JOURNAL OF CRUSTACEAN BIOLOGY, 26(3): 436–440, 2006

CONSERVATION OF IMPERILED CRAYFISH—*ORCONECTES* (*FAXONIUS*) *INDIANENSIS* HAY (DECAPODA: CAMBARIDAE)

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Introduction

Common Name.—Indiana crayfish (Simon, 2001).

Conservation status.—Rare (Taylor et al., 1996). Based on the species' limited distribution (<20,000 km^2) and the loss of populations, as reported in this study, *O. indianensis* has been classified as Vulnerable, VU B1b(iv), following IUCN (2001).

Identification.—The Indiana crayfish (Fig. 1), *Orconectes indianensis*, was first described by Hay (1896) from the Patoka River near the town of Patoka, Gibson County. The species is a member of the subgenus *Faxonius* and displays the subgenus' characteristic first form male gonopod having both a short mesial process and central projection. The two rami are strongly divergent in both first and second form males, the rostrum is fixed with a median, distal carina, a strongly developed cervical spine is found on each side of the cervical groove, and the annulus ventralis displays bilateral anterior knobs.

Natural History

Distribution.—The geographic range of *Orconectes indianensis* is restricted (Fig. 2) and has been considered "Rare" or "Special Concern" (Page, 1985; Page, 1994; Simon, 2001; Taylor et al., 1996). Hobbs (1989) reports that the species is endemic to southeastern Illinois and southwestern Indiana, but it has been extirpated from a large portion of its historic range in Illinois (Page, 1985; Page, 1994) and has been reported from very few sites in Indiana (Hay, 1896; Eberly, 1955; Page and Mottesi, 1995).

Rhoades (1962) described the historic and current range of *O. indianensis* in relation to glaciation. The species was considered to have been present throughout the entire Wabash River drainage and the dominant crayfish in the White River prior to the Illinoian glacier. The farthest advance of the Illinoian glacier filled the lower White River drainage causing changes at the ice front as it formed three marginal lakes that supported *O. indianensis* populations. Effluents later connected the three lakes and formed the Patoka River and other Illinoian drainages, the Little Pigeon and Anderson River drainages. The Wisconsin glacier did not have an effect on the distribution of the species (Rhoades, 1962).

The first records of *O. indianensis* from Illinois were reported by Rietz (1912). However, some of the localities cited in his study are believed based on misidentification as one of two other species (Page, 1985), i.e., *Orconectes stannardi* Page, 1985 and *O. propinquus* (Girard, 1852). Records for the South Fork Saline River in Gallatin County and the North Fork Saline River in Saline County are considered valid, but additional records for the North Fork Saline River remain unverified. Brown (1955) provided additional distribution records for *O. indianensis* in Cypress Ditch, Gallatin County. Page (1985) found a similar distribution for the species reported by Brown (1955) during a statewide survey in Illinois from 1972 to 1982. Additional records were found for Williamson, Johnson, Saline, Pope, and Gallatin Counties, and Ohio River drainages in Hardin County. Additional records for Sugar Creek (Saline River drainage) in Williamson County, and Brushy Slough (Ohio River drainage) in White County were found in museum collections. In 1993, Page (1994) sampled the same sites in Illinois where historical collections had been made. The species was found at all but three sites sampled during 1993 as they were during 1972-1982. The species was not collected from Rock Creek (Hardin County), Rock Branch Battle Fork Creek (Saline County), and Brushy Slough (White County). Page (1994) stated that although the Illinois population does not appear to be declining, the reduction of the species' historical range and threats to the main population requires State protection. In Illinois, the species is stable but remains in a precarious state, since the majority of populations are found in the Saline River system, now degraded by oil and gas exploration, coal mining, and acid mine drainage (Smith, 1971; Page, 1994; Simon et al., 1995). *Orconectes indianensis* significant range reduction is a result of changing land use (Smith, 1971; Page, 1995).

In Indiana, *Orconectes indianensis* is found in extreme southwestern Indiana in the Patoka River system, a tributary of the Wabash River; in the Black River, a small tributary of the Wabash River in Posey County; and in Ohio River tributaries from Pigeon Creek, Vanderburgh County to Anderson River in Perry County (Page, 1994; Page and Mottesi 1995). Page (1994) indicated that the Patoka River was one of the last remaining watersheds that possessed populations of *O. indianensis*. Several studies indicate that this watershed is at risk of degradation similar to that in the Saline River watershed in Illinois (Simon et al., 1995; Simon et al., 2005). We confirmed that *O. indianensis* distribution is currently limited to the Patoka and Black

Fig. 1. *Orconectes indianensis* Hay in rock habitat.

River systems (Wabash River drainages) and Pigeon Creek and Anderson River (Ohio River drainage) in southwestern Indiana and the Saline River and Honey Creek systems (Ohio River drainage) in southeastern Illinois. These six basins encompass approximately 2200 km^2 total drainage area. Hay (1896) first described the species from the Patoka River, Gibson County, Indiana. Rhoades (1962) reported collecting specimens in the Patoka River from Gibson, Pike, Dubois, and Orange Counties; the Little Pigeon River, Warrick County; and Anderson River, Perry County, Indiana. Specimens were also found by Page (1994) in the United States National Museum, The Ohio State Museum of Biodiversity, and the Illinois Natural History Survey. These new museum collections validate records for Spencer, Posey, and Vanderburgh Counties. Page (1994) reported that *O. indianensis* was extirpated from Gibson and Dubois Counties; however, our surveys during 2001-2003 found that the species is still extant in these areas. Page (1994) believed that the species status was stable in Indiana. Surveys conducted in Indiana during 2001-2003 found additional localities in the upper Patoka River on public lands (Fig. 2.1). Individuals of *O. indianensis* were found at 42 sites (34.4% of 125 sites collected); however, only two of the historic sites surveyed by Page (1994) retained populations.

Abundance.—The relative abundance of *O. indianensis* is high (0.76 individuals/m^2) in streams with cobble, rubble bottoms ($R = 0.259$) and low sediment loads, and absent or low abundance having only 1-2 individuals in heavily sedimented streams (Fig. 2.2). Smaller headwater and intermittent streams produced the largest numbers of crayfish. The largest number of *O. indianensis* collected at a single site was 106 individuals (0.707 crayfish/m^2).

Habitat and ecology.—*Orconectes indianensis* inhabits streams with coarse substrates primarily of large rocks or woody debris, and slow to moderate current (Page, 1985; Page, 1994). Our studies found *Orconectes indianensis* to prefer high gradient streams having riffles, runs, and pools with clear water of moderate nutrient levels. Presence of *O. indianensis* is strongly correlated with the presence of rock cobble or boulder habitat (Table 1). The preferred stream size includes perennial headwater and intermittent streams; however, the species also occurs in the main channel of the Patoka River at the type locality and further downstream near the mouth of the Patoka River near the confluence with the Wabash River. This extensively channelized site, characterized by riffle habitat, is uncharacteristic of the lower Patoka River. The species has not been collected from areas that are heavily silted, which is especially common in channelized stream reaches. *Orconectes indianensis* is a tertiary burrower (Hobbs, 1981) constructing simple chambers under rocks during the warmer, dry months of the year.

Reproduction.—Page (1985) recorded the presence of ovigerous females during April and May. We observed first form males and females (Wetzel, 2002) during only a short reproductive season in late fall and early spring. Two ovigerous females carried 81 and 9 eggs total and five females with attached instars carried 16 to 108 individuals ($\bar{x} = 36.8$).

Conservation Factors

Threats.—Stream modifications, especially channelization; increased nutrient and sediment loads; strip mining activities and their consequent influence on pH changes threaten this species. The North and Middle Forks of the Saline River are extremely polluted as a result of water quality degradation from strip-mining, oil-field pollution, siltation, and desiccation (Smith, 1971). Rhoades (1962) suggested that the Patoka River was the stronghold for the species. Currently, coal mining, stream channel clearing, channelization, and poor water quality threaten this watershed. In the Patoka River drainage, eight of the eleven sites sampled by Page (1994) failed to provide continued

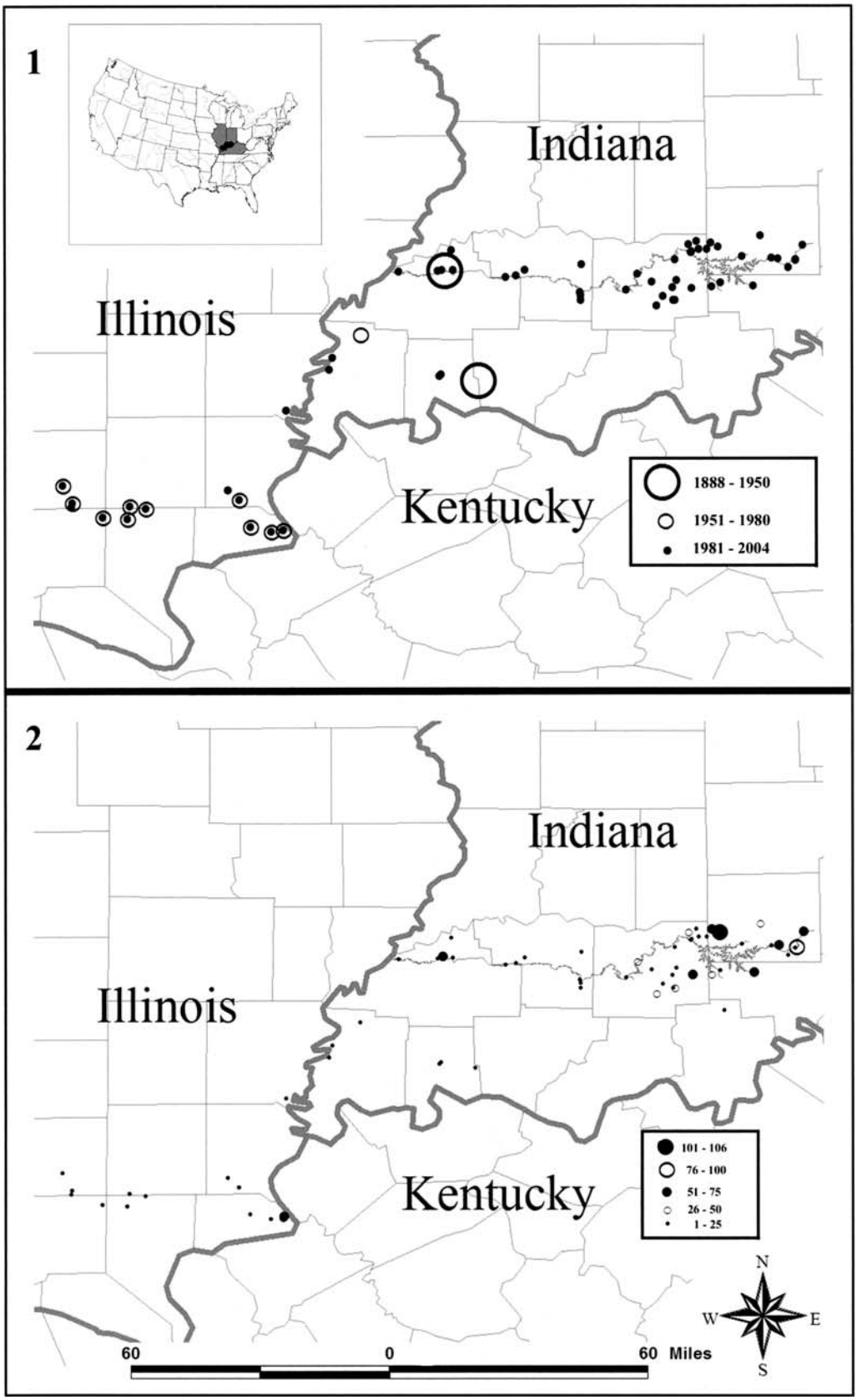

Fig. 2. 1) Present and historical distribution of *Orconectes indianensis* Hay in Illinois and Indiana. Large open circles = 1950 and earlier; medium open circles = 1951-1980; solid circles = 1981-2004. 2) Abundance of *Orconectes indianensis* Hay in Illinois and Indiana. Increasing dot size represents increasing relative abundance captured at each site. Small solid dots = 1-25 crayfish; medium hollow dots = 26-50 crayfish; medium solid dots = 51-75 crayfish; large hollow dots = 76-100 crayfish; and large solid dots = 101-106 crayfish.

Table 1. Correlations of environmental variables with *Orconectes indianensis* abundance. All variables are significant at $P < 0.05$, $N = 133$.

	Correlation
Positively correlated variables	
Riffle score	0.315
Substrate score	0.304
QHEI	0.300
Cover score	0.285
Overhanging vegetation	0.269
Number of substrate types	0.264
% Boulder/cobble	0.259
Gravel	0.253
Limestone	0.252
No embededness	0.243
Moderate sinuosity	0.225
No channelization	0.224
Riffle depth 10-50 cm	0.223
Riffle embeddedness	0.222
Gradient	0.221
Pool score	0.219
pH	0.215
Stream development good	0.214
Channel score	0.212
Riffles stable	0.211
Cobble	0.206
Pool depth >100 cm	0.197
Temperature	0.197
Boulder cobble cover	0.184
Narrow riparian	0.179
Negatively correlated variables	
Specific conductivity	−0.172
Salinity	−0.174
Recent channelization	−0.180
Poor stream development	−0.199
Sparse cover	−0.200
Silt abundance	−0.205
Cover lacking	−0.206
Bank erosion heavy	−0.207
No riffles	−0.217
Silt heavy	−0.220
Extensive embeddedness	−0.227
Low streambed stability	−0.230
No sinuosity	−0.237
Riffles unstable	−0.245

evidence of *O. indianensis* during our 2001-2003 surveys. Two of the eight sites were badly polluted. Efforts by the Patoka National Wildlife Refuge to reduce water quality impacts of acid mine drainage and oil brine along the perimeter of the Refuge should increase available habitat. *Orconectes rusticus* (Girard, 1852) invasion of streams occupied by *O. indianensis* will likely result in drastic reductions of *O. indianensis* and confinement of populations to a few small, low nutrient headwater streams in the basin.

Conservation action.—*Orconectes indianensis* is presently not considered Federal Endangered and is not state listed by Indiana (Simon, 2001). Page (1994) reported that a total of 18 historic localities were sampled in both Indiana and Illinois in 1993. Six of the sites no longer have documented populations, three have declining populations, and 9 have stable populations. Sites sampled during 2001-2003 showed that only two of the nine sites previously possessing Indiana crayfish remained stable in Indiana. The remaining sites no longer support populations (Simon and Thoma, 2003). This loss of historic populations is a troubling trend for the future of the species.

Orconectes indianensis has a narrow distribution and large areas of its range have been impacted in ways that have greatly reduced its abundance. Further non-point impacts and habitat modifications will further reduce the abundance of *O. indianensis* and the establishment of the rusty crayfish (*O. rusticus*) could cause the species to slip into the endangered range. Continued monitoring of the species is required to maintain knowledge of its status.

Conservation recommendations.—Streams with suitable water quality would benefit from the placement of rock-rubble substrates in the stream. The addition of rock-rubble substrates will greatly enhance the potential for establishment and expansion of *O. indianensis* populations. Prevention of non-point run off by employing wooded and grassed buffer strips on stream and ditch edges will also enhance *O. indianensis* habitat. Further efforts to secure additional public lands along the edges of Hoosier National Forest, the U.S. Fish and Wildlife Service Patoka River National Wildlife Refuge, and land owned by the Army Corps of Engineers would benefit the long-term stability of this species.

Remarks.—*Orconectes indianensis* was found to be more widely distributed and more abundant than initially considered prior to conducting this survey (Fig. 2.2). New populations found during surveys conducted during 2001-2003 in the headwaters of the Patoka River drainage include numerous sites in Hoosier National Forest, Patoka National Wildlife Refuge, and on public land owned by the Army Corps of Engineers. It does not meet criteria to be designated Federal Endangered. Threats posed by potential introduction of rusty crayfish to streams inhabited by *O. indianensis* are considered to be extreme. Similar to populations of *Orconectes propinquus* or *Orconectes sanbornii* (Faxon, 1884) observed in Ohio (Thoma and Jezerinac, 2000), *O. indianensis* shows a propensity to prosper in small first order streams with low nutrient levels. Such areas in Ohio have proven to be important refuges for the two species as *O. rusticus* does not prosper in waters low in nutrient that lack aquatic plant growth such as filamentous algae (Thoma and Jezerinac, 2000).

CONCLUSIONS

The status of *Orconectes indianensis* is more secure than previously thought in Indiana and remains stable in Illinois (Page, 1994; Page and Mottesi, 1995; Simon and Thoma, 2003). This species has remained stable in Illinois despite widespread degradation in the Saline and Patoka River drainages. We noted absence of the species in sites where populations were previously reported. We found populations at 27 additional new sites in the headwaters of the Patoka River. Habitat enhancement for *O. indianensis* can be facilitated by increasing rock-rubble coverage of stream bottoms and reducing the coverage of silt and sand. Establishment of wooded riparian cover would prove to be beneficial to this species. Establishment of *O. rusticus* populations in stream basins with *O. indianensis* should be immediately and completely eliminated.

ACKNOWLEDGEMENTS

The authors thank Foster Purrington for field and laboratory assistance in the collection and processing of specimens from this study. This study was funded through the U.S. Fish and Wildlife Service Contaminants program through grant number 31440-1261-3N29 to TPS. The opinions expressed do not necessarily represent those of the U.S. Fish and Wildlife Service although this study may have been funded entirely or in part by that agency.

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RECEIVED: 16 August 2005.
ACCEPTED: 20 January 2005.