Western Mosquitofish Status in Wisconsin – 2009

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Summary: In September 2009, populations of the non-native western mosquitofish (*Gambusia affinis*) were found to be successfully reproducing in two discrete areas of southwestern Wisconsin, Pool 11 of the Mississippi River in Grant County and the Sugar River near Brodhead in Green County. The source of these mosquitofish populations is unknown, but the species probably entered the state directly via human introductions rather than through gradual northward colonization. In the past, introductions of mosquitofish failed to become established in the state because of winter severity, but with moderating climate the species may now be able to persist in certain areas of southern Wisconsin. Elsewhere, mosquitofish introductions have caused major declines in native fishes, amphibians, and invertebrates. The native fish species in Wisconsin most threatened by the establishment of the western mosquitofish is the state-endangered starhead topminnow (*Fundulus dispar*). If western mosquitofish do become established in Wisconsin they will probably be impossible to eliminate, so management should focus on preventing their spread.

Mosquitofish occurrences in Wisconsin: The western mosquitofish is native to the south-central United States, with the northern edge of its range in southern Indiana and Illinois and northern Missouri. The very similar eastern mosquitofish (*Gambusia holbrooki*), which until recently was considered a subspecies of *G. affinis*, is found in the southeastern United States. A number of other *Gambusia* species occur in Texas, Mexico, Central America, and on Caribbean islands.

The eastern and western mosquitofish have been widely introduced outside of their native range for mosquito control, including all continents except Antarctica. From the 1920's through the present, western mosquitofish have been stocked into various northern Illinois waters and on at least one occasion prior to the 1950's into unspecified southern Wisconsin waters. The Wisconsin introductions were unsuccessful, apparently because winter conditions were too harsh for mosquitofish to endure. A few small populations did become established in the Chicago region and the Rock River basin south of Rockford. The nearest of these populations to Wisconsin is the Waukegan River, which drains into Lake Michigan at Waukegan, Illinois, about 7 miles south of the border. None of the Chicago area populations have as yet expanded into Wisconsin.

In recent years, western mosquitofish have been observed mixed in shipments of fathead minnows (*Pimephales promelas*) from fish farms in Arkansas to bait fish wholesalers in Wisconsin. Fathead minnows are native to Wisconsin and cultured here for bait, but demand often exceeds supply, and wholesalers import farm-raised fatheads from other states. There is an unconfirmed report that mosquitofish were found in a shipment of fathead minnows used as food for walleyes at the WDNR Lake Mills Fish Hatchery in Jefferson County in 2002. In 2007, mosquitofish were encountered among fatheads in a

bait dealer's tank at Yellowstone Lake State Park in Lafayette County. However, no mosquitofish were reported from the natural waters of Wisconsin prior to 2008.

The first records of mosquitofish in the wild in Wisconsin came from Pool 11 of the Mississippi River. In July 2008, University of Dubuque researchers captured 3 western mosquitofish from Mud Lake, an embayment on the Iowa side of Pool 11 of the Mississippi River, about 8 river miles upstream of the Illinois/Wisconsin border and opposite the mouth of the Platte River and the town of Dickeyville in Grant County, Wisconsin. On September 6, 2009, University of Wisconsin-Madison Wildlife Ecology graduate student Jeff Lorch captured and photographed a western mosquitofish from the lower reaches of Sinnippee Creek, about 0.5 miles upstream from Pool 11 near the town of Keiler in Grant County. The mouth of Sinnippee Creek is located 5 river miles upstream of the Illinois border. Jeff estimated that 80-100 mosquitofish were present at the site, which is within the state-owned Fenley Recreation Area. On Sept 15, 2009, WDNR Fish Manager Bradd Sims and I visited the Sinnippee Creek site and collected 57 western mosquitofish and observed many more. All life stages were present, from young-of-year to adult, and individuals were widespread in this reach of the creek. We also checked the lower reaches of the Platte River at the Banfield Bridge Boat Landing, 1.5 miles up from Pool 11, and found western mosquitofish to be common (> 100 observed) and widespread. Again, all life stages were present. On September 18, 2009, Bradd found western mosquitofish in Pool 11 at the mouth of McCartney Branch, about 11 river miles upstream of the mouth of the Platte River and 19 miles upstream of the Illinois border. Here they were less common than at the Platte. Bradd did not observe mosquitofish at the Bertom Lake Boat Landing on the Mississippi River, located 3 miles further upstream from the mouth of McCartney Branch and 22 miles from the Illinois border. On September 26, 2009, I checked several miles of Cassville Slough of the Mississippi River, located 10-17 miles upstream from McCartney Branch and 29-36 miles upstream of the Illinois border, and failed to encounter mosquitofish. I have sampled small fishes in Cassville Slough annually since 1995 without finding mosquitofish. The upper end of Cassville Slough is near Lock and Dam 10, the upstream boundary of Pool 11. So at present, mosquitofish appear to occur only in the lower half of Pool 11 and the lower reaches of its tributaries. Within that area they are common and widespread where suitable habitat is present (see below). Their presence in Pool 11 in both 2008 and 2009 indicates that they survived the relatively cold 2008-09 winter. Whether they will be able to survive a series of Wisconsin winters remains to be seen.

Independently and without knowledge of the situation in Pool 11, on September 11, 2009, WDNR Stream Biologists Jim Amrhein and Mike Sorge and retired WDNR Stream Biologist Dave Marshall discovered western mosquitofish during a survey of the Sugar River at the CTH F Boat Landing at the town of Brodhead in Green County. Hundreds of mosquitofish from young-of-year to adult were observed in a small, deep slough along the highway. I had sampled this slough in 1984, 1987, and 1994 without encountering mosquitofish. Jim, Mike, Dave, and I had conducted sampling in similar habitats on the Sugar River located 7 river miles upstream and 1 to 12 river miles downstream of this slough on May 21, July 17, and September 11, 2009 and failed to find mosquitofish. This suggests that the CTH F population is recently established and localized in occurrence.

The CTH F site is located about 19 river miles upstream of the Illinois border. The Sugar River joins the Pecatonica River in Illinois and ultimately the Rock River, and the Rock River drains to the Mississippi River. Via river channels, the Sugar River site is more than 340 miles from Pool 11, with multiple intervening dams that impede fish movement.

The habitat occupied by mosquitofish was similar between the Sugar River and the Pool 11 sites, and generally matches the conditions favored by mosquitofish elsewhere. In both locations, mosquitofish were found in shallow areas close to shore with little to no current. Usually they were observed near aquatic vegetation or other cover. Except when disturbed and trying to elude capture, they held just under the surface in groups and, despite their small size, were fairly conspicuous. Most of the sites where mosquitofish were found had evidence of localized groundwater seeps. Ground water inputs that moderate water temperatures may be essential to allow mosquitofish to survive Wisconsin winters. Although they inhabited similar microhabitats at all sites, mosquitofish were found over a wide range of macrohabitats, including sloughs and backwaters, small creeks, small rivers, and the edge of the Mississippi River.

Sources of the Wisconsin mosquitofish populations: There are three plausible ways in which western mosquitofish may have arrived in Pool 11 and the Sugar River. One was through a gradual northward expansion from populations further south in Illinois and the Mississippi River. A second was as a possible "contaminant" in fishing bait, inadvertently released by anglers. The third was through escapees from private waters where mosquitofish may have been introduced for mosquito control. I find gradual northward expansion the least likely scenario. The population in the Sugar River appears to be isolated, and there is no evidence of mosquitofish further downstream. If mosquitofish had colonized from Illinois, populations likely would occur between the CTH F site and the Illinois border. Furthermore, there is no likely source population in northern Illinois for colonizing fish. The nearest established population in the Rock River basin in Illinois is in a small tributary southeast of Rockford, over 40 river miles from the Wisconsin border and below a dam on the Rock River that blocks upstream movement. Similarly, there are no nearby populations to allow for colonization of Pool 11. The nearest established population in the Mississippi River is in Pool 14, 98 miles downstream with three intervening dams. Pool 13, 43 miles downstream with two intervening dams, has been intensively sampled for small fishes since 1993 by Iowa DNR staff, and only one western mosquitofish (in 2007) has been captured there.

Both inadvertent releases with fishing bait and escapes from deliberate stockings for mosquito control seem equally likely to me as possible sources for the western mosquitofish populations in Pool 11 and the Sugar River. As previously noted, mosquitofish have appeared in fishing bait shipments in recent years. Bait bucket releases are a major source of fish introductions throughout North America. Pool 11 and the Sugar River are popular fishing areas, and in both rivers mosquitofish were captured near boat landings where anglers are likely to have released unused bait at the end of their fishing trips (despite recent regulations outlawing this practice). Mosquitofish are still promoted for stocking in garden and golf course ponds, rain barrels, and watering tanks to control mosquitoes in northern Illinois and many other areas, particularly in response

to recent concerns over mosquito-borne diseases such as West Nile Virus. Mosquitofish are readily available for purchase on the internet, and until new invasive species rules were enacted in the summer of 2009, it was not clearly illegal to possess live mosquitofish in Wisconsin. So it seems likely that some stocking of mosquitofish in private waters had occurred in Wisconsin. A trend toward milder winters over the last 30 years may have allowed these stocked mosquitofish populations to survive beyond a single summer. The record flooding in southern Wisconsin in summer 2007 and 2008 could have washed mosquitofish out of isolated private waters into natural rivers, possibly resulting in the established populations in Pool 11 and the Sugar River in 2009.

Mosquitofish biology: Because of their long-standing use as mosquito-control agents, the life history and ecology of mosquitofish are well known. The western mosquitofish is a member of the livebearer family (Poeciliidae), and as the names implies, gives birth to live young rather than laying eggs. Mature males in the livebearer family have their anal fin modified into a long thin appendage, known as a gonopodium, used for internal fertilization of the female (Figure 1). All native Wisconsin fishes lay eggs that are fertilized externally. Other well-known members of the livebearer family include the popular aquarium species guppies (*Poecilia reticulata*), mollies (*Poecilia mexicana* and other species), swordtails (*Xiphophorus helleri* and other species), and platies (*Xiphophorus variatus* and *X. maculatus*).

Mosquitofish are fairly distinctive and not readily confused with native species upon careful inspection. See http://wiscfish.org for identification. However, because they are small and nondescript, mosquitofish could be easily missed when mixed in a group of other small fishes. Their small size also means they can only be captured with small-mesh nets (< ¼" bar) and would not be detected in surveys using only coarser mesh nets.

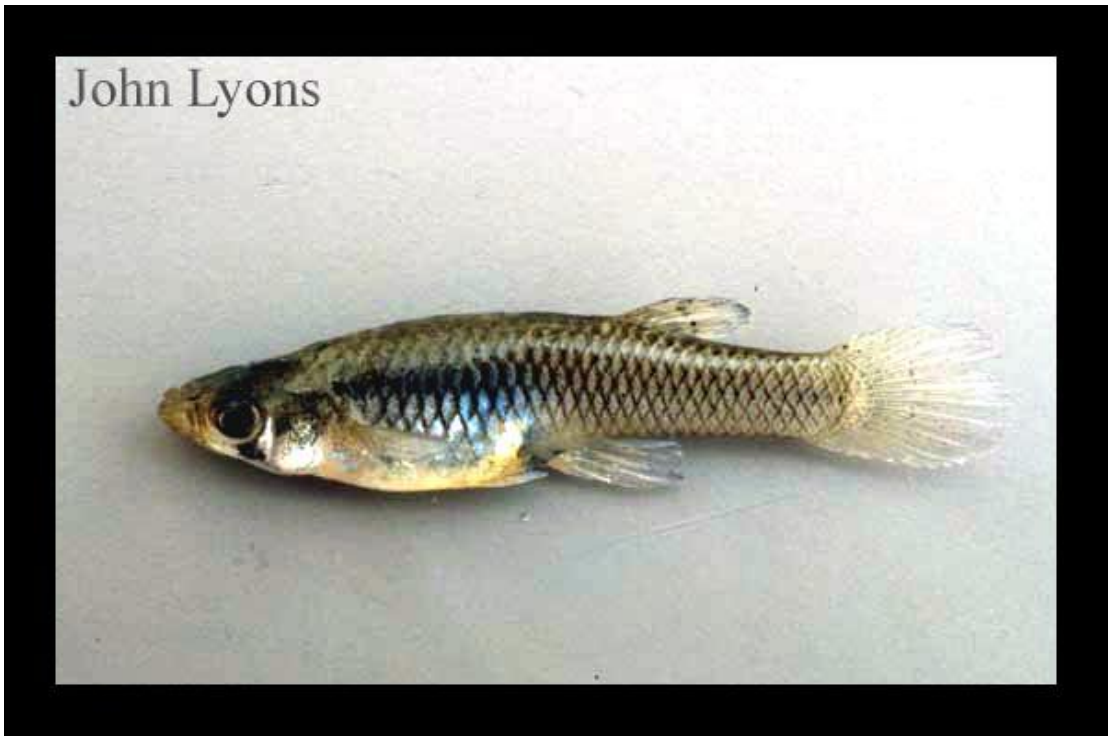

Figure 1 – Top: Female western mosquitofish, approximately 1.3 inches in total length. Bottom: Male western mosquitofish, approximately 0.9 inches in total length. Note that the anal fin is modified into a gonopodium, an appendage for internal fertilization of the female.

Mosquitofish reproduce rapidly with a short generation time. Female western mosquitofish typically produce broods of 40-50 young, with a maximum of 218 reported. They can generate a brood every 21-28 days at water temperatures near 70 F and may give birth to two to six broods over the course of a single growing season. Females can store sperm internally for long periods, so multiple broods can result from a single mating. At the northern edge of their range, mosquitofish tend to produce smaller but more frequent broods of slightly larger young than they do in more southerly populations. The reproductive characteristics of mosquitofish make them particularly adept at colonizing new areas; one pregnant female mosquitofish entering a suitable habitat in the spring can result in multiple generations of thousands of mosquitofish by the fall.

Western mosquitofish are small and short-lived. The maximum size is about 2.5 inches for females and 1.3 inches for males, although most fish are much smaller, with females over 1.5 inches and males over 1 inch usually rare. Newly born juveniles are about 0.3 inches long and are almost immediately mature and capable of reproduction. Under ideal conditions, a female can release her first brood less than a month after her birth at a size of only 0.4-0.6 inches. Lifespan is very brief; males and females born in the spring usually reproduce several times over the course of the growing season and then die before winter. Males and females born late in the growing season defer maturation over the

winter and reproduce for the first time early the next summer but die soon thereafter. Very few females and almost no males survive to the maximum reported age of 1.5 years (i.e., two growing seasons), and western mosquitofish are essentially an "annual" species.

Western mosquitofish can live in a wide range of water bodies, including lakes, ponds, wetlands, ditches, streams, and rivers. They tend to do best in quiet, shallow water along the shoreline, usually in areas with vegetation or other cover. They avoid high-gradient fast-flowing streams, coldwater trout streams, and exposed wave-swept areas of lakes or large rivers.

Western mosquitofish are tolerant of a wide range of environmental extremes. They can survive in water with extremely low dissolved oxygen (< 0.2 mg/l), in part because their small size and surface orientation allows them to use a thin layer of more oxygenated water at the air-water interface. They occupy waters with salinities up to about 10 parts per thousand and with gradual acclimation can withstand up to 58 ppt (seawater = 35-36 ppt). Although they prefer clear water, they often inhabit turbid areas. They are highly tolerant of many pollutants, including paper mill wastes and sewage effluents. They persist in water temperatures up to about 95 F.

Water temperature is a key factor determining the distribution and behavior of the western mosquitofish. Mosquitofish reproduction only occurs when water temperatures exceed about 60 F. Feeding activity and growth is greatest between 77 and 86 F, and feeding ceases below 50 F. Western mosquitofish can tolerate water temperatures near freezing for short periods (hours to days), but die after longer exposures. Extended periods of near-freezing water temperatures are what limit the northern distribution of western mosquitofish, and the winters of Wisconsin were long thought to be too severe to allow mosquitofish to persist in the state. However, with a trend towards mild winters, perhaps coupled with mosquitofish use of microhabitats where groundwater inputs keep temperatures above freezing, western mosquitofish may now be able to survive year-round in Wisconsin. There are also reports that a fish farmer in Nebraska who sells mosquitofish regionally has selectively bred a more cold-tolerant western mosquitofish that can survive Nebraska winters in ponds under the ice.

Western mosquitofish are largely carnivorous. As their name implies, they feed on mosquito larvae and pupae, but their dependence and impact on mosquito populations has been overstated in the popular literature. In addition to mosquitoes, mosquitofish consume a variety of foods that include other insects, small crustaceans, zooplankton, fish eggs and larvae, amphibian eggs and larvae, and perhaps small amounts of plant material or detritus. Mosquitofish feed primarily at or near the water surface. Mosquitoes only rarely dominate the diet of mosquitofish, and there is little unequivocal scientific evidence that mosquitofish can control mosquito populations in natural environments. Even in situations where mosquitofish do consume large numbers of mosquitoes, some studies indicate that they are no more effective predators than other small fish species.

Mosquitofish potential impacts in Wisconsin: When introduced outside their native range, western mosquitofish have caused great damage to aquatic communities. They consume the eggs and larvae of native fishes and amphibians, compete with native fishes for food and depress populations of native invertebrates, and directly harass and displace small native fish. They have reduced or eliminated native fishes, amphibians, and invertebrates in streams, ponds, and wetlands in many locations. The best documentation of these impacts is from the western U.S., Spain, and Australia. In nearly all cases, any benefit that introduced mosquitofish may have provided from mosquito control was more than offset by the damage they did to the native fauna. In some cases their ability to control mosquitoes was less than that of the native species they displaced. In a detailed analysis, the Michigan DNR concluded that non-native western mosquitofish would provide little benefit in terms of mosquito control but could be very harmful to the native aquatic fauna, and they recommended against mosquitofish introductions in Michigan. The World Conservation Union considers the western mosquitofish to be one of the 100 worst invasive species in the world.

Based on experiences from elsewhere, the western mosquitofish poses a potential threat to Wisconsin's native fish fauna. The species most likely to be at risk are those with similar ecological requirements and habitats, including a number of small non-game fishes, particularly topminnows and killifish of the genus *Fundulus*. Three species of *Fundulus* occur in Wisconsin, the relatively common blackstripe topminnow (*F. notatus*), which is found broadly in southeastern Wisconsin, the special-concern banded killifish (*F. diaphanus*), which is found sporadically statewide mainly in lakes, and the state-endangered starhead topminnow (*F. dispar*), which is found only in a few areas of southern Wisconsin. All three species are surface oriented like the mosquitofish and occupy a similar habitat of shallow nearshore areas with vegetation or other cover. In the Sugar River the blackstripe topminnow is common and the starhead topminnow was present historically, although it has not been seen since the 1970's. None of the three *Fundulus* species occurs in Pool 11. However, if the mosquitofish is able to establish itself in Pool 10, the next pool upstream in the Mississippi River, it will then have direct access to the sloughs of the lower Wisconsin River, the largest and most important habitat remaining in the state for the starhead topminnow. If mosquitofish are able to access the glacial lakes of southeastern Wisconsin, they will come in contact with banded killifish populations.

Mosquitofish management options: If western mosquitofish do prove able to consistently tolerate Wisconsin winters and become established in the southern part of the state, I believe that they will be impossible to eradicate by management activities. Although fairly easy to capture individually, the small size, abundance, and use of difficult-to-sample habitats by mosquitofish makes their populations highly resistant to elimination by netting or electroshocking. Because of their tolerance to pollution and low dissolved oxygen, they are relatively insensitive to fish toxicants and probably could not be eliminated by localized poisoning. In any case, application of toxicants at the Sugar River and Pool 11 sites would be problematic because of the presence of valuable gamefishes and several state threatened and endangered fishes. If mosquitofish elimination were attempted by either direct capture or poisoning, complete eradication of

all mosquitofish present would be required, because the survival of one impregnated female could repopulate a site within a few months. However, the nature of the species makes complete eradication unlikely.

Given that direct elimination of western mosquitofish from Wisconsin is probably impractical, I feel that the best management option is to minimize the chance of their further spread. For Pool 11, Lock and Dam 10, at the upper end of the Pool, may be an effective barrier to further upstream movement. Although some fish species do use the lock to move through the dam, such movement would require mosquitofish to traverse a large stretch of deep open water, a habitat they usually avoid because of their vulnerability to predators in this sort of habitat. During high water, the dam's roller gates are open and some fish species can swim upstream through the dam, but under these conditions river currents are very strong, and it is uncertain whether a small and relatively weak swimmer such as the mosquitofish could actually traverse the gate openings. For the Sugar River, mosquitofish have unimpeded access to about 21 miles of the Sugar River mainstem, from the Illinois border to the impassable dam that forms Decatur Lake 2 miles upstream from the CTH F site, plus many backwaters, sloughs, and tributaries.

I am convinced that a critical step in stopping the expansion of mosquitofish outside of Pool 11 and the Sugar River below Decatur Lake is the prevention of direct human transfers of mosquitofish, whether through bait bucket releases or introductions for mosquito control. An existing regulation prohibits the collection of bait "minnows" from the Mississippi and lower Wisconsin rivers, and I believe that this rule should be expanded to include the Sugar River and perhaps other likely mosquitofish habitats in southern Wisconsin as well. Newly enacted regulations that prohibit the importation and possession of mosquitofish in Wisconsin should be publicized and strictly enforced. Where biological mosquito control is desired, the use of native species such as fathead minnows should be promoted. Existing education and publicity programs that explain the dangers of the spread of invasive species should now include the mosquitofish as a potential risk.

I recommend that the Wisconsin DNR carries out targeted monitoring of suitable habitats in southern Wisconsin over the next five years to determine whether western mosquitofish have truly become established in the state and whether they have spread. At a minimum, this monitoring should include Pool 11 and the lower reaches of its tributaries, adjacent areas of Pool 10 and its tributaries, and the Sugar River and its tributaries above and below the Decatur Lake Dam. Sampling should employ small-mesh seines and dip-nets in the shallow, slow-moving, marginal areas of sloughs/backwaters, streams, and rivers. Surveys should take place in late summer when mosquitofish are most active, numerous, and vulnerable to capture.