



A preliminary study on the size structure and sex ratio of orange-spotted grouper (*Epinephelus coioides* Hamilton, 1822) harvested from Kwandang Bay, Sulawesi Sea, Indonesia

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ABSTRACT

Orange-spotted grouper is one of the coral reef fish has the economic value and exploited by local fisherman. Information about the size structure and sex ratio are urgent to formulate a policy for sustainability. This research aims to analyze the size structure and sex ratio of the orange-spotted grouper in Kwandang Bay. The research was conducted from December 2016 to November 2017. Sampling is carried out twice a month for one year. The total sample of orange-spotted grouper used for the analysis of the sex ratio was 149 individuals. Sample of orange-spotted grouper collected from fish landed and middlemen (grouper traders) at the Kwandang Fishing Port. Data analysis applying chi-square. The results show that males bigger than females. The sex ratio of orange-spotted grouper is 87.25 % female, 7.38 % male, and 5.37 % hermaphrodites. Orange-spotted grouper dominated by females and undergoes a gonad differentiation to male (protogynous hermaphrodite). It is concluded that The size of the male orange-spotted grouper is larger than that of the female grouper. The caught orange-spotted grouper is dominated by the female phase and undergoes a differentiation of the gonad from female to male (protogynous hermaphrodite)

Introduction

Orange-spotted grouper (*Epinephelus coioides*) is one of the widespread sources of commercial fisheries in the Western Indo Pacific Waters (Heemstra and Randall, 1993; Kuiter and Tonzuka, 2001) such as Gulf of Arabia (Tharwat *et al.*, 2005), South China Sea (Wang *et al.*, 2011), Iranian Waters (Fouroughifard *et al.*, 2017), Oman Waters (McIlwain *et al.*, 2016) and Chinese Waters (Wang *et al.*, 2011; Guo *et al.*, 2016) as well as Indonesian waters including Kwandang Bay, Sulawesi Sea (Achmad *et al.*, 2018). Kwandang Bay is one of the main bases of fishery activities in the Sulawesi Sea (Faizah *et al.*, 2014) including grouper.

Especially for orange-spotted grouper research, it is still limited, including the spawning season (Achmad *et al.*, 2019) and fecundity (Achmad *et al.*,

2020). The two pieces of information do not describe a description related to the orange-spotted grouper in Kwandang Bay. Information about biological aspects such as the size structure and sex ratio of orange-spotted grouper is a need in the provision of brood and seeds, both for aquaculture and conservation purposes (Begossi and Silvano, 2008; Williams *et al.*, 2009; Condini *et al.*, 2013).

Information related to sex ratio also serves to analyze sex changes in orange-spotted groupers. Studies on the sex ratio of orange-spotted grouper have been conducted by previous researchers such as Al Marzouqi *et al.*, (2015) and Sitepu (2014). The results showed the ratio of females was bigger than males and there was a change in sex at a certain size (Ranjeet *et al.*, 2015; Ohta and Ebisawa, 2016; Osman *et al.*, 2018).

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Sex ratio imbalance in grouper due to its protogynous hermaphrodite properties (Wyanski et al., 2000; Andrade et al., 2003; Andamari, 2005). The sex ratio for protogynous hermaphrodite fish is a female phase, transition phase, and male phase of an individual population (Ozen and Balci, 2012; Kuwamura et al., 2020). Therefore, research into the structure of size and sex ratio of orange-spotted grouper in Kwandang Bay, Sulawesi Sea to prove the assertion that orange-spotted grouper undergo sex change from female to male.

Materials and Methods

Site and fish sampling

This research was conducted from December 2016 to November 2017 in Kwandang Bay, Sulawesi Sea (Figure 1). Sampling is carried out twice a month for one year (24 times). The total sample of orange-spotted grouper used for the analysis of the sex ratio was 149 individuals. Orange-spotted grouper collected from fish landed and middlemen (grouper traders) at the Kwandang Fishing Port. Orange-spotted grouper obtained at each sampling stored in a cold box containing and then taken to the laboratory of Fish Quarantine Station, Quality Control and Safety of Fishery Products class I Gorontalo.

The total length of the orange-spotted grouper is measure above the measuring board with a scale of 0.1 cm (Figure 2). Sex ratio determined based on visual observations based on primary sexual markings based on Tan and Tan (1974) namely: the gonad maturity stage (GMS) I, II, III, and IV are the stages of gonad development in a female. In GMS VII, VIII, IX, and X are the stages of development in males.

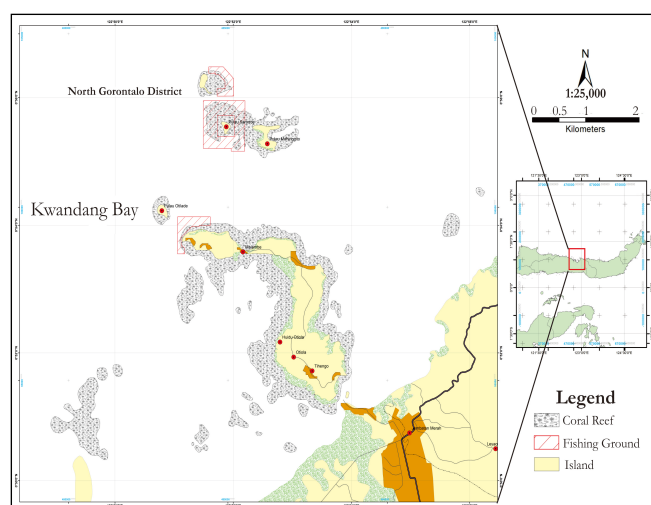


Figure 1. Orange-spotted grouper fishing ground in Kwandang Bay, Sulawesi Sea.



Figure 2. Orange-spotted grouper from Kwandang Bay.

Data analysis

Differences in male and female sex ratio of orange-spotted grouper in analysis with Chi-Square test (Zar, 2010) with formulation:

$$\chi^2 = \sum_{i=1} \frac{(O_i - E_i)^2}{E_i}$$

where O_i is the observation value, E_i is the expected value.

Results

The results showed that the total length of orange-spotted grouper (*Epinephelus coioides*) males, females and transition is 80-100 cm (90.30 ± 7.15 cm) and 17-78.5 cm (45.56 ± 15.16 cm) and 74-89 cm (78.13 ± 4.76 cm) respectively. The study found seven classes of sizes for females and three classes of male sizes (Figure 3). The dominant male orange-spotted grouper is caught in the class of 55-64 cm in size while the female in the class measures 75-84 cm.

The observation of the sex ratio of orange-spotted grouper caught around the Kwandang Bay waters from December 2016 to November 2017 consisted of 130 individuals (87.25 %) female, 11 individual (7.38 %) male, and 8 individual (5.37 %) hermaphrodites phase (Figure 4) or 16:1:1. Chi-Square's analysis showed the sex ratio between male and female each month significantly different ($\chi^2=20.02$; $df=11$; $p<0.05$).

Therefore, the study showed that the female was smaller than the male, while the transition phase was bigger than the female but smaller than the male. The ratio of males and females each month significantly different. Female caught every month while the male only caught on December, February, May, June, July, August, and September. Indicated that the orange-spotted grouper undergoes a gonad differentiation from females to males (protogynous hermaphrodites).

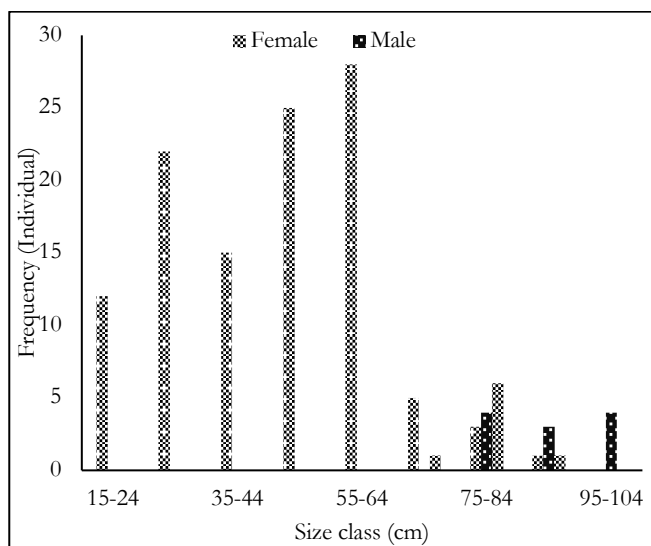


Figure 3. Total length of male and female orange-spotted grouper in Kwandang Bay.

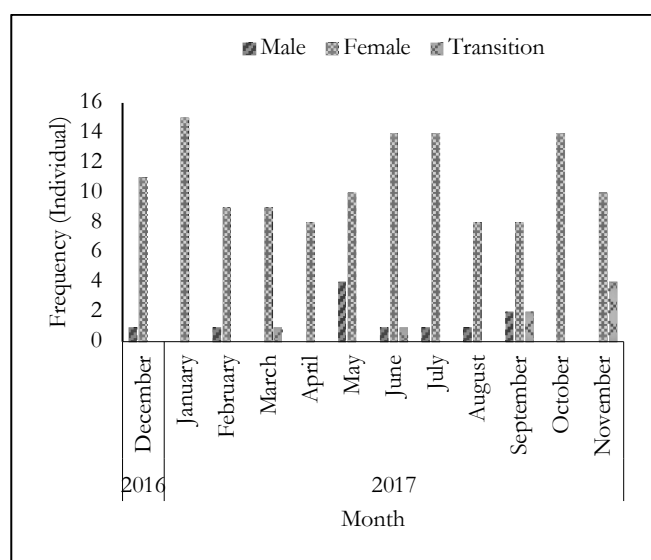


Figure 4. Sex ratio of orange-spotted grouper caught in Kwandang Bay.

Discussion

The total length of male orange-spotted grouper harvested from Kwandang Bay, Sulawesi Sea bigger than females. Similar reported in orange-spotted grouper in the Arabian Sea, Oman (Al Marzouqi et al., 2015), Southwest Atlantic Waters (Condini et al., 2014), and Australian Waters (Pears et al., 2006). However, the size of the orange-spotted grouper caught in Kwandang Bay is smaller than the orange-spotted grouper caught in the South Arabian Gulf (Grandcourt et al., 2009) and the waters of Northern Oman (McIlwain et al., 2016). The difference in grouper size caused by fishing grounds (Ernaningsih et al., 2014) and fishing gear selectivity (Pears et al., 2006; Al Marzouqi et al., 2015; Putra et al., 2020). Furthermore, the difference in male and female sizes is caused by the reproductive pattern of the orange-

spotted grouper which is classified as a protogynous hermaphrodite, where the initial phase is female then changes to male at a certain size and age. Orange-spotted grouper of protogynous hermaphrodite were also found in the Waters of Northern Oman (McIlwain et al., 2016) and the Arabian Gulf (Tharwat et al., 2005). In addition, a protogynous hermaphroditism was also reported in the white spotted grouper *Epinephelus coeruleopunctatus* harvested from Padang Bay waters, Indonesia (Bulanin et al., 2017). According to Andrade et al., (2003) and Geba (2015), coral reef fish from the Serranidae family are classified as protogynous hermaphrodite. Especially for the genus *Ephinephelus* has been widely reported classified as a protogynous hermaphrodite.

The phenomenon of sex change in protogynous hermaphrodites is caused by three factors, the first being age (Andrade et al., 2003; Condini et al., 2014). Grouper sex change from female to male in the age range of 7-12 years (Renones et al., 2010; Geba, 2015) is proven by the presence of sperm cells and eggs in its gonad tissue (Widodo, 2006). The second factor is social control where, female fish will turn into males when the population of males in nature is very small (Coleman et al., 1996). The right time for grouper to sex change during spawning season (Erisman et al., 2010). According to Pears et al., (2006) and Gaspare and Bryceson (2013), not all female groupers sex change to males even though the number of females is very dominant in a population.

Furthermore, sex changes in grouper are also caused by body weight (Warner, 1975; Mayunar, 1994). According to Achmad et al., (2019), orange-spotted grouper in Kwandang Bay with a body weight above 6,500 g have undergone a gender change from female to male. This is why on January, April, and October there are no male orange-spotted grouper because in that month no fish are caught with a body weight above 6,500 g.

In fish classified as protogynous hermaphrodites, male fish of large size can monopolize mating and small male fish are difficult to reproduce (Suharti, 1999). According to Smith (1967), the change in the sex of females to males occurs when the population between males and females is not balanced. Furthermore, according to Smith (1967) that in fish that hermaphrodite protogini, male fish are large so that it can fertilize more than one female fish. According to Suharti (1999) that protogini hermaphrodite fish can sex change at any time in their adult life until the sex ratio in the population is reached.

Conclusions

The size of the male orange-spotted grouper is larger than that of the female grouper. The caught orange-spotted grouper is dominated by the female phase and undergoes a differentiation of the gonad from female to male (protogynous hermaphrodite).

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