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Some Biological Aspects of Spotted Barb *Barbodes binotatus* (Valenciennes, 1842) in Tamblingan Lake

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ABSTRACT The biological aspects of the spotted barb, *Barbodes binotatus* (Valenciennes, 1842) in Tamblingan Lake were not published yet. This study aims to determine the biological aspects of spotted barb in Tamblingan Lake. Fish samples were captured using gill nets with various mesh sizes at five fixed stations monthly from January to December 2019. A total of 357 individuals of the spotted barb was collected, with the total length of the specimens ranging from 3.9 to 15.6 cm, and total weight varied between 0.93 and 60.30 g. The length-weight relationship for males and females were expressed as $W = 0.0375L^{2.83}$ and $W = 0.0272L^{3.02}$, respectively. The growth pattern for males and females was allometric negative and isometric, subsequently. The male-female sex ratio was 1.10:1, and the condition factor for males and females were 0.75-1.42 and 0.40-1.49, respectively. We observed male fish with gonad maturity stage I to IV. In contrast, female fish have gonad maturity stage II to V. The highest gonadosomatic index of male and female fish was found in September, indicating a peak of the spawning time. Fecundity ranged from 57-23.897 eggs, with an average of 5.901 eggs.

Keywords: *Barbodes binotatus*; biological aspects; Tamblingan Lake

INTRODUCTION

Spotted barb (*Barbodes binotatus*) is freshwater fish that belongs to the family Cyprinidae. *B. binotatus* has several synonymous names in the scientific literature, including *Puntius binotatus*, *Systomus binotatus, Capoeta binotata, and Barbus* maculatus (Kottelat, 2013). This species is native to Southeast Asia, widely distributed in Laos, Vietnam, Cambodia, Myanmar, Brunei Darussalam, Malaysia, the Philippines, Thailand, and Indonesia (Jenkins *et al*., 2015). *B. binotatus* is occurred in freshwater of Sumatra (Vitri *et al*., 2012; Situmorang *et al*., 2013), Java (Saepudin, 1999; Rahmawati, 2006; Mujtahidah, 2014), Bali (Sari *et al*., 2017; Pertami *et al*., 2020), Sulawesi (Parenti *et al*., 2014), and Kalimantan Islands (Jusmaldi & Hariani, 2018; Pratama *et al*., 2018). The distribution of this species is extensive, so this species is often used as an environmental indicator to assess habitat degradation or aquatic health (Isa *et al*., 2010; Zakeyudin *et al*., 2012).

Several studies related to *B. binotatus* have been carried out on a laboratory scale, such as egg development (Iswahyudi *et al*., 2014), evolutionary identification through DNA barcodes (Hutama *et al*., 2017), taxonomy (Roesma *et al*., 2019; Ahmad *et al*., 2020), and recombinant growth hormone (Sutarjo *et al*., 2020). Meanwhile, some biological aspects have been discussed, such as reproductive biology (Rahmawati, 2006), morphological analysis (Dorado *et al*., 2012; Vitri *et al*., 2012), comparison of food types (Situmorang *et al*., 2013), growth patterns (Lim *et al*., 2013; Jusmaldi & Hariani, 2018; Pratama *et al*., 2018), population dynamics (Batubara *et al*., 2019), and morphometric asymmetry (Astuti *et al*., 2020).

Based on the literature review, only studies or information on *B. binotatus* related to ichthyofauna were found in Buyan and Tamblingan Lakes (Sari *et al*., 2017) and a length measurement of *Barbodes binotatus* in Tamblingan Lake (Pertami *et al*., 2020). Information on other aspects of spotted barb in Tamblingan Lake has not been studied, so efforts to manage the resources of this fish species cannot be carried out. This study describes growth pattern, condition, sex ratio, gonad maturity stage, gonadosomatic index, and fecundity of spotted barb in Tamblingan Lake.

METHODS

The research with descriptive and quantitative methods was conducted at Tamblingan Lake from January to December 2019. A sampling of the spotted barb was determined using the purposive sampling method at five stations. The characteristics of the five stations already represented the condition of the Tamblingan Lake. The map of research locations and features of each sampling station can be seen in Figure 1 and Table 1.

Gill nets captured fish specimens with a width of 300 m and a height of 2m, and a mesh size of 0.5; 1.0; 1.5; 2.0; 2.5; 3.0 cm. The nets were settled at 5 PM and hauled in the next day at 8 AM. Fish samples were taken alternately. On the first day, the nets were fixed at stations 1, 2, and 3, and on the second day, the nets were settled at stations 4 and 5. Before the nets were hauled, measurements and water conditions were carried out in the morning.

Table 1. Characteristics of each fish sampling station.

Number	Station	Coordinate	Characteristics
1.	Lenggang	S:08°25'307" E:115°10'193"	It is overgrown with aquatic plants (*Nymphoides* sp.) and rocks; the topography is rather steep.
2.	Pura Dalem	S:08°25'657" E:115°10'212"	Edge of a rocky lake, aquatic plants (*Cyperus* spp.).
3.	Tirta Mengening	S:08°24'987" E:115°09'732"	The edge of the lake has cliffs, dead tree trunks.
4.	Tengah	S:08°26'281" E:115°09'787"	Location for fishers to spread their nets, the water current is quite strong.
5.	Pos Nelayan	S:08°26'524" E:115°09'441"	It is overgrown with aquatic plants (*Nymphoides* sp.), a sloping littoral zone, a location for a fisher to catch fish.

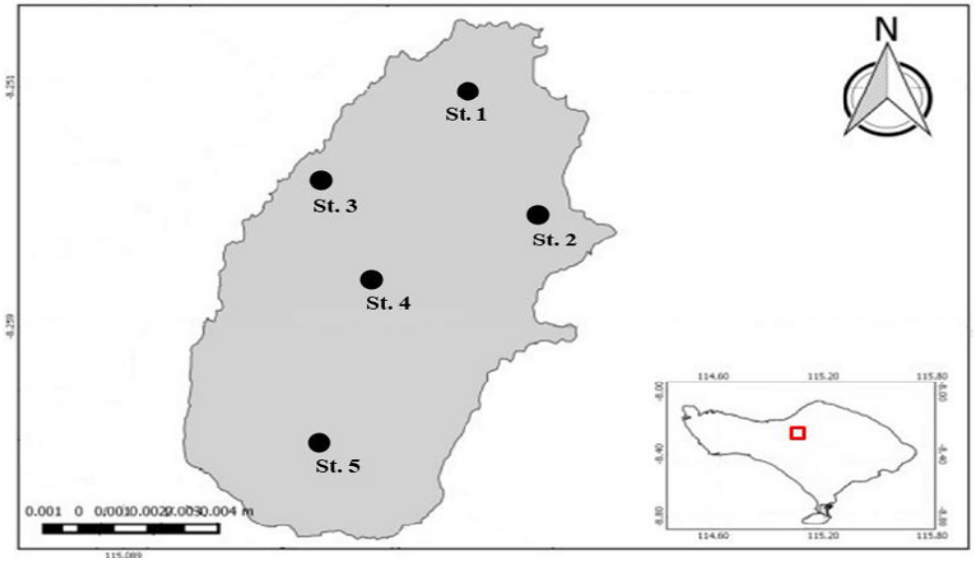

Figure 1. Map of sampling stations in Lake Tamblingan, Bali.

Samples of spotted barb were measured in length and weighed. Fish length measured included total length (TL), fork length (FL), and standard length (SL). The fish length was measured using a ruler with an accuracy of 0.1 cm. The length used in this analysis was the standard length because some samples have damaged caudal fin, so the standard size was used to analyze the length-weight relationship. The weight of the fish was weighed using a digital scale with an accuracy of 0.0001 g.

Fish samples were dissected to observe sex and gonad maturity stage. The gonads of male and female fish were weighed using a digital scale of 0.0001 g to calculate the gonadal maturity index. Eggs in female fish gonads at gonad maturity stage III and IV were taken and then calculated fecundity using the gravimetric method. Samples of the gonads used in calculating fecundity were taken from the anterior, middle, and posterior parts.

Data analysis

The length-weight relationship (LWR) of fish was determined using the formula according to Effendie (2002) as follows:

$$W = aL^b$$

Description: W: weight (g), a and b: length-weight regression constant, L: fish length (cm)

The relative condition factor (Kn) is calculated using the formula according to Rahardjo & Simanjuntak (2008) as follows:

$$K_n = \frac{W}{W^*}$$

Description: K_n: relative condition factor, W: weighted body weight (g), W*: bodyweight calculated (g) from the LWR equation.

Sex ratio, which is based on the number of male and female fish caught, is calculated using the formula according to Omar *et al*. (2014) as follows:

$$NK = \frac{J}{B}$$

Description: NK: sex ratio, J: number of male fish, B: number of female fish

To determine sex balance, the chi-square test is used using the equation according to Steel & Torrie (1993) as follows:

$$X^2 = \sum \frac{(o_i - e_i)^2}{e_i}$$

Description: X2: chi-squared value, oi: observed frequency of male and female fish, ei: expected frequency of male and female fish in balanced condition.

Adebiyi (2013) stated that the gonadosomatic index could be measured by comparing the weight of the gonads with the body weight of the fish. The gonadosomatic index formula is as follows:

$$GSI = \frac{BG}{BI} X\ 100$$

Description: GSI: gonadosomatic index, BG: gonad weight (g), BI: fish weight (g)

Calculation of fish fecundity using the gravimetric method according to Effendie (2002) as follows:

$$F = \frac{G}{Q} X\ N$$

Description: F: fecundity (eggs), G: gonad weight (g), Q: sub-gonadal weight (g), N: number of eggs in sub gonads (eggs).

RESULTS AND DISCUSSION

Length-weight relationship

Fish's length-weight relationship (LWR) is significant to know fish and fish stocks (Rosli & Isa, 2012). LWR is used as a biological indicator of an aquatic ecosystem (Courtney *et al*., 2014; Radhi *et al*., 2018). Based on LWR analysis of male fish from January to December 2019, the equation W = 0,0375$L^{2.83}$ with the coefficient of determination (R^2) of 0.91 (Figure 2). The b value obtained based on the test results is 2.83. This indicates that the growth pattern of fish is negative allometric. While the equation obtained LWR of female fish from January to December 2019, W = 0,0272$L^{3.02}$ with the coefficient of determination (R^2) of 0.91 (Figure 3). The b value obtained for female fish was 3.02. This indicates that the growth pattern of female fish is isometric.

The growth pattern of *B. binotatus* that differed between sexes was also reported by other studies. Rahmawati (2006) found that the growth pattern of *B. binotatus* was male negative allometric while the female was isometric. The growth pattern of *B. binotatus* in Kerian River Malaysia was positive allometric (Isa *et al*., 2010). Jusmaldi & Hariani (2018) found that the growth pattern of *Barbodes binotatus* in the Barambai River was positive allometric. Differences in fish growth patterns influenced by gonadal development (Jenning *et al*., 2001; Froese, 2006), location (Offem *et al*., 2007), gender (Anvar *et al*., 2008; Metín *et al*., 2011), season (Anene, 2005), population (Fontoura *et al*., 2010), life phase (Niyonkuru & Laleye, 2012), food and body size (Ebrahim & Ouraji, 2012), and environmental quality (Zargar *et al*., 2012).

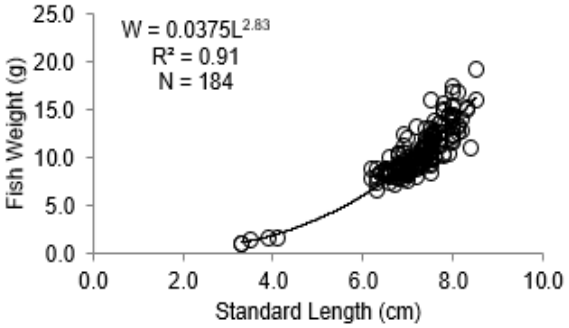

Figure 2. Length-weight relationship of male spotted barb (*Barbodes binotatus* Valenciennes, 1842) in Tamblingan Lake from January to December 2019.

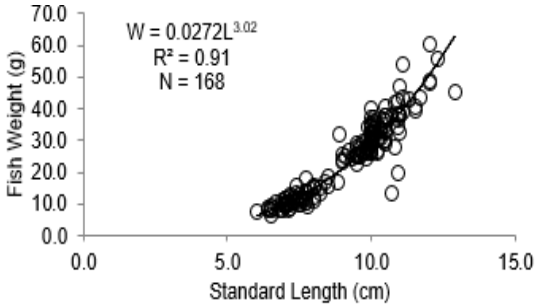

Figure 3. Length-weight relationship of female spotted barb (*Barbodes binotatus* Valenciennes, 1842) in Tamblingan Lake from January to December 2019.

Relative condition factor (Kn)

According to Gubiani *et al*. (2020), a condition factor is a number that indicates fish fatness. Condition factors indirectly indicate fish's physiological condition that influences intrinsic factors such as gonad development and fat reserves and

Table 2. The range and average relative condition factor of the spotted barb in Tamblingan Lake from January to December 2019.

Month	Total (n)	Female		Total (n)	Female	
		Range	Average		Range	Average
Jan	8	0.90-1.12	1.00	9	0.82-1.21	1.01
Feb	17	0.80-1.18	1.00	15	0.78-1.19	1.01
Mar	57	0.75-1.42	1.01	50	0.50-1.49	1.01
Apr	5	0.88-1.19	1.01	12	0.77-1.19	1.01
May	6	0.89-1.09	1.00	4	0.96-1.03	1.00
Jun	18	0.92-1.18	1.00	5	0.91-1.12	1.00
Jul	6	0.92-1.06	1.00	11	0.89-1.13	1.00
Aug	15	0.92-1.21	1.00	16	0.40-1.26	1.03
Sep	22	0.90-1.19	1.00	17	0.88-1.08	1.00
Oct	21	0.85-1.16	1.00	15	0.88-1.16	1.00
Nov	2	1.00	1.00	1	1.02	1.02
Dec	7	0.82-1.12	1.01	13	0.79-1.17	1.01
Total	184	0.75-1.42	1.00	168	0.40-1.49	1.01

extrinsic factors like food resources and environmental pressure. Condition factor helps evaluate various fish spawning areas (Ribeiro *et al*., 2004).

The average value of the relative condition factor (Kn) of male and female fish was calculated every month. It is known that the range of condition factors of male fish was 0.75-1.42, while the female fish was 0.40-1.49 (Table 2). Lim *et al*. (2013) stated that if the value of the relative condition factor is slightly greater than one, it indicates that the fish has achieved the expected growth. A high condition factor value is an indication that the fish are in good condition and there is a match between fish with their habitat (Dias *et al*., 2005). The average value of the condition factor of female fish is greater than that of male fish. This follows research from Pratama *et al*. (2018), which shows that female fish tend to be fatter at the same size as male fish. Several factors that can affect condition factors in fish include food availability (Rahardjo & Simanjuntak, 2008), stomach fullness (Faradonbeh *et al*., 2015), body size (Samat *et al*., 2008), season (Sarkar *et al*., 2013), and gonadal maturity (Dan-Kishiya, 2013; Jusmaldi & Hariani, 2018).

Sex ratio

Sex ratio is a reproductive parameter for determining the possibility of availability of male and female fish and can show the existence of excessive exploitation of one sex and an indication of environmental changes (Effendie, 2002; Omar *et al*., 2014). The sex ratio of male and female fish in Tamblingan Lake from January-December 2019 based on the results of the analysis carried out, the chi-square value was obtained 0.39 (> 0.05), which means the sex ratio of the spotted barb is in a balanced condition. The number of male fish in Tamblingan Lake was 184 individuals, and females were 168 individuals. The sex of five fish specimens was not able to identify due to the damaged gonads.

The chi-square test results show that the proportion of male fish is more than that of female fish. The ratio between male and female sex is 1.10:1 (Table 3). This condition indicates that the sex ratio of spotted barb in Tamblingan Lake is balanced. Jusmaldi & Hariani (2018) reported that the sex ratio of male and female spotted barb in the Barambai River, East Kalimantan, was balanced (1:1.12). Furthermore, Rahmawati (2006) stated that a balanced sex ratio of male and female spotted barb (1.15:1) was found in the upstream part of the Ciliwung Watershed, West Java. The balance in the number of male and female fish caught was thought, because male and female fish were in the same area when spawning, resulting in the same chance of being caught. Pratama *et al*. (2018) stated that in maintaining the survival of a population, the ratio of male and female fish is expected to be in a balanced condition; at least there are more female fish. Differences in environmental factors can affect the sex ratio. Environmental factors that can affect the sex differences of various fish species are temperature, pH, dissolved oxygen levels, and population density (Baroiler *et al*., 2009).

Gonad maturity stage

Gonad maturity stage of male fish from January to December 2019 was found in stage I-IV (Figure 3). At the same time, the female fish were found in stage II-V (Figure 4). The gonad maturity stage of male and female spotted barb in Tamblingan Lake from January to December 2019 are shown in Table 4 and Table 5.

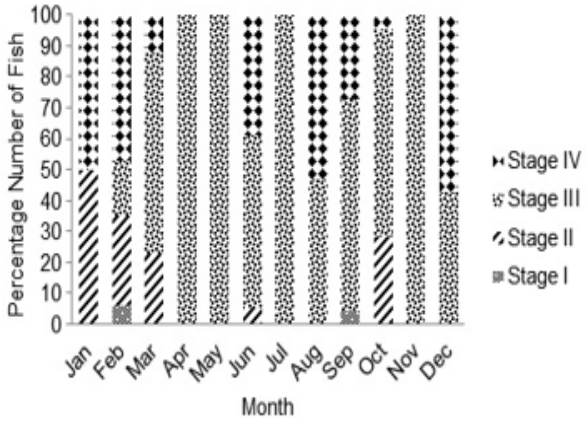

Figure 3. Gonad maturity stage of male spotted barb (*Barbodes binotatus* Valenciennes, 1842) in Tamblingan Lake from January to December 2019.

Table 3. Sex ratio of spotted barb in Tamblingan Lake from January to December 2019.

Month	Total (n)			Ready to spawn		
	Male	Female	Sex Ratio	Male	Female	Sex Ratio
Jan	8	9	0.89	4	3	1.33
Feb	17	15	1.13	8	5	1.60
Mar	57	50	1.14	7	32	0.22
Apr	5	12	0.42	0	6	0.00
May	6	4	1.50	0	2	0.00
Jun	18	5	3.60	7	2	3.50
Jul	6	11	0.55	0	3	0.00
Aug	15	16	0.94	8	9	0.89
Sep	22	17	1.29	6	17	0.35
Oct	21	15	1.40	1	14	0.07
Nov	2	1	2.00	0	1	0.00
Dec	7	13	0.54	4	8	0.50
Total	184	168	1.10	45	102	0.44

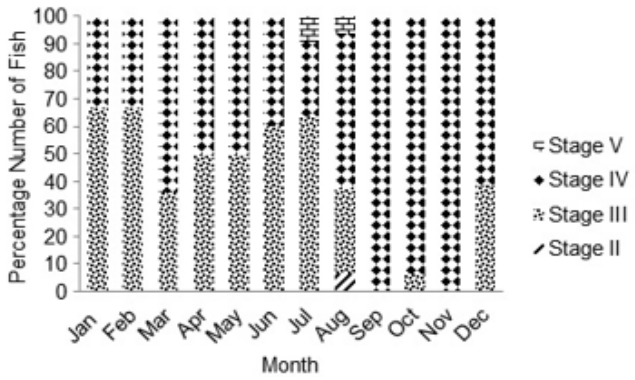

Figure 4. Gonad maturity stage of female spotted barb (*Barbodes binotatus* Valenciennes, 1842) in Tamblingan Lake from January to December 2019.

The mature fish were found at 8.2 cm for male fish and 8.5 cm for female fish. Rahmawati (2006) reported that male fish begins to mature at a size of 5.0 cm, while female fish at 5.6 cm. Each species of fish reaches its first maturity in a different size. Several factors influence the maturation of fish gonads, including the presence of hormones, food, and water temperature (Tang & Affandi, 2002).

Fish sampling found that fish dominated the male gonad maturity stage with stage III and stage IV for females. In March, the highest frequency of male and female fish was with stage III and stage IV. The increasing gonad maturity stage is characterized by size, colour, and shape. In male fish, it is characterized by the testes' shape, the testes' size, and the colour of the testes. Whereas in female fish, it is based on size, shape, and colour of the ovaries, size of the eggs in the ovaries, and smoothness of the surface of the ovaries (Effendie, 2002).

Table 4. Observations of male gonad maturity stage in Tamblingan Lake.

Gonad Maturity Stage	Documentation	Description
Stage I		The testes are a pair of threads, short and precise.
Stage II		The testes are whitening, and the size larger than Stage I,
Stage III		The superficial of the testes is serrated, fills almost half of the body cavity, and the colour is white.
Stage IV		The testes are getting bigger than stage III, stiffer, solid, and white.

Table 5. Observations of female gonad maturity stage in Tamblingan Lake.

Gonad Maturity Stage	Documentation	Description
Stage II		The superficial of the ovary is smooth, the egg's grain can't be seen one by one with the eye, and the colour is soft orange.
Stage III		The size of the ovaries is more significant than in Stage II; the eggs are visible to the eye, the egg's grain is more significant than stage II.
Stage IV		The ovaries are getting bigger, the eggs have been seen with much larger granules than Stage III and yellow.
Stage V		The ovaries still look Stage IV, but certain parts have collapsed because the eggs were released during spawning.

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Gonadosomatic index

The range of gonadosomatic index of male fish in Tamblingan Lake was between 0.23-6.25, with an average value of 2.26. While for female fish, between 0.37-40.51 with an average of 10.51 (Table 6). The gonadosomatic index value of females was more significant than males. The highest gonadosomatic index value of male and female fish occurred in September.

Based on the calculation of the gonadosomatic index, female fish have a more excellent value than male fish. The average value of the gonadosomatic index of male and female fish was highest in September. This shows that a peak spawning for spotted barb in Tamblingan Lake occurs in the rainy season. Tampubolon *et al*. (2008) stated that the spawning season of motan fish (*Thynnichthys thynnoides*), which belongs to Cyprinidae, is in the rainy season. The rainy season strongly correlates with the spawning of fish that live in the tropics due to an increase in water mass in rivers and lakes (Muchlisin *et al*., 2010). The gonadosomatic index value of female fish is more significant than male fish because, at the same stage of gonad maturity, the gonad weight of female fish is more significant than male fish (Rizky, 2016).

Fecundity

There were 63 individuals on stage III and 102 individuals on stage IV. The value of the fecundity range of female fish was obtained between 57-23.897 eggs. The lowest fecundity was found in May and the highest in March (Table 7). The highest was found at a total length of 14.3 cm, with a fish bodyweight of 48.84 g and a gonad weight of 9.22 g. The lowest fecundity was found at a total length of 9.7 cm, with a fish bodyweight of 13.65 g and a gonad weight of 0.24 g. The average fecundity of spotted barb in Tamblingan Lake was 5.901 eggs. Compared to Rahmawati (2006), the average fecundity of spotted barb in the upstream part of the Ciliwung watershed (2.588 eggs) is lowest than in Tamblingan Lake. Furthermore, a study from Mujtahidah (2014) shows that the fecundity of the spotted barb ranged from 3.586-7.814 eggs. This difference in fecundity is thought to be related to

Table 7. The range and average fecundity of spotted barb in Tamblingan Lake from January to December 2019.

Month	Total (n)	Fecundity	
		Range	Average
Jan	9	144-6.949	2.791
Feb	15	286-11.840	5.096
Mar	50	141-23.897	7.107
Apr	12	525-6.534	3.344
May	4	57-15.397	7.355
Jun	5	497-17.017	7.169
Jul	10	960-13.028	6.592
Aug	14	604-7.856	4.503
Sep	17	705-19.740	4.618
Oct	15	944-21.899	8.148
Nov	1	12.682	12.682
Dec	13	303-15.466	5.936
Total	165	57-23.897	6.278

Table 6. The range and average gonadosomatic index spotted barb in Tamblingan Lake from January to December 2019.

Month	Total (n)	Male Fish		Total (n)	Female Fish	
		Range	Average		Range	Average
Jan	8	0.32-1.89	1.14	9	0.64-12.26	5.91
Feb	17	0.23-3.57	1.90	15	1.86-18.44	11.65
Mar	57	0.69-5.33	2.08	50	1.73-40.51	11.87
Apr	5	1.31-2.22	1.75	12	3.77-12.12	8.36
May	6	1.00-2.84	1.97	4	1.79-12.77	8.06
Jun	18	1.11-2.73	1.80	5	2.12-14.40	7.02
Jul	6	1.28-2.16	1.87	11	0.37-15.66	9.36
Aug	15	0.51-3.76	2.45	16	1.59-16.05	9.03
Sep	22	1.24-6.25	3.53	17	3.50-47.59	14.39
Oct	21	1.48-5.16	3.10	15	6.67-18.13	13.16
Nov	2	2.05-2.32	2.18	1	16.72	16.72
Dec	7	2.02-4.40	3.32	13	2.59-15.03	10.64
Total	184	0.23-6.25	2.26	168	0.37-40.51	10.51

aquatic environmental conditions, variations in fish size, and food availability (Effendie, 2002).

CONCLUSION AND RECOMMENDATION

Conclusion

Some reproduction aspects of spotted barb in Tamblingan lake were in excellent condition. The growth pattern was allometric negative and isometric, the condition was good, balanced sex ratio, the mature fish, almost founded every month with fecundity around 57-23.897 grain eggs and the highest GSI was found in September.

Recommendation

This research recommends managing spotted barb in Tamblingan Lake to fix the gill net's mesh size that adapts to the maturity size of spotted barb and assigns the spawning ground to ensure the recruitment is still sustained.

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