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Assessment of Controlled Spawning Practices and Female Broodstock Replacement on Reproductive and Production Metrics in Culture of Gourami (*Osphronemus goramy*)

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Abstract

Gourami (*Osphronemus goramy*) is a freshwater fish species that has gained significant popularity among consumers due to its economic value and high nutritional content. However, various challenges in aquaculture have led to an imbalance in gurami production, influenced by factors such as low fecundity, fertilization rates, hatching success, and a limited spawning season that occurs only from February to July. Outside of this period, the spawning performance of gourami tends to decline. Consequently, it is essential to implement effective spawning manipulation techniques to enhance seed production in gurami aquaculture, particularly through controlled spawning methods that involve the replacement of female broodstock post-spawning to improve production outcomes. This study examines the production performance of controlled spawning (with broodstock replacement) versus uncontrolled spawning (without broodstock replacement) to fecundity, fertilization rates, hatching success, and the productivity of spawning containers. The research employs two treatments with three replications each: controlled and uncontrolled spawning. The findings indicate no significant differences (P>0.10) between controlled and unchecked spawning regarding fecundity, hatching success, fertilization rates, and spawning container productivity. Thus, it can be concluded that there are no significant differences in outcomes between the two treatments, suggesting that both methods can be effectively utilized.

Keywords: Fecundity; Fertilization Rates; Hatching Rates; Gonadal Maturation

1. Introduction

The gourami fish is a significant freshwater species with considerable economic value. In addition to its high economic importance, gourami is also rich in nutritional content. According to Bekhit (2022), 100 grams of gourami contains 125 calories, comprising 41% fat and 59% protein. The importance of fish as a source of animal protein has led to an increasing market demand for gourami. However, this rising demand is not matched by a corresponding increase in production levels.

The substantial interest in gourami among consumers has created an imbalance between demand and supply. To address this disparity, it is essential to enhance aquaculture practices. Nonetheless, various challenges hinder the cultivation of gourami, including low fecundity, poor fertilization rates, and low hatching success (Subhan and Hartono, 2022). This situation arises because gourami can spawn only 2 to 4 times a year, with spawning frequency influenced by seasonal conditions.

One potential strategy for aquaculturists is to implement spawning manipulation techniques to increase the yield of eggs and fry. This can be achieved by alternating female broodstock during the spawning period, a method referred to as controlled spawning.

According to Superio *et al.* (2021), changing broodstock after spawning affects the spawning interval, and the time between successive spawning events, significantly influencing the quantity of eggs produced. This study compares reproductive growth between controlled spawning (with broodstock replacement) and uncontrolled spawning (without broodstock replacement) by examining fecundity, fertilization rates, hatching success, and spawning container productivity.

2. Material and Methods

2.1. Time and Place of Research

This research was carried out - - at the Sungai Gelam Freshwater Aquaculture Fisheries Center (BPBAT), Muaro Jambi Regency, Jambi Province.

2.2. Experimental Design

This study employs two treatments, each replicated three times: a controlled treatment and an uncontrolled treatment, with a sex ratio of 2:1 (2 females to 1 male). In the controlled treatment, the female parent is replaced after spawning, whereas in the uncontrolled treatment, no replacement of the female parent occurs post-spawning. The

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experimental design is illustrated in Figure 1 and Figure 2.

A. Controlled (with change of female parent)

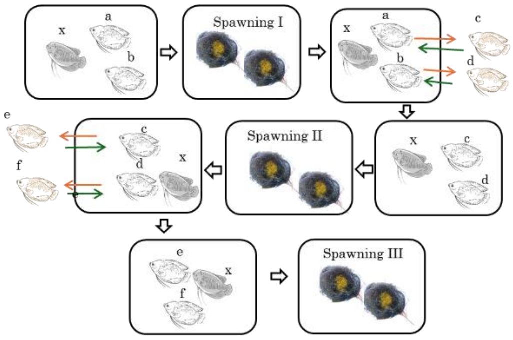


Figure 1. Controlled treatment experimental design (with replacement of female parents)

B. Uncontrolled (no change of female parent)

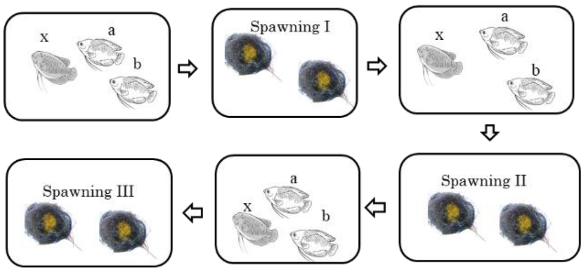
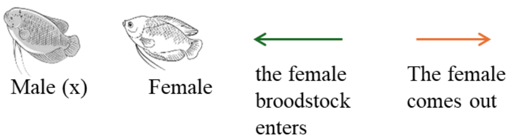


Figure 2. Uncontrolled treatment experimental design (without changing female parents)

Note:



2.3. Broodstock Gonad Maturation

Gonad maturation was conducted in a semi-intensive pond equipped with five hapa, where a stocking density of 25 fish per hapa was maintained. Four hapas were designated for females and one for males over a duration of one month. During the gonad maturation process, the fish were fed ad satiation with sente leaves and indigofera leaves, in addition to commercial feed supplemented with vitamin C and vitamin E. The feeding method employed was ad satiation, with feed provided twice daily, specifically at 08:00 a.m. and 12:30 p.m. .

2.4. The Selection of Broodstock

The selection of broodstock is conducted in the morning to minimize stress in the fish caused by temperature fluctuations. Before the selection process, the fish are fasted for one day. Subsequently, sampling of the broodstock is performed to identify individuals with mature gonads, as well as to assess the weight and length of the gourami broodstock. The criteria for selecting gourami broodstock ready for spawning include the absence of deformities, with male broodstock being 30 months old and averaging 1.5 to 2 kg in weight. In contrast, female broodstock suitable for spawning are typically 36 months old, with an average weight ranging from 2 to 2.5 kg, characterized by enlarged abdomen and more vividly colored genitalia (BSN, 2000).

2.5. Spawning

The spawning process was conducted in a semi-intensive pond that had been partitioned into six sections, each measuring 4×4×1.5 m³, with a sex ratio of 2:1 (two females to one male). During the spawning period, the fish were fed ad libitum with sente leaves and indigofera leaves. Additionally, commercial feed amounting to 1% of the biomass, specifically Migami and Vitality, was supplemented with vitamin C and vitamin E. This feed was administered using an ad satiation method, with feeding occurring twice daily, at 08:00 a.m and 12:30 p.m.

2.5. Egg Hatching

The hatching process is conducted within a closed aquarium measuring 60×50×40 cm³, with a water height of 20-25 cm. The water in the hatching container is treated with methylene blue at a concentration of 0.00125 ppm, and water hyacinth is added to provide a surface for the larvae to attach to after they hatch.

2.6. Research Parameters

The parameters measured were the growth and survival of seahorse juveniles

a) Relative Fecundity

Relative fecundity is a significant factor influencing fish productivity levels. It refers to the number of mature eggs released by a female parent, or the total number of eggs spawned during a breeding event. Relative fecundity can be calculated using the following equation:

$$\text{Relative Fecundity} = \frac{\text{Total of eggs}}{\text{Weight of broodstock (kg)}}$$

b) Fertilization rate (FR)

The fertilization rate refers to the percentage of eggs that are fertilized out of the total number of eggs released during the spawning process. This rate can be calculated using a specific equation based on:

$$\text{FR} = \frac{Q_t}{Q_0} \text{ X } 100\ \%$$

Note:

FR : Fertilization rate (%)

Qt : The number of fertilized eggs (units)

Q_0 : The number of sample eggs (units)

c) Hatching Rate (HR)

The hatching rate refers to the capacity of eggs to hatch or the number of eggs that successfully hatch.

Egg hatchability is defined as the percentage of fertilized eggs that result in hatching. The hatchability rate can be calculated using the following equation:

$$\mathrm{HR} = \frac{\mathrm{Q_u}}{\mathrm{Q_t}} \mathrm{X}\ 100\ \%$$

Note:
HR : Hatching rate (%)
Qu : The number of hatching eggs (units)
Qt : The number of fertilized eggs (units)

d) The Productivity of Spawning Container

The productivity of a spawning habitat refers to the quantity of nests produced within a designated spawning area.

2.7. Data Analysis

To assess the impact of different spawning methods on fecundity, fertilization rates, hatching success, and the productivity of spawning containers, a statistical analysis was conducted utilizing an independent-sample t-test with a confidence level of 90%. Additionally, water quality was analyzed descriptively.

4. Results and Discussion

4.1. Results

The findings from the research indicate that the fecundity of the batanghari gourami fish under controlled conditions was measured at 900±90.61, while the fecundity under uncontrolled conditions was recorded at 1,063±241.86 (Table 1). The t-test analysis revealed no significant difference in fecundity between the controlled and uncontrolled treatments for the batanghari gourami fish.

In terms of fertilization rates, the i gourami fish exhibited a rate of 12.67±5.42 under controlled conditions, compared to 18.37±11.87 under uncontrolled conditions (Table 1). The t-test analysis similarly indicated no significant difference in fertilization rates between the two treatment conditions.

Regarding hatching rates, the gourami fish showed a rate of 74.75±2.80 in controlled conditions, while the rate under uncontrolled conditions was 75.88±8.17 (Table 1). Again, the t-test analysis confirmed that there was no significant difference in hatching rates between the controlled and uncontrolled treatments.

The productivity of the breeding containers for gourami fish under controlled conditions was measured at 1±0.00, while the productivity under uncontrolled conditions was recorded at 1.67±0.58 (Table 1). Analysis using the t-test revealed no significant difference in productivity between the controlled and uncontrolled treatments for the breeding containers of gourami fish.

Table 1. The relative fecundity, fertilization rate, hatching rate, and productivity of breeding containers for the gourami fish (*Osphronemus goramy*) under both controlled and uncontrolled spawning systems.

Parameters	Controlled (with replacement of female parents)	Uncontrolled (without changing female parents)
Relative fecundity (eggs/kg)	90.0±0.61[a]	1063±241.86[a]
Fertilization rate (%)	12.67±5.42[a]	18.37±11.87[a]
Hatching rate (%)	74.75±2.80[a]	75.88±8.17[a]
Productivity of spawning container (broodstock)	1±0.00[a]	2±0.58[a]

Note: the same superscript letter indicates there is no significant difference in each treatment (P>0.10)

Throughout the study, water quality parameters remained within optimal ranges, including temperature, dissolved oxygen (DO), and pH levels in the breeding containers. The temperature ranged from 27.2 to 30 ˚C, the DO levels varied between 2.27 and 8.66 mg/L, and the pH values were found to be between 7.34 and 9.01.

Table 2. Range of water quality during the maintenance period.

Parameters	Time		Standard*)
	Morning	Afternoon	
Temperature (˚C)	27,2-28,7	28,3-30	25-30
DO (mg/L)	2,27-4,52	6,34-8,66	Min 3
pH	7,34-9,93	8,12-9,01	6,5-8,5

Note: *) BSN (2015)

4.2. Discussion

During the research, it was found that the controlled treatment yielded a fecundity of 900 eggs/kg, while the uncontrolled treatment produced a result of 1,063 eggs/kg. The fertilization rate for the controlled treatment was recorded at 12.67%, whereas the uncontrolled treatment achieved a fertilization rate of 18.37%. In terms of hatching rates, the controlled treatment resulted in 74.75%, while the uncontrolled treatment had a hatching rate of 75.88%. Statistical analysis using the t-test indicated that there were no significant differences between the controlled and uncontrolled spawning methods regarding fecundity, fertilization rates, and hatching rates. This phenomenon may be attributed to various factors, including the timing of spawning, which may not align with optimal seasonal conditions. When spawning occurs outside the designated season, the outcomes tend to be suboptimal. This observation aligns with Nurdiansyah (2020), who noted that the peak spawning season for the gourami fish in Batanghari occurs from February to July; outside of this period, spawning activity is minimal, leading to a reproductive vacuum. Furthermore, Singh *et al.* (2021) stated that spawning outside the optimal season can adversely affect the reproductive performance of the fish, thereby influencing the quantity of eggs, fertilization rates, and hatching success. Additionally, the quantity of sperm produced by male breeders during off-season spawning is often inadequate. This is supported by Andriani *et al.* (2023), who indicated that breeding outside the spawning season results in suboptimal spawning performance, leading to a reduced quantity of sperm and consequently lower fertilization and hatching rates. In aquaculture, off-season breeding is crucial for ensuring a continuous supply of fish seed, which supports year-round production (Ajithkumar *et al.*, 2022). By studying breeding outside the natural season, researchers can identify methods to overcome suboptimal performance, such as through environmental conditioning, optimized nutrition, or hormonal treatments.

Another factor believed to contribute to the low fecundity, fertilization rates, and hatching success in controlled treatments is that the broodstock used were first-time spawners, resulting in suboptimal egg quality. This observation aligns with the findings of Slembrouck *et al.* (2020), which indicate that young gourami broodstock at their initial spawning phase typically produce eggs with lower fecundity and inferior quality compared to those that have spawned multiple times. Additionally, these first-time spawners require a longer period to reach gonadal maturity than those that have spawned previously. First-time spawners represent a baseline or starting point in the reproductive cycle of fish. Studying them can provide fundamental data about the physiological processes, environmental triggers, or nutritional requirements for successful gonadal maturation (Calcaterra *et al.*, 2021). Suwarsito (2023) further notes that first-time spawning gourami may yield eggs with low maturity levels, leading to reduced hatching success.

In uncontrolled treatments, although the broodstock had spawned at the beginning of the study without replacement after spawning, there was a gradual increase in fecundity, fertilization rates, and hatching success. However, the short duration of the study, limited to two months, was insufficient to produce significant results. According to BPBAT Sungai Gelam (2013), gourami spawning occurs twice a year, with a spawning process lasting six months. After this period, the broodstock is conditioned to recover before subsequent spawning. Anderson *et al.* (2020) asserts that prolonged or continuous spawning cycles can enhance the quality of the spawning outcomes. As noted by Yang *et al.* (2021), the spawning success of a fish species tends to increase and reach its peak during the spawning season, subsequently declining as the season concludes.

During the research, it was found that the controlled treatment yielded an average productivity of one spawning nest, while the uncontrolled treatment resulted in an average of 1.67 nests. The productivity parameters of the spawning nests, assessed using a t-test between the controlled and uncontrolled treatments, indicated no significant differences in productivity. According to Slembrouck *et al.* (2020), optimal productivity in the spawning of gourami fish occurs when the broodstock reaches an age of 2.5 years, whereas broodstock aged 8 years demonstrates suboptimal productivity. Gourami fish spawn approximately every 40 days. This finding aligns with the research conducted by Arifin *et al.* (2020), which indicated that a male-to-female ratio of 1:1 in gourami spawning results in each broodstock spawning again every 40 days. Consequently, in this study, the two-month research period did not yield different results in spawning nest productivity for the treatment involving broodstock replacement. According to BPBAT Sungai Gelam (2013) and Arifin *et al.* (2020), a spawning cycle of gourami conducted over six months can produce an average of 3.66 nests.

Water quality is a critical factor influencing the sustainability of aquaculture fish species. The parameters assessed during this study included temperature, dissolved oxygen (DO), and pH levels. The spawning medium temperature ranged from 27.2 to 28.7˚C in the morning and from 28.3 to 30˚C in the afternoon. These temperatures are considered suitable for spawning, as indicated by BSN (2015), which states that the optimal temperature range for the spawning of the gourami fish is between 25 and 30˚C. Measurements of dissolved oxygen (DO) during the study revealed levels of 2.27 to 4.52 mg/L in the morning and 6.34 to 8.66 mg/L in the afternoon. The lower DO levels in the morning can be attributed to the consumption of oxygen by microorganisms during the night for respiration, prior to the onset of photosynthesis. Conversely, the higher DO levels in the afternoon are due to sufficient light intensity, which facilitates photosynthesis by phytoplankton in the water. Despite the lower DO levels in the morning, gourami fish do not experience oxygen deficiency, as noted by BSN (2000b), since gourami fish aged 14 to 28 days possess an additional respiratory structure known as a labyrinth, allowing them to extract air directly from the surface in low-oxygen environments. The pH values during the spawning period ranged from 7.34 to 9.93 in the morning and from 8.12 to 9.01 in the afternoon. These pH levels are adequate for gourami spawning, as BSN (2015) recommends a pH range of 6.5 to 8.5 for optimal spawning conditions.

5. Conclusion

The findings indicate no significant differences ($P>0.10$) between controlled and unchecked spawning regarding relative fecundity, hatching rates, fertilization rates, and spawning container productivity.

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