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RESEARCH ARTICLE

Sexual Dimorphism, Reproductive Biology, and Growth Patterns of Sumatran Combtail (*Belontia Hasselti*, Cuvier 1831) From the Kelekar River, South Sumatra, Indonesia

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ABSTRACT

Sexual dimorphism, reproductive biology, and growth patterns are fundamental knowledge in fisheries studies. This study aimed to analyze the sexual dimorphism, reproductive biology, and growth patterns of *Belontia hasselti*. Samples were collected in the Kelekar River, South Sumatra, Indonesia. Traditional fishing gear, specifically fish traps ("bubu" and "pengilar"), was used to catch fish samples. The samples were transported to the Basic Fisheries Laboratory of the Universitas Sriwijaya for collecting study parameters. A total of 100 *B. hasselti* were used in this study: 56 males (TL: 8.00-13.24 cm, BW: 9.50-37.49 g) and 44 females (TL: 8.00-13.99 cm, BW: 9.00-38.99 g). The results showed that there were morphometric differences between male and female *B. hasselti* in CFL, AFL-1, AFL-2, VF-AF, and PrDL characters, but there were no differences in meristic characters. The HSI ranged from 0.46% to 2.71% for males and from 0.57% to 3.30% for females. The GSI for males ranged from 0.05 to 0.57%, while for females it ranged from 0.35 to 11.09%. The gonadal maturity stage for males ranged from I to IV, while for females it ranged from II to V. The sex ratio was 1.19:1.00 (male: female). Fecundity ranged from 1011 to 4370 eggs. Egg diameter ranged from 0.8 to 1.7 mm. The growth pattern of males was positively allometric ($y = 0.0125x^{3.0987}$, $R^2 = 0.8182$), while females exhibited negatively allometric growth ($y = 0.0596x^{2.4031}$, $R^2 = 0.7942$). These findings are highly valuable for the implementation of the *B. hasselti* breeding program.

Keywords: Egg diameter, Fecundity, Growth pattern, Sexual characteristics, Sex ratio

Introduction

The Kelekar River is a slow-flowing river extending from Ogan Ilir Regency to Prabumulih City. The local community utilizes the Kelekar River as a source of livelihood and for the needs of local fishermen. Fish in river waters contribute to community welfare, especially for fishermen. The biodiversity of freshwater fish species in the floodplain of the Kelekar River is categorized as moderate.[1] The Kelekar River and its floodplain contain various fish species. One of the fish species found in the floodplain of the Kelekar River is the Sumatran combtail (*Belontia hasselti*, Cuvier 1831). The local people named it the "selincah" fish.

The *B. hasselti* is a species of gourami native to Southeast Asia, where it is found in the peat swamps and floodplains of the Malay Peninsula and the Greater Sunda Islands.[2,3] In Indonesia, this species is found on the islands of Sumatra, Kalimantan, and Java.[2] This species is found in the Kelekar flood-

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plain of South Sumatra.[4] In Thailand, *B. hasselti* is endemic to the peat swamp forest of To Daeng.[5] This species belongs to the Osphronemidae.[6] *B. hasselti* has a lung-like labyrinth organ. The labyrinth apparatus allows *B. hasselti* to extract oxygen from the air. It is a morpho-physiological innovation that has had a dramatic impact on the behavior of this fish.[7]

B. hasselti is a freshwater species with economic value and potential for cultivation. Besides being used for food, this fish also has potential as an ornamental fish. *B. hasselti* remains an undomesticated species. Its production still relies on wild catches, as its cultivation has not yet been established. This practice is unsustainable under current fishing pressures, limiting the supply of *B. hasselti*

Sexual dimorphism can be defined as differences between males and females based on primary or secondary sexual characteristics. Sexual dimorphism, along with features such as genital papilla, body pigmentation, and fin shape, is a component of external morphological variation between the sexes.[8] Sexual dimorphism is the most striking difference between the sexes.[9,10] Sexual dimorphism occurs in many fish species.[11–13] Typically, female fish are larger than males of the same age. However, in some species, males are larger than females, such as in *Gobio gobio*,[14] *Clarias gariepinus*,[15] *Oreochromis mossambicus*[16] and *Brachaluteres ulvarum*.[17] The reasons for this disparity in size are not clear.[18] Some authors suggest that the evolution of larger body size in males is likely a result of male-male competition associated with polygynous mating systems.[9,18] Therefore, exploring the nature and extent of sexual dimorphism can aid in understanding social structure and adaptation, as well as species identification. Sexual dimorphism represents systematic external differences between individuals of different sexes within the same species, and secondary sexual characteristics are used to differentiate male and female fish. Understanding sexual dimorphism is very important, and some insights conveyed by sexual dimorphism can provide much valuable information, such as the process of mating and intrasexual competition,[19] changes in strategies,[20] selection of parent fish for breeding,[21,22] and social structure and adaptation.[9]

Knowledge of fish reproductive biology is crucial for the rational utilization of fish stocks and sustainable production.[23] Understanding fish reproductive aspects is also essential for providing sound scientific advice in fisheries management.[24,25] Length-weight relationships have been applied as a basic tool for stock assessment and population evaluation.[26] In fish, size is generally more biologically relevant than age, primarily because several ecological and physiological factors depend more on size than age. Therefore, length-weight regressions are often used to estimate weight from length, as direct weight measurements can be time-consuming in the field.[27]

The objective of this study was to analyze the sexual dimorphism, reproductive biology, and growth patterns of *B. hasselti* from the Kelekar River in Ogan Ilir Regency, South Sumatra, Indonesia. The results of this study are expected to provide basic information for the future management of *B. hasselti* resources, especially in broodstock selection and breeding programs.

Material and methods

Study area

This study employed a direct observation methodology. The study was conducted in the Kelekar River, Ogan Ilir Regency, South Sumatra Fig. 1. The sampling locations were determined based on the findings of previous research, which indicated the presence of *B. hasselti* in these areas.[4,22] This region possesses a tropical rainforest climate characterized by high annual humidity (87%) and distinct seasonal shifts in precipitation. The wet season extends from October to May, peaking in April with 307 mm of rainfall, while the dry season occurs from June to September, reaching a minimum of 58 mm in August.

The river exhibits slightly acidic to neutral conditions with a pH range of 5.6–7.2 and very low mineral content (TDS: 7–11 mg L^{-1} Total Alkalinity: 10–18 mg L^{-1}). Thermal conditions remain relatively stable, with water temperatures ranging from 28.3°C to 31.8°C, which is optimal for the metabolic requirements of tropical anabantoids. The water current is slow-flowing (0.17–0.30 m s^{-1}) with low transparency (16–20 cm). Dissolved oxygen (DO) levels fluctuate between 4.82 and 6.93 mg L^{-1}. Furthermore, ammonia levels ranging from 0.47 to 0.70 mg L^{-1} reflect the high organic decomposition typical of the peat-influenced floodplains in this river system.[28]

Fish samples were collected from four locations or stations (3°14’03.9"S 104°36’27.7"E, 3°14’05.4"S 104°36’25.6"E, 3°14’16.2"S 104°36’20.5"E, 3°14’34.4"S 104°36’15.4"E) in the Kelekar River, Ogan Ilir Regency, South Sumatra, Indonesia Fig. 1.

Fish collection

A total of 100 individuals of B. hasselti (56 males and 44 females) were collected over four months from December 2022 to March 2023. The sample size is consistent with previous studies on *B. hasselti*.[29] The

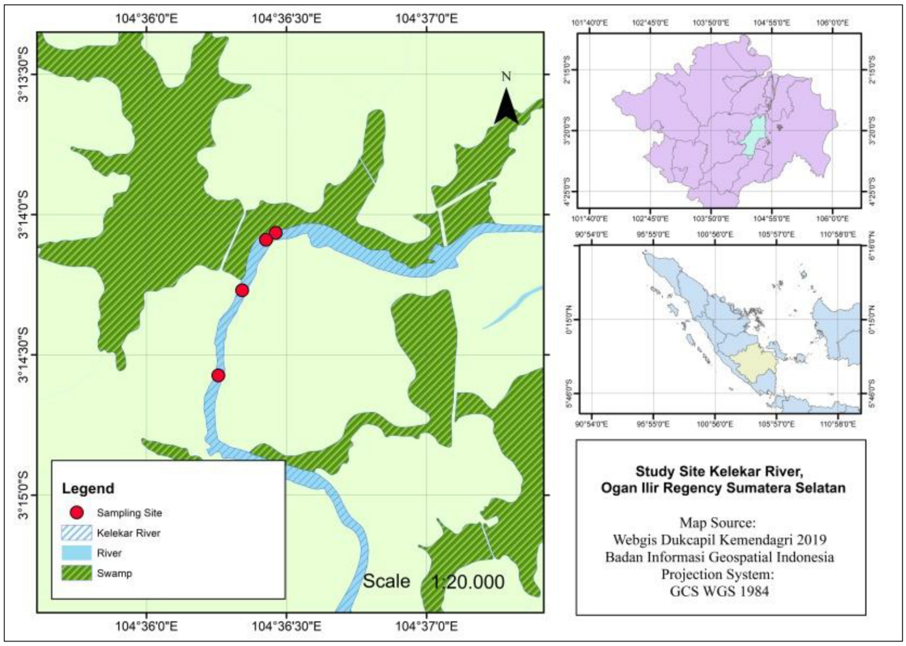

Fig. 1. Map of sampling sites for the *Belontia hasselti* from the Kelekar River, South Sumatra, Indonesia.

male specimens (n = 56) ranged from 8.00–13.24 cm in total length (TL) and 9.50–37.49 g in body weight (BW), while the females (n = 44) ranged from 8.00–13.99 cm TL and 9.00–38.99 g BW.

Fish were captured using traditional Indonesian passive traps locally known as "penggilar" and "bubu" (bamboo and mesh portable basket traps). Immediately following capture, the fish were transported to the Basic Fisheries Laboratory at Universitas Sriwijaya in 5-litre plastic bags at a density of 20 individuals per bag using a motorcycle with a travelling time of less than 20 minutes.

In the laboratory, the fish were distributed among five glass aquaria (40 × 40 × 30 cm) with a stocking density of 20 individuals per unit. Before dissection, the specimens were euthanized using Tricaine Methanesulfonate (MS-222) to ensure humane handling and minimize physiological stress

Measurement of length and weight

In the laboratory, the fish were weighed with a digital scale with an accuracy of 0.01 g, and their total length was measured with a ruler with an accuracy of 0.1 cm. The data on length and weight for both male and female fish were compiled into a tabulated format.

Measurement of morphometric-meristic characters

The meristic counts and morphometric measurements were recorded in accordance with the methodology outlined in.[30] The morphometric measurements included total length (TL), standard length (SL), pre-dorsal length (PrDL), dorsal fin length (DFL), head length (HL), eye diameter (ED), head width (HW), body depth (BD), pectoral fin length (PFL), ventral fin length (VFL), and other measurements as indicated. Additionally, the following measurements were taken: pelvic length (PrVL), distance from ventral fin to anal fin (VF-AF), caudal fin length (CFL), dorsal fin length-1 (DFL-1), dorsal fin length-2 (DFL-2), anal fin length-1 (AFL-1), and anal fin length-2 (AFL-2), as well as caudal peduncle depth (CPD) Fig. 2. The meristic character of the fish was determined by the number of rays and spines present in the dorsal, pectoral, ventral, anal, and caudal fins.

Fish dissection

The dissection of the fish was conducted using a standardized set of dissection tools, beginning with the pelvic fin and continuing in a posterior direction towards the dorsal region below the lateral line until reaching the midpoint of the anal fin. The gonads and liver of each sample were excised from the abdominal cavity. The liver was weighed in order to calculate the hepatosomatic index (HSI), which is defined as follows:

$$HSI\,(\%) = \frac{liver\ weight\ \ (g)}{body\ weight\ \ (g)} \times 100 \tag{1}$$

Similarly, the gonads were weighed in order to calculate the gonadosomatic index (GSI), which is

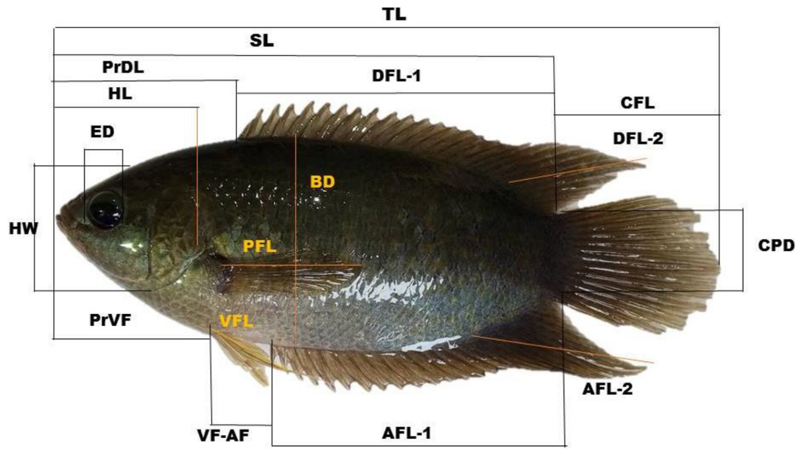

Fig. 2. Measurement of morphometric characters of *Belontia hasselti*.

defined as follows:

$$GSI\,(\%) = \frac{\text{gonad weight (g)}}{\textit{body weight (g)}} \times 100 \tag{2}$$

Fecundity (F) was calculated using the following formula:

$$\text{Fecundity (F)} = \frac{\text{ovary weight (g)}}{\text{subsample weight (g)}} \times \text{number of ova in subsample (eggs)}\ 30^{27} \tag{3}$$

Additionally, the analysis of gonadal maturity stages (GMS) was conducted. The morphology of the male and female gonads was documented using a digital camera. A total of 100 oocytes were observed under a digital USB microscope endoscope (1600X magnification) in order to measure the diameter of the oocytes.

Data analysis

Prior to statistical analysis, the normality of all parameters was assessed using the Shapiro-Wilk test. The statistical analysis of morphometric was conducted using Principal Component Analysis (PCA) and the Mann-Whitney U test. While reproductive aspects were analyzed using the Mann-Whitney U test. The value of character proportions was obtained by comparing character values with the total length. Differences in meristic, color, and gonadal maturity stages were analyzed descriptively.

The formula of Le Cren was used for the determination of the length-weight relationship[31]:

$$W = aL^b \tag{4}$$

Where:

W= weight (g)

L=total length (cm).

To estimate the parameters a (intercept) and b (slope/growth exponent), the equation was log-transformed equation was transformed into a linear regression model:

$$\log(W) = \log(a) + b\log(L) \tag{5}$$

To determine the growth pattern, the calculated slope (b) was tested against the isometric value (b = 3) using a one-sample t-test with the following formula:

$$t = \frac{|b - 3|}{SE^b} \tag{6}$$

Where SE_b represents the standard error of the slope b. The resulting t-value was compared to the critical t-table value (df = n-2) at a 95% confidence level ($\alpha = 0.05$).

Deviations from the expected 1:1 sex ratio were evaluated using Chi-square (X^2) analysis. All statistical procedures were conducted in R Studio (R version 4.5.3).

Result and discussion

Morphometric-meristic characters

The body shape of *B. hasselti* is characterized by a compressed morphology (compressiform). The tail is of a rounded morphology. The species is characterized by the presence of ctenoid scales, which are rectangular, thin, flexible, and overlapping, and which bear small teeth, or ctenae. The body color differs between males and females, with males exhibiting a darker brownish-black hue, while females

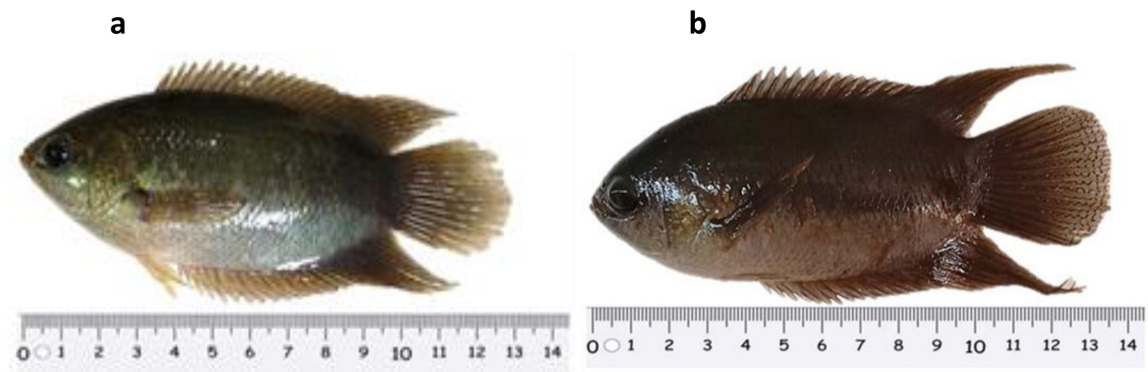

Fig. 3. Morphology of *Belontia hasselti* male (a) and female (b) from the Kelekar River, South Sumatra, Indonesia.

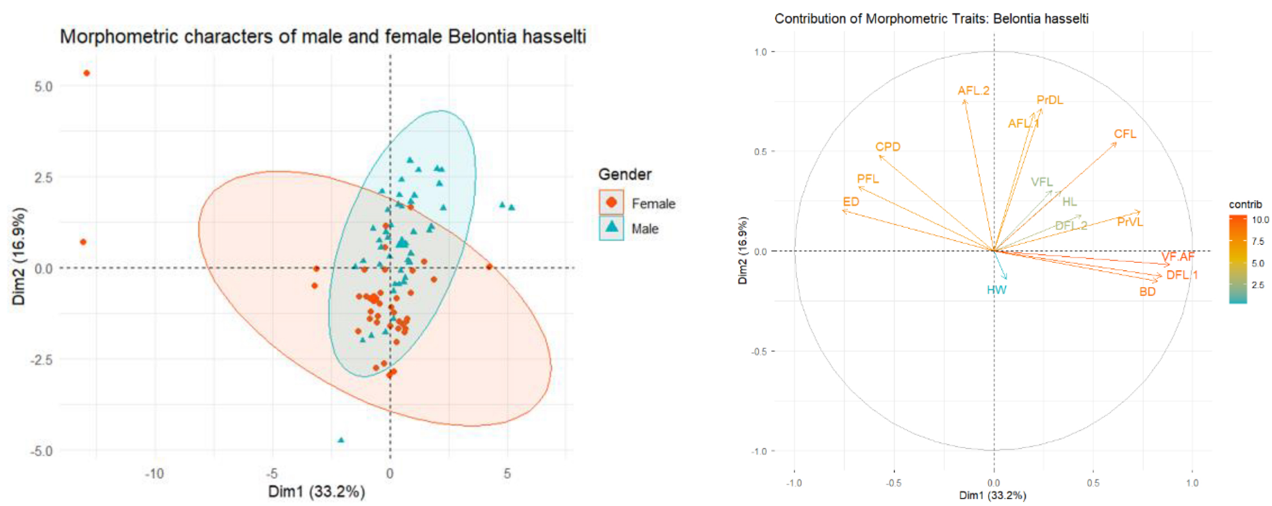

Fig. 4. Left: Principal Component Analysis (PCA) of *Belontia hasselti* morphometric characters. Right: Impact of each morphometric paramaters.

are blue and lighter in color Fig. 3. The correlation between morphometric characters of *Belontia hasselti* is shown in Fig. 4. The findings of the morphometric character measurements and the results of the Mann-Whitney U test are presented in Table 1. The results of the meristic character calculation are shown in Table 2.

Morphometric analysis showed that differences between male and female fish in characters such as CFL, AFL-1, AFL-2, VF-AF, and PrDL. These findings are similar to,[32] particularly in PrDL and VF-AF characters. The Principal Component Analysis identified the specific morphometric drivers of sexual dimorphism in *Belontia hasselti* Fig. 4. Dimension 1 (33.2%) effectively separates the sexes, primarily driven by fin morphology. Male *Belontia hasselti* correlate strongly with the positive axis of Dim1, a pattern characterized by significantly longer fins. This includes AFL.1 (2.59±0.34 cm), AFL.2 (2.76±0.43 cm), CFL (2.56±0.29 cm), and PrDL (2.69±0.30 cm), all of which are longer than their female counterparts Table 2. Conversely, female morphology (negative Dim1) is characterized by a more robust body profile, such as VF.AF was longer in females (0.85±0.27 cm) compared to males (0.79 ± 0.16 cm).

However, the meristic characters between males and females do not differ. According to,[32] the meristic characters of male *B. hasselti* include dorsal fins (D.XVI-XVIII.10-13), anal fins (A.XV-XVII.11-13), pectoral fins (P.10-12), ventral fins (V.I.4-6), and caudal fins (C.14-16). Female fish have dorsal fins (D.XVI-XVIII.10-12), anal fins (A.XV-XVII.11-13), pectoral fins (P.11-12), ventral fins (V.I.4-6), and caudal fins (C.14-16). According to,[33] *B. hasselti* have dorsal fins (D.XVI-XIX.10-13), anal fins (A.XV-XVII.11-13), and pectoral fins (P.11-12).

Reproductive biology

The gonadal maturation stage of male and female *B. hasselti* is presented in Fig. 5. The sex ratio is the comparison between male and female fish in a

Table 1. Morphometric characters of male and female *Belontia hasselti* from the Kelekar River, South Sumatra, Indonesia.

	Male		Female			
Morphometric Character	Range (cm)	Mean±SD	Range (cm)	Mean±SD	Shapiro-Wilk test	Mann-Whitney
SL (Standard Length)	6.20-10.00	7.20±0.74	6.00-10.00	7.20±0.98	< 0.001	0.636ns
HL (Head Length)	2.00-03.10	2.30±0.24	2.00-06.60	2.48±0.91	< 0.001	0.983ns
HW (Head Width)	1.70-03.00	2.06±0.30	1.60-09.10	2.24±1.10	< 0.001	0.835ns
ED (Eye Diameter)	0.60-00.90	0.76±0.06	0.60-02.00	0.85±0.35	< 0.001	0.436ns
BD (Body Depth)	2.40-04.20	3.00±0.36	0.70-04.20	2.97±0.64	< 0.001	0.899ns
VFL (Ventral Fin Length)	1.80-03.50	2.31±0.35	1.60-03.80	2.25±0.40	< 0.001	0.171ns
CFL (Caudal Fin Length)	2.10-03.50	2.56±0.29	2.00-03.20	2.32±0.26	< 0.001	<0.001*
CPD (Caudal Peduncle Depth)	1.00-01.80	1.26±0.16	1.00-02.80	1.28±0.32	< 0.001	0.281ns
DFL.1 (Dorsal Fin Length 1)	2.60-06.50	3.88±0.68	1.00-06.00	3.74±0.84	< 0.001	0.521ns
DFL.2 (Dorsal Fin Length 2)	2.40-06.40	3.53±0.69	2.50-06.10	3.45±0.61	< 0.001	0.544ns
AFL.1 (Anal Fin Length 1)	1.60-03.40	2.59±0.34	1.30-02.90	2.06±0.38	0.033	<0.001*
AFL.2 (Anal Fin Length 2)	1.70-03.80	2.76±0.43	1.52-02.80	2.17±0.26	< 0.001	0.016*
PFL (Pectoral Fin Length)	1.70-03.00	2.17±0.26	1.70-03.70	2.08±0.35	< 0.001	0.383ns
VF.AF (Ventral-Anal Dist.)	0.60-01.20	0.79±0.16	0.70-02.00	0.85±0.27	< 0.001	0.008*
PrDL (Pre-Dorsal Length)	2.20-03.70	2.69±0.30	0.70-03.90	2.51±0.50	0.027	<0.001*
PrVL (Pre-Ventral Length)	2.20-03.60	2.80±0.28	1.60-03.70	2.71±0.32	< 0.001	0.104ns

Ns (no significant), *(significant).

Table 2. Meristic characters of male and female *Belontia hasselti* from the Kelekar River, South Sumatra, Indonesia.

Meristic Characters	Male	Female
Number of spines and rays on dorsal fin	D.XVI-XVIII.11-12	D.XVII-XVIII.10-12
Number of spines and rays on anal fin	A.XV-XVI. 11-13	A.XV-XVI.11-12
Number of spines and rays on pectoral fin	P.11-12	P.11-12
Number of spines and rays on ventral fin	V.I.5	V.I.5
Number of spines and rays on caudal fin	C.16	C.16

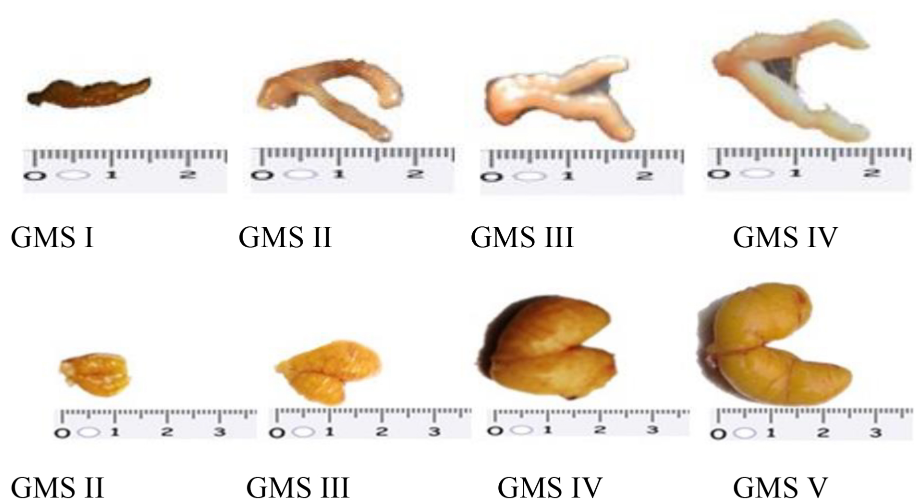

Fig. 5. Gonadal maturity stages of *Belontia hasselti* male (top) and female (below) from the Kelekar River, South Sumatra, Indonesia.

Table 3. Sex ratio of *Belontia hasselti* during sampling periods.

	Number				
Sampling	Male	Female	Sex Ratio	X^2	P-value
December	13	14	0.93 : 1.00	0.04	0.84
January	15	08	1.27 : 1.00	2.13	0.14
February	18	11	1.64 : 1.00	1.69	0.19
March	10	11	0.91 : 1.00	0.05	0.83
Total	56	44	1.19: 1.00	1.44	0.23

population. The sex ratio of *B. hasselti* obtained based on the sampling period under study is presented in Table 3.

Table 4 shows differences in GSI and HSI between male and female fish, with female GSI and HSI being larger than those of males. Statistical analysis revealed a highly significant sexual dimorphism in reproductive parameters ($p < 0.05$), with females (median IGS = 4.08%) exhibiting substantially higher

Table 4. Reproductive biology of *Belontia hasselti* from Kelekar River, South Sumatra, Indonesia.

	Male		Female			
Parameter	Range	Mean±SD	Range	Mean±SD	Shapiro-Wilk test	Mann-Whitney U
GSI (%)	0.05-0.57	0.11±0.08	0.35-11.09	4.96±1.14	< 0.001	<0.001*
HSI (%)	0.46-2.71	1.24±0.45	0.57-3.30	1.14±0.45	< 0.001	0.051Ns
Egg diameter (mm)	-		0.8- 1.7		-	
Fecundity (eggs)	-		1011-4370		-	
GMS	immature-ripe		early maturing-spawned		-	

Ns (no significant), *(significant).

Table 5. Description of the gonadal maturity stage of the *Belontia hasselti* in this study.

GMS	Male	Female
I	The testes are characterized by their minute size, thinness, threadlike appearance, and transparency, with IGS values that range between 0.05 and 0.25%.	No data
II	The testes are larger than GMS I, exhibiting a milky white coloration. The IGS value is 0.30–0.37%.	The ovaries are light yellow in color, the oocyte granules are not separable, and the IGS values range from 0.68% to 1.60%.
III	The testes are becoming increasingly white in color and appear jagged; the IGS value is 0.43-0.44%.	The ovary is yellow in color, and the oocytes are not yet separable. The IGS value is 2.04-4.83%.
IV	The testes are exhibiting increased size and a roughened surface. Upon palpation, they display elasticity. Their dimensions exceed those of the GMS III. Sperm remains retained within the abdomen when the abdominal wall is distended. The IGS value is within the range of 0.49 to 0.55%.	The ovary increases in size and fills the abdominal cavity. The oocyte granules can be separated, with an IGS value of 5.24-8.86%. The oocyte diameter ranges from 0.8 to 1.2 mm.
V	No data	The ovary is bright yellow, the blood membrane enveloping the ovary is clearly visible, the IGS value is 9.32-11.10%, and the oocyte diameter ranges from 1.3-1.7 mm.

GMS I (immature), GMS II (early maturing), GMS III (late maturing), GMS IV (ripe), GMS V (spawned).

gonadal development than males (median IGS = 0.08%). While the Hepatosomatic Index (IHS) was higher in males, this difference was not statistically significant (p = 0.051), suggesting a potential but unconfirmed correlation between liver energy storage and egg production in females. In this study, the GMS of females ranged from early-maturing to spawned, while that of males ranged from immature to ripe Fig. 5 and Table 5.

Analysis shows that male fish were more frequently found than females, resulting in differing sex ratios across sampling periods, as shown in Table 3. Therefore, the chi-square test result ($X^2 = 1.44$, $p = 0.23$) indicates that the observed sex ratio does not significantly deviate from the expected 1:1 ratio. This confirms that the sampled population is representative.

Growth pattern

The total length of the female *B. hasselti* ranges from 8.00 to 13.24 cm, while the male specimens exhibits a range of 8.00 to 13.99 cm. The total length of female fish is classified into seven groups, while males are grouped into six. The total weight of female *B. hasselti* ranges from 9.00 to 38.99 g, while for males, it ranges from 9.50 to 37.4 g. The weight of female fish is divided into six groups, while males are divided into seven groups Table 6. The relationship between length and weight in male and female *B. hasselti* is illustrated in Fig. 6.

The males *B. hasselti* showed a b-value of 3.0987. Furthermore, the t-test indicated that males exhibit isometric growth ($p > 0.05$), wherein the increase in body weight occurs in proportion to the increase in length. In the case of females, the b value is less than 3 (2.4031); the t-test showed that the b-value was negative allometry ($p > 0.05$). This suggests that females have a slimmer physical profile than males since their length increases more quickly than their weight, resulting in a slender body profile compared to males. The length-weight relationship is a fundamental tool in fisheries assessment,[34] and it can also be used to estimate and simulate aquatic ecosystems, create stock assessment models, and compare the life cycle and morphological characteristics of populations of a particular species living in various places.[35] The condition factor is an index that reflects the interaction between biotic and abiotic factors in the physiological conditions of fish. Consequently, the condition factor may vary among fish species in different locations.[29]

Table 6. Distribution and frequency of total length and body weight for *Belontia hasselti* from this study.

	Female			Male	
Total length (cm)	Frequency	Percentage (%)	Length (cm)	Frequency	Percentage (%)
08.00-08.74	07	15.91	08.00-08.99	06	10.71
08.75-09.49	11	25.00	09.00-09.99	33	58.93
09.50-10.24	16	36.36	10.00-10.99	12	21.43
10.25-10.99	04	09.09	11.00-11.99	03	05.36
11.00-11.74	02	04.55	12.00-12.99	01	01.79
11.75-12.49	02	04.55	13.00-13.99	01	01.79
12.50-13.24	02	04.55	-	-	-
Total	44	100.00		56	100.00
Body weight (g)					
09.00-13.99	27	61.36	09.50-13.49	27	48.21
14.00-18.99	09	20.45	13.50-17.49	19	33.93
19.00-23.99	05	11.36	17.50-21.49	05	08.93
24.00-28.99	02	04.55	21.50-25.49	02	03.57
29.00-33.99	00	00.00	25.50-29.49	01	01.79
34.00-38.99	01	02.27	29.50-33.49	01	01.79
-	-	-	33.50-37.49	01	01.79
Total	44	100,00		56	100,00

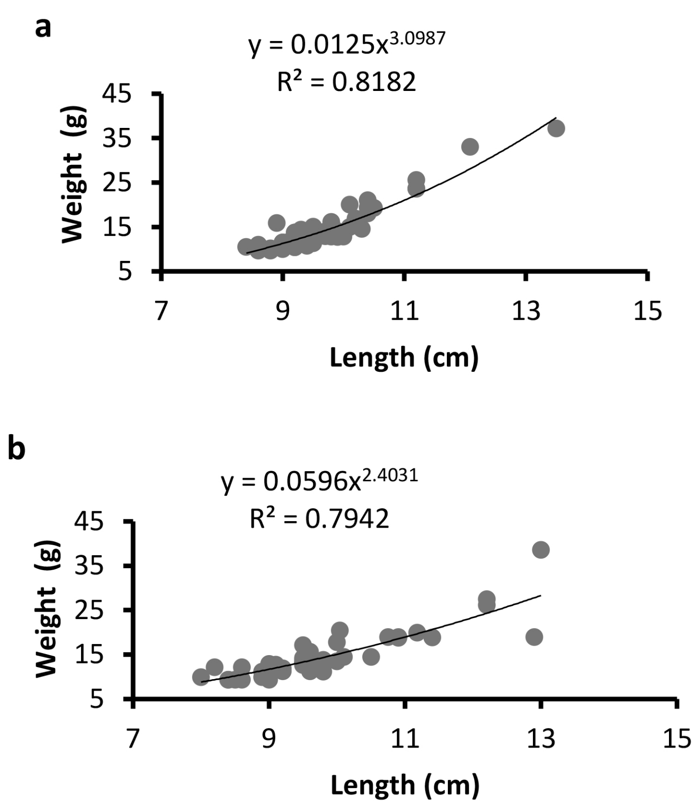

Fig. 6. The length-weight relationship of male (a) and female (b) *Belontia hasselti* from the Kelekar River, South Sumatra, Indonesia.

Conclusion

The findings of this study indicate that there are differences in the morphometric characters of male and female *B. hasselti* in CFL, AFL-1, AFL-2, VF-AF, and PrDL, while no differences were observed in meristic characters. The male fish exhibit darker body colors, whereas the females display blue and greenish hues. The GSI and HSI values for female fish are observed to be higher than those for males. The diameter of the oocyte at GMS V is observed to range from 1.3 to 1.7 mm. The data obtained from this research can be utilized as a source of information for the cultivation of *B. hasselti*, particularly in the selection of broodstock.

Authors' declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images that are not ours have been included with the necessary permission for re-publication, which is attached to the manuscript.
- The author has signed an animal welfare statement.
- No human studies are present in the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at Universitas Sriwijaya.

Authors' contributions statements

M.M., S.O. designed the study, drafted the manuscript, revised, and proofread. E.S., M.R.A.P. acquired data, analysis, interpretation, and drafted the manuscript.

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الازدواج الجنسي، والبيولوجيا التناسلية، وأنماط النمو لسمكة ذيل المشط السومطرية (Belontia hasselti، Cuvier 1831) من نهر كيليكار، جنوب سومطرة، إندونيسيا

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الخلاصة

يُعد التمايز الجنسي، والبيولوجيا التكاثرية، وأنماط النمو من المعارف الأساسية في دراسات المصايد السمكية. هدفت هذه الدراسة إلى تحليل التمايز الجنسي، والبيولوجيا التكاثرية، وأنماط النمو لسمكة Belontia hasselti. تم جمع العينات من نهر كليكار في جنوب سومطرة، إندونيسيا. وقد استُخدمت أدوات صيد تقليدية، وبالتحديد المصائد السمكية ("البوبو" و"بينغيلار")، لجمع العينات السمكية. نُقلت العينات إلى مختبر المصايد الأساسية في جامعة سريويجايا لغرض قياس وتسجيل المعايير الدراسية. شملت الدراسة 100 فرد من B. hasselti: 56 ذكراً (الطول الكلي: 8.00–13.24 سم، الوزن الكلي: 9.50–37.49 غ) و44 أنثى (الطول الكلي: 8.00–13.99 سم، الوزن الكلي: 9.00–38.99 غ). أظهرت النتائج وجود اختلافات مورفومترية بين الذكور والإناث في صفات CFL وAFL-1 وAFL-2 وVF-AF وPrDL، في حين لم تُلاحظ فروق في الصفات الميريستية. تراوح معامل مؤشر الكبد (HSI) بين 0.46% و2.71% للذكور، وبين 0.57% و3.30% للإناث. كما تراوح معامل مؤشر المناسل (GSI) بين 0.05% و0.57% للذكور، وبين 0.35% و11.09% للإناث. وامتدت مراحل نضج المناسل للذكور من المرحلة I إلى IV، بينما تراوحت للإناث من المرحلة II إلى V. وكانت نسبة الجنس 1.19:1.00 (ذكر:أنثى). تراوحت الخصوبة بين 1011 و4370 بيضة، بينما تراوح قطر البيض بين 0.8 و1.7 مم. أظهر نمط النمو للذكور نمواً ألوأومترياً موجباً ($y = 0.0125x^{3.0987}$، $R^2 = 0.8182$)، في حين أظهرت الإناث نمواً ألوأومترياً سالباً ($y = 0.0596x^{2.4031}$، $R^2 = 0.7942$). وتُعد هذه النتائج ذات أهمية كبيرة لتطبيق برامج استزراع وتكثير B. hasselti

الكلمات المفتاحية: قطر البيض، الخصوبة، نمط النمو، الصفات الجنسية، نسبة الجنس.