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DISTRIBUTION PATTERNS OF FRESHWATER SHRIMP AND CRAYFISH (DECAPODA: CAMBARIDAE) IN THE PATOKA RIVER BASIN OF INDIANA

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ABSTRACT. Eleven species of crayfish and freshwater shrimp were collected during a study of the Patoka River drainage of Indiana between 2000–2002. The Mississippi grass shrimp *Palaemonetes kadiakensis* was the only shrimp species collected from wetland ponds and stream areas adjacent to vernal ponds. Several rare species were encountered, including *Orconectes (Faxonius) indianensis* and *O. (Orconectes) inermis inermis*. *Orconectes (Orconectes) inermis inermis* was collected from a single cave location near Valeene. *Orconectes (Faxonius) indianensis* was found throughout the watershed, but was most common in the upper third of the watershed within the Hoosier National Forest. *Procambarus (Ortmannicus) acutus* and two *Erebicambarus* species members, *Cambarus laevis* and *C. tenebrosus*, were collected from small streams emanating from caves and karst springs. Three primary burrowing crayfish forms (*Fallicambarus (Creaserinus) fodiens*, *Cambarus (Tubericambarus)* sp. A and *Cambarus (Lacunicambarus)* sp. A.) were more common throughout the watershed, while *Cambarus (L.)* sp. A was collected only from the glaciated portions of the watershed.

Keywords: *Cambarus*, *Orconectes*, *Fallicambarus*, *Procambarus*, *Palaemonetes*, Cambaridae, Palaemonidae

The crayfish family Cambaridae represents a large group of over 300 described and undescribed species in two subfamilies (Hobbs 1989). Simon (2001) provided a checklist of Indiana species that documented the occurrence of two freshwater shrimp and 22 crayfish species within the political boundaries of Indiana. Despite the study of decapod crustaceans within Indiana for the last 130 years (Cope 1872; Packard 1873; Bundy 1877), limited surveys have documented the faunas of complete watersheds. The most studied Indiana faunas have been the crayfish of northern Indiana (Bundy 1877; Williamson 1907), Lake Maxinkuckee (Evermann & Clark 1920), and cave faunas (Cope 1872; Packard 1873; Hay 1893; Lewis 1983; Lewis et al. 2002, 2003).

The Patoka River drainage is a large tributary of the lower Wabash River that flows into the Ohio River and possesses an interesting crayfish fauna because of the east to west direction of flow and the crossing of several physiographic provinces (Schneider 1966). Virtually nothing is known of the decapod fauna of the Patoka River drainage; however, Simon et al. (1995) collected fish throughout the watershed and reported on anthropogenic changes between 1888 and 2001 (Simon et al. 2003). No previous distribution studies of the crayfish and freshwater shrimp have been conducted in the Patoka River watershed. The purpose of the current study was to document the shrimp and crayfish fauna of a large watershed in southern Indiana.

METHODS

Study area.—The Patoka River is a narrowly-confined tributary of the lower Wabash River that originates near Valeene, Orange County, Indiana (Simon et al. 1995). We sampled at 125 lentic and lotic sites throughout the entire watershed (Fig. 1). The Patoka River flows west for 162 miles (260 km) across the Crawford Upland and the Wabash Lowland physiographic units (Schneider 1966), draining 862 square miles (1388 km^2) in Gibson, Pike, Dubois, and Orange Counties. Sev-

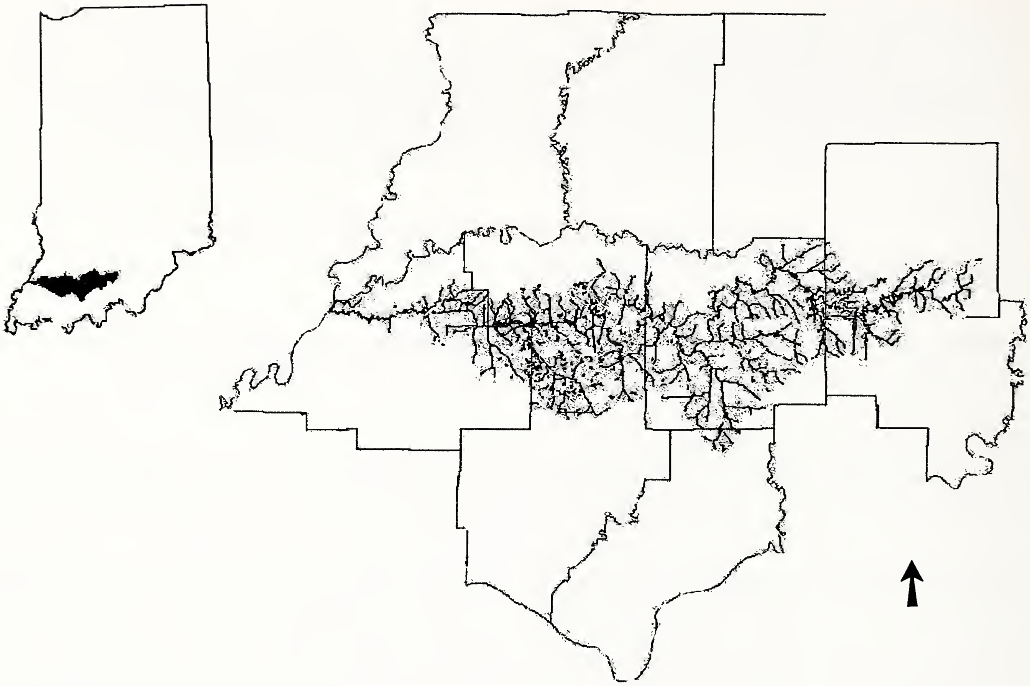


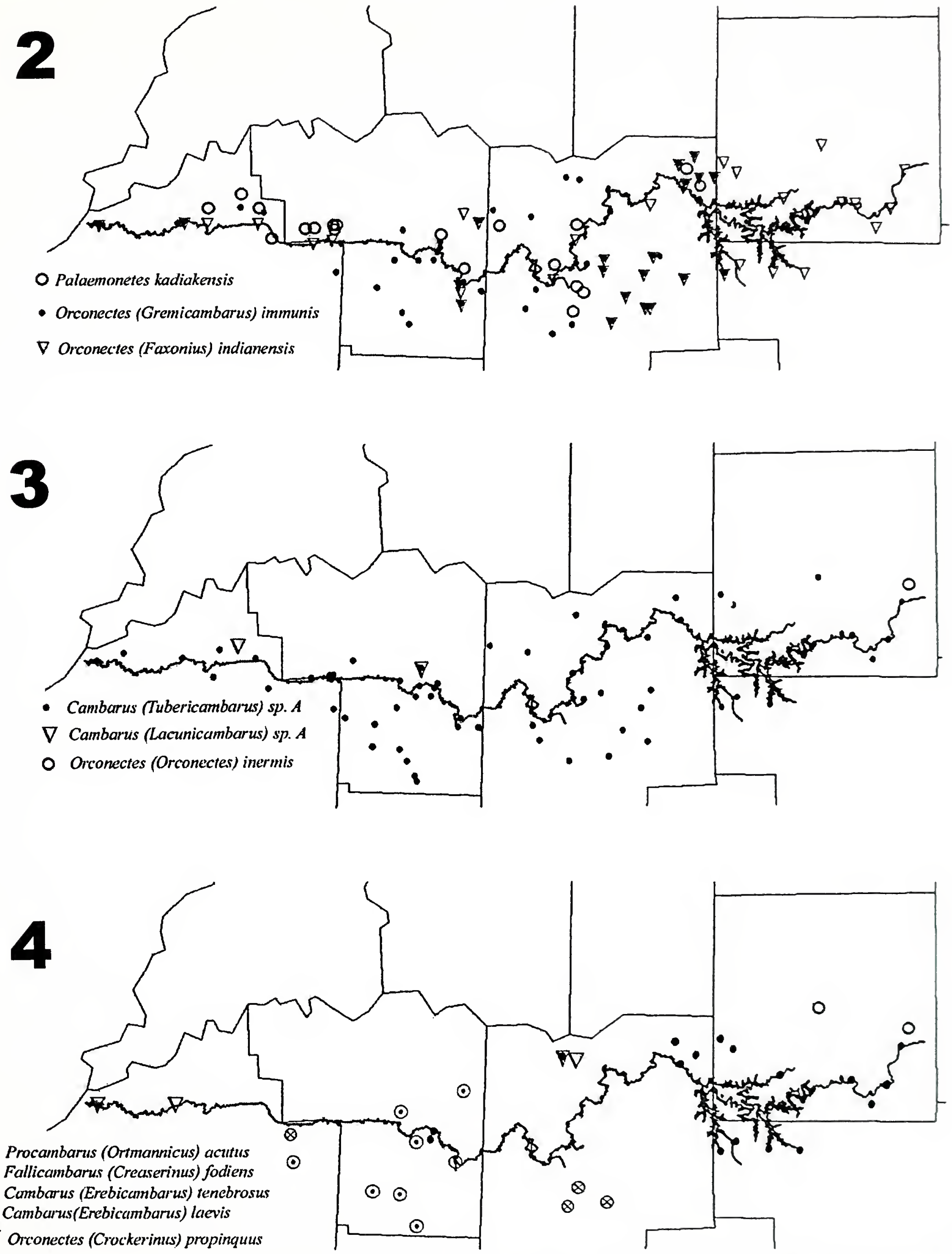
Figure 1.—The Patoka River watershed runs from east to west in southwestern Indiana. Including the meanders of the channel (not a straight measurement), the river is 162 miles (260 km) long. It joins the Wabash River near the borders of Gibson County and Knox County. The Wabash River drains into the Ohio River. Sampling was done in 2001 and 2002.

eral large public land holdings include the Patoka River unit of the Hoosier National Forest, Patoka Lake and the U.S. Army Corps of Engineers holdings, and the U.S. Fish and Wildlife Service's Patoka River National Wildlife Refuge.

Collection methodology.—Open-water crayfish and freshwater shrimp were sampled by seining, dipnetting, or electrofishing of all representative habitats at a locality (Simon 2001). Electrofishing included the use of a pulsed DC Smith-Root generator backpack electrofishing unit capable of 300 V output and usually 3–6 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 large-to-moderate sized rivers. Oxbow pond and lake littoral shoreline habitat was surveyed for 500 m. 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 in a live well and retained until the end of the collecting zone.

Burrowing crayfish were collected using two approaches. Prairie crayfish that remained in burrows were collected using a modified toilet plunger to force the crayfish from the burrow (Simon 2001). Water was poured into the burrow until full, then suction was applied at the entrance so that a good seal was established. Plunging the burrow caused the exit holes to be exposed, and after several attempts the exit holes were examined for the presence of the resident crayfish. If the plunger did not reveal the crayfish, then a spade was used to excavate the burrow. Depths that were excavated in the Patoka River drainage ranged between 0.6–2 m.

Specimens retained for laboratory identification were identified using Page (1985),



Figures 2–4.—Distribution of crayfish and freshwater shrimp species in the Patoka River. 2. Distribution of *Palaemonetes kadiakensis*, *Orconectes (Gremicambarus) immunis*, and *Orconectes (Faxonius) indianensis*; 3. Distribution of *Cambarus (Tubericambarus)* sp. A, *Cambarus (Lacunicambarus)* sp. A, and *Orconectes (Orconectes) inermis inermis*; 4. Distribution of *Procambarus (Ortmannicus) acutus*, *Fallicambarus (Creaserinus) fodiens*, *Cambarus (Erebicambarus) tenebrosus*, *Cambarus (Erebicambarus) laevis*, and *Orconectes (Crockerinus) propinquus*.

Table 1.—List of collection information and corresponding spatial coordinates (decimal degree) for sites sampled in the Patoka River drainage between 2001 and 2002. Abbreviations include, CR = County Road, SR = State Road, mi = miles, Twp = Township, u/s = upstream, d/s = downstream.

Site number	County	Site	Latitude (N)	Longitude (W)
1	Gibson	Hull ditch, CR 350 N bridge, 3 mi E East Mt. Carmel, White River Twp	38.40711°	87.68587°
2		Tripplet ditch, CR 400 N bridge, 2.5 mi E Patoka, Washington Twp	38.41376°	87.50745°
3		Lost Creek, CR 50 N bridge, 2.5 mi N Francisco, Center Twp	38.36307°	87.44113°
4		Tributary E Branch Keg Creek, CR 50 N bridge, 2.5 mi E Francisco	38.36307°	87.39940°
5		W Fork Keg Creek, SR 64 bridge, 2 mi E Francisco, Columbia Twp	38.32655°	87.39950°
6		Turkey Creek, CR 1275 E bridge, 0.75 mi E Oakland City, Columbia Twp	38.33827°	87.33295°
7	Pike	Hat Creek, CR 50 E bridge, 1 mi N Coe, Monroe Twp	38.32513°	87.25730°
8		Tributary South Fork Patoka River, CF 900 S bridge, 1 mi S Coe, Monroe Twp	38.28945°	87.26575°
9		Rough Creek, CR 1000 S bridge, 0.5 mi E Spurgeon, Monroe Twp	38.24602°	87.25209°
10		Wheeler Creek, CR 775 S bridge, 1 mi E Coe, Monroe Twp	38.30800°	87.28200°
11		Tributary Turkey Creek, unnamed CR, 2 mi SW Arthur, Monroe Twp	38.32667°	87.22233°
12		Durham ditch, CR 800 S bridge, 0.25 mi NW Scottsburg, Monroe Twp	38.30383°	87.22233°
13		South Fork Patoka River, near CR 200 E bridge, 2 mi W Stendal, Monroe Twp	38.25217°	87.19350°
14		Rock Creek, CR 1000 E bridge, 1.5 mi E Pikesville, Lockhart Twp	38.31683°	87.08567°
15		South Fork Patoka River, CR 1200 S bridge, 2.5 mi E Spurgeon, Monroe Twp	38.24600°	87.18967°
16		Cup Creek, SR 257 bridge, 0.3 mi SW Pikeville, Lockhart Twp	38.31667°	87.12050°
17		Farm field adjacent Cup Creek mouth, 0.5 mi NW Pikeville, Lockhart Twp	38.33100°	87.12500°
18		Barren ditch, unnamed CR bridge, 2 mi SW Winslow, Patoka Twp	38.34083°	87.22517°
19		South Fork Patoka River, CR 875 S bridge, 1.2 mi E Coe, Monroe Twp	38.29300°	87.29400°
20		South Fork Patoka River, CR 300 E bridge, 1.5 mi SE Coe, Monroe Twp	38.28717°	87.21933°
21		Tributary Rough Creek, CR 200 E bridge, 1.5 mi SSE Coe, Monroe Twp	38.28150°	87.24233°
22		Rough Creek, CR 200 E bridge, 1.75 mi SSE Coe, Monroe Twp	38.28000°	87.24250°
23		Rough Creek, CR 200 E bridge, 2.5 mi S Coe, Monroe Twp	38.26470°	87.25000°
24		Stone Coe Creek, SR 64 bridge, 0.25 mi N Winslow, Patoka Twp	38.39450°	87.22017°
25		Robinson Creek, CR 475 E bridge, 1.2 mi NE Winslow, Patoka Twp	38.41950°	87.18817°
26		Bruster Branch, CR 200 S bridge, 0.75 mi NE Winslow, Patoka Twp	38.39367°	87.18733°
27		Patoka River, SR 61 bridge, Winslow, Patoka Twp	38.37550°	87.21950°
28		Tributary Patoka River, SR 364 bridge, 0.75 mi S Winslow, Patoka Twp	38.35533°	87.23333°
29		Mill Creek, u/s SR 364 bridge, 0.8 mi SE Winslow, Patoka Twp	38.35550°	87.19333°
30		Mill Creek, d/s CR 450 E bridge, 0.8 mi SE Winslow, Patoka Twp	38.36933°	87.18733°
31		Tributary Patoka River, SR 364 bridge, 1.5 mi SE Winslow, Marion Twp	38.35583°	87.16683°
32		Tributary Patoka River, Forest Road, 2.0 mi E Winslow, Patoka Twp	38.36717°	87.16100°
33		Tributary Patoka River, CR 450 E bridge, 2 mi E Winslow, Marion Twp	38.38033°	87.15550°

Table 1.—Continued.

Site number	County	Site	Latitude (N)	Longitude (W)
34	Dubois	E Branch Ell Creek, CR 585 W bridge, 2.0 mi WSW Huntingburg, Patoka Twp	38.29433°	87.01183°
35		Ell Creek, CR 400 S bridge, 2.0 mi NW Huntingburg, Patoka Twp	38.31950°	86.99400°
36		Flat Creek, CR 250 S bridge, 4 mi SSE Otwell, Madison Twp	38.38583°	87.05850°
37		Flat Creek, SR 257 bridge, 2.5 mi S Otwell, Marion Twp	38.40917°	87.09183°
38		Flat Creek, CR 300 W bridge, 1.8 mi SSW Otwell, Marion Twp	38.42350°	87.11433°
39		Little Flat Creek, CR 300 W bridge, 2 mi SE Otwell, Madison Twp	38.42250°	87.06867°
40		Unnamed tributary, SR 56 bridge, Ireland, Madison Twp	38.41500°	87.00417°
41		Mill Creek tributary, SR 231 bridge bypass, 1.5 mi S Haysville, Harbison Twp	38.46367°	86.92467°
42		Mill Creek, CR 600 N bridge, 1.5 mi SW Haysville, Boone Twp	38.46717°	86.94717°
43		Flat Creek, CR 230 S bridge, 0.5 mi E Mathersville, Jackson Twp	38.34817°	86.88100°
44		Indian Creek, SR 64 bridge	38.29933°	86.91533°
45		Hall Creek tributary, Meridian Road	38.35450°	86.90983°
46		Short Creek, Sunset Road, 1.5 mi SE Huntingburg, Ferdinand Twp	38.27433°	86.93217°
47		Indian Creek, SR 162 bridge	38.28083°	86.86583°
48		Patoka River, SR 162 bridge	38.38750°	86.92800°
49		Davis Creek, Cuzco Road bridge, Crystal, Columbia Twp	38.48783°	86.75633°
50		Cane Creek tributary, CR 650 S bridge, 1 mi E Cuzco, Columbia Twp	38.47233°	86.69633°
51		Cane Creek, CR 500 S bridge, 4.5 mi S French Lick, Jackson Twp	38.47900°	86.65883°
52		Cane Creek, Cuzco Road bridge, S Cuzco, Columbia Twp	38.47050°	86.72200°
53		Patoka River, Dubois-Cuzco Road bridge, 0.8 mi SW Cuzco, Columbia Twp	38.45933°	86.74917°
54		Patoka River tributary, Jasper-Dubois Road bridge, 0.5 mi S Dubois, Marion Twp	38.43550°	86.80417°
55		Beaver Dam Lake Creek, CR 175 E bridge, 4.5 mi NW Jasper, Marion Twp	38.42333°	86.87083°
56		Flat Creek, CR 450 S bridge, 0.5 mi W St. Anthony, Jackson Twp	38.31433°	86.84383°
57		Flat Creek, CR 600 E bridge, 1 mi ESE St. Anthony, Jackson Twp	38.30067°	86.80183°
58		Grassy Fork, Santine Road bridge, 1.25 mi NNE St. Anthony, Jackson Twp	38.34400°	86.81217°
59		Unnamed tributary Patoka Lake, 0.25 mi SW Wickliffe, Patoka Twp	38.35850°	86.65067°
60		Hall Creek, Santine Road bridge, 1.25 mi SW Celestine, Marion Twp	38.36666°	86.79733°
61		Hall Creek, Schnellville-Birdseye Road bridge, 0.25 mi E Schnellville, Jefferson Twp	38.33950°	86.74567°
62		Unnamed tributary Patoka Lake, 1.2 mi N Birdseye, Patoka Twp	38.34633°	86.67833°
63	Crawford	Unnamed tributary Patoka Lake, 1 mi NW Taswell, Patoka Twp	38.34967°	86.59366°
64		Unnamed tributary Patoka Lake, 0.8 mi N Taswell, Patoka Twp	38.34833°	86.54133°
65		Dog Creek, CR 33 bridge, 1.2 mi NE English, Sterling Twp	38.36617°	86.44283°
66	Orange	Unnamed tributary Patoka Lake, CR 650 W bridge, 1 mi SW Greenbrier, Hoosier National Forest, Jackson Twp	38.44650°	86.57800°
67		Young's Creek, CR 600 S bridge, Youngs Creek, Hoosier National Forest, Greenfield Twp	38.51583°	86.51567°
68		Patoka River, SR 37 bridge, 1.5 mi S Pine Valley, Southeast Twp	38.44033°	86.45650°

Table 1.—Continued.

Site number	County	Site	Latitude (N)	Longitude (W)
69	Dubois/Orange	Unnamed tributary Crane Creek, Cuzco-Norton Road bridge, 3.25 mi SW French Lick, Columbia/ Jackson Twp	38.49300°	86.68217°
70	Orange	Unnamed tributary Patoka River, 0.2 mi E Bacon, Hoosier National Forest, Southeast Twp	38.40883°	86.42100°
71		Patoka River, CR 375 E bridge, 0.1 mi S Valeene, Southeast Twp	38.43517°	86.39667°
72		Patoka River unnamed tributary, CR 825S bridge, Valeene, Southeast Twp	38.43417°	8639750°
73		Patoka River, CR 500 E bridge, 2 mi SSE Chambersburg, Stampers Creek Twp	38.48433°	86.37367°
74		Spring Spring Cave, CR 475 path into State Forest, Stampers Creek Twp	(see Indiana	Cave Atlas)
75	Gibson	South Fork Patoka River, SR 57 bridge, 2 mi N Oakland City, Columbia Twp	38.37733°	87.33617°
76		Patoka River, CR 1200 E bridge, 2.25 mi N Oakland City, Columbia/Logan Twp	38.38317°	87.33283°
77		Patoka River, SR 57 bridge, 2.25 mi N Oakland City, Columbia Twp	38.38283°	87.33816°
78		Patoka River, CR 1050 E bridge, 2 mi SE Oatsville, Columbia Twp	38.37800°	87.37067°
79		Houchins ditch, CR 450 E bridge, 1 mi SW Wheeling, Washington Twp	38.40333°	87.46467°
80		Patoka River, Old SR 41/CR 75 W bridge, Patoka, White River Twp	38.40233°	87.58633°
81		Patoka River, US 41 bridge, access off Service Road, 1 mi W Patoka, White River Twp	38.39867°	87.59900°
82		Patoka River, CR 890 W bridge, 1 mi NNE East Mt Carmel, White River Twp	38.39700°	87.73000°
83		Patoka River, CR 850 E, 2 mi E East Mt. Carmel, White River Twp	38.37719°	87.38542°
84		Patoka River, 350 m E CR 450 N, 2 mi SW Cuzco, Columbia Twp	38.44116°	86.28818°
85		Yellow Creek, N CR 400 N, 1.2 mi E Wheeling, Washington Twp	38.41468°	87.45415°
86		Cup Creek, CR 625 N, ca 0.25 mi W HWY 257, 0.5 mi W Pikeville, Lockhart Twp	38.32717°	87.12247°
87	Dubois	Hall Creek, S Celestine Road, 1.25 mi S Celestine, Hall Twp	38.36598°	86.78764°
88		Ell Creek unnamed tributary, 200 m N SR 64 bridge, 2 mi W Huntingburg, Patoka Twp	38.30034°	86.98246°
89	Orange	Patoka River, 0.5 mi E CR 150 W bridge	38.44104°	86.47832°
90	Pike	South Fork Patoka River, CR 300 E bridge, 2.25 mi SSE Coe, Monroe Twp	38.27296°	87.20605°
91	Dubois	Patoka River. CR 300 W, 5.5 mi S Jasper, Patoka Twp	38.33564°	86.96543°
92		Short Creek, 200 m W SR 231, 4.25 mi S Jasper, Bainbridge Twp	38.26234°	86.96615°
93		Hall Creek tributary, Hall Creek Road, 0.75 mi W SR 162, 1.6 mi SE Jasper, Bainbridge Twp	38.36204°	86.87996°
94	Pike	Flat Creek, 0.25 mi W Flat Creek Road	38.42045°	87.11727°
95	Dubois	Hunley Creek, 0.5 mi N SR 64, 3 mi W Huntingburg, Patoka Twp	38.30687°	86.92697°
96	Gibson	Patoka River, 0.5 mi N CR 400 N, 3 mi W Wheeling, Washington Twp	38.42058°	87.49355°
97	Dubois	Davis Creek, 200 m S SR 56, 2 mi N Cuzco, Columbia Twp	38.49864°	86.73064°
98	Pike	Cup Creek, 0.5 mi S SR 64, 1.5 mi S Pikeville, Lockhart Twp	38.30055°	87.11840°
99	Dubois	Flat Creek, 200 m S SR 64, 0.75 mi W St. Anthony, Jackson Twp	38.30016°	86.80841°
100	Pike	Bruster Branch, CR 200 N, 2 mi NE Winslow, Patoka Twp	38.39312°	87.18423°
101	Gibson	Patoka River, CR 350 N, 0.5 mi S Patoka, White River Twp	38.40180°	87.54927°
102	Dubois	Dillon Creek, 0.25 mi N Dubois-Cuzco Road at CR 850 E, 1.5 mi SW Cuzco, Columbia Twp	38.46348°	86.74559°

Table 1.—Continued.

Site number	County	Site	Latitude (N)	Longitude (W)
103	Gibson	Indian Creek, CR 150 N bridge, 2.5 mi NE Princeton, Patoka Twp	38.37806°	87.53528°
104	Pike	Flat Creek tributary, CR 125 S bridge, 1 mi S Glezen, Washington Twp	38.40222°	87.30167°
105		Flat Creek, CR 125 S bridge	38.40183°	87.30067°
106		Sugar Creek	38.39867°	87.27900°
107		Patoka River, Survant	38.37250°	87.15567°
108		Patoka River, SR 257 bridge	38.32900°	87.11533°
109		Hog Branch, Sugar Ridge State Park, 0.75 mi SW Survant, Marion Twp	38.36722°	87.16083°
110		Unnamed tributary, SR 364 bridge, 1.5 mi SSW Winslow, Patoka Twp	38.35528°	87.23417°
111	Gibson	Wabash and Erie Canal, CR 50 N bridge, 2 mi N Francisco, Center Twp	38.36361°	87.44083°
112	Pike	Lick Creek, CR 300 S, 0.5 mi W Survant, Marion Twp	38.37528°	87.16444°
113	Orange	Patoka Lake	38.29488°	86.60517°
114		Patoka Lake	38.40171°	86.61315°
115		Patoka Lake	38.41473°	86.67350°
116		Patoka Lake	38.43208°	86.64675°
117	Dubois	Patoka Lake	38.37540°	86.68725°
118		Patoka Lake	38.37040°	86.61808°
119		Huntingburg Lake	38.29488°	86.98229°
120		Huntingburg Lake	38.29087°	86.97665°
121		Beaver Dam Lake	38.39849°	86.84378°
122	Pike	New Oakland City Lake	38.31928°	87.32203°
123		New Oakland City Lake	38.31757°	87.32003°
124	Dubois	Big Bottom wetland	38.39538°	86.91330°
125	Orange	Tucker Lake	38.48425°	86.56184°

Table 2.—Freshwater shrimp and crayfish species collected from the Patoka River drainage. The numbers represent sites listed in Table 1, while numbers in parentheses refer to the number of individuals collected. The sequence of species follows Simon (2001).

Species	Sites where species was collected
Family Palaemonidae (freshwater shrimp)	
Palaemonetes kadiakensis Rathbun, Mississippi grass shrimp	3(3), 36(1), 44(110), 46(11), 48(88), 75(1), 76(9), 77(7), 78(18), 79(2), 83(4), 84(1), 91(2), 95(2), 96(30), 101(2), 102(1), 107(11), 108(2)
Family Cambaridae (crayfish)	
Procambarus (*Ortmannicus*) *acutus* (Girard), White River crayfish	4(5), 44(3), 46(1), 47(1)
Orconectes (*Crockerinus*) *propinquus* (Girard), northern clearwater crayfish	41(2), 42(2), 81(2), 82(4)
O. (*Faxonius*) *indianensis* (Hay), Indiana crayfish	16(2), 37(1), 43(11), 47(41), 48(38), 49(53), 50(21), 51(106), 52(20), 53(11), 54(2), 56(2), 57(26), 58(11), 59(16), 60(3), 61(12), 62(12), 63(36), 64(54), 66(9), 67(30), 68(65), 69(63), 70(1), 71(79), 72(2), 73(67), 77(1), 78(6), 79(2), 80(1), 82(5), 86(1), 89(5), 91(1), 93(1), 94(5), 97(8), 98(2), 99(4), 101(8), 102(8)
O. (*Gremicambarus*) *inmunis* (Hagen), papershell crayfish	6(4), 7(1), 14(5), 20(1), 24(2), 28(15), 29(2), 31(5), 32(1), 33(3), 34(5), 35(5), 37(1), 39(18), 40(14), 41(33), 42(11), 43(15), 45(29), 46(173), 47(58), 49(15), 50(37), 52(4), 55(41), 56(1), 57(28), 58(11), 60(12), 61(1), 62(5), 80(2), 81(1), 82(1), 84(1), 85(14), 86(3), 87(7), 90(2), 92(8), 93(5), 96(2), 97(5), 98(1), 99(3), 102(1), 107(1), 108(8)
O. (*Orconectes*) *inermis inermis* Cope, Indiana cave crayfish	74(2)
Fallicambarus (*Creaserinus*) *fodiens* (Cottle), digger crayfish	5(1), 8(1), 15(1), 17(2), 20(2), 24(1), 29(1), 38(4)
Cambarus (*Erebicambarus*) *laevis* Faxon, karst crayfish	67(5), 74(3)
C. (*E.*) *tenebrosus* Hay, cavespring crayfish	31(3), 32(3), 42(1), 49(1), 51(6), 52(1), 53(6), 59(8), 62(1), 63(2), 64(3), 66(12), 68(1), 69(14), 70(3), 71(1), 72(1), 73(3)
C. (*Lacunicambarus*) sp. A, great plains mudbug	96(2), 100(1)
C. (*Tubericambarus*) sp. A, painted-hand mudbug	1(3), 2(1), 3(1), 6(3), 7(1), 8(1), 11(5), 13(3), 14(1), 15(3), 16(2), 18(2), 20(2), 26(4), 27(5), 29(5), 30(1), 31(2), 32(1), 35(1), 39(2), 40(3), 41(1), 45(8), 46(6), 47(1), 48(1), 49(2), 51(2), 53(6), 54(1), 55(13), 56(1), 57(3), 58(11), 59(2), 60(12), 62(3), 63(1), 67(1), 68(2), 69(7), 70(2), 71(1), 73(5), 75(2), 76(1), 77(4), 78(5), 79(7), 80(1), 82(2), 88(1), 90(1), 93(2), 100(1), 103(1), 105(6), 107(3), 108(1)

Pflieger (1996), and Thoma & Jezerinac (2000). All specimens were deposited in the crustacean collection of the Indiana Biological Survey, Bloomington.

RESULTS AND DISCUSSION

Distribution of decapods.—The Patoka River drainage includes 10 species of crayfish and a single freshwater shrimp (Tables 1, 2).

Only a single species of freshwater shrimp was collected from the watershed (Fig. 2). The Mississippi grass shrimp *Palaemonetes kadiakensis* was found primarily in the mainstem Patoka River; however, the species was also found in small tributaries adjacent to vernal ponds and wetlands. This species is usually more common in pond, marsh, and slough habitats than in streams. Female specimens collected during April were ovigerous and were pigmented with lime-green bars along their sides.

Ten Cambaridae species were collected from the Patoka River drainage including members of each of the four Indiana crayfish genera (Tables 1, 2). *Procambarus acutus* was the only *Procambarus* species collected (Fig. 4). The species was most common in small headwater streams that possessed overhanging grasses and dense root wads along the stream margins. No ovigerous females were collected during this study.

Two *Erebicambarus* species, *Cambarus laevis* and *C. tenebrosus* were collected from karst areas of the watershed (Tables 1, 2; Fig. 4). Taylor (1997) has considered these species as synonymous; however, we follow Simon (2001) in separating them until further study can verify Taylor's hypothesis. *Cambarus laevis* was collected from two sites in the upper portion of the watershed (Fig. 4). One site was inside Spring Spring cave and the other from a breakdown area where groundwater was emanating from a newly forming cave. The two species were found beneath large boulder rocks in springs outflows and near the entrances of caves. Within the Patoka River drainage the two species were not sympatric; however, elsewhere the two species are commonly collected together at the same site (Simon unpubl. data).

Three primary burrowing species were collected from the watershed (Fig. 3, 4). Two *Cambarus* species and *Fallicambarus (Creaserinus) fodiens* were collected from roadside ditches, farm fields, and wetland habitats (Tables 1, 2). The widest-ranging burrowing species was *Cambarus (Tubericambarus)* sp. A (Fig. 3). This species was mentioned by Jezerinac (1993) as ranging throughout southern Indiana, Ohio, and Illinois. This species was the only crayfish at many of the sites affected by acid mine drainage, oil brine, and coal mining. *Fallicambarus (Creaserinus) fodiens* was the second most abundant and widest distributed burrowing species (Fig. 4). We collected *F. (C.) fodiens* and *Cambarus (T.)* sp. A together and *Cambarus (T.)* sp. A and *Cambarus (Lacunicambarus)* sp. A at several of the same sites, but all three burrowing species are not sympatric at the same site.

Four secondary burrowing species of the genus *Orconectes* were collected during this study (Tables 1, 2). The most abundant and widely distributed was *O. (Gremicambarus) immunis*, which was collected from among woody debris, overhanging vegetation, and debris piles (Fig. 2). *Orconectes (Crockerinus) propinquus* was collected from four sites in the lower Patoka River (Fig. 4). Surprisingly, *Orconectes (Faxonius) indianensis* was much more common than previously considered (Thoma & Simon unpubl. data), primarily being collected from the upper third of the watershed (Fig. 2). The troglobitic crayfish *O. inermis inermis* was found in a single cave in the extreme headwaters of the Patoka River. Thoma et al. (unpubl. data) has reviewed the distribution of records for the northern cave crayfish and found that the species was not as broadly distributed in the Patoka River drainage as originally considered (Fig. 3).

Several sites were dry or were intermittent during the sampling period. They include Flat Creek tributary (site 104), Hog Branch (site 109), unnamed tributary at SR 364 bridge (site 110), Wheeler Creek (site 10), the old Wabash and Erie Canal (site 111), and Lick Creek (site 112). All of these streams also lacked water during the sampling conducted in 1993 and 2000 (Simon et al. 1995).

No crayfish were collected from Rough Creek (sites 9, 22, 23), Wheeler Creek (site 10), Durham ditch (site 12), South Fork Patoka River (site 19), Rough Creek tributary (site 21), Robinson Creek (site 25), and Sugar Creek (site 106). These sites were affected by acid mine drainage, oil brine, or coal mining (Simon et al. 1995, 2003). No crayfish were collected from any of the lake or oxbow sites sampled in the watershed. The lakes and oxbows sampled included Patoka Lake (sites 113–118), Huntingburg Lake (sites 119, 120), Beaver Dam Lake (site 121), New Oakland City Lake (sites 122, 123), Big Bottom wetland (site 124), and Tucker Lake (site 125).

Gradient Patterns Affecting Distribution.—The distribution of crayfish and shrimp follows several landscape scales including Ecoregions, Sub-ecoregions, and Natural Divisions. Omernik and Gallant (1988) defined Ecoregions for the midwest states, Woods et al. (1996) defined Sub-ecoregions for Indiana and Ohio, while Natural Divisions were defined by Homoya et al. (1985). Both Ecoregion frameworks are based on climate, land use, physiography, potential natural vegetation at different scales, while Natural Divisions include zoogeographic patterns. The Patoka River contains two Ecoregions, the Interior River Lowland to the west and the Interior Plateau to the east, while several Sub-ecoregions are recognized within the Interior River Lowland. Homoya divided the Patoka River into six subdivisions. These subdivisions from west to east include the Southern Bottom Lands, Southwestern Lowlands-glaciated, Southwestern Plainville, Southwestern Lowlands-driftless, and Shawnee Hill-Crawford Upland.

Species distributions that were exclusively contained within the Interior River Lowland Ecoregion included *Procambarus (Ortmannicus) acutus*, *Cambarus (Lacunicambarus)* sp. A, *Fallicambarus (Creaserinus) fodiens*, and *O. (Crockerinus) propinquus* (Figs. 3, 4). Species distributions that are contained within the Interior Plateau Ecoregion include *Cambarus (Erebicambarus) tenebrosus* and *O. (Orconectes) inermis inermis*. No pattern in ecoregion distribution was observed for *Palaemonetes kadiakensis*, *Cambarus (Tubericambarus)* sp. A, *O. (Gremicambarus) immunis*, and *O. (Faxonius) indianensis*.

Cambarus (L.) sp. A (Fig. 3) and *Palaemonetes kadiakensis* (Fig. 2) occur along the Southwestern Lowlands-glaciated subdivision portions of the watershed, while *Fallicambarus (C.) fodiens* is limited to the Southwestern Lowlands-driftless subdivision (Fig. 4). *Cambarus (E.) tenebrosus* and *O. inermis inermis* were limited to the Shawnee Hill-Crawford Upland subdivision (Fig. 3).

Patterns in zoogeographic distributions of Indiana crayfish species are largely determined by the last glacial advance (Simon unpubl. data). The Wisconsian glacier only covered the western-most portion of the lower Patoka River. Because glacial refugia were established and more southern species were able to remain in these areas, watersheds such as the Patoka River are more faunistically diverse than northern watersheds that were completely obliterated (Simon 2001). Thus, southern portions of Indiana that were not affected by the last glacial advance will require further collection efforts to document the biodiversity of the crayfish and shrimp fauna.

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