

Length-weight relationships and ponderal index of three reef fish (Teleostei: Labridae) off the Tanjung Tiram coast, Southeast Sulawesi, Indonesia

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Abstract. Asriyana A, Irawati N, Halili H. 2020. Length-weight relationships and ponderal index of three reef fish (Teleostei: Labridae) off the Tanjung Tiram coast, Southeast Sulawesi, Indonesia. *Biodiversitas* 21: 1279-1286. Parameters of length-weight relationship and ponderal index were estimated for first time for three reef fish (Labridae), *Cheilinus trilobatus*, *Cheilinus chlorourus*, and *Choerodon anchorago*, off the Tanjung Tiram coast, Indonesia. A total of 292 specimens (*C. trilobatus* 146 specimens; *C. chlorourus* 100 specimens; *C. anchorago* 46 specimens) were collected monthly in experimental gillnets in coral reefs and seagrass beds from January to June 2018. The length-weight relationship and ponderal index were calculated for each species. *C. trilobatus* showed total length and weight of 9.0-17.2 cm and 12.33-78.79 g, respectively, while *C. chlorourus* was 8.5-17.5 cm and 10.41-100.21 g, and *C. anchorago* 9.0-27.0 cm and 18.51-414.00 g. *C. trilobatus* showed negative allometric growth, while *C. chlorourus* and *C. anchorago* had isometric growth. The length-weight relationship of *C. trilobatus* followed the linear equation of $W=0.10TL^{2.35}$, while *C. chlorourus* and *C. anchorago* fit to $W=0.03TL^{2.83}$; $W=0.03TL^{2.91}$ respectively. The highest ponderal index occurred in May for *C. trilobatus* and in June for *C. chlorourus* and *C. anchorago* indicating a peak of the spawning season. The study results could be used as baseline information for future fisheries management of the area.

Keywords: Growth pattern, isometric, Labridae, negative allometric, Southeast Asia

INTRODUCTION

Wrasses (Teleostei: Labridae) are reef-associated fishes among the dominant species in coral reefs (Meekan et al. 1995; Green 1996; Khalaf et al. 2005). Labridae is composed of at least 548 known species in 70 genera and considered as the second-highest in species diversity after Pomacentridae (Parenti and Randall 2018). Labridae is widespread along the coast of the Indian, Pacific and Atlantic Oceans (Nelson 1994; Helfman et al. 2009; Skiftesvik et al. 2014) and also represents a trophic major fish group in coral reefs (Setiawan 2010) known to clean dirt and biofouling on net in salmon commercial aquaculture (Kvenseth 1996) perform cleaning fish to control the attack of ectoparasite *Lepeophtheirus salmonids* (salmon lice) copepods in commercial Atlantic salmon culture (*Salmo salar*) and trout (*Oncorhynchus mykiss*) (Skiftesvik et al. 2014). Labridae is also known to have various trophic guilds and functional groups and fundamental roles in maintaining the health of coral reef systems (Cardozo-Ferreira and Joyeux 2016).

Various species of Labridae are well distributed in Indonesia's waters and are caught as by-catch in Scaridae (parrotfish) fisheries (Aswady et al. 2019, Dayuman et al. 2019). The important roles of Labridae in maintaining the health of coral reef ecosystems and fisheries require their exploitation to be regularly monitored to ensure its sustainability. One of the basic information that is currently lacking to support this management effort is about the

relationship between the length-weight and the ponderal index. The length-weight relationship is very important in fisheries management since it can be to determining biomass by converting length measurements to weights, studying life history, comparing species growth between seasons and places, and assessing fish biology, physiology, ecology, and fisheries (Ricker 1975; Gonçalves et al. 1997; Moutopoulos and Stergiou 2002; Oscoz et al. 2005; Mimeche and Biche 2015). Information generated from length-weight relations can also be used to assess fish conditions and fish growth patterns, whether isometric or allometric (Zhu et al. 2008; Asriyana 2015; Hashim et al. 2017; Okomoda et al. 2018). The study of a fish population using ponderal index or condition factors is based on body length-weight analysis in which fish that is heavier with respect to its length is considered to be in healthier condition (Bolger and Connolly 1989; Asriyana et al. 2010; Asriyana 2015).

There have been studies on Labridae larvae ecology (Victor 1986); age, growth, and reproduction (Hostetter and Munroe 1993; Donaldson 1995); eco-structure and spatial distribution (Hukom 1999; Locham et al. 2010); distribution, preference, habitat, and density (Dorf and Powell 1997; Skiftesvik et al. 2014, Rahman and Syam 2015); Phylogenetic (Westneat and Alfaro 2005) and community structure (Khalaf et al. 2005). Relationships of length-weight have been calculated for *C. trilobatus* (Letourneur 1998; Kulbicki et al. 2005, Gumanao et al. 2016), *C. chlorourus* (Letourneur et al. 1998, Kulbicki et

al. 2005, Gumanao et al. 2016), genera *Symphodus* and *Pomatoschictus* (Gurkan et al. 2010), for *Labrus mixtus* (Matić-Skoko et al. 2013), *Cheilinus undulatus* (Kamikawa et al. 2015), *Lachnolaimus maximus* (Pérez-Chacón and Aguilar-Perera 2015), *C. anchorago* (Gumanao et al. 2016, Palla et al. 2018). However, the research on the length-weight relationship of Labridae family in Indonesia's reef is scarcely available, and none has been off the Tanjung Tiram coast. The objective of this study was to determine the length-weight relationships and the ponderal index of *C. trilobatus* Lacepede, *C. chlorourus* Bloch, and *C. anchorago* Bloch off the Tanjung Tiram coast, Indonesia.

MATERIALS AND METHODS

Research site

This study was conducted off the Tanjung Tiram coast, Southeast Sulawesi, Indonesia from January to June 2018 (04°01'39"–04°02'42"S and 122°40'27.9"–122°40'23.6"E, Figure 1). The number of sampling sites was determined using purposive sampling technique in the area between coral reefs and seagrass beds. The aim of purposive sampling was to collect Labridae samples that do daily migration from coral reef area to seagrass beds and vice versa.

Fish collection

Fish were captured using experimental gill nets made from nylon monofilament material of 80 m long; each had a different mesh size of 1, 1¼, 1½, 2, and 3 inches. Sampling was carried out every month in the three locations. The net was set in the sea at 1.5 to 3 m deep during low tide and lifted at the highest level of high tide. Trapped fish were collected and identified according to Allen (1999), Carpenter and Niem (2001), Kuitert and Tanozuka (2001), Froese and Pauly (2019). All samples were kept in cool boxes for further analysis in the laboratory where samples of male and female fish were not

separated. Fish were measured in total length (TL), which is the length of the fish from the front end of the head to the last end of the tail using a 1 cm fish gauge and the weight determined using a scale with the accuracy of 0.1 g.

Data analysis

The length-weight relationships (LWRs) were calculated using the equation of Le Cren (1951), Tesch (1971), Ricker (1975), Froese (2006), Asriyana (2015), and Oladipo et al. (2018):

$$W = aL^b$$

Where; W is weight of fish (g); L is total length of fish (cm); a, b are constants. To test whether the value of $b = 3$ or not, the statistical t-test was used. The value of $b \neq 3$ means that the fish has an allometric growth pattern, whereas if $b = 3$ means the fish growth pattern is isometric (Sokal and Rohlf 1995). The Excel Microsoft Office v.10 was used in the length-weight relationships analysis.

The ponderal index or condition factor is calculated based on the growth pattern of the length-weight relationship. If the growth pattern was isometric, then the ponderal index was calculated using the equation below (Hile 1936):

$$K = \frac{10^5 \times W}{L^3}$$

If the growth pattern was allometric, then the relative ponderal index was calculated (Hile 1936):

$$K_n = \frac{W}{aL^b}$$

Where; K_n is relative ponderal index; K is ponderal index; W is weight of fish (g); L is total length of fish (cm); a, b is constant from length-weight relationship.

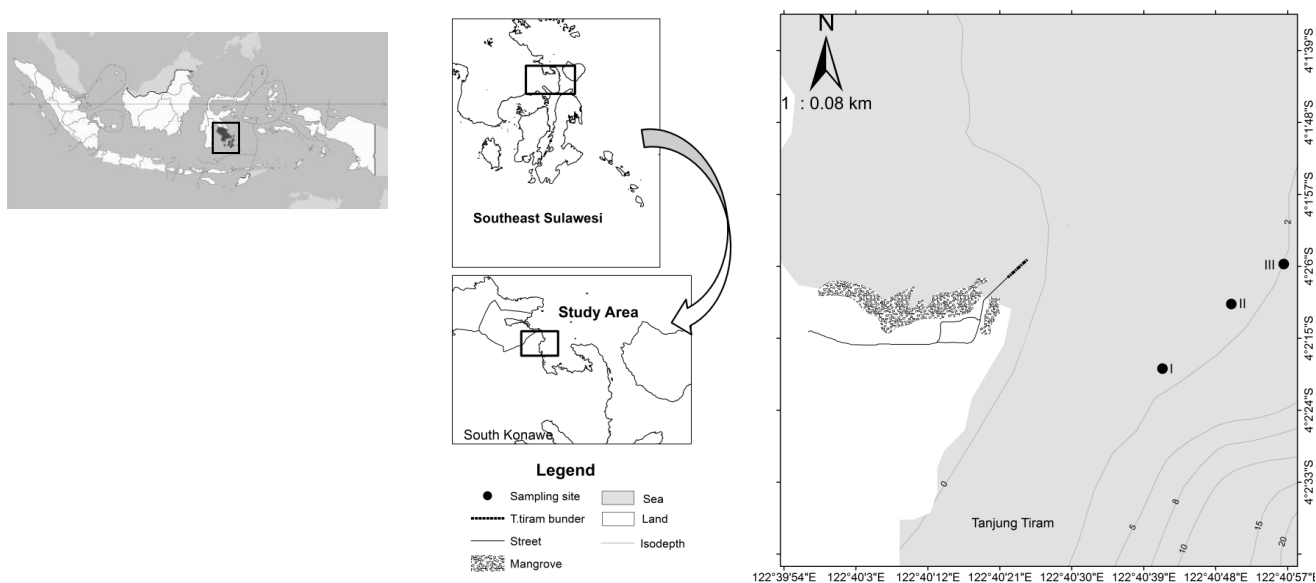


Figure 1. Map of Tanjung Tiram coast and locations of sampling stations, Southeast Sulawesi, Indonesia

Table 1. Descriptive statistics of fish species (Labridae) from coral reefs off the Tanjung Tiram coast, Indonesia

Month	Tripletail wrasse, <i>C. trilobatus</i> Lacepede 1801			Floral wrasse, <i>C. chlorourus</i> Bloch 1971			Orange-dotted tusk fish, <i>C. anchorago</i> Bloch 1791		
	n	Length (cm)	Weight (g)	N	Length (cm)	Weight (g)	n	Length (cm)	Weight (g)
Jan.	26	9.8-12.5	17.89-35.00	9	9.5-17.5	13.71-89.00	1	14.8	57.74
Feb.	3	9.9-12.0	16.68-31.40	45	8.5-17.0	10.41-84.83	19	13.0-26.2	47.28-414.00
Mar.	30	10.9-17.2	22.66-78.79	19	10.5-16.9	22.07-100.21	12	10.8-26.1	29.39-159.86
Apr.	22	9.0-12.5	12.33-42.22	6	10.0-15.5	22.74-92.17	8	10.0-17.6	26.55-133.80
May	36	9.0-13.0	19.32-52.92	16	10.0-16.0	31.56-91.90	2	15.0-20.0	98.01-103.22
Jun.	39	9.5-13.8	26.51-45.32	5	14.0-16.5	65.82-91.33	4	9.0-18.0	20.31-121.22
Total	146	9.0-17.2	12.33-78.79	100	8.5-17.5	10.41-100.21	46	9.0-26.2	20.31-414.00

Note: n: sample, Jan.: January, Feb.: February, Mar.: Maret, Apr.: April, Jun.: June

In population level, the average K indicates whether the population is in a better condition ($K > 1$) or worse ($K < 1$) than the average population (Bolger and Connolly 1989). To determine whether there were differences in the ponderal index values among the species of the Labridae family, non-parametric statistic Kruskal-Wallis with significant 0.05 (Sokal and Rohlf 1995) was used using SPSS software ver. 16.0.

RESULTS AND DISCUSSION

Length size distribution

Total fish caught during the study was 292 (Table 1) where *C. anchorago* Bloch had the highest weight size compared to the other two species.

The complete frequency distributions based on the group length measurements for each species are presented in Figure 2. In *C. trilobatus*, the group with the length size range of 10.03-11.05 cm had the highest percentage (27.50%) compared to the other group size ranges. In *C. chlorourus*, the fish group with length size between 14.37-15.54 cm had the highest percentage (27.98%) while *C. anchorago*, the fish group with length size between 14.19-16.78 cm had the highest percentage (41.13%).

Length-weight relationship

Based on the regression analysis, Table 2 presents the total length and weight relationship of fish collected in each month. The table shows that the Labridae family has varied growth patterns. The t-test results indicated that the growth pattern of *C. trilobatus* was negative allometric ($b < 3$), which tells that the fish length increases faster than fish weight gain. Both *C. chlorourus* and *C. anchorago* have growth pattern which indicated an isometric growth pattern ($b = 3$).

The relationship equation model of length (TL) and weight (W) of *C. trilobatus* can be represented as $W = 0.10 TL^{2.35}$ ($r = 0.88$; $R^2 = 0.77$). For *C. chlorourus* and *C. anchorago*, their length-weight relationship are represented with $W = 0.03 TL^{2.84}$ ($r = 0.95$; $R^2 = 0.93$) and $W = 0.02 TL^{2.94}$ ($r = 0.93$; $R^2 = 0.91$), respectively.

Ponderal index

The ponderal indexes or condition factors of the three species of Labridae family found the study were varied (Figure 3). The result of the Kruskal-Wallis test revealed that there were significant differences in the ponderal index values among the three species ($P < 0.05$; $\alpha = 5\%$, $db = n-1$). The ponderal index values of *C. anchorago* was higher than the other two species ranging between 0.49-4.33. The value simply that *C. anchorago* has better conditions than the other two species.

Discussion

This study has found that *C. trilobatus* and *C. chlorourus* in the waters of Tanjung Tiram have relatively higher number of individuals than *C. anchorago*. A similar situation was reported at Malindi Marine Park, Kenya where *C. trilobatus* and *C. chlorourus* are caught at a higher rate on fringing reefs compared to the other Labridae genera (Locham et al. 2010). This might be due to the fact that fringing reef has highest benthic algae cover (Hamilton and Brakel 1984) which provides protection from predatory compared to the habitat close to beach area. Fringing reef also provides *C. trilobatus* and *C. chlorourus* sufficient food such as mollusks, benthic crustacean, small fish, and Echinodermata (Setiawan 2010). These are the reason why the *Cheilinus* genera are found in a large number in this specific habitat compared with other genera.

Based on the distribution of the dominant length group (Figure 2), most of caught *C. trilobatus*, *C. chlorourus*, and *C. anchorago* were still within the juvenile stage. This is based on the report Lau and Li (2000), that *C. trilobatus* and *C. anchorago* in Asia-Pacific waters have a maximum length of 45 cm TL and 50 cm TL and reach gonad maturity approximately at the size of 26 cm TL and 23 cm TL, respectively. *C. chlorourus* found in Karimunjawa, Indonesia is reported to have a maximum size of 45 cm TL (Setiawan 2010) and reaches gonad maturity at 19.8 cm TL (May and Robinson 2005; Clements et al. 2012). Based on that, the size range juvenile of *C. trilobatus*, *C. chlorourus*, and *C. anchorago* in Tanjung Tiram waters were 9.0-17.2 cm TL, 8.5-17.5 cm TL, and 9.0-26.2 cm TL, respectively.

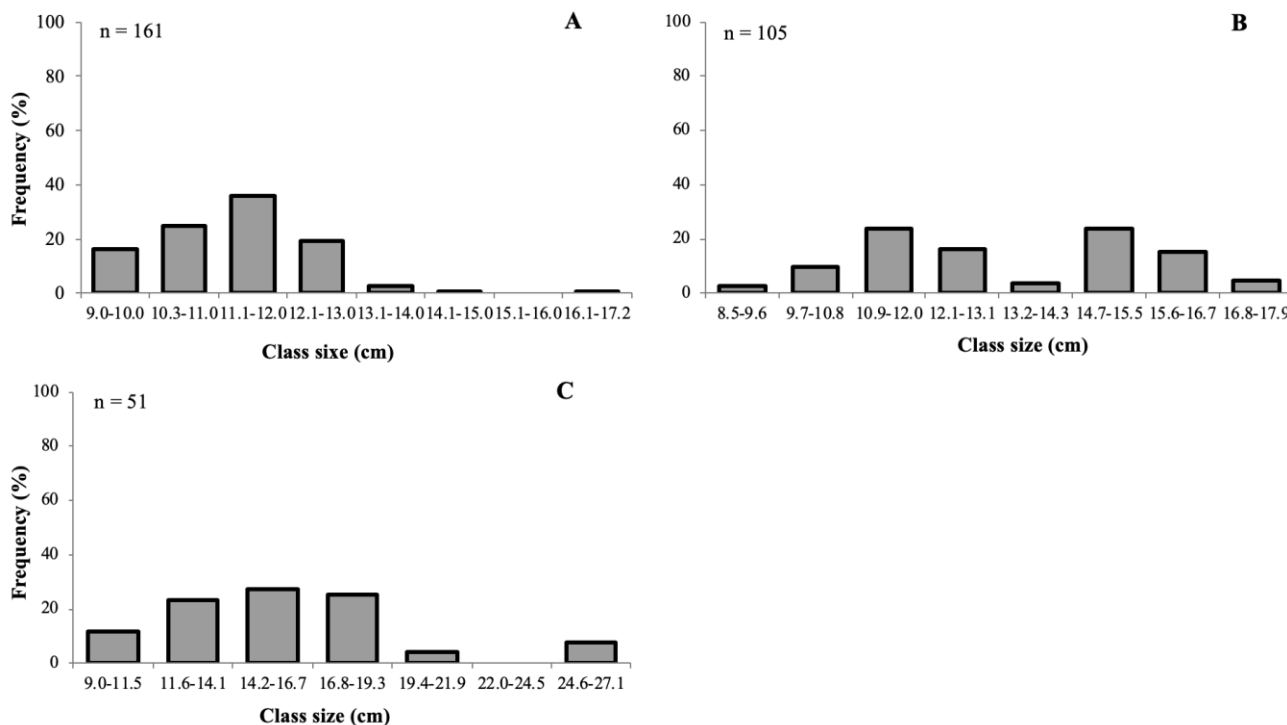


Figure 2. Size-frequency distributions of three species of Labridae: A. *C. trilobatus* Lacepede; B. *C. chlorourus* Bloch; C. *C. anchorago* Bloch

Most studies regarding length-weights relationships are limited to certain species of Labridae (Matic-Skoko et al. 2013; Kamikawa et al. 2015; Cardozo-Ferreira and Joyeux 2016) in which *C. trilobatus*, *C. chlorourus*, and *C. anchorago* have never been studied in Indonesia. This study provides baseline information for the three species of Labridae. This study has revealed that *C. trilobatus* has a faster increase in length compared to weight gain ($b < 3$), while *C. chlorourus* and *C. anchorago* has a proportional length to weight increase ($b = 3$) (Tabel 2). Furthermore, there is a high correlation between length and weights in the three species of Labridae ($r \geq 0.85$), which can be used to convert length to weight. The negative allometric growth patterns observed in *C. trilobatus* might be attributed to the moderately damaged coral reefs in the study sites with coral reef coverage of only 15-30% (University Halu Oleo Research Center-UHO RC 2011). The degraded coral reef condition in this area has limited the supply of food for the species resulting in a low body weight gain. However, the negative allometric observed in the species could also be caused by the condition of the species which was in the juvenile stage where energy requirement is mostly used for somatic growth. The relatively small number of samples might also affect the result calculation of the growth pattern.

Some studies showed that the Labridae family does not always have negative allometric and isometric growth patterns (Table 3). Growth patterns are related to the exponential values (b) of length and weight which can change. These changes are related to environmental

parameters (seasonal temperature regimes) and habitat availability (Hostetter and Munroe 1993); optimal temperature, adequate food, and seasonal changes (Arslan et al. 2004, Gupta and Gupta 2006; Olopade et al. 2018); ontogenetic development (Türkmen et al. 2002); season, habitat, feeding rate, and fish health (Zhu et al. 2008); sexual dimorphism (Artigues et al. 2003); gonadal development and spawning period (Yilmaz and Polat 2009); and reproduction stage (Ouannes-Ghorbel and Bradai 2002); procedures for sampling (sample size and length range) (Ecoutin et al. 2005); parasitic pressure (Neff and Cargelli 2004); health, habitat, regional/seasonal influences, gastric fullness, samples preservation techniques, and differences in specimen size ranges (Wootton 1998; Verdiell-Cubedo et al. 2006); high dissolved oxygen concentration and circulation of water (Pathak et al. 2013). The higher the value of b indicates that the environmental conditions are relatively productive (Gopakumar et al. 1991; Olopade et al. 2018).

Table 2. Length-weight relationship of three dominant species of Labridae

Species	n	a	b	r	R ²	Growth pattern
<i>C. trilobatus</i>	146	0.10	2.35	0.88	0.77	Negative allometric
<i>C. chlorourus</i>	100	0.03	2.84	0.95	0.93	Isometric
<i>C. anchorago</i>	46	0.02	2.94	0.93	0.91	Isometric

Note: n= sample, a= intercept, b= slope, r= correlation, R²= coefficient of determination

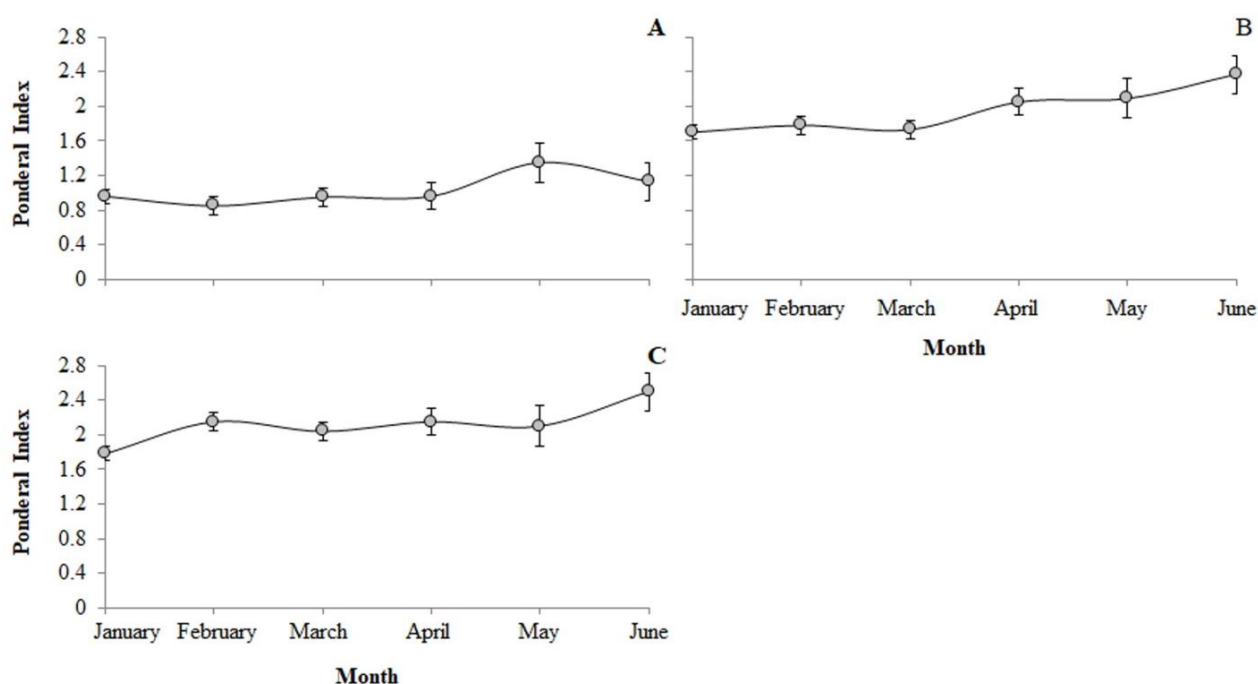


Figure 3. Ponderal index of three species of Labridae family: A. *C. trilobatus* Lacepede; B. *C. chlorourus* Bloch; C. *C. anchorago* Bloch

The ponderal index of the three Labridae species varied in values (Figure 3) with the highest index occurred in May (*C. trilobatus* $K_n = 1.14$) and June (*C. Chlorourus* and *C. anchorago*, each have a value of $K = 2.17$). The high ponderal index is suspected of being related to the spawning season of *C. trilobatus*. In Kimbe Bay waters of Papua New Guinea, *C. trilobatus* fish spawn between December and April during high tide (Claydon et al. 2014). The spawning information of the species is not available for Tanjung Tiram waters. The result of this study strongly indicates that *C. trilobatus* spawning occurs in May characterized by the high average of ponderal index value. Similarly, the spawning season of *C. Chlorourus* and *C. anchorago* is strongly suspected to occur in June indicated by the ponderal index value increases towards the peak of the spawning season (June) and decreases after the spawning period. During the spawning season, the increase in reproductive activity resulting in an increase in body weight and ponderal index value.

The increased of ponderal index values during reproductive activity was also reported on family Characidae at Brazil river floodplain (Lizama and Ambrósio 2002), *Trachurus mediterraneus* in the Aegean Sea (Tzikas et al. 2007), *Johnius belangerii* in Mayangan beach, Indonesia (Rahardjo and Simanjuntak 2008), *Sardinella atricauda* in Kendari Bay, Indonesia (Asriyana 2015), *Pseudorhombus triocellatus* in Parangipettai Coast, India (Bharadhirajan et al. 2019). This phenomenon can be understood as during the time of spawning, the main energy source used for gonadal development and spawning (Lizama and Ambrósio 2002) resulting in the increased values of Gonado Somatic Index (GSI) and ponderal index. High ponderal index values can also describe the conditions of reproductive activity (time and duration of

gonadal maturation), abundance of food conditions in nature, and health of the aquatic ecosystem (Weatherley and Gill 1987; Abowei and Hart 2009; Ighwela et al. 2011). The somatic energy content is linearly related to the ponderal index (K) and somatic index (SI) values. In addition, GSI is positively correlated with gonadal energy. Linear trends were found between somatic parameters (K, SI, and energy content) and gonadal parameters (GSI and energy content) (Encina and Granado-Lorencio 1997). Fluctuations in the values of the ponderal index every month from the three species are thought to be related to differences in fish size, food availability, time, and spawning period of *C. trilobatus*, *C. chlorourus*, and *C. anchorago* in Tanjung Tiram waters. A similar observation was reported on *Barbus sclateri* in the upper Guadalete River, Spain (Enchina and Granado-Lorencio 1997), family Labridae along the Jordanian coast (Khalaf et al. 2005, Neff and Cargnelli 2004), *Sardinella atricauda* in the waters of Kendari Bay, Indonesia (Asriyana 2015).

Among the three Labridae species, *C. anchorago* had the highest ponderal index values in the range of 0.49-4.33 (mean 2.09) as the result of a greater average of body mass *C. anchorago* compared to the other genera (Table 1). The populations *C. chlorourus* and *C. anchorago* are in better condition ($K > 1$) than that of *C. trilobatus*. At the population level, the K average indicates whether the population is in a better condition ($K > 1$) or worse ($K < 1$) than the average population (Bolger and Connolly 1989). The variations in the ponderal index values were also reported on *Dicentrarchus fish labrax*, *Solea senegalensis*, *Pomatoschistus microps*, and *Trachurus trachurus* in the Tejo Estuary waters (Duarte et al. 2018).

Table 3. The value of the regression coefficient of the length-weight relationship of Labridae family

Species	n	a value	b value	R ²	Locations	References
<i>C. chlorourus</i>	22	0.03	2.85	0.99	Lagoon, New Caledonia	Letourneur et al. 1998
<i>C. trilobatus</i>	42	0.02	2.97	0.98	Réunion	Letourneur 1998
<i>C. chlorourus</i>	44	0.02	2.99	0.99	New Caledonia	Kulbicki et al. 2005
<i>C. trilobatus</i>	9	0.02	3.06	0.99	New Caledonia	Kulbicki et al. 2005
<i>C. chlorourus</i>	92	0.04	2.95	0.97	Davao Gulf, Philippines	Gumanao et al. 2016
<i>C. trilobatus</i>	133	0.03	3.04	0.99	Davao Gulf, Philippines	Gumanao et al. 2016
<i>C. anchorago</i>	98	0.03	3.07	0.96	Davao Gulf, Philippines	Gumanao et al. 2016
<i>C. anchorago</i>	98	0.02	3.00	0.99	Palawan, Philippines	Palla et al. 2018
<i>C. trilobatus</i>	146	0.10	2.35	0.77	Tanjung Tiram coast, Indonesia	This study 2019
<i>C. chlorourus</i>	100	0.03	2.84	0.93	Tanjung Tiram coast, Indonesia	This study 2019
<i>C. anchorago</i>	46	0.02	2.94	0.91	Tanjung Tiram coast, Indonesia	This study 2019

Note: n: sample, a: intercept, b: slope, R²: coefficient of determination

As discussed before, the high correlation between the length and weight of the Labridae population can be used to convert length to weight. The negative allometric growth patterns in *C. trilobatus* can be associated with the damage condition of coral reef habitat classified as moderate, the condition of the species which was in the juvenile stage, and relatively small number of samples. The high ponderal index during May and June was suspected as the spawning season of the three species in the waters of Tanjung Tiram. This study recommends that to maintain the biodiversity of living organisms in general and Labridae family in particular, coral reef habitat in Tanjung Tiram has to be protected to prevent further damage and allows the ecosystem to heal itself.

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