
Noteworthy Natural History and Ecological Information on Crayfishes (Decapoda) and Fishes (Actinopterygii) from Oklahoma

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Abstract: Here, in our second contribution on the subject, we include several noteworthy observations on the natural history and ecology of four cambarid crayfishes and five native fishes of Oklahoma. Information is given on reproduction, food habits, deformities, and other miscellaneous aspects of their biology. Our purpose is to help complement and fill gaps in our limited biological knowledge of this biota that should help in future studies conducted in the state.

Introduction

Although biological knowledge has been summarized on the 31 species of crayfishes (Morehouse and Tobler 2013; Taylor and Robison 2016) and over 180 species of fishes (Miller and Robison 2004) of Oklahoma, additional data on the natural history and ecology of select species is important to fill gaps in knowledge. Here, we provide noteworthy facts on several aspects of the natural history of four species of crayfishes and five taxa of native fishes of the state.

Methods

Crayfishes were collected by hand from various locales in McCurtain County and preserved in 70% isopropyl alcohol. Measurements on crayfishes were made using a Vernier caliper following Wang et al. (2011). We follow the classification scheme of Crandall and De Grave (2017) for the taxonomy of the crayfish family Cambaridae.

Fishes from a site in Adair County (35° 57' 28.44"N, 94° 46' 46.056"W), the Illinois River in Cherokee County (35° 57' 34.149"N, 94°

46' 30.8202"W), and locales at Lukfata (34° 03' 10.0866"N, 94° 48' 11.2536"W), Yanubbee (34° 02' 45.618"N, 94° 43' 19.7328"W), and two sites on Yashau (34° 01' 8.0112"N, 94° 45' 24.5088"W and 33° 59' 14.496"N, 94° 44' 36.5712"W) creeks, McCurtain County. Fishes were collected with 3.1 × 1.8 m or 6.1 × 1.8 m seines (3.2 mm mesh) and/or with a backpack electrofisher, preserved in 10% formalin, and stored in 45% isopropanol. Total length (TL) was measured on all fishes, and specimens were examined for reproductive characters, and their eggs measured. Highland Stonerollers (*Campostoma spadiceum*) and Green Sunfishes (*Lepomis cyanellus*) were examined for ciliates following McAllister et al. (2016). All localities are reported as GPS (latitude and longitude) coordinates. Crayfish voucher specimens are deposited in the Southern Arkansas University (SAU) Collection, Magnolia, AR., and voucher fishes are deposited in the Henderson State University (HSU) Collection, Arkadelphia, AR.

Results and Discussion

The collections listed herein represent important records of observations of their natural history and are reported below in an annotated format and phylogenetic order.

**Crustacea: Decapoda: Cambaridae
(Cambarid crayfishes)**

***Cambarus ludovicianus* Faxon, 1884 – Painted Devil Crayfish.** To date, ovigerous females of *C. ludovicianus* have not been reported from Oklahoma (Morehouse and Tobler 2013). On 4 December 1999, an ovigerous female with 104 ova (1.0–1.5 mm in diameter) was collected by hand from a roadside burrow off St. Hwy 3, 4.0 km SE of Haworth, McCurtain County (33° 49' 22.4898"N, 94° 36' 58.917"W). To our knowledge, no one has discussed reproduction of *C. ludovicianus* in the state (Creaser and Ortenburger 1933; Reimer 1968; Morehouse and Tobler 2013). In Louisiana, Penn and Marlow (1959) reported ovigerous females in December and January, whereas Walls (2009) revealed gravid females in that state were most likely to be found during the winter and spring. This is the first time ova have been quantified from an ovigerous *C. ludovicianus* from Oklahoma.

***Fallicambarus fodiens* (Cottle, 1863) – Digger Crayfish.** Creaser (1931) reported copulations of *F. fodiens* occurring in the fall and early spring. Morehouse and Tobler (2013) noted other studies corroborated this report with the collection of form I males, ovigerous females, and females with young from February through May, and August through November, depending on the latitude (Creaser 1931; Bovbjerg 1952; Page 1985; Jezerinac et al. 1995; Pflieger 1996; Taylor and Schuster 2004). In Louisiana, Walls (2009) found females with eggs and young during the cooler months of the year from November to March. On 15 April 2000, an ovigerous female *F. fodiens* with 138 ova (1.5–2.0 mm in diameter) was dug from a burrow in a roadside ditch on St. Hwy. 3, ca. 5.1 km N of Tom, McCurtain County (33° 47' 36.4272"N, 94° 34' 22.5114"W). To our knowledge, the present report is the first documented occurrence of an ovigerous female of *F. fodiens* in Oklahoma. In Arkansas, Hobbs and Robison (1989) reported egg masses of three ovigerous females with 177, 190, and 196 eggs, and diameters ranged from 1.9–2.0 mm. They noted ovigerous females were collected in February, April, and November, whereas females carrying young were taken in January,

February, and March. In Ohio, Norrocky (1991) revealed *F. fodiens* bred in late spring or early summer and by October most mature females were carrying eggs containing embryos in an advanced stage of development: each female carried an average of 115 eggs and/or 74 young.

***Faxonius (=Orconectes) palmeri longimanus* (Faxon, 1898) – Western Painted Crayfish.** An unusually large male *F. p. longimanus* with extremely large chela (Fig. 1) was collected on 17 January 2014 by CTM from the Mountain Fork River at Beavers Bend State Park, McCurtain County (34° 08' 17.6994"N, 94° 41' 17.2032"W). Measurements (in mm) of this specimen are as follows: left chelae length (L) and width (W), 45.4 and 14.6, right chelae L and W, 53.6 and 17.5; body (carapace) L, W, and depth (D), 38.1, 24.2, and 22.2, respectively; abdomen L, 51.2, W, 20.2, and D, 14.3. Neither Williams (1954) for Arkansas specimens, Reimer (1968) for Oklahoma specimens, or Pflieger (1996) for Missouri specimens gave a maximum size for this crayfish. Because our specimen has a TL of 89.3 mm, and Morehouse and Tobler (2013) stated that this crayfish in Oklahoma rarely exceeds 80 mm in TL, we document a record size for the subspecies.

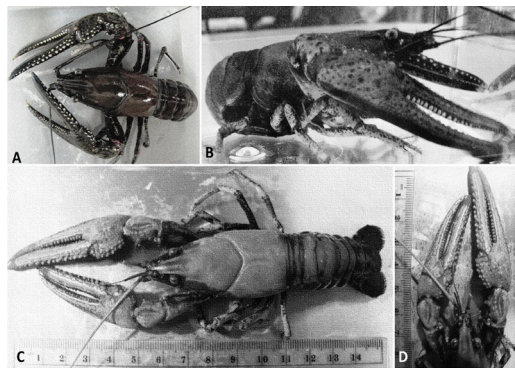


Figure 1. Large *Faxonius palmeri longimanus* from Mountain Fork River, McCurtain County, Oklahoma. A. Dorsal view of live specimen. B. Lateral view of same. C. Same specimen (preserved), showing its total length; note scale ruler. D. Same, showing large chelae; note scale ruler.

***Procambarus curdi* Reimer, 1975 – Red River Burrowing Crayfish.** Reimer (1975) originally described *P. curdi*, and listed several collecting localities in southern Oklahoma, including three near Idabel, McCurtain County. Unfortunately, no natural history information was included in his original description. McAllister et al. (2011) found 16 adult (including Form I and II males, females) and many juvenile and subadult *P. curdi* on the Eastern Oklahoma State Campus just N of Idabel, McCurtain County. More recently, Morehouse and Tobler (2013) revealed males (Form I and II) and females have been collected year round in Oklahoma from burrows. However, to our knowledge, no ovigerous females or females with young have been reported in Oklahoma. On 16 April 2000, a single ovigerous female with 121 ova (1.1–1.6 mm in diameter) was collected in a burrow from a roadside ditch on U.S. Hwy. 70 (259) ca. 8.5 km NE of Idabel, McCurtain County (33° 56' 27.1536"N, 94° 45' 30.2754"W).

Actinopterygii: Cypriniformes: Cyprinidae (carps and minnows)

***Campostoma spadiceum* (Girard, 1856) – Highland Stoneroller.** Populations representing this species in Oklahoma were formerly assigned to *Campostoma anomalum pullum* with *C. spadiceum* recognized as a distinct species and redescribed by Cashner et al. (2010). On 10 November 2017, an adult female (77 mm TL) *C. spadiceum* was collected from Yashau Creek, McCurtain County, which possessed an unusual white growth on its mid-body region and dorsal fin (Fig. 2A). Examination of biopsies of this growth using light microscopy revealed live colonies (Figs. 2B-C) comprising various numbers of individuals, with a branched and smooth, noncontractile stalk and partially to fully expanded zooids. *Epistylus* spp. are ciliates and present as sessile peritrichous organisms (Hoffman 1999; Dias et al. 2006; Lynn 2008). If these ciliates are present in large colonies, attachment sites can cause lesions that get inflamed, necrotic, and ulcerated, leaving the fish susceptible to secondary infection (Hoole et al. 2001). There are previous reports of *Epistylus* in other cyprinids, including two of 18 (11%) Common Carps (*Cyprinus carpio*) and

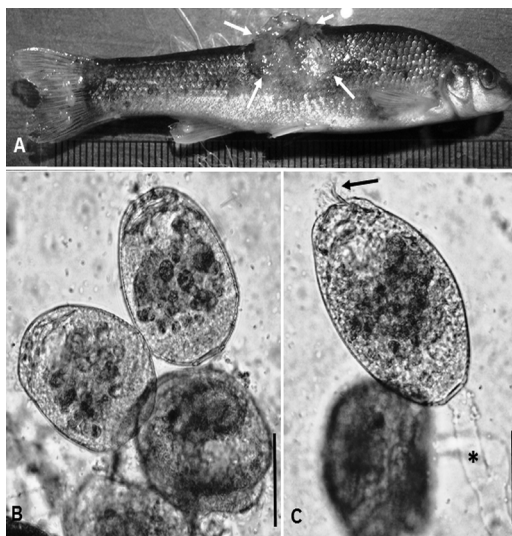


Figure 2. Highland Stoneroller (*Campostoma spadiceum*) from Yashau Creek, McCurtain County, with *Epistylis* sp. A. Gross lateral view of infested fish with whitish growth (arrows) on mid-body and covering dorsal fin. B. Wet mount of colony of partially expanded *Epistylis* zooids. C. Wet mount of single fully expanded zooid showing cilia (arrows) and stalk (*). Scale bars = 25 µm.

two of five (40%) Golden Shiners (*Notemigonus crysoleucus*) (Miller and Chapman, 1976), one of 95 (1%) *N. crysoleucus* and two of 670 (0.3%) Whitefin Shiners (*Cyprinella nivea*) (Lewis et al., 1978), and one of 23 (4%) *N. crysoleucus* (Cloutman et al., 1978), all collected from North Carolina; additional minnows and shiners were examined in these studies and did not harbor *Epistylis*. Interestingly, we have collected over 100 *C. spadiceum* from various McCurtain County watersheds (including Yashau Creek) and have never seen one individual with a similar condition. Thus, based on the prevalence noted above, cyprinids appear to be rare hosts of *Epistylis*. Here, we document the first report of *Epistylis* sp. from *C. spadiceum*, and to our knowledge, the first time from Oklahoma.

***Luxilus cardinalis* (Mayden, 1988) – Cardinal Shiner.** Previously, Moore and Paden (1950) and Miller (1967) noted spawning of *L. cardinalis* (= *Notropis pilsbryi*) in the Illinois River and Spavinaw Creek, respectively,

in northeastern Oklahoma. Herein, we supplement their observations with those of one of us (HWR) of *L. cardinalis* spawning on two separate dates four years apart: namely 24 April 1979 and 5 May 1983 in the Baron Fork of the Illinois River at Proctor, Adair County.

Observations in the Illinois River in Arkansas while snorkeling revealed the Cardinal Shiner is a midwater, schooling species that feeds from the surface and the water column. Tuberculate males and gravid females were present at the Proctor site. Breeding males developed brilliant, crimson red coloration on the underside of the head from the top of the snout to the occiput, and on the chin, and the anterior third of the gular area (Robison and Buchanan 1988); the snout region was a powder blue color. In addition, red coloration was well developed on the lower sides and on the base of the anal fin and all fins also had red pigment. Males exhibited intensely dark, broad lateral bands and were highly tuberculate with prominent tubercles showing on the head region.

Our observations of the breeding activities of *L. cardinalis* were similar to those noted by Miller (1967) who witnessed spawning of *L. cardinalis* over Creek Chub (*Semotilus atrocaudalis*) nests in deep water (1.2 m) pool situations, whereas Moore and Paden (1950) had earlier observed their breeding activities in 2.5 to 3.8 cm of water. In field observations on both dates and years noted herein, HWR observed a mass aggregation of male and female *L. cardinalis* schooling in pools where water depth was approximately 0.7 to 1.2 m deep, clear, and with a moderate current. Water temperatures in the pool areas ranged from 19.1 to 20.6°C while air temperatures ranged from 21.5 to 22.3°C on the two occasions of observations. Miller (1967) had previously noted a close correlation between water temperature and timing of breeding in this species.

Initially, nest building activities of *S. atromaculatus* attracted the attention of HWR who was seining fishes from the stream. He later stopped to observe three to five large *S. atromaculatus* picking up stones in their mouths

and depositing them upstream of their nest area. Interestingly, at the same time, an aggregation of 30 to 50 individuals (mostly males) of *L. cardinalis* was seen initially congregating over the rear of the *Semotilus* nest area. This breeding aggregate of *L. cardinalis* constantly moved back and forth over the cleared nest, but seemed to stay primarily in the posterior portion of the nest area. They only moved toward the center portion of the pit when *Semotilus* males were either distracted or carried pebbles upstream to the front of the nest area, thereby leaving the center of the nest unguarded. Male *L. cardinalis* appeared to line up over the pit facing upstream only 2.5-5.0 cm above the substrate while females tended to remain above and behind them in the water column. Courtship in *L. cardinalis* began when a male would pursue a female and appeared to nudge or bump her side. Individuals remained just above the cleared substrate and often moved toward the center of the pit. Such behavior was repeated numerous times. Unfortunately, HWR did not observe clasping in *L. cardinalis*, but did observe males rolling from side to side as reported by Moore and Paden (1950). Miller (1964) suggested that it is possible this species does not utilize a clasp. Rolling side to side is also typical of courtship behavior in the Common Shiner, *L. cornutus* (Miller 1967), a relative of *L. cardinalis*. Aggressive tendencies were shown by males if another male came close to the area of interaction as the first male would dart out and drive the other male away. Numerous brilliantly colored males jockeyed for position near less brilliantly colored females and aggressive males were seen twice to engage in parallel swimming. This is the first documentation of parallel swimming in *L. cardinalis*. Following field observations, a small hand screen was used to collect eggs of *L. cardinalis* from the gravel.

Percopsiformes: Aphredoderidae

Aphredoderus sayanus (Gilliams, 1824) – **Pirate Perch**. An anomalous 80 mm TL *A. sayanus* was collected on 31 May 2017 from Yanubbee Creek, McCurtain County. Deviation of the spine on the coronal or frontal planes (scoliosis) was noticed (Fig. 3A). Seven other *A. sayanus* collected from the same site did not

possess this anomaly nor did 19 others from nearby Yashau Creek, McCurtain County. Fish affected by this deformity do not usually swim efficiently, are less capable of acquiring food, are at a greater risk of predation, as well as being more susceptible to physiological imbalances (Silverstone and Hammel 2002). This is the first time, to our knowledge, that this deformity has been documented in *A. sayanus*.

Percidae: Centrarchidae

***Lepomis cyanellus* Rafinesque, 1819 – Green Sunfish.** A 145 mm TL *L. cyanellus* collected on 6 November 2016 from Yanubbee Creek, McCurtain County, had lordosis or swayback (Fig. 3B). Although this type of deformation is considered rare in wild fish populations (Boglione et al. 2001), spinal malformations represented by dorso-ventral deviation (kyphosis and lordosis) or curvature in the coronal plane (scoliosis) are the most frequent types. Lordosis remains the utmost diffused type of backbone deformity and is one of the most severe skeletal deformities observed in fish (Chatain and Dewavrin 1989). When fish are affected, the backbone shows a typical V shape with a more or less pronounced angle.

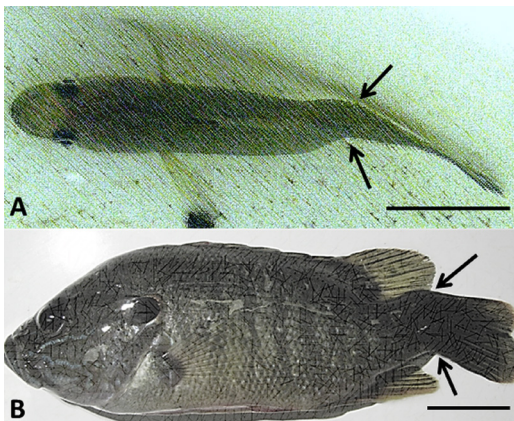


Figure 3. Pirate Perch (*Aphredoderus sayanus*) and Green Sunfish (*Lepomis cyanellus*) from Yanubbee Creek, McCurtain County, Oklahoma, with skeletal deformities. **A.** Dorsal view of Pirate Perch showing deviation of caudal spine (scoliosis, arrows). **B.** Lateral view of Green Sunfish with lordosis (arrows). Scale bars = 20 mm.

Although these deformities can be caused by a number of environmental factors (temperature, infectious diseases, malnutrition, and exposure to pollutants), researchers have found that the genetics of the parents can also play an important role as well (Evans and Neff 2009). This affected fish was the only one of 15 from Yanubbee Creek affected with this disorder and three others from Yashau Creek appeared normal. To the best of our knowledge, occurrence of spinal deformations in *L. cyanellus*, a common centrarchid in Oklahoma, had not previously been reported.

Five of 20 (25%) *L. cyanellus* (109.0 ± 40.7, 76–175 mm) collected on 9 October (2 of 6 [33%]), 6 November (1 of 2 [50%]), 11 November (1 of 3 [33%]), and 27 November 2016 (1 of 1 [100%]) from Yanubbee Creek were found to be infested with an *Epistylis* sp. (Fig. 4). McAllister et al. (2016) recently reported a similar *Epistylis* from *L. cyanellus* from Arkansas; however, this is the second report of this ciliate from any Oklahoma fish.

Perciformes: Percidae

***Etheostoma radiosum* (Hubbs & Black, 1941) – Orangebelly Darter.** A 55 mm TL female with eggs was collected on 24 June 2015 from Yashau Creek, McCurtain County. Spawning in *E. radiosum* in Oklahoma occurs between the middle of March and the middle of April but can begin as early as February (Scalet 1973; Miller and Robison 2004). This extends the known breeding season of the species in Oklahoma.

Another *E. radiosum* (41 mm TL male) collected on 24 November 2015 from Lukfata Creek, McCurtain County, was found to have two unidentified species of water mites (Acari: Hydrachnidae) in its stomach. We are not aware of any reports of this darter feeding on water mites. In Oklahoma, young *E. radiosum* feed primarily on crustaceans, and adults on mayflies and other insect larvae (Scalet 1972).

Scorpaeniformes: Cottidae

***Cottus carolinae* (Gill, 1861) – Banded Sculpin.** A 117 mm TL female with eggs was

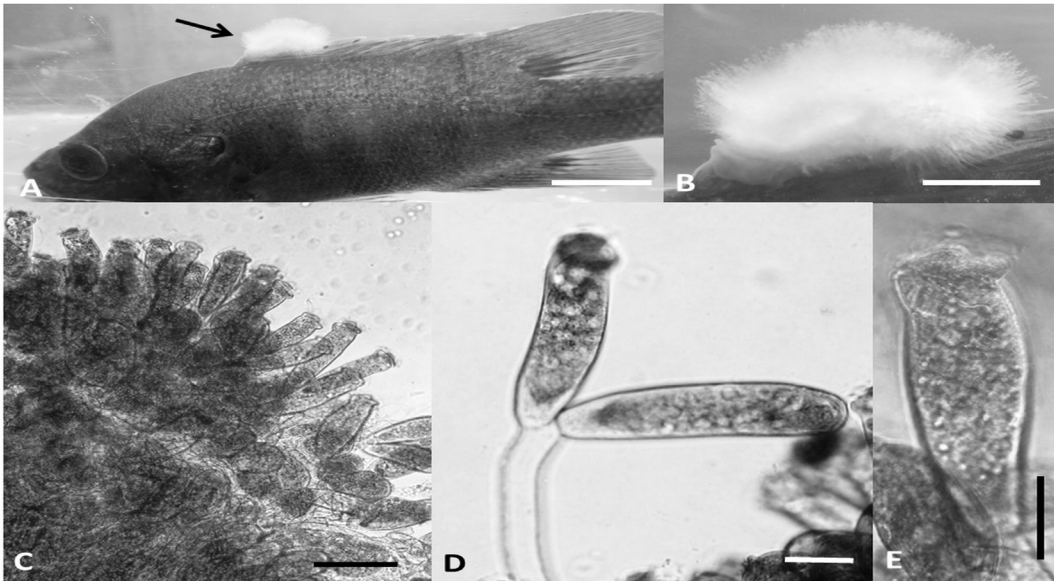


Figure 4. Green Sunfish (*Lepomis cyanellus*) from Yanubbee Creek, McCurtain County, with *Epistylis* sp. A. Gross lateral view of infested fish with whitish growth (arrow) on anterior part of dorsal fin. B. Close-up of same growth. C. Colony of *Epistylis* zooids. D. Pair of *Epistylis* zooids showing stalk. E. Microscopic view of single *Epistylis* zooid. Scale bars A = 30 mm; B = 10 mm; C = 100 μ m; D–E = 50 μ m.

collected on 13 March 2017 from the Illinois River, Cherokee County. The Banded Sculpin spawns in late winter and early spring (Miller and Robison 2004). However, this is the first time a female with eggs has been reported from Oklahoma.

In conclusion, Oklahoma supports a great variety of biota in its vast ecoregions. Biologists can gain novel natural history information on both invertebrates and vertebrates of the state by providing updated data as we document herein. This represents our second contribution (McAllister and Robison 2016) on the subject as we continue to develop additional articles to update the state of knowledge of the natural history of Oklahoma's fauna. Documentation of similar natural history is warranted in other ecoregions, particularly in the Great Plains of the western and Panhandle regions of the state where observations on several species are sorely needed.

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