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REPRODUCTIVE BIOLOGY OF NATURAL BETTA FISH (*Betta picta*) IN THE GENDING MERTOYUDAN RIVER, MAGELANG REGENCY

BIOLOGI REPRODUKSI IKAN CUPANG ALAM (*Betta picta*) DI SUNGAI GENDING MERTOYUDAN KABUPATEN MAGELANG

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Abstract

Natural betta fish is one of the Betta fish that comes from nature and still has high genetic diversity because it has not been crossed with cultivated Betta fish. Many environmental changes affect the reproduction of natural betta fish in their natural habitat, so it is necessary to carry out studies related to the reproductive biology of natural betta fish (*Betta picta)*. This research aims to determine various reproductive biology and the influence of water quality on the gonad maturity level of natural betta fish (B. *picta)*. The research was conducted from October to November 2023 in the Gending River, Mertoyudan District, Magelang Regency, and the Integrated Laboratory of Tidar University. Fish samples were caught using a seser and placed in plastic containers for observation in the laboratory. The gonad maturity level, or *GMI,* was observed morphologically and analyzed descriptively. The results of this research were that the TKG consisted of TKG I-TKG V, the IKG value was 4.7%, the IG value was 48.2, the HSI value was 0.7%, the sex ratio was 1:1, the relationship between length and weight was allometric negative, and plankton abundance was 166.6ind/l. There was an increase in the second week of observation up to the sixth week.

Keywords*: natural betta fish, reproductive biology, gonad maturity level, Gending river*

Abstrak

Ikan cupang alam yaitu salah satu ikan cupang yang berasal dari alam dan masih memiliki keragaman genetik yang tinggi, karena belum mengalami persilangan dengan ikan cupang dari hasil budidaya. Banyaknya perubahan lingkungan yang mempengaruhi reproduksi ikan cupang alam yang ada di habitat alamnya sehingga perlu dilakukan untuk melakukan studi terkait biologi reproduksi ikan cupang alam (*Betta picta*). Tujuan dari penelitian ini adalah untuk mengetahui berbagai biologi reproduksi dan pengaruh kualitas air terhadap tingkat kematangan gonad ikan cupang alam (*B.picta*). Penelitian dilakukan pada bulan Oktober – November 2023 yang dilakukan di Sungai Gending, Mertoyudan, Kabupaten Magelang dan Laboratorium Terpadu Universitas Tidar. Sampel ikan cupang alam yang diambil yaitu 90 ekor dan diamati di laboratorium. Parameter yang diamati yaitu tingkat kematangan gonad (TKG), indeks kematangan gonad (IKG), indeks gonad (IG), *hepato somatic index* (HSI), rasio kelamin, hubungan panjang berat, kelimpahan plankton, dan pengukuran kualitas air. Hubungan panjang berat dianalisis menggunakan Microsoft Excel, sedangkan kualitas air dianalisis dengan menggunakan SPPS. Hasil penelitian ini yaitu TKGnya terdiri dari TKG I-TKG V, nilai IKG sebesar 4,7%, nilai IG sebesar 48,2, nilai HSI sebesar 0,67%, perbandingan rasio kelamin sebesar 1:1, hubungan panjang dan berat bersifat allometrik negatif, dan kelimpahan plankton sebesar 166,7ind/l. Adanya peningkatan pada pengamatan minggu kedua sampai dengan pengamatan minggu keenam dan juga kualitas air berpengaruh terhadap tingkat kematangan gonad.

Kata Kunci : *ikan cupang alam, biologi reproduksi, TKG, Sungai Gending*

1. Introduction

The Gending River, located in Gendongan Hamlet, Bondowoso Village, Mertoyudan Subdistrict, Magelang Regency, is a watercourse that is still well preserved in terms of nature and ecosystem. The aquatic ecosystem of the Gending River is one of the aspects that can determine the quality of the biota living in that ecosystem. The Gending River area is quite far from residential areas, creating a natural environment where the Gending River still has beautiful nature, which is proof that the existing ecosystem is still very well preserved (Susilo, 2022). The existence of a preserved natural environment and ecosystem has become an aspect of the life of aquatic biota, namely *the Betta splendens* fish.

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Betta fish are one of the most iconic fish with their colorful appearance and wide variety of species. However, among the many species, there is one particularly interesting betta fish, namely the wild betta fish (*Betta picta*). Wild betta fish are betta fish that originate from the wild and still have high genetic diversity because they have not been crossbred with farmed betta fish (Adnan et al., 2020). In a natural ecosystem with native biota, wild betta fish (*Betta picta)* have a very good reproduction rate in their natural habitat. This is in line with the opinion of Musrin et al. (2014), that the success of a fish species in its life cycle is determined by the ability of fish to reproduce in a fluctuating environment in order to maintain their population. It can be concluded that fish reproduction depends on the conditions of their natural environment, which can increase their reproduction.

Fish reproductive biology is a fundamental aspect of fish biology that is important for the management and utilization of fishery resources. The assessment of sex and gonadal maturity in its application can be basic knowledge of the reproductive biology of a stock and its reproductive potential (Makmur et al., 2003). Studies on the biology of wild betta fish (*Betta picta)* have begun to be tested on a research scale, but are still limited to feed and environmental factors. This research needs to be conducted because it is one of the requirements for the domestication of wild betta fish to prevent extinction.

Several factors influence the reproductive biology of fish, namely internal and external factors. Internal factors include fish species and hormones, while external factors include temperature, food, stocking density, light intensity, and others. The main external factors that influence reproductive biology are feed and environment (Syafei et al., 1992 *in* Sitiady, 2008). These environmental factors can be temperature, pH, or dissolved oxygen. The ideal temperature for betta fish is 27.4˚–28.6˚C, pH ranges from 5.3 – 5.8, and dissolved oxygen (DO) ranges from 3.43 – 3.7 mg/L (Siregar et al., 2018).

Based on the above background, this study was conducted to determine the reproductive biology of wild betta fish (*Betta picta*), including gonadal maturity level (GML), gonadal maturity index (GMI), gonadal index (GI), *hepatosomatic index (*HSI), sex ratio, growth patterns, plankton abundance, and water quality in the Gending Mertoyudan River, Magelang Regency.

2. Materials and Methods

2.1. Time and Place

The research was conducted from October to November 2023. This research was carried out in the Gending River, Mertoyudan, Magelang Regency, Central Java Province. Observation of fish samples was carried out at the Laboratory of the Faculty of Agriculture, Tidar University.

2.2. Research Procedure

a. Sampling of wild betta fish, Wild betta fish (*Betta picta*) used were caught in the wild. The fish were caught using a scoop and then placed in a temporary bucket before being transferred to plastic containers to be taken to the laboratory. The number of wild betta fish required was 30 fish per observation, and since this study involved three observations, the total number required during the study was 90 fish. This is in accordance with Raden (2014), who states that for studies using statistical data analysis, the minimum sample size is 30 fish, so the sample taken was 30 fish per observation. Observations were conducted once every two weeks from October to November. *Simple random sampling* is the collection of samples from a population conducted randomly without regard to the strata in the population (Sugiyono, 2017). The method of collecting fish samples was by using a scoop.
b. Observation and data collection: Before dissection, the length and weight of wild betta fish were measured using a ruler and scale. After that, dissection was performed on the abdomen to view the gonads. Dissection began by cutting the fish's abdomen from the anus to the ventral area, then to the front of the body, ending just behind the head (Ledheng et al., 2018). Observing the fish's gonads to determine their maturity level. Measuring the weight of the fish's gonads to determine the gonadal maturity index and gonadal index as well as the length-weight relationship. Counting the males and females to determine the sex ratio of wild betta fish.
c.

2.3. Water Quality Measurement and Experimental Design

Fish samples were taken at three stations on the Gending River, namely upstream, midstream, and downstream, where each station, such as upstream, took 10 wild betta fish, midstream took 10 fish, and downstream took 10 fish, so that the total number of observations was 30 wild betta fish. Sampling points were chosen at the upstream, middle, and downstream areas because these areas are the habitat of wild betta fish. This is in accordance with the research by Purwanto et al. (2014), which states that non-experimental research station determination uses *purposive sampling (*from upstream to downstream), where the consideration for taking samples is based on the description of the river water conditions and the fact that wild betta fish are often found under aquatic plants located at these stations. The sampling points between the upstream, middle, and downstream had a distance of 75 m between stations. This is in accordance with the research by Fajar and Rudianti (2016), where sampling was carried out at 3 different stations with a distance of 75 m between stations.

Water quality measurements in this study included temperature, pH, and DO, which were conducted at the time of fish sampling. Temperature was measured using a thermometer, pH using a pH meter, and DO using a DO meter.

2.4 Parameters Observed

a. Gonadal Maturity Level (GML)

Gonad maturity level (GML) can be observed microscopically. Microscopic observation was conducted to determine the length, weight, color, and development of the gonad contents. After measuring the weight of the gonad, the gonad maturity level was observed morphologically according to Kesteven *in* Effendie (2002), namely:

Table 1.
Criteria for gonad maturity level in fish

NO.	GMS	Gonad Morphology
I	Female	Transparent testes and ovaries, colorless to grayish. Eggs are not visible to the naked eye
II.	Female development	The testes and ovaries are clear, reddish gray. They are half or less than half the length of the lower cavity. Individual eggs can be seen with a magnifying glass.
III.	Development 1	The testes and ovaries are oval-shaped, reddish in color with capillaries. The gonads ( ) fill approximately half of the space toward the lower part. The eggs appear as white powder.
IV.	Development 2	The testes are reddish-white. No sperm is present when the abdomen is pressed. The ovaries are reddish-orange. The eggs are clearly

		distinguishable as oval-shaped. The testes and ovaries fill approximately two-thirds of the lower cavity.
V.	Pregnant	Sexual organs fill the lower cavity. The testes are white, and sperm droplets are released when the abdomen is pressed. The eggs are round in shape, some of which are clear and mature.

Source: Kesteven (1973)

b. Gonadal Maturity Index (GMI)

The Gonadal Maturity Index (GMI) is calculated based on the ratio of gonad weight to fish weight, using the formula (Sadekarpawar and Parikh, 2013):

$$GMI = \left(\frac{Wg}{Wt}\right) \times 100\%$$

Notes:
GMI : Gonadal Maturity Index (%)
Wg : Gonad Weight (g)
Wt : Total fish weight (g)

c. Gonad Index (GI)

The gonadal index (GI) can be calculated using the following formula (Batts, 1973 *in* Effendie, 1979):

$$GI = \frac{Wg}{L^3} \times 10^8$$

Explanation:
GI : Gonadal Index
Wg : Gonad Weight (g)
L : Fish length (mm)

d. *Hepato Somatic Index* (HSI)

The Hepato Somatic Index (HSI) can be calculated based on the ratio of liver weight to body weight of the tested fish, using the formula Bucacker et al., (1990) *in* Suhaili et al., (2017):

$$HSI = \frac{Wh}{W} \times 100\%$$

Explanation:
HSI: *Hepatosomatic Index* (%)
Wh: Liver weight of the fish (g)
W: Fish body weight (g)

e. Sex Ratio (Sex Ratio)

The sex ratio can be calculated using the following formula (Effendi, 2002):

$$\text{Sex ratio} = \frac{A}{B} \times 100\%$$

Explanation:
A = Number of fish samples (male or female)
B = Total number of fish individuals present (tails)

f. Growth Pattern

The length-weight relationship can be analyzed using the formula (Hile, 1963 *in* Effendie, 1979):

$$W = aL^b$$

Explanation:
W : Fish body weight (g)
L : Total length of fish (mm)
a,b : Constants

The growth pattern of fish can be determined from the value of constant b in the length-weight relationship of the fish. If b=3, then the growth is isometric (increase in length is proportional to increase in weight). If b is not equal to 3, then the relationship formed is allometric (increase in length is not proportional to increase in weight). If b>3, the relationship is positive allometric, meaning that weight gain is more dominant than length gain, while if b<3, the relationship formed is negative allometric, meaning that length gain is more dominant than weight gain (Effendie, 1979).

g. Plankton Abundance

Plankton abundance can be calculated using the following formula (Sachlan, 1982 *in* Amanta and Hasan, 2012):

$$\boldsymbol{N = n \times \frac{Vr}{Vo} \times \frac{1}{Vs}}$$

Explanation:
N: Plankton abundance (ind/l)
n: Total number of identified plankton
Vr: Volume of filtered water
Vo: Volume of water observed
Vs: Volume of filtered water

2.6 Data Analysis

The data obtained from this study are qualitative and quantitative data. The variables observed in this study were fish weight (grams), total length (mm), gonad weight (grams), gonad maturity level (TKG), gonad maturity index (IKG), gonad index (IG), *hepato somatic index (*HSI), sex ratio, growth pattern, plankton abundance, and water quality. The data obtained in this study were processed using *Microsoft Excel.*

3. Results and Discussion

a. Results of General Environmental Condition Observations

In general, the sampling environment, namely the Gending River, Mertoyudan, Magelang Regency, can be described as follows: the river has very clear water and is covered with aquatic plants such as kale.

Figure 1. Environmental Conditions of the Sampling Site at the Gending River

The sampling location conditions are consistent with the natural habitat of wild betta fish. This is in line with Wahyudewantoro's (2017) opinion that betta fish prefer places with abundant aquatic vegetation, as it provides protection from fish-eating birds.

b. Gonadal Maturity Levels of Wild Betta Fish

Various levels of gonadal maturity of wild betta fish samples from the first to the third in a 14-day interval over 1.5 months were observed visually and then compared with the classification of gonadal maturity levels from Kesteven *in* Effendie (2002). The general results of direct observation of the differences between male and female wild betta fish ( ) are that male wild betta fish have a more slender body morphology, a bluish color on their anal fins, and aggressive and agile movements, while female wild betta fish have a larger body size, a golden yellow color on their anal fins, slow movements, and a larger abdomen when their gonads are mature. This is consistent with the opinion of Tan and Kottelat (1998), that male wild betta fish have more attractive colors, while female wild betta fish have a golden yellow color.

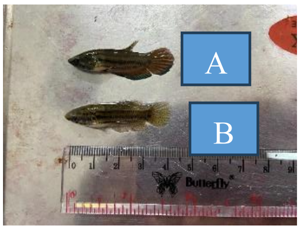

Figure 2. Wild Betta Fish A) Male B) Female

The results of observations on the gonadal maturity level of wild betta fish show that there are changes in TKG, as presented in Table 2.

Table 2.
Gonadal Maturity Level of Wild Betta Fish in the Gending River

Week	Station	Gonadal Maturity Level	Number of Fish (tails)
II	1	I: 10	
	2	I: 6, III: 3, V: 1	30
	3	I: 6, II: 1, V: 1	
IV	1	II: 6, III: 1	
	2	II: 3, IV: 1, V: 6	30
	3	I: 1, II: 5, III: 1, IV: 1, V: 2	
VI	1	III: 1, IV: 2, V: 7	
	2	II: 2, III: 3, IV: 3, V: 2	30
	3	I: 1, III: 5, V: 4	

Source: Personal Data (2023)

Based on Table 2, it can be seen that in the second week at station 1, the average wild betta fish entered TKG I (Dara), which can be seen morphologically as transparent testicles and ovaries, colorless to gray in color, with eggs not visible to the naked eye. Station 2 was found to have TKG I, TKG III, and TKG V, with TKG I (Dara) being the most abundant, characterized by transparent testes and ovaries, colorless to grayish, with eggs not visible to the naked eye. Station point 3 was found to have TKG I, TKG II, and TKG V, with the most abundant being TKG I (Dara), which are transparent, colorless to grayish testicles and ovaries, with eggs not visible to the naked eye.

In the fourth week at station point 1, TKG I, TKG II, TKG III, and TKG V were found, with TKG II (developing female) being the most abundant. Morphologically, it consists of clear, reddish-gray testes and ovaries, with individual eggs visible under a magnifying glass. Station 2 was found to have TKG III, TKG IV, and TKG V, with TKG V (pregnant) being the most numerous. Morphologically, the sexual organs filled the lower cavity, the testes were white, sperm droplets were released when the abdomen was pressed, and the eggs were round, yellow, and mature. Station 3 was found to have TKG I, TKG II, TKG III, TKG IV, and TKG V, with TKG II (developing) being the most common. Morphologically, the testes and ovaries were clear, reddish gray, and the eggs were visible one by one with a magnifying glass.

In week VI at station point 1, TKG III, TKG IV, and TKG V were observed, with TKG V (pregnant) being the most common. Morphologically, the sexual organs filled the lower cavity, the testes were white, sperm droplets were observed when the abdomen was pressed, and the eggs were round, yellow, and mature. Station 2 was found to have TKG II, TKG III, TKG IV, and TKG V, with TKG IV (Development II) being the most numerous, where the testes were reddish-white, the ovaries were reddish-orange, and the eggs could be distinguished by their round shape. Station 3 was found to have TKG I, TKG III, and TKG V, with the most common being TKG III Development I, where the testicles and ovaries are egg-shaped, reddish in color with capillaries, and the eggs can be seen as white powder.

The variation in TKG values obtained at each station is thought to be due to differences in environmental conditions, food availability, and temperature at each station. This is in line with the opinion of Tarigan et al. (2017) that TKG variation is caused by the environmental conditions in which the fish live, the availability of food, and temperature. Mariskha and Abdulgani (2012) also argue that fish that do not have the same TKG values despite having the same length and weight range are influenced by environmental conditions, food availability, temperature, salinity, and the growth rate of the fish themselves. The graph of TKG observations of wild betta fish (*Betta picta)* in the Gending River during three sampling periods (October–November 2023) can be seen in the figure below.

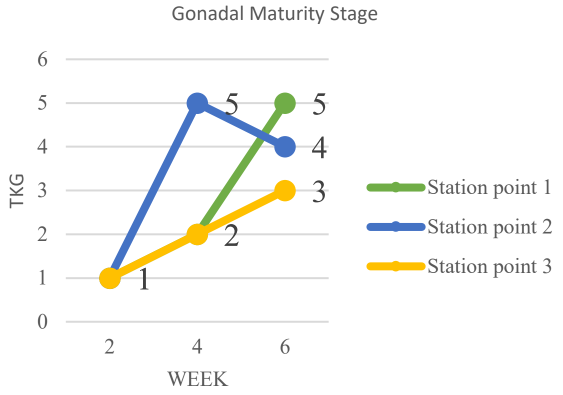

Figure 3. TKG Graph of Wild Betta Fish; Source: Personal Data (2023)

The results from the graph above show that at Station 1, there was an increase from the second week to the sixth week. Station 2 experienced an increase from the second week to the fourth week, while the fourth week to the sixth week experienced a decrease. According to Makmur et al. (2023), this is thought to be due to factors such as food availability, adaptation patterns, survival strategies, and the growth rate of the fish. Station 3 experienced an increase from the second week to the sixth week.

The TKG graph results for station 1, station 2, and station 3 show an increase each week, with the second week averaging TKG I, the fourth week averaging TKG II, and the sixth week averaging TKG V. This occurred because the observations were made in October–November, which is the beginning of the rainy season. This is in line with Yuniar's (2017) opinion that fish usually reproduce at the beginning of the rainy season.

The highest TKG value was obtained in the sixth week, when the gonads were mature ( ). This was also influenced by rainfall. This is in accordance with Sitiady (2008), who states that changes in TKG are also influenced by external factors such as temperature, food, light intensity, rainfall, and so on. Rainfall in November reached 280.5 mm/month. This rainfall intensity is classified as fairly high (moderate). According to BMKG *in* Supriyati et al. (2018), rainfall is divided into four categories, namely low (0-100 mm/month), moderate (100-300 mm/month), high (300-500 mm/month), and very high (>500 mm/month).

c. 's Gonad Maturity Index (GMI)

The Gonadal Maturity Index (GMI) is the percentage of the weight of the fish's gonads relative to the weight of the fish's body. This gonadal maturity index is obtained by dividing the weight of the fish gonads by the total body weight of the fish and multiplying by 100% (Ferreri et al., 1987 in Astuti et al., 2019). The average GMI values for each observation are presented in the figure below.

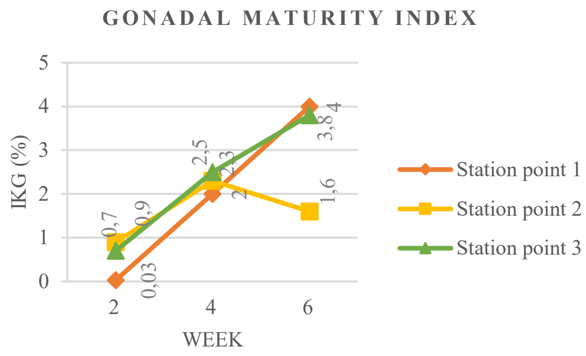

Figure 4. GMI Graph of Wild Betta Fish; Source: Personal Data (2023)

Based on the graph above, it can be seen that the GMI value at station 1 increased from the second week to the sixth week. Station 2 experienced an increase from the second to the fourth week, while the fourth to the sixth week experienced a decrease. Station 3 experienced an increase from the second to the sixth week. The IKG value in wild betta fish (*Betta picta)* showed the highest average percentage in the sixth week of observation at station 1, which was 4% in November.This study obtained data on the increase in IKG from the second week to the sixth week of observation, namely in the second week of observation, the average IKG was 0.5%, in the fourth week of observation, the average was 2.3%, and in the sixth week of observation, the average was 3.2%. This IKG value is influenced by the weight of the gonads and the body weight of the fish, where the larger the size of the gonads in the fish's body, the greater the gonadal maturity index in the fish (Hendri, 2010). According to Effendie (1997), the greater the level of gonadal maturity, the greater the gonadal maturity index value. Based on the calculation of this gonadal maturity index, the peak of natural betta fish reproduction occurs in November (Appendix 2). This is in accordance with the graph above, which shows that the gonadal maturity index of natural betta fish (*Betta picta)* ranges from 0.03% to 4%. The gonadal maturity index values of fish before and after spawning are 3 to 4% . The results of the GMI observations from the second to the sixth week show that the TKG criteria based on the GMI value are immature because they are less than 20%. Based on Setyaningrum (2016), the TKG criteria based on the GMI value are that if the GMI value is more than 20%, the TKG condition is mature, while if it is less than 20%, the TKG condition is immature.

According to Effendi (2002), fish gonads will increase in size when spawning, causing the gonadal maturity index to be high. Fish gonads before spawning tend to be smaller, and the fish's food metabolism will be channeled for gonadal development. Gonad weight increases rapidly and significantly during spawning and will decrease rapidly once spawning has taken place.

d. Natural Betta Fish Gonadal Index

The GI values in this study obtained at station 1 from the second week to the sixth week showed an increase. Station 2 from the second week to the sixth week also showed an increase. Station 3 from the second week to the sixth week also showed an increase. The GI values are presented in the figure below.

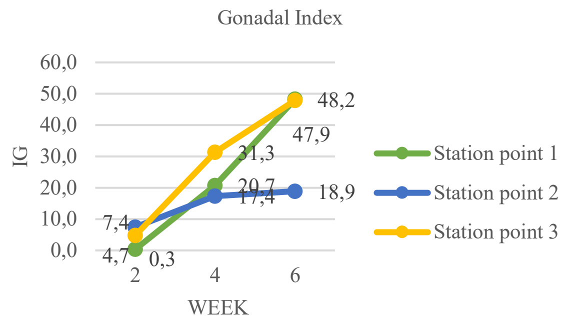

Figure 5. IG Graph of Wild Betta Fish; Source: Personal Data (2023)

Based on the graph above it is stated that the IG value in wild betta fish (*Betta picta*) showed the highest value in the sixth week observation at station point 1, which was 48.2. The average results of the observations showed an increase: the second week's observation was 4.2, the fourth week's observation was 26.8, and the sixth week's observation was 38. These average results indicate that in each observation, the gonadal index ranged from immature to mature. The classification of gonadal maturity levels based on the gonadal index can be seen in Table 3 below.

Table 3.
Classification of Gonad Maturity Levels Based on the Gonad Index

Week	Station	GI	Classification
II	1	0.3	Immature gonads
	2	7.4	Maturing gonads
	3	4.7	Cooked gonads
IV	1	20.7	Mature gonads
	2	17.4	Mature gonads
	3	31.3	Mature gonads
VI	1	48.2	Mature gonads
	2	18.9	Mature gonads
	3	47.9	Mature gonads

Source: Personal Data (2023)

Based on the table above, it can be seen that in the second week at stations 1 to 3, the classification ranges from immature gonads to cooking gonads; in the fourth week at stations 1 to 3, the classification ranges from cooked gonads to mature gonads; and in the sixth week at stations 1 to 3, the classification ranges from cooked gonads to mature gonads. This is in line with the classification of gonad maturity levels, where the gonad index values obtained are consistent with the findings of Effendie (2002).

Generally, the gonad index value is calculated by comparing fish length, while fish length is related to fish growth. Fish growth is influenced by many factors, resulting in a wide variety of growth rates. The fish gonad index, which is the ratio of gonad weight to fish length, varies among fish species. The observations made from October to November 2023 were during the rainy season. According to Makmur et al. (2003), the rainy season is the spawning phase for freshwater fish living in tropical waters. This is because rainfall affects water surface fluctuations and water discharge, causing water circulation that affects the temperature of the water. Water fluctuations, discharge, and circulation cause the water temperature to become warm, which supports fish spawning.

e. *Hepato Somatic Index of* Wild Betta Fish

The HSI value can be calculated based on the fish's body weight and liver weight. The HSI value is measured by weighing the liver obtained from dissecting wild betta fish and comparing it to the total weight of the wild betta fish. The HSI value of wild betta fish can be seen in the image below.

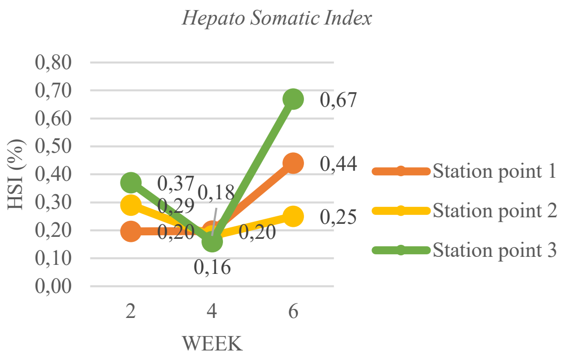

Figure 6. HSI Graph of Wild Betta Fish; Source: Personal Data (2023)

Based on the graph above, it can be seen that the HSI value at station 1 increased from the second week to the sixth week. Station 2 decreased from the second week to the fourth week, while increasing from the fourth week to the sixth week. Station 3 also experienced a decline from the second week to the fourth week, while from the fourth week to the sixth week, there was a fairly rapid increase. The HSI value per station was obtained from the average HSI value per observation, namely 0.29% for the second week, 0.18% for the fourth week, and 0.45% for the sixth week. The HSI values at each station point in the second to sixth weeks of observation increased, although there was a decrease between the second and fourth weeks of observation. This occurred because in the fourth week observation, the number of male and female fish was balanced, but even though it was balanced, the HSI value decreased, presumably because the fat stored in the liver was used for the vitelogenesis process by the gonads, so that the liver weight decreased, or the stored fat was energy that would be used for the ovarian development process. This is in line with the opinion of Sudarshan and Kulkarni (2013), that the decrease in HSI value is due to the use of energy stored in the liver for the ovarian development process. The average HSI value obtained between male and female fish was higher in female fish than in male fish, namely 0.54% for female fish and 0.19% for male fish (Appendix 4). This occurs because during the oogenesis process in female fish, more vitellogenin is required, causing the liver to enlarge compared to the spermatogenesis process (Herawati et al., 2015).

f. Sex Ratio

The sex ratio is the relative frequency of male and female sexes from the catch or after sex determination, but it may not be accurate. Sex ratio comparison can be used to estimate the population balance between males and females (Yusra, 2013). The sex ratio values obtained from the second to sixth week of observation can be seen in Table 4 below.

Table 4
Sex Ratio of Wild Betta Fish

Week	Station Point	Male Fish	Female Fish	Sex Ratio (Male : Female)
II	1	3	7	1:2
	2	5	5	1:1
	3	7	3	2:1
IV	1	6	4	2:1
	2	3	7	1:2
	3	6	4	2:1
VI	1	3	7	1:2
	2	5	5	1:1
	3	4	6	1:2
Total		42	48	1:1

Source: Personal Data (2023)

Based on the data in Table 4, the sex ratio is presented based on observations from the second week to the sixth week. Overall, the number of female wild betta fish (*Betta picta*) was 48, and the number of male wild betta fish (*Betta picta*) was 42. This proves that the sex ratio between male and female fish is 1:1 fish. This is in accordance with the research by Priyadi et al. (2021), which states that wild betta fish spawn in pairs, namely 1 male : 1 female.

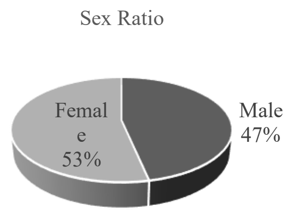

Figure 7. Percentage of Sex Ratio of Wild Betta Fish

The number of female wild betta fish is greater than the number of male wild betta fish. The sex ratio obtained is 1:1 . The imbalance in the number of fish occurs due to differences in their feeding habits. Feeding habits are also influenced by the fish's habitat, preference for certain types of food, season, size, and age (Roul et al., 2017). According to Omar et al. (2015), the sex ratio in nature is not absolute but is influenced by distribution patterns caused by food availability, population density, and food chain balance. Omar et al. (2015) also state differences in growth patterns, age differences, first size at gonadal matu , and the addition of new fish species to an existing fish population.

g. Length and Weight Relationship

The relationship between the length and weight of male and female wild betta fish (*Betta picta*) is presented in Figure 8. Based on the results of the study, 90 wild betta fish caught from October to November 2023 had an average body weight of 0.699 grams and an average length of 3.99 cm. The results of the length-weight relationship analysis obtained a b value of 1.008261, indicating that the growth pattern of male and female wild betta fish (*Betta picta)* is negatively allometric (b<3), which means that body length grows faster than body weight. Several factors that cause a smaller b value are environmental factors, fish development, sex, fish stock, and even differences or changes in stomach contents caused by changes in time. This is in accordance with the findings of Nasution and Machrizal (2021), who obtained negative allometric growth patterns when analyzing the length-weight relationship of *Barbonymus gonionotus* in Aek Maili. Fish growth or increase in length and weight is influenced not only by hereditary factors, sex, food, parasites, and disease, but also by water quality, such as temperature, dissolved oxygen, and carbon dioxide in their habitat.

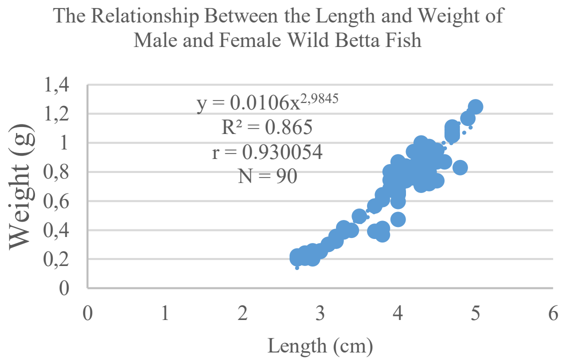

Figure 8. Relationship between Length and Weight of Male and Female Wild Betta Fish

The results of regression analysis and the length-weight relationship graph (Figure 8) have a regression equation of $y = 0.0106x^{2.9845}$ with a coefficient of determination of $R^2 = 0.865$, which means that 86.5% of the increase in fish body weight occurs due to an increase in fish body length, while 13.5% of the increase in fish weight is caused by other factors, namely environmental factors and age. Food availability is a major factor in the length-weight relationship for most fish species (Dewanti et al., 2014).

The relationship between the length and weight of male wild betta fish (*Betta picta*) is presented in Figure 9 below. Based on the results of the study, 42 male wild betta fish were obtained with an average weight of 0.71 grams and an average length of 4.04 cm. The analysis of the length and weight relationship yielded a b value of 1.011147, indicating that the growth pattern of male betta fish is negatively allometric (b<3), which means that length growth is faster than body weight growth. Negative allometry describes that the energy obtained from the nutritional intake given to fish tends to be used more for physiological activities and movement (Kusmini et al., 2018). Muchlisin et al. (2010) stated that the magnitude of the b value is influenced by fish behavior, where fish that swim actively show a lower b value compared to fish that swim passively.

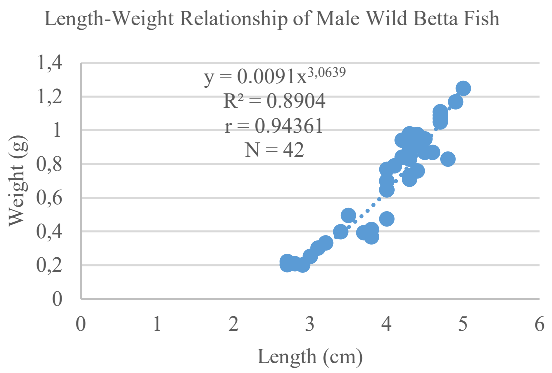

Figure 9. Relationship between Length and Weight of Male Wild Betta Fish

The results of the regression analysis and the length-weight relationship graph (Figure 9) have a regression equation of $y = 0.0091x^{3.0639}$ with a coefficient of determination of $R(2) = 0.8904$, which means that 89.04% of the increase in fish body weight occurs due to an increase in fish body length, while 10.96% of the increase in fish weight is caused by other factors such as environmental factors and age. Examples of these environmental factors include differences in temperature, salinity, geographical location, pH, sampling conditions, and biological conditions (gonadal development) (Muchlisin, 2010).

The relationship between the length and weight of female wild betta fish (*Betta picta*) is also presented in Figure 10 below. Based on the results of the study, 48 female wild betta fish were obtained with an average weight of 0.689 grams and an average length of 3.95 cm. The analysis of the relationship between the length and weight of female wild betta fish yielded a b value of 1.004789, indicating that the growth pattern of female wild betta fish is negative allometric (b<3), which means that length growth is faster than body weight growth. According to Jenning et al. (2001), the b value depends on physiological and environmental conditions such as temperature, pH, salinity, geographical location, and sampling techniques, as well as biological conditions such as gonadal development and food availability (Froese, 2006).

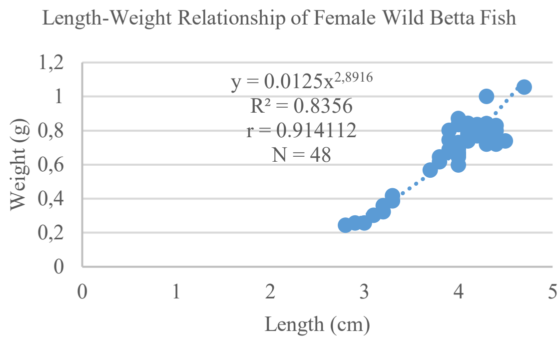

Figure 10. Relationship between Length and Weight of Female Wild Betta Fish

The results of the regression analysis and the length-weight relationship graph (Figure 10) have a regression equation of $y = 0.0125x^{2.8916}$ with a coefficient of determination of $R^2 = 0.8356$, which means that 83.56% of the increase in fish body weight occurs due to an increase in fish body length, while 16.44% of the increase in fish weight is caused by other factors such as environmental factors. Muchlisin (2010) argues that the magnitude of the coefficient b is influenced by fish behavior. For example, active swimming fish (pelagic fish) tend to have lower b values compared to passive swimming fish (mostly *demersal* fish*)* ( ). This can also be attributed to the allocation of energy expended for movement and growth. Wild betta fish (*Betta picta)* are fast or active swimmers, as evidenced by the difficulty in obtaining samples of these fish due to their agile movements and fast swimming. In addition, according to Agustina et al. (2019), it is important to note that fish growth and population dynamics in each water area vary greatly due to seasonal differences.

h. Plankton Abundance

Based on the research results, the plankton abundance obtained during the second week of observation to the sixth week of observation is presented in the figure below.

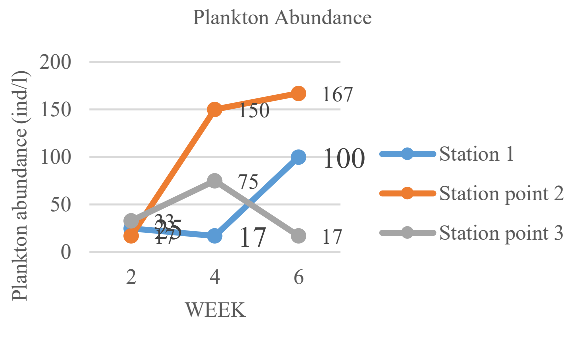

Figure 11. Plankton Abundance Graph; Source: Personal Data (2023)

Based on the image above, it can be seen that station 1 experienced a decline from the second week to the fourth week, while the fourth week to the sixth week experienced an increase. Station 2 experienced an increase from the second week to the sixth week. Station 3 experienced an increase from the second week to the fourth week, while the fourth week to the sixth week experienced a decline. The total plankton abundance in this study ranged from 17 ind/l to 167 ind/l. The highest plankton abundance was found at station 2 in the sixth week with a total abundance of 167 ind/l, while the lowest plankton abundance was found at station 1 in the fourth week and station 3 in the sixth week with a total abundance of 17 ind/l. The high plankton abundance at these stations is thought to be due to the input of organic and inorganic materials that affect plankton abundance, as well as the possibility of being influenced by fairly calm waters, resulting in optimal sunlight intensity. The low plankton abundance is thought to be due to the presence of trees covering the water at these stations, resulting in less sunlight intensity, which is one of the factors affecting plankton abundance in rivers. This is in line with the opinion of Sanders et al. (1987) *in* Abida (2010), that environmental factors greatly influence the dominance of a species and succession, namely temperature, light, concentration, ratio, and chemical form of nutrients. The differences in the composition and abundance of phytoplankton found at each station may be influenced by several factors. It is possible that the physical and chemical factors of the water may affect the composition and abundance of phytoplankton. This is in accordance with the opinion of Fachrul (2007) that the presence of plankton in a body of water is influenced by physical, chemical, and biological factors. Plankton species richness is also influenced by water discharge mass and current velocity, where faster currents result in lower or fewer plankton being found, as plankton movement is greatly influenced by current velocity.

i. Water Quality

Observations during the study showed that water quality is one of the important factors supporting the growth of wild betta fish. Environmental factors that influence the development of fish gonads are temperature, pH, and DO. Based on the results of water quality observations (temperature, pH, and DO), the average water quality results are presented in Table 5 below.

Table 5.
Water Quality Measurements

Parameter	Measurement Results			Suitability
	Second Week	Fourth Week	Sixth Week	
Temperature (˚C)	27.2	27.4	28.3	27–29*
pH	6.36	6.63	6.46	4.8 – 6.7*
DO (ppm)	7.6	7.76	7.86	>4**

Source: Primary Data Analysis (2023); *Kusrini et al. (2010); **Arman (2001)

Based on the results of water quality measurements taken from the second week to the sixth week of observation, the average temperature was 27.2˚C. This temperature is still considered optimal. This is in accordance with the opinion of Kusrini et al. (2010), that the ideal temperature in the natural habitat of betta fish is 27˚–29˚C. This is because the temperature obtained in the study is still optimal. In accordance with Parker (2012), aquatic animals approach the temperature of their environment because the energy required to regulate body temperature will be used for growth. As the water temperature increases, the level of gonadal maturity will also develop. Temperature can affect fish during spawning, in the development and survival of eggs and larvae, and influence the distribution, aggregation, migration, and behavior of juveniles and adults (Zainuddin et al., 2004). Temperature also affects plankton abundance, where the temperature obtained in the study is also the optimal temperature for phytoplankton growth, in accordance with Sofarini (2012), who states that the optimum temperature for phytoplankton growth is 20–35°C.

The pH obtained in this study ranged from 6.2 to 6.7, which is still very good. This is in accordance with the opinion of Kusrini et al. (2010), that in its natural habitat, the ideal pH for wild betta fish is 4.8 to 6.7. Meanwhile, according to Cholik et al. (2005) *in* Santika et al. (2021), the pH of water in ponds around 6.5-9 is a good condition for fish production, while for freshwater aquaculture it is 6.5-8. This statement is reinforced by Pateda (2014), who states that the water characteristics that are most suitable for betta fish maintenance are a pH value ranging from 6 to 7. pH also affects the abundance and growth of phytoplankton, as the optimum pH for phytoplankton growth ranges from 6.5 to 8 (Widiana, 2012).

The results of dissolved oxygen measurements during the study ranged from 6.6 to 9.6 mg/l. The dissolved oxygen (DO) value is classified as very good. This is in accordance with Arman (2001), who states that the ideal dissolved oxygen content for betta fish fry is above 4 ppm (mg/l). Meanwhile, Kusrini et al. (2010) argue that the ideal dissolved oxygen level for betta fish is between 5 and 6 mg/l. This is reinforced by Fauzan et al. (2018), who argue that the ideal dissolved oxygen level for fish breeding media is >5 ppm. Dissolved oxygen in water is used for the respiratory and metabolic processes ( ) in fish, which are used to produce the energy needed for the activities, growth, and reproduction of biota, especially fish (Hayati, 2019). Optimal water quality will help the survival of organisms and optimize growth. This makes water quality very important to prevent aquatic organisms from contracting diseases, as well as to maintain the survival and growth of fish.

4. Conclusion

Based on the results of the research conducted, it can be concluded that:
The reproductive biology of wild betta fish (*Betta picta*) in the Gending River consists of TKG I-TKG V, with an IKG value of 4%, an IG value of 48.2, an HSI value of 0.67%, a sex ratio of 1:1, a negative allometric relationship between length and weight, and a plankton abundance in the Gending River of 167 ind/l with several types of phytoplankton found, namely *Dinophysis* sp., *Ceratium* sp., *Gyrodinium* sp., *Dinobryon* sp., *Gloeocapsa* sp., *Lauderia detonula, Spirulina* sp., *Thallassiosira antarctica, Polykrikos schwatzill, Hemiaulus* sp., *Leptocylindrus* sp., *Radiococcus plantonicus, Stephanodiscus* sp., *Amylax* sp., and *Woronichinia* sp. There was an increase in observations from the second week to the sixth week.

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