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Conservation Challenges for *Macrognathus acuelatus*: A Case Study of Threatened Fish in Bengawan Solo and Brantas Rivers, East Java

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ABSTRACT

Macrognathus aculeatus is a local fish from the Bengawan Solo and Brantas Rivers that is threatened with extinction. Due to the lack of literacy on the biology of this fish. Biological parameters can be used to determine the condition of this fish in nature. Field observations at five stations from the two rivers were conducted to obtain samples. Biological and reproductive parameters such as weight and length, gonad maturity level (GML), Gonadosomatic Index (GSI), Hepatosomatic Index (HSI), and Condition Factor (CF) were the parameters observed in this study. All data obtained were presented as mean and standard deviation. Furthermore, analysis of variance was conducted using ANOVA ($p < 0.05$) to determine differences in samples from each observation station. The results showed that some biological factors had significant results ($p < 0.05$) on Gonadosomatic Index and Hepatosomatic Index). However, there was no significant difference ($p > 0.05$) in the condition factor. On the other hand, there were significant differences ($p < 0.05$) in body weight, total length, ovary weight, and fecundity parameters across all sampling sites.

Keywords: *M. aculeatus*, Gonadosomatic Index, Hepatosomatic Index, Factor Condition

INTRODUCTION

The Lesser spiny eel (*Macrognathus aculeatus*) is a freshwater fish endemic to Asia and Africa (Friecke *et al.,* 2020). It thrives in fertile rivers and swampy areas with clay, sandy soil, black sand, or rocky waters (Sultana *et al.,* 2017). This species is particularly abundant in nutrient-rich environments such as the upper river at Mount Merapi and the Progo River in Yogyakarta (Djumanto, 2023). Known for its nutritional richness, it boasts approximately 15.3% carcass protein, 22.1% muscle protein, 4.12% fat, 78.1% moisture, and 2.35% ash, and provides an energy yield of 5.3 KJ/g, contributing to its economic value in various countries (Hossain *et al.,* 1999). Despite its popularity, unsustainable large-scale fishing poses a threat to its survival without adequate conservation efforts (Ohee *et al.,* 2018; Herawati *et al.,* 2021). The species exhibits a limited annual reproductive cycle (isochronal), with mating occurring exclusively during the summer months for both males and females (Abujam and Biswas, 2011). Research on the biology of *M. aculeatus* in Indonesia remains scarce, emphasizing the necessity for comprehensive studies. Similar investigations conducted in Southeast Asian countries, focusing on ecobiology, have been pivotal (Afroz *et al.,* 2014; Rahman *et al.,* 2009). The ecological challenges faced by these fish in their natural habitats, including degradation and pollution, significantly impact their biological and reproductive activities (Islam *et*

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al., 2017). Indonesia, notably on the island of Java, has a major river such as the Bengawan Solo and Brantas, spanning Central Java to East Java. These rivers serve vital roles in agriculture, industry, and local fishing practices (Suryani *et al.,* 2023). However, anthropogenic pressures such as erosion and increasing waste threaten water quality (Hasan *et al.,* 2023). While intensive fishing practices contribute to declining fish populations (Aida *et al.,* 2022). Given *M. aculeatus* slow reproductive rate (Abujam *et al.,* 2023), this study aims to assess its distribution in these rivers and observe key biological parameters to inform conservation efforts.

MATERIAL AND METHOD

Time and Place

Sampling was conducted from March to September 2022 in two major rivers in Java, namely the Bengawan Solo and the Brantas River. A total of five stations were selected to represent these rivers based on the sediment characteristics of each station (Table 1). The Bengawan Solo River is the longest river on the island of Java, flowing from Central Java to East Java.

Table 1. Coordinate points of sampling in this study

No	Coordinate Points	Fish	Location	Land used
1.	N -7.071455^0 E 112.252251^0	39	St.1 (RM)	Clay
2.	N-7.074693 E 112.274597	20	St.2 (RP)	Clay
3.	N -7.04278^0 E 112.212184^0	11	St.3 (NG)	Clay
4.	N -7.865183^0 E 111.447705^0	6	St.4 (SK)	Sand-mud
5.	N -7.249404^0 E 112.741076^0	7	St.5 (PN)	Sand-mud

Information. St.1: Rawa Manyar, Lamongan, St.2: Rawa Pucuk, Lamongan, St.3: Nggilis, Tuban, St.4: Sekayu, Ponorogo, St.5: Peneleh, Surabaya.

Material and Equipment

A total of 32 samples were obtained from five sampling stations and subsequently stored in a low-temperature storage for measurements. Measurements of sample length were conducted using a ruler, while individual weight, gonad weight, and liver weight were measured using a digital scale with a precision of 0.01. Furthermore, organ dissection and observation were performed using a dissecting set. All sample observations were conducted at the Anatomy Laboratory, Faculty of Fisheries and Marine Sciences, Airlangga University.

Biological Analysis

This biological analysis, based on Sultana *et al.* (2017), involved making a vertical incision on the fish's stomach for biological studies. Subsequently, the gonads, intestines, and liver were sequentially separated and weighed using an analytical balance. Calculations such as Gonadosomatic Index (GSI), Hepatosomatic Index (HSI), and condition factor (CF) were carried out following methods described by Prameshwaran *et al.* (1974), Delahunty and Vlaming (1980), Hynes (1950), and Hile (1936).

GSI = (Weight of Gonad/Body weight) x 100
HSI = (Weight of liver/Body weight) x 100
CF = (Body weight x 100)/ Total length

Data Analysis

All data collected were analyzed using one-way ANOVA (SPSS software, 26 series) and Duncan tests to assess differences in biological

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parameters among samples obtained at each station.

RESULT AND DISCUSSION

The Gonad Index serves as a crucial indicator for discerning the spawning patterns of fish in their natural habitats. For *M. aculeatus*, the highest gonadosomatic index rates among females occur from August to September, indicating a once-a-year spawning cycle (Nabi & Hossain, 1996). Additionally, significant differences ($p < 0.05$) in biological parameters were observed among *M. aculeatus* samples collected from five observation stations (Table 2). While overall fish morphology did not vary significantly across stations, distinct motifs and colorations were noted among samples (Figure 1). Moreover, there is observable variation in gonad coloration between male and female *M. aculeatus*, with females displaying more intense hues, in contrast, to the typically brighter or clearer colors in males (Figure 2). The differentiation of sexually mature *M. aculeatus* males and females can also be based on the appearance of their genital papillae (Suresh *et al.*, 2019).

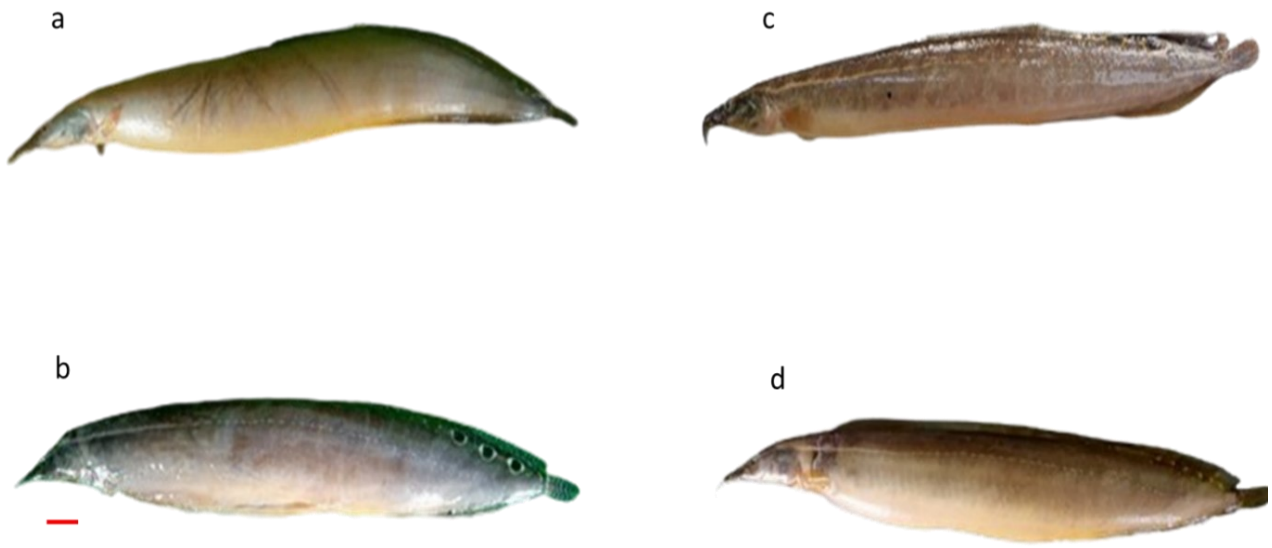

Figure 1. Some documentation of fish morphology and biology from each station, Note. A) Lamongan 1, b: Lamongan 2, c: Tuban, d: Brantas

Furthermore, male genital papillae are notably long and prominent, contrasting with the oval shape of female genital papillae when in good condition. The female reproductive organs appear as paired elongated structures resembling fringed bands, extending width-wise along the ventral body cavity with unequal lengths. Ovaries exhibit varying colors from reddish brown to pink. In contrast, male reproductive organs consist of paired elongated testes located bilaterally in the posterior abdominal cavity, attached dorsally by mesorchium connective tissue. The color of the testes ranges from whitish to creamy white or dull white, characterized by a smooth texture with distinct lobes (Ali *et al.*, 2016). Several biological parameters are indicative of gonad maturity levels. The Gonadosomatic Index (GSI), Hepatosomatic Index (HSI), and condition factor (CF) demonstrate good values

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in both rivers, with the average CF of females closely following that of males. In the Bengawan Solo River, the GSI values are higher in males compared to females, whereas in both rivers, the HSI shows dominance in females. The Gonad Index predominately favors males in the Bengawan Solo River, correlating with factors such as condition factors. Additionally, CF and GSI are associated with liver weight, indexed by HSI. Specifically, in April and June, GSI values for males were 10.41 and 11.18, respectively, while females exhibited notably lower GSI values in both rivers during these months.

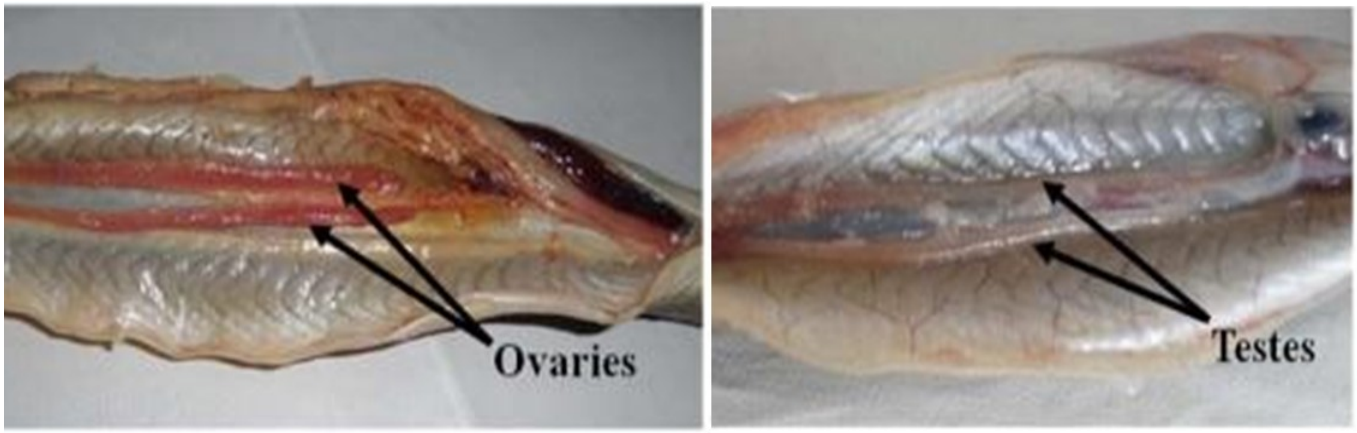

Figure 2. Reproduction Lesser Spiny Eels (a. Ovaries, b. Testes)

Table 2. Biological parameters observed during the study from various sampling locations

Parameters	LMG_1 (n=6)	LMG_2 (n=10)	TBN_1 (n=9)	BRNTS_1 (n=7)	Nilai F	Nilai Sig
Body weight (g)	44.75±30.08	86.00±14.93	45.46±10.03	46.35±17.80	11.370	0.000
Total Length (cm)	19.71±3.30	25.50±1.27	21.57±1.55	22.41±2.88	9.703	0.000
Weight ovary (cm)	2.60±4.74	4.20±0.91	2.53±1.42	0.32±0.21	4.217	0.014
Fecundity (grain)	1266.67±512.51	1600±286.74	1283.33±200	342.85±88.64	26.257	0.000
Gonad Weight (g)	0.71±1.8	2.23±2.01	2.3±1.5	0.32±0.21	4.638	0.02
Liver Weight (g)	0.60±0.41	0.86±0.71	0.99±0.40	0.32±0.12	3.065	0.021
Intestinal weight (g)	1.2±0.86	1.5±1.3	0.8±0.31	1.2±0.74	1.828	0.132
Gonadosomatic Index	1.5±2.0	3.8±1.8	5.2±3.2	0.63±0.27	12.004	0.000
Hepatosomatic Index	1.6±0.97	2.0±1.4	2.25±0.51	0.76±0.25	2.714	0.036
CF	8.6±5.8	12.08±10.24	9.3±3.1	10.8±5.2	2.714	0.036
Gonad maturity level	III	III	III, IV	III	-	-

Note. LMG; Lamongan, TBN; Tuban, BRNTS; Brantas

On the other hand, significant differences in weight and length were observed among the samples collected. The highest absolute weight and length were found at station LMG_2, whereas the values from the other three stations were relatively similar. Additionally, similar patterns were noted in other biological parameters such as gonad weight and fecundity, with samples exhibiting the highest absolute weight and length also displaying the highest fecundity. These findings suggest potential variations in fertility among the sampling stations. The disparity in sex distribution within the two rivers is influenced by three interconnected biological factors. The Gonadosomatic Index (GSI) is particularly sensitive to natural food availability and diet composition. The diversity of available food types in river environments significantly impacts the overall biological condition of fish. This diversity plays a pivotal role in affecting various biological indices such as liver index and condition factors (Sang & Bui, 2018), especially notable in males (Faridi *et*

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al., 2016).

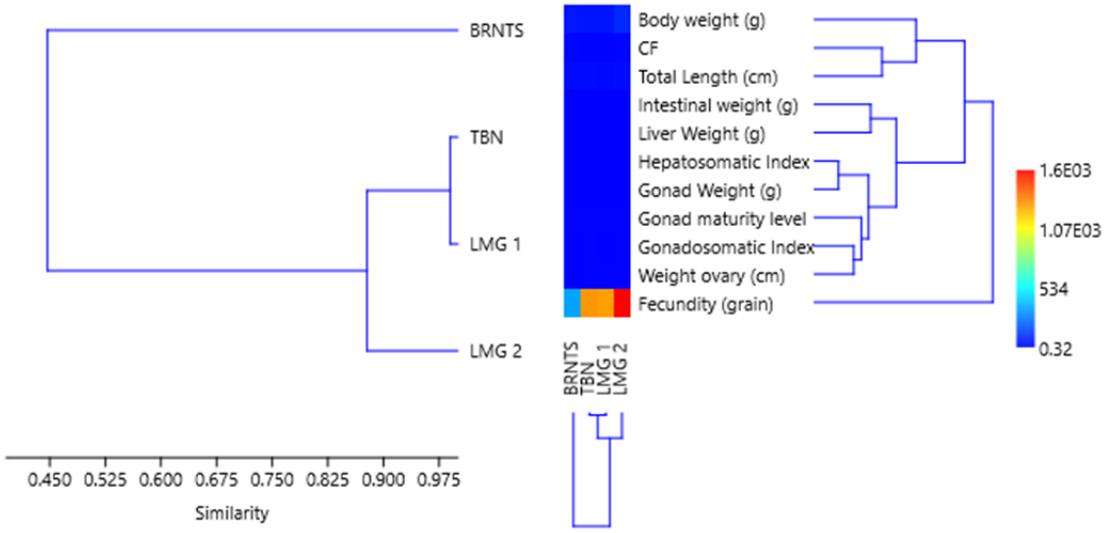

Figure 3. Similarity of stations based on biological characteristics of each sample

In the Bengawan Solo River, male fish exhibited the highest liver index value recorded at 3.89. Condition factor values across the two rivers show a balanced trend, with notable distinctions. The Brantas River recorded its highest value for females in June at 14.8, whereas the Bengawan Solo River reached its peak at 16.57 in September. Condition factors serve as critical indicators of fish health within an ecosystem (Abowei & Hart, 2009), reflecting ecological conditions and factors such as the specific locations (upstream vs downstream) and seasonal variations of fish specimens collected (Egbal *et al.,* 2011).

CONCLUSION

Some biological parameters of *M. aculeatus* in the Bengawan Solo River and Brantas River showed significant results ($p < 0.05$) for Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI), indicating differences among sampling locations. However, the Condition Factor did not show significant differences ($p > 0.05$) between the rivers. ANOVA tests on body weight, total length, ovary weight, GSI, and fecundity all yielded significance values ($p < 0.05$), further confirming variations across sampling sites. Furthermore, the study highlights notable variations in biological parameters among samples collected from different stations. Station LMG_2 stood out with the highest absolute weight and length measurements, correlating with increased gonad weight and fecundity. These findings underscore the potential influence of station-specific factors on fish fertility. Further research into the ecological and environmental differences among sampling sites could provide deeper insights into these variations and their implications for fish populations in the studied rivers.

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AUTHORS CONTRIBUTION

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The first author acted as data processor and correction, and the second and third authors provided data input and data revision.

CONFLICT OF INTEREST

All authors declare that they have no conflict of interest.

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