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## Geographic Distribution and Life History Aspects of the Freshwater Shrimps, *Macrobrachium ohione* and *Palaemonetes kadiakensis* (Decapoda: Palaemonidae), in Arkansas

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# Geographic Distribution and Life History Aspects of the Freshwater Shrimps, *Macrobrachium ohione* and *Palaemonetes kadiakensis* (Decapoda: Palaemonidae), in Arkansas

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## Abstract

Two species of shrimps occur in Arkansas; they include the Ohio shrimp, *Macrobrachium ohione* (Smith) and the Mississippi grass shrimp, *Palaemonetes kadiakensis* Rathbun. The present survey is based on collections made between 1974 and 2008 with additional supplemental data from museum specimens to document the overall distribution of the 2 species. Our survey found a total of only 42 specimens of *M. ohione* from 6 localities (2 counties) in Arkansas, all taken from the Mississippi River. Specimens were seined over sandy substrates in 0.6-0.9 m of water without vegetation. A 1914 museum collection of 5 individual *M. ohione* is the only known occurrence of *M. ohione* from Phillips County. All other specimens were taken between 1974-1975 near the US 82 bridge (Chicot County). It appears that *M. ohione* is a relatively rare shrimp in Arkansas. Since specimens were documented from a single drainage system (Mississippi River) in only 2 counties, we recommend a “threatened” conservation status of *M. ohione* in Arkansas because of this restricted distributional range. However, *P. kadiakensis* is relatively abundant in Arkansas. This shrimp had previously been reported from 10 counties of the state. Over 3,400 specimens of *P. kadiakensis* were documented during this study from various sites in 49 counties and most were released upon capture. Grass shrimp were commonly found in sluggish backwater regions of streams especially preferring heavily vegetated lentic areas of pool regions. Mississippi grass shrimp have remained abundant and widespread in occurrence for the past 35 years. The Nature Conservancy lists populations of *P. kadiakensis* as secure (G5) in rounded global status. Indeed, Mississippi grass shrimp populations in Arkansas are also secure and in no need of special protection.

## Introduction

Freshwater shrimp are conspicuous members of Arkansas’ aquatic macroinvertebrate fauna, and yet, have received little attention. Of the few species that are endemic to or range into the north temperate regions of the Western Hemisphere, only 2 species are known from Arkansas (Bouchard and Robison 1980). These 2 freshwater caridean shrimps are represented by 2 genera in the family Palaemonidae of the crustacean Order Decapoda. In North America, the Palaemonidae includes 68 described species in 16 genera (Williams 1989) and is cosmopolitan in distribution. Caridean shrimps are distinguished from crayfish by possessing 2 pairs of chelipeds while crayfish have 3 pairs as well as major differences in body shape (Bauer 2004).

The Ohio shrimp, *Macrobrachium ohione* (Smith), is migratory, the larger (up to 110 mm total length [TL]) of the 2 species of Arkansas shrimps and was the basis of formerly more extensive food and bait fisheries in the Mississippi River drainage (Hedgpeth 1949). The smaller (up to 53 mm TL) shrimp species native to Arkansas is the Mississippi grass shrimp, *Palaemonetes kadiakensis* Rathbun. This shrimp is often used as fish bait and for fish forage in farm ponds. Because of its limited commercial value, the grass shrimp has been little studied across its range (Cheper 1988). Most published information is new distributional records or range extensions of the species (Cheper 1988, 1992, Taylor 1992, Conaway and Hrabik 1997, Pigg and Cheper 1998, Poly and Wetzel 2002, Cooper 2011).

The Ohio shrimp is endemic to coastal rivers in the central and southeastern U.S., and ranges from Alabama to Texas and is on the northern periphery of its range in Illinois and Ohio (Page 1985). It also occurs along the Atlantic Coast from Florida to Virginia (Page 1985, Taylor 1992). The Mississippi grass shrimp ranges from northeastern Mexico, north to the Great Lakes and east to Florida (Page 1985).

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Little is known about the distributional limits of these shrimps in Arkansas and even less about their natural history, ecology, reproduction, habitat characteristics, and general biology. Limited previous collecting of these species is primarily responsible for this lack of knowledge. Surveys of aquatic macroinvertebrates of various parts of the state include collections of *P. kadiakensis* reported by Harp and Harp (1980) in Crittenden County, Cargill and Harp (1987) in Clay County, Cochran and Harp (1990) in Craighead, Greene, and Poinsett counties, Chordas et al. (1996) in Arkansas, Desha, Monroe and Phillips counties, and Harp and Robison (2006) in Lawrence County.

Specific objectives of our study were (1) to determine the relative abundance and precise distributional limits of the range of *M. ohione* and *P. kadiakensis*; (2) to gather data on life history aspects of these shrimp species including information on habitat, reproductive period, and any other biological data available; (3) to document data on ecological and habitat characteristics of these shrimp species; and (4) to assess the current conservation status of *M. ohione* and *P. kadiakensis* based on the collected distributional data.

### Materials and Methods

This survey of the shrimps of Arkansas is based on collections that we made between 1974-2008. Collecting methods included the use of conventional seines (3.1 × 1.8 m with 3.2 mm mesh or 6.1 × 1.8 m with 3.2 mm mesh) and standard aquatic dipnets. Most individuals were released unharmed at the collection site; however, representative voucher specimens were preserved in 70% isopropanol and deposited in the invertebrate collection at Southern Arkansas University (SAU), Magnolia. The number of specimens

(Appendix) is the number of specimens preserved or the total number found at an individual site.

In addition to our collections, supplemental museum specimens housed at the United States National Museum of Natural History (USNM 2009), Washington, D.C., Illinois Natural History Survey, Champaign, Illinois (INHS 2010), and the G. L. Harp Aquatic Macroinvertebrate Collection, Arkansas State University, Jonesboro, Arkansas (ASUMZ) were used to document the overall distribution of the 2 species in the state. Previous literature dealing with these shrimp species was also consulted. Both our survey data and historical county collection locales were plotted on maps (see Figs. 1-2).

### Results and Discussion

Our survey found a total of only 42 specimens of *M. ohione* from 6 localities in 2 counties (Table 1) whereas 3,418 specimens of *P. kadiakensis* from 238 localities in 49 counties (Table 2; Appendix) were documented.

### *Macrobrachium ohione* (Smith, 1874)

#### Taxonomic Remarks

Holthius (1952) revised the subfamily Palaemoninae from the Americas including all known U.S. species of *Macrobrachium*. There are 6 species of *Macrobrachium* in the U.S. (Bowles et al. 2000); however, only *M. ohione* inhabits the Mississippi River drainage in Arkansas. It is characterized by having the first pairs of legs chelate, the second pair of chelipeds (pereopods 2) longer and more robust than first chelipeds (pereopods 1), the carpus of the second leg not subdivided, a hepatic spine present, and the upper edge of the rostrum curved with 9-13 teeth and a toothless dagger-like tip.

Table 1. Records of 42 *M. ohione* from Arkansas.

County	Locality	Date	Number	Collector	Museum Collection
<b>Chicot</b>	Mississippi River at US 82 bridge	17 Aug. 1974	3	HWR	SAU
	Mississippi River at US 82 bridge near boat landing	9 Jul. 1975	2	HWR	SAU
	Mississippi River, 11.3 km S US 82 bridge, Even Oaks Lodge	10 Jul. 1975	2	HWR	SAU
	Mississippi River, sandbar across from Grand Lake	10 Jul. 1975	25	HWR	ASUMZ 071075A-1
	Mississippi River, 4.8 km N US 82 bridge	11 Jul. 1975	5	HWR	SAU
<b>Phillips</b>	Mississippi River at Helena	1914	5	unknown	USNM 153841

### Relative Abundance

It appears that *M. ohione* is a relatively rare shrimp in Arkansas with only 42 specimens from 2 counties (Fig. 1) documented during a collection period spanning nearly 100 years. Since our last collection in July 1975 (Table 1), we have not been able to locate vouchers of this shrimp in any museum collection or collect additional *M. ohione* in the state.

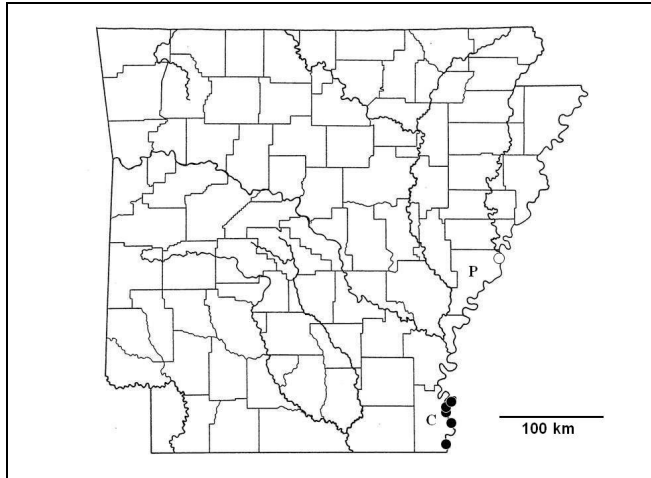


Figure 1. Arkansas counties with genuine vouchers of *M. ohione*. Open dot (previous USNM record); solid dots (new county record). Abbreviations: C (Chicot County); P (Phillips County).

### Habitat

Barko and Hrabik (2004) found *M. ohione* occupied open side channels and main channel borders of the Mississippi River in Missouri. Conaway and Hrabik (1997) reported Ohio shrimp occupied low velocity waters; however, open side channels have flow during normal river elevations (Barko and Herzog 2003). They occur in the borders of the river channels, especially when the borders are flooded and plant and animal material are available for foraging (Truesdale and Mermilliod 1979). Hobbs (2001) reported this shrimp receives reproductive cues from spring floods and uses flooded terrestrial habitat for reproduction.

All specimens of *M. ohione* collected in Arkansas were taken from the Mississippi River. Specimens were seined over sandy substrates at depths of 0.6-0.9 m without vegetation. No appreciable current was detected in these areas 6-9 m offshore adjacent to sand bars.

### Distribution

The Ohio shrimp was originally described from specimens collected from the Ohio River in Indiana (Smith 1874), and ranged up to the downstream end of Washington County, Ohio; however, there are

apparently no recent records, museum or otherwise from those areas. The species occurs in the Mississippi River basin, Gulf Coastal drainages, and also in some Atlantic coast drainages from Georgia north to Virginia (Hedgpeth 1949, Holthius 1952, Hobbs and Massman 1952, Cooper 2011). The Ohio shrimp declined in abundance drastically after the 1930's (Page 1985) especially in the northern areas of its former range (Simon 2001). Less than 10 specimens have been reported from the Ohio River since 1977 (Taylor 1992, Conaway and Hrabik 1997). The species was formerly abundant in the Mississippi River as far north as Chester, Illinois (and possibly St. Louis, Missouri) and in the Ohio River as far upstream as southeastern Ohio (Poly and Wetzel 2002). Thoma and Jezerinac (2000) speculated that *M. ohione* may have been extirpated from Ohio due to migration obstruction by dams, levees and wing dikes. However, *M. ohione* remains abundant in the lower Mississippi River system of southern Louisiana (Truesdale and Mermilliod 1977) and apparently around Jackson, Mississippi (RT Bauer pers. comm.).

The Ohio shrimp has been collected in portions of the Mississippi River along Missouri and Illinois as far north as Grand Tower, Jackson County, Illinois (Taylor 1992, Conaway and Hrabik 1997) indicating that the species was increasing in numbers, was recolonizing portions of its former range, and/or was overlooked earlier because sampling methods were ineffective (Poly and Wetzel 2002).

In Arkansas, *M. ohione* has reportedly been taken from the Arkansas, Mississippi, and Red rivers (Bauer 2011a, fig. 3); however, documentation during this survey indicated occurrence only in the Mississippi River and we know of no recent specimens from any other stream in the state. One collection of 5 individuals was located in the Smithsonian Institution (USNM 153841) from the Mississippi River at Helena, Phillips County, collected in 1914 (Karen Reed, pers. comm.). This represents the only known occurrence from Phillips County (Fig. 1). The other 37 specimens were taken in August 1974 and July 1975 by the first author (HWR) while seining fish in the Mississippi River at various sites in Chicot County (Appendix, Fig. 1). Despite a search of additional regional and national museum collections, no additional specimens of *Macrobrachium* from Arkansas were located. Furthermore, there are only a few specimens of *M. ohione* reported from 3 counties of the Mississippi River of Missouri in the INHS (INHS 2010).

### Life History Aspects

All U.S. species of *Macrobrachium* have a life-

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history pattern that is amphidromous, that is, they spawn in saltwater (optimally 10-15% salinity) and must migrate upstream to complete their life cycles (McDowall 1992, Bauer 2011a,b). Ortmann (1902) hypothesized that the genus *Macrobrachium* had probably only “recently” evolved migratory behavior into freshwater. However, recent estimates suggest radiation of their ancestors into freshwater during the Jurassic (see Bauer 2011a). Biological characteristics indicative of this relatively recent adaptation include high hemolymph osmo-ionic concentrations, tolerance of high salinities, dependence on saline waters for larval development with many larval stages and migratory behavior (McNamara 1987).

The Ohio shrimp is the least colorful of the 6 species occurring in the U.S. The base color is pale gray to olivaceous with light blue spots and a blue telson and uropod (Hedgpeth 1949).

Ohio shrimp can reach a TL of over 100 mm, but average 60 mm TL (Hunter 1977, Taylor 1992). Males only reach about 70 mm TL (Hedgpeth 1949). The largest *M. ohione* found in our survey was a female measuring 68 mm TL. Females are larger than males with the former being as large as 110 mm TL, although ovigerous specimens as small as 35 mm TL are known (Bowles et al. 2000). To our knowledge, no ovigerous females have ever been collected in Arkansas.

### Parasites

Several parasites have been reported from *M. ohione*, including the branchial bopyrid isopod, *Probopyrus pandalicola* Packard from the Atchafalaya and Mississippi rivers, Louisiana (Truesdale and Mermilliod 1977, Conner and Bauer 2010). We did not examine Arkansas *M. ohione* for any parasites.

### Conservation Status

The Ohio shrimp has been collected sporadically and rarely over the past 40 years (Page 1985, Conaway and Hrabik 1997). Possible reasons for decline include overharvesting, river channelization, dredging, levee construction, water pollution, and habitat loss (Page 1985, Bowles et al. 2000). This shrimp must have a direct and/or unobstructed connection with estuarine areas (Bueno and Rodrigus 1995). In addition, larvae must be exposed to saline water in order to complete development (Bauer and Delahoussaye 2008, Rome et al. 2009).

The Nature Conservancy suggests that populations of the Ohio shrimp are apparently secure (G4) in rounded global status (NatureServe 2010) but there is no ranking for the species in Arkansas. Since a total of

only 42 specimens were documented by seining from a single drainage system (Mississippi River) in only 2 counties of the state, we recommend a “threatened” conservation status for *M. ohione* in Arkansas because of its restricted distributional range. An intensive search for this species along the eastern tier of counties adjacent to the Mississippi River using additional collecting methods (trawling and trapping) is urged in the future, including possible rediscovery of *M. ohione* in Phillips County.

### *Palaemonetes kadiakensis* Rathbun, 1902

#### Taxonomic Remarks

*Palaemonetes kadiakensis* is one of 3 members of the genus found in surface streams in the U.S. (Strenth 1976). Three additional species are known from subterranean waters of Florida and Texas. This shrimp can be differentiated from the Ohio shrimp by having the second pair of legs only slightly longer than the first pair, only 6-8 teeth occurring along the upper edge of the rostrum, and possessing a branchiostegal spine, without a hepatic spine.

#### Relative Abundance

The Mississippi grass shrimp is relatively abundant in Arkansas. A total of 3,415 specimens of *P. kadiakensis* were documented during this study, including 2,901 (85%) deposited in the ASUMZ, and most were released at their collection site.

The entire USNM dataset (31 specimens) comprised only 4 sites in 4 counties (Ashley, Stone, White, and Woodruff) of the state (Appendix). In addition to the USNM collections, INHS data yielded 14 collections (91 specimens) taken from 11 Arkansas counties by various collectors (Appendix).

#### Habitat

The Mississippi grass shrimp is common in the vegetation of lentic habitats and slower moving streams as well as in the sheltered areas of more rapidly flowing environs below the Fall Line zone in Arkansas (Bouchard and Robison 1980). It has also been found in a rapid flowing tributary of the Sabine River in Louisiana (Bouchard and Robison 1980). However, in Illinois, Page (1985) found that *P. kadiakensis* was common in sluggish freshwater habitats, including backwaters of the Mississippi River and in swamps and swamp-like streams. In addition, Simon and Thoma (2003) documented this shrimp in the Patoka River basin of Indiana in wetland ponds and stream areas adjacent to vernal ponds.

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Table 2. ASUMZ records of 2,901 specimens of *P. kadiakensis* from Arkansas.

County <sup>1</sup>	Locality	Date	Number	Collector	ASUMZ Acc. No.
<b>Arkansas<sup>1</sup></b>	Roadside ditch, St. Hwy. 79, 3.2 km S of Stuttgart	1 May 1978	1	B. Stephens	BS092478A-1
	Crooked Creek off US 79, 11.3 km SW of Pine Bluff	26 Jul. 1982	4	GR. Harp	HP072682-3
	Big Island Chute, White River NWR	18 Nov. 1989	24	S. Chordas	SC 111889-4
	E of Ethel, S entrance to White River NWR	18 Nov. 1989	2	S. Chordas	SC 111889B-5
	Little White Lake, White River NWR	18 Nov. 1989	1	S. Chordas	SC 111889C-4
	Lake Gut, White River NWR	16 Dec. 1989	1	S. Chordas	SC 121689-5
	Burnt Lake, White River NWR	17 Dec. 1989	1	S. Chordas	SC 121789-7
	Hurricane Pond, White River NWR	17 Dec. 1989	18	S. Chordas	SC 121789C-5
	Columbus Lake, White River NWR	20 Jan. 1990	7	S. Chordas	SC 012090-5
	Prairie Bayou, White River NWR	20 Jan. 1990	52	S. Chordas	SC 012090A-6
	H-Lake, White River NWR	20 Jan. 1990	5	S. Chordas	SC 012090B-6
	Prairie Lake, White River NWR	20 Jan. 1990	27	S. Chordas	SC 012090C-7
	Wolf Lake, White River NWR	20 Jan. 1990	16	S. Chordas	SC 012090D-4
	Wolf Bayou, White River NWR	17 Feb. 1990	2	S. Chordas	SC 021790-7
	Honey Locust Bayou, White River NWR	18 Feb. 1990	4	S. Chordas	SC 021890A-6
	Reservoir in SW 1/4, White River NWR	18 Feb. 1990	45	S. Chordas	SC 021890B-3
	H-Landing, White River NWR	22 Jul. 1990	2	S. Chordas	SC 072290A-1
	Wolf Bayou at flood gate, White River NWR	11 Aug. 1990	19	S. Chordas	SC 081190-8
	Beaver Pond No. 1, White River NWR	11 Aug. 1990	8	S. Chordas	SC 081190A-4
	Big Horseshoe Lake, White River NWR	29 Sept. 1990	3	S. Chordas	SC 092990-2
	Escrogens Lake, White River NWR	30 Sept. 1990	75	S. Chordas	SC 093090A-8
	Essex Bayou, White River NWR	30 Sept. 1990	42	S. Chordas	SC 093090-6
	<b>Ashley</b>	Lake Georgia Pacific, 19.3 km NW of Crossett	13 Nov. 1988	17	G. Harp
<b>Bradley</b>	Warren Prairie NA	4 Mar. 1995	1	R. Smith	RS030495-11
<b>Clark</b>	Hollywood Creek at bridge off St. Hwy. 26	20 Feb. 1997	4	C. Davidson	CD022097B-5
<b>Clay<sup>1</sup></b>	Current River, vic. St. Hwy. 211, 0.3 km S state line	18 Sept. 1976	5	P. Harp	PH091876A-3
	Lake Hubble, 3.2 km W, 1.6 km N of Peach Orchard	14 Jul. 1984	2	G. Harp	HP071484-1
	Sugar Creek off US 49S, Piggott	31 Aug. 1985	1	K. Cargill	KC083185A03
<b>Chicot</b>	Macon Bayou off US 82	12 Nov. 1988	20	G. Harp	HP111288B-2
<b>Cleveland</b>	Saline River at US 79, S of Rison	27 Jun. 1976	12	M. Johnson	MJ112776A-5
	Saline River, 1.6 km N, 4.8 km W of Rison	21 Aug. 1986	12	G. Harp	HP083186-4
<b>Columbia</b>	Lake Columbia, N side of bridge at boat ramp	25 Jan. 1991	2	J. Nichols	JN012591B-1
<b>Craighead<sup>1</sup></b>	Big Creek, US 63B, Jonesboro	21 Nov. 1976	2	P. Harp	PH112176-3
	6.6 km S of St. Hwy 1	9 Feb. 1981	1	A. Berry	AB020981-3
	3.2 km S Jonesboro off St. Hwy 1, field ditch	2 Mar. 1981	2	A. Price	AP030281D-2
	7.2 km S Jonesboro off St. Hwy. 1, field ditch	2 Mar. 1981	2	A. Price	AP030281C-2
	8.9 km E of Cash, roadside pothole	5 Apr. 1981	3	A. Berry	AB040581B-2
	Big Creek, 4.2 km W jct St. Hwy 141/US 63B	16 Apr. 1981	1	R. Smith	RS 041681-1
	1.6 km S Sedgewick, roadside ditch	5 Mar. 1981	5	A. Price	AP030581-5
	St. Francis River at Lake City	18 Apr. 1981	3	U. Moka	UM041881-5
	Cooper's Pond off Airport Road, Jonesboro	3 Jan. 1983	37	L. Lee	LL030183-3
	Stumpy Riverlake Oxbow, St. Francis SL	22 Aug. 1987	104	B. Cochran	BC 082287C-10
	Cane Donnick Chute, St. Francis SL	22 Aug. 1987	213	B. Cochran	BC 082287D-10
	Gum Island Sawmill, St. Francis SL	19 Sept. 1987	29	B. Cochran	BC 091987-4
	St. Francis River, Lake City Boat Ramp	19 Sept. 1987	27	B. Cochran	BC 091987B-6
	Fletcher Landing, St. Francis River, SFSL	19 Sept. 1987	15	B. Cochran	BC 091287C-6
	Jake Butler Landing, St. Francis SL	19 Sept. 1987	40	B. Cochran	BC 091987D-4
	Cockle-Burr Ditch, St. Francis SL	19 Sept. 1987	9	B. Cochran	BC 091987E-4
	Deep Landing, St. Francis SL	17 Oct. 1987	29	B. Cochran	BC 101787-3
	Lake City boat ramp, St. Francis River, SFSL	23 Mar. 1988	13	B. Cochran	BC032388A-8
	Turkey Island Slough, St. Francis SL	22 Jul. 1988	37	B. Cochran	BC072288C-3
	St. Francis SL, 4.8 km E Lake City bridge	5 Feb. 1993	2	B. Richards	BR 020593A-3
	St. Francis River, E of Lake City bridge	5 Feb. 1993	4	B. Richards	BR 020593-4
	Slough at intersection Washington Ave. and St. Hwy. 18	13 Feb. 1993	18	B. Richards	BR 021393-4
	Jonesboro, jct. Washington Ave. and St. Hwy. 349	15 Feb. 1993	9	J. May	JM 021593-2
	St. Francis River at Lake City	28 Jan. 1995	4	S. Bearden	SB012895-4
	1.0 km S Sedgewick, slough at US 63 bridge	2 Apr. 1995	4	B. Posey	BP040295A-3
	ASU Pavilion Pond, Jonesboro	2 Apr. 1999	1	L. Morris	LM040299-1
<b>Crittenden<sup>1</sup></b>	Borrow pit, Wapanocca NWR	24 May 1977	4	P. & G. Harp	PH052477A-7
	NW corner Woody Pond 2, Wapanocca NWR	11 Aug. 1977	6	P. & G. Harp	PH081177B-6
	Levee borrow pit, Wapanocca NWR	29 Oct. 1977	3	P. & G. Harp	PH102977A-5
	NW corner Woody Pond 1, Wapanocca NWR	28 Jul. 1978	4	P. & G. Harp	PH072878-3
	Unnamed slough, 8.0 km E of Marion	22 Oct. 1978	2	R. McDaniel	MC102278-1
	Wapanocca Lake NWR, observation platform	25 Mar. 1993	5	B. Richards	BR 032593A-3

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Table 2. *continued.* ASUMZ records of 2,901 specimens of *P. kadiakensis* from Arkansas.

<b>Cross</b>	4.0 km S Cherry Valley, roadside ditch off St. Hwy. 1	1 Mar. 1981	1	A. Berry	AB030181-2	
	NE corner of Village Creek SP	19 Mar. 1983	4	J. Reid	JR031983A-4	
<b>Desha<sup>1</sup></b>	0.2 km S of Fair Oaks off US 49	10 Jan. 1987	2	M. Marks	MM011687-1	
	Slough at picnic area off US 65, McGehee	12 Nov. 1988	1	G. Harp	HP111288A-1	
	Scrubgrass Bayou No. 1, White River NW	21 Apr. 1990	2	S. Chordas	SC 042190-6	
	Scrubgrass Bayou No. 2, White River NWR	21 Apr. 1990	5	S. Chordas	SC 042190A-3	
<b>Drew</b>	East Moon Lake, White River NWR	22 Apr. 1990	8	S. Chordas	SC 042290A-4	
	Lake on UA-Monticello campus	11 May 1978	6	R. McDaniel	MC051178-2	
	Seven Devils Swamp, E side, 4.8 km N of Collins	14 Apr. 1983	6	G. Harp	HP061483-2	
<b>Faulkner</b>	Seven Devils Swamp, W of dam, 2.6 km NW of Collins	14 Apr. 1983	2	G. Harp	HP061483A-2	
	Saline River, Ozment Bluff Access, 2.4 km W St. Hwy. 8	14 Sept. 1993	1	B. Richards	BR 0901493E-1	
	East Fork Cadron Creek	7 Feb. 1981	1	J. Farris	JF020781-3	
	Caney Creek, Conway	7 Feb. 1981	6	J. Farris	JF020781A-3	
<b>Greene<sup>1</sup></b>	Lake at Crowley's Ridge State Park	14 Jun. 1976	8	P. Harp	PH061476	
	St. Francis River bridge at AR/MO state line	21 Apr. 1981	9	J. Dunivan	JD041281-2	
	St. Hwy 69, roadside ditch along dirt road	20 Feb. 1983	4	L. Lee	LL022083-4	
	Blue Hole Oxbow, SFSL	22 Aug. 1987	74	B. Cochran	BC 082287A-6	
	Blue Hole exit, SFSL	22 Aug. 1987	27	B. Cochran	BC 082287B-9	
	Lake Walcott, SE & E shoreline	10 Feb. 1991	1	P. Rust	PR 021091-1	
	Lake Frierson overflow	23 Apr. 1993	1	J. May	JM 042393-1	
<b>Independence</b>	Salado Creek at St. Hwy. 14 bridge	23 Feb. 1981	12	A. Carter	AC022381C-2	
	Caney Creek at US 167, S of Batesville	7 Mar. 1987	2	G. & P. Harp	WN030787-2	
<b>Jackson</b>	Village Creek S of Alicia	9 Oct. 1976	9	T. Burnham	TB100976B-3	
	Village Creek off US 67, vic. Tuckerman	9 Oct. 1976	7	T. Burnham	TB100976C-2	
	Village Creek at St. Hwy 14	9 Oct. 1976	315	M. Johnson	MJ 100976D-3	
	Sewage lagoon, off St. Hwy. 18 in Grubbs	3 Jun. 1978	2	B. Stephens	BS110378A-1	
	Swifton, 0.2 km E US 67	30 Jan. 1983	1	J. Reid	JR013083A-4	
	4.8 km W Tuckerman off St. Hwy. 226, Hout Ditch	27 Feb. 1983	4	J. Reid	JR022783-4	
	1.6 km S St. Hwy. 226, ditch	7 Mar. 1983	10	J. Reid	JR030783-3	
	Cache River at St. Hwy. 14	22 Apr. 1989	3	S. Sifford	SS042289-1	
	New Home Community, 7.2 km NW of Swifton	31 Jan. 1991	2	A. Holt	AH013191-2	
	4.8 km NW Swifton off New Home Road	2 Feb. 1991	3	A. Holt	AH020291-4	
	Tupelo Brake, 4.0 km N int. St. Hwy. 18/384	10 Mar. 1993	10	B. Richards	BR 031093-2	
<b>Jefferson</b>	Cache River at St. Hwy. 18, E of Grubbs	7 Mar. 1993	8	J. May	JM 030793-4	
	Black Roll Creek, vic. Swifton	10 Apr. 1995	2	R. Smith	RS041095A-1	
	Bayou Bartholomew at US 79, S of Pine Bluff	27 Jun. 1976	25	M. Johnson	MJ112776B-1	
	Borrow Pits N & S of US 79, jct. St. Hwy. 88	26 Jul. 1982	2	GR. Harp	HP072682A-3	
	Village Creek, 1.6 km S Alicia off section road	23 Mar. 1974	28	G. Harp	GH-32374B-4	
	Village Creek at St. Hwy. 37 bridge, Guffey Lake	23 Mar. 1974	18	G. Harp	GH032374C-4	
	Village Creek at St. Hwy. 14 bridge	23 Mar. 1974	2	G. Harp	GH032374D-2	
	Village Creek at Minturn	9 Oct. 1976	1	S. Bounds	SB100976-7	
	Village Creek off St. Hwy. 37, E of Tuckerman	9 Oct. 1976	1	S. Bounds	SB100976C-1	
	Portia Bay at US 63	19 Nov. 1976	2	S. Bounds	SB111976-4	
<b>Lawrence<sup>1</sup></b>	Hill Slough, Raney Brake WMA	3 Apr. 1981	2	U. Moka	UM040381-2	
	Black River, Big Eddy, 9.7 km E of Lynn	3 Apr. 1981	3	J. Ferris	JF040381B-1	
	Horseshoe Lake, Raney Brake WMA, SE of Lynn	3 Apr. 1981	2	J. Ferris	JF040381C-3	
	Red Barn Creek, Raney Brake WMA	3 Apr. 1981	1	R. Smith	RS04031A-3	
	Dry Creek, 2.4 km SE of Lynn, Raney Brake WMA	3 Apr. 1981	2	A. Price	AP040381-b	
	Coon Creek at St. Hwy. 25, 1.1 km W of Walnut Ridge	26 Mar. 1983	31	G. Harp	HP032683D-2	
	Strawberry River, 0.5 km N St. Hwy. 115	16 Jan. 1987	1	M. Marks	MM011687A-1	
	Lake Charles at St. Hwy. 25	24 Jan. 1993	11	B. Richards	BR 012493B-2	
	Slough at Shirley Bay Raney Brake WMA	20 Feb. 1993	6	J. May	JM 022093B-5	
	Black River at St. Hwy. 25, Powhatan Landing	4 Feb. 1995	1	S. Bearden	SB020495-2	
	Ditch N of Sedgwick off US 63	20 Feb. 1997	6	M. Barfield	MB022097A-1	
	Borrow pits near L' Anguille River at St. Hwy. 1	25 Mar. 1989	14	M. Harvill	MH032589A-5	
	Bayou off US 79, 8.0 km W of Moro	18 Mar. 1995	1	S. Bearden	SB031895-6	
	<b>Lincoln</b>	Arkansas River backwater, Lock & Dam 3, USACE	1 Sept. 1986	34	G. Harp	HP090186-5
		Long Lake at St. Hwy. 11, 12.9 km N of Grady	1 Sept. 1986	3	G. Harp	HP090186A-2
<b>Logan</b>	Blue Mountain Lake, Hise Hill Use Area	2 Sept. 1984	8	G. Harp	HP090284-2	
	Petit Jean River at St. Hwy. 23, 1.6 km S of Booneville	2 Sept. 1984	2	G. Harp	HP090284A-2	
<b>Lonoke</b>	White Oak Branch (Sec. 26, T4N, R10W)	8 Feb. 1981	8	J. Farris	JF020881A-2	
	Magness Creek off St. Hwy. 319, W edge of Ward	13 Aug. 1983	6	G. Harp	HP081383-2	
	Prairie Creek at St. Hwy. 5	3 Mar. 1989	1	B. Justis	BJ030389-3	
<b>Mississippi</b>	Mississippi River channel at island, vic. Luxora	14 May 1977	2	N. Childers	NC051477-1	
	Big Lake, Big Lake WMA	2 Sept. 1978	7	J. Rettig	JR090278-1	
	Butterfly Hole, Mississippi River levee, 3.2 km N of Tomato	27 Jan. 1981	2	A. Carter	AC012781A-4	
	Lee's Pond, Mississippi River levee, 0.4 km E of Tomato	27 Jan. 1981	8	A. Carter	AC012781B-1	
	Big Lake WMA, below bridge off St. Hwy. 18	5 Feb. 1993	7	B. Richards	BR 020593B-5	

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Table 2. *continued* ASUMZ records of 2,901 specimens of *P. kadiakensis* from Arkansas.

<b>Monroe</b> <sup>1</sup>	Waters Bayou at White River NWR	13 Oct. 1989	1	S. Chordas	SC 101389-2	
	Swan Lake, White River NWR	14 Oct. 1989	21	S. Chordas	SC 101489-2	
	Buck Lake, White River NWR	14 Oct. 1989	25	S. Chordas	SC 101489A-1	
	Little Moon Lake, White River NWR	14 Oct. 1989	4	S. Chordas	SC 101489B-4	
	Indian Bayou at St. Hwy. 1 bridge, White River NWR	14 Oct. 1989	15	S. Chordas	SC 101489C-4	
<b>Nevada</b>	Indian Bay boat ramp, White River NWR	18 Nov. 1989	2	S. Chordas	SC 111889A-1	
	St. Hwy. 24 and Caney Creek	25 Feb. 1995	6	P. Daniel	PD022595E-2	
	Freeo Creek at St. Hwy. 7	25 Jun. 1976	4	M. Johnson	MJ112576B-3	
<b>Ouachita</b>	Berg Lake, N side St. Hwy. 4B, W edge of Camden	27 Jul. 1982	2	GR. Harp	HP072782A-2	
	Tates Bluff bridge, Ouachita River, off St. Hwy. 24	24 Feb. 1995	3	P. Daniel	PD022495B-4	
<b>Phillips</b> <sup>1</sup>	Storm Creek Lake overflow	2 Apr. 1993	2	B. Richards	BR 040293-3	
	Storm Creek, below Storm Creek Lake	2 Apr. 1993	1	J. May	JM 040293A-5	
	Borrow Pit at refuge levee mile 36, White River NWR	22 Apr. 1990	6	S. Chordas	SC 042290B-5	
<b>Poinsett</b> <sup>1</sup>	Borrow Pit No. 2, White River NWR	15 Sept. 1990	1	S. Chordas	SC091590A-5	
	St. Francis River at ditch 23, 2.4 km E of Trumann	16 Jan. 1981	2	U. Moka	UM 011681-6	
	Greenfield, off St. Hwy. 1, roadside ditch	20 Feb. 1983	17	L. Lee	LL022083B-3	
	County Line Public Access, St. Francis River, SFSL	17 Oct. 1987	251	B. Cochran	BC 101787A-11a	
	Steven's Landing, St. Francis River, SFSL	10 Oct. 1987	42	B. Cochran	BC 101787B-20	
	Snoden's Field Bridge, St. Francis River, SFSL	10 Oct. 1987	123	B. Cochran	BC 101787C-13	
	Oak Donnick Gage, St. Francis River, SFSL	21 Oct. 1987	20	B. Cochran	BC112187-6	
	Railroad trestle at jct. 2 main channels, SFSL	21 Nov. 1987	4	B. Cochran	BC112187A-2	
	Ditch 61, SFSL	21 Nov. 1987	8	B. Cochran	BC112187B-2	
	Siphon Access, St. Francis River, SFSL	21 Nov. 1987	2	B. Cochran	BC112187C-2	
	E end Ditch 10, SFSL	21 Nov. 1987	97	B. Cochran	BC112187D-4	
	Main channel St. Francis River, E of Steven's Landing	23 Dec. 1987	5	B. Cochran	BC1222387-5	
	St. Francis Lake, SFSL	23 Dec. 1987	12	B. Cochran	BC122387B-8	
	Temporary stream, W of Snoden's Bridge, SFSL	26 Apr. 1988	3	B. Cochran	BC042688A-12	
	Old River bank, St. Francis River, SFSL	20 Jun. 1988	17	B. Cochran	BC062088-10	
	Oxbow, SFSL	20 Jun. 1988	2	B. Cochran	BC062099A-10	
	Oak Donnick Chute, SFSL	22 Jun. 1988	11	B. Cochran	BC062288B-6	
	Levee Milepost #50/51, SFSL	18 Jul. 1988	16	B. Cochran	BC071888-5	
	Landing Strip N, SFSL	22 Jul. 1988	138	B. Cochran	BC072288A-10	
	Pumping station, St. Francis River, SFSL	22 Jul. 1988	2	B. Cochran	BC072288B-1	
	S shore of Lake Poinsett near boat ramp	20 Jan. 1991	2	P. Rust	PR012091-3	
	Lake Poinsett overflow pool, below dam	21 Jan. 1993	2	B. Richards	BR 013193B-2	
	0.8 km W Wiener, rice field pond	27 Feb. 1995	2	P. Daniel	PD022795A-2	
	<b>Prairie</b>	Cache River, 8.0 km S of Little Dixie	30 Aug. 1993	2	B. Richards	BR 083093C-1
		Faulkner Lake, 1.6 km E of Prothro Jct	23 Apr. 1981	1	A. Carter	AC042381-5
		Pinnacle Mountain SP	11 Feb. 1995	1	S. Clem	SC021195-2
	<b>Pulaski</b>	Bringle Creek downstream of St. Hwy. 10 bridge	30 Jan. 1997	2	C. Davidson	CD013097A-3
Little Ditch off US 67, between Pocahontas/Fourche Creek		28 Feb. 1976	2	S. Bounds	SB022876-2	
Fourche River at US 67		17 Sept. 1976	8	M. Johnson	MJ091776-3	
Mill Creek, Pocahontas		5 Jun. 1977	1	N. Childers	NC110577B-3	
1804 Decker Street, pond		3 Mar. 1981	7	A. Price	AP030381-3	
Village Creek near St. Hwy. 90 bridge		6 May 1988	29	R. Looney	RL100688-1	
Fourche River, near St. Hwy. 328 bridge		27 Jan. 1991	5	P. Rust	PR012791-3	
Fourche Creek at St. Hwy. 115 bridge		27 Mar. 1993	5	B. Richards	BR 0327980-3	
Black River at Old Davidsonville SP		8 Feb. 1999	2	D. Feldman	DF020899-1	
Saline River off US 67, Benton		24 Sept. 1978	6	K. Paige	KP092478-4	
<b>Saline</b>	Borrow pits near Saline River off I-30	24 Sept. 1978	10	L. Dorman	LD092478-2	
	Martin Creek off St. Hwy. 63	11 Mar. 1983	1	L. Lee	LL031183B-4	
<b>Sharp</b>	County road bridge, 1.6 km S end St. Hwy. 261	2 Apr. 1993	2	B. Richards	BR 053093C-1	
	Sandy Creek bridge between St. Hwys. 160 & 172	25 Mar. 1995	7	P. Daniel	PD032595C-5	
<b>St. Francis</b>	Little Mingo Creek at US 64, 4.8 km E of Bald Knob	12 Apr. 1983	4	A. Price	AP041283A-3	
	Big Creek near Letona	14 Feb. 1987	16	P. McLarty	PM021487-4	
	Unknown stream entering Little Lake, N of Russell	12 Mar. 1993	6	B. Richards	BR 031293-4	
	Mile marker 62, off US 67	12 Mar. 1993	6	J. May	JM 031393-4	
	Hurricane Lake WMA	29 Feb. 1997	1	R. Mitchell	RM022997-1	
<b>Union</b>	Black Swamp, Cache River	30 Sept. 1978	6	L. Dorman	LD093078-3	
	Cache River, Black Swamp area	30 Sept. 1988	16	R. Meurer	RM093078-5	
<b>White</b>	Petit Jean River at St. Hwy. 10, Danville	1 Sept. 1984	4	G. Harp	HP090184A-01	

<sup>1</sup>Records for these counties previously published (Harp and Harp 1980, Cargill and Harp 1987, Cochran and Harp 1990, Chordas et al. 1996, Harp and Robison 2006.)



## Geographic Distribution and Life History Aspects of the Freshwater Shrimps, *Macrobranchium ohione* and *Palaemonetes kadiakensis* (Decapoda: Palaemonidae), in Arkansas

Creaser (1932) reported high abundance of *P. kadiakensis* in pools with low fish abundance. Grass shrimp like high visibility and low water velocity (Barko and Hrabik 2004). In large rivers *P. kadiakensis* can be found associated with low velocity waters (Hobbs and Jass 1988). In an Oklahoma study, Pigg and Cheper (1998) found *P. kadiakensis* inhabiting large rivers, large turbid impoundments, and small turbid ponds filled with aquatic vegetation in the flood plains of large rivers or new pools and bar ditches filled by recent floodwaters.

In the present study, grass shrimp were commonly found in sluggish backwater regions of Coastal Plain streams especially in heavily vegetated lentic areas of pool regions. They appear to have an association with American lotus (*Nelumbo lutea*), swamp smartweed (*Polygonum hydropiperoides* var. *opelosanum*), water milfoil (*Myriophyllum* sp.) and marsh mermaidweed (*Proserpinacea palustris*), abundant aquatic plants of lowland streams. Page (1985) also found *P. kadiakensis* almost always associated with living aquatic vegetation. Occasionally, they were found in backwater reaches of larger rivers of the state, but generally occurred in smaller stream systems.

### Distribution

*Palaemonetes kadiakensis* is commonly found below the Fall Line zone in the Gulf Coastal Plain (GCP) physiographic province of Arkansas, but ascends the Arkansas River Valley continuing west along the Arkansas River into eastern Oklahoma to LeFlore and Sequoyah counties and beyond (Cheper 1988, Pigg and Cheper 1998). By far, the 2,901 specimens of *P. kadiakensis* from the 193 individual collection sites of 39 counties housed in the ASUMZ (Table 2) added many new localities to the overall geographic distribution of *P. kadiakensis* in the state (Fig. 2).

During our study, 45 new collections of the Mississippi grass shrimp were documented (see Appendix). Of the total Mississippi shrimp collections, *P. kadiakensis* was found at 238 localities (Table 2; Appendix) in 49 of 75 counties (65% of Arkansas counties). While numerous new localities for *P. kadiakensis* were documented, most were located where they might be expected in the GCP of Arkansas; however, this shrimp was noticeably absent in most counties of the Ouachita and Ozark plateaus (Fig. 2).

Interestingly, a collection in 1972 of 15 specimens (USNM 237816) was made by an individual signified only by "jH" in North Sylamore Creek near Fifty-six, Stone County, Arkansas. This represents the farthest

range penetration of *P. kadiakensis* into the Interior Highlands (Ozark Mountains) within the state (Fig. 2). The farthest upstream collections in the Arkansas Valley physiographic province are in Crawford and Sebastian counties (Fig. 2; Appendix).

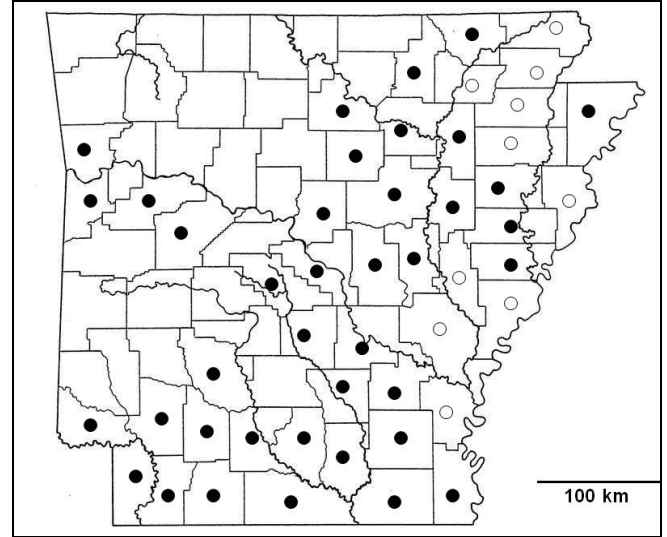


Figure 2. Arkansas counties with genuine vouchers of *P. kadiakensis*. Open circles (10 previous records); closed circles (39 new county records).

### Life History Aspects

Life history of *P. kadiakensis* has been studied in Louisiana by Meehan (1936), in Missouri by Nielsen and Reynolds (1977) and in Wisconsin by Hobbs and Jass (1988). These studies indicated that shrimp reproduction occurs from May through August with a peak in mid-June. In Illinois, reproduction occurs from April-August. In Louisiana, reproductive period extends from February-October (Meehan 1936, White 1949), while in Missouri it is from May-August (Nielsen and Reynolds 1977). In Arkansas, our studies indicate reproduction occurs from April through July. The post-reproductive individuals die, and the larvae grow rapidly, obtaining 50% of their ultimate length in the first 3 months of life (Nielsen and Reynolds 1977). Mississippi grass shrimp populations in Arkansas seem to be made up of individuals that hatch in the summer, grow during the autumn months, survive the winter, and then reproduce and die in the late spring to early fall, thus having only a 1-yr life cycle, similar to that reported by Cheper (1992) in Oklahoma.

Living specimens are transparent with green eyes, red brown antennae, and many very small red-brown specks on the body. Often, a bright green vegetation-filled intestine is apparent (Page 1985).

Mississippi grass shrimp are reported to reach a TL of 53 mm in Louisiana (Meehan 1936), whereas Cheper (1988) reported a 46 mm TL specimen from Oklahoma. In our study, the smallest specimen was 13 mm TL and the largest 32 mm TL. Females were generally slightly larger than males while gravid females were much larger. Sex ratio of *P. kadiakensis* collected in our survey was 1♂:1.9♀. Oviparous females were collected in April through July and eggs (embryos) on 12 females ranged from 38-141 (mean = 67.7). Also see Anderson (1985) for additional reproductive information.

### Parasites

Unfortunately, we did not survey Arkansas *P. kadiakensis* for parasites. However, the digene *Alloglossidium renale* Font and Corkum has been reported from the antennary gland of *P. kadiakensis* from the Mississippi River of Louisiana (Carney and Brooks 1991) and Pike County, Alabama (Landers and Jones 2009). In addition, a ciliophoran (*Lagenophrys verecunda*) was described from the gill lamellae of *P. kadiakensis* from Lake Jackson, Florida (Felgenhauer 1982) and aquatic fungi (*Saprolegnia parasitica* and *Achlya flagellata*) infected laboratory-reared larval *P. kadiakensis* (Hubschman and Schmidt 1969).

### Conservation Status

Page (1985) attributed the reduction in distribution and abundance of *P. kadiakensis* in Illinois to increased turbidity and sedimentation and the resultant loss of vegetation. In Arkansas, however, Mississippi grass shrimp have remained abundant and widespread in occurrence for the past 35 years. The Nature Conservancy lists populations of *P. kadiakensis* as secure (G5) in rounded global status. Indeed, Mississippi grass shrimp populations in Arkansas appear secure and in no need of special protection.

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**APPENDIX.** Locations of 514 specimens of *Palaemonetes kadiakensis* collected in Arkansas during this survey (locality [township, section and range or latitude/longitude in decimal degrees when available, as estimated from collection locations], date of collection, collector [all by HWR unless otherwise noted], museum collection, and number of specimens in parentheses, if known).

#### ARKANSAS (514 specimens)

##### ASHLEY COUNTY (12 specimens)

1. Hank's Creek, 0.6 km W of jct. of US 82 & St. Hwy. 52 on St. Hwy. 52. 1 May 1992. B. Burr. USNM 260374 (3).
2. Thompson Creek, 11.3 km NW of Crossett (Sec. 11, T18S, R9W). 23 Sept. 1994. SAU (9).

##### BRADLEY COUNTY (50 specimens)

1. Moro Creek at Moro Bay State Park (Sec. 21, T16S, R12W). 17 Oct. 1998. SAU (17).

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2. Snake Creek at Broad (Sec. 30, T16S, R9W). 17 Jun. 2002. SAU (5).
  3. L'Aigle Creek at co. rd., 14.5 km S of Hermitage (Sec. 18, T16S, R10W). 10 Jul. 2005. SAU (28).
- COLUMBIA COUNTY** (80 specimens)
1. Dorcheat Bayou at co. rd., 4.8 km SW of Philadelphia (Sec. 16, T18S, R22W). 4 Sept. 1993. SAU (23).
  2. Big Creek at St. Hwy. 98, 6.4 km S of Village (Sec. 3, T18S, R19W). 5 Nov. 1993. SAU (13).
  3. Sloan Creek at St. Hwy. 57 (Sec. 11, T16S, R19W). 5 Nov. 1993. SAU (29).
  4. Horsehead Creek at US 19, 12.9 km SW of Magnolia (Sec. 32, T18S, R21W). 21 Nov. 2001. SAU (4).
  5. Dorcheat Bayou at St. Hwy. 160, 6.4 km E of Taylor (Sec. 9, T19S, R22W). 19 May 2004. SAU (11).
- CALHOUN COUNTY** (6 specimens)
1. 1.0 km W of Locust Bayou. 8 Apr. 1982. L. Page, M. Retzer, R. Mayden, & D. Swofford. INHS 51 (6).
- CHICOT COUNTY** (3 specimens)
1. Crooked Bayou at St. Hwy. 82 (Sec. 22, T17S, R3W). 10 Sept. 1976. SAU (3)
- CLARK COUNTY** (14 specimens)
1. Tupelo Creek at St. Hwy. 7 bridge (Sec. 35, T7S, R19W). 20 Oct. 1978. SAU (14).
- CLEBURNE COUNTY** (6 specimens)
1. Tributary of Little River, 9.0 km W of Hiram on Cooter Neck Rd. (35.47417°N, 91.96686°W). 29 Oct. 2008. B. Wagner & S. Sanders. INHS 11089 (6).
- CLEVELAND COUNTY** (2 specimens)
1. Panther Creek at US 79, 1.6 km NE of Kingsland (Sec. 6, T10S, R11W). 13 Oct. 1977. SAU (2).
- CRAWFORD COUNTY** (7 specimens)
1. Crooked Slough, 2.6 km SE of Dyer (35.47335°N, 94.11531°W). 5 Dec. 2007. B. Wagner & S. Sanders. INHS 11028 (7).
- DREW COUNTY** (20 specimens)
1. Bayou Bartholomew, 3.2 km W of Winchester at St. Hwy. 138. 8 Apr. 1988. B. Burr & D. Fletcher. INHS 8499 (8).
  2. Cut-Off Creek at St. Hwy. 35, 1.1 km E of Collins (Sec. 31, T13S, R4W). 13 Apr. 1993. SAU (12).
- GRANT COUNTY** (6 specimens)
1. Cane Creek, 16.9 km NNE of Sheridan on co. rd. 58 (34.4458°N, 92.3205°W). 21 Sept. 2001. B. Wagner & M. Miller. INHS 9266 (6).
- HEMPSTEAD COUNTY** (30 specimens)
1. Bois d'Arc Creek, 3.2 km SW of jct. St. Hwys. 73/195 (Sec. 13, T12S, R26W). 26 Nov. 1995. SAU (30).
- INDEPENDENCE COUNTY** (12 specimens)
1. Mud Creek S of Newark at Neark Energy Plant (35.68015°N, 91.42883°W). 29 Nov. 2006. B. Wagner & M. Kottmyer. INHS 10795 (12).
- JEFFERSON COUNTY** (24 specimens)
1. Drainage from Yellow Lake at Pine Bluff Arsenal (Sec. 35, T4S, R10W). 9 Oct. 1999. SAU (24).
- LAFAYETTE COUNTY** (69 specimens)
1. Bayou Bodcau, 1.6 km N of Lewisville (Sec. 7, T15S, R23W). 5 Jul. 1992. SAU (18).
  2. Bayou Bodcau off US 82 (Sec. 7, T16S, R23W). 11 Oct. 1995. SAU (31).
  3. Bayou Dorcheat, 1.3 km E of Buckner off US 82 bridge (35.35907°N, 93.41778°W). 25 Oct. 1993. J. Rader. INHS 10999 (20).
- LINCOLN COUNTY** (6 specimens)
1. Bayou Bartholomew at St. Hwy. 293, 12.9 km E of Star City (Sec. 15, T9S, R6W). 7 Nov. 1974. SAU (6).
- LITTLE RIVER COUNTY** (14 specimens)
1. Cypress Creek at St. Hwy. 234 in Winthrop (Sec. 7, T11S, R31W). 6 Jun. 1989. SAU (5).
  2. Little River backwater at US 71, 3.2 km N of Wilton (Sec. 24, T11S, R29W). 5 Oct. 2001. SAU (9).
- MILLER COUNTY** (15 specimens)
1. Roadside ditch at Boggy Creek off US 71, 3.2 km S of Fouke (Sec. 33, T17S, R27W). 23 Sept. 1976. SAU (15).
- NEVADA COUNTY** (47 specimens)
1. Terre Rouge Creek, 11.3 km SE of Prescott on St. Hwy. 24 (Sec. 3, T12S, R22W). 20 Oct. 1983. SAU (22).
  2. Middle Creek, 14.5 km N of Prescott on St. Hwy. 19 (Sec. 27, T9S, R23W). 21 Oct. 1983. SAU (9).
  3. Caney Creek, 4.8 km N of Bluff City on St. Hwy. 24 (Sec. 22, T11S, R20W). 21 Oct. 1983. SAU (16).

**OUACHITA COUNTY** (7 specimens)

1. Flooded roadside ditch, 1.7 km N of Amy (Sec. 35, T11S, R17W). 9 Oct. 1978. SAU (7).

**PULASKI COUNTY** (2 specimens)

1. Fourche Creek, 3.2 km W of Mabelvale (34.6561°N, 91.4234°W). 18 Oct. 2002. B. Wagner et al. INHS 9287 (2).

**SALINE COUNTY** (5 specimens)

1. Otter Creek, 6.0 km WSW of Mabelvale on Alexander Rd. (34.6408°N, 92.4122°W). 18 Oct. 2002. B. Wagner & F. Leone. INHS 10931 (4).
2. Lorange Creek, 4.8 km. WSW of Iron Springs on Chicot Rd. (34.5805°N, 92.3666°W). 23 Oct. 2003. B. Wagner. INHS 9362 (1).

**SEBASTIAN COUNTY** (4 specimens)

1. 11.3 km N Greenwood, tributary of Grayson Creek (35.31623°N, 94.27109°W). 28 Nov. 2007. B. Wagner & F. Leone. INHS 10931 (4).

**STONE COUNTY** (15 specimens)

1. North Sylamore Creek at Fifty-six. 6 Sept. 1972. "Jh." USNM 237816 (15).

**UNION COUNTY** (35 specimens)

1. Smackover Creek at co. rd. 68, 3.2 km N of Norphlet (Sec. 3, T16S, R15W). 20 Sept. 1992. SAU (9).
2. Grand Marais Lake at Felsenthal (Sec. 16, T19S, R10W). 18 Sept. 1996. SAU (12).
3. Ouachita River backwater at US 167 (Sec. 10, T16S, R14W). 26 May 1997. SAU (14).

**WHITE COUNTY** (15 specimens)

1. Tributary of Overflow Creek, 2.3 km SE of Bald Knob (35.29253°N, 91.55329°W). 1 Oct. 2008. B. Wagner & S. Sanders. INHS 11076 (6).
2. Little Mingo Creek, 6.0 km ESE of Bald Knob at US 64 bridge (35.29654°N, 91.50343°W). 21 Oct. 2008. B. Wagner & S. Sanders. INHS 11091 (4).
3. Pumpkin Branch, 13.4 km NW of Bald Knob off St. Hwy. 157 (35.39145°N, 91.67546°W). 18 Nov. 2008. B. Wagner. INHS 11082 (5).

**WOODRUFF COUNTY** (8 specimens)

1. Fair Oaks off US 64, 3.2 km W of St. Hwy. 39. 14 Apr. 1973. H. H. Hobbs, Jr. USNM 149827 (8).
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