurements for two species of *Semotilus* from Atlantic coast drainages of the Carolinas. Measurements were converted to percent of SL and linearly regressed against SL. Significance levels greater than 0.01 were considered not significant. Following each character the correlation coefficient (r) is given first, followed by the significance level.

	Semotilus lumbee			
Character	Males; N=24 81.3 – 191.5 mm SL		Females; N=25 81.0 – 133.8 mm SL	
Predorsal Length	–0.70;	0.00006		
Postdorsal Length	0.80;	0.00001		
Prepelvic Length	–0.72;	0.00003		
Preanal Length	–0.81;	0.00001		
Peduncle Length	0.57;	0.00193		
Peduncle Depth	–0.51;	0.00566		
Head Depth			–0.49;	0.00663
Snout Length	0.80;	0.00001		
Orbit Length	–0.93;	0.00001	–0.93;	0.00001
Gape Width	0.77;	0.00001		
Dorsal Fin Length	0.49;	0.00921		
Anal Fin Length	0.64;	0.00035		
Pectoral Fin Length	–0.86;	0.00001	–0.53;	0.00347
Pelvic Fin Length	–0.75;	0.00001	–0.51;	0.00513
	Semotilus atromaculatus			
Character	Males; N=35 80.7 – 143.8 mm SL		Females; N=17 84.6 – 128.8 mm SL	
Peduncle Length			–0.57;	0.00796
Peduncle Depth			–0.71;	0.00067
Snout Length	0.56;	0.00023		
Orbit Length	–0.89;	0.00001	–0.59;	0.00595
Dorsal Fin Length	0.48;	0.00223		
Anal Fin Length	0.54;	0.00046		

Table 6. Summary of major diagnostic differences between *Semotilus lumbee* and populations of *S. atromaculatus* from Atlantic coast drainages of the Carolinas.

	lumbee	*atromaculatus*
Dorsal Fin Rays	9	8
Anterior Basidorsal Spot	Usually absent; may be poorly formed in large adults	Usually present and well defined
Body Form	More robust; dorsal fin more anterior; head shorter; snout more pointed in lateral and dorsal views; mouth smaller; fins larger	More elongate; dorsal fin more posterior; head longer; snout more bluntly rounded in lateral and dorsal views; mouth larger; fins smaller
Scales	Larger	Smaller
Lateral Line	Usually 45–50	Usually 48–54
Circumference	Usually 33–37	Usually 38–45
Caudal Peduncle Below LL	Usually 7	Usually 8–9
Anterior Dorsolateral	Usually 22–26	Usually 26–32
Cephalic Lateral Line		
POM	98% interrupted; pores usually 5+6 or fewer	86% interrupted; pores either 11–14, or 6+6 or more
ST	35% interrupted	99% interrupted

Etheostoma neopterum, a new percid fish from the Tennessee River system in Alabama and Tennessee

W. Mike Howell
Department of Biology, Samford University, Birmingham, AL 35209

Guido Dingerkus
Section of Ecology and Systematics, Cornell University, Ithaca, NY 14850

ABSTRACT: Howell, W. Mike and Guido Dingerkus, *Etheostoma neopterum*, a new percid fish from the Tennessee River system in Alabama and Tennessee. Bulletin Alabama Museum of Natural History, Number 3, 14 pages, 4 figures, 13 tables, 1977. *Etheostoma neopterum*, a new percid fish, is described from 218 specimens collected from tributaries to the Tennessee River. The new darter is known from two populations: one in the Shoal Creek drainage of northwest Alabama and southwest Tennessee, and the other in tributaries to Kentucky Lake in west Tennessee. Adult males of *E. neopterum* differ from all known darters in that the rays of the second dorsal fin terminate in fleshy flaps. Furthermore, the interradial membranes are absent from the distal half of this fin, allowing the rays in this region to be separate and free from one another.

***E. neopterum* is assigned to the subgenus *Catonotus* and is most closely related to *Etheostoma squamiceps* Jordan, with which it is sympatric at three known localities in the Shoal Creek drainage. In addition to its unique dorsal fin morphology, *E. neopterum* is distinguished from *E. squamiceps* by the following: fewer soft dorsal rays (modally, 11 vs. 13), a greater modal number of pectoral rays (24 vs. 22), larger fleshy knobs on the tips of the spines in the first dorsal fin of adult males, lesser nape pigmentation (unpigmented vs. a dark blotch), differences in the color pattern on the interradial membranes of the soft dorsal fin in adult males (2-4 horizontal rows of tiny white spots vs. 5-6 white, wavy horizontal lines), and a specific habitat preference (beneath creek banks vs. general stream distribution).**

Introduction

The taxonomy of the spottail darter, *Etheostoma squamiceps* Jordan, is poorly understood. There are at least three undescribed species presently confused with *E. squamiceps*. One of these is found in the Caney Fork drainage of the Cumberland River system and is being described by M. E. Braasch and L. M. Page Another occurs in the Cypress Creek drainage, Tennessee River system in northwest Alabama, and its description is being prepared by Herbert Boschung and W M. Howell. The third undescribed form is found in certain tributaries of the Tennessee River in northwest Alabama and west Tennessee. It is the purpose of this paper to describe this last form and to compare it to sympatric or near-sympatric populations currently referred to *E. squamiceps*. It is not the intent of this paper to present a complete systematic treatment of *E. squamiceps* as the problem is being currently studied by M. E. Braasch.

A major difficulty in defining *E. squamiceps* is that the exact location of the type-locality is not known. Jordan's types came from "Russellville, Logan Co., Kentucky," a town which sits on the divide between the Cumberland and Green River systems. The forms of *E. squamiceps* in these two river systems have differentiated slightly, but whether they have diverged enough to be recognized as two distinct species is not presently known. Jordan's type specimens, U.S. National Museum 197968 and 108664 have been examined; they resemble the Cumberland River form of *E. squamiceps* more than the Green River form. We consider our comparative material on *E. squamiceps* used herein from Alabama and Tennessee to be conspecific with Jordan's types.

The new species was first discovered by Donald Dycus and W. M. Howell on 18 April 1972 in Little Butler Creek, a tributary to Shoal Creek, Tennessee River System, at Pruitton, Lauderdale County, Alabama. The dis-

Editorial committee for this paper:
Dr. Lawrence M. Page, Illinois Natural History Survey, Urbana, IL 61801
Dr. David Etnier, Department of Zoology, University of Tennessee, Knoxville, TN 37916

tinctiveness of this new darter was confirmed in March 1973 when we collected it sympatrically with *E. squamiceps* in a tributary to Shoal Creek. Additional populations of the new darter were concurrently discovered by David Etnier and students in tributaries to Kentucky Lake (impoundment on the Tennessee River) in western Tennessee.

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Thanks are due Mr. Byron Clark, Jr., for providing the distribution map and certain locality records for specimens from West Tennessee and the Kentucky Lake region.

We thank Reeve M. Bailey for suggesting the name, *neopterum,* and Herbert Boschung, for selecting the common name, "lollypop darter."

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Methods

Except as noted, counts and measurements were made by methods defined by Hubbs and Lagler (1958: 19-26). Proportional measurements are expressed as thousandths of standard length. Transpelvic distance was measured from the base of the right pelvic spine to the base of the left pelvic spine. Interpelvic distance was measured from the base of the innermost ray of the right pelvic fin to the base of the innermost ray of the left pelvic fin. Pelvic fin base was measured from the base of the left pelvic spine to the base of the innermost pelvic ray on the left pelvic fin.

The scale rows in a transverse series were counted downward and backward from the origin of the second dorsal fin to the anal fin base. In most instances, a small secondary scale was present between the second dorsal fin origin and the first primary scale row, and likewise, between the anal fin base and the last primary scale row. These secondary scales were not counted.

The cephalic canals of the lateral-line system were analyzed in accordance with the methods of Hubbs and Cannon (1935).

The nape, cheek, opercle, prepectoral, and breast regions were examined for the extent of squamation. These areas were defined by Cole (1957; 1967) and his delimitations are utilized herein. The total area covered by scales was estimated to the nearest 10 percent (similar to the method used by Lagler and Bailey, 1947). Values for the holotype appear in boldface in tables 2-13.

Etheostoma neopterum new species
Lollypop Darter

Figure 1 A and B

TYPE MATERIAL.—The holotype, U.S. National Museum, USNM 217529, an adult male, 57.9 mm in standard length (SL), was collected by W. M. Howell and G. Dingerkus on 18 March 1973 in Little Butler Creek, approximately 0.6 kilometers E of Tennessee Route 13 and 0.8 kilometers N of Alabama-Tennessee State Line, Wayne County, Tennessee. In the same collection we obtained the following specimens: the allotype, USNM 217530, an adult female, 43.8 mm SL; 1 paratopotype, Cornell University, CU 64509, an adult female, 41.8 mm SL. Other paratypes include: *Shoal Creek drainage, Tennessee River System.* **Alabama:** LAUDERDALE COUNTY: American Museum of Natural History, AMNH 36551 (1, 35) Butler Creek at Pruitton where crossed by Co. Rt. 8 at railroad tracks, 10 Feb. 1976; AMNH 36552 (2, 27-44) Little Butler Creek, approx. 0.5 mi S of Pruitton where crossed by Co. Rt. 61, at railroad tracks, 22 Feb. 1976; AMNH 36553 (1, 52) Sour Branch of Little Butler Creek where crossed by Co. Rt. 8 approx. 1 mi W of Pruitton, 22 Feb. 1976; University of Michigan Museum of Zoology, UMMZ 200767 (4, 24-55) Sour Branch of Little Butler Creek where crossed by road, approx. 1.25 mi W of Pruitton, sec 6, T 1S, R 10W, 18 March 1973; CU 64504 (3, 28-41) Little Butler Creek, 0.7 airmi SW of Pruitton at Co. Rt. 61, sec 8, T 1S, R 10W, 18 March 1973; CU 64515 (7, 31-51) Little Butler Creek, trib. of Shoal Creek, at Pruitton, 18 April 1972; Tulane University, TU 102024 (7, 39-54) Small trib. to Little Butler Creek, approx. 2 mi W of Pruitton, T 1S, R 10W, 3 April 1976. **Tennessee:** WAYNE COUNTY: AMNH 36548 (6, 40-59 Stults Branch of Butler Creek, where crossed by dirt road, approx. 1 airmi W Cedar Grove Church, 3 April 1976, and AMNH 36548 (2, 51 and 60) same locality and date, specimens cleared and stained; AMNH 36549 (3, 40-56) Butler Creek approx. 1 mi N Cedar Grove Church, 15 Feb. 1976; AMNH 36550 (10, 32-39) Factory Creek where crossed by Co. Rt. 532 near Bethlehem Baptist Church, 4 May 1976; CU 64511 (21, 27-55) Butler Creek approx. 0.25 mi NE of Cedar Grove Church, 19 March 1973; CU 64513 (9, 26-54) Swanegan Branch by its entrance to Butler Creek, 1.1 airmi N of Cedar Grove Church, 19 March 1973; University of Alabama Ichthyological Collection, UAIC 5342.01 (5, 30-40) Mill Branch of Butler Creek where crossed by dirt road approx. 0.75 mi NW of Cedar Grove Church, 3 April 1976. *Kentucky Lake Drainage, Tennessee River System.* **Tennessee:** BENTON COUNTY: AMNH 36545 (112, 25-60) Beaverdam Creek at County Road 8043, 28 May 1971; AMNH 36546 (4, 37-49) Sycamore Creek at Tenn. Rt. 69, 2 mi E of Holladay, 18 May 1974; AMNH 36547 (4, 44-49) Little Sulpher Creek, 7.5 airmi SE of Big Sandy, 6 Dec. 1973; UAIC 5343.01 (4, 47-53) Beaverdam Creek at County Road 8043, 12 May 1973; University of Tennessee, UT 91. 1389 (2, 39 and 52) Morgan Creek off

Tenn. Rt. 69, 28 April 1974; DECATUR COUNTY: UAIC 5344.01 (3, 30-32) Lick Creek, 1 mi NE of Jeanette on Tenn. Rt. 69, 19 March 1977; HENRY COUNTY: UT 91.1067 (2, 34 and 35) Clifty Creek on road 3.5 mi SE of Paris, 14 Sept. 1974.

DIAGNOSIS.—*Etheostoma neopterum* is a member of the fish family Percidae, genus *Etheostoma*, subgenus *Catanotus*. (See Kuehne and Small, 1971, for subgeneric diagnosis, and Collette, 1965, for a discussion of relationships among *Catonotus*.) *E. neopterum* is distinguished from all known members of *Etheostoma* by the unique morphology of the soft dorsal fin of adult males (Fig. 1 A and 2 C). Each ray of this fin terminates in an expanded, flattened flap. In addition, interradial membranes are absent from the distal half of this fin allowing the rays

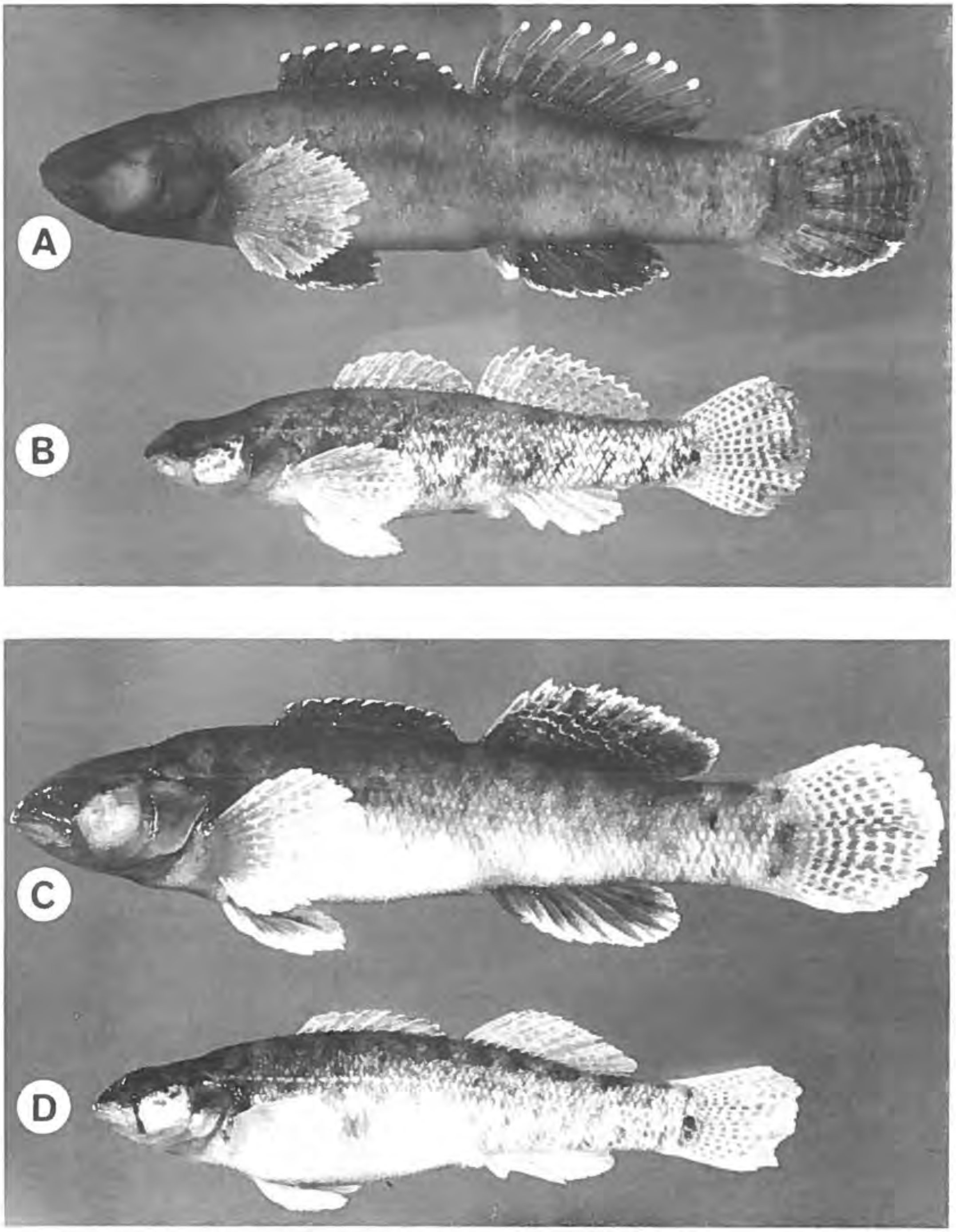

Fig. 1. (A) *Etheostoma neopterum* n. sp., holotype, USNM 217529, a nuptial male, 57.9 mm SL. (B) *Etheostoma neopterum* n. sp., allotype, USNM 217530, a nuptial female, 43.8 mm SL. (C) *Etheostoma squamiceps*, CU 64508, a nuptial male, 83.0 mm SL, collected sympatrically with holotype and allotype of *E. neopterum*. (D) *Etheostoma squamiceps*, CU 64508, a nuptial female, 67 mm SL, collected sympatrically with the holotype and allotype of *E. neopterum*.

in this region to be free from one another. The soft dorsal fin of its nearest relative, *E. squamiceps*, is fringed along the distal edge and interradial membranes are present almost to the fin's edge (Fig. 1 C and 2 D).

Coloration of the soft dorsal fin also distinguishes the two species (Fig. 2 C and D). *E. neopterum* has two to four horizontal rows of tiny clear spots on the interradial membranes of this fin; *E. squamiceps* lacks these spots but has, instead, five or six white, wavy, horizontal lines which cross the fin.

Males of *E. neopterum*, like other *Catonotus* forms of the *E. flabellare* and *E. squamiceps* species-groups, bear bulbous fleshy knobs on the tips of the spines of the first dorsal fin (Fig. 1 A). In *E. neopterum*, these fleshy knobs are larger than those of *E. squamiceps* (Fig. 1 A and C).

Nape pigmentation is a useful characteristic with which to distinguish most specimens of *E. neopterum* from *E. squamiceps* (Fig. 2 A and B). In *E. neopterum*, the nape is mostly unpigmented and not crossed by a dorsal blotch. In *E. squamiceps*, the nape is crossed by a dark dorsal blotch which is broken by a longitudinal, mid-dorsal light line.

E. neopterum and *E. squamiceps* differ significantly in the number of soft dorsal rays (Table 8). *E. neopterum* has a modal number of 11 dorsal rays while *E. squamiceps* has 13. A two-sample test (or difference of the means) revealed that, in this characteristic, there is a significant difference between the means at the .05 risk level. The two species differ in the total number of pectoral rays, with *E. neopterum* having a modal count of 24 while *E. squamiceps* has a modal count of 22 (Table 9).

E. neopterum is a moderate-size species with males reaching a maximum size of 62 mm SL while females reach only 47 mm SL. *E. squamiceps* attains a much greater maximum size with males reaching 87 mm SL while females reach 64 mm SL.

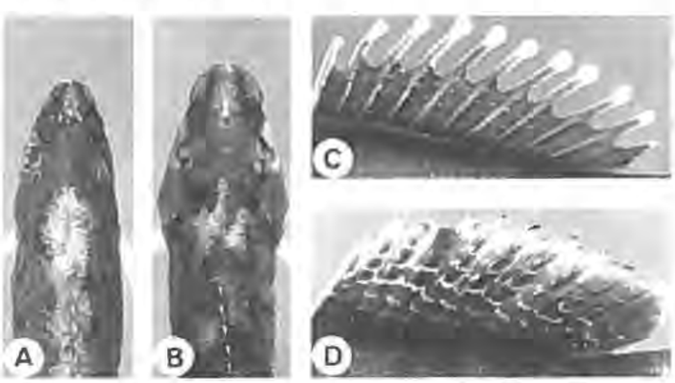

Fig. 2. (A) Dorsal view of head region of *Etheostoma neopterum* n. sp., allotype, USNM 217530, showing largely unpigmented nape not crossed by a dorsal blotch. (B) Dorsal view of head region of *Etheostoma squamiceps*, female, CU 64508, showing nape region crossed by a dark blotch which is broken by a longitudinal, mid-dorsal light line. (C) Soft dorsal fin of holotype of *Etheostoma neopterum*, USNM 217529, a nuptial male, showing unique free fin rays and expanded fin ray tips. (D) Soft dorsal fin of *Etheostoma squamiceps*, CU 64508, a nuptial male. Note that fin rays are not free and that the fin is fringed.

The two species differ markedly in habitat preference. *E. neopterum* is almost always found beneath undercut creek banks, while *E. squamiceps* is generally distributed throughout the stream.

COMPARATIVE DESCRIPTION.—Comparative body shapes of *E. neopterum* and *E. squamiceps* are shown in Fig. 1 A-D. Comparative body proportions are given in Table 1. Sexual dimorphism is present in both *E. neopterum* and *E. squamiceps*. Within *E. neopterum*, males have higher soft dorsal rays, a greater caudal peduncle depth, a longer first anal spine, a greater interpelvic space, a greater transpelvic distance, and a wider pelvic fin base. Females have a greater orbit diameter, a greater body depth at dorsal origin, and longer pectoral rays (Table 1). *E. squamiceps* also shows sexual dimorphism in several characteristics (Table 1). A comparison of body proportions of *E. neopterum* with *E. squamiceps* shows that *E. neopterum* has a smaller head width, a smaller fleshy interorbital width, a greater distance from lower jaw to the junction of the gill membranes, a lesser head depth at occiput, a lesser body depth at dorsal origin, a lesser body width, longer pectoral rays, a greater distance from pelvic insertion to the junction of the gill membranes, and higher dorsal spines (Table 1).

Frequency distributions of scale counts for *E. neopterum* and *E. squamiceps* are given in Tables 2-6. The number of total lateral-line scales does not distinguish the two species (Table 2). The Shoal Creek population of *E. squamiceps* has a distinctly higher mean ($\overline{X} = 51.52$), but the Kentucky Lake *E. squamiceps* with a lower mean ($\overline{X} = 48.04$) is indistinguishable in this respect from both the Shoal Creek and Kentucky Lake populations of *E. neopterum* ($\overline{X} = 47.39$ and 48.63, respectively). The lateral line is straight and incomplete in both species. The number of pored lateral line scales (Table 3) is of no value in distinguishing the two species. The Shoal Creek population of *E. neopterum* has fewer pored lateral line scales ($\overline{X} = 29.96$), while the Kentucky Lake population ($\overline{X} = 33.78$) is closer to the Shoal Creek and Kentucky Lake populations of *E. squamiceps* ($\overline{X} = 33.84$ and 32.88). A comparison of the number of unpored lateral line scales (Table 4) shows that the Shoal Creek and Kentucky Lake populations of *E. neopterum* have diverged somewhat ($\overline{X} = 17.52$ vs. 14.91) as have the Shoal Creek and Kentucky Lake populations of *E. squamiceps* ($\overline{X} = 17.64$ vs. 15.16). The number of scales in the transverse series (Table 5) varies from 12 to 16 in both *E. neopterum* and *E. squamiceps*. In the number of scale rows around the caudal peduncle, the Shoal Creek and Kentucky Lake populations of *E. neopterum* ($\overline{X} = 19.58$ and 20.10) are similar to the Shoal Creek population of *E. squamiceps* ($\overline{X} = 20.10$), while the Kentucky Lake population of E. *squamiceps* is somewhat divergent ($\overline{X} = 18.80$).

Fin-ray counts for *E. neopterum* and *E. squamiceps* are given in Tables 7-10. The number of dorsal spines varies from 8 to 11 with a strong mode at 9 in both species (Table 7). The number of rays in the second dorsal fin is the best meristic characteristic for separating *E. neopte-*

rum from *E. squamiceps* (Table 8). There is very little overlap in this characteristic: *E. neopterum* has 9 to 12 rays and a strong mode at 11; *E. squamiceps* varies from 12 to 14 with the mode at 13. The total number of pectoral rays is of some diagnostic value since *E. neopterum* has a modal number of 24, while *E. squamiceps* has a mode of 22 (Table 9). The modal number of anal rays is 7 in examined populations of both species (Table 10). The number of branched caudal rays varied in both species from 12 to 15 with most specimens having 14.

A comparison of the percentages of the cheek regions covered by scales shows that although this characteristic varied from 0 to 100 percent in *E. neopterum*, it varied from only 0 to 70 percent in *E. squamiceps*. *E. neopterum* modally has a greater percentage of the cheek covered by scales (Table 11). The Shoal Creek and Kentucky Lake populations of *E. neopterum* have more of the opercle covered by scales ($\overline{X} = 47.70$ and 57.25) than do the two populations of *E. squamiceps* ($\overline{X} = 31.69$ and 31.60). The percentage of the nape covered by scales was modally 100 percent in both species (Table 13); however, the nape squamation was slightly reduced in the Kentucky Lake population of *E. squamiceps* ($\overline{X} = 88.20$).

Examination of the cephalic canals of the lateral line system showed the following to be characteristic of both species: a complete lateral canal with 5 pores; an incomplete supratemporal canal with 2 pores on each side branch; postorbital, coronal, interorbital, posterior nasal, and anterior nasal pores present; a complete preoperculomandibular canal with 10 pores; an infraorbital canal which was almost always incomplete with 3 pores anteriorly and 4 pores posteriorly, but occasionally with a count of 2 + 4, 4 + 4, or 3 + 5. Specimens of *E. squamiceps* from Sycamore and Little Sulpher Creeks, Benton County, Tenn., were atypical in having a complete infraorbital canal with 8 pores.

The upper lip was bound to the snout by a well-developed frenum in both species. Nuptial tubercles were absent in both species.

The dorsal spines of both species terminate in whitish, fleshy knobs in breeding males (Fig. 1 A and C). These knobs are distinctly larger in *E. neopterum* than in *E. squamiceps*. During breeding season, the flesh of the head and nape in adult males of both species becomes greatly swollen. This phenomenon was also noted in other *Catonotus* species such as *E. flabellare* and *E. kennicotti*.

In 99 percent of the specimens of *E. neopterum*, the gill membranes were distinctly overlapped anteriorly. In *E. squamiceps*, 85 percent of the specimens had the gill membrances overlapped anteriorly, while 15 percent had the membranes moderately connected.

GENERAL COLOR DESCRIPTION.—Sexual dichromatism is evident in nuptial specimens of *Etheostoma neopterum* (Fig. 1 A and B). Freshly preserved breeding males are usually homogeneously gray to black with contrasting white tips on the rays of the spinous dorsal, soft dorsal, caudal, anal, and pelvic fins (Fig. 1 A). In living males, the tips of the fins are yellowish in color, but rapidly bleach to white in formalin or alcohol. Some males collected at the height of the breeding season had about 10 to 12 prominent, vertical dark bars on the sides extending from just behind the pectoral fin to the caudal fin. Breeding females are plain, being mottled with tannish brown to black pigment (Fig. 1 B). Except for faint barring, the fins of the females are clear. Sub-adult or non-breeding males have a color pattern similar to that of females.

Breeding specimens of *E. squamiceps* are shown in Fig. 1 C and D. Sexual dichromatism is also evident in *E. squamiceps* with males assuming dark pigment dorsolaterally while females remain plain with tannish brown to black pigments predominating. Generally, the belly in *E. squamiceps* is largely devoid of dark pigment, providing a more contrasting color pattern than in the more homogeneously pigmented *E. neopterum* (Fig. 1 A-D). As in males of *E. neopterum*, the spines of the dorsal fin in males of *E. squamiceps* have whitish knobs which contrast with the dark fin; however, the knobs are usually not as large nor as white as those of *E. neopterum* (Fig. 1 A and C). The soft dorsal fin of *E. squamiceps* differs strikingly from that of *E. neopterum* in color as well as in morphology. The tips of the rays in *E. squamiceps* do not terminate in white fleshy flaps, but rather in a fringe with each ray being tipped with black (Fig. 2 C and D). Additionally, the fin in *E. squamiceps* has 5 or 6 wavy, horizontal lines which cross the fin, while *E. neopterum* lacks these horizontal lines but has, instead, two to four horizontal rows of tiny, clear spots (Fig. 2 C and D). Comparative views of the nape region are seen in Fig. 2 A and B. The nape in *E. neopterum* is usually devoid of dark pigment (Fig. 2 A). The nape of *E. squamiceps* is crossed by a dark saddle which is broken in the mid-dorsal line (Fig. 2 B). While this pattern may be somewhat obscured by dark pigment in breeding males, it is evident in all females and non-breeding males. In breeding males of *E. neopterum*, the lateral line is usually pigmented and is indistinguishable in color from the rest of the body (Fig. 1 A). In most breeding males of *E. squamiceps* the lateral line is largely unpigmented and the pores can be easily seen (Fig. 1 C). In females and non-breeding males of both species, the lateral line is more evident, but it is still less conspicuous in *E. neopterum* than in *E. squamiceps* (Fig. 1 B and D).

DETAILED COLOR DESCRIPTION.—The following color description of the holotype and male paratypes is a composite description taken from living and freshly-preserved specimens. The head is either mottled or homogeneously dark brown to black. Three orbital bars are present in pre-nuptial males; these may be obscured by dark pigment in nuptial males. The suborbital bar, usually present in both pre-nuptial and nuptial males, originates below the center of the eye and slants downward and backward to a point even with the posterior margin of the eye. The preorbital bar originates level with the center of the eye, continues forward through the nostril, and extends onto the upper lip. A broken postorbital bar begins just below the center of the eye and continues posteriad, slants slightly upward and becomes a broken line parallel to and just below the lateral line. Both the cheek and opercle are mottled with brown pigment in pre-nuptial males, but become increasingly dark brown to black as the breeding season approaches. The top of the head, pre- and interorbital regions, are light to dark brown. The isthmus, branchiostegal membranes, and lower jaw are light brown to black. The eye is a uniform dark brown to black with no traces of metallic colorations. A humeral spot, present in pre-nuptial males, is often obscured by dark pigment in nuptial males. The prepectoral area and breast are uniformly white in pre-nuptial males but become dark gray in breeding males. The lateral line in the nuptial male is usually indistinguishable in color from the rest of the body; however, it is often not pigmented in non-breeding males and is evident against the darker background of the body. The lower third of the body and the midventral belly region are uniformly light tan to brown. The rest of the body varies from uniform brown to mottled brown to black, with 6 to 11 dark, ill-defined saddles crossing the dorsum. The saddles are partially or totally obscured by the dark pigment assumed by nuptial males.

In the spinous dorsal fin, a white basal line about 1/6 to 1/4 the height of the dorsal fin is present. The remainder of the fin is black except for the terminal white fleshy knobs on the spines and a single row of small, clear, oval spots spaced about 1/2 to 2/3 the distance from the fin base to the fin margin. The soft dorsal fin has a clear basal band about 1/6 to 1/4 the width of the membranous portion of the fin (Fig. 2 C). The remainder of the fin membrane is black except for 2 to 4 rows (usually 3) of small, clear, oval spots. Usually, the 3 rows of spots are spaced 1/4, 1/2 and 3/4 the distance from the fin base to the tip of the rays. Each soft dorsal ray terminates in an expanded flap of tissue, ranging in color from yellow in living specimens to white in preserved individuals (Fig. 1 A and Fig. 2 C). Both spinous dorsal knobs and soft dorsal fin-ray flaps are absent in very young males, occasionally present in formative stages in sub-adult males, and always present in adult males. Generally, in non-breeding males these fins are largely clear with small blocks of brown pigment along the spines and rays. The caudal fin usually has 5 to 10 bold black vertical bars, which in nuptial males are almost 4 times as wide as the interspaced white bars (Fig. 1 A). In non-breeding males the black and white bars are about equal in width. A fine white fringe is present along the margin of the caudal fin.

RANGE.—*Etheostoma neopterum* is presently known only from certain tributaries to the Tennessee River in northwest Alabama and west Tennessee (Figs. 3 and 4). In the Shoal Creek drainage (Fig. 3), *E. neopterum* is relatively common in Little Butler and Big Butler Creeks. In Little Butler Creeks, we have taken *E. neopterum* and *E. squamiceps* together with no evidence of interbreeding. *E. squamiceps* is not common in the Shoal Creek drainage except in Cowpen Creek where a large population exists. In west Tennessee, both *E. neopterum* and *E. squamiceps* occur in tributaries to Kentucky Lake, but have an allopatric distribution (Fig. 4). *E. neopterum* is more northerly distributed within this system, being found from Henry County southward to Decatur County. *E. squamiceps* occurs in Decatur County southward to Alabama (Fig. 4). The two species occur in Decatur County in adjacent creeks, *E. neopterum* in Lick Creek and *E. squamiceps* in Horny Head Creek less than five miles away. We suspect that the two species will be found together in the lower reaches of Lick Creek near Kentucky Lake. The two species may exhibit a type of competitive exclusion as they are rarely taken together.

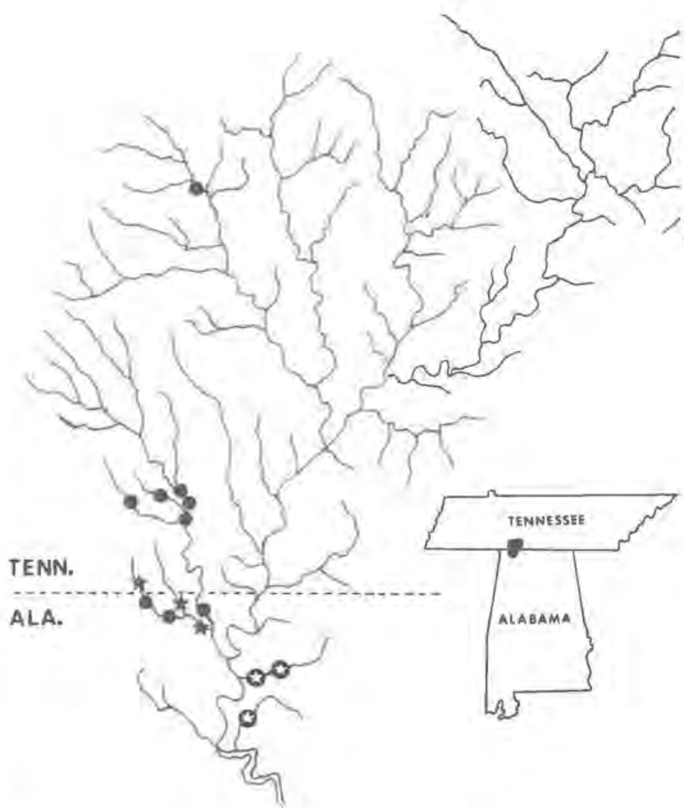

Fig. 3. Distribution records for *Etheostoma neopterum* (solid circles) and *Etheostoma squamiceps* (starred circles) in the Shoal Creek drainage of the Tennessee River System. Solid black stars indicate localities where the two species were sympatric.

HABITAT.—In the Shoal Creek drainage, *Etheostoma neopterum* prefers cool, spring-fed upland creeks usually less than 10 meters in width with depths less than 1 meter. *E. neopterum* is very habitat-specific, being found almost exclusively beneath shallow undercut creek banks in the slower moving areas of the stream. In the areas of capture, the bottom was of sand or chert gravel usually covered with leaf-litter and detritus. Often thick masses of entangled roots extended a short distance from the undercut banks onto the stream bottom. *E. neopterum* is very secretive and relatively difficult to collect. The

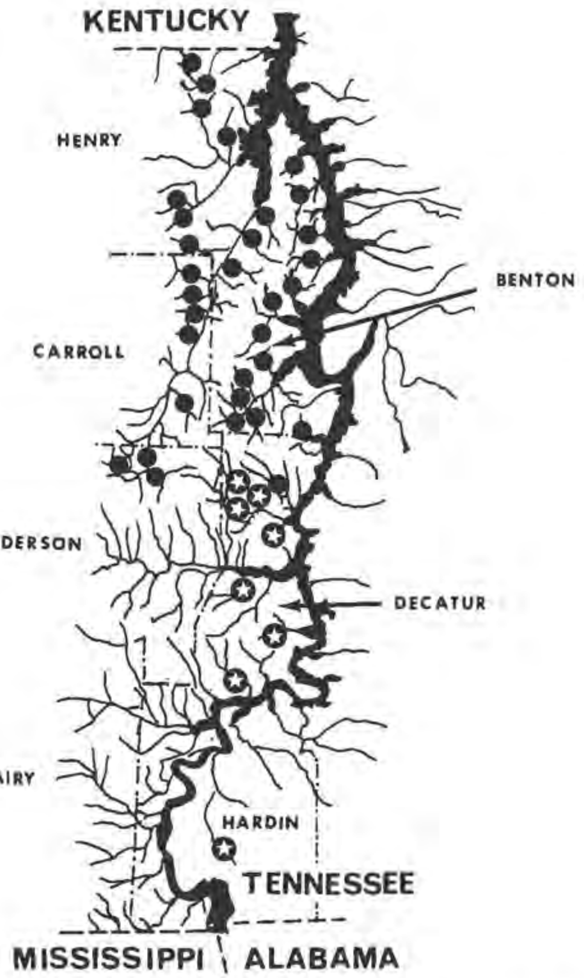

Fig. 4. Distribution records for *Etheostoma neopterum* (solid circles) and *Etheostoma squamiceps* (starred circles) in tributaries to Kentucky Lake (map and most locality records from Clark, 1974).

best collecting technique involved stationing a portion of a four foot nylon seine beneath the bank. Then the undercut bank areas above the net were kicked in order to drive the fishes downstream into the seine.

E. neopterum was very rarely collected in mid-stream or riffle areas. Apparently, its activities are limited largely to the detritus and root areas near and beneath the stream banks. Occasionally, an individual was collected in shallow slough areas characterized by a bottom of leaf-litter and very little water flow. We have not collected enough specimens of *E. neopterum* in Kentucky Lake drainage to determine if the habitat-specificity described here for Shoal Creek is also true of that area.

At the three localities where *E. neopterum* and *E. squamiceps* were taken together (Fig. 3), *E. squamiceps* was not common, and was generally distributed throughout the stream in pools and areas of moderate to slow flow. Page (1974) found that *E. squamiceps* showed a strong preference for streams with a slab rock substrate. Apparently slab rocks are more important to *E. squamiceps* than other physical factors such as stream current and temperature. This preference was shown to be related to the fact that *E. squamiceps* selects nesting sites along the undersides of these slab rocks. In Illinois and Kentucky, *E. squamiceps* was not found in streams which lacked a slab rock substrate (Page, 1974). In the Shoal Creek drainage, slab rocks were conspicuously absent in most of the streams in which *E. neopterum* was found. At the 3 localities where *E. neopterum* and *E. squamiceps* were sympatric, a few slab rocks were present. At Cowpen Creek, Lauderdale Co., Alabama, where *E. squamiceps* abounds and no *E. neopterum* was found, the stream bottom was liberally strewn with slab rocks.

REPRODUCTIVE HABITS.—In March 1976, pre-nuptial specimens of *Etheostoma neopterum* were collected in Little Butler and Butler Creeks from beneath undercut banks. When we returned to the same site in mid-April through May, we did not collect *E. neopterum*. However, we did collect nuptial specimens several miles upstream in tiny tributaries to these streams. It seems that there is a migratory movement of *E. neopterum* just prior to spawning from the moderate-sized creeks into smaller creeks and brook tributaries. In these smaller creeks, some slab rocks were present. *E. neopterum* may utilize these slab rocks for spawning as all other species of *Catonotus* studied spawn beneath slab rocks (Lake, 1936; Winn, 1958a, 1958b; Page, 1974, 1975a, 1975b; Page and Burr, 1976). However, we did not find any specimens associated with these rocks. Instead, they were still found beneath the banks. During this time, males were running milt and females extruded eggs at the slightest pressure on their abdomens. The spawning sites of *E. neopterum* are still unknown.

Page (1974) thoroughly studied the reproductive behavior of *E. squamiceps* from Illinois and Kentucky. He found that it spawned from late March through May on the undersides of slab rocks. During the spawning act, both males and females assumed an inverted position. After spawning, the males guarded the eggs. A large spawning population of *E. squamiceps* was found on 30 April 1976 in Cowpen Creek by Herbert Boschung, Ann Black, and W. M. Howell. Slab rocks were abundant in all areas of the stream. Nearly every rock had either a spawning pair of *E. squamiceps* beneath it, or a single male guarding an egg mass. The usual absence of slab rocks in streams where *E. neopterum* is found may explain the absence of *E. squamiceps* there.

SPECIES ASSOCIATES.—In the Shoal Creek drainage, the 10 species most often found with *Etheostoma neopterum* (in descending order of association) were: *Semotilus atromaculatus, Campostoma anomalum, Etheostoma duryi, Etheostoma simoterum, Clinostomus funduloides, Etheostoma caeruleum, Hypentelium nigricans, Cottus carolinae, Etheostoma rufilineatum* and *Fundulus olivaceus*. Other darters encountered in the same streams were: *Etheostoma blennius, E. flabellare, E. zonale, E. squamiceps* and *Percina caprodes*.

Etheostoma blennius, E. caeruleum, E. flabellare, E. rufilineatum and *E. zonale* tended to inhabit the swifter riffles and were never taken in the same net haul with

E. neopterum. Occasionally, *E. duryi* and *E. simoterum*, and rarely, *E. squamiceps*, were collected in the net with *E. neopterum*.

PREDATION.—Several specimens of *E. neopterum*, at various stages of digestion, were found among the gut contents of *Cottus carolinae* and the aquatic salamander, *Necturus maculosus*.

ETYMOLOGY.—The specific name, *neopterum*, is a latinized Greek adjective derived from *neos*, "new", and the neuter *pteron*, "wing, feather or fin", and calls attention to the unique structure of the soft dorsal fin in adult males. The vernacular name "lollypop darter" is given because, in adult males, each slender soft dorsal ray with its expanded tip is somewhat similar in appearance to that of a "lollypop."

Discussion

The description of *Etheostoma neopterum* brings to nine the number of species of darters comprising the subgenus *Catonotus*. Originally, Bailey and Gosline (1955) placed only five species into *Catonotus*: *E. flabellare*, *E. kennicotti*, *E. obeyense*, *E. squamiceps* and *E. virgatum*. Later, Collette (1965) arranged these five species into two species-groups based on the presence or absence of fleshy knobs or bulbs at the tips of the spines in the first dorsal fin. The species-group with bulbs included *E. flabellare*, *E. kennicotti* and *E. squamiceps*. This group has become known as the *E. flabellare species-group*. The species-group lacking knobs contained *E. virgatum* and *E. obeyense*. This became known as the *E. virgatum* species-group. Later, Kuehne and Small (1971) described *E. barbouri*, the sixth species of *Catonotus* and placed it into the *E. virgatum* group. Page (1975a) considered *E. squamiceps* as primitive and sufficiently distinctive to be removed from the *E. flabellare* species-group. Thus, three species-groups of *Catonotus* were recognized: *E. flabellare* group, *E. virgatum* group and *E. squamiceps*. These relationships were earlier supported by comparative studies on lactate dehydrogenase isozymes (Page and Whitt, 1973). We herein support Page's (1975a) arrangement of species-groups within *Catonotus*. Recently, Page and Braasch (1976; 1977) described the seventh and eighth species of *Catonotus*, *E. smithi* and *E. striatulum*, and placed them into the *E. virgatum* species-group.

E. neopterum, the ninth species of *Catonotus*, is obviously a specialized derivative of *E. squamiceps* stock and is assigned to the *E. squamiceps* species-group. Like most other species of darters, *E. neopterum* is a mosiac of both generalized and specialized characters. We feel that *E. neopterum* is more generalized than is *E. squamiceps* in having more pectoral rays and more scales on the cheek and opercle. *E. neopterum* is more specialized than *E. squamiceps* in having: a smaller maximum body size, fewer soft dorsal rays, a more highly specialized soft dorsal fin structure, larger knobs on the spines of the first dorsal fin, and a more specialized habitat preference.

It is of interest to speculate on the function of the unique soft dorsal fin of *E. neopterum*. It has been observed that nest-guarding males of *Catonotus* continuously brush their dorsal fins across the egg masses which are laid on the undersides of slab rocks (Page, 1975a). It was suggested that the fleshy knobs on the dorsal spines in *E. flabellare*, *E. kennicotti* and *E. squamiceps* may have arisen because of strong selective pressures to reduce the sharpness of the dorsal spines in order to protect the eggs (Page, 1975a). We believe that the fleshy knobs on the dorsal spines of *E. neopterum* serve the same protective function. Furthermore, we suggest that the same selective pressures responsible for the evolution of spinous dorsal knobs are responsible for the evolution of the unique soft dorsal fin in *E. neopterum*. The unusually flexible and soft rays, which are free distally from the interradial membranes, would surely be less likely to damage or dislodge eggs when the dorsal fins are brushed across the overlying egg masses. The unique dorsal fin of *E. neopterum* could further function as a species-recognition device. These hypotheses need verification by field and laboratory observations.

Comparative Material Examined

Etheostoma squamiceps Jordan, 1877.

The lectotype (USNM 1145, recatalogues USNM 197968) is a male 59 mm SL, from Russellville, Logan Co., Kentucky.

Shoal Creek drainage, Tennessee River System. **Alabama:** LAUDERDALE COUNTY: AMNH 36555 (8, 39-87) Cowpen Creek at jct. of Rts. 8 and 34, 17 May 1976, and AMNH 36555 (1, 54) same locality and date, specimen cleared and stained; AMNH 36556 (3, 41-54) Canerdy Branch, trib. to Shoal Creek, by dirt road approx. 2 mi from Lone Cedar Church off Co. Rt. 47, 18 May 1976; AMNH 36561 (3, 35-39) Sour Branch of Little Butler Creek where crossed by Co. Rt. 8, approx. 1 mi W of Pruitton, 22 Feb. 1976; AMNH 36562 (3, 31-54) Little Butler Creek, approx. 5 mi S of Pruitton, where crossed by Co. Rt. 61 and railroad tracks, 22 Feb. 1976; CU 64503 (7, 48-84) Cowpen Creek, at jct. of Co. Rts. 8 and 34, parallel to Co. Rt. 8, 18 March 1973; CU 64502 (18, 30-70) Unnamed spring trib. to Cowpen Creek, at jct. of Rts. 8 and 34, parallel to Co. Rt. 34, 18 March 1973; CU 64505 (2, 33 and 34) Sour Branch of Little Butler Creek where crossed by road approx. 1.25 airmi W of Pruitton, sec 16, T 1S, R 10W, 18 March 1973; UAIC 5153.07 (14, 19-80) Cowpen Creek, trib. to Shoal Creek 30 April 1976. **Tennessee:** WAYNE COUNTY: CU 64508 (2, 67-83) Little Butler Creek, 0.25 mi N of Tenn.-Ala. State Line, and 0.3 mi E of Tenn Rt. 13, 18 March 1973.

Kentucky Lake drainage, Tennessee River System. **Tennessee:** DECATUR COUNTY: AMNH 36557 (25, 33-66) Short and Dirty Creek, approx. 1 mi E of Tenn. Rt. 69 and 2.5 mi NE of Parsons, 19 March 1977; AMNH 36558 (15, 39-60) Horny Head Creek, trib. to Cub Creek, 1.5 mi W of Cub Creek bridge on Tenn. Rt. 69, 19 March 1977; AMNH 36559 (7, 36-54) White's Creek, approx. 8 mi SE of Decatursville on Tenn. Rt. 69, 20 March 1977; HARDIN COUNTY: AMNH 36560 (3, 32-52) Unnamed trib. to Horse Creek, approx. 2.5 mi NNW of Holland Creek on Tenn. Rt. 69, 20 March 1977.

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Table 1. Proportional Measurements of *Etheostoma neopterum* and *E. squamiceps* Expressed as Thousandths of Standard Length

	Etheostoma neopterum						*Etheostoma squamiceps*			
	Holotype ♂ USNM 217529	Allotype ♂ USNM 217530	*Paratypes AMNH 36549; TU 102024; UAIC 5343.01				AMNH 36557; AMNH 36558 CU 64502; SU 64503			
			N=10 Range ♂	X̄ ♂	N=10 Range ♀	X̄ ♀	N=10 Range ♂	X̄ ♂	N=10 Range ♀	X̄ ♀
Standard length, mm	57.9	43.8	47.1-62.2	51.7	38.0-46.9	41.1	46.3-82.0	59.5	41.1-64.0	52.1
Snout length	60	57	55-66	62	53-72	63	57-66	61	57-71	66
Orbit diamenter	64	71	63-72	67	66-77	71	61-73	65	62-71	68
Head length	276	285	280-303	292	284-322	303	278-306	289	278-302	288
Head width	173	169	156-176	166	145-173	162	173-194	185	161-180	175
Fleshy interorbital width	60	50	41-59	52	48-60	52	56-66	60	52-61	56
Upper jaw length	92	91	87-101	95	86-95	92	90-100	95	77-97	86
Lower jaw—jct. gill membranes	140	121	131-152	140	131-151	142	131-145	136	119-146	132
Head depth at occiput	169	151	155-173	165	160-176	166	163-180	171	154-181	172
Body depth at dorsal origin	234	258	182-224	203	200-233	217	203-246	226	211-272	244
Body width	173	183	135-169	155	140-172	156	167-191	175	170-212	192
Longest pectoral ray	214	228	211-249	233	219-261	245	200-242	224	213-236	222
Pelvic fin length	211	201	179-223	202	181-224	209	192-225	206	173-213	193
Pelvic fin base	45	41	39-55	47	34-49	43	35-54	48	33-44	39
Transpelvic distance	92	80	79-109	95	72-90	79	85-96	91	75-90	82
Interpelvic space	21	21	11-26	21	13-24	19	16-27	23	19-25	22
Pelvic insertion—jct. gill membranes	159	155	155-185	168	161-177	167	130-145	136	132-157	147
Highest dorsal spine	71	84	74-100	87	75-102	89	66-97	80	72-95	81
Highest dorsal soft ray	149	128	144-179	163	121-158	140	141-179	161	127-146	136
First anal spine	67	80	61-106	81	64-91	72	62-108	82	61-100	77
Highest anal soft ray	135	148	127-171	144	130-156	142	133-175	156	129-154	141
Caudal peduncle length	222	221	205-263	237	207-262	234	216-260	237	203-261	227
Caudal peduncle depth	143	119	131-154	140	109-138	122	124-152	137	110-123	119
Caudal fin length	216	228	211-248	227	208-247	231	215-242	229	188-222	208

* Five non-paratype specimens, uncatalogued, from University of North Alabama, were included in these measurements.

Table 2. Frequency Distribution of Total Lateral Line Scales in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Total Lateral Line Scales																									
	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	N	$\bar{X}$	SD	SE
Etheostoma neopterum																										
Shoal Creek Population	2	1	4	5	4	15	15	10	14	9	5	4											87	47.39	2.52	.270
Kentucky Lake Population	5	2	4	5	9	13	13	12	15	15	11	7	8	4		7		1					131	48.63	3.67	.321
Etheostoma squamiceps																										
Shoal Creek Population					1	1	5	1	6	5	13	8	5	5	3	4	1					1	59	51.52	3.02	.393
Kentucky Lake Population			1	3	4	4	4	11	12	7	1	1	2										50	48.04	2.21	.312

Table 3. Frequency Distribution of Number of Pored Lateral Line Scales in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Pored Lateral Line Scales																																					
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	N	$\overline{X}$	SD	SE
Ehteostoma neopterum																																						
Shoal Creek Population	1		1	1	1	2	4	2	3	9	10	10	13	14	6	7		1		2															87	29.96	3.37	.362
Kentucky Lake Population							1	7	2	2	1	8	6	10	17	16	18	19	13	5	2	2		1	1										131	33.78	3.40	.297
Ehteostoma neopterum																																						
Shoal Creek Population							1	1	2	1	1	3	5	12	7	2	8	5	3	3	1	1					1	1						1	59	33.84	4.52	.587
Kentucky Lake Population					2		1		4		3	2	3	7	3	6	4	4	6	3	2														50	32.88	3.98	.563

Table 4. Frequency Distribution of Number of Unpored Lateral-Line Scales in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Unpored Lateral-line Scales																													
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	N	$\overline{X}$	SD	SE
Etheostoma neopterum																														
Shoal Creek Population				1			3	5	8	13	9	7	10	9	7	4	4	2		1	1	2				1	87	17.52	3.73	.399
Kentucky Lake Population		1	2	1	5	10	20	7	14	16	17	8	11	6	6	4		1	2								131	14.91	3.34	.292
Etheostoma squamiceps																														
Shoal Creek Population	1				1	1	1		7	3	5	7	8	9	6	3	3	1	1	1							59	17.64	3.46	.450
Kentucky Lake Population		1		1	4	4	4	4	5	2	6	6	4	2	2	2	2		1								50	15.16	3.79	.536

Table 5. Frequency Distribution of Number of Scales in Transverse Series in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Scales in Transverse Series								
	12	13	14	15	16	N	X̄	SD	SE
Etheostoma neopterum									
Shoal Creek Population	47	17	21	1	1	87	12.75	.934	.100
Kentucky Lake Population	29	22	72	5	3	131	13.47	.952	.083
Etheostoma squamiceps									
Shoal Creek Population	1	3	43	10	2	59	14.15	.632	.082
Kentucky Lake Population	10	33	7			50	12.94	.580	.082

Table 6. Frequency Distribution of Number of Scale Rows Around Caudal Peduncle in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Scale Rows Around Caudal Peduncle												
	16	17	18	19	20	21	22	23	24	N	X̄	SD	SE
Etheostoma neopterum													
Shoal Creek Population	1		3	37	35	11				87	19.58	.838	.089
Kentucky Lake Population			3	6	102	17	1	1	1	131	20.10	.690	.060
Etheostoma squamiceps													
Shoal Creek Population				6	42	10	1			59	20.10	.573	.074
Kentucky Lake Population	1	5	9	24	10	1				50	18.80	1.00	.141

Table 7. Frequency Distribution of Number of Dorsal Spines in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Dorsal Spines							
	8	9	10	11	N	X̄	SD	SE
Etheostoma neopterum								
Shoal Creek Population	17	66	4		87	8.85	.467	.050
Kentucky Lake Population	32	93	6		131	8.80	.500	.043
Etheostoma squamiceps								
Shoal Creek Population	10	48	1		59	8.85	.404	.052
Kentucky Lake Population	19	29	1	1	50	8.68	.614	.086

Table 8. Frequency Distribution of Number of Rays in Second Dorsal Fin in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Rays in Second Dorsal Fin									
	9	10	11	12	13	14	N	X̄	SD	SE
Etheostoma neopterum										
Shoal Creek.Population		2	58	27			87	11.29	.500	.053
Kentucky Lake Population	1	14	110	6			131	10.93	.421	.036
Etheostoma squamiceps										
Shoal Creek.Population				27	31	1	59	12.56	.529	.068
Kentucky Lake Population				17	30	3	50	12.72	.567	.080

Table 9. Frequency Distribution of Number of Total Pectoral Rays (Both Sides) in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Total Pectoral Rays (both sides)										
	20	21	22	23	24	25	26	N	X̄	SD	SE
Etheostoma neopterum											
Shoal Creek.Population			9		76		2	87	23.83	.692	.074
Kentucky Lake Population	8		49	1	65	2	6	131	23.10	1.370	.119
Etheostoma squamiceps											
Shoal Creek.Population		1	52		6			59	22.18	.623	.081
Kentucky Lake Population	2	4	31	7	6			50	22.22	.901	.127

Table 10. Frequency Distribution of Number of Anal Rays in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Number of Anal Rays							
	6	7	8	9	N	X̄	SD	SE
Etheostoma neopterum								
Shoal Creek.Population	17	61	9		87	6.90	.538	.057
Kentucky Lake Population	8	119	3	1	131	6.97	.337	.029
Etheostoma squamiceps								
Shoal Creek.Population	7	50	2		59	6.91	.381	.049
Kentucky Lake Population	1	30	18		50	7.34	.517	.073

Table 11. Frequency Distribution of the Percentage of the Cheek Region Covered by Scales in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Percentage of Cheek Region Covered by Scales														
	0	10	20	30	40	50	60	70	80	90	100	N	X̄	SD	SE
Etheostoma neopterum															
Shoal Creek Population	7	9	11	16	2	2	4	9	23	3	1	87	46.55	30.20	3.23
Kentucky Lake Population	47	21	10	14	4	2	5	3	10	3	12	131	29.54	34.59	3.02
Etheostoma squamiceps															
Shoal Creek Population	54	4	1									59	1.02	3.53	.459
Kentucky Lake Population	10	14	16	7	2			1				50	16.40	13.23	1.87

Table 12. Frequency Distribution of the Percentage of the Opercle Region Covered by Scales in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Percentage of Opercle Region Covered by Scales														
	0	10	20	30	40	50	60	70	80	90	100	N	X̄	SD	SE
Etheostoma neopterum															
Shoal Creek Population		5	10	21	4	14	9	6	17	1		87	47.70	22.87	2.45
Kentucky Lake Population		5	10	12	13	19	24	12	20	6	10	131	57.25	24.08	2.10
Etheostoma squamiceps															
Shoal Creek Population	1	2	20	17	8	6	4		1			59	31.69	14.74	1.92
Kentucky Lake Population			13	24	7	5		1				50	31.60	10.46	1.48

Table 13. Frequency Distribution of the Percentage of the Nape Region Covered by Scales in *Etheostoma neopterum* and *Etheostoma squamiceps*

Species and Population	Percentage of Nape Region Covered by Scales														
	0	10	20	30	40	50	60	70	80	90	100	N	$\bar{X}$	SD	SE
Etheostoma neopterum															
Shoal Creek Population										3	84	87	99.65	1.82	.195
Kentucky Lake Population									1	8	122	131	99.23	2.93	.256
Etheostoma squamiceps															
Shoal Creek Population									1	2	56	59	99.32	3.12	.406
Kentucky Lake Population						2	4	4	6	9	25	50	88.20	15.05	2.13

Taxonomy, ecology and phylogeny of the subgenus *Depressicambarus*, with the description of a new species from Florida and redescriptions of *Cambarus graysoni*, *Cambarus latimanus* and *Cambarus striatus* (Decapoda: Cambaridae)

Raymond William Bouchard
Department of Biology, University of North Alabama, Florence, AL 35630

ABSTRACT: Bouchard, Raymond William, Taxonomy, ecology and phylogeny of the subgenus *Depressicambarus*, with the description of a new species from Florida and redescriptions of *Cambarus graysoni*, *Cambarus latimanus* and *Cambarus striatus* (Decapoda:Cambaridae). Bulletin Alabama Museum of Natural History, Number 3, 34 pages, 14 figures, 4 tables, 1977. A study of the subgenus *Depressicambarus* is presented to further the understanding of this widely distributed group of crayfishes in the southeastern United States. The definition of the subgenus is emended to include recent information. In addition to diagnoses of the 11 present members of *Depressicambarus*, relationships and phylogeny are discussed, nomenclatorial changes are proposed, one new species is described and three are redescribed. *Cambarus pyronotus*, a new species of primary burrowing crayfish from Torreya State Park in Liberty County, Florida, is described and illustrated. *Cambarus graysoni*, *C. latimanus* and *C. striatus* are redescribed and illustrated. *Cambarus jordani* and *C. floridanus* are synonymized with *C. latimanus* and *C. striatus*, respectively. Color notes, life history notes, and ecological data are presented for the four described species.

Introduction

With the exception of the monotypic subgenera *Veticambarus* and *Exilicambarus*, the eight other nominal subgenera of *Cambarus* are fraught with taxonomic problems. One of the most imposing groups is *Depressicambarus*, a widespread subgenus of epigean and burrowing crayfishes ranging from North Carolina to the Florida panhandle and westward to Mississippi and Kentucky. Most of the problems associated with this subgenus are related to the burrowing activities and variability of the taxonomic features of many of its members. Because of the arduous task of collecting burrowers, they are poorly represented in museum collections. In addition, many populations of morphologically similar crayfish (especially burrowers) often exhibit seemingly significant variations from one another, compounding the problem of analysis of morphological characters. This latter problem was noted early by students of crayfishes. As stated by Kingsley (1899): "The discrimination of the species is not easy . . . difficulties which surround the systematic arrangement of these forms can be seen from the fact that the late William Stimpson, our most accurate student of the Crustacea, would not touch the crayfish, remarking that either we had only one species of *Cambarus* [=Cambarinae and Cambarellinae] in our country, or each mud puddle has its own species."

This study of the subgenus *Depressicambarus*, including several proposed nomenclatorial changes and the description of a new species, should provide a better understanding of this widely distributed group and hopefully will serve as a basis for assessing newly discovered populations belonging to *Depressicambarus*. While this work attempts to define the relationships and morphological limits of the known members of the subgenus, complete analysis is not possible until additional specimens of *Cambarus latimanus* from Alabama, *C. striatus* from Alabama and Mississippi and *C. reduncus* from North Carolina are collected and the descriptions of new species are

Editorial committee for this paper:

Dr. Horton H. Hobbs, Jr., Smithsonian Institution, Washington, D.C. 20013
Dr. Joseph F. Fitzpatrick, Jr., University of South Alabama, Mobile, AL 36688

published. This paper includes an emended diagnosis of the subgenus *Depressicambarus*, diagnoses of and a key to the species, mensural data and drawings of variation in the gonopods. Because the original descriptions of *C. latimanus*, *C. graysoni* and *C. striatus* were brief, redescriptions and drawings of the three species are included, and a new species from Florida is described. All measurements are from adult specimens, with juveniles tending to possess shorter areolae that would increase range values of morphometric data involving this structure. Morphometric data in parentheses refer to single measurements lying outside the clustered range for the species.

Although I originally had no thought of examining the entire subgenus, the broad subject encompassed in this paper was precipitated by a study of the Tennessee fauna. Here members of *Depressicambarus*, exhibiting three different color patterns (see color notes under *Cambarus graysoni* and *C. striatus*), are found together in central Tennessee. One of these color morphs is easily recognizable as a dominant epigean species of the Nashville Basin (Bouchard, 1974) referred to in the literature as *C. striatus*. After morphological analysis, the remaining two color forms were determined to be color morps of the same species, closely related to *C. striatus*. The most surprising aspect of this study was the discovery that this latter species is conspecific with the type-specimens of *C. striatus*, and the species identified as *C. striatus* for more than thirty years is actually Faxon's (1914) *C. graysoni*. A consistent character (epistomal zygoma) for separating *C. graysoni* from *C. striatus* was known (see Bouchard, 1973), so additional research leading to this presentation centered around defining the variability within *striatus* and finding characters to separate it from other morphologically similar species.

A brief recounting of the taxonomic histories of *C. latimanus*, *C. striatus* and *C. graysoni* is helpful in revealing factors that may have contributed to our confusion in identifying *C. striatus*. *Cambarus striatus* was described from Nashville, Tennessee, by Hay (1902) as *C. latimanus striatus*. His designation of *striatus* as a subspecies of *latimanus* was in keeping with the taxonomic interpretation in astacology at that time. Populations of crayfishes that did not differ greatly in morphology from certain nominal species were designated as subspecies of that species.

Ortmann (1931) believed *C. striatus* to be "more closely related to *C. bartoni* than to *latimanus*" and in keeping with contemporary taxonomic principles designated *striatus* a subspecies of *bartonii*. He also stated that Faxon's "*graysoni* . . . is very likely the same as *striatus*" [Faxon (1914) had described *C. graysoni* from Grayson County, Kentucky, considering it "related to *C. ortmanni*"]. *Rhoades* (1944), in his study of Kentucky crayfishes, supposedly followed Ortmann in regarding *striatus* as a subspecies of *bartonii*: "*Cambarus bartoni striatus* is represented by several local varieties and races which intergrade into each other to a greater or lesser degree. I have not seen my way clear to create new subspecies and, furthermore, I have followed Ortmann in uniting *Cambarus graysoni* with *C. b. striatus*. . . ." I do not interpret Ortmann (1931) as definitely uniting *graysoni* with *striatus* (see above). Rhoades (1944) himself is the first to state definitely that *C. graysoni* is a junior synonym of *C. striatus* as follows: "*Cambarus graysoni* is . . . a local variety of *striatus* equivalent to the others listed here." Of special interest is another statement by Rhoades (1944) concerning specimens related to *C. striatus*: "I possess four collections of mostly small individuals of a variety from the lower Green River drainage which is probably a distinct species." Rhoades (1944) noted some differences in this probable new species but "did not describe this form because of the lack of mature specimens." My examination of those specimens, which were deposited in the United States National Museum, shows them to be *C. striatus*.

For later astacologists, another factor obscuring the identity of *C. striatus* was that *C. graysoni* is the most common member of the subgenus *Depressicambarus* collected in epigean waters near Nashville, Tennessee (the type-locality for *C. striatus*). Since these two species are morphologically very similar, collections of *graysoni* in this area were assumed to represent *C. striatus* but have proven to be inseparable from topotypic *C. graysoni*.

When close relatives of *C. striatus* were examined in the course of this study, no mensural or meristic character could be found to distinguish *C. floridanus* populations from *C. striatus*. The red color attributed to *C. floridanus* (Hobbs and Hart, 1959; Hobbs, 1969) also proved to be an inadequate character. The color pattern of live topotypic material (kindly supplied by Horton H. Hobbs, Jr.) is not drastically different from *C. striatus* (see color notes for *C. striatus*). Therefore, without a difference between *C. floridanus* and *C. striatus*, the former is here regarded as a synonym of *C. striatus*. The bright orange-red colored populations of *C. floridanus* in Torreya State Park, Liberty County, Florida (Hobbs, 1942; Hobbs and Hart, 1959), are distinct enough to be considered a separate species which is described herein.

A morphologically close ally of *C. striatus* is *C. latimanus*. They are both considered valid species, although certain individuals cannot be clearly assigned to either species (see relationships). The crayfishes are distinct and easily separable in syntopic populations where *C. striatus* generally prefers a burrowing habitat and exhibits a larger branchial chamber reflected in its longer and narrower areola. *Cambarus latimanus* dominates the open stream and displays a comparatively shorter and wider areola. The most consistent character to separate all populations of *C. striatus* from *C. latimanus* appears to be the ratio of areola length to width, although the range of measurements from occasional individuals and certain populations of each overlaps.

An examination of *C. latimanus* material revealed considerable variation in a number of characters but most importantly in spination. Among populations of *C. latimanus*, the range of variation in the development of spines on the rostrum and cephalothorax, a character thought to be highly variable in many members of the genus *Cambarus* (Bouchard, 1976b), suggests that *C. jordani* is a form of *C. latimanus*. In those populations of *C. latimanus* in which the juveniles possess rostral spines, (Fig. 2*b*) these spines usually become reduced with maturity. An adult population may possess rostral margins that blend indiscernably with the acumen, margins that are well inflated above the acumen, or margins with tubercles representing remnants of the juvenile spines (Fig. 2*a*).

The description of *C. jordani* (Faxon, 1884) from the Etowah River near Rome, Floyd County, Georgia, was based upon a single juvenile male which had well-developed rostral spines (*cf.* Faxon, 1885: plate 3, figure 3). Specimens assignable to *C. jordani* from localities near the type-locality do not differ from *C. latimanus*. The only distinctive character in *C. jordani*, spines or tubercles on the rostrum, is not uncommon in members of *C. latimanus*. The variation in rostral spination among populations of *C. latimanus* encompasses populations considered to be *C. jordani*, and the latter should, therefore, be considered a synonym of *C. latimanus*.

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Diagnosis of the Subgenus *Depressicambarus*

Cambarus (*Depressicambarus*) Hobbs, 1969:102. Type-species: *Astacus latimanus* Le Conte, 1856:402. Eyes variable in size and pigmented. Rostrum with or without tubercles or small spines (spination most evident on juveniles), margins variable in thickness. Areola width variable, obliterated to 2.9 times longer than broad and constituting 29.8 to 45.7 percent of total length of carapace (38.2 - 50.7 percent of postorbital carapace length); bearing as many as 7 shallow punctations across narrowest part. Postorbital and cervical spines rare except in *C. englishi*, *C. halli*, *C. obstipus* and some populations of *C. latimanus*. Suborbital angle obsolete to moderately well developed except in *C. cymatilis*, *C. graysoni* and some populations of *C. halli* in which well developed. Branchiostegal spines present. Chela broadly subtriangular, strongly depressed (less so in *C. halli*, *C. englishi* and some populations of *C. sphenoides*) with mesial margin of palm comparatively short and bearing two major rows of tubercles, small squamous tubercles and/or punctations studding dorsal surface; lateral margin of fixed finger strongly costate and punctate; fingers never widely gaping but with well-defined longitudinal ridges dorsally, proximal opposable margin of dactyl never deeply concave; conspicuous tuft of setae never present at mesial base of fixed finger, lateral base flattened. First form male with first pleopods almost contiguous at base and with distal portion of shaft almost straight, never inclined caudad; terminal elements consisting of (i) blade-like, broad or tapering central projection recurved at angle of approximately 90 to 155 degrees to main shaft, subapical notch present or absent, (ii) mesial process tumescent, caudally directed, and sometimes exceeding tip of central projection caudally, contracted apical portion sometimes with two or more projections, (iii) caudal knob typically vestigial or absent (well developed in some populations of *C. striatus*, rarely so in *C. latimanus*) (See Fig. 12*a, d, j*). Hook on ischium of third pereiopod simple, overreaching basioischial articulation and generally not opposed by tubercle on basis.

Key to the Species of the Subgenus *Depressicambarus*

1. Propodus of chela with opposable margin bearing conspicuous gap between second and third tubercles from base (Fig. 1*j*)........*cymatilis*
   Propodus of chela with opposable margin lacking conspicuous gap between second and third tubercles from base (Fig. 4*i*)........2
2. Epigtomal zygoma gently bent (Fig. 2*c*)........*graysoni*
   Epistomal zygoma moderately well to strongly arched (Fig. 2*d-f*) LL3
3. First pleopod of first form male aciculate (Fig. 3*h*)........*reduncus*
   First pleopod of first form male not aciculate (Fig. 3*c*)........4
4. Abdominal pleura with moderately sharp caudoventral angles (Fig. 1*b*)........*englishi*
   Abdominal pleura with broad caudoventral angles (Fig. 1*a*)........5
5. Antennal scale moderately narrow with steeply declivous mesial margin (Fig. 1*c*)........*catagius*
   Antennal scale moderately broad to broad with declivous to angulate mesial margin (Fig. 1*e*)........6
6. Dactyl of chela with opposable margin bearing 8 or 9 fairly evenly sized tubercles (Fig. 1*i*)....*obstipus*
   Dactyl of chela with opposable margin bearing 4 or 5 dominant basal tubercles, first, fourth or fifth; first and fourth or first and fifth largest (Fig. 4*i*)........7
7. Areola densely punctate (Fig. 1*f*)........*halli*
   Areola moderately to sparsely punctate or obliterated (Fig. 1*g*)........8
8. Suborbital angle obsolete (Fig. 9*b*); proximolateral portion of telson with caudolateral corners bearing single immovable spine (rarely movable spine also present)........*pyronotus*
   Suborbital angle poorly to moderately well developed (Fig. 10*b*); proximolateral portion of telson with caudolateral corners bearing single movable and immovable spines........9
9. Epistomal zygoma strongly arched (*cf.* Fig. 2*f*); fingers of chela with opposable margins bearing double or triple row of denticles (*cf.* Fig. 1*k, l*)........*sphenoides*
   Epistomal zygoma moderately well arched (Fig. 2*d, e*); fingers of chela with opposable margins bearing double row of denticles only (Fig. 1*l*)........10
10. Areola narrow, length 10 or more times greater than width, or obliterated (occasional individuals from above the Fall Line, especially the Tallapoosa River system, range as low as 9.1 times) (Figs. 10*i*, 11*i*)........*striatus*
    Areola broader, length less than ten times greater than width (populations from below the Fall Line in Georgia and Alabama, and upper Savannah and Santee River systems, South Carolina, with proportions up to 11.8 and 12.3 times, respectively) (Fig. 5*l*)........*latimanus*

Cambarus (Depressicambarus) catagius Hobbs and Perkins, 1967

DIAGNOSIS.—Rostrum excavate dorsally with slightly concave, subparallel margins devoid of marginal spines or tubercles. Areola narrow and long, 14.4 to 32.0 times longer than broad, comprising 37.0 to 40.1 percent of total length of carapace [(43.6) 44.4 - 47.3 percent of postorbital carapace length], with no punctations or as many as 2 across narrowest part. Carapace vaulted; cervical spines reduced to small, rounded tubercles. Suborbital angle weakly developed and rounded. Antennal scale moderately narrow; margin of lamellar portion steeply declivous (Fig. 1*c*). Cephalic portion of epistome of medium width; epistomal zygoma moderately well arched (*cf.* Fig. 2*d, e*). Chela with opposable margin of dactyl bearing 4 dominant tubercles, first or fourth largest (fourth primarily), sometimes subequal in size; opposable margin of propodus with 3 dominant tubercles increasing in size distally, third largest; opposable margins of both fingers with double row of denticles (*cf.* Fig. 1*l*). First pleopod of first form male with central projection lacking subapical notch or bearing very shallow one and recurved at angle of approximately 115 to 120 degrees. Annulus ventralis situated deep in sternum, suboval in outline; caudal wall conspicuously thickened and elevated above cephalic portion, latter bearing shallow sinus flanked by low ridges.

RANGE.—*Cambarus catagius* is known from only Greensboro, Guilford County, North Carolina. Greensboro is in the Piedmont province and the Cape Fear River basin.

Cambarus (Depressicambarus) cymatilis Hobbs, 1970

DIAGNOSIS.—Rostrum excavate dorsally with slightly concave, subparallel margins devoid of spines or tubercles. Areola long, comprising 41.7 to 44.8 percent of total length of carapace (48.1 - 50.4 percent of postorbital carapace length) and obliterated to narrow with space for no more than 1 punctation in narrowest part. Carapace vaulted; cervical spines reduced to small rounded tubercles. Suborbital angle well developed and acute. Antennal scale narrow; margin of lamellar portion steeply declivous. Cephalic portion of epistome narrow; epistomal zygoma moderately well arched. Chela with opposable margin of dactyl bearing 2 dominant tubercles, distal one larger; corresponding margin of propodus with 3 dominant tubercles, proximal 2 increasing in size distally followed by large gap between second and third (Fig. 1*j*); opposable margins of both with single row of evenly spaced denticles (Fig. 1*m*). Central projection of first pleopod of first form male short, with well-defined subapical notch and recurved at angle of approximately 95 to 105 degrees. Annulus ventralis situated deep in sternum, suboval in outline; caudal wall conspicuously thickened and elevated above cephalic portion, latter bearing shallow sinus flanked by low ridges.

RANGE.—This primary burrowing crayfish has been collected from the Coosa River basin in the Ridge and Valley province. Within this drainage *C. cymatilis* is known from Murray County, Georgia, and Bradley County, Tennessee.

Cambarus (Depressicambarus) englishi Hobbs and Hall, 1972

DIAGNOSIS.—Rostrum of adults lacking or possessing tubercles, but if absent, base of acumen generally delimited by conspicuous angles; that of juveniles with spines or tubercles decreasing in size with maturity; margins concave and subparallel; surface excavate. Areola moderately long, 33.2 to 38.0 percent of total length of carapace (41.3 - 46.7 percent of postorbital carapace length); 3.4 to 4.9 times longer than broad (as low as 3.3 in some juveniles) and bearing 4 to 6 punctations across narrowest part. Carapace depressed; cervical spines small and acute. Suborbital angle weakly to moderately well developed and rounded to obsolete. Antennal scale somewhat broad; margin of lamellar portion angulate (*cf*. Fig. 5*h*) to declivous. Cephalic portion of epistome of medium width; epistomal zygoma moderately well arched. Chela with opposable margin of dactyl bearing 4 or 5 dominant tubercles, first and fourth or first and fifth largest; corresponding margin of propodus with 3 or 4 dominant tubercles, third or fourth largest; opposable margins of both with single or double row of crowded denticles. Central projection of first pleopod of first form male tapering, lacking subapical notch and recurved at angle of approximately 105 to 115 degrees; element long. Annulus ventralis situated moderately deep in sternum, subquadrangular in outline; caudal wall elevated; cephalic portion bearing shallow sinus flanked by low ridges. Cephalic portion of annulus ventralis sometimes equal in height to caudal wall.

RANGE.—*Cambarus englishi* occurs in that portion of the Tallapoosa River system which drains the Piedmont province in Georgia and Alabama. This crayfish has been collected from Haralson County, Georgia, and Clay, Cleburne and Tallapoosa counties, Alabama.

Cambarus (Depressicambarus) graysoni Faxon, 1914

DIAGNOSIS.—Body and eyes with pigment. Rostrum usually without tubercles. Areola 9.0 to 15.1 times longer than broad and constituting 37.1 to 41.1 (43.9) percent of total length of carapace [(43.2) 44.2 - 49.2 percent of postorbital carapace length] with 2 to 4 punctations across narrowest part. Cervical spines reduced to small, rounded tubercles or absent; hepatic spines absent; branchiostegal spines present; suborbital angle well developed, acute, sometimes terminating in small spine or tubercle; postorbital ridge moderately strong, rounded cephalically. Antennal scale moderately broad to wide; margin of lamellar portion angulate. Cephalic portion of epistome comparatively wide; epistomal zygoma with anterior margin gently bent. Chela with 2 rows of 8 or less tubercles on mesial surface of palm; opposable margin of dactyl with proximal 4 tubercles prominent—first, fourth or first and fourth largest; corresponding margin of propodus with proximal 3 or 4 tubercles dominant in size, third or fourth largest; opposable margins of both with irregular double to quadruple row of denticles, increasing to triple and quadruple row with age; lateral margin costate and lateral base of fixed finger impressed above, less so below. Hook on ischium of third pereiopod of male overreaching basioischial articulation and not opposed by tubercle on basis. First pleopod of first form male with central projection corneous, bladelike, lacking subapical notch, recurved at angle of approximately 115 to 140 degrees; mesial process tumescent, tapering to subacute tip, and directed caudally at angle of approximately 90 degrees to shaft of appendage. First pleopod of second form male noncorneous; central projection rounded distally; mesial process tapering to subacute tip. Annulus ventralis asymmetrical, subquadrangular, with caudal portion somewhat movable; cephalic half bearing longitudinal median trough between subparallel ridges, and caudal half with sinuate sinus and elevated caudal wall. First pleopod of female uniramous and reaching beyond midlength of annulus when abdomen flexed.

The following description of *C. graysoni* is based upon topotypes collected from Bear Creek, Grayson Springs, Grayson County, Kentucky. After comparing a second form male and a female from the syntypic series (3 males, form II; 1 female) with topotypes, I concluded that, without a doubt, they represent the same species.

TOPOTYPIC MALE, FORM I (USNM 144571).—Body subovate, slightly depressed (Fig. 4*b*). Abdomen narrower than thorax (15.3 and 18.0 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (18.0 and 12.6 mm). Areola 10.6 times longer than broad with 2 punctations across narrowest part; length of areola 38.5 percent of total length of carapace (44.2 percent of postorbital carapace length). Rostrum excavate dorsally with subparallel, thickened margins devoid of marginal spines or tubercles. Acumen set off from basal portion of rostrum with concave, oblique margins, not swollen; small upturned tubercle at tip broken; upper surface with submarginal punctations and others scattered between. Postorbital ridges moderately strong, shallowly grooved dorsolaterally and rounded cephalically. Suborbital angle strong; branchiostegal spine small. Cervical spines or tubercles absent; hepatic area and lateral portion of branchiostegite tuberculate; dorsal portion of carapace punctate.

Abdomen longer than carapace (36.1 and 33.0 mm); pleura of moderate length with caudoventral extremity broadly angular. Cephalic section of telson with single movable and immovable spines in each caudolateral corner; separated from caudal section by paired oblique excisions. Basal podomere of uropod with spines extending over mesial and lateral rami. Lateral ramus of uropod with median ridge terminating in acute spine at transverse flexure; additional small ridge lateral to median one; proximal portion with row of small spines distally and movable spine submarginally at caudolateral corner. Mesial ramus of uropod with median ridge terminating distally in premarginal acute spine. Caudal margin of tail fan with plumose setae; dorsal surface lightly setiferous.

Cephalic lobe of epistome (Fig. 4*k*) pentagonal with slightly upturned cephalolateral margins and with small cephalomedian projection; ventral surface convex. Basal portion of epistome with deep median fovea and pair of obliquely disposed slitlike fossae immediately cephalic and subparallel to thickened, gently bent anterior margin of epistomal zygoma; lateral extremities lacking tubercles. Proximal segment of antennule with small spine on ventral surface at base of distal third. Antennae broken. Antennal scale (Fig. 4*d*) moderately broad, broadest slightly distal to midlength; thickened lateral portion terminating in acute, corneous-tipped spine projecting forward beyond tip of rostrum; lamellar area with mesial margin broadly angulate, crenulate and edged with long, plumose setae.

Left chela (Fig. 4*i*) approximately 2 times longer than broad (23.2 and 11.4 mm), depressed, although more inflated proximolaterally; mesial margin of palm with 2 rows of 6 tubercles each in primary and secondary rows, and several smaller tubercles on dorsal surface over mesial half of palm; distoventral surface of palm with 2 large, swollen tubercles at base of dactyl, mesial one with very small, rounded, corneous tip. Lateral surface of propodus costate with row of punctations rendering proximolateral margin of fixed finger irregular in dorsal aspect. Fixed finger with proximolateral base impressed dorsally, less so ventrally; dorsal and ventral surfaces with distinct submedian ridges flanked by setiferous punctations; opposable surface with row of 5 tubercles along proximal three-fifths of finger, fourth largest, decreasing in size proximally; additional small tubercle present on lower level at base of distal two-fifths, and double row of minute denticles extending proximally from corneous tip of finger to fourth tubercle from base, interrupted by fifth. Dorsal and ventral surfaces of dactyl with median longitudinal ridges, flanked by setiferous punctations; opposable margin with row of 6 tubercles, first largest; mesial margin of dactyl tuberculate along nearly proximal two-thirds and punctate distally; row of minute denticles extending from corneous tip to third tubercle, interrupted by fourth.

Carpus longer than broad with deep oblique furrow dorsally; mesial surface with large procurved spine near midlength and with smaller one located caudally and one ventrally; distoventral margin with strong spiniform tubercle; dorsomesial surface with 3 small, rounded tubercles; podomere otherwise punctate.

Dorsodistal surface of merus with 3 rounded tubercles; ventral surface with lateral row of 4 tubercles, some corneous-tipped, and mesial row of 9 corneous-tipped, acute tubercles; both rows decreasing in size proximally. Ischium with row of 4 small tubercles on mesial margin.

Hook on ischium of third pereiopod only (Fig. 4*h*); hook simple, overreaching basioischial articulation and not opposed by tubercle on basis. Coxa of fourth pereiopod with prominent caudomesial boss; fifth pereiopod without prominence. For measurements see Table 1.

Table 1. Measurements (mm) of *Cambarus* (*Depressicambarus*) *graysoni*

	Topotypic Male, Form I	Topotypic Female	Topotypic Male, Form II
Carapace			
Height	12.6	15.8	11.3
Width	18.0	24.6	17.2
Total length of carapace	33.0	44.4	31.9
Postorbital carapace length	28.7	38.5	27.3
Areola			
Width	1.2	1.5	1.1
Length	12.7	17.4	12.1
Rostrum			
Width	4.5	5.9	4.4
Length	4.3	5.9	4.6
Chela			
Length, mesial margin of palm	7.0	8.8	5.7
Width, palm	11.4	14.7	19.7
Length, lateral margin	23.2	30.1	19.7
Length, dactyl	14.7	19.0	12.2

First pleopods (Fig. 4*e*, *f*, *g*) reaching caudal portion of coxae of third pereiopods when abdomen flexed. See "Diagnosis" for description.

Topotypic Female (USNM 144571).—Differing from topotypic male, form I, in following respects: tip of acumen terminating in small, rounded, corneous tubercle. Primary row of tubercles on mesial margin of palm consisting of 7 tubercles, secondary row of 5. Carpus with 2 tubercles caudal to large procurved spine on mesial surface; dorsomesial surface with 5 and 4 small, rounded tubercles on right and left, respectively. Ventral surface of merus of right cheliped with 5 tubercles on lateral margin and 11 on mesial margin of left. Ischia of chelipeds with row of 3 tubercles on each. Opposable margin of right propodus with 7 tubercles. Opposable margin of dactyl with 5 tubercles on both left and right chelipeds; row of minute denticles extending from corneous tip to second tubercle, interrupted by third and fourth tubercles from base. Cervical spines consisting of small, rounded tubercle with setal tuft.

Annulus ventralis (Fig. 4*j*) subquadrangular, broader than long and situated moderately deep in sternum with cephalic portion fused to sternum and caudal half movable. Annulus ventralis divided by sinus into C-shaped and triangular portions, latter with basal tongue projecting into concavity of "C." Cephalic half with sinus broadening into median longitudinal trough flanked by subparallel, longitudinal ridges; caudal portion elevated and nearly bisected by shallow sinus. Postannular sclerite subconical and approximately two-thirds width of annulus.

TOPOTYPIC MALE, FORM II (USNM 147861).—Differing from topotypic male, form I, in following respects: tip of acumen terminating in small, upturned, corneous tubercle. Areola with 3 punctations across narrowest part. Opposable margin of propodus with 7 tubercles on both right and left chelae. Opposable margin of dactyl with 5 tubercles on each chela. Carpus with 2 tubercles proximal to large procurved spine on mesial surface of left cheliped and 6 small, rounded tubercles on dorsomesial surface of both left and right. Upper surface of merus with 2 spines on each cheliped; ventral margin with 11 and 10 tubercles in mesial row of right and left chelipeds, respectively. Suborbital angle terminating in small spine. Cervical spines reduced to small, rounded tubercle with setal tuft.

Hook on ischim of third pereiopod much reduced, not reaching basioischial articulation, and not opposing tubercle on basis; boss on coxa of fourth pereiopod somewhat smaller and less sharply defined. First pleopod of uniform texture and reaching caudal portion of coxa of third pereiopod when abdomen flexed. See "Diagnosis" for description.

COLOR NOTES.—Cephalothorax and abdomen mottled or concolorous brown, green-brown to green. Abdomen with or without pair of submedian and paired lateral, narrow, broken, dark brown stripes extending onto dorsolateral part of thorax as very small sinistral and dextral horns. Occasional individuals with blue or red color patterns. Young crayfish well mottled, color pattern becoming concolorous with maturity and abdominal stripes less discernible. Gastric region with paired, lighter, vermiculated areas marking attachment of mandibular muscles. Branchiostegites and hepatic areas mottled to concolorous brown, green-brown to green dorsally, fading to white ventrad. Pleural regions of abdomen with distinct ventral, broad, mottled, cream to yellow colored margin, often most evident on first abdominal segment as cream through yellow colored spot on each side; spots especially striking in populations from Green River system in Kentucky and Tennessee. Ventral aspects of cephalothorax and abdomen white, occasionally tinged with blue.

Rostral margins yellow, tan or brown. Postorbital ridges light brown or same color as cephalothorax. Tubercles, spines and articular condyles yellow through cream. Lateral margin of antennal scale darker than lamellar portion. Antennae generally dark green or brown.

Chelae brown, green-brown, green to green-blue dorsally with lighter proximolateral area; white ventrally. Distal ends of fingers red, orange, yellow or cream, fading with age or if living in turbid waters. Pereiopods same general color as cephalothorax but lighter dorsolaterally; white ventrolaterally. Distal podomeres darker dorsally than proximal ones.

TYPE-LOCALITY.—Bear Creek (Green River System), at Grayson Springs, Grayson County, Kentucky (Faxon, 1914). On 11 May 1973 a collection from the type-locality revealed the following crayfish associates: *Cambarus (Erebicambarus) tenebrosus* and *Orconectes putnami*.

DISPOSITION OF TYPES.—The syntypes, consisting of 1♂II and 3♀ were collected by F. W. Putnam on 24 October 1874 and deposited in the Museum of Comparative Zoology, Harvard College, (MCZ 3593). Two series of topotypes consisting of 2♂I, 5♂II, 10♀, 19 juv.♂ and 12 juv.♀ are in the National Museum of Natural History, Smithsonian Institution.

RANGE.—This crayfish is a common inhabitant of streams primarily draining limestone deposits of the Highland Rim and Nashville Basin sections (Bouchard, 1974) and occurs at the western edge of the Cumberland Plateau (Bouchard, 1976b) in Kentucky, Tennessee and Alabama. In valleys at the western edge of the Cumberland Plateau, *C. graysoni* has primarily penetrated streams draining Mississippian limestone deposits. The streams here have notched headward into the predominantly Pennsylvanian sandstone cap exposing the underlying Mississippian limestones.

VARIATIONS.—The most significant variations exhibited by *C. graysoni* are in the gonopod of the first form male and on the rostrum. The central projection of the first form male gonopod varies in its length relative to the cephalocaudal diameter of the shaft of the appendage (see Fig. 3*d, e*), being generally longer in populations south of the Green River system. In most populations of *C. graysoni*, the rostrum is unadorned, although it is not uncommon for very small juveniles to exhibit small spines on the cephalic ends of the margins. These spines are usually lost with maturity, but in some populations remnants are retained in the form of tubercles. These rostral tubercles are especially noticeable in populations from the Caney Fork (Cumberland) River system, Tennessee.

SIZE.—The largest specimen available is a female from Smith County, Tennessee, with a carapace length of 68.6 mm (postorbital carapace length 59.7 mm).

Cambarus (Depressicambarus) halli Hobbs, 1968

DIAGNOSIS.—Rostrum with or without tubercles on adults, but if absent, base of acumen delimited by conspicuous angles; juveniles with spines or tubercles decreasing in size with maturity; margins nearly straight and slightly converging, excavate dorsally. Areola short, 28.9 to 35.1 percent of total length of carapace [39.3 - 42.5 (43.3) percent of postorbital carapace length], and 2.9 to 4.5 times longer than broad, moderately to densely punctate, with space for 5 to 7 punctations across narrowest part. Carapace subovate; cervical spines small and acute. Suborbital angle moderately to well developed and obtuse to rounded. Antennal scale of medium breadth and lamellar portion with declivous margin (Fig. 1*e*). Cephalic portion of epistome of medium width; epistomal zygoma moderately well arched. Opposable margin of dactyl of chela with proximal 4 or 5 tubercles prominent—first, fourth or fifth or first and fourth or first and fifth largest; corresponding margin of propodus with proximal 3 or 4 tubercles dominant in size, third or fourth largest; opposable margins of both with single or double row of crowded denticles. Central projection of first pleopod of first form male moderately long, bearing subapical notch and recurved at angle of approximately 120 to 130 degrees. Annulus ventralis situated moderately deep in sternum; subquadrangular in outline; caudal wall elevated; cephalic portion bearing shallow sinus flanked by low ridges.

RANGE.—*Cambarus halli* is known from only that portion of the Tallapoosa River system draining the Piedmont province in Alabama and Georgia. This crayfish has been collected from Carroll and Haralson counties, Georgia, and Chambers, Clay, Cleburne, Lee, Randolph and Tallapoosa counties, Alabama.

Cambarus (Depressicambarus) latimanus (LeConte, 1856)

Cambarus jordani, 1884:119.

DIAGNOSIS.—Body and eyes with pigment. Rostrum with or without tubercles in adults; juveniles often with spines or tubercles, decreasing in size with maturity; sometimes low carina; margins subparallel to acuminate. Areola variable, 3.4 to 12.3 times longer than broad and constituting 29.8 to 38.9 percent of total length of carapace (38.2 - 45.8 percent of postorbital carapace length) with 2 to 5 punctations across narrowest part. Cervical spines variable, prominent or reduced to small, rounded tubercles or absent; hepatic spines absent; branchiostegal spine present; suborbital angle moderately well developed and rounded to acute, sometimes with small spine or tubercle; postorbital ridge somewhat strong, rounded cephalically or terminating in acute spine or tubercle. Antennal scale moderately broad to wide; margin of lamellar portion angulate. Cephalic portion of epistome comparatively wide; epistomal zygoma moderately well arched. Chela with 2 rows of 8 or fewer tubercles on mesial surface of palm; opposable margin of dactyl with proximal 4 or 5 tubercles prominent—first, fourth or fifth or first and fourth or first and fifth largest; corresponding margin of propodus with proximal 3 or 4 (rarely 5) tubercles dominant in size, third, fourth or fifth largest; opposable margins of both with irregular double row of denticles; lateral margin costate and lateral base of fixed finger impressed above, less so below. Hook on ischium of third pereiopod of male overreaching basioischial articulation and not opposed by tubercle on basis. Central projection of first pleopod of first form male corneous, bladelike, with or without subapical notch, recurved at angle of 100 to 145 degrees; mesial process tumescent, tapering to subacute tip, and directed caudolaterally at angle of approximately 90 degrees to shaft of appendage (Fig. 5*e, f, g*). First pleopod of second form male noncorneous; central projection rounded distally; mesial process tapering to subacute tip. Annulus ventralis asymmetrical, subquadrangular, with caudal portion somewhat movable; cephalic half bearing longitudinal median trough between prominent or reduced subparallel longitudinal ridges, and caudal half with sinuate sinus and elevated caudal wall. First pleopod of female uniramous and reaching at least to midlength of annulus when abdomen flexed.

According to Hobbs (1974), there are only two individuals of *C. latimanus* that can be considered type-specimens. These are a dry second form male at the Museum of Comparative Zoology, Harvard University, and a dry female (Faxon, 1914) at the Academy of Natural Sciences of Philadelphia. Taking thorough, descriptive notes and figures from such specimens would not be possible and would probably damage them. Therefore, the following descriptions are based upon topotypes collected in Athens, Clarke County, Georgia.

TOPOTYPIC MALE, FORM I (USNM 146435).—Body subovate, slightly depressed (Fig. 5*b*). Abdomen narrower than thorax (14.8 and 17.1 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (17.1 and 12.6 mm). Areola 5.8 times longer than broad with 2 punctations across narrowest part; length of areola 35.4 percent of entire length of carapace (42.8 percent of postorbital carapace length). Rostrum excavate dorsally with subparallel, thickened margins devoid of marginal spines or tubercles and elevated well above acumen; upper surface with submarginal punctations and others scattered between. Acumen set off from proximal portion of rostrum with concave, oblique margins, not swollen, and terminating in corneous, acute, upturned tubercle. Postorbital ridges moderately strong, with a somewhat deep groove dorsolaterally and rounded cephalically. Suborbital angle acute; branchiostegal spine large. Cervical spines reduced to single small, rounded tubercle on each side; hepatic area and lateral portion of branchiostegite tuberculate; dorsal surface of carapace punctate.

Abdomen longer than carapace (33.5 and 31.1 mm); pleura of moderate length with caudoventral extremity broadly angular. Cephalic section of telson with single movable and immovable spines in each caudolateral corner, separated from caudal section by paired oblique excisions. Basal podomere of uropod with spines extending over mesial and lateral rami. Lateral ramus of uropod with median ridge terminating in acute spine at transverse flexure; additional small ridge lateral to median one; proximal portion with row of small spines distally and movable spine (missing on right side) located submarginally at caudolateral corner. Mesial ramus of uropod with median ridge terminating distally in premarginal acute spine; lateral margin terminating in acute spine. Caudal margin of tail fan with plumose setae; dorsal surface lightly setiferous.

Cephalic lobe of epistome (Fig. 5*k*) pentagonal with slightly upturned cephalolateral margins and with small cephalomedian projection; ventral surface convex. Basal portion of epistome with deep median fovea and pair of obliquely disposed slitlike fossae immediately cephalic and subparallel to thickened, moderately well-arched epistomal zygoma; lateral extremities without tubercles. Proximal segment of antennule with small acute spine on ventral surface at base of distal third. Antennae broken. Antennal scale (Fig. 5*h*) moderately broad, broadest slightly distal to midlength; thickened lateral portion terminating in acute, corneous-tipped spine projecting forward beyond tip of rostrum; lamellar area with broadly angulate mesial margin, crenulate and edged with long, plumose setae.

Left chela (Fig. 5*i*) approximately 2 times longer than broad (22.1 and 11.4 mm), depressed, although more inflated proximolaterally; mesial margin of palm with 2 rows of 6 tubercles each in primary and secondary rows, and squamous tubercles over dorsal surface of palm; distoventral surface of palm with 2 large, swollen tubercles at base of dactyl, with small, rounded, corneous, acute tip. Lateral surface of propodus costate with row of punctations rendering proximolateral margin of fixed finger irregular in dorsal aspect. Fixed finger with proximolateral base impressed dorsally, less so ventrally; dorsal and ventral surfaces with distinct submedian ridges flanked by setiferous punctations; opposable surface with row of 6 tubercles along proximal three-fifths of finger, fourth largest, decreasing in size proximally; additional small tubercle on lower level at base of distal third broken; double row of minute denticles extending proximally from corneous tip of finger to fifth tubercle, interrupted by sixth from base. Dorsal and ventral surfaces of dactyl with median longitudinal ridges, flanked by setiferous punctations; opposable margin with row of 8 tubercles, first and fourth largest; mesial margin of dactyl tuberculate along nearly proximal three-fifths and punctate distally; double row of minute denticles extending from corneous tip to fourth tubercle from base, broken by fifth and sixth.

Carpus longer than broad with deep oblique furrow dorsally; mesial surface with large procurved spine near midlength and small ones located proximally, proximoventral and ventral to large spine; distoventral margin with strong subspiniform tubercle and additional smaller one proximodorsally; dorsomesial surface with 10 rounded tubercles; podomere otherwise punctate.

Dorsodistal surface of merus with 2 subacute tubercles; ventral surface with lateral row of 5 tubercles decreasing in size proximally, some corneous-tipped, and mesial row of 11 corneous-tipped, acute tubercles. Ischium with row of 4 small tubercles on mesial margin.

Hook on ischium of third pereiopod only (Fig. 5*d*); hook simple, overreaching basioischial articulation and not opposed by tubercle on basis. Coxa of fourth pereiopod with prominent caudomesial boss, fifth pereiopod without prominence. For measurements see Table 2.

First pleopods (Fig. 5*e, f, g*) reaching caudal portion of coxae of third pereiopods when abdomen flexed. See "Diagnosis" for description.

TOPOTYPIC FEMALE (USNM 116986).—Differing from topotypic male, form I, in following respects: margins of rostrum less swollen. Areola with 3 punctations across narrowest part. Cervical spines consisting of slightly larger rounded tubercles. First chelipeds missing.

Annulus ventralis (Fig. 5*j*) subquadrangular, broader than long and situated moderately deep in sternum with cephalic portion fused to sternum and caudal half movable. Annulus ventralis divided by sinus into C-shaped and triangular portions, latter with basal tongue projecting into concavity of "C." Cephalic half with sinus broadening into median longitudinal trough flanked by subparallel, longitudinal ridges; caudal portion elevated and nearly bisected by shallow sinus. Postannular sclerite subconical and approximately half width of annulus.

Table 2. Measurements (mm) of *Cambarus* (*Depressicambarus*) *latimanus*

	Topotypic Male, Form I	Topotypic Female	Topotypic Male, Form II
Carapace			
Height	12.6	12.5	11.2
Width	17.1	17.0	15.6
Total length of carapace	31.1	31.7	30.2
Postorbital carapace length	25.7	26.8	25.0
Areola			
Width	1.9	2.2	1.7
Length	11.0	11.5	10.6
Rostrum			
Width	3.5	3.8	3.5
Length	5.4	4.9	5.2
Chela			
Length, mesial margin of palm	6.7	*	6.5
Width, palm	11.4	*	10.7
Length, lateral margin	22.1	*	21.9
Length, dactyl	13.7	*	13.6

* no chelae

TOPOTYPIC MALE, FORM II (USNM 118442).—Differing from topotypic male, form I, in following respects: margins of rostrum less swollen. Areola with 3 punctations across narrowest part. Cephalic portion of epistome with anterior edges rounded. Chelae with 5 and 4 tubercles in secondary row on mesial surface of palm of right and left ones, respectively. Propodus of each cheliped with 9 tubercles along opposable margin and additional smaller one on lower level, third largest on right propodus; row of denticles extending from corneous tip to third tubercle from base on right (fourth on left), interrupted by fourth tubercle (fifth on left). Opposable margin of dactyl of each chela with 9 tubercles; denticles extending from corneous tip to third tubercle from base on right dactyl, interrupted by fourth and fifth tubercles (fifth on left). Carpus with 2 tubercles located proximad to large procurved spine on mesial surface, lacking distoventral tubercle on left carpus and ventrally disposed one on right; ventral margin with 2 tubercles situated proximodorsad to large one on distoventral margin. Merus with 3 tubercles on dorsodistal surface of each cheliped; mesial row on ventral surface with 10 tubercles on both left and right chelipeds. Ischium of right with row of 5 small tubercles.

Hook on ischium of third pereiopod much reduced, not reaching basioischial articulation and not opposing tubercle on basis; boss on coxa of fourth pereiopod somewhat smaller and less sharply defined. First pleopods of uniform texture and reaching caudal portion of coxae of third pereiopods when abdomen flexed.

COLOR NOTES.—*Cambarus latimanus* exhibiting dimorphic color pattern. Cephalothorax and abdomen mottled to concolorous, usually brown, green-brown or green. Abdomen with (i) pair of complete, moderately broad, submedian, and narrower, broken, lateral, dark brown stripes or, (ii) pair of submedian and lateral narrow, broken stripes. Abdominal stripes extending onto thorax as sinistral and dextral horns, darker in color morph with solid stripes and often extending length of branchiostegites. Abdominal stripes, especially narrow, broken ones, often less discernible on mature specimens. Gastric region with paired, lighter, vermiculated areas marking attachment of mandibular muscles. Branchiostegites and hepatic areas mottled to concolorous brown, green-brown or green dorsally, fading to white ventrad. Caudal margins of abdominal terga sometimes bearing inconspicuous, narrow, red border. Pleural regions of abdomen with obvious ventral, light, mottled margin sometimes terminating dorsally on first abdominal segment as conspicuous, single, large spot on each side, varying from cream through yellow. Ventral aspects of cephalothorax and abdomen white, occasionally tinged with blue. Young crayfish more mottled than adults, becoming more concolorous with age.

Rostral margins yellow, tan or brown. Postorbital ridges yellow, light-brown, or same color as cephalothorax. Tubercles, spines and articular condyles yellow through cream. Lateral margin of antennal scale darker than lamellar portion. Antennae generally dark-green or brown.

Chelae brown, green-brown or green dorsally with lighter proximolateral area; white ventrally. Distal ends of fingers red, orange, yellow or cream, fading with age or if living in turbid waters. Pereiopods same general color as chelae dorsolaterally, only lighter; white ventrolaterally. Distal podomeres darker dorsally than proximal ones.

TYPE-LOCALITY.—"Georgia superiore" (LeConte, 1856). The type-locality was restricted by Hagen (1870) to Athens, Georgia, based upon an examination of a female type-specimen on deposit at the Academy of Natural Sciences of Philadelphia and more than a dozen specimens deposited at the Museum of Comparative Zoology, Harvard College, and collected by LeConte from Athens.

DISPOSITION OF TYPES.—According to Hobbs (1974) the only extant specimens that can be regarded as types are syntypes consisting of 1♂I (MCZ 3378) at the Museum of Comparative Zoology, Harvard University, and a single female (ANSP 329) at the Academy of Natural Sciences, Philadelphia. At the National Museum of Natural History there are 59 specimens that probably represent topotypic material from Athens, Clarke County, Georgia.

RANGE.—This crayfish is common in the Piedmont and Coastal Plain provinces from the Pamlico River drainage in North Carolina to the Altamaha River system in Georgia and from the Apalachicola River basin westward to the Escambia and upper Alabama rivers and their tributary systems in Florida and Alabama. *Cambarus latimanus* is conspicuously absent from the Pee Dee River drainage of North Carolina and South Carolina. [Curiously, only in the Pee Dee River system does *C. acuminatus* (*sens. lat.*) possess prominent abdominal stripes typical of *C. latimanus* (Hobbs, personal communication).] *Cambarus latimanus* also occurs at the southern end of the Blue Ridge province in Georgia and southeastern Tennessee as well as in the Coosa River basin draining the Ridge and Valley province in Tennessee, Georgia and Alabama and the eastern edge of the Cumberland Plateau in Georgia and Alabama where limestone exposures are present (Bouchard, 1976b). Besides those aforementioned drainages of the Atlantic and Gulf of Mexico, *C. latimanus* has crossed into the Tennessee River system of Georgia and Tennessee. Here the species occurs downstream in the Ocoee (Tennessee) River drainage to the Little Frog Mountains in Polk County, Tennessee. This species has also been collected from a single locality in the French Broad River system (Blue Ridge province) in Transylvania County, North Carolina, and may represent an introduction since it is the only record from the Tennessee River system outside the Ocoee River basin.

VARIATIONS.—The most notable variations exhibited by this species other than an expected range in meristics are seen in the suborbital angle, rostrum, relation of areola width to length, annulus ventralis, morphology of the first form male gonopod and development of spination on the body. The suborbital angle varies from rounded to acute and may possess a small spine or tubercle. The cephalic extremities of the rostral margins often bear small, acute spines on juveniles (Fig. 2*b*) which become reduced with maturity. Adults display all grades of development of the rostral margins from tubercles (Fig. 2*a*) to margins that merge imperceptably with the acumen. The margins of the rostrum also vary from subparallel to acuminate. The areola is typically less than 10 times as long as broad in populations of *C. latimanus* above the Fall Line except for occasional populations in the Savannah and Santee River drainages in South Carolina where the areola may be as much as 12.3 times as long as broad. Below the Fall Line in Alabama and Georgia it may attain a length of 11.8 times. The annulus ventralis varies in its development of the cephalic ridges bordering the anterior trough, from well developed to indiscernible. The trough itself ranges in width from narrow to moderately wide. The caudal wall ranges from broadly rounded to angulate. The gonopod of the first form male varies in the angle of the central projection to the shaft of the appendage from approximately 100 to 145 degrees (Figs. 6, 7, 8). The length of the central projection is also variable with populations north of the Pee Dee River drainage in North Carolina usually exhibiting a longer one (Fig. 6*c-j*). The central projection may or may not bear a subapical notch with an array of notch development when present (Figs. 6, 7, 8). The mesial process exhibits one to several distal projections (Figs. 6, 7, 8), a common feature in many members of the genus *Cambarus*. Over most of the range, no apparent caudal element is exhibited in populations of *C. latimanus* except in the Apalachicola and Coosa River systems (Figs. 7*e, g, o*). The spination of the body and appendages varies from acute spines to rounded tubercles depending on the populations and the amount of abrasion of these structures.

SIZE.—The largest specimen available is a female from Orange County, North Carolina, with a carapace length of 64.0 mm (postorbital carapace length 54.0 mm).

LIFE HISTORY NOTES.—Of the numerous collections of *C. latimanus* that have been made, only three specimens are females with eggs (or young). This probably indicates that the female retreats to a burrow to lay eggs. Two of these ovigerous females were collected from under a large, flat rock which partly rested upon the shore in a tributary of the Tallapoosa River in Cleburne County, Alabama, on 22 April 1973. The third ovigerous female was collected from a tributary (Brier Creek?) of the Neuse River in Wake County, North Carolina, on 16 April 1977.

Cambarus (Depressicambarus) obstipus Hall, 1959

DIAGNOSIS.—Rostrum with or without tubercles in adults, but if absent, base of acumen delimited by conspicuous angles; juveniles with spines or tubercles, decreasing in size with maturity; excavate dorsally with margins concave and subparallel to subacuminate. Areola comparatively long, (33.7) 35.4 to 39.6 percent of total length of carapace (34.0 - 47.0 percent of post orbital carapace length) and 6.5 to 11.1 times longer than broad, moderately punctate with space for 2 to 4 (modal number 3) punctations across narrowest part. Carapace subovate; cervical spines small and acute. Suborbital angle moderately well developed and rounded. Antennal scale of medium breadth, lamellar portion possessing angulate to declivous margin. Cephalic portion of epistome wide; epistomal zygoma moderately well to strongly arched. Chela with opposable margin of dactyl bearing 8 or 9 fairly evenly sized tubercles, first and/or fourth or first and/or fifth sometimes slightly larger; propodus with proximal 4, 5 or 6 tubercles large, fourth, fifth or sixth largest; opposable margins of both with single or double row of crowded tenticles. First pleopod of first form male with central projection short, tapering, bearing shallow subapical notch and recurved at angle of approximately 90 to 100 degrees. Annulus ventralis situated moderately deep in sternum, subquadrangular in outline; caudal wall elevated; cephalic portion elevated equal to or greater in height than caudal wall.

RANGE.—*Cambarus opstipus* has been collected from the Black Warrior River system where it drains the predominantly Pennsylvanian sandstone and shale deposits of the Cumberland Plateau in Blount, Cullman, Fayette, Jefferson, Tuscaloosa, Walker and Winston counties, Alabama (Bouchard, 1976b). An additional locality in Marion County, Alabama (one specimen from the Buttahatchee River), probably represents an introduction, and it is unknown if a population is established.

Cambarus (Depressicambarus) pyronotus, new species

DIAGNOSIS.—Body and eyes with pigment. Rostrum without tubercles or spines. Areola 18.3 to 26.0 times longer than broad and constituting (37.8) 39.0 to 40.3 percent of total length of carapace (43.8 - 46.2 percent of postorbital carapace length) with 1 punctation in narrowest part. Cervical and hepatic spines absent; suborbital angle obsolete; postorbital ridge somewhat strong, rounded cephalically. Antennal scale moderately broad to wide; margin of lamellar portion angulate. Cephalic portion of epistome comparatively narrow; epistomal zygoma moderately well arched. Chela with 2 rows of 4 to 6 tubercles on mesial surface of palm; opposable margin of dactyl with proximal 4 tubercles prominent, first and/or fourth largest; corresponding margin of propodus with proximal 3 tubercles dominant in size, third largest; opposable margins of both with irregular double row of denticles; lateral margin costate; lateral base of fixed finger impressed above, less so below. Hook on ischium of third pereiopod of male overreaching basioischial articulation and probably not typically opposed by tubercle on basis (see "Holotypic male, form I"). First pleopod of first form male with central projection corneous, bladelike, bearing very shallow subapical notch, recurved at angle of approximately 115 degrees; mesial process tumescent, tapering to subacute tip and directed caudolaterally at angle of approximately 90 degrees to shaft of appendage. First pleopod of second form male noncorneous; central projection rounded ventrodistally; mesial process tapering to subacute tip. Annulus ventralis asymmetrical, subquadrangular, with caudal portion somewhat movable; cephalic half bearing longitudinal median trough between subparallel, longitudinal ridges; caudal half with sinuate sinus and elevated caudal wall. First pleopod of female uniramous and reaching midlength of annulus when abdomen flexed.

HOLOTYPIC MALE, FORM I.—Body subovate, slightly vaulted (Fig. 9*b*). Abdomen narrowed than thorax (10.2 and 13.9 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (13.9 and 12.2 mm). Areola 18.7 times as long as road with 1 punctation across narrowest part; length of areola 39.0 percent of total length of carapace (44.6 percent of postorbital carapace length). Rostrum excavate dorsally with swollen, subparallel, slightly concave, thickened margins devoid of marginal spines or tubercles. Acumen set off from proximal portion of rostrum, oblique margins concave, not swollen and terminating in corneous, acute, upturned tubercle; upper surface of rostrum with submarginal punctations and others scattered between. Postorbital ridges moderately strong, grooved dorsolaterally and rounded cephalically. Suborbital angle absent; branchiostegal spine small. Cervical spines consisting of row of 3 small, rounded tubercles on each side; hepatic area and lateral portions of branchiostegites tuberculate; dorsal surface of carapace punctate.

Abdomen shorter than carapace (25.6 and 28.7 mm); pleura of moderate length with caudoventral extremity broadly angular. Cephalic section of telson with single immovable spine in each caudolateral corner, separated from caudal section by paired oblique excisions. Basal podomere of left uropod with spine extending over mesial ramus. Lateral ramus of uropod with median ridge terminating in acute spine at transverse flexure; additional small ridge lateral to median one; proximal portion with row of small spines distally and movable spine submarginally at caudolateral corner. Mesial ramus of uropod with median ridge terminating distally in premarginal acute spine; additional acute spine at distolateral margin. Caudal margin of tail fan with plumose setae; dorsal surface lightly setiferous.

Cephalic lobe of epistome (Fig. 9*k*) triangular with slightly upturned cephalolateral margins; ventral surface convex. Basal portion of epistome with deep median fovea and pair of obliquely disposed slitlike fossae immediately cephalic and subparallel to thickened, moderately well-arched epistomal zygoma; lateral extremities without tubercles. Proximal segment of antennule with small, acute spine on ventral surface at base of distal fourth. Antennae broken. Antennal scale (Fig. 9*h*) moderately broad, broadest slightly distal to midlength; thickened lateral portion terminating in acute, corneous-tipped spine projecting forward to level of tip of rostrum; lamellar area with angulate mesial margin, crenulate and edged with long, plumose setae.

Both chelae regenerated. Hook on ischium of third pereiopod only (Fig. 9*d*); hook simple, overreaching basioischial articulation and opposed by small, rounded tubercle on right (lacking on left). Coxa of fourth pereiopod with prominent caudomesial boss, fifth pereiopod without prominence. For measurements see Table 3.

Table 3. Measurements (mm) of *Cambarus (Depressicambarus) pyronotus*

	Holotype	Allotype	Morphotype
Carapace			
Height	12.2	13.9	11.6
Width	13.9	15.7	12.7
Total length of carapace	28.7	32.1	27.5
Postorbital carapace length	25.1	28.0	23.8
Areola			
Width	0.6	0.7	0.6
Length	11.2	12.8	11.0
Rostrum			
Width	3.1	3.6	3.3
Length	3.6	4.1	3.7
Chela			
Length, mesial margin of palm	*	6.9	5.1
Width, palm	*	10.6	8.2
Length, lateral margin	*	22.9	16.5
Length, dactyle	*	15.2	10.8

* chelae regenerated

First pleopods (Fig. 9*e, f, g*) reaching caudal portion of coxae of third pereiopods when abdomen flexed. See "Diagnosis" for description.

ALLOTYPE.—Differing from holotype in following respects: rostrum broader and cephalic portion of epistome terminating in small cephalomedian projection. Single dominant cervical tubercle on each side.

Right chela (Fig. 9*l*) approximately 2 times longer than broad (22.9 and 10.6 mm), depressed, although more inflated proximolaterally; mesial margin of palm with 2 rows of tubercles, 6 and 4 in primary and secondary rows, respectively; small, squamous tubercles over mesial half of palm; distoventral surface of palm with 2 large, swollen tubercles at base of dactyl, mesial one with small, corneous, acute tip. Lateral surface of propodus costate with row of punctations rendering proximolateral margin of fixed finger irregular in dorsal aspect. Fixer finger with proximolateral base impressed dorsally, less so ventrally; dorsal and ventral surfaces with distinct submedian ridges flanked by setiferous punctations; opposable surface with row of 5 and 6 tubercles on right and left chelae, respectively, third largest, decreasing in size proximally; additional small tubercle present on lower level at base of distal two-fifths, and double row of minute denticles extending proximally from corneous tip of finger to third tubercle, interrupted by fourth to sixth tubercles from base on right chela (fourth and fifth on left). Dorsal and ventral surfaces of dactyl with median longitudinal ridges, flanked by setiferous punctations; opposable margin with row of 7 tubercles on each chela, fourth largest; mesial margin of dactyl tuberculate along nearly proximal half and punctate distally; double row of minute denticles extending from corneous tip to fourth tubercle from base, interrupted by sixth and seventh tubercles on both chelae.

Carpus longer than broad with deep oblique furrow dorsally; mesial surface with large, corneous-tipped procurved spine near midlength with 5 smaller, rounded ones nearby on each cheliped; distoventral margin with corneous-tipped tubercle and additional one proximodorsally; dorsomesial surface with 9 and 7 small, rounded tubercles on left and right chelipeds, respectively.

Merus with 3 tubercles dorsodistally on right cheliped (2 on left); ventral surface with lateral row of 6 and 8 tubercles on right and left chelipeds, respectively, decreasing in size proximally, and mesial row of 11 tubercles on right cheliped (10 on left). Ischium with row of 3 very small tubercles on mesial margin of each cheliped.

Annulus ventralis (Fig. 9*j*) subquadrangular, broader than long, and situated deep in sternum with cephalic portion fushed to sternum and caudal half movable. Cephalic half bearing median longitudinal trough flanked by low subparallel, longitudinal ridges; caudal half bearing high caudal wall and divided by sinistral, sinuate sinus. First pleopods uniramous and extending to cephalic half of annulus when abdomen flexed. Postannular sclerite subconical with flattened caudal surface and approximately three-fifths width of annulus.

MORPHOTYPIC MALE, FORM II.—Differing from holotype in following respects: rostrum broader with sharply delimited acumen and single cervical tubercle conspicuously larger than others. Cephalic portion of epistome with cephalomedian projection. Proximal segment of antennule lacking spine on ventral surface.

Right cheliped (left regenerated) differing from allotype (those of holotype regenerated) as follows: mesial margin of palm with secondary row of 6 tubercles. Opposable margin of dactyl with 6 tubercles; row of denticles extending from distal end to second tubercle from base, interrupted by third through sixth. Dorsal surface of carpus with 3 small, rounded tubercles. Ischium with row of 4 small tubercles on mesial margin.

Hook on ischium of third pereiopod much reduced, not reaching basioischial articulation and not opposing tubercle on basis; boss on coxa of fourth pereiopod somewhat smaller and less sharply defined. First pleopods of uniform texture and reaching caudal portion of coxae of third pereiopods when abdomen flexed. See "Diagnosis" for description.

COLOR NOTES.—I have not seen live or freshly preserved specimens, but Hobbs (1942) indicates the species to be a "distinct orange-red."

TYPE-LOCALITY.—This species was dug from burrows along a tributary of the Apalachicola River south of Indian Ridge, Torreya State Park, Liberty County, Florida. The first permanent creek south of Indian Ridge is Beaver Dam Creek. This stream, some 4 to 10 feet wide and less than a foot deep, flows over a mostly sandy substrate, although scattered brush and leaf litter are present as well as a few scattered rocks immediately downstream from a trickling water fall. The shore consists of moss near the water, especially above and downstream from the waterall, while the surrounding area, as described by Hubbell (1939) is as follows: "'Camp Torreya' is a deep ravine situated about one mile south of Rock Bluff Landing—one of many cutting back into the sandy uplands which border the Apalachicola River valley on the east. Moist and cool, these ravines contain an interesting assemblage of plants and animals which comprise southern species, northern relicts, and a number of endemics of very limited distribution. The steep slopes and bottoms of the ravines are covered with dense forest in which beech, magnolia, red oak, hickories and sweet gums are dominant, and ironwood, wild plum, slippery elm, holly, spruce pine and other trees are also common. The undergrowth is composed largely of stinking cedar or savron (*Tumion taxifolium*, formerly *Torreya*), a coniferous shrub or small tree confined to the Apalachicola ravines, as is also the less common Florida yew (*Taxus floridana*). A characteristic member of the ground flora is the needle palm (*Rhapidophyllum hystrix*), growing side-by-side with such northern types as bloodroot, Trillium, hepatica, and toothwort. The sandy soil is thickly carpeted with dead leaves and humus, and brush heaps and decaying logs are numerous."

DISPOSITION OF TYPES.—The holotypic male, form I (no. 146761), the allotype (no. 146762) and the morphotypic male, form II (no. 146763) are deposited in the National Museum of Natural History, Smithsonian Institution. Paratypes consisting of 7♀, 7 juv. and 5 juv.♀ are in the National Museum of Natural History.

RANGE AND SPECIMENS EXAMINED.—This new species of crayfish is known from only Torreya State Park in Liberty County, Florida. The species has been collected from burrows in the following localities: (i) ravine in northern part of Torreya State Park, 17 March 1939, J. S. Rogers, et al., 2 juv.♂ and 2 juv.♀, (ii) Rock Bluff, deep ravine in Torreya State Park, 13 December 1939, L. Berner and H. H. Hobbs, Jr., 1 juv.♂ and 1 fragment, (iii) ravine south of Indian Lodge in Torreya State Park, 8 April 1941, H. H. H., 1♂II, 1♀, 4 juv.♂ and 2 juv.♀, (iv) stream south of Indian Ridge, Torreya State Park, 28 November 1941, H. H. H., 1♂I, 7♀ and 1 juv.♀.

VARIATION.—The most notable variation exhibited by this species concerns the caudolateral corners of the proximal portion of the telson. Two of the 21 specimens examined possessed a single movable spine on each side of the telson, absent in all others.

SIZE.—The largest specimen available is a female with a total carapace length of 33.0 mm (postorbital carapace length 28.9 mm). The only first form male available has corresponding lengths of 28.8 and 25.1 mm. Females with eggs or young have not been collected to date.

ECOLOGICAL NOTES.—Hobbs (1942) noted that "From a ravine in the northern part of Torreya State Park where *latimanus* occurs I have several specimens which were taken from complex burrows . . . [and] were a distinct orange-red." A description of the burrows in Torreya is presented by Hobbs (1942) as follows and is applicable to *C. pyronotus* as well as *C. latimanus* (Hobbs, personal communication): "The rill and brook occupying this ravine . . . empties into the Apalachicola River. . . . Also along this stream are many complex burrows which extend downward and beneath its banks. Because there is such an entwined mass of roots in this soil, digging into these burrows is a laborious job that seldom yields any specimens."

Collected with *C. pyronotus* at Torreya State Park were *Cambarus* (*Lacunicambarus*) *diogenes* Girard (1852) and *C.* (*D.*) *latimanus*.

ETYMOLOGY.—*Pyr* (Gr.), fire, in combination with *notos* (Gr.), back; so named because of the orange-red color exhibited by the species at the type-locality.

Cambarus (Depressicambarus) reduncus Hobbs, 1956

DIAGNOSIS.—Rostrum excavate dorsally with nearly straight and subparallel to subacuminate margins devoid of marginal spines or tubercles. Areola 6.6 to 28.4 times longer than broad and constituting 36.4 to 42.1 percent of total length of carapace [(40.0) 43.2 - 47.8 percent of postorbital carapace length]. Carapace subovate to somewhat vaulted; cervical spines lacking or reduced to small rounded tubercles. Suborbital angle obsolete to weakly developed and rounded. Antennal scale narrow; margin of lamellar portion angulate to steeply declivous. Cephalic portion of epistome of medium width; epistomal zygoma moderately well arched. Chela with opposable margin of dactyl bearing 4 prominent basal tubercles, first and fourth largest; propodus with 3 or 4 major basal tubercles, third or fourth largest; opposable margins with irregular double row of denticles. First pleopod of first form male with central projection long, aciculate, well separated from mesial process and inclined at angle of approximately 130 to 140 degrees. (Fig. 3*h*). First pleopod of second form male with conspicuous wide gap between central projection and mesial process (Fig. 3*i*). Annulus ventralis situated deep in sternum; suboval to subquadrangular in outline; caudal wall conspicuously thickened and elevated above cephalic portion, latter bearing sinus flanked by low ridges; sinus deep and often very wide, greater than one-third width of cephalic portion.

REMARKS.—In Catawba County, North Carolina, there are populations of a crayfish that probably represent variants of this species. The carapace is more vaulted and the areola is obliterated or nearly so constituting 41.5 to 42.6 percent of the total length of the carapace (46.4 - 48.4 percent of postorbital carapace length). The color pattern is blue (Hobbs, personal communication) rather than typical grayish olive to brown (Hobbs, 1956). In other regards, especially the distinctive gonopod of the first form male, there appears to be little significant difference between these populations and others of *C. reduncus*. Because the areola width is narrower than in any other known population, I have not included the areola measurements of these populations with those of typical *C. reduncus* in the "Diagnosis." When more populations of *C. reduncus* are sampled the gap between the two sets of data may not remain. These morphological differences possibly reflect the more fossorial behavior of the variant populations much in the same manner as in some primary burrowing populations of *C. striatus* which sometimes also exhibit a blue color pattern.

RANGE.—This species of crayfish has been collected in the Piedmont province from the Cape Fear River drainage in North Carolina southward to the Santee River basin in South Carolina.

Cambarus (Depressicambarus) sphenoides Hobbs, 1968

DIAGNOSIS.—Rostrum lacking tubercles or spines in adults; small juveniles occasionally with small spines or tubercles; margins subparallel to subacuminate; surface excavate to comparatively flat and often with low carina. Areola 32.8 to 39.3 per cent of total length of carapace [(41.6) 42.4 - 45.6 (46.5) percent of postorbital carapace length], 5.0 to 9.2 times longer than broad with space for 2 to 5 punctations across narrowest part. Carapace subovate; cervical spines reduced to small rounded tubercles. Suborbital angle poorly to moderately well developed, rounded to acute, sometimes exhibiting small tubercle. Antennal scale moderately broad to wide; margin of lamellar portion angulate to declivous. Cephalic portion of epistome comparatively wide; epistomal zygoma strongly arched. Chela with dorsal surface of palm bearing numerous small squamous tubercles; opposable margin of dactyl with basal 4 or 5 tubercles prominent, first, fourth or fifth or first and fourth or first and fifth largest; opposable margin of propodus with basal 3 tubercles conspicuous, third largest; opposable margins of fingers with irregular double or triple rows of denticles, increasing to triple row with age. First pleopod of first form male with subapical notch on central projection; element moderately long, tapering little and inclined at angle of approximately 115 to 130 degrees (Fig. 3*j*). Annulus ventralis situated moderately deep in sterum; subquadrangular in outline; caudal wall elevated; cephalic portion bearing shallow sinus flanked by low ridges.

RANGE.—*Cambarus sphenoides* is endemic to the Cumberland Plateau from Marion County, Tennessee, northward to Jackson County, Kentucky, in the Tennessee, Cumberland and Kentucky (one locality) River systems.

Cambarus (Depressicambarus) striatus Hay, 1902

Cambarus floridanus Hobbs, 1941:114.

DIAGNOSIS.—Body and eyes with pigment. Rostrum without spines or tubercles; sometimes with low carina. Areola obliterated to 9.1 times longer than broad and constituting 33.9 to 43.6 (45.7) percent of total length of carapace [41.6 - 49.7 (50.7) percent of postorbital carapace length] usually with 1 or 2 punctations across narrowest part. Cervical spine reduced to small, rounded tubercle or absent; hepatic spines absent; branchiostegal spine present; suborbital angle weakly to moderately well developed, rounded to obtuse; postorbital ridge somewhat strong, rounded cephalically. Antennal scale moderately broad to wide; margin of lamellar portion angulate. Cephalic portion of epistome comparatively wide; epistomal zygoma moderately well arched. Chela with 2 rows of 8 or fewer tubercles on mesial surface of palm; opposable margin of dactyl with proximal 4 or 5 tubercles prominent—first, fourth or fifth or first and fourth or first and fifth largest; corresponding margin of propodus with proximal 3 or 4 (rarely 5) tubercles dominant in size, third, fourth or fifth largest; opposable margins of both with irregular double row of denticles; lateral margin costate and lateral base of fixed finger impressed above, less so below. Hook on ischium of third pereiopod of male overreaching basioischial articulation and not opposed by tubercle on basis. First pleopod of first form male with central proection corneous, bladelike, with or without subapical notch and recurved at angle of 95 to 155 degrees (Figs. 12-14); mesial process tumescent, tapering to one to several subacute to acute tips, generally directed caudally at angle of approximately 90 degrees to shaft of appendage (Figs. 12*d*, *r*). First pleopod of second form male noncorneous; central projection rounded distally; mesial process tapering to subacute tip. Annulus ventralis asymmetrical, subquadrangular, with caudal portion somewhat movable; cephalic half bearing longitudinal median trough usually between subparallel, longitudinal ridges, and caudal half with sinuate sinus and elevated caudal wall. First pleopod of female uniramous and reaching at least midlength of annulus ventralis when abdomen flexed.

SYNTYPIC MALE, FORM I (USNM 25109).—Body subovate, slightly depressed (Fig. 10*b*). Abdomen narrower than thorax (15.5 and 18.3 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (18.3 and 13.7 mm). Areola 38.0 times longer than road with 1 punctation across narrowest part; length of areola 43.6 percent of entire length of carapace (49.5 percent of postorbital carapace length). Rostrum excavate dorsally with subparallel, thickened margins devoid of marginal spines or tubercles; upper surface with several submarginal punctations with few scattered between. Acumen set off from proximal portion of rostrum with concave oblique margins, latter not swollen, and terminating in small upturned tubercle at tip. Postorbital ridges moderately strong with moderately deep grove dorsolaterally and rounded cephalically. Suborbital angle weak; branchiostegal spine small. Cervical tubercles bituberculate; hepatic area and lateral portion of branchiostegites tuberculate; dorsal portion of carapace punctate.

Abdomen shorter than carapace (33.1 and 34.9 mm); pleura of moderate length with caudoventral extremity broadly angular. Cephalic section of telson with single movable and immovable spines in each caudolateral corner; separated from caudal section by paired oblique excisions. Basal podomere of uropod with spine extending over mesial and lateral rami. Lateral ramus of uropod with median ridge terminating in acute spine at transverse flexure; additional small ridge lateral to median one; proximal portion with row of small spines distally and movable spine submarginally at caudolateral corner. Mesial ramus of uropod with median ridge terminating distally in premarginal acute spine. Caudal margin of tail fan with plumose setae; dorsal surface lightly setiferous.

Cephalic lobe of epistome (Fig. 10*j*) pentagonal with slightly upturned cephalolateral margins and bearing cephalomedian projection; ventral surface convex. Basal portion of epistome with deep median fovea and pair of obliquely disposed slitlike fossae immediately cephalic and subparallel to thickened, moderately well-arched epistomal zygoma; lateral extremities with single tubercle on each side. Proximal segment of antennule with small spine on ventral surface at base of distal third. Antennae broken. Antennal scale (Fig. 10*h*) moderately broad, broadest slightly distal to midlength; thickened lateral portion terminating in acute, corneous-tipped spine projecting forward beyond tip of rostrum; lamellar area with mesial margin broadly angulate, crenulate and edged with long, plumose setae.

Right chela (Fig. 10*l*) approximately 2 times longer than broad (24.4 and 11.6 mm), depressed, although more inflated proximolaterally; mesial margin of palm with 2 rows of 6 and 5 tubercles in primary and secondary rows, respectively; several smaller squamous tubercles on dorsal surface over slightly less than half of mesial portion of palm; distoventral surface of palm with 2 large, swollen tubercles at base of dactyl. Lateral surface of propodus costate with row of punctations rendering proximolateral margin of fixed finger irregular in dorsal aspect. Propodus with proximolateral base of finger impressed dorsally, less so ventrally; dorsal and ventral surfaces with distinct submedian ridges flanked by setiferous punctations; opposable margin with row of 6 tubercles along proximal two-thirds of finger, fourth largest, basal 4 decreasing in size proximally; additional small tubercle present on lower level near base of distal third; double row of minute denticles extending proximally from corneous tip of finger to fifth tubercle from base, interrupted by sixth. Dorsal and ventral surfaces of dactyl with median longitudinal ridges, flanked by setiferous punctations; opposable margin with row of 8 tubercles, first and fourth largest, second and third slightly smaller; double row of minute denticles extending from corneous tip to sixth tubercle from base, interrupted by seventh and eighth; mesial margin of dactyl tuberculate along proximal two-thirds and punctate distally.

Carpus longer than broad with deep oblique furrow dorsally; mesial surface with large procurved spine near midlength and smaller ones located proximally and proximoventrally with additional small tubercle near base of spine; distoventral margin with large subacute tubercle; dorsomesial surface with 5 small, rounded tubercles; podomere otherwise punctate.

Dorsodistal surface of merus with 4 rounded tubercles; ventral surface with lateral row of 5, decreasing in size proximally, and mesial row of 11 tubercles, some corneous-tipped. Ischium with row of 3 very small tubercles on mesial margin.

Hook on ischium of third pereiopod only (Fig. 10*d*); hook simple, overreaching basioischial articulation and not opposed by tubercle on basis. Coxa of fourth pereiopod with prominent caudomesial boss, fifth pereiopod without prominence. For measurements see Table 4.

Table 4. Measurements (mm) of *Cambarus* (*Depressicambarus*) *striatus*

	Syntypic Male, Form I	Syntypic Female	Syntypic Male, Form II
Carapace			
Height	13.7	13.4	12.7
Width	18.3	17.5	16.0
Total length of carapace	34.9*	**	31.2
Postorbital carapace length	30.7	29.2	27.3
Areola			
Width	0.4	0.5	0.4
Length	15.2	13.8	13.4
Rostrum			
Width	4.1*	4.0	3.6
Length	4.2*	**	3.9
Chela			
Length, mesial margin of palm	7.3	6.9	5.9
Width, palm	11.6	10.6	10.2
Length, lateral margin	24.4	22.2	19.6
Length, dactyl	15.8	13.9	12.7

* rostrum damaged (see Fig. 10*i*)

** tip of acumen missing

First pleopods (Fig. 10*e, f, g*) reaching caudal portion of coxae of third pereiopods when abdomen flexed. See "Diagnosis" for description.

SYNTYPIC FEMALE (USNM 25019).—Differing from syntypic male, form I, in following respects: cervical spine consisting of low, rounded tubercle and bearing several setae. Areola open but lacking punctations across narrowest part. Left chela (right missing) with 3 tubercles in secondary row on mesial surface of palm. Dorsomesial tubercles of left carpus consisting of single very small proximal and proximoventrally disposed ones. Opposable margin of propodus with row of minute denticles extending from corneous tip proximally to fourth tubercle, interrupted by fifth. Opposable margin of dactyl with row of minute denticles extending from corneous tip proximally to fifth tubercle from base, interrupted by sixth and seventh.

Annulus ventralis (Fig. 10*k*) subquadrangular, broader than long, and situated moderately deep in sternum with cephalic portion fused to sternum and caudal half movable. Annulus ventralis divided by sinus into C-shaped and triangular portions, latter with basal tongue projecting into concavity of "C." Cephalic half with sinus broadening into median longitudinal trough flanked by low, subparallel, longitudinal ridges; caudal portion elevated and nearly bisected by shallow sinus. Postannular sclerite subconical and approximately three-fifths width of annulus.

SYNTYPIC MALE, FORM II (USNM 25019).—Differing from syntypic male, form I, in following respects: rostrum with median carina present on acumen. Areola narrow and open but lacking punctations across narrowest part. Cervical spines consisting of single low, rounded tubercle on each side bearing several setae. Cephalic portion of epistome with cephalomedian projection. Chelae with 5 tubercles in primary row on mesial surface of palm; 6 tubercles in secondary row of right. Opposable margin of propodus of right chela with row of denticles extending from corneous tip proximally to sixth tubercle. Opposable margin of dactyl of right chela with 9 tubercles; row of denticles extending from corneous tip proximally to fourth tubercle from base, interrupted by fifth, sixth and seventh on each chela.

Hook on ischium of third pereiopod much reduced, not reaching basioischial articulation, and not opposing tubercle on basis; boss on coxa of fourth pereiopod somewhat smaller and less sharply defined. First pleopods of uniform texture and reaching caudal portion of coxae of thirdpereiopods when abdomen flexed. See "Diagnosis" for description.

COLOR NOTES.—*Cambarus striatus* exhibiting dimorphic color pattern. Cephalothorax and abdomen mottled to concolorous, usually brown, green-brown or green. Abdomen with (i) pair of complete, moderately broad, submedian, and narrower, broken, lateral, dark brown stripes or, (ii) pair of submedian and lateral narrow, broken stripes. Abdominal stripes extending onto thorax as sinistral and dextral horns, darker in color morph with solid stripes and usually extending length of branchiostegites. Populations known with blue, blue-gray or dark red-brown coloration. Abdominal stripes, especially narrow, broken ones, often less discernible on mature specimens. Gastric region with paired, lighter, vermiculated areas marking attachment of mandibular muscles. Branchiostegites and hepatic areas mottled to concolorous brown, green-brown or brown dorsally, fading to white ventrad. Pleural regions of abdomen bearing inconspicuous ventral, narrow, light, mottled margin sometimes terminating dorsally on first abdominal segment as distinct single large spot on each side, varying from cream through yellow. Ventral aspects of cephalothorax and abdomen white, occasionally tinged with blue. Young crayfish more mottled than adults, becoming more concolorous with maturity.

Rostral margins yellow, cream, tan or brown. Postorbital ridges yellow, light-brown or same color as cephalothorax. Tubercles and spines yellow through cream. Articular condyles of chelae red, yellow or cream. Lateral margin of antennal scale darker than lamellar portion. Antennae generally dark green or brown.

Chelae colored as cephalothorax with lighter proximolateral area, white ventrally. Distal ends of fingers red, orange, yellow or cream, fading with age or if living in turbid waters. Pereiopods same general color as chelae dorsolaterally, only lighter; white ventrolaterally. Distal podomeres darker dorsally than proximal ones.

Specimens from Leon County, Florida (type-locality, *C. floridanus*), more colorful with chelae exhibiting blue fingers and orange tubercles. Postorbital ridges orange; margins of rostrum and articular condyles of chela reddish-orange. Caudal margin of abdominal terga, distal edge of transverse flexure of outer ramus of uropod and lateral edge of telson margined with red. Tail fan blue. Pereiopods with blue tips and orange articulations. Abdominal pleura with white ventral margins.

Additional color notes are provided by Hay (1902), and Hobbs and Hart (1959) furnish the following color notes from specimens collected from southwestern Georgia and adjacent portions of Florida: "purplish-red dorsally fading to pinkish-lavender along the lower lateral margins of the carapace. The chelipeds are also purplish-red with dark tubercles."

TYPE-LOCALITY.—Reported as "near Nashville, Tennessee," by Hay (1902). The exact locality cannot be defined but was surely a part of the Cumberland River system and probably in Davidson County, Tennessee. There apparently were no crayfish associates collected with *C. striatus* at the type-locality.

DISPOSITION OF TYPES.—The syntypes, consisting of 1 ♂I, 3 ♀II, 4 ♀ (USNM 25019) and 1 ♂I, 1 ♂II and 3 ♀ (MCZ 7348), were collected by E. B. Williamson and deposited in the National Museum of Natural History, Smithsonian Institution, and Museum of Comparative Zoology, Harvard College, respectively.

RANGE.—This crayfish is widespread above and below the Fall Line east and south of the Mississippi and Ohio rivers. It is known to occur in the following geomorphic regions above the Fall Line: Highland Rim, Cumberland Plateau, Nashville Basin, Shawnee Hills, Ridge and Valley, Blue Ridge and Piedmont. Below the Fall Line *C. striatus* inhabits waters in the Gulf (including the Mississippi Embayment but minus the Mississippi Aluvial Plain) and Atlantic Coastal plains. In the Mississippi River drainage, this species is known from the Green River system, Kentucky, downstream to the Homochitto River system in Mississippi. *Cambarus striatus* occurs upstream in the Cumberland River system onto the Cumberland Plateau in Tennessee and Kentucky and in the Tennessee River basin to Jefferson and Knox counties, Tennessee. This species is also known from the Pearl River drainage eastward to and including the entire Mobile Bay basin (*i.e.*, Tombigbee, Black Warrior, Coosa and Tallapoosa River systems) and from the Gulf drainages east of Mobile Bay to the Ochlockonee River basin. In the Atlantic drainages, *C. striatus* has been collected from the Altamaha River system.

VARIATIONS.—The most outstanding variations exhibited by this species are in the gonopod of the first form male, the length-width ratio of the areola, annulus ventralis and in the rostrum. Most populations of *C. striatus* lack a subapical notch on the first form male gonopod, although certain populations in the Pearl, Coosa, Altamaha, lower Cumberland and upper Tennessee River system exhibit a well-defined notch (Fig. 13*m, s, t*). The central projection of the first form male gonopod also varies in its angle to the shaft of the appendage (Figs. 12, 13, 14). In many populations a well-developed caudal shoulder can be observed on the gonopod of the first form male, and the mesial process offers a great deal of variation in the number of apical projections (Figs. 12, 13, 14). The areola varies in its length and width usually relative to the fossorial behavior of the population, narrower in the burrowing members. The width of the areola varies from obliterated to 9.1 times the length. The annulus ventralis varies in its development of the cephalic ridges bordering the anterior trough, from well developed to indiscernible. The trough itself ranges in width from narrow to moderately wide. The rostrum of *C. striatus* also varies from subparallel to a more acuminate condition in some populations. Compare Figs. 10 and 11.

SIZE.—The largest specimen available is a female from Murray County, Georgia, with a carapace length of 60.1 mm (postorbital carapace length 52.8 mm).

LIFE HISTORY NOTES.—Only a single female with eggs or young has been collected. The female, carrying 5 eggs, was taken from Rickwood Cavern in Blount County, Alabama, on 11 March 1966. This species appears to occupy burrows during the period of egg laying.

Ecology

Crayfishes of the subgenus *Depressicambarus* occur in a wide range of epigean waters as well as in the subsurface water table as burrowers. The invasion of the subsurface water table has contributed greatly to their radiation and speciation. The epigean species [*C. englishi*, *C. graysoni* (in part), *C. halli*, *C. latimanus* (in part), *C. obstipus*, *C. sphenoides* (in part) and *C. striatus* (in part)] occupy lotic and lentic habitats ranging from small to large streams, springs and ponds where they can be found under rocks, in leaf litter, roots of riparian trees and in mats or dense growths of algae and aquatic vascular plants. While most epigean species occur primarily in pool areas, *C. obstipus* is also commonly found in riffles. *Cambarus englishi* is more likely to inhabit riffle areas, including those in large streams, than the other species and exhibits morphological characteristics that may be advantageous to locomotion in fast flowing waters by reducing resistance to water flow. The dorsoventrally flattened carapace and sharply angulate abdominal pleura (moderately sharp caudoventral angles in *C. englishi*) are especially distinct in some of its relatives of the cambaroid line (within the subfamily Cambarinae, after Hobbs, 1969), *Barbicambarus cornutus* (Faxon, 1884), C. (*Erebicambarus*) *hubbsi* Creaser (1931) and *C.* (*E.*) *rusticiformis* Rhoades (1944), all three of which commonly inhabit areas of streams with a rapid or moderately rapid flow. Since these three species live in regions dominated by the genus *Orconectes* (Bouchard, 1976a) and *C. englishi* lives in a river system that possesses three close relatives—*C. halli*, *C. latimanus* and *C. striatus*, the above characters possibly assist in exploiting an available habitat. The flattened body is probably the more important of the two characters for an existence in fast flowing waters. That such modifications are not limited to inhabitants of swiftly flowing water is evidenced by members of the subgenus *Hobbsastacus* (Bouchard, in press) of the genus *Pacifastacus* which also exhibit sharply angulate abdominal pleara, and at least *P. fortis* and *P. connectens* (Faxon, 1914) occur primarily in pool areas of streams. It also should be noted that members of the genus *Orconectes* occur in riffle areas of streams and do not exhibit either of the above characters.

Most species of Depressicambarus are well adapted to a burrowing existence and are divisible into three overlapping categories as defined by Hobbs (1942). The primary burrowers are those that are restricted to burrows. This group includes *C. catagius*, *C. cymatilis*, *C. pyronotus* and certain populations of *C. reduncus* and *C. striatus*. The secondary burrowers generally occupy burrows but at times occur in open waters (slightly modified from Hobbs, 1942) and include *C. reduncus* (in part) and *C. striatus* (in part). Those species that are abundant in open waters but burrow either in periods of seasonal low water levels, to lay eggs or because of the paucity of epigan habitats constitute the tertiary burrowers (modified from Hobbs, 1942). These include *C. graysoni* (in part), *C. latimanus* (in part), *C. sphenoides* (in part) and *C. striatus* (in part). Although *C. obstipus* has never been collected from a burrow, its moderately narrow areola and broad, flat chelae, similar to those of fossorial species, indicate an adaptation to burrow.

Cambarus latimanus adults are most common as burrowers below the Fall Line, probably due to the lack of well-indurated rocks to provide cover. *Cambarus striatus* adults, on the other hand, are more frequently found in surface waters in the Tennessee River basin from the Hiwassee River system (Tennessee) downstream to Hardin County, Tennessee, and in the Mobile Bay drainage above the Fall Line in Tennessee, Georgia and Alabama.

Relationships

The subgenus *Depressicambarus* appears to be a distinct group of closely related crayfishes within the genus *Cambarus* the members of which generally exhibit a broadly subtriangular, depressed chela bearing two major rows of tubercles along the mesial margin of the palm. Based upon morphological and color pattern similarities within the subgenus, it is further divisible as termed here into the *halli* and *latimanus* groups. In the *halli* group, *C. halli*, *C. englishi* and *C. obstipus* are distinctly more closely related to one another than to any other member of the subgenus and display more plesiomorphic characters. The *latimanus* group, exhibiting more apomorphic characters, includes *C. latimanus*, *C. striatus*, *C. sphenoides*, *C. graysoni*, *C. pyronotus*, *C. catagius*, *C. cymatilis* and *C. reduncus*. Members of this group display a wider array of morphological variation than do those of the *halli* group; this is in part due to their utilization of and adaptation to diverse habitats. Convergent evolution in the burrowing members of the *latimanus* group has obscured many morphological characters that would provide a clearer understanding of relationships within this group.

The *halli* group generally possesses rostral tubercles (often reduced or lacking in adults, but if absent, base of the acumen is usually delimited by conspicuous angles) and well-developed cervical spines and displays a bright-green color pattern with red, reddish-orange or reddish-brown postorbital ridges and margins of the rostrum. The chelae exhibit red, reddish-orange or reddish-brown articular condyles and a pale-white coloration on approximately the distal half of the fingers. The ventral and caudal margins of the abdominal pleura and caudal edge of the terga (except the sixth) are white, that of the first tergum broader and more conspicuous. Some populations of *C. obstipus* display a more subdued coloration of the dimorphic, striped, abdominal patterns typical of *C. latimanus*, *C. sphenoides* and *C. striatus* (see color notes in the sections on *C. latimanus* and *C. striatus*).

Within the *halli* group, *C. halli* is morphologically more similar to *C. englishi*, and the three species are separable utilizing the following characters. The central projection of the gonopod of *C. obstipus* is distinctive, being short and bearing a shallow subapical notch (Fig. 3*g*). The moderately long central projection of the first form male gonopod of *C. halli* possesses a distinct subapical notch (Fig. 3*f*); the longer one of *C. englishi* lacks a notch (Fig. 3*c*). The most rheophilic *C. englishi* exhibits a more dorsoventrally flattened carapace and possesses abdominal pleura that are less broadly angulate (Fig. 1*b*) than in any other member of the subgenus (Fig. 1*a*). In *C. obstipus* the opposable margin of the dactyl on the chela is distinct from the rest of the subgenus in possessing a row of 8 or 9 fairly evenly sized tubercles (Fig. 1*i*). All other species in *Depressicambarus* bear 2 to 5 dominant basal tubercles on the opposable margin of the dactyl.

Of the three, *Cambarus obstipus* possesses the narrowest, least punctate areola: 6.5 to 11.1 times longer than broad with space for 2 to 4 punctations (modal number 3) across the narrowest part. In *C. halli* the areola is 2.9 to 4.5 times as long as broad with 5 to 7 punctations (Fig. 1*f*) and in *C. englishi* 3.4 to 4.9 times as long with 4 to 6 punctations (Fig. 1*h*). *Cambarus halli* has a shorter areola [28.9 - 35.1 percent of the total length of the carapace or 39.3 to 42.5 (43.3) percent of the postorbital carapace length] than does *C. englishi* (33.2 - 38.0 percent and 41.3 - 46.7 percent). In addition, *C. halli* possesses straighter rostral margins (concave in *C. englishi*) and lacks an elevated cephalic portion on the annulus ventralis which is typical of *C. obstipus* and present in populations of *C. englishi* that are syntopic with *C. halli*. Syntopic populations of *C. halli* and *C. englishi* exhibit some character displacement in the areola (length, width and number of punctations), rostrum and annulus ventralis and are much easier to separate into their respective species than allotopic populations which show a broader overlap in these characters.

Members of the *latimanus* group are morphologically more diverse with only one species sharing some of the distinctive characters of the *halli* group. Certain populations of *C. latimanus* bear moderately well-developed cervical spines or rostral tubercles and/or have a short, broad areola similar to that in *C. halli*. These two characters—spination and the length-width ratio of the areola —are the only consistent morphological characters that will separate *C. latimanus* from its close ally *C. striatus*. The small rostral spines found on the young of *C. latimanus* are lacking in *C. striatus*. The areola of *C. latimanus* is normally wider than that of *C. striatus* which generally is 10 or more times longer than broad. Exceptions for both species occur, however. This ratio may be as low as 9.1 for *C. striatus*, especially in the Tallapoosa River system, Alabama and Georgia, above the Fall Line. Populations of *C. latimanus* with individuals that exhibit an areola greater than 10 times as long as broad (up to 12.3) are found below the Fall Line in Alabama and Georgia and in the upper Savannah and Santee River drainages in South Carolina.

Cambarus sphenoides is morphologically similar to *C. latimanus* and *C. striatus*, sharing with them a dimorphic striped color pattern (see color notes for *C. latimanus* and *C. striatus*). *Cambarus sphenoides* may be separated from these two species using a combination of the following characters. While *C. latimanus* and *C. striatus* have a moderately well-arched epistomal zygoma (Fig. 2*d*, *e*), it is more strongly arched in *C. sphenoides* (*cf.* Fig. 2*f*). Both *C. latimanus* and *C. striatus* have a double row of denticles along the opposable margins of the fingers, while *C. sphenoides* has a double or triple row (increasing to triple row with age). In addition, *C. sphenoides* differs from *C. striatus* in exhibiting a broader areola, 5.0 to 9.2 times longer than broad (Fig. 1*g*) (9.1 to obliterated in *C. striatus*, Figs. 10*i*, 11*i*), and often more convergent rostral margins with an intervening surface that is comparatively flat and often bearing a low carina (Fig. 1*g*). The rostrum of *C. striatus* has subparallel margins with a deeply excavate surface (Figs. 10*i*, 11*i*).

Cambarus graysoni bears a close resemblance to *C. sphenoides* and *C. striatus* and has long been confused with the latter. *Cambarus graysoni* with a gently bent epistomal zygoma (Fig. 4*k*) differs from *C. striatus* and all other members of the subgenus *Depressicambarus* which possess one that is at least moderately well arched (Fig. 2*d, e, f*). *Cambarus graysoni* is further distinguished from *C. sphenoides* by the lack of a subapical notch on the central projection of the gonopod (Fig. 3*d, e*). In addition, the areola of *C. graysoni* is 9.0 to 15.1 times longer than broad (5.0 - 9.2 times in *C. sphenoides*) and the rostrum bears subparallel margins and a concave surface (often subacuminate with a comparatively flat surface in *C. sphenoides*).

Cambarus pyronotus is more closely related to *C. striatus* than to any other species but differs from *C. striatus* in the following characters. It bears an obsolete suborbital angle which is usually moderately well to weakly developed in *C. striatus*. The opposable margin of the propodus bears 3 dominant tubercles proximally in *C. pyronotus* and generally 4 in *C. striatus* (Figs. 9*l*, 10*l*, and 11*l*). The caudolateral corners of the proximal portion of the telson of *C. pyronotus* lack a movable spine (2 of the 21 specimens examined actually do possess a movable spine on each side) while the telson of *C. striatus* generally bears both a movable and an immovable spine in each corner, rarely only the immovable spine. In addition, *C. pyronotus* is a bright, orange-red color not found in *C. striatus*.

Two morphologically similar relatives of *C. cymatilis* are *C. catagius* and *C. reduncus*, all three of which are burrowers. In *C. cymatilis* the opposable margins of the fingers of the chela are distinct with the dactyl bearing 2 dominant basal tubercles (3 - 5 in other members of the subgenus, except *C. obstipus* usually with 8 or 9 fairly evenly sized ones Fig. 1*i*), the distal one largest, and the propodus with 3 dominant basal tubercles, the proximal 2 of which increase in size distally, followed by a large gap between the second and third (Fig. 1*j*) (no such large gap exists in any other nominal member of the subgenus, Figs. 4*i*, 5*i*, 9*l*, 10*l*, 11*l*). A narrow to moderately narrow, steeply declivous antennal scale (Fig. 1*c, d*) is shared by all three although *C. reduncus* also exhibits one that varies from steeply declivous to angulate. In addition, the weakly developed suborbital angle, often obsolete, of *C. reduncus* is in contrast to the well-developed and acute suborbital angle in C. *cymatilis* and the moderately well developed and rounded one in *C. catagius*. All three species display a suboval and deeply situated annulus ventralis with a conspicuously thickened caudal wall. The very wide cephalic trough is a distinguishing feature of the annulus ventralis of some populations of *C. reduncus*. The first form male gonopod of *C. cymatilis* bears a short central projection with a well-defined subapical notch (Fig. 3*b*) and differs from that of *C. catagius* which bears a central projection of moderate length with a subapical notch that is poorly defined or lacking (Fig. 3*a*). In *C. reduncus* the long, aciculate central projection (Fig. 3*h*) of the male gonopod is unique among the members of the genus. The gonopod of the nonreproductive male is also distinctive, bearing a wide gap between the central projection and mesial process (Fig. 3*i*). The latter feature also serves to separate the second form male of this species from any other member of the subgenus.

Phylogeny

The two most likely sites of origin of the subgenus *Depressicambarus* are the Cumberland Plateau section and the Piedmont province. Hobbs (1969) proposed that the subgenus probably originated on the slopes of the Cumberland Plateau. An equally viable hypothesis is that the ancestral stock of the subgenus arose on the southern end of the Piedmont. These regions are not too far removed from one another, and outliers of the Cumberland Plateau actually lie in close proximity to the Piedmont province in Alabama. It is in these regions that members of the subgenus exhibiting the most plesiomorphic characters are found. These members, *C. englishi, C. halli* and *C. obstipus*, constitute a distinctive unit (*halli* group) within the subgenus. *Cambarus englishi* and *C. halli* are endemic to the Tallapoosa River system (Piedmont province) in Georgia and Alabama as is *C. obstipus* to the Black Warrior River system (Cumberland Plateau section) in Alabama. The Tallapoosa drainage seems to have undergone two occupations by the *halli* group, first by *C. halli* and later by *C. englishi*.

The *halli* group may have moved northward along the strikes of the Piedmont, Ridge and Valley and Cumberland Plateau, although no member of this group is presently known outside the southern portions of the Piedmont and Cumberland Plateau. Based upon the present distribution of other crayfishes within these physiographic regions, movement along the dispersal corridors seems to be a probable avenue of migration (Bouchard, 1976a). Movements among the Piedmont, Ridge and Valley and Cumberland Plateau seem certain based upon present distributions of the *halli* group. This migration was facilitated by (i) the close proximity of the three regions in the southern parts of their ranges, (ii) the lower elevaation of the eastern escarpment of the Cumberland Plateau toward its southern end before it is overlapped by Coastal Plain deposits and (iii) the presence of the Coosa River system which not only drains the Ridge and Valley but also the eastern and western flanks of the Cumberland Plateau and Piedmont, respectively.

The members of the *latimanus* group display a wider variation in morphological characters, many of which are mode advanced than those of the *halli* group. Within the former group the closest relative to the more plesiomorphic *halli* group is *C. latimanus* with some populations displaying the more primitive short, broad areola and well-developed spination on the body typical of *C. halli*. The *latimanus* group (*C. catagius, C. cymatilis, C. graysoni, C. latimanus, C. pyronotus, C. reduncus, C. sphenoides* and *C. striatus*) probably also arose on the Piedmont province, but further to the northeast than the *halli* group in the Georgia-South Carolina area, and utilized several corridors of migration.

The *latimanus* group moved northeast following the strike of the Piedmont as well as southwest onto the Ridge and Valley province. From here it probably moved southwest and northeast, following exposures of the Ridge and Valley and westward through Walden Gorge, gaining access here to the predominantly Mississippian limestone streams of the Highland Rim section. This Tennessee River corridor through the Cumberland Plateau has been utilized by a number of crayfishes [*C. girardianus, Orconectes forceps, O. erichsonianus* and *O. spinosus* (*sens. lat.*)], distributions of which predominantly occur in limestone areas on both sides of the Cumberland Plateau. The *latimanus* group also entered the Cumberland Plateau either along the eastern escarpment of the region where it borders the Ridge and Valley or along the Sequatchie Valley. In addition, streams draining the Blue Ridge province in the Tennessee and Georgia area were penetrated by this group from the Ridge and Valley. Migrations into the Coastal Plain province probably initially occurred from the Piedmont and Ridge and Valley. From here they spread along the Coastal Plain.

Cambarus pyronotus probably represents a recently derived species having been isolated from *striatus* stock that migrated along the Apalachicola River drainage into the Torreya Ravine area. Torreya Ravine is a unique area in that it supports an assemblage of plants and animals representing southern species, northern relicts that were isolated in the area after the last glacial egression and some endemics of limited distribution (Hubbell, 1939).

The ancestral stock of the subgenus *Depressicambarus* probably exhibited the following characteristics, many of which are presently found in *C. halli* and in the chela of some populations of *C. sphenoides* north of the Obey and Emory River systems in Tennessee and Kentucky: (i) eyes large, (ii) carapace subovate, (iii) rostrum with straight, subparallel margins bearing distal rostral tubercles, (iv) suborbital angle acute, (v) antennal scale with mesial margin of lamellar portion angulate (Fig. 11*h*), (vi) postorbital ridge with cephalic spine, (vii) cervical spine present, (viii) areola short (29 - 35 percent of total length of carapace or 39-43 percent of postorbital carapace length), broad (less than 4.5 times longer than broad) and densely punctate (5 - 7 punctations across narrowest part), (ix) chela subovate and subrectangular with squamous tubercles over dorsal surface of palm and with two primary rows of larger ones along mesial margin of moderately long palm; opposable margins of fingers with triple row of crowded denticles, (x) annulus ventralis subquadrate and situated moderately deep in sternum; caudal wall elevated; cephalic portion elevated, at least equal in height to caudal wall and divided by median trough extending caudally as sinuate sinus that divides caudal wall, (xi) first form male gonopod with central projection short, corneous, bladelike, directed caudally, bearing subapical notch and inclined at angle of approximately 90 degrees to main shaft of appendage; mesial process caudally directed and tumescent; caudal element conspicuous; (xii) color bright green with dark saddle at caudal end of cephalothorax; margins of rostrum and postorbital ridges red; chelae with at least distal half of fingers pale white and articular condyles red; abdominal segments with caudal margins of terga (except sixth) and ventral and caudal margins of pleura white, that of first tergum broader and more conspicuous. This species probably was most common under rocks in pool areas of small to medium-sized streams.

Evolutionary trends in the epigean members of the subgenus *Depressicambarus* have involved the following changes: (i) reduction of spination on rostrum, postorbital ridges and cervical spines, (ii) mesial margin of antennal scale becoming declivous, (iii) lengthening and narrowing of areola with reduction in number of punctations, (iv) chela becoming more subtriangular and flattened; reduction in number of squamous tubercles over surface and shortening of mesial margin of palm; opposable margins of fingers with reduction in number of rows of crowded denticles; lateral margin of propodus becoming more impressed, (v) annulus ventralis with elevated cephalic portion reduced to ridges bordering cephalic trough and lower in height than caudal wall, (vi) first form male gonopod with central projection becoming longer, reduction in subapical notch and inclining toward angle of more than 90 degrees to main shaft of appendage, (vii) color pattern more subdued greens and browns with margins of rostrum and articular condyles yellow, if light colored; chelae with distal tips of fingers red, orange, yellow or cream; abdominal segments retaining only lighter ventral pleural margins.

The burrowing species of the subgenus, especially the more fossorial primary burrowers, exhibit further changes in morphology as follows: (i) reduction in size of eyes, (ii) vaulting of carapace, (iii) narrowing of rostrum, (iv) postorbital ridges becoming reduced, (v) antennal scale narrower and with more steeply declivous mesial margin (Fig. 3*b*), (vi) suborbital angle further reduced, (vii) areola narrower and longer, (viii) chela broader and more depressed with reduction in number of tubercles and rows of denticles along opposable margins of fingers, (ix) deepening of sternum, (x) annulus ventralis becoming suboval with conspicuously thickened caudal wall, (xi) abdomen reduced in width, (xii) color variable, red, blue or subdued browns or greens.

Addendum

In view of the paucity of information concerning life history aspects of *C. latimanus* and *C. striatus* additional information has been obtained subsequent to the submission of this paper and is added as follows: A single female with young of *C. striatus* was collected under a rock approximately a half meter from shore in a tributary of Spring Creek (Coosa River system) off Alabama State Highway 35, Cherokee County, Alabama, R10E-T8S-S21NE, on 9 October 1977. A copulating pair of *C. latimanus* was observed in midstream under a bridge crossing a tributary of Talladega Creek (Coosa River system) at Talladega County Road 9, Talladega County, Alabama, R6E-T20S-S3NE, on 2 November 1974.

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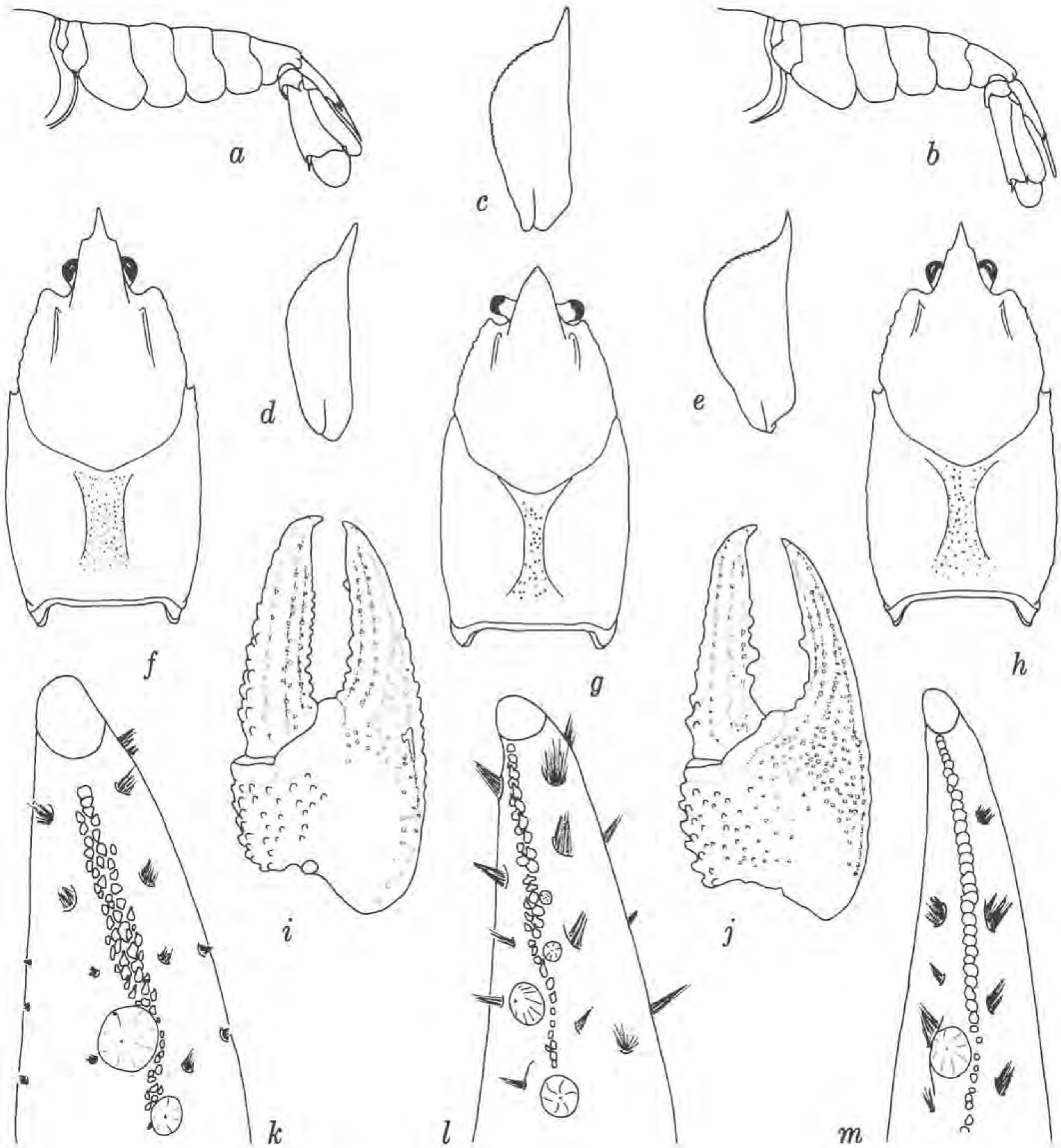

Fig. 1. *a*, *C. halli*, Lateral view of abdomen; *b*, *C. englishi*, Lateral view of abdomen; *c*, *C. cymatilis* Antennal scale; *d*, *C. catagius*, Antennal scale; *e*, *C. halli*, Antennal scale; *f*, *C. halli*, Dorsal view of carapace; *g*, *C. sphenoides*, Dorsal view of carapace; *h*, *C. englishi*, Dorsal view of carapace; *i*, *C obstipus*, Dorsal view of chela; *j*, *C. cymatilis*, Dorsal view of chela; *k*, *C. graysoni*, Opposable margin of distal end of propodus; *l*, *C. latimanus*, Opposable margin of distal end of propodus; *m*, *C. cymatilis*, Opposable margin of distal end of propodus.

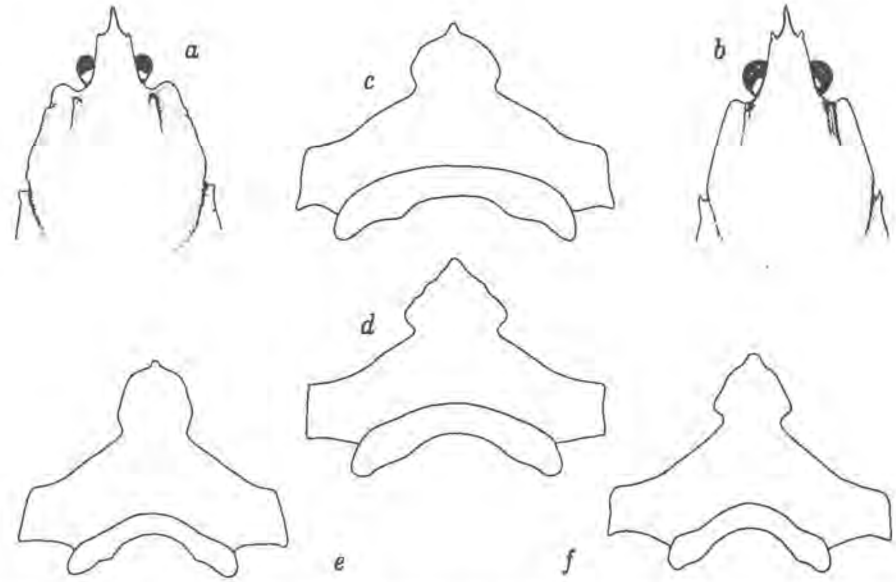

Fig. 2. *a, C. latimanus,* Dorsal view of carapace; *b. C. latimanus,* Juvenile, Dorsal view of carapace; *c, C. graysoni,* Epistome with gently bent epistomal zygoma; *d, C. striatus,* Epistome with moderately well-arched epistomal zygoma; *e, C. striatus,* Epistome with moderately well-arched epistomal zygoma; *f, C. obstipus,* Epistome with well-arched epistomal zygoma.

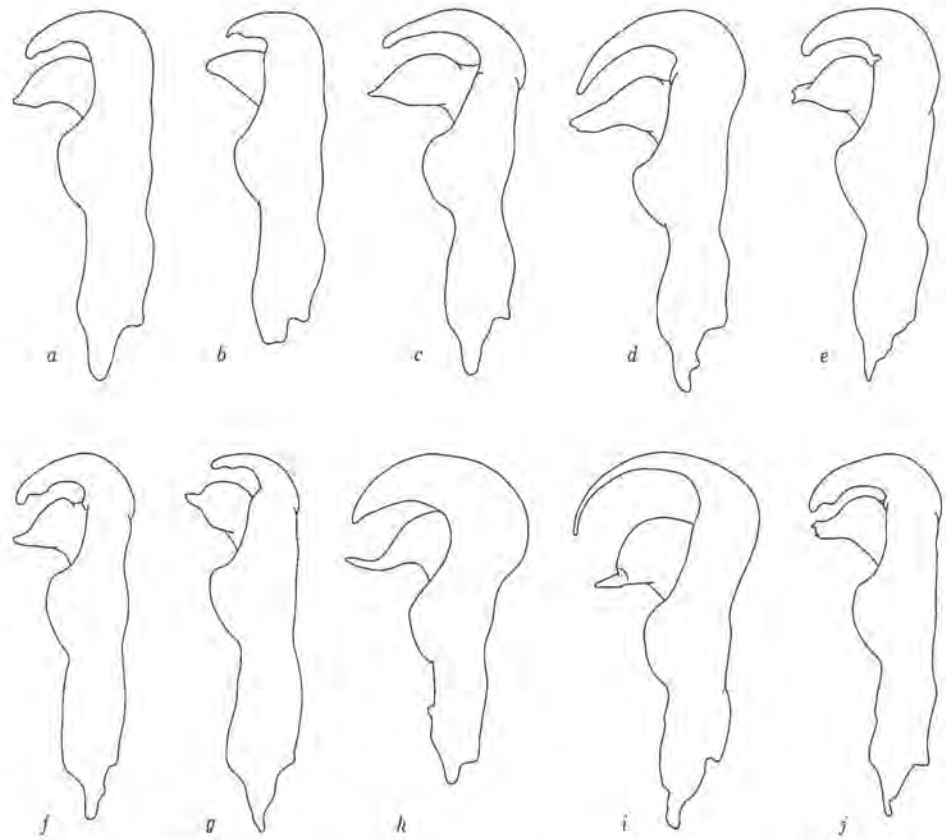

Fig. 3. Lateral view of left first pleopod of eight species of *Depressicambarus. a-g, i-j,* Male, form I; *h,* Male, form II; *a, C. catagius,* Guilford Co., N.C.; *b, C. cymatilis,* Murray Co., Ga.; *c, C. englishi,* Haralson Co., Ga.; *d, C. graysoni,* Lincoln Co., Tn.; *e, C. graysoni,* Grayson Co., Ky.; *f, C. halli,* Haralson Co., Ga.; *g, C. obstipus,* Lawrence Co., Al.; *h, C. reduncus,* Chatham Co., N.C.; *i, C. reduncus,* Fairfield Co., S.C.; *j, C. sphenoides,* Cumberland Co., Tn.

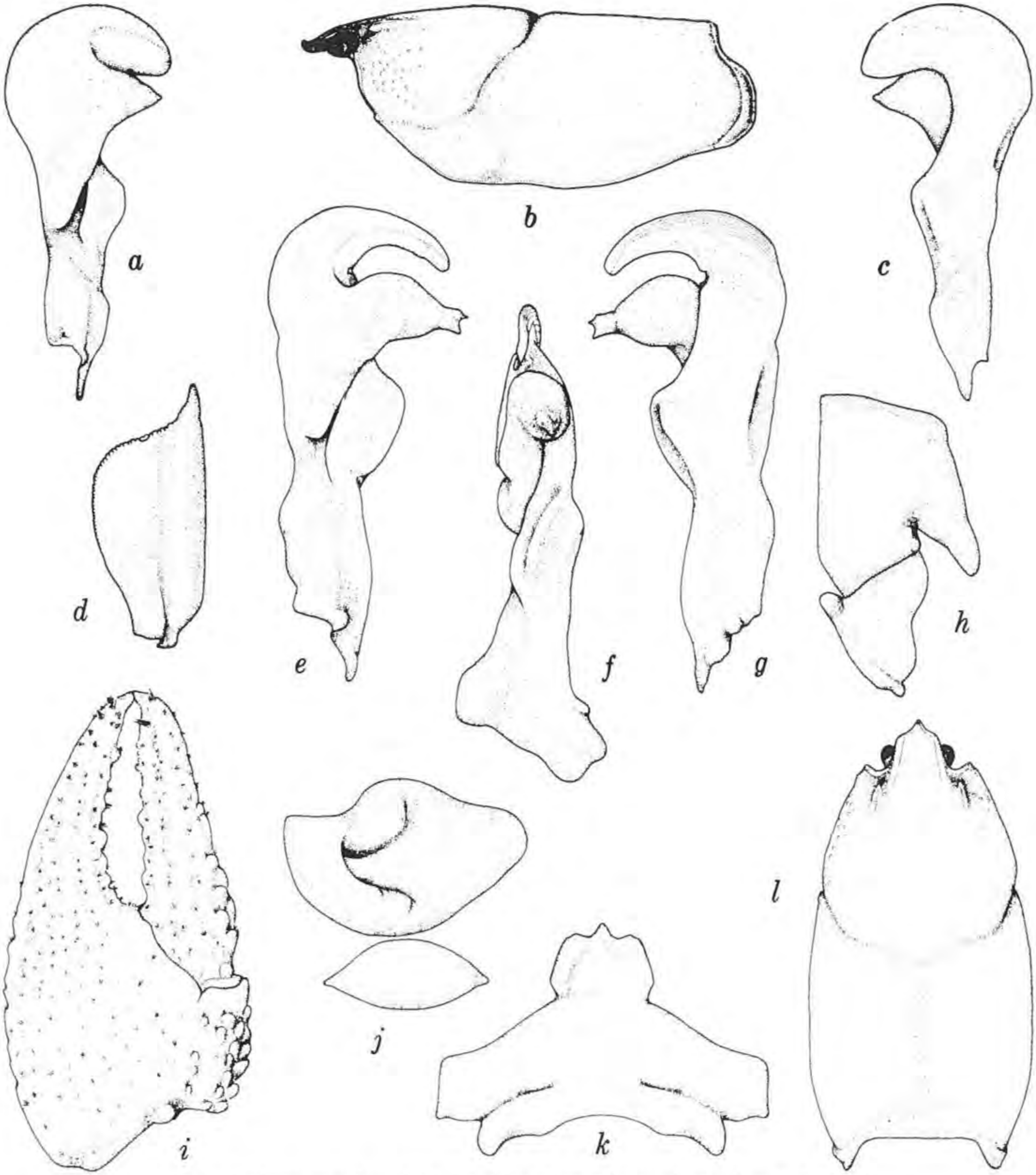

Fig. 4. *Cambarus graysoni*. *a*, Mesial view of first pleopod of topotypic male, form II; *b*, Lateral view of carapace of topotypic male, form I; *c*, Lateral view of first pleopod of topotypic male, form II; *d*, Antennal scale of topotypic male, form I; *e*, Mesial view of first pleopod of topotypic male, form I; *f*, Caudal view of first pleopod of topotypic male, form I; *g*, Lateral view of first pleopod of topotypic male, form I; *h*, Basipodite and ischiopodite of third pereiopod of topotypic male, form I; *i*, Dorsal view of chela, Lincoln Co., Tn.; *j*. Annulus ventralis of topotypic female; *k*, Epistome of topotypic male, form I; *l*, Dorsal view of carapace of topotypic male, form I.

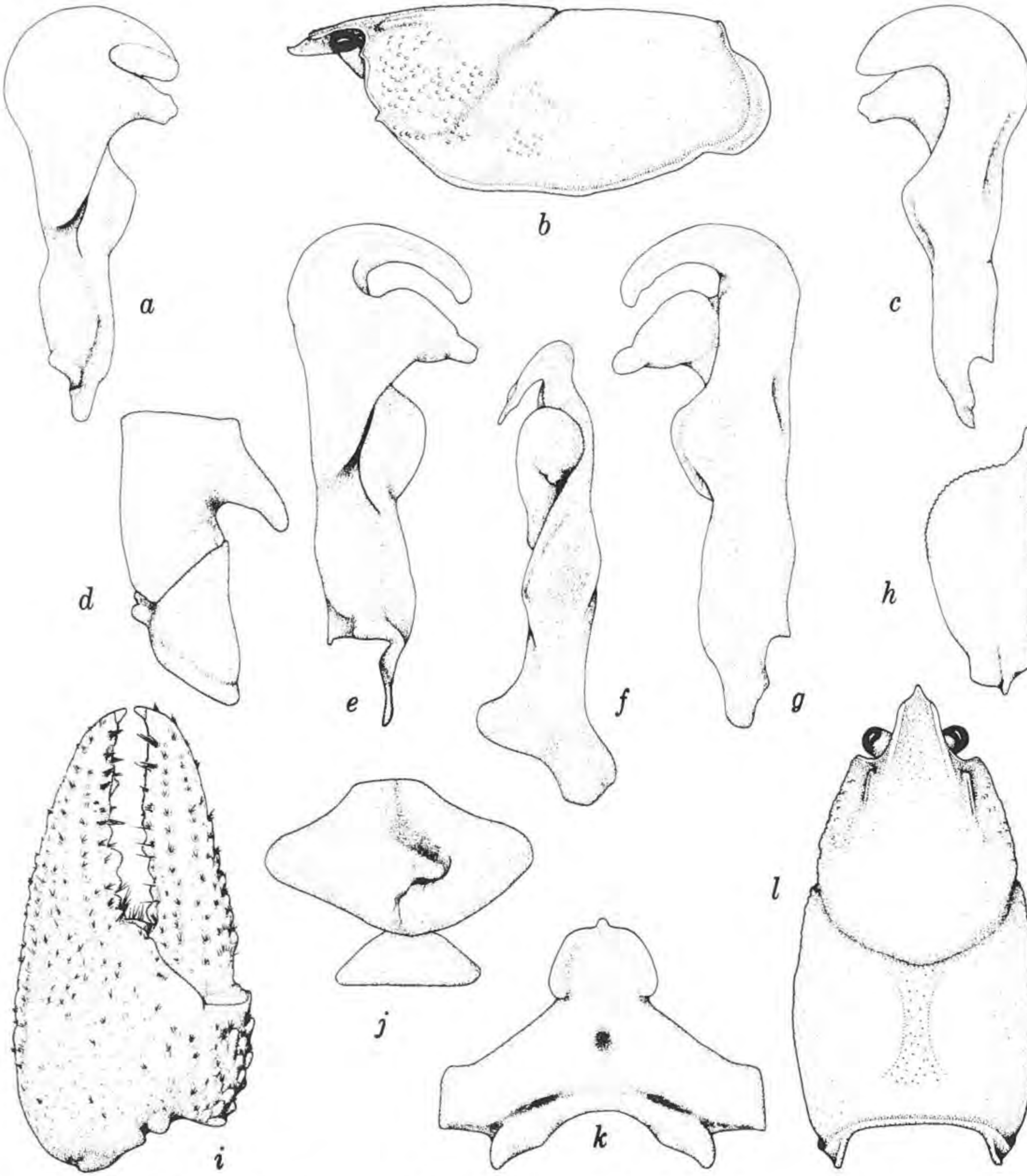

Fig. 5. *Cambarus latimanus*. *a*, Mesial view of first pleopod of topotypic male, form II; *b*, Lateral view of carapace of topotypic male, form I; *c*, Lateral view of first pleopod of topotypic male, form II; *d*, Basipodite and ischiopodite of third pereiopod of topotypic male, form I; *e*, Mesial view of first pleopod of topotypic male, form I; *f*, Caudal view of first pleopod of topotypic male, form I; *g*, Lateral view of first pleopod of topotypic male, form I; *h*, Antennal scale of topotypic male, form I; *i*, Dorsal view of chela, topotypic male, form I; *j*, Annulus ventralis of topotypic female; *k*, Epistome of topotypic male, form I; *l*, Dorsal view of carapace of topotypic male, form I.

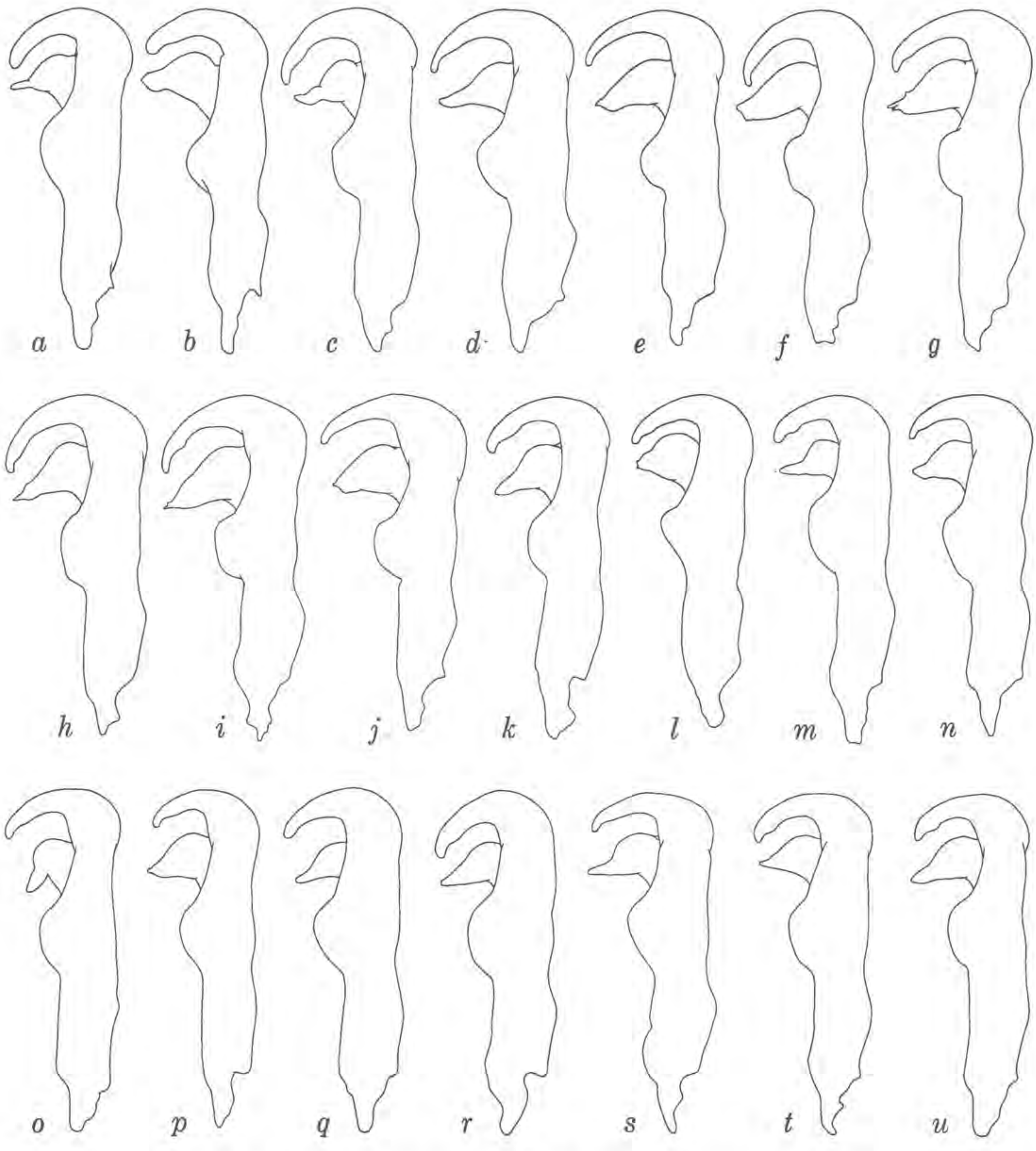

Fig. 6. *C. latimanus*. Lateral view of left first pleopod, male, form I. *a-b*, Polk Co., Tn.; *c-d*, Craven Co., N.C.; *e-g*, Durham Co., N.C.; *h*, Halifax Co., N.C.; *i*, Onslow Co., N.C.; *j*, Orange Co., N.C.; *k*, Aiken Co., S.C.; *l*, Anderson Co., S.C.; *m*, Chester Co., S.C.; *n*, Fairfield Co., S.C.; *o*, Greenville Co., S.C.; *p*, Oconee Co., S.C.; *q*, Pickens Co., S.C.; *r-u*, Richland Co., S.C.

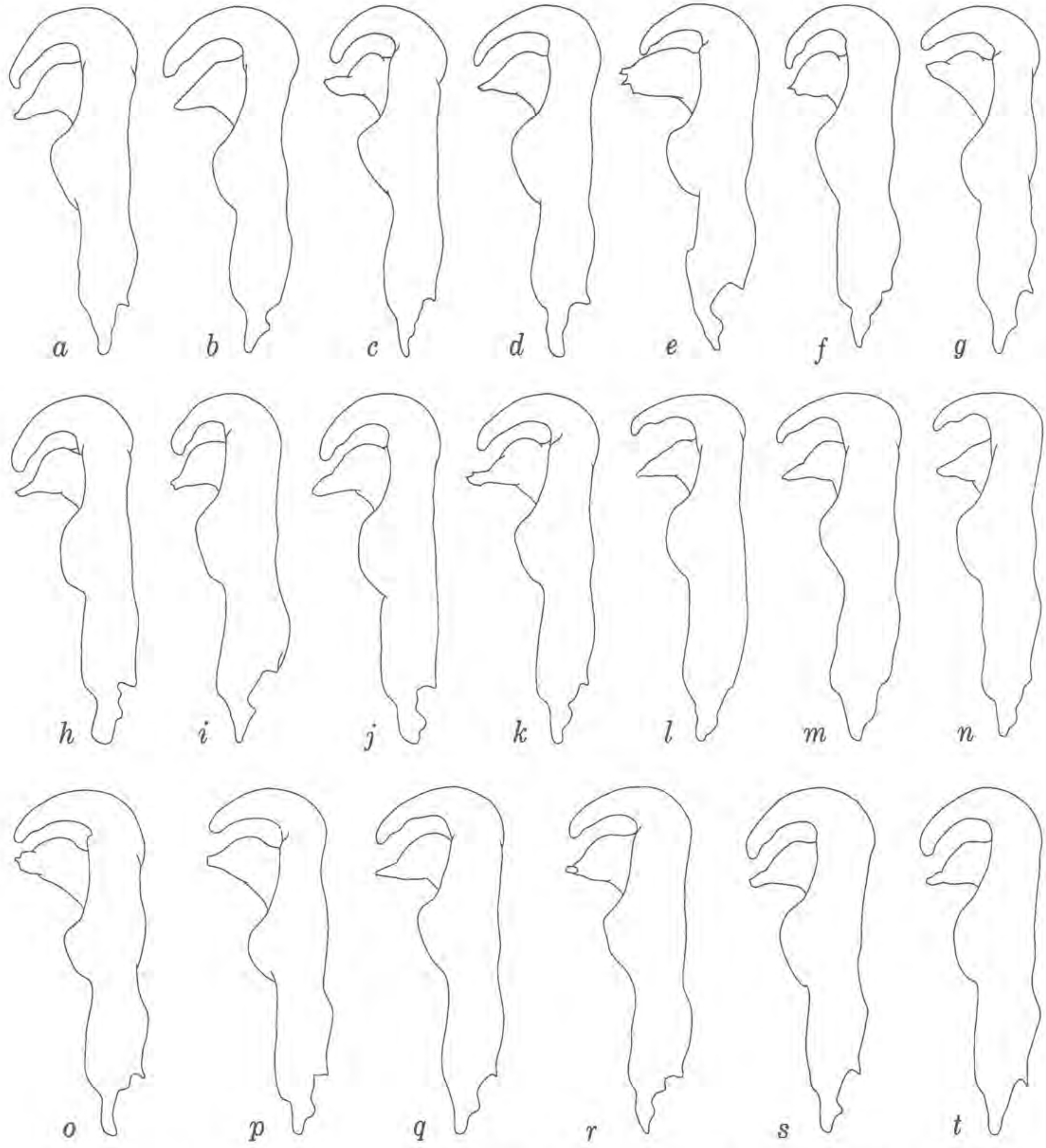

Fig. 7. *C. latimanus*. Lateral view of left first pleopod, male, form I. *a-b*, Lee Co., Al.; *c*, St. Clair Co., Al.; *d*, Shelby Co., Al.; *e*, Talladega Co., Al.; *f*, Tallapoosa Co., Al.; *g*, Bartow Co., Ga.; *h*, Bibb Co., Ga.; *i*, Carroll Co., Ga.; *j*, Chattooga Co., Ga.; *k*, Douglas Co., Ga.; *l*, Elbert Co., Ga.; *m*, Hancock Co., Ga.; *n*, Madison-Franklin cos., Ga.; *o*, Pickens Co., Ga.; *p*, Polk Co., Ga.; *q*, Richmond Co., Ga.; *r*, Walton Co., Ga.; *s-t*, Liberty Co., Fl.

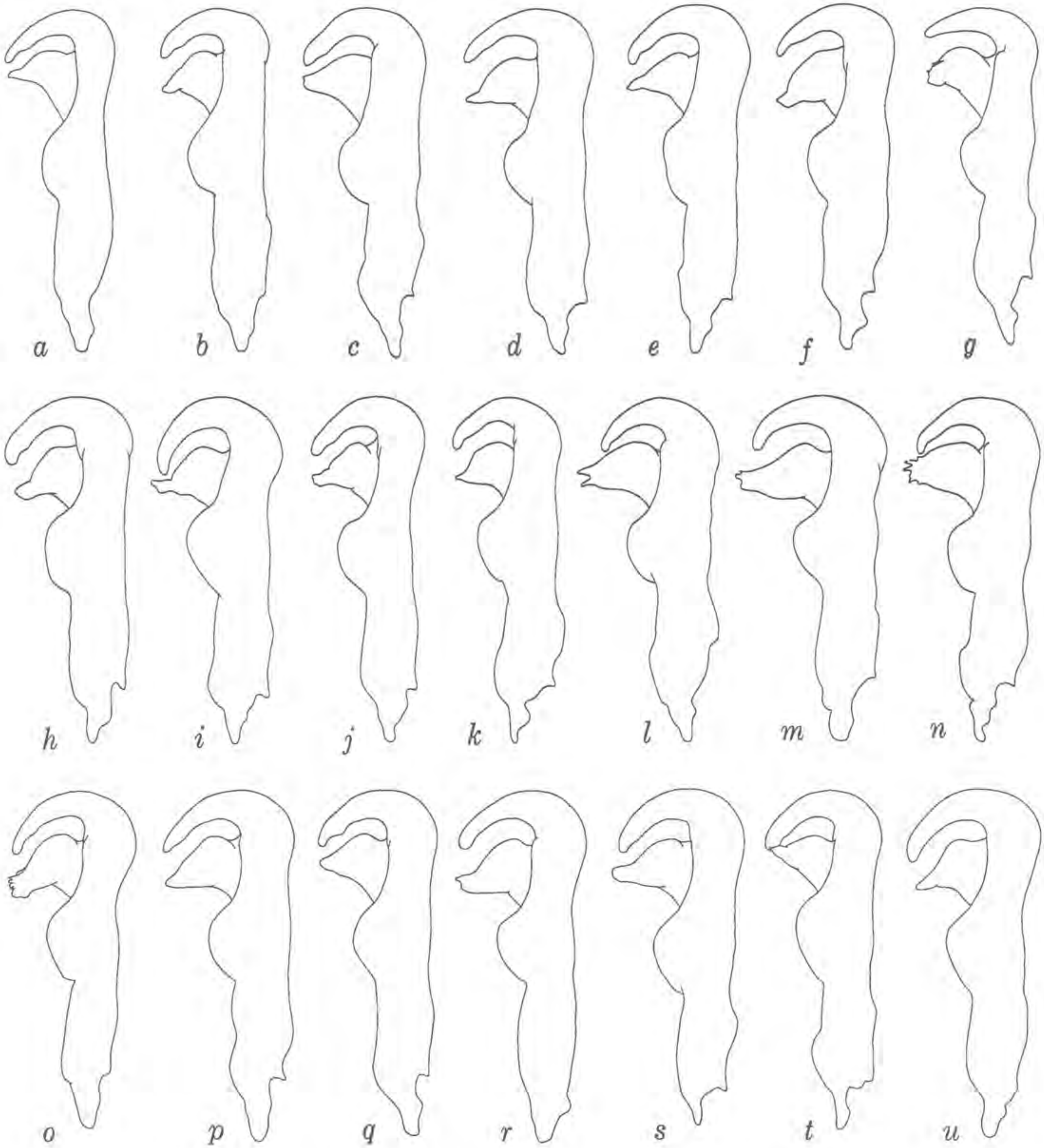

Fig. 8. *C. latimanus*. Lateral view of left first pleopod, male, form I. *a-g*, Calhoun Co., Al.; *h*, Chambers Co., Al.; *i*, Cherokee Co., Al.; *j*, Chilton Co., Al.; *k-o*, Clay Co., Al.; *p-r*, Cleburne Co., Al.; *s-t*, Coosa Co., Al.; *u*, Lee Co., Al.

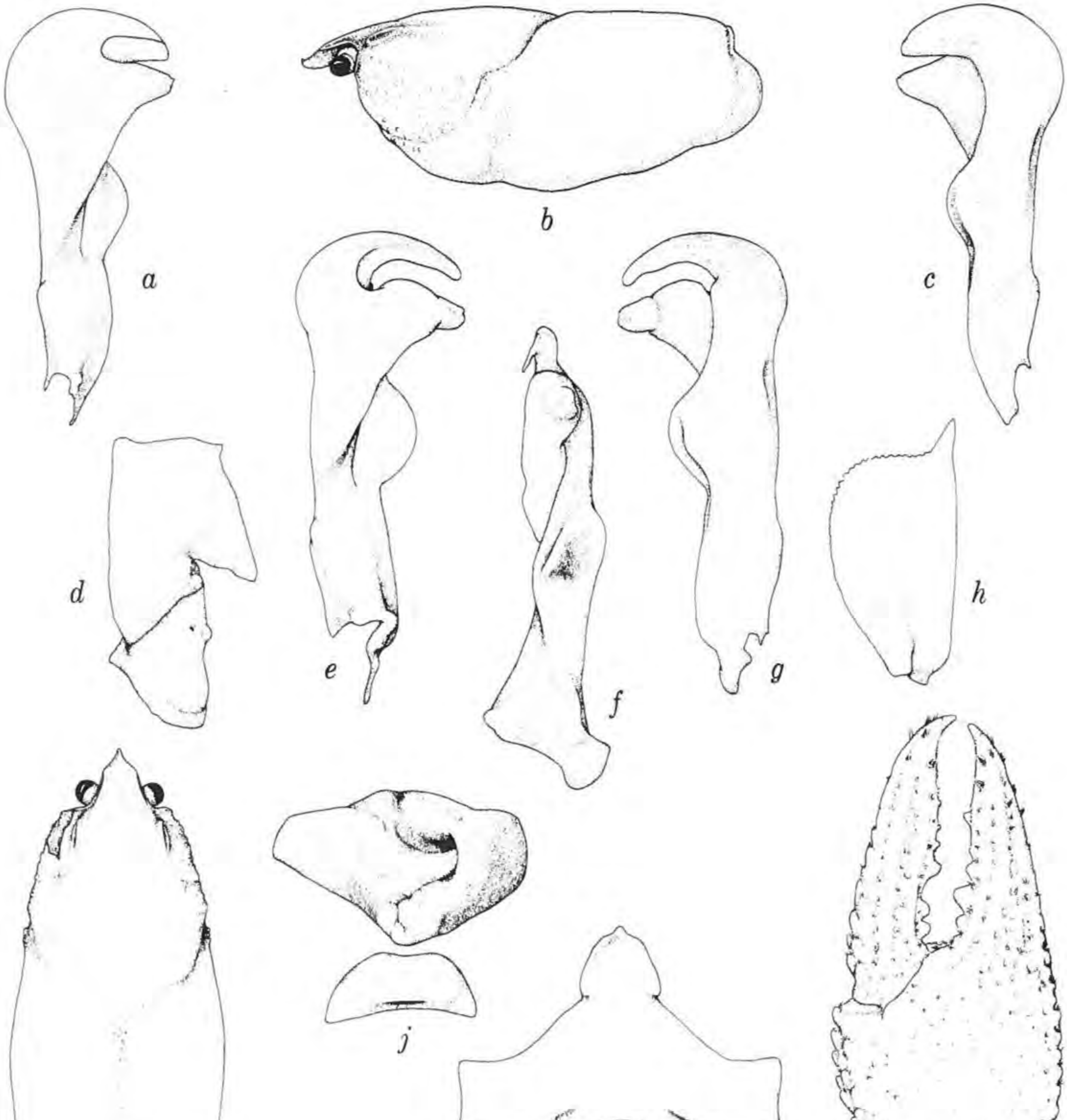

Fig. 9. *Cambarus pyronotus*, new species. *a*, Mesial view of first pleopod of morphotypic male; *b*, Lateral view of carapace of holotype; *c*, Lateral view of first pleopod of morphotypic male; *d*, Basipodite and ischiopodite of third pereiopod of holotype; *e*, Mesial view of first pleopod of holotype; *f*, Caudal view of first pleopod of holotype; *g*, Lateral view of first pleopod of holotype; *h*, Antennal scale of paratypic female; *i*, Dorsal view of carapace of holotype; *j*, Annulus ventralis of allotype; *k*, Epistome of morphotypic male; *l*, Dorsal view of chela of morphotypic male.

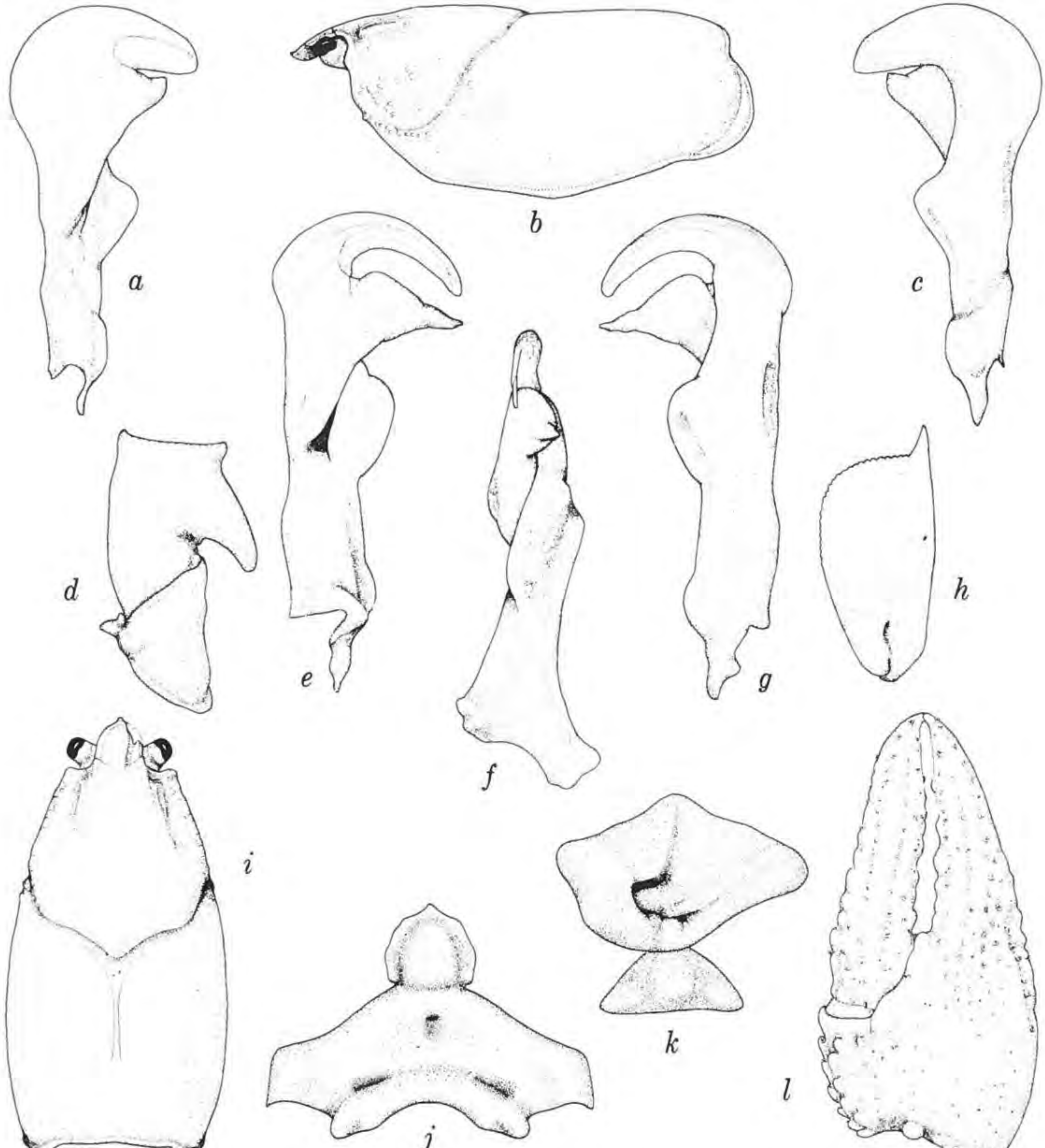

Fig. 10. *Cambarus striatus*. *a*, Mesial view of first pleopod of topotypic male, form II; *b*, Lateral view of carapace of topotypic male, form I; *c*, Lateral view of first pleopod of topotypic male, form II; *d*, Basipodite and ischiopodite of third pereiopod of topotypic male, form I; *e*, Mesial view of first pleopod of topotypic male, form I; *f*, Caudal view of first pleopod of topotypic male, form I; *g*, Lateral view of first pleopod of topotypic male, form I; *h*, Antennal scale of topotypic male, form II; *i*, Dorsal view of carapace of topotypic male, form I; *j*, Epistome of topotypic male, form I; *k*, Annulus ventralis of topotypic female; *l*, Dorsal view of chela of topotypic male, form I.

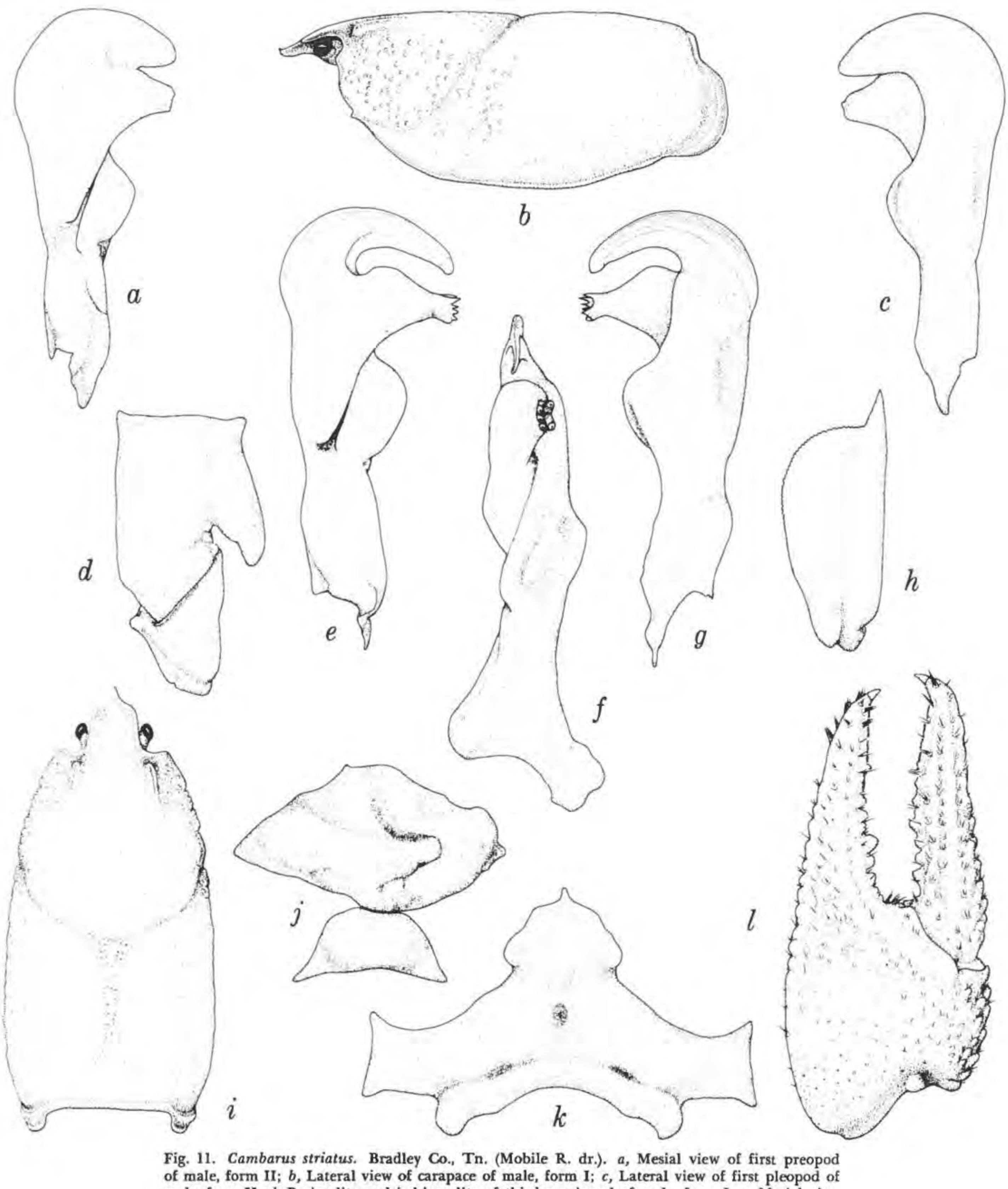

Fig. 11. *Cambarus striatus.* Bradley Co., Tn. (Mobile R. dr.). *a*, Mesial view of first preopod of male, form II; *b*, Lateral view of carapace of male, form I; *c*, Lateral view of first pleopod of male, form II; *d*, Basipodite and ischiopodite of third pereiopod of male, form I; *e*, Mesial view of first pleopod of male, form I; *f*, Caudal view of first pleopod of male, form I; *g*, Lateral view of first pleopod of male, form I; *h*, Antennal scale of male, form II; *i*, Dorsal view of carapace of male, form I; *j*, Annulus ventralis of female; *k*, Epistome of male, form I; *l*, Dorsal view of chela of male, form I.

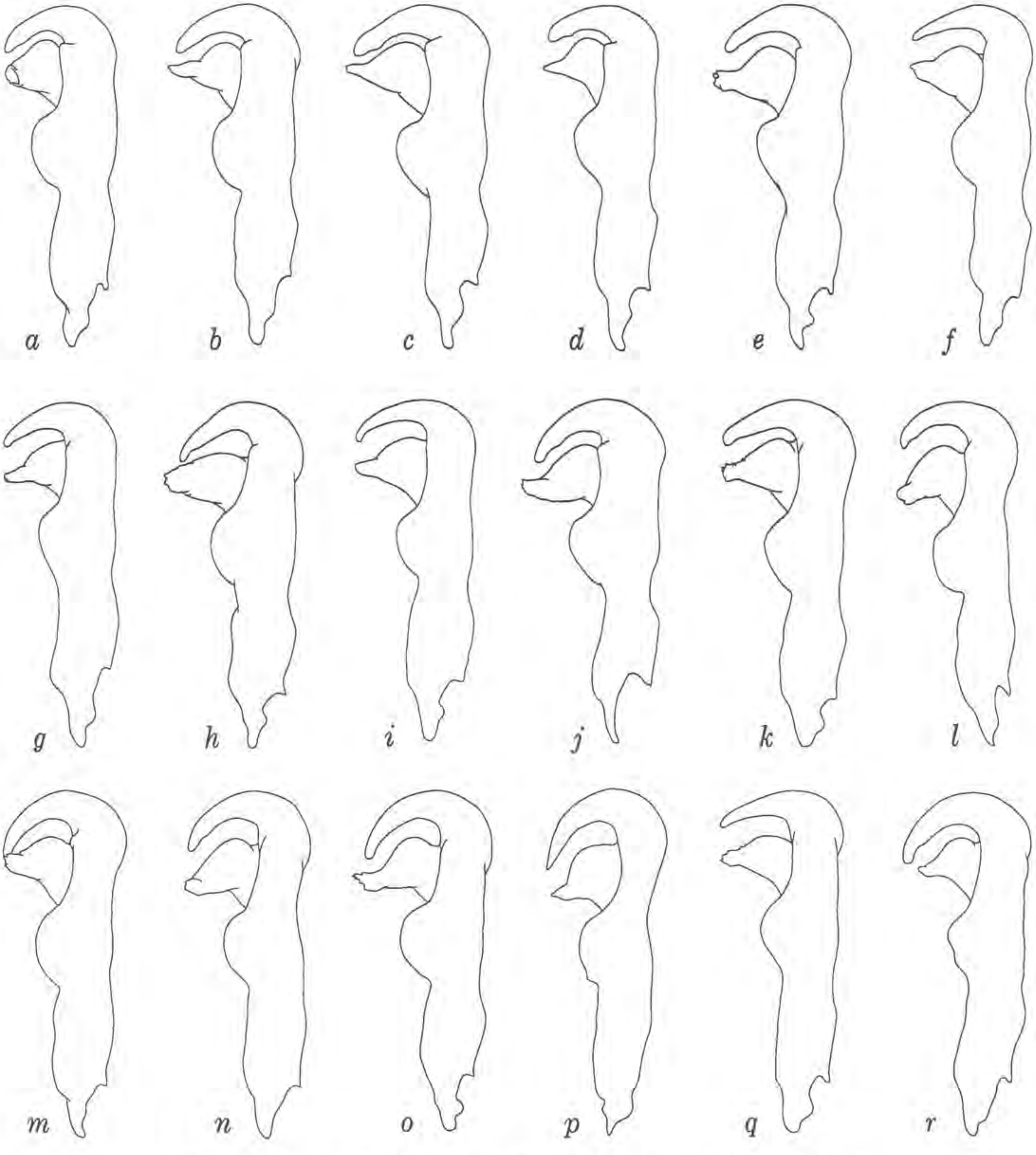

Fig. 12 *C. striatus.* Lateral view of left first pleopod, male, form I. *a*, Blount Co., Al.; *b*, Cullman Co., Al.; *c-d*, DeKalb Co., Al.; *e*, Etowah Co., Al.; *f-g*, Fayette Co., Al.; *h*, Hardin Co., Tn.; *i*, Henry Co., Al.; *j-k*, Jefferson Co., Al.; *l-n*, Lee Co., Al.; *o-p*, Macon Co., Al.; *q*, Madison Co., Al.; *r*, Marion Co., Al.

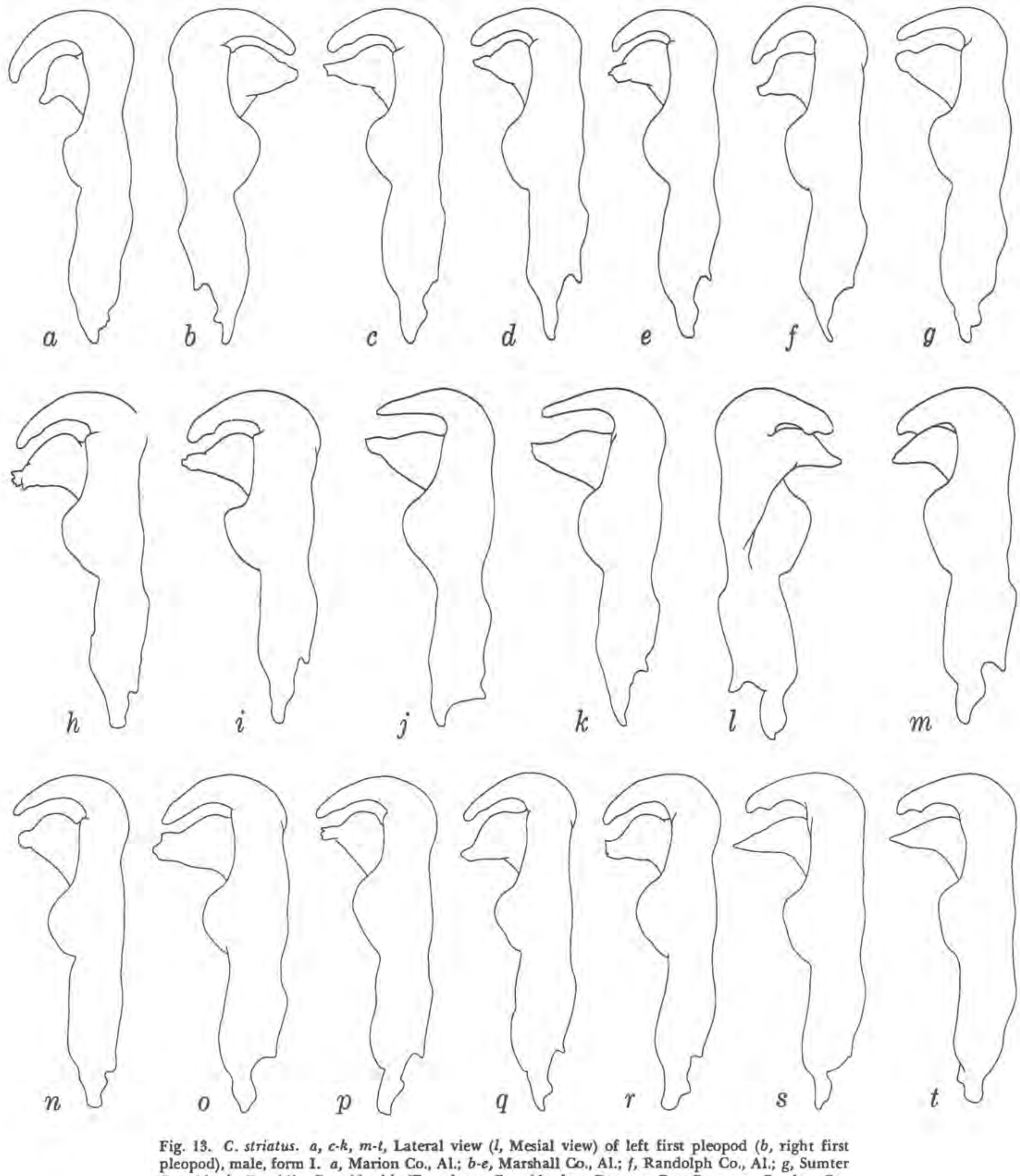

Fig. 13. *C. striatus.* *a, c-k, m-t,* Lateral view (*l,* Mesial view) of left first pleopod (*b,* right first pleopod), male, form I. *a,* Marion Co., Al.; *b-e,* Marshall Co., Al.; *f,* Randolph Co., Al.; *g,* Sumter Co., Al.; *h,* Franklin Co., Al.; *i-k,* Tuscaloosa Co., Al.; *l-m,* Dawson Co., Ga.; *n-o,* Gordon Co., Ga.; *p,* Harris Co., Ga.; *q,* Walker Co., Ga.; *r,* Whitfield Co., Ga.; *s-t,* Wilkinson Co., Ga.

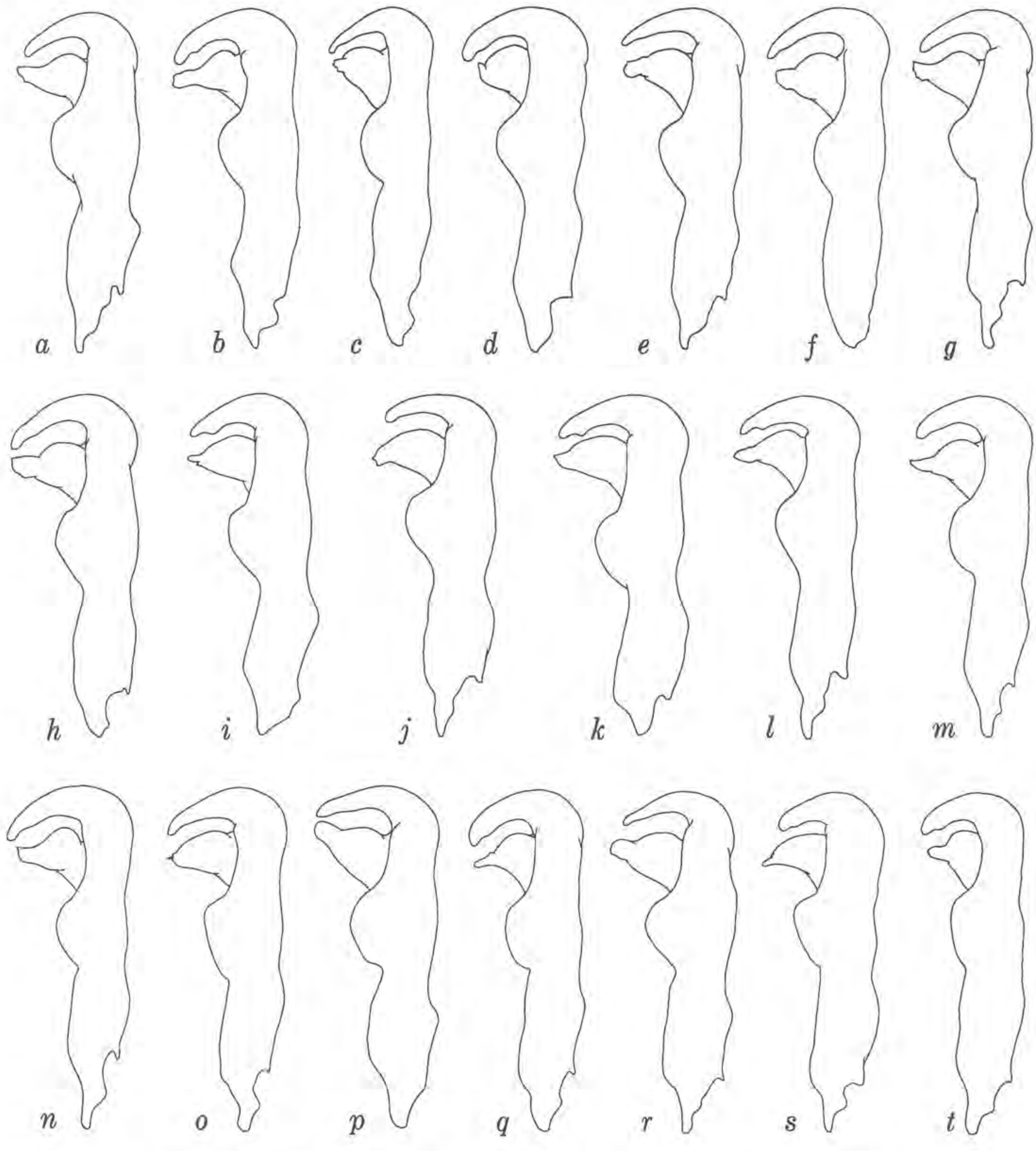

Fig. 14. *C. striatus.* Lateral view of left first pleopod, male, form I. *a*, Bledsoe Co., Tn.; *b*, Cheatham Co., Tn.; *c*, Coffee Co., Tn.; *d*, Davidson Co., Tn.; *e*, Hardin Co., Tn.; *f-h*, Henderson Co., Tn.; *i*, Knox Co., Tn.; *j*, Lincoln Co., Tn.; *k*, Loudon Co., Tn.; *l*, Montgomery Co., Tn.; *m*, Rhea Co., Tn.; *n*, Rutherford Co., Tn.; *o*, Scott Co., Tn.; *p*, Lafayette Co., Ms.; *q*, Lowndes Co., Ms.; *r*, Monroe Co., Ms.; *s-t*, Winston Co., Ms.