

# ***Orconectes pardalotus*, a new species of crayfish (Decapoda: Cambaridae) from the lower Ohio River, with notes on its life history**

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Accepted: 01.06.2005

## **Keywords**

*Procericambarus*, Illinois, zebra mussel, form alternation, carpal spine, morphotype female, water level

## **Abstract**

A new crayfish is described from the main channel of the lower Ohio River between Illinois and Kentucky based on examination of over 185 specimens. The new species, with gonopods of form I males typical of the subgenus *Procericambarus* (*sensu* Fitzpatrick), accounts for some of the variation previously ascribed to *Orconectes placidus* in Illinois. *O. pardalotus* is most similar to allopatric *O. forceps*, *O. barrenensis*, and *O. durelli* but can be distinguished from them and other species using colour in life, shape of chelae, and other characters. Colour in life can be used to diagnose *O. pardalotus*, and preserved specimens can be distinguished from sympatric *O. placidus* and many other species by the shape of the chelae and the absence of a distomedian carpal spine on the first pereiopod of *O. pardalotus* (present in *O. placidus*) and can be distinguished further from *O. luteus* using denticle arrangement on the chelae and structure of the gonopods of form I males. *O. pardalotus* is associated with rocky microhabitats at and below the summer minimum water level of the Ohio River. Notes about reproductive period and oviposition of captive specimens are provided.

## **Zusammenfassung**

Beschrieben wird eine neue Flusskrebsart vom Hauptarm des unteren Ohio River zwischen Illinois und Kentucky auf der Grundlage von über 185 Exemplaren. Die Merkmale der Gonopoden bei männlichen Exemplaren (Form I) der neuen Art, wie sie für die Untergattung *Procericambarus* (*sensu* Fitzpatrick) typisch sind, entsprechen teils den Variationen, die früher *Orconectes placidus* in Illinois zugeordnet wurden. Am meisten ähnelt *O. pardalotus* den allopatrischen Formen *O. forceps*, *O. barrenensis* und *O. durelli*, doch lässt sich die neue Art durch Lebendfärbung, Form der Scheren und weitere Merkmale unterscheiden. Die

Lebendfärbung eignet sich zur raschen Bestimmung von *O. pardalotus*, während bei konservierten Exemplaren die Unterscheidung zur sympatrischen Art *O. placidus* und vielen anderen Arten durch die Gestalt der Scheren möglich ist; außerdem fehlt bei *O. pardalotus* am ersten Pereiopod der distomediane Carpalstachel (bei *O. placidus* vorhanden); zur Unterscheidung von *O. luteus* dienen die Anordnung der Zähnchen an den Scheren und die Struktur der Gonopoden bei Männchen (Form I). Lebensraum von *O. pardalotus* bilden felsige Mikrohabitatem unterhalb des sommerlichen Niedrigwasserspiegels im Ohio. Angefügt sind einige Bemerkungen zur Fortpflanzungszeit und Eiablage nach Beobachtungen an gefangenen Exemplaren.

## **Résumé**

Est décrite une nouvelle Ecrevisse du cours principal du bas Ohio River, entre l'Illinois et le Kentucky, sur base de l'examen de plus de 185 spécimens. La nouvelle espèce, avec de gonopodes de la forme I des mâles typiques pour les sous-genre *Procericambarus* (*sensu* Fitzpatrick), rend compte de la variation autrefois attribuée à *Orconectes placidus* de l'Illinois. *O. pardalotus* se rapproche le plus des allopatriques *O. forceps*, *O. barrenensis* et *O. durelli*, mais se distingue d'elles et d'autres espèces par la couleur *in vivo*, la forme de la chéla et d'autres caractéristiques. La couleur *in vivo* peut servir à diagnostiquer *O. pardalotus* et les spécimens conservés peuvent se distinguer de l'*O. placidus* sympatrique et de beaucoup d'autres espèces par la forme de la chéla et l'absence d'une épine carpienne distomédiane sur le première péréiopode d'*O. pardalotus* (présente chez *O. placidus*) et peut être distinguée ensuite d'*O. luteus* par l'agencement des denticules sur la chéla et par la structure des gonopodes de mâles de forme I. *O. pardalotus* est inféodé aux microhabitats rocheux, à hauteur de et sous le niveau minimum estival de l'Ohio River. Des données sont fournies sur la période de reproduction et sur le positionnement des oeufs pour des spécimens en captivité.

## Sommario

Una nuova specie di gambero è descritta dal canale principale del fiume Ohio inferiore tra l'Illinois e il Kentucky sull'esame di oltre 185 esemplari. La nuova specie, con gonopodi maschili di forma I tipici del genere *Procericambarus* (*sensu* Fitzpatrick), raccoglie alcune delle variazioni precedentemente descritte per *Orconectes placidus* dell'Illinois. *Orconectes pardalotus* è più simile alle specie allopatriche *O. forceps*, *O. barrenensis*, e *O. durelli*, ma può essere distinta da esse e da altre specie sulla base del colore in vita, della forma delle chele e di altri caratteri. La colorazione può essere usata per diagnosticare *O. pardalotus* e gli esemplari conservati possono essere distinti dalla specie simpatica *O. placidus* e da molte altre specie per la forma delle chele e per l'assenza di una spina carpale distomediana sul primo pereiopode di *O. pardalotus* (presente in *O. placidus*) e può essere distinta ulteriormente da *O. luteus* utilizzando la disposizione dei dentelli sulle chele e la struttura dei gonopodi maschili di forma I. *Orconectes pardalotus* è associato a microhabitat rocciosi a livello o al di sotto del limite idrometrico estivo minimo del fiume Ohio. Vengono fornite alcune note sul periodo riproduttivo e la deposizione delle uova in specie in cattività.

## Introduction

*Orconectes placidus* (Hagen, 1870), a species listed as endangered in Illinois, has been considered to be highly variable across its Illinois distribution from Big Creek and its tributaries in the lower Ohio River through its confluence with the Mississippi River up to the mouth of the Kaskaskia River (Page, 1985). The variants within the Mississippi River were found to be *O. luteus* (Creaser, 1933) and could be distinguished using life colour, structure of the gonopod in form I males, and chela morphometrics (Wetzel and Poly 2000, Poly and Wetzel 2003). Variants in the lower Ohio River (the species described herein) were distinguishable from *O. placidus* based on absence of the distomedian carpal spine, distinctive shape of the chelae, and colour in life (Poly and Wetzel 2003). Confusion also has existed between *O. luteus* and *O. rusticus* (Girard, 1852) in adjacent states of Iowa and Minnesota with the former having been mistakenly identified as the latter for over 100 years (Wetzel et al. 2004).

An early complicating factor involved the difficulty in acquiring specimens of the species described herein because of its preferences for relatively inaccessible habitats in the main channel of the Ohio River. Strong current and an irregular rocky substrate limits the efficiency of most standard sampling gear and techniques, and acquisition of specimens for this description required low water levels. In our description, we include an additional morphotype based upon the recent recognition of form alternation in female *Orconectes* spp. (Wetzel 2002); therefore, we chose a form I male as the holotype, a form I female as the allotype, and

form II male and form II female as morphotypes. Juveniles are not distinguished from form II adults. A description, illustrations, and colour photographs of the new species are provided herewith.

## Materials and Methods

We sampled seven sites on the Ohio River between 1999-2004 (some sites were sampled several times) and collected crayfishes by hand and with small dip nets by turning rocks while wading, or by snorkeling to detect crayfish by touch. Crayfishes were taken alive to the laboratory for colour photography and the extraction of abdominal muscle for genetic analyses. Crayfishes were then preserved in 70% ethyl alcohol for morphological study and later deposited in the Museum of Comparative Zoology, Harvard University (MCZ), Illinois Natural History Survey, Champaign (INHS), North Carolina State Museum of Natural Sciences, Raleigh (NCSM), and Ohio State University Museum of Biological Diversity, Columbus (OSUMC). We also collected and borrowed additional specimens of other species for comparison with the new species (see Appendix). Specimens were categorized to sex (male = M, female = F) and form (sexually competent = I, sexually incompetent = II) prior to making measurements. Carapace length (CL) and 20 standard measurements were recorded to the nearest 0.1 mm using digital calipers. We measured 150 specimens (7 MI, 72 MII, 6 FI, 65 FII), and examined a total of over 185 specimens of the new species, excluding any specimens with regenerated chelae from calculations involving chela measurements. Measurements also were taken on 29 *O. forceps* (7 MI, 6 MII, 9 FI, 6 FII, 1FI/II?; all syntypes or topotypic specimens) and 65 *O. placidus* (35 MI, 3 MII, 22 FI, 5 FII). Width of the abdomen at pleonite 2 was recorded for female crayfishes to check for differences between female forms (Wetzel 2002). Because form I males and females were collected infrequently at first, several form II males and females from Lock & Dam 53 (12 August 2001) were held in captivity until moulting to form I. An additional 2 females (form II) from Joppa and 10 females (7 form I, 3 form II) from Lock & Dam 53 collected on 12 August 2004 were measured for width of abdomen and CL only, but the 3 females collected as form II (from Lock & Dam 53 only) moulted in captivity and were measured in the form I condition only.

Several juvenile and adult animals collected at various times were held in aquaria to gather life history information. Care of most was secondary to the fishes with which they were housed, although 2 form I females, one each collected 16 November 2001 and 12 October 2003, were kept in the laboratory to promote oviposition and spawning. A first female collected 16 November 2001 was held in thermally (minimum 3°C and maximum 25°C) and photically (25 watt incandescent) controlled aquaria and subjected to a compressed seasonal cycle (12 months to 4 months). The second form I female collected 12 October 2003 was

held at 6°C in continuous darkness until 29 June 2004, then abruptly warmed to 23°C and held under a 16 light: 8 dark photoperiod. Females were housed individually (except for the first female which was held in the company of a conspecific form I male for the first 2 weeks) in 37.8 L aquaria each with a mixture (95:5) pea gravel and crushed oyster shell to a depth of 4 cm and a water depth no less than 10 cm. Clay flowerpot bases were provided as cover, and supplemental aeration from an airstone was continuous. Animals were checked weekly and fed cultured live foods (amphipods *Hyalella azteca*, bloodworms *Chironomus tentans*, and chopped nightcrawlers *Lumbricus* sp.).

**Orconectes (*Procericambarus*)  
*pardalotus* n. sp.** Wetzel, Poly & Fetzner  
leopard crayfish  
(Figs. 1-4; Tables I-II)

*Orconectes placidus*: Page 1985 (in part)

*Orconectes* n. sp. (leopard crayfish): Poly and Wetzel 2003 (their Figs. 5C, F, and I [all from MCZ 47143, 26.1 mm CL, form I male, paratype as designated herein] and Fig. 6D [= Fig. 2A, holotype as designated herein])

**Holotype:** MCZ 64477, 33.2 mm CL male (form I), Ohio River at Lock & Dam 53, 5 km NE of Olmsted, Pulaski Co., T15S, R2E, Sec. 18, NW 1/4, Lat./Long.: 37°12'12"/89°02'29", 12 August 2001, W.J. Poly & J.E. Wetzel.

**Paratypes:** MCZ 64510, 26.1 mm CL female (form I, allotype) (caught as form II, kept in captivity, moulted, and preserved on 7 January 2002 as form I); morphotypic male, MCZ 64512, 26.4 mm CL male (form II); morphotypic female, MCZ 64511, 24.8 mm CL female (form II);

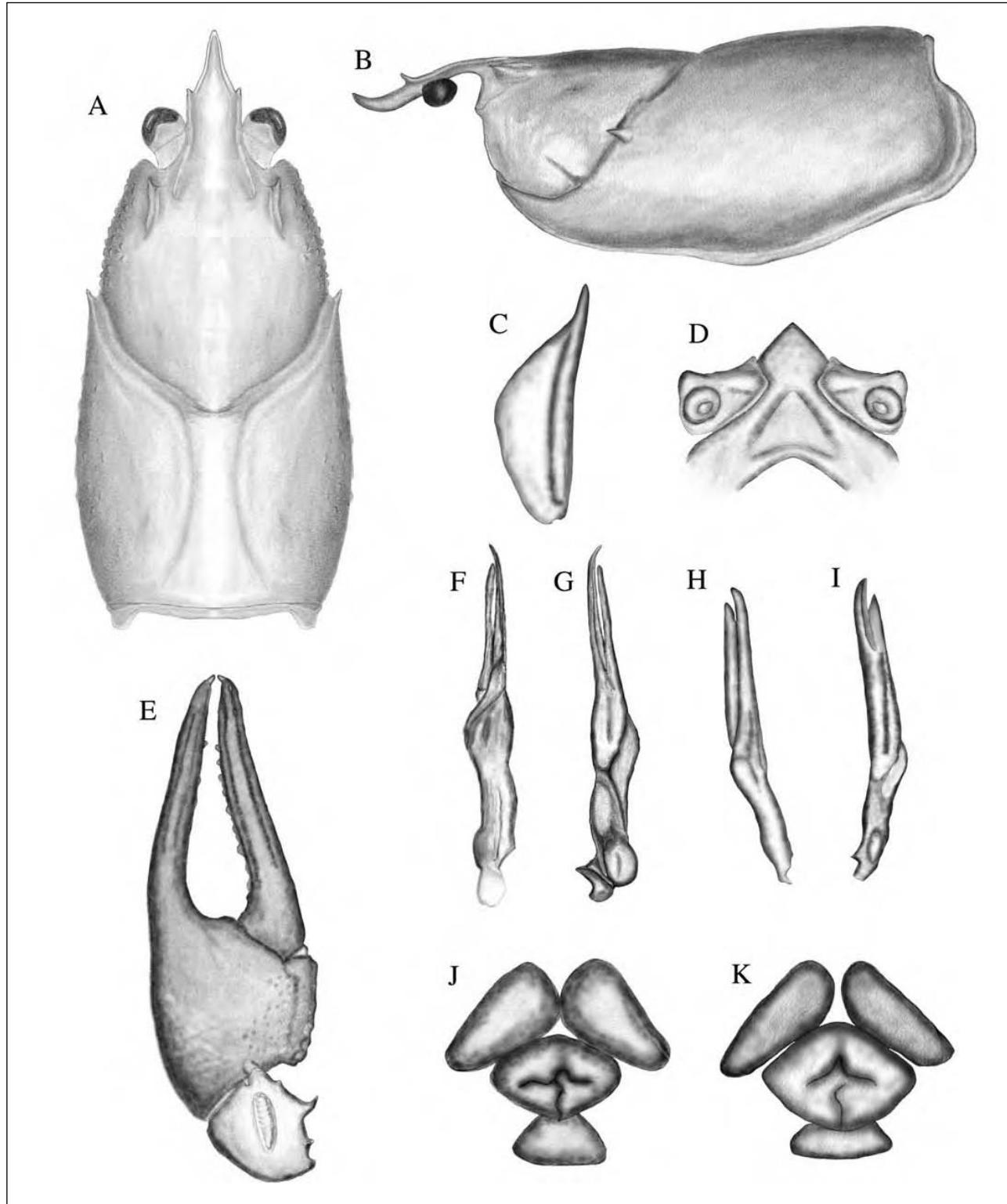
other paratypes, MCZ 47140 (n = 39 [20 MII, 19 FII]), INHS 9109 (n = 19 [11 MII, 8 FII]), OSUMC 4252 (n = 19 [12 MII, 7 FII]), MCZ 47143 (n = 1 [MI] (caught as form II, kept in captivity, moulted to form I, and preserved on 30 December 2001)); W.J. Poly, personal collection (n = 4 [1 MI (caught as form II, kept in captivity, moulted, and preserved in December 2001), 1 MII, 1 FI (caught as form II, kept in captivity, moulted, and preserved in early 2002), 1 FII]); J. E. Wetzel, personal collection (n = 6 [5 MII, 1 FI]); John E. Schwegman, personal collection (n = 1 MII); all paratypes listed above were collected with the holotype; J. E. Wetzel, personal collection (n = 15 collected 12 August 2004 [5 MI, 3 FI (collected as form II, kept in captivity, moulted, preserved late 2004) and 7 FI]).

**Non-types:** ILLINOIS: INHS 3075 (n = 6), Ohio River, 2 miles S of Hillerman, Massac Co., 12 August 1976, L. M. Page & M. A. Morris. INHS 3516 (n = 12), Ohio River, 2.5 miles NE of Olmsted, Pulaski Co., 16 July 1975, L. M. Page & M. A. Morris. INHS 4434 (n = 2), Ohio River, 1 mile S of Hillerman, Massac Co., T15S,

R3E, Sec. 16, SW 1/4, 18 August 1994, K.S. Cummings & C. A. Mayer. INHS 6778 (n = 1), Ohio River, Joppa, Massac Co., T15S, R3E, Sec. 24, SE 1/4, 28 August 1998, L. M. Page et al. INHS 7278 (n = 2), Ohio River, S of Hillerman, Massac Co., 6 October 1988, K.S. Cummings, C. A. Mayer & R. E. Caldwell. MCZ 47138 (n = 2), Ohio River at Joppa boat ramp, Massac Co., T15S, R3E, Sec. 23, NE 1/4, Lat./Long.: 37°12'02"/88°50'41", 25 July 2001, J. E. Wetzel & W. J. Poly. MCZ 47133 (n = 11), [same locality as MCZ 47138 above], 10 August 2001, J. E. Wetzel & W. J. Poly. MCZ 47139 (n = 15), [same locality as MCZ 47138 above], 12 August 2001, W. J. Poly & J.E. Wetzel. INHS 9110 (n = 9), Ohio River at Mound City boat ramp, Pulaski Co., T16S, R1W, Sec. 25, SE 1/4, Lat./Long.: 37°05'10"/89°09'26", 12 August 2001, J. E. Wetzel & W. J. Poly. MCZ 47136 (n = 28), Ohio River at Cairo boat ramp (East side), Alexander Co., T17S, R1W, Sec. 25, SE 1/4, Lat./Long.: 37°00'10"/89°09'57", 12 August 2001, W.J. Poly & J. E. Wetzel. NCSM 23769 (n = 1), Ohio River, 5.5 km ESE of Joppa near coal conveyors, River Mile 947.8, Massac Co., T15S, R4E, Sec. 29, Lat./Long.: 37°10'53"/88°47'21", 15 September 2001, J. E. Schwegman. INHS 9102 (n = 1), [same locality as MCZ 47136 above], 30 September 2001, J.E. Wetzel & W. J. Poly. NCSM 23770 (n = 1), Ohio River, 4 km ESE of Joppa, River Mile 949, Massac Co., T15S, R4E, Sec. 30, Lat./Long.: 37°11'23"/88°48'31", 17 November 2001, J. E. Schwegman. J. E. Wetzel personal collection (n = 3), [same locality as MCZ 47138 above], 12 August 2004, J. E. Wetzel.

### Diagnosis

Body pigmented, eyes well developed. Rostrum, with thickened lateral carinae, broad basally, concave laterally, basally convergent to mid-length, anterior half parallel to base of acumen where studded with paired, conspicuous, anterior-dorsal projecting spines; median carinae absent to weakly developed, apex of acumen with similar, anterior-dorsal directed spine. Postorbital ridges thickened and capped at anterior extremity with prominent, corneous, usually spiniform tubercle. Suborbital angle obtuse, usually rounded. Cervical spines present; dorsolateral areas of carapace densely punctate, transitioning to granulate ventrally, dorsal surface with punctations scattered and nearly entire. Areola of adults 3.8 to 5.3 times longer than wide, its length comprising 33.9 to 36.1% of entire length of carapace (44.2 to 46.3% of postorbital carapace length), and bearing 4 to 5 punctations (average 4) across narrowest part (for specimens in Table I). Chelae; with poorly defined punctations on mesial surface of palm. Fingers with tubercles restricted to opposable margins; both fingers with well defined dorsomedian longitudinal ridges. Dorsomedian carpal spine usually absent. Prominent subacute hook on ischium of third pereiopod distinctly overreaching basoischial articulation in form I males



**Fig. 1.** *Orconectes pardalotus* n. sp. **A)** Carapace, dorsal view. **B)** Carapace, lateral view. **C)** Antennal scale, dorsal view (setae not shown). **D)** Epistome, ventral view. **E)** Chela (propodus and dactylus) and carpus, dorsal view. **F)** Pleopod 1 (gonopod), form I, lateral view. **G)** Pleopod 1, form I, mesial view. **H)** Pleopod 1, form II, lateral view. **I)** Pleopod 1, form II, mesial view. **J)** Annulus ventralis, form I, ventral view. **K)** Annulus ventralis, form II, ventral view. A–G (from holotype), H, I (from morphotypic male), J (from allotype), K (from morphotypic female). Drawings by J. E. Wetzel.

**Table I.** Measurements (in mm) of holotype, allotype, and morphotypes of *Orconectes pardalotus* n. sp.

Structure	Holotype male (form I) (MCZ 64477)	Allotype female (form I) (MCZ 64510)	Morphotype male (form II) (MCZ 64512)	Morphotype female (form II) (MCZ 64511)
Total length	65.1	52.6	53.3	50.7
Carapace				
Length	33.2	26.1	26.4	24.8
Postorbital length	25.9	20.3	20.5	19.0
Height	12.5	9.7	9.9	8.9
Width	16.0	13.0	13.1	12.1
Rostrum				
Total length	7.3	5.8	5.9	5.8
Acumen length	2.9	2.0	2.1	1.8
Base width	2.8	2.4	2.4	2.1
Antennal scale				
Length	6.8	5.1	6.1	5.3
Width	2.5	2.0	2.1	2.0
Areola				
Length	12.0	9.0	9.4	8.4
Width	2.6	2.4	2.2	1.6
Chela (right, except allotype)				
Lateral margin length	37.1	21.1	24.5	21.1
Palm mesial margin length	9.3	5.4	6.5	5.2
Dactyl length	22.5	13.4	16.0	13.5
Palm width	13.7	9.3	10.3	8.0
Carpus length	9.9	7.6	7.9	6.9
Carpus width	8.1	5.9	6.3	5.1
Abdomen				
Length	31.9	26.5	26.9	25.9
Width	13.3	12.3	10.8	10.5
Depth	7.8	6.7	7.0	6.2

only. Pleura of second through fifth abdominal segments tapering to subacute apices. Pleuron 1 pleopod/gonopod of first form male terminating in 2 elements; slightly curved, scythe-like, tapering central projection with apex, directed anterodistally, corneous; and mesial process subequal in length to central projection, noncorneous, distal half flattened, reflexed mesially and directed anteromesially with apex situated mesial to apex of central projection. Pleuron 1 pleopod of form II male non-corneous, extending to just beyond the anterior edge of the basis, central projection curved, mesial process straight and subequal in length; both elements tapering to rounded tips. Colour tan to light brown (sometimes with greenish tint) with randomly distributed darker blotches and speckles (density variable among individuals). First pleopods present on female.

### Description

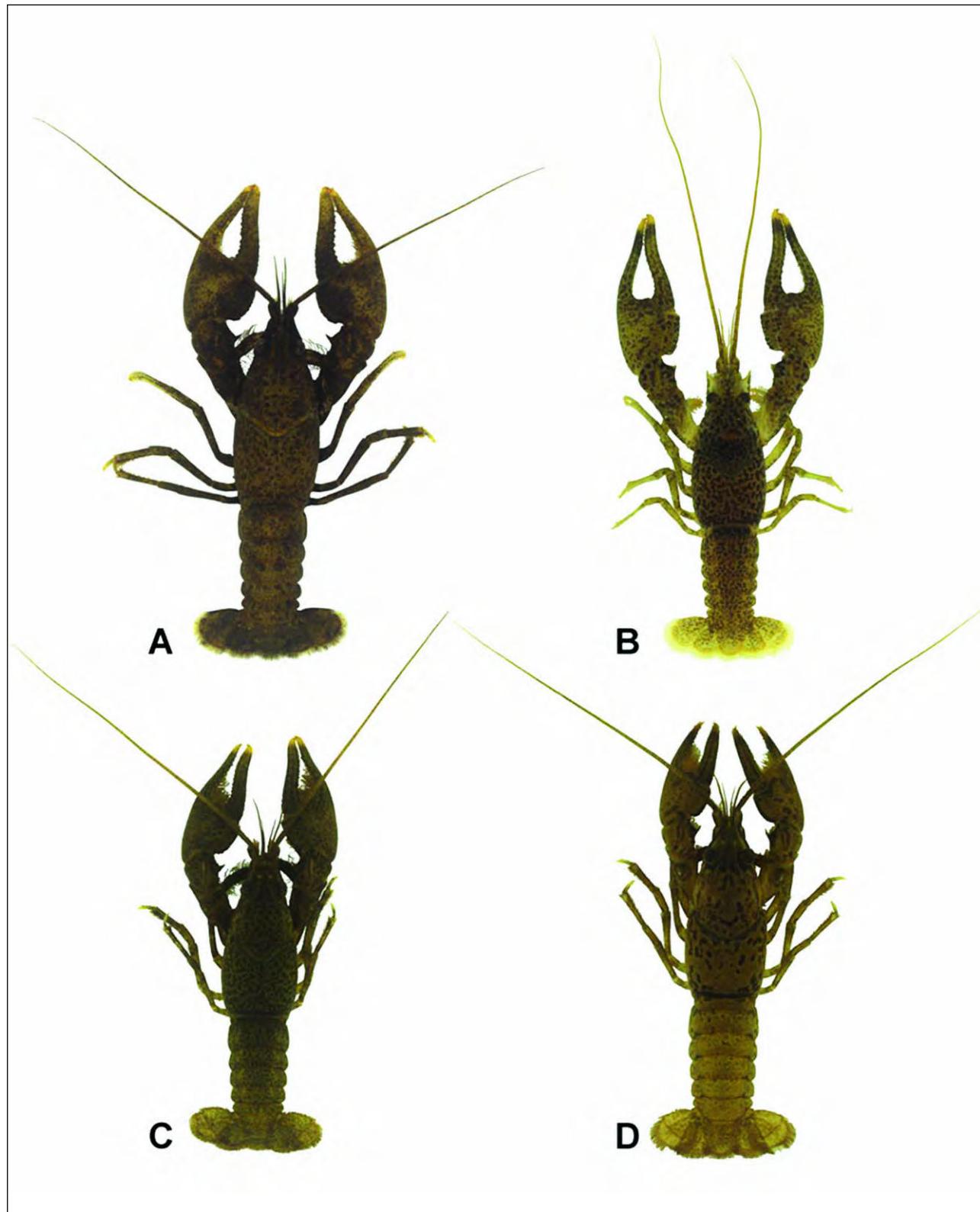
**Holotypic male, form I.** Carapace (Figs. 1A, B): length (33.2 mm), slightly depressed and wider than abdomen (16.0 and 13.3 mm, respectively), greatest width broader than height at caudodorsal margin of cervical groove (16.0 to 12.5 mm). Postorbital carapace length (25.9 mm) 78% of carapace length. Areola 4.6 times longer (12.0 mm) than wide (2.6 mm) with punctations

across the narrowest part arranged in poorly defined rows of 2 to 5; length of areola 36% of carapace length. Rostrum densely covered with punctations, dorsally concave, margins thickened laterally, anterior halves parallel terminating in diverging corneous spines, posterior halves diverging, median carina weakly developed. Acumen terminating in upturned corneous spine reaching distal end of antennular peduncle. Post orbital ridges well developed, terminating in corneous spines with less developed secondary ridge immediately dorsal. Suborbital angle obtuse. Hepatic tubercles present. Cervical spines corneous; dorsolateral areas of carapace densely punctate, ventrally transitioning to granulate, dorsal surface with punctations scattered and nearly entire.

**Cephalon:** Antennal scale (Fig. 1C) broadest distal to mid-length; mesial and lateral margins subparallel for more than half length; thickened lateral margin terminating in large corneous spine, lateral margin with single row of lateral punctations and setiferous with setae in ventrolateral groove, anteromesial margin setose. Right antennal scale about 2.7 times as long as wide (6.8 and 2.5 mm, respectively); extended anteriorly beyond apex of rostrum. Ventral surface of proximal podomere of antennule setose; with well developed spine at about base of distal half and slightly mesial of



**Fig. 2.** Variation in shape of chelae and pigmentation of *Orconectes pardalotus* n. sp. (dorsal views). **A)** Holotype, MCZ 64477, 33.2 mm CL, form I male. **B)** Allotype, MCZ 64510, 26.1 mm CL, form I female. **C)** Morphotypic male, MCZ 64512, 26.4 mm CL, form II male. **D)** Morphotypic female, MCZ 64511, 24.8 mm CL, form II female. Photos by C. Broadie and W. J. Poly. Fig. 2A reproduced from Poly and Wetzel (2003, their Fig. 6D) with kind permission from D. K. Camp on behalf of The Crustacean Society.



**Fig. 3.** Variation in shape of chelae and pigmentation of *Orconectes pardalotus* n. sp. (dorsal views). **A)** Paratype, MCZ 47140, 30.3 mm CL, form II male. **B)** Paratype, WJP coll., 26.5 mm CL, form I male. **C)** Paratype, MCZ 47140, 24.1 mm CL, form II male. **D)** Non-type, MCZ 47133, 21.5 mm CL, form II female. Photos by C. Broadie and W. J. Poly.

**Table II.** Range of values, means, relationship to carapace length, and R<sup>2</sup> for relationship as a function of sex and form within *Orconectes pardalotus* n. sp. (n = 150; holotype, allotype, and morphotypes included).

Structure	Male (form I)	Female (form I)	Male (form II)	Female (form II)
Total length	(51.9-65.7; 57.9) 2.02(CL)-0.74; 0.97	(51.6-69.3; 58.5) 1.66(CL)+9.29; 0.99	(26.3-67.3; 43.4) 1.94(CL)+1.38; 0.99	(26.6-60.4; 45.2) 1.98(CL)+0.72; 0.99
Carapace Length	(26.1-33.2; 29.0) NA	(25.2-36.4; 29.6) NA	(13.2-35.3; 21.7) NA	(13.4-30.6; 22.5) NA
Postorbital length	(20.2-25.9; 22.8) 0.76(CL)+0.75; 0.98	(19.5-28.0; 22.8) 0.76(CL)+0.42; 0.99	(9.6-28.0; 16.7) 0.82(CL)-1.17; 0.99	(10.1-24.1; 17.3) 0.81(CL)-0.90; 0.99
Height	(9.7-12.5; 10.9) 0.45(CL)-2.11; 0.97	(9.3-13.8; 11.1) 0.41(CL)-1.11; 0.98	(4.2-13.1; 8.0) 0.38(CL)-0.29; 0.95	(5.0-11.5; 8.3) 0.38(CL)-0.30; 0.95
Width	(12.8-16.4; 14.5) 0.47(CL)+0.79; 0.91	(11.8-16.8; 14.2) 0.43(CL)+1.53; 0.97	(5.5-16.6; 10.1) 0.53(CL)-1.26; 0.97	(5.9-14.7; 10.4) 0.49(CL)-0.71; 0.97
Rostrum				
Length	(5.4-7.3; 6.2) 0.24(CL)-0.75; 0.85	(5.7-8.4; 6.8) 0.24(CL)-0.42; 0.89	(3.4-7.3; 5.0) 0.18(CL)+1.17; 0.86	(3.3-6.8; 5.2) 0.19(CL)+0.90; 0.88
Acumen length	(1.7-2.9; 2.3) 0.14(CL)-1.69; 0.70	(2.0-3.1; 2.6) 0.09(CL)-0.01; 0.67	(1.1-3.1; 2.0) 0.06(CL)+0.70; 0.45	(1.4-3.1; 2.2) 0.07(CL)+0.54; 0.59
Width at base	(2.1-3.2; 2.6) 0.10(CL)-0.39; 0.66	(2.4-3.2; 2.7) 0.07(CL)+0.58; 0.86	(1.3-3.2; 2.1) 0.08(CL)+0.31; 0.90	(1.3-2.8; 2.1) 0.08(CL)+0.24; 0.88
Antennal scale				
Length	(5.3-6.8; 6.1) 0.19(CL)+0.73; 0.73	(4.6-7.6; 6.0) 0.26(CL)-1.60; 0.89	(3.1-7.5; 4.9) 0.19(CL)+0.74; 0.89	(2.6-6.4; 5.1) 0.19(CL)+0.80; 0.87
Width	(1.9-2.7; 2.2) 0.09(CL)-0.25; 0.78	(1.7-2.8; 2.3) 0.09(CL)-0.32; 0.94	(1.0-2.7; 1.7) 0.07(CL)+0.08; 0.91	(1.1-2.6; 1.8) 0.08(CL)+0.04; 0.91
Areola				
Length	(9.1-12.0; 10.4) 0.40(CL)-1.37; 0.98	(9.0-12.5; 10.3) 0.33(CL)+0.42; 0.99	(4.3-13.1; 7.5) 0.38(CL)-0.79; 0.98	(4.4-10.7; 7.7) 0.36(CL)-0.44; 0.96
Width	(1.6-2.6; 1.9) 0.07(CL)+0.04; 0.21	(1.7-3.0; 2.4) 0.10(CL)-0.52; 0.71	(0.9-2.9; 1.7) 0.07(CL)+0.15; 0.51	(1.0-2.6; 1.8) 0.07(CL)+0.10; 0.59
Chela				
Lateral margin length	(26.9-37.1; 32.0) 1.32(CL)-6.49; 0.91	(18.6-32.6; 25.0) 1.13(CL)-8.44; 0.95	(9.0-36.9; 18.6) 1.27(CL)-8.83; 0.97	(8.4-26.6; 17.2) 0.96(CL)-4.52; 0.88
Palm mesial margin length	(6.8-9.4; 8.1) 0.36(CL)-2.40; 0.88	(5.2-7.9; 6.4) 0.26(CL)-1.19; 0.97	(2.5-9.2; 4.9) 0.31(CL)-1.89; 0.94	(2.3-7.0; 4.7) 0.25(CL)-0.94; 0.92
Dactyl length	(17.3-23.3; 20.3) 0.85(CL)-4.39; 0.77	(11.6-20.8; 15.9) 0.70(CL)-4.79; 0.90	(5.6-23.7; 11.7) 0.82(CL)-5.97; 0.95	(5.0-16.9; 10.9) 0.63(CL)-3.40; 0.94
Palm width	(11.4-15.0; 12.8) 0.40(CL)+1.09; 0.82	(7.8-12.2; 10.1) 0.33(CL)+0.22; 0.89	(3.6-13.6; 7.5) 0.49(CL)-3.02; 0.96	(3.3-10.4; 7.1) 0.40(CL)-1.94; 0.95
Carpus length	(7.8-10.7; 9.0) 0.35(CL)-1.22; 0.88	(6.6-10.0; 8.1) 0.26(CL)+0.31; 0.95	(3.3-11.1; 6.2) 0.35(CL)-1.42; 0.96	(3.2-8.7; 6.0) 0.30(CL)-0.80; 0.94
Carpus width	(6.6-8.7; 7.4) 0.27(CL)-0.32; 0.86	(4.7-7.7; 6.2) 0.23(CL)-0.49; 0.90	(2.3-8.6; 4.7) 0.30(CL)-1.85; 0.94	(2.2-6.4; 4.5) 0.24(CL)-0.91; 0.93
Abdomen				
Length	(25.4-33.5; 28.9) 1.02(CL)-0.74; 0.91	(26.1-32.9; 28.9) 0.66(CL)+0.929; 0.95	(13.1-32.0; 21.8) 0.94(CL)+1.38; 0.96	(13.2-29.8; 22.7) 0.98(CL)+0.72; 0.97
Width	(10.4-14.1; 11.9) 0.45(CL)-1.08; 0.89	(11.4-17.0; 13.5) 0.45(CL)+0.17; 0.96	(5.2-13.6; 8.7) 0.40(CL)+0.05; 0.98	(5.3-13.0; 9.4) 0.43(CL)-0.30; 0.98
Depth	(6.4-8.3; 7.4) 0.14(CL)+3.34; 0.27	(6.4-8.9; 7.2) 0.21(CL)+1.02; 0.91	(3.5-8.2; 5.5) 0.23(CL)+0.61; 0.91	(3.1-7.4; 5.6) 0.22(CL)+0.62; 0.94

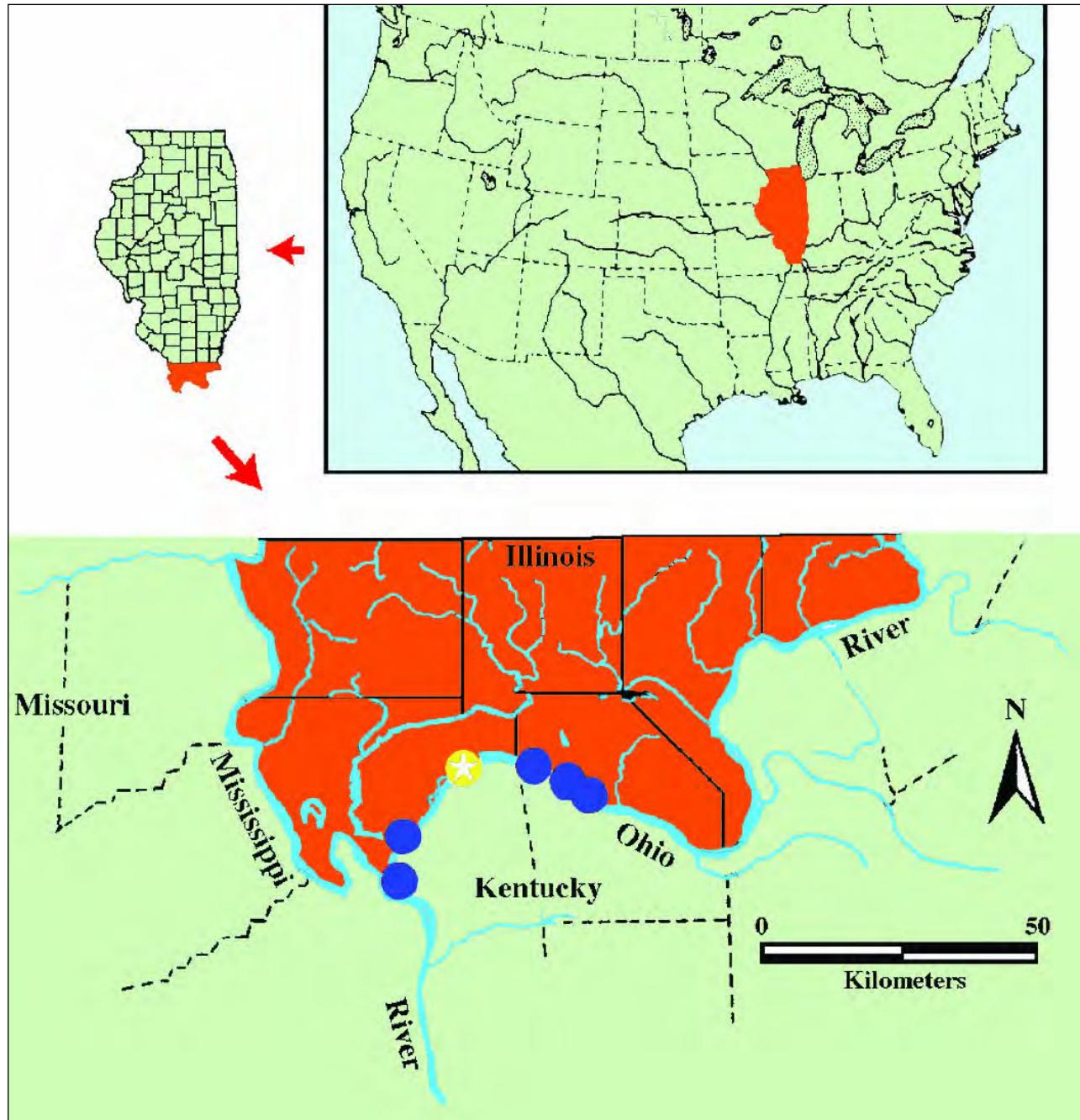
median line of podomere. Antennal peduncle setose mesially, sparse ventral punctations with setae; intact antennal flagellum extending posteriorly beyond posterior margin of telson, antennae moderately compressed dorsoventrally. Mandible with 2 large rounded teeth distally, 2 to 3 small teeth proximally, and 2 molariform teeth proximal and dorsal to other teeth; distal molar well developed and cornified, proximal molar flattened, immaculate, not cornified (mandibles not sym-

metrical). Epistome; cephalomedian lobe diamond shaped, lateral points depressed ventrally; ventral surface setose; main body with distinct fovea anteromedially, depression becoming shallower as it extends posteriorly in roughly triangular-shaped area; 2 distinct, angled grooves at junction of epistome and epistomal zygoma; epistomal zygoma arched (Fig. 1D).

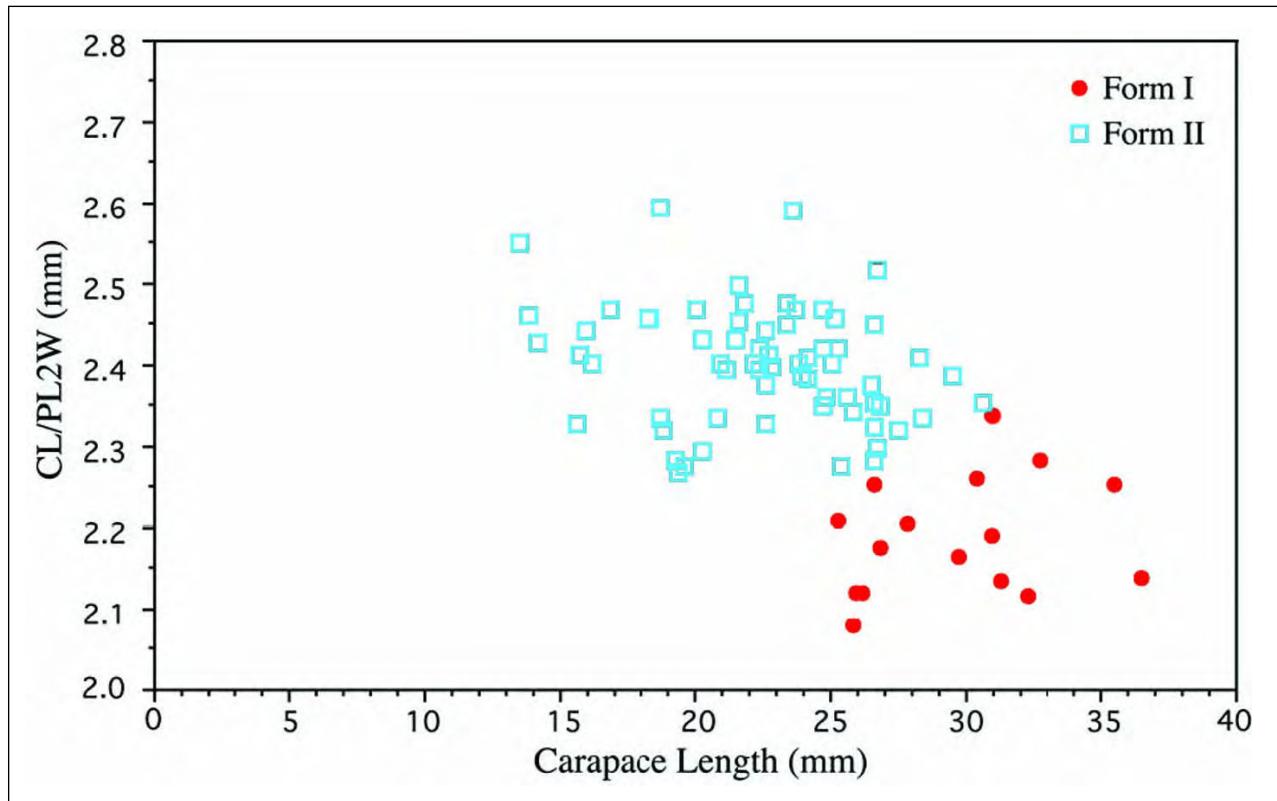
**Thorax:** Maxilliped 3; ischium crista dentata (left 20, right 18) distal tooth largest, some proximal teeth quite

small, ischium ventral surface bearing long stiff setae, setae scattered over lateral half short and prostrate; distolateral extremity of podomere not produced. Chela; length (37.1 mm) about 2.7 times width (13.7 mm), moderately depressed, large gap maximal in proximal one-third of finger length (Figs. 1E, 2A).

Propodus; palm moderately depressed; mesial margin bearing single large proximal tubercle containing a socket that articulates with carpus, and distally with 2 rows of low tubercles (mesial row (left 6, right 5), dorsomesial row 6), mesial row offset distally to dorsomesial row; palm dorsal surface, 2 rows of low tubercles



**Fig. 4.** Distribution of *Orconectes pardalotus* n. sp. in the lower Ohio River between Illinois and Kentucky. Starred (yellow) circle is the type locality (Lock & Dam 53 near Olmsted, Illinois), and solid (blue) circles represent other collection sites (some circles represent multiple collections at the same site or multiple sites that are near one another). Collection localities encompass Massac, Pulaski, and Alexander counties, Illinois. Insets: box at upper right, map of the United States of America with the State of Illinois darkened (orange); at upper left, Illinois with study area darkened (in orange).



**Fig. 5.** Scatterplot of the ratio carapace length/pleonite 2 width (CL/PL2W, mean  $\pm$  SD) for form I (= reproductive form) ( $2.2 \pm 0.072$ , n = 16) and form II female *Orconectes pardalotus* n. sp. ( $2.4 \pm 0.071$ , n = 67).

extending distally replaced laterally to lateral margin by rows of punctations, lateral margin with ridge defined by dorsolateral and ventrolateral rows of punctations, ventral surface with rows of punctations (punctuation rows of dorsal and ventral surfaces appear to radiate from proximal margin of propodus and lateral rows continue onto finger). Palm of propodus with length of mesial margin (9.3 mm) subequal to greatest width (13.7 mm) of podomere. Propodus finger; dorsal surface, basally with several irregular rows of punctations decreasing to 3 rows along greater part of finger length with distal end having only 2 rows, median longitudinal ridge between medial dorsal and mesial dorsal punctuation rows; lateral margin accentuated by punctations dorsally and ventrally, ventral surface with 3 punctuation rows proximally decreasing to 2 distally; mesial margin, flattened proximally becoming more rounded distally, distal two-thirds to tip straight and nearly parallel to lateral margin, rounded tubercles (left 15, right 17) with increased spacing distally with last tubercle ventral to lateral margin, denticles interspersed with distal tubercles, denticles increasing in size and abundance distally, forming 2 generally alternating rows. Dactyl; mesially with 1 row of tubercles basally intergrading into single row of punctations distally; dorsally with low median ridge defined by punctations that become more pronounced; laterally (opposable margin) with rounded

tubercles (left 15, right 14) distally dispersed, denticles interspersed with distal tubercles; ventrally with 1 weakly developed longitudinal ridge defined laterally by punctations. Denticles of both fingers proximally dispersed in single row, distally transitioning into 2 more densely arranged alternating rows, most distal denticles in single row (denticles continue in row dorsal to last tubercle of propodus finger). Fingers of propodus and dactylus with rounded subterminal corneous tip, contacting each other only along denticulate margins distally. All tubercles and punctations of propodus and dactylus not associated with points of articulation or opposable margins; setae originating from tubercles oriented distally, setae of low relief distal punctations more or less erect relative to exoskeleton surface, within tubercles relief increasing distally, within punctations relief decreasing distally. Carpus; dorsally with deep oblique furrow; dorsomesial margin (basal to distal) with 1 small tubercle, 1 large procurred spine at mid-length and 2 small tubercles at base of large dorsal distal-articulating tubercle; ventrally with 1 postule just mesial to mid-length of distal margin, furrow mesial to distolateral corner enlarged and globular with weakly-developed spine at base of ventral distal-articulating tubercle articulating with cusp on propodus ventroproximal margin, lacking distomedian carpal spine. Merus; dorsally with 1 procurred spine and tubercles;

dorsodistal margin entire, ventrolateral margin with 2 or 3 tubercles and 1 spine (proximal to distal), ventromesial margin 1 row of (left 5, right 6) tubercles (each with single erect seta), terminating by large procurred spine, lateral margin with 1 spine at base of tubercle articulating with carpus. Pereiopod 3 only with ischial hook; hook simple, overreaching basioischial articulation. Sternum between third and fourth pereiopods depressed ventrally, setose, broadly U-shaped, with rounded angular caudal margin. Pereiopod 4 and 5 dactylus length 6.1 and 6.5 times depth at mid-length, respectively. Pereiopod 5 gonopore (on coxa) enlarged and protruding with mesial setal tuft reaching well-developed and erect "sternite XIV setal tuft" (two tufts of setae on last thoracic sternite) that extends ventrally from raised boss.

Abdomen: shorter than carapace (31.9 and 33.2 mm,



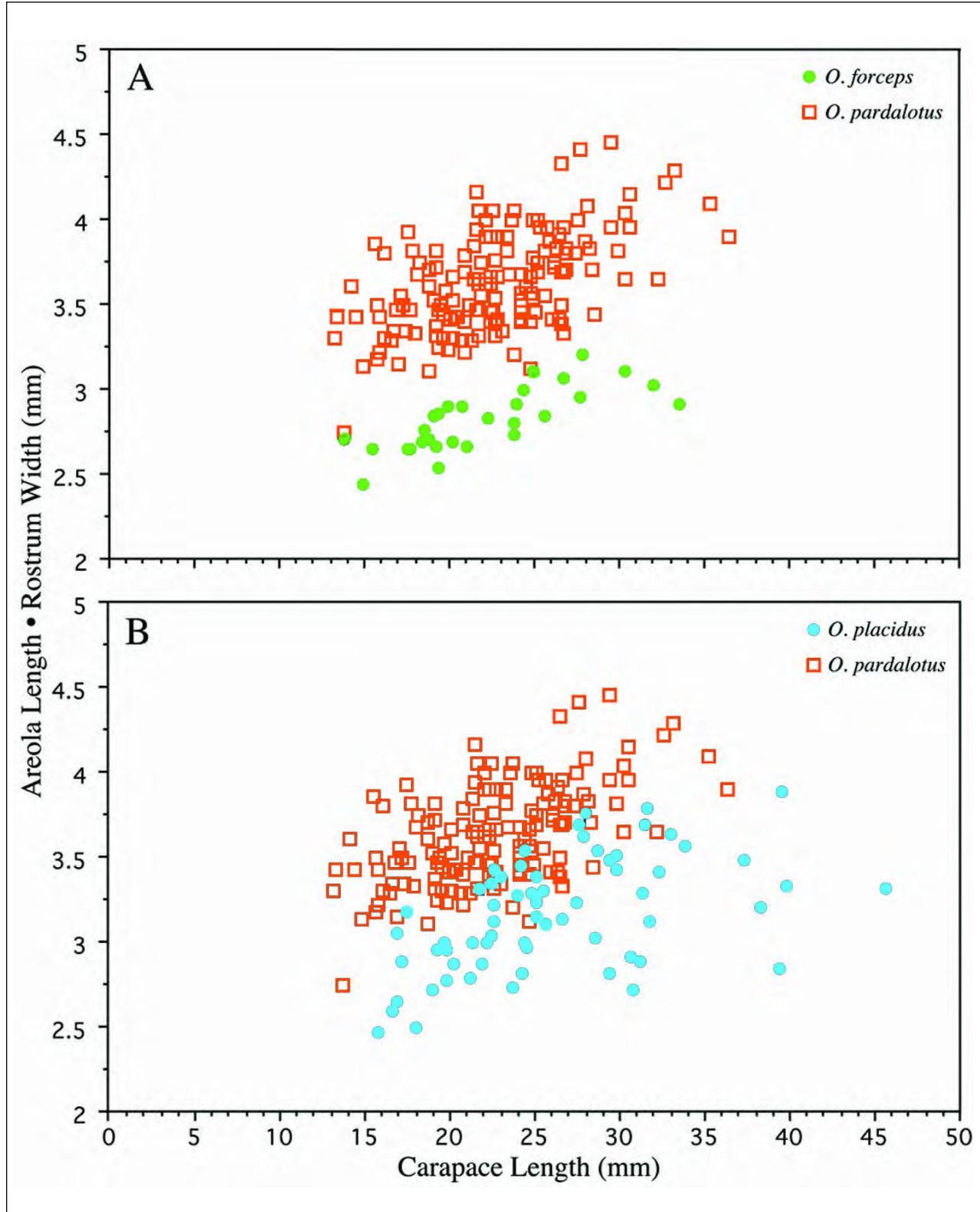
**Fig. 6.** *Orconectes forceps* from Cypress Creek, Lauderdale Co., Alabama (33.5 mm CL, form I male, dorsal view). Photo by C. Broadie and W. J. Poly.

respectively); pleura rounded and fringed with setae. Pleuron 1 pleopod expanded to form gonopod (Figs. 1F, G) as in Diagnosis, central projection constituting 37% of total length of pleopod. Pleuron of pleopod 2 expanded to form accessory gonopod. Pleopods of pleurons 3, 4 and 5 present as functional swimmerets. Pleopod 6 supports uropods and telson. Dorsal surfaces of abdominal pleura, telson, and uropods with numerous punctations. Cephalic dorsal region of telson with lateral margins parallel anteriorly, slightly convergent posteriorly with 2 spines at each caudolateral corner; mesial flexible spine shorter than lateral fixed spine. Anus opens on telson ventrally. Telson and exopodites of uropods with flexible caudal sections about one-third (exopodites) or one-half (telson) length of cephalic sections. Protopodite of uropod dorsally with spine extending over endopodite and spine in caudolateral corner extending over exopodite. Cephalic section of exopodite; caudal margin with fixed corneous spines (left 17, right 16), large flexible spine located mesially to largest fixed spine on caudolateral margin; prominent median ridge, bordered by parallel depressions. Endopodite with prominent median ridge terminating in corneous spine. Uropod exopodite caudal section with median ridge defined anteriorly with a tubercle with ridge topography reducing as it extends posteriorly to be obliterated at mid-length of caudal section. Uropod endopodite with prominent median ridge terminated by premarginal spine and caudolateral spine. Dorsal surfaces of telson and uropods setiferous and posterior margins fringed with setae. Ventral surfaces of telson and uropods entire. See Table I for measurements of holotype.

Allotypic female, form I. Differing from holotype as follows. Carapace: length (26.1 mm), carapace slightly wider than abdomen (13.0 and 12.3 mm, respectively), areola 3.8 times longer than wide. Acumen terminating in upturned spine reaching just beyond base of antenular peduncle.

Cephalon: mandible (proximal to distal) with 2 molari form, 3 to 4 small, and 2 large teeth. Epistome; cephalomedian lobe (asymmetrical) spade-shaped anteriorly, slightly rounded with small anterior projection.

Thorax: maxilliped 3; ischium crista dentata (left 22, right 19). Chela; length (21.1 mm) about 2.3 times width (9.3 mm) (Fig. 2B); propodus mesial margin with 2 rows of tubercles (mesial (left 9, right 8) and dorsal mesial (left 6, right 8)); propodus finger mesial margin tubercles (left 14, right 13); dactyl lateral margin tubercles (left 13, right 15). Pereiopod 3 genital pore present on coxa with membranous flap over opening surrounded by ring of well-developed setae, ischial hook absent. Thoracic sternites 3 and 4; produced, entire, broadly V-shaped, with angular caudal margin; posteriorly modified into annulus ventralis (Fig. 1J) outgrowth of sternite, corneous and strongly convoluted, irregularly ovate with greater axis lying transversely, about 1.4 times as broad as long; cephalomedian trough



**Fig. 7.** Scatterplot of the multiplication of areola length and rostrum width (mean  $\pm$  SD) for: **A**) *Orconectes pardalotus* n. sp. ( $3.6 \pm 0.289$ ,  $n = 150$ ) and *O. forceps* ( $2.8 \pm 0.183$ ,  $n = 29$ ), both sexes combined. **B**) *Orconectes pardalotus* n. sp. ( $3.6 \pm 0.289$ ,  $n = 150$ ) and *O. placidus* ( $3.2 \pm 0.332$ ,  $n = 65$ ), both sexes combined.

deep, flanked by conspicuous cephalolateral prominences, transverse sulcus well defined with tongue extending anterodextrally, disappearing under high, longitudinally creased caudal wall. Postannular sclerite two-thirds width of and less than one-half length of annulus ventralis. Sternite 5 entire.

**Abdomen:** length longer than carapace length (26.5 and 26.1, respectively). Pleura flared. Pleopods; first pleopod reduced, 2 to 5 functional as swimmerets. Ventral surfaces of telson and uropods with low protuberances, each with apical pit (many with 2 pits and some form U-shape opening posteriorly). See Table I for measurements of allotype.

**Morphotypic male, form II.** Excluding primary sexual characteristics, differing from holotype as follows. **Carapace:** length (26.4 mm), areola 4.3 times longer than wide. Acumen terminating in upturned spine reaching distal one-third of antennular peduncle, median carina absent. Epistome; cephalomedian lobe (asymmetrical) spade-shaped, rounded anteriorly.

**Thorax:** maxilliped 3; ischium crista dentata (left 18, right 17). Chela; length (24.5 mm) about 2.4 times width (10.3 mm) (Fig. 2C); propodus mesial margin with 2 rows of tubercles (mesial (left 8, right 7) and dorsal mesial (left 8, right 8)), propodus finger mesial margin tubercles (left 14, right 14), dactyl lateral margin tubercles (left 15, right 15); bushy fringe of setae on propodus (in gap of chela). In terms of primary and secondary sexual characteristics, differing from holotype as follows. Pereiopod 3 ischial hook not overreaching basioischial articulation. Pereiopod 5 gonopore reduced with mesial setal tuft not reaching "sternite XIV setal tuft."

**Abdomen:** longer than carapace (26.9 and 26.4 mm, respectively). Gonopods; see Diagnosis (Figs. 1H, I). See Table I for measurements of morphotypic male.

**Morphotypic female, form II.** Excluding primary sexual characteristics, differing from holotype as follows. **Carapace:** length (24.8 mm), carapace wider than abdomen (12.1 and 10.5 mm, respectively), areola 5.3 times longer than wide. Acumen terminating in upturned spine reaching just beyond distal end of antennular peduncle. Mandible (proximal to distal) with 2 molariform, 3 to 4 small, and 2 large teeth. Epistome; cephalomedian lobe (asymmetrical) spade-shaped, rounded anteriorly.

**Thorax:** maxilliped 3; ischium crista dentata (left 17, right 19). Chela; length (21.1 mm) about 2.6 times width (8.0 mm) (Fig. 2D); propodus mesial margin with 2 rows of tubercles (mesial (left 9, right 8) and dorsal mesial (left 9, right 6)); propodus finger mesial margin tubercles (left 13, right 13); dactyl lateral margin tubercles (left 11, right 10); bushy fringe of setae on propodus (in gap of chela). In terms of primary and secondary sexual characteristics, differing from allotype as follows. Annulus ventralis mirror image of allotype although less cornified and convoluted; lateral edges less rounded (Fig. 1K). Low protuberances on telson

and uropod ventral surfaces less pronounced, excavations not U-shaped. Abdominal pleura less flared. See Table I for measurements of morphotypic female.

**Size:** Maximum CL of 36.4 mm (TL = 69.3 mm) was observed in a form I female. The minimum CL for form I males and females were 26.1 and 25.2 mm, respectively; however, smaller form I animals undoubtedly exist, and the number of form I specimens in this study was small. The maximum CL for form II males and females were 35.3 and 30.6 mm, respectively. The minimum TL of 7.4 mm was observed for laboratory reared third instar juveniles.

**Variations:** There is some allometry of the chelae, with propodus and dactylus fingers proportionally narrower with increasing chela size (Figs. 2-3). Chela length and width increases faster than carapace length. Distomedian carpal spines are absent on most specimens examined for this character ( $n = 165$ , 96%), whereas 1 form I female and 5 form II females (4%) from Joppa had small spines on one ( $n = 4$ ) or both sides ( $n = 2$ ). On some specimens a spine is present (rather than tubercle) posterior of the dorsal distal-articulating tubercle of the carpus. Form II males and females have a bushy fringe of setae on the propodus (in gap of chela), but the setae are much less developed or lacking in form I males and females. Ranges, means, and linear regression equations for all standard measurements as a function of CL appear in Table II.

**Colour in life:** Pigmentation of *Orconectes pardalus* is variable. The base colour of late juveniles through adults (Figs. 2-3) is tan to light brown (sometimes with greenish tint) with a range of tones. Occasional bluish-coloured animals collected 16 August 2004 at Lock & Dam 53 were found at greater depths than animals with more typical coloration. Foreground pigmentation (darker than base colour) in the form of randomly-dispersed spots covering the carapace, abdomen, and chelae, varying from almost none to extensive and from small spots to larger blotches. Posterior margins of pleonites bordered with red. Area ventral to the suborbital angle same as base colour of carapace, yellow to red colouration lacking. Chelae; propodus and dactylus tips creamy-white to yellow, from a distal aspect tubercles on opposable margins form a yellow line that when chelae are greater than 90% open highlight an obvious bright red membrane of the distal point of articulation between the propodus and dactylus.

Early juvenile, instars 3 through 5, carapace and abdomen integument translucent with brownish cast, legs opaque. Numerous bright red spots throughout the integument (carapace and abdomen, spots small and distinct; pereiopods 4 and 5, spots larger and less distinct providing the appearance of red patches on merus, carpus and propodus; antennae and fingers of chelae with numerous large spots that appear red when individual spots can not be resolved.

Substrate colour can affect coloration of integument of adults and juveniles. Animals on a dark background

tend to be darker, whereas those confined over light substrates develop lighter pigment patterns. Contrast between an animal's base coloration and substrate is reduced in juvenile to adults after instar advancement. Early juvenile *O. pardalotus* can minimize contrast within minutes without instar advancement. Epizoic organisms can cover much of the crayfish's natural coloration, thus the best assessment of coloration is obtained from animals freshly moulted or that have been living under conditions that limit epizoic growth.

**Colour in alcohol:** After preservation in alcohol, the base colour fades fairly rapidly. On some specimens the pattern of speckles and blotches can remain for several years, but eventually a complete loss of the original colour pattern will occur (a typical result for preserved crayfishes).

### **Etymology**

The species-group name, *pardalotus*, is latinized from the Greek adjective "pardalotos" ( $\pi\alpha\rho\delta\alpha\lambda\omega\tau\circ\zeta$ ), which means "spotted like a leopard," and refers to the distinctive pigmentation pattern on the body of many specimens. We treat the name as a noun in apposition.

### **Distribution**

This new crayfish has been collected only in the lower main channel of the Ohio River in Massac, Pulaski, and Alexander counties, Illinois (Fig. 4).

### **Ecological notes**

*Orconectes pardalotus* has been collected only from the main channel of the Ohio River where the bottom is covered with rocks or gravel. All collection sites represent anthropogenically-modified areas with artificially high concentrations of rocks used to stabilize the stream bottom. Specimens collected during daylight were under rocks where tertiary burrows had been constructed. On 12 August 2001 we collected specimens from underneath rocks both below and well above the water line at the type locality. Animals collected above the water line were "stranded" due to rapidly changing water levels, but they probably can persist in moist burrows under the rocks for a considerable period of time. Management of the Ohio River by the U.S. Army Corps of Engineers has been to promote navigation and flood control and water levels fluctuate widely, sometimes over short periods of time. Range of depth and abundance of *O. pardalotus* is unknown due to difficulties with sampling the main channel away from the edge. At the type locality the only other crayfish that we collected was *Cambarus* cf. *rusticiformis* Rhoades, 1944; however, *Orconectes placidus*, O. sp. indet., and C. cf. *rusticiformis* were collected with *O. pardalotus* at the Joppa boat ramp site.

### **Life history notes**

Evidence suggests copulation begins prior to mid October (see below), and form I females collected in

mid November were observed copulating with form I males while in confinement. Animals held indoors were observed to couple only while intermoult in a form I instar. Females close to oviposition (gair development maximal and/or subsequent oviposition) appeared particularly stimulating to male copulatory behavior. Form I females post-oviposition, with or without dependent offspring, were not observed to copulate. Crayfish collected as form I in August were larger than average.

Two form I females oviposited under lab conditions. The first, collected 16 November 2001 from the Joppa site oviposited with increasing temperature and light 12 January 2002 (temperature = 12°C; photoperiod 14 light: 10 dark). Oviposition was typical for the genus *Orconectes* with attachment of eggs to the pleopods while they were enveloped in a single bag of glair. Following oviposition temperature was raised approximately 0.5°C/day until it reached 22°C (14 d post-oviposition) when embryos hatched. Offspring were dependent on the parental female for 2 post-hatch instars and until approximately 24 hr after entering the third instar. Beginning 24 hr into the third instar juveniles made brief excursions away from the female when she was sedentary. The female readily fed at this time but appeared to exhibit no cannibalistic tendencies. The parental female would not swim when disturbed but was highly aggressive. Juveniles in the third and earlier instars would clump together when isolated from the parental female although the third instar juveniles would begin to disperse after only about an hour. Juveniles in the third instar moved slowly and restricted their movements to close proximity of or on the parental female. Dispersing juveniles were more active, avoided each other, and were inclined to find small structures and begin burrowing into the substrate. The second ovipositing female (evidence for pre-mid October copulation) collected 12 October 2003 oviposited 1 July 2004 and by 6 July 2004 several embryos showed signs of development. Independent juveniles and adults, associated strongly with burrows or other refugia during daylight hours. Movement and feeding activities were engaged mostly at night.

Both males and females preparing to moult and females with dependent offspring sequestered themselves under structures where some of the displaced gravel was used to plug the entrance. Feeding activities and movement were greatly reduced during the periods surrounding moulting. Adults of both sexes exhibited form alternation, some changing from form II to form I and some changing from form I to form II. Females of *O. pardalotus* exhibit 2 forms based on the ratio of carapace length/pleonite 2 width (Fig. 5) and development of glair glands, but the number of form I females collected was low (especially smaller females) because river levels are high during much of the time period in which females are form I, and thus, they are difficult to collect.

Zebra mussels (*Dreissena polymorpha*) were found

attached to the left ventral surface of pleuron 3 of a form I female *O. pardalotus* (CL = 36.0 mm) collected at the Joppa site on 12 October 2003.

### Remarks

*Orconectes pardalotus* differs from all other members of the genus *Orconectes* by possessing a unique combination of pigmentation, chela shape, carapace, carpal spine pattern, and form I male pleopod characters, and is most similar to *O. forceps* (Faxon, 1884). Other crayfishes that have a large gap between the fingers of the chela include *O. neglectus* (Faxon, 1885), *O. placidus*, *O. forceps*, *O. mirus* (Ortmann, 1931), *O. barrenensis* Rhoades, 1944, and *Cambarus chasmodactylus* James, 1966. The overall shape of the chelae of *O. pardalotus* is most similar to those of *O. forceps* and *C. chasmodactylus*, whereas the other 3 species mentioned above possess dissimilar-shaped chelae. The gonopods of form I specimens of *O. pardalotus* are quite similar to those of *O. forceps*, *O. placidus*, *O. durelli* Bouchard and Bouchard, 1995, *O. barrenensis*, *O. neglectus*, and *O. mirus*. Of these, *O. mirus*, and *O. neglectus* have moderately to well developed cephalic shoulders on the gonopod, whereas *O. forceps*, *O. placidus*, *O. durelli*, and *O. barrenensis* resemble *O. pardalotus* in lacking a shoulder. The carapace of *O. barrenensis* and *O. mirus* are laterally compressed, whereas that of *O. pardalotus* is not. In addition, *O. mirus*, *O. barrenensis*, and *O. neglectus* lack cervical spines, but *O. pardalotus* has well-developed cervical spines. The ventrolateral margins of the carapace of *O. pardalotus*, *O. forceps*, and *O. placidus* possess granulations, producing a rough, sandpaper-like texture, whereas *O. neglectus*, *O. barrenensis*, *O. mirus*, *O. luteus*, and *O. durelli* possess only punctations providing a surface that feels relatively smooth. The rostrum lateral carinae of *O. forceps*, *O. barrenensis*, *O. mirus*, and *O. neglectus* are convergent throughout their length towards the acumen base, whereas *O. pardalotus* and *O. placidus* have convergence only on the proximal half with the distal half parallel. The basal lateral spine of the antenna is present on *O. pardalotus* and lacking on *O. neglectus*. The distomedian carpal spine is absent on *O. pardalotus* (except as noted above), *O. durelli*, *O. barrenensis*, and *O. neglectus*, whereas it is present on *O. placidus* and *O. luteus*. The distomedian carpal spine is usually absent on *O. forceps*, but when present, is usually only a bump or small spine (mostly on females). On *O. mirus* the distomedian carpal spine varies from well developed in females to moderately developed or lacking in males.

Life colour of *O. pardalotus* differs from all the other species that share morphological similarities with it and from all species that occur sympatrically or in adjacent areas of Missouri, Illinois, Indiana, and Kentucky (compare with figures and remarks in Hobbs 1981, Page 1985, Pflieger 1996, Poly and Wetzel 2003). Topotypic specimens of *O. forceps* were collected in September

2004 and life colour differs from *O. pardalotus* (Fig. 6). Poly and Wetzel (2003) found a significant difference for the ratio dactylus length/chela gap width between *O. pardalotus* and *O. placidus*. *Orconectes pardalotus* can be separated from both *O. forceps* and *O. placidus* by the multiplication of areola length and rostrum width vs. carapace length (Figs. 7A, B). However, specimens of *O. placidus* from the Ohio River at Joppa, Illinois, where it occurs with *O. pardalotus*, group with that species more closely, whereas most specimens from Big Creek (Hardin Co., Illinois) are more distinctive (data not shown in Fig. 7). Even though specimens of *O. placidus* from Joppa tend to group with *O. pardalotus* for this quantitative index and a few specimens of *O. pardalotus* from Joppa had small distomedian carpal spines, haplotypes of the 16S rRNA gene from specimens of *O. placidus* from Joppa were the same as those from Big Creek (see Wetzel et al. 2004). Comparison of 16S rRNA gene sequences supports the distinctiveness of the sympatric species *O. pardalotus* and *O. placidus* (Illinois populations only), which have an average sequence divergence of 5.8% (unpublished data).

### Discussion

*Orconectes pardalotus* has a distinctive pigment pattern (when living) making it easily discernable from congeners. The base colour is tan to light brown with darker blotches and speckles on the dorsal/lateral surfaces of the chelae, carapace and abdomen without any belt or band of pigment on the dorsal posterior margin of the carapace or associated with the cervical groove (Figs. 2-3). The chelae of this species are uncommon in possessing a large, teardrop-shaped gap between the fingers. Other crayfishes with similar chelae include *Orconectes forceps*, *O. neglectus*, and *Cambarus chasmodactylus* (James 1966, Hobbs 1981, Pflieger 1996). The structure of the first pleopods is consistent with the definition of the subgenus *Procericambarus* within the genus *Orconectes*; however, molecular data do not support that the subgenus is monophyletic as defined currently (Fetzner 1996, Crandall and Fitzpatrick 1996, Wetzel et al. 2004). Other species exhibiting a *Procericambarus* type of gonopod structure with contiguous or overlapping ranges include *O. placidus* and *O. luteus*. Differences in sculpturing of the gonopod were observed between *O. placidus* and *O. pardalotus* by Poly and Wetzel (2003), but consistency of these differences between the taxa remains to be studied in more detail.

### Appendix. Comparative material.

*Orconectes forceps*. ALABAMA: MCZ 3582 (n = 2, syntypes), Cypress Creek, Lauderdale Co., October 1882, C. L. Herrick. USNM 4880 (n = 7, syntypes), Cypress Creek, Lauderdale Co., October 1882, C. L. Herrick. Authors' collection uncat. (n = 20), Cypress Creek, Lauderdale Co., 18 September 2004, J. E. Wetzel & W. J. Poly.

*Orconectes neglectus*. MISSOURI: Authors' collection uncat. (n = 39), North Fork River upstream of State Route 76 bridge, Douglas Co., T27N, R11W, Sec. 32, NE 1/4, 9 February 2002, J. E. Wetzel & W. J. Poly. Authors' collection uncat. (n = 39), Bryant Creek downstream of State Route 76 bridge, Douglas Co., T26N, R14W, Sec. 7, 9 February 2002, J. E. Wetzel & W.J. Poly.

*Orconectes barrenensis*. KENTUCKY: INHS 5016 (n = 7), Gasper River 10 miles west of Bowling Green on Highway 1083, Warren Co., 2 March 1995, C.A. Taylor, P. A. Ceas & J. C. Porterfield.

*Orconectes mirus*. TENNESSEE: INHS 4940 (n = 15), Hurricane Creek, 5 miles west of Tullahoma, Raysville Rd., Moore Co., 2 November 1994, C.A. Taylor & P. A. Ceas. Authors' collection uncat. (n = 22), Hurricane Creek at Cumberland Spring Rd. bridge, Moore Co., 12 October 2001, J. E. Wetzel.

*Orconectes durelli*. KENTUCKY: INHS 6338 (n = 22), Jonathan Creek, 3.8 miles east-southeast of Dexter, Co. Rt. 1346, Calloway Co., 26 October 1997, M. H. Sabaj, C. A. Taylor & T. J. Near. Authors' collection uncat. (n = 13), Jonathan Creek at 464 bridge, Calloway Co., 7 October 2001, J.E. Wetzel.

*Orconectes placidus*. ILLINOIS: INHS 3064 (n = 2), Ohio River, Fort Massac State Park, Massac Co., 12 August 1976, M. A. Morris & L. M. Page. INHS 3066 (n = 4), Ohio River, Fort Massac State Park, Metropolis, Massac Co., 17 June 1976, M. A. Morris & J. A. Boyd. INHS 6869 (n = 1), Ohio River, Fort Massac State Park, Massac Co., T16S, R5E, Sec. 7, SW 1/4, 29 August 1998, L. M. Page et al. INHS 9101 (n = 7), Big Creek at County Road 400 E bridge, 5 km South of Karbers Ridge, IL, Hardin Co., T11S, R8E, Sec. 28, 12 October 1999, J. E. Wetzel & E. C. Poynter. MCZ 47135 (n = 10), [same locality as INHS 9101 above], 28 October 2001, W. J. Poly & J. E. Wetzel. INHS 9112 (n = 21), Ohio River at Golconda, along rocky area of shoreline near concrete boat ramp, Pope Co., T13S, R7E, Sec. 30, 31 October 1999, J. E. Wetzel & W.J. Poly. INHS 9108 (n = 5), Ohio River at Joppa boat ramp, Massac Co., T15S, R3E, Sec. 23, NE 1/4, 25 July 2001, J. E. Wetzel & W. J. Poly. MCZ 47132 (n = 4 [of 17]), [same locality as INHS 9108 above], 10 August 2001, J. E. Wetzel & W. J. Poly. MCZ 296 (n = 1, syntype), Quincy [locality considered erroneous by WJP and JEW]. MCZ 47137 (n = 34), Big Creek at Iron Furnace, approximately 7 km NNE of Rosiclare, IL, Hardin Co., T12S, R8E, Sec. 4, SE 1/4, 31 October 1999, J. E. Wetzel & W. J. Poly. MCZ 47148 (n = 1), Ohio River at Fort Massac State Park near boat ramp, Metropolis, Massac Co., T16S, R4E, Sec. 7, 8 February 2000, W. J. Poly & J. E. Wetzel.

*Orconectes luteus*. Refer to Material Examined section in Poly and Wetzel 2003.

## Acknowledgements

William G. Dyer and John E. McPherson, Jr. (South-

ern Illinois University) facilitated loans of specimens and provided lab space and equipment. Steve Mueller and Cheryl Broadie aided us with illustrations and photographs, Tim Wagner (U.S. Army Corps of Engineers) provided access to Lock & Dam 53 near Olmsted, Illinois, and John E. Schwegman supplied specimens from his personal collection. Ardis Johnston (MCZ), Chris Taylor (INHS), John Cooper (NCSM), Roger Thoma (OSUMC), and Janice (Clark) Walker, Karen Reed, T. Chad Walter, and Frank D. Ferrari (USNM) loaned or catalogued specimens. David K. Camp, editor of *Journal of Crustacean Biology*, granted permission to reproduce the figure of the holotype.

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