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A Study on Morphometric and Mouth Structure of *Luciocephalus pulcher* Gray, 1830 from the Sibam River, Pekanbaru

Studi Tentang Morfometrik dan Struktur Mulut Luciocephalus pulcher Gray, 1830 dari Sungai Sibam, Pekanbaru

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Abstract

Luciocephalus pulcher lives in peat swamps, and the male incubates the eggs in the mouth. A study aimed to determine morphometric characters and differences in the oral structure of male and female fish was conducted from June to July 2024. Fish samples were caught in the upper Sibam River. 5 times, once/week. The morphometrical characteristics were measured, and the fish mouth structure was observed. Results showed that 32 fish were caught, consisting of 21 males and 11 females. Of the 37 morphometric characters observed, 18 differed between males and females. These characters included total length, head length, body height, caudal peduncle height, eye diameter, anal fin to caudal fin base distance, dorsal fin base length, pectoral fin base length, anal fin height, ventral fin base length, caudal fin base length, lower jaw length, upper jaw length, lower jaw width, gular sac width, lower lip length and upper lip length. The total length of male fish ranged from 48-135 mm, while females were 48-135 mm. Fin characteristics in male and female fish were the same, with the formula D.I, 8-12 P.12-15 V.6-7 A.I, 14-20 C.13-15. The difference in mouth characters was seen in the gular sac. The gular sac of male fish was wider with thicker tissue, more folded, more flexible, elastic skin tissue, and smaller, more flexible hyoid bone. In contrast, female fish have smaller, less elastic gular sacs, thinner tissue, and less folded and thicker hyoid bone.

Keywords: Peat Swamps, Gular Sac, Hyoid Bone.

Abstrak

Ikan teplusok (*Luciocephalus pulcher*) hidup di rawa gambut dan induk jantan mengerami telur di dalam mulut. Penelitian yang bertujuan untuk mengetahui karakter morfometrik dan perbedaan struktur mulut ikan jantan dan betina telah dilakukan pada bulan Juni sampai Juli 2024. Sampel ikan ditangkap di hulu Sungai Sibam 5 kali, dengan interval satu minggu sekali. Karakter morfometrik ikan diukur dan struktur mulut ikan diamati. Hasil penelitian menunjukkan bahwa 32 ekor ikan tertangkap, terdiri dari 21 ekor jantan dan 11 ekor betina. Diantara 37 karakter morfometrik yang diamati, terdapat 18 karakter yang berbeda antara jantan dan betina. Pada ikan betina, karakter-karakter ini lebih panjang dari pada jantan, karakter tersebut antara lain panjang total, panjang kepala, tinggi badan, tinggi batang ekor, diameter mata, jarak sirip anus ke pangkal sirip ekor**,** panjang dasar sirip punggung, panjang dasar sirip dada, tinggi sirip anus, panjang dasar sirip perut, panjang dasar sirip caudal, panjang rahang bawah, panjang rahang atas, lebar rahang bawah, lebar kantung gular,

panjang bibir bawah, panjang bibir atas. Panjang total ikan jantan berkisar 48-135 mm, sedangkan betina 48-135 mm. Karakteristik sirip pada ikan jantan dan betina sama antan dan betina sama, dengan rumus D.I, 8-12 P.12-15 V.6-7 A.I, 14-20 C.13-15. Perbedaan bagian mulut terlihat pada bagian kantung gular. Kantung gular ikan jantan lebih lebar dengan jaringan lebih tebal, lebih berlipat-lipat, jaringan kulit lebih fleksibel dan elastis, serta tulang hyoid lebih kecil dan lentur. Pada ikan jantan, ikan betina ukuran kantung gular kecil, bentuk kurang elastis, jaringan lebih tipis, kurang berlipat serta tulang hyoid lebih tebal.

Kata kunci: Rawa gambut, Kantong Gular, Tulang Hyoid

1. Introduction

Indonesia Sibam River is one of the tributaries located in the Siak sub-watershed. The headwaters of this river are located in Karya Indah Village, Tapung Subdistrict, Kampar Regency, and border Pekanbaru City. The Sibam River is about 8 km long, 1-5 m wide, and the depth ranges from 60-70 cm. The substrate consists of sandy mud (Lola et al., 2015). There are various types of wild fish, some of which have interesting shapes and colours that have the potential to be used as ornamental fish.

One type of ornamental fish in these waters is pikehead (*Luciocephalus pulcher*). The body shape of a pikehead is attractive, with a yellowish-brown colour on the upper body and a white colour on the abdomen. This carnivorous fish feeds on small fish and insects (Lauder & Liem, 1981). The habitat of pikehead is generally found around overhanging vegetation or submerged in rivers. However, this fish is increasingly challenging to find. The rarity is thought to be caused by habitat and environmental degradation due to anthropogenic factors, such as land conversion, pollution, and climate change (Kottelat & Whitten, 1993). The pikehead is currently listed as a threatened species on the International Union for Conservation of Nature (IUCN) red list (but in the least concern category) (IUCN, 2019).

In addition to an attractive body shape, the reproductive biology of pikehead is unique in that the male parent can incubate the eggs in the gular sac or the oral cavity. Fertilization occurs externally, and the fertilized eggs are then deposited in the mouth of the male parent (Fujaya, 2002). The incubation process lasts for 2-3 days. During the incubation period, the gular sac of the male parent is enlarged, and the fish cannot eat because the mouth is used to store the eggs. The incubation activity is only done by males, while females do this. There may be differences in anatomy, morphometrics, and oral structure between males and females. Therefore, it is necessary to research differences in the oral structure of male and female pikeheads.

2. Material and Method

2.1. Time and Place

The research was conducted from June to July 2024. Fishing was conducted in the upstream waters of the Sibam River. Morphometric observations and fish mouth structure were conducted at the Aquatic Biology Laboratory, Faculty of Fisheries and Marine, Universitas Riau. Meanwhile, histology preparation of the gular sac was conducted at Bogor Institute (IPB).

2.2. Methods

Pikeheads were taken from 3 sampling points. The first point was located upstream with a slow current, sandy mud substrate, and vegetation overhanging the water. The second point was about 500 m from the first, with moderate water current, sandy mud substrate, and little vegetation overhanging the water. The third point was located 300 meters from the second sampling point, with faster water flow, sandy soil substrate and little vegetation overhanging the water. Sampling was conducted 5 times, once a week. Morphometric observations and oral structure studies were conducted at the Aquatic Biology Laboratory, Faculty of Fisheries and Marine, Universitas Riau. Fish mouth shape was observed macroscopically, including external structures such as lips, jaws, teeth, and mouth position in fish, according to Saanin (1968); Kottelat et al. (1993); Windarti (2020). Mouth parts (length, width, and depth of the mouth) were measured using a ruler with an accuracy of 1 mm.

2.3. Procedure

2.3.1. Fish Morphometric and Meristic Measurement Methods

Morphometric measurements were made using a digital calliper ruler with an accuracy of 0.1 mm, referring to Chan (2001). The parts of the fish body that were measured can be seen in Figure 1. The measured parts of the mouth of *L. pulcher* can be seen in Figure 2.

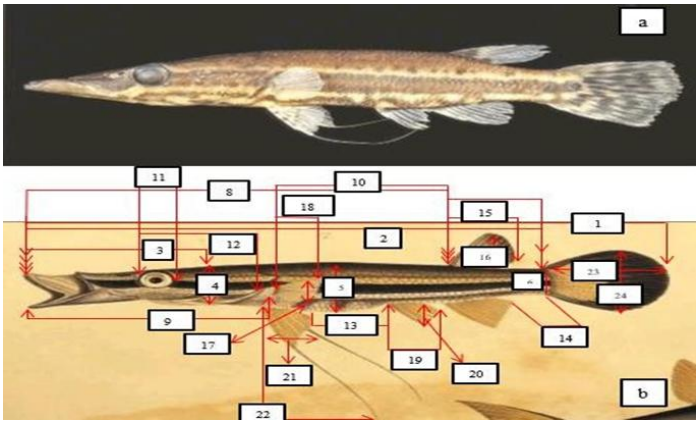


Figure 1. Illustration of the measured body parts of *L. pulcher* (Gray 1830)

Description:

1. Total length
2. Default length
3. Head length
4. Head height
5. Body height
6. Tail stem height
7. Body width
8. Mouth to Dorsal Distance
9. Mouth to Base of Fin Distance Chest
10. Dorsal Fin Distance to Base of Tail Fin
11. Diameter of Eye
12. Eye to Gill Lid Distance
13. Abdominal fin to base of anus fin distance
14. Distance from anus fin to base of tail fin
15. Dorsal fin base length
16. Dorsal fin height
17. Chest fin base length
18. Chest fin height
19. Anus fin base length
20. Anus fin height
21. Abdominal Fin Base Length
22. Abdominal Fin Height
23. Length of Cudal Fin Base
24. Caudal fin height

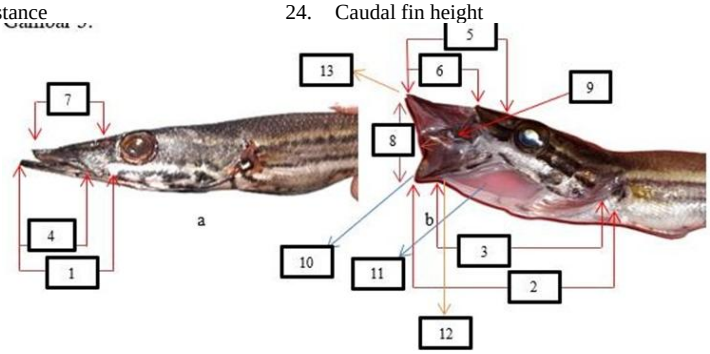


Figure 2. Measurement of the mouth part structure of *L. pulcher* fish

Description: 1. Mouth Eye Distance (MED), Mouth to Base of Abdominal Fin Distance (MBAFD), Gular Pouch Length (GPL), Lower Jaw Length (LJL), Total Length of Upper Jaw (TLUJ), Pronounced Upper Jaw Length (PUJL), Upper Jaw Length (UJL), Mouth Opening Length (MOL), 9. Width of Mouth Opening (WMO), 10. Width of Lower Jaw (WLJ), 11. Width of Gular Sac (WGS), 12. Length of Lower Lip (LLL), 13. Length of Upper Lip (LUL).

Meristic characters of pikehead observed: number of dorsal fin spokes, number of pectoral fin spokes, number of pelvic fin spokes, number of anal fin spokes, number of caudal fin spokes, number of scales in front of the dorsal fin, number of scales around the body, number of scales at the base of the tail stem, number of scales in the linea literal, number of scales above the linea literal, number of scales below the linea literalism.

2.3.2. Oral Structure Observation Method

Observations of the mouth structure of the pikehead were made with a dissecting microscope. Characteristics observed included mouth shape, position, and presence of teeth, as well as mouth length and width. The tissue structure of the gular sac was observed using histology preparations of the organ. According to Wahyuni et al. (2017), histology preparations were made and stained with Haematoxylin and Eosin (HE). The preparations were then observed using a microscope. Morphometric data and gular sac tissue structure were analyzed to understand morphological variation and functional adaptation of pikehead mouth in the Sibam River habitat. Furthermore, the data were analyzed descriptively.

3. Result and Discussion

32 pikeheads were caught (21 males and 11 females). The morphological characteristics of a pikehead are an elongated body, bilaterally symmetrical, tapered head and a crocodile head (pikehead). The type of pikehead scales is ctenoid. The body length of the pikehead is 5-6 times the body's height; there is a straight line of black, brown-white stripes starting from the tip of the mouth to the tip of the tail shaft. Pikeheads belong to the class of

fish with jaws. There are two pairs of nostrils (dirhinos). Fish eyes are located on the right and left sides of the head, at the upper end of the mouth, abdominal fins (ventral) modified to form a whip situated under the pectoral fins (thoracic), dorsal fins are in the anterior part of the body, caudal fins rounded with black spots. The mouth of the pikehead is protractile.

In general, the morphological characteristics of pikeheads do not differ between males and females. However, there are differences in the secondary sexual characteristics of male and female fish. According to Effendie (2006), secondary sexual characteristics are external signs that can be used to distinguish male and female fish. The morphometric characters of the pikehead measured were 37 characters, with 13 of them being oral characters. These characters are the mouth-to-eye distance (MED), mouth-to-base of ventral fin distance (MBVFD), gular sac length (GSL), mandible length (ML), total maxilla length (TML), posterior maxilla length (PML), maxilla length (ML), mouth opening length (MOL), mouth opening width (MOW), mandible width (MW), gular sac (GS). Based on body length, caught pikeheads were divided into six size classes. The smallest fish measured 48-63 mm, and the largest measured 128-143 mm. The most significant number of fish was found in size class one, while the least were in size classes five and six.

Female fish were not found in class IV. Male fish were not found in classes V and VI. If the majority of fish in a population are small, it indicates a problem with reproduction or suboptimal environmental conditions for fish growth (Froese, 2019). However, if most fish are significant, environmental conditions favour fish life. Thirty-seven morphometric characteristics were observed (including standard length). The maximum and minimum size of each character of male and female fish can be seen in Table 1.

Table 1. Maximum and Minimum Size of Morphometric Characters of Pikehead

No.	Morphometric Character	code	Female		Male	
			Maks	Min	Maks	Min
1.	Total length	TL	135	48	115	53
2.	Standard length	SL	114	43	99	43
3.	Head length	HL	47	12	40	11
4.	Head height	HH	17	5	11	6
5.	Height	H	16	6	16	6
6.	Tail stem height	TSH	14	2	17	1
7.	Body width	BW	13	4	13	3
8.	Mouth to Dorsal Distance	MDD	94	35	83	35
9.	Distance from Mouth to Pectoral Fin Base	DMPFB	50	20	48	20
10.	Distance from Dorsal Fin to Tail Fin Base	DDFTFB	22	9	15	8
11.	Eye diameter	ED	8	3	17	3
12.	Distance from Eye to Gill Cover	DEGC	55	11	23	9
13.	Distance from Pelvic Fin to Base of Anal Fin	DPFBAF	33	8	21	8
14.	Distance from Anal Fin to Base of Tail Fin	DAFBTF	35	12	29	12
15.	Dorsal fin base length	DFBL	18	3	13	2
16.	Dorsal fin height	DFH	13	4	10	3
17.	Pectoral fin base length	PFBL	6	2	5	2
18.	Pectoral fin height	PFH	9	3	8	2
19.	Anal fin base length	AFBL	25	10	18	10
20.	Anal fin height	AFH	15	5	18	5
21.	Pelvic fin base length	PFBL	4	2	3	1
22.	Pelvic fin height	PFH	47	15	30	15
23.	Cudal fin base length	CFBL	19	10	15	7
24.	Caudal fin height	CFH	23	9	21	7
25.	Mouth-to-Eye Distance	MED	18	6	18	6
26.	Distance from Mouth to Pelvic Fin Base	DMPFB	58	22	49	22

Table 1 shows that the pikehead's standard length (PB) ranged from 43-114 mm, and the total length (TL) ranged from 48-135 mm. According to Tan & Ng (2005), the total length (TL) of pikehead ranged from 120-125.6 mm, and the standard length (SL) ranged from 50.8-56.8 mm. The size of the fish caught in this study was smaller than that obtained by Tan & Ng (2005). It is thought that the difference in size is due to the water environment or food availability. This study's environmental conditions in the Sibam River were less favourable for pikehead. Pikeheads usually feed on insects that land on vegetation that protrudes above the water surface. However, community activities include expanding and cleaning the river environment by dredging the riverbed and cliffs and clearing vegetation on the riverbank. The absence of vegetation that protrudes above the river's surface makes it difficult for pikeheads to get food because insects commonly use the plants for perching. These insects are the food of pikehead. Because the food source of pikehead is reduced, the result is slow growth and small body size.

The morphometric measurements of pikehead in this study show that female fish are larger than male fish. However, the mouth parts of male fish, especially the gular sac, are larger than those of females. In male fish, the size of the gular sac ranges from 3-25 mm, while in females, it is only 3-13 mm. The proportion of each morphometric character of pikehead calculated based on the comparison or ratio between the length of the measured character and the standard length can be seen in Table 2.

Table 2. The proportion of morphometric characters to standard length and ratio.

No.	Character Morphometrics	Male		Female	
		Average (%)	Ratio (%)	Average (%)	Ratio(%)
1.	TL	115.20	157	118.31	220
2.	SL	38.13	38	39.56	40
3.	HL	18.39	14	13.44	14
4.	HH	16.11	16	15.24	14
5.	H	7.43	75	7.69	78
6.	TSH	11.11	11	10.24	11
7.	BW	82.66	83	84.12	83
8.	MDD	49.14	50	49.81	50
9.	DMPFB	18.00	17	18.05	17
10.	DDFTFB	8.18	83	7.43	75
11.	ED	23.09	25	25.86	25
12.	DEGC	19.72	20	23.30	25
13.	DPFBAF	27.94	28	26.12	25
14.	DAFBTF	7.80	100	7.68	75
15.	DFBL	10.68	11	11.40	11
16.	DFH	5.39	50	6.01	57
17.	PFBL	6.93	67	6.94	67
18.	PFH	20.87	20	21.13	20
19.	AFBL	11.42	11	12.80	13
20.	AFH	3.62	33	4.11	40
21.	PFBL	32.46	33	36.11	33
22.	PFH	17.67	17	19.09	20
23.	CFBL	19.80	20	18.69	20
24.	CFH	18.90	20	18.57	20
25.	MED	48.89	50	51.22	50
26.	DMPFB	24.57	25	26.12	25
27.	GPL	17.91	17	18.18	20
28.	LJL	22.51	22	22.41	22
29.	TLUJ	14.95	14	15.24	14
30.	LUJS	8.87	89	9.22	100
31.	UJL	15.53	17	15.49	17
32.	MOL	7.19	71	7.43	75
33.	MOW	5.12	50	5.64	57
34.	LJW	10.35	62	9.74	11
35.	GPW	9.75	100	8.98	89
36.	LLL	11.91	12	11.14	11

Of the 37 morphometric characters observed, 18 differed between males and females. In female fish, these characteristics are longer than males, and these characteristics include total length, head length, body height, tail bar height, eye diameter, anal fin distance to the base of the caudal fin, dorsal fin base length, pectoral fin base length, anal fin height, ventral fin base length, caudal fin base length, lower jaw length, upper jaw length, lower jaw width, gular sac width, lower lip length, upper lip length. Differences in the proportion of morphometric characters, especially those related to reproduction, are usually influenced by age, size and sex. In fish that are still small or young, secondary sexual characteristics are not yet visible. However, with increasing age and larger size, secondary sexual characteristics have developed and show differences between males and females.

The fins of the pikehead do not have hardened weak fingers; they are only stiff and weak fingers. Meristic characters in fish did not show significant differences. The meristic characteristics of fish observed in this study are more than those obtained by Tan & Ng (2005). Comparison of fish meristic characters in this research and Tan & Ng (2005) research can be seen in Table 3.

Table 3. Meristic Characteristics of Pikehead

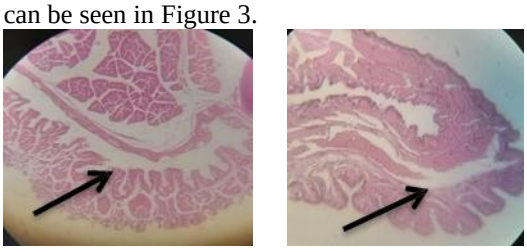
No.	Meristic Character	In this research	Tan & Ng (2005)
1.	Number of Scales:		
	In front of the dorsal fin	44-84	42-45
	Around the body	30-40	--
	Around the tail stem	14-22	$9^{1/2}$-12
	In the literal line	66-115	60-65
	Above the literal line	6-9	71/2 − 81/2
	Below the literal line	7-9	15-17
2.	Number of dorsal fin rays	D.I, 8-12	D.10-12
3.	Number of pectoral fin rays	P.12-15	P.16-18
4.	Number of pelvic fin rays	V.6-7	V.5
5.	Number of anal fin rays	A.I, 14-20	A.I, 19-21
6.	Number of tail fin rays	C.13-15	C.11-15

In this study, pikehead scales and fins were more than the number of scales and fins obtained by Tan & Ng (2005). It is estimated that the difference in the number of scales and fins of fish is influenced by the speed of development of the shape and meristics of fish caused by age. In addition, this difference may be caused by

environmental conditions such as the amount of vegetation in the river and water quality that supports the speed of development of pikehead. This follows the opinion of Rahardjo et al. (2011), who state that meristic character traits, such as the number of fins, scales, and gill plates, can experience variations influenced by environmental conditions.

The mouth of the pikehead has a large opening that is useful for capturing live prey such as insects or small fish and reflects an adaptation to a carnivorous diet. This distinctive mouth structure is well suited for capturing prey in calm water environments and dense vegetation. The relatively fast movement of the pikehead reflects its adaptation to capture prey efficiently. The pikehead moves at high speed to prey on fish and will protrude the premaxilla, where this movement is triggered by the mauthner cells to open the jaws (cranial elevation). The jaws' rapid movement involves extreme premaxillary protrusion and cranial elevation (the ability of the head to bend/lookup).

Pikeheads capture prey with a suction-feeding strategy. The flexible structure of the jaw bones supports this mechanism, enabling fast and efficient movement while hunting. The gular sac of pikehead, especially in males, is not used to store food but is more related to reproductive behaviour. The gular sac is where the male fish stores and protects the eggs until their reproductive process. During spawning, the female's role is complete after releasing the eggs, and the full responsibility of guarding and protecting the eggs is transferred to the male. Observation of the guar sac tissue structure shows a clear difference between the gular sac structure of male and female fish. These differences can be seen in Figure 3.



(a) (b)

Figure 3. Structure of gular sac tissue (a) male and (b) female pikehead

Observations showed differences in the tissue structure of male and female gular pouches. The male gular pouch is wider than the female gular pouch, and the skin of the male gular pouch is thicker and more folded. The width of the gular pouch in males is very supportive for egg incubation. When the eggs enter the mouth of the male fish mother for incubation, the gular sac widens and accommodates all the eggs in the mouth. The folded tissue appears thick when the eggs are not in the sac but expands when there are eggs, making it appear thin. Meanwhile, in female fish, the gular sac tissue structure is thin and less folded. This occurs because the sac only captures prey and is a mouth structure that plays a role in swallowing food before entering the oesophagus and stomach.

In the center between the left and right gular sacs is a bone called the hyoid bone, more specifically known as the Branchiostegal ray in fish anatomy. This bone is part of the skeleton that supports the gill and mouth structures, including assisting the movement of the gular sacs. The hyoid bone structure in male and female fish shows differences in size and structure. This difference is due to a unique reproductive mechanism in male fish that uses the gular sac to incubate eggs. The results of observations of the hyoid bone of male and female pikeheads can be seen in Figure 4.

(a) (b)

Figure 4. Shape of the hyoid bone of pikehead (a, c) male (b, d) female

The hyoid bone of male fish is smaller, more flexible and pliable. This is necessary to support the widening of the gular sac when depositing eggs so as not to damage the eggs. In addition, the hyoid bone strengthens the gular sac to withstand pressure during incubation. Unlike male fish, the hyoid bone in female fish tends to be thicker and harder. This is because the gular sac in female fish is not used for egg incubation but only functions to process food. The hyoid bone of male fish is flexible and flexible to facilitate the expansion of the gular sac when eggs enter the mouth in large numbers. According to Kottelat et al. (1993), male pikehead mothers can keep their eggs in the mouth with up to 90 eggs. The gular sac supports the eggs. The position of the egg when it is in the mouth of the male fish during the incubation period can be seen in Figure 5.

Figure 5. Eggs are in the mouth of the male pikehead

The egg incubation process in pikehead usually takes 2 to 3 weeks, depending on temperature and environmental conditions. In this incubation process, the mouth of the pikehead, which is not too large, can store the eggs in the gular sac, providing protection and oxygen necessary for the development of the eggs. Eggs stored in gular sacs are well protected and not near the fish's teeth. Pikeheads have sharp teeth that catch and hold prey, especially small fish. This fish's teeth are of the conical type, pointed and designed to penetrate the body of prey. However, the shape of the teeth is not intended to damage eggs stored in sugar sacs. Pikehead teeth can be seen in Figure 6.

Figure 6. Teeth Shape in Pikehead

The jaws of the pikehead are strong and equipped with small but sharp teeth, which grip prey, mainly insects or small fish. These teeth are designed so that prey entering the mouth cannot escape. The shape of this fish's teeth is very sharp and smooth, curved inward and shaped like fangs, per its lifestyle as a small predator. The mouth of the pikehead can also adapt well to environments with low oxygen levels. With its ability to hunt various types of prey smaller than its body, this fish plays a vital role in maintaining the balance of the aquatic ecosystem.

The relationship between standard length (SL) and weight of pikehead in the Sibam River shows the correlation coefficient (r). The r coefficient value for female fish is 0.9943, and male fish is 0.8825. The b value for male fish is 2.8948 (negative allometric). The increase in length is faster than the increase in weight. On the other hand, the female b value is 3.0659 (positive allometric), which means that weight gain is faster than length increase. The b value for females is greater than for males. This is due to the fish's reproductive behaviour, where the male fish does not eat during the egg incubation period. On the other hand, female fish can continue to eat, so female growth is faster. Thus, the fish's reproductive behaviour influences the differences in growth patterns in male and female pikeheads.

4. Conclusions

The number of pikeheads caught in this study was 32 (21 males, 11 females). The size of female fish is longer than that of males, with a total length of 48-103 mm for male fish and 48-135 mm for females. The differences in the morphology of male and female pikeheads include the color and pattern of the male's body, which is more shiny and bright compared to the female, which has a dark brownish color. The meristic characteristics of male and female pikeheads are the same, including having complete fins with the D.I formula, 8-12 P.12-15 V.6-7 A.I, 14-20 C.13-15. The gular sacs of male and female fish are different. In males, the gular sac is larger, thicker, and more folded than in females. The hyoid bone of male fish is more supple and flexible. The shape and structure of the gular sac in this male fish support its function as a place to incubate eggs.

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