Sex ratio and first maturity of blackeye thicklip wrasse

*Hemigymnus melapterus* Bloch, 1791 in Spermonde Archipelago

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**Abstract.** Blackeye thicklip wrasse *Hemigymnus melapterus* is a Labridae that was widespread throughout the tropical and subtropical waters of Indo-Pacific. In eastern Indonesia, blackeye thicklip wrasse found from the Strait of Bali, Mentawai Islands, Raja Ampat Islands, Manado and surrounding areas, and Banggai; while in central Indonesia, blackeye thicklip wrasse found in the waters of the Spermonde Archipelago. This research aims to analyze the sex ratio, gonad maturity stage, and the size at first maturity of blackeye thicklip wrasse in the Spermonde Archipelago. This research was done on the population of blackeye thicklip wrasse in the Spermonde Archipelago, South Sulawesi, Indonesia. Samples were collected from fishermen caught landed in the Rajawali Makassar Fisheries Port at Makassar City. Blackeye thicklip wrasse sex ratio was not balanced. This imbalance was thought to have something to do with the "r" reproductive strategy where blackeye thicklip wrasse tries to produce as many eggs as possible to maintain its population. The success of this strategy probably supported by protogynous reproduction patterns where young fish can produce eggs as fast and as much as possible before being devoured by predators. Based on its gonad structure, blackeye thicklip wrasse could be classified as fish with a total spawning pattern that take place long spawning period or individual different spawning period throughout the year. The size at the first maturity of blackeye thicklip wrasse female was 21.4 cm; it was much smaller than half the size that has ever been caught.

1. **Introduction**

Blackeye thicklip wrasse *Hemigymnus melapterus*, Bloch. 1791 is a Labridae family [1,2] that can reach 50 cm in the body length. Blackeye thicklip wrasse is widespread throughout the Indo-Pacific tropical and subtropical waters, from the east coast of Africa including the red sea to Polynesia, and Southern Japan [2,3]. Blackeye thicklip wrasse can live at a depth of 1 to 30 m and like coral areas such as coral debris, sand and the outer part of coral cliffs [4]. In Indonesia, blackeye thicklip wrasse is found starting from the strait of Bali, Mentawai Islands, Raja Ampat Islands, Manado and surrounding areas, and Banggai [4], and Spermonde Islands waters [5].
Spermonde Islands are located in the Makassar Strait, South Sulawesi Province. This archipelago is one of the fishing areas which cover about 2,500 km². Spermonde Islands is the habitat of high diversity reef fish [5-8]. In the Spermonde Islands there are 120 islands with a total human population of around 50,000 people whose livelihoods depend directly or indirectly on fish catches [5].

These blackeye thicklip wrasse live solitaire or in small groups. Blackeye thicklip wrasse is a benthic predator that mainly consume small marine invertebrates such as crustaceans, mollusks, worms and echinoderms [4]. Blackeye thicklip wrasse has an important role in controlling the growth and development of corals because it can reduce or prey on coral competitors attached to coral branches, that is why this Blackeye thicklip wrasse can be considered as an indicator of coral conditions [9].

Blackeye thicklip wrasse is associated with coral [10] so it has an important ecological role in coral ecosystems. Blackeye thicklip wrasse has also an important economic role because at the time of blackeye thicklip wrasse classified as sea water aquarium fishes, while the large-sized fish, 30-40 cm is traded in the market for local consumption [5].

Previous study indicated that ecologically, blackeye thicklip wrasse has been studied extensively, such as parasitic aspects [11-24], species diversity [5], habitat and distribution [4, 25], taxonomy [26], recruitment [27], mortality [28], predator [29, 30], behavior [31], physiology [32], and genetic [33, 34]. The previous studies indicated that reproductive biology blackeye thicklip wrasse has not been studied. In Indonesia, especially in the Spermonde Islands, there have never been the results of previous studies that examined the biological aspects of blackeye thicklip wrasse. Therefore it is necessary to analyze the reproductive biology of blackeye thicklip wrasse in the Spermonde islands waters. This study aims to analyze aspects of reproductive biology including sex ratio, maturity stages, and the size of the first maturity of blackeye thicklip wrasse in the Spermonde Islands waters.

2. Materials and Methods
Blackeye thicklip wrasse samples were collected at Rajawali Makassar Fisheries Port, Makassar City (Figure 1) every mid-month. Based on the participatory mapping involving fishermen who landed fish at TPI Rajawali, it was known that blackeye thicklip wrasse originates from nine fishing locations in the Spermonde Islands, namely the waters around of Lumu-lumu, Lanyukang, Bonebatang, Panambung, Langkai, Kodingarengkeke, Kodingarenglompo, Barranglompo, and Barrangcaddi (Figure 2). After the interviews with fishermen at Rajawali Makassar Fisheries Port, it was found that blackeye thicklip wrasse was captured using nets, spears and fishing rods. Fishing can be done by fishermen every day of the year. The parameters measured were total body length, body weight, gonad weight, and gonad length. The observed aspects were sex, gonad colour, gonad structure, and gonad development. The analyzed aspects were sex ratio, maturity stages, and first maturity. Weight measurements were carried out using scales with the accuracy of 0.01 g.

Sex ratio was calculated using equations: \[ NK = \frac{\Sigma J}{\Sigma B} \] where: NK = sex ratio, \( \Sigma J \) = number of males, \( \Sigma B \) = number of female. The sex ratio significance was tested by using chi-square [35] and data arranged in the form of a contingency table [36].

Maturity stages were determined morphologically by observing the gonad colour, gonad length, and gonad weight. Maturity stages determination refers to other wrasse C. fasciatus that live in the Spermonde Island waters [37]. Maturity stage distribution was analyzed based on sampling period and length classes distribution.
Figure 1. Blackeye thicklip wrasse *Hemigymnus melapterus* during measuring parameters in the laboratory (a-b) and in their habitat (Randall, 2013) (c) and (Kretzberg, 2011) (d).

Figure 2. Participatory map of capture areas of blackeye thicklip wrasse *Hemigymnus melapterus* in the Spermonde Islands, South Sulawesi, Indonesia

First maturity is estimated based on length where 50% (L₁₅₀) of adult mature (MS III, IV, and V) [38], according to the equation: L₁₅₀ = L₅₀, where: L₅₀ was the total length at 50% of the samples were mature.
3. Results

3.1. Sex Ratio
During the study, 78 were collected, consisting of 2 males, 51 females and 25 sexes unidentified. The sex ratio between males and females was 1: 25.50, unidentified and female was 1: 2.04, and male+unidentified and female was 1: 1.89 (Figure 2). The statistical test indicated that the three sex ratios based on the sampling time were significantly different (P <0.05). Sex ratios based on maturity stage and length classes show the female dominance (Figure 4). The statistical test indicated that the three sex ratios based on the maturity stage and length classes were significantly different (P <0.05).

![Figure 3. Sex ratio of blackeye thicklip wrasse Hemigymnus melapterus related to sampling period for female, male and unidentified](image)

![Figure 4. Blackeye thicklip wrasse Hemigymnus melapterus sex ratio related to maturity stage for female, male and unidentified sex(a), and length classes (b)](image)

3.2. Maturity Stages
During the study, females were dominants, especially MS III and IV. The ovaries colors were red-orange to brownish red (Figure 5).
Figure 5. Macroscopic characteristics of blackeye thicklip wrasse *Hemigymnus melapterus* female at the MS IV early (a) MS IV late (b). O: Ovary.

Monthly sampling indicates that the maturity stage present variedly (Figure 6). Maturity stages present variedly in each length class, where the MS II (unidentified maturity stages) and MS IV (mature) were dominant (Figure 7).

Figure 6. Maturity stages blackeye thicklip wrasse *Hemigymnus melapterus* related to sampling period.

Figure 7. Maturity stages blackeye thicklip wrasse *Hemigymnus melapterus* related to length classes.

3.3. *First Maturity*

The first maturity in males was not estimated because the number of males found in the sample was too small. Females reach the first maturity at a length of 21.4 cm (Figure 6).
Figure 8. First maturity blackeye thicklip wrasse *Hemigymnus melapterus* at the female related to length classes.

4. Discussion

4.1. Sex Ratio

The presence of females dominantly indicates an imbalance of population structure in blackeye thicklip wrasse. This sex ratio imbalance in blackeye thicklip wrasse has never been reported before. The imbalance of sex ratio on reef fish that has been previously reported was on *Scarus rivulatus*, with male and female ratios being 1:3.5 [39]. In reproductive terms, this imbalance sex ratio indicated that blackeye thicklip wrasse population is likely to have a "r" reproductive strategy, a strategy in which blackeye thicklip wrasse population tries to produce as many eggs as possible to maintain their population. This strategy is needed to face very high competition in coral reef ecosystems. Very high competition in the coral reef ecosystem caused a shorter lifetime, so that there is a possibility that reef fish will choose the reproductive pattern of protogyny. This reproductive pattern allows the young fishes to produce eggs as fast and as much as possible before being devoured by predators. Sex ratio imbalance due to protogyny does not interfere with the reproduction process and population survival because naturally, the male can produce enough sperm to fertilize eggs produced by many females.

If blackeye thicklip wrasse is assumed to be a protogyny, and the MS II under the smaller size of male assumed to be female, and MS II which is larger than male assumed to be male, then the sex ratio distribution will show a transition from female domination to males in larger length classes. This assumption makes the appearance of Figure 4b become look like Figure 9. Figure strengthens the suspicion that blackeye thicklip wrasse is protogyny.

Alleged protogyny on blackeye thicklip wrasse still needs further study through a histological approach. Protogyny was a reproductive pattern often found in reef fish [40]. In protogyny, female fish will turn into a male after a reproductive period ends [41]. Other than hermaphroditism, sex ratio can also be influenced by many factors, such as behavior, growth patterns, mortality rates, and differences age at the first maturity [42].

4.2. Maturity Stages

The macroscopic characteristics of MS IV gonad walls were very thin and resembled the empty bag after spawning (MS V) lead to the assumption that blackeye thicklip wrasse is the total spawning pattern, where during spawning all gametes are removed. Marine organisms that have a total spawning pattern generally absorb gonads that have gone through a reproductive cycle and then form new
gonads [43]. This assumption is supported by the difficulty of distinguishing between MS V and MS II because in post-spawning, the gonad size was very small and assumed as MS II.

![Sex ratio distribution at the blackeye thicklip wrasse Hemigymnus melapterus related to the protogynous assumption, and unidentified incorporation into females and males.](image)

*Figure 9.* Sex ratio distribution at the blackeye thicklip wrasse *Hemigymnus melapterus* related to the protogynous assumption, and unidentified incorporation into females and males.

The presence of MS IV for most of the year and MS V in some sampling periods indicated that there was a possibility that blackeye thicklip wrasse has an annual reproduction cycle with a long spawning process or different individual spawning times throughout the year. The blackeye thicklip wrasse spawning period looks like similar to other wrasses spawning periods [44]. Spawning wrasses have something to do with the lunar cycle [45], and habitat use [46]. Although, in certain fish families, spawning can occur several times [47], however, the suspicion of a long spawning process or different individual spawning times throughout the year on blackeye thicklip wrasse population still requires further study through observing the gonad microscopic structure and distribution of egg size.

The presence of fewer male was thought to have something to do with MS II, which was mostly found during one-year sampling. In MS II, the gonad size was still too small, so it was difficult to identify the sex. This is the case with other wrasse species, where at the early stages of gonad maturation, MS I, II and III in males are very difficult to distinguish macroscopically because the gonad size is still very small [37]. The complexity of the development of maturity stages causes the differences or variation in determining the phases of gonad development, especially in maturation and post-spawning stages in wrasses, fish and other marine organisms [43, 48-52].

4.3. First Maturity

The first maturity was only estimated at the females because the number of males found during sampling was not enough to analyze the size at first maturity. The first maturity which was 21.4 cm, it was relatively small compared to the maximum size that can be achieved by blackeye thicklip wrasse in nature, which was 90 cm [53] or the maximum size of blackeye thicklip wrasse ever caught, which is 50 cm [4].

Even it was never reported before about the first maturity, but the first maturity of blackeye thicklip wrasse was smaller than other species of wrasse, such as *Cheilinus undulatus*, that have the first maturity 45-50 cm at the female, and 70 cm at the male [54]. The first maturity, besides being influenced by biological factors, it is also influenced by environmental factors that differ from one geographical condition to another [55].
5. Conclusion

Blackeye thicklip wrasse sex ratio was not balanced. This imbalance was thought to have something to do with the "r" reproductive strategy where blackeye thicklip wrasse tries to produce as many eggs as possible to maintain its population. The success of this strategy probably supported by protogyny reproduction patterns where young fish can produce eggs as fast and as much as possible before being devoured by predators. Based on its gonad structure, blackeye thicklip wrasse could be classified as fish with a total spawning pattern that takes place long spawning process or different individual spawning times throughout the year. The size at the first maturity of blackeye thicklip wrasse female was 21.4 cm; it was much smaller than half the size that has ever been caught.

Acknowledgment

We would like to thank Universitas Hasanuddin for providing research funding (contract number 1585/UN4.22/PT.01.03/2020 dated May 27th, 2020).

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