

New and Little-known  
Crayfishes of the *virilis* Section  
of Genus *Orconectes*  
(Decapoda: Cambaridae) from the  
Southeastern United States

MARTHA R. COOPER  
and  
HORTON H. HOBBS, JR.

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SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY • NUMBER 320

New and Little-known Crayfishes  
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SMITHSONIAN INSTITUTION PRESS

City of Washington

1980

## ABSTRACT

Cooper, Martha R., and Horton H. Hobbs, Jr. New and Little-known Crayfishes of the *virilis* Section of Genus *Orconectes* (Decapoda: Cambaridae) from the Southeastern United States. *Smithsonian Contributions to Zoology*, number 320, 44 pages, 13 figures, 6 tables, 1980.—Descriptions, illustrations, and all available information concerning the following previously known species are presented: *Orconectes alabamensis* (Faxon, 1884), *O. mississippiensis* (Faxon, 1884), and *O. validus* (Faxon, 1914). Similar treatments are accorded three new species: *O. cooperi* from the Flint River basin in Alabama and Tennessee, *O. holti* from the Alabama River watershed in Alabama, and *O. chickasawae* from the Tombigbee drainage system in Mississippi.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year*. SERIES COVER DESIGN: The coral *Montastrea cavernosa* (Linnaeus).

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### Library of Congress Cataloging in Publication Data

Cooper, Martha R

New and little-known crayfishes of the *virilis* section of genus *Orconectes* (Decapoda: Cambaridae) from the Southeastern United States.

(Smithsonian contributions to zoology ; no. 320)

Bibliography: p.

Supt. of Docs. no.: SI 1.27:320

1. *Orconectes*—Classification. 2. Crustacea—Classification. 3. Crustacea—Southern States—Classification. I. Hobbs, Horton Holcombe, Jr., 1914, joint author. II. Title.

III. Series: Smithsonian Institution. Smithsonian contributions to zoology ; no. 320.

QL1.S54 no. 320 [QL444.M33] 591s [595.3'841] 80-607029

# Contents

	<i>Page</i>
Introduction .....	1
Acknowledgments .....	2
<i>Orconectes alabamensis</i> (Faxon) .....	2
<i>Orconectes validus</i> (Faxon) .....	8
<i>Orconectes cooperi</i> , new species .....	17
<i>Orconectes holti</i> , new species .....	23
<i>Orconectes chickasawae</i> , new species .....	29
<i>Orconectes mississippiensis</i> (Faxon) .....	35
Literature Cited .....	43



# New and Little-known Crayfishes of the *virilis* Section of Genus *Orconectes* (Decapoda: Cambaridae) from the Southeastern United States

*Martha R. Cooper*  
and *Horton H. Hobbs, Jr.*

## Introduction

Prompted in part by a need to know the components of the crayfish fauna in the area of the proposed Tennessee-Tombigbee Waterway in western Alabama and northeastern Mississippi, several years ago we initiated a joint study of the genus *Orconectes* in the westward-flowing segment of the Tennessee River basin and in the Mobile River watershed. The members of the *virilis* section have been particularly in need of clarification. This report provides redescrptions, illustrations, discussions of range and variation, notes on the life history and ecology, and a list of crayfish associates for three previously known species: *Orconectes alabamensis* (Faxon, 1884), *O. validus* (Faxon, 1914) and *O. mississippiensis* (Faxon, 1884). In addition, three species are described as new: one restricted to the Flint River watershed (Tennessee River basin) in Alabama and Tennessee, one from tributaries of the Alabama River in Alabama, and the third from the Tombigbee drainage system in Mississippi. Additional reports are planned as first form males

become available from many localities which are at this time inadequately represented in collections at hand.

Unfortunately, without first form males, we have been unable to identify specimens of the genus from many localities in the Mobile and Tennessee basins. Among those species that possess a depressed, strongly costate chela in which the dactyl bears a serrate row of tubercles mesially and a distinct excision on the proximal half of the opposable surface, the nonsecondary sexual characters may not always be reliable. Until the limits of variation of these characters in each of the species have been determined, a knowledge of the structure of the first pleopod of the first form male is indispensable.

As an illustration of the nature of the problem of identification of members of this complex, Hobbs (1972), in preparing a key to the North and Middle American crayfishes, found that the first pleopod of the syntypic male, form I, of *Orconectes mississippiensis* had been broken, and he chose a presumable topotypic specimen to illustrate the species (p. 80, fig. 63a). The two specimens appeared to be so markedly similar (except that the areola of the supposed topotype was

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linear instead of being obliterated along part of its length) that he failed to note the relative lengths of the central projection of the first pleopods in them. He thus depicted the pleopod of one of the new species described herein instead of that of a specimen of *O. mississippiensis*. Actually, the first pleopod of the first form male of the latter species (Figure 11*b,d,f,h*) is easily distinguishable from that of the new species (Figure 10*b,f*); however, those of the second form male are virtually identical (cf. Figures 11*c,g* and 10*c,e*). Obviously, the first pleopod of the first form male must be available in order to determine whether the specimens in question are grouped with those species having pleopods with long rami, as in *O. etnieri* Bouchard and Bouchard (1976:459) and *O. mississippiensis*, or with those possessing short ones, as in *O. immunis* (Hagen, 1870:71) and two of the new species described herein (Figures 8 and 10).

Reference is made in the text to "adult males" which are considered by us to include those males in the first form or second form males that have experienced at least one previous molt to first form. The measurement of the "total" or "mesial" length of the first pleopod follows that of Fitzpatrick (1967: fig. 1*f*), and constitutes the straight-line distance between the levels of the proximal and distal extremities of the pleopod (Figure 5*j, ml*). The annuli ventrales are described as being firmly, but not inflexibly, fused to the sternum; the sense of this is explained as follows. The annulus ventralis of certain crayfishes occurs as a sclerite surrounded by unsclerotized areas of the exoskeleton and is therefore freely movable. In other species, the annulus is joined to the sternum immediately anterior to it by a partially sclerotized membrane, thus "firmly fused" but slightly movable. In many, if not most, members of the genus *Orconectes*, for example *O. erichsonianus* (Faxon, 1898:659), the junction between the annulus and the sternum anterior to it is so heavily sclerotized that in respect to the sternum the annulus is "inflexibly fused" to it.

ACKNOWLEDGMENTS.—We are indebted to a number of persons for the specimens on which this report is based. Special thanks are extended

to Herbert T. Boschung and Thomas S. Jandebour of the University of Alabama, Eugene C. Beckham of Cornell University, Joseph F. Fitzpatrick, Jr., of the University of South Alabama, and Harold Wahlquist of the Alabama Power Company for the large series of crayfishes donated to the Smithsonian Institution. We are also grateful to the following persons who assisted us in collecting other specimens: Glenn H. Clemmer of Mississippi State University; John E. Cooper of the North Carolina State Museum of Natural History; H. H. Hobbs III of Wittenberg University; Kenneth R. Martin of Atlanta, Georgia; James F. Payne of Memphis State University; Daniel J. Peters of Yorktown, Virginia; Jean E. Pugh of Christopher Newport College; John S. Ramsey of Auburn University; Samuel R. Telford of the University of Florida; and James D. Williams, Office of Endangered Species, Fish and Wildlife Service, Washington, D.C. Thanks are also extended to Raymond W. Bouchard of the University of North Alabama both for lending specimens to us and for records of the occurrence in Tennessee of one of the new species described herein. Others whose assistance in obtaining specimens is appreciated are included under the several paragraphs devoted to "Specimens Examined."

For their criticisms of the manuscript and/or aid in its preparation, we are grateful to John E. Cooper and Joseph F. Fitzpatrick, Jr., and to Margaret A. Daniel and Raymond B. Manning of the Smithsonian Institution.

### *Orconectes alabamensis* (Faxon)

FIGURES 1, 2*a*

- Cambarus Alabamensis* Faxon, 1884:124, 125–127, 146; 1885a: 85, 86, 102, 104–105, 161, 168, 174, 178, pl. IV: fig. 4; pl. X: fig. 3, 3', 3a, 3a'; 1885b:359.—Underwood, 1886:366.
- Cambarus alabamensis*.—Hay, 1899:960, 962.—Ortmann, 1902:278; 1905:110, 112, 117, 127; 1931:90, 91–93.—Steele, 1902:7.—Harris, 1903:60, 70, 137, 146.—Faxon, 1914:383, 420.
- Cambarus (Faxonius) alabamensis*.—Ortmann, 1905:112.
- Faxonius alabamensis*.—Creaser, 1933a:3 [by implication]; 1933b:16; 1962:2 [by implication].
- Faxonius (Faxonius) alabamensis*.—Creaser, 1933b:21 [by implication].



*Orconectes alabamensis*.—Hobbs, 1942a:352 [by implication]; 1968:K12, K31, fig. 31h; 1972:89, 148, figs. 70f, 71d; 1974:26, fig. 166.—Hart and Hart, 1974:75, 90.—Bouchard, 1976b:14.—Fitzpatrick, 1976:56.—Hobbs and Walton, 1977:602.

*Orconectes (Orconectes) alabamensis*.—Hobbs, 1942b:154 [by implication]; 1959:894.

**DIAGNOSIS.**—Body and eyes with pigment. Rostrum with median carina and marginal tubercles present at base of acumen. Areola 3.6 to 6.4 times as long as wide and comprising 26.4 to 31.9 percent of entire length of carapace (34.7 to 41.1 percent of postorbital carapace length) with 4 to 7 punctations in narrowest part. Cervical spine small but well developed; suborbital angle vestigial; postorbital ridge well developed with small acute spines or tubercles cephalically. Antennal scale approximately 2.5 times as long as wide, broadest at or slightly distal to midlength. Chela with palm inflated, bearing row of about 7 squamous tubercles on mesial surface; fingers gaping, and mesial margin of dactyl with vestigial adpressed tubercles; opposable margin of dactyl not excised. Hook on ischium of third pereopod of male. First pleopod of first form male without angular shoulder on cephalic surface, distal three-fifths inclined caudally, terminal elements with distal portions recurved and central projection reaching cephalic margin of coxa of second pleopod when abdomen flexed; pleopod length divisible into carapace length 2.7 to 3.0 (average 2.9) times; terminal elements slender, subparallel; central projection constituting 30.6 to 33.5 (average 31.7) percent of total length of pleopod, bladelike, tapering to apex, and not extending so far caudally as mesial process; mesial process subcylindrical in section proximally, troughlike distally. Annulus ventralis as figured. First pleopod present in female.

**SYNTYPIC MALE, FORM I.**—Body and eyes pigmented. Cephalothorax (Figure 1*a*,*i*) subovate in section; abdomen narrower than carapace (10.9 and 11.6 mm), width of latter greater than depth in caudodorsal margin of cervical groove (11.6 and 10.2 mm). Areola broad, 4.4 times as long as wide, with 6 punctations across narrowest part, length 29.7 percent of entire length of carapace

(38.2 percent of postorbital carapace length). Rostrum with margins not thickened, slightly elevated and gently converging to marginal tubercles; acumen reaching slightly beyond ultimate podomere of antennular peduncle; upper surface of rostrum with low carina cephalically, basal portion weakly excavate and thickly set with punctations. Subrostral ridge weakly developed, evident in dorsal aspect along basal half of rostrum. Postorbital ridge moderately strong, grooved dorsolaterally, and terminating cephalically in small tubercle. Suborbital angle vestigial, broadly rounded. Cervical spine small but well defined. Branchiostegal spine well developed. Carapace densely punctate except cephaloventrally where punctations replaced by granulations. Abdomen longer than carapace (28.0 and 23.5 mm); pleura truncate ventrally, and with rounded caudoventral extremities; cephalic section of telson with 2 spines in each caudolateral corner. Proximal podomere of uropod with spine on each lobe, that on lateral one small; both rami with median keel, that on mesial ramus terminating in premarginal spine.

Cephalic lobe of epistome (Figure 1*g*), with prominent cephalodorsally directed cephalomedian projection, set off from main body of epistome by contracted base; cephalolateral margins rounded, slightly elevated; main body of epistome with prominent fovea; epistomal zygoma broadly arched. Basal segment of antennule with spine on ventral surface slightly distal to midlength. Antennal peduncle with spine on lateral surface of basis and on ischium. Antenna reaching tergum of second abdominal segment. Antennal scale (Figure 1*l*) 2.5 times as long as broad, broadest at about midlength; mesial border of lamella evenly rounded except for weak hump distomesially; apical spine slightly overreaching antennular peduncle. Ventral surface of ischium of third maxilliped clothed in plumose setae; distolateral angle of podomere acute.

Right chela (Figure 1*j*) with palm inflated (ratio of depth to width 0.70), lacking lateral costa, shorter than carapace (18.5 and 23.5 mm), and 2.3 times as long as wide; thickness slightly more than two-thirds length of areola and little

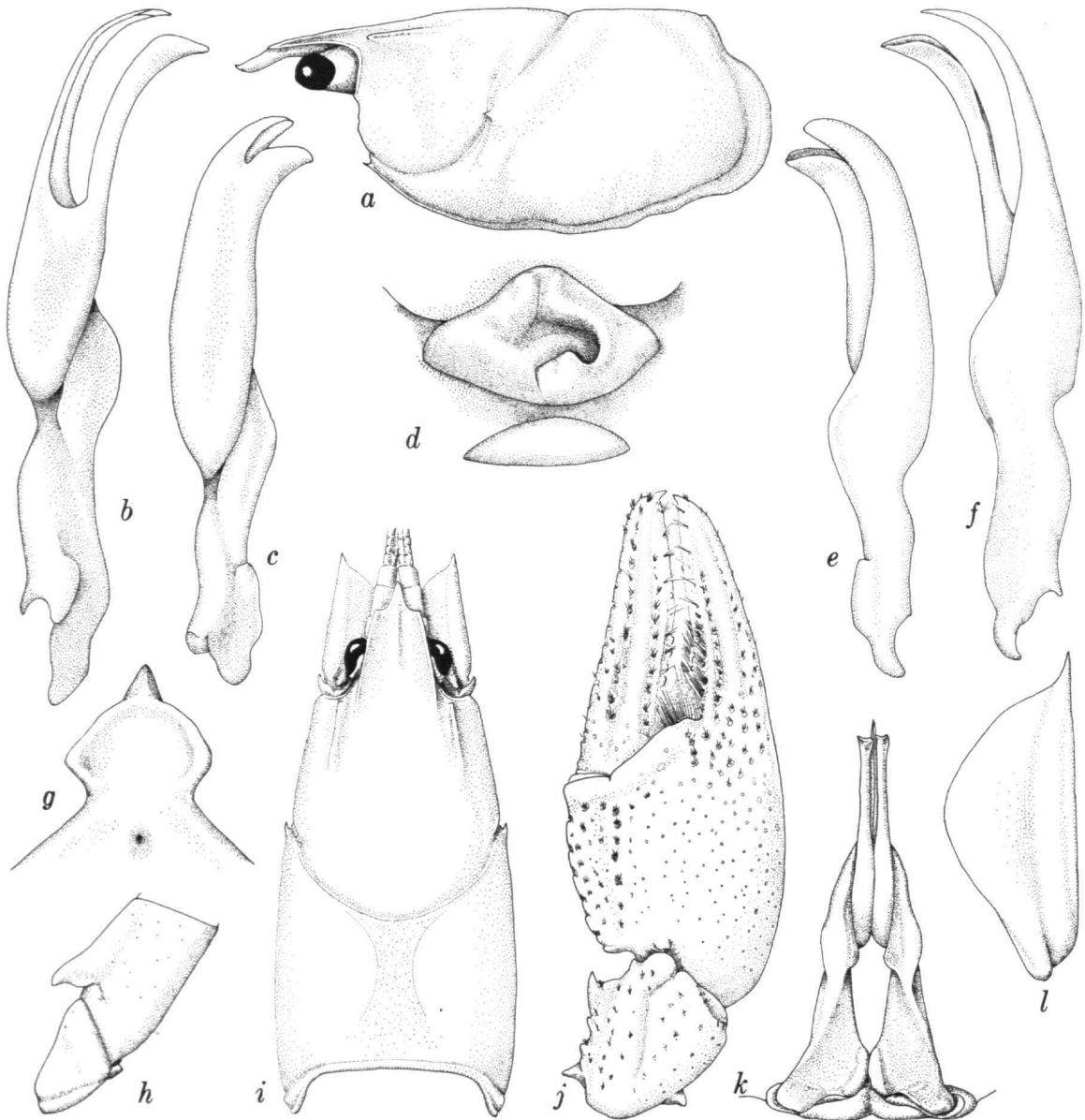


FIGURE 1.—*Orconectes alabamensis* (syntypes, all from ♂I except *c*, *e*, from ♂II, and *d* from ♀): *a*, lateral view of carapace; *b*, *c*, mesial view of first pleopod; *d*, annulus ventralis; *e*, *f*, lateral view of first pleopod; *g*, epistome; *h*, basis and ischium of third pereiopod; *i*, dorsal view of carapace; *j*, dorsal view of distal podomeres of cheliped; *k*, caudal view of first pleopods; *l*, antennal scale.

more than four-fifths length of mesial margin of palm, latter with 3 rows of small to vestigial tubercles: 8 in ventralmost, 7 in middle, and 6 in dorsal row (left chela with 5, 6, and 7, respec-

tively); remainder of chela punctate, lacking tubercles except on opposable margins of fingers. Latter slightly gaping basally. Opposable surface of fixed finger with conspicuous tuft of plumose

setae along basal half, denser ventrally than dorsally, margin with row of 9 tubercles along proximal two-thirds, and band of minute denticles extending from fifth tubercle to base of corneous tip of finger; dorsal and ventral surfaces with well-defined submedian longitudinal ridge flanked by setiferous punctations; setae on proximomesial side of ventral ridge contributing to setal tuft at base of finger; lateral margin of finger rounded with weak longitudinal ridge. Opposable margin of dactyl with row of 9 low rounded corneous tubercles along proximal two-thirds and band of minute denticles extending from fifth tubercle to corneous tip of finger; dorsal and ventral surfaces of finger with submedian longitudinal ridge; mesial surface with row of vestigial, strongly adpressed tubercles proximally giving way to setiferous punctations distally. Carpus 1.4 times as long as broad, with shallow groove dorsally, groove with angle at base of distal fourth; dorsal and lateral surfaces punctate; mesial surface with prominent procurved spine and 2 large tubercles proximal to it; ventral surface punctate except for acute spine on lateral articular condyle. Dorsal surface of merus with 2 premarginal tubercles one of which spiniform; lateral and mesial surfaces largely polished and sparsely punctate; ventral surface with only 1 spiniform tubercle representing lateral row and 11 spiniform ones constituting mesial row; distolateral apophysis with spiniform tubercle. Ventromesial margin of ischium of cheliped with 1 tubercle.

Ischium of third pereiopod (Figure 1*h*) with simple hook overreaching basioischial articulation, not opposed by tubercle on basis. Ventral membrane on coxa of fifth pereiopod studded with short setae.

First pleopods (Figure 1*b,f,k*) symmetrical and reaching second pereiopod when abdomen flexed. (See "Diagnosis" for description.)

**SYNTYPIC FEMALE.**—Differing from male, form I, in following respects: width of abdomen subequal to that of carapace (12.9 and 12.8 mm); fovea on epistome not nearly so prominent; ratio of depth to width of chela 0.66; palm of chela less inflated, mesial surface with 7 tubercles in ventralmost row, 7 in middle, and 6 in dorsal (left

chela with 6, 7, and 5, respectively); fingers not conspicuously gaping; mesial surface of carpus with 3 tubercles proximal to major spine; dorsal surface of merus with 2 premarginal spiniform tubercles, ventrolateral row of tubercles represented by 1 well-developed spiniform tubercle and 2 or 3 vestigial ones, ventromesial row consisting of 10 (left with 12) subspiniform to spiniform tubercles. (See Table 1.)

Annulus ventralis (Figure 1*d*) firmly, but not inflexibly, fused to sternum, subrectangular in outline and about 1.7 times as broad as long. Cephalic half with median trough narrow and reaching submedian fossa slightly cephalic to level of maximum width; digitiform tongue arched caudosinistrally; sinus in form of tilted reversed S, its caudal extremity situated on midline of caudal wall. Postannular sclerite approximately 3 times as broad as long, about three-fourths width of annulus, and approximately two-fifths as long. First pleopod extending cephalically to midlength of annulus when abdomen flexed.

**SYNTYPIC MALE, FORM II.**—Differing from male, form I, in following respects: areola with punctations more sparsely distributed, 5 across narrowest part; antenna reaching tergum of fifth abdominal segment; palm of chela less inflated, ratio of depth to width 0.69; mesial surface of palm with 5 tubercles in ventralmost row, 7 in middle, and 6 in dorsal (left chela with 4, 7, and 5, respectively); fingers not conspicuously gaping; hook on ischium of third pereiopod greatly reduced. (See Table 1.)

First pleopod (Figure 1*c,e*) reaching coxa of second pereiopod, conspicuously less deeply cleft than in first form male, terminal elements shorter and more robust, and central projection less acute.

**COLOR NOTES.**—Based on specimen from a tributary to Cox Creek, Lauderdale County, Alabama. Basic coloration pale olive with brownish-olive and white to cream-olive markings. Dorsal part of cephalic region of carapace olive mottled with cream near apex of rostrum and with irregular brownish spots on most of rostrum and anterior gastric area; large oblique dark brown spots

TABLE 1.—Measurements (in mm) of *Orconectes alabamensis* (Faxon)

Characters	<i>Syntypic male Form I</i>	<i>Syntypic female</i>	<i>Syntypic male Form II</i>
Carapace			
Total length	23.5	26.1	19.4
Postorbital length	18.3	19.9	14.5
Height	10.2	11.1	9.1
Width	11.6	12.8	9.7
Areola			
Width	1.6	1.4	1.5
Length	7.0	6.9	5.3
Rostrum			
Width	3.9	4.4	3.3
Length	6.0	7.6	5.5
Chela			
Length of mesial margin of palm	6.5	5.5	3.6
Width of palm	7.9	6.5	4.2
Depth of palm	5.5	4.3	2.9
Length of lateral margin	18.5	15.8	11.5
Length of dactyl	11.0	9.4	6.9
Abdomen			
Width	10.9	12.9	8.6
Length	28.0	30.4	22.1

overlying origins of mandibular adductor muscles joined by narrow posteromedian band; paired green markings flanking cephalic side of cervical groove largely separated from those over mandibular adductor muscles by 3 cream spots, paired elongate ones situated cephalolateral to caudomedian one. Postorbital ridges mostly pale olive but with brownish margins matching those on rostrum. Lateral surface of cephalic region progressively paler ventrally, olive with irregular olive-tan markings, cephaloventral area cream to white. Thoracic section of carapace with conspicuous pair of large irregular splotches disposed subparallel to cervical groove and smaller pair abutting caudal margin of carapace, neither invading areola, latter pale olive with small brownish-olive splotches; lateral part of branchiostegites not covered by large splotches, fading ventrally to cream or white, and splotches becoming paler and more diffuse, disappearing along ventral margin. Abdominal terga pale olive mottled with darker olive and bearing paired brownish-olive splotches which viewed together constituting pair

of dorsolateral longitudinal stripes (splotches on anterior terga large but decreasing in size on more posterior ones, those on sixth very narrow and extending laterally, abutting proximal podomere of uropod). Row of brownish splotches present along bases of pleura. Telson olive with dark triangle anteriorly and with pair of dark spots at base of caudal section. Lateral borders of rami of uropods brownish but otherwise mostly pale olive mottled with small darker spots. Antennular and antennal peduncles pale olive mottled in cream and brownish splotches. Antennal scale with lateral thickened areas cream to white, lateral margin brown, and dorsal surface of lamellar area pale, mottled with brownish olive. Chelipeds olive mustard mottled with pale brown from mid-length of merus to orange tips of fingers; more proximally, cream to white. Remaining pereopods mostly olive cream mottled with darker olive spots and splotches.

TYPE-LOCALITY.—Second Creek, Waterloo, Lauderdale County, Alabama.

TYPES.—Syntypes: National Museum of Nat-

ural History, Smithsonian Institution, 4876 (14♂I, 16♀, 4♂II); Museum of Comparative Zoology, 3565 (2♂I, 2♀, 2♂II).

**RANGE AND SPECIMENS EXAMINED.**—We have examined 443 specimens from northern tributaries of the Tennessee River from Shoal Creek in Lawrence County, Tennessee, and Lauderdale County, Alabama, westward through the latter and Wayne County, Tennessee, to the north-flowing segment of the river in Hardin County, Tennessee. This crayfish occurs on both sides of the divide between Cypress Creek and the Buffalo River in Wayne County, and is present in several localities in the headwaters of the latter stream. It appears that the species is restricted to the Fort Payne chert formation which occurs on the north side of the Tennessee River.

**VARIATIONS.**—Perhaps correlated with the comparatively small range of this crayfish, no clinal or locally restricted variations seem to exist. Whereas the rostrum always bears a median carina, the margins may vary from subparallel to rather strongly convergent, and the marginal spines may be long and acute, short and rounded, or represented by very small tubercles. Likewise, there is considerable difference in the development of the cervical spines; nevertheless, in no specimens examined by us could they be termed vestigial. For ranges of variations in proportions, see "Diagnosis." The first pleopod of a single male from Buffler Spring in Lauderdale County, Alabama (Figure 2a) is markedly aberrant. (See last paragraph of "Variations" under *Orconectes validus*.)

**SIZE.**—The largest specimen available is a female from the Cypress Creek watershed in Lauderdale County, Alabama, possessing a carapace length of just under 35 (postorbital carapace length 27.1) mm. The corresponding lengths of the smallest first form male (a syntype) are 14.6 (11.3) mm; those of the largest male (Cypress Creek) are 33.0 (25.3) mm.

On the basis of collections at hand, some of the members of the species occurring in tributaries of Cypress Creek (Lauderdale County, Alabama, and Wayne County, Tennessee) attain a greater carapace length (often more than 30 mm) than

do those from Second Creek and adjacent tributaries to the Tennessee River (usually less than 25 mm).

**LIFE HISTORY NOTES.**—First form males were collected from October to April, and ovigerous females were found in February, March, and May. Of approximately 80 adult males collected from May to July, none was in the first form. No collections are available that were made in August or September. In October, of the 16 adult males, two were in the breeding form. Data on the ovigerous females are as follows:

Carapace length and (postorbital carapace length) (in mm)	Number of eggs	Diameter of eggs (in mm)
28.3 (21.4)	151	2.0-2.1
26.2 (19.7)	89	1.5-1.7
22.1 (17.1)	40	1.5-1.6
21.1 (16.4)	154	1.6-1.8
17.1 (13.2)	60	1.6-1.7

**ECOLOGICAL NOTES.**—Second Creek, the type-locality, at a road that joins County Roads 1 and 14, approximately 3 air miles (4.8 km) northeast of Waterloo (T 1S, R 14W, Sec 20), is a clear, swiftly flowing stream with a rock littered bed, in some areas so swift as to be difficult to maintain a foothold. In such areas, *Orconectes alabamensis* was found along the lee sides of curves in littoral areas where leaves and debris had accumulated. In two other localities in Lauderdale County, Alabama, this crayfish was found in dense mats of vegetation in spring runs.

In one locality on Buffalo Creek, Wayne County, Tennessee, the clear stream, some two to three meters wide and as much as 50 centimeters deep, flowed over bedrock with interspersed pools containing tree litter and a few rocks. There, all except one of the known crayfish associates, *Cambarus (Hiaticambarus)* sp., were collected with *Orconectes alabamensis* in the pools.

**RELATIONSHIPS.**—See "Relationships" under *Orconectes cooperi*.

**CRAYFISH ASSOCIATES.**—*Cambarus (Depressicambarus) striatus* Hay (1902:437), *Cambarus (Hiaticambarus)* sp., *Orconectes compressus* (Faxon, 1884:127), *O. forceps* (Faxon, 1884:133), and *O. spinosus* (Bundy, 1877:173).

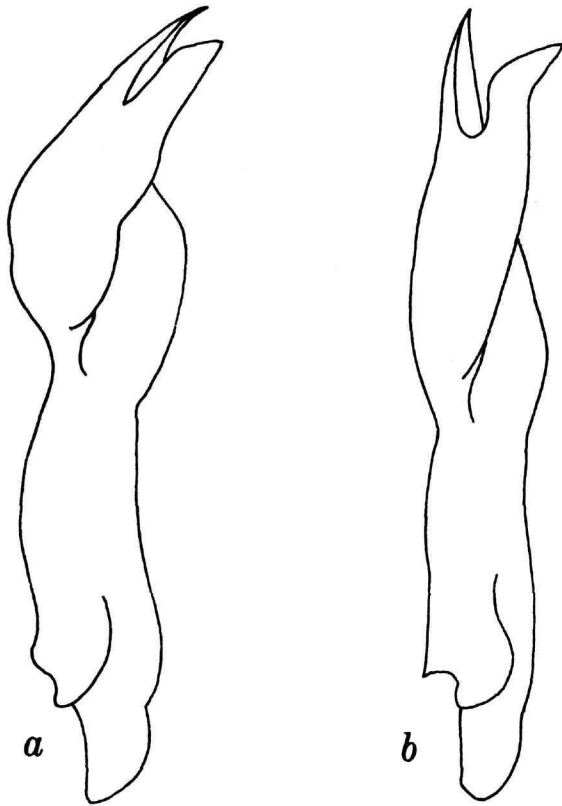


FIGURE 2.—Mesial view of atavistic (?) first pleopods of ♂I: *a*, *Orconectes alabamensis* from Buffler Spring on Mars Hill Road, 1.5 mi (2.3 km) NE of Coxes Creek Parkway, Florence, Lauderdale County, Alabama; *b*, *Orconectes validus* from a tributary to Brown's Creek, 2.5 mi (4 km) E of Arab on St Rte 69, Marshall County, Alabama.

### *Orconectes validus* (Faxon)

FIGURES 2b, 3-6

*Cambarus immunis*.—Hagen, 1870:73 [in part].

*Cambarus validus* Faxon, 1914:382, 383 [in part], 421, pl. VII: figs. 4, 8; pl. XIII: fig. 1.—Ortmann, 1931:91, 93, 94 [in part].—Hobbs, 1949:19.—Bouchard, 1976a:582.

*Faxonius validus*.—Creaser, 1933a:3 [by implication]; 1962:2 [by implication].

*Faxonius (Faxonius) validus*.—Creaser, 1933b:21 [by implication].

*Orconectes validus*.—Hobbs, 1942a:352 [by implication]; 1949: 23; 1968:K14, K32, fig. 31f; 1972:90, 149, fig. 72b; 1974: 42, fig. 168.—Bouchard, 1976a:563, 574, 576, 582; 1976b: 14.—Bouchard and Bouchard, 1976:466, 467, fig. 2c, d.— Fitzpatrick, 1976:56.

*Orconectes (Orconectes) validus*.—Hobbs, 1942b:154 [by implication]; 1959:895.

**DIAGNOSIS.**—Body and eyes with pigment. Rostrum lacking carina, usually with marginal tubercles, occasionally with distinct spines, and infrequently tapering to apex without distinct angle at base of acumen. Areola obliterated (along part of length) to 7.4 times as long as wide and comprising 26.5 to 34.2 percent of entire length of carapace (36.3 to 43.9 percent of postorbital carapace length), with 0 to 2 punctations across narrowest part. Cervical spine present, sometimes reduced to tubercle. Suborbital angle obsolete. Postorbital ridge well developed, with or without small apical tubercle. Antennal scale approximately 2.5 times as long as broad, widest at or slightly distal to midlength. Chela with palm inflated, bearing mesial row of about 8 subsquamous tubercles, and with irregular rows of tubercles subtending it; fingers gaping; fixed finger with proximal half of opposable margin studded with dense tufts of plumose setae. Hook on ischium of third pereopod. First pleopod of first form male without angular shoulder on cephalic surface, with distal three-fifths inclined caudally; terminal elements curved throughout and usually reaching base of second pereopod when abdomen flexed; pleopod length divisible into carapace length 2.6 to 3.6 (average 3.2) times; terminal elements slender and subparallel: central projection, constituting 26.7 to 38.6 percent of total mesial length of appendage, bladeliike, tapering from base and not extending so far caudally as mesial process; mesial process expanded distally and with shallow groove extending from near midlength of cephalic surface to caudally directed tip of process. Annulus ventralis as figured. First pleopod of female extending cephalically to midlength of annulus when abdomen flexed.

**TOPOTYPIC MALE, FORM I.**—Body and eyes pigmented. Cephalothorax (Figure 3a, *i*) subcylindrical in section; abdomen narrower than carapace (15.4 and 18.5 mm), width of latter greater than depth at caudodorsal margin of cervical groove (18.5 and 14.7 mm). Areola narrow, 27.8 times as long as wide with single punctation in

narrowest part. Length of areola 31.8 percent of entire length of carapace (41.1 percent of postorbital carapace length). Rostrum with slightly thickened, elevated borders converging to base of acumen, and bearing corneous marginal tubercles; acumen reaching slightly beyond midlength of ultimate podomere of antennular peduncle and terminating in corneous, acute, upturned tip; upper surface concave and punctate. Subrostral ridge weakly developed and evident in dorsal aspect only in caudalmost portion. Postorbital ridge strong, grooved laterally, and with subacute, corneous apical tubercle. Suborbital angle virtually obsolete. Cervical spine moderately heavy, short (left member bispinous), and only slightly larger than branchiostegal spine. Carapace punctate dorsally, punctations crowded and rather deep in cephalic gastric region; strongly granulate laterally except immediately ventral to cervical spines and near caudal extremity. Abdomen and carapace subequal in length (35.2 and 34.9 mm). Pleura of moderate length, rounded ventrally. Cephalic section of telson with 2 spines in each caudolateral corner. Proximal podomere of uropod with short, corneous spine on each lobe; mesial ramus with moderately well-developed dorsomedian keel terminating in small premarginal spine.

Cephalic lobe of epistome (Figure 3g) distinctly broader than long with weak cephalomedian prominence and with cephalolateral borders undulating; main body of epistome with distinct fovea situated at cephalic end of median groove; epistomal zygoma broadly arched. Basal segment of antennule with dense band of long plumose setae on mesial surface partially obscuring ventral spine located near midlength. Antennal peduncle with spine on lateral surface of basis and minute one on ischium. Antenna broken, but in other specimens reaching slightly beyond midlength of abdomen. Antennal scale (Figure 3l) about 2.4 times as long as broad, greatest width approximately at midlength; thickened lateral area with apical spine reaching level of tip of rostrum. Third maxilliped with almost entire ventral surface of ischium and peduncle of exopodite bearing dense mat of plumose setae.

Chela (Figure 3j) about 2.3 times as long as wide; palm inflated, its mesial margin with mesial row of 8 tubercles, subtended dorsally and ventrally by irregular rows of 8 and 6, respectively; remainder of palm punctate except for prominent tubercle ventrally opposite base of dactyl; lateral margin of chela subcostate almost from base to near midlength of finger, costa rounded laterally and polished. Fixed finger strongly arched laterally with opposable surface bearing, among setae, row of 11 tubercles along proximal three-fourths, fifth from base largest and all knoblike; large tubercle at lower level between ninth and tenth tubercles from base; minute denticles extending distally from between seventh and eighth tubercles to corneous tip of finger; tubercles along proximal half of finger flanked by conspicuous tufts of plumose setae; dorsal and ventral surfaces of finger with broad, low submedian ridge flanked by setiferous punctations; secondary ridge present between median ridge and setal tufts. Dactyl with opposable margin concave basally and bearing row of 11 tubercles decreasing in size distally and extending along basal three-fourths of finger; minute denticles extending from fifth tubercle from base to corneous tip of finger interrupted by more distal tubercles; dorsal and ventral surfaces of finger with low submedian longitudinal ridge flanked by setiferous punctations; secondary ridge situated between submedian ridge and opposable margin; mesial surface of dactyl tuberculate in proximal three-fourths and punctate distally.

Carpus 1.6 times as long as broad with deep oblique furrow on upper surface; mesial surface bearing prominent spine near midlength and 2 tubercles proximally; dorsal distomesial margin with low tubercle; ventrodorsal margin with submedian corneous-tipped tubercle and another on ventrolateral condyle; ventromesial surface with 2 rounded tubercles.

Merus with 2 subdistal spines dorsally; mesial and lateral surfaces punctate; ventral surface with lateral row of 6 tubercles (third and sixth from base spikelike) and mesial row of 11, none of which spikelike; also lateral extremity with spine. Ischium with row of 3 small tubercles, proximalmost largest.

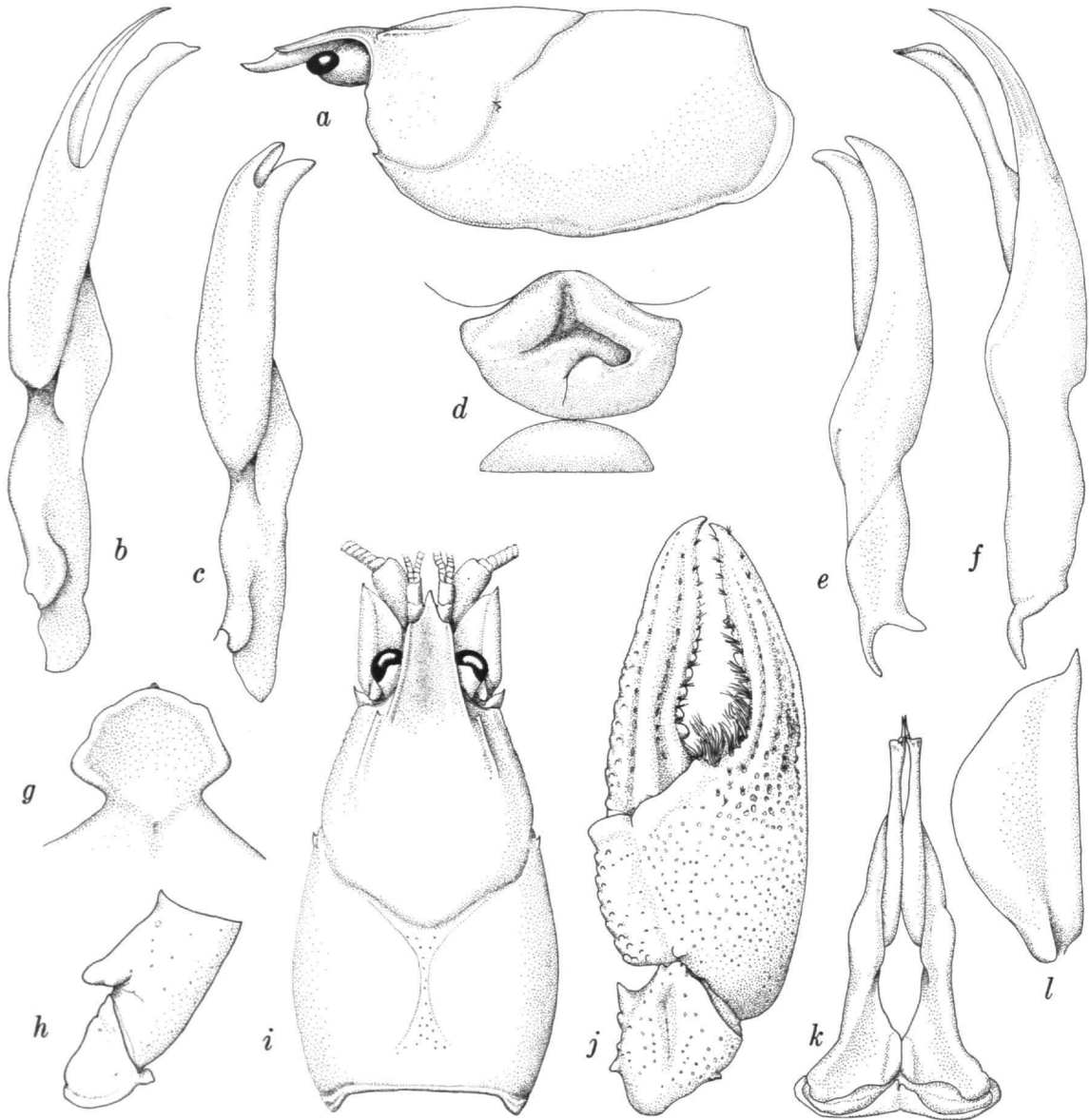


FIGURE 3.—*Orconectes validus* (topotypes, all from ♂I except *c*, *e* from ♂II, and *d* from ♀): *a*, lateral view of carapace; *b*, *c*, mesial view of first pleopod; *d*, annulus ventralis; *e*, *f*, lateral view of first pleopod; *g*, epistome; *h*, basis and ischium of third pereiopod; *i*, dorsal view of carapace; *j*, dorsal view of distal podomeres of cheliped; *k*, caudal view of first pleopods; *l*, antennal scale.



Mesial surface of carpus and propodus of second pereiopod not densely setose.

Ischium of third pereiopod with simple hook extending proximally over distal extremity of basis; hook not opposed by tubercle on basis.

First pleopods (Figures 3*b,f,k*) symmetrical, extending cephalically to second pereiopod when abdomen flexed. (See "Diagnosis" for description.)

**TOPOTYPIC FEMALE.**—Differing from male, form I, in following respects: abdomen and cephalothorax subequal in width (14.9 and 14.8 mm); areola only moderately narrow, 13.9 times as long as wide; marginal tubercles of rostrum minute; acumen reaching level of distal end of antennular peduncle; length of chela only 71 percent that of carapace, with inflation of palm and curvature of fixed finger less pronounced; mesial margin of palm with mesial row of 9 tubercles subtended by irregular rows of 6 dorsally and 4 ventrally; fixed finger with 7 tubercles along proximal half of opposable margin, large one at lower level slightly distal to midlength,

and denticles beginning at midlength and extending almost to tip of finger; opposable margin of dactyl with 8 tubercles along proximal three-fifths; ridges on dorsal and ventral surfaces of fingers slightly stronger than in male; mesial surface of carpus with additional 3 small tubercles dorsal to those present on male. (See Table 2.)

Annulus ventralis (Figure 3*d*) moderately deeply embedded in sternum, firmly fused with latter cephalically; cephalic portion with antero-median trough flaring between and beneath oblique cephalolateral walls; digitiform tongue present, and wall of annulus caudal to tip of tongue strongly elevated and thickened; sinus originating under cephalosinistral wall slightly cephalic to midlength, following contour of tilted, reversed S, and ending on caudomedian wall of annulus. Postannular plate approximately 3 times as broad as long and about three-fourths width of annulus. First pleopod extending cephalically slightly beyond midlength of annulus when abdomen flexed.

**TOPOTYPIC MALE, FORM II.**—Differing from

TABLE 2.—Measurements (in mm) of *Orconectes validus* (Faxon)

Characters	Topotypic male Form I	Topotypic female	Topotypic male Form II
Carapace			
Total length	34.9	30.0	30.4
Postorbital length	27.0	22.9	23.1
Width	14.8	12.8	12.5
Height	18.7	14.8	15.2
Areola			
Width	0.4	0.7	0.6
Length	11.1	9.7	9.7
Rostrum			
Width	5.5	4.6	4.9
Length	9.6	7.9	8.2
Chela			
Length of mesial margin of palm	10.0	7.1	6.5
Width of palm	14.2	8.6	9.5
Depth of palm	8.3	5.5	6.0
Length of lateral margin	32.7	21.4	23.4
Length of dactyl	21.4	12.5	15.0
Abdomen			
Width	15.3	15.1	13.5
Length	36.1	32.4	31.3

male, form I, in following respects: cephalic lobe of epistome trapezoidal with no cephalomedian projection; mesial margin of palm with mesial row of 8 tubercles, subtended by 7 dorsally and irregular row of about 4 ventrally; fixed finger with 14 tubercles along opposable margin, with 1 ventral to row; dactyl with 13 tubercles along opposable margin; hooks on ischia reduced and not overreaching distal extremity of basis. (See Table 2.)

First pleopod (Figure 3*c,e*) differing from that of first form male chiefly in decidedly shorter terminal elements, in the absence of corneous texture of central projection, in shallower cleft between elements, and in absence of groove on mesial process.

COLOR NOTES.—Based on specimens from Limestone County, Alabama. Cephalic part of carapace dark brown dorsally, fading ventrally but with irregular dark line extending caudally from level of antennal peduncle to cervical groove. Area over origins of mandibular adductor muscle with very dark brown reticulate pattern, and paired smaller, similarly dark patches along cervical groove immediately caudomesial to reticulate areas. Areola and branchiostegites mostly orange tan; dark brown saddle present caudally with horns produced cephaloventrally along ventral margin of carapace at least as far cephalically as level of cervical spine or tubercle. Basic color of abdomen dark brown; cephalic part of first abdominal tergum almost black, and caudal part as well as succeeding terga with paired dorsolateral dark brown splotches flanked laterally by 2 or 3 pale orange-tan spots at base of pleura. Telson and uropods also dark brown, cephalic section of former with pale lateral areas. Antennular and antennal peduncles mottled, flagella orange tan to brown. Chelipeds mostly orange tan with dark markings on distal half of merus; palm of chela with prominent black spot on dorsodistal condyle fading mesially along ridge flanking base of dactyl; lateral margin of propodus black, and both fingers with broad black transverse band between midlength and crimson to orange band on distal extremities; tubercles on cheliped pale orange to cream. Remaining per-

eiopods bearing brown bands on tan background.

Specimens from Hardin County, Tennessee, differing chiefly in possessing prominent dark splotches on cephalolateral parts of branchiostegites; caudal saddle on carapace not reaching ventral margin of branchiostegites; and dark oblique markings present along caudal margins of abdominal pleura. Some individuals with basic colors olive to gray, with dark gray to black markings.

TYPE-LOCALITY.—Huntsville (probably Huntsville Spring Branch within city limits), Madison County, Alabama.

TYPE.—Museum of Comparative Zoology, 301 (1♂I). Topotypes, National Museum of Natural History, Smithsonian Institution, 132651 (5♂I, 9♂II, 20♀).

RANGE AND SPECIMENS EXAMINED.—We have examined approximately 900 specimens from the Tennessee River basin in Alabama and Tennessee and from the Black Warrior River system in Alabama. In the Tennessee Basin, *Orconectes validus* ranges from the Paint Rock watershed in Jackson County, Alabama, downstream to Benton County, Tennessee. Bouchard and Bouchard (1976:467) recorded "a single female from Montgomery County, Tennessee, (Cumberland River system) [which] may also be a member of this species possibly indicating a large range." In Alabama, north of the Tennessee River, it is common in tributaries east of the Elk River, but few records of its occurrence downstream from the Elk watershed are available, and it has not been found within the range of *O. alabamensis* north of the Tennessee River (from Shoal Creek westward). South of the Tennessee River proper, our collections indicate that it is common in Lawrence County and in the Bear Creek watershed in Colbert, Franklin, and Marion counties. Perhaps because of inadequate sampling, it is known from only a few localities in Marshall, Morgan, and Colbert counties. According to Bouchard (1976a: 576), writing of the crayfishes on the Cumberland Plateau, this crayfish "occurs in the sandstone and shale areas of the Plateau but is more common in limestone streams of the Highland Rim."

In the Black Warrior Basin, it is widespread in

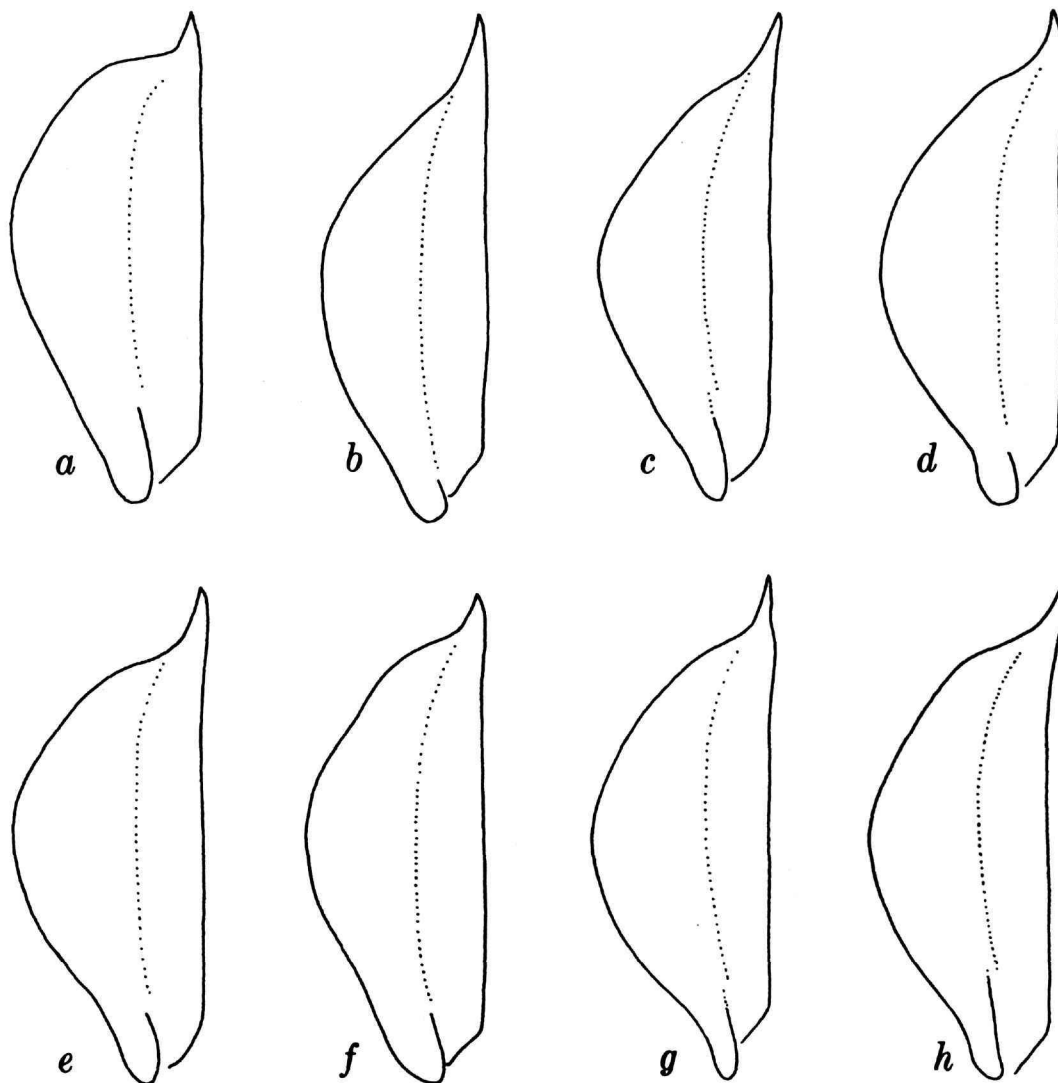


FIGURE 4.—Antennal scales of *Orconectes validus* (a–g, Tennessee Basin; h, Black Warrior Basin): a, Dry Creek, 2 mi (3.2 km) E of Monrovia, Madison County, Alabama; b, 3.6 mi (5.8 km) W of Athens, Limestone County, Alabama; c, 2.8 mi (4.5 km) NW of Brudy Lake, Lawrence County, Alabama; d, tributary to Bear Creek, 6.5 mi (10.4 km) S of Russellville on U.S. Hwy 43, Franklin County, Alabama; e, Bear Creek, 5.9 mi (9.4 km) S of Mackelberg on St Rte 5, Marion County, Alabama; f, 4.9 mi (7.8 km) N of Bath Springs at junction of St Rtes 69 and 114, Decatur County, Tennessee; g, Cypress Creek in Camden, Benton County, Tennessee; h, 15.7 mi (25.1 km) S of Double Springs on St Rte 195, Walker County, Alabama.

the Sipsy Fork and other tributaries of the lower Mulberry Fork in Winston and Walker counties. It occurs commonly in tributaries of the Locust Fork in Jefferson County and in those of the North River in Fayette County.

**VARIATIONS.**—On the basis of our specimens in the Black Warrior Basin this crayfish matures at a smaller size (carapace length less than 20 mm) but does not attain a carapace length as great as do those populations in the Tennessee drainage system (carapace length often greater than 30 mm). The relative degree of development of the marginal spines on the rostrum and cervical spines is quite variable: although in most populations the smaller individuals have more acute spines than do the larger ones, in some localities the spination, even in the adults, is markedly stronger than in individuals of comparable sizes in other populations. In some larger specimens, the spines on the rostrum are reduced to tubercles and the cervical spines are exceedingly small.

Occasional individuals have a low median carina on the rostrum, and the antennal scale is by no means uniform in outline (Figure 4).

In considering variations in the areolar width, the following arbitrary values have been used: obliterated (Figure 5*a,d*); narrow, more than 12 times as long as broad (Figure 5*e*); and wide, 12 or less times as long as broad (Figure 5 *b,c,f*). While there is some variation in the relative width among individuals frequenting a single stream, greater differences occur between those occupying different streams. Within the range of the species, however, the extremes of variation are irregularly dispersed. In general, within the Tennessee Basin the areolae are narrow, except in two streams in Limestone County (Limestone and Round Island creeks) where they are obliterated, and in the following in which they are wide: tributaries to Bear Creek (Franklin and Marion counties), Wheeler Spring (Limestone County), some individuals in tributaries of the Flint River (Madison County), and most in Indian and Dry creeks (Madison County). In contrast, most of the material we have examined from the Black Warrior Basin possesses a wide areola; however, in several tributaries of Mulberry Fork, in the vicinity of

the Walker-Winston county line, the individuals are distinct from those elsewhere in the watershed in possessing an obliterated areola.

In comparing the length of the areola to that of the total length of the carapace, in the Tennessee Basin it constitutes 28.0 to 34.2 (average 30.9) percent for 112 specimens; in the Black Warrior, the corresponding range is 26.5 to 32.2 (average 29.7) percent for 48 specimens.

The ventral surface of the third maxilliped of specimens from the Bear Creek watershed (Tennessee Basin) in Franklin and Marion counties, Alabama, is not nearly so setose as that in specimens from other localities; the plumose setae on the lateral half of the ischium and on the merus are much shorter and far less conspicuous than in specimens from elsewhere in the range. In crayfish from the Black Warrior Basin, these plumose setae are more conspicuous than are those in the Bear Creek specimens, but the setae on the distal part of the lateral half of the ventral surface of the ischium are not nearly so long as those in specimens from elsewhere in the Tennessee Basin.

In collections from the North River watershed in the Black Warrior Basin, the fingers of the chela (Figure 6*a*) are proportionately longer than in most specimens from other localities. Variations in configuration and setation of the chela in several populations are illustrated in Figure 6.

The ratio of the length of the central projection of the first pleopod to the mesial length of the latter varies from 26.7 to 38.6 (average 31.3) percent (Figure 5*g-m*). In the Tennessee Basin, the ratio ranges from 26.7 to 36.5 percent. In the Bear Creek watershed of this basin two specimens exhibit ratios of 32.5 and 36.5 (the latter occurring in the only specimen available from that watershed with a ratio greater than 35.4 percent). In the Black Warrior Basin the ratio varies from 30.5 to 38.6 (average 34.4) percent.

A single first form male from the Tennessee Basin (small creek near Arab, Marshall County) bears a first pleopod with extremely short terminal elements (Figure 2*b*) unlike those in any known species. Repeated attempts by both of us independently to collect additional specimens have produced no more *Orconectes* from the same

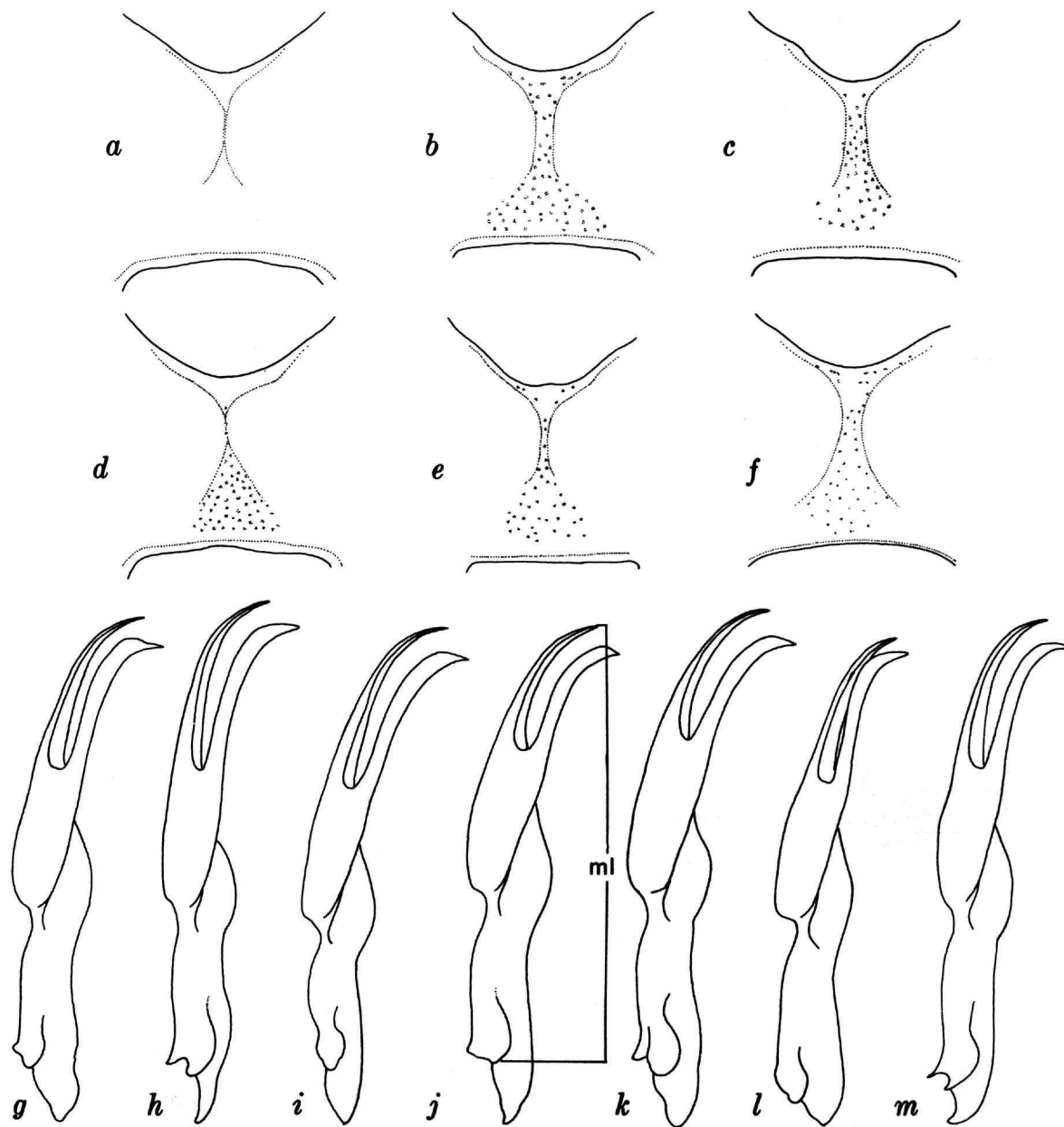


FIGURE 5.—*Orconectes validus* (*a-f*, areolae; *g-m*, mesial view of left first pleopod of  $\delta I$ ; *a-c*, *g-i* from Black Warrior Basin; *d-f*, *j-m* from Tennessee Basin): *a*, Cane Creek, Walker County, Alabama; *b*, tributary to Mud Creek, Jefferson County, Alabama; *c*, tributary to Sipsey Fork, Winston County, Alabama; *d*, tributary to Round Island Creek, Limestone County, Alabama; *e*, Cave Spring Cave, Morgan County, Alabama; *f*, The Dismals, Franklin County, Alabama; *g*, same as *b*; *h*, North River, Fayette County, Alabama; *i*, same as *a*; *j*, Cypress Creek, Benton County, Tennessee (ml = mesial length); *k*, Fox Creek, Lawrence County, Alabama; *l*, same as *d*; *m*, same as *f*.

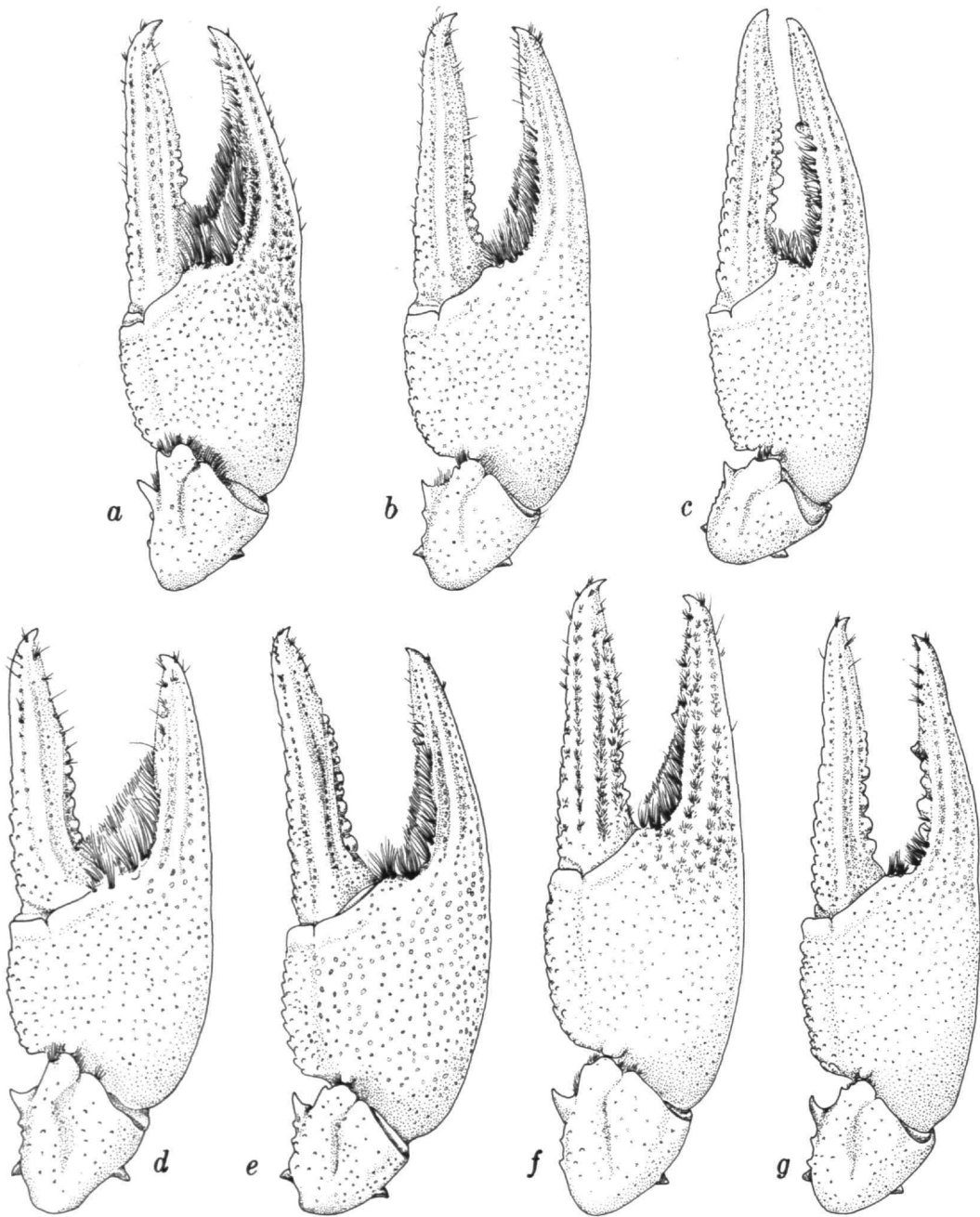


FIGURE 6.—Chelae of ♂ *Orconectes validus* (*a-c*, Black Warrior Basin; *d-g*, Tennessee Basin): *a*, North River, Fayette County, Alabama; *b*, tributary to Mud Creek, Jefferson County, Alabama; *c*, Cane Creek, Walker County, Alabama; *d*, Fox Creek, Lawrence County, Alabama; *e*, Cypress Creek, Benton County, Tennessee; *f*, The Dismals, Franklin County, Alabama; *g*, Bear Creek, Franklin County, Alabama.

locality. Since the animal in all other respects appears to be more similar to *O. validus* than to any other species, and in view of the similar abnormally short pleopod found in a single specimen among a large series of the closely related *O. alabamensis* (Figure 2a), we tentatively assign this specimen to *O. validus*, assuming a possible atavistic trait in its first pleopod.

**SIZE.**—The largest specimen available, a topotypic female, possesses a carapace length of 40.6 (postorbital carapace length 31.7) mm. The corresponding lengths of the smallest first form male are 18.8 (13.9) mm, and those of the largest, 38.6 (29.4) mm. The ranges of the corresponding lengths of the ovigerous females are 29.6 (22.0) to 19.5 (14.8) mm.

**LIFE HISTORY NOTES.**—First form males have been obtained during every month of the year except January and December, months during which none and only two adult specimens, respectively, have been collected. Fifteen ovigerous females and a single female carrying young were found in April. Data on 12 of the ovigerous females are as follows:

Carapace length and (postorbital carapace length) (in mm)	Number of eggs	Diameter of eggs (in mm)
29.2 (21.7)	158	2.0–2.1
28.4 (20.9)	183	1.8–1.9
28.4 (21.8)	180*	1.8–1.9
26.9 (20.7)	139*	1.8–1.9
26.8 (19.9)	69	1.9–2.0
25.8 (19.3)	128	1.9–2.0
25.4 (19.8)	206*	1.8–1.9
25.3 (19.6)	132*	1.8–1.9
24.5 (18.5)	179*	1.8–1.9
23.8 (18.4)	146*	1.8–1.9
21.2 (15.7)	100*	1.5–1.6
19.3 (14.8)	62*	1.6–1.7

\* These specimens were preserved in a single container in which an additional 49 eggs, lost by one or more of the specimens, were found on the bottom of the jar.

**ECOLOGICAL NOTES.**—Bouchard (1976a:582) noted that *Orconectes validus* occurs in “springs and small to medium sized streams under rocks, in leaf litter and in concentrations of aquatic vascular plants.” Most of the collections examined by us have come from temporary and permanent streams with a rock-littered substrate. During dry

spells, some of the streams cease to flow, and the stream bed becomes dry except for occasional pools. In one stream bed in Madison County, there was no water on 23 September 1968, but a series of specimens was taken from beneath rocks. In a stream 4.9 miles (7.8 km) west of Athens on U.S. Highway 72, the turbid water flows with a sluggish current over bedrock, gravel, and sand with few rocks in the stream bed. There this crayfish was collected among vegetation and from roots and debris along undercut banks of the stream.

**RELATIONSHIPS.**—See “Relationships” under *Orconectes cooperi*.

**CRAYFISH ASSOCIATES.**—Collected with *Orconectes validus* in one or more localities were the following: *Cambarus* (*Depressicambarus*) *obstipus* Hall (1959:221), *C. (D.) striatus*, *Cambarus* (*Hiaticambarus*) sp., *C. (Lacunicambarus) diogenes* subsp., *Falliacambarus* (*Creaserinus*) sp., *Orconectes compressus*, *O. cooperi*, new species described herein, *O. erichsonianus*, *O. etnieri*, *O. forceps*, *O. mirus* (Ortmann, 1931: 81), *O. perfectus* Walls (1972:451), *O. spinosus*, and *Procambarus* (*Ortmannicus*) *acutus acutus* (Girard, 1852:91).

### *Orconectes cooperi*, new species

FIGURE 7

**DIAGNOSIS.**—Body and eyes with pigment. Rostrum with or without median carina, acumen delimited basally by marginal spines or tubercles. Areola 4 to 6 times as long as wide and comprising 25.3 to 29.9 percent of total length of carapace (35.4 to 41.5 percent of postorbital carapace length). Cervical spine small; suborbital angle very weak to obsolete; postorbital ridges moderately well developed with small corneous tubercle cephalically. Antennal scale approximately 2.7 times as long as wide, broadest at about mid-length. Chela of adult males conspicuously inflated, not costate laterally; tubercles on mesial margin of palm small and strongly depressed; fingers gaping and conspicuous tuft of setae present along opposable basal part of fixed finger;

opposable margin of dactyl not excised in basal third. Hook on ischium of third pereopod of male. First pleopod of first form male (divisible into carapace length 2.9 to 3.2 times) reaching at least midlength of coxa of second pereopod when abdomen flexed, without angular shoulder on cephalic surface; terminal elements subparallel and gently recurved along distal fifth; central projection constituting 35 to 38 percent of entire length of pleopod, blade-like and tapering from base to caudodistally directed apex; mesial process subcylindrical in section proximally, trough-like distally, its tip directed caudodistally not extending so far distad as central projection. Annulus ventralis as figured. First pleopod present in female.

**HOLOTYPE MALE, FORM I.**—Body and eyes pigmented. Cephalothorax (Figure 7*a,i*) subovate in section; abdomen narrower than carapace (15.6 and 13.3 mm), width of latter greater than depth at caudodorsal margin of cervical groove (15.6 and 14.8 mm). Areola moderately broad, 7.7 times as long as wide with 4 or 5 punctations across narrowest part; length of areola 28.9 percent of entire length of carapace (38.6 percent of postorbital length). Rostrum with margins little thickened, elevated, and bearing small marginal tubercles at base of acumen, latter reaching slightly beyond distal end of antennular peduncle; upper surface irregular with low median elevation distally and almost entirely punctate. Subrostral ridge weak, disappearing completely in dorsal aspect before reaching midlength of rostrum. Postorbital ridge rather heavy with short dorsolateral groove and terminating cephalically in small, acute, corneous tubercle. Suborbital angle almost obsolete, delimited ventrally by shallow, broad, rounded notch. Cervical spine very small and acute. Carapace densely punctate dorsally and laterally, punctations deep and moderately large, and granulate ventrolaterally. Abdomen longer than carapace (33.5 and 31.8 mm); pleura well developed, subtruncate ventrally and subangular caudoventrally; cephalic section of telson with 2 spines in each caudolateral corner. Proximal podomere of uropod with spine on each lobe, that on lateral lobe very small, both rami of

uropod with median keel ending in spine, that on mesial ramus premarginal.

Cephalic lobe of epistome (Figure 7*g*) with weak cephalomedian projection and irregular cephalolateral margins, latter elevated (ventrally), ventral surface with scattered setae; main body of epistome, set off from cephalic lobe by distinctly narrow base of latter, bearing deep cephalomedian fovea; epistomal zygoma broadly arched. Proximal segment of antennule provided with large spine near midlength, spine partly concealed by plumose setae extending from ventromesial margin of podomere. Antennal peduncle with small spines on basis and ischium, flagellum reaching tergum of fourth abdominal segment. Antennal scale (Figure 7*i,l*, latter from allotype) approximately 2.6 times as long as wide, broadest at midlength; thickened lateral area with apical spine reaching slightly beyond distal end of antennular peduncle. Ventral surface of ischium of third maxilliped with thick submarginal lateral row of long plumose setae, and surface between row and median ridge with several thick tufts proximally and scattered shorter ones distally, mesial half studded with dense mat of very long plumose and stiff hairlike setae; distolateral extremity of ischium with distinct corneous spine.

Right chela shorter than carapace (28.4 and 31.8 mm) (Figure 7*j*), about 2.2 times as long as wide with palm conspicuously inflated (ratio of depth to width 0.71), thickness subequal to length of areola and only slightly less than length of mesial margin of palm; latter with row of 7 very small squamous tubercles extending along proximal three-fourths, tubercles replaced distally by 2 conspicuous punctations; proximal part of row of tubercles flanked dorsolaterally by few additional smaller tubercles, palm otherwise punctate. (Left chela with tubercle on ventral surface opposite base of dactyl.) Fingers gaping, with low submedian longitudinal ridges dorsally and ventrally; fixed finger with conspicuous mat of plumose setae at base and along proximal half of ventromesial surface of finger; opposable margin with row of 6 low, rounded corneous tubercles along basal three-fifths, and large one on lower



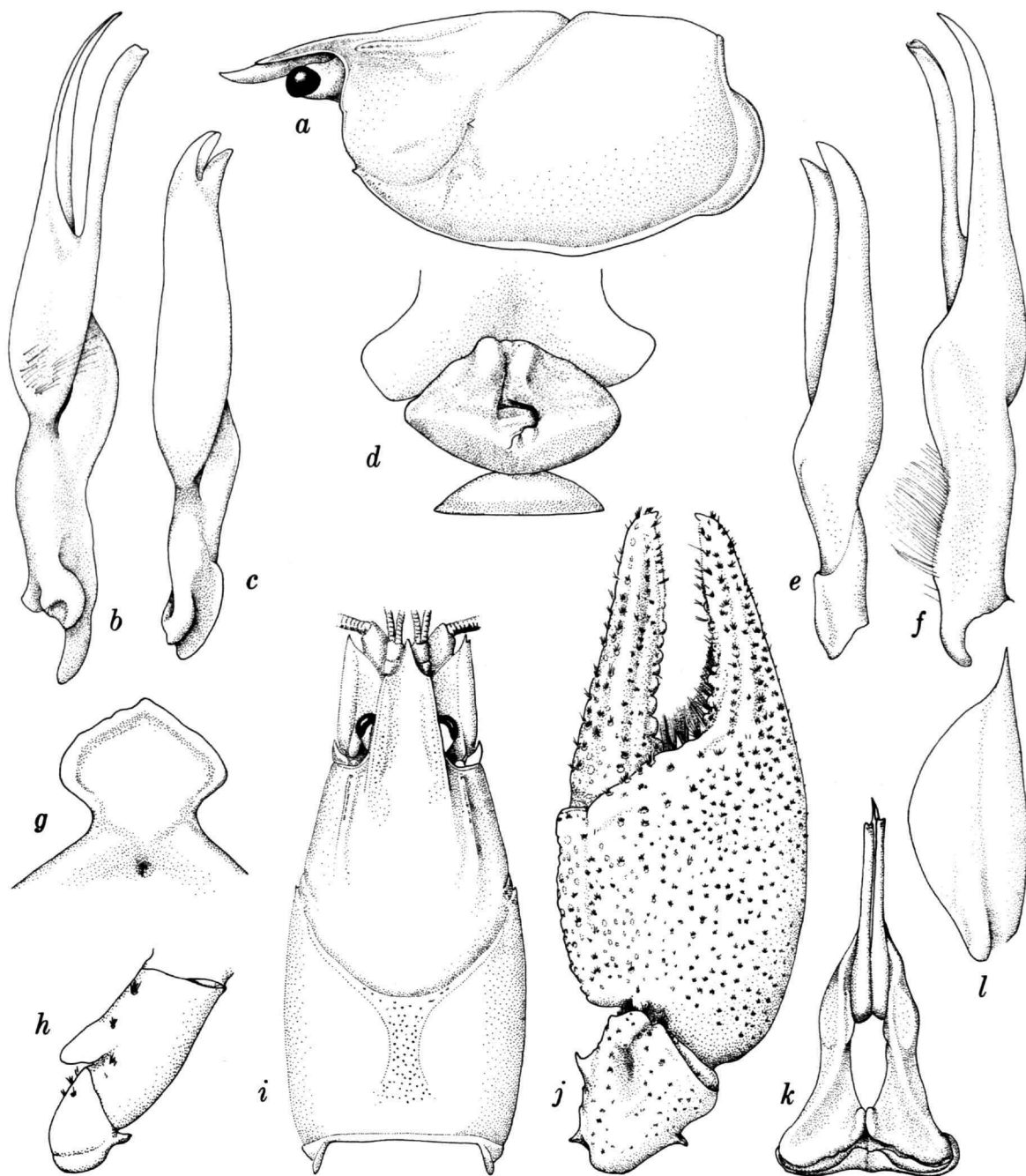


FIGURE 7.—*Orconectes cooperi* (all from holotypic male, form I, except *c*, *e*, from morphotypic male, form II, and *d*, *l*, from allotype): *a*, lateral view of carapace; *b*, *c*, mesial view of first pleopod; *d*, annulus ventralis; *e*, *f*, lateral view of first pleopod; *g*, epistome; *h*, basis and ischium of third pereiopod; *i*, dorsal view of carapace; *j*, dorsal view of distal podomeres of cheliped; *k*, caudal view of first pleopods; *l*, antennal scale.

level at base of distal third; band, very broad distally, of minute denticles extending almost entire length of finger interrupted by members of tubercle row. Opposable margin of dactyl not excised, with row of 9 tubercles similar to those of fixed finger; band of minute denticles extending distally from seventh tubercle and few situated between more proximal tubercles; mesial surface of dactyl punctate, lacking tubercles.

Carpus 1.4 times as long as broad, with oblique dorsomedian furrow; mesial surface with prominent spiniform tubercle flanked proximally by 3 smaller rounded ones; dorsal distomesial angle with small tubercle; ventral surface with scattered punctations and single submarginal tubercle on distal end of articular condyle. Merus with 2 subdistal tubercles dorsally and 1 on ventral distolateral extremity, ventral surface with mesial row of 10 or 11 tubercles and single prominent one as remnant of ventrolateral row; few additional tubercles situated immediately lateral to mesial row; podomere otherwise punctate. Ventromesial margin of ischium with single tubercle.

Ischium of third pereopod (Figure 7*h*) with

simple hook overreaching basioischial articulation, not opposed by tubercle on basis.

First pleopods (Figure 7*b,f,k*) symmetrical and extending cephalically to second pereopod. (See "Diagnosis" for description.)

**ALLOTYPIC FEMALE.**—Differing from holotype in following respects: abdomen and carapace subequal in width; suborbital angle essentially obsolete; carapace lacking granules except for few in ventral hepatic region and cephaloventral area of branchiostegite; cephalic section of telson with mesial spine in each caudolateral corner broken; left chela (right regenerated) with palm not conspicuously inflated (ratio of depth to width 0.62); mesial margin of palm with irregular row of 9 more elevated tubercles and additional smaller ones dorsolateral to row; opposable margin of fixed finger with row of 6 tubercles, that of dactyl with 10. Spine on dorsal distomesial angle of carpus larger; ventral surface of merus with mesial row of 8 tubercles; 2 tubercles on ventromesial margin of ischium. (See Table 3.)

Annulus ventralis (Figure 7*d*) moderately deeply embedded in sternum, very slightly mov-

TABLE 3.—Measurements (in mm) of *Oreconectes cooperi*, new species

Characters	Holotype	Allotype	Morphotype
<b>Carapace</b>			
Total length	31.8	29.9	20.4
Postorbital length	23.8	22.1	15.2
Height	14.8	14.0	9.5
Width	15.6	14.5	9.5
<b>Areola</b>			
Width	1.2	1.3	1.0
Length	9.2	8.5	5.7
<b>Rostrum</b>			
Width	5.5	4.8	3.5
Length	9.3	8.8	6.0
<b>Chela</b>			
Length of mesial margin of palm	10.8	(left)6.7	4.1
Width of palm	12.7	7.3	4.3
Depth of palm	9.0	4.5	3.1
Length of lateral margin	28.4	17.6	11.7
Length of dactyl	15.4	10.1	6.6
<b>Abdomen</b>			
Width	13.3	14.1	8.2
Length	36.2	34.5	22.5

able, suboval in shape and about 1.6 times as broad as long; cephalomedian area elevated and traversed by deep submedian trough; transverse ridge immediately posterior to midlength interrupted by sinistral U-shaped sinus, and tongue extending from dextral ridge; caudal arm of sinus turning caudally on median line and ending on midcaudal wall of annulus; fossa disappearing beneath sinistral arm of transverse ridge. Postanular plate about 4.7 times as broad as long, approximately five-sixths as broad as annulus and about one-third as long. First pleopod reaching cephalic margin of annulus when abdomen flexed.

**MORPHOTYPIC MALE, FORM II.**—Differing from holotype in following respects: specimen much smaller than holotype or allotype (see Table 3); all spines and tubercles more prominent; chela proportionately smaller in relation to dimensions of carapace; opposable margin of dactyl with only 6 tubercles; merus with 2 spines representing ventrolateral row. Hook on ischium of third pereopod tuberculiform, not overreaching basioischial articulation. First pleopod (Figure 7*c,e*) with rami heavier, and cleft between them decidedly shorter.

**COLOR NOTES.**—Entire dorsum of carapace, abdomen, and chelae grayish cream with numerous black or dark brown spots varying in size from almost microscopic to following more conspicuous ones: dorsal surface of rostrum with almost symmetrically paired series of 4 spots decreasing in size and converging apically; prominent dorso-medial irregular spot in midgastric region flanked by paired, narrow, oblique splotches extending cephaloventrally onto hepatic region; conspicuous dorsomedian spot at cephalic extremity of areola followed caudally by narrow stripe extending to caudal margin of carapace; branchiostegites with paired, large, irregular oblique splotches dorsolaterally, narrowing cephalolaterally but well onto lateral surface; and caudodorsal extremity of carapace with paired broad splotches extending ventrolaterally but leaving broad light area between them. Thus, viewed laterally, carapace with 3 dark subparallel bands inclined cephaloventrally. Cervical, postor-

bital, and other prominent spines grayish cream. Abdominal segments with paired subrectangular, dorsolateral splotches (in line dorsally with paired markings on carapace) cephalically and another pair at cephalic bases of pleura; remainder of terga and pleura with irregular reticulate pattern. Telson and uropods similarly reticulate. Telson with transverse dark band at base, paired cephalolateral splotches in cephalic section, and paired spots in cephalic area of caudal section. Uropods with lateral part of lateral ramus, its distal section, and mesial part of mesial ramus darker than other parts of tail fan. Dorsum of chelipeds from midlength of merus distally with reticulate pattern broken by irregular, conspicuous large dark spots and very few pale ones. Dorsum of remaining pereopods grayish to greenish cream marked with transverse darker spots and bands. Lateral portion of antennal scale and peduncle of antennule also roughly "banded."

**TYPE-LOCALITY.**—Brier Fork of the Flint River at U.S. Highway 231-431, about 2 miles (3.2 km) north of Meridianville (T 2S, R 1E, Sec 7), Madison County, Alabama. There the stream, some seven or eight meters wide, flows with a moderate to swift current through a deciduous woods. Most of the specimens of *Orconectes cooperi* were collected from leaf litter in shallow littoral areas out of the main current. Of the 17 crayfishes collected in the leaf litter, only two (one each of *O. validus* and *O. mirus*) were not members of this species. In this locality, on 24 September 1968, the following crayfishes were obtained: 44 *Orconectes forceps* (Faxon, 1884:133), 15 *O. cooperi*, eight *O. validus*, seven *O. mirus*, three *O. erichsonianus*, and three *Cambarus (Depressicambarus) striatus*.

**DISPOSITION OF TYPES.**—The holotype, allotype, and morphotype (147722, 147723, and 147724, respectively) are deposited in the National Museum of Natural History, Smithsonian Institution, as are the following paratypes: 7♂I, 3♂II, 5♀, 4j♂, and 12j♀; 1♂I, 1♂II, and 1♀ are in the North Carolina State Museum of Natural History.

**RANGE AND SPECIMENS EXAMINED.**—Restricted to the Flint River watershed (Tennessee River

basin) in Madison County, Alabama, and Lincoln County, Tennessee.

ALABAMA: MADISON COUNTY: (1) Type-locality, 4♂I, 4♂II, 2j♂, 5j♀, 24 Sep 1968; (2) Beaver Dam Creek at U.S. Hwy 231-431, about 1 mi (1.6 km) S of Meridianville (T 2S, R 1E, Sec 30), 1♀, 2j♂, 7j♀, 24 Sep 1968; (3) West Fork of Flint River at U.S. Hwy 231, about 3 mi (4.8 km) SE of Fisk (T 1S, R 1E, Sec 18), 1♂I, 2♀, 24 Sep 1968; 4♂I, 1♂II, 3♀, 23 Oct 1968; (4) Flint River about 2.25 airmi (3.6 km) ESE of Meridianville (T 2S, R 1E, Sec 21), 1♀, 12 June 1967. These five lots were collected by John E. Cooper and M.R.C.

Raymond W. Bouchard (pers. comm.) has kindly informed us that he has collected specimens of this species in (5) Brier Fork at St. Rte 92, SE of Elkwood (T 1S, R 1W, Sec 7); (6) Fowler Creek, 5.2 mi (8.3 km) E of Elkwood (T 1S, R 1W, Sec 1), both in Madison County, Alabama; and (7) headwaters of the Flint River in Lincoln County, Tennessee.

VARIATIONS.—The available specimens of *Orconectes cooperi* are remarkably uniform. The only differences noted are in the degree of development of the marginal rostral and cervical spines which, although seldom prominent except the former in juveniles, range from minute to moderate size. The mesial margin of the palm of the chela in larger specimens has only five to seven tubercles along the proximal three-fourths; in smaller adults, there may be as many as nine dispersed along the entire length. This observation suggests the reduction of the more distal tubercles with increase in size (probably also with age). The setae on the chela of the holotype are much less prominent than in the other specimens examined. In some of the smaller adults, the entire chela is studded with short plumose setae which are especially well developed along the dorsomesial surface of the palm and on the fingers.

SIZE.—The largest specimen available is the holotype, possessing a carapace length of 31.8 (postorbital carapace length 23.8) mm; corresponding lengths of the largest and smallest first form males are 28.5 (22.7) and 17.0 (12.1) mm.

LIFE HISTORY NOTES.—First form males have been collected in March (Bouchard, pers. comm.), September, and October, the only months during which collections have been made. Bouchard also informed us that he had found ovigerous females in March. Two discrete size classes of adults were

present in the fall collections, one with approximate carapace lengths of 17 to 21 mm, and the other less abundant, with lengths of 26 to 32 mm.

ECOLOGICAL NOTES.—Beaver Dam Creek, Brier Fork, and West Fork are similar streams in affording a wide variety of habitats—a central channel, abundant rock cover, shallow riffle areas, calm flat areas with leaf debris, and occasional mud flats with pools and burrows—to support the rich diversity of crayfishes present. As stated for the type-locality, *Orconectes cooperi* was taken most commonly near the edges of the streams among leaf litter, as was true for *O. alabamensis* in similar habitats farther west. All three streams were observed to acquire dramatically increased depth and current during flooding from late winter and spring rains.

RELATIONSHIPS.—*Orconectes cooperi* is more closely allied to *O. alabamensis* than to its other relatives, *O. rhoadesi* Hobbs (1949:19) and *O. validus*. All of them share a chela with small depressed tubercles along the mesial surface of the palm, usually with conspicuous tufts of setae along the opposable proximal surface of the fixed finger; the dactyl lacks both a basal excision on the opposable surface and a serrate row of tubercles on the mesial surface. With few exceptions, the ischium of the third maxilliped bears conspicuous tufts of plumose setae forming a dense mat proximally and more distal ones largely concealing the lateral half of the podomere. *Orconectes cooperi* and *O. alabamensis* are further similar, and differ from *O. rhoadesi* and *O. validus* in possessing a broad areola; also the palm of the chela in adult males is at least three-fifths as long as the dactyl, bears very small, strongly depressed tubercles, and the lateral surface of the chela is at most weakly costate. *Orconectes cooperi* may be distinguished from *O. alabamensis* by the usual absence of a median carina on the rostrum, by the less strongly bent rami of the first pleopod of the male (in this respect resembling *O. rhoadesi*), and by the almost unique annulus ventralis in which the centrally located fossa is subcircular as opposed to ovate with the greatest diameter in the transverse axis.

CRAYFISH ASSOCIATES.—*Cambarus (Depressicam-*

*barus*) *striatus*, *C. (Hiaticambarus) sp.*, *Orconectes erichsonianus*, *O. forceps*, *O. mirus*, and *O. validus*.

ETYMOLOGY.—It is our pleasure to name this crayfish in honor of John E. Cooper, its co-discoverer, whose efforts in obtaining specimens and information about crayfish populations have contributed to our understanding of them, and whose support and companionship have greatly enhanced his wife's enjoyment of their study.

### *Orconectes holti*, new species

FIGURES 8, 9

DIAGNOSIS.—Body and eyes with pigment. Rostrum without median carina, acumen distinctly delimited basally by marginal spines. Areola obliterated along part of its length and comprising 26.0 to 29.9 percent of total length of carapace (37.2 to 40.5 percent of postorbital carapace length). Cervical spine well developed; suborbital angle obtuse; postorbital ridge moderately strong with acute spine cephalically. Antennal scale 2.5 to 2.8 times as long as wide, broadest at or proximal to midlength. Chela depressed, lateral margin costate, tubercles on mesial margin forming subserrate row; fingers gaping and mesial margin of dactyl with subserrate (in silhouette) row of tubercles along at least basal two-thirds; opposable margin of dactyl with rather distinct excision in proximal third. Hook on ischium of third pereopod in male. First pleopod of first form male without angular shoulder on cephalic surface, with rami curved throughout their length and reaching caudal part of coxa of second pereopod when abdomen flexed; pleopod length divisible into carapace length 3.6 times (in only first form male available); terminal elements slender and subparallel; central projection constituting about 23 percent of entire length of pleopod, bladelike, and tapering from base to caudadly directed apex; mesial process subcylindrical in section proximally, troughlike distally, its caudadly directed tip extending caudadly beyond end of central projection. Annulus ventralis as figured. First pleopod present in female.

HOLOTYPE MALE, FORM I.—Body and eyes pigmented. Cephalothorax (Figure 8*a*,*i*) subcy-

lindrical in section; abdomen narrower than carapace (12.8 and 15.2 mm), width of latter greater than depth at caudodorsal margin of cervical groove (15.2 and 13.5 mm). Areola obliterated for some distance along cephalic half, its length constituting 28.2 percent of entire length of carapace (39.3 percent of postorbital carapace length). Rostrum with slender, elevated margins converging from base to marginal spines delimiting acumen, latter reaching distal end of ultimate podomere of antennular peduncle and slightly depressed; upper surface distinctly depressed with numerous weakly setiferous punctations. Subrostral ridge weak and evident in dorsal aspect only at base of rostrum. Postorbital ridge moderately strong, grooved dorsolaterally, and terminating cephalically in strong spine. Suborbital angle moderately prominent but obtuse. Cervical and branchiostegal spines well developed. Carapace punctate, slightly granulate only in ventral part of cephalolateral area. Abdomen longer than carapace (36.2 and 33.3 mm); pleura well developed, subtruncate ventrally, and subangular caudoventrally; cephalic section of telson with 2 spines in each caudolateral corner. Proximal podomere of uropod with spine on each lobe, that on lateral very small; both rami with medial keel ending in spine, that on mesial ramus pre-marginal.

Cephalic lobe of epistome (Figure 8*g*) with cephalomedian projection, and delimited basally by distinctly contracted base; margins irregular, slightly elevated (ventrally) ventral surface with scattered setae, main body of epistome with broad cephalomedian depression bearing longitudinal trough; epistomal zygoma broadly V-shaped. Basal podomere of antennule with prominent spine on ventral surface slightly distal to midlength. Antennal peduncle with moderately strong spine on lateral surface of basis and another on ventral surface of ischium. Antenna reaching slightly beyond base of telson. Antennal scale (Figure 8*l*) 2.7 times as long as wide with greatest width proximal to midlength; mesial border of lamella subangular near distal extremity; apical spine reaching slightly beyond distal end of antennular peduncle. Ventral surface of is-

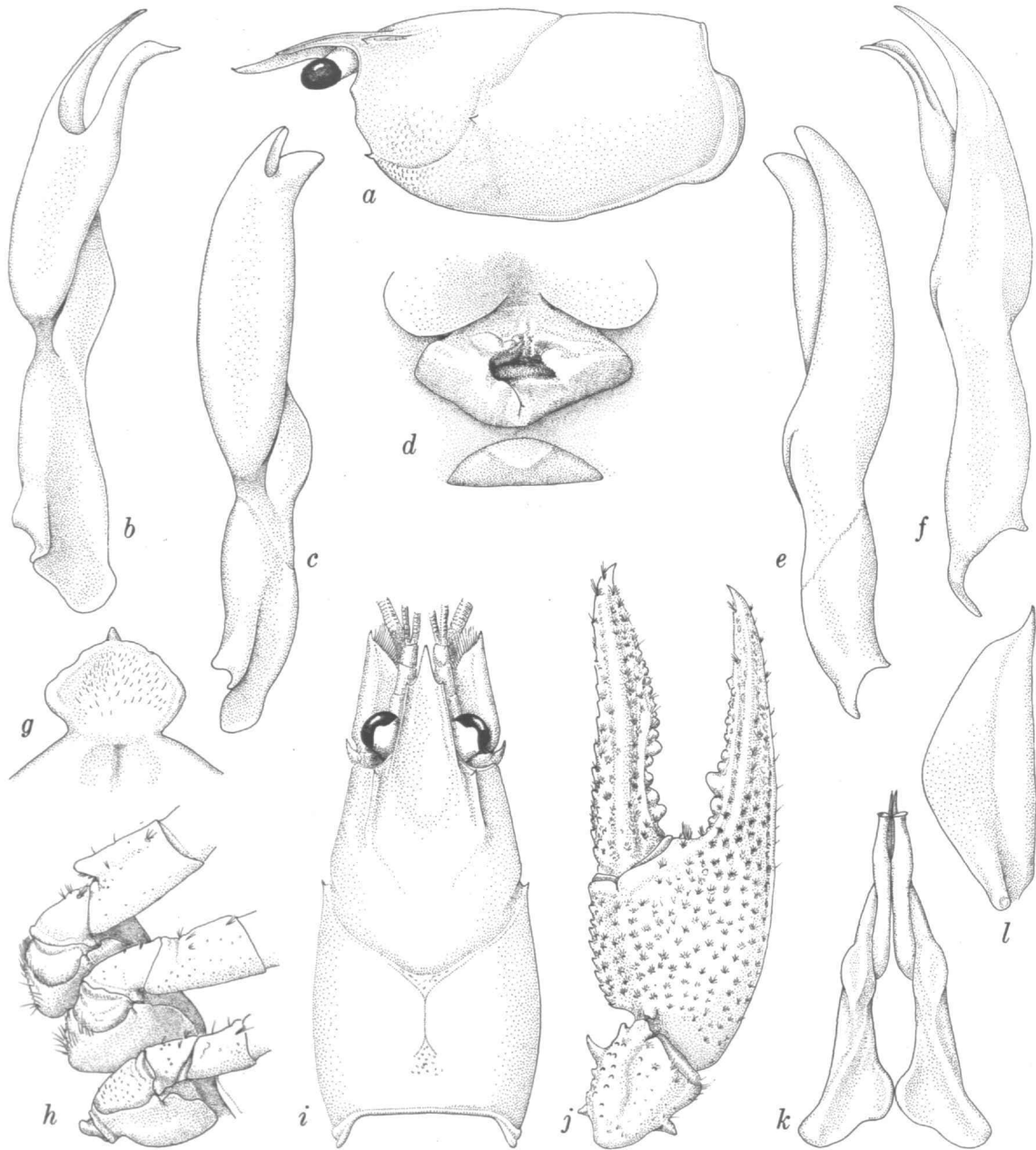


FIGURE 8.—*Orconectes holti* (all from holotypic male, form I, except *c*, *e*, from morphotypic male, form II, and *d* from allotype): *a*, lateral view of carapace; *b*, *c*, mesial view of first pleopod; *d*, annulus ventralis; *e*, *f*, lateral view of first pleopod; *g*, epistome; *h*, basal podomeres of third through fifth pereiopods; *i*, dorsal view of carapace; *j*, dorsal view of distal podomeres of cheliped; *k*, caudal view of first pleopods; *l*, antennal scale.

chium of third maxilliped with submarginal lateral row of long, plumose setae, lateral half of surface with scattered ones, mesial half studded with stiff hairlike setae; distolateral extremity of ischium with distinct corneous spine.

Right chela (Figure 8j) strongly depressed (ratio of depth to width 0.61), not so long as carapace (27.9 and 33.3 mm) and 3.3 times as long as wide; thickness equivalent to about two-thirds length of areola, and little more than four-fifths length of mesial margin of palm; latter with 8 (9 on left) tubercles, in mesialmost row subtended dorsally and ventrally by rows of 8 and 2 (left with 4), respectively; additional tubercles present on mesial third of dorsal surface, tubercles progressively more squamous laterally; remaining surfaces of palm punctate; ventral margin adjacent to opposable base of dactyl with row of 4 tubercles (ventralmost largest, others very small), and additional premarginal prominent one situated proximolateral to row. Fingers gaping, with inconspicuous small tuft of plumose setae extending distally from basal part of fixed finger. Opposable margin of latter with row of 17 knoblike tubercles (fifth from base largest) extending from base almost to corneous tip of finger (left with 13); except for small size of eighth from base, tubercles decreasing in size distally from fifth; large tubercle present more ventrally between thirteenth and fourteenth, and smaller one between fifteenth and sixteenth; single interrupted row of minute denticles extending distally from sixth tubercle from base; dorsal surface of finger with prominent submedian ridge and lesser one immediately lateral to row of tubercles on opposable surface, ridges flanked by row of setiferous punctations; lateral costa extending proximally along distal third of palm and basal half of finger; ventral surface punctate and with submedian longitudinal ridge. Opposable margin of dactyl with row of 20 knoblike tubercles (first and fifth from base larger than others, latter marking distal end of excised area of finger) decreasing in size from first through fourth and from fifth distally; interrupted row of minute denticles extending distally from sixth tubercle from base to corneous tip of

finger; dorsal and ventral surfaces similar to those of fixed finger; mesial surface with cluster of tubercles along proximal three-fifths of finger, contracting to single row reaching slightly beyond base of distal fifth, those along mesialmost margin appearing serrate in silhouette. Carpus about 1.3 times as long as broad with sinuous dorsal sulcus flanked mesially by tubercles and laterally by few tubercles and setiferous punctations; mesial surface with prominent spikelike tubercle, 2 smaller ones proximal to it, and another more dorsally situated and lying proximomesial to articular eminence; ventral surface with 2 large spiniform tubercles on distal margin, more lateral one on condyle, other submedian; 4 additional smaller tubercles present ventromesially. Dorsal surface of merus with 2 spiniform tubercles and several small rounded ones near distal end; ventral surface with lateral and mesial rows of 5 and 12 tubercles, respectively (left with 8 and 12), few of which spikelike; distolateral apophysis with spiniform tubercle, and few additional tubercles immediately distal to fracture line.

Ischium of third pereopod (Figure 8k) with simple hook overreaching basioischial articulation and opposed by vestige of tubercle on basis; hook heavy and with free end truncate and somewhat flattened. Ventral membrane on coxa of fifth pereopod studded with short setae.

First pleopods (Figure 8b, f, k) symmetrical and reaching coxa of second pereopod when abdomen flexed. (See "Diagnosis" for description.)

ALLOTYPIC FEMALE.—Differing from holotype in following respects: acumen overreaching antennular peduncle by one-fifth its length; antennal flagellum reaching base of fifth abdominal segment; ratio of depth to width of chela 0.58, chela distinctly shorter than carapace (20.0 and 30.9 mm); mesial surface of palm of left chela (right regenerated) with 2 rows of tubercles represented by 7 and 5, ventral row absent; opposable margin of fixed finger of chela with row of 8 tubercles (third from base largest) along proximal three-fourths of finger and single tubercle on lower level opposite distalmost member of row; opposable margin of dactyl with row of only 15

tubercles (proximal 5 subequal in size), and distal limit of excision not nearly so distinct as in holotype; setal tufts at base of fixed finger more abundant; mesial surface of carpus with only 2 tubercles, large spikelike one and another smaller at its proximal base; ventral surface of merus with lateral row of 7 tubercles and mesial one of 12. (See Table 4.)

Annulus ventralis (Figure 8*d*) firmly but not inflexibly fused to sternum, somewhat subrhomboid in outline, about 1.8 times as broad as long, and strongly sculptured with very high transverse ridges interrupted by conspicuously deep median fossa; cephalic third subplane, sloping caudoventrally, and bearing shallow median trough leading caudally which, before reaching fossa, flanked by low longitudinal ridges, latter merging with transverse elevations; caudal slope of ridges occupying caudal half of annulus, its sinistral side steeper than dextral; sinus originating in cephalic part, and on dextral side, of fossa; following dextral extension and making hairpin turn, continuing caudosinistrally to median line where

ending on caudal wall of annulus; deeply situated tongue directed dextrally. Postannular sclerite about 3.3 times as broad as long, slightly more than two-thirds as wide as annulus, and only little more than one-third as long. First pleopod reaching cephalically beyond midlength of annulus when abdomen flexed.

MORPHOTYPIC MALE, FORM II.—Differing from holotype in following respects: main body of epistome with less well-defined trough in depressed area; lamella of antennal scale with less angular distomesial margin; ratio of depth to width of chela 0.59, length distinctly less than that of carapace (23.1 and 32.7 mm); mesial surface of palm of chela with rows of setae consisting of 4, 9, and 6 on right member and 4, 7, and 6 on left (latter cheliped probably regenerated); opposable margin of fixed finger with row of 11 tubercles (third from base largest) and 1 on lower level at base of distal third (left member with 14 and 2, respectively); opposable margin of dactyl with row of 20 tubercles (some of which minute and situated dorsal to row of denticles), none on lower

TABLE 4.—Measurements (in mm) of *Orconectes holti*, new species

Characters	Holotype	Allotype	Morphotype
Carapace			
Total length	33.3	30.9	32.7
Postorbital length	24.4	21.0	24.3
Width	15.2	14.1	15.8
Height	13.5	13.2	14.1
Areola			
Width	0	0	0
Length	9.6	8.5	10.8
Rostrum			
Width	4.9	4.9	5.3
Length	9.5	9.6	9.8
Chela			
Length of mesial margin of palm	7.5	5.9	6.5
Width of palm	10.5	7.9	8.4
Depth of palm	6.4	4.6	5.0
Length of lateral margin	27.9	20.0	23.1
Length of dactyl	18.3	13.5	15.2
Abdomen			
Width	12.8	14.6	13.0
Length	36.2	40.5	38.8



level (left member with 24 and 2, respectively); excision of dactyl slightly less conspicuous; tubercles on mesial surface of dactyl more nearly arranged in rows; setal tufts at base of fixed finger more conspicuous and widespread than in holotype; mesial surface of carpus of left cheliped with additional tubercle proximal to spikelike tubercle; ventral surface of merus of right cheliped with 4 tubercles in lateral row and 11 in mesial, that of left with 6 and 16, respectively. Tubercles of chelipeds, other than those on opposable surfaces of fingers, much more acute. Hook on ischium of third pereopod much reduced, not overreaching basioischial articulation. (See Table 4.)

First pleopod (Figure 8*c,e*) with more robust rami, and cleft between them conspicuously shorter; juvenile suture present.

**COLOR NOTES.**—Carapace with pale tan background fading to cream ventrally and marked with dark olive-gray to black splotches. Most conspicuous marking consisting of paired black spots on hepatic area immediately dorsal to cervical spine; spots bleeding dorsally over hepatic area and ventrally on branchiostegite in flaring expansions. Paired black areas occurring submarginally on caudodorsal region of branchiostegite, these spots also with dilution spreading over moderately large area adjacent to caudal margin. Third prominent black area in form of oblique bar extending caudoventrally from orbit, flanked ventrally by conspicuous pinkish-cream area extending to cephaloventral arm of cervical groove. Remaining markings on carapace irregular in outline and of varied sizes, few symmetrically arranged. Abdomen similarly mottled but only first abdominal tergum with sizable splotches, these consisting of 2 pairs of suboval olive-gray spots, arranged transversely. Second through fifth pleura with broad olive-gray chevrons at base, and with small irregular similarly colored spots on cream background more ventrally. Telson with dark splotches cephalolaterally, and, except for transverse series of small ones between marginal spines, it and uropods with small flecks scattered over entire dorsal surface; flecks on

lateral margin of lateral ramus of uropods darker than others. Antennular peduncle with penultimate podomere very dark dorsally, and ultimate podomere of antennal peduncle with prominent dark splotch; antennal scale mottled laterally and with dark elongate splotch along lamellar area adjacent to thickened lateral part of scale. Cheliped cream to white with conspicuous irregular blackish markings on distal part of merus, carpus, and palm of chela. Those on fingers very large, some coalescing to form three broad bands on each finger; scarlet tips of fingers abutting distalmost dark band. Remaining pereopods white to cream with distinct olive-gray splotches on dorsal and cephalic surfaces of merus, carpus, and propodus, giving them banded appearance; spots on second pereopod pale.

**TYPE-LOCALITY.**—Bogue Chitto Creek, 2.3 miles (3.7 km) west of Marion on State Route 14 (T 19N, R 7E, Sec 11), Perry County, Alabama. The stream at this locality is approximately five meters wide and less than one meter deep and flows with a moderate current over a sand and clay bed strewn with decaying tree litter. On one of the two occasions when collections were made there, the water was clear but pale reddish brown; on the other, it was cloudy with suspended silt. Among the trees shading the stream were *Liquidambar styraciflua*, *Platanus occidentalis*, *Acer* sp., *Pinus* sp., and *Quercus* sp. Other crayfishes sharing the stream were *Procambarus (Ortmannicus) acutissimus* (Girard, 1852:91), *P. (O.) lophotus* Hobbs and Walton (1960:123), and *Cambarus (Depressicambarus) striatus*.

**DISPOSITION OF TYPES.**—The holotype, allotype, and morphotype (147149, 147150, and 147151, respectively) are deposited in the National Museum of Natural History, Smithsonian Institution, as are the paratypes (which are limited to specimens from the type-locality) consisting of 4♂II, 12♀, and a second form test of the holotype.

**RANGE AND SPECIMENS EXAMINED.**—Alabama River basin in Dallas, Lowndes, Montgomery, Perry, and Wilcox counties, Alabama. We have no records of its occurrence in the Cahaba, Coosa,

or Tallapoosa watersheds, all major tributaries of the Alabama River.

ALABAMA: DALLAS COUNTY: (1) Big Swamp Creek, 4.0 airmi (6.4 km) SSE of Orrville (T 15N, R 8E, Sec 25), 4♂II, 1♀, 20 Feb 1973, H. Wahlquist and R.A. Jones, Jr., coll.; (2) Big Swamp Creek, 5.9 airmi (9.4 km) SE of Orrville (T 15N, R 11E, Sec 32), 1j♂, 5j♀, 12 Jul 1972, HW and J. Lochamy; 1♀, 20 Feb 1973, HW and RAJ; (3) Big Swamp Creek, 7.8 airmi (12.5 km) SE of Orrville (T 14N, R 9E, Sec 3), 3♂II, 6♀, 6j♂, 1j♀, 12 Jul 1972, HW and JL; 2♀, 18 Oct 1972, HW and RAJ; (4) Big Swamp Creek, near Five Points (T 14N, R 8E, Sec 25), 3♂II, 3♀, 4 Apr 1972, HW and D. Mathur; (5) Big Swamp Creek, about 2 mi (3.2 km) E of Tasso (T 14N, R 9E, Sec 3), 1♂II, 1♀, 4 Apr 1972, HW and DM; (6) Mush Creek on Dallas-Lowndes County line, 2.5 airmi (4 km) N of Pleasant Hill on Co Rd 7 (T 14N, R 11E, Sec 12), 1♀, 11 Jul 1972, HW and JL. LOWNDES COUNTY: (7) Mush Creek, 1.8 airmi (2.9 km) NW of Collirene (T 14N, R 12E, Sec 10), 2♂II, 3♀, 36j♂, 28j♀, 10 Jul 1972, HW and JL; 1♂II, 3♀, 2j♂, 21 Feb 1973, HW and RAJ; (8) Mush Creek (T 14N, R 12E, Sec 15), 2♂II, 6♀, 2j♀, 5 Apr 1972, HW and GM. MONTGOMERY COUNTY: (9) White Slough, trib to Catoma Creek 4 airmi (6.4 km) NE of Snowdoun (T 15N, R 18E, Sec 9), 1♂II, 16 Oct 1971, Thrasher and Jones; (10) Catoma Creek, 5 mi (8.0 km) SW of Montgomery (T 16N, R 17E, Sec 20), 1♂II, 18 Sep 1929, E.P. Creaser and C. Becker. PERRY COUNTY: (11) Type-locality, 1♂II, 2♀, 24 Apr 1970, K.R. Martin and HHH; 5♂II (1 molted to first form

on 14 Jul 1974), 11♀, 16 Apr 1974, D.J. Peters and HHH. WILCOX COUNTY: (12) Bear Creek, 4.5 mi (7.2 km) NW of Pine Apple (T 11N, R 10E, Sec ?), 1♂II, 17 Sep 1929, EPC and CB.

VARIATIONS.—The variations noted among the paratypes are not markedly different from those pointed out in the descriptions of the holotype, allotype, and morphotype. The rostrum always bears lateral spines or at least conspicuous tubercles, and frequently the spines are long. The rostral margins are convergent in all of the specimens except the lone second form male from Wilcox County in which they are parallel from the base to the marginal spines. The areola may be either obliterated or sublinear, wide enough to accommodate 1 punctation in the narrowest part. The antennal scale (Figure 9) varies considerably, but usually the distomesial angulation is evident; it may have its greatest width at or slightly proximal to midlength. Occasionally there are 3 spines in the caudolateral corner of the cephalic section of the telson. The chelae show the greatest range of variation: along the mesial margin of the palm, the fewest and most tubercles in the mesialmost row are 6 and 8, in the flanking ventral row, 0

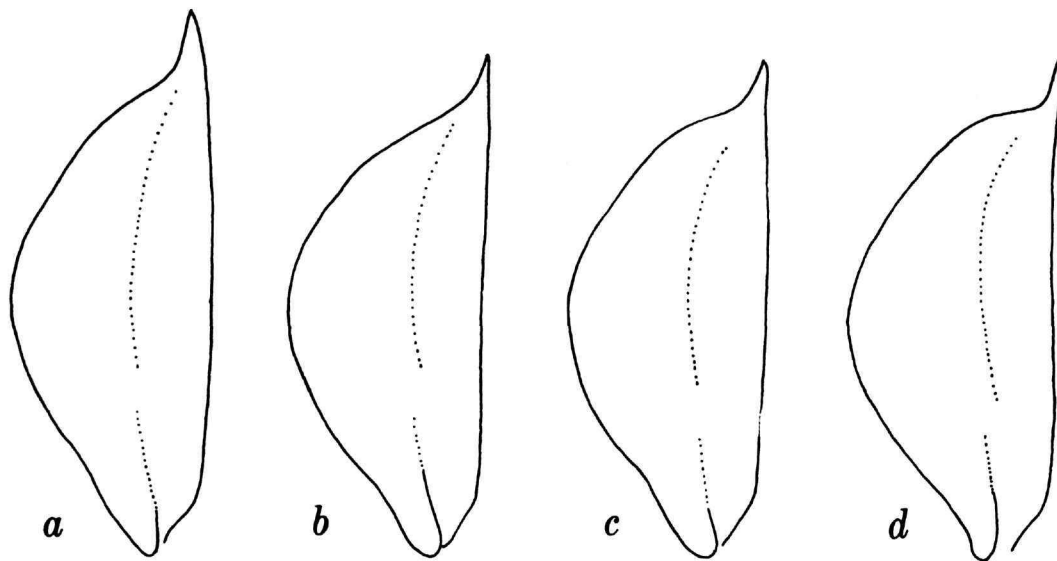


FIGURE 9.—Antennal scales of *Orconectes holti* from Alabama: a, Bear Creek, Wilcox County; b, Big Swamp Creek, Dallas County; c, Mush Creek, Lowndes County; d, White Slough (to Catoma Creek), Montgomery County.

and 4, and in the dorsal row, 5 and 7; along the opposable margin of the fixed finger, the range is 6 and 12, with 1 or 2 on lower level, while on the corresponding margin of the dactyl there are 11 to 15 with the first and/or fifth from base larger than the others; the setal tuft borne on the base of the fixed finger may be very dense, extending beyond the level of the fifth tubercle, or it may consist of a few clusters of comparatively short setae (reduced setation seems not always to be associated with wear). The centrally located depressed area of the annulus ventralis is sometimes more, occasionally less, deeply excavate in some specimens than in the allotype. In them, the transverse ridges flanking the depression are correspondingly much higher or lower. In one female, there is a hook present on the ischium of the third pereopod.

**SIZE.**—The largest available specimen is a female with a carapace length of 34.4 (postorbital carapace length 25.5) mm.

**LIFE HISTORY NOTES.**—The holotype was in the second form when collected on 16 April 1974 and was kept in the laboratory until it molted to form I on 14 July 1974 (preserved on July 22). None of the females were ovigerous. It is somewhat surprising that among the 149 specimens collected during February, April, July, September, and October, no first form males were encountered.

**ECOLOGICAL NOTES.**—This crayfish has been found only in lotic habitats in which the current was sluggish to moderate. The comparatively few specimens collected by one of us (Hobbs) were taken from accumulations of debris and among roots of trees along undercut banks of the stream bed.

**RELATIONSHIPS.**—*Orconectes holti* seems to have its closest affinities with *O. chickasawae* (described herein), *O. etnieri*, *O. immunis*, and *O. mississippiensis*. See "Relationships" under *Orconectes chickasawae*.

**CRAYFISH ASSOCIATES.**—Collected with *Orconectes holti* in one or more localities were *Cambarus (D.) striatus*, *C. (Lacunicambarus) sp.*, *Procambarus (O.) acutissimus*, *P. (O.) lophotus*, *P. (O.) sp.* (Planirostris Group), and *P. (Pennides) versutus* (Hagen, 1870:51).

**ETYMOLOGY.**—This crayfish is named in honor of our mutual friend and colleague, Perry C. Holt, eminent student of the Branchiobdellida (annelid symbionts of crayfishes), who has contributed greatly to our knowledge of crayfishes through the donation of numerous specimens to the national collection and through his postulates correlating the ranges of the worms and their hosts.

### *Orconectes chickasawae*, new species

FIGURE 10

*Orconectes mississippiensis*.—Hobbs, 1972:80, fig. 63a.

**DIAGNOSIS.**—Body and eyes with pigment. Rostrum without median carina, with or without marginal tubercles or small spines. Areola 16 to 100 times as long as wide and comprising 27.9 to 32.8 percent of entire length of carapace (37.1 to 42.6 percent of postorbital carapace length), with only 1 punctation in narrowest part. Cervical spine small; suborbital angle vestigial to obsolete; postorbital ridge well developed with small acute spine or tubercle cephalically. Antennal scale approximately 2.3 times as long as wide, broadest at about midlength. Chela depressed, tubercles on mesial margin of palm forming subserrate row; fingers gaping, and mesial margin of dactyl with subserrate row of often acute tubercles extending along almost entire length of finger; opposable margin of dactyl with distinct excision. Hook on ischium of third pereopod of male. First pleopod of first form male without angular shoulder on cephalic surface, with rami curved throughout their length, and central projection reaching caudal part of coxa of second pereopod when abdomen flexed; pleopod length divisible into carapace length 3.0 to 3.7 (average 3.3) times; terminal elements slender, subparallel; central projection constituting 20.8 to 26.4 (average 21.9) percent of mesial length of pleopod, bladelike, tapering to caudally directed apex, and not extending so far caudally as mesial process, latter subcylindrical in section proximally, troughlike distally. Annulus ventralis as figured. First pleopod present in female.

**HOLOTYPE MALE, FORM I.**—Body and eyes pigmented. Cephalothorax (Figure 10*a,i*) subcylindrical in section; abdomen narrower than carapace (15.4 and 18.1 mm), width of latter greater than depth at caudodorsal margin of cervical groove (18.1 and 17.2 mm). Areola narrow, 30 times as long as wide, with 1 punctation in narrowest part; length of areola 33.2 percent of entire length of carapace (41.2 percent of postorbital carapace length). Rostrum with only slightly thickened, elevated borders, lacking marginal spines or tubercles, converging to base of short acumen, latter reaching distal end of penultimate podomere of antennular peduncle; upper surface subplane with thickly set, setiferous punctations. Subrostral ridge weakly developed and evident in dorsal aspect only at base of rostrum. Postorbital ridge moderately strong, grooved laterally, and terminating cephalically in small tubercle. Suborbital angle vestigial, broadly rounded. Cervical spine small. Branchiostegal spine well developed. Carapace densely punctate dorsally, finely granulate laterally except for longitudinal row of moderately large tubercles immediately ventral to cephalic portion of cervical groove. Abdomen and carapace subequal in length (36.5 and 36.1 mm); pleura well developed and subtruncate ventrally; cephalic section of telson with 2 spines in each caudolateral corner. Proximal podomere of uropod with short, corneous spine on each lobe, mesial ramus with moderately well-developed dorsomedian keel terminating in small premarginal spine.

Cephalic lobe of epistome (Figure 10*g*) lacking cephalomedian projection, and delimited basally by distinctly contracted base; margins crenulated, slightly elevated ventrally; main body with shallow fovea; epistomal zygoma broadly arched. Basal segment of antennule with spine on ventral surface slightly distal to midlength. Antennal peduncle devoid of spines except laterally on basis. Antenna reaching slightly beyond caudal margin of telson. Antennal scale (Figure 10*l*) 2.2 times as long as broad, with greatest width near midlength; mesial border of lamella evenly rounded; apical spine weak and reaching ultimate podomere of antennular peduncle. Ventral surface of

ischium of third maxilliped with submarginal lateral row of long, plumose setae and with scattered shorter plumose ones on surface between lateral row and broad mesial band of stiff hairlike setae.

Right chela (Figure 10*j*) depressed, costate laterally, longer than carapace (43.5 and 36.1 mm) and 2.6 times as long as wide. Mesial surface of palm with 3 rows of tubercles: 8 in mesialmost and 10 (9 on left chela) and 6 in flanking dorsal and ventral rows, respectively. Mesial half of dorsal surface of palm tuberculate, tubercles progressively more squamous laterally; remaining surfaces of palm punctate; ventral surface with 2 large marginal tubercles at base of dactyl and 3 smaller ones situated more proximally. Fingers gaping basally. Opposable margin of fixed finger with dorsal row of 18 knoblike tubercles (fourth from base largest) decreasing in size distally, and almost reaching corneous tip of finger; ventral row of 6 tubercles along distal third of finger, proximalmost largest and large gap between it and second tubercle of row; finger devoid of minute denticles; dorsal surface with broad submedian ridge and narrower mesial one flanking base of dorsal row of tubercles on opposable margin, ridges flanked by setiferous punctations; lateral margin of finger costate, costa extending proximally to midlength of palm; ventral surface with submedian longitudinal ridge, otherwise punctate. Opposable margin of dactyl with conspicuous excavation in basal portion, bearing row of 23 knoblike tubercles (fifth from base largest and marking distal end of excavation) extending from base almost to corneous tip, tubercles decreasing in size distally from fifth; in addition 2 smaller tubercles on lower level at base of distal fourth, and minute denticles present between and distal to tubercles along distal three-fifths of finger; dorsal and ventral surfaces similar to those of fixed finger; mesial surface with cluster of subacute tubercles proximally, cluster narrowing distally to single row, surface in silhouette appearing serrate. Carpus about 1.4 times as long as broad, with sinuous groove dorsally, flanked mesially by tubercles and laterally by setiferous punctations; mesial surface with 3 prominent

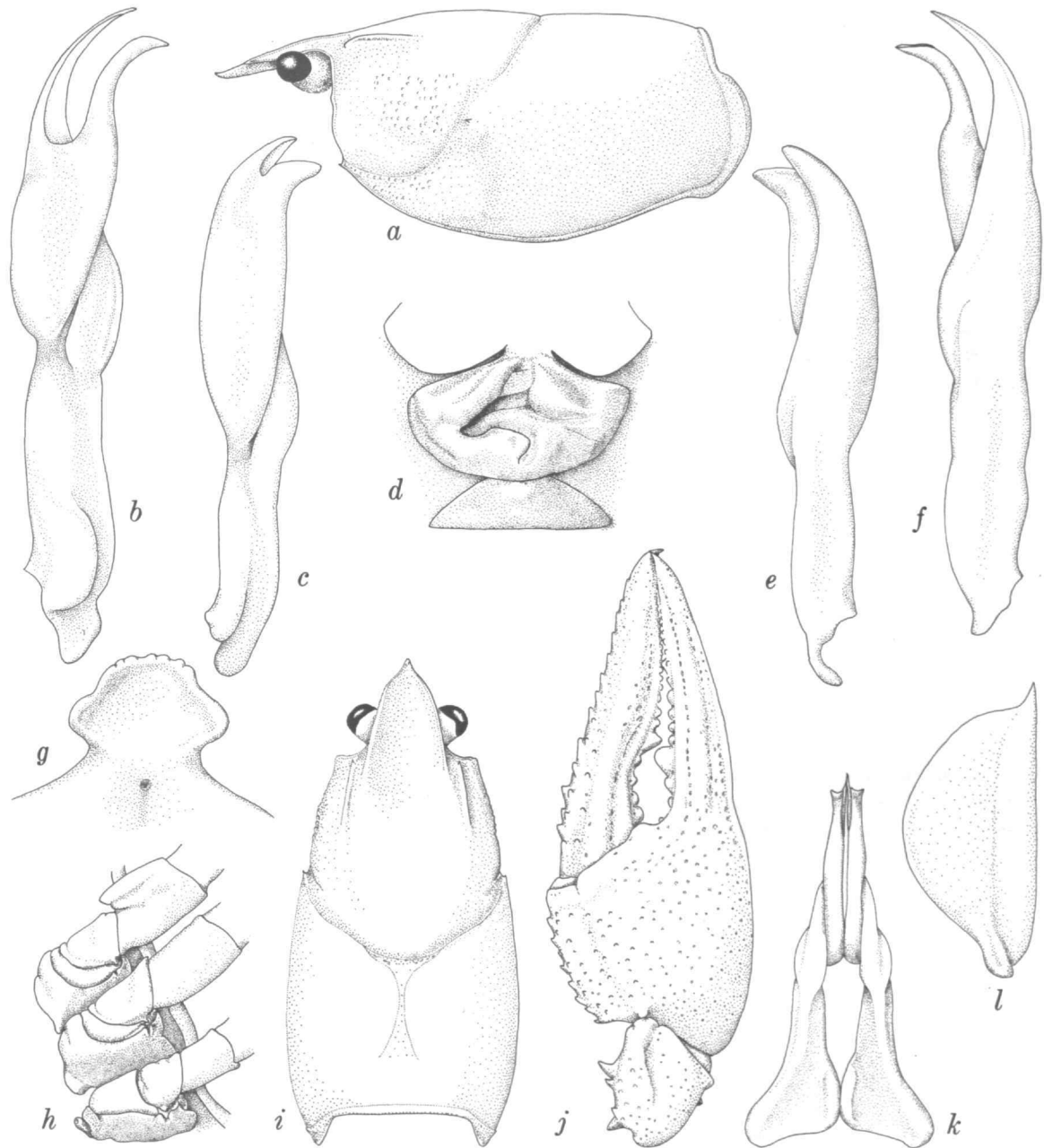


FIGURE 10.—*Orconectes chickasawae* (all from holotypic male, form I, except *c*, *e*, from morphotypic male, form II, and *d* from allotype): *a*, lateral view of carapace; *b*, *c*, mesial view of first pleopod; *d*, annulus ventralis; *e*, *f*, lateral view of first pleopod; *g*, epistome; *h*, basal podomeres of third through fifth pereopods; *i*, dorsal view of carapace; *j*, dorsal view of distal podomeres of cheliped; *k*, caudal view of first pleopods; *l*, antennal scale.

tubercles, distal 2 spikelike and distalmost largest; ventral surface with 2 large rounded tubercles on distal margin, 1 on lateral condyle and other submedian; ventromesial surface with cluster of 4 smaller tubercles opposite level of spikelike tubercles on mesial surface. Dorsal surface of merus with 5 subdistal tubercles (4 on left chela); lateral and mesial surfaces punctate; ventral surface with lateral row of 7 tubercles and mesial one of 14 (left chela with 7 laterally and 12 mesially) flanked by few additional tubercles; distolateral apophysis with small subacute tubercle. Ventromesial margin of ischium of cheliped with single tubercle. Ischium of third pereopod (Figure 10*h*) with simple hook overreaching basioischial articulation and opposed by small tubercle on basis; hook massive, with free end truncate and subspatulate. Ventral membrane on coxa of fifth pereopod studded with short setae.

First pleopods (Figure 10*b, f, k*) symmetrical and reaching caudal portion of second pereopods when abdomen flexed. (See "Diagnosis" for description.)

**ALLOTYPIC FEMALE.**—Differing from holotype in following respects: abdomen and carapace subequal in width; areola only 23 times as long as wide, comprising 31.3 percent of carapace length (41 percent of postorbital carapace length); minute marginal tubercles at base of acumen; left postorbital ridge ending bluntly; abdomen longer than carapace (39.5 and 36.8 mm); cephalic lobe of epistome with margin less crenulate and with moderate cephalomedian projection; right chela shorter than carapace (28.9 and 36.8 mm); mesialmost row of tubercles on mesial margin of palm of chela consisting of 7, and flanking dorsal and ventral rows of 6 and 4, respectively; left chela probably regenerated; opposable margin of fixed finger with single row of 13 tubercles, 1 large one at base of distal three-fifths on lower level, single row of minute denticles between and distal to sixth tubercle from base, and proximomesial angle of finger with conspicuous tuft of plumose setae; opposable margin of dactyl with row of 17 tubercles; ventrodistal margin of carpus of cheliped with 1 additional tubercle. (See Table 5.)

Annulus ventralis (Figure 10*d*) moderately deeply embedded in and firmly fused to sternum, subpentagonal in outline, and about 1.5 times as broad as long. Cephalic half with median trough curving dextrally across midlength; sinus originating just cephalic to midlength in median trough, extending caudodextrally along and around long, digitiform tongue, following latter sinistrally—crossing median line—and, curving caudodextrally, ending before reaching caudal margin of annulus. Postannular plate about 3 times as broad as long, only little narrower than annulus. First pleopod extending well over (ventrally) annulus when abdomen flexed.

**MORPHOTYPIC MALE, FORM II.**—Differing from holotype in following respects: areola 37 times as long as wide, comprising 31.6 percent of carapace length (41.2 percent of postorbital carapace length); rostrum with marginal tubercles; cephalic portion of epistome slightly more rounded cephalically and with small cephalomedian projection; ischium of antennal peduncle with ventral spine; right chela shorter than carapace; mesial surface of palm with 7 tubercles in mesialmost row and 6 and 4 in flanking dorsal and ventral rows, respectively; ventral surface with group of 3 more proximal tubercles rudimentary; fixed finger with single row of 11 tubercles (fourth from base largest), single large tubercle ventral to row (situated between eighth and ninth tubercles of row), very small tubercle between tenth and eleventh, and minute denticles extending distally from fifth tubercle; proximomesial angle of finger with conspicuous tuft of plumose setae; dactyl with row of only 16 tubercles on opposable margin; mesial surface of right carpus with 4 prominent tubercles and additional prominent one immediately proximal to distal articular knob; ventral surface with 2 submarginal distal acute tubercles and 2 smaller rounded ones; dorsal surface of merus with 2 acute tubercles; ventral surface with lateral row of 4, and mesial row of 13 tubercles; ischium of third pereopod with reduced hook not overreaching basioischial articulation. (See Table 5.)

First pleopod (Figure 10*c, e*) with terminal elements conspicuously heavier, more rounded, and

TABLE 5.—Measurements (in mm) of *Orconectes chickasawae*, new species

Characters	Holotype	Allotype	Morphotype
Carapace			
Total length	36.1	36.8	34.8
Postorbital length	29.1	28.0	26.7
Height	17.2	15.7	15.6
Width	18.1	17.8	17.0
Areola			
Width	0.4	0.5	0.3
Length	12.0	11.5	11.0
Rostrum			
Width	6.4	5.9	5.6
Length	9.6	9.0	9.4
Chela			
Length of mesial margin of palm	12.1	8.4	7.7
Width of palm	17.0	11.9	10.4
Depth of palm	10.1	6.8	6.2
Length of lateral margin	43.5	28.9	28.6
Length of dactyl	30.9	20.0	18.8
Abdomen			
Width	15.4	17.3	15.2
Length	36.5	39.5	38.1

distinctly shorter than those of holotype—shorter by virtue of much shallower cleft between two elements.

**COLOR NOTES.**—Basic colors greenish-gray to brown mottlings on pale olive to tan background. Carapace with irregular, but somewhat symmetrically arranged, dark splotches of variable sizes; paired suboval splotches in caudolateral gastric areas somewhat larger than others in cephalic region; branchiostegites with paired, rather conspicuous, dark markings both caudolaterally and cephalolaterally, latter and other dark markings fading ventrally. First abdominal tergum with pair of square to rectangular, dark transverse bars dorsolaterally; succeeding terga with arched dark markings forming 2 irregular stripes extending caudally from transverse bars on first tergum; bases of epimera also marked by dark oblique to ventrally convex lines; remaining portions of terga flecked with same dark color; cephalic section of telson with paired dark spots cephalo- and caudolaterally; peduncles of antennules and antennae mottled; lateral margin of antennal scale with narrow dark band (occasionally broken) and

subparallel one on lateral base of pale lamellar area. Dorsal surface of cheliped from merus distally with same colors as carapace; splotches highly variable in size and less dense on chela than on carapace; prominent tubercles cream to white, smaller tubercles on cheliped dark brown to black; ridges flanking dorsal side of opposable surfaces of fingers mostly dark; broad dark band across fingers at midlength. Tips of fingers yellowish to orange. Dorsal surface of remaining pereopods, from merus through propodus, mottled, some appearing banded; otherwise all podomeres pale grayish or tannish cream. These notes based on several first form males from localities in Chickasaw and Monroe counties, Mississippi.

A single male from James Creek, at Gibson, Monroe County, differs in possessing an almost concolorous, mauve dorsum of the carapace with cervical and branchiocardiac grooves margined with cream. Chelipeds with bluish-green suffusion dorsally over distal portion of merus, carpus, distal part of palm, and fingers.

**TYPE-LOCALITY.**—Town Creek, 3.5 miles (5.6 km) southeast of Muldon, 3 miles (4.8 km) east of

State Route 45W (CS: T 16S, R 7E, Sec 7 and 18), Monroe County, Mississippi. At this locality, the maximum width of the creek is four meters and its depth less than one meter. The water flows slowly over a clay bottom. Fourteen species of fishes were collected in the same area.

**DISPOSITION OF TYPES.**—The holotype, allotype, and morphotype (144924, 144925, and 144926, respectively) are deposited in the National Museum of Natural History, Smithsonian Institution, as are the following paratypes: 13♂I, 29♂II, 38♀, 11j♂, and 29j♀; paratypes consisting of 1♂I, 1♂II, and 1♀ are in the North Carolina State Museum of Natural History, and 2♂I, 5♂II, 8♀, 1j♂, and 1j♀ are in the collection of J.F. Fitzpatrick, Jr., at the University of South Alabama.

**RANGE AND SPECIMENS EXAMINED.**—Known from western tributaries of the Tombigbee River in Chickasaw, Clay, Lowndes, and Monroe counties, Mississippi. Probably it ranges northward at least into Lee, Pontotoc, and Union counties, from which considerable material is available, but we defer assigning specific names to these populations without larger samples including first form males, and further detailed analyses.

**MISSISSIPPI: CHICKASAW COUNTY:** (1) Chico Creek, 1 mi (1.6 km) W of Houston on St Rte 8 (CS: T 14S, R 3E, Sec 5), 2♂II, 2♀, 30 Apr 1968, H.H. Hobbs III and HHH, coll. **CLAY COUNTY:** (2) Spring Creek, 3.2 mi (5.2 km) E of West Point (CS: T 20N, R 7E, Sec 9), 2♂II, 15 Apr 1972, H.T. Boschung; (3) Chookatonchee Creek at St Rte 8, W of Gibson (CS: T 22N, R 5E, Sec 1), 2♂II, 3♀, 15 Apr 1972, E.C. Beckham III; (4) Sun Creek at Oktibbeha County line on St Rte 389 (CT: T 20N, R 13E, Sec 28), 3♂I, 3♂II, 4♀, 12 Feb 1969, J.F. Fitzpatrick, Jr., and HHH III; 7♂II (2 molted to form I on 17 Apr 1976), 8♀, 1j♂, 1j♀, 10 Apr 1976, B.A. Laning and JFF. **LOWNDES COUNTY:** (5) Roadside ditch 9.1 mi (14.6 km) N of Noxubee County line on U.S. Hwy 45 (CT: T 18N, R 17E, Sec 22), 2♂I, 2♀, 14 Apr 1954, J.E. Pugh, S.R. Telford, and HHH; (6) James Creek, 0.5 mi (0.8 km) N of Noxubee County line on U.S. Hwy 45 (CT: T 17N, R 17E, Sec 31), 6♂I, 18♂II, 8j♂, 15j♀, 14 Apr 1954, JEP, SRT, and HHH. **MONROE COUNTY:** (7) Type-locality, 3♂I, 7♂II, 7♀, 1j♀, 15 Apr 1972, ECB; (8) Pool in drying headwater tributary of Town Creek, about 1.5 mi (2.4 km) NE of Muldon on St Rte 25 (CS: T 15S, R 6E, Sec 23), 1♂I, 1♀, 30 Apr 1968, HHH III and HHH; (9) Headwaters of Town Creek about 2.5 mi (4 km) NE of Muldon on St Rte 25 (CS:

T 15S, R 6E, Sec 24), 2♂I, 30 Apr 1968, HHH III and HHH.

**VARIATIONS.**—The variations noted are essentially all individual in nature; however, in the series of specimens from James Creek, the areolae are consistently linear, and those in the Chickasaw County locality are somewhat broader. The base of the fixed finger of the chela in all adults from James Creek bears a moderately conspicuous tuft of plumose setae. Some specimens have a rostrum totally devoid of marginal prominences; others bear marginal tubercles, and the smallest specimens may have subacute tubercles or spines. Either or both terminal elements of the first pleopod may be curved slightly more or slightly less than in the holotype.

**SIZE.**—The largest specimen available is a first form male from Lowndes County which possesses a carapace length of 40.8 mm, postorbital length, 32.1 mm. The corresponding lengths of the smallest first form male are 22.2 and 16.6 mm, and those of the largest female, the allotype, are 36.8 and 28.0 mm.

**LIFE HISTORY NOTES.**—First form males have been collected in both April and October, the only months during which collections have been made. Two second form males obtained on 10 April 1976 by B.A. Laning and J.F. Fitzpatrick, Jr., molted to form I in the laboratory on 17 April 1976. No ovigerous females or ones carrying young are available.

**ECOLOGICAL NOTES.**—*Orconectes chickasawae* frequents roadside ditches and sluggish streams flowing over a clay bed. Two first form males were dug from burrows in Monroe County. One of the excavations consisted of a horizontal passage at water level (probably constructed below the water before the surface had receded during a dry period) which led into a vertical one, the lower arm of which penetrated the water table to a depth of about 30 centimeters. The upper arm ascended some 60 centimeters to open through a low chimney on the inclined bank.

**RELATIONSHIPS.**—*Orconectes chickasawae*, *O. etnieri*, *O. holti*, *O. immunis*, and *O. mississippiensis* share a number of features in common: the cheliped is comparatively long, depressed, bears two or three



rows of tubercles on the mesial surface of the palm, the lateral margin of the hand is costate, and the mesial surface of the dactyl is provided with a subserrate row of tubercles extending from near base at least to midlength. These five species are the only members of the genus *Orconectes* that typically possess a distinct excision in the proximal half of the opposable margin of the dactyl. The areola is narrow to obliterated except in *O. etnieri*; the annuli ventrales of all except *O. holti* are markedly similar, and the two rami of the first pleopod of the first form male, although differing in relative length among the five, are distinctly recurved with the mesial process troughlike. *Orconectes chickasawae* differs from *O. mississippiensis* in possessing much shorter, more strongly recurved rami of the first pleopod of the first form male, the central projection constituting no more than 26.4 percent of the mesial length of the pleopod. The areola is usually broad enough to allow at least one punctation in the narrowest part, whereas in *O. mississippiensis* it is usually obliterated along part of its length. It may be distinguished from *O. immunis* by the relatively longer central projection of the first pleopod of the first form male—constituting no less than 20 percent of the length of the pleopod, whereas in *O. immunis* the central projection constitutes no more than 18 percent of the length. Furthermore, in *O. chickasawae* the central projection is never curved caudally so much as in *O. immunis* in which the apex is directed at 90 degrees to the shaft of the appendage. In *O. immunis*, the mesial surfaces of the carpus and palmar area of the propodus of the second pereopod bear mats of plumose setae which are most conspicuous in first form males; such setal mats are absent in *O. chickasawae* and *O. holti*. It differs from *O. holti* in possessing an open areola in which there is always room for one punctation in the narrowest part as opposed to being obliterated (usually) or linear along part of its length and lacking punctations in the linear area. Furthermore, rarely do adult members of the species exhibit marginal spines on the rostrum or well developed postorbital and cervical spines. It may be distinguished from *O. etnieri* in possessing an areola that is at least 16 times as long as

broad, as opposed to being less than eight, and the central projection of the first pleopod of first form males constitutes no more than 27 percent of the carapace length as opposed to 30 percent.

**CRAYFISH ASSOCIATES.**—The following species were collected in one or more of the localities frequented by *Orconectes chickasawae*: *Cambarus (D.) striatus*, *Hobbsseus cristatus* (Hobbs, 1955:95), *Procambarus (O.) a. acutus*, *P. (O.) hayi* (Faxon, 1884:108), and *P. (O.) hybus* Hobbs and Walton (1957:39).

**ETYMOLOGY.**—The name of this crayfish recognizes an important Indian tribe, the Chickasaw, which once lived in the region that is now the northern part of Mississippi.

### *Orconectes mississippiensis* (Faxon)

FIGURES 11, 12, 13

- Cambarus Mississippiensis* Faxon, 1884:123–126, 146; 1885a: 85, 86, 101–102, 104, 105, 108, 161, 168, 173, pl. III: fig. 2, pl. X: fig. 4, 4', 4a, 4a'.—Underwood, 1886:370.
- Cambarus mississippiensis*.—Hay, 1899:960, 962.—Ortmann, 1902:278, 1905:110, 111, 114, 117; 1931:90, 94.—Harris, 1903:59, 108, 138, 144, 151, 153.—Faxon, 1914:383, 422.
- Cambarus (Faxonius) mississippiensis*.—Ortmann, 1905:113.—Lyle, 1938:76.
- Faxonius mississippiensis*.—Creaser, 1933a:3 [by implication].
- Faxonius (Faxonius) mississippiensis*.—Creaser, 1933b:21 [by implication].
- Orconectes mississippiensis*.—Hobbs, 1942a:352 [by implication]; 1968:K13, K28, fig. 31e; 1972:149 [not p. 80, fig. 63a, see *O. chickasawae*]; 1974:35, fig. 161.—Penn, 1957: 236.—Fitzpatrick and Payne, 1968:20.—Payne, 1972:27.
- Orconectes (Orconectes) mississippiensis*.—Hobbs, 1942b:154 [by implication]; 1959:892.

**DIAGNOSIS.**—Body and eyes with pigment. Rostrum without median carina, acumen in adults seldom delimited basally by marginal tubercles. Areola obliterated along part of its length and comprising 28.8 to 33.2 percent of total length of carapace (38.3 to 41.8 percent of postorbital carapace length). Cervical spine small or tuberculi-form; suborbital angle at most vestigial; postorbital ridge moderately well developed with small spine or tubercle cephalically. Antennal scale approximately 2.3 times as long as wide, broadest at or distal to midlength. Chela depressed, lateral margin costate, tubercles on mesial margin forming subserrate row; fingers gaping and mesial

margin of dactyl with subserrate (in silhouette) row of tubercles along at least basal two-thirds; opposable margin of dactyl with distinct excision in proximal third. Hook on ischium of third pereopod of male. First pleopod of first form male without angular shoulder on cephalic surface, with rami almost straight proximally and curved distally, reaching midlength of coxa of second pereopod when abdomen flexed; pleopod length divisible into carapace length 2.8 to 3.2 times; terminal elements slender and subparallel; central projection constituting about 31.5 to 36.6 percent of entire length of pleopod, bladeliike, and tapering from base to caudodistally directed apex; mesial process subcylindrical in section proximally, troughlike distally, its tip directed almost caudally, and reaching about same level caudally as central projection. Annulus ventralis as figured. First pleopod present in female.

**SYNTYPIC MALE, FORM I.**—Body and eyes pigmented. Cephalothorax (Figure 11*a,k*) subovate in section; abdomen narrower than carapace (14.5 and 17.1 mm), width of latter greater than depth at caudodorsal margin of cervical groove (17.1 and 15.9 mm). Areola obliterated for some distance along cephalic half, its length constituting 29.9 percent of entire length of carapace (39.6 percent of postorbital carapace length). Rostrum with low, adpressed (particularly cephalically) borders gently converging from base to subangular contraction at base of acumen, there with minute corneous tubercle; tip of acumen reaching about midlength of ultimate podomere of antennular peduncle; upper surface of rostrum shallowly excavate with numerous small punctations. Subrostral ridge weak and barely evident in dorsal aspect from base almost to midlength of rostrum. Postorbital ridge moderately well developed, grooved dorsolaterally, and terminating cephalically in minute corneous tip. Cervical spine small; branchiostegal spine moderately well developed. Carapace punctate dorsally, rather strongly granulate laterally with larger granules concentrated cephaloventrally. Abdomen slightly shorter than carapace (35.7 and 36.5 mm); pleura well developed, with ventral borders broadly rounded; cephalic section of telson with 2 spines

in each caudolateral corner. Proximal podomere of uropod with spine on each lobe, that on lateral one very small; both rami with median keel, that on mesial ramus ending in premarginal spine.

Cephalic lobe of epistome (Figure 11*i*) with cephalomedian projection, and delimited basally by contracted base; margins irregular, distinctly angular cephalolaterally, and elevated (ventrally), ventral surface with few scattered setae; main body of epistome with median longitudinal depression in which 2 foveae present, cephalic one more conspicuous; epistomal zygoma broadly arched. Basal podomere of antennule with prominent spine on ventral surface slightly distal to midlength. Antennal peduncle with spine on lateral surface of basis and another on ventral surface of ischium. Antenna broken. Antennal scale (Figure 11*n*) 2.7 times as long as wide with greatest width distal to midlength; mesial border of lamella rounded but with suggestion of angle mesiodistally and another at level of widest part; apical spine, although broken, probably reaching level of distal extremity of antennular peduncle. Ventral surface of third maxilliped with submarginal lateral row of long, plumose setae, lateral half of surface with scattered shorter ones, mesial half with stiff hairlike setae; distolateral extremity of ischium with subacute spine.

Right chela (Figure 11*l*) strongly depressed (ratio of depth to width 0.57), subequal in length to carapace (36.2 and 36.5 mm) and 2.6 times as long as wide; thickness slightly more than three-fourths as long as areola and almost four-fifths length of mesial margin of palm; latter with 6 tubercles in mesialmost row and 5 and 3 in flanking dorsal and ventral rows, respectively (left chela with 5, 6, and 3); additional tubercles, most arranged in irregular linear series, present on mesial half of dorsal surface, also few proximal to mesial base of fixed finger, remaining dorsal and lateral surfaces punctate; ventral surface of palm with 3 marginal tubercles at base of dactyl, arclike row of 4 proximolateral to them, and 2 proximolateral to arc, remaining surface punctate. Fingers gaping, moderately prominent row of plumose setal tufts along ventral side of opposable margin of fixed finger, margin bearing row of 16

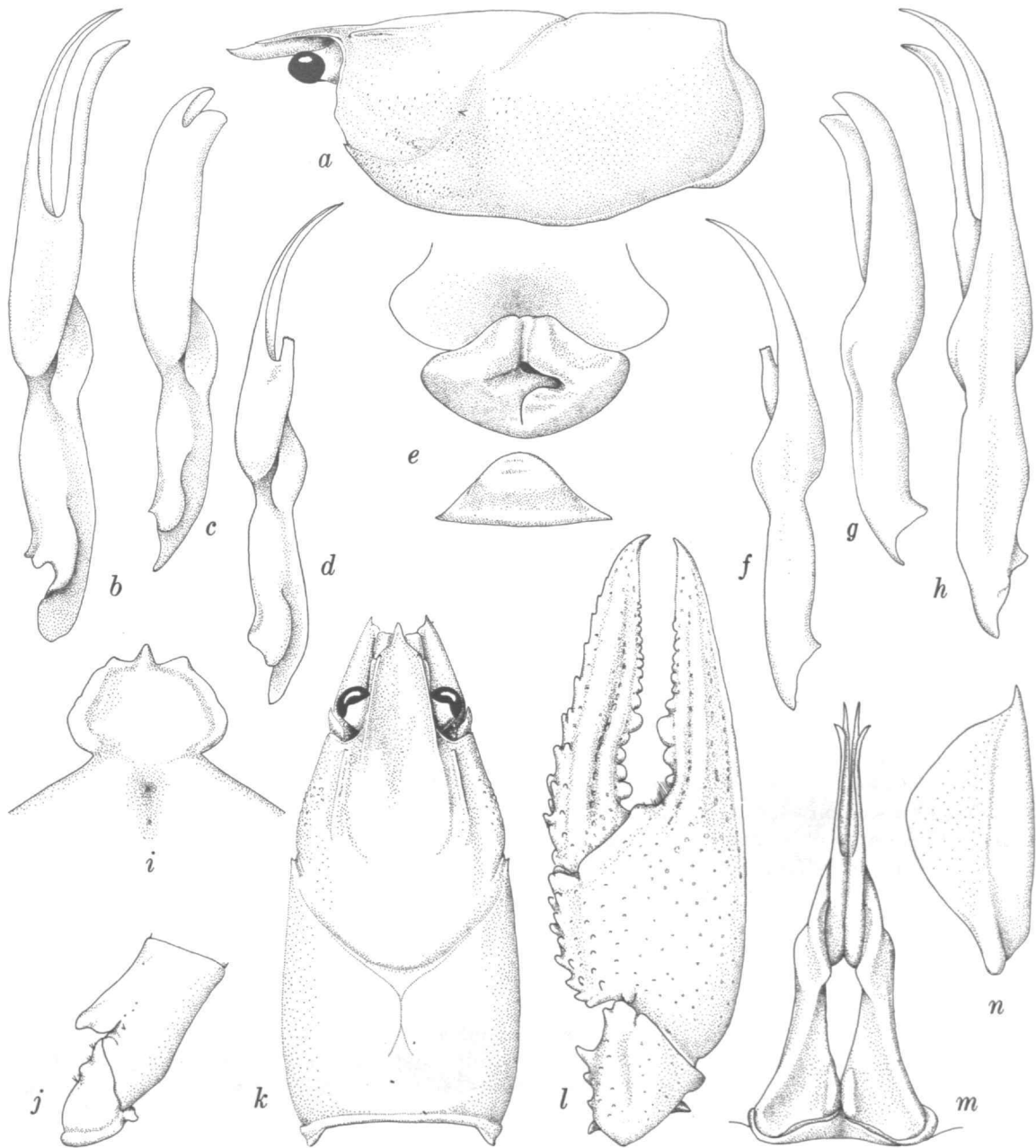


FIGURE 11.—*Orconectes mississippiensis* (all from syntypes except *b, h, m* from Wahalak Creek at U.S. Highway 45, Kemper County, Mississippi; *c, g* from ♂II, *e* from ♀, others from ♂I): *a*, lateral view of carapace; *b-d*, mesial view of first pleopod; *e*, annulus ventralis; *f-h*, lateral view of first pleopod; *i*, epistome; *j*, basis and ischium of third pereiopod; *k*, dorsal view of carapace; *l*, dorsal view of distal podomeres of cheliped; *m*, caudal view of first pleopods; *n*, antennal scale.

tubercles (fourth from base largest and distal 5 minute) and single more ventrally situated one opposite thirteenth from base, row of minute denticles extending distally from level of more ventral tubercle to corneous tip of finger; dorsal surface with prominent submedian ridge, and smaller one present immediately lateral to row of tubercles on opposable surface, ridges flanked by rows of setiferous punctations; lateral costa extending proximally along finger and onto distal half of palm; ventral surface of finger punctate with submedian longitudinal ridge. Opposable margin of dactyl with row of 18 tubercles (fifth from base largest, marking distal end of excised area of finger, and distal 5 minute) and interrupted row of minute denticles extending distally from twelfth tubercle from base to corneous tip of finger; dorsal and ventral surfaces similar to those of fixed finger; mesial surface with cluster of tubercles along basal three-fifths of finger, contracting to single row approaching distal end of finger, in silhouette those along mesialmost margin forming subserrate row. Carpus about 1.8 times as long as broad with slightly sinuous dorsal sulcus flanked mesially by small tubercles and laterally by setiferous punctations; mesial surface with prominent spikelike tubercle, 2 smaller ones proximal to it, and another, more dorsally situated, lying proximomesial to articular eminence; ventral surface with 2 marginal tubercles, 1 on condyle, other submedian; 5 additional tubercles situated ventromesially. Dorsal surface of merus with 2 acute tubercles near distal end and 2 smaller ones proximal to them; ventral surface with lateral and mesial rows of 10 and 11 tubercles respectively; distolateral apophysis with spiniform tubercle, and few additional ones between rows. Ventromesial margin of ischium with 4 small tubercles.

Ischium of third pereiopod (Figure 11j) with simple hook, appearing almost bituberculate, overreaching basioischial articulation and opposed by tubercle on basis; hook heavy with broadly rounded distal extremity. Ventral membrane on coxa of fifth pereiopod studded with short setae.

First pleopods (Figure 11d,f, from syntypic male, form I; b,h,m, from male, form I, from

Kemper County, Mississippi) symmetrical and reaching coxa of second pereiopod when abdomen flexed. (See "Diagnosis" for description.)

SYNTYPIC FEMALE (USNM 19760).—Differing from syntypic male, form I, in following respects: marginal spines present on rostrum; acumen reaching end of ultimate podomere of antennular peduncle; postorbital ridge ending cephalically in well developed spine; lateral surface of carapace much less granular; left antennal scale broadest almost at midlength. (Chela regenerated; following notes based on specimen collected from roadside ditch off U.S. Hwy 82 about 1 mile [1.6 km] east of Clayton Village [Starkville], Oktibbeha County, Mississippi.) Ratio of depth to width of chela 0.60, distinctly shorter than carapace (24.5 and 31.8 mm); mesial surface of palm with 4 tubercles in ventral row, 6 in middle, and 4 in dorsal; tubercles on ventral surface of palm differing in absence of 2 proximolateral ones and presence of 2 between margin and arclike row; opposable margin of fixed finger with row of 12 tubercles (sixth from base largest), large tubercle situated more ventrally between tenth and eleventh tubercles; opposable surface of dactyl with row of 13 tubercles (fourth from base largest); ventrolateral row of only 6 tubercles on merus; ventromesial margin of ischium with only 2 tubercles. (See Table 6.)

Annulus ventralis (Figure 11e) firmly but not inflexibly fused to sternum, somewhat diamond shaped in outline, about 1.6 times as broad as long; cephalomedian trough flanked by high ridges flaring laterally at about midlength of annulus where forming cephalic wall of centrally located depression; sinus originating at cephalomedian side of depression, extending caudosinistrally, and, after making hairpin curve and bending caudodextrally to median line, extending caudally before ending on caudal wall; tongue extending sinistrally. Postannular sclerite about 2.5 times as broad as long, slightly more than four-fifths as wide as annulus and about one-half as long. First pleopod reaching almost midlength of annulus when abdomen flexed.

SYNTYPIC MALE, FORM II.—Differing from syntypic male, form I, in following respects: rostrum

TABLE 6.—Measurements (in mm) of *Orconectes mississippiensis* (Faxon)

Characters	<i>Syntypic male Form I</i>	<i>Syntypic female</i>	<i>Syntypic male Form II</i>
Carapace			
Total length	36.5	32.3	31.0
Postorbital length	27.5	24.6	23.5
Height	15.9	14.6	13.6
Width	17.1	14.9	13.8
Areola			
Width	0	0	0
Length	10.9	10.0	9.4
Rostrum			
Width	5.7	5.5	5.2
Length	9.7	9.1	8.6
Chela			
Length of mesial margin of palm	10.0	6.3*	(left)6.5
Width of palm	13.8	10.1*	9.2
Depth of palm	7.9	6.1*	5.5
Length of lateral margin	36.2	24.5*	24.5
Length of dactyl	23.6	16.2*	16.4
Abdomen			
Width	14.5	13.9	13.0
Length	35.7	33.7	31.3

\* From female collected 1 mile E of Clayton Village (Starkville), Mississippi, chela of which described herein; carapace lengths 31.8 (25.2) mm.

with marginal spines; postorbital ridge with spine cephalically; chela with ratio of depth to width 0.60, length less than that of carapace (24.5 and 31.0 mm); mesial surface of palm of chela with 5 tubercles in ventralmost row, none proximal to arc of tubercles on ventral surface; opposable margin of fixed finger of chela with row of 13 tubercles, and single tubercle located more ventrally, between tenth and eleventh of row; opposable margin of dactyl with row of 19 tubercles; merus with ventrolateral row of 8; hook on ischium of third pereopod reduced, not overreaching basioischial articulation. First pleopod (Figure 11c,g) with more robust rami, and cleft between conspicuously shorter. (See Table 6.)

COLOR NOTES.—Carapace with pale gray to tan background fading to cream ventrally, and marked with brown or dark gray splotches and flecks. Most conspicuous markings consisting of small paired brownish-black spots situated short

distance caudodorsal to cervical spine (or tubercle), large dark brown splotch with sinuous dorsal margin extending from cervical groove over most of hepatic area, reaching gastric region and continuing cephalically along ventral edge of postorbital ridge to orbit; antennal area white; moderately large paired oblique (diverging posterolaterally) brown spots flanking obliterated part of areola; caudodorsal area of branchiostegites with paired dark brown subrectangular markings bleeding ventrally along caudolateral margin of carapace. Abdomen with paired broken linear series of dark brown splotches dorsolaterally, 1 pair on each tergum: that on first largest and subrectangular, succeeding ones becoming smaller, more triangular, and paler; linear series of similarly colored scallops present along bases of pleura, each of latter very pale cephaloventrally. Telson with paired dark spots cephalolaterally and at base of marginal spines; otherwise,

it and uropods with slightly lighter maculations. Distal podomeres of antennular and antennal peduncles with dark brown markings; antennal scale with dark brown stripe laterally and another on lamellar area immediately mesial to thickened lateral part. Cheliped with dorsal surface of distal part of merus through dactyl tan or gray with dark brown or almost black markings, most of which small and subcircular; palm with conspicuously larger irregular splotches near proximo-dorsal articular condyle, another along distomesial ridge, and 2 large ones proximal to mesial base of fixed finger; fingers with large dark splotches proximal to midlength, and corneous tips preceded by reddish band. Remaining pereopods from merus through propodus banded with dark markings.

**TYPE-LOCALITY.**—Eastern Mississippi. Restricted to Macon, Noxubee County, Mississippi, by Faxon (1914:422). Label on USNM 19759 bears in Faxon's hand writing "Eastern Mississippi"; that on USNM 19760, "Macon, Miss."

**TYPES.**—Syntypes, National Museum of Natural History, Smithsonian Institution, 19760 (♂I, ♀), 19759 (♂II, ♀); Museum of Comparative Zoology, 3563 (♀).

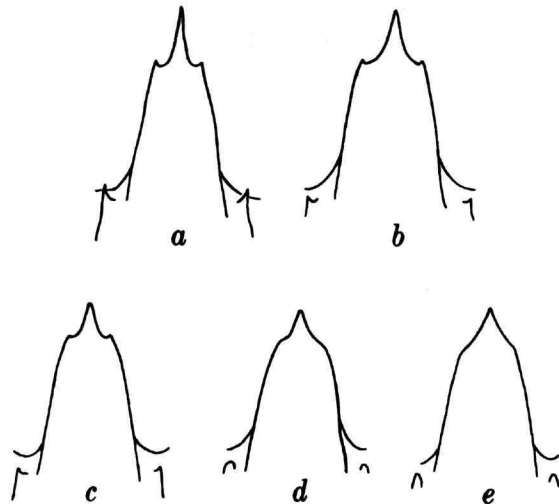


FIGURE 12.—Rostra of *Orconectes mississippiensis* from Sand Creek, Oktibbeha County, Mississippi: a, juvenile; b–e, adult male.

**RANGE AND SPECIMENS EXAMINED.**—Records of this crayfish are limited to the Prairie Section of the Noxubee River basin and in other tributary systems of the Tombigbee River northward to the Catalpa Creek basin in Kemper, Noxubee, Lowndes, and Oktibbeha counties, Mississippi. We have examined 566 specimens (in 52 lots) from 25 localities. All except the following are in the Sand Creek watershed in Lowndes and Oktibbeha counties.

**KEMPER COUNTY:** (1) Wahalak Creek, 3.5 mi (5.6 km) S of Noxubee County line on U.S. Hwy 45 (T 12N, R 17E, Sec 12, 13), 1♂I, 1♂II, 1♀, 14 Apr 1954, J. E. Pugh, S. R. Telford, and HHH, coll. **LOWNDES COUNTY:** (2) Oak Slough Creek, 3.3 mi (5.3 km) NW of U.S. Hwy 82-45, about 6 airmi W of Columbus (T 19N, R 17E, Sec 15, 22), 1♂I, 3♂II, 5♀, 29 June 1966, J. F. Payne and S. Chien; (3) Big Ditch Creek, about 1 mi (1.6 km) NNE of Togo (T 17N, R 18E, Sec 35), 1j♀, 16 June 1972, H. T. Boschung; (4) McCowers Creek, about 8 airmi (12.8 km) SSW of Columbus (T 17N, R 18E, Sec 5), 7j♂, 10j♀, 29 June 1966, JFP and SC. **NOXUBEE COUNTY:** (5) Tributary to Wahalak Creek, on U.S. Hwy 45 just N of Kemper County line (T 13N, R 17E, Sec 35), 1j♂, 17 Oct 1966, JFP and SC; (6) 0.9 mi (1.4 km) N of Shuqualak on U.S. Hwy 45 (T 13N, R 17E, Sec 9), 2♂II, 19 Mar 1966, J. F. Fitzpatrick, Jr., L. E. Fleming, and JFP; (7) Bogue Chitto Creek, about 1.5 airmi (2.4 km) N of Dinsmore (T 15N, R 19E, Sec 33), 1j♂, 2j♀, 16 June 1972, HTB; (8) Horse Hunters Creek, 4.7 mi (7.5 km) SE of Brooksville (T 16N, R 17E), 1j♂, 1j♀, 22 Jul 1931, E. P. Creaser. **OKTIBBEHA COUNTY:** (9) Woodland Pond near Rock Hill Community, about 4.5 mi (7.2 km) N of Starkville (T 19N, R 14E, Sec 1), 1♀, 7j♂, 2j♀, 4 Jul 1967, JFP; (10) Tributary to Catalpa Creek, about 1.5 airmi (2.4 km) SE of Sessums (T 18N, R 15E, Sec 23, 26), 1♂I, 7♂II, 2♀, 25 Mar 1972, HTB.

**VARIATIONS.**—The most conspicuous variations noted are in the presence or absence of spines on the rostrum and postorbital ridges (Figure 12) and the relative size of the cervical spine. In many juveniles and some adults, small marginal spines are present on the rostrum, but in most of the larger adults they may be entirely lacking or are represented by only an angle at the base of the acumen. Similarly, the spines on the postorbital ridges and the cervical spines are usually reduced to small tubercles or are virtually obsolete. The areola is typically obliterated along part of its length, but in occasional specimens it is linear, although never have we observed punctations in the narrowest part. Variations in the antennal

scale are depicted in Figures 11*n* and 13. (See "Diagnosis" for ranges of variation in morphometric features.)

SIZE.—The largest available specimen is a first form male having a carapace length of 37.4 mm (postorbital carapace length, 29.1 mm). The

smallest first form male has corresponding lengths of 22.6 and 17.2 mm, and those of the smallest ovigerous female 24.3 and 18.0 mm.

LIFE HISTORY NOTES.—Collections (other than of two small juveniles) are available only from March to July. First form males were found from

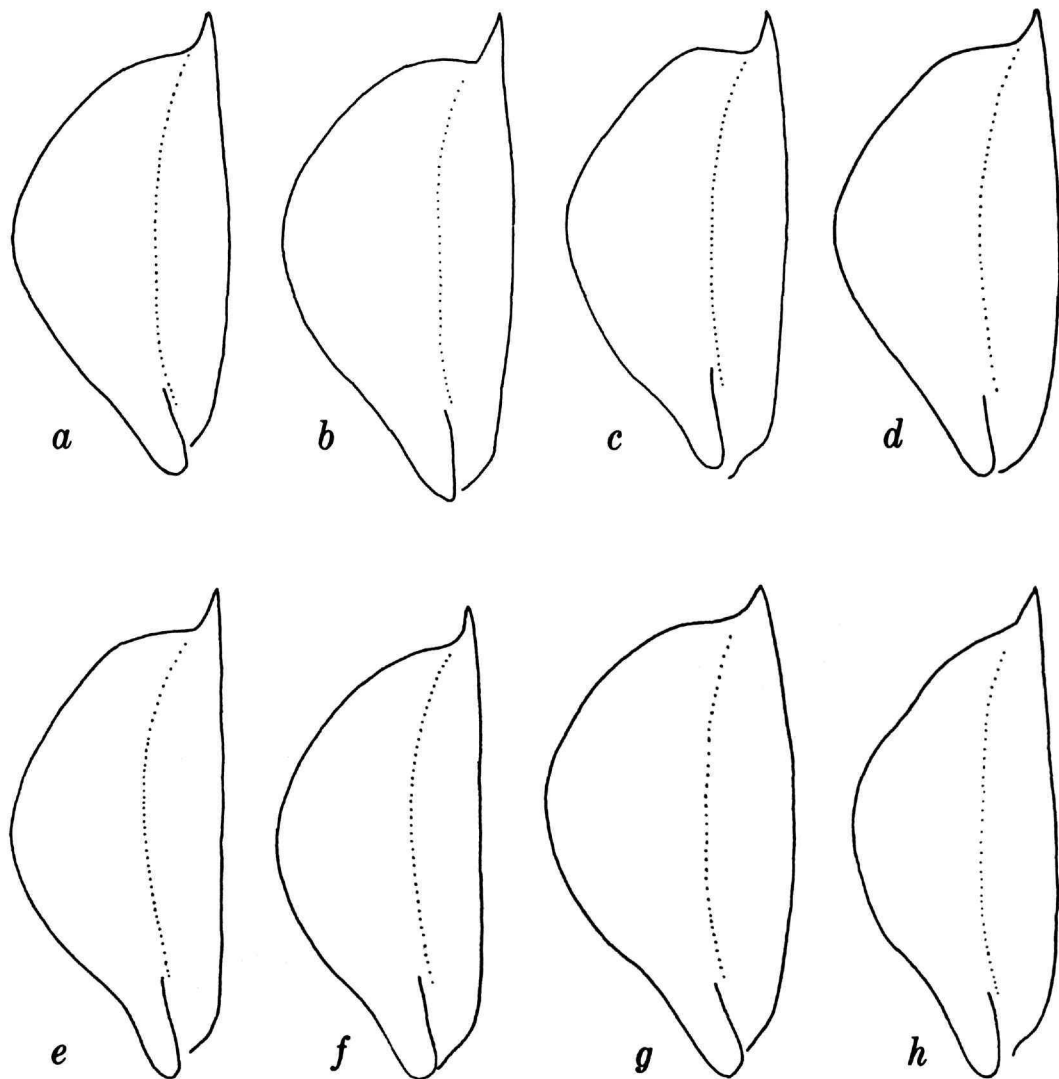


FIGURE 13.—Antennal scales of *Orconectes mississippiensis*: *a, b*, tributary to Catalpa Creek, Oktibbeha County, Mississippi; *c*, 1 mi (1.6 km) E of Clayton Village, Starkville, Oktibbeha County; *d*, Oak Slough Creek, Lowndes County, Mississippi; *e*, 2.4 mi (3.8 km) S of Mayhew Junction on St Rte 45, Lowndes County; *f*, Horse Hunters Creek, Noxubee County, Mississippi; *g, h*, Wahalak Creek, Kemper County, Mississippi.

March to June, and three ovigerous females were collected in March. Data on the ovigerous females are as follows:

<i>Carapace length and (postorbital carapace length) (in mm)</i>	<i>Number of eggs</i>	<i>Diameter of eggs (in mm)</i>
27.8 (21.2)	289	1.8-1.9
27.5 (21.6)	77	1.8-1.9
24.2 (17.9)	119	1.4-1.5

ECOLOGICAL NOTES.—This crayfish has been

found in sluggish to moderately flowing streams, roadside ditches, and woodland ponds.

RELATIONSHIPS.—*Orconectes mississippiensis* has its closest relatives in *O. chickasawae*, *O. etnieri*, *O. holti*, and *O. immunis*. See "Relationships" under *Orconectes chickasawae*.

CRAYFISH ASSOCIATES.—Collected with *Orconectes mississippiensis* in one or more localities were *Cambarus (D.) striatus*, *Fallicambarus (C.)* sp., *Hobbseus orconectoides* Fitzpatrick and Payne (1968: 17), *Procambarus (O.) acutissimus*, and *P. (O.) hayi*.



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**Front matter** (preceding the text) should include: **title page** with only title and author and no other information, **abstract page** with author/title/series/etc., following the established format, **table of contents** with indents reflecting the heads and structure of the paper.

**First page of text** should carry the title and author at the top of the page and an unnumbered footnote at the bottom consisting of author's name and professional mailing address.

**Center heads** of whatever level should be typed with initial caps of major words, with extra space above and below the head, but with no other preparation (such as all caps or underline). Run-in paragraph heads should use period/dashes or colons as necessary.

**Tabulations** within text (lists of data, often in parallel columns) can be typed on the text page where they occur, but they should not contain rules or formal, numbered table heads.

**Formal tables** (numbered, with table heads, boxheads, stubs, rules) should be submitted as camera copy, but the author must contact the series section of the Press for editorial attention and preparation assistance before final typing of this matter.

**Taxonomic keys** in natural history papers should use the aligned-couplet form in the zoology and paleobiology series and the multi-level indent form in the botany series. If cross-referencing is required between key and text, do not include page references within the key, but number the keyed-out taxa with their corresponding heads in the text.

**Synonymy** in the zoology and paleobiology series must use the short form (taxon, author, year:page), with a full reference at the end of the paper under "Literature Cited." For the botany series, the long form (taxon, author, abbreviated journal or book title, volume, page, year, with no reference in the "Literature Cited") is optional.

**Footnotes**, when few in number, whether annotative or bibliographic, should be typed at the bottom of the text page on which the reference occurs. Extensive notes must appear at the end of the text in a notes section. If bibliographic footnotes are required, use the short form (author/brief title/page) with the full reference in the bibliography.

**Text-reference system** (author/year/page within the text, with the full reference in a "Literature Cited" at the end of the text) must be used in place of bibliographic footnotes in all scientific series and is strongly recommended in the history and technology series: "(Jones, 1910:122)" or ". . . Jones (1910:122)."

**Bibliography**, depending upon use, is termed "References," "Selected References," or "Literature Cited." Spell out book, journal, and article titles, using initial caps in all major words. For capitalization of titles in foreign languages, follow the national practice of each language. Underline (for italics) book and journal titles. Use the colon-parentheses system for volume/number/page citations: "10(2):5-9." For alinement and arrangement of elements, follow the format of the series for which the manuscript is intended.

**Legends** for illustrations must not be attached to the art nor included within the text but must be submitted at the end of the manuscript—with as many legends typed, double-spaced, to a page as convenient.

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**A few points of style:** (1) Do not use periods after such abbreviations as "mm, ft, yds, USNM, NNE, AM, BC." (2) Use hyphens in spelled-out fractions: "two-thirds." (3) Spell out numbers "one" through "nine" in expository text, but use numerals in all other cases if possible. (4) Use the metric system of measurement, where possible, instead of the English system. (5) Use the decimal system, where possible, in place of fractions. (6) Use day/month/year sequence for dates: "9 April 1976." (7) For months in tabular listings or data sections, use three-letter abbreviations with no periods: "Jan, Mar, Jun," etc.

**Arrange and paginate sequentially EVERY sheet of manuscript**—including ALL front matter and ALL legends, etc., at the back of the text—in the following order: (1) title page, (2) abstract, (3) table of contents, (4) foreword and/or preface, (5) text, (6) appendixes, (7) notes, (8) glossary, (9) bibliography, (10) index, (11) legends.

