

**PROCEEDINGS
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THREE NEW CRAWFISHES RELATED TO
ORCONECTES DIFFICILIS (FAXON) (DECAPODA:
ASTACIDAE)¹

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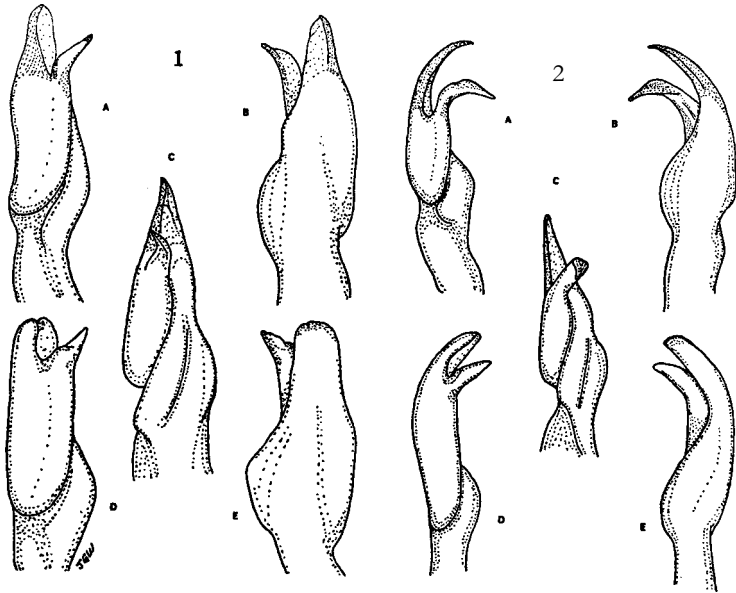
During an investigation of the taxonomy of *Orconectes dif-*
ficilis (Faxon, 1898) and *Orconectes palmeri* (Faxon, 1884),
two new subspecies of *Orconectes difficilis* were discovered,
and the evolutionary significance of a related new species was
realized. As it appears that the complete study will not be
published immediately, I take this opportunity to describe the
new taxa mentioned above. Complete lists of specimens
examined, natural history and distributional notes, and a dis-
cussion of the evolution of these taxa are available in Walls
(1970), and will be presented at a later date.

Measurements follow Penn (1957) except for width of cen-
tral projection, which is measured as a straight line from the
cephalic edge of the central projection to the base of the mesial
process, in mesial view. Abbreviations: CL, carapace length;
G, gonopod length; DMS + CP, length of distal mesial shaft
plus central projection; WCP, width of central projection; CP,
central projection length; MP, mesial process length. Ratios
are presented as percentages; mean and range (in parentheses)
are given in most descriptions. Illustrations are semi-diagram-
matic and may be based on more than one specimen.

Paratypic series of the two new subspecies of *Orconectes*
difficilis will be deposited in the Smithsonian Institution,

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Fm. 1: Left gonopods of *Orconectes perfectus*. A. Male I, mesial view; B. Male I, lateral view; C. Male I, caudal view; D. Male II, mesial view; E. Male II, lateral view.

Fm. 2: Left gonopods of *Orconectes difficilis maletae*. A. Male I, mesial view; B. Male I, lateral view; C. Male I, caudal view; D. Male II, mesial view; E. Male II, lateral view.

Museum of Comparative Zoology (MCZ), Tulane University, and the collections of Dr. J. F. Fitzpatrick, Jr., Dr. Joe B. Black, and the author. Allotypes and morphotypes are purposefully not designated.

Thanks are due to Dr. Horton H. Hobbs, Jr., and Fenner A. Chace, Jr., Smithsonian Institution, Alfred E. Smalley, Tulane University, J. F. Fitzpatrick, Jr., Randolph-Macon Woman's College, Herbert W. Levi, Harvard University, and Rollin D. Reimer, Jr., Texas A. & M. University, for loans of important specimens. Leroy Abel, Frank Amsden, Norman Arnold, Harry Nash, Jr., Robert Shelton, Tom Williams, and Sherry Manuel aided in the field. Dr. Joe B. Black provided specimens, directed the study, read the manuscript, and provided numerous useful hints; his assistance is especially appreciated.

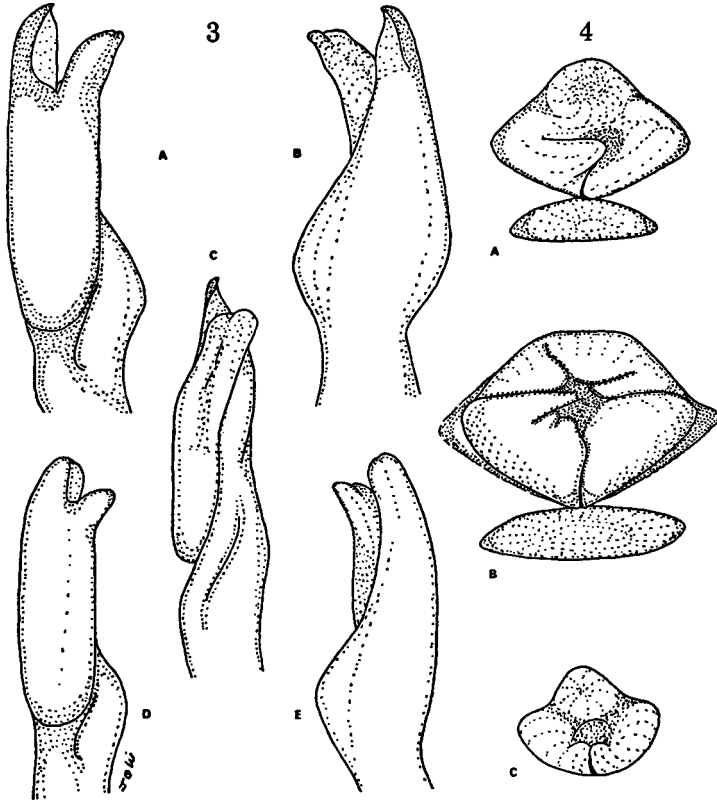


FIG. 3: Left gonopods of *Orconectes difficilis blacki*. A. Male I, mesial view; B. Male I, lateral view; C. Male I, caudal view; D. Male H, mesial view; E. Male II, lateral view.

FIG. 4: Annuli ventrales. A. *Orconectes difficilis blacki*; B. *Orconectes difficilis maletae*; C. *Orconectes perfectus*.

***Orconectes perfectus* new species**

Figures 1A—E, 4C

Diagnosis: Rostral margins not markedly thickened, parallel to slightly convergent; areola closed, slightly open and impunctate, or open and with one row of punctations; chela indistinctly costate, fingers not or only slightly gaping; immovable finger tapering from palm to tip, not distinctly flattened; fingers not ridged dorsally, with one row of large punctations near cutting edges of fingers. Gonopod of Form I male

short, 25.6% length of carapace, reaching to third coxa when in situ, centrocaudal and centrocephalic processes about equal in length and width; in lateral view, caudal margin of centrocaudal process straight, slanting proximocaudally from apex; central projection 33.2% length of DMS + CP, blunt; mesial process thin, twisted, with sharp edges, and not troughed. Annulus wide-oval to subrhomboid; cephalic margin appearing scalloped, weakly inflated; caudal margin strongly **inflated**.

Description: Rostral margins not greatly thickened, parallel to **slightly** convergent; antennal scale evenly rounded; rostral, postorbital, branchiostegal, and cervical spines all well developed. Areola closed, narrowly open and impunctate, or open and with one row of punctations. Chela **weakly** costate; immovable finger gradually diminishing in thickness from palm to tip, not flattened. Fingers of chela not ridged dorsally, with only one row of large punctations adjacent to cutting edge of each finger. Gape of fingers small or absent; **tubercles** of cutting edges of fingers weak. Palm with two distinct rows of **tubercles** mesially. Carpal furrow shallow.

Form I male: (Figs. 1A–C). Gonopod 25.6% (26.3–24.5%) length of carapace, short, reaching to third coxa when in situ. Central projection 33.2% (37.5–28.5%) length of DMS + CP, thick basally; centrocephalic and centrocaudal processes about equal in length and width; centrocaudal process slanting sharply proximocaudally from apex of central projection, its caudal edge straight in lateral view. Central projection 17.6% (19.6–14.2%) length of gonopod, its width 48.1% (50.0–40.0%) of its length. Mesial process 77.7% (100.0–57.1%) length of central projection, and 25.7% (31.0–17.8%) length of DMS + CP; mesial process directed caudolaterally at about **45** angle to gonopod shaft, thin, and twisted, appearing wider in lateral view than in mesial view; mesial edge sharp, tip without trough. Gonopods symmetrical; distinct shoulder absent, though cephalic margin of central projection slanting slightly caudad. Copulatory hook on third pereopod only, large, blunt; mesial edge indented; ischiopodite with ciliated depression on caudoventral surface near junction with meropodite. Second pleopod with basal half straight, distal half very slightly bowed. Sternum densely setose, both from coxae and sternal plates.

Form II male: (Figs. 1D–E). Gonopod 25.1% (27.7–21.6%) length of carapace, thick, with rounded distal margin; central projection appearing to tilt slightly mesially. Central projection 17.6% (19.6–14.2%) length of gonopod, and 18.1% (23.5–15.7%) length of DMS + CP. Mesial process small, directed caudolaterally at about **70** angle to gonopod shaft. Copulatory hook in form of low tubercle; sternum sparsely setose or bare.

Female: (Fig. 4C). Annulus ventralis wide-oval to almost **subrhomboidal**. Caudal margin strongly inflated, evenly rounded posteriorly, sometimes with slight caudal eminence. Median cephalic area depressed; cephalic margin appearing scalloped. Fossa very shallow; sinus

distinct, long; tongue formed by sinus and fossa short and broad, often indistinct; dextral or sinistral.

Holotype: Form I male, USNM 131256.

Type-locality: Alabama, Clarke Co., Satilpa Creek, 8.7 mi. E Grove Hill; coll. E. T. Hall, Jr., 28 March 1957.

Specimens examined: 42 (13♂ I, 10♂ II, 179, 2 juv.), from five localities in Clarke and Choctaw Counties, Alabama, and Clay and Lowndes Counties, Mississippi. Only the 14 specimens from the type-locality are considered paratypes (USNM 129533).

Variation: The annulus appears to be variable with age and breeding condition. The cephalic margin is most elevated in breeding condition, seeming almost subrhomboidal in some breeding females. Annular length varies from 53 to 74% of its width, with most measurements in the 60-70% range. Figure 4C is of a small topotypic specimen.

The areola appears to vary individually and perhaps geographically. Specimens from the lower Tombigbee River drainage in Alabama vary from closed to barely open to distinctly open; all appear to be impunctate, however. Specimens from the upper Tombigbee drainage in Mississippi generally have the areola distinctly open and with one row of punctations; a few specimens have closed areolas.

Mississippi specimens also differ from the Alabama collections in having a longer mesial process (MP/CP = 100-88.8%, as opposed to 78-57% in Alabama Form I males) in proportion to central projection in males. This is possibly due to the large size of the Mississippi specimens (CL, I = 26.0-28.7 mm) as compared to the very small Alabama specimens (CL, ♂ I = 15.0-21.5 mm).

Relationships and comparison: *Orconectes perfectus* is closely related to *O. shoupi* Hobbs, 1948a, *O. wrighti* Hobbs, 1948b, and *O. difficilis bathawayi* Penn, 1952. From *O. shoupi* and *O. wrighti*, it is easily distinguished by the blunt central projection, closed or very narrow areola, and (*O. shoupi* only) chela shape. In general appearance *O. perfectus* is very similar to *O. difficilis bathawayi*; meristically the two are inseparable. *O. perfectus* may be distinguished from *O. d. bathawayi* by the non-flattened immovable finger with only one indistinct row of deep punctations on each finger, resulting in a ridgeless finger; *O. d. bathawayi* possesses a distinctly flattened immovable finger in adults, with two rows of punctations and resulting distinct ridges. No specimens of *O. d. bathawayi* with punctations in the areola are known, although juveniles with narrowly open areolas have been seen. Several differences exist in the gonopod, the most obvious being the sharp-edged, twisted mesial process (thick and of different configuration in *O. d. bathawayi*), straight-edged centrocaudal process (often concave in *O. d. bathawayi*), and the generally thicker, shorter appearance of the *O. perfectus* central projection. The gonopod of *O. d. bathawayi* is well illustrated in the original description. The exact shape of the *O. perfectus* annulus is not found in *O. d. bathawayi*, though very large female

O. perfectus approach the subrhomboidal condition found in *O. d. hathawayi*.

There is little doubt in my mind that *O. perfectus* represents a stock similar to, or perhaps even identical with, the ancestor of *O. d. hathawayi*. The great similarity of gonopod morphology and meristics indicate that *O. perfectus* may be a subspecies of *O. difficilis*, but it is retained as a full species because of its retention of a probably primitive chela and annulus ventralis. The large gap between the ranges of *O. perfectus* and *O. difficilis* also indicates that interbreeding is physically impossible under natural conditions.

Etymology: L., perfectus, complete. In reference to the seemingly complete sequence of species showing the evolution of *O. difficilis* and *O. palmeri* from the Limosus Group.

***Orconectes difficilis blacki* new subspecies**

Figures 3A–E, 4A

Diagnosis: Gonopod of Form I male short, 25.9% length of carapace, reaching third coxa when in situ; centrocaudal process wider in lateral view than centrocephalic, convex or straight proximally and concave distally; central projection 29.3% length of DMS + CP; mesial process thick, fleshy, greatly enlarged; in mesial view, mesial process appearing as wide as or wider than base of central projection. Central projection of Form II males 14.7% DMS + CP, slanting mesially. Annulus ventralis subrhomboid.

Description: Rostral margins slightly convergent, base of rostrum depressed; carina weak or absent. Postorbital, rostral, cervical, and branchiostegal spines strong; suborbital angle weak. Areola closed except in some juveniles. Lateral edge of chela strongly keeled; immovable finger flattened in adults; distinct mesial and lateral rows of punctations dorsally, and accompanying ridges, present on immovable finger; carpal furrow deep. Antennal scale evenly rounded distally.

Form I male: (Figs. 3A–C). Gonopod 25.9% (29.0–21.9%) length of carapace, appearing very stout. Central projection 29.3% (34.6–22.6%) length of DMS + CP, and much as in *O. d. hathawayi*, except caudal edge of centrocaudal process deeply concave just proximal to apex; central projection erect, not slanting laterally. Central projection 17.9% (20.0–13.7%) length of gonopod, its width 49.5% (60.0–37.5%) of its length. Mesial process 100.6% (114.3–77.6%) length of central projection, 30.0% (37.0–22.0%) length of DMS + CP. Mesial process twisted, with keel situated on mesial edge, and directed caudolaterally at about 45° angle to gonopod shaft; usually ending in acute tip and extremely thick, in mesial view appearing as wide as or wider than base of central projection.

Form II male: (Figs. 3D–E). Similar to *O. d. hathawayi* except mesial process as wide as or wider than base of central projection; central projection slanting mesially. Gonopod 25.7% (27.5–22.8%) length

of carapace; central projection 9.5% (12.0-7.7%) length of gonopod, 14.7% (21.4-13.0%) length of DMS + CP.

Female: (Fig. 4A). Annulus length 54.5-94.5% of width, averaging 70.5%; subrhomboid, all margins inflated in breeding condition. Fossa shallow, sinus and tongue usually distinct; sinistral or dextral. Chela coloration, breeding: lateral keel dark blue; fingers brown basally, followed by dark blue, especially on movable finger; blue area succeeded by bright yellow ring at base of distal fourth of both fingers; tips of fingers red. Nonbreeding: similar, except yellow completely or partially replaced by narrow cream area.

Holotype: Form I male, USNM 131255.

Type-locality: Louisiana, Beauregard Parish, Bearhead Creek on La. St. Hwy. 109, 4 mi. SW Juanita; coll. Joe B. Black and class, 30 Sept. 1969.

Specimens examined: 297 (51 ♂ I, 101 II, 120 ♀, 25 juv.), from six localities in Beauregard and Calcasieu Parishes, Louisiana. Only specimens from Bearhead and Beckwith Creeks, Beauregard Par., are considered paratypes. In addition, 55 specimens (9 ♂ I, 23 II, 23 ♀) from seven localities in the Calcasieu River drainage of Allen, Beauregard, Calcasieu, and Vernon Parishes, Louisiana, represent intergradation between *O. d. blacki* and *O. d. hathawayi*.

Variation: Little obvious variation occurs in this subspecies. The mesial process is always greatly expanded, but sometimes ends bluntly; in some specimens, especially from Bearhead Creek, a distinct trough is present. The caudal edge of the centrocaudal process may be either straight or convex basally, but there is always a distinct notch distally. The proportions and appearance of the annulus are especially variable, as they are in all the subspecies of *O. difficilis* and in *O. palmeri*.

Relationships and comparison: *Orconectes difficilis blacki* is closely related to *O. d. hathawayi*, but is easily distinguished by the enormously developed mesial process of Form I males and the mesial slant of the Form II male central projection (lateral in *O. d. hathawayi*). From all other subspecies of *O. difficilis*, it also differs in the short central projection of both Form I and Form II males. Important meristic characters of the subspecies of *O. difficilis* are given in Table 1.

O. d. blacki seems to represent a population which became isolated from the parental *O. d. hathawayi* stock relatively recently. *O. d. hathawayi* is typically found in streams which flow through Pliocene or early Pleistocene sediments in central Louisiana, while the range of *O. d. blacki* is apparently restricted to streams in late Pleistocene deposits. The rather large area of intergradation also seems to indicate a recent origin for this subspecies.

Etymology: It is a pleasure to name this subspecies in honor of Dr. Joe B. Black, who has contributed greatly to our knowledge of the crawfishes of Louisiana and Mississippi.

Orconectes difficilis maletae new subspecies

Figures 2A—E, 4B

Diagnosis: Gonopod of Form I male short, 27.9% length of carapace, reaching to third coxa when in situ; central projection narrow in lateral view, gently curved caudad; central projection 48.2% length of DMS + CP; mesial process thin, directed caudolaterally, troughed. Central projection of Form II males 24.9% length of DMS + Cp; terminal elements somewhat resembling an open beak. Annulus ventralis subrhomboid.

Description: Body and chela characters as described for *O. d. blacki*.

Form I male: (Figs. 2A—C). Gonopod 27.9% (30.2-26.1%) length of carapace, less stout than in *O. d. difficilis* or *O. d. bathawayi*, but not as slender as in *O. palmeri*, reaching about to third coxa when in situ, occasionally longer. Central projection 48.2% (52.7-44.0%) length of DMS + CP, gently curved caudally, pointed; centrocephalic and **centrocaudal** processes subequal in width, but centrocephalic process distinctly longer; caudal border of centrocaudal process straight or slightly concave in lateral view; central projection slanting mesially, its tip not twisted. Central projection 29.9% (32.7-27.5%) length of gonopod, its width 25.7% (31.8-21.4%) of length. Mesial process 77.6% (90.9—66.6%) length of central projection, and **37.3%** (44.4-30.3%) length of DMS + CP; mesial process directed caudolaterally at about 80-90° angle to shaft, keeled, with tip expanded or shallowly troughed. Cephalic shoulder absent, but distinct shallow notch sometimes present in its position; central projection strongly slanting caudally, but its base not distinctly delimited from cephalic margin of gonopod.

Form II male: (Figs. 2D—E). Gonopod 27.5% (29.6-25.2%) length of carapace; more elongated than in other subspecies, and with central projection and mesial process both curved caudally. Central projection 16.9% (18.9-15.3%) length of gonopod and 24.9% (26.6-23.0%) length of DMS + CP. Terminal elements of gonopod somewhat resembling open beak; tip of central projection truncate, especially so in larger specimens. Mesial process much as in *O. palmeri*.

Female: (Fig. 4B). Indistinguishable morphologically from females of *O. palmeri* and other *O. difficilis* subspecies. Chela coloration, breeding; lateral keel light tan, not marked with blue or distinct from background color of palm; fingers with pale blue band present over proximal two-thirds of immovable finger and on mesial edge of palm, but faint or absent on movable finger; distal third of fingers butter-yellow, very conspicuous; red tips absent or reduced. Nonbreeding: similar, but blue darker and yellow often replaced with cream.

Holotype: Form I male, USNM 131254.

Type-locality: Louisiana, Natchitoches Parish, Bayou Santabarb on La. St. Hwy. 117 (third branch north of Kisatchie), coll. Walls, M. Milson, S. Manuel, 7 Oct. 1967.

Specimens examined: 113 (13 ♂ I, 41 ♂ II, 44 ♀, 15 juv.), from

Table 1. Mean and corrected mean (\pm two standard errors of the mean) for selected characters of *Orconectes difficilis* subspecies. Abbreviations as in text. MCZ 4359 is a specimen of *O. d. difficilis* designated by Faxon as "type."

	G/CL (%)		CP/DMS + CP (%)		CP/G (%)		MP/DMS + CP (%)		
	\bar{x}	$\bar{x} \pm 2s_{\bar{x}}$	\bar{x}	$\bar{x} \pm 2s_{\bar{x}}$	\bar{x}	$\bar{x} \pm 2s_{\bar{x}}$	\bar{x}	$\bar{x} \pm 2s_{\bar{x}}$	
<i>O. d. bathawayi</i>									
I	27.0	27.5-26.5	33.4	34.5-32.3	18.9	19.5-18.3	26.1	27.5-24.7	
II	26.6	27.4-25.8	18.9	19.8-18.0	11.4	11.8-11.0	—	—	
<i>O. d. blacki</i>									
I	25.9	26.5-25.3	29.3	30.2-28.4	17.9	18.4-17.4	30.0	31.2-28.8	
II	25.7	26.3-25.1	14.7	15.8-13.6	9.5	9.9- 9.1	—	—	
<i>O. d. difficilis</i>									
I	26.2		41.5		23.5		31.7		
II	27.4		21.2		12.5		—		
MCZ 4359, I	23.6		36.3		19.7		29.5		
<i>O. d. maletae</i>									
I	27.9	28.6-27.2	48.2	49.6-46.8	29.9	30.8-29.0	37.3	39.5-35.1	
II	27.5	28.1-26.9	24.9	25.5-24.3	16.9	17.4-16.4	—	—	

seven localities in Natchitoches and Sabine Parishes, Louisiana, and Upshur Co., Texas. All are considered paratypes except for Sabine Par. specimens. In addition, three specimens (2 ♂ I, 1 ♀) from Coal Co., Oklahoma, seem to be integrades with *O. d. difficilis*.

Variation: Large Form II males possess more truncate and curved gonopods than small specimens. Some Form I males have the gonopods extending to the second coxa when in situ.

Relationships and comparison: This subspecies is a derivative of *O. d. difficilis*, differing from it in the longer, more curved central projection and the expanded mesial process which is more smoothly curved than in *O. d. difficilis*. Although the ratios are narrowly separated, *O. d. maletae* differs from *O. palmeri* by its shorter gonopods (usually reaching to third coxa instead of second as in *O. palmeri*), shorter central projection (male I, 52.7-44.0% DMS + CP in *O. d. maletae*, and 68.3-53.3% in *O. palmeri*, based on data from Penn, 1957), and the stouter appearance of the central projection as compared to that of *O. palmeri*.

Etymology: This subspecies is christened after my wife, Maleta, who helped collect many of the original specimens and who has been of great aid during many difficult periods.

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