Sexual dimorphism in morphometric characters of *Mystus singaringan* from Klawing River in Central Java, Indonesia: Strategic instruction for conservation development

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Abstract. *Pramono TB, Arfiati D, Widodo MS, Yanuhar U. 2019. Sexual dimorphism in morphometric characters of* Mystus singaringan *from Klawing River in Central Java, Indonesia: Strategic instruction for conservation development. Biodiversitas 20: 1133-1139.* This study aims to determine the sexual dimorphism of *Mystus singaringan* (Senggaringan fish) based on morphometric characters. The measurement of 24 morphometric characters in 30 *M. singaringan* from Klawing River was carried out using a digital caliper (0.01 mm). Morphometric data of *M. singaringan* analyzed using t-test have showed significant difference in 12 morphometric characters between sexes, such as standard length, head height, distance of the tip of the muzzle to eyes, distance of the tip of the muzzle to adipose fin, height of dorsal fin, height of pectoral fin, basic length of adipose fin, height of adipose fin, maximum height, length of first nasal barbel, length of first mandibular barbel, and length of second mandibular barbel. Analysis of growth of morphometric characters shows that there is a linear relationship between all morphometric characters and total length. The type of growth of all morphometric characters in both male and female *M. singaringan* is negative allometric.

Keywords: Dimorphism, female, indigenous species, *Mystus singaringan*, male, morphometric

INTRODUCTION

Bagridae is family to which 205 species of fish belong. The family spreads in Africa and Asia with 45 species from the genus of Mystus spread in East Asia, South Asia, Southwest Asia (Eschemeyer and Fong 2015) and in Indonesia, to be exact in Java, Sumatra, and Kalimantan (Hubert et al. 2015). Fish species from the Bagridae family that can be found in Java is *Mystus singaringan* or senggaringan fish (Dahrudin et al. 2016; Pramono et al. 2017). *M. singaringan* have high economic value in the area of Purbalingga District, Central Java, Indonesia. However, senggaringan fish supply is still from wild catch fisheries. This certainly will have an impact on population stability and make senggaringan fish prone to extinction. To prevent its extinction, conservation and domestication are needed. The success of conservation and domestication is influenced by several things including basic biological information related to sexual dimorphism.

Sexual dimorphism is defined as a systemic morphological difference or phenotypic differentiation between individuals from different sexes in the same species that is used to distinguish sexes externally (Dimijan 2005; Saurabh et al. 2013; Suryaningsih et al. 2014). In addition, sexual dimorphism can also be interpreted as the variation of intraspecific phenotype (McGee and Wainright 2013). Sexual dimorphism can be identified from primary sexual characters, namely genital papilla or genital pore (Musa and Bhuiyan 2006; Esmaeili et al. 2017), and from secondary characteristics of color, body size, morphology,

physical strength and other body characters (Dimijan 2005), the relation between length and condition factor (Nahar et al. 2018). However, sexual dimorphism of some taxa is often unclear (Levitan 2005) and vague when it is observed by unaided eye (Andersson et al. 1994). Some types of fish sometimes show clear characteristics of sexual dimorphism as spawning period approaches. Therefore, it is necessary to do an easy and authentic initial approach to determine sexual dimorphism.

Sexual dimorphism can be determined using morphometric methods. Detailed examination of morphometric methods is carried out based on morphometric characters or parts of aquatic organism morphological characters, in both the size and shape, by measuring distances of particular external body parts quantitatively (Kim et al. 2008; Maurya et al. 2018). Determination of sexual dimorphism, especially sex differentiation based on morphometric characters, has been done with fairly accurate results, for example, determination of sexual dimorphism on red chick barb or *Puntius orphoides* (Suryaningsih et al. 2014), European perch or *Perca fluviatilis* (Ulicevic et al. 2018), and pink skunk clownfish or *Amphiprion perideraion* (Abol-Munafi et al. 2011). However, until now there has never been informed about sexual dimorphism of *M. singaringan* that is based on morphometric methods.

Understanding on sexual dimorphism is very important and some findings conveyed by sexual dimorphism can give many valuable information, such as the process of receiving signals (Taborsky 1998), social structure and

adaptation (Kim et al. 2008), change strategies (Shaurabh et al. 2013), rationalization of fishery catch in public waters (Suryaningsih et al. 2014), and choice in parent fish for breeding (Esmaeili et al. 2017), mate and intrasexual competition (Taborsky 1998). This study aims to determine the sexual dimorphism of *M. singaringan* based on morphometric characters. The research of sexual dimorphism of *M. singaringan* is expected to be a useful basis for developing new strategies in the conservation and domestication program of *M. singaringan*.

MATERIALS AND METHODS

Animal sampling

Thirty samples of *M. singaringan* (16 males, 14 females) were collected from January to March 2017 from the Klawing River, in Purbalingga District, Central Java. Fish were caught using gill nets. The caught fish were stored in deep-frozen condition and then analyzed for morphometry in the laboratory. Morphometry measurements were carried out using digital caliper 0.01 mm accuracy with the position of the fish head facing to the left (Suryaningsih et al. 2014).

The measured morphometric characters were total length (TL), standard length (SL), head length (HL), eye diameter (ED), the distance between mouth and eye or periorbital distance (POD), predorsal distance of dorsal fin (PDDF), predorsal distance of adipose fin (PDAF), maximum body height (BH), minimum body height (bH), dorsal fin length (DFL), height of dorsal fin (HDF), pectoral fin length (PFL), height of pectoral fin (HPL), ventral fin length (VFL), height of ventral fin (HVL), anal fin length (AFL), anal fin length (AFL), height of anal fin length (HAFL), base length of adipose fin (BAF), height of

adipose fin (HAF), upper barbeus length (UBL1), upper barbeus length (UBL2), bottom barbeus length 1 (BBL1), bottom barbeus length 1 (BBL2), length of caudal peduncle (LCP). After the measurement was done, dissection was performed to determine the sex of the fish.

Statistical analysis

The obtained data were analyzed statistically using SPSS version 16. The measurement results of all morphometric characters were compared to the total length to see allometric growth patterns. Differences in morphometric characters were analyzed by t-test. Significance of parameter was calculated using t-test at a confidence interval of 95% and 99.9% (Zar 1999). Allometric growth, referring to Minos et al. (1995), is calculated using regression analysis based on the function $Y = aTL^b$, where 'Y' is a morphometric variable, 'a' is a constant, and 'b' is a slope. Allometric growth variable consists of positive allometric (A +) with slope b> 1, negative allometric b <1, and isometric b = 1.

RESULTS AND DISCUSSION

Results

Data obtained from the measurement of morphometric characters in 30 samples of *M. singaringan* (16 males and 14 females) from Klawing River are presented in Table 1. The total length of female fish ranged from 150-234 mm, and the average length was 196.07 ± 25.01 mm, while the total length of male fish ranged from 165-204 mm with average length of 182.56 ± 12.00 mm. In addition, it is revealed that the average value of morphometric characters of female *M. singaringan* is bigger than that of male *M. singaringan*.
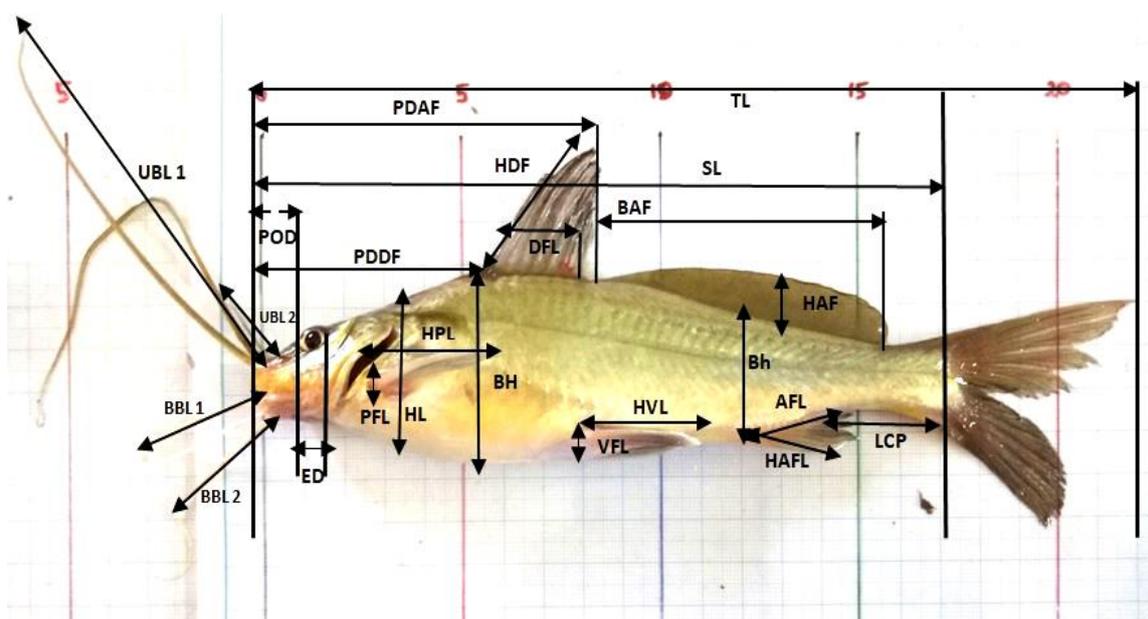

Figure 1. Morphometric measurements of *Mystus singaringan*

Based on the results of the t-test, from 24 morphometric characters, there were 12 characters which showed very significant differences (P <0.05; P <0.001), namely the character of standard length (SL), head height (HL), the distance of the muzzle to the eyes (POD), the distance of muzzle to adipose fin (PDAF), maximum height (H), height of dorsal fin (HDF), height of pectoral fin (HPL), base length of adipose fin (BAF), height of adipose fin (HAF), upper barbeus length (UBL1), bottom barbeus length 1 (BBL1), and bottom barbeus length 1 (BBL2). Meanwhile, other characters, such as total length (TL), eye diameter (ED), predorsal distance of dorsal fin (PDDF), minimum height (bH), dorsal fin length (DFL), pectoral fin length (PFL), ventral fin length (VFL), anal fin length (AFL), height of pelvic fin (HVL), height of anal fin (HAFL), upper barbeus length 2 (UBL2), length of caudal peduncle (LCP), did not show significant differences. Those significantly different characters become discriminator for the sex of *M. singaringan*. Another thing that strengthens the determination is that the measured characters did not show too overlapping values, and vice versa, other characters that are not significantly different had high heterogeneous values. *M. singaringan* dimorphism can be seen in Figure 2.

In this study, the growth of morphometric characters of *M. singaringan*, both male and female, has a linear relation with total length. The growth pattern of all morphometric characters of *M. singaringan* was included in negative allometric category (b <1), as it is presented in Table 3.

In this study, sexual dimorphism of *M. singaringan* can be determined from 12 significantly different morphometric characters and from 12 other morphometric characters that are not significantly different (Table 2). However, other fish from Bagridae family, such as *Mystus pelusius*, do not show any different form of sexual dimorphism in terms of body size (Esmaeili et al. 2017), whereas in *Mystus gulio*, standard length, body depth, and head length become markers for sexual dimorphism of male and female fish (Begum et al. 2008). Those different results indicate that each fish species has different absolute size (Nugroho et al. 2016) and has certain geographical distribution which is controlled by the physical conditions of the environment (Ariyanto and Imro 2008). The size, distribution, and variation of the morphometric characters are supposed to be the adaptation of these fish species to their environment or habitat. Farrag et al. (2015) have emphasized that the influence of environmental interactions can trigger morphometric differences, such as variations in growth, development, and maturation, among species.

Discussion

Research on sexual dimorphism of fish from other families, as reported by Kim et al. (2008), has found out that in Korean Chub (*Zacco koreanus*) from Cyprinidae family, out of 37 morphometric characters, there are 12 morphometric characters that are significantly different between male and female fish. The most distinctive morphometric characters (P <0.001) in Korean Chub or *Zacco koreanus* is the pectoral fin length (PECL) and the distance between the dorsal fin insertion and insertion of the anal fin (IDF-IAF) (Kim et al. 2008).
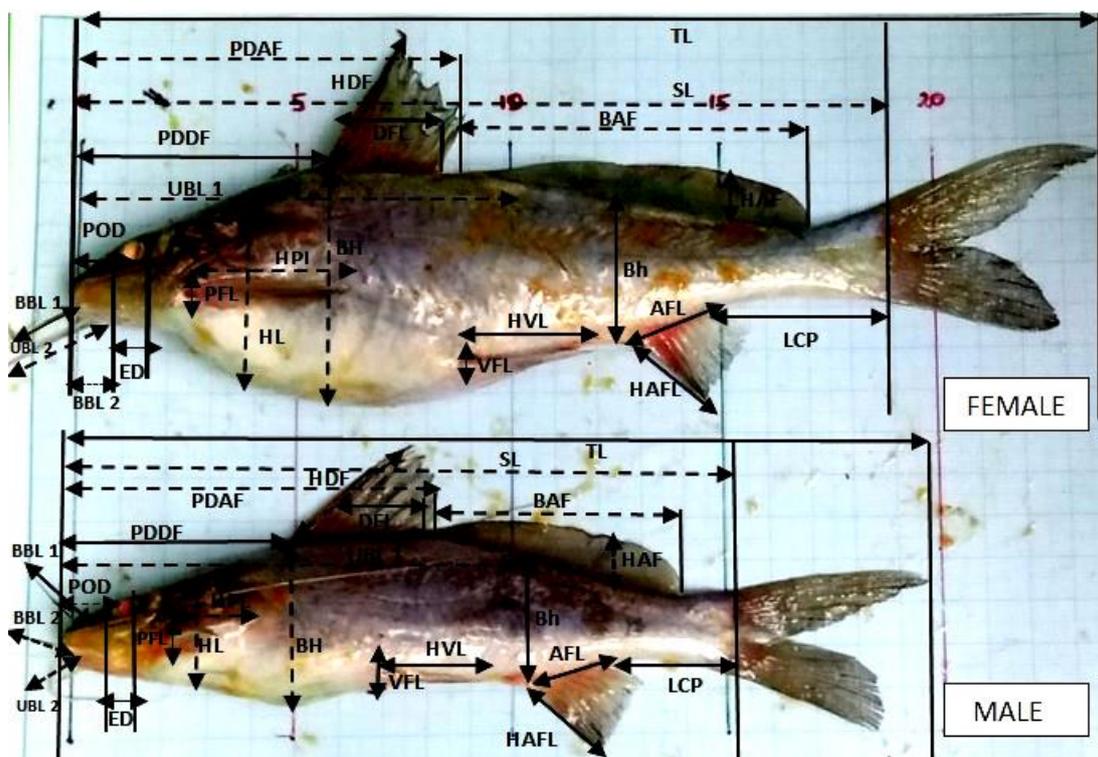

Figure 2. Male and female *Mystus singaringan* sexual dimorphism

Table 1. Diagnostic character of *Mystus singaringan* with references (Aryani et al. 2013)

Morphometric character (mm)	Male					Female				
	N	M	Min	Max	SD	N	M	Min	Max	SD
TL	16	182.56	165	204	12.00	14	196.07	150	234	25.01
SL	16	139.18	128	155	8.56	14	153.14	123	178	18.58
HL	16	23.20	20.8	27.7	1.88	14	37.26	27.78	53.4	8.49
ED	16	5.05	4.2	6.2	0.50	14	5.04	4.1	5.9	0.46
POD	16	10.89	8.2	11.92	1.02	14	14.59	9.68	17.25	2.39
PDDF	16	46.52	28.1	55.92	6.76	14	51.36	38.7	61.25	6.74
PDAF	16	65.22	58.14	71.2	4.02	14	77.93	63.44	89.22	7.53
Bh	16	15.71	13.38	20.9	1.91	14	17.26	12.4	21.6	2.83
BH	16	30.27	26.09	36.78	3.16	14	41.74	26.9	51.55	7.28
DFL	16	18.07	15.2	23.7	2.31	14	19.07	16.1	24.3	2.61
HDF	16	30.25	26.2	32.8	1.99	14	36.31	28.1	41.22	4.38
PFL	16	5.71	4.5	7.6	0.86	14	5.50	4.4	6.3	0.62
HPL	16	22.64	19.7	27.7	1.95	14	24.07	14.9	30.01	4.89
VFL	16	4.36	3.35	5.8	0.69	14	4.337	3.1	5.6	0.82
HVL	16	24.89	19.85	28.5	2.36	14	24.07	14.9	30.1	4.89
AFL	16	11.73	9.3	15.2	1.61	14	12.97	10.2	16.9	2.24
HAFL	16	20.80	15.82	24.1	2.04	14	19.69	10.5	23.5	3.91
BAF	16	63.06	56.6	68.89	1.16	14	73.88	57.9	74.64	7.41
HAF	16	9.869	7.8	12.9	1.16	14	11.49	7.8	14.84	2.05
UBL1	16	110.35	94.1	126.36	11.04	14	130.15	115.97	146.26	9.91
UBL2	16	75.70	63.1	89.58	6.62	14	79.99	67.3	88.9	7.51
BBL1	16	47.72	30.2	58.02	6.58	14	53.67	30.9	62.88	8.83
BBL2	16	28.64	19.10	36.7	4.06	14	33,72	28.38	37.46	2.88
LCP	16	30.09	23.52	35.38	3.78	14	30.81	25.34	37.79	3.92

Note: M=Mean, SD=Standard Deviation, Min=Minimum value, and Max=Maximum value

Table 2. T-test results of morphometric characters of male and female *M. singaringan*

Morphometric character	Male and female (t-test)	
	T	Sig (2-tailed)
TL	1.925	.064
SL	2.700**	.012
HL	6.459**	.000
ED	0.058	.954
POD	5.644**	.000
PDDF	1.959	.060
PDAF	5.871**	.000
Bh	1.772	.087
BH	5.723**	.000
DFL	1.103	..279
HDF	4.982**	.000
PFL	-0.737	.467
HPL	5.097**	.000
VFL	-.093	.926
HVL	.009	.553
AFL	0.146	.089
HAFL	0.041	.331
BAF	5.126**	.000
HAF	3.997**	.000
UBL1	5.136**	.000
UBL2	1.664	.107
BBL1	2.107**	.044
BBL2	3.889**	.001
LCP	0.510	.614

Note: Significantly different Sig <0.05; *; Sig <0.001; **

Table 3. Relation of morphometric characters and growth patterns of male and female *M. singaringan* with their total length

Morphometric character	Female		Male	
	Regression parameters	Slope (b)	Regression parameters	Slope (b)
PS	Y=26.274+0.647TL	AN	Y=24.233+0.630TL	AN
TK	Y=-13.846+0.312TL	AN	Y=3.004+0.111TL	AN
DM	Y=3.951+0.006TL	AN	Y=1.143+0.021TL	AN
JMM	Y=-2.156+0.085TL	AN	Y=-0.943+0.065TL	AN
JMSP	Y=3.320+0.245TL	AN	Y=11.026+0.194TL	AN
JMAF	Y=23.464+0.278TL	AN	Y=7.366+0.317TL	AN
h	Y=-3.094+0.104TL	AN	Y=-6..928+0.124TL	AN
H	Y=-11.113+0.270TL	AN	Y=-14.057+0.243TL	AN
PDSP	Y=2.959+0.082TL	AN	Y=-1.734+0.1/08TL	AN
TSP	Y=6.113+0.154TL	AN	Y=3.509+0.146TL	AN
PDSD	Y=2.088+0.017TL	AN	Y=-3.356+0.050TL	AN
TSD	Y=6.478+0.106TL	AN	Y=9.468+0.072TL	AN
PDSPr	Y=-0.758+0.026TL	AN	Y=-3.562+0.043TL	AN
TSPr	Y=-7.760+0.162TL	AN	Y=0.601+0.133TL	AN
PDSA	Y=-2.531+0.079TL	AN	Y=-2.948+0.080TL	AN
TSA	Y=-6.490+0.134TL	AN	Y=6.433+0.079TL	AN
PDAF	Y=23.538+0.257TL	AN	Y=9.560+0.293TL	AN
TAF	Y=-2.874+0.073TL	AN	Y=-4.531+0.075TL	AN
PSA1	Y=66.585+0.324TL	AN	Y=55.536+0.300TL	AN
PSA2	Y=25.559+0.278TL	AN	Y=-1.797+0.424TL	AN
PSB1	Y=1.350+0.267TL	AN	Y=28.028+0.108TL	AN
PSB2	Y=17.376+0.083TL	AN	Y=-10.133+0.212TL	AN
JASPE	Y=41.030-0.052TL	AN	Y=48.470-0.101TL	AN

Note: b <1 is allometric negative (AN)

Research of Ulicevic et al. (2018) on European perch fish (*Perca fluviatilis*) from Cyprinidae family has obtained 7 out of 19 morphometric characters as discriminators for male and female fish, namely, head length, periorbital distance, predorsal distance of first dorsal fin, predorsal distance of second dorsal distance, first dorsal fin height, second dorsal fin height, and pectoral fin length. Periorbital distance and predorsal distance of first dorsal fin characters showed very significant differences (P <0.001). Head length, predorsal distance of second dorsal distance, and second dorsal fin height showed significant differences (P <0.01,) while first dorsal fin height and pectoral fin length showed significant differences between two sexes (P <0.05) (Ulicevic et al. 2018). In addition, in *Amphiprion perideraion*, there are 7 of 15 morphometric characters that distinguish sexual dimorphism, including body depth, direct distance between the anterior edge of the upper lip and the posterior of the last dorsal fin, above eye to origin of dorsal fin, above eye to origin of pelvic fin, tip of dorsal fin to anal fin, tip of dorsal fin to the tip of anal fin, tip of dorsal fin to the tip of caudal fin (Abol-Munafi et al. 2011). The direct distance between the anterior edge of the upper lip was very significantly different (P <0.001) while the body depth was significantly different (P <0.05).

Various studies on sexual dimorphism and morphometric characters mentioned above have shown the data of morphology differences between two sexes in several species of fish. It confirms that morphometric variations in some species of fish are reflection of different adaptations by fish to the environment (Jawad and Al-Janabi 2016), food (McGee and Wainwright 2013), type of prey (Reimchen and Nosil 2004), and/or other abilities in their habitat. The detected morphometric variations are form of morphological adaptation to competition for food or to swimming migration and habitat control (Turan and Basusta 2001; Zimmerman et al. 2009; Herler et al. 2010; Lima et al. 2012), and to ecological selection (Schluter 2001; Cott et al. 2013; Zahorska et al. 2013).

In this study, the sexual dimorphism of *M. singaringan* fish based on morphometric characteristics is strongly influenced by the value of the condition and the relatively good water quality of the River Klawing (data not shown). Value of condition factors is related to food availability (Blackwell et al. 2000) and habitat conditions (Richter 2007), and gonadal development (Ayo-Olalusi 2014). Heltonika (2009) also reported that the size of first mature M gonads was 14.89 cm and the gonadal maturity was related to the composition of food in the stomach. Energy deposits from food are good for growth, gonad maturation until the spawning process is stored in several organs such as the back muscles, adipose fin, and viscera. Thus, fin adipose is one of the morphometric characters of the singaringan sexual dimorphism marker. In other *Mystus* species such as *Mystus vittatus, M. cavasius*, and *M. blekeeri*, their morphometric characteristics are influenced by climate, geographical factors and availability of nutrients in their habitat (Chakravorty et al. 2016), and on fish from other *Bagridae* families, *Hemibagrus nemurus* ecology and human activities (Aryani et al. 2013). In fish from the *Cyprinidae* family, *Perca fluviatilis,* its

morphometric characters are influenced by nutritional diets (Ulicevic et al. 2018) and in *Labeo calbasu,* they are caused by environmental changes (Hossain et al. 2010), while in *Mystacoleucus padangensis,* they are influenced by current velocity (Nofrita et al. 2015). Referring to unpublished data and a number of previous studies, nutritional or food availability factors greatly influenced morphometric characters and could eventually show *M. singaringan* sexual dimorphism markers

Morphometric characters as discriminators for *M. singaringan* in this study, such as height of dorsal fin and height of pectoral fin, are suspected to be related to swimming and hunting ability. The same notion is reported by Lenarz and Echeverria (1991), who have stated that the character of pectoral fin of Sebastes fish is related to swimming and hunting ability, while the characters of upper barbeus length 1, bottom barbeus length 1, and bottom barbeus length 1 are related to the ability to detect prey. The base length of adipose fin and the height of adipose fin are thought to be related to energy storage. Heltonika (2009) has said that adipose fin is energy storage for growth and reproduction. Jawad and Al-Janabi (2016) have reported that *Silurus triostegus* in Shatt al-Arab River have larger mouth, including larger upper jaw and lower jaw, than *S. triostegus* in Tigris River. This larger upper jaw and lower jaw indicate that *S. triostegus* usually eat large-sized prey. Georgakopoulou et al. (2007) have also informed that in sea bass fish, the change in water temperature greatly affected morphometric characters of head length and head depth, caudal peduncle, and body depth. The same phenomenon also occurs in swordtail fish or *Xyphophorus hellerii* (Eagderi et al. 2015) and *S. triostegus* from the Tigris River in Iraq (Jawad and Al-Janabi 2016). Low-temperature water condition generally increases water viscosity and water density. Changes in morphometric characters are forms of morphological adaptation by shifting towards a fusiform body shape in order to overcome barriers (Wimberger 1992; Sfakianakis 2011).

Sexual dimorphism growth in female *M. singaringan* was larger than that in male *M. singaringan*. It is shown by the mean values of most morphometric characters measured (Table 1). Female *Puntius orphoides* from Cyprinidae family (Suryaningsih et al. 2014), female *Mystus gulio* from Bagridae family (Begum et al. 2008), and female *Mystus blekeeri* (Musa and Bhuiyan 2006) also have larger body size, compared to its male. Larger body size in female fish is very closely related to reproduction, given egg fecundity that keeps increasing and requires a cavity that is large enough to accommodate ovum (Leveque 1997; Suryaningsih et al. 2014: Ulicevic et al. 2018). However, the case is quite different in the Korean Chub or *Zacco koreanus* and Sebastes fish. Morphometric characters of male Korean Chub fish are larger than the female. Characters of pectoral fin length IDF-IAF (0.263-0.024) and the distance between mouth and eye SNL (0.085-0.007) (Snout Length) of female fish are bigger than those of male fish, while PECL character is larger in male (0.213-0.016) than it is in female (0.195-0.017) (Kim et al. 2008). The same things were also found in Sebastes genus,

of which male fish are larger in terms of head length, width of orbit, interorbital width, length of upper jaw, longest pectoral fin ray, and longest dorsal spine (Lenarz and Echeverria 1991). Different body size between male and female in some types of fish explains the adaptive process of intrasexual selection, choosing mate and partner competition (Taborsky 1998; Paiva et al. 2013; Zahorska et al. 2013), reproductive strategies (Velasco et al. 2006; Kim et al. 2008; Silva-Junior et al. 2013) and reproduction methods (Anderson 1994).

Morphometric character growth in *M. singaringan* that is linear to its total length has also been found in *M. gulio* (Begum et al. 2008) and *Perca fluviatilis* (Ulicevic et al. 2018). On the other hand, the relation between characters growth in top mouth gudgeon or *Pseudorasbora parva* is different. There is character growth that is linear, linear split, and quadratic split (Zahorska et al. 2013). Characters that are linear to total length in male *Pseudorasbora parva* are postorbital distance, head depth, predorsal distance, preventral distance, caudal peduncle, pectoral fin length, ventral fin length, and anal fin length. Whereas in female *Pseudorasbora parva*, characters that are linear to total length are postorbital distance, head depth, predorsal distance, preanal distance, pelvic-ventral, ventral-anal, Da-Anal, DP-distance, caudal peduncle ventral, postdorsal distance, postanal distance.

Allometric growth pattern of all morphometric characters of *M. singaringan* is characterized as negative allometric. This result shows that the growth of morphometric characters of *M. singaringan* is slower than the total length. All negative-allometric-type morphometric characters were also found in the *S. triostegus* (Jawad and Al-Janabi 2016). However, in other types of fish, negative allometric growth pattern was found only in certain characters. For example, in male *Perca fluviatilis*, negative allometric growth pattern was only found in 7 characters, namely horizontal eye diameter (Oh), anal fin length (IA), length of caudal peduncle (Lpc), second dorsal fin height (hDII), ventral fin length (IV), pectoral fin length (IP), and anal fin height (hA). Whereas in female *Perca fluviatilis*, there are 5 allometric-negative morphometric characters, namely horizontal eye diameter (Oh), first dorsal fin height (hDI), ventral fin length (IV), pectoral fin length (IP), and anal fin height (hA) (Ulicevic et al. 2018).

The results of determination of *M. singaringan* sexual dimorphism in this study have shown clear morphometric characters and character growth pattern in both male and female *M. singaringan*. This research finding is important and very useful as basic information for future conservation strategies and future plan of mass production in captivity. Of course, further studies on morphology and reproduction are still expected to be conducted in the future.

In conclusion, sexual dimorphism of *M. singaringan* is in standard length (SL), head length (HL), the distance from the muzzle to the eyes, the distance from the muzzle to adipose fin, the height of the dorsal fin, the maximum height, the height of the pectoral fin, the base length of adipose fin, height of fin adipose, upper barbeus length, bottom barbe length 1, and bottom barbeus length 1. Morphometric characters are strongly influenced by nutrients and energy obtained from nutrients influences linear growth patterns of measured morphometric characters, so they can eventually be used as a marker of sexual dimorphism.

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