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First Record of the Opossum Shrimp, *Mysis diluviana* (Crustacea: Mysida) From Arkansas

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Running Title: *Mysis diluviana* in Arkansas

Opossum shrimps are tiny aquatic crustaceans (Crustacea, Malacostraca, Mysida) which superficially resemble true shrimps. The mysid species of the North American Great Lakes, formerly identified as *Mysis relicta*, has been renamed *Mysis diluviana* Audzijonyte and Väinölä based on molecular studies (Väinölä et al. 1994, Audzijonytë and Väinölä 2005, Dooh et al. 2006). These works separated *M. relicta* into 4 separate species and collectively these species are now referred to as the *M. relicta* species group. *Mysis diluviana* inhabits continental freshwater lakes of the once-glaciated northern North America, including the Great Lakes (Audzijonytë and Väinölä 2005). The purpose of this note is to provide the first documentation of *M. diluviana* in Arkansas with voucher specimens deposited in a museum repository.

Between 13–16 November 2012, 32 specimens of opossum shrimps were collected from the lower Cache River at the Monroe/Prairie County line (34.581364°N, 93.883678°W), by NW using a D-frame aquatic dip net (Appendix). All specimens were initially sent to HWR for identification. Following a tentative identification of *M. diluviana*, 2 specimens were forwarded to the Curator of Crustaceans, Dr. C.A. Taylor, Illinois Natural History Survey (INHS), Champaign, Illinois, for verification of the original identification and deposition in the INHS Crustacean Collection. Dr. Taylor confirmed the identity of specimens as *M. diluviana*. The remaining 30 opossum shrimp are currently in the personal collection of KS.

Description

Opossum shrimps are quite small (12–14 mm), with stalked compound eyes, and a single carapace covering the head and thorax without completely masking the underlying parts (Fitzpatrick 1983). The carapace is not attached posteriorly as it is in decapod crustaceans (crabs, lobsters, shrimps and crayfishes). Thoracic appendages in these shrimps are thin and biramous, and only the first 2 are maxillipeds. Males may be distinguished by having a modified fourth pleopod, the exopod of which is very long, while in females, the last 2 pairs of periopods have flattened, lamellar, ventrally projecting endites, called oostegites. The oostegites form a marsupium in which the eggs are incubated thus giving the group its name, opossum shrimps. Each of the 4 species of the *M. relicta* group has distinct genetic and morphological characteristics and morphological features such as length and shape of the setae can also be examined to identify them. They are not easily confused with 2 other freshwater shrimps inhabiting Arkansas (see Robison and McAllister 2011), *Paleomonetes kadiakensis* or *Macrobrachium ohione*, both much larger than opossum shrimps.

Geographic Distribution

Mysis diluviana inhabits continental freshwater lakes of the once-glaciated northern North America, including the Great Lakes and other deep coldwater lakes across Canada and in northern parts of the United States, including those in Wisconsin and New York (Dadswell 1974, Pennak 1989, Audzijonyte and Väinölä 2005). The species has been termed a glacial relict since it inhabits areas covered by ice sheets during the last glacial period.

Introductions

Mysis diluviana has been introduced to lakes outside its native range as a forage base for fishes, including Lake Tahoe in California and Nevada and Kootenay Lake in British Columbia, Canada (Clemens et al. 1939, Sparrow 1964). Additional stockings were made at 5 Montana lakes upstream of Flathead Lake (Bosworth 2011), and in many other lakes of the western USA and Canada (Spencer et al. 1999). A single *M. diluviana* was collected from Lake Demopolis, Alabama in 2004 (Foster et al. 2015). Opossum shrimps have also been previously reported

from adjacent coastal Louisiana and Texas (Fitzpatrick 1983, Porter et al. 2008). However, they have not been previously documented from Arkansas (Bouchard and Robison, 1980, Robison and McAllister, 2011) despite numerous intensive aquatic macroinvertebrate surveys in the state by Cather and Harp (1975), Harp and Harp (1980), Farris and Harp (1982), Guntharp and Harp (1982), Higgins and Harp (1983), Cochran and Harp (1990), Chordas et al., (1996), Harp and Robison (2006), and over 45 yrs of personal collecting in Arkansas by Dr. G.L. Harp (Arkansas State University [ASU]) and HWR.

Ecology

Mysis diluviana is typically found in deep, cold oligotrophic lakes with high levels of dissolved oxygen where it occurs mainly below the thermocline, however, it has also been reported from brackish and estuarine waters (Dadswell 1974, Pennak 1989). It opportunistically feeds on zooplankton when abundant but when scarce, it will feed on phytoplankton, suspended organic debris, or from the surface of benthic organic deposits (Pennak 1989, Anderson 2010). They live for just 2 yr and become sexually mature at 12–14 mm. Breeding takes place in the winter with adults carrying young in a brood pouch until fully developed in spring (Pennak 1989).

Helminth Parasites

Opossum shrimps have been reported to harbor procercoids of the cestode, *Cyathocephalus truncatus* Pallas (Amin 1978), nematodes, *Cystidicola stigmatura* (Leidy) (Smith and Lankester 1979), an echinorhynchid acanthocephalan cystacanth (Wolff 1984), and *Echinorhynchus leidyi* (Van Cleave) (Prychitko and Nero 1983). Although we did not examine our *M. diluviana* for endoparasites, this information suggests that these shrimp can serve as intermediate hosts of a suite of parasites and could potentially introduce them into Arkansas.

Significance

Within its native range *M. diluviana* has been shown to be an important prey item for freshwater fishes (Nesler and Bergersen 1991). However, when introduced into what was considered to be an "empty" niche, its impact on the aquatic community is significant. Dramatic changes and species extinctions of native zooplankton communities have been attributed to the opportunistic feeding habits of *M. diluviana.* This change in the primary consumer composition has led to drastic ecosystem shifts in Flathead Lake, Montana (Spencer et al. 1999). The smaller opossum shrimp replaced larger native species but were unable to keep up with the growth of algae in the Lake. Furthermore, the benthic tendencies of this species provided a massive new food source for bottom dwelling lake trout, allowing the trout to increase their population and overtake kokanee (non-anadromous form of sockeye salmon) as top predator in Flathead Lake (Bosworth 2011).

Study Sites in Arkansas

The lower Cache River at the Monroe/Prairie County line (Fig. 1) is characterized by 2 different channel types. The upper portion of the lower Cache River above the Bayou DeView confluence remains sinuous and only altered by levees and channelization in the extreme headwaters. The Cache River below the Bayou DeView confluence is channelized to the confluence with the White River near Clarendon (~11 km). However, The Nature Conservancy and partners are working to restore and reconnect previously disconnected backwaters. Overall, both portions of the Cache River are best described as highly turbid, deltaic systems. Aquatic habitat of the study area was predominantly sand with small clay aggregates forming gravel like substrate. At all 4 of our collection sites (Appendix), aquatic vegetation was sparse with large woody debris being the primary instream structure.

It is obvious that *M. diluviana* is not a native member of the Arkansas aquatic fauna but why have they eluded capture previously or are they from a more

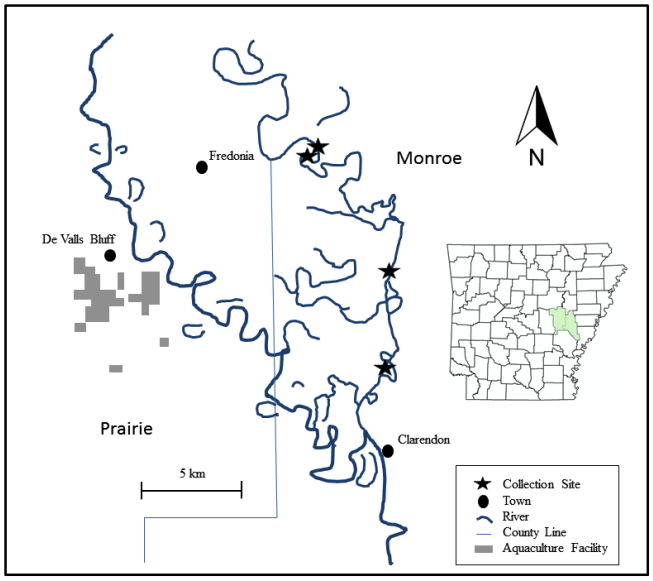

Figure 1. Four collection locations (stars) of *Mysis diluviana* in the Cache River, Monroe County, Arkansas.

recent introduction? In 2014, a re-sampling of this area took place; however, the water was much lower and the original sites could not be accessed so only snags (dead and down woody debris in the form of stumps, root wads, bark, and limbs >3cm in circumference) were sampled. No additional specimens of *M. diluviana* were taken.

Since these *M. diluviana* individuals do represent an introduction, where did they come from? Several possibilities exist. The first is that *M. diluviana* escaped from barge traffic in the area. The sample location in Monroe County is physically close to the port of Clarendon on the White River. Clarendon is the last stop for most barge traffic heading up the White River and is at the confluence of the Cache River approximately 3.5 river km downstream of the lowest observation. Given the movement of goods between the Great Lakes and Mississippi River basin, a barge may have released ballast water with *M. diluviana* individuals. A second possibility is that one of the large aquaculture facilities that culture baitfish (Golden Shiner, *Notemigonus crysoleucas*) located 11 km W of our localities may have introduced the *Mysis* specimens into the White River near the confluence of the Cache River. The 2 rivers become broadly connected in late fall and winter when the bottomlands flood (NJW and KS, *pers. obs*.). Since the areas were sampled in mid-winter, the temperatures would have been low enough to sustain *M. diluviana*.

In summary, our collection represents the first documentation of the Order Mysida in Arkansas, and specifically, the first report of *M. diluviana* in the state. Future sampling is planned at the same areas where the opossum shrimps were previously taken as well as checking in watersheds in adjoining Prairie County.

Acknowledgments

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APPENDIX. Four locations of 32 specimens of *Mysis diluviana* collected by N. Wentz in Arkansas (locality [latitude/longitude in decimal degrees], date of collection and number of specimens).

MONROE/PRAIRIE CO. LINE (Cache River, just S of US 70 bridge, E of Biscoe)

1. (34.77°N, 91.31°W). 13 Nov. 2012. 1.
2. (34.824°N, 91.345°W). 16 Nov. 2012. 9.
3. (34.819°N, 91.351°W). 16 Nov. 2012. 1.
4. (34.726°N, 91.316°W). 16 Nov. 2012. 21.