Blue-barred parrotfish *Scarus ghobban* Forsskål, 1775: is it a protogynous?

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Abstract. The blue-barred parrotfish *Scarus ghobban* is a reef fish that has not been a target fish in the past, but is now becoming a target fish. The blue-barred parrotfish is a monochromatic fish, so that the sex of individual cannot be identified based on secondary sexual characters. This research aimed to determine whether the blue-barred parrotfish is protogeny. The parameters observed were sex ratio, gonad maturity and size at first maturity. The sex ratio of Blue-barred parrotfish was not balanced. This study cannot reinforce the previous assumption that Blue-barred parrotfish was protogeny because the distribution of sex ratio related to the length class was dominated by males. This study cannot also reinforce the previous assumption that Blue-barred parrotfish is protogeny because the distribution of sex ratio related to the length class was dominated by males. The size at first maturity of the male Blue-barred parrotfish is 24.0 cm and the female is 31.6 cm. Small length class which was dominated by males, and size at first maturity of males which was smaller than females reinforces the assumption that Blue-barred parrotfish was not hermaphrodite protogynous, but dioecious. This is just a preliminary suspicion, more detailed studies are ongoing.

1. Introduction

Blue-barred parrotfish *Scarus ghobban* is the Scaridae family that spreads widely in the Indo-Pacific, covering the Red Sea and the Gulf of Algoa, South Africa to the Rapa and Ducie Islands, from North to South Japan, South to Perth, New South Wales and India [1]. Blue-barred parrotfish is a reef fish that can live up to a depth of up to 35 m [2]. Blue-barred parrotfish is a species of parrotfish caught in Spermonde waters [3-5]. Spermonde waters are part of Fisheries Management Area (FMA) 713 [6,7] which is in the Wallace line trajectory which is inhabited by many species of reef fish [8,9]. The waters of Spermonde are an artisanal fishing area that has experienced over fishing [10,11].

Blue-barred parrotfish can be identified by its dull orange color with five incomplete stripes of blue patches on its body. The dorsal and anal fins are yellow with blue stripes. On the body there is a blue bar. Single notched tail fin. The dorsal and anal fins are yellow with blue margins. The tail fin is a crescent shape (Figure 1) [1].

Blue-barred parrotfish can be found in lagoons and coral reefs from the coast to the sea [12]. These fish live solitary or in small groups and can reach lengths of up to 90 cm. Blue-barred parrotfish get their food by grazing or eating algae that grow on rocks and corals [13,14]. Blue-barred parrotfish are herbivorous fish that have an important role in the balance of the coral reef ecosystem. Blue-barred parrotfish can limit the formation and growth of algal communities which can hinder coral recruitment [15]. Therefore, Blue-barred parrotfish is one of the supporters of mutualism life system in the coral reef ecosystems.

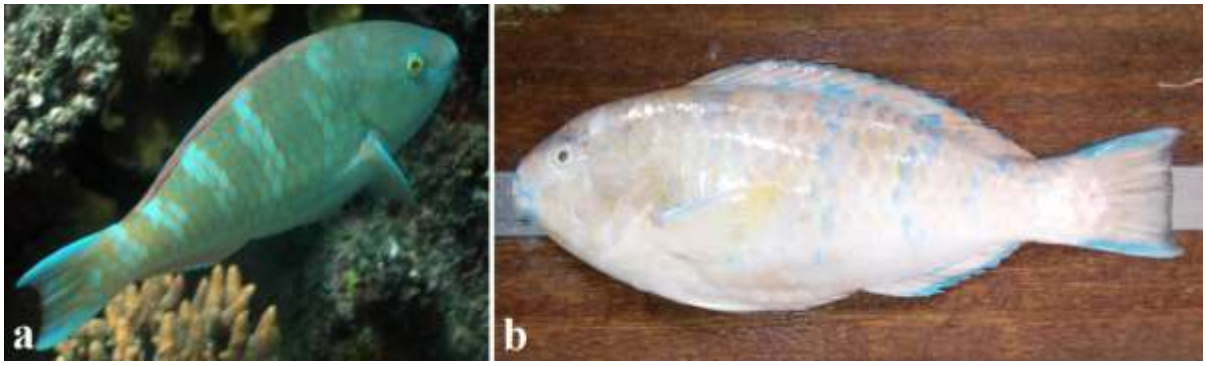

Figure 1. Blue-barred parrotfish Scarus ghobban while living in nature [16] (a) and during laboratory observations (b)

Apart from having an important ecological role, it also has important economic value. Blue-barred parrotfish are traded live, fresh and dried [17]. The economic value that continues to increase will cause the fishing rate to also increase. The increase in fishing rate can affect the population structure of Blue-barred parrotfish. Intensive fishing can lead to a decrease in population size, even extinction, which in turn will affect the ecological balance of the coral reef ecosystem [18].

As grazers, intensive fishing of Blue-barred parrotfish can disrupt the balance of the coral ecosystem, therefore, the sustainability of Blue-barred parrotfish needs to be maintained. Biologically, there are three things that must be passed by an organism to survive, namely adaptation to physical, chemical and biological aquatic factors, adaptation in terms of obtaining food or energy, and reproduction adaptation [19]. Failure of one or more of these three factors can lead to extinction. In this study, one aspect of reproduction adaptation was be examined.

Previous studies have reported that parrotfish are generally protogeny hermaphrodites, but the hermaphroditism in gonochoric parrotfish is not always easily recognized, so there is always some doubt. Although previous studies have reported a lot about hermaphrodite protogeny in coral reef fishes [20,21] and parrotfish [22], However, coral reef fishes, particularly gonochoric parrotfish, still need a deeper study, for example in Blue-barred parrotfish. Therefore it is necessary to study the form of hermaphroditism (protogeny or protandry) in Blue-barred parrotfish. This study aims to further study the hermaphroditism in Blue-barred parrotfish which has been previously reported as a photogenic hermaphrodite [23,24]. The reproductive biology parameters associated with hermaphroditism studied were sex ratio, gonad maturity level, and size at first maturity.

2. Materials and Methods

This research was conducted from July 2019 to June 2020, using samples of Blue-barred parrotfish from Spermonde Islands waters which were landed at the Rajawali Fish Landing Site, Makassar City (Figure 2).

Blue-barred parrotfish samples were taken every mid-month. Each fish sample was measured by total length and body weight. The total length was measured from the front of the mouth to the end of the tail using a measuring rod with an accuracy of 1 mm. The weight was weighed using a digital scale with an accuracy of 0.01 g. Determination of the sex of the sample was carried out based on primary

sexual characteristics, namely by dissecting and determining the sex, male or female (testes or ovaries). Sex ratio was calculated by comparing the number of males and females. Maturity stage was determined morphologically, based on macroscopic characters, including color, shape and size of the gonads (testes or ovaries). The gonads removed from the body cavity were weighed to the nearest 0.01 gram.

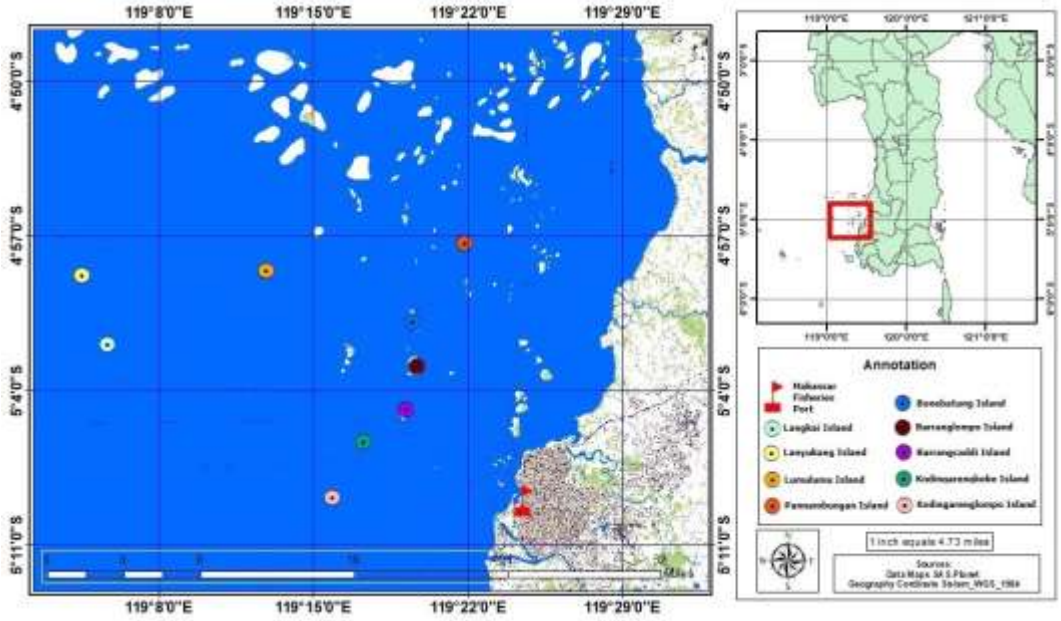

Figure 2. The participative map of fishing area of Blue-barred parrotfish *Scarus ghobban* in Spermonde Islands

Sex ratio (SR) was calculated using equations $SR = \frac{\sum M}{\sum F}$, where ∑M was number of male and ∑F was number of female [25]. To determine the sex ratio between male and female related to the sampling period and maturity stage, the chi-square test was used [26].

Gonad development was qualitatively determined by observing the gonads maturity level based on the gonads morphology [27]. The level of gonad maturity was determined morphologically which includes the color, shape and size of the gonads. Gonad observation with reference to previous research [27] which divides the gonad development of the other parrotfish *Scarus niger* parrot fish into 5 stages, namely, MS I (immature), MS II (early ripening), MS III (ripening), MS IV (mature), MS V (spawn). The MS distribution was analyzed based on the sampling time and length class distribution.

Size at first maturity related to the total length was estimated using the length of the sample that had matured gonads (MS III, IV and V). Size at firs maturity ($FM_{50\%}$) were the length at 50% of the samples were mature. The first maturity curve was calculated using a polynomial trendline in the Microsoft Excel software program.

3. Results

3.1. Sex ratio

During the study period, there were 169 samples of Blue-barred parrotfish consisting of 22 male fish, 26 female fish, and 121 unidentified sex (Figure 3a). Sex ratio related to the sampling period showed that the numbers of males and females differed slightly, 1:1.2**,** but the distribution was not balanced and significantly different ($P < 0.05$).

During the study period, there were 9 samples at MS I (immature), 112 fish at MS II (early maturation), 36 fish at MS III (maturation) consisting of 21 males and 14 females, 12 samples at MS IV (mature) consisting of 1 male and 11 female, and 1 female sample at MS V (post-spawning). Sex

ratio related to the MS showed that the number of females and males was almost the same (Figure 3b), but the distribution was not balanced and significantly different (P <0.05).

Sex ratio related to the length class shows that the number of males is less than females, but the distribution is not balanced and significantly different (P <0.05). The range of total length for males is 17.5-42.4 cm, while females are 17.5-5.4 cm (Figure 3c).

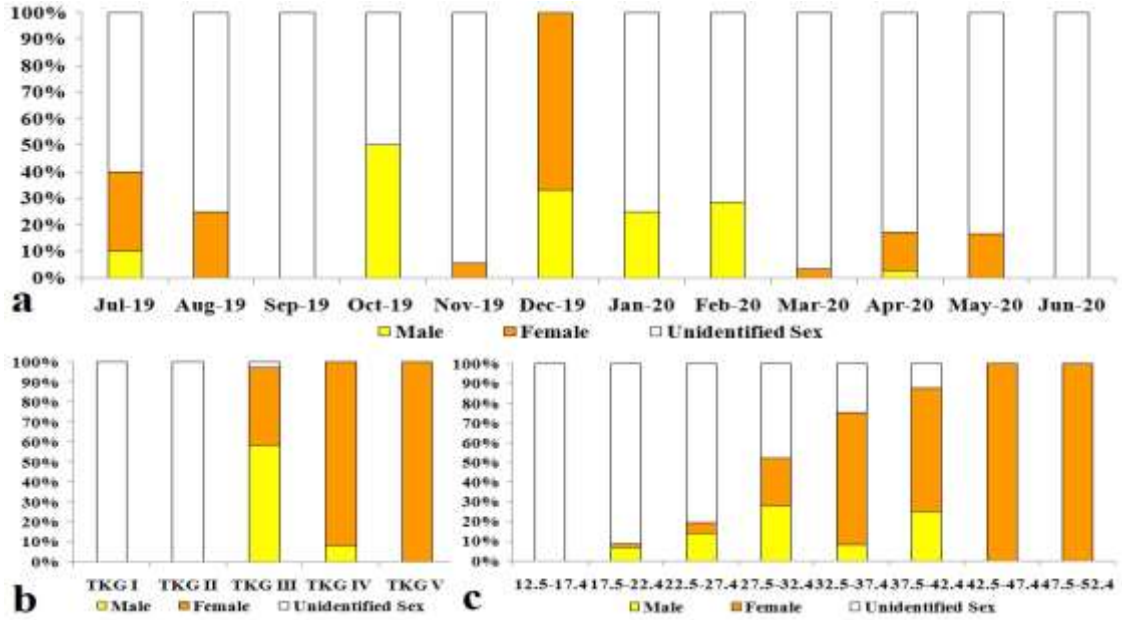

Figure 3. Sex ratio of Blue-barred parrotfish *Scarus ghobban* related to the sampling period (a), maturity stage (b) and length class (c)

3.2. Maturity stages

3.2.1. Macroscopic characteristic. Based on the macroscopic structure of the gonads, male and female gonads of Blue-barred parrotfish can be differentiated based on their colour and size (Table 1, Figure 4). Male gonads were characterized by clear gonads, the higher maturity level of the gonads, the colour of the gonads will be milky white. The female gonads were characterized by gonads that are brownish white to brownish red.

Table 1. Macroscopic characteristics of the Blue-barred parrotfish *Scarus ghobban* gonads at the males and females. MS: maturity stages

MS	Male	Female
I	Macroscopically, the gonads cannot be differentiated between male and female. The gonads were clear and elongated like threads. Gonads weigh less than 0.01 g.	
II	Macroscopically, the gonads cannot be distinguished with certainty between male and female, but the direction of development has begun to appear to male or female. The gonads were clear. The gonadal weight varied from 0.01-0.18 g with a mean weight of 0.03 ± 0.03 g.	
III	The testes were milky white. Gonad weight varied from 0.06-0.60 g with a mean weight of 0.18 ± 0.09 g.	Ovaries were brownish white. Their weight varied from 0.06-0.23 g with a mean weight of 0.13 ± 0.05 g.
IV	The testes were milky white. Their weight varies from 0.33-1.37 g with an average weight of 0.76 ± 0.29 g.	Ovaries were brownish red. Their weight varies from 0.20-0.60 g with a mean weight of 0.04 ± 0.10 g.
V	-	Ovaries were brownish red and wrinkled. Weight 0.07 g.

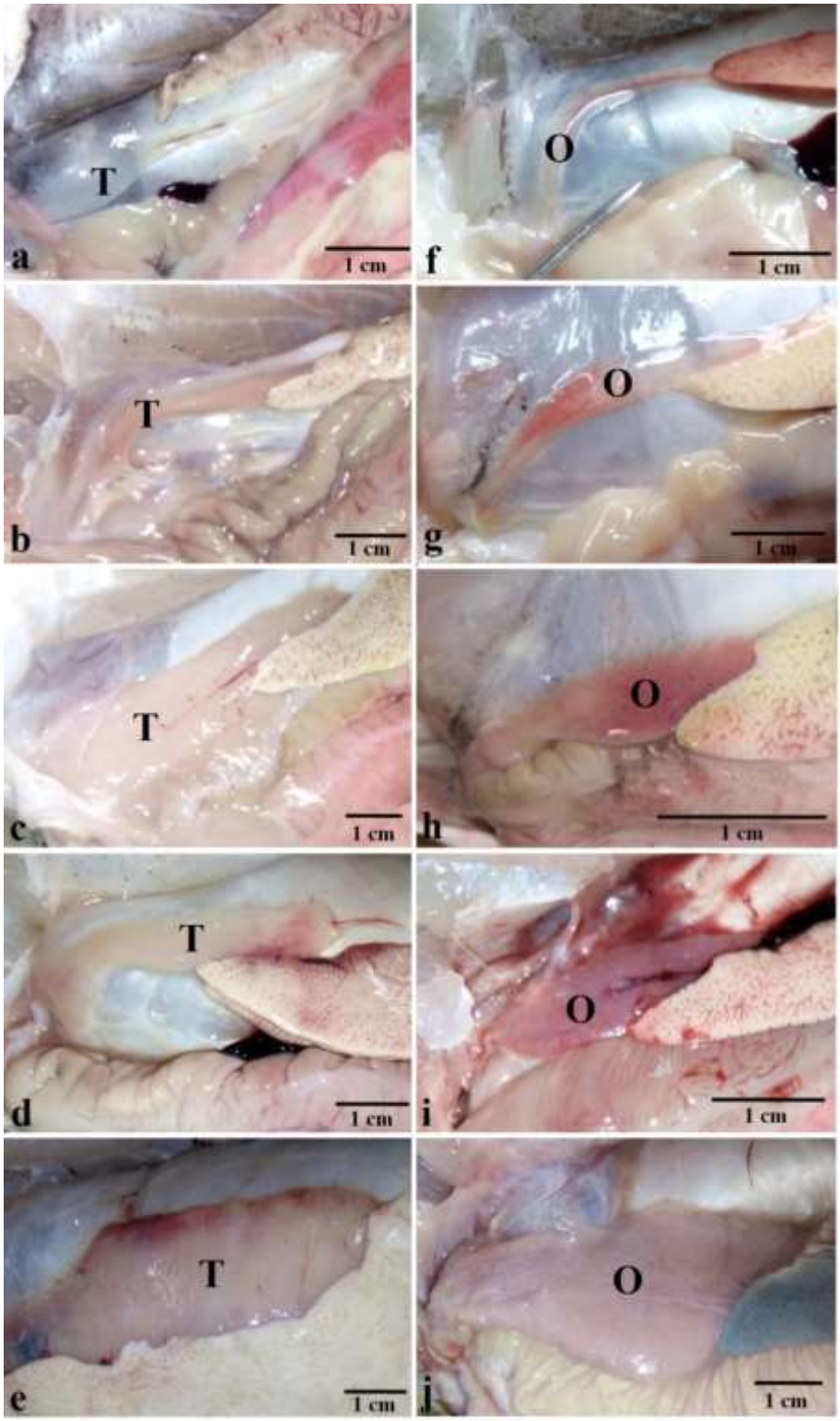

Figure 4. Macroscopic characteristics of the testes (a-e) and ovaries (f-j) of the Blue-barred parrotfish *Scarus ghobban*. T: Testes, O: Ovaries, a and f: MS II, b and g: MS III early, c and h: MS III late, d and i: MS IV early, and e and j: MS IV late

3.2.2. Maturity stages related to the sampling period. In general, maturity stages distribution of Blue-barred parrotfish related to the sampling period was dominated by MS II. MS II, MS III and MS IV were found in almost all sampling periods (Figure 5a). Maturity stages spread randomly in each length class, but MS IV was more dominant in large length classes. Meanwhile, MS II spreads to all length classes. MS II spreads in almost all length classes (Figure 5b).

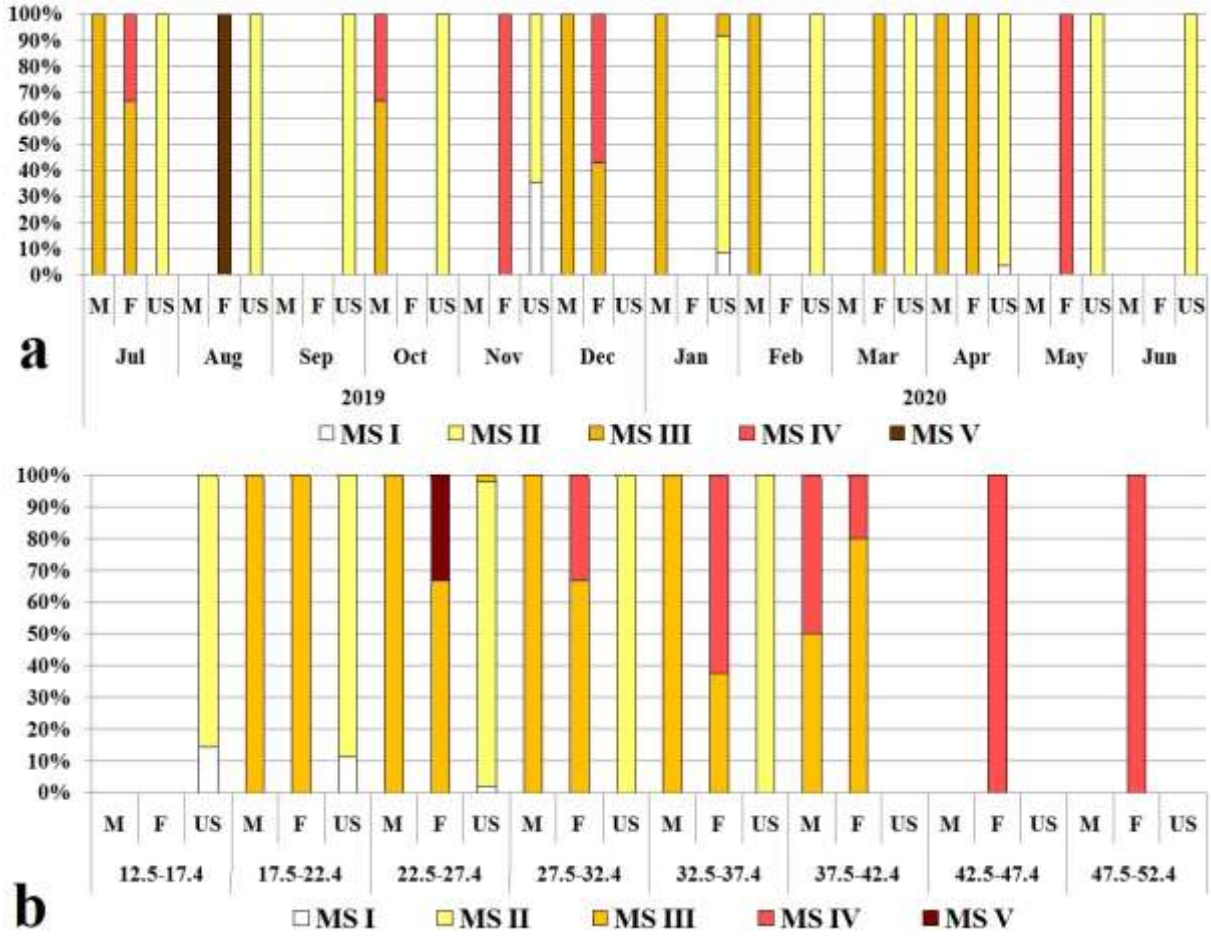

Figure 5. Maturity stages of the Blue-barred parrotfish *Scarus ghobban* related to the sampling period (a) and length class (c). MS: maturity stages

3.3. Size at first maturity

Male fish reached their first size for gonad maturation at 24.0 cm (Figure 6a), while female fish reached their first size for gonad maturation at 31.6 cm (Figure 6b).

4. Discussion

4.1. Sex ratio

Sex ratio is the ratio of males and females in a population. The sex ratio is one of the parameters in determining the availability of male and female parent stock. Besides functioning as an indicator of reproduction, sex ratio also functions as an indicator of exploitation and changes in environmental conditions; sex ratio can describe the condition of over fishing in a population [28].

The unbalanced sex ratio of Blue-barred parrotfish male and female in this study was the same as previously reported in previous studies (1:1.2), but the previously reported imbalance was greater, 1: 3.5 [29]. An unbalanced sex ratio can be caused by factors of distribution, food, density and balance of

the food chain [30]. Blue-barred parrotfish was gonochoric so that male and female Blue-barred parrotfish cannot be distinguished based on secondary characteristics.

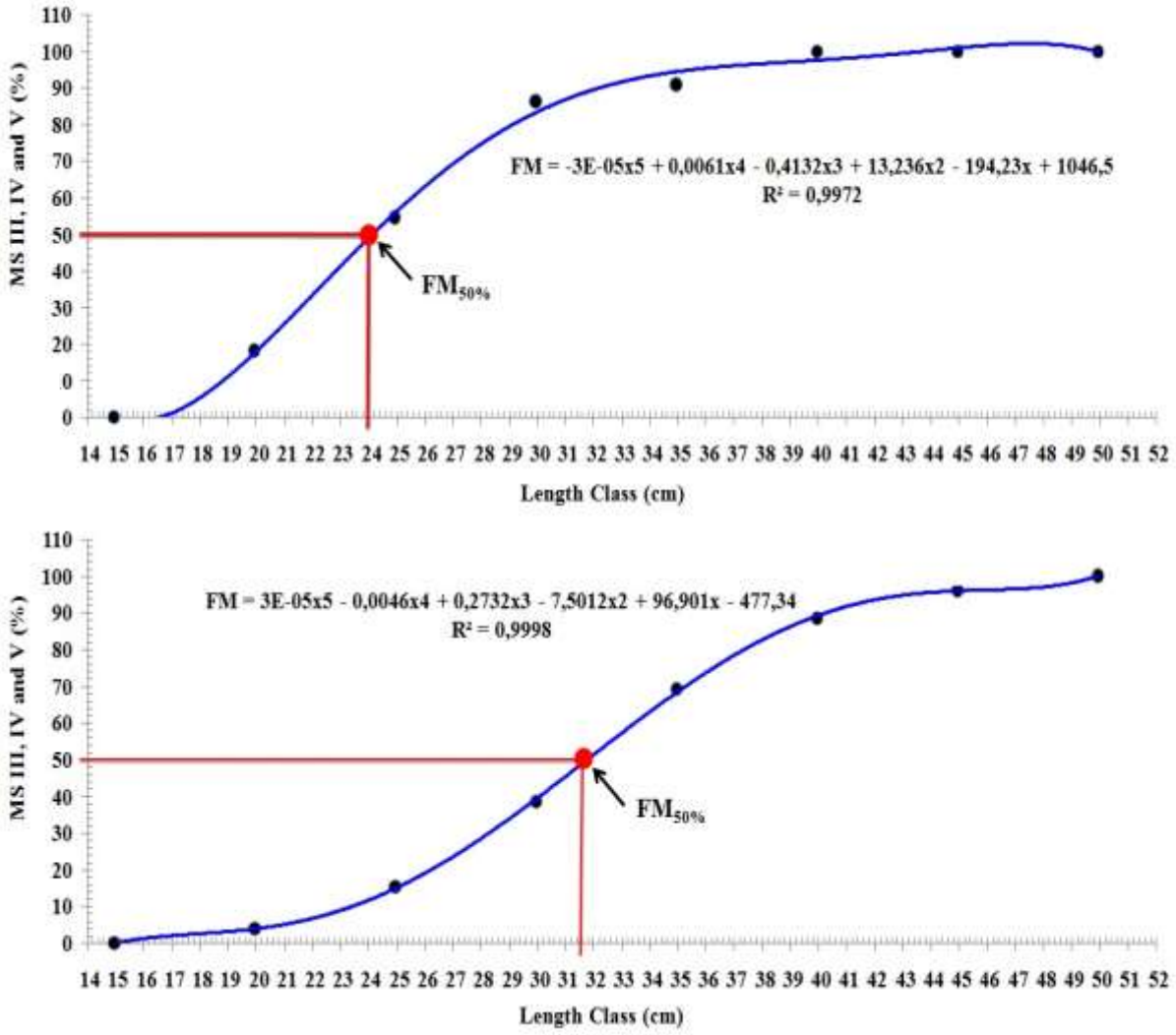

Figure 6. The size at the first maturity of Blue-barred parrotfish *Scarus ghobban* based on length class. Male fish (a) and female fish (b)

4.2. Maturity stage

Gonad maturity level can be used to predict the reproductive status of a stock [31], The more fish that are found in the mature condition of the gonads (MS IV), the stronger the indication that the exploited fish are in their peak reproductive stage [32]. Gonad maturity can be influenced by temperature and food, differences in environmental conditions, and the availability of food in a water [30]. The number of MS II found during the sampling period was strongly associated with the post-spawning period. If this is true, it will reinforce the notion that individually Blue-barred parrotfish can spawn at any time, resulting in year-round breeding. Reproductive strategies like this are often found in marine animals in tropical waters, both in other parrotfish [22, 33, 34], as well as in other reef fish [33, 35, 36], and other marine animals [37]. This reproductive strategy was very different from the fish reproductive strategy [38] and other animals [39] which live in sub-tropical and temperate.

Blue-barred parrotfish is thought to be a total spawner because the ovaries in MS V resemble a deflated bag. In the total spawner pattern, the eggs are completely removed during spawning [40]. This reproductive strategy also occurs in other parrot fish *Scarus niger* (Yanti *et al*., 2019) and other reef fish *Cheilinus fasciatus* (Tresnati *et al*., 2019) who live in the waters of Spermonde [4,27].

Previous studies have reported that Blue-barred parrotfish [23], other parrotfishes [27], and coral reef fish [33, 35, 36] was protogenic gonochoric. This was not confirmed in this study. The results of this study cannot strengthen the assumption that Blue-barred parrotfish is protogeny because the small class size of sex ratio related to the length class is dominated by males.

4.3. Size at first maturity

Size at first maturity is the basis for determining the fish smallest size that may be caught. In this study, the size at the first maturity of Blue-barred parrotfish at the males was smaller than the females. The size at first maturity of Blue-barred parrotfish was larger than other reef fish which were relatively the same size in nature [29]. Size at first maturity is not the same for each species because many factors can influence it, for example latitude. The difference in size at first maturity will increase with increasing degrees of latitude. Each additional five degrees, will cause a difference in size and age at the first maturity [30]. The smaller size at first maturity of males than females strengthens the previous suspicion that Blue-barred parrotfish are not protogenic, and strongly suspected that Blue-barred parrotfish was not hermaphrodite protogynous, but dioecious. This is just a preliminary suspicion, more detailed studies are ongoing.

5. Conclusion

The sex ratio of Blue-barred parrotfish was not balanced. This study cannot reinforce the previous assumption that Blue-barred parrotfish was protogeny because the distribution of sex ratio related to the length class was dominated by males. This study cannot also reinforce the previous assumption that Blue-barred parrotfish is protogeny because the distribution of sex ratio related to the length class was dominated by males. The size at first maturity of the male Blue-barred parrotfish is 24.0 cm and the female is 31.6 cm. Small length class which was dominated by males, and size at first maturity of males which was smaller than females reinforces the assumption that Blue-barred parrotfish was not hermaphrodite protogynous, but dioecious.

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