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Distribution, Habitat, and Life History Aspects of the Dwarf Crayfishes of the Genus *Cambarellus* (Decapoda: Cambaridae) in Arkansas

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Cover Page Footnote

HWR especially wants to thank his former SAU students who assisted with field collections (1972 to 2008) of crayfishes including Ken Ball, Nick Covington, Daryl Koym, Christa Marsh, and Jan Rader. We thank Dr. Guenter Schuster (Richmond, KY) for Fig. 2. The Arkansas Game and Fish Commission issued Scientific Collecting Permits to the authors.

Distribution, Habitat, and Life History Aspects of the Dwarf Crayfishes of the Genus *Cambarellus* (Decapoda: Cambaridae) in Arkansas

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Running Title: *Cambarellus* Crayfishes of Arkansas

Abstract

The dwarf crayfishes of the genus *Cambarellus* are represented in Arkansas by only 2 species: *Cambarellus* (*Pandicambarus*) *puer* (Hobbs) and *C. (P.) shufeldtii* (Faxon). Both species are quite small and uncommonly encountered in the state. Between 1972 and 2018, we made 368 crayfish collections throughout the 75 counties of Arkansas. A total of 34 collections (our collections, plus museum specimens), and those previously collected by Reimer (1963) yielded a total of 304 specimens of *C. puer* and 12 collections of *C. shufeldtii* returned 54 specimens of *C. shufeldtii*. Herein, we document these 2 dwarf crayfishes from primarily the Coastal Plain and Mississippi Alluvial Plain physiographic provinces of Arkansas. *Cambarellus puer* is documented from 24 counties whereas *C. shufeldtii* was recorded from only 12 counties. With regard to conservation status, both *C. puer* and *C. shufeldtii* should be considered as “Currently Stable” due to their widespread distribution and general abundance in Arkansas.

Introduction

Freshwater crayfishes of the families Astacidae, Cambaridae, and Parastacidae are native to every continent except Antarctica and Africa (Hobbs 1988). Cambarid crayfishes reach their greatest diversity in North America north of Mexico totaling 374 species with new species described each year (Taylor *et al.* 2007; Crandall and Buhay 2008). Crayfishes inhabit a variety of aquatic habitats including streams, rivers, lakes, reservoirs, swamps, roadside ditches, wet pastures, and fields (Bouchard 1978; Morehouse and Tobler 2013). Here, they function as important components of aquatic ecosystems (Huryn and Wallace 1987; Momot 1995; Usio and Townsend 2004).

The genus *Cambarellus* contains the smallest crayfishes found in Arkansas as fully adult individuals

reach only 3.7 cm (1.5 in.). In Arkansas, 2 species of dwarf crayfishes of the genus *Cambarellus* occur, namely the Swamp Dwarf Crayfish, *C. (Pandicambarus) puer* (Hobbs) and the Cajun Dwarf Crayfish, *C. (P.) shufeldtii* (Faxon). The precise distribution of these 2 diminutive species in Arkansas is poorly known, and neither has had much published concerning their natural history and ecology, including reproductive biology, habitat characteristics, or general biology. This study was initiated to learn more about these species and to discern their geographical distribution in the state and aspects of their natural history and ecology.

Specific objectives of our study were to: (1) determine the relative abundance and precise distributional limits of the range of *C. puer* and *C. shufeldtii* in Arkansas, (2) gather data on life history aspects of both species, including information on habitat, reproductive period, and any other biological data available, (3) document data on their ecological and habitat characteristics, and (4) assess the current conservation status of each species based on the previously collected distribution data in the state.

Materials and Methods

Field work was conducted between 1972 and 2018 with a total of 368 collections made in all 75 counties in Arkansas. The bulk of the field work occurred during the fall, spring, and summer, which are prime collecting periods. A combination of aquatic dipnets, seines, and baited crayfish traps were employed to collect crayfishes, *C. puer* and *C. shufeldtii*. While most individual crayfish were released unharmed at the collecting site, voucher specimens of each *Cambarellus* species were preserved in 60% isopropanol or ethanol for later analysis. Total length (including chelae) was taken of all specimens in mm. The number of specimens in the Appendices represents the number of specimens preserved (historical data) or the total number collected

at an individual site. Preserved vouchers were originally deposited in the Southern Arkansas University (SAU) Invertebrate Collection, the Illinois Natural History Survey (INHS) Crayfish Collection (INHS 2019), and the Smithsonian Institution (SI) Crayfish Collection. In addition to collections made during this survey, museum specimens housed at the United States National Museum of Natural History (USNM) (USNM 2019), INHS, and SAU were used to document the historic distribution of the 2 *Cambarellus* species in Arkansas. Published literature dealing with these crayfish species was also consulted. Both our survey and historical collection locations were converted to Section, Township, and Range (Sec, T, R) for mapping when known precisely.

Results and Discussion

Our survey produced 304 specimens of *C. puer* documented from Arkansas from 24 counties (Fig. 1, Appendix I). These include 162 specimens of *C. puer* taken in our personal collections, 81 specimens reported by Reimer (1963), and 61 specimens housed in museums not collected by us (Appendix I). This species was found in ditches, backwater areas of streams, and lakes. In addition, we documented 54 individuals of *C. shufeldtii* in 12 collections from 12 counties in Arkansas (Appendix II). *Cambarellus shufeldtii* was taken from roadside ditches, swamps, and backwater areas of streams and lakes.

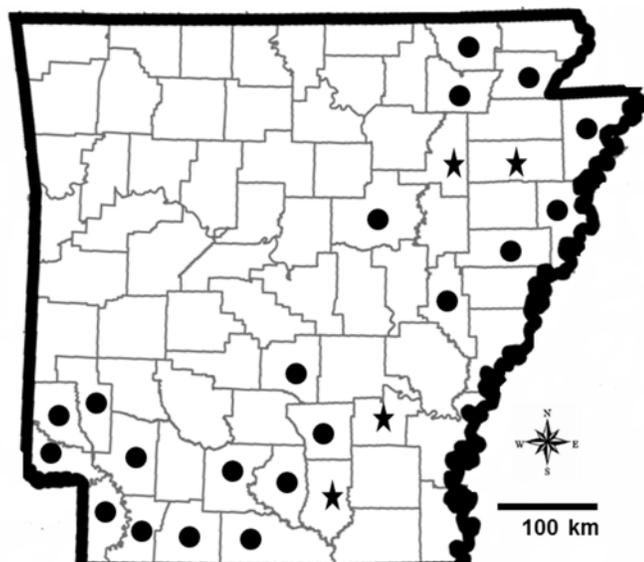


Figure 1. Counties with records of *Cambarellus puer*. Dots = previous county records; stars = new county records.

Recognition Characters of *Cambarellus*

Dwarf crayfishes of the genus *Cambarellus* Ortmann are small crayfishes ranging from 1.5 to 3.7 cm (0.6 to 1.5 in.). No species of *Cambarellus* in the United States is more than 3.7 cm (1.5 in.) in total length (Walls 2009). Form I males resemble those of several species of *Procambarus*, but always lack the cephalic process and caudal knob (Walls 2009). Males have copulatory hooks on the second and third legs. The hook on leg three is often split. Females have a characteristic annulus that looks like a wide tongue projecting from between the hind pair of legs; it is easily flexed up and down (Walls 2009).

CAMBARELLUS (PANDICAMBARUS) PUER HOBBS, 1945 - SWAMP DWARF CRAYFISH

Recognition Characters

This is a tiny crayfish under 3.7 cm (1.5 in.) in total length as a full adult with a reddish-brown to gray body coloration (Fig. 2). The ventral surface is white or cream-colored. The chelae have a long, cylindrical palm at least as long as the fingers; fingers and palm are smooth, without conspicuous tubercles. Tips of the chelae lack orange coloration. The surface of the rostrum of *C. puer* is flat, without the central trough-like depression found in many other crayfishes. The rostrum has lateral rostral spines and a well-developed acumen. The areola is present and broad. The antennal scales are large and broadest in the middle. Adults are generally 1.8 to 3.3 cm (0.7 to 1.3 in.) and rarely exceed 3.7 cm (1.5 in.) (Walls 2009). Females tend to be slightly larger than males. The carapace is laterally compressed and moderately arched dorsoventrally with strong cervical spines and the areola is open (Morehouse and Tobler 2013). The rostrum is flat and terminates in small lateral



Figure 2. *Cambarellus puer*.

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spines at the base of the acumen. Chelae are small and slender with rather short fingers. In form I males, the gonopod has 3 terminal processes (mesial, central, and caudal) that are all strongly curved and about equal in length. The annulus ventralis of females is movable, subcircular, with a flattened or shallowly notched caudal edge, and has a strongly elevated central region (Taylor and Schuster 2004). Interestingly, there are 2 color phases in nature as follows: (1) the striped phase where the body is brownish with two broad, dark brown to black stripes running from above the edges of the telson and often outlined with dark, or (2) a spotted phase where 2 rows of dark brown spots run from above the eyes to the telson and are seldom outlined with dark pigment. Walls (2009) reports both patterns occur in both sexes. *Cambarellus puer* can only be consistently separated taxonomically from *C. shufeldtii* by the strongly curved terminal process on the male gonopod of *C. puer* whereas that terminal process is nearly straight in *C. shufeldtii* (Pflieger 1996). In addition, the rostrum of *C. puer* is broader and its lateral margins are slightly convex and not nearly straight as occurs in *C. shufeldtii*.

Relative Abundance

It appears that *C. puer* is a relatively uncommon to locally abundant crayfish within certain parts of Arkansas. Reimer (1963) made a total of 289 collections amassing 7,300 specimens among 33 species in 4 genera in his master's study (unpublished thesis) of the crayfishes of the state. Of his total of 7,300 specimens, he collected just 81 individuals of *C. puer* in 8 collections. In the present study, a total of 166 specimens of *C. puer* were taken in 15 collections out of 356 (0.4%) personal collections made in Arkansas since 1972. Thus, by combining our data with that of Reimer (1963) as well as existing museum specimens, we found that out of a total of 34 collections of *C. puer* made in Arkansas (1963 to 2017), 304 individuals of *C. puer* have been collected from the state. Most of these specimens are housed in museums, but a few were sent to Brigham Young University (Provo, Utah) for eventual DNA analyses. Collections of *C. puer* at individual sites in Arkansas ranged from 1 to 82 specimens (USNM 146051).

Habitat

In adjacent Oklahoma, *C. puer* is known from a single location: along the Little River in McCurtain County and has not been collected from the state since 1975 (Morehouse and Tobler 2013). In Louisiana, Walls (2009) found that *C. puer* was seldom found in

permanent waters deep enough for predatory fish, but preferred shallow ditches, sloughs, and ponds with permanent vegetation. Most of Walls' collections were from habitats with mud or mud and sand bottoms and with little or no aquatic vegetation present. Penn (1950) took *C. puer* from lowland roadside ditches, cypress swamps, and swamp ponds. Pflieger (1996) collected this crayfish in Missouri from small intermittent creeks and the shallows of seasonally flooded sloughs and swamps. Interestingly, this crayfish species can survive drying conditions by finding refuge under woody debris and thick vegetation patches as it has been classified as a tertiary burrower (Pflieger 1996; Taylor and Schuster 2004).

In Arkansas, Reimer (1963) noted that his specimens of *C. puer* were from shallow roadside ditches with abundant aquatic vegetation, slow moving streams with clumps of vegetation, sloughs with mud bottoms, and streams with pebble-sized gravel bottoms and mud banks. In our 44 yr of collecting field data on crayfishes in all 75 counties in Arkansas, *C. puer* is established as an inhabitant of shallow, lowland roadside ditches, shallow sloughs with heavy vegetation, oxbow lakes, and along the margins of swamps. Substrates have typically been sand, mud, and/or clay. We found *C. puer* in shallow water with vegetation or deep leaf litter and usually a lack of predaceous fishes. Just as with *C. shufeldtii*, they do not truly burrow, but rather live just under the mud in small cells.

Distribution

Cambarellus puer occurs from southern Illinois and southeastern Missouri southward along the Mississippi River Basin to Louisiana and southwestern Alabama and westward to eastern and southern Arkansas, southeastern Oklahoma and southeastern Texas (Walls 2009; Morehouse and Tobler 2013). Data from our field trips (1972 to 2018) showed an absence of *C. puer* from the Ozarks and Ouachita Mountains physiographic regions as well as the Arkansas River Valley with a presence in the Coastal Plain physiographic province.

Reimer (1963) made 8 personal collections of *C. puer* which yielded 81 specimens and documented this crayfish from 8 counties in Arkansas including Cleveland, Grant, Lawrence, Little River, Miller, Ouachita, Randolph, and Union. In addition, Reimer (1963) added Greene and Howard counties based on collections by Dr. Horton H. Hobbs, Jr., with vouchers deposited at the USNM. Tumilson *et al.* (2016) added 6 collections and 6 new counties to the known distribution of *C. puer* in Arkansas. Our studies amassed a total of

15 new collections of *C. puer* from 4 additional counties in Arkansas (Fig. 2). These new county records include Bradley, Jackson, Lincoln, and Poinsett. Specific localities for *C. puer* ($n = 304$ specimens) are listed in Appendix I. *Cambarellus puer* was documented from a total of 24 counties throughout the Coastal Plain of Arkansas. Within the province, this crayfish was collected most in southwestern and eastern Arkansas and was less abundant in northeastern Arkansas. The highest number of *C. puer* specimens collected at one time in the state was 82 individuals (USNM 146051) collected by HWR on 23 August 1974 from a roadside ditch of Bodcaw Bayou 9.6 km (4 mi.) N of Lewisville, Lafayette County. Of all the 24 counties in which it was found, *C. puer* was most common in Lafayette County in southwestern Arkansas (Red River drainage) where 4 populations from 4 localities have been documented. At most of these other locations, however, *C. puer* proved to be uncommon.

In Louisiana, Penn and Fitzpatrick (1963) reported that *C. shufeldtii* appears to be extending its range at the expense of *C. puer* as sites formerly inhabited by the latter species now yield only *C. shufeldtii*. Under experimental conditions, *C. shufeldtii* was dominant over *C. puer* in most aggressive encounters and they tentatively concluded that competitive exclusion may be responsible for replacement of *C. puer* by *C. shufeldtii*. Interestingly, in Louisiana and Illinois, *C. puer* and *C. shufeldtii* were rarely found in the same body of water (Penn 1950; Page 1985). In fact, we never found *C. puer* and *C. shufeldtii* together at the same Arkansas locality, nor have we documented any instance of replacement of *C. puer* by *C. shufeldtii* in the state.

Life History Aspects

In Louisiana, Form I males of *C. puer* have been collected from August to November (Walls 2009) which corresponds to the peak of their breeding activities according to Black (1966). In Missouri, form I males were collected from January to May. Males require 13 to 14 molts to achieve sexual maturity, and most will not breed during their first year of life (Pflieger 1996). Females with eggs were taken on 7 separate dates between 26 February and 12 May (Pflieger 1996). The latter reported 14 egg-bearing females ranging in length from 2.5 to 3.3 cm (1.0 to 1.3 in.) with the number of eggs per female varying from 43 to 110, averaging 79. The eggs were about 1 mm (0.04 in.) in diameter. Page (1985) reported ovigerous females and females carrying young were collected from March to May in Illinois. Juveniles have been found in Louisiana in late spring into early summer (Walls 2009). The life span of *C. puer*

is approximately 15 to 18 months after hatching (Black 1966).

In Arkansas, Reimer (1963) collected Form I males (1 each) of *C. puer* during April, June, and July. Second form (II) males were collected in June (17 specimens) and July (2 specimens) and females in June (28 specimens) and July (4 specimens). One ovigerous female was taken in July by Reimer (1963) which had 45 olive brown eggs.

In our study, Form I males of *C. puer* were collected or documented on 26 April (USNM 1176846- 3), 31 July (USNM 117743-2; USNM 117744-6), 12 October (SAU-1), and 26 October (USNM 146704-1). Form II males were collected on 14 April (USNM 144583), 7 May (USNM 208635-2), and 11 October (SAU-2). We collected or documented single ovigerous females on 20 and 26 April, 23 May, and 26 and 28 July. Egg numbers varied from 49 to 82. No adult females with young attached were found during in our study. Regarding size, adult specimens of *C. puer* in the study ranged from 2.0 to 3.7 cm (0.8 to 1.5 in.) in length.

Decapod Associates

Decapod crayfish associates of *C. puer* in this study include the Digger Crayfish (*Fallicambarus fodiens*), Painted Devil Crayfish (*Lacunicambarus ludovicianus*), Ditch Fencing Crayfish (*Faxonella clypeata*), Twin Crayfish (*Procambarus geminus*), White River Crayfish (*P. acutus*), Swamp Crayfish (*P. clarkii*), and Vernal Crayfish (*P. viaeveridus*). Reimer (1963) reported 5 additional crayfish associates of *C. puer* in Arkansas including the Devil Crawfish (*L. diogenes*), Western Painted Crayfish (*Faxonius palmeri longimanus*), Shrimp Crayfish (*F. lancifer*), Ouachita River Crayfish (*P. ouachitae*), and Southern Plains Crayfish (*P. simulans*).

Conservation Status

In a report on the North American crayfish fauna, Taylor *et al.* (2007) estimated that 48% of species required some sort of conservation status and protection. Specifically, they designated *C. puer* (based on its entire species range) as a “Currently Stable” species, defined as a species or subspecies whose distribution is widespread and stable and is not in need of immediate conservation management actions. Our discovery of 304 individuals of *C. puer* across a 24 county area of Arkansas establishes this crayfish as uncommon in the state. However, we feel more concentrated collecting in eastern Arkansas would yield additional localities and individuals, even though this area has been heavily polluted with weed killing herbicides and various

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insecticides, particularly those targeting cotton destroying insects. Although NatureServe has not provided a state ranking, we nevertheless concur with Taylor *et al.* (2007) with the CS (Currently Stable) designation for *C. puer* in Arkansas.

CAMBARELLUS (PANDICAMBARUS) SHUFELDTII (FAXON, 1884) - CAJUN DWARF CRAYFISH

Recognition Characters

When fully adult, *C. shufeldtii* is a small crayfish 1.5 to 3.1 cm (0.6 to 1.2 in.) in length (Fig. 3). Females tend to be larger than males and have a maximum length of 3.3 cm (1.3 in.) (Pflieger 1996). The rostrum is flat above, with lateral spines and a well-developed acumen. The areola is broad. Males possess hooks on the second and third pereopods. The chela has a long, cylindrical palm at least as long as the fingers; fingers and palm smooth, without obvious tubercles. The antennal scale is large and broadest in the middle. The male gonopod has 3 projections (mesial, central, and caudal) that are all straight or nearly so. The annulus ventralis of the female is tongue-like. Two distinct color patterns occur in *C. shufeldtii*, a spotted phase and a striped phase. In the former, the spots are arranged in lengthwise rows along the carapace and abdomen (Pflieger 1996) whereas in the latter, the spots are fused into uninterrupted bands. These color patterns occur in both sexes and no anatomical differences are associated with the phases. Volpe and Penn (1957) studied this situation extensively and they concluded that the color difference was due to a single gene, with the striped condition dominant over the spotted condition. *Cambarellus shufeldtii* can be consistently distinguished from *C. puer* by the male gonopod, which has straight terminal



Figure 3. *Cambarellus shufeldtii*. Modified from Robison *et al.* (2017).

processes in *C. shufeldtii* rather than strongly curved terminal processes in *C. puer*. In addition, the raised portion of the female sperm receptacle is asymmetrical in *C. shufeldtii*, but not symmetrical as in *C. puer*.

Relative Abundance

Our data suggests that *C. shufeldtii* is a relatively uncommon crayfish in Arkansas. Of Reimer's (1963) total of 7,300 crayfish specimens collected among 289 collections, he collected just 3 individuals of *C. shufeldtii* in 1 collection. In the present study, a total of 20 specimens of *C. shufeldtii* were taken in 7 collections out of 356 collections (0.02%) made in Arkansas since 1972. By combining our data with Reimer (1963) and various museum specimens ($n = 31$), we found that of a total of 649 collections made in the state (1963 to 2018), only 54 individuals of *C. shufeldtii* have been collected. Many of these are housed in the USNM. Collections at individual sites ranged from 1 to 28 specimens (USNM 144583), although most collections yield low numbers (1 to 2 individuals).

Habitat

In Louisiana, Penn (1950) summarized the physical and biological factors affecting the habitats of *C. shufeldtii*. He found this species occurs primarily in clear, shallow, permanent water exposed to sunlight. Most of his collections were from habitats with mud bottoms with luxuriant growths of aquatic vegetation. Penn (1950) also reported that *C. shufeldtii* was not an obligate burrower, but rather survived short periods of drought in small "cells" several inches below the surface of the soil in which they survive until the next rain. No passageways connecting to the surface were found. Also in Louisiana, Walls (2009) reported *C. shufeldtii* is a species of shallow, rather muddy water habitats with either weed beds or deep layers of leaf-litter. Supportive of Penn (1950), Walls (2009) also found that rather than burrow when a slough or ditch dries up, this species does not actively burrow, but forms shallow cells just under the drying mud interface. In Tennessee, *C. shufeldtii* was found among decaying leaves and twigs in protected waters less than 15.2 cm (6 in.) deep along the edges of sloughs (Hobbs and Marchand 1943). In Missouri, Pflieger (1996) reported this species occurred in swamps, sloughs, and roadside ditches that were shallow, with no noticeable current, and choked with aquatic vegetation. Pflieger (1996) also reported that *C. shufeldtii* is not actually a burrower, but occupies cells as reported by other researchers.

In Arkansas, Reimer (1963) found *C. shufeldtii* in Bayou DeView (Monroe County) in clear, shallow

water (less than 30.5 cm [12 in.] deep) devoid of vegetation and only slightly moving. Our study found similar habitat in Arkansas to that reported in Louisiana and Missouri studies. We collected *C. shufeldtii* from clear, shallow areas of vegetated backwaters of streams, swamps, and standing water in shallow roadside ditches.

Distribution

Cambarellus shufeldtii occurs along the Gulf Coast from southcentral Texas eastward to southwestern Alabama and northward in the lowlands along the Mississippi River to Illinois (Pflieger 1996; Walls 2009).

Little has been published on *C. shufeldtii* in Arkansas. The first actual collection of *C. shufeldtii* in Arkansas was apparently a single specimen by A. B. Leonard in White County (USNM 132713) and later reported by Williams (1954). In his unpublished thesis, Reimer (1963) made only 1 collection of *C. shufeldtii* in the entire state from Monroe County and referred to the White County specimen reported by Williams (1954). Later, Tumilson *et al.* (2016) added 5 new counties to the known range of *C. shufeldtii* in Arkansas including Columbia, Jackson, Lafayette, Lawrence, and Woodruff counties.

The present study documented a total of 12 collections of *C. shufeldtii* in Arkansas including 5 new county records in Clay, Crittenden, Desha, Miller, and Union (Fig. 4). Specific localities for all 12 collections of *C. shufeldtii* documented in the state ($n = 54$ specimens) are listed in Appendix II. *Cambarellus shufeldtii* was documented from 12 counties in the

Coastal Plain ranging from Miller County in extreme southwestern Arkansas to Clay County in extreme northeastern Arkansas. At most of these locations *C. shufeldtii* was an uncommon crayfish. However, the highest number of specimens collected at one time was 28 (USNM 144583) individuals collected from Woodruff County on 14 August 1973 by H. H. Hobbs, Jr. Historic records by one of us (HWR) show an absence of *C. shufeldtii* from the Ozarks and Ouachita Mountains physiographic regions as well as the Arkansas River Valley.

Life History Aspects

The biology of *C. shufeldtii* has been studied extensively in Louisiana (Penn 1942, 1950; Lowe 1956, 1961; Black 1966) and Missouri (Pflieger 1996). Penn (1942, 1950) found a continuous period of reproductive activity with 2 peaks in Louisiana. The first peak occurred in the late winter (shortest day length) while the second peak was in early spring and June which had the longest day length. Females mature at about 1.8 cm (0.7 in.) in length and may produce 2 broods during their life span of about 1 yr (Pflieger 1996). An average of 35 eggs per brood is produced by females (Penn 1950). Eggs hatch and they are carried by females beneath their tails. Young remain attached for about 3 weeks (Lowe 1961) until they molt. Males may breed twice by the time they are one year old, but may live 15 to 18 months. Males undergo 12 to 13 molts before maturity and they may breed during the first breeding season after the one in which they were spawned (Pflieger 1996).

In Louisiana (Walls 2009), Form I males have been collected year-round, and ovigerous females are also commonly encountered. Reproduction peaks in the cooler months and again in midsummer because females can produce 2 clutches of young per year. Form I males predominated in collections made in February, July, October, and November. Females with eggs were collected during February, March, and July. In Missouri, Pflieger (1996) found Form I males predominated in his collections in February, July, October, and November, while females with eggs were collected during February, March, and July. In Illinois, Page (1985) reported females with eggs or young were collected in April, May, and June. In 8 females ranging in lengths from 2.0 to 3.0 cm (0.8 to 1.2 in.) from Missouri, the number of eggs per female averaged 64, with a maximum of 108 (Pflieger 1996).

Little is known about the biology of *C. shufeldtii* in Arkansas. In our study, Form I males of *C. shufeldtii* has been documented in Arkansas on 14 April (USNM 144583-3) and 7 May (USNM 298635-3). Form II males

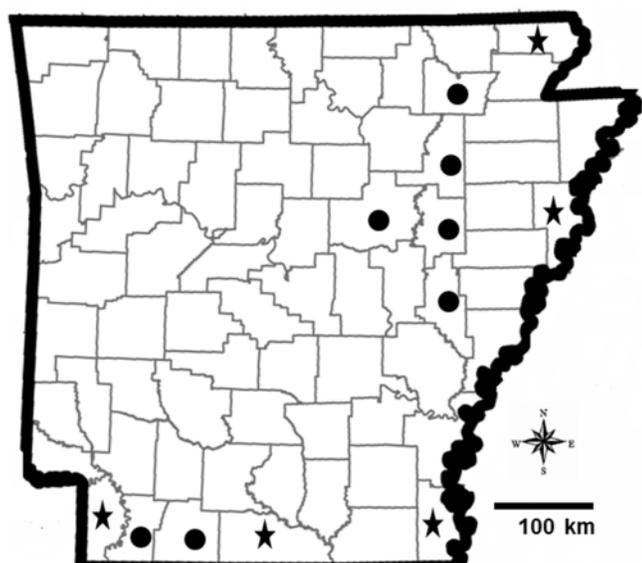


Figure 4. Counties with records of *Cambarellus shufeldtii*. Dots = previous county records; stars = new county records.

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were collected on 14 April (USNM 144583-1) and on 7 May (USNM 208635-2) in the state. We collected or documented ovigerous females from Arkansas from April to October (14 April [USNM 144583-1], 7 May [USNM 208635-1], and 11 October [SAU-1]). Egg numbers of female *C. shufeldtii* varied from 45 to 73. No adult females with young attached were found during our study. Regarding size, adult specimens of *C. shufeldtii* in our study ranged from 2.2 to 3.0 cm (0.9 to 1.3 in.) in length.

Decapod Associates

Nine decapod crayfish associates were collected in this study while searching for *C. shufeldtii*, including *F. fodiens*, *L. ludovicianus*, *L. diogenes*, *F. clypeata*, *P. geminus*, *P. acutus*, *P. ouachitae*, and Giant Bearded Crayfish (*P. tulaneii*). Reimer (1963) reported 2 additional crayfish associates: *F. p. longimanus*, and *F. p. palmeri*.

Conservation Status

Cambarellus shufeldtii is common along the Gulf Coast from southcentral Texas eastward to southwestern Alabama and northward in lowlands along the Mississippi River to Missouri (Lincoln County). This crayfish has a large distribution and is able to inhabit a wide range of habitats. There are no known threats currently impacting the population. Taylor *et al.* (2007) designated *C. shufeldtii* (based on its entire range) as a “Currently Stable” species. Our discovery of only 54 individuals of *C. shufeldtii* across a 12-county area in Arkansas, despite considerable effort, establishes this crayfish as uncommon in the state; however, we feel more concentrated collecting in appropriate habitat in southeastern and northeastern Arkansas would yield additional records, even though this area has been heavily polluted with weed killing herbicides and various insecticides. Although NatureServe doesn’t provide a state ranking for this crayfish, we still concur with the range-wide status given *C. shufeldtii* by Taylor *et al.* (2007) of CS (Currently Stable).

In summary, within Arkansas, both *C. puer* and *C. shufeldtii* inhabit primarily the Coastal Plain and Mississippi Alluvial Plain physiographic provinces. Our research indicates that while both species are fairly widely distributed, both are rather uncommon in the state. The distributional range of *C. puer* includes 24 of 75 counties in the state and most populations are located principally in the Coastal Plain in southwestern and Mississippi Alluvial Plain in eastern Arkansas. At each location within these 24 counties, *C. puer* was typically

uncommon. The distributional range of *C. shufeldtii* in Arkansas mimics that of *C. puer*, but populations only inhabit 12 counties in the Coastal Plain province in southwestern and Mississippi Alluvial Plain in eastern Arkansas. Within the state, *C. shufeldtii* was uncommon at each locality surveyed. Interestingly, these species were never found to occur at the same locality in the state.

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Literature Cited

- Black JB.** 1966. Cyclic male reproduction activities in the dwarf crawfish *Cambarellus shufeldtii* (Faxon) and *Cambarellus puer* (Hobbs). Transactions of the American Microscopical Society 25:214–232.
- Bouchard RW.** 1978. Taxonomy, distribution, and general ecology of the genera of North American crayfishes. Fisheries 3:11–19.
- Crandall KA and JE Buhay.** 2008. Global diversity of crayfish (Astacidae, Cambaridae, and Parastacidae-Decapoda) in freshwater. Hydrobiologia 595:295–301.
- Hobbs HH Jr.** 1945. Two new species of crayfishes of the genus *Cambarellus* from the Gulf Coast States, with a key to the species of the genus (Decapoda, Astacidae). American Midland Naturalist 34:466–474.
- Hobbs HH Jr.** 1988. Crayfish distribution, adaptive radiation and evolution. In Holdrich DM and Lowery RS, editors. Freshwater crayfish: Biology, management and exploitation. Croom Helm (London). p 52–82.
- Hobbs HH Jr and LC Marchand.** 1943. A contribution toward a knowledge of the crayfishes of the Reelfoot Lake area. Journal of the Tennessee Academy of Science 81:6–35.
- Huryn AD and JB Wallace.** 1987. Production and litter processing by crayfish in an Appalachian mountain stream. Freshwater Biology 18:277–286.
- Lowe ME.** 1956. Dominance and subordination in the crawfish *Cambarellus shufeldtii*. Tulane Studies in Zoology 4:139–170.

- Lowe ME.** 1961. The female reproductive cycle of the crayfish *Cambarellus shufeldti*: The influence of environmental factors. *Tulane Studies in Zoology* 8:157–176.
- INHS (Illinois Natural History Survey Database).** 2019. INHS Crustacean Collection Database. Available at: <http://ellipse.inhs.uiuc.edu:591/INHSCollections/crustsearch.html>. (Accessed 2019 February 10).
- Momot WT.** 1995. Redefining the role of crayfish in aquatic ecosystems. *Reviews in Fisheries Science* 3: 33–63.
- Morehouse RL and M Tobler.** 2013. Crayfishes (Decapoda: Cambaridae) of Oklahoma: Identification, distributions, and natural history. *Zootaxa* 3717:101–157.
- Page LM.** 1985. The crayfishes and shrimps (Decapoda) of Illinois. *Illinois Natural History Survey Bulletin* 33:335–448.
- Penn GH.** 1942. Observations on the biology of the dwarf crawfish *Cambarellus shufeldti* (Faxon). *American Midland Naturalist* 28:644–647.
- Penn GH.** 1950. The genus *Cambarellus* in Louisiana (Decapoda, Astacidae). *American Midland Naturalist* 44:421–426.
- Penn GH and JF Fitzpatrick.** 1963. Interspecific competition between two sympatric species of dwarf crawfishes. *Ecology* 44:793–797.
- Pflieger WL.** 1996. The crayfishes of Missouri. Jefferson City (MO): Missouri Department of Conservation. 152 p.
- Reimer RD.** 1963. The crawfish of Arkansas. [MS thesis]. Fayetteville (AR): University of Arkansas. 170 p. Available from: University of Arkansas Library, Fayetteville.
- Robison HW, KA Crandall, and CT McAllister.** 2017. An annotated checklist of the crayfishes (Decapoda: Cambaridae) of Arkansas. *Journal of the Arkansas Academy of Science* 71:17–34.
- Taylor CA and GA Schuster.** 2004. The crayfishes of Kentucky. *Illinois Natural History Survey Special Publication Number 28* (University of Illinois at Urbana-Champaign, Champaign, IL). 227 p.
- Taylor CA, GA Schuster, JE Cooper, RJ DiStefano, AG Eversole, P Hamr, HH Hobbs Jr., HW Robison, CE Skelton, and RF Thoma.** 2007. A reassessment of the conservation status of crayfishes of the United States and Canada after 10+ years of increased awareness. *Fisheries* 32:272–389.
- Tumlison R, HW Robison, and TL Tumlison.** 2016. New records and notes on the natural history of selected invertebrates from Arkansas. *Journal of the Arkansas Academy of Science* 70:296–300.
- USNM (Smithsonian National Museum of Natural History).** 2019. Invertebrate Zoology Collections search site. Available at: <http://collections.nmnh.si.edu/emuwebizweb/pages/nmnh/iz/Query.php>. (Accessed 2019 January 15).
- Usio N and CR Townsend.** 2004. Roles of crayfish: Consequences of predation and bioturbation for stream invertebrates. *Ecology* 85:807–822.
- Volpe EV and GH Penn.** 1957. Dimorphism of chromatophore patterns on the dwarf crawfish. *Journal of Heredity* 48:90–96.
- Walls JG.** 2009. *Crawfishes of Louisiana*. LSU Press (Baton Rouge, LA). 240 p.
- Williams AB.** 1954. Speciation and distribution of the crayfishes of the Ozark Plateaus and Ouachita Provinces. *University of Kansas Science Bulletin* 34:961–1012.

APPENDIX I. Collection locations of 300 specimens of *Cambarellus puer* in Arkansas (locality [township, section and range, when known], date of collection, collector, number of specimens, and vouchers, if known). Includes 81 specimens of *C. puer* reported by Reimer (1963); however, he did not list any dates or number of specimens at his 8 collecting localities. Abbreviations: RWB (Raymond W. Bouchard); HHH (Horton H. Hobbs, Jr.); RR (Roland Reimer); HWR (Henry W. Robison).

Bradley County (n = 3)

(1) Roadside ditch, 5.1 km (3.2 mi.) SE of Banks on St. Hwy. 278. 19 Apr. 1986. HWR. (SAU, 3).

Calhoun County (n = 50)

(1) Ouachita River backwaters along US 167 N of Calion. 26 Oct. 1974. HWR. (USNM 146704, 1 Form I male, 1 female, 47 juveniles = 49).

(2) Champagnolle Creek, 1.6 km (1.0 mi.) W of Hampton Oil Field (Sec. 3, T15S, R14W). 25 May 1975. S. Pelt. (USNM 147715, 1 ovigerous female).

Cleveland County (n = 11)

(1) Big Creek, 8.0 km (5 mi.) W of Pansy. No date. RR. (Reimer 1963).

(2) Stream at US 97, 4.8 km (3 mi.) NE of Jct. with St. Hwy. 15. 15 Aug. 1960. J. Bohlke. (USNM 116031, 1 Form II male, 3 females, 7 juveniles = 11).

Cambarellus Crayfishes of Arkansas**Columbia County (*n* = 4)**

- (1) Roadside ditch, 9.7 km (6 mi.) S of Magnolia on US 79. 12 Oct. 2015. HWR. (SAU, 2 Form II males).
 (2) Bayou Dorcheat at US 82, W of Magnolia. 11 Oct. 2015. HWR. (SAU, 2 females).

Crittenden County (*n* = 1)

- (1) Big Creek, 17.9 km (11.1 mi.) N of Marion (35.3646°N, 90.2544°W). 14 Jun. 1977. HWR. (SAU, 1).

Grant County (*n* = not given)

- (1) Ditch, 1.9 km (1.2 mi.) N of Saline River on US 167. No date. RR. (Reimer 1963).

Greene County (*n* = 9)

- (1) Small stream, 7.9 km (4.9 mi.) NE of Paragould on St. Hwy. 1. 28 Jul. 1941. HHH. (USNM 117744, 6 form I males and 1 female specimens = 7).
 (2) Ditch, 21.6 km (13.4 mi.) W of Paragould on St. Hwy. 25. 28 Jul. 1941. HHH. (2 females).

Howard County (*n* = 1)

- (1) Roadside ditch, 20.1 km (12.6 mi.) W of Nashville on US 371. 20 May 1997. HWR. (SAU, 1).

Jackson County (*n* = 5)

- (1) Village Creek at St. Hwy. 37 E of Tuckerman. 26 Jul. 1976. RWB. (1 male II, 3 females, 1 ovigerous female = 5).

Lafayette County (*n* = 97)

- (1) Roadside backwater of unnamed tributary of Bodcaw Bayou, 6.4 km (4 mi.) N of Lewisville. 23 Aug. 1974. HWR. (USNM 146051, 36 Form II males, 46 additional specimens = 82).
 (2) Unnamed tributary to Bodcaw Bayou, 5.6 km (3.5 mi.) from jct. of St. Hwy. 29 & Sunray Road on Sunray Road, 6.4 (4 mi.) N of Lewisville. 23 Mar. 1975. HWR. (SAU, 9).
 (3) Tributary to Bodcaw Bayou, 5.6 km (3.5 mi.) from jct. of St. Hwy. 29 & Sunray Road on Sunray Road, 6.4 km (4 mi.) N of Lewisville. 26 April 1976. R. W. Bouchard. (USNM 176846, 3 Form I males, 1 ovigerous female = 4).
 (4) Unnamed bayou, 1.3 km (0.8 mi.) NE of Buckner at St. Hwy. 82. 25 Oct. 1993. J. S. Rader. (INHS 11000, 2).

Lawrence County (*n* = not given)

- (1) Unnamed creek, 3.2 km (2 mi.) SE of Hoxie off St. Hwy. 5 (36.0270°N, 90.9315°W). RR. (Reimer 1963).

Lincoln County (*n* = 2)

- (1) Bayou Bartholomew off St. Hwy. 54 at Garrett Bridge (33.866647°N, 91.6562°W). 19 Aug. 1975. HWR. (SAU, 2 Form II males)

Little River County (*n* = 6)

- (1) Slough, 0.2 km (0.1 mi.) S of Little River Bridge on Hwy. 71. RR. (Reimer 1963).
 (2) Ditch, 23.7 km (14.7 mi.) S of Lockesburg on St. Hwy. 59. 31 Jul. 1941. HHH. (USNM 117743 - 2 Form I males 4 juveniles = 6) (Hobbs 1945, see p. 474).

Miller County (*n* = 2)

- (1) Roadside ditch, 1.6 km (1.0 mi.) SW of Red River on US 71. No date. RR. (Reimer 1963).
 (2) Roadside ditch, 3.2 km (2 mi.) SW of Red River on US 71. 16 Jun. 1979. HWR. (SAU, 2)

Mississippi County (*n* = 3)

- (1) Pemiscot Bayou at US 61, ca. 3.2 km (2 mi.) N of Blytheville. 10 Jul. 1993. HWR. (SAU, 3 females).

Monroe County (*n* = 1)

- (1) Stream at St. Hwy. 17, 14.5 km (9 mi.) S of jct. with US 70. 17 Aug. 1960. J. Bohlke. (USNM 116035, 1 female).

Nevada County (*n* = 1)

- (1) Roadside ditch, Terre Rouge Creek at St. Hwy. 371. 6 Jun. 1980. D. Koym. (USNM 218558 - 1 Form II male).

Ouachita County (*n* = 1)

- (1) Roadside ditch, 0.2 (0.1 mi.) S of Two Bayou Creek on St. Hwy. 4. No date. RR. (Reimer 1963).
 (2) Roadside ditch, 4.8 km (3.0 mi.) S of Two Bayou Creek on St. Hwy. 4. 20 Apr. 1979. HWR. (SAU, 1 ovigerous female).

Poinsett County (*n* = 1)

- (1) Roadside ditch, 6.4 km (4 mi.) W. of Harrisburg. 16 Aug. 1974. HWR. (SAU, 1 Form I male).

Randolph County (*n* = not given)

- (1) Roadside ditch, 1.6 km (1.0 mi.) SW of Current River on US 67. No date. RR. (Reimer 1963)

Sevier County (*n* = 11)

- (1) Little River backwater swamp, ca. 1.6 km (1.0 mi.) N of St. Hwy. 41. 12 Oct. 1974. HWR. (USNM 146696, 2 Form I males).

(2) Ditch southeast of Eagletown, OK. 29 Apr. 1972. W. Hayes. (USNM 146081, 1).

(3) Ditch, 19.8 km (12.3 mi.) S of Lockesburg on St. Hwy. 71. 31 Jul. 1941. HHH. (USNM 117743, 3 male juveniles, 5 female juveniles = 8) (Hobbs 1945).

St. Francis County ($n = 1$)

(1) Unnamed stream at US 70, 9.7 km (6 mi.) E of Godwin. 14 Aug. 1960. J. Bohlke. (USNM 116029, 1 Form II male).

Union County ($n = 4$)

(1) Tributary of Smackover Creek, 10.1 (6.3 mi.) N of El Dorado. RR. (1) (Reimer 1963).

(2) Ditch, 11.9 km (7.4 mi.) E of El Dorado. 19 Jun. 1980. HWR. (SAU, 2).

(3) Calion Lake spillway at Calion. 11 Jun. 1981. D. Cummings. (USNM 177606, 1 Form II male and 1 female = 2).

White County ($n = 5$)

(1) Ditch near Bayou Des Arc, 9.7 km (6.0 mi.) NE of McRae on US 67. 14 Aug. 1960. J. Bohlke (USNM 116030, 4 Form II males, 1 female = 5).

APPENDIX II. Collection locations of 54 specimens of *Cambarellus shufeldtii* in Arkansas (locality [township, section and range, when known]), date of collection, collector, number of specimens, and vouchers, if known). Abbreviations: RWB (Raymond W. Bouchard); RR (Roland Reimer), HWR (Henry W. Robison).

Columbia County ($n = 3$)

(1) Bayou Dorcheat at US 82, W of Magnolia. 11 Oct. 2015. HWR. (SAU, 2 Form II males, 1 ovigerous female = 3) (Tumilson *et al.* 2016)

Clay County ($n = 1$)

(1) Roadside ditch at Greenway. 19 Jun. 1979. HWR. (SAU, 1).

Crittenden County ($n = 1$)

(1) Unnamed creek, 20.1 km (12.5 mi.) N of Marion. 19 Jun. 1979. HWR. (SAU, 1).

Desha County ($n = 1$)

(1) Unnamed creek, 2.9 km (1.8 mi.) E of Dumas. 18 Aug. 1974. HWR. (SAU, 1 male).

Jackson County ($n = 1$)

(1) Village Creek at St. Hwy. 37, E of Tuckerman. 19 Feb. 1977. RWB. (1 female) (Tumilson *et al.* 2016).

Lafayette County ($n = 11$)

(1) Unnamed oxbow lake of the Red River, 1.0 km (0.6 mi.) SW of Boyd. 7 May 1982. HWR. (USNM 208635, 3 male I, 2 male II, 3 females ovigerous, 3 other females = 11).

Lawrence County ($n = 1$)

(1) Village Creek at Minturn. 19 Feb. 1977. RWB. (1 female) (Tumilson *et al.* 2016).

Miller County ($n = 3$)

(1) Roadside ditch, ca. 14.5 km (9 mi.) W of Garland. 12 May 1984. HWR (SAU, 3).

Monroe County ($n = 1$)

(1) Bayou DeView at St. Hwy. 17, S of Cotton Plant. No Date. RR. (Reimer 1963) (1).

Union County ($n = 2$)

(1) Roadside ditch, 2.4 km (1.5 mi.) E of Strong on US 82 (Sec. 35, T18S, R12W). 23 Jul. 2000. HWR. (SAU, 2).

White County ($n = 1$)

(1) Slough, 23.2 km (14.4 mi.) W of Augusta. 8 Sept. 1948. A. B. Leonard. (USNM 132713, 1).

Woodruff County ($n = 28$)

(1) Roadside ditch and culvert on US 64, 3.2 km (2 mi.) W of jct. of US 64 & St. Hwy. 39 at Fair Oaks. 14 Apr. 1973. HHH. (USNM 144583, 18 Form I males, 1 Form II male, 1 female adult, 4 female ovigerous, 4 female juvenile = 28).
