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A New Crayfish of the Subgenus *Jugicambarus* from Tennessee with an Emended Definition of the Subgenus (*Astacidae*, *Decapoda*)

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ABSTRACT: A more accurate method of measuring the carapace is proposed. The use of the posterior margin of the epistome as a possible taxonomic structure is introduced. The subgenus *Jugicambarus* is emended. *Cambarus crinipes*, a new species of crayfish from the Cumberland Plateau in Tennessee, is described. Color notes, relationships, distribution, life history notes and ecological data are given.

In crayfish systematics the length of the carapace has been traditionally measured from the tip of the rostrum to the midcaudodorsal margin of the carapace ("total length of carapace"). Damaged rostrums, coupled with the intrinsic variability of the structure, suggested that a more consistent measurement of the length of the carapace would be one currently utilized in the suborder Natantia and several sections of the suborder Reptantia: the distance from the angle of the orbit to the midcaudodorsal margin of the carapace (carapace length). Computations using this measurement usually attenuate range values. Narrower ranges of variation hopefully will make data more useful in comparing specimens. The term carapace length is so similar to total length of carapace that to avoid confusion it is here proposed to designate the measurement from the angle of the orbit as *postorbital carapace length*. Besides possible taxonomic merit, postorbital carapace length has a manual benefit. In measuring, calipers tend to slip off the tip of the acumen. Also, specimens in late premolt stages or early postmolt are so pliable that the rostrum and caudal margin of the carapace bend. The reinforced suborbital angle maintains itself so that only concentration on the caudal margin of the carapace need be maintained. By subtracting postorbital carapace length from total length of carapace, a more stable rostrum length is attained, thus removing the problem of deciphering the cephalic extremities of the postorbital ridges.

During recent studies of existing problems with certain crayfish groups, a structure not previously mentioned, and only occasionally illustrated, has proven to be of considerable importance. Since the group in which use of this structure has shown some merit occupies a large geographic range still under study, it is introduced here so that other researchers may become aware of its potential taxonomic value. This structure, here designated the *epistomal zygoma* (Fig. 1j), is the thickened posterior margin of the epistome lying immediately anterior to the mouth.

Hobbs (1969), in his proposals of subgeneric groupings for the genus *Cambarus*, erected the subgenus *Jugicambarus*, which encom-

passes those members of the genus possessing a subrectangular chela with the mesial margin of the palm bearing a high ridge of fused tubercles ("cristiform row"). In the description of *Cambarus bouchari* (Hobbs, 1970) the fairly consistent lack of a cristate row is pointed out. This feature, along with a primitive pleopod similarly

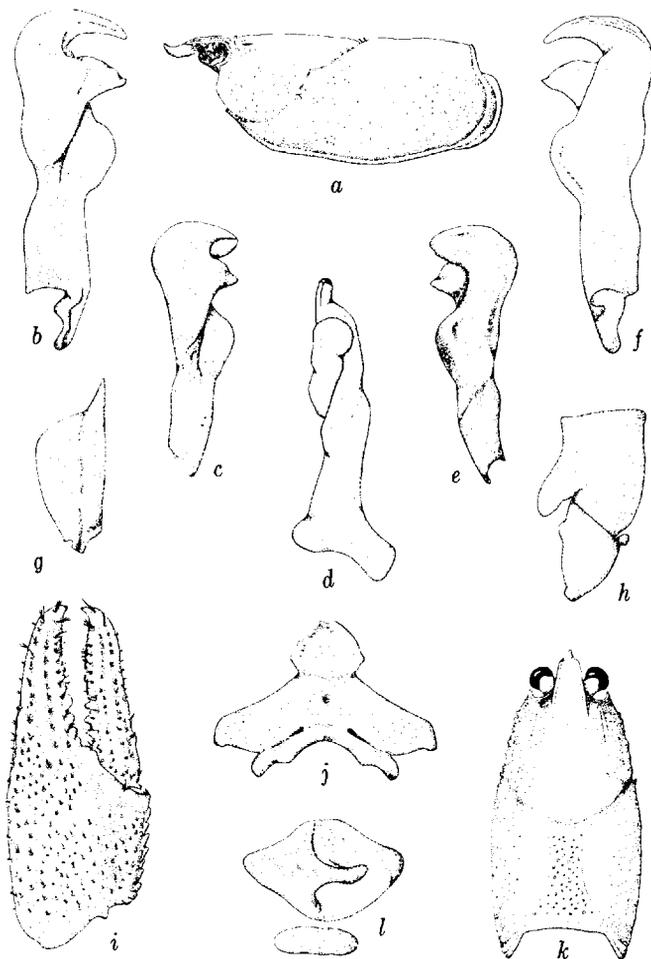


Fig. 1.—*Cambarus crinipes*, n. sp. *a*, Lateral view of carapace of paratypic male, form I. *b*, Mesial view of first pleopod of holotype. *c*, Mesial view of first pleopod of morphotypic male. *d*, Caudal view of first pleopod of holotype. *e*, Lateral view of first pleopod of morphotypic male. *f*, Lateral view of first pleopod of holotype. *g*, Antennal scale of paratypic male, form I. *h*, Basipodite and ischiopodite of third pereiopod of holotype. *i*, Dorsal view of chela of holotype. *j*, Epistome with epistomal zygoma of holotype. *k*, Dorsal view of carapace of holotype. *l*, Annulus ventralis of allotype

possessed by *Cambarus pristinus* and *Cambarus obeyensis*, provided the rationale for uniting the three in the subgenus *Veticambarus* (Hobbs, 1970). Since the description of *C. bouchardi*, further study has shown that *C. unestami* (Hobbs and Hall, 1969), the species described herein, and two undescribed *Jugicambarus* lack the true cristate row. Furthermore, a third undescribed species that would currently conform to the subgenus *Jugicambarus* exhibits a pleopod more primitive than that of any species of the genus *Cambarus* known to date. In view of these observations, I propose that the formerly monotypic subgenus *Veticambarus* be based on the original diagnosis (Hobbs, 1969) and that *C. obeyensis* be returned to the subgenus *Jugicambarus*, and its diagnosis be emended to encompass *C. bouchardi*.

Cambarus unestami was placed in the subgenus *Puncticambarus* (Hobbs and Hall, 1969) mainly because of two rows of tubercles on the palm, a common feature in the subgenus. The lack of a cristate row did not indicate a close relationship with *Jugicambarus*. Hobbs and Hall (1969) pointed out that the chelae are not as depressed as in typical *Puncticambarus*. *Cambarus unestami*, in fact, possesses inflated subrectangular chelae, a character of *Jugicambarus*. The presence of a cristate row is no longer considered an essential character of the subgenus. The habitat of *C. unestami* on a dissected portion of the Cumberland Plateau (Lookout Mountain) and the presence of its undescribed closest known relative on that portion of the Cumberland Plateau flanked by the Sequatchie Valley and Great Valley indicate a probable assemblage long separated by the valley of the Tennessee River as it now flows west through Walden Ridge. Based on the characters of its chelae and its relationship with an undescribed member of the subgenus *Jugicambarus*, I recommend *C. unestami* be placed in the subgenus *Jugicambarus*.

Subgenus *Jugicambarus* Hobbs, 1969, emended
Cambarus (Jugicambarus) Hobbs, 1969: 106

DIAGNOSIS: Eyes pigmented except in troglobitic species. Antennae not heavily fringed on mesial border; antennal scale of troglobitic species less than twice as long as broad. Rostrum rarely with marginal spines or tubercles and with or without thickened margins. Postorbital and cervical spines present or absent, latter conspicuous only in troglobitic *C. setosus*. Suborbital angle present or absent. Branchiostegal spine usually small or absent. Areola broad to linear (3.8 to 29.0 times longer than wide), constituting 33.0-46.2% of entire length of carapace and sparsely to densely punctate. Chela subrectangular, rather short except in troglobitic species, and somewhat depressed only in burrowing species. Mesial surface of palm with single serrate or cristiform row of tubercles, occasionally with second row above and as many as three rows in troglobitic species. Dorsal surface of chelae usually deeply pitted and both palm and fingers frequently bearing conspicuous setae. Fingers never widely gaping and with well-defined longitudinal ridges dorsally; proximal opposable margin of dactyl never deeply concave. Conspicuous tuft of setae never present at mesial base of fixed finger; lateral base never deeply impressed. First form male with coxa of fourth pereiopod lacking large ventral setiferous pit on caudomesial boss. First pleopods contiguous, or almost so, basally and

with distal portion of shaft almost straight or with cephalic convexity; never inclined caudad. Terminal pleopod elements consisting of (1) bladelike, usually tapering central projection, sometimes with subapical or subdistal notch and recurved as little as 55 degrees to shaft but most often much more and occasionally forming arc of 155 degrees; (2) subconical, usually long mesial process frequently extending farther caudad than central projection; (3) caudal knob seldom conspicuous, usually reduced or lacking.

Using Hobbs' key (1969: 95) to the subgenera it is necessary to modify "couplet 2" in view of the emended diagnosis of *Jugicambarus*.

2. Pigmented members with tubercles on mesial surface of palm of chela forming serrate or cristiform row (chela subrectangular if serrate); palm and fingers often studded with long setae. Albinistic members with antennal scale less than twice as long as broad *Jugicambarus*
 Pigmented members with tubercles on mesial surface of palm of chela never forming cristiform row (chela subtriangular if serrate); palm and fingers never studded with long setae. Albinistic members with antennal scale more than twice as long as broad 3

Dr. Horton H. Hobbs, Jr., was the first to recognize this crayfish from a drainage survey of the Big South Fork of the Cumberland River (Hobbs and Shoup, 1942). Due to broad interpretations of species by earlier authors and lack of good series, it seemed wise to indicate this supposed sibling species as a variant of *Cambarus bartonii* (Fabricius, 1798) rather than bury it under synonymy of that species. The description of *Cambarus distans* by Rhoades (1944) removed some of the confusion on the status of the Big South Fork variants, but the lack of sufficient material from the Cumberland Plateau did not preclude the possibility that this form was a variant of *C. distans*. Additional collections in the Tennessee and Kentucky area in the late 1960's confirmed its distinctness.

Cambarus crinipes n. sp.

Cambarus bartonii bartonii "Regionally Restricted Variant 6." — Hobbs and Shoup, 1942: 636, 640, 642 [part], 638, 643, plate 1, figs. 6 and 7. [Not: 637].

DIAGNOSIS: Body and eyes pigmented. Rostrum with convergent margins, lacking marginal spines or tubercles. Areola width 18 to 31% of length (three to five times longer than broad), comprising 43 to 45% of postorbital carapace length (33 to 36% total length of carapace); moderately punctate, with space for four to six shallow punctations across narrowest part. Cervical spines acute to obtuse. Suborbital angle acute. Postorbital ridges with or without small cephalic tubercle or spine. Cephalic portion of epistome variable; epistomal zygotoma well arched with paired depressions at anterolateral edges. Chelae with one serrate row of tubercles along mesial margin of palm, occasional tubercle above; well-defined longitudinal ridges on dorsal surface of fingers. Fingers bent ventrally. Lateral edge of fixed finger costate. Chelae covered with aggregates of short setae most conspicuous on fingers and less so on inflated proximolateral portion. First pleopod (Figs. 1b, f) of first form male with central projection recurved at 90 to 100 degree angle, tapering, without subterminal notch or with slight indication of subdistal one. Caudal knob sometimes conspicuous. Mesial process bulbous but tapering distally. Annulus ventralis (Fig. 11) symmetrical or asymmetrical with sinus bisecting sclerite. One part C-shaped; other shaped like isosceles triangle with process from base

projecting into concavity of "C." Caudal margin of triangular part sometimes convex. Caudal wall of annulus elevated ventrally. Anterior third of sinus widened into median trough paralleled by ridges. Sinus sinistral or dextral.

HOLOTYPE MALE, FORM 1: Body subcylindrical, not strongly depressed. Abdomen narrower than thorax (13.9 and 16.5 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (16.5 and 11.0 mm). Areola width 24.3% of length (4.1 times longer than broad) with six punctations across narrowest part. Cephalic section of carapace 63.9% of total length of carapace (1.8 times longer than areola). Areola 44.2% of postorbital carapace length (36.1% total length of carapace). Rostrum excavate dorsally with subparallel, thickened margins devoid of marginal spines or tubercles. Acumen set off from proximal portion of rostrum with concave oblique margins, not swollen and terminating in a small upturned tubercle; upper surface with submarginal punctations and others scattered between. Lateral surface of carapace granular, with scattered fine setae. Row of sparse setae parallel to posterior margin of cervical groove. Subrostral ridges visible in dorsal aspect only along basal third of rostrum. Postorbital ridges little prominent, grooved dorsolaterally, terminating in a small tubercle cephalically. Suborbital angles terminating in acute spine. Branchiostegal spine small and obtuse. Carapace punctate dorsally and tuberculate laterally with scattered fine setae. Cervical spines small and acute. Epistome (Fig. 1j) distinctly broader than long with small cephalomedian indentation; anterolateral margins elevated; fovea present. Epistomal zygoma well arched with paired depressions at anterolateral edge.

Abdomen slightly longer than carapace (32.6 and 31.9 mm). Cephalic sections of telson with two spines in each caudolateral corner. Basal podomere of right uropod with spines extending over mesial and lateral rami; absent on left. Lateral rami of uropods with median ridge terminating in acute spine at transverse flexure. Proximal portion of lateral rami with row of small spines distally. Mesial rami of uropods with median ridge terminating distally in premarginal acute spine. Dorsal surface of telson and uropods lightly setiferous.

Antennules of usual form with small spine at midlength of ventral surface of basal segment. Antennae extending caudad to cephalic end of sixth abdominal tergum. Antennal scale with cylindrical lateral portion terminating in small acute spine; lamellar area with sharply rounded mesial margin, crenulate and edged with long setae. Width of antennal scale 45.1% of length (2.2 times longer than broad), broadest distal to midlength with widest lamellar area 65.2% of width.

Chela (Fig. 1i) subcylindrical, with dorsal and ventral surfaces punctate; punctations with clusters of setae. Palm of right chela with serrate row of eight tubercles; left with ten. Fingers not conspicuously gaping and both with well-defined longitudinal ridges dorsally and ventrally, flanked by punctations bearing tufts of small setae. Opposable margin of fixed finger with four rounded tubercles along proximal two-fifths increasing in size distally; band of denticles extending almost entire length of finger broken only by tubercles; tubercles and denticles flanked by deep punctations bearing conspicuous setal tufts; small corneus spiniform tubercle below band of denticles at base of distal two-fifths of finger; lateral margin of finger costate. Opposable margin of dactyl with three rounded tubercles along proximal third increasing in size distally; band of denticles and tufts of setae as on fixed finger; small corneus spiniform tubercle below band of denticles at midlength.

Carpus of cheliped longer than broad with oblique longitudinal furrow dorsally and conspicuously punctate dorsally and laterally. Mesial surface with

large spine and smaller one at its proximal base; two additional tubercles proximodorsad, and two ventrad.

Merus of cheliped with mesial and lateral surfaces bearing shallow punctations. Upper surface tuberculate with two prominent subdistal ones. Ventrolateral margin with row of three tubercles and ventromesial margin with 10. Row of five tubercles on right ischium, three on left, corresponding to mesial row on merus.

Hooks on ischia of third pereopods only (Fig. 1h); hooks simple, extending proximad of distal margin of latter and opposed by tubercle on basis. Coxa of fourth pereopod with caudomesial boss; fifth without prominence.

Sternum moderately deep between fourth and fifth pereopods, with marginal tufts of plumose setae between bases of third, fourth and fifth.

First pleopods (Figs. 1b, d, f) symmetrical and reaching coxa of third pereopods when abdomen is flexed (see DIAGNOSIS).

ALLOTYPE FEMALE: Differing from holotype in following respects: areola constituting 44.6% of postorbital carapace length (35.9% total length of carapace) and width 21.5% of length (4.7 times longer than broad) with five punctations across narrowest part. Postorbital ridges with small acute spines cephalically. Suborbital angles terminating in larger acute spines. Branchiostegal spines larger and more acute. Basal podomere of left uropod with acute spine over mesial ramus and small obtuse one over lateral. Epistome pentagonal with apex rounded. Palm of right chela with row of six tubercles; left seven. Opposable margin of dactyl of right chela with four tubercles. Mesial surface of left carpus with three tubercles proximodorsad to large spine and three ventrad; right carpus lacking small spine at base of largest spine, with three proximodorsad and four ventrad spines or tubercles. Upper surface of merus with two spines, lateral one acute. Ventrolateral margin of right merus with row of five tubercles; ventromesial margin of both with 11. Row of four tubercles on right ischium.

Sternum between fourth pereopods V-shaped and moderately deep. Annulus ventralis (Fig. 1i) with width 62.5% of length (1.6 times longer than broad), firmly fused to sternum cephalically but caudad half movable (see DIAGNOSIS).

MORPHOTYPE MALE, FORM II: Differing from holotype in following respects: rostrum less acuminate with margins more nearly parallel and slightly more concave. Areola constituting 41.7% of postorbital carapace length (34.1% total length of carapace) and width 26.2% of length (3.8 times longer than broad) with five punctations across narrowest part. Subrostral ridges slightly more prominent. Cervical tubercles obtuse. Basal podomere of uropods with acute spine over both mesial rami. Epistome rounded distally. Merus of cheliped with ventrolateral margin bearing row of five tubercles and ventrolateral margin of right merus with 12. Row of four tubercles on left ischium. As usual, hooks on ischiopodites of third pereopod and boss on coxa of fourth reduced. First pleopod (Figs. 1c, e) with neither element corneous and central projection heavier.

TYPE LOCALITY: White Oak Creek, a tributary of Clear Fork Creek (Big South Fork of the Cumberland River system) at U.S. 27 in Sunbright, Morgan Co., Tenn. Here the stream is approximately 5 to 10 feet wide consisting of standing pools during the summer. The pool bottoms are mostly sand and silt with scattered, small rocks. The dry interspaces consist mainly of rocks and are riffle areas during the spring. The stream is bordered by a small field, deciduous trees and a few town buildings.

DISPOSITION OF TYPES: The holotypic male, form I, the allotypic female, and the morphotypic male, form II, are deposited in the United States National

Museum (nos. 132342, 132343, 132344, respectively) as are paratypes consisting of 13 males, form I; seven males, form II; 13 females; three juvenile males; and one female with eggs. All other paratypes are deposited in the University of Tennessee Museum, consisting of 35 males, form I; five males, form II; 24 females; two juvenile males; and seven juvenile females.

SIZE: The largest male, form I, has a postorbital carapace length of 30 mm (37.1 mm total length of carapace), the largest female 29.1 mm (37.2 mm), the smallest first form male 17 mm (22.1 mm), and the smallest female with eggs 17.4 mm (22.4 mm).

RANGE AND SPECIMENS EXAMINED: This species is known from the headwaters of the East Fork of the Obey River (Obey River system), Clear Creek (Emory River system) and Clear Fork Creek (Big South Fork of the Cumberland River system) in Cumberland, Fentress, Morgan, Overton, Putnam and Scott counties on the Cumberland Plateau in Tennessee. Specimens from the following localities are designated as paratypes.

TENNESSEE—CUMBERLAND Co., Clear Creek at station one, 7/14/52, Parsons (2 males II, 4 females); Clear Creek at station eight, Jones Ford, 7/16/52, Parsons (3 males II, 5 females). CUMBERLAND—FENTRESS Co., Clear Creek, S of Clarkrange at U.S. 127, 8/20/41, Shoup (8 male I, 2 male II, 2 females); Clear Creek, south of Clarkrange at U.S. 127, 2/22/63, Hobbs and Fitzpatrick (2 male II, 1 female, 2 male juv., 1 female with eggs). FENTRESS Co., North Prong Clear Fork Creek at Co. Rd. 4242, 8/15/69, Bouchard (19 male I, 1 male II, 8 females, 2 male juv., 2 female juv.); South Prong Clear Fork Creek off Co. Rd. 4242, NE of Roslin, 8/15/69, Bouchard (9 male I, 1 male II, 9 females, 4 female juv.); Slate Creek off Co. Rd. 4462, 8/18/69, Bouchard (6 male I, 2 male II, 3 females, 1 female juv.). MORGAN Co., White Oak Creek at U.S. 27, 6/28/68, Bouchard (1 male I).

COLOR NOTES: Cephalothorax and abdomen concolorous brown to green-brown dorsally with pair of submedian and paired lateral broken, dark brown, stripes on abdomen, extending onto dorsolateral part of thorax as sinistral and dextral horns (*see* Hobbs, 1958). Gastric region with paired lighter areas marking attachment points of mandibular muscles. Branchiostegites and hepatic region brown to green-brown dorsally, fading to cream or white ventrad, sometimes mottled. Ventral aspects of cephalothorax and abdomen cream to white. Occasionally, tinged with blue, if from clean, cool spring habitat.

Chelae brown dorsally with lighter proximolateral area; cream to white ventrally. Distal ends of fingers red in young, fading with age and increased water turbidity to orange, yellow or cream. Pereiopods brown to green-brown dorsolaterally; cream to white ventrolaterally. Distal podomeres darker dorsally than proximal ones, often with bluish tinge in specimens occurring in clean, cool spring habitats.

Rostral margins, postorbital ridges, tubercles, spines, and articular sockets light brown to yellow and cream. Lateral margin of antennal scale and antennae brown to green-brown.

LIFE HISTORY NOTES: Form I males have been collected from June to October and two females with eggs were collected 17 April 1960 and 22 February 1963.

RELATIONSHIPS: *Cambarus (Jugicambarus) crinipes* has its closest affinities with *Cambarus (Jugicambarus) distans*. It differs by generally having more cylindrical setiferous chelae, shorter areola and a male, form I, pleopod without a subterminal notch (*see* Rhoades, 1944). In dorsal aspect *C. crinipes* appears more similar to *C. (J.) obeyensis*, but the central projection on the gonopod of the latter is inclined at an angle of approximately 120 degrees, and

the annulus ventralis has much higher ridges paralleling the anterior third of the sinus (*see* Hobbs and Shoup, 1947). All three species occupy similar stream habitats on the Cumberland Plateau but have not as yet been collected together (*see* ECOLOGY).

ETYMOLOGY: *Grinis* (L.), hair, in combination with *pes* (L.), foot; so named because of the distally hairy pereopods.

CRAYFISH ASSOCIATES: Collected with *C. crinipes* in one or more localities were *Cambarus sphenoides* Hobbs (1968) and an undescribed *Cambarus* of the subgenus *Puncticambarus*.

ECOLOGY: *Cambarus crinipes* is found under rocks or stream debris, in leaf litter or algal mats, and in short burrows in the stream bank on the Cumberland Plateau. Here the stream bottoms usually consist of sand, gravel or clay with sandstone, shales, conglomerate, siltstone, limestones, chert fragments, flint and occasional scattered bits of coal. The species prefers small streams. In larger streams specimens usually inhabit shorelines.

VARIATION: Specimens from Clear Creek (Tennessee River system) have a conspicuously narrower areola, 18-26% of length (length 4.0 to 5.5 times width), than specimens from the Obcy and Big South Fork systems (Cumberland River system), width 24-31% (3.1 to 4.2 times width). Male, form I, gonopods from White Creek (Tennessee River system) and White Oak Creek (Cumberland River system) usually possess a prominent caudal knob.

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TABLE 1.—Measurements (mm) of *Cambarus crinipes*

	Holotype	Allotype	Morphotype
Carapace			
Height	11.0	9.3	10.2
Width	16.5	15.6	14.8
Carapace length	26.0	24.0	24.7
Total length of carapace	31.9	29.8	30.2
Rostrum			
Width	2.8	2.3	2.7
Length	11.5	10.7	10.3
Areola			
Width	3.8	3.8	4.0
Length	5.9	5.8	5.5
Chela			
Length, palm	8.9	7.1*
Width, palm	10.7	9.1
Length, lateral margin	25.1	20.7
Length, dactyl	14.3	11.9

* Chelae regenerated

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