

NOTES ON INDIANA CRAYFISH (DECAPODA: CAMBARIDAE) WITH COMMENTS ON DISTRIBUTION, TAXONOMY, LIFE HISTORY, AND HABITAT

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ABSTRACT. Large collections of crayfish made throughout Indiana during the past several years have increased our knowledge of various aspects of the biology of Indiana's crayfish fauna, including *Orconectes (F.) indianensis*, a species that had conservation status. New information on distribution, taxonomy, life history, or habitat is provided for *Orconectes (Faxonius) indianensis*, *Orconectes (Trisellescens) immunis*, *Orconectes (Crockerinus) propinquus*, *Orconectes (Procericambarus) rusticus*, *Cambarus (Tubericambarus) sp. "A,"* *Cambarus (Erebicambarus) tenebrosus*, *Cambarus (Erebicambarus) laevis*, *Procambarus (Ormannicus) acutus* and *P. (Scapulicambarus) clarkii*. Reproductive biology, fecundity, egg diameter size, and instar lengths are provided for *Orconectes (F.) indianensis*, *Orconectes (T.) immunis*, *Orconectes (C.) propinquus*, *Cambarus (T.) sp. "A,"* and *Procambarus (S.) clarkii*, including chronology of appearance on the female abdomen. The largest ova diameters belong to *Cambarus (T.) sp. "A"* and *Procambarus (S.) clarkii* with diameters between 2.1–2.5 mm, while *Orconectes (T.) immunis* had the smallest ova ranging between 1.4–2.0 mm.

Keywords: Distribution, taxonomy, life history, habitat

Hobbs (1989), less than 20 years ago, indicated that 17 species of crayfish were known to occur in Indiana. Our knowledge of the biology and zoogeography of Indiana species is limited to mostly those species occurring in the northern portions of the state; however, the species composition of the southern portions of the state has been clouded by taxonomic and ecological uncertainties. Since the publication of the Hobbs list, Page & Mottes (1995) and Simon (2001) have presented checklists of the crayfish fauna of Indiana, adding several species previously unknown to occur in the state, and have reported on the recommended conservation status. Simon & Thoma (unpubl. data) and Simon (2002) expanded the range of another introduced crayfish, while Taylor (2000) described a new species that ranges into the state. Further investigation and field surveys have discovered additional new species (Simon unpubl. data).

Several hundred collections made during the past several years have added significantly to our understanding of the biology of many Indiana crayfish, including several species that

have limited ranges or the greatest parts of their ranges within the State. This paper provides new distribution, taxonomic, and habitat data for nine species that occur in Indiana, and reproductive information on five of these species.

METHODS

Crayfish carapace length (CL) was measured from the anterior tip of the rostrum to the posterior margin of the areola using digital calipers that measured to the nearest 0.1 mm. Ova diameters and instar lengths were measured using an optical micrometer inserted in a Bausch and Lomb Stereozoom 7 microscope. All ova and instars were measured to the nearest 0.01 mm. All crayfish were collected legally, with permission from the appropriate state government agencies. Life history and distribution information is based on new observations from referenced Indiana collections. We do not repeat previously published distribution information published in Simon & Thoma (2003) and Thoma et al. (in press); however, information presented on significant reproductive biology information is

based on material from the Patoka River collections which is included for the reader's benefit.

The following abbreviations are used in the text: INBS = Indiana Biological Survey, Crustacean Collection, Bloomington; US = United States highway; SR = Indiana state highway; CR = Indiana secondary (county) road; d/s = downstream; lat = latitude; lon = longitude. Names of collectors are provided in first usage, initials thereafter. Specimen abbreviations include PCL = postorbital carapace length, TCL = total carapace length, MI = first form male, MII = second form male, F = female, FE = female with eggs, FOVIG = ovigerous female, juv = juvenile, and P = partial specimen (usually a chelae). Catalogue numbers are those of voucher specimens in the INBS Crustacean Collection unless otherwise noted.

RESULTS AND DISCUSSION

Orconectes (Faxonius) indianensis (Hay) Indiana Crayfish

The Indiana crayfish *Orconectes (F.) indianensis* is a state Species of Special Concern and was considered a federal candidate species until the release of a conservation status report published by Page (1994). Simon (2001) recommended that the state list the Species as Special Concern because of its apparent rarity until further studies could be completed.

Distribution.—Page & Mottes (1995) determined that *O. (F.) indianensis* did not warrant conservation status because the species had been found at 10 locations in Indiana. The majority of these sites were in the Patoka River drainage, an area that is threatened from oil and gas exploration and coal extraction (Simon et al. 1995; Simon et al. 2005). The species presence was investigated in the Patoka River drainage to determine whether additional occupied locations existed (Simon & Thoma 2003). Simon & Thoma (unpubl. data) evaluated the conservation status of the species in the Patoka River drainage and found that it was much more common than previously known.

The species was collected from the following additional locations: **PATOKA RIVER DRAINAGE: Dubois County:** Little Flat Creek, CR 300 W bridge, 2 mi SE Otwell, Madison Twp., lat 38.4225 N, lon 87.0687 W,

11 April 2001., 4 FE, 4 FOVIG, 10 MI, 10 MII, (Thomas P. Simon). Mill Creek, CR 600 N bridge, 1.5 mi SW Haysville, Boone Twp., lat 38.4672 N, lon 86.7563 W, 11 April 2001, 4 FE, 1 MI, 1 MII, 2 juv, (TPS). Davis Creek, Cuzco Road bridge, Crystal, Columbia Twp., lat 38.4878 N, lon 86.7563 W, 19 May 2001, 2 FOVIG, 25 MI, 18 MII, (TPS, Roger F. Thoma & Foster Purrington). *Orange County:* Cane Creek, CR 500 S bridge, 4.5 mi S French Lick, Jackson Twp., lat 38.4790 N, lon 86.6588 W, 19 May 2001, 47 FE, 2 FOVIG, 59 MII, (TPS, RFT & FP). Unnamed tributary Patoka River, CR 825 S bridge, Valeen, Southeast Twp., lat 38.4342 lon 86.3975 W, 21 May 2001, 1 FE, 1 FOVIG, (TPS, RFT & FP).

Life history.—Limited information is available on the reproductive biology of *O. (F.) indianensis*. The species is lithophilic, requiring minimal amounts of rock, and usually associated with the areas beneath bridges (Simon & Thoma unpubl. data). The earliest date in 2001 that a female was found carrying ova was mid-April, while the latest that instars were observed was late May (Table 1). Page (1985) reported females carrying ova during March and April and young only during May. Ova ranged from 1.2–1.8 mm diameter (Table 1). First form males were collected in Indiana during April, July, and October, while Page (1985) indicated that first form males were present in Illinois during March, August, September, and October.

Orconectes (Trisellescens) immunis (Hagen) Calico Crayfish

Distribution.—*Orconectes (G.) immunis* has one of the widest geographical ranges, occurring from Maine and Connecticut to eastern Colorado and Wyoming, and from Alabama to southern Manitoba, Ontario, and Quebec (Hobbs 1989). The distribution of the species in Indiana has not been completely surveyed; however, it occurs statewide with perhaps the greatest abundance in southwestern Indiana.

Life history.—Despite the thousands of specimens residing in research collections, limited life history information is available for the species in Indiana. Life history information has been reported for northern populations from Ontario (Crocker & Barr 1968), Wisconsin (Hobbs & Jass 1988), and Illinois

Table 1.—Reproduction biology of select crayfish species including information on chronology of appearance, ova size, and instar development. Columns include Indiana Biological Survey (INBS) Crustacean Collection number, postorbital carapace length (PCL), date of collection, number, and condition (ova and instar size and number).

Collection number	PCL (mm)	Date	Condition
<i>Orconectes (F.) indianensis</i>			
93	22	11 April 2001	155 1st instar young, ca. 3–4 mm PCL (rostrum undeveloped);
	25		205 1st instar young, ca. 3–4 mm PCL (rostrum undeveloped)
	21		101 ova with eyespots on verge of eclosion, ca. 1.5-mm diameter
	22		159 ova, 1.2–1.8 mm diameter
79	23	11 April 2001	209 ova, 1.5–1.7 mm diameter
83	19	19 May 2001	16 1st instars, ca. 3–4 mm PCL (rostrum undeveloped)
51	14		23 1st instars, ca. 3–4 mm PCL (rostrum undeveloped)
200	21	19 May 2001	20 1st instars, ca. 3–4 mm PCL (rostrum undeveloped)
	17		17 1st instars, ca. 3–4 mm PCL (rostrum undeveloped)
193	20	21 May 2001	108 1st instars, ca. 4 mm PCL
<i>Orconectes (T.) immunis</i>			
67	30	4 April 2001	367 ova, 1.7–2.0 mm diameter
128	21	5 April 2001	194 ova, 1.0–1.5 mm diameter
141	22	5 April 2001	194 ova, 1.5–2.0 mm diameter
	27		237 ova, 1.4–2.1 mm diameter
70	23	5 April 2001	204 ova, 1.2–1.8 mm diameter
	25		229 ova, 1.6–1.8 mm diameter
73	32	5 April 2001	191 ova, 1.9–2.1 mm diameter
160	18	10 April 2001	104 ova, 1.4–2.0 mm diameter
178	13	11 April 2001	33 ova, 1.2–1.5 mm diameter
87	21	11 April 2001	185 ova, 1.5–1.7 mm diameter
87	26		372 ova, 1.5–1.8 mm diameter
87	26		68 ova, 1.1–2.0 mm diameter
126	25	11 April 2001	333 1st instar young, ca. 3 mm PCL (rostrum undeveloped); 1 ova with eyespots on verge of eclosion, ca. 1.8 mm diameter
136	22	11 April 2001	90 ova, 1.5–1.8 mm diameter
136	23		184 ova, 1.7–2.0 mm diameter
162	24	11 April 2001	33 1st instars, ca. 3–4 mm PCL
136	27		58 1st instars, ca. 3–4 mm PCL
56	23	11 April 2001	209 ova, 1.6–2.0 mm diameter
<i>Orconectes (C.) propinquus</i>			
215	25	16 June 2001	232 ova, 2.0–2.1 mm diameter
219	25	2 August 2001	34 1st instars, ca. 4 mm PCL
222	20	21 August 2001	5 ova with eyespots on verge of eclosion, ca. 2.0–2.2 mm diameter
<i>Cambarus (T.)</i> sp. "A"			
67	29	4 April 2001	75 1st instar young, ca. 4 mm PCL (rostrum undeveloped); 1 ova with eyespots on verge of eclosion, ca. 2.4 mm diameter
67	34		118 1st instar young, ca. 4–5 mm PCL
163	47	23 March 2001	234 ova, 2.1–2.5 mm diameter
64	35	21 May 2001	36 instars, ca. 4–5 mm PCL; 5 ova, 2.1–2.4 mm diameter
224	42	16 June 2001	72 1st instars, ca. 4–5 mm PCL; 36 ova, 2.1–2.5 mm diameter
<i>Procambarus (S.) clarkii</i>			
226	34	8 July 2000	198 ova, 2.0–2.5 diameter
227	37	21 September 2002	132 1st instar young, ca. 3–4 mm PCL (rostrum undeveloped); 4 ova with eyespots on verge of eclosion, ca. 2.0–2.4 mm diameter

(Page 1985). Detailed life histories for this species have been done by Tack (1941) and Caldwell & Bovbjerg (1964).

First form males were collected from southern Indiana during April, May, July, and August. The earliest ovigerous female found was during early April in the South Fork Patoka River, CR 300 E bridge, 1.5 mi SE Coe, Monroe Twp., lat 38.2872 N, lon 87.2193 W, 4 April 2001, (TPS) (Table 1). Ova ranged in diameter from 1.0–2.0 mm. Juvenile crayfish were collected in mid-May and July.

Orconectes (Crockerinus) propinquus
(Girard)

Northern Clearwater Crayfish

Distribution.—Our data are based on these specimens: **EAST FORK WHITE RIVER DRAINAGE: Monroe County:** Jordan River, 1.5 mi E Bloomington, Bloomington Twp., lat. 39.16648 lon 86.52454, (TPS). Jackson Creek, d/s Rogers Road, 2.75 mi SE Bloomington, Perry Twp., 16–18 June 2002, lat 39.13656 N, lon 86.50660 W, (TPS & Cameron C. Simon). Bean Blossom Creek, Currie Pike Rd, 7 mi N Bloomington, Bloomington Twp., 26 June 2001, lat 39.2377 N, lon 86.5275 W, (TPS).

Life history.—Most life history information for *Orconectes (C.) propinquus* is based on data from Ontario, Wisconsin, and limited data from Illinois (Crocker & Barr 1968; Hobbs & Jass 1988; Page 1985). Life history data from the southern portions of the range in Indiana are lacking. First form males from the above sites in southern Indiana were collected during April, July, August, and October. Females carried ova from mid-June until late August (Table 1). Ova ranged from 2.0–2.2 mm diameter.

Orconectes (Procericambarus) rusticus
(Girard)

Rusty Crayfish

Distribution.—The native range of *Orconectes (P.) rusticus* in Indiana includes the Whitewater, Greater Miami, and Maumee river drainages (Hay 1896). The transport and spread of this species through bait-bucket transfer of adults has had devastating effects on the aquatic assemblages of northern Wisconsin lakes (Lodge et al. 1986; Lodge et al. 1994). Taylor & Redmer (1996) reported on the spread of *Orconectes rusticus* in Illinois,

but no information exists for the status of the species in Indiana. Specimens obtained from the Bureau of Water Quality, City of Muncie, from surveys during the early 1970s document the species as common in the upper West Fork White River from multiple locations near Muncie (Simon unpubl. data). Surveys in the West Fork of the White River found the species to be dominant in tributaries extending from the Ohio state line west to Indianapolis and in the upper East Fork and major tributaries (Simon unpubl. data). Taylor & Redmer (1996) documented the spread of *O. rusticus* in Illinois. A similar study has not been completed in Indiana so exact distribution of the species is unknown. A life history study is also being conducted in the Little Mississippine River, Randolph County.

Cambarus (Tubericambarus) sp. "A"
Painted-hand Mudbug

Taxonomy.—Jezerinac (1993) created the subgenus *Tubericambarus* and indicated that there were multiple undescribed species within the *Cambarus diogenes* complex. The species assigned as *Cambarus (T.) sp. "A"* by Jezerinac (1993) is currently being described (Thoma et al. in press). This species is distributed from southeastern Michigan south to Tennessee, and from western Pennsylvania to eastern Missouri.

Distribution.—The type locality is **PATOKA RIVER DRAINAGE: Pike County:** Flat Creek, CR 124 S bridge, Washington Twp., lat 38.4019 N, lon 87.3066 W, 24 March 2001, 4 MI, 3 MII, 8 F (TPS, RFT & FP). Thoma et al. (in press) provides thorough distribution information for this species. Further research on the *Cambarus diogenes* complex will result in the recognition of other species from Indiana, and possibly another six species throughout that species' former range.

Life history.—First form males were collected from southern Indiana in 2001 during March, April, and May. Females were first found carrying ova in early April, and instars were last collected in mid-June (Table 1). Juveniles were collected in mid-May.

Cambarus (Erebicambarus) laevis Faxon
Karst Crayfish

Taxonomy.—Taylor (1997) synonymized *Cambarus (E.) laevis* with *Cambarus (E.) tenebrosus* based on morphological characters

and found fewer differences among sites than within sites. However, based on our observations, several key morphological differences were observed among Indiana populations of these two forms. We observed preliminary differences in first form male gonopod structure, branchiostegal tubercle presence, chelae shape, size of first form males, and pigmentation (Simon unpubl. data).

Distribution.—*Cambarus (E.) laevis* is a wide-ranging species found throughout central and southern Indiana, but few published records exist for the species outside of Monroe County. The following collections, all represented by voucher specimens, establish the presence of *Cambarus (E.) tenebrosus* into southern Indiana: **EAST FORK WHITE RIVER: Monroe County:** Unnamed tributary, Birdie Galien Road, 8.5 mi E Bloomington, Salt Creek Twp., lat 39.15301 N, lon 86.38444 W, 18 December 1998, 1 F (TPS, TPS IV, CCS). **PATOKA RIVER DRAINAGE: Pike County:** Unnamed tributary Patoka River, SR 364 bridge, 1.5 mi SE Winslow, Marion Twp., lat. 38.3558 N, lon 87.16683 W, 18 May 2001, 1 F, 2 P (TPS). **Dubois County:** Mill Creek, CR 600 N bridge, 1.5 mi SW Haysville, Boone Twp., lat 38.46717 N, lon 86.94717 W, 27 March 2001, 1 F (TPS). **Orange County:** Cane Creek, CR 500 S bridge, 4.5 mi S French Lick, Jackson Twp., lat 38.4790 N, lon 86.65883 W, 11 May 2001, 1 F, 3 MII, 2 juv, (TPS, RFT & FP). Cane Creek, Cuzco Road, S Cuzco, Columbia Twp., lat. 38.4705 N, lon 86.7220, 1 F (TPS, RFT & FP). Young's Creek, CR 600 S bridge, Hoosier National Forest, Greenfield Twp., lat. 38.51583 N, lon. 86.51567 W, 11 April 2001, 1 F, 1 MI, 1 MII, 2 juv, (TPS, RFT & FP). Unnamed tributary Patoka River, CR 825 S bridge, Valeen, Southeast Twp., lat 38.434167 N, lon 86.3975 W, 21 May 2001, 1 F (TPS, RFT & FP). Patoka River, CR 500 E bridge, 2 mi SSE Chambersburg, Stampers Creek Twp., lat 38.48433 N, lon 86.37367 W, 7 June 2001, 1 F (TPS).

Life history.—The karst crayfish *Cambarus (E.) laevis* is generally found in small brooks, creeks, and streams beneath large flat stones. These stones can be distributed throughout the width of the stream, but generally are found along the edges of the stream in the greatest current. First form males from

the Patoka River drainage were collected in May.

Cambarus (Erebicambarus) tenebrosus Hay
Cavespring Crayfish

Taxonomy.—We recognize Taylor's (1997) recommendation to synonymize *Cambarus (E.) laevis* with *Cambarus (E.) tenebrosus*, but we have chosen to keep these two forms separate until further cladistic and genetic analysis can be accomplished since we observed several differences, which might prove that the species are distinct.

Distribution.—*Cambarus (E.) tenebrosus* occurs in southern Indiana along the edge of the Wisconsin glacial advance south into karst areas. Distribution of the species occurring primarily throughout Monroe County and further south has not been well-documented. Our new records include: **PATOKA RIVER DRAINAGE: Orange County:** Unnamed tributary Patoka River. Spring Spring's cave outlet, CR 475, Stumpers Creek Twp., lat 38.48966 N, lon 86.36317 W, 21 May 2001, 1 FE, 1 MI, 1 MII, (TPS, RFT & FP).

Life history.—The cavespring crayfish is generally found within caves near the outlet of small to moderate-sized streams beneath large flat stones with non-imbedded cobble substrates. Large adults are generally found beneath the largest slab stones along either the edge or in the center of the stream. First form males were collected during December.

Procambarus (Ortmannicus) acutus (Girard)
White River Crayfish

Distribution.—*Procambarus (O.) acutus* is widespread and abundant in the Coastal Plain and the Piedmont Plateau of North Carolina (Cooper 2002), but is limited to lowland streams in Indiana. The following are new vouchered records for the species: **PATOKA RIVER DRAINAGE: Pike County:** Unnamed tributary Cup Creek, unnamed CR, 0.75 mi NW Pikeville, Lockhart Twp., lat 38.32733 N, lon 87.12893 W, 26 March 2001, 1 F (TPS, RFT & FP). **Dubois County:** Indian Creek, SR 64 bridge, lat 38.299333 N, lon 86.91533 W, 18 May 2001, 1 F (TPS, RFT & FP). Short Creek, Sunset Road, 1.5 mi SE Huntingburg, Ferdinand Twp., lat. 38.2743 N, lon. 86.9322 W, 18 May 2001, 1 F (TPS, RFT & FP).

Life history.—We have collected this spe-

cies from the West Fork White River drainage in intermittent and perennial headwater streams. The species is more common in southwestern Indiana, occurring in wetlands, small vernal ponds, and stream habitats (Simon unpubl. data).

Procambarus (Scapulicambarus) clarkii
(Girard)

Louisiana Red Swamp Crayfish

Distribution.—Page (1985) indicated that *Procambarus (S.) clarkii* was limited to the Coastal Plain lowlands of Illinois and that the species was rare in Indiana. Simon & Thoma (unpubl. data) found the species along the southern shore of Lake Michigan in drowned river mouth coastal wetlands. The species has since been found in additional locations including: **LAKE MICHIGAN DRAINAGE: Lake County:** East Branch Grand Calumet River, d/s Kennedy Avenue, East Chicago, Lake Twp., 18 November 1999, 1 FOVIG, (TPS & James R. Smith). West Branch of the Grand Calumet River, d/s Indianapolis Boulevard, East Chicago, Lake Twp., 2 December 1999, lat 41.61430 N, 8747975 W, 3 FOVIG, 1 MI, (TPS & Alex Peine).

Life history.—Ovigerous females collected from the West Branch of the Grand Calumet River and from Illinois, Lake County, Dead River mouth in Illinois Beach State Park included females with 1st instar and ova with eyespots on the verge of eclosion (Table 1). First form males were collected in July, September, November, and December from Indiana and Illinois populations. Ovigerous females had ova that ranged from 2.0–2.5 mm diameter (Table 1).

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