Growth pattern, reproduction and food habit of palau fish
*Osteochilus vittatus* in Batanghari River, Jambi Province, Indonesia

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Abstract. Batanghari River is one of the fishing locations in Jambi Province, Indonesia. One of the commercial freshwater fish in this river is silver shark minnow *Osteochilus vittatus*. Presently, there was no study on the bioecology of this species in Batanghari river. Therefore, the aims of this research were to analyze the growth pattern, reproduction, and food habits of silver shark minnow in Batanghari River, Indonesia. Data were collected in February, April, June, September, and October 2018. The samples were preserved with alcohol 70%. The length-weight relationships were analyzed using the linear allometric model, gonad maturity was observed by morphologically, and fecundity was calculated by the gravimetric method. The results showed that this fish had an isometric growth pattern. The fish fed on phytoplankton and indicated as herbivorous plankton feeder. Bacillariophyceae and Chlorophyceae were predominant food items. The fish spawn around the year partially with fecundity between 2,726 - 19,202 eggs. The gonad maturity index ranges from 5.38% to 11.44%, and the egg diameter ranged from 0.40 to 1.27 mm.

1. Introduction
Silver shark minnow *Osteochilus vittatus* or locally known as the palau fish is one of the native freshwater fish species in Indonesia [1]; this species is also an important moderate-priced of fish consumption [2]. Previously, this fish was known as *O. hasseltii*, and now changed to *O. vittatus*. This species is distributing in the Sunda Strait, Indochina, Burma, and it has also introduced to South Sulawesi [3]. The *O. vittatus* prefers the temperatures between 18-28 ºC, shallow and slow current waters. This species matured at nine months old [4]. The fish has high protein and calcium content and reasonable price in the local market [5]; therefore, it is very promising for aquaculture [2]. The artificial breeding of the *O. vittatus* has reported by several researchers [6-8]. Besides, studies of the nutrition requirement have been reported by Akhyar et al. [9], Asma et al. [10], and Mayana et al. [11].

The utilization of fish resources in the Batanghari River is quite high, especially for *O. vittatus*. In Batanghari Rivers, the fishers usually using non-selective fishing gear such as hand lift net and gill net
with mesh size <1 inch. According to Kaban [12], the degradation ecosystems might cause the damage of fish habitat and decrease of fish catch. In terms of fisheries management, the data of bioecology, for example, length-weight relationships, habits, and fecundity, are crucial. The relationship between fish lengths is useful for fisheries, for example in determining of biomass, because the direct measurements of fish weight in the field are difficult to conduct, therefore indirectly biomass can be used to estimate fisheries production [13]. According to Rostika [14], the length-weight relationship with gonad maturity in the culture of *O. vittatus* can be used for the right harvest period with the optimum size of the egg.

Food is one of the important factors that determine fish populations, growth, and condition of fish. So that we needed for food habits in the type of fish, It used to see the ecological relationship between fish and other organisms in waters, for example, predatory forms, rivals and food chains [15]. The feed is the main factor in influencing the distribution of fish, especially freshwater ecosystem [16].

Reproduction is very important of fish’s life cycle, one of the way to knowing the reproductive biology of fish especially on the level of gonad maturity, fecundity, frequency, spawning season, the size of the fish first gonads mature and spawn time [17]. Fecundity is the total number of fish eggs in the ovary, which will then be released during spawning [18]. The fecundity of fish is important to learn about the productivity, potential reproductive, dynamics population, and aquaculture fields, especially for seed aspects. The aim of this study was to analyze some biological aspects of *O. vittatus* such as length-weight relationships, food habits, morphology and fecundity in the Batanghari River, Jambi Province, Indonesia as a basic data to strategize a better conservation plan.

### 2. Materials and Methods

#### 2.1 Time and site

The study was conducted in February, April, June, September and October 2018 in Batanghari River, Jambi. A total of eight sampling sites were determined purposively based on river zonation (upper, middle and lower stream), namely: Pulang Musang, Mangun Jaya, Muara Bulian, Penyengan Rendah, KJA (Olak Penyengan), Kunangan, Muara Sabak and Nipah Panjang (Figure 1). The sampled fish were analyzed at Laboratory of Research Institute for and Inland Fisheries and Extension located in Palembang. The fish biology aspects such as fecundity, stomach contents were examined in the laboratory.

![Figure 1. Map of sampling sites in Batanghari River](image-url)
2.2 Length Weight Relationship
The Length Weight relationship follows the linear allometric model which is expressed as the weight of the fish as the third power of the length in the equations:

\[ W = a L^b \]  

Remarks:
- \( W \) = Weight of fish (gr)
- \( L \) = Length of fish (cm)
- \( a \) = intercept
- \( b \) = regression viewpoint

To find out the growth pattern, we must know the value of regression viewpoint (b). The regression value gets from analysis of the length-weight of the fish \( \log(W) = \log(a) + b \log(L) \). After getting the regression value, furthermore carry out of "t test" with a confidence interval level 95% [19]. If the t-value is smaller than t-table it concluded that the value of \( b = 3 \), it explained that the fish growth pattern is "isometric" (the length growth is proportional with weight growth). If value of t-count is greater than t-table was concluded the value of \( b \neq 3 \), it explained that the fish growth patterns are allometric (the length growth is not proportional with the weight growth). If value of \( b <3 \), it concluded that the growth of the fish is allometric negative (length growth is faster than weight growth). If value of \( b >3 \), it concluded that the growth of the fish is allometric positive (length growth is slower than weight growth).

2.3 Food Habits
The food habits were analyzed based on macroscopic observations of the fish stomach. The method used to analyze food habits include the type and amount of food is the index of the largest part (index of preponderance) based on Effendie [15, 20-21] as follows:

\[ IP = \frac{\sum Vi x Fi}{\sum Vi x Fi} \times 100 \]  

\( IP \) = index of preponderance  
\( Vi \) = percentage volume of one type of food  
\( Fi \) = percentage frequency of occurrence of one type of food  
\( \sum Vi x Fi \) = the amount of Vi x Fi from all kinds of food

Identification of the types of food contained in the intestine or stomach is used as a reference [22-25].

2.4 Gonad Maturity Stages
Determination of gonad maturity level is based on modification which consists of Gonad Maturity Stages I to V [9].

2.5 Fecundity and Gonad Maturity Index (GMI)
Fecundity is calculated as the number of eggs contained in the ovary in gonadal ripe fish (Stage-IV). Total fecundity is calculated based on the gravimetric method [26] as follows:

\[ F = \left( \frac{G}{g} \right) n \]  

Remarks:
- \( F \) = total number of eggs in gonads (fecundity)  
- \( G \) = total weight of gonads in one fish (g)  
- \( g \) = weight of some gonad in one fish (g)  
- \( n \) = number of eggs from gonad samples
The GMI is calculated by measuring the gonad weight and body weight of the fish including the gonads based on Effendie [15] as follows:

\[
\text{GMI} = \frac{G}{F} \times 100
\]  

(4)

Remarks:

M = Gonad Maturity Index

G = Gonad Weight (gr)

F = Fish Weight (gr)

3. Results And Discussion

3.1 Length-weight relationship

Analysis of length-weight relationship of *O. vittatus* showed that value of constant \( a = 0.009 \); \( b = 3.096 \) with a regression coefficient \( r \) of 0.977 so that the equation of the length-weight relationship is: \( W = 0.009 L^{3.096} \) (Figure 2). After the t-test at the significance level of 95% for the value of \( b \) is obtained \( t \) count < \( t \) table. Thus the value of \( b = 3 \) (isometric) is accepted, It is shows that there is a balance between length growth and weight growth.

The growth pattern of *Osteochilus vittatus* on the Batanghari River, Jambi is an isometric growth pattern. This finding is in agreement to Hamid [27] who found that the *Osteochilus hasseltii* in the Temengor Reservoir in Malaysia with a length-weight relationship equation: \( W = 0.010 L^{3.038} \) showed an isometric growth pattern. The isometric growth indicate that there is a balance between length growth and weight growth and also it’s indicated that food and water quality factors are still supportive for growth. Furthermore, Rochmatin [3] said that Palau or Nilem fish in Rawa Pening, Semarang Regency were negative allometric with a value of \( b \) is 2.8392. It is shows that the environmental conditions in Rawa Pening are less supportive for *Osteochilus hasseltii* growth. According to Aida [28] the growth and population of the *Osteochilus hasseltii* decreased due to increasingly turbid waters. According to Effendie [15] that the pattern of fish growth is influenced by the amount of food available, age of fish, gonad maturity level, and water quality.

![Figure 2. Length-weight relationship of Silver shark minnow (*Osteochilus vittatus*)](image-url)
3.2 Feeding habits
Based on the preponderant index of *Osteochilus vittatus* were examined, the main feed is phytoplankton, namely Bacillariophyceae (42.8%) and Chlorophyceae (39.6%). The complementary feed is Cyanophyceae (6.5%), Macrophyta (2.4%), Rotifera (1.8%) and Crustacea (1.1%) (Figure 3). The most consumed types of phytoplankton from the Bacillariophyceae group are *Cyclotella* sp., *Melosira* sp., *Tabellaria* sp., *Synedra* sp., *Navicula* sp. and *Surirella* sp. The Chlorophyceae group consists of *Ankistrodesmus* sp., *Ulothrix* sp., *Spirogyra* sp. and *Cladophora* sp. Complementary feeds from the Cyanophyceae group include *Anabaena* sp., *Lyngbya* sp. and *Oscillatioria* sp. Based on food habits analysis, it can be grouping for herbivore community and tend to plankton feeders.

![Figure 3. Food habit composition of Silver Shark minnow (*Osteochilus vittatus*)](image)

Based on the food composition obtained in Figure 3, it could be stated that *Osteochilus vittatus* is herbivorous tend to plankton feeders. According to Yap [29] the *Osteochilus hasseltii* in the Bukit Merah Reservoir Malaysia are fish belonging to herbivores. In other area Amarasinghe [30] said that in several reservoirs in Sri Lanka and Thailand *Osteochilus hasseltii* fed on phytoplanktons such as macrophytes and detritus. In addition Ekawati [31] stated that it was categorized as herbivores which composite of food: Bacillariophyceae and Chlorophyceae as main feed with a preponderant index of 44.09% and 40.06% and Cyanophyceae as supplementary feed with an index preponderant 15.85%.

According to Kottelat [3] how to determine the type of food eaten by fish apart from its eating habits can also be known by observing intestinal length, then compared with the length of the fish body. The intestine of the fish which belongs to the herbivorous group is of a much longer length than its body size, usually reaching 3 to 7 times the body length. Based on observations in the laboratory, the length of the Palau intestine ranges from 5.2 - 6.5 times the length of the fish body, so this further reinforces that the *Osteochilus hasseltii* is indeed included in the group of herbivorous fish. Furthermore, according to Utomo [32] that Chlorophyceae, Bacillariophyceae and aquatic insects were the main natural feed of *O. hasseltii* in the waters of the Musi River.

3.3 Gonad maturity stages
Based on the gonad maturity stages showing in Table 1, it was seen almost every month that gonadal mature of *Osteochilus vittatus* were ready to spawn on stage IV (21.7 - 42.4%), especially in
September and October (36.8- 42.4%). Almost every month there are also it have spawned on stage V (3.5 - 17.5%) and reaching the peak in February (17.5%).

Based on Table 1 it can be concluded that the fish in the Batanghari River Jambi could be spawn throughout the year because almost every month and It was found in the spawning phase (Stage-V), but reach a peak in February (rainy season). It also in accordance with the results of Rochmatin [3] explained that the spawn most of the year and peak spawning occurs at the end of the rainy season. Furthermore, according to Utomo [32] it could be spawn throughout the year in nature but peak spawning season at the beginning of the rainy season. The Fish live in waters that are generally not fast-flowing, on lakes, low-lying rivers. In the Flood Area, It tend to live in the main river, only when the floods into the exposure of the flood, which has a lot of vegetation to look for food and spawning.

Table 1. Gonad maturity stage of Osteochilus vittatus in Batanghari River.

| Gonad maturity stage | February (n = 23) | April (n = 0) | June (n = 29) | September (n = 33) | October (n = 38) |
|----------------------|-------------------|--------------|--------------|--------------------|-----------------|
| I                    | -                 | -            | 17.2         | 24.2               | 10.5            |
| II                   | 21.7              | -            | 20.7         | 9.1                | 15.8            |
| III                  | 39.1              | -            | 27.6         | 15.2               | 31.6            |
| IV                   | 21.7              | -            | 31.0         | 42.4               | 36.8            |
| V                    | 17.5              | -            | 3.5          | 9.1                | 5.3             |

According to Wooton [33] fish can spawn partially like Osteochilus hasseltii are because the process of gonad maturation of fish is not the same, It indicated that the fish is partial spawning, because the egg ripening process in in the ovary event does not occur simultaneously. The results of interviews with several fishers in Batanghari River, they said that palau fish indeed spawned throughout the year proved to be found in seed-sized it at all times, especially those caught with lift net and nets.

3.4 Fecundity and gonad maturity index (GMI)

Table 2 showed that there are a relationship between fish size, GMI and fish fecundity. The bigger the size of the fish the higher the value of GMI and the more fecundity. The fecundity of Osteochilus vittatus in Batanghari River with the size of 34 g - 136.2 g ranges from 2,726-19,202 grain points. The fecundity of Osteochilus vittatus in the Batanghari River in the size of 24.2-136.2 g ranges from 2,609 -19,202 eggs (Table 2). Furthermore, according to Utomo [32] were reported at a size of 23 cm has an individual fecundity of 26,700 eggs. The results of the research by Rochmatin [3] founded that Osteochilus hasseltii had a fecundity of 2,966 eggs with a length of 12.7 cm and the weight of 21.3 g. While the length of 25.3 cm and weighs 244.1 g have a fecundity of 156,695 eggs. According to Triyani [34] the fecundity of one fish species is influenced by the size of the fish, environmental factors, genetic, feed availability, and age of fish. In the other statement [32] explained that the total weight of fish has more influence on the amount of fecundity compared to the total length of fish. According Muchlisin [26] there was a positive correlation between fecundity with body weight of the fish, where the fecundity tend to increase as increasing body weight.

The GMI value of Osteochilus vittatus in Batanghari River range from 5.38% to 11.44% (Table 2). According to Effendie [15] states that a high GMI value indicates that the size of the gonad of the fish is greater. Furthermore according to Nasution [35] said that for fish have a GMI value smaller than 20% might be spawning several times each year.

3.5. Eggs diameter

The range of egg diameter range from 0.40 mm to 1.27 mm. The highest number of eggs in the diameter was 0.84 - 0.94 mm (41.63%), while the least was in the diameter of 0.4-0.5 mm (0.72%)
The size of the egg diameter that is not uniform indicates that the fish can be spawning partially.

**Table 2. Relationship of Fecundity and Gonad Maturity Index of *Osteochilus vittatus***

| No. | Total Length (cm) | Total weight (g) | Gonad weight (g) | Fecundity (eggs) | GMI (%) |
|-----|-------------------|------------------|------------------|------------------|---------|
| 1.  | 17.3              | 61.2             | 3.50             | 5,591            | 5.72    |
| 2.  | 19.0              | 83.1             | 5.80             | 11,220           | 6.98    |
| 3.  | 14.2              | 37.1             | 2.27             | 3,726            | 6.12    |
| 4.  | 18.3              | 78.2             | 5.40             | 8,072            | 6.90    |
| 5.  | 20.2              | 109.9            | 7.26             | 13,628           | 6.61    |
| 6.  | 17.0              | 51.6             | 3.44             | 5,822            | 6.67    |
| 7.  | 23.0              | 136.6            | 13.45            | 19,202           | 9.85    |
| 8.  | 13.5              | 34.0             | 1.83             | 2,726            | 5.38    |
| 9.  | 18.2              | 75.1             | 5.07             | 7,493            | 6.75    |
| 10. | 18.0              | 72.3             | 4.10             | 6,623            | 5.67    |
| 11. | 16.5              | 37.5             | 2.26             | 2,930            | 6.03    |
| 12. | 21.3              | 119.9            | 8.52             | 16,876           | 7.11    |
| 13. | 18.6              | 82.8             | 5.55             | 8,450            | 6.70    |
| 14. | 18.7              | 96.4             | 7.94             | 14,244           | 8.24    |
| 15. | 14.3              | 35.1             | 2.85             | 4,167            | 8.12    |
| 16. | 18.1              | 73.0             | 4.25             | 7,338            | 5.82    |
| 17. | 17.1              | 56.8             | 3.58             | 5,498            | 6.30    |
| 18. | 18.0              | 64.0             | 3.84             | 6,130            | 6.00    |
| 19. | 19.1              | 92.0             | 5.90             | 11,495           | 6.41    |
| 20. | 17.2              | 58.2             | 4.06             | 6,628            | 6.98    |
| 21. | 18.1              | 69.3             | 5.45             | 8,609            | 7.86    |
| 22. | 15.6              | 46.5             | 5.32             | 7,369            | 11.44   |
| 23. | 18.3              | 80.6             | 7.51             | 13,304           | 9.32    |
| 24. | 19.3              | 97.9             | 8.47             | 14,933           | 8.65    |
| 25. | 12.9              | 24.2             | 1.82             | 2,609            | 7.52    |
| 26. | 16.5              | 42.5             | 3.10             | 5,076            | 7.29    |
| 27. | 17.0              | 58.6             | 4.06             | 7,257            | 6.93    |

**Figure 4.** Range of eggs diameter of *Osteochilus vittatus* in Batanghari River, Jambi
Where, \((A) = 0.40-0.50 \text{ mm} ; (B) = 0.51-0.61 \text{ mm} ; (C) = 0.62-0.72 \text{ mm} ; (D) = 0.73-0.83 \text{ mm} ; (E) = 0.84-0.94 \text{ mm} ; (F) = 0.95-1.05 \text{ mm} ; (G) = 1.06-1.16 \text{ mm} ; (H) = 1.17-1.27 \text{ mm}.

The eggs of *Osteochilus hasselti* in Batanghari River range from 0.40 to 1.27 mm. The size of the egg diameter in Batanghari is not much different from the size of the egg diameter of was reported by Triyani [34] which is between 0.8 mm - 1.2 mm. The highest frequency of fecundity was 0.84 - 0.94 mm (41.63%), while the lowest was 0.4-0.5 mm (0.72%). The size of the egg diameter that is not uniform indicates that it is spawning partially. Statement of Haryanti [36] the variety of egg diameter sizes often also depend on the type of fish. The gonad ripe fish have two types of egg diameter sizes, which are still small (immature) and large (ripe). They have a variety of egg diameter sizes, some are ripe and some are immature. It indicates that *Osteochilus vittatus* experience spawning in stages so that the type of spawning is called partial spawn. According to Effendie [15] and Unus [37] stated that the fish and invertebrates often found a diameter distribution of bimodal eggs (two modes), namely the first mode consisted of immature eggs and the other are mature eggs. Fish whose fecundity is bimodal, generally fish spawn with partial spawning.

4. Conclusion

The growth pattern of *Osteochilus vittatus* in the Batanghari River is isometric, where are length growth balanced with its weight growth. It were categorized as herbivorous fish, with main phytoplankton feed dominated or called plankton feeder. The fecundity of *O. vittatus* ranged from 2,609 to 19,202 eggs, the gonad maturity index range from 5.38% to 11.44% and egg diameter ranged from 0.40 mm to 1.27 mm. This fish spawns throughout the year with spawning peak during rainy season.

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References

[1] Nur S, Yustiati A and Sriati 2015 *Marine and Fisheries Journal, University of Padjadjaran*. 6(2) 101- 106
[2] Muchlisin Z A 2013 *Jurnal Ikhtiologi Indonesia* 13 91-96.
[3] Kottelat M, Whitten A J, Kartikasari, S N & Wirjoatmodjo S 1993 the freshwater fishes of Western Indonesia and Sulawesi (p.293) Periplus Editions EMDI Project
[4] Rochmatin S Y, Solichin A, Saputra S W 2014 *Diponegoro Journal Of Maquares, Management of Aquatic Resources* 3(3) 153-159
[5] Titrawani, Windarti and Anggraini V 2014 *Al-Kauniyah Biology Journal* 7(1) 27-17
[6] Muchlisin ZA, Arfandi G, Adlim M, Fadli N and Sugianto S 2014 *AACl Bioflax* 7(5) 412-418.
[7] Muthmainnah CR, Eriani K, Hasri I, Irham M, Batubara A S and Muchlisin Z A 2018 *Theriogenology* 122 30-34
[8] Eriani K., Syahrin A and Muchlisin Z A 2017 *Biosaintifikasi* 9(2) 298-303.
[9] Akhyar S, Muhammadar A A and Hasri I 2016 *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah* 1(3) 425-433
[10] Asma N, Muchlisin Z A and Hasri I 2016 *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah* 1(1) 1-11
[11] Mayana M, Muchlisin Z A and Dewiyanti I 2017 *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah* 1(1) 25-34
[12] Kaban S, Asyari, Fatah K, Marini M, Nanda T, Burnawi and Nasution D 2015 Study of Degradation stage and resources of fish potential in Batanghari River, Jambi, Annual Report (p.57) RIIF

[13] Smith K M M 1996 *Journal of Fish Biology* 49 731–734

[14] Rostika R, Andriani Y & Junianto 2017 *Asia Journal of Agriculture* 1(1) 17-21

[15] Effendia M I 1992 Fisheries biology methodds. (p.112). Faculty of Fisheries, Ichtiology IPB.

[16] Macpherson E 1981 *Mar. Ecol. Prog. Str*. 39 183-193

[17] Nikolsky GV 1963 The ecology of fishes. (p.325) Academic Press London

[18] Hunter J R, Macewicz B J, Lo N C and Kimbrell C A 1992 Fecundity, spawning, and maturity of female Dover sole Microstomus pacificus, with an evaluation of assumptions and precision. Fishery Bulletin 90 (1) Southwest Fisheries Science Center National Marine Fisheries Service. NOAA. La Job California. P.101-129

[19] Walpole R E 1992 Introduction to statistics Thirds edition. (P.515). PT. Gramedia Jakarta.

[20] Biswas S P 1993 *Manual of methods in fish biology*. South Asian Publisher Pvt Ltd., New Delhi, India.

[21] Muchlisin Z A, Batubara A S, Siti-Azizah M N, Adlim M, Hendri H, Fadli N, Muhammadar A A and Sugianto S 2015 *Biodiversitas* 16(1) 89-94.

[22] APHA 1981 Standart methods for examinations of water and waste water (p.1134) APHA Inc, New York

[23] Merrit R W & Cummins K W 1996 An introduction to the aquatic insect of North America.

[24] Needham JG, & Needham D R 1962 Freshwater biology (p.108) Holden Day Inc. Sanfransisco

[25] Pennak R W 1978 Freshwater invertebrates of United Stated. Second Edition. A. Wellow Inter Science Publication. (p.803) Jhon Willey and Sons New York

[26] Muchlisin Z A, Musman M, Fadli N and Siti-Azizah M N 2011 *AACl Bioflux* 4 273-279.

[27] Hamid M A, Mansor M & Azizah M N 2015 *Sains Malaysiana* 4(1) 61-66

[28] Aida S N and Utomo A D 2016 *Widya Research Capture Fisheries* 8(3) 173-182.

[29] Yap SY 1988 *Hydrobioiogia* 157 143 – 160

[30] Amarasinghe U S, Weliange W S, Kakkaeo M, Villanueva M C & Moreau J 2008 Diel feeding pattern and food compsumtion of selected fish population in Asian reservoir (p.14-200)

[31] Ekawati D, Astuty S and Dhahiyat Y 2011 *Akuatika Journal Faculty of Marine and Fisheries* 2(2) 15

[32] Utomo A D, Muflikah N, Nurdhawati S, Rahardjo M F and Makmur S 2007 Ichtyofauna Musi River, South Sumatra RIIF

[33] Wootton R J and Pott G W 1984 Fish reproduction strategies and tactic. (p.55-75). Academic Press London

[34] Triyani E 2002 Fertilization of Nilem eggs (*Osteochilus hasselti*) for three hours after spawning time, Faculty of Ichthyology, Jenderal Soedirman University, Purwokerto

[35] Nasution S H 2005 *Research Journal on Fisheries, Edition on resources and capture* 11(2) 29 – 37

[36] Haryanti 2013 *Journal of Fisheries Science and Technology* 8(2) 18-24

[37] Unus F and Omar A S B 2008 *Journal of Marine and Fisheries* 20 (1) 37- 43