Morphological Analysis of Sili (Macrognathus sp.) in Some Regencies in East Java Province

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Abstract. Sili (Macrognathus sp.) is one of freshwater fishes that has high economic value in Asia, since it is beneficial as a consumable fish and an ornamental fish. The economic potential of Sili triggers overfishing, especially in East Java. Domestication is a method to preserve Sili in East Java, preceded by identifying potential species of Macrognathus sp. from the natural catchment. This study aims to characterize the morphological differences of Macrognathus sp. in several regencies in East Java based on morphological and morphometric phenotypes. Samples were collected at five different locations, specifically: Tulungagung (Boyolangu Watersheds), Kediri (Brantas Watersheds), Mojokerto (Brantas Watersheds), Lamongan (Bengawan Solo Watersheds), and Malang (Karangkates Reservoir). The main parameters observed were morphology and morphometry. The morphological analysis used identification guidelines, while morphometric data were obtained through 14 parameters measurement then analyzed using one-way Anova test on SPSS 25 software. Based on the morphological and morphometric analysis, it is known that the species of Sili in some regencies in East Java are Macrognathus tapirus and Macrognathus aculeatus. The results showed that samples from Tuban and Kediri are Macrognathus tapirus. Furthermore, the samples collected from Mojokerto, Lamongan, and Malang are Macrognathus aculeatus. One-way Anova test showed Sili from the five locations were significantly different based on the result value of p<0.05.
1. Introduction

Sili (Macrognathus sp.) is one of freshwater fishes that has a high nutritional element including minerals (Cu, Zn, and Fe), vitamin A, and vitamin E [1]. The nutritional value in sili fish and its tastiness make it a consumable fish. Some regions make Sili fish as a side dish of regional specialties, including Lamongan Regency. Currently, it has been cultivated as an ornamental fish, since it has a unique body shape and attractive body pattern. The economic potential of sili fish results in an overfishing, which triggers a decrease in Sili fish production. Therefore, it is necessary to do cultivation efforts. Information about a population’s genetic resources diversity is an essential element in conducting sustainable cultivation programs. One of which is a breeding program based on phenotypic variations [2].

Phenotype observations can be undertaken morphologically. One of the morphological observation techniques with high accuracy is morphometric measurements of fish body structure [3]. Morphometrics is one of the quantitative analytical studies by measuring special characteristics and body parts of living organisms. It aims to discover the taxonomy. Morphometric analysis is accurate in identifying differences between species, describing morphological diversity between populations and species, and classifying phylogenetic relationships [4]. The availability of information on the diversity of Sili fish species in East Java based on morphological and morphometric characters will be utilized to support a sustainable aquaculture development. This study aims to characterize the morphological distinctions of Sili fish at East Java waters based on morphological and morphometric phenotypes.

2. Materials and methods

The instruments used in this study were digital scale, ruler, and SPSS 25 software. The material used was Sili fish (Macrognathus sp.).

2.1. Data collection

Samples were collected from five districts in East Java Province (Figure 1). They were located through the Bengawan Solo Lamongan river, the Mojokerto Brantas river, the Kediri Brantas river, and the Boyolangu Tulungagung river which is a tributary of the Brantas River, and the Karangkates Reservoir (Table 1). Each location contributes four fish with an average weight of 26.27 grams and an average length of 18.74 cm.

![Figure 1. Map of Sili Fish Sampling Locations](https://www.google.co.id/maps)
Table 1. Sample Location Coordinates

| Location Coordinates | Location                  |
|----------------------|---------------------------|
| N 8.1103° E 111.8954°| Sungai Boyolangu, Tulungagung |
| N 7.8150° E 112.0073°| Sungai Brantas, Kediri     |
| N 7.4443° E 112.4413°| Sungai Brantas, Mojokerto  |
| N 6.9868° E 112.3570°| Sungai Bengawan Solo, Lamongan |
| N 8.1599° E 112.4468°| Waduk Karangkates, Malang   |

2.2. Morphological identification of Macrognathus sp.
Morphological identification in sili fish is undertaken visually on external characteristics including body shape, color, mouth shape, and fin shape [5]. Analysis of morphological data refers to www.fishbase.se and various supporting references from other researchers [6,7,8], determining the type of Sili fish based on morphological characteristics. *Macrognathus* sp. morphological characteristics have a taeniform body shape, an inferior mouth position with a trunk-like shape, rounded fin shape, cycloid scale type, and has ocelli on the caudal or dorsal fins [7]. There are three types of Sili fish that have been identified in Indonesia: *M. tapirus*, *M. aculeatus*, and *M. siamensis*.

*M. tapirus* has a dark brown body color pattern with a lighter color on the abdomen and on the back of the eyes to the base of the tail. Moreover, it has a taeniform body shape, inferior mouth position, rounded caudal fin shape, separate dorsal and caudal fins, and has ocelli on the base dorsal and caudal fins [7]. Similar to *M. tapirus*, *M. siamensis* has ocelli at the base of the dorsal and caudal fins [6]. *M. siamensis* also has a rounded tail, and the dorsal, caudal, and unfused anal fins, while *M. aculeatus* has long but unfused dorsal and anal fins, and has a rounded caudal fin (https://www.fishbase.se/). Furthermore, *M. aculeatus* has a yellowish-brown body color, several stripes on the dorsal and caudal fins, and has 3-11 ocelli at the base of the dorsal fin [8].

2.3 Morphometric Measurement

Analysis of the morphometric data obtained was analyzed using SPSS 25 statistical software to determine the diversity of morphometry through one-way univariate analysis (ANOVA) on each of the morphometric parameters tested. The number of morphometric parameters calculated is 14 parameters [9]. The morphometric data was then processed using PAST 4.07b software from all morphometric parameters measured to determine the relationship between species. Morphological parameters measured in Figure 2.
3. Results and discussion

3.1. Results
The results of morphological observations at the five sample locations possessed several similarities to Sili fish in terms of morphological characteristics, which were taeniform body shape, downward mouth position (inferior), elongated trunk-like shape on the snout, rounded caudal fin shape, brown body color with a lighter color on the abdomen, and there were ocelli on the dorsal and caudal fins (rounded patches of two circles, a darker inner circle and lighter the outer circle with an irregular shape) (Table 2). The morphological characters of each sample from different locations are described in Table 2.

Table 2. Sili Fish Morphological Characters

| Location | Morphology Figures | Information |
|----------|--------------------|-------------|
| Kediri   | -Taeniform-shaped body | -No ventral fin |
|          | -The body is dark brown at the base of the dorsal fin and yellowish brown on the abdomen | -The mouth is elongated like a trunk, inferior mouth position |
|          | -Has eight ocelli at the base of the dorsal fin, caudal fin, and anal fin | -Rounded caudal fin |
|          | -White markings on the caudal fin, dorsal fin, and anal fin | - |
| Location     | Description                                                                 |
|--------------|------------------------------------------------------------------------------|
| Tulungagung  | - Taeniform-shaped body                                                      |
|              | - No ventral fins                                                           |
|              | - The body is brownish black on the dorsal and light brown on the abdomen   |
|              | - Has four ocelli on the base of the dorsal and caudal fins, and one incomplete ocelli on the anal fin |
|              | - Has a pattern on the dorsal and caudal fins                               |
|              | - Rounded caudal fin                                                         |
|              | - Inferior mouth position                                                   |
| Mojokerto    | - Taeniform-shaped body                                                      |
|              | - Inferior mouth position                                                   |
|              | - The body has a yellowish-brown color on the dorsal and yellow on the abdomen |
|              | - Has a pattern on the dorsal, caudal, and anal fins                        |
|              | - No ventral fins                                                           |
|              | - A rounded caudal fin                                                       |
|              | - Ocelli are only located at the base of the dorsal fin, with a total of six eye spots |
| Malang       | - Taeniform-shaped body                                                      |
|              | - Inferior mouth position                                                   |
|              | - Very clear stripes on the caudal fin                                       |
|              | - Has two ocelli at the base of the dorsal fin                              |
|              | - The body is grayish black on the dorsal and yellow on the abdomen          |
|              | - Rounded caudal fin                                                         |
|              | - Clearly visible lateral line                                               |
| Lamongan     | - The body is dark brown on the dorsal and yellowish brown on the abdomen    |
|              | - Taeniform-shaped body                                                      |
|              | - Inferior mouth position                                                   |
|              | - Clearly visible stripes on the caudal fin, and some white markings on the dorsal and anal fins |
|              | - Unfused dorsal and anal fins with caudal fins                              |
|              | - Rounded caudal fin                                                         |
Morphometric analysis was undertaken using one way ANOVA test and PAST 4.07b software by calculating the value of F in each of the tested morphometric parameters referring to the supporting journals [9]. The number of morphometric parameters calculated is 14 parameters. Several characteristics were able to distinguish *Macrognathus* species significantly (p<0.05). The diversity of morphometry is shown in Figure 4 for the M. *tapirus* species from Kediri and Tulungagung districts, it can be seen that the morphometric parameters that have the furthest point are DBL (second dorsal fin length) and IJL (lower jaw length), while for M. *aculeatus* the parameters with the farthest points being HD (head width) and IJL (lower jaw length).

![Figure 3](image)

*(a) (b)*

**Figure 3.** Intraspecies Morphometric Diversity Pattern (a) M. *tapirus* and (b) M. *aculeatus* using PAST 4.07b software

The morphometric analysis was undertaken using the one way ANOVA test by calculating the F value for each morphometric parameter tested referring to the supporting journal [9] (Table 3.) The number of morphometric parameters calculated was 14 parameters. Several characteristics were able to significantly distinguish *Macrognathus* sp. species based on the calculated F value that was greater than the F table (p <0.05).
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Table 3. Morphometric Parameter ANOVA Test Results

| Karakteristik | Tulungagung   | Kediri      | Mojokerto | Lamongan | Malang | F value |
|---------------|---------------|-------------|-----------|----------|--------|---------|
|               | N=4           | N=4         | N=4       | N=4      | N=4    |         |
| TL            | 17.90±25.00   | 21.50-27.50 | 16.60-16.90 | 16.00-19.30 | 14.10-16.40 | 13.574  |
|               | 20.75±13.13   | 24.02±2.51  | 16.75±0.13 | 17.15±1.49 | 15.00±0.99 |         |
| SL            | 16.10-23.30   | 20.00-26.00 | 15.00-15.80 | 15.00-18.00 | 13.60-15.10 | 10.897  |
|               | 18.47±3.27    | 22.40±2.54  | 15.40±0.41 | 15.87±1.44 | 14.07±0.69 |         |
| HL            | 3.60-5.20     | 4.50-6.00   | 2.90-3.30  | 3.00-4.40 | 2.70-3.20 | 9.589   |
|               | 4.27±0.69     | 4.97±0.69   | 3.12±0.17  | 3.50±0.63 | 3.00±0.21 |         |
| UJL           | 1.50-2.70     | 1.60-2.70   | 0.90-1.60  | 1.30-2.10 | 0.90-1.60 | 3.270   |
|               | 2.05±0.50     | 2.00±0.49   | 1.27±0.33  | 1.52±0.38 | 1.30±0.31 |         |
| JL            | 1.00-2.20     | 1.10-2.20   | 0.50-1.10  | 0.80-1.60 | 0.40-1.10 | 3.255   |
|               | 1.55±0.50     | 1.50±0.49   | 0.80±0.29  | 1.02±0.38 | 0.80±0.31 |         |
| ED            | 0.30-0.50     | 0.30-0.50   | 0.20-0.30  | 0.20-0.30 | 0.20-0.30 | 4.250   |
|               | 0.35±0.10     | 0.40±0.08   | 0.25±0.05  | 0.27±0.05 | 0.22±0.05 |         |
| HD            | 1.60-2.00     | 1.60-2.00   | 1.50-2.00  | 1.40-2.10 | 1.00-1.50 | 5.623   |
|               | 1.77±0.17     | 1.77±0.17   | 1.65±0.23  | 1.75±0.28 | 1.15±0.23 |         |
| PFL           | 1.10-1.70     | 1.30-1.60   | 1.00-1.20  | 1.00-1.10 | 0.90-1.10 | 7.852   |
|               | 1.35±0.25     | 1.45±0.12   | 1.10±0.81  | 1.07±0.05 | 1.00±0.81 |         |
| DDP           | 2.90-4.20     | 4.20-5.30   | 2.90-3.60  | 2.90-4.90 | 3.20-3.60 | 5.136   |
|               | 3.70±0.59     | 4.80±0.49   | 3.15±0.31  | 3.62±0.88 | 3.47±0.18 |         |
| DSBL          | 5.40-7.20     | 6.40-7.50   | 4.10-5.50  | 4.50-5.30 | 4.20-4.50 | 16.796  |
|               | 6.30±0.77     | 6.80±0.49   | 4.87±0.57  | 4.97±0.35 | 4.27±0.15 |         |
| BD            | 2.40-3.10     | 2.70-4.00   | 1.70-2.20  | 2.20-2.50 | 1.70-2.30 | 12.210  |
|               | 2.62±0.32     | 3.40±0.53   | 2.07±0.25  | 2.32±0.15 | 1.97±0.25 |         |
| DDA           | 2.40-3.20     | 2.60-4.00   | 1.80-2.10  | 2.20-2.30 | 2.00-2.40 | 10.405  |
|               | 2.65±0.36     | 3.40±0.58   | 2.12±0.22  | 2.25±0.05 | 2.12±0.18 |         |
| DBL           | 5.50-7.00     | 6.70-15.00  | 4.70-6.00  | 5.00-5.70 | 4.60-5.00 | 4.422   |
|               | 6.02±0.68     | 9.37±3.79   | 5.37±0.53  | 5.27±0.30 | 4.82±0.20 |         |
| ABL           | 5.10-6.70     | 6.80-8.60   | 3.90-5.00  | 3.90-5.40 | 4.20-4.60 | 13.423  |
|               | 5.60±0.74     | 7.35±0.86   | 4.60±0.52  | 4.62±0.78 | 4.40±0.23 |         |

The color matrix of the two species was represented in Figure 4. The color pattern showed the diversity of the morphometric parameters of M. tapirus (a) and M. aculeatus (b). The highest diversity was shown in the ED parameter (Eye Diameter), and the lowest diversity was shown in the DBL parameter (second dorsal fin length). The morphometric closeness of kinship was shown through the Neighbor Joining Cluster in Figure 5, showing two types of the identified Sili fish. For M. tapirus (a) species, it was shown that groups from Tulungagung and Kediri districts were separated and gathered in the same clade, thus it can be seen that the population was the original one of the two districts. In the Neighbor Joining M. aculeatus diagram (b), several clades appeared consisting of several types of fish from different districts.
3.2. Discussion

Based on the five samples obtained, the morphological identification results indicated that there were two types of *Macrognathus* sp, which are *Macrognathus tapirus* (Tulungagung and Kediri Districts) (Figure 2) and *Macrognathus aculeatus* (Mojokerto Regency, Lamongan Regency, and Malang Regency) (Figure 3).

*M. tapirus* had a blackish dark brown body on the dorsal side, while the belly was yellowish in color. *M. tapirus* species from Kediri and Tulungagung districts had 4–8 ocelli on the dorsal and caudal bases. The caudal and dorsal fins had stripes (Figure 2). The range of weight and length of samples of *M. tapirus* from Tulungagung was 18.30 – 41.90 grams and 17.90 – 25.00 cm. In addition, those from Kediri Regency were 38.80–90.40 grams and 21.50 – 27.50.

Morphological identification of samples from Mojokerto Regency, Lamongan Regency, and Malang Regency confirmed that Sili fish from the three locations was *M. aculeatus* (Figure 3). Those were characterized by the presence of ocelli located only at the base of the dorsal fin, the rounded caudal fin shape, and had a taeniform body shape. The sample in Mojokerto Regency had a weight range of 10.20 – 17.20 grams and a length of 16.60 – 16.90 cm, Lamongan Regency weighs 17.10 – 22.90 grams and a length of 16.00 – 19.30 cm, and Malang 11.10 – 17.30 grams and length 14.10 –
The diversity of morphometry of *M. tapirus* species from Kediri Regency and Tulungagung Regency was shown in Figure 3. It can be seen that the morphometric parameters that have the farthest point were DBL (second dorsal fin length) and IJL (lower jaw length). Furthermore, the parameters with the farthest points in *M. aculeatus* were HD (head width) and IJL (lower jaw length). Therefore, the conclusion was obtained from the comparison between t count and t table. The value of t-count on the morphometric parameters of *M. tapirus* with the farthest distance (DBL and IJL), shows greater than t table, thus it can be concluded that the two parameters from the two locations were significantly different, as well as for the morphometric parameter of *M. aculeatus* with the farthest distance, which were HD (head width) and IJL (maxilla length).

The morphometric analysis was undertaken using the one way ANOVA test by calculating the F value for each morphometric parameter tested referring to the supporting journal [9] (Table 3). The number of morphometric parameters calculated was 14 parameters. Several characteristics were able to significantly differentiate *Macrognathus* sp. species based on the calculated F value that was greater than the F table (p < 0.05). The diversity of morphometry was shown in Figure 3 for *M. tapirus* species from Kediri Regency and Tulungagung Regency. It can be seen that the morphometric parameters that had the farthest point were DBL (second dorsal fin length) and IJL (lower jaw length). Moreover, for *M. aculeatus*, the parameters with the farthest point were HD (head width) and IJL (lower jaw length). Therefore, the conclusion was obtained from the comparison between t count and t table. The value of t-count on the morphometric parameters of *M. tapirus* with the farthest distance (DBL and IJL), shows greater than t table, thus it can be concluded that the two parameters from the two locations were significantly different. Similarly, the morphometric parameters of *M. aculeatus* with the farthest distances were HD (head width) and IJL (maxilla length).

The color matrix of the two species was represented in Figure 4. The color pattern showed the diversity of the morphometric parameters of *M. tapirus* (a) and *M. aculeatus* (b). The highest diversity was shown in the ED parameter (Eye Diameter), and the lowest diversity was shown in the DBL parameter (second dorsal fin length). Intraspecies kinships can also be identified from morphometric data in several districts, such as *Macrognathus tapirus* (Tulungagung and Kediri districts) and *Macrognathus aculeatus* (Mojokerto, Lamongan, and Malang districts) using Neighbor Joining Clustering on PAST 4.07b software in Figure 5.

In the two identified sili fish species, the morphometric closeness of kinship was shown through the Neighbor Joining Cluster in Figure 5. In the *M. tapirus* species (a), groups from Tulungagung Regency and Kediri Regency were separated and gathered in the same clade, thus it can be seen that the population was the original population of the two districts. In the Neighbor Joining *M. aculeatus* diagram (b), several clades appeared consisting of several types of fish from different districts. This was due to the possibility that *M. aculeatus* in Mojokerto, Lamongan, and Malang Regencies were an introduced species originating from the same location. Introductory activity was one of the factors that play a role in the kinship of a species in several areas [10]. Meristic parameter measurement results indicated that the species obtained from Tulungagung and Kediri districts was *M. tapirus*. Moreover, according to the identification of the two species at https://www.fishbase.se and several literature journals, it can be seen that samples from the other three districts were *M. aculeatus*. This strengthened the results of the morphological and morphometric analysis of the five Sili fish samples (Table 3).

Morphological differences in fish were emerged from several factors, including genetic factors, differences in environmental conditions, geographical positions, and different habitats. They affected fish diversity through adaptation of body shape, color, and fins [12]. The five research samples were collected from sampling locations with different conditions of the aquatic environment.

### 4. Conclusion

Based on the results of the study, it is concluded that Sili fish from five districts in East Java are distinguished into of *M. tapirus* and *M. aculeatus*. *M. tapirus* species of Tulungagung District and Kediri District morphometrically possess different morphological characteristics and separate kinship,
indicating that the *M. tapirus* population is a native species in both districts. Moreover, *M. aculeatus* species from Mojokerto District, Lamongan District, and Malang Regency possess almost the same characteristics and close kinship. The characteristics of Sili fish are diverse in nature, thus genetic analysis is imperative to confirm the clarification of each species.

5. References

[1] Olgunoglu, A. 2011. Determination of The Fundamental Nutrition Components in Fresh and Hot Smoked Spiny Eel (*Mastacembelus mastacembelus*, Bank and Solander, 1794). Scientific Research and Essays 6, 6448-6453

[2] Gustiano, R., T. Oktaviani., D. Soelistyowati., I. Kusmini., Wahyutomo., dan G. Huwoyon. Analisis Ragam Genotip RAPD dan Fenotip Truss Morfometrik pada Tiga Populasi Ikan Gabus (*Channastriata* (Bloch, 1793)). Jurnal Berita Biologi 12, 325-333

[3] Kristanto, A. H., J. Subagjjo., W. Cahyant., dan O. Ariffin. 2017. Evaluasi Variasi Fenotipe dan Genotipe Populasi Ikan Tambakan dari Kalimantan Tengah, Jawa Barat, dan Jambi dengan Truss Morfometrik dan Random Amplified Polimorphic DNA (RAPD). Jurnal Riset Akauakultur 12, 203-211

[4] Mahfuj, S., F. Hossain., S. Jinia., and A. Samad. 2019. Meristic and Morphometric Variations of Critically Endangered Butter Catfish, *Ompok pabo* Inhabiting Three Natural Sources. International Journal of Biosciences 14, 518-527

[5] Mahrus dan Syukur. 2019. Karakter Morfologi dan Identifikasi Molekuler dengan Menggunakan Marka Gen 12S rRNA pada Ikan Baronang (*Siganus sp.*) di Perairan Laut Selatan Pulau Lombok. Jurnal Sains Teknologi dan Lingkungan 6, 105-115

[6] Britz, R. 2009. Species Species of the *Macrognathus aculeatus* Group in Myanmar with Remarks on *M. caudioellatus* (Teleostei: Synbranchiformes: Mastacembelidae). Ichtyological Exploration of Freshwaters 20(4): 295-308

[7] Handayani, B., S. Rahayu., dan D. Listyorini. 2015. Identifikasi Ikan Sili Berdasarkan Karakter Morfologi dan DNA Barcode Cytochrome-C Oxidase Sub Unit I. Jurnal Pendidikan Biologi

[8] Das, S. K. and Kalita, N. 2003. Captive breeding of peacock eel, *Macrognathus aculeatus*. Aquaculture Asia 8, 17–18

[9] Duong, T., L.V.D. Tran., N.T Nguyen., J.A.F Jamaluddin., and M.N.S Azizah. 2020. Unravelling taxonomic ambiguity of the Mastacembelidae in the Mekong Delta (Vietnam) through DNA barcoding and morphological approaches. Tropical Zoology 33, 63-76

[10] Herdiana, L., M.M Kamal., N.A Butet., dan R. Affandi. 2017. Keragaman Morfometrik dan Genetik Gen COI Belut Sawah (*Monopterus albus*) Asal Empat Populasi di Jawa Barat. Jurnal Ilmu Pertanian Indonesia 22, 180-190

[11] Ayyubi, H., A. Buddiharjo., and Sugiyarto. 2018. Studi Keragaman Populasi Ikan Tawes (*Puntius javanicus*) di Sungai Bengawan Solo, Sungai Dengkeng, dan Sungai Opak Berdasarkan Morfometri. Seminar Nasional Pendidikan Biologi dan Saintek III: 222-228

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