

Morphometric and meristic characteristics of an endemic *Lagusia micracanthus* Bleeker, 1860 in the rivers of Maros and Walanae Cenranae Watersheds

[Karakteristik Morfometrik dan Meristik Ikan Endemik, *Lagusia micracanthus* Bleeker, 1860 pada Sungai-Sungai di Daerah Aliran Sungai (DAS) Maros dan DAS Walanae Cenranae]

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Abstract

Pirik (*Lagusia micracanthus* Bleeker, 1860) is one of endemic fishes in Sulawesi. Morphometric and meristic information of Pirik population in various habitats are unknown. The present study aimed to determine the morphometric and meristic variations of Pirik in Maros and Walanae Cenranae Watersheds. Sampling collection was carried out monthly from May 2018 to April 2019 in the Maros watershed, namely Pattunuang River (M1), Bantimurung River (M2), Pucak River (M3); and in Walanae Cenranae watershed particularly in Camba River (W1), Sanrego River (W2), and Ompo River (W3). Morphometric measurements consisted of 31 characters and meristic measurements consisted of 10 characters. Morphometric data was standardized by dividing all morphometric characters by standard length (SL). Analysis of variance (ANOVA) and discriminant analysis (Discriminant Function Analysis) were applied for data analysis. The results showed that the Pirik taken from rivers in the Maros and Walanae Cenranae watershed are two different population groups. There are 12 distinguishing morphometric features for Pirik of the Maros and Walanae Cenranae watershed, i.e. TL (total length), SL (standard length), BDdSA (body depth-dorsal fin origin), HL (head length), JIup (upper-jaw length), PAfL (pre-anal fin length), ABL (Anal fin base length), PeIRL (pelvic ray length), AFRL (anal fin ray length), CPL (caudal peduncle length), CLLup (upper caudal lobe length) and CLLmid (mid-caudal length). There is no significant difference of meristic characters of Pirik obtained from the Maros and Walanae Cenranae watersheds.

Keywords: morphometric, meristic, *Lagusia micracanthus*, Maros and Walanae Cenranae Watershed

Abstrak

Ikan pirik (*Lagusia micracanthus* Bleeker, 1860) merupakan ikan endemik Sulawesi. Informasi morfometrik dan meristik untuk mengungkap perbedaan antar populasi *L. micracanthus* pada berbagai habitat belum pernah dilakukan. Penelitian ini bertujuan menganalisis perbedaan morfometrik dan meristik ikan pirik di Daerah Aliran Sungai (DAS) Maros dan DAS Walanae Cenranae. Manfaat penelitian ini adalah sebagai dasar dalam penentuan strategi konservasi dan pengelolaan ikan pirik secara berkelanjutan. Pengambilan sampel dilakukan pada bulan Mei 2018 hingga April 2019, di DAS Maros yang meliputi Sungai Pattunuang (M1), S.Bantimurung (M2), S.Pucak (M3) dan DAS Walanae Cenranae, yang meliputi S.Camba (W1), S.Sanrego (W2) dan S.Ompo (W3). Pengukuran morfometrik terdiri atas 31 karakter dan penghitungan meristik terdiri atas 10 karakter. Data morfometrik dibakukan dengan membagi semua karakter morfometrik dengan panjang standar (SL). Analisis data menggunakan analisis varian (ANOVA) dan analisis diskriminan (*Discriminant Function Analysis*). Hasil analisis menunjukkan bahwa ikan pirik yang berasal dari sungai-sungai di DAS Maros dan DAS Walanae Cenranae merupakan dua kelompok populasi yang berbeda. Terdapat 12 karakter morfometrik yang menjadi penciri ikan pirik sungai-sungai di DAS Maros dan di DAS Walanae Cenranae yaitu TL (panjang total), SL (panjang baku), BDdSA (tinggi badan dari sirip punggung), HL (panjang kepala), JIup (panjang rahang atas), PAfL (panjang sebelum sirip anal), ABL (panjang dasar sirip anal), PeIRL (panjang sirip perut), AFRL (panjang jari-jari lemah sirip anal), CPL (panjang batang ekor), CLLup (panjang lobus ekor bagian atas), CLLmid (panjang tengah ekor). Karakter meristik antara ikan pirik di DAS Maros dan Walanae Cenranae tidak memiliki perbedaan yang nyata.

Kata penting: morfometrik, meristik, *Lagusia micracanthus*, DAS Maros, DAS Walanae Cenranae

Introduction

Pirik (*Lagusia micracanthus* Bleeker, 1860) is one of the endemic fish species in Sulawesi (Vari 1978; Kottelat *et al.* 1993; Parenti 2011; Omar 2012; Vari & Hadiaty 2012; Hadiaty 2018). This fish previously known as *Datnia micracanthus*, was first described in 1860 by Bleeker in the Lagusi River with a very limited sample number, three specimens only (Vari & Hadiaty 2012). The scientific name of the Pirik was revised from *Datnia micracanthus* to *Lagusia micracanthus* based on phylogenetic analysis of fish from the Terapontidae family (Vari 1978). Many studies about Pirik *L. micracanthus* have documented the in the past 15 decades. Nonetheless, the sample size used in those studies was very small which leading to inadequate information on other aspects of the *L. micracanthus* species (Vari & Hadiaty 2012).

Morphometric refer to quantitative analysis of fish body size, while meristic is features related to the number of fish body parts. Studies on morphometric and meristic have been carried out on various fish species due to its benefits including identification of fish species (Muchlisin 2013; Ukenye *et al.* 2019), fish populations differences (Palma & Andrade 2002; Ahammad *et al.* 2018), migratory fish (Giducus *et al.* 2015), the male and female fish characteristics (Nath & Kundu, 2017) and fish stock assessment (Turan *et al.* 2004; Mojekwu & Anumudu 2015; Siddik *et al.* 2016). Morphometric and meristic currently become one of the most widely used information in fisheries management and conservation (Turan *et al.* 2005)

Studies on morphometric and meristic of *L. micracanthus* Pirik in various habitats have not been done yet. The basic morphometric and meristic information of *L. micracanthus* already

been conducted (Vari & Hadiaty 2012). However, the study was conducted in limited location. The present study aims to analyze the morphometric and meristic characteristics of *L. micracanthus* population from two different region in South Sulawesi, namely Maros and Walanae Cenranae watersheds. The information obtained from this study is expected to be useful in determining conservation strategies and sustainable management model of Pirik.

Materials and methods

Study sites

Fish sampling was conducted monthly from May 2018 to April 2019. Fish sampling was carried out at six locations, which consisted of three rivers in the Maros watershed, i.e. Pattunuang River (M1), Bantimurung River (M2) and Pucak River (M3) and three rivers in the Walanae Cenranae watershed namely Camba River (W1), Sanrego River (W2) and Ompo River (W3) (Figure 1).

Sampling collection

Sampling was carried out using a backpack electrofishing unit (12 V & 9 A). Backpack electrofishing unit was operated in a zig-zag manner, against the current and operated for 200 m, for 30 minutes. The fish caught was preserved in a 1000 ml containing a 10% formalin solution. The samples were labeled based on the location, station and collection dates. After 24 hours, the fish specimens were rinsed with running water and transferred to containers containing 70% alcohol and then ready to be analyzed.

Morphometric measurements and meristic counts

Morphometric measurement and meristic counting of pirik (*L. micracanthus*) were carried out on 180 specimens, consisting of 90 specimens originating from the Maros watershed

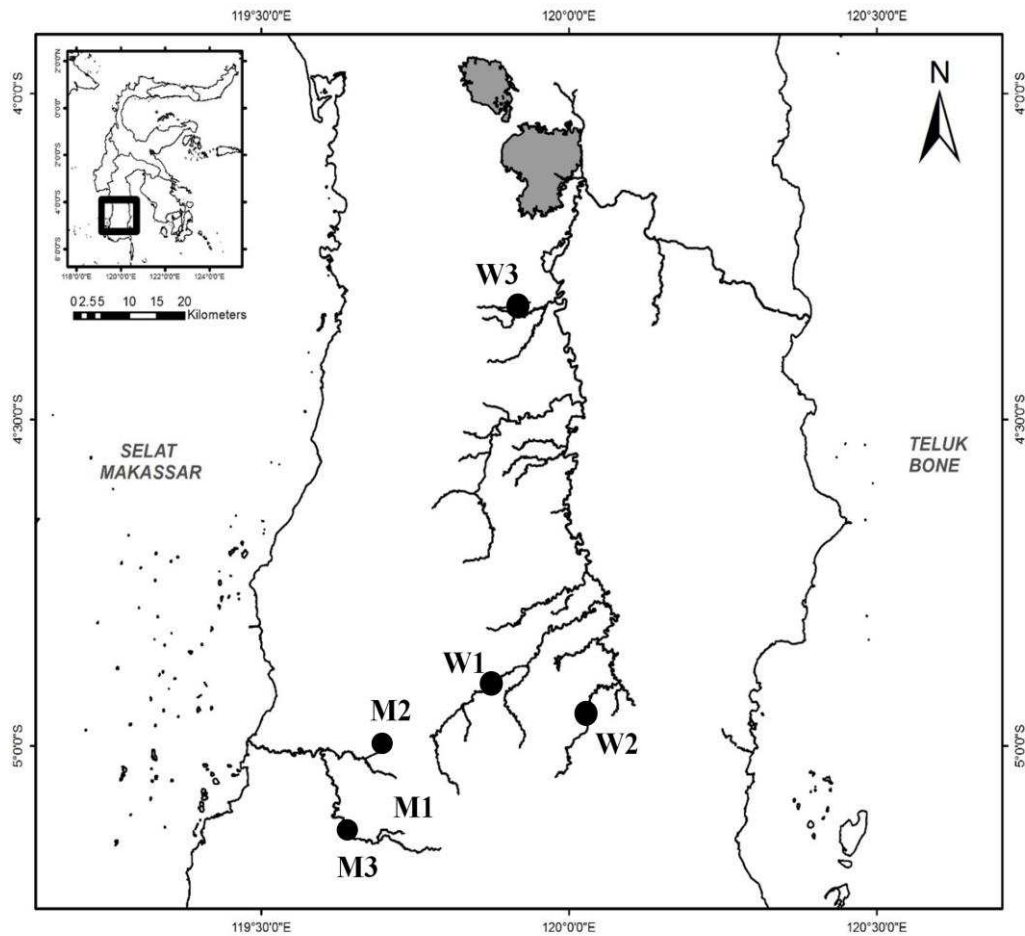


Figure 1. Map of sampling sites in two watersheds (the Maros Watershed and the Walanae Cenranae Watershed).

Annotation: M1 Pattunang River, M2 Bantimurung River, M3 Pucak River, W1 Camba River, W2 Sanrego River, W3 Ompo River

(i.e. 30 individuals from M1 Patunung R., 30 individuals from M2. Bantimurung R. and 30 individuals from Pucak R.) and the other 90 specimens were from the Walanae Cenranae watershed (i.e. 30 individuals from W1 Camba R., 30 individuals from W2 Sanrego R. and 30 specimens from W3 Ompo R.). Morphometric measurement was carried out using 0.01 mm of digital calipers and meristic calculation was performed with the aid of a magnifying glass.

Morphometric character measurements and meristic counts refer to Vari (1978), Vari &

Hutchins (1978), and Shelley *et al.* (2017) who conducted morphometric and meristic studies on freshwater Terapontid fishes. Additional calculations and other measurements refer to Hubbs & Lagler (1974). In order to make comparisons, abbreviations were used to describe the character of the measurement. Morphometric measurements consisted of 31 characters (Figure 2 & Table 1) and meristic counts consisted of 10 characters (Figure 3 and Table 2).

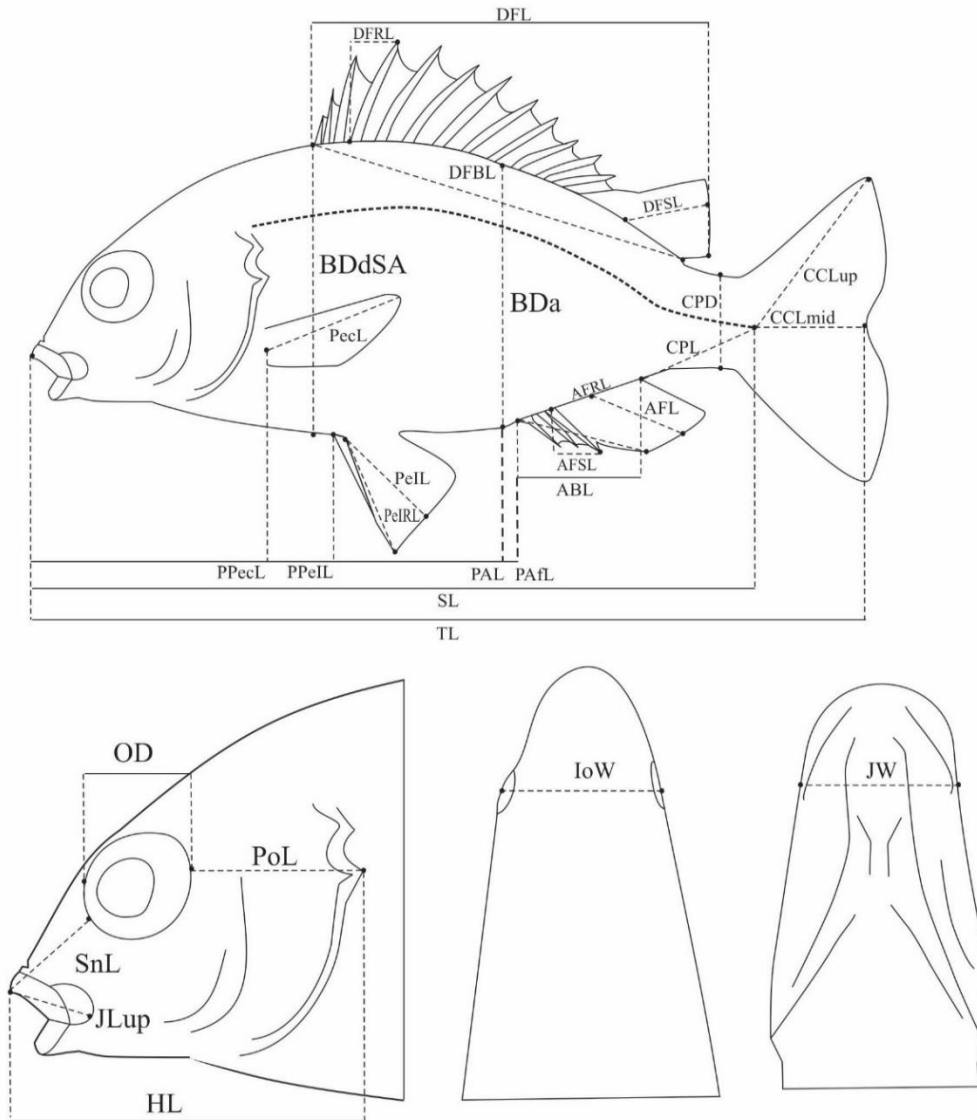


Figure 2. Morphometric characters of Pirik (*Lagusia micracanthus* Bleeker, 1860).

Annotation: TL (Total length), SL (Standard length), ABL (Anal fin base length), AFL (Anal fin length), AFRL (Anal fin ray length), AFSL (Anal fin spine length), Bda (Body depth-anal fin origin), BDdSA (Body depth-dorsal fin origin), CLLmid (Mid-caudal length), CLLup (Upper caudal lobe length), CPD (Caudal peduncle depth), CPL (Caudal peduncle length), DFBL (Dorsal fin base length), DFL (Dorsal fin length), DFRL (Dorsal fin ray length), DFSL (Dorsal fin spine length), HL (Head length), IoW (Interorbital width), JW (Jaw width), OD (Orbital diameter), PAL (Pre-anus length), PAfL (Pre-anal fin length), PDFL (Pre-dorsal fin length), PeL (Pelvic fin length), PeiRL (Pelvic ray length), PecL (Pectoral fin length), PoL (Postorbital length), PpEcL (Pre-pectoral fin length), PpEiL (Pre-pelvic fin length), PelSL, (Pelvic spine length), SnL (Snout length), Jlup (Upper-jaw length).

Table 1 Description of morphometric characters

Code	Character	Description
TL	Total length	The length from the tip of the snout to the tip of the tail
SL	Standard length	The length from the tip of the snout to the base of the hypural plate
ABL	Anal fin base length	The distance from the base of the first anal fin spine to the posterior base of the last anal ray
AFL	Anal fin length	The distance from the base of the first anal fin spine to the posterior-most margin of the anal fin
AFRL	Anal fin ray length	The length of the longest anal fin ray, from its base to its tip
AFSL	Anal fin spine length	The length of the longest anal fin spine, from its base to its tip
BDA	Body depth-anal fin origin	The vertical distance from the base of the anal fin to the edge of the dorsal body margin
BDdSA	Body depth-dorsal fin origin	The length of the longest anal fin spine, from its base to its tip
CLLmid	Mid-caudal length	The distance from the base of the caudal fin (hypural plate) to the midpoint of the caudal fin's outer margin.
CLLup	Upper caudal lobe length	The distance from base of the caudal fin (hypural plate) to the outer-most margin of the upper caudal fin
CPD	Caudal peduncle depth	The vertical distance from the dorsal margin to the ventral margin, at the narrowest point on the caudal peduncle
CPL	Caudal peduncle length	The distance between the posterior end of the anal fin base to the base of the caudal fin
DFBL	Dorsal fin base length	The distance from the base of the first dorsal fin spine to the posterior base of the last dorsal ray
DFL	Dorsal fin length	The distance from the base of the first dorsal fin spine to the posteriormost margin of the dorsal fin
DFRL	Dorsal fin ray length	The length of the longest dorsal fin ray, from its base to its tip
DFSL	Dorsal fin spine length	The length of the longest dorsal fin spine, from its base to its tip
HL	Head length	The distance from the tip of the snout to the most posterior point of the opercular margin
IoW	Interorbital width	The shortest distance between the edges of the orbits
JW	Jaw width	The distance between the posterior margins of the jaw
OD	Orbital diameter	The horizontal diameter of the orbit
PAL	Pre-anus length	The distance from the tip of the snout to the anterior edge of the anus
PAfL	Pre-anal fin length	The distance from the tip of the snout to the base of the anal fin

Table 1 (continued) Description of morphometric characters

Code	Character	Description
PDFL	Pre-dorsal fin length	The distance from the tip of the snout to the base of the dorsal fin
PelL	Pelvic fin length	The distance from the base of the pelvic fin spine to the posterior-most margin of the pelvic fin
PelRL	Pelvic ray length	The length of the longest pelvic fin ray, from its base to its tip
PecL	Pectoral fin length	The distance from the anterior base of the pectoral fin to the posterior-most margin of the pectoral fin
PoL	Postorbital length	The distance from the posterior edge of the orbit to the posterioro percular margin
PPeL	Pre-pelvic fin length	The distance from the tip of the snout to the base of the pelvic fin
PPeL	Pre-pectoral fin length	The distance from the tip of the snout to the base of the pectoral fin
PelSL	Pelvic spine length	The length of the pelvic fin spine, from its base to its tip
SnL	Snout length	The distance from the anterior edge of the orbit to the tip of the snout
Jlup	Upper-jaw length	The length from the tip of the snout to the base of the hypural plate

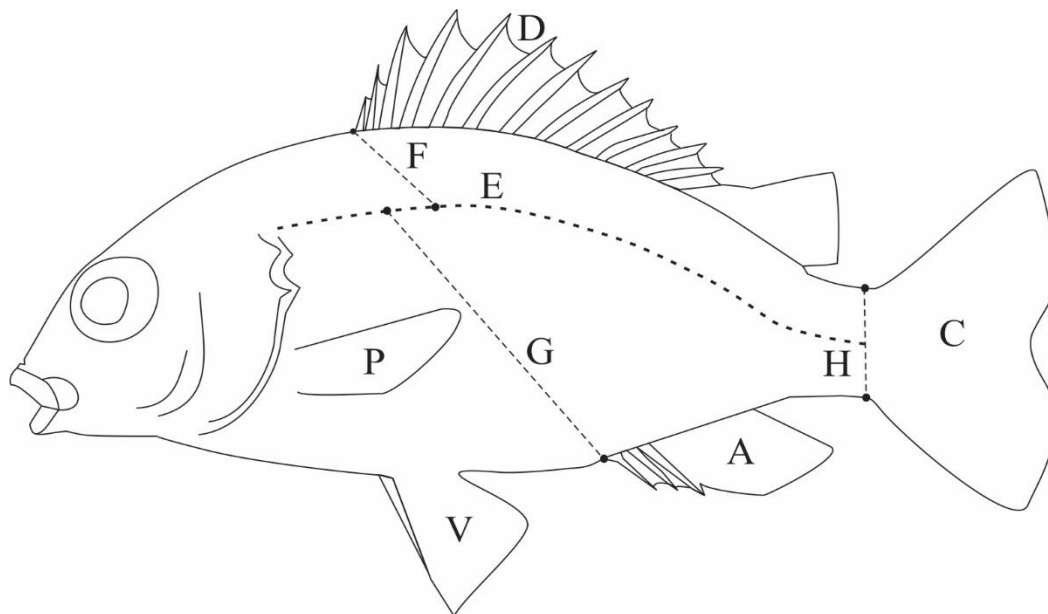


Figure 3. Meristic characters of Pirik (*Lagusia micracanthus* Bleeker, 1860).

Annotation : Dorsal fin spines and rays (D), Anal fin spines and rays (A), Caudal fin spines and rays (C), Ventral fin spines and rays (V), Pectoral fin spines and rays (P), Lateral line scale (E), Scale above lateral line (F), Scale below lateral line (G), Scale on the caudal peduncle (H).

Table 2 Description of meristic characters

Code	Character	Description
D	Dorsal fin spines and rays	The number of dorsal fin spines and rays
A	Anal fin spines and rays	The number of anal fin spines and rays
C	Caudal fin spines and rays	The number of caudal fin spines and rays
V	Ventral fin spines and rays	The number of ventral fin spines and rays
P	Pectoral fin spines and rays	The number of pectoral fin spines and rays
E	Lateral line scale	The number of scale rows from the lateral line to the anal fin origin
F	Scale above lateral line	The number of scale above lateral line
G	Scale below lateral line	The number of scale below lateral line
H	Scale on the caudal peduncle	The number of scale on the caudal peduncle

Data analysis

Morphometric data of specimens was standardized by dividing all morphometric characters with standard length (SL). The One-way ANOVA analysis of morphometric and meristic were applied for statistical analysis. Furthermore, fish morphometric and meristic were distinguished using Discriminant Function Analysis. Making dendrogram using expensive cluster analysis' distances that described the separation and relationship between the populations of fish being compared. Data analysis was carried out using SPSS (Statistical Program for Social Science) software version 26.0.

Results

The Table 3 illustrates that a total of 31 morphometric characters was tested, and 27 morphometric characters were significantly different ($P < 0.05$) between Pirik population in Maros and Walanae Cenranae Watershed including TL (total length), SL (standard length), ABL (anal fin base length), AFL (anal fin length), AFRL (anal fin ray length), Bda (body depth-anal fin origin), BDdSA (body depth-dorsal fin origin), CLLmid (mid-caudal length), CLLup (upper caudal lobe length), CPD (caudal peduncle depth), CPL (caudal peduncle length), DFBL

(dorsal fin base length), DFL (dorsal fin length), DFRL (dorsal fin ray length), DFSL (Dorsal fin spine length), HL (head length), JW (jaw width), PAL (pre-anus length), PafL (pre-anal fin length), PDFL (pre-dorsal fin length), PelRL (pelvic ray length), PecL (pectoral fin length), PoL (postorbital length), PpelL (pre-pelvic fin length), PpecL (pre-pectoral fin length), PelSL, (pelvic ray length) and JIup (upper-jaw length). There were four characters that were not significantly different between two pirik population, namely AFSL (anal fin spine length), OD (orbital diameter), SnL (snout length) and IoW (interorbital width).

Stepwise analysis was carried out to determine the morphometric characteristics that characterize two populations of Pirik in Maros and Walanae Cenranae watersheds (Table 4). The results showed that there are 12 morphometric characters that characterize or differentiate groups of Pirik in Maros and Walanae Cenranae watersheds, for instances BDdSA (body depth-dorsal fin origin), PelRL (pelvic ray length), CLLup (upper caudal lobe length), SL (standard length), AFRL (anal fin ray length), JIup (upper-jaw length), CPL (caudal peduncle length), PafL (pre-anal fin length), TL (total length), ABL (Anal fin base length), HL (head length) and CLLmid (mid-caudal length).

Table 3. Descriptive statistics of morphometric measurements of Pirik fish (*Lagusia micracanthus* Bleeker, 1860)

Character	Maros Watershed			Wallanae Cenrana Watershed			Wilks' Lambda	Significance
	M1	M2	M3	W1	W2	W3		
TL	71.08±29.42 ^a	71.75±16.5 ^a	71.24±16.31 ^a	77.51±11.32 ^b	74.53±11.26 ^b	65.92±9.22 ^b	0.924	0.016*
SL	59.14±26.67 ^a	58.61±12.73 ^a	56.93±12.11 ^a	61.92±9.87 ^b	58.74±8.85 ^b	53.14±7.41 ^b	0.921	0.013*
ABL	10.57±4.54 ^a	11.27±2.22 ^a	11.05±2.68 ^a	10.12±1.62 ^b	9.58±2.32 ^b	8.8±1.48 ^b	0.655	0.000*
AFL	13.96±5.53 ^a	14.48±3.34 ^a	13.73±3.78 ^a	13.83±2.44 ^b	12.25±2.51 ^b	10.65±1.95 ^b	0.628	0.000*
AFRL	9.55±3.47 ^a	10.08±1.98 ^a	10.17±2.26 ^a	8.69±1.60 ^b	8.07±1.54 ^b	6.58±1.01 ^b	0.549	0.000*
AFSL	8.26±8.61 ^a	7.63±1.79 ^a	7.18±1.60 ^a	6.84±1.87 ^a	6.72±1.74 ^a	5.48±1.31 ^a	0.967	0.314
BDa	19.07±8.63 ^a	19.48±4.15 ^a	19.69±3.70 ^a	18.03±3.18 ^b	15.88±3.07 ^b	14.06±2.84 ^b	0.535	0.000*
BDdSA	22.28±9.39 ^a	21.13±4.81 ^a	21.37±4.06 ^a	20.51±3.6 ^b	17.92±3.25 ^b	15.96±3.16 ^b	0.460	0.000*
CLLmid	9.68±3.73 ^a	10.82±3.27 ^a	11.92±3.22 ^a	10.00±1.33 ^b	9.09±1.86 ^b	8.46±2.31 ^b	0.730	0.000*
CLLup	13.69±6.21 ^a	15.76±11.68 ^a	14.87±3.25 ^a	13.26±2.27 ^b	11.79±2.08 ^b	9.92±2.66 ^b	0.833	0.000*
CPD	9.99±11.71 ^a	6.82±1.76 ^a	6.86±1.61 ^a	6.38±0.96 ^b	5.99±1.47 ^b	5.05±1.21 ^b	0.910	0.005*
CPL	11.56±4.07 ^a	11.41±3.29 ^a	12.93±3.04 ^a	10.73±1.86 ^b	10.93±2.66 ^b	8.71±1.55 ^b	0.600	0.000*
DFBL	28.98±12.95 ^a	26.71±6.06 ^a	28.49±6.65 ^a	25.97±4.47 ^b	23.9±5.88 ^b	20.12±4.23 ^b	0.544	0.000*
DFL	32.82±13.39 ^a	30.88±6.0 ^a	31.18±7.6 ^a	30.83±10.2 ^b	28.58±6.58 ^b	24.35±4.83 ^b	0.822	0.000*
DFRL	9.26±4.18 ^a	9.46±2.65 ^a	10.05±2.34 ^a	8.41±2.05 ^b	8.17±2.33 ^b	6.58±1.32 ^b	0.614	0.000*
DFSL	9.58±3.27 ^a	9.03±2.01 ^a	10.35±1.96 ^a	8.7±2.12 ^b	8.15±1.67 ^b	6.51±1.61 ^b	0.591	0.000*
HL	18.63±7.14 ^a	19.35±3.86 ^a	21.82±14.67 ^a	17.04±3.7 ^b	16.41±2.16 ^b	14.73±2.71 ^b	0.830	0.000*
IoW	9.98±15.17 ^a	7.85±2.13 ^a	8.21±1.63 ^a	7.8±1.46 ^a	6.55±0.78 ^a	6.12±1.55 ^a	0.938	0.048
JW	7.66±9.10 ^a	5.85±1.56 ^a	5.86±1.80 ^a	4.98±1.09 ^b	4.65±1.03 ^b	4.14±0.96 ^b	0.921	0.013*
OD	5.66±2.11 ^a	6.45±0.92 ^a	6.59±1.26 ^a	5.38±0.83 ^a	7.55±8.36 ^a	4.92±1.17 ^a	0.947	0.088
PAL	33.76±17.2 ^a	34.72±7.93 ^a	33.97±8.41 ^a	30.28±6.18 ^b	28.65±5.87 ^b	24.88±4.85 ^b	0.627	0.000*
PAfL	38.22±16.6 ^a	37.04±8.61 ^a	34.85±7.73 ^a	32.41±8.41 ^b	31.01±5.65 ^b	27.1±4.84 ^b	0.509	0.000*
PDFL	25.5±10.84 ^a	25.45±5.08 ^a	25.66±4.96 ^a	23.06±4.43 ^b	21.41±3.93 ^b	18.96±3.70 ^b	0.557	0.000*
PeIL	10.66±5.75 ^a	10.01±2.57 ^a	14.84±6.35 ^a	18.36±14.23 ^b	11.78±5.79 ^a	12±3.54 ^a	0.900	0.002*
PeRL	12.41±6.10 ^a	12.67±3.42 ^a	11.45±3.23 ^a	9.39±3.01 ^b	10.53±2.77 ^b	6.93±2.14 ^b	0.515	0.000*
PecL	12.45±5.08 ^a	15.67±18.28 ^a	13.66±2.76 ^a	11.21±2.41 ^b	10.03±1.91 ^b	8.38±2.05 ^b	0.902	0.003*
PoL	11.79±8.77 ^a	7.87±1.63 ^b	8.23±2.26 ^a	7.17±1.61 ^b	7.04±1.15 ^b	8.47±7.82 ^b	0.899	0.002*
PPeIL	21.79±8.89 ^a	23.7±5.22 ^a	23.57±6.81 ^a	21.34±6.55 ^b	19.1±3.07 ^b	16.37±3.42 ^b	0.686	0.000*
PPecL	18.02±6.73 ^a	18.77±3.62 ^a	18.94±4.08 ^a	15.87±4.18 ^b	15.76±3.34 ^b	13.35±2.52 ^b	0.560	0.000*
SnL	5.9±2.35 ^a	5.71±1.78 ^a	6.27±1.23 ^a	7.9±11.85 ^a	5.43±0.93 ^a	4.86±1.30 ^a	0.973	0.431
Jlup	5.36±2.36 ^a	5.51±1.36 ^a	6.04±1.20 ^b	5.35±0.96 ^a	4.62±0.98 ^b	4.42±0.98 ^b	0.658	0.000*

Note: * the value in the same row indicates with different superscripts shows significant differences (P<0.05).

Table 4. Stepwise analysis of morphometric measurements of Pirik (*Lagusia micracanthus* Bleeker, 1860) in Maros and Walanae Cenranae watersheds

Physical features	Special features values (sorted from highest to lowest values)
BDdSA (Body depth-dorsal fin origin)	0.460
PeRL (Pelvic ray length)	0.294
CLLup (Upper caudal lobe length)	0.210
SL (Standard length)	0.147
AFRL (Anal fin ray length)	0.118
Jlup (Upper-jaw length)	0.093
CPL (Caudal peduncle length)	0.079
PAfL (Pre-anal fin length)	0.069
TL (Total length)	0.061
ABL (Anal fin base length)	0.054
HL (Head length)	0.048
CLLmid (Mid-caudal length)	0.043

Further analysis is required to obtain the discriminant function of the two analyzed populations of Pirik fish. From this analysis is obtained Wilks' lambda value of 0.43 ($p < 0.001$), which showed the data was appropriate for discriminant analysis, while the eigenvalues obtained were 7.93 and correlation the canonical value of 0.92 indicates that the canonical function is suitable to differentiate the two populations of fish in the Maros watershed and the Walanae Cenranae watershed.

Discriminant analysis of the population for Pirik was divided into two different populations of the Pirik (Figure 4). The Pirik originated from first group is in the positive sector, namely the Maros watershed, which consists of the population of Pirik from Pattunuang River (M1), Bantimurung River (M2) and Pucak River (M3). The second group is classified in the negative sector, namely the population originating from the Walanae Cenranae watershed, namely Camba River (W1), Sanrego River (W2) and Ompo River (W3). The results of the final classification

of the second discriminant group of the Pirik population suggests that the Pirik fish population in the Maros watershed, originated from the Pattunuang River (M1) has a 13% similarity with the Pirik in S.Bantimurung (M2) and 10% similarity found in Pirik species from Pucak river (M3). The Pirik in Bantimurung river has 3% similarity with Pirik in Pucak River and 3% Pattunuang River. The Pirik obtained from Pucak River (M3) has 13% similarity to Pirik of the Bantimurung River and 10% to pirik of Pattunuang River. Meanwhile, the pirik in the Walanae Cenranae watershed, the W1 (Camba River) has a 13% similarity to Pirik of the Sanrego river (M2) and 3% with Pirik species in the Ompo River. The Pirik in Sanrego River has 13% similarity with Pirik in the Ompo River and 3% similarity with Pirik of the Pattunuang River. The Pirik in the Ompo river (M3) has 17% similarity with Pirik in Camba River and 7% with Pirik in Sanrego River. In general, the Pirik in Maros watershed does not have identical

characteristics with the Pirik in rivers of the Walanae Cenranae watershed.

Furthermore, the cluster analysis illustrates that there are two different groups of Pirik fish populations, namely the Maros watershed and the Walanae Cenranae watershed (Figure 5). The Pirik of the Maros watershed is a fish species from the same population. However, Pirik originating from Bantimurung River (M2) and

Pucak River (M3) are the closest kinship compared to Pirik originating from Pattunuang (M1). In the Walanae Cenranae watershed, the population of Pirik is also from the same population, but the Pirik originating from Sanrego River (W2) and W3 Ompo River are the closest kinship compared to Pirik originating from Camba River (W1).

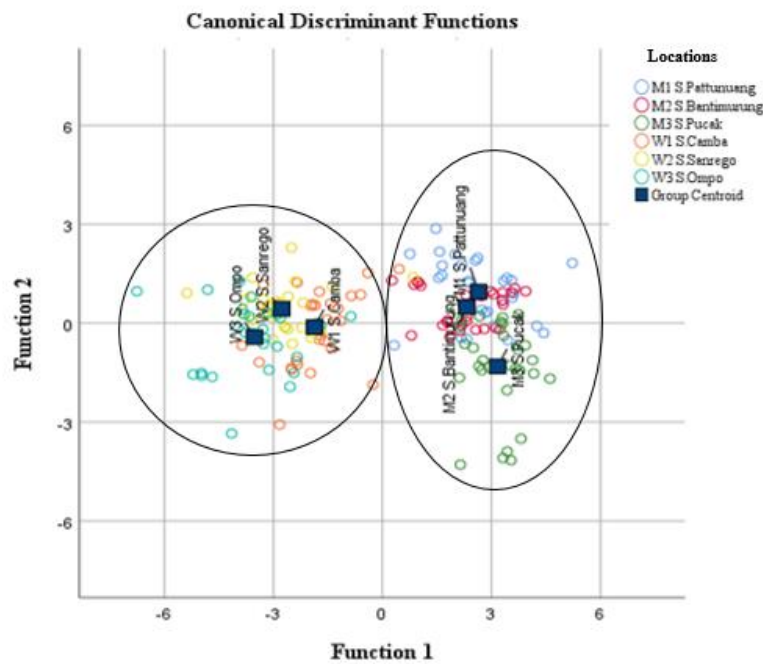


Figure 4. Scatter plot centroid of discriminant analysis of Pirik fish (*Lagusia micracanthus* Bleeker, 1860) in Maros Watershed and Walanae Cenranae

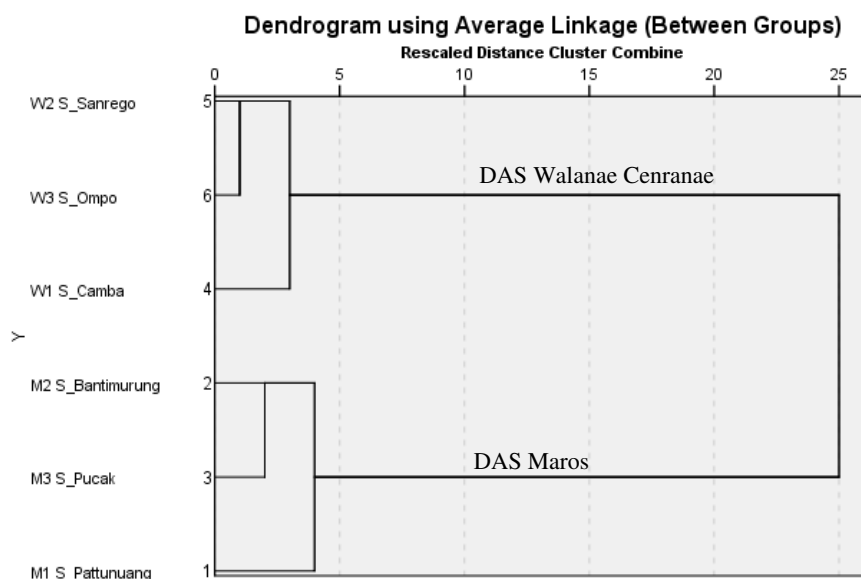


Figure 5. Dendograms are based on cluster analysis of pirik fish (*Lagusia micracanthus* Bleeker, 1860) in Maros Watershed and Walanae Cenranae

Table 5. Meristic count of pirik fish (*L. micracanthus* Bleeker, 1860) in the Maros Watershed and Walanae Cendranae Watershed

Meristic character	Maros Watershed			Walanae Cenranae Watershed		
	M1	M2	M3	M1	M2	M3
Dorsal fin spines and rays (D)	D.XIII.9 ^a	D.XIII.9 ^a	D.XIII.9-10 ^a	D.XIII.9 ^a	D.XIII.9 ^a	D.XIII.9 ^a
Anal fin spines and rays (A)	A.III.8 ^a	A.III.8 ^a	A.III.8 ^a	A.III.8 ^a	A.III.8 ^a	A.III.8 ^a
Caudal fin spines and rays (C)	C.16-18 ^a	C.16-18 ^a	C.17-18 ^a	C.16-17 ^a	C.17-18 ^a	C.17-18 ^a
Ventral fin spines and rays (V)	V.I.5 ^a	V.I.5 ^a	V.I.5 ^a	V.I.5 ^a	V.I.5 ^a	V.I.5 ^a
Pectoral fin spines and rays (P)	P.14-15 ^a	P.14-15 ^a	P.14-15 ^a	P.15-16 ^a	P.14-15 ^a	P.14-15 ^a
Lateral line scale (E)	38-44 ^a	38-44 ^a	40-48 ^a	40-48 ^a	42-48 ^a	40-48 ^a
Scale above lateral line (F)	5-6 ^a	5-6 ^a	5-7 ^a	6-8 ^a	6-8 ^a	6-8 ^a
Scale below lateral line (G)	10-12 ^a	10-12 ^a	10-12 ^a	11-22 ^a	11-14 ^a	9-12 ^a
Scale on the caudal peduncle (H)	4-7 ^a	6-8 ^a	6-8 ^a	7-8 ^a	6-9 ^a	6-8 ^a

Note: *), the value in the same row indicates with different superscripts shows significant differences (P<0,05).

The results of counting fish meristic characters including dorsal fin spines and rays (D), anal fin spines and rays (A), caudal fin spines and rays (C), ventral fin spines and rays (V), pectoral fin spines and rays (P), lateral line scale (E), scale above lateral line (F), scale below lateral line (G) and scale on the caudal peduncle (H) are presented in Table 5.

Table 5 illustrates that the characteristics of the meristic pirik fish showed no significant differences between the population of pirik fish obtained from rivers in Maros watershed and the Walanae Cenranae watershed. Therefore, meristic characters which including dorsal fin spines and rays (D), anal fin spines and rays (A), caudal fin spines and rays (C), ventral fin spines and rays (V), pectoral fin spines and rays (P), lateral line scale (E), the scale above lateral line (F), scale below the lateral line (G) and scale on the caudal peduncle (H) cannot be a distinguishing characteristic of two populations of the pirik fish.

Discussion

The differences in morphometric characteristics between the population of Pirik in the Maros watershed and in the Walanae Cenranae watershed were confirmed in this present study. The Pirik populations in the Maros watershed consists of fish populations obtained from Pattunuang River (M1), Bantimurung River (M2) and Pucak River (M3) are the same morphometric group. Similarly, the population of Pirik in the Walanae Cenranae watershed consists of fish populations obtained from Camba River (W1), Sanrego River (W2) and Ompo River (W3) are also the same morphometric group. The results showed that the distribution of Pirik population only occurs in habitats in the same watershed. There is no connectivity between pirik population of the Maros watershed with Pirik population of the Walanae Cenranae watershed.

The Maros watershed and the Walanae Cenranae watershed geographically are two separate watersheds which located in different geo-

graphical areas. The two watersheds are separated or bounded by Kars Mountain, which is located in the Bantimurung-Bulu Saraung National Park, Maros Regency South Sulawesi. The Maros watershed, located in the western part of South Sulawesi, has a lower altitude than the Walanae Cenranae watershed in the eastern part of South Sulawesi. Pirik habitat in Pattunuang River (M1) is at an altitude of 43 masl, M2 Bantimurung River at an altitude of 42 masl and M3 Pucak River at an altitude of 46 masl. Meanwhile, Pirik habitat in Camba River (W1) is at an altitude of 379 masl, Sanrego River (W2) at an altitude of 147 masl and the Ompo River (W3) at an altitude of 88 masl.

The existence of natural geographical barriers, has been contributed to the emergence of differences among fish populations (Palma & Andrade 2002). The differences in isolated geographical areas, resulting in morphometric and genetic differences. It leads to the absence of gene flow between these populations (Turan & Ergüden 2004). Isolated habitat conditions have different environments leading to fish populations in these isolated habitats becoming small, mutated, gene flow is interrupted, genetic drift processes and natural selection (Budiharjo 2001).

The differences in the population of Pirik in the Maros and Walanae Cenranae watersheds are characterized by 12 morphometric characters for instances, TL (total length), SL (standard length), BDdSA (body depth-dorsal fin origin), HL (head length), Jlup (upper-jaw length), PAfL (pre-anal fin length), ABL (Anal fin base length), PelRL (pelvic ray length), AFRL (anal fin ray length), CPL (caudal peduncle length), CLLup (upper caudal lobe length), CLLmid (mid-caudal length). The differences in morphometric characters can be caused by differences in the

habitat environment of the Maros and Walanae Cenranae watersheds. Turan *et al.* (2015) stated that differences in the populations possibly correlate to different habitat characteristics, such as temperature, turbidity, food availability, water depth, and flow velocity.

The average BDdSA (body depth-dorsal fin origin), HL (head length), Jlup (upper-jaw length), PAfL (pre-anal fin length), ABL (Anal fin base length), PelRL (pelvic ray length), AFRL (anal fin ray length), CPL (caudal peduncle length), CLLup (upper caudal lobe length), CLLmid (mid-caudal length) of Pirik obtained from rivers in the Maros watershed were greater than of the Walanae Cenranae watershed. The degree of variance of morphometric character is highly related to habitat conditions, for instance, food availability and more stable habitat temperatures. This factor is due to canopy cover in riparian zone of the Maros watershed which is better than the Walanae Cenranae watershed which has been degraded due to agricultural activities. The Pirik in Walanae Cenranae watershed characterized based on TL (total length), SL (standard length) which is longer than the Maros watershed. This is closely considered relate to environmental factors, especially water current. The water current in the Walanae Cenranae watershed ranges from 0.1 to 0.8 m/s while in the Maros watershed ranges from 0.1 to 1.6 m/sec. Moreover, the Pirik inhabit the rivers in the Walanae Cenranae watershed has a body shape which more elongated, so that fish will ease to swim and minimize friction with fast flowing water. Hossain *et al.* (2010) stated that fish species is very sensitive to environmental changes and quickly adapts to morphometric changes as required.

Several environmental factors consider to alter fish phenotypes or morphology (Vehanen & Huusko 2011). In the same species, fish size can vary due environmental factors such as temporal variations in the condition of aquatic habitat (Muchlisin 2013), temperature and food abundance (Eyo 2003). Water current is one of the important abiotic factors that affects the morphology of the body (Pakkasmaa & Piironen 2001; P'aez *et al.* 2008). The fish inhabits river with high water current tend to have body shape than fish that lives in low water current (Michel *et al.* 2017). In addition, other factor that may affect fish are fish reproductive and gonad development (Kashefi *et al.* 2012). According to Swain *et al.* (1991), the differences in morphological characteristics of fish indicate the high flexibility of a fish species in response to environmental changes.

The characteristics of Pirik including dorsal fin spines and rays, anal fin spines and rays, Caudal fin spines and rays, Ventral fin spines and rays, radius of the pectoral fin, Lateral line scale, Scale above lateral line, Scale below lateral lined and scale on the caudal peduncle are shown in Table 5. This table 5 illustrates that the meristic character does not become a distinguishing feature between the Pirik groups in the Maros and the Walanae Cenranae watersheds, although the two watersheds are known to differ geographically and in their environmental characteristics. Moreover, Smith *et al.* (2002) revealed that fish characteristic are the result of gene expression, but environmental components can also modify the expression of these genes.

Conclusions

Pirik in the Maros and Walanae Cenranae watershed are two different population based on morphometric and meristics features. Pirik

populations in the those two watersheds are characterized by 12 morphometric characters, including TL (total length), SL (standard length), BDdSA (body depth-dorsal fin origin), HL (head length), JIup (upper-jaw length), PAfL (pre-anal fin length), ABL (Anal fin base length), PeRL (pelvic ray length), AFRL (anal fin ray length), CPL (caudal peduncle length), CLLup (upper caudal lobe length) and CLLmid (mid-caudal length).

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References

- Ahammad AKS, Ahmed MBU, Akhter S, Hossain MDK. 2018. Landmark-based morphometric and meristic analysis in response to characterize the wild Bhagna, *Labeo ariza* populations for its conservation. *Journal of the Bangladesh Agricultural University*, 16(1):164–170.
- Budiharjo A. 2001. Changes in morphological character of Tawes (*Barbodes gonionotus*) that live in Serpeng Lake, Gunung Kidul. *Biodiversitas*, 1(2):104-109.
- Eyo JE. 2003. Congeneric discrimination of morphometric characters among members of the pisces genus: *Clarias* (*Clariidae*) in Anambra River, Nigeria. *The Zoologist*, 2(1):1-17.

- Giducos CS, Karim SI, Diamalon AL, Piang MM, Torres MAJ, Requieron EA. 2015. Describing the shape of *Sardinella lemuru* from Sarangani Bay, Philippines using the landmark-based geometric morphometric analysis. *Aquaculture, Aquarium, Conservation & Legislation Bioflux*, 8(6):1072-1080.
- Hadiaty RK. 2018. Taxonomy status of endemic ichthyofauna in Sulawesi freshwater Sulawesi. *Jurnal Iktiologi Indonesia*, 18(2):175-190.
- Hossain MAR, Nahiduzzaman M, Saha D, Khanam MUH, Alam MS. 2010. Landmark-based morphometric and meristic variations of the endangered carp, *Kalibaus labeo calbasu*, from stocks of two isolated rivers, the Jamuna and Halda, and a hatchery. *Zoological Studies*, 49:556-563
- Hubbs CL, Lagler KF. 1974. *Fishes of the Great Lakes Region*. Univ. Michigan Press, Ann Arbor. 214 pp.
- Kashefi P, Bani A, Ebrahimi E. 2012. Morphometric and meristic variations between non-reproductive and reproductive kutum females (*Rutilus frisii kutum* Kamensky, 1901), in the Southwest Caspian Sea. *Italian Journal of Zoology*, 79(3):337-343.
- Kottelat M, Whitten AJ, Kartikasari SN, Wirjoatmodjo S. 1993. *Freshwater Fishes of Western Indonesia and Sulawesi (Ikan Air Tawar Indonesia Bagian Barat dan Sulawesi)*. Periplus Editions-Proyek EMDI. Jakarta. 377 p.
- Michel MJ, Beachum CE, Knouft JH, Chien H, Bennett MG. 2017. Climate change, hydrology, and fish morphology: predictions using phenotype-environment associations. *Climatic Change*, 140:563-576.
- Mojekwu TO, Anumudu CI. 2015. Advanced techniques for morphometric analysis in fish. *Journal of Aquaculture Research & Development*, 6(354):1-8.
- Muchlisin ZA. 2013. Morphometric variations of rasbora group (pisces: cyprinidae) in Lake Laut Tawar, Aceh Province, Indonesia, based on truss character analysis. *Hayati Journal of Biosciences*, 20(3): 38-143.
- Nath RP, Kundu JK. 2017. Morphometric analysis: a tool to identify green puffer fish *Tetraodon fluviatilis* (Hamilton, 1822) from the Digha Coastal Region, West Bengal, East coast of India. *International Journal of Zoology Studies*, 2(5):203-211.
- Omar SBA. 2012. *Fish World*. Yogyakarta (ID): Gadjah Mada University Press. 478 pp.
- P'aez DJ, Hedger R, Bernatcher L, Dodson JJ. 2008. The morphological plastic response to water current velocity varies with age and sexual state in juvenile Atlantic salmon, *Salmo salar*. *Freshwater Biology*, 53(8):1544-1554.
- Pakkasmaa S, Piironen J. 2001. Water velocity shapes juvenile salmonids. *Evolutionary Ecology*, 14:721-730.
- Palma J, Andrade JP. 2002. Morphological study of *Diplodus sargus*, *Diplodus puntazzo*, and *Lithognathus mormyrus* (Sparidae) in the Eastern Atlantic and Mediterranean Sea. *Fisheries Research*, 57(2002):1-8.
- Parenti LR. 2011. Endemism and conservation of the native freshwater fish fauna of Sulawesi, Indonesia. As cited in: Simanjuntak CPH, Zahid A, Rahardjo MF, Hadiaty KH, Krismono, Haryono, Tjakrawidjaja AH. *Prosiding Seminar Nasional Ikan VI & Kongres Masyarakat Iktiologi Indonesia III*. 8-9 Juni 2010. Cibinong, Indonesia. Cibinong (ID): Masyarakat Iktiologi Indonesia. Hlm. 1-10.
- Shelley J, Delaval A, Feuvre LM. 2017. *A Revision of The Grunter Genus Syncomistes (Teleostei, Terapontidae, Syncomistes) with Descriptions Of Seven New Species from The Kimberley Region, Northwestern Australia*. Magnolia Press, New Zealand. 103 pp.
- Siddik MAB, Chaklader MR, Hanif MA, Islam MA, Sharker MR, Rahman M. 2016. Stock identification of critically endangered olive barb, *Puntius sarana* (Hamilton, 1822) with emphasis on management implications. *Journal of Aquaculture Research & Development*, 7(411):1-6.
- Smith PJ, McMillan PJ, Bull B, McVeagh SM, Gaffney PM, Chow S. 2002. Genetic and meristic variation in black and smooth oreos in the New Zealand exclusive economic zone. *New Zealand Journal of Marine and Freshwater Research*, 36(4):737-750.
- Swain SL, Bradley LM, Croft M, Tonkonogy S, Atkins G, Weinberg AD, Huston G. 1991. Helper t-cell subsets: phenotype, function and the role of lymphokines in regulating

- their development. *Immunological Reviews*, 123(1):115–144.
- Turan C, Erguden D, Turan F, Gurlek M. 2004. Genetic and morphologic structure of *Liza abu* (Heckel, 1843) populations from the Rivers Orontes, Euphrates and Tigris. *Turkish Journal of Veterinary and Animal Sciences*, 28(4):729–734.
- Turan C, Yalçın S, Turan F, Okur E, Akyurt I. 2005. Morphometric comparisons of African catfish, *Clarias gariepinus* populations in Turkey. *Folia Zoologica*, 54(1-2):165-172.
- Ukenye EA, Taiwo IA, Anyanwu PE. 2019. Morphological and genetic variation in *Tilapia guineensis* in West African coastal waters: a mini review. *Biotechnology Reports*, 24(2019):1-3.
- Vari RP, Hadiaty RK. 2012. The endemic Sulawesi fish genus *Lagusia* (Teleostei: Teraponidae). *The Raffles Bulletin of Zoology*, 60(1):157-162.
- Vari RP, Hutchins JB. 1978. New species of terapon perches (Percoidei, Teraponidae) from Australia. *American Museum Novitates*, 2654:1–8.
- Vari RP. 1978: The Terapon Perches (Percoidei, Teraponidae). A cladistic analysis and taxonomic revision. *Bulletin of the American Museum of Natural History*, 159(5):175-340.
- Vehanen T, Huusko A. 2011. Brown trout *Salmo trutta* express different morphometrics due to divergence in the rearing environment. *Journal of Fish Biology*, 79:1167-1181.