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CHECKLIST OF THE CRAYFISH AND FRESHWATER SHRIMP (DECAPODA) OF INDIANA

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ABSTRACT. Crayfish and freshwater shrimp are members of the order Decapoda. All crayfish in Indiana are members of the family Cambaridae, while the freshwater shrimp belong to Palaemonidae. Two genera of freshwater shrimps, each represented by a single species, occur in Indiana. *Palaemonetes kadiakensis* and *Macrobrachium ohione* are lowland forms. *Macrobrachium ohione* occurs in the Ohio River drainage, while *P. kadiakensis* occurs statewide in wetlands and lowland areas including inland lakes. Currently, 21 crayfish taxa, including an undescribed form of *Cambarus diogenes*, are found in Indiana. Another two species are considered hypothetical in occurrence. Conservation status is recommended for the Ohio shrimp *Macrobrachium ohione*, Indiana crayfish *Orconectes indianensis*, and both forms of the cave crayfish *Orconectes inermis inermis* and *O. i. testii*.

Keywords: Cambaridae, Palaemonidae, conservation, ecology

The crayfish and freshwater shrimp belonging to the order Decapoda are among the largest of Indiana's aquatic invertebrates. Crayfish possess five pair of periopods, the first is modified into a large chela and dactyl (Pennak 1978; Hobbs 1989). The North American crayfish belong to two families, Astacidae and Cambaridae with all members east of the Mississippi River belong to the family Cambaridae (Hobbs 1974a). The freshwater shrimps are represented by two genera in a single family, Palaemonidae.

The species of Cambaridae in North America represent a large family of over 300 described and numerous undescribed species in two subfamilies (Hobbs 1989). The family also occurs in Japan, Korea, and the Amur basin of eastern Asia (Hobbs 1974). The Cambarellinae include only the genus *Cambarellus*, while the Cambarinae include ten genera (Hobbs 1974, 1977; Hobbs & Carlson 1983). The Palaemonidae is represented in North America by 68 described species in 16 genera (Williams et al. 1989). The family is worldwide in distribution.

The purpose of this paper is to list the species of crayfish and freshwater shrimp known to occur in Indiana and describe the range, relative abundance, and recommended conservation status.

METHODS

Distribution and range.—This present survey of Indiana freshwater shrimp and crayfish is based on collections between 1990 and 2000. Collections were made at over 3000 localities statewide, made in every county of the state, but most heavily concentrated in southern Indiana, where the greatest diversity of species occurs.

The current list of species is intended to provide a record of the extant and those extirpated from the fauna of Indiana over the last two centuries (Table 1). This list includes new information and taxonomic changes. This effort is the first step of the Indiana Biological Survey to compile a listing of all known species of biota in Indiana. The taxonomic and nomenclature sources include Hobbs (1989), Williams et al. (1989), Page (1985), Jezerinac et al. (1995) and Pflieger (1996). Many crayfish species do not possess common names. Species without accepted common names following Williams et al. (1989) are highlighted in brackets to signify those proposed in this study. These names were based on those from adjacent state lists in Missouri (Pflieger 1996) and Ohio (Thoma & Jezerinac 2000a). Subgenera are indicated for all crayfish species. Crandall & Fitzpatrick (1996) and Fetzner (1993) have completed recent molecular studies on the phylogeny of *Orconectes* subgenera, which suggests that these relationships may be doubtful. Use of the *Orconectes* phylogeny relationships presented in this paper follows Fitzpatrick (1987).

Historical collections of Indiana crayfish and freshwater shrimps curated at the Ohio State University Museum (OSM), Illinois Natural History Survey (INHS), National Museum of Natural History (NMNH), and University of Michigan Museum of Zoology (UMMZ) were compiled. Historical and recent records were compiled to formulate the current distribution of Indiana crayfish.

The following codes were established to facilitate documentation of species in the State (Table 1). The general range in Indiana is indicated as statewide (I), north (N), south (S), west (W), east (E), and various combinations of these regions. Relative abundance refers to the general population levels of the species within the State. These are based on the abundance and number of localities where the species has been found. Depending on local and seasonal conditions, population levels will vary. Relative abundance is listed as four categories: abundant (A) designations are species that are easily found at a site in a particular region, common (C) are species that are regularly found at a site (generally greater than 25 individuals) in an area but perhaps not at all locations, occasional (O) designations are for species that are found at either fewer than five locations or represent less than five specimens at a site, and rare (R) designations are for species that occur at less than five locations or are represented by a single individual at a site. Extirpated species (Ex) are listed along with the estimated date of disappearance. The State of Indiana does not have a formal conservation listing for crayfish or freshwater shrimp. The recommended conservation status has no formal or legal impetus; instead it refers to information based on our data. Federally endangered species are denoted as federally endangered (FE), federally threatened (FT), and federal candidates for Federal listing as FC; however, the candidate listing has no formal status. State endangered species will be represented by three codes: endangered (StE), threatened (StT), and special concern in need of further study (SC). An additional designation, exotic (X) is included for accidentally or deliberately released species.

Collection methodology.—Open water crayfish and freshwater shrimp were sampled by seining, dipnetting, or electrofishing all representative habitats at a locality. Electrofishing included the use of a pulsed DC 1850-watt T & J generator capable of 300 V output and usually 6–8 amps. All specimens observed were captured and a portion was retained for later identification in the laboratory. Sites were sampled so that a minimum distance of 15 times the stream width was sampled. Each surveyed site consisted of a minimum distance of 50 m and a maximum distance of 500 m in streams and rivers. Lake and great river habitats were surveyed for 500 m of littoral shoreline habitat. All available habitats were sampled at each location including riffle, run, pool, various instream cover types (e.g., woody debris, slab bedrock crevices, boulders, aquatic macrophytes), and beneath undercut banks. All specimens were placed into a live well and retained until the end of the collection zone.

Burrowing species of crayfish were more difficult to obtain. Two collection procedures were attempted. For prairie crayfish that remained in burrows, a modified toilet plunger was used to force the crayfish from the burrow. An aliquot of water was poured into the burrow until full, then suction was established at the entrance so that a good seal was established. Plunging the burrow caused the exit holes to become noticeable, and after several attempts the exits were examined to determine if crayfish were present. Attempts to excavate the burrow by digging was foolishly attempted next; however, if this failed the identity of the crayfish was based on the external morphology of the burrow. Large multiple chambered chimney-type burrows was assumed to be *Cambarus diogenes*, while piled burrows were assumed to be *Procambarus gracilis*. Single chambered chimney-type burrows were considered *Fallicambarus fodiens*. More than likely I underestimated the distribution of prairie species since many of our collections were not completed during times when they would have been more vulnerable to our collection methods (December–May).

RESULTS AND DISCUSSION

Crayfish systematics.—The cambarid crayfish differ from the Astacidae of western North America and Europe by the presence of hooks on the ischia of the second through fourth pereiopods and dimorphic cycling in males (Hobbs 1974). Astacids do not exhibit cyclic dimorphism nor ischial hooks. Cambarid crayfish have a variety of ornate termi-

nal elements on the gonopod, while astacid crayfish have simple cylindrical distal elements. The cambarid females have an annulus ventralis that is lacking in astacid females. During the reproductive season, males develop one or more terminal elements on the gonopods (first pleopods) that are corneous. These males are referred to as form I.

Historical studies of Indiana crayfish and freshwater shrimp.—Most historical information published on Indiana crayfish and freshwater shrimp can be found in Cope (1872), Packard (1873), Bundy (1877), Hay (1891, 1893, 1896), Williamson (1907), Evermann & Clark (1920), Eberly (1955), Hobbs (1989), Page (1994), and Page & Mottesi (1995). Cope (1872) published on the cave fauna of Wyandotte Cave, while Packard (1873) published on cave crayfish throughout the State. Bundy (1877) was the first to publish on crayfish distributions outside of caves in Indiana, focusing on species in northern Indiana. Hay (1891) published on the crustaceans of Indiana, including information on freshwater shrimp, and followed with a paper on the observations of blind cave crayfish including the description of *Cambarus inermis testii* (Hay 1896). Hay (1896) first published an annotated species list that included information on the taxonomy of crayfish species occurring in Indiana. Williamson (1907) published information on the crayfish of Wells County and described a new species (*Cambarus ortmanni*). Evermann & Clark (1920) listed the species occurring in Lake Maxinkuckee. Eberly (1955) summarized distributions of five species and included new distribution records. Page (1994) conducted a study to determine the conservation status of *Orconectes indianensis* that included a listing of the species of crayfish found in Indiana (Page & Mottesi 1995); and he indicated that 17 species and an additional undescribed species are known to occur in Indiana.

Life history and distribution information for Indiana crayfish include *C. diogenes* (Grow 1981), *C. fodiens* (Bovbjerg 1952), *C. tenebrosus* (Prins 1968), *O. immunis* (Tack 1941), *O. propinquus* (Van Deventer 1937; Bovbjerg 1952), *O. rusticus* (Langlois 1935; Busch 1940; Prins 1968), *O. sloani* (Rhoades 1962; Jezerinac 1986; St. John 1988) and *O. virilis* (Bovbjerg 1953, 1970; Hazlett et al. 1974; Threinen 1958; Caldwell & Bovbjerg 1969; Momot 1967, 1978; Aiken 1969; Weagle & Ozburn 1972; Momot & Gowing 1977).

Life history strategies of Indiana crayfish.—The life history strategies occurring among Indiana crayfish include cave-dwelling, non-burrowing and burrowing species. Cave-dwelling species are adapted for spending their entire existence in caves. Non-burrowing crayfish carry out their entire life history in surface waters. Burrowing species spend variable amounts of time in surface waters and periodically leave their burrows to mate (Simon et al. 2000). Adults of these species remain above ground only during periods of late winter to spring flooding (January–May). Sexually mature *P. gracilis* leave their burrows on warm rainy nights but are otherwise seldom found out of their burrows. Adult *C. diogenes* leave their burrows on the edge of stream banks more often than the other burrowing species and may forage as well as mate. Roaming occurs most frequently during the mating season and when females are carrying eggs or young.

Distribution and conservation status.—The State of Indiana possesses 21 crayfish taxa representing 19 species and possibily another two undescribed species (R. Thoma, pers. commun.). Page & Mottesi (1995) indicated that 18 crayfish species occurred in Indiana; however, their list did not include the recently-elevated *O. juvenilis* nor *Cambarus robustus*. Hobbs (1989) tentatively listed *O. putnami* from Indiana. Page & Mottesi (1995) found *O. putnami* to be widespread in southeastern portions of the State as did I. Taylor (1997) synonymized *C. laevis, C. ornatus,* and *C. tenebrosus* east of the Mississippi River as *C. tenebrosus* based on meristic and morphometric characters. This present paper still maintains the separate listing of the species for Indiana while further work is being conducted to support this revision.

An additional two species are considered hypothetical for their occurrence in the State. The possibility that *C. thomai* exists in southeastern Indiana is based on the species distribution in southwestern Ohio (Jezerinac 1993; Thoma & Jezerinac 2000b). Finally, *O. stannardi* occurs as an endemic of the Little Wabash River in Illinois. The possibility of the species occurring in direct tributaries to the Wabash River near the Little Wabash River needs further survey.

Table 1.—Checklist of the crayfish and freshwater shrimp (Decapoda) of Indiana following Hobbs (1974) including distribution, relative abundance, and recommended conservation status. Common names follow Williams et al. (1988), with the exception of names in brackets, which are suggested additions based on Pflieger (1996) and Thoma & Jerezinac (2000a). Subgenera of *Orconectes* follow Fitzpatrick (1987). Statewide (I), north (N), south (S), west (W), east (E), and various combinations of these regions. *Relative abundance:* R = rare; C = common; O = occasional. *Conservation status:* StE = state endangered; FC = candidate for federal listing; SC = candidate for special concern; NI* = nonindigenous, and introduction has occurred in a portion of the species range in Indiana.

Taxa	Range	Relative abundance	Recommended conservation status
Order Decapoda			
Family Palaemonidae (freshwater shrimp)			
Macrobrachium ohione (Smith), Ohio shrimp	S	R	StE
Palaemonetes kadiakensis Rathbun, Mississippi grass shrimp	I	C	
Family Cambaridae (crayfish)			
Genus *Procambarus*			
Subgenus *Girardiella*			
P. gracilis (Bundy), prairie crayfish	W	O	
Subgenus *Ortmannicus*			
P. acutus (Girard), White River crayfish	I	O	
Subgenus *Scapulicambarus*			
P. clarkii (Girard), red swamp crayfish	NW, SW	R	NI*
Genus *Orconectes*			
Subgenus *Crockerinus*			
O. propinquus (Girard), northern clearwater crayfish	I	C	
Subgenus *Faxonius*			
O. indianensis (Hay), [Indiana crayfish]	SW	R	FC, SC
Subgenus *Gremicambarus*			
O. immunis (Hagen) [papershell crayfish]	I	C	
O. virilis (Hagen), northern crayfish	I	C	
Subgenus *Orconectes*			
O. inermis inermis Cope [Indiana cave crayfish]	S	R	StE
O. inermis testii Cope [Hoosier cave crayfish]	S	R	StE
Subgenus *Procericambarus*			
O. putnami (Faxon) [Putnam's crayfish]	SE	O	
O. juvenilis (Faxon) [miniature crayfish]	SE	R	
O. rusticus (Girard), rusty crayfish	I	C	NI*
Subgenus *Rhoadesius*			
O. sloanii (Bundy) [Sloan's crayfish]	SE	R	
Genus *Fallicambarus*			
Subgenus *Creaserinus*			
F. fodiens (Cottle) [digger crayfish]	I	O	
Genus *Cambarus*			
Subgenus *Cambarus*			
C. bartoni cavatus (Fabricius) [Ohio crawfish]	SE	R	
C. ortmanni Williamson [Ortmann's mudbug]	N	R	
Subgenus *Erebicambarus*			
C. laevis Faxon [karst crayfish]	S	C	
C. tenebrosus Hay [cavespring crayfish]	S	C	
Subgenus *Lacunicambarus*			
C. diogenes Girard, devil crayfish	I	R	
Subgenus *Tubericambarus*			
C. cf *diogenes* new species [Painted hand mudbug]	S	R	
Subgenus *Puncticambarus*			
C. robustus Girard [bigwater crayfish]	NE	O	
Hypothetical in occurrence in Indiana			
Subgenus *Tubericambarus*			
Cambarus thomai (Jezerinac) [little brown mudbug]	SE		
Subgenus *Crockerinus*			
O. stannardi Page [Little Wabash River crayfish]	SW		

The rusty crayfish *O. rusticus* and red swamp crayfish *Procambarus clarki* have been found in the Lake Michigan drainage (Simon, unpubl. data). The rusty crayfish is a native species of southeastern Indiana that has been widely distributed through bait bucket release by anglers. The species is native to the Whitewater River drainage and should be considered non-indigenous outside of that watershed. The red swamp crayfish was collected during 2000 from Lake Michigan. Page & Mottesi (1995) indicated that this species was among the rarest crayfish of Indiana. The red coloration of the species and the recent marketing of them as freshwater lobster in the aquarium trade perhaps have aided in the spread of the species into the West Branch of the Grand Calumet River.

Although the State of Indiana does not recognize any conservation status for crustaceans, I recommend that three rare species be designated as either State Endangered or State Special Concern. Page (1994) surveyed for the Indiana crayfish *O. indianensis* (Hay), a Federal candidate species, over the historic range of the species in Illinois and Indiana. The species was collected from the Patoka River and at additional locations in several watersheds in southwestern Indiana. The watersheds where this species occurs are prone to severe land use disturbance from oil and gas explorations, acid mine drainage and coal mining. The species has been severely reduced in its former range in Illinois, but Page did not recommend the species for listing since it occurred at many of the historic sites where it had been collected in Indiana. Due to the species primary distribution in areas severely impaired by anthropogenic disturbance in the Patoka and Pigeon River drainage and southwestern Indiana, it is recommended that the species be considered "State Special Concern" until it can be determined whether the species range is being threatened.

Orconectes inermis inermis and *O. inermis testii* are cave-dwelling crayfish found in southern Indiana. The two taxa are rare with *O. inermis testii* being restricted to Monroe County, while *O. inermis inermis* being broader ranging. The two taxa are seldom considered abundant. It is recommend that both forms be considered "State Endangered" because of the fragile nature of karst ecosystems.

The Ohio shrimp (*M. ohione*) has been severely reduced over the species' former range. The species, reaching 100 mm carapace length (CL), once occurred throughout the Ohio River and lowland tributaries. During our study we did not collect a single specimen and consider the species so rare as to warrant "State Endangered" status. It may already be extirpated from Indiana's portion of the Ohio River. However, Hobbs & Massmann (1952) suggested that the species occurs in deeper waters, which requires trapping to collect. The species rarity may only be a reflection of the collection methods attempted or could be extirpated as a result of the navigation lock and dam system on the Ohio River prevented migration.

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