Indoor Spawning and Raising of Warmouth, *Lepomis gulosus*

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The Warmouth, *Lepomis gulosus,* is similar in body shape to the common and widespread Green Sunfish, *Lepomis cyanellus*. As a result the two species are frequently considered to be very similar in other aspects including behavior and culture requirements. Sorenson (1991) and Rollo (1994) report successfully propagating the Green Sunfish indoors, therefore we attempted to spawn Warmouth indoors to see how they compare. Herein we report our observations of Warmouth sexual dimorphism (morphology, coloration and behavior) and efforts to breed and rear Warmouth using indoor systems. Some of the techniques are of a scale suitable for the home aquarium or small laboratory.

Photography/remote monitoring: Culture systems and adult and juvenile Warmouth greater than 25 mm total length (TL) were imaged using a Nikon D80 Digital Camera with a Nikon DX AF-S NIKKOR 18-55 mm 1:3.5-5.6 G2 ED Lens. Photographs of early developmental stages were taken using a LEICA MZ95 dissecting microscope with a 1.0x objective lens and a LEICA DFC 290 digital camera. Remote webcams (LINKSYS® Wireless-G Internet Home Monitoring Camera™) were used to monitor fish in breeding systems from a computer in a different room. Webcams enabled multi-tasking of authors when breeding activity was low and minimized disturbance that could disrupt breeding behaviors.

Observations On Sexual Dimorphism

Coloration and morphology: We were able to readily distinguish male and female adult Warmouth based upon primary and secondary sexual characters for both wild-caught and tank-reared fish. Gender was confirmed by the manual expression of gametes. Males, especially those from the wild, have more apparent red spotting on the flanks. Males also had a well developed orange-red spot at the base of the dorsal fin rays which the female lacked, or if present on the latter, was a pale yellow. *Editor's note: To preserve the detail of these diagnostic features, color photos of these traits have been included on page 13.* Some males also had a reddish flexible margin on the operculum. Reds and yellows were less developed in tank-reared fish fed only pellets. Opercular tabs as well as dorsal and anal fins were notably larger on males relative to similar-sized females. The urogenital opening (Figure 1) of the male is smaller, more elongate and tighter in appearance relative to the female (Brauhn 1975). Color differences as a function of sex, but not related to red coloration, were more developed and enhanced by body and fin posturing. Males darkened overall with pelvic fins becoming nearly jet black. Black spots adjacent to light yellow spots on flanks resulted in a dappled appearance that was enhanced by the male's movement. Vertical fins of posturing males were extended with darkened membranes enhancing the interspersed silvery spots. Nesting male base coloration darkened by increased black spots on the flanks and pelvic fins becoming a grayish black. Females appeared more yellow, especially on the lower abdomen. Ripe female base coloration has darker mottling with the distended abdomen more contrasted by increased yellowing. Eyes of ripe females approaching the nest darkened and remained so as long as on the nest with the male. Other differences were noticed between captive-raised and wild-caught stocks. Other than having more intense coloration, fish collected from a wild population (a quarry on the Lincoln University of Missouri campus) had noticeably smaller eyes and a larger mouth relative to TL than indoor-reared fish. We believe variation in mouth size is due to the diet and feeding habits like that found in Orangespotted Sunfish, *L. humilis* (Hegrenes 2001).

Behavior

Both sexes, when courting, would approach another adult Warmouth and gently roll about 10 degrees exposing the ventral abdomen to the other fish. Only males were observed defending a territory. Larger males were most successful at defending territories. Nest construction was performed by males rhythmically moving their caudal fin in a sweeping motion immediately above the nesting substrate, causing the formation of a bowl-shaped indention in the gravel. Only courting males would approach another fish with gills flared and attempt to lead a female to the nest site. Females approaching the nest of a courting male would blanch with darkened eyes and move

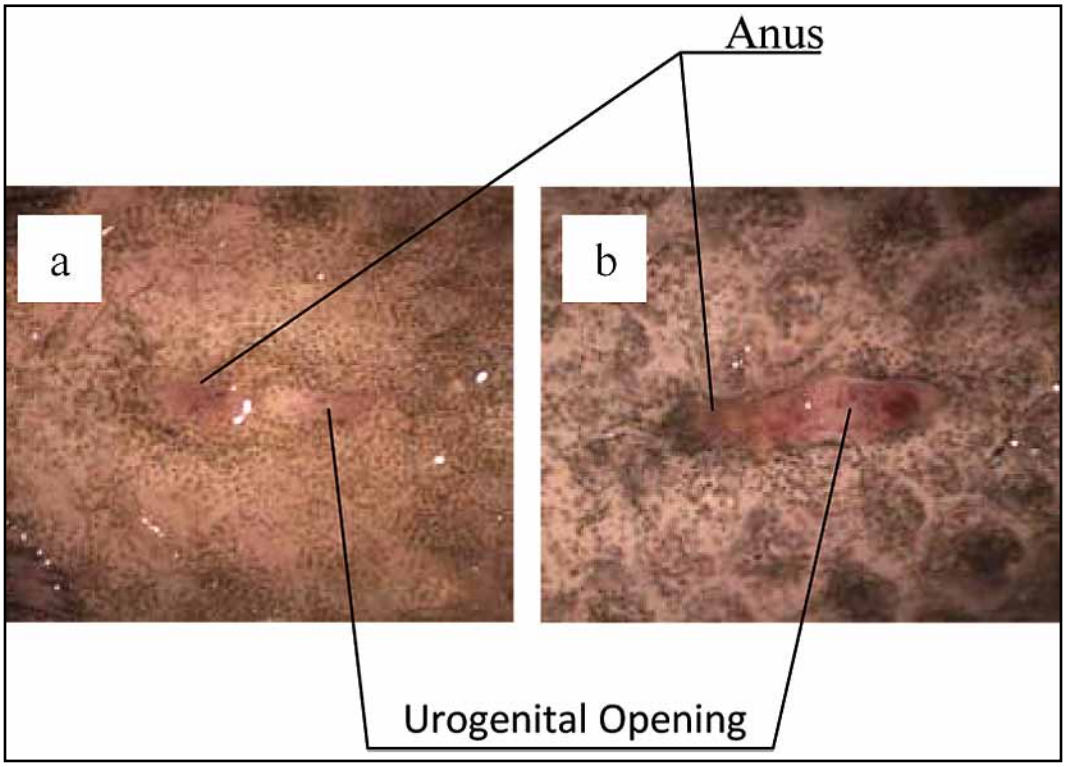

Fig. 1.
Photograph of ventral aspect Warmouth, *L. gulosus*, showing anus and urogenital openings of a) ripe male and b) nearly ripe female. Anterior oriented to left.

directly into the nest to engage in rock biting (Wetzel 2007). A courting male with a female on or near his nest would swim actively around the nesting site with increased black pigment and attempt to turn the female on the nest. A spawning female, while turning with the male on the nest, would rub her ventral area against/near the male's flank as eggs were extruded. The extrusion process was accompanied by a series of rapid jaw movements and trembling which was also noted by Larimore (1957). The jaw movements have not been observed in other *Lepomis spp.* Brood care was performed only by males. Brooding (paternal) males used their pectoral and anal fins to fan (direct water flow over) embryos and prolarvae. The paternal males frequently chased other fish off or away from the nest site. Paternal males would occasionally tail-sweep the nest with the brood present but this behavior decreased as the brood matured and the males transitioned more to the fanning behavior. Paternal investment ended once the larvae left the nest.

Environmental

All systems were indoors with overhead flourescent lighting (16 h per day lights on) and ambient air temperatures keeping water temperatures in the range of 20.7° to 28° C. Filtration was a combination of mechanical and biological to maintain water quality within a range suitable for housing most freshwater fishes. Silica-glass diffusers powered by a regenerative blower provided supplemental aeration. Tanks were bare except for pre-fabricated nests and partitions of breeding systems. We provided each male with a nest (50.8 cm wide x 8.3 cm deep circular black oil pan) filled to a depth of 2.75 cm with pea gravel (Figure 3). Semi-permeable partitions (Figure 2) were constructed to allow passage of water between compartments within tanks but control interactions between courting males and the females, especially with tighter confinement. Tanks were scrubbed and siphoned as needed to remove organic debris. Great care was taken to not contact early development stage warmouth with cleaning equipment.

Feeding Regimens

Feeds and method of application varied as a function of fish size. Adult fish were fed twice daily to *ad libitum* with Mazuri™ Omnivore Aquatic Gel Diet®. Both sexes were able to build up adequate reservoirs for spawning if fed sufficiently for more than 28 days. We used a variety of feeding regimens for young fish in an effort to find a system that worked effectively. Transition from live freshly hatched brine shrimp nauplii (BS) to a dry formulated diet (Bio Oregon® Bio vita® 0# Crum) occurred at either 14 d, 28 d or 37 d post-exodus and involved a co-feeding period of at least 7 d. Co-feeding was the application of both types of feed at the same time. As fish grew, pellet size of the same formulation increased to #1 crumb, #2 crumb and

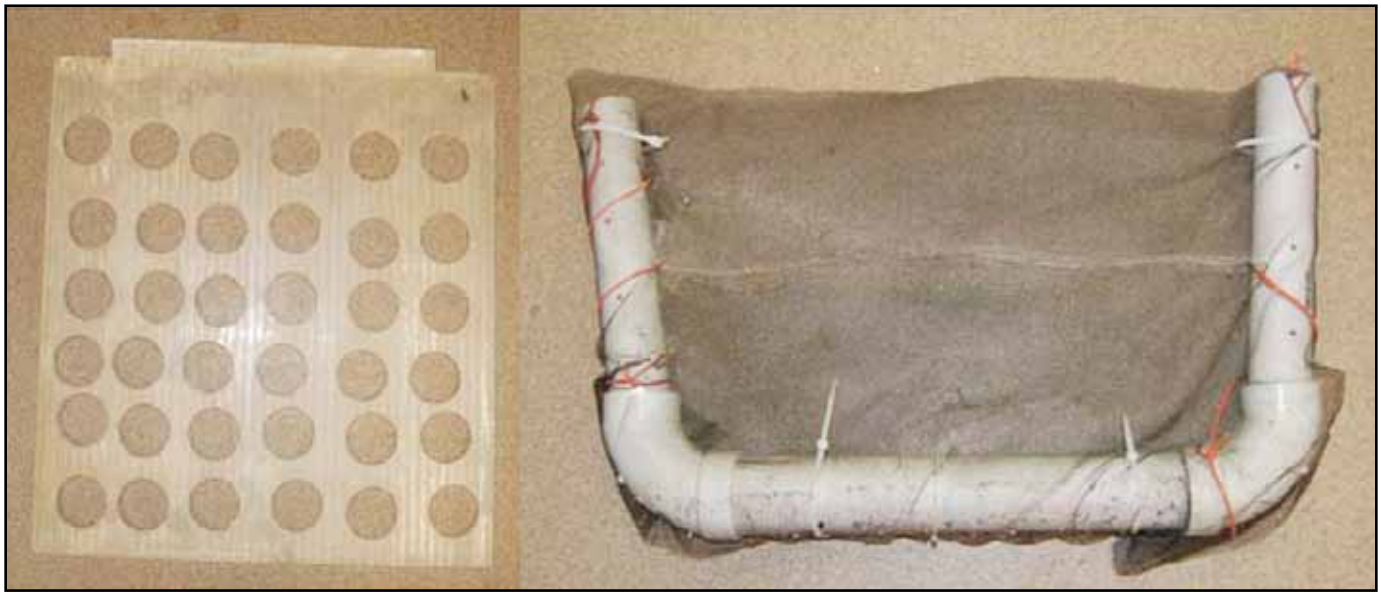

Fig. 2.
Photograph of partitions used in 40-gal glass aquarium (left) and 120-gal fiberglass raceway (right).

ultimately 1.2 mm. The dry formulated diet was applied either by hand or 12-h belt feeder.

Breeding Systems/Methods

Three configurations were used following methods found successful in propagating other sunfish. Males and nests were acclimated over a period of one to several days prior to addition of females into the system. This allowed time for males to establish territories and define hierarchy.

Fig. 3.
Photograph of pre-fabricated nest used by male Warmouth, *L. gulosus*.

The single male system (SM) with one or more females used a 150-L (40-gal) glass aquarium (91.5cm x 46cm x 42.5cm) filled to a working depth of 36 cm. The male and nest were placed to one side of the tank and the following day conditioned female(s) were introduced and confined to the other side using the plastic partition (Figure 2). By day three, females were attempting to go through the partition, so the partition was removed and immediately the male began to court the females. The partition was removed allowing the sexes to interact only when fishes could be monitored. Remote monitoring with a wireless webcam was from a horizontal aspect. Video recordings of spawning behavior were made once a female committed to a spawning effort. To keep the male receptive to ripe females, we eliminated parental obligations by removing the nest once eggs hatched. On several occasions, multiple, apparently, ripe females entered the nest and the males would abruptly stop courting. The females would attempt to vent-rub even though the male's courting has ceased. Courtship and spawning would only occur successfully with a single female on the nest. Several males that failed to construct and defend a nest site were replaced. Males observed to be reluctant to display courtship and spawning behaviors were replaced.

A problem noted with this setup is that once females were removed, the male would often neglect parental duties and brood survival was greatly reduced. Successful incubation required either leaving at least one female in the tank or removal of the nest for incubation in another tank with water flow provided by an air-diffuser placed in the center of the nest. Males were often observed to be reluctant to spawn when they were the only male in the system; adding another male often promoted more intense courting, possibly because of competition between the males.

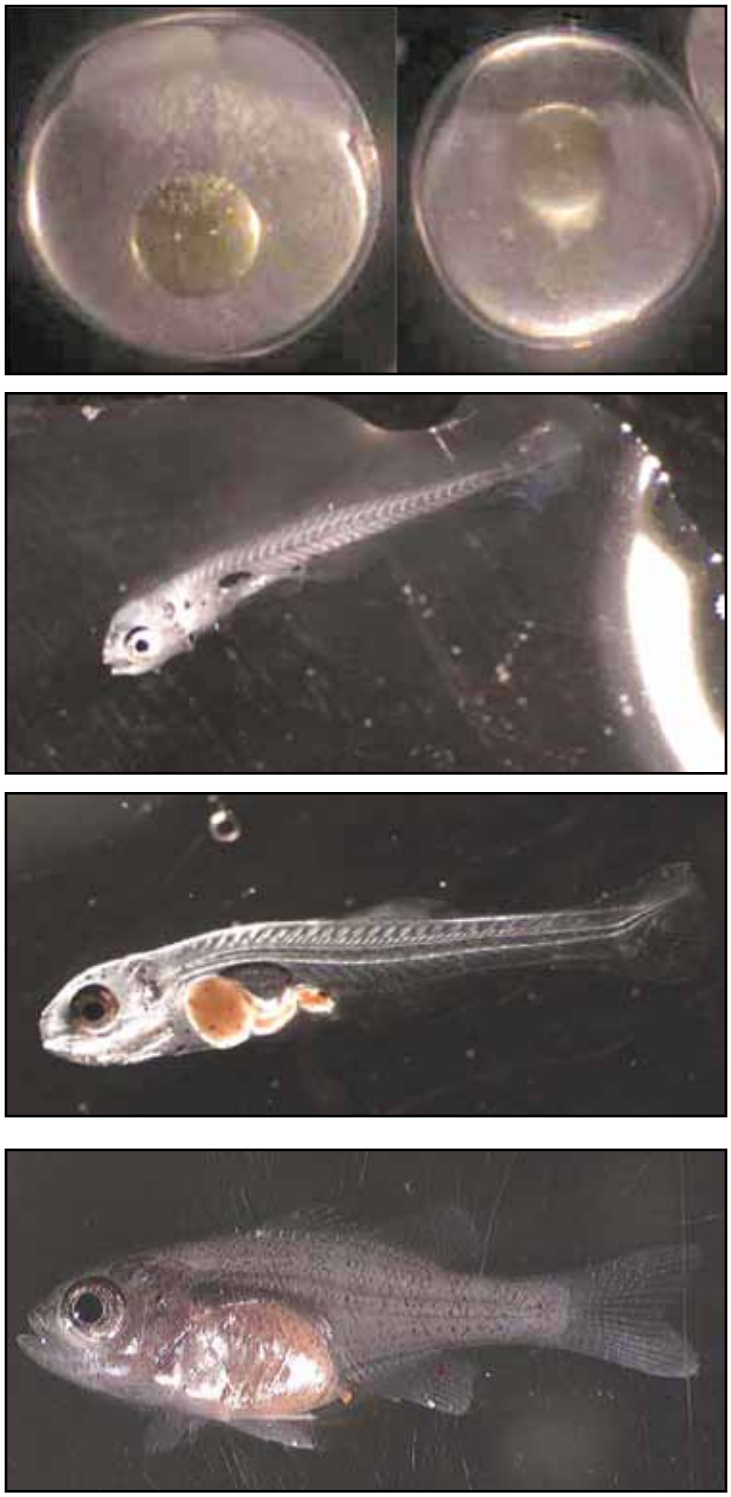

Fig. 5.
Photographs of early life stage Warmouth, *L. gulosus* at second division (4-cell) and gastrulation (top left), prolarvae immediately post-hatch (top right), a larva at exodus (second left), at 6 days post-exodus (second right), at 8 days post-exodus (third left), at 11 days post-exodus (third right), and at 35 days post-exodus fry TL = 15.9 mm (above). All photos by Luke Hirsch.

The two-male system (TM) used a 454-L (120-gal) fiberglass raceway (240 cm x 60 cm x 30 cm) filled to a working depth of 24 cm. A partition divided the tank so that the side with the two males and nest represented approximately 66% of the tank volume. The temperature was 20.7° C when males were stocked. Males quickly feuded over the single nest and within an hour one male had become dominant and claimed the nest. Conditioned females (n=7) were confined as a group to the smaller volume by the partition. At the beginning of the work day the partition was removed allowing the females to interact with the males over nests. At day's end, the females were driven by hand to the smaller section and the partition replaced. Remote monitoring was accomplished using a wireless webcam placed above the tank. When the females were released, only the dominant male could defend a nest and successfully court the females. The second male

would attempt to defend a territory but was unable to court the females.

Conditioning of the females was minimal and only required the females to be fed good amounts of food a couple weeks prior to spawning. Courting behavior includes a male swimming toward the females swaying his body while flaring his operculum then returning to his designated nest; this is repeated several times before a female responds by returning to the nest with the male. Often times more than one female would enter a nest site. During trials, as many as five females were observed in a single nest. Males would refuse to spawn when more than two females were in a nest at one time. So in order to induce spawning, several females had to be removed. Three females were left in the raceway and within minutes a female returned to the nest.

Larval Rearing and Early Development

Development/Ontogeny at 25 °C: Eggs when fully water hardened averaged 0.67 mm. Hatching as prolarvae occurred between 32-40 hrs post–fertilization followed by exodus (swim up) of larvae 6 days post-fertilization. Exodus appeared to be a nocturnal event as observed with Bantam Sunfish, *Lepomis symmetricus,* (Wetzel 2007). Live freshly hatched brine shrimp nauplii (BS) were fed 8 times daily starting the night before the predicted exodus. Transition from BS to a dry formulated diet (Bio Oregon® Bio vita® 0# Crum) started 37 d post-exodus and involved a 7-d co-feeding period when both types of feed were applied at same time. The pellet size of the same formulation was increased to #1 crumb, #2 crumb and ultimately 1.2 mm as the fish grew. The formulated diet was applied either by hand or a 12-hr belt feeder. A total of 191 fish were raised to 89 days post-exodus. Of those, 30 were randomly selected and measured for total length (TL) and weight. TL ranged from 21.1 to 43.0 mm and averaged 31.7 mm. Weights ranged from 0.12 g to 1.59 g and averaged 0.68 g. At 18 months of age most of the brood exceeded 15 cm TL and all were sexually mature. *Editor's note: Photographs of various larval stages can be seen as Figure 5 on the preceeding page.*

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Citations

Brauhn, J.L. 1975. A Suggested Method for Sexing Bluegill: Methods to sex non-spawning or juvenile bluegill. *American Currents,* Jan-Feb 3(1):18.

Larimore, R.W. 1957. Ecological life history of the warmouth (*Centrarchidae*). *Ill. Nat. Hist. Surv. Bull.*, 27 (1):1-83.

Hegrenes , S. 2001. Diet-induced phenotypic plasticity of feeding morphology in the orangespotted sunfish, *Lepomis humilis*. *Ecology of Freshwater Fish* VL: 10

Rollo, P. R. 1994. Successfully spawning and raising green sunfish (*Lepomis cyanellus*). *American Currents.* Spring.

Sorensen, M. D. 1991. Spawning of the Green Sunfish, *Lepomis cyanellus*: Rearing and spawning the green sunfish in aquaria. *American Currents* Fall 17(3):18-19.

Wetzel, J.E. 2007. Successful spawning of the bantam sunfish *Lepomis symmetricus. American Currents* 33:11-15.

Reminder

For color photos depicting key diagnostic variations of wild-caught and captive-bred Warmouth, please see page 13.