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Morphological Characteristics and Habitat of *Oryzias celebensis* (Weber 1894) (Beloniformes; Adrianichthyidae) in South Sulawesi River

Ardyansyah Kahar[1], Andi Iqbal Burhanuddin[2]*, and Khusnul Yaqin[2]

[1]Doctoral Program in Fisheries Science, Faculty of Marine Science and Fisheries, Hasanuddin University. Jl. Perintis Kemerdekaan Km.10, Tamalanrea, Makassar 90245, South Sulawesi, Indonesia

[2]Faculty of Marine Science and Fisheries, Hasanuddin University. Jl. Perintis Kemerdekaan Km.10, Tamalanrea, Makassar 90245, South Sulawesi, Indonesia

***Corresponding Author: iqbalburhanuddin@yahoo.com**

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ABSTRACT

Oryzias celebensis, an endemic ricefish species of Sulawesi, Indonesia, plays a crucial role in ecological studies and conservation due to its sensitivity to environmental changes. This study aimed to analyze the morphological characteristics and habitat conditions of *O.celebensis* by examining morphometric and meristic traits and assessing water quality parameters across different locations in South Sulawesi. Morphometric analysis was conducted using conventional measurement techniques, while meristic traits were determined by counting key anatomical structures. Habitat conditions were evaluated based on temperature, salinity, dissolved oxygen (DO), and pH. The findings indicate significant variations in standard length, pelvic fin height, and body depth across different sampling sites, suggesting possible genetic stability and environmental influences on growth patterns. In addition, this study highlights that *O. celebensis* thrives in freshwater environments with slow currents, aquatic vegetation, and moderate dissolved oxygen levels, making it a potential bioindicator species. The results provide essential data for conservation efforts and the sustainable management of this endemic fish species.

INTRODUCTION

Oryzias fish is commonly referred to as the ricefish because it is generally found in rice field ecosystems, ponds, ditches, and lakes. It can live in both freshwater and brackish water **(Sen & Sreeraj, 2022)**. This fish belongs to the Adrianichthyidae family, which is widely distributed in South and East Asia **(Sudasinghe *et al.*, 2022)**. Numerous studies on ricefish have been conducted in Asian countries such as Japan, Korea, Taiwan, China, and Indonesia **(Yuan *et al.*, 2022)**. One species of *Oryzias* found in Indonesia and endemic to South Sulawesi river is *Oryzias celebensis* **(Hasanah *et al.*, 2022)**.

Oryzias celebensis exhibits a small body with an elongated and laterally compressed shape, adorned with small and slender scales **(Hasanah *et al.*, 2022)**. This fish typically inhabits freshwater environments with calm water conditions, including

lakes, swamps, and small river systems **(Kottelat & Whitten, 1993)**. The availability of vegetation and sufficient food sources significantly influences the abundance and distribution of *O. celebensis*, making this species crucial in ecological and conservation studies **(Ueda *et al.*, 2024)**. However, studies on the habitat and morphology of *O. celebensis* remain limited due to its lack of economic value, even though its presence in aquatic environments serves as a sentinel organism of water quality monitoring and assessment **(Yaqin *et al.*, 2022, 2024)**.

Therefore, this study examined the morphological characteristics of *O. celebensis* fish morphometrically and meristically and analyzed the water conditions forming the habitat of *O. celebensis* fish. Morphological characters consisting of morphometrics and meristics are the basis of fish taxonomy. Fish identification can be done through morphometric and meristic characters. Morphometric characters are used to determine shape and growth rate through measuring morphological structures, while meristic characters are performed by calculating numerical elements to determine species and classes. These studies are important to support proper exploitation and management of species populations **(Soliman *et al.*, 2018)**. Reviewing the habitat conditions of a fish population is very important, especially endemic fish, as the Indonesian government's efforts in the Decree of the Minister of Environment and Forestry Number P.106/MENLHK/SETJEN/KUM.1/12/2018, which lists protected flora and fauna species, including several endemic fish species. This measure aims to prevent uncontrolled exploitation and regulate the protection of their habitat.

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MATERIALS AND METHODS

Research area

This study was conducted at several locations in South Sulawesi Province (Table 1), selected based on suitable characteristics for the presence of *O.celebensis.*

Table 1. Description sampling location *O.celebensis* in South Sulawesi River

Location	Coordinates	Description
Walannae River, Bone Regency	$4^0$52’31, 122” S, 120^{0}4’19,62”	Plantation area
Pattunuang River, Maros Regency	-5^{0}2'28. 08” S, 119^{0}41'46,392” E	Residential area
Dewi Lamsang Pond, Pangkep Regency	-4^{0}49'072” S, 119^{0}36'38,473” E	Recreational area
Takalar River, Takalar	-5^{0}21 '10.878” S, 119^{0}30'49.026” E	Plantation area

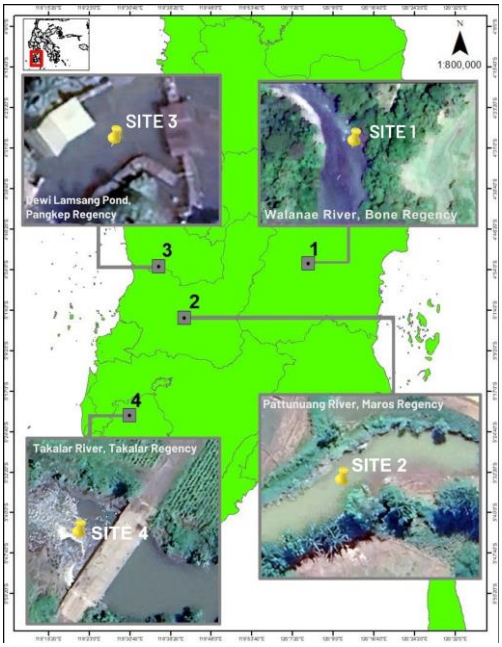

Fig. 1. Sampling location *Oryzias celebensis* in South Sulawesi River

Sampling procedure

Field sampling

Sampling points were determined using the purposive sampling method, which is a non-random sampling technique based on specific considerations relevant to the research objectives. The samples were collected using a 2-meter-long beach seine net. The captured fish were then separated based on the target species, *O. celebensis*. The separated fish were photographed to document body coloration. To clarify the description of body color, photographs of fish that were not preserved with preservatives were taken. After that, the samples were preserved in 70% alcohol and were stored in a cool box containing ice crystals. The samples were then taken to the Laboratory Marine Biology, Faculty of Marine Science and Fisheries, Hasanuddin University for morphometric measurements and meristic counts.

Habitat observation

The habitat conditions of *O. celebensis* were assessed by measuring water quality parameters at three different points. The parameters measured included dissolved oxygen using a DO meter (AZ Instrument AZ-8403), temperature using a mercury thermometer, and salinity using a digital Brix refractometer.

Morphometric measurement

Morphometric measurements were carried out using conventional methods based on measurements by **Magtoon and Termvidchakorn (2009b)**. The body parts of the fish that were measured were only the left side consisting of standard length, total length, head length, snout length, eye diameter, body size, tail stem length, tail stem height and height of all fins on the body.

Meristic count

Meristic characteristics were determined based on the method by **Magtoon and Termvidchakorn (2009b)**, involving the count of fin rays and other key structures including pectoral fin ray, pelvic fin ray, dorsal fin ray, anal fin ray, upper caudal fin ray and lower caudal fin ray.

Data analysis

To determine the relationship between dissolved oxygen (DO), temperature, and salinity with the abundance of *O. celebensis*, principal component analysis (PCA) was conducted using XLStat software. Morphological observations were analyzed descriptively and statistically using Excel and SPSS (Statistical Product and Service Solution) version 20.0. One-way ANOVA was used to determine significant differences in the morphological characteristics of *O. celebensis* across different locations, followed by discriminant analysis to identify the variables that differentiate populations.

RESULTS AND DISCUSSION

Morphological characteristics, comprising morphometric and meristic traits, remain a reliable method for identifying and describing fish species in the field **(Chandrasekar & Arunkumar, 2023)**. Morphometric traits involved measurements of fish body parts related to growth and body shape, while meristic traits included counts of specific structures such as fins, vertebrae, or scales, aiding in classification and understanding variations among species **(Raja *et al.*, 2024)**.

1. Morphometrics

Oryzias celebensis, known as one of the endemic fish species of Sulawesi, exhibits distinctive morphological characteristics. It has a small body with varying sizes across different observation locations.

Table 2. Morphometric character with %SL of *Oryzias celebensis* in South Sulawesi River

Morphometric character	**Walannae River, Bone Regency** (mean ± sd)	**Pattunuang River, Maros Regency** (mean ± sd)	**Dewi Lamsang Pond, Pangkep Regency** (mean ± sd)	**Takalar River, Takalar Regency** (mean ± sd)
Standard length	(31,0 ± 2,1)	(29.8 ± 1,2)	(24.0 ± 1,6)	(26.5 ± 2,3)
Percent of standard length				
Total length	(121,2± 0,9)	(125.0± 2,6)	(124.2± 2,7)	(124.8± 4,0)
Head length	(23.4± 0,9)	(24.2 ± 0,5)	(24.3 ± 0,6)	(25.4± 1,6)
Snout length	(15,5± 0,5)	(17.8± 0,4)	(23,7 ± 1,0)	(22,2± 1,2)
Eye diameter	(10.4± 5,1)	(9.7± 0,7)	(10.3 ± 0,8)	(9.5± 0,6)
Prepectoral - fin length	(26.2± 1,7)	(27.8± 1,2)	(30.2 ± 2,0)	(29.3± 2,9)
Pectoral - fin length	(20.6± 1,8)	(20.5 ± 2,1)	(20.8 ± 2,7)	(16.9± 3,3)
Predorsal - fin length	(79.8± 1,4)	(78.0 ± 6,1)	(78.7 ± 3,4)	(80.9± 3,3)
Dorsal - fin length	(19.9± 5,1)	(18.3± 5,4)	(22.1 ± 4,2)	(19.9± 3,1)

Long of dorsal fin base	(9.9± 1,7)	(10.1± 1,8)	(11.9 ± 1,3)	(10.3 ± 1,4)
Caudal penduncle length	(11.1 ± 1,3)	(11.0 ± 1,4)	(9.3 ± 1,5)	(12.0± 1,9)
Caudal penducle depth	(9.9 ± 0,3)	(9.6 ± 1,1)	(10.1 ± 1,4)	(10.0 ± 1,3)
Prepelvic - fin length	(44.6± 2,1)	(49.0± 2,4)	(47.5 ± 2,5)	(47.3 ± 2,8)
Pelvic - fin length	(12.4± 1,5)	(14.9 ± 1,4)	(11.0± 1,5)	(11.9 ± 0,9)
Preanal length	(54.6 ± 2,9)	(60.5± 1,9)	(57.4± 1,5)	(57.8± 3,2)
Preanal - fin length	(60.4± 1,1)	(63.8 ± 2,2)	(61.2± 1,8)	(62.7 ± 3,5)
Anal - fin length	(19.1 ± 3,8)	(21.0± 5,7)	(22.9 ± 6,4)	(22.6 ± 5,6)
Long of anal fin base	(26.6 ± 1,8)	(26.9 ± 1,3)	(27.5 ± 0,9)	(27.5 ± 2,0)
Body depth at origin of anal fin	(21.7 ± 1,1)	(25.5 ± 1,4)	(26.7± 1,4)	(25.9 ± 2,0)
Body depth at origin of dorsal fin	(16.1± 1,6)	(16.7± 0,7)	(17.0± 0,6)	(18.0 ± 1,5)

The body size at the start of the first dorsal fin (SL) ranges from 14.8–18.8mm in Bone District, 15.7–17.5mm in Maros District, 15.9–17.5mm in Pangkep District, and 15.9–19.7mm in Takalar District. The body size at the beginning of the anal fin (SL) ranges from 20.4–23.1mm in Bone District, 23.3–26.7mm in Maros District, 24.6–28.1mm in Pangkep District, and 23.1–28.1mm in Takalar District.

The head is less compressed than the body, with a flat frontal region and varying sizes relative to SL: 22.3–24.7mm (Bone District), 23.4–24.7mm (Maros District), 23.5–25.1mm (Pangkep District), and 23.9–28.1mm (Takalar District). The snout is shorter than the eye diameter, measuring 4.2–5.7mm in Bone District, 4.6–5.8mm in Maros District, 4.5–7.2mm in Pangkep District, and 4.1–7.4mm in Takalar District. The mouth is terminal and almost horizontal, while both the premaxillary and dentary bones contain large teeth.

Based on the analysis of 20 morphometric characteristics (Table 5), significant differences were found in standard length, pelvic fin height, and body depth in front of the anal fin among the species from the four locations under estimation. This is presumed to be due to the low genetic diversity or high genetic stability of *Oryzias celebensis*. As a result, their body size tends to vary **(Marjanovic *et al.*, 2016)**. Additionally, fish body size reflects habitat and environmental conditions such as temperature, salinity, and dissolved oxygen, which support their growth process **(Nash *et al.*, 2013)**.

2. Meristic

The meristic characteristics, consisting of six components (Table 4), are consistent with the description by **Magtoon and Termvidchakorn (2009a)**. These characteristics include pectoral fin rays ranging from 10 to 11, with 11 being the most observed. The pelvic fin rays fall consistently at number six. The anal fin rays were found to be 21, which falls within the reported range of 20–23. Additionally, the caudal fin rays also align with the findings of **Magtoon and Termvidchakorn (2009a)**.

Table 3. Meristic count *O. celebensis* in South Sulawesi River

Meristic count	Magtoon and Termvidchakorn (2009)	Walannae River, Bone Regency	Pattunuang River, Maros Regency	Dewi Lamsang Pond, Pangkep Regency	Takalar River, Takalar Regency
Pectoral fin ray	10-11 (11)	11	11	11	11
Pelvic fin ray	6	6	6	6	6
Dorsal fin ray	8-9 (9)	9	9	9	9
Anal fin ray	20-23(22)	21	21	21	21
Upper caudal fin ray	4-5 (5)	5	5	5	5
Lower caudal fin ray	4-5 (4)	4	4	4	4

Oryzias celebensis and *Oryzias nigrimas* are generally very similar, making them difficult to distinguish **(Lifmawati *et al.*, 2015; Serdiati *et al.*, 2020)**. Additionally, both species are distributed in freshwater ecosystems in Sulawesi, particularly in South Sulawesi **(Mandagi *et al.*, 2021)**. However, *O. celebensis* can be differentiated by its meristic characteristics, as it has fewer pectoral fin rays compared to *O. nigrimas* **(Magtoon & Termvidchakorn, 2009a)**. Differences in the number of anal fin rays observed compared to **Magtoon and Termvidchakorn (2009a)** are suspected to be influenced by several factors, including water quality and interactions with other organisms that affect growth, ultimately impacting the meristic characteristics of the species, including fish **(Lamadi *et al.*, 2023; Bertin *et al.*, 2020; Sintondji *et al.*, 2020)**.

Body coloration

Oryzias celebensis has a predominantly pale-yellow body on the dorsal and lateral sides, with a translucent dorsal fin membrane. The anal fin exhibits a pale yellowish hue at its base, while the caudal fin features a submarginal yellow-orange band on both the upper and lower sections. The pelvic fin membrane also appears pale yellow, contributing to its distinctive appearance. The operculum area in both sexes reflects a silvery sheen, serving as one of the key visual characteristics of this species. These body color traits not only aid in species identification but also indicate their adaptation to their habitat **(Magtoon & Termvidchakorn, 2009a; Herder & Chapuis, 2010)**.

Fig. 2. *Oryzias celebensis* (male,31,3 SL) from Maros Regency

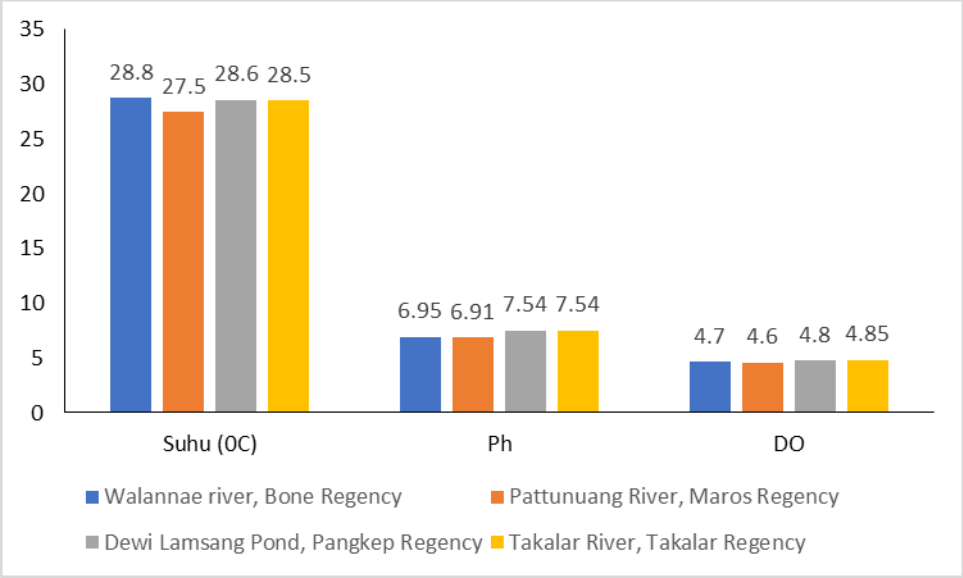

Fig. 3. Water parameters in the *Oryzias celebensis* habitat

Aquatic environmental conditions play a crucial role in the adaptation and color adjustment processes in fish **(Pavlidis *et al.*, 2008)**. In species like *Oryzias celebensis*, rapid body color changes, including the appearance of dark markings on the fins and body sides, serve a dual function as both a camouflage mechanism and a social signal. Research by **Herder and Chapuis (2010)** indicates that these color changes help the fish blend with their surroundings, such as sandy substrates or aquatic vegetation, to evade predators. Additionally, dark markings in males are utilized in social interactions, particularly to display dominance or status during aggressive behavior. The ability to quickly adjust body coloration enables *O. celebensis* to adapt to diverse habitat conditions, thereby enhancing their survival and reproductive success **(Ueda *et al.*, 2024)**.

***Oryzias celebensis* habitat**

Oryzias celebensis is an endemic fish species of Sulawesi **(Parenti, 2008)** and is typically found in calm river streams with aquatic vegetation **(Hasanah *et al.*, 2022)** (Fig. 2). Aquatic vegetation in these streams serves a crucial role, particularly for *O.celebensis*,

as a substrate for egg attachment and a stable environment for embryo development **(Dharmono *et al.*, 2022)**. In addition to aquatic vegetation, *O. celebensis* habitats are characterized by slow-moving currents. The water in these habitats is generally clear with sufficient dissolved oxygen levels to support survival **(Risnawati *et al.*, 2015)**. According to previous studies in the Maros River, *O. celebensis* can thrive in dissolved oxygen concentrations ranging from 3.19 to 3.6mg/ L **(Risnawati *et al.*, 2015)**.

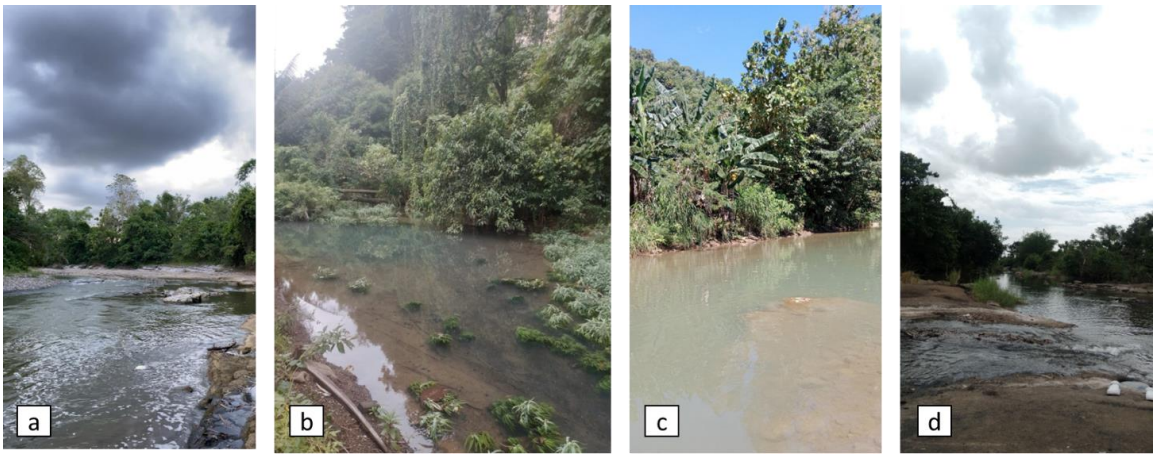

Fig. 3. Habitat of *O. celebensis* fish in South Sulawesi Waters: a. Walannae River, Bone Regency, b. Pattunuang River, Maros Regency, c. Dewi Lamsang Pond, Pangkep Regency, d. Takalar River, Takalar Regency

The principal component analysis (PCA) diagram (Fig. 4) illustrates the distribution of fish sampling locations and their relationship with environmental factors such as temperature, pH, dissolved oxygen (DO), and salinity. The first principal component (PC 1) accounts for 76,72% of the variation in the data, while the second principal component (PC 2) explains 17.12% of the variation. Environmental factors are visualized as vectors, indicating their direction and magnitude of influence on the differences between locations. The red dots represent sampling locations, including sites such as the Takalar River, Walannae River, and Dewi Lamsang Pond, which are distributed across different areas in the diagram. This analysis identifies the environmental factors that influence fish distribution across different aquatic habitats.

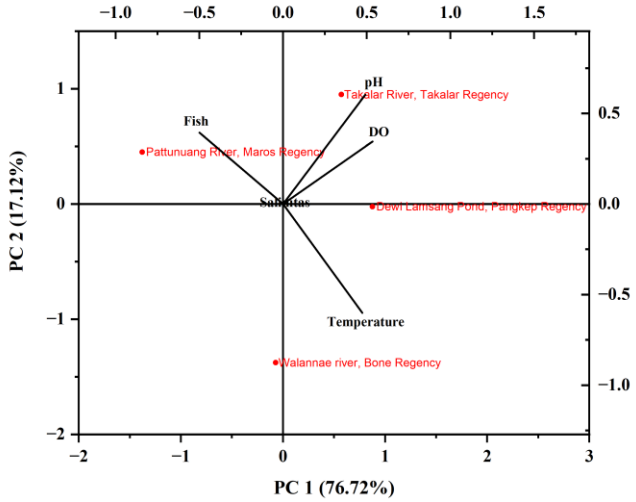

Fig. 4. Results of the principal component analysis (PCA) test between fish abundance and water parameters

The principal component analysis (PCA) test shows that Pattunuang River, Maros Regency, is characterized by fish abundance and dissolved oxygen (Fig. 3). The *O. celebensis* fish found in Pattunuang River totaled 28 individuals (Table 5) with a dissolved oxygen value of 4.6mg/ L (Table 6). Dewi Lamsang Pond is characterized by temperature and pH parameters, with values of 28.60°C and 7.5. The parameter conditions (Ph, DO, and Salinitas) in the four observation locations are consistent with previous studies to support the survival of *O.celebensis* fish **(Risnawati *et al.*, 2015)**. High temperatures can disrupt reproduction in fish, thus affecting the fitness and improvement of fish populations **(Lopes *et al.*, 2020)**.

CONCLUSION

This study provides a comprehensive analysis of the morphological characteristics and habitat conditions of *O. celebensis*, an endemic freshwater fish of Sulawesi, Indonesia. The results reveal significant variations in morphometric traits, particularly in standard length, pelvic fin height, and body depth, across different sampling locations, suggesting a combination of genetic stability and environmental influences. The meristic traits remained relatively consistent, reinforcing their role in species identification. Habitat analysis indicates that *O. celebensis* thrives in freshwater environments with slow currents, adequate aquatic vegetation, and moderate levels of dissolved oxygen, highlighting its potential as a bioindicator species. These findings contribute valuable data for conservation strategies and the sustainable management of this endemic species, emphasizing the importance of preserving its natural habitat to maintain biodiversity in Sulawesi's freshwater ecosystems.

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