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## **Reproductive Biology of Barb Fish (*Barbonymus balleroides* Val. 1842) in Fragmented Habitat of Upstream Serayu River Central Java, Indonesia**

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### **Abstract**

The study of reproductive biology of barb fish, *Barbonymus balleroides* was conducted for one year in Serayu River, Central Java, between June 2012 and May 2013. The aims of this study are to access sexual dimorphism, the size at first maturity, reproductive potency, and spawning season. Fish sampling was conducted in three zones, 2 stations in each zone by using gill net, cast net, and electro fishing. The caught fishes were preserve in formalin and they were observed in laboratory. The results showed that this fish has sexual dimorphism, the size at first maturity of males 150-182 mm and females and 175-202 mm. The fecundity varied from 2,760 to 50,085 eggs with mean 17,347 eggs. The relationships between fecundity and body length, and fecundity and body weight were linear, positive and significant. The gonad maturity is consisted of five stages. The highest mean Gonado Somatic Index (GSI) of female was found in the upper zone which was followed by the lower zone, i.e. 2.43 and 2.34 respectively.

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The egg diameter was ranged between 0.10 mm and 1.49 mm with average 0.94 mm. This fish species breeds the whole year round, with the peak spawning season in August and September. This indicates that the peak breeding season of this barb fish is quite unusual, i.e. outside of rainy season.

**Keywords:** dimorphism; fecundity; gonad maturity; spawning

## **1. Introduction**

Barb fish (*Barbonymus balleroides* Val. 1842) is a popular consumption fish belong to the family Cyprinidae. This species is widely distributed in inland waters, both in lentic and lotic of Java and Kalimantan island [1,2,3]. The presence of this fish has been reported from many reservoirs such as Lahor [4], Jatiluhur [5], and Gadjah Mungkur [6]; and also rivers such as Cimanuk River in Sumedang [7, 8], and Serayu River [9, 10, 11].

Information on reproductive biology of barb fish in Serayu River is limited, especially that of in the upstream which habitat has been fragmented by Panglima Besar Jenderal Soedirman Reservoir or most famous known as Mrica Reservoir since 1988. The presence of a reservoir in a river system has permanently cut off fish migration which in turn reduce the fish diversity [12, 13], and it can also reduce the anatomy structure of the fish [14]. Migration is a part of the fish life cycle in form of adaptation and strategy to improve the survivalship, growth, and reproduction. Reference [15] stated that migration is an important process related to biological interaction and function in aquatic ecosystems. Reference [12] reported that in the world there are around 39,000-45,000 large dams with total inundation area of 500,000-1,500,000 km<sup>2</sup> with various negative impacts on fish communities.

The existence of the Mrica dam has impacted the population of the barb fish which has migration habits to the upstream areas for spawning. The results of previous studies show that river fragmentation due to the dam presence has impacted to the genetic variation [16], which is indicated on the barb fish reproduction process [17]. Based on the above results, a more complete study on the reproductive biology aspect of the barb fish was conducted in one year. The aims of this study are to evaluate sexual dimorphism, size of first maturity, reproductive potency, and spawning season in the upstream area of Serayu River.

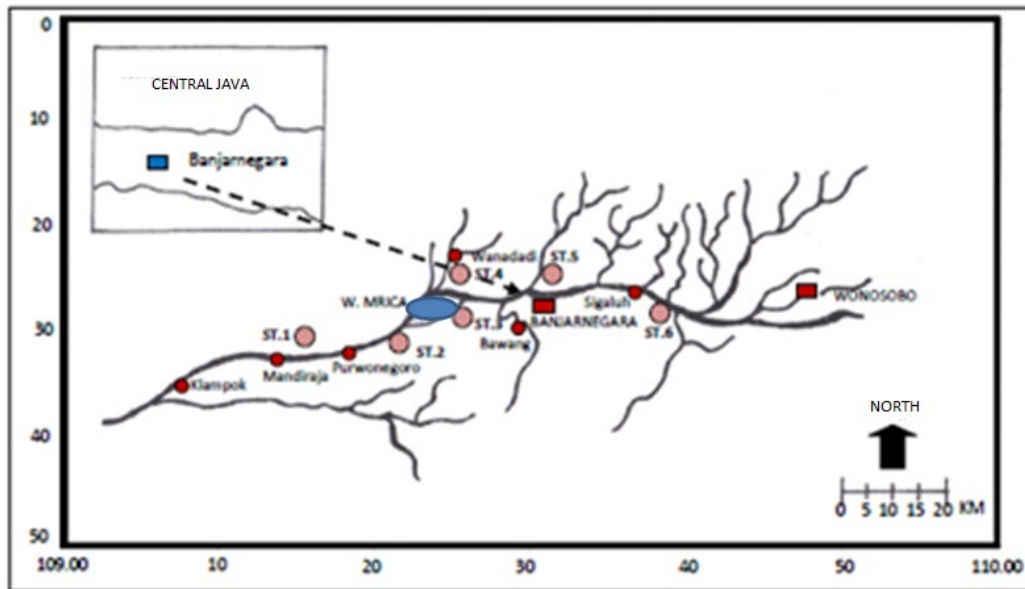
## **2. Materials and Methods**

The study was conducted in Serayu River of Banjarnegara Regency, Central Java Indonesia. The study location were grouped into three zones based on their position towards of the reservoir, i.e. lower zone (St.1 and St.2), middle zone (St.3 and St.4), and upper zone (St.5 and St.6), the position of each station is presented in Figure 1.

Monthly sampling was conducted for one year from June 2012 to May 2013 mainly using gillnet with length of 20 m and height of 4 m and mesh size of 1, 1.5 and 2 inches. Additional gears were by cast net with diameter of 3 m and electro fishing. All specimens were preserved in 4-10% formalin then the specimens were transferred to the laboratory for monthly observation.

The total length (TL) of all individuals was measured to the nearest 0.01 mm by using digital calipers, while the

body weight was recorded by using digital balance to 0.01 gram accuracy. All collected specimens were sexed by making an incision in the abdomen and visually observe the shape of the gonad to determine the sex and the gonad maturity stage. Sexual dimorphism was observed based on morphological characters of male and female.



**Figure 1:** Site study in Serayu River Central Java, Indonesia

The gonad maturity was observed anatomically based on the size, the color, and the volume in the abdominal cavity. The gonad maturity was classified into five stages (Table 1). The size of fish at the first maturity was analysed based on the total length refer to [18]. Later, the results were correlated with the body depth.

The gonad of each individual was taken out and weighed using digital balance with 0.0001-g accuracy, then the gonado somatic index (GSI) was calculated through the formula:

$$GSI = \frac{Wg}{Wb} \times 100$$

where, GSI is the gonado somatic index, Wg is the gonad weight (g), and Wb is body weight (g).

Fecundity was calculated based on gravimetric and then correlated with the total length and the body weight with the following equations:

- The relationship between fecundity and total length was analysed based on [19]:

$$F = aL^b$$

- The relationship between fecundity and body weight was analysed based on [19]:

$$F = a + bW$$

where, F is fecundity (number of egg), L is total length (mm), W is body weight (gram), a and b are constants

The egg diameter of matured gonads (stage IV) was measured by taking sub-samples from anterior, middle, and posterior of the ovary with total 100 eggs. The eggs were placed in a petri disk and were observed by using a stereo microscope which equip with ocular micrometer. The distribution of the diameter of the eggs was presented in a histogram. The data obtained during this study was processed and analyzed by using Microsoft Excel.

**Table 1:** Criteria of gonad maturity stage of barb fish *Barbonymus balleroides*

Gonads	Female	Male
<b>mature</b>		
I (Immature)	Ovaries as thread-like, length up to the front of the abdominal cavity, clear, slippery surface.	Testes as thread-like, shorter and not reach up to the front of the abdominal cavity, and clear.
II (Developing)	Ovaries extend up to front of the abdominal cavity, fill less than tenth of abdominal cavity, clear white, and small oocytes visible as granules.	Testes is larger, milky white color, shape more clearly than the first stage.
III (Developed)	Ovaries fill nearly half of the abdominal cavity, the eggs begin clear visible, yellowish ovary.	Testes fill nearly half of the abdominal cavity, and white milk color.
IV (Mature)	Ovaries fill most of the abdominal cavity, the color becomes yellow and darker. The eggs are clearly visible, separated from each other.	Testes grew, they are white milk in color, and fills most of the abdominal cavity.
V (Spent)	Ovaries there the rest of the yellow-green, eggs throughout the ovary. Ovary deflated in the posterior because the eggs has been released when spawning.	Testes deflated at the posterior end.

### 3. Results

A total of 2,466 individuals barb fish were collected during the study consisted of 1,073 males and 1,393 females. The total length and body weight of males ranged from 58 to 236 mm and 2 to 172 g, respectively, while the females ranged from 63 to 309 mm and 3 to 350 g respectively.

**Sexual dimorphism**

The results of the morphological observation from 30 individuals show that the secondary sexual dimorphism between male and female of barb fish is present which are presented in detail in Table 2.

**Table 2:** Sexual dimorphism characters of barb fish in Serayu River

Characters	Male	Female
Body shape	Body elongated and slimmer than females	Body elongated and rounded
Head shape	Pointed	Rounded
Backs shape	Straight between the head and backs	Concavity between head and backs
Tubercle on the cheek	Present. Seems clear from cheek, near lips and upper part of head	None both at cheek and upper part of head
Ventral fin	More strong, color is orange and continuous, more light than female	Weak, color is orange but faded
Pectoral fin	First rays (spine) is rough with tubercle	First rays (spine) is smooth, no tubercle
Shape and color of cloaca	In mature fish, cloaca shape is tapered and pointed, white color	In mature fish, cloaca shape is rounded, red color

**The size at first maturity**

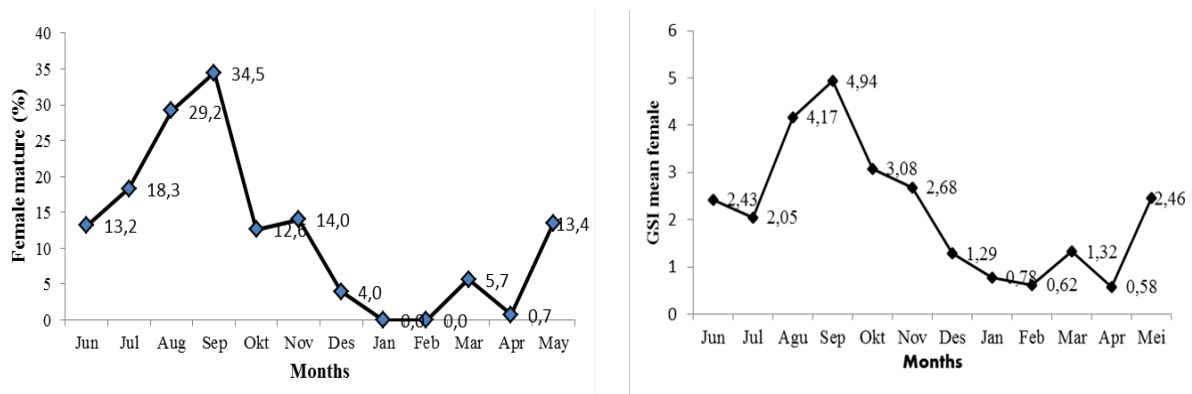
The size at first maturity male barb in Serayu River varied among zones, the smallest was found in the upper part zone (150 mm) and the largest was in the middle zone (182 mm). The smallest female was found in the middle zone (175 mm) and the largest in the lower zone (202 mm) (see Table 3). The linear regression between total length (TL) and body depth (BD) of males is  $BD = 0.2987TL - 4.5075$  and females is  $BD = 0.2763TL - 1.9754$ .

**Table 3:** The size of at first maturity of barb fish among zone

Zone	Male (n = 1073)		Female (n = 1393)	
	n	Total Length (mm)	n	Total Length (mm)
Lower	337	154	467	202
Middle	343	182	452	175
Upper	393	150	474	178
Mean		162		185

**Gonad maturity stage and gonado somatic index (GSI)**

The gonad mature females varied based on zone. The gonad mature females were found in almost every month with the peak in August and September. The mean value of GSI varied for both males and females which ranged from 0.74 to 3.88 and 0.58 to 4.94, respectively. Generally, the GSI of males is smaller than those of females and this value is increasing in line with the development of the gonad. The highest GSI of females is in August and September (Figure 2).



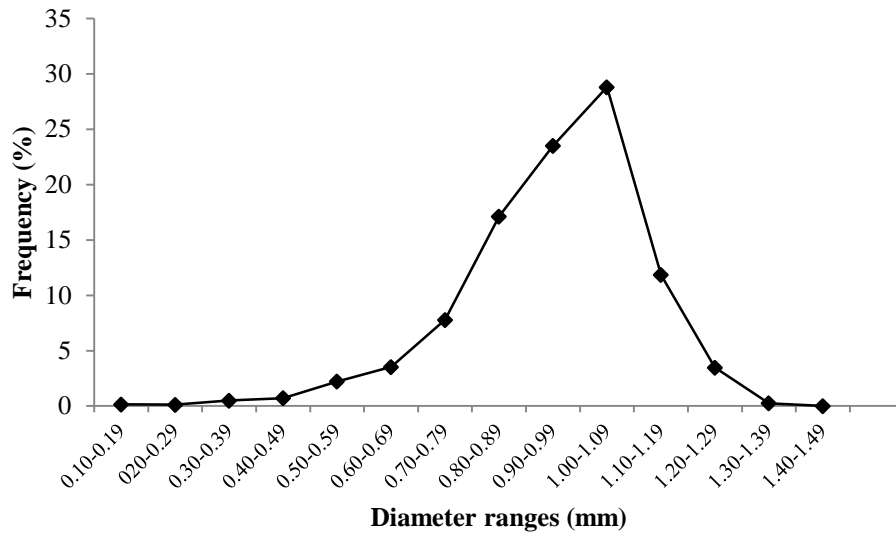
**Figure 2:** Percentage of the female mature (left) and gonado somatic index (right)

**Fecundity**

The fecundity of 157 mature females was 2,760 to 50,085 eggs (mean 17,347 eggs). The fecundity range in the lower zone was between 11,575 and 33,036 eggs, in the middle zone from 7,158 to 19,316 eggs, and in the upper zone from 9,020 to 26,278 eggs. Generally, the highest fecundity was in the upper zone, i.e. 18,230 eggs, followed by the lower zone with 17,655 eggs, and the middle zone 15,352 eggs. The relationship between fecundity and total length is  $F=0.0364L^{2.4388}$  ( $r= 0,5989$ ) and with body weight is  $F = 4443,6 +123,92W$  ( $r= 0,6290$ ).

**Spawning**

The mature females were almost encountered every month with various number. Based on zone, the most mature females ready for spawning were found in the upper zone (40.76%), while the lowest was in the middle zone (23.57%). However, the longest spawning period (number of encountered months/12 months) was in the lower zone (75%). Mostly, the barb spawns in dry season compared to the wet season with peak between August and September. The peak season is indicated by the high number of mature females, i.e. the total of the three zones in August and September which was the highest compared to the other months. The egg diameter of 101 mature females from all zones ranges between 0.10 mm and 1.48 mm (mean 0.94 mm) with one modal or peak at 1.00-1.09 mm (Figure 3).



**Figure 3:** Egg diameter distribution of female mature

#### 4. Discussion

Morphologically, the barb males and females are different; the males is more slender than the females and the dorsal is straight but it is hollow in females. Generally, the females of family Cyprinidae are larger than the males, such as *Capoeta damascina* in Zayandeh River Iran [20]. The dimorphism in fish is a part of reproductive characters [21]. The purpose of females being large is increasing its fecundity, on the other hand the purpose of males being large is protecting territory [22]. The color of the pectoral fin of the male is brighter than that of the female. This fact is agree with the finding of [23] that in several species the males are brighter than the females. Furthermore, the cheek of the male has white and coarse tubercles, while the females are smooth. The presence of the tubercles is related to the steroid hormone produced by the gonad [24]. Likewise, [25] also reported that the cheek and snout of male *Barbus melanampyx* of India has tubercles during spawning season. The same morphological appearance is also found among mahseer (*Tor* spp.) males in Indonesia [26]. Other secondary sex characters is the cloaca shape; the males have pointed shape and the females have rounded one. This character is to be recognized both in shape and coloration particularly in gonad mature adult fish. The size of at first maturity barb various among zones. The various sizes indicate that there are environmental condition differences among the zones. Generally, the larger the fish reach its first maturity the better is the environment. The influencing environmental factors i.e., temperature, quantity and quality of the food availability, population density, and the water system where the fish live [20, 27]. The size of the first maturity can also be affected by exploitation. According to [28], population with high exploitation and disturbance will have smaller body size and is faster gonad mature. This pattern is related to the strategy in maintaining the long lasting of the generation. During the study, the most males caught were 100-120 mm length and the most females obtained were 120-142 mm length. Based on the size of the first maturity, almost all of the caught fish had not spawned yet This indicates that the catching fish activity in Serayu River can threat the sustainability of

the barb population. Therefore, a good fish management is needed by regulating the allowed size fish caught and the permitted mesh size of the gear to be used. The linear regression between the total length and the body depth among males is  $BD = 0.2987TL - 4.5075$  and among females is  $BD = 0.2763TL - 1.9754$ . These equations show that the size of the first maturity males was 49.86 mm body depth and females was 53.84 mm body depth. Therefore, the safe fish gear used is at least 54 mm or 2 inches mesh size.

The fecundity of the barb ranges between 2,760 to 50,085 (mean 17,347) eggs. This fecundity is considerably high, and this fact is related to the migration habit of this barb. Generally, migratory fishes do not guard their juveniles and they have high high fecundity [29]. The similar pattern is found also in *Barbonymus schwanefeldii* [30]. The fecundity range is lower compared with the same species from Lahor Reservoir in East Java which was ranged 12,224-207,261 eggs [4]. The fecundity difference was due to the different characteristic of the two water bodies, i.e. reservoir and river. The main environmental factor differentiating the two water bodies is water current that implicate the other environmental factors such as food. Based on zones, the highest fecundity was found in upper zone. It was possible due to the better water condition such as lower turbidity, higher current and higher dissolved oxygen. Beside that, the upper zone fish is larger than the others with mean of 210 m. On other hand, low fecundity was encountered in the lower zone caused by the decreasing of water quality due to the waste water from the reservoir. According to [31], the discarded water from reservoir contains toxic caused the decrease of the water quality of the lower zone causing the decline of the fish fecundity. The correlation between fecundity and total length and body weight were not distinct, but tend to body weight. Therefore, body weight is more appropriate to predict fecundity. In many fish, fecundity has stronger correlation with body weight compare to total length [32, 33, 34].

The fully mature barb (stage IV) was found in almost every month. The number of barb which was ready to spawn was higher in the upper zone (40.76%) and the lowest was in middle zone (23.57%). These facts show that the upper and lower zones support the spawning process of the barb due to its migration behavior and the availability of nursery ground. The river has bedrock substrate, fast current water, and high dissolved oxygen. More mature females found in the upper zone caused by minimum exploitation and perhaps part of the fish were from the middle zone.

The mean GSI was higher during, dry season compared to the wet season, i.e. 2.32% and 1.97%, respectively. This indicates that most of the barb in the study site spawn in dry season. The peak spawning season was between August and September (Figure 2). According to [35] and [36], the percentage of mature females and GSI can be used as indicator to determine peak spawning season. This spawning pattern is different from the most tropical fish habits that spawn in the early of wet season. The occurrence of spawning during the dry season was related to the opening and closing of the reservoir. This water fluctuation is responded by the mature females as coming flood in form of spawning. According to [29], the spawning of cyprinids are influenced by the rising of water surface or flood. The water fluctuation affected the water temperature. The fact is in line with [20], who stated that temperature is an important factor influencing the fish spawning.

The egg diameter distribution of the three zones has similar pattern (Figure 3), i.e. form a modus which is directed to the right. This shows that the eggs of the barb is homogen and they are released in one time.



Therefore, the barb in Serayu River is considered as total spawner [29, 24]. However, not all barbs are total spawner, as reported by [4] that the egg size of the barb in Lahor Reservoir East Java is not uniform with two modals so they are partial spawner. The different spawning pattern is affected by the environmental condition such as water fluctuation and temperature [29]. It might due to the stabil water of Lahor Reservoir compared to that of Serayu River. In stabil water, the fish becomes partial spawner with longer spawning period compared to that of fluctuate waters. According to [37] different spawning pattern can occur among populations of same species.

## 5. Conclusion

The morphologically the male and female barb are different. The gonad of the male is mature faster than that of female. The barb is total a spawner with peak spawning season between August and September. The fecundity of barb ranges between 2.760-50.085 eggs. In conserving the barb, fish management has to be applied by regulating the mesh size of the fishing gear of at least 2 inches. Besides that, a regulation to prohibit capturing of barb brood stock during its spawning migration.

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