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RESEARCH ARTICLE

MORPHOLOGICAL CHARACTERISTICS OF RABBITFISH *SIGANUSARGENTEUS* (QUOYDANGAIMARD, 1825) FROM MANADO BAY, NORTH SULAWESI, INDONESIA

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ABSTRACT

This study was aimed to determine variations of morphological characters (Morphometrics and meristics) of rabbitfish (*Siganusargenteus*.) andcompare them with the fork length, head length and other morphometric characters. It was also intended to determine the morphological characters usable for species identification. The fish samples were collected from Manado Bay waters, North Sulawesi, and there was a total of 3 individuals of *S. argenteus* whose morphological characters were analyzed. Results showed that their taxonomic characters covering quantitative morphology (Morphometric and meristic) and qualitative morphology (color and typical characters) could be used to describe and identify the rabbitfish, *S. argenteus*. It also exhibited variations in value range of the morphometric character among individuals of the species.This species possesses nearly fusiform-like body shape. Caudal fin is forked. Mouth position is rather ventral and small-sized with blunt snout.

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INTRODUCTION

Rabbitfish, *S. argenteus,* have been differently classified by fish experts. The first scientific classification is as follows: Kingdom Animalia, phyllumChordata, super-class Osteichthyes, class Actinopterygii, sub-classNeopterygii, super-order Acanthopterygii, order Perciformes, sub-order Achanthuroidea, family Siganidae, genus *Siganus* Forsskål, 1775, and species. *Argenteus* (QuoydanGaimard, 1825) (Masuda *et al.* 1984, Randall *et al*., 1990, Woodland, 1990). Other classification has put this species into Kingdom Animalia, phyllumChordata, Subphyllum Vertebrata, Super-class Gnathostomata, Super-classPisces (being discussed), class Actinopteri, sub-classNeopterygii, OrderPerciformes, Sub-order: Achanthuroidei, FamilySiganidae, and Genus *Siganus* Forsskål, 1775/(QuoydanGaimard, 1825) (Bailly, 2015) (http://www.marinespecies.org/aphia.php?p=taxdetail &id=273912), Catalog of Fish (Eschmeyer, 2016) (http://researcharchive.calacademy.org) and Fishbase (2016). Morphological characters (morphometric and meristic) are important for taxonomy. Morphometrics is characters related with fish body size or body part, for instance total length and fork length. These measurements are taxonomic characteristics used for fish identification. There are 26 morphometric characters commonly employed to identify fish (Affandi *et al*., 1992), such as total length, length up to branch baseof the caudal fin, head length, distance before dorsal fin, length of dorsal and anal fin base, length of caudal peduncle, body height, height of caudal peduncle, head height, head width, body width, length of dorsal fin and anal fin, length of pectoral fin and pelvic fin, the longest length of pectoral fin, length of spine and soft rays, snout length, length of space between eyes, eye width, length of head part behind the eye,height below the eye, distance between eye and pre-operculum angle, cheek height, length of upper jaw, length of lower jaw, mouth opening width. Morphometricandmeristic study of rabbitfish was conducted Bone Bay and Makassar strait (Sahabuddin, 2014). Even though this study has combined morphological characteristics and genetic aspects, it

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was done on *S. canaliculatus*. Morphological study of *S. argenteus* from Manado Bay is the first study recently carried out. This study was aimed at determining the morphological characters (morphometric and meristic) of *S. argenteus* and comparing with the fork length, head length, and other specific morphometric characters.

MATERIALS AND METHODS

Rabbitfish samples were collected from Manado Bay, North Sulawesi.Three individuals were collected and analyzed to describe the morphology of *S. argenteus*. Tissue (fin) of one specimen was taken for genetic-based species identification using Mitochondrial Cytochrome Oxidase 1 (CO1) DNA marker. Several morphometric characters-standard length ratiosof *S. argenteus* (Table 1) measured were total length (TL), natural length (NL), fork length (FL), pre-dorsal length (PDL), head length (HL), basal length of dorsal fin (BLDF), basal length of anal fin (BLAF), the longest length of soft caudal fin (LLSCF), length of middle part of soft caudal fin (LMPSCF)**,** the longest length of soft pectoral fin ($LLSP_1F$)**,** length of pelvic spine of the outer part (LP_2FSOP), the tallest body height (TBH), body width (BW), distance of posterior edge of anal to the base of the first anal spine (DPEA-BFAS), distance of the base of second dorsal spine to the base of outer pelvicspine(DBSDS-BOP_2S), distance of the base of dorsal spine edge to the base of anal spine edge (DBDSE- BASE), distance of the sixth soft dorsal fin base to the fifth soft dorsal fin base (DSSDFB-FSDFB)**,** distance of anterior edge of lower jaw to anterior base of pectoral fin base (DAELJ-ABP_1FB),distance of anterior edge of lower jaw to the base of outer pelvic spine (DAELJ-BOP_2S),distance of posterior edge of the operculum to the base of outer pelvic spine (DPEO-BOP_2S), and distance of upper operculum space to the base of the first dorsal fin(DUOS-BFDS). Several morphometric parameters-head length ratios measured (Table 2) weresnout length (SL), preorbital length (PrOL), postorbital length (POL), upper jaw length (UJL), lower jaw length (LJL), head height (HH), cheek height(CH), head width (HW), inter-orbital width (IOW), orbital diameter(OD), distance of lower edge of the orbital bone circularto pre-operculum angle (DLEOBC-POA), distance of anterior to posterior nostril (DA-PN), distance of anterior nostril to posterior edgeoforbital bone circular (DAN-PEOBC), distance of posterior nostril to anterior edge of orbital bone circular (DPN-AEOBC), anddistance of dorsoposterioredge of upper jaw to posterior nostril (DDPEUJ-PN). Morphometric characters-othermorphometric characters paramters compared were (Table 3) were length of anal spine(LAS), length of soft dorsal fin *(LSDF),* length of pelvic spine (LP_2S), length of soft anal fin (LSAF), height of caudal peduncle (HCP), length of anal fin base (LAFB), length of dorsal spine (LDS), length of middle part of soft anal fin (LMPSAF), length of caudal peduncle (LCP), length of dorsal fin base (LDFB)*,* length of the longest soft pectoral fin ($LLSP_1F$), length of the longest soft caudal fin(LLSCF), length of middle part of soft caudal fin (LMPSCF), distance of anal posterior edge of anus to the base of first anal spine (DAPEA-BFAS),distance of anterior nostril to the posterior edge of the orbital bone circular (DAN-PEOBC).

The morphometric and meristic characters measured (Table 4) were pre-operculum angle (POA),angle between upper jaw and snout (AUJS), angle between upper jaw and line projected through the nostril opening (ABUJLPNO), number of dorsal spines (NDS), number of soft dorsal fins(NSDF)**,** number of softpectoral fins (NSP_1F).

RESULTS AND DISCUSSION

S.argenteus was identified based on genetic analysis using genetic marker of Mitochondrial Cytochrome Oxidase1 (CO1) DNA. The phylogenetic tree demonstrated that the sample of rabbitfish belonged to the same group as *S. argenteus* of the genbank (Fig. 1). *S. argenteus*sample exhibited 100% similarity to the CO1 sequence of*S. argenteus*from various

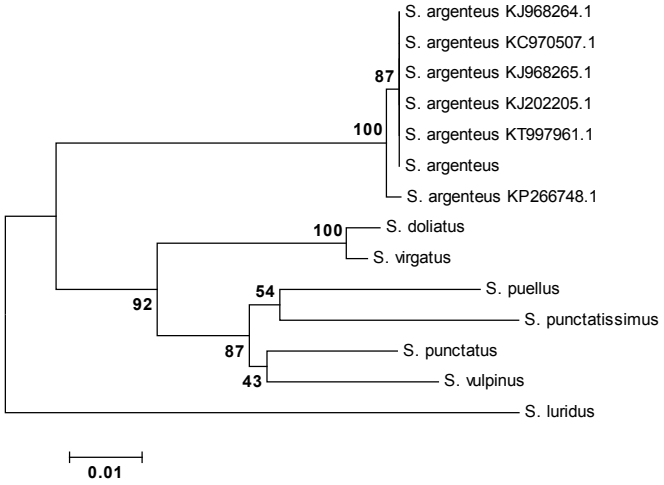

Figure 1. Phylogenetic tree based on Neighbor-Joining of CO1 genetic datawith 1000 *boostrap*. *S. argenteus*is sample specimen (529 bp). *S. argenteus* KJ968264.1, KC970507.1, KJ968265.1, KJ202205.1, KT997961.1 and KP266748.1 are CO1sequence of *S. argenteus* from the genbank. *S. doliatus*, *S. virgatus*, *S. puellus*, *S. punctatissimus*, *S. punctatus*, *S. vulpinus*, and*S. Luridus* are out group sequences

areas, KJ968264.1 and KJ968265.1from Polynesia, France (Hubert *et al*., 2014), KC970507.1KC970507.1from Philippine (Yambot *et al*., 2013), KJ202205.1from Philippine (Ordonio *et al*., 2014), KT997961.1 from Malaysia (Zolkaply 2015), and KP266748.1 from China (Li & Lin 2014). These data reveal that the rabbitfish collected from Manado Bay are *Siganusargenteus*.

Morphology

Physical appearance of *S. Argenteus* (Quoy and Gaimard, 1825) is presented in Fig. 2. The morphological data measurements, morphometric andmeristic, are given in Table 1, 2, 3, and 4.

Number of scales covering the cheek part highy varied, from several scales at the anterior (Fig. 3) or central cheek part nearly entirely is covered with scales; pelvic ridges andmid ventral part do not have scale (Fig. 4), or sometimes few scales occur at the outer anterior of the pelvic ridges (Fig. 5). The posterior edge of anterior nostril circular haslong flapreaching

the posterior nostrilin small-sized fish and its length reduces up to half or less of the distance between anterior nostril and posterior one in bigger individuals. Line projected passing the nostril opening is located above the mid point of posterior edge of the orbital bone circular.

Figure 2. *S.argenteus*

Table 1. Several morphological characters compared with standard length of *S. argenteus*

MORPHOMETRIC CHARACTERS						
TL	NL	FL	PDL	HL	BLDF	BLAF
0,78-0,80	0,79-0,83	0,84-0,93	3,55-3,83	4,17-4,49	1,49-1,52	2,33-2,43
MORPHOMETRIC CHARACTERS						
LLSCF	LMPSCF	$LLSP_1F$	LP_2FSOP	TBH	BW	DPEAF-BFAS
3,53-4,40	10,14-14,64	5,88-6,77	8,45-8,89	2,44-2,85	6,89-7,96	8,76-9,58
MORPHOMETRIC CHARACTERS						
DSBSDF-BOP_2S	DBDSE- BASE	DSSDFB-FSDFB	DAELJ-ABP_1FB	DAELJ-BOP_2S	DPEO-BOP_2S	DUOS-BFDS
2,85-3,12	3,09-3,63	5,72-6,94	4,37-4,80	3,21-3,41	5,29-5,48	7,67-8,22

Table 2. Several morphometric characters compared with head length of *S.argenteus*

MORPHOMETRIC CHARACTERS				
SL	PrOL	POL	UJL	LJL
2,29-2,60	2,73-2,86	2,70-2,75	3,71-4,31	5,50-6,47
MORPHOMETRIC CHARACTERS				
HH	CH	HW	IOW	OD
1,09-1,28	2,88-3,67	1,73-1,97	2,31-2,49	3,25-3,41
MORPHOMETRIC CHARACTERS				
DLEOBC-POA	DA-PN	DAN-PEOBC	DPN-AEOBC	DDPEUJ-PN
3,04-3,43	11,07-13,93	1,95-2,05	6,78-7,27	5,29-5,36

Table 3. Several morphometric characters compared with other morphometric characters of *S. argenteus*

MORPHOMETRIC CHARACTERS				
LAS	LSDF	LP_2S	LSAF	HCP
1,10-1,27	1,09-1,27	0,80-0,92	0,89-1,61	2,50-2,79
COMPARING MORPHOMETRICCHARACTER				
LAFB	*LDS*	LMPSAF	*LCP*	LDFB
MORPHOMETRIC CHARACTERS				
LAFB	LSAF	*$LLSP_1F$*	*LLSCF*	*LMPSCF*
1,56-1,62	1,26-1,60	1,50-1,77	2,30-2,94	0,71-1,00
COMPARING MORPHOMETRICCHARACTER				
LAS	*PDS*	*LSDF*	*LSDF*	*LSDF*
MORPHOMETRIC CHARACTERS				
	DAPEA-BFAS	DANPEOBC	LP_2S	
	1,08-1,16	1,09-1,25	1,14-1,23	
COMPARING MORPHOMETRICCHARACTER				
	LSDF	*LSDF*	*LSDF*	

Table 4. Range of several morphometric and meristic characters of*S.(S) argenteus*

MORPHOMETRIC AND MERISTIC CHARACTERS					
POA	AUJS	ABUJLPNO	NDS	NSDF	NSP_1F
80-100	30-50	30-40	13	10	15-16

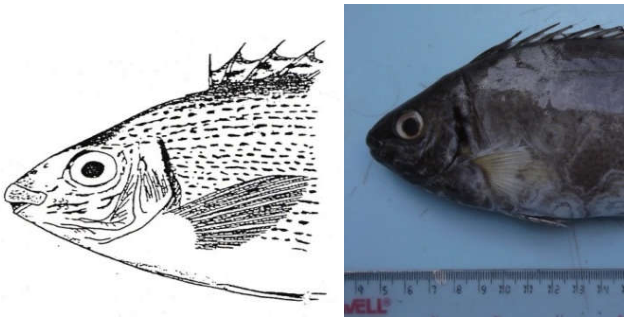

Figure 3. Head part of *S. argenteus*.

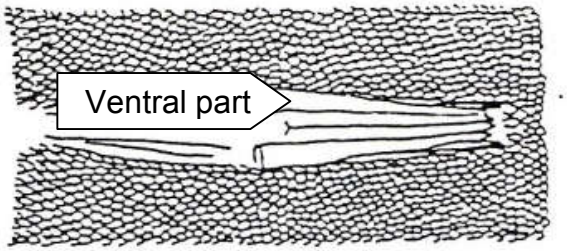

Figure 4. Pelvic and mid ventral ridges of *S.argenteus* (no scale)

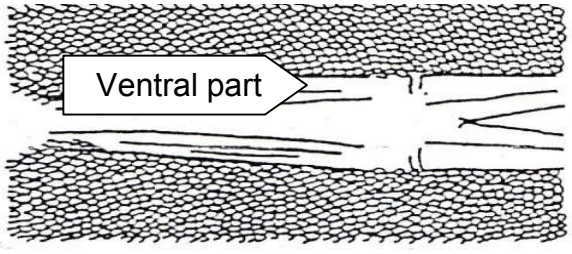

Figure 5. Pelvic and mid ventral ridges of *S. argenteus* (few scales on the outer side of the anterior ridges)

The dorsal and anal fins are flat (Fig. 6). Space between spine part and softdorsal and anal fins is clear. Forked-caudal fin has deep middle part (Fig.7 a, b).

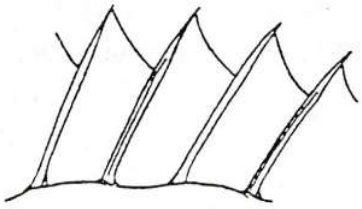

Figure 6. Dorsal fin spine of*S.argenteus* (flat)

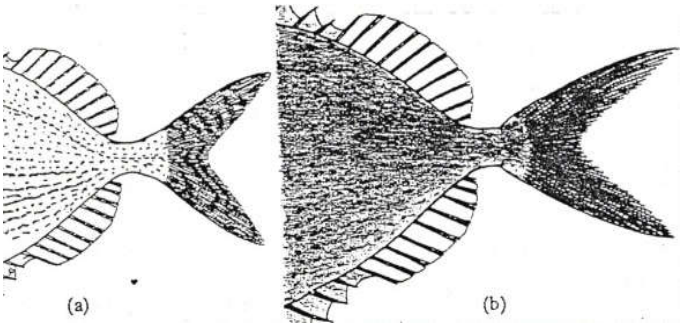

Figure 7. Caudal fin shape of *S.argenteus* (a) small, (b) bigger

The color patternsof *S.argenteus* in fresh condition areas follows: Nape, body side to caudal peduncle is covered with yellow spots of rounded, bar, and coma-shaped. These spots merge and make wavy lines at the lower part of the body side. Small fish sometimes possess several blacky spots. Base color of the body is silverish to blueish white, and sometimes there are large-sized blackish splotches. Big fish have dark blue to black base color. There are several irregular yellow short line on the cheek part. Soft pectoralfins are yellow. Spines of dorsal fin, anal fin and pelvic fin have small blacky splotches, but these are not clear in big-sized fish. Each soft dorsal fin and anal fin are indicated with blackish grey intermittently arranged. In bigger fish, all dorsal and anal fins are black. Several wavy blackish grey bars occur on the caudal fin, but these bars are not clear in bigger fish. This finding demonstrated that the taxonomic characters, quantitative morphology (morphometric and meristic) and qualitative morphology (color pattern and specific characters), could be used to describe and identify the fish species of Siganid. These characters have been used as a tool to describe and identify fish species, including family Siganid (Woodland, 1990). The morphological characters that are located outside the body and easily observed are good characters for fish identification and determination (Calliet, *et al*., 1986). Species description and identification are fundamental in biological studies (National Geographic, 2009; Pires and Marinoni, 2010). Without taxonomy, biologists of various disciplines cannot report their findings or access to the available information on the target species due to the uncertainty of the organism identity. Since taxonomy gives the base to build the life tree, yields the baseline data for conservation and ecological studies, and enables to take advantages of underutilized resources offered by the biodiversity in the earth (Wilson, 2004; Cruz-Barraza *et al*., 2012).

Table (1-4) presents variations – in value range patterns – of the intraspecific morphometric characters. These variationsare potential to occur in a population due to variations in body size, age-related functional effect, nutrition and etc. (Strauss and Bond, 1990). These variations are related with growth – in general fish possess allometric growth (Strauss and Bond,

1990) – including members of family siganid (Woodland, 1990). The allometric growth results in proportional alteration of morphological structures during theontogeny (history of individual organism development). This proportional change can occur quickly or slowly during the entire life (Cailliet *et al*., 1986). It is a phenotypic complexity that becomes taxonomic limiting based upon morphology (Hebert *et al*., 2003; Pires and Marinoni, 2010). This finding also exhibits interspecificvariation in morphometric character range, and the variation is highly affected by genetic factors (Cailliet *et al*., 1986) andenvironmental factors. Moreover, variations appeared also in meristic characters of familySiganid andits members in relation with value range format. It could be caused by genetic factors, environmental factor modification to the phenotype (Hebert *et al*., 2003; Pires and Marinoni, 2010) or combination of both (Lindsey, 1988). The environmental factors that can modify the meristic characters – through ontogeny in early developmental stage – are temperature, dissolved oxygen, salinity and food availability (Lindsey, 1988; Strauss and Bond, 1990; Hebert *et al*., 2003; Pires and Marinoni, 2010). Beside intraspecific and interspecific variations, there are narrow, broader, outer or overlapping variation with range (Woodland, 1990). These variations are caused by (1) different sampling site and its environmental factors. According to Strauss and Bond (1990), intraspecific variation is brought about by geographic varitions among population and it is related with different response to the environmental factors; (2) sample numbers, 50 – 100 specimens are recommended andsize variations to describe changable characters in a population;and (3) accuracy level and calculation failures. Based on qualitative morphological characters, i.e. body shape, caudal fin form, mouth position, mouth size, snout shape, and color pattern, these observations showed thatmembers of family Siganidpossess flat body, despite some of nearly fusiform as *S. argenteus*. Comparison in body width (BW) and body height (BH) against standard length (SL) is presented in Table 1. According to Affandi *et al.* (1992), fish will be classified having flat body shape if the body width is smaller than body height and length. This flat body is adapted to movement in narrow space, such as in reef crevices, dense aquatic plant beds or dense school (Moyle and Cech, 1988). It is in agreement with Woodland (1990) that fish of Siganid, in general, live in the estuary, seagrass beds, stony intertidal and coral reefs,even though some live in deeper waters, such as *S.argenteus*.

The shape of caudal fin infamily Siganidaeobserved during the study was nearly up-right, single curve, forked, and forked with deep middle part.The shape and the structure of the anal fin are related with their function. Fish of indented, up-right and rounded caudal fin show less active movement (Cailliet *et al*., 1986), while forked caudal fin and deepest fork occur in very active fish (Moyle danCech, 1988). In *S. argenteus,*beside having forked-tail, deepest fork and nearly fusiform body shape, they have small caudal peduncle, but longer than other members of family Siganids. It was also supported by Woodland (1990) that adult *S.argenteus* possessed a number of morphological characters of fast swimmer fish. This character is related with its habitat in deeper waters around the reef slope and they were often seen feeding around the wavy reef edge. Mouth position of family Siganidaeis terminal toward ventral, small-sized with blunt snout ingenus *Siganus*. This character is related with food and feeding habits (Moyle and Cech, 1988). Rabbitfish (Siganidae) is herbivore with seaweed andseagrass as food. Color pattern variations occur among species and in the species. Color pattern of each species is genetically controlled and used as species marker (Strauss and Bond, 1990; Woodland, 1990; National Geographic, 2009), especially sibling species,despite sometimes misleading. This variation could result from age, time, and habitat (Moyle and Cech, 1988).

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