Strategies to Breed Bluegill for Use in Aquaponics Systems

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Abstract

Bluegill, *Lepomis macrochirus*, is a freshwater sunfish that can thrive in an aquaponics system. Inspired by the aquaponics project located in the Sustainable Technology Outdoor Research Center (STORC) at Sacramento State University, the goal of this experiment is to produce an artificial, competitive environment that will entice bluegill fish to reproduce. This research can be used to replenish aquaponics systems, which would add to the sustainability of aquaponics by cutting dependency on aquaculture to purchase juvenile fish for restocking, increasing the economic gain and self-sufficiency of aquaponics systems.

Introduction

The Sustainable Technology Outdoor Research Center, or STORC, is located on the Sacramento State University campus and created an aquaponics project in January of 2014. Professors Dr. Dudley Burton and Dr. Brooke Murphy spearheaded the aquaponics projects which has been a great hands on educational learning tool (Sac State Magazine, 2014). The center serves as a place for students, faculty, and staff to work together to find innovative ways to be sustainable. Students from many majors work at the center on projects such as aquaponics, composting, vermiculture, biodiesel, energy technology, and water technology (Sac State Magazine, 2014).
Aquaponics is a multitrophic, sustainable agricultural system that combines hydroponics and aquaculture. The combination of these two practices creates a system that produces organic vegetables and fish for consumption. This is possible because fish waste is acting as a natural, organic fertilizer for the plants and promotes growth (Diver and Rinehart, 2010). Aquaponics systems mimic the natural ecological processes that occur in the wild and act as a biofilter.

The biological filtration cycle starts with the fish. Water containing fish waste, ammonia and fecal matter, is pumped up to a growbed where bacteria convert it to nitrite, then nitrate (Figure 1). The plants use up the nitrates, cleaning the water before it is cycled back to the fish. Nutrient monitoring is important for maintaining balance in an aquaponics system. Nitrite and nitrate levels are good indicators of system health. However, it is also important to be aware of dissolved oxygen, ammonia, pH, and chlorine levels within a system (Diver and Rinehart, 2010). Dissolved oxygen is required for fish to breathe using their gills, making it an important factor in aquaponics. For example, bluegill is unable to tolerate dissolved oxygen levels below 5 mg/l (NJDFW, 2008). Ammonia levels are helpful in determining whether a balance has been achieved between the living bacteria, plants, and fish. If there are more fish and waste being produced than can be used by the bacteria and
plants, then ammonia levels will rise and become toxic to fish. Also, the acidity or alkaline qualities of a system can be determined by testing pH levels, which for bluegill must remain between 6.5 to 8.5 to maintain a health population.

Aquaponics makes an important contribution to agricultural sustainability, improving economic profits as water is recycled in the system and saving expenses otherwise put toward water purchases for irrigation (Diver and Rinehart, 2010). Also, because water is only lost through evaporation or transpiration only one percent of water is used compared to the production of fish through Aquaculture alone (Diver and Rinehart, 2010). Aquaponics requires a consistent flow of fish to restock a system, breeding bluegill diminishes reliance on aquaponics farms or fishing adding to the economic benefits accumulated by a system. Purchasing fish from aquaculture farms can produce considerable expense. Likewise, fishing rarely yields enough replacement fish to maintain a viable population for large systems.

Bluegill, *Lepomis macrochirus*, were first found across the eastern and central United States; however, they are now found across the nation (MDNR, 2014) largely due to the fact that they are a popular sport fish often stocked in ponds and lakes for sport anglers. Bluegills are well suited for aquaponics systems because they are a sturdy species. They also cohabitate well with other fish species, providing a variety of protein options in aquaponics production. At the STORC bluegill have shared tanks with goldfish, largemouth bass, and catfish successfully.

Bluegill range in color from dark blue or purple to yellow and have a black ear tab, a good indicator of a fish's sex (Table 1). Large, protruding ear tabs accompany males and small, shorter ear tabs are found on females. Adult bluegills average 20 centimeters in size and forage on small crustaceans, worms, insects, plant material, and even smaller fish (MDNR, 2014).
Bluegill Sex Identification:

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holds weight under chin</td>
<td>Holds weight in belly</td>
</tr>
<tr>
<td>Large, elongated ear tab</td>
<td>Short ear tab</td>
</tr>
<tr>
<td>Generally larger in size</td>
<td>Eggs are present in females if belly is swollen</td>
</tr>
</tbody>
</table>

Table 1: Compares sex identifying features of bluegill (Created by Amber Dewey).

Bluegill are group nesters and require competition to entice breeding. Each male excavates a nest, which is a bowl-like crevice in the ground (Figure 2). Nests are spaced close together with the larger males residing at the center of the nesting community due to a greater tendency for brood loss in nests on the outskirts of a group (Willis, 2005), which shows that there is a distinct advantage to nesting in communities. When a male bluegill's nest is ready, he will circle it and once a female has been attracted to that nest, she joins in circling the nest before laying her eggs for the male to fertilize. At this time the female leaves and the male remains to guard the nest (MDNR, 2014) and fan the eggs to aerate them, showing relatively high parental investment (Coleman et al.,

Figure 2: Identifies a bluegill's nest (PhotoCourtesy of Amber Dewey).
Due to the difficult nature of breeding bluegill in captivity and their compatibility with aquaponics systems, the goal of this research is to produce an alternative fish source that is sufficient to decrease reliance on outside sources for stocking these systems.

Methods

To accomplish the goal of breeding bluegill—a notoriously difficult fish to breed in captivity—an attempt was made to mimic the natural, competitive environment they would find in the wild. Two 68.135 liter fish tanks were placed side by side so that the fish could see each other without being able to fight. A 35.56-centimeter by 45.72-centimeter growbed was placed above the tanks to act as a bio-filter (Table 2). The growbed was then filled with lava rocks and planted with wheat grass, then basil after the wheat grass was harvested. In the fish tanks, playground sand was placed in the bottom for nesting material along with several rocks varying in size. A pump cycled water to the growbed, which was drained back into the tank using a bell siphon, creating an ebb-and-flow of the water on plant roots. Finally, a grow light was placed above the plants to complete the aquaponics system and one male bluegill and two females were placed in each tank. A removable barrier was constructed on top to prevent the bluegill from breaching the tanks. Tap water was used for this experiment, allowing 24 hours for chlorine to dissipate before being added to the fish tanks. The bluegill used in this experiment consisted of both farm raised and wild caught specimens. Also, fish were removed from the breeding tanks only after their behavior suggested they were no longer reproductively viable (Figure 3). This was portrayed by males when they stopped guarding their nest and were uninterested in the female bluegill. All research took place in a lab located at the STORC on Sacramento State University campus.
Results

Three breeding groups were analyzed during this experiment. Each group consisted of two tanks, side-by-side consisting of 2 males and 4 females (Figures 4-10). In all groups, breeding behavior was observed. Each male dug its nest within 24 hours and displayed nest guarding. One breeding set in each group also engaged a female in circling their nest with them. However, no eggs were produced from this experiment.
Breeding Group 1

Figures 4 & 5: Shows images of breeding group 1 (Photos Courtesy of Amber Dewey).

Breeding Group 2

Figures 6 & 7: Shows images of breeding group 2 (Photos Courtesy of Amber Dewey).

Breeding Group 3

Figures 8, 9, & 10: Shows images of breeding group 3 (Photos Courtesy of Amber Dewey).
Discussion

The results gathered from this experiment merit further research. The bedding material was shown to encourage nest building. Competitive behavior was also achieved showing the setup of the tanks to be sufficient. However, no eggs were laid.

Tank size was believed to be a limiting factor in this experiment. A solution could be to repeat the experiment using larger tanks or a small raised pond with a separator between breeding groups. Due to the colony based breeding habits of bluegills, if a constructed pond is used for future research, a natural bluegill breeding community could emerge and be more encouraging for reproduction (Willis, 2005). Another possible problem is that the breeding sets are not compatible. For example, some males were too aggressive. The males in some cases would injure the female to the point of making her ill by attacking her fins, making it difficult for the female to swim. Again, tank size is believed to be related to this factor as well. Many of the male’s nests encompassed most of the tank, leaving very little space for a female to escape a guarding male. Also, timing could be another factor in compatibility if the female is not ready to lay her eggs when the male's nest is ready. Bluegills prefer to nest in areas with high vegetative cover (Kaemingk et al., 2013). A lack of vegetative cover in the experiment tanks could have been a factor in why eggs were not laid. Water turbulence may have disrupted the fish as well (Casterlin and Reynolds, 1978). The ebb and flow of the research tanks may have caused too great of a disturbance in the water.

Another determining factor in why the bluegill did not reproduce may have been consistency of care. Many people were helping to feed and regulate the fish. Often times the
door to the lab was left open, changing the temperature in the lab. Sometimes overfeeding occurred as well, causing solid buildup in the system. This eventually clogged the pump that was cycling the water and allowed for a buildup of ammonia.

If this experiment had been successful it would have improved the sustainability of aquaponics systems. These systems are the future of agriculture due to their ability to cycle and preserve water. In a time of climate change and increasing drought, water is an invaluable resource. These systems are of particular importance to the needs of people in arid regions (Diver and Rinehart, 2010). Also, by being able to breed juvenile bluegill, instead of purchasing them, there will be an increase in the economic gain of aquaponics systems.
References Cited


Figure 1: http://diyaquaponicsguide.com/

Figures 2-10: Courtesy of Amber Dewey, 2014

Tables 1-2: Created by Amber Dewey, 2014