Penja fish (Genus: Sicyopterus) from Karama River, West Sulawesi, Indonesia: Growth pattern and habitat characteristics

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Abstract. Muthiadin C, Aziz IR, Hasymuuddin, Nur F, Sijid SA, Azman S, Hadiaty RK, Alimuddin I. 2020. Penja fish (Genus: Sicyopterus) from Karama River, West Sulawesi, Indonesia: Growth pattern and habitat characteristics. Biodiversitas 21: 4959-4966. Sicydiinae gobies have been widely collected and identified throughout tropical Indo-Pacific, except in Karama River, Mamuju, West Sulawesi, Indonesia. Penja was the goby fish's local name, where their belly has the adhesive disc entirely formed by the pelvic fins. This study aims to describe the habitat and growth patterns of genus Sicyopterus in Karama river, which passes through three sub-districts. The research was conducted in Karama River from four sites: Kalumpang, Bonehau, Arassi, and Kalonding. Fish growth was described by Deroberts and William model, and continued with habitat characteristics. The total number of fish from four sites about 71 adults Sicyopterus species (family Gobiidae). Sicyopterus longifilis and Sicyopterus pugnans. The average growth pattern in all sites is isometric negative (b<3), except in the Kalumpang sites, growth pattern for S. longifilis is isometric (b=3) whereas in S. pugnans in the Kalumpang sites growth pattern is positive allometric (b>3). The value of condition factor (K) ranges between 1.89-2.28, it means the average shape of fish is flat. It is related to the average growth pattern from four sites that are allometric (growth of length more than the growth of weight). Nevertheless, the value of Wr in average 100, which describe that environment of fish is good, related from abiotic measurement in all site showed fit condition for Sicyopterus species habitat. Further studies will be focused on the food supply and predator of Sicyopterus.

Keywords: Goby fish, growth model, length-weight relationship, Sicyopterus longifilis, Sicyopterus pugnans

INTRODUCTION

Sicydiinae gobies have shown the highest level of diversity and endemism, classified as amphidromous fishes (Ebner et al. 2011; Keith et al. 2011) that migrates between freshwater and the ocean at different stages in their life cycle (Hoareau et al. 2012; Iida et al. 2013; Boseto et al. 2016) which critically on the integrity of the mountain-lake-river-ocean corridor (Roche et al. 2013; Eagderi et al. 2018; Christoffersen et al. 2019). The migration plays an important role in their life cycle, including recruitment, growth, maturation, and reproduction (Ellien et al. 2014; Teichert et al. 2014). The larvae drift immediately downstream to the estuary (Iida et al. 2015), and after 2 to 6 months, the post-larvae migrate back into the rivers (Bauer 2013; Shiao et al. 2015; Olli et al. 2017; Tran et al. 2018). Besides hydro-ecological characteristics, high-nutrient found in the estuary can cause a high abundance of phytoplankton that affects zooplankton and fish at the early life stage, including postlarvae, which acts as consumers (Bhaumik et al. 2011; Taillebois et al. 2012; Cloern 2018).

Trading of goby fish has been a common practice in traditional markets in the Indo-Pacific area. Gobies caught by fishermen using traps and nets are sold in traditional markets and consumed as alternative food in Philippines (Mahilum et al. 2013; Vedra and Ocampo 2014). In Taiwan, Japan, China, and Thailand, local people consume gobies in soups and salads due to the delicacy and high nutritional value (Rojtinnakorn et al. 2012; You et al. 2015; Kachhi et al. 2020). Sicydiinae gobies in Indonesia are a typical food of West Sulawesi Province with various preparations (Gani et al. 2019; Nurjirana et al. 2019). The local community usually preserved these fishes by salting and sun-drying then sold them in the traditional and online markets.

Even though Sicydiinae gobies have been collected and identified from freshwater streams throughout the tropical Indo-Pacific, however, it still many islands of this region have never been collected. The lower, middle and upper reaches are the main inhabited part of rivers in the Pacific area by genus Sicyopterus (Ellien et al. 2011; Artzrouni et al. 2014; Keith et al. 2015). On the belly side of the body, these gobies bear the pelvic disc as an adhesive organ (Keith et al. 2014; Lord et al. 2019). The first observation of Sicyopterus species (Penja fish) in West Sulawesi was made by some fishermen. They found the juvenile was live in the river. Penja fish were identified as Sicyopterus species, and it was hypothesized that Penja fish would school with other species Awaous melanocephalus (Muthiadin et al. 2017).

Information about the existence of Sicyopterus gobies is only obtained from fishermen and the local community.
Further, there has been no record of *Sicyopterus* species from the selected river on the FishBase database. In this study, we aim to describe *Sicyopterus* species from Karama River, West Sulawesi, Indonesia, along with its growth patterns and morphological characteristic. This study would help improve fishery management strategies in Karama River in order to preserve biodiversity and protect sustainability while maintaining continuous harvesting for domestic and trade commercial.

**MATERIALS AND METHODS**

**Study area**

The research was conducted in Karama/Karana River, which passes through three sub-districts of Kalumpang, Bonehau, and Sampaga (Figure 1), Pangale District, Mamuju Regency, West Sulawesi Province, Indonesia in May, 2018 with the rainy season. The location used by the fishermen as sampling point of Penja (*Sicyopterus* sp.). Sample found in four sites: Kalumpang, Bonehau, Arassi, and Kalonding.

**Procedures**

**Sampling procedure**

Sampling was conducted at four sites (Figure 1). The location used as a sampling point for Gobiidae fish was conducted with fishermen. The samples were caught using casting nets and temporary stored in each jar. The sampled specimens were preserved in 4% formalin and then transported to the Laboratory of Zoology, Universitas Islam Negeri Alauddin Makassar for further analysis.

**Physical data measurement**

Habitat characteristics, including the pH, dissolved oxygen (DO), temperature, depth, current velocity, substrate type, salinity, altitude from sea level, and the growth pattern of the fish were recorded (Table 1).

**LT and LS measurement**

Dial vernier caliper (Tricle brand ®) was used to measure total length (LT) and standard length (LS) of the specimens to the nearest 0.02 mm and weight to the nearest 0.01 g (Kern KB3600) (Keith et al. 2015). The formula: \( W = aLT^b \) was applied to calculate the length-weight relationship, where \( W \) is weight in grams, \( LT \) is total length in centimeters, and \( a \) and \( b \) are regression coefficient and exponent, respectively (Greenfield and Randall 2010).

**Data analysis**

This research uses the long-weight relationship formula using the Linear Allometric Model (LAM) equation as an analysis of the sample to be observed based on DeRoberts and William (2008). \( W = aL^b \), which \( W \) = fish weight (grams), \( L \) = total length of fish (mm), \( a \) and \( b \) parameters.

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**Figure 1.** Location of four sampling sites: Kalumpang (2°28'10.0"S, 119°29'05.0"E), Bonehau (2°25'02.0"S, 119°23'01.0"E), Arassi (2°23'11.0"S, 119°18'03.0"E), and Kalonding (2°20'11.0"S, 119°15'03.0"E)
The value of b is used to estimate the growth pattern of the fish which is analyzed whether the value of b = 3 or the value of b ≠ 3. If the value of b = 3 shows an isometric growth pattern, which means that the increase in length is the same as the increase in weight, if the value of b <3 shows a negative allometric growth pattern, which means that the length increase is greater than the weight gain and if the value of b> 3 shows a positive allometric growth pattern which means the increase the weight is greater than the increase in length. The exponent b often has the coefficient a value close to 3 (in isometry), but ranges between 2 and 4. The value b = 3 indicates that the fish grows symmetrically or isometrically. Values other than 3 indicate allometric growth. Data analysis was using Microsoft excel.

RESULTS AND DISCUSSION

The upstream area of Karama is located in Kalumpang village (Kalumpang subdistrict) and the estuary of the river is located in Sampaga village (Sampaga Sub-district) with a long straight line of approximately ± 40 km. The upstream section is at an altitude of ± 90 m above sea level. In this study, data for Sampaga station has excluded. At Kalumpang upstream station, we found 19 samples, 15 samples at Bonehau station, 17 samples at Arassi station, and 20 samples at Kalonding station. We identified two species of Sicydiinae, belonging to Genus Sicyopterus: Sicyopterus longifilis and Sicyopterus pugnans.

The external morphology of Sicydiinae Gobiidae

**Sicyopterus longifilis**

The body shape is fusiform and elongated with whitish brown coloration and seven-eight black bands on the body. The ventral margin of the eye is marked with triangular black to the posterior end of the mouth. Mouth ventrally orientated with lateral cleft of the lip and without median cleft. Dentary with four or seven canine (cone)-like symphysisal teeth on each side. Premaxillary teeth are tricuspid. First dorsal fin is whitish with spines elongate and some black spots on the base. One spine in the second dorsal fin and ten soft rays. Second to fourth rays of dorsal fin are filamentous. Caudal fins are about 1-1.2 mm, has pale to grayish coloration, and are rounded. Anal fin is dark gray with one spine, ten soft rays, and cycloid scales on the base. Pectoral fins are blackish with white bands at the end. Pelvic fins about 0.6 mm in length translucent and form a strong disk (Figure 2A-H).

**Sicyopterus pugnans**

The body shape is fusiform and elongated with brownish orange coloration and six pale black bands on the body. The eye to the posterior end of the mouth is marked with pale bands. Mouth ventrally oriented with lateral cleft of the lip and without median cleft. Dentary has two or four canine (cone)-like symphysisal teeth on each side. Premaxillary teeth are bicuspid. First dorsal fin is whitish with spines elongated and without black spots on the base. One spine in the second dorsal fin with ten soft rays. Caudal fins are about 0.7-1 mm in length, pale orange, and rounded. Anal fin is pale orange to grayish with one spine and ten soft rays. Cup-like disk is attached to belly. Pectoral fins are pale gray with vague blotchings. Pelvic fins, forming a disk, are about 0.4-0.7 mm in length and translucent (Figure 3A-H).

**Habitat characteristics of Sicydiinae Gobiidae**

Sandy and rocky substrate is the habitat preference of Sicydiinae Gobiidae in Karama River, in addition to other environmental characteristics that are also interrelated. Data about the characteristics of the habitat and abiotic parameters shown in Table 1.

**Length-weight relationship and growth pattern of Sicydiinae Gobiidae**

A total of 71 individual adult Sicydiinae Gobiidae found at four sites were dominated by 87% *S. longifilis* while *S. pugnans* was only around 13%. Distribution and results of length-weight relationships are presented in Table 2.

![Figure 2](image2.png) **Figure 2.** Morphology of *Sicyopterus longifilis* found in Karama River. A: Eye; B: spiny dorsal fin; C: soft dorsal fin; D: caudal fin; E: anal fin; F: pectoral fin; G: pelvic fin; H: mouth

![Figure 3](image3.png) **Figure 3.** Morphology of *Sicyopterus pugnans* found in Karama River. A: Eye; B: spiny dorsal fin; C: soft dorsal fin; D: caudal fin; E: anal fin; F: pectoral fin; G: pelvic fin; H: mouth
Table 1. Characteristics of Sicydiinae Gobiidae fish habitat in four sites in Karama River, West Sulawesi, Indonesia

| Characters of habitat | Kalumpang (upstream) | Bonehau | Arassi | Kalonding |
|-----------------------|-----------------------|----------|--------|-----------|
| Altitude (m a.s.l.)    | 88                    | 44       | 31     | 20        |
| pH                    | 7.5                   | 7.8      | 7.2    | 7.9       |
| Temperature (ºC)       | 23                    | 24       | 25     | 25        |
| DO (mg/L)              | 8.1                   | 7.9      | 7.8    | 7.5       |
| Brightness (m)         | 0.32                  | 0.26     | 0.22   | 0.23      |
| Velocity (cm.s⁻¹)      | 20                    | 140      | 160    | 80        |
| Salinity (ppt)         | 0                     | 0        | 0      | 0         |
| Depth (m)              | 0.46                  | 0.23     | 0.19   | 0.17      |
| Substrate              | large rocks, slightly, sandy | small rocks, sand | small rocks, sand | small rock, sand |

Table 2. Estimated parameters for length-weight relationships in *S. longifilis* and *S. pugnans* in four sample sites

| Site            | Species               | n  | Growth pattern            | Wr  | K     |
|-----------------|-----------------------|----|---------------------------|-----|-------|
| Kalumpang       | *Sicyopterus longifilis* | 13 | Isometric (*b*= 3.003)    | 0.960 | 1.997 |
|                 | *Sicyopterus pugnans*  | 6  | positive allometric (*b*= 3.457) | 0.936 | 1.899 |
| Bonehau         | *Sicyopterus longifilis* | 15 | negative allometric (*b*= 2.610) | 0.895 | 1.974 |
| Arassi          | *Sicyopterus longifilis* | 17 | negative allometric (*b*= 2.888) | 0.817 | 2.134 |
| Kalonding       | *Sicyopterus longifilis* | 17 | negative allometric (*b*= 2.468) | 0.855 | 2.282 |
|                 | *Sicyopterus pugnans*  | 3  | negative allometric (*b*= -0.25) | 0.007 | 2.196 |

Note: n = total of individual; Wr = weight relative (g); K = condition factor; a & b = regression coefficient and exponent; where $W_s = aLT^b$

Figure 4. Relationship between total length and weight of *Sicyopterus* collected from Kalumpang station. A: *S. longifilis*; B: *S. pugnans*; C: Bonehau station (*S. longifilis*); D: Arassi station (*S. pugnans*); E: Kalonding station (*S. longifilis*); F: *S. pugnans*
Prior to this study, reports and notes regarding the presence and distribution of this genus are still unclear in four sites. The total number of fish from four sites is about 71 adult Gobiidae fish, where *S. longifilis* was found in all sites, while of 62 samples, nevertheless *S. pugnans* was found nine in total at Kalumpang and Kalonding only. The value of $b$ is then used to estimate the growth pattern of the fish analyzed whether $b = 3$ or $b \neq 3$. The scatter plot reflects the exponential growth in weight with increasing length, shown in Figure 4.

**Discussion**

The description of body shape and morphological structure of Goby fish becomes a vital basis in precise taxonomy and systematic process, with some additional ecological dataset, distribution, growth pattern, and other supporting data. The latest identification data is continuously added to meet the stabilized of a particular genus. Misidentification is inevitable even when the genus taxonomy has sufficiently detailed. Maeda and Saeki (2018) conducted a revision of de Beaufort (1912) with genus *Sicyopterus*’ description according to their findings in Japan. New records of this genus continues to grow in Indonesia, particularly in Sulawesi. Penja fish was found by Nur et al. (2018) in Karema River, West Sulawesi, but the genus has not been identified. Gani et al. (2019) found *Sicyopterus lagocephalus* and *S. longifilis* in Biak and Koyoan River, Central Sulawesi. *S. longifilis* and *S. pugnans* were also identified by Olii et al. (2019) in Gorontalo Bay and Bone River, Gorontalo waters. A total of 96 individuals of *Sicyopterus* species found by Nurjirana et al. (2019), including *Sicyopterus lagocephalus*, *S. longifilis*, and *Sicyopus zosterophorum* in Leppard River, West Sulawesi. We identified morphological variations in two species of *Sicyopterus*, sustaining the presence of this genus in Karama River.

The morphology of *S. longifilis* in Karama River (Figure 2) has a different color with *S. longifilis* described by Gani et al. (2019) in Biak River. The body coloration is dominated by brown in *S. longifilis* in Karama River, which is reported to be similar to *S. longifilis* from Japan (Maeda and Saeki 2018), while *S. longifilis* in Biak River is dominated by blue. Black triangular bar was located below the eye. Median cleft at upper lip was not found as Maeda and Saeki (2018) reported in contrast with de Beaufort (1912). Dorsal fin, caudal fins, anal fins, pectoral fins and pelvic fins are similar to characteristics described by Keith et al. (2015). The morphology of *S. pugnans* have in common with *S. longifilis*, except in following cases, the body color, pectoral fin of *S. pugnans* has a pale gray, whereas in *S. longifilis* is black with white bands, *S. longifilis* showed dorsal fin with black mottling on body three fourth, while in *S. pugnans* only on body top and sides (Figure 3).

In general, the value of $b$ depends on the physiological and environmental conditions (Mir et al. 2012; Jisr et al. 2018) such as temperature, climate change, pH, conductivity, salinity, dissolved oxygen, geographical location, and sampling techniques (Pankhurst and Munday 2011; Elboray et al. 2012; Nehemia et al. 2012; Davies et al. 2013; Muchlisin et al. 2015; Makori et al. 2017; Sánchez-González et al. 2020) as well as biological factors, for instance, gonadal development and food availability (Ighwela et al. 2011; Hossain et al. 2012; Lui et al. 2013; Akombo et al. 2014). The station’s altitude on Karama River reaches 20-88 m above sea level from Sampaga estuary to the upstream of Kalumpang (Table 1). This indicates that *Sicyopterus* can migrate upstream even though its elevation reaches high above sea level (<100 m). In line with this, Teichert et al. (2013) caught *Sicyopterus* species downstream stations (<100 m) on perennial rivers of Reunion Island. In addition, the presence of *Sicyopterus* species also provided by Ebner et al. (2011) at at highest density with an elevation of approximately 10-50 m above sea level in Noah Creek and Pauls Pocket Creek.

Rocky substrate mixed with sand is habitat preference of *Sicyopterus* species in Karama River. Rocky surfaces are a growing medium for diatoms and algae, beside the benthic surface. Algae and diatoms as the main source of food scrapped by adults using rake-like of upper jaw premaxillary teeth (Lord et al. 2012; Cullen et al. 2013; Sahara et al. 2016). The rocky substrate also offering hiding spots (Lord et al. 2012; Barbeyron et al. 2017), safe place for large number of small eggs (Teichert et al. 2013; Ellien et al. 2016), and also as climbing surface using their oral and pelvic sucker with an inching behavior (Blöb et al. 2013; Cullen et al. 2013; Christy and Maie 2019).

The average growth pattern in all sites is negative allometric ($b < 3$), except in the Kalumpang sites, growth pattern for *S. longifilis* is isometric ($b = 3$) whereas in *S. pugnans* fish in the station Kalumpang growth pattern is positive allometric ($b > 3$). This implies that *S. longifilis* and *S. pugnans* generally in Karama River become longer, thus making them more slender. The body proportion of these fish in grams is below the increase in total length, which is measured from the tip of snout to the tip of caudal fin (Figure 4). Compared with the findings of Nur et al. (2018), negative allometric growth was also measured on Penja fish in Karema River. Although the total length range is shorter in comparison *Sicyopterus* in Karama River. The growth pattern varies and changeable according to specific environmental, biological factors, and trophic levels (Freitas et al. 2017; Saberi et al. 2017). The negative allometric pattern in this study may be attributed to the adaptation effort of *Sicyopterus* toward the site's condition. The slender body will make easiness to hide in the substrate gap from predator attacks, like a fish-eating bird, crab, and shrimp. There is allometric relation between fish body size and water-flow velocity (Hockley et al. 2014; Del Signore et al. 2016) which interpreted the slender body of *Sicyopterus* will help to improve the swimming velocity and swimming ability through the rocky substrate. Based on water-flow velocity, four sites on Karama River are classified as low (10-25 cm.s$^{-1}$) to high (>100 cm.s$^{-1}$) current velocities, respectively; 20, 140, 160, and 80. Low current velocity has an indirect effect on food availability (García et al. 2011; Kemp et al. 2011; Mims et al. 2012) at composition assembly in diatoms. Silica and other organic
matters as the energy source for diatoms found in sand and rock powder can be deposited longer. There are no tidal currents and pressure waves to carry them. In addition, low current velocity may be attributed as a direct effect on aquatic substrate formation in Kalumpang upstream. *S. longifilis* showed a single distribution in two sites in Karama River towards high-flow. This result is similar to the findings reported by Donaldson et al. (2013) that *S. lagocephalus* in Australian wet tropics is one species possible to reach extremely high-flow while incapable of other species.

Condition factors were calculated to assess fish health generally, productivity, and physiological conditions of fish populations (Dalu et al. 2013; Van Beveren et al. 2014; Lederou et al. 2016). This condition factor reflects the body’s morphological characteristics growth rate (Enberg et al. 2012; Ara et al. 2014; Killen et al. 2016). The value of condition factors owned by each fish is expected to have high enough fecundity as a fish adaptation to maintain its population in nature.

The range of condition from the data analysis factor is 1.89-2.28 (Table 2), whereas if more > 2 then dominated by fish with maturity level of gonad (Esmaeili et al. 2017; Masoom J, Taillebois L, Teiche et al. 2012; Van Beveren et al. 2008). Weight of an endemic cyprinid adult Gobiidae fish identified as *Sicyopterus* stimpsoni, *Sicyopterus japonicus* (Teleostei: Gobiidae) on the New Georgia Group, Solomon Islands, Pacific Conserv Biol 22 (3): 281-291. DOI: 10.1071/PC14934.

In conclusion, adult Gobiidae fish identified as *S. longifilis* and *S. pugnans* found in four sites from Karama River. The average growth pattern in all sites is isometric negative, except in the Kalumpang sites, growth pattern for *S. longifilis* is isometric, while *S. pugnans* shows positive allometric.

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