The influence of water turbidity on the spawning success of giant gourami *Osphronemus goramy* Lacepède, 1801

Sularto[1,*], *Nunuk* Listiyowati[1], and *Bambang* Gunadi[1]

[1]Research Center for Fishery, National Research and Innovation Agency, Cibinong Bogor, West Java, Indonesia

Abstract. The natural spawning of gourami (*Osphronemus goramy* Lac.) is influenced by various factors, including both intrinsic fish factors and external conditions like water quality, which significantly affect the spawning process's success. This study aimed to investigate how water turbidity affected the spawning process of gourami. Six ponds measuring 200 m^2, classified into three categories based on turbidity levels (A. <100 NTU, B. 100 – 200 NTU, and C. >200 NTU), were monitored. Each category was replicated twice under Randomized Block Design. Parameters like spawning frequency, egg quantity, and quality were considered. The results indicated that ponds with a turbidity level of <100 NTU (with a brightness of 40-80 cm) yielded better results compared to those with 100 - 200 NTU turbidity levels (brightness of 20 - 40 cm). Conversely, ponds with >200 NTU turbidity level (brightness 10 cm) showed no signs of brood spawning. The result showed that Spawning Frequency was 83.33% (A), 61.90% (B), and 0% (C), Fecundity was 2975 eggs (A), 2795 eggs (B), and 0 egg (C), and Fertilization Rate 84.29% (A), 78.02 (B) and 0% (C). Hence, successful spawning of gourami requires water with turbidity levels below 200 NTU.

1 Introduction

Giant gourami has high economic value with a price on the market of around Rp.30,000-50,000/kg. The giant gourami has been reared for decades in Indonesia, especially Java, Sumatra, and Borneo Islands, as the main gourami producer. Five countries in Southeast Asia that are also gourami producers are Thailand, Myanmar, Malaysia, Philippines, and Singapore [2]. This fish has become one of the main species being farmed and is in great demand in the food aquaculture industry [16].

The aquatic environment for fish lives on which fish depend is mainly composed of two aspects, namely the biological environment and the abiotic environment. The natural environment mainly includes plankton, benthic animals, fish, and amphibians. The abiotic environment mainly includes temperature, salinity, pH, oxygen, water flow, water pressure,

* Corresponding author: totosularto61@gmail.com

and light. Fishes are adaptable to environmental conditions, but this adaptation has a specific range [1].

The natural spawning of gourami (*Osphronemus goramy* Lac.) is influenced by various factors, including internal factors of the fish itself and external factors such as water quality, which serves as an important medium for fish survival and plays a significant role in the success of the spawning process.

Gourami spawning was carried out naturally, and artificial spawning efforts have been carried out, but the results were meager. Namely, the degree of fertilization of fish eggs was 4.30%, with a hatching rate of 78.50% [5]. Gourami hatchery centers such as Banyumas, Tasikmalaya, Bogor, Majalengka, and Pandaan areas are highlands that have relatively clear water sources. Breeders generally carried out the gourami hatchery business for generations. Only a few factors supporting the success of fish spawning are known. Therefore, a scientific approach is needed so that the hatchery business can be carried out anywhere according to the physiological needs of gourami fish. Gourami spawning occurs throughout the year [13].

[10] conducted a study on the influence of water turbidity on the spawning success of sandgoby fish (*Pomatoschistus minutus*). It was reported that turbidity hurt their mating success. Furthermore, it was found that spawning in clear water increased fecundity. According to the research by [11], male fish experienced reduced attention from females or even avoidance of spawning in turbid water. This behavior could be attributed to male fish's challenges in protecting many eggs, leading them to cease their courtship behaviors. Turbidity increases sediment formation, harming developing eggs [4], [14].

Research activities are needed to determine the supporting factors for the successful natural breeding of gourami fish. According to [17], fish need certain requirements to be able to spawn, and it is difficult to change these requirements; therefore, suitable habitat for spawning is important to fulfill. Good water quality and a comfortable environment are also necessary for reproductive activities [1]. However, it should be noted that water quality factors do not solely determine reproductive success.

2 Material and methods

2.1 Research time and location

The study was conducted at the Research Institute for Fish Breeding, Sukamandi, West Java, Indonesia, from February to December 2021.

2.2 Experimental fish

In this research, female broodstock, with a size of 1.8 - 2.4 kg, and male broodstock, with a size of 2.2 - 3.0 kg with an age of 3.5 - 4 years, were used. The male-to-female ratio was 1:3. The stocking density in each pond consisted of 28 broodstocks, comprising 21 female broodstocks and seven male broodstocks.

2.3 Ponds design

This research was conducted using six earthen ponds of 200 m2 each. To assess the productivity performance of the breeding ponds based on different turbidity levels, the ponds were categorized into different types based on the turbidity levels, i.e., Type A pond: turbidity level less than 100 NTU (Figure 1.), type B pond: turbidity level 100 - 200 NTU (Figure 2.), type C pond: turbidity level higher than 200 NTU (Figure 3.).

All treatments were replicated twice. The observed parameter was the spawning frequency or number of spawned broodstocks in each pond.

a) Pond A1 b) Pond A2

Fig. 1. The pond with a transparency level of more than 25 cm or turbidity level (turbidity) of 85 NTU (less than 100 NTU).

a) Pond B1 b) Pond B2

Fig. 2. The pond with a transparency level of more than 10 cm or turbidity level (turbidity) of 185 NTU (less than 200 NTU).

a) Pond C1 b) Pond C2

Fig. 3. The pond with high sediment and a clarity level of < 10 cm or turbidity level (turbidity) > 200 NTU).

2.3 Data analysis

A descriptive analysis was conducted on the research data, which encompassed water quality and spawning performance—the analysis aimed to thoroughly comprehend the collected data and emphasize the study's significant findings.

3 Results and discussions

3.1 The water quality parameters

During the 11-month study, three ponds with different turbidity levels were investigated (Table 1). Pond A had a turbidity range of 45 to 92 NTU, while Pond B exhibited higher turbidity levels ranging from 125 to 189 NTU. The highest turbidity was recorded in Pond C, with levels ranging from 260 to 301 NTU. Alongside turbidity, other water quality parameters varied among the ponds. Dissolved oxygen levels ranged from 1.6 to 3.1 mg/L in Pond A, 1.6 to 2.2 mg/L in Pond B, and 1.6 to 2.0 mg/L in Pond C. Temperature showed fluctuations, with Pond A ranging from 28.1 to 30.6°C, Pond B ranging from 28.2 to 30.7°C, and Pond C ranging from 28 to 30.8°C. Additionally, pH levels ranged from 5.99 to 7.58 in Pond A, 6.09 to 7.54 in Pond B, and 6.08 to 7.68 in Pond C. These turbidity and water quality parameter variations allowed for a comprehensive evaluation of their potential impacts on fish spawning performance and the overall habitat conditions.

Table 1. Water quality parameters

Parameters	Pond A	Pond B	Pond C
DO (mg/L)	1.8 – 3.1	1.6 – 2.2	1.6 – 2.0
Temperature (°C)	28.1 – 30.6	28.2 – 30.7	28 – 30.8
pH	5.99 – 7.58	6.09 – 7.54	6.08 – 7.68
Turbidity (NTU)	45 – 92	125 – 189	260 – 301

3.2 Reproduction performance of giant gourami

Several giant gourami spawning broods (Figure 4.), fecundity (Figure 5.), and fertilization rate (Figure 6.) show the reproduction performance of giant gourami during the experiment in 2021.

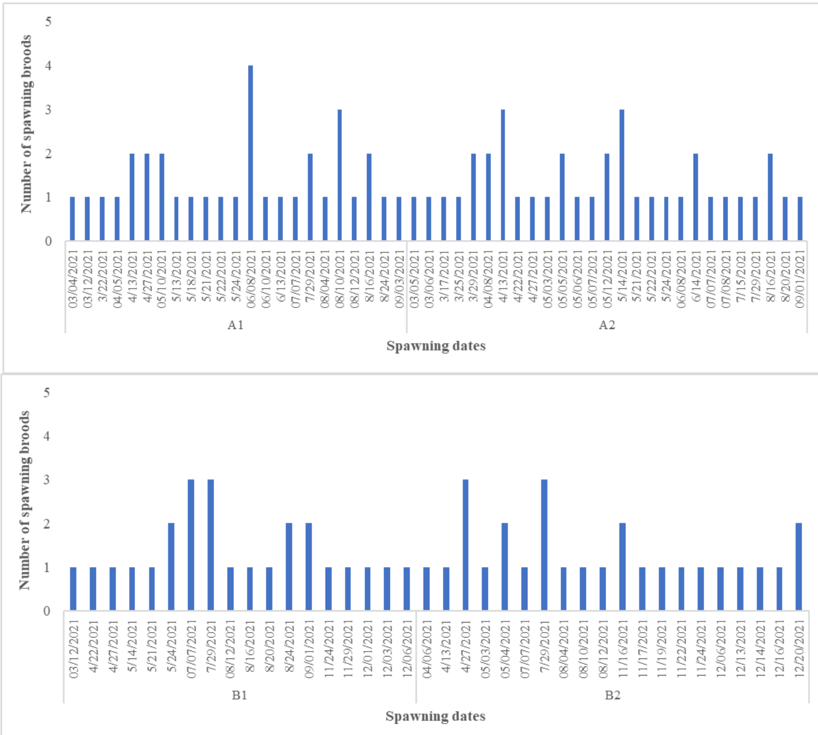

Fig. 4. The number of spawning giant gourami broods in Pond A (A1, A2) and Pond B (B1, B2)

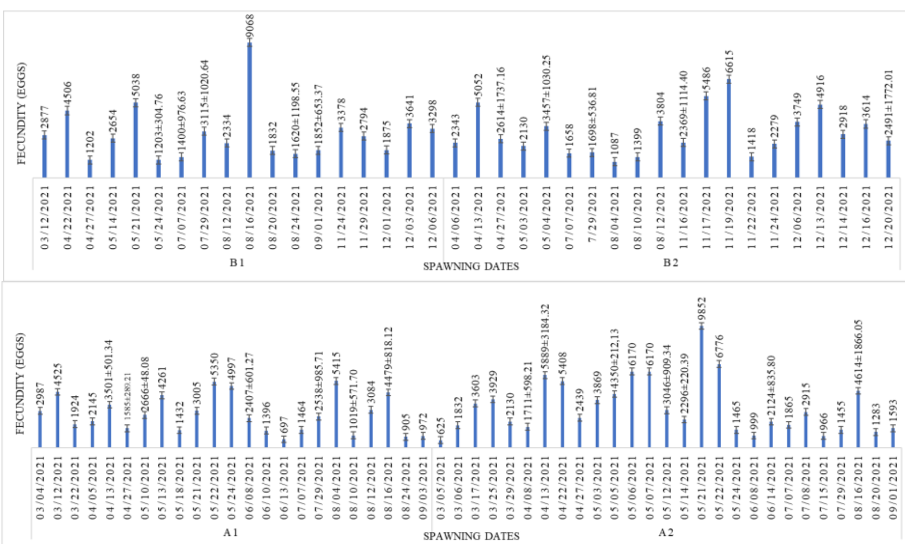

Fig. 5. Fecundity of giant gourami broods in Pond A (A1, A2) and Pond B (B1, B2)

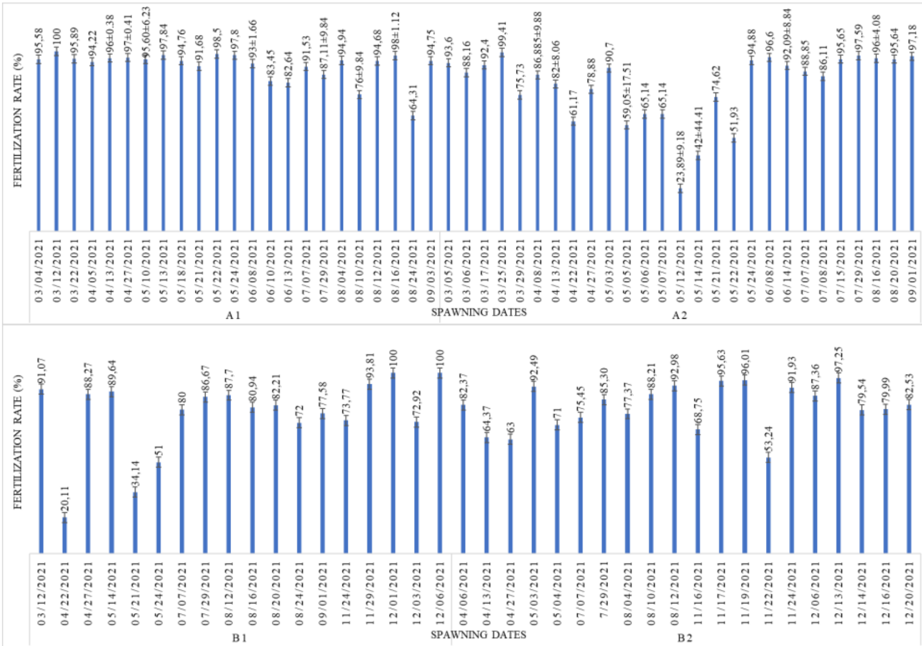

Fig. 6. Fertilization Rate (%) of giant gourami eggs from pond A (A1, A2) and pond B (B1, B2)

The findings indicated a clear correlation between turbidity levels and fish spawning performance (Table 2). The spawning frequency in Pond A (turbidity of 45-92 NTU) ranged from 78.57% to 88.10%, while the fecundity ranged from 2629.61 to 3320.43 eggs. The fertilization rate in Pond A varied from 91.49% to 77.09%. In Pond B (turbidity of 125-189 NTU), the spawning frequency ranged from 59.52% to 64.29%, with fecundity ranging from 2695.64 to 2893.59 eggs. The fertilization rate in Pond B varied from 76.59% to 79.44%.

Interestingly, no spawning activity was observed in Pond C (turbidity of 260-301 NTU), resulting in a spawning frequency, fecundity, and fertilization rate of 0%. This could be attributed to the extremely high turbidity levels in Pond C.

Table 2. Spawning performances of gourami under different turbidity of spawning pond water

Pond Treatment Turbidity	Replicates	Spawning Frequency		Fecundity (egg)	Fertilization Rate %
		Frequency	%		
A (45 - 92 NTU)	1	33	78.57	2630	91.49
	2	37	88.10	3320	77.09
	Average	35.00	83.33	2975	84.29
B (125 -189 NTU)	1	25	59.52	2696	76.59
	2	27	64.29	2894	79.44
	Average	26	61.90	2795	78.02
C (260 - 301 NTU)	1	0	0	0	0
	2	0	0	0	0
	Average	0	0	0	0

The effects of low-level turbidity on fish habitat were investigated from March 2021 to December 2021 in experiment ponds at the Research Institute for Fish Breeding. Water Turbidity level at Pond C was 260 – 301 NTU) according to [6] that high category level. Turbidity also had a direct effect on the fish's physical state. [15] reported that high turbidity can affect the life of trout larvae and can even cause death. Turbidity affects light penetration and causes darkness in the bottom. Furthermore, it is reported that the turbidity value greatly affects the life of aquatic biota [6], [12], so it is likely to affect significantly the proportion of spawning broodstock and the degree of fertilization rate of gourami because spawning occurs naturally [13]. [11] suggested that water turbidity affects the success of fish spawning.

According to [12], turbidity reduced male stickleback fish's aggressive interaction, presumably due to reduced visibility. [3] stated that high water turbidity causes above 100 ppm, spawning of largemouth bass, redear sunfish, and bluegill is severely disrupted and even causes no spawning. The gills of fish are delicate and easily harmed by abrasive mud particles. When sediments accumulate on the gill filaments, fish excessively open and close their gills to expel the mud. If the irritation persists, mucus is produced to protect the gill surface, which can impede water flow over the gills and disrupt fish respiration [9]. Chronic turbidity during the emergence and rearing of young anadromous salmon can impact the quantity and quality of the resulting fish [8]. Suspended sediments in the water column have been found to negatively affect sockeye under yearlings, including gill trauma [7].

However, [11] also reported that fish spawning would be more prevalent in turbid waters than in clear waters. It can be understood that in waters that are too clear, fish will be disturbed by the noise around the pond; therefore, it is a consideration in determining the layout of spawning ponds away from the crowd, or there is an effort to prohibit activities around the pond, especially during certain hours for spawning.

Giant gourami spawning was carried out naturally, where the male parent takes the eggs using his mouth, deposits them into a previously prepared nest, and then guards them. Based on this spawning behavior, the eye organ's functioning is needed to pick up eggs released from the female parent in the spawning process, so it requires relatively clear water or low turbidity. It shows that successful spawning gourami can be achieved in ponds with less than 200 NTU turbidity. Our finding is by the argument of [17] that fish need certain requirements to spawn in terms of water turbidity. In general, water sources for ponds in the lowlands have high turbidity levels, so using aquatic plants such as water hyacinth, hydrilla, and others as natural filters is one alternative that can be used to reduce the water turbidity level.

4 Conclusion

The turbidity in water has an impact on the spawning of giant gourami. There is a noticeable difference in the productivity and frequency of spawning in giant gourami. To ensure successful spawning of gourami, the turbidity value should be lower than 200 NTU. The water should have a turbidity value below 100 NTU for optimum spawning conditions for giant gourami.

Acknowledgments: The author would like to thank the Head of the Research Institute for Fish Breeding for allowing carrying out this research. The author also expressed his gratitude to the technicians, namely Mr. Sugiyo and Mr. Nurdiyansyah, who have helped a lot in taking research data.

References

1. B. Song, X. Li, H. Zan, C. Yang. Intl. J. Anim. Res. **1-5**, 5-39 (2020)
2. D. Caruso, Arifin, Z.O., Subagja, J., Jacques Slembrouck, J. and New, M. *Osphronemus goramy* (FAO Cultured Aquatic Species Information Programme, Rome, 2023)

3. D.H. Buck, Trans. 21st N. A. Wildl. Conf., 249-261 (1956)
4. G.W. Potts, MHA Keenleyside, JM Edwards. J. Mar. Bio. Assoc UK. **68**, 277–286 (1988)
5. H. Arfah, L. Maftucha, O. Carman. J.Akua.Ind. **103-112**, 5-2 (2006)
6. I.K. Birtwell, M. Farrell, and A. Jonsson, Canadian Manuscript Report of Fisheries and Aquatic Sciences **2852**, 72 (2008)
7. J.A. Servizi, D.W. Martens, Can. Spec. Publ. Fish. Aquat. Sci., **96**, 254-264 (1987)
8. J.W. Sigler, T.C. Bjornn, F.H. Everest. Trans. Am. Fish. Soc, **113**, 142-150 (1984)
9. L. Berg, Proc. of the Carnation Creek workshop: a ten-year review. Dept. of Fisheries and Oceans, Pacific Biological Station, 177-196 (1982)
10. M. Järvenpää, K. Lindström, Proc. Biol. Sci., **271**, 1555 (2004)
11. M. Järvenpää. D.P. Beatriz, K. Lindström. J. Eco. Bio. **73**, 140 (2019)
12. OEDC.Turbidity Technical Review. *Summary of Sources, Effects, and Issues Related to Revising the Statewide Water Quality Standard for Turbidity* (Oregon Department of Environmental Quality, Portland 2014)
13. Sularto, N. Listiyowati, W. Hadie. Pros. Sem. Nas. Kan. Luh, 403 – 416 (2018) [in Bahasa Indonesia]
14. S. Gray, L. Chapman, N. Mandrak. Environ Biol Fish. **94**, 689–694 (2012)
15. T.A. Stuart. Scottish Home Dept. Freshwater and Salmon Fisheries Research, **5** (1953)
16. T. Amornsakun, S. Kullai. A. Hassan. Song. J. Sci. Tech. **493-498**, 36-5 (2014)
17. Z. Yang, Q. Zhu, J. Cao, Y. Jin, N. Zhao, W. Xu, H. Liu, H. Tang, Y. Qiao, X. Chen. Sci. Tot. Env. Elsv. **787**, 1-19 (2021)