Eastern Mosquitofish, *Gambusia holbrooki*, for Control of Mosquito Larvae[1]

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Introduction

There are approximately 3500 species of mosquitoes globally, 80 of which are found in Florida (Connelly et al. 2014). Although not all species of mosquito can transmit pathogens to humans, many species do transmit pathogens that lead to public health concerns. Diseases transmitted to humans by mosquitoes include chikungunya, dengue, Eastern equine encephalitis, St. Louis encephalitis, West Nile fever and encephalitis, and zika (Connelly et al. 2014; Parker et al. 2016). Florida's climate is suitable for mosquito population growth and year-round integrated pest management efforts are conducted to curtail that growth. These pest management efforts include source reduction, chemical control, and biological control. The use of native animal species, particularly fish, to reduce mosquito populations is popular in multiple states including Florida (Connelly et al. 2014). This EDIS publication details the use of eastern mosquitofish, *Gambusia holbrooki*, for mosquito control purposes (Figure 1). It also discusses other native fish species that may reduce mosquito populations and help reduce public health concerns.

Figure 1. Female eastern mosquitofish, *Gambusia holbrooki*, showing the distinguishing dark spot just posterior to the gut.
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Natural History

The eastern mosquitofish is a native species in the Atlantic and Gulf slope drainages and is common throughout Florida (Page and Burr 2011). The north end of its range is located from New Jersey down through the eastern portion of the Atlantic seaboard reaching as far west as southern Alabama (Boschung and Mayden 2004; Page and Burr 2011). Its coloration is silver to forest green on top and on the sides and sometimes exhibits a dark bar below the eye (Boschung and Mayden 2004; Page and Burr 2011). The scales are typically outlined, giving the body a cross-hatched appearance. It also has an upturned mouth and rounded tail fin, and it reaches lengths of 2–3 inches (5–8 cm) with females being larger than males (Boschung and Mayden 2004; Page and Burr 2011). They are typically found on the surface and edges of ponds, lakes, backwaters, canals, and sluggish streams (Boschung and Mayden 2004; Page and Burr 2011). Mosquitofish can tolerate variation in water temperature, salinity, and dissolved oxygen, making them adept at surviving in stagnant pools, large puddles, and swamps (Page and Burr 2011). They are often associated with vegetated areas in these water bodies where they feed on small insects, crustaceans, and plant material (Page and Burr 2011). Most fish within the family Poeciliidae, including mosquitofish, are live bearers, meaning they give birth to live young. The eastern mosquitofish matures in 4–6 weeks and can produce broods throughout the year (Page and Burr 2011; Pyke 2008). The gestation period of

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the eastern mosquitofish lasts about a month, and each brood yields roughly 40 to 60 offspring; but larger broods of 350 have been documented (Boschung and Mayden 2004; Pyke 2008).

Culture Techniques

Eastern mosquitofish are quite adaptable to their environment and, therefore, can be grown with many different culture techniques and containers. Below we will briefly discuss how to breed and grow fish in both tanks and ponds.

Pond Culture

Growing and maintaining populations of eastern mosquitofish in ponds is less technical and more labor efficient than growing them in tanks (Figure 2). Earthen ponds are common throughout Florida due to its low lying elevation and access to the water table. Furthermore, the number of earthen ponds throughout Florida is increased by the ornamental fish aquaculture industry, which uses these ponds to produce ornamental fish (Hill and Yanong 2016). When using earthen ponds for mosquitofish production, careful planning and cooperation with the appropriate regional permitting agencies is recommended. Once dug, the pond should have a water source to maintain the water level, which is reduced by evaporation and seepage. This is best achieved through access to wells containing water that has not been chemically treated. Well water often contains hydrogen sulfide, which can be toxic to fish. Thus, it is best to have the well water inlet placed above the pond's water surface to agitate incoming water, which degasses hydrogen sulfide. Once filled with new freshwater (for the first time or after subsequent cleanings), the water should be fertilized to encourage growth of phytoplankton and zooplankton (Watson and Cichra 2016). These tiny plants and animals will serve as food for the stocked fish population. The newly excavated pond is now ready to be stocked with fish.

Figure 2. A small pond at the University of Florida's Tropical Aquaculture Laboratory where thousands of eastern mosquitofish, *Gambusia holbrooki*, are grown.
Credits: UF/IFAS

Mosquitofish, however, are quite amenable to a variety of water body types and don't need an excavated, managed pond to be grown efficiently. They can grow well in retention and detention ponds as well as other water bodies that allow mosquitofish to be harvested efficiently and legally. County or municipal retention ponds can provide low-cost, reliable sources of eastern mosquitofish for stocking programs. For any ponds that are not privately owned, always check with the owner, including ponds owned by municipal, county, or state government, for permission to access the pond and harvest mosquitofish. Feed may not be added to some retention and detention ponds because their purpose is to filter nutrients and sediments from storm water runoff.

STOCKING AND PRODUCTION

The size of the pond and the demand for mosquitofish will determine numbers of fish to stock into your pond. Mosquitofish are prolific breeders with a quick maturation period (Pyke 2008), so they will quickly fill a pond. Just like in tank culture, they reproduce and grow faster at the higher end of their optimal temperature range (Pyke 2008). One of the benefits of pond culture is the availability of aquatic organisms for mosquitofish to feed on throughout the day (Watson and Cichra 2016). Pond culture, warm temperatures, and additional feedings ensure fast mosquitofish growth. At the University of Florida's Tropical Aquaculture Laboratory (TAL) we feed our mosquitofish pond cultures twice daily with Purina Tropical Fish Chow Pond Meal (33% crude protein). Although mosquitofish are prolific feeders and will feed off of pellets twice their size, smaller pellet sizes will be consumed and utilized more efficiently for multiple life stages of mosquitofish. Other diets with varying protein levels can also be fed.

HARVEST

There are two ways to harvest small fish from a pond; trapping and netting (Crosby et al. 2014a). Traps are often used with livebearers because the fish reproduce continually and can be graded for size once harvested (Crosby et al. 2014a). Using a trap is sufficient for harvesting a portion of the population without disrupting the water quality and majority of fish within the pond. There are different types of traps that can be utilized for this procedure, all of which are easy to operate. Trapping is done by baiting the trap and returning after sufficient numbers of fish are caught. Baits vary and can be fish or pet feed, mashes based on oatmeal or bread, or canned fish such as jack mackerel or sardines (Crosby et al. 2014a). Soak time (time where the baited trap is deployed) can vary from a few minutes to 2–3 hours depending on fish density and attraction to the bait.

Care should be taken with traps fished below the surface or for extended time periods (e.g., overnight). In these cases, the fish may use the available oxygen in the traps and die. When setting traps for mosquitofish it is advantageous to have some of the trap break the water's surface, so trapped fish can utilize oxygen from the air in the event that oxygen levels in the water become reduced.

A dip net or hand net can also be used to harvest small numbers of fish from a pond with minimal effort. From the shore, food or bait can be fed to the pond and as the fish come to the surface the net can be used to collect them. The needed number of fish can then be retrieved from the net and placed into a bucket of pond water.

Seine nets are used to harvest most of the fish that are in a pond at one time (Crosby et al. 2014a). With livebearers, such as the eastern mosquitofish, this practice is not often employed because multiple age classes and sizes will be harvested, which is not ideal as the young will have to be re-stocked into another pond. Additionally, most of the water may have to be pumped out of the pond to seine efficiently (Crosby et al. 2014a). This along with sediment disrupted by pulling the seine net reduces water quality and may lead to fish kills, though not commonly with eastern mosquitofish. However, in instances when a whole pond needs to be harvested, using a seine net is the most ideal method. It is also possible to use a seine net with a larger mesh that will allow the smaller fish to pass through and only catches the larger individuals. If water is not pumped out, the pond should remain in good condition for fish culture.

Tank Culture

Tank culture has advantages and disadvantages relative to pond culture. The eastern mosquitofish can tolerate varied water quality conditions. However, tank culture allows for more control of those water quality parameters, keeping them in the range for optimal growth. Although preference has been shown for temperatures between 31°C–35°C (88°F–95°F); they tolerate a range from 1°C–40°C (33°F–104°F) (Pyke 2008). Temperatures closer to the preference range will provide for better growth, reproduction, and survival. In general, pond culture is far easier, usually cheaper (if one has access to a pond), and is more productive. Eastern mosquitofish in tank culture often show aggression and kill one another, can be more susceptible to disease outbreaks, and will eat most of their own offspring. These disadvantages can be reduced with pond culture.

BROODSTOCK AND SPAWNING

Mosquitofish mature in about 4–6 weeks depending on the temperature (Pyke 2008). When mature, males have a gonopodium, a modified anal fin that is designed to deliver sperm to the female (Pyke 2008). A female will have no gonopodium, but will have a dark spot (pregnant spot) just posterior to the gut (Figure 1). Male eastern mosquitofish can breed continuously under ideal conditions, but females cannot become pregnant while carrying a litter (Boschung and Mayden 2004; Pyke 2008). Since gestation can last up to a month it is best to have a breeding population that consists of more females than males.

It is important to remove any fry from the system quickly because the live young will be eaten by adults. One method to deal with this is to remove pregnant females from the breeding population and put them into a fry growout system. When the fry are born, the mother can then be easily removed with a net. This practice increases labor, necessitates additional tanks, and adds handling of the females. Another solution is to have a fry growout tank in succession with the breeding tank with the water flowing from the breeding tank to the growout tank. With a net or screen in place to keep the adults in, the fry will pass through and be collected in the growout tank. Undoubtedly, some will be consumed by adults or remain in the breeding tank, but some will also pass through to the growout tank. Placing natural or artificial plants into the system as cover for the offspring can help, but large numbers of fry are still eaten. In general, production in tank systems will be less than in pond systems.

A very effective method is to place a refuge in the tank for the fry to go into. A floating plastic basket with openings small enough to keep the breeders outside but allow the fry inside is often used for eastern mosquitofish and other live bearing species. Attaching artificial cover, such as plastic aquarium plants around the edges of the basket, will allow the females to release their young in a somewhat protected area. The fry can then be netted, or dipped, out of the basket and moved into a separate tank for growout.

GROWOUT

Raising eastern mosquitofish fry is fairly straightforward. Multiple daily feedings and water quality monitoring and maintenance will ensure quick growth. They are opportunistic feeders and graze on a number of prey items in the wild so any standard flake or pellet diet will suffice for feeding eastern mosquitofish (Pyke 2008). Depending on the feeding rate, temperature, and target size, the growout period should last about a month. The appropriate size mosquitofish for stocking to control mosquitoes is approximately one inch (2.5 cm), which will likely be attained within a few weeks. At this size, they can also be reintroduced into any adult population. A few more weeks (approximately one month total) and breeding size will be attained.

HARVEST

The difficulty of harvesting from a tank is dictated by the size and shape of the tank used. If the tank is large, methods used for pond harvest are probably best adapted for use in tanks. Otherwise, there are a variety of net shapes and sizes that can accommodate complete or partial removal of fish from the tank. If needed, the tank can be drained and completely harvested, cleaned, and filled back up, making removal of fish simple.

Other Species

Although mosquitofish have the namesake, other native Florida species will also consume mosquito larvae. Other native poeciliids (live bearers) found in Florida include the sailfin molly (*Poecilia latipinna*) and least killifish (*Heterandria formosa*); the latter is considered one of the better mosquito control candidates (Kern 2017). Numerous fish species will consume mosquito larvae at some time during their life cycle, especially during the early growth periods when mosquito larvae can constitute a portion of fry or juvenile fish diets. The smaller fish will continually graze down mosquito larvae populations while the larger species will out-grow them and move onto larger prey items. In Kern (2017), a list of native Florida species that are ideal for mosquito control in small ponds is available.

Commercial Availability

Florida has a robust aquaculture industry throughout the state, with many commercial producers offering a wide variety of native species for stocking purposes. In addition, the ornamental tropical fish industry often will have ponds with eastern mosquitofish. Thus, it is often easier and cheaper to purchase fish compared to establishing a culture system. A list of fish suppliers in Florida is available from the Tropical Aquaculture Laboratory, many UF/IFAS Extension offices, the Florida Fish and Wildlife Conservation Commission, and an internet search.

Use in Mosquito Control

Prior to becoming adults, most mosquito larvae hatch and develop in water (Connelly et al. 2014). It is this vulnerable waterborne larval stage that is targeted by Mosquito Control Programs that utilize mosquitofish (*Gambusia* sp.) as biological control agents. Because of their tolerance to variable and even sub-standard water quality, mosquitofish can be stocked into artificial containers housing standing water; such as rain barrels, fountains, water buckets, and planters (Pyke 2008). When possible, rather than being stocked with mosquitofish, these containers should be emptied to discourage the proliferation of mosquito populations. Other locations as varied as retention ponds, abandoned swimming pools, and cattle troughs can be stocked effectively. One adult mosquitofish can consume up to 100 mosquito larvae a day. This consumption rate coupled with the ease of reproduction reduces the number of mosquitofish needed to start a viable population. We recommend 3–5 fish for small structures like rain barrels and 5–7 fish for small, backyard ornamental ponds, making sure to stock 1 or more females. For larger structures, such as detentions ponds or unused swimming pools, we recommend 1 fish for every 20 square feet of surface.

If growing fish for mosquito control distribution purposes, they should be placed in a tub or tank with clean well water of similar temperature after harvest. At this point, they can be prepared for distribution or shipping. Depending on the amount of time they will spend in transit, certain shipping practices may have to be implemented to ensure healthy arrival at their destination (Crosby et al. 2014b). If they will be stocked that day into their new water, then sealing the bag with ambient air will suffice. Once at their destination, let them float in their new water with the bag sealed for approximately 15 minutes. This allows for temperature acclimation to occur. Following acclimation, mosquitofish can be released into the new water.

Conclusion

Mosquitoes and their related public health problems are a major concern for people living in warm weather climates, such as Florida. Implementing multiple management strategies is the best way to combat public health issues associated with mosquitoes. By using native fish species that eat mosquito larvae, including eastern mosquitofish, we are able to utilize an additional tool to help alleviate those concerns. Furthermore, eastern mosquitofish are relatively easy to grow and maintain, readily available from commercial farms, and thrive within their natural, native environment.

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