

NEW TROGLOBITIC CRAYFISH OF THE GENUS *ORCONNECTES*, SUBGENUS *ORCONNECTES* (DECAPODA: CAMBARIDAE), ENDEMIC TO SHELTA CAVE, HUNTSVILLE, ALABAMA

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Orconectes (Orconectes) sheltae is a new species of troglotic crayfish endemic to Shelta Cave, Huntsville, Alabama, where it is the smallest and rarest member of a subterranean crayfish triad that includes *O. (O.) a. australis* and *Cambarus (A.) jonesi*. The new species may be distinguished from all other members of the subgenus by a combination of: (1) the absence of first pleopods in the female, (2) a broad median trough in the annulus, (3) the narrow, elongate chela of the cheliped, with its very long palm and subvertical orientation, (4) the length, conformation, and orientation of the terminal elements of the form I male gonopod (first pleopod), and (5) the lack of prominent spines on the mesial margin of the carpus. The mature oocytes of *O. sheltae* are large and few (8-12), and the young at recruitment may be larger than those of *O. a. australis* and *C. jonesi*.

The first troglotic crayfish reported in the literature was *Astacus pellucidus* [= *Orconectes (Orconectes) pellucidus* (Tellkamp)], described in 1844 from Mammoth Cave, Kentucky. Since then, 35 additional troglotic taxa have been described, 5 of them in the genus *Orconectes*: *Orconectes (Orconectes) australis australis* (Rhoades), *Orconectes (Orconectes) australis packardi* Rhoades, *Orconectes (Orconectes) incomptus* Hobbs and Barr, *Orconectes (Orconectes) inermis inermis* Cope, and *Orconectes (Orconectes) inermis testii* (Hay). Hobbs et al. (1977) provided an excellent review of all the species and subspecies of troglotic decapods known from the Americas as of 1975 (8 of the 36 crayfishes were described between 1976 and 1993).

Within the genus *Orconectes*, 5 of the 6 troglotites variably have been treated as closely related species or as subspecies in one combination or another, making up a complex generally considered to display the most plesiomorphic characters seen in the genus. Hobbs and Barr (1972) provided the current nomenclature and classification, and erected a *Pellucidus* Section of the genus for all six taxa, then Fitzpatrick (1987) brought them together in the subgenus *Orconectes*. On the basis of the number of plesiomorphies displayed by the members of the subgenus, Fitzpatrick (1987: 63) expressed the opinion that it is "close to the stem population from which the genus descended." Monophyly of the genus *Orconectes* has recently been questioned (Crandall & Fitzpatrick, 1996; Fetzner, 1996), but no nomenclatorial changes have yet resulted from these studies.

Shelta Cave has long been known to harbor populations of two species of troglotic crayfishes. It is the type locality of

O. a. australis, described as *Cambarus (Faxonius) pellucidus australis* (Rhoades, 1941), and was the first reported locality for specimens of *Cambarus (Aviticambarus) jonesi* Hobbs and Barr, which Rhoades (1941: 148) tentatively had identified as "??*Cambarus (Cambarus) hamulatus* (Cope)." The surprising presence of a third species in the cave was discovered serendipitously on 24 August 1963 when we made a random collection of 7 crayfish for experimental studies that MRC was conducting in the laboratory of Thomas L. Poulson at Yale University. Four of the seven turned out to be specimens of this new species. In the light of our subsequent efforts to obtain more material for its description, and considering what we later discovered about the rarity of the animal, it is remarkable that this crayfish made up 57% of our initial collection. In 9 other trips to the cave between 22 December 1963 and 7 July 1968, usually involving up to 8 hours per visit spent in intensive searching, we collected only 15 additional specimens and observed 3 others. Seventeen of the collected specimens comprise the type series, but some data also were obtained from 97 other individuals that were examined, marked, and released during an ecological study of Shelta's crayfishes conducted between November 1968 and July 1975 (Cooper, 1975).

ORCONNECTES (ORCONNECTES) SHELTAE, NEW SPECIES

Figures 1, 2A; Table 1

Three new species. —Cooper and Cooper, 1966: 39 (in part); Cooper, 1967: 14 (in part).

Rare endemic form. —Cooper, 1968a: 34.

New *Orconectes*. —Cooper and Cooper, 1968: 23.

New species. —French, 1968: 31.

Undescribed *Orconectes*. –Hobbs, 1969: 130; Rheams et al., 1994: 65.

Troglobitic crayfishes. –Cooper and Cooper, 1971: 30 (in part); Cooper and Cooper, 1976: 52 (in part).

Orconectes? sp.; *O.* sp.; new species. –Cooper, 1974: 5.

Two smaller species. –Cooper and Cooper, 1976: 52 (in part).

Cambarus (Aviticambarus) sp. B. –Bouchard, 1976: 14, 17.

Two crayfishes of subgenus *Aviticambarus* (genus *Cambarus*). –Hobbs et al., 1977: 5 (in part).

Two undescribed troglobites. –Hobbs et al., 1977: 75 (in part).

Three troglobitic crayfishes. –Cooper and Cooper, 1977: 44 (in part).

Undescribed form. –Cooper and Cooper, 1977: 44.

Undescribed species. –Cooper and Cooper, 1978: 44.

Two *Aviticambarus*. –Culver, 1982: 51 (in part; incorrect usage of generic name from unpublished source).

Aviticambarus sheltae. –Culver, 1982: 65 (nomen nudum; incorrect usage of genus and species names from unpublished source).

C. (A.) sp. B. –Fitzpatrick, 1990: 78.

Orconectes sp. –Hobbs, 1992: 93.

The above is a selected synonymy, including only references that have appeared in the literature; no citations from dissertations, or from open-file and similar reports, are included.

Diagnosis—Albinistic; eyes reduced, unpigmented, recessed. Rostrum acarinate, with narrow, subparallel to moderately converging margins and strong marginal spines delimiting base of acumen; latter comprising 33.3 to 43.2 (mean = 39.0) percent of rostrum length, which constituting 22.8 to 26.1 (mean = 24.5) percent of total carapace length (TCL); floor (dorsal surface) of rostrum deeply excavate, margins elevated. Areola 3.5 to 7.0 (mean = 4.9) times as long as wide, constituting 39.6 to 42.4 (mean = 41.2) percent of TCL and 53.5 to 55.9 (mean = 54.4) percent of postorbital carapace length (PCL), with 5 to 8 (usually 6) punctations across narrowest part. Total carapace length 1.5 times length of cephalic section of cephalothorax. Cervical spines strong, 1 to 3 (usually 2) each side of carapace. Branchiostegal spine relatively strong, acute; hepatic area with small, scattered tubercles. Suborbital angle absent; portorbital ridge moderately strong, groove nearly obsolete, cephalic margin with strong spine. Antennal scale 2.2 times as long as wide, lateral margin thickened and terminating distally in long spine.

Chela of cheliped attenuated, nearly vertically oriented; palm subovate in cross-section, 2.8 to 3.6 (mean = 3.1) times as long as wide, length comprising 44.2 to 49.5 (mean = 46.7) percent of chela length, mesial margin with 2 to 3 rows of minute tubercles. Fingers not gaping, without tuft of plumose setae at base of opposable margin of fixed finger. Carpus of cheliped devoid of strong spines or tubercles on mesial surface.

Hook on ischium of third pereiopod of male, that of form I

male slightly overreaching basioischial articulation, not opposed by tubercle on corresponding basis. Coxa of fourth pereiopod with prominent caudomesial boss. Gonopods (first pleopods) of form I male symmetrical, proximomesial apophyses separated; length of gonopod approximately 23% of TCL, tip reaching to about midlength of coxa of third pereiopod when abdomen flexed. Gonopod in lateral aspect without shoulder at base of central projection, but with pronounced, cephalomesially-folded convexity along cephalodistal margin near base of central projection; greatest cephalocaudal diameter of shaft more than twice that immediately proximal to base of central projection; terminal elements constituting approximately 12% of gonopod length, both inclined caudadistally, mesial process more strongly inclined of two; central projection corneous, subconical in lateral aspect, tip directed mesially at about 43° and caudally from 47 to 62°; axis of central projection twisted and element flattened in cephalocaudal plane, with lateral margin thickened and mesial portion a thin, transparent, winglike extension; distal margin symmetrically concave; mesial process noncorneous, robust, tapering from broad base to subacute tip, which directed caudally about 35° and laterally about 50°; process moderately constricted and more strongly tilted caudadistally at base of distal two-thirds and, in caudal aspect, obscuring proximolateral margin of central projection; in mesial aspect, bases of terminal elements separated by cleft, surface of gonopod without setae.

Female lacking first pleopod, position indicated by very slight thickening of sclerite on either side. Annulus ventralis with median one-third of cephalic margin arched, entire, usually clearly delimited but fused with preannular sternite; caudal margin slightly movable; annulus about 1.5 times wider than long, with longitudinal ridge on each side of midline, ridges separated by shallow median trough occupying cephalic four-fifths of annulus length and about one-fifth of annulus width; trough and ridges originating near cephalic margin, descending caudally with little or no curvature through cephalic three-fifths before gently curving caudodextrally. Arlike sinus originating near caudomedian margin and following oblique, curved path dextrally within caudal one-fifth of annulus, ending in small, deep fossa; indistinct continuation of sinus directed for short distance cephalosinistrally from dextral extremity of fossa, partly shielded by ridge forming dextral wall of trough; caudal margin of annulus on either side of sinus with narrow, slightly elevated rim. Postannular sclerite subovoid, with broad, transverse ventral ridge, sclerite about 4 times as wide as long, width 35.0% of annulus width. Preannular sternite with narrow, tapered mesial surfaces, subacute ventral angles, and broad, concave cephalolateral margins.

Measurements of type specimens provided in Table 1.

Holotypic male, form I—Albinistic; eyes reduced, recessed, without pigment. Cephalothorax (Figures 1A,D; 2A) subcylindrical, thoracic region slightly depressed dorsally; carapace 1.3 times wider than depth at caudodorsal margin of cervical groove, slightly wider than abdomen. Areola 5.2 times longer than wide, occupying 18.1% of carapace width at nar-

Table 1. Measurements (mm) of types, *Orconectes (O.) sheltae*, new species.

	Holotype	Allotype	Morphotype
Carapace			
Total length	16.1	17.1	19.7
Postorbital length	12.4	13.9	15.5
Length cephalic section	9.3	10.2	11.4
Width	7.2	7.8	8.5
Depth	5.5	6.1	6.5
Rostrum			
Length	4.2	4.4	4.5
Width at base	1.8	2.1	2.4
Length acumen	1.4	1.9	1.8
Areola			
Length	6.8	7.5	8.3
Width	1.3	1.4	1.9
Antennal scale			
Length	3.7	3.7	4.0
Width	1.7	1.7	1.8
Abdomen			
Length	20.1	20.2	22.1
Width	5.7	6.4	6.6
Cheliped			
Length lateral margin chela	11.5	9.3	10.9*
Length mesial margin palm	5.4	4.4	5.4*
Width palm	1.9	1.5	1.5*
Depth palm	1.7	1.3	1.3*
Length dactyl	6.0	5.1	5.6*
Length carpus	3.4	2.4	3.3*
Width carpus	1.6	1.3	1.5*
Length dorsal margin merus	8.0	7.3	7.9*
Depth merus	1.7	1.5	1.6*
Gonopod length	3.9		4.2

* Left cheliped; right regenerate.

rowest part, where with 7 punctations across; areola length 42.2% of TCL (54.8% of PCL). Cephalic section of cephalothorax comprising 57.8% of TCL. Rostrum constituting 26.1% of TCL, acarinate, margins narrow and slightly converging to bases of strong marginal spines; rostrum deeply excavate, margins well elevated and with rows of setae mesial and lateral to margin, mesial row continuing cephalically from marginal spines; floor of rostrum slightly concave, with scattered setiferous punctations; acumen slender, length 33.3% of rostrum length, distal one-fourth curving cephalodorsally in lateral aspect and apex extending nearly to distal margin of first article of antennular flagellum; subrostral ridges narrowly visible to bases of marginal spines. Postorbital ridge with nearly obsolete groove bearing setiferous punctations, cephalic margin with strong spine. Suborbital angle absent, margin of orbital rim oblique, somewhat uneven. Cervical spines strong, 2 each side, ventralmost largest. Branchiostegal spine small, acute; hepatic region with small, scattered tubercles. Carapace with fine, setiferous punctations dorsally, fine granules laterally; ventral margin of cephalic portion of cervical groove with small tubercles, groove continuous; cephalolater-

al branchiostegal region with small bulbous protrusion just ventral to cervical spine.

Antennal peduncle with strong cephalolateral spine on basis, weaker, semi-erect ventral spine on ischium, and rounded boss at ventromesial margin of coxa; antennular peduncle with small spine near mesial margin of ventral surface at base of distal one-fourth of proximal podomere, ventral and mesial margins of podomere devoid of setae. External flagellum of antennule longer and broader than internal one; antennal flagellum 44 mm long, tip extending well beyond caudal margin of telson when flagellum adpressed. Antennal scale (Figure 1L) 2.2 times longer than wide; lateral margin thickened, curved, and with long distal spine, tip of which reaching distal margin of first article of antennular flagellum; lamella of scale about twice as wide as thickened lateral portion; distal margin of lamella subtransverse, then curving to widest part just distal to midlength; mesial margin broadly rounded before tapering to base.

Abdomen longer than TCL, latter 80.1% of abdomen length; abdomen width 79.2% of carapace width; second through fifth abdominal pleura with curved cephaloventral margins, rectilinear caudoventral margins, and very acute caudoventral angles. Proximal podomere of uropod with small spine on lateral lobe, larger spine on mesial lobe; cephalic section of lateral ramus of uropod with broad, foreshortened median ridge devoid of caudal spine, mesial ramus with strong caudolateral spine, and low, foreshortened median ridge without distal spine. Cephalic section of telson with 2 strong spines each caudolateral corner, mesialmost one moveable; transverse suture of telson obsolete, caudal margin domelike. Dorsal surfaces of uropods and telson with sparse setae.

Epistome (Figure 1H) with cephalic lobe broader than long, cephalic and cephalolateral margins thickened, generally semicircular but somewhat undulant in outline, devoid of cephalomedian projection; caudolateral apices slightly thickened, not flared; floor (ventral surface) of cephalic lobe essentially flat, moderately punctate, caudal margin broadly V-shaped and apex penetrating fovea of body; lamellae mostly glabrous, strongly tapering and subacute laterally, with tubercle at caudolateral corner; lamellae with shallow sulcus and moundlike cephalomesial convexity on each side of midline; zygoma weakly arched.

Third maxilliped with tip reaching distal margin of ultimate podomere of antennal peduncle; tip of exopodite reaching midlength of merus of endopodite, and basal podomere of exopodite not hirsute; cephalolateral corner of ischium slightly produced; lateral ridge of ischium subtended mesially by row of minuscule punctations bearing sparse, short setae; ventrolateral half of ischium with row of punctations along mesial border and scattered punctations elsewhere, ventromesial half with long, dense setae, and mesial margin with about 23 (mostly minute) denticles on right. Mandible with 7 denticles on right incisor ridge, 6 on left.

Chela of cheliped (Figures 1M, 2A) attenuated, subvertically oriented, 6.1 times longer than wide, length 71.4% of

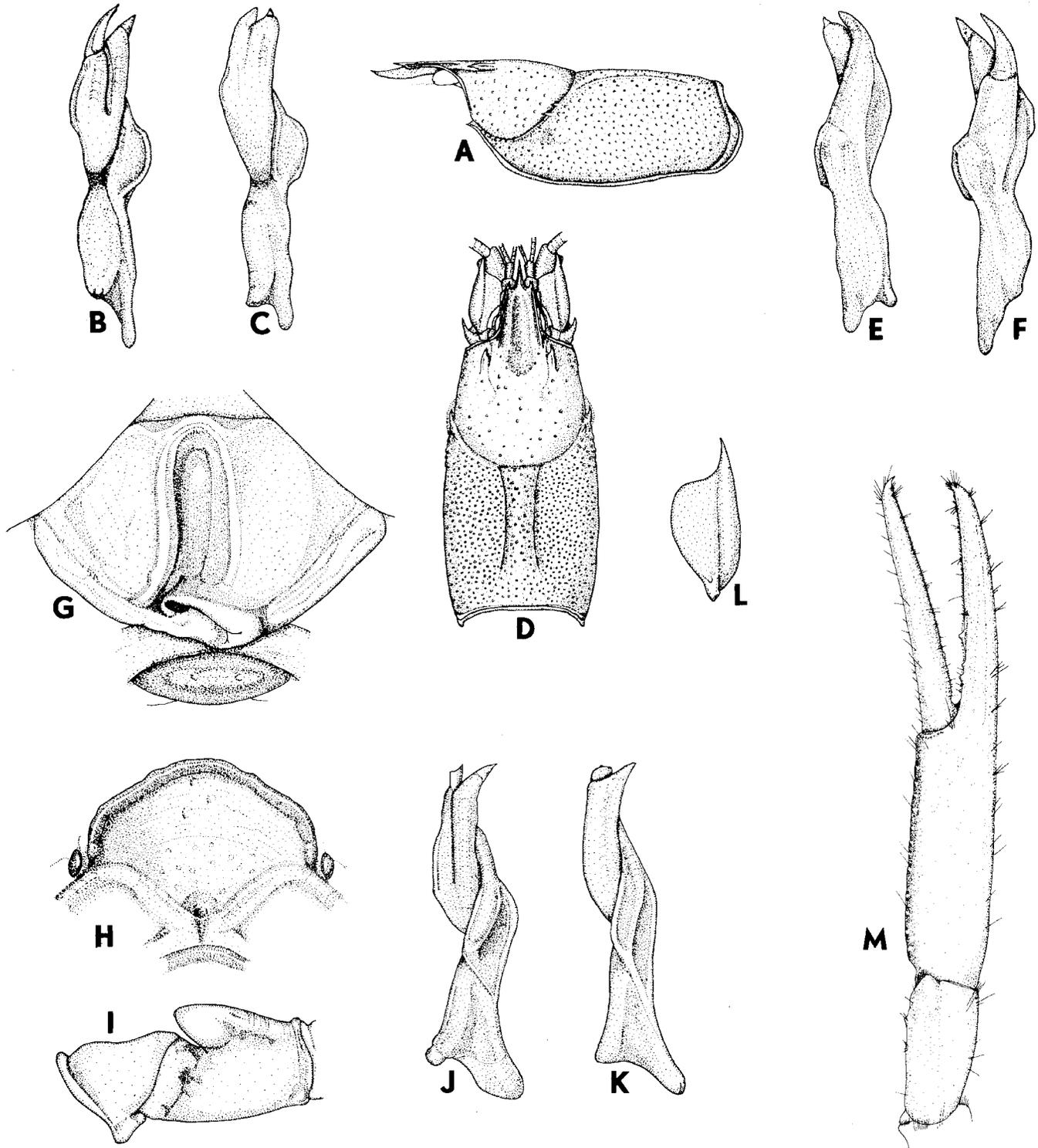


Figure 1. *Orconectes (Orconectes) sheltae*, new species (all from holotypic male, form I, except C, E, K, from morphotypic male, form II, and G from allotypic female; setae illustrated only in M): A, lateral aspect of carapace; B, C, mesial aspect of gonopod (first pleopod); D, dorsal aspect of carapace; E, F, lateral aspect of gonopod; G, annulus ventralis and postantennular sclerite; H, epistome; I, basal podomeres of third pereopod; J, K, caudal aspect of gonopod; L, antennal scale; M, distal podomeres of cheliped.

TCL; palm subovate, 1.1 times wider than deep; dorsal surface with small punctations, some minute squamous tubercles, short recumbent setae, and sparse tufts of long, erect setae; distal articular ridges of palm nearly obsolete dorsally and ventrally, with weak mesial eminence; ventrolateral eminence devoid of tubercle; lateral margin of palm rounded, punctate, with longer recumbent setae and several minuscule tubercles, each with 1 or 2 long setae; mesial margin of palm with row of about 12 minute tubercles, flanked each side by irregular row of minuscule tubercles. Fingers long, thin, curving slightly distoventrally, both subtriangular in cross-section. Fixed finger with moderate longitudinal ridges dorsally and ventrally, ridges flanked each side by row of punctations, surfaces covered with short, recumbent setae; lateral margin of finger punctate; opposable margin with prominent subconical tubercle ventral to denticles at base of distal two-thirds of finger, and 2 prominent tubercles proximal to subconical one; denticles in single row along entire opposable margin. Dactyl with moderate longitudinal ridges dorsally and ventrally, ridges flanked each side by row of punctations, surfaces covered with short, recumbent setae; rows of long, sparse, erect setae just dorso-lateral and ventromesial to opposable margin, and along distal two-thirds of mesial margin; latter mostly punctate, but with some minute tubercles near base; opposable margin with subconical tubercle ventral to denticles near base, denticles in single row along entire margin.

Carpus of cheliped (Figure 1M) attenuated, 2.1 times longer than wide, length 29.6% of chela length and 21.1% of TCL, with very shallow dorsal sulcus and some minute tubercles distolaterally and distomesially; ventral margin with small distal spine, ventral surface with 9 or 10 small tubercles; mesial margin without spines, with 5 or 6 small, acute tubercles and 12 to 15 minute squamous tubercles; dorsolateral and lateral surfaces with scattered minute tubercles, other surfaces with setiferous punctations. Merus of cheliped 4.7 times longer than deep, depth fairly uniform throughout length, latter 69.7% of chela length and 49.7% of TCL; dorsal surface with single small subdistal spine, and many minute tubercles on dorsal ridge and mesial and lateral surfaces; ventrolateral ridge with large spine ventral to articular condyle, and numerous minuscule tubercles; ventromesial ridge with large distal spine, and numerous minuscule tubercles. Ischium with several minuscule tubercles ventrally; sufflamen obsolete.

Hook on ischium of third pereopod (Figure 1I) simple, flattened on mesial surface and inflated on lateral surface, with tip overreaching basioischial articulation, not opposed by tubercle on basis. Coxae of all pereopods, and sternites between them, with setae, which sparse cephalically, denser caudally. Coxa of fourth pereopod with prominent, caudomesially disposed boss, caudal surface of which expanded into smooth horizontal arc; coxa of fifth pereopod with narrow projection cephalic to penis papilla, tip of projection with tuft of long setae.

For description of gonopod (Figures 1B, F, J), see "Diagnosis."

Allotypic female—Exclusive of secondary sexual characters, differing from holotype in following respects: Areola 5.4 times longer than wide, occupying 17.9% of carapace width, with 6 punctations across narrowest part; areola length 42.4% of TCL (54.0% of PCL). Cephalic section of cephalothorax comprising 57.6% of TCL. Acumen length constituting 43.2% of rostrum length, which comprising 24.9% of TCL. Cervical spines 3 left, 2 right. Width of abdomen 82.1% of carapace width, TCL 87.6% of abdomen length. Transverse suture of telson complete but weak. Cephalic lobe of epistome with broadly rounded, semicircular margin. Chela of cheliped 6.2 times longer than wide, length 52.2% of TCL; palm 1.2 times wider than deep. Carpus of cheliped 1.8 times longer than wide, length 25.8% of chela length and 13.6% of TCL, with somewhat more obvious dorsal sulcus and lacking distinct distal spine on ventral margin. Merus of cheliped 4.9 times longer than deep, length 78.5% of chela length and 41.2 percent of TCL.

For description of annulus (Figure 1G), see "Diagnosis."

Morphotypic male, form II—Differing from holotype in following respects: Areola 4.4 times longer than wide, occupying 22.4% of carapace width at narrowest part; areola length 42.1% of TCL (53.5% of PCL). Acumen comprising 40.0% of rostrum length, which constituting 22.8% of TCL; acute tip of acumen directed cephalically. Width of abdomen 77.6% of carapace width; TCL 89.1% of abdomen length. Cervical spines 2 left, 3 right. Transverse suture of telson complete but weak. Right cheliped regenerate; chela of left cheliped 7.3 times longer than wide, length 55.3% of TCL; palm 1.2 times wider than deep. Carpus of cheliped 2.2 times longer than wide, length 30.3% of chela length and 16.7% of TCL. Merus of cheliped 4.9 times longer than deep, length 72.5% of chela length and 40.1% of TCL. Ischium of third pereopod with reduced hook, tip not quite reaching basioischial articulation. Gonopods (Figures 1C, E, K) with proximomesial apophyses nearly abutted; central projection noncorneous, short, blunt; mesial process larger and longer than central projection; both terminal elements disposed approximately as in holotype.

Disposition of types—The holotype, allotype, and morphotype are in the crustacean collections of the North Carolina State Museum of Natural Sciences (NCSM), Raleigh (catalogue numbers NCSM C-3361, 3362, 3363, respectively), as are the following paratypes: 1 ♂ II (NCSM C-3364); 1 ♀ (NCSM C-3365); 1 j ♂, 2 ♀ (NCSM C-3366); 1 ♂ I, 1 ♀ (NCSM C-3367); 1 j ♀ (NCSM C-3368); 1 ♂ II, 1 j ♂, 2 ♀ (NCSM C-3371). Additional paratypes consisting of 1 ♂ I and 1 j ♀ have been deposited in the collections of the National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC (USNM 131575, 131576, respectively).

Type locality—Alabama, Madison County, Huntsville, Shelta Cave (Meridianville 7.5' USGS Quadrangle, Sec. 27, T.3S, R.1W). Shelta Cave is designated AL4 in the cave cataloguing system of the Alabama Cave Survey, an official project of the National Speleological Society (NSS). The two pit entrances to the cave are located in a shallow wooded sink in

northwest Huntsville, behind the headquarters of the NSS, which owns the entrance properties and controls general access to the cave. Research there is restricted by policies and guidelines of the NSS.

For a complete description of Shelta Cave, including its physical characteristics and fauna, see Cooper (1975), Hobbs III and Bagley (1989), McGregor et al. (1994), Moser and Rheams (1992) and Rheams et al. (1992, 1994).

Range and specimens examined—Endemic to the type locality, where we collected the following specimens (other collectors as noted): 1 ♂ II, 1 j ♂, 2 ♀, 24 August 1963, with F.E. McKinney, T. Sawyer; 1 ♂ II, 1 ♀, 22 December 1963, with W. Sanborn; 1 ♂ II, 1 j ♀, 3 January 1964; 1 ♂ I, 2 ♀, 1 j ♀, 7 August 1965; 2 ♂ I, 11 April 1966, with J.E. Cooper, Jr.; 1 j ♂, 2 ♀, 20 November 1966, with J. Reddell; 1 ♂ II, 27 July 1968, L. Morin, R. Graham; 1 ♂ II, 10 April 1969; 1 ♀, 8 December 1968; 1 ♀, 12 August 1969; 1 ♂, II, 27 November 1970; 1 ♂ II, 14 July 1975; 1 ♂ I, 15 July 1975; 2 ♀, 16 July 1975. All specimens are catalogued at NCSM, except several that are catalogued at USNM.

As previously mentioned, some additional data were obtained from 97 other individuals that were examined and released. We also examined crayfishes of the appropriate sizes collected by Ronald A. Brandon and Ronald Altig in November 1964, as well as all Shelta crayfishes in the collections of the National Museum of Natural History and Tulane University (TU); all were either *C. jonesi* or juvenile *O. a. australis*.

Variations—Combining the data from the type series and specimens examined during the ecological study, most individuals have 2 cervical spines on each side of the carapace. However, 8 had 3 spines on one side and 2 on the other, 14 had a single spine on one side and 2 on the other, and 5 had but a single spine on each side. The dimensions of the areola vary within the limits provided in the “Diagnosis;” juveniles and subadults have somewhat shorter and broader areolae than adults. The cephalic lobe of the epistome of several specimens has a small cephalomedian projection instead of the usual, relatively featureless margin. Carapace width varies from 1.2 to 1.4 times carapace depth. Sexual dimorphism is evident in chela length, with the chelae of form I males averaging 75.5% of TCL, those of both females and form II males averaging 59.2% of TCL. Width of the palm varies from 1.1 to 1.3 times its depth, regardless of sex or male form. The carpus of females is shorter and somewhat narrower than that of all males. The merus of females and form II males is shorter than that of form I males, but the length of the podomere is about 4.9 times its depth in all specimens measured. The annulus shows some variation in dimensions and shape; width in adults ranges from 1.3 to 1.7 times length, but width is greater in juveniles. In addition, some specimens have a pair of broad tubercles at the cephalic margin of the median trough.

Size—The largest specimen in the type series is the morphotype, which has a TCL of 19.7 mm. The largest form I male has a TCL of 17.3 mm, and the smallest measures 16.1 mm

TCL. During the mark-release phase of our study (Cooper, 1975), the smallest specimen we found was a juvenile male of about 9.2 mm TCL. Four others also had TCLs of less than 11.0 mm. The size ranges of adult males were 13.5 to 17.1 mm (mean = 15.4 mm, $n = 8$) for form I males and 13.5 to 17.6 mm (mean = 15.3 mm, $n = 34$) for males considered to be form II rather than juveniles. The range for adult females was 13.3 to 18.0 mm (mean = 15.2 mm, $n = 42$). Thus, we found no significant differences in mean TCL of mature animals of either sex or male sexual form (range for all adults 13.3 to 18.0, mean = 15.3, $n = 84$).

Life history notes—Form I males (numbers in parentheses) were found in April (2), July (3), August (5), September (5), October (12), November (6), and December (2), but were always a small percentage of the *O. sheltae* found during sampling in any time period. They may have been present in other months as well since very few individuals of this species were encountered during periods of elevated water levels.

Although no female bearing attached ova or young has ever been found, some reproductive data have been obtained. The annulus of the allotype, collected on 7 August 1965, contained the remnants of a sperm plug, indicating that mating had occurred, perhaps sometime near that date. A female of 16.8 mm TCL, with late-stage oocytes and weakly developed cement glands, and a form I male measuring 15.3 mm TCL, were observed in prolonged amplexus in a container within the cave on 18 October 1969. The smallest oocytes first appeared in females at about 13 mm TCL. Larger, late stage oocytes, often accompanied by fully developed cement glands, were seen in 9 females measuring 13.3 to 16.8 (mean = 15.0) mm TCL. Four of them were collected in July, and one each in August through December. One of these females collected on 10 July 1969 and measuring only 13.8 mm TCL had 8 very large oocytes (ca. 1.5–2.0 mm diameter) crowding the ovary, and all cement glands were highly developed. The number of oocytes observed in all females ranged from 8 to 12, which reflects a very low reproductive potential.

The young of *O. sheltae* at recruitment may be larger than the young of the other two, larger troglobitic crayfishes of Shelta Cave. The smallest individuals of *O. sheltae* ever found were two juvenile males, measuring 9.2 and 10.3 mm TCL that we examined and released. They were 2 to 3 times larger than the smallest *C. jonesi* (3–5 mm TCL), and twice the size of the smallest *O. a. australis* (5–6 mm TCL). A larger size at recruitment for young of this fragile species could give them a competitive edge by increasing their foraging efficiency, and by decreasing the probability of being eaten by the troglobitic fish, *Typhlichthys subterraneus* Girard. This fish is the most significant predator in the cave’s aquatic community, where larger individuals, although not often observed in our study, are known to feed on the troglobitic shrimp, *Palaemonias alabamiae* Smalley (Cooper & Cooper, 1974). We do not know for certain, however, if *O. sheltae* of 9 to 10 mm TCL are recently recruited juveniles, despite the fact that they are the smallest ever found in a number of years of intensive search-

ing and trapping.

Relationships—We are in the process of evaluating the relationships among *O. sheltae* and a number of other crayfishes of the southern Cumberland Plateau, Sequatchie Valley, and Highland Rim. Since this evaluation includes species of other genera, extensive comments at this time would be inappropriate. However, based on the nature of the secondary sexual structures of form I males and females of taxa within the subgenus *Orconectes*, *O. sheltae* appears to be closer to the *O. inermis-australis-incomptus* line of descent than to that which led to *O. pellucidus* (Hobbs & Barr, 1972). Within this group, the form I male gonopod of *O. sheltae* is most like that of *O. i. inermis*, as are several other features, including the percentage of areola length of TCL (<43%). The annulus, however, differs from that of *O. inermis* and *O. australis*, being more similar to that of *O. incomptus*.

In most respects, *O. sheltae* is quite different from the other troglobitic members of the genus, as limned by Hobbs and Barr (1972), Hobbs et al. (1977), and Fitzpatrick (1987), and is readily distinguished from them by (1) the absence of first pleopods in the female; (2) the broad median trough of the annulus; (3) the narrow, elongate chela, with its long palm and subvertical orientation; (4) the longer terminal elements of the form I male gonopod, their greater degree of curvature, and the cephalocaudal flattening of the central projection; (5) the great depth of the cephalocaudal axis of the shaft of the gonopod, immediately proximal to the base of the central projection; (6) the absence of prominent spines on the mesial margin of the carpus; and (7) the smaller size, with a maximum TCL of 19.7 mm, as compared to the maximum TCL range of from 24.3 mm for *O. incomptus* to 48.0 mm for *O. a. australis*.

Crayfish and other associates—In addition to *C. jonesi* and *O. a. australis* (Figure 2B, C, respectively), 6 specimens of a large, pigmented crayfish, referred to the common troglophile, *Cambarus (Erebicambarus) tenebrosus* Hay (s.l.), were found in Shelta Cave. Both of the troglobitic species far outnumbered *O. sheltae*. In 18 extended sampling periods we processed 1,314 individual crayfish: 959 *O. a. australis* (72.9%), 266 *C. jonesi* (20.2%), and 89 *O. sheltae* (6.8%). The only other decapod that we found in Shelta Cave was the atyid shrimp, *P. alabamae*.

Two troglobitic ectocommensals occur on the Shelta crayfishes, the entocytherid ostracod, *Sagittocythere barri* (Hart and Hobbs) (Hart & Hart, 1966; Hart & Hobbs, 1961), and the branchiobdellid worm, *Cambarincola sheltensis* Holt (Holt, 1973). Although we did not specifically search for them, we did note their presence when observed. No ostracods were recorded on any *O. sheltae*, and we noted branchiobdellids on only two of those handled. Both of the ectocommensals were commonly observed on *C. jonesi*, and far more frequently on *O. a. australis*. Other macroscopic troglobites found in the aquatic community are two species of amphipods of the genus *Stygobromus* (J.R. Holsinger, in litt.); a triclad turbellarian of the genus *Sphalloplana*; *T. subterraneus*; and a perennibranch salamander, *Gyrinophilus pallescens* subspecies, which was

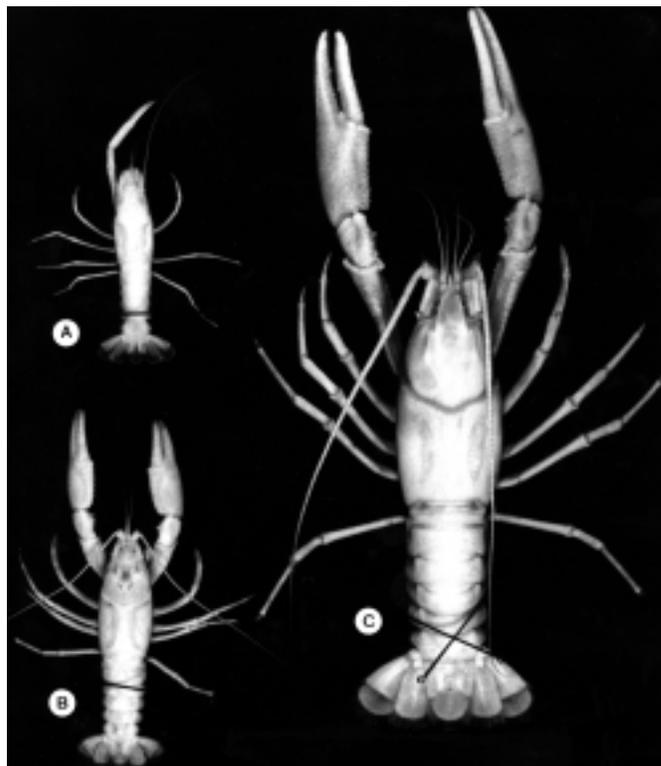


Figure 2. Comparative sizes and configurations (dorsal aspect) of form I males of the troglobitic crayfish triad that occurs in Shelta Cave. A, *Orconectes (O.) sheltae*, new species, 17.1 mm TCL; first and third right pereiopods missing. B, *Cambarus (A.) jonesi*, 21.0 mm TCL. C, *Orconectes (O.) a. australis*, 41.2 mm TCL; right cheliped regenerate.

rarely encountered (Cooper, 1968b; Cooper & Cooper, 1968).

Remarks—We know of only one other troglobitic crayfish triad whose members exist syntopically, or ostensibly so, in American caves. At least two sinkholes in Alachua County, Florida—Squirrel Chimney and Goat Sink—are occupied by *Procambarus (Ortmannicus) pallidus* (Hobbs), *Procambarus (Ortmannicus) lucifugus alachua* (Hobbs), and *Troglocambarus maclanei* Hobbs. Just as in the case of the three Shelta species, one of the Florida species, *P. l. alachua*, is very large, with a maximum TCL of 45.2 mm, which is very large, with a maximum reported TCL of 39.6 mm, which is larger than *C. jonesi*; and *T. maclanei* is a diminutive, fragile species, with a maximum reported TCL of 15.5 mm, which is close to *O. sheltae*.

Etymology—The species name, *sheltae*, is after Shelta Cave, the only known locality for the species. The name of the cave was at one time Bolen James' Cave, but in 1888 Henry M. Fuller purchased the land containing the entrances and renamed the cave Shelta, after his daughter (French, 1968). Suggested vernacular name: Shelta Cave Crayfish.

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