Maturity stages of the redbreasted wrasse *Cheilinus fasciatus*

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**Abstract.** The redbreasted wrasse *Cheilinus fasciatus* is an ornamental fish exploited for the marine aquarium trade. Even though it has white flesh, the redbreasted wrasse is not popular as a food fish because the flesh is quite thin. The redbreasted wrasse is widely distributed in the Indian and Pacific Oceans. It lives in tropical waters at depths of 4 to 60 m and at temperatures of 23 to 27°C. The objective of this study was to describe the gonad maturity stages of this fish using macroscopic characteristics. Sampling was carried out at Makassar Fishing Port from January 2018 to May 2019. The parameters observed in both male and female specimens were gonad length, width, weight, and gonad colour. Each specimen was also weighed and measured. Five gonad maturity stages were identified and described: Stage I (Immature or transition), Stage II (Early maturation), Stage III (maturation), stage IV (mature) and Stage V (post spawning or spent). These stages were described based on macroscopic structure and morphometric parameters of the gonads. The five stages coincided with changes in the Gonadosomatic Index (GSI), indicating that the five stages were valid. These stages could be used as a practical reference for identifying gonad maturity and describing the reproductive cycle of the redbreasted wrasse *C. fasciatus*.

1. **Introduction**

The redbreasted wrasse *Cheilinus fasciatus* is a marine fish native to the Indian Ocean and the western Pacific Ocean. The redbreasted wrasse lives in association with corals at a depth of 4 to 60 m [1], more typically 4 to 40 m, in tropical waters with mean temperatures from 23°C to 27°C [2]. The distribution of the redbreasted wrasse extends from 32 ° N - 36 ° S, and 24 ° E - 170 ° W, from the Red Sea and East Africa to Micronesia and Samoa, and north to the Ryukyu Islands [2,3] (Figure 1).

The redbreasted wrasse is marketed in small numbers, and occasionally seen in the marine aquarium trade [4]. Redbreasted wrasse feed mainly on benthic, hard-shelled invertebrates, including molluscs, crustaceans and sea urchins [5]. The redbreasted wrasse is oviparous, with pair formation before breeding [6]. *Cheilinus fasciatus* is similar to *Cheilinus quinquecinctus*, a wrasse endemic to the Red Sea [7].

Previous research has examined several aspects of redbreasted wrasse bioecology, such as energy and oxygen consumption [8], biochemical photo adaptation in vision [9], morphometric characters [10], biometry [11], biomechanics [12], ecomorphology of locomotion [13] population dynamics [14],
and courtship and spawning behaviour [15]. However, there do not appear to be any reports or studies on redbreasted wrasse reproductive biology or quantitative studies on *Cheilinus fasciatus*.

Figure 1. The redbreasted wrasse (left) and its distribution in the Indo-Pacific (right).

Quantitative studies require practical and valid reference standards. Determining reference standards, for example regarding maturity phases, requires comprehensive research. The objective of this study was to describe the maturity stages of the redbreasted wrasse *Cheilinus fasciatus* based on gonad macroscopic characteristics. The descriptive stages were further validated using a quantitative parameter, the Gonadosomatic Index. This paper is one output from a long-term monitoring program to analyse the impact of global warming and climate change on the reef fish community which has been ongoing since 2014 in the Spermonde Islands, South Sulawesi, Indonesia.

2. Materials and Methods
Sampling was carried out at Makassar Fishing Port from January 2018 to May 2019. Makassar Fisheries Port is a principle fish landing site for fisheries in the Makassar Straits (Figure 2). The Makassar Strait region is one of the main fishing grounds in Indonesia [16].

The parameters measured for both male and female specimens were gonad length, width and weight, while gonad colour and condition were also observed. The total length (TL) and weight of the fish were also measured. The length was measured with a precision of 1 mm, while the weight was measured with a precision of 0.01 g.

The gonad maturity stages were determined by using macroscopic characteristics, namely gonad morphometric characters, gonad condition and gonad colour. Gonad maturity stages were validated using the Gonadosomatic Index (GSI). GSI was calculated using the formula in [17]:

\[
GSI = \left( \frac{\text{Gonad weight}}{\text{Body weight}} \right) \times 100
\]
3. Results

3.1. Maturity stage

The redbreasted wrasse is dioecious, but sex was not easily differentiated in the early stages of gonad development and after spawning. Gonads were very small in the early stages. The maturity stages became easily identifiable at Stage III and IV.

3.1.1. Macroscopic characteristic of stage I - Immature or Transition. The immature stage was only found in small fish $\pm 9.9 \text{ g}$ that had never developed ripe gonads. In this stage, the gonad was very small, resembling a thread (Figure 3) with a weight less than 0.05 g. GSI was around 0.06% (Table 1). Specimens with immature gonads were found in July, August and September 2018. In Stage I, the gonad was transparent in colour, small and smooth with a diameter of less than 1 mm (Figure 3). Testes and ovaries cannot be distinguished macroscopically in this phase.

| N=28 | Total Length (mm) | Body Weight (g) | Gonad Weight (g) | GSI |
|------|-------------------|-----------------|------------------|-----|
| Mean | 148               | 45.00           | 0.03             | 0.06|
| SD   | 23                | 9.19            | 0.01             | 0.03|
The transition stage was found in large fish (283.98±114.18g) which had already spawned, just before entering the early maturation stage. The structure and size of the gonads, and the GSI value were similar to the immature stage (Table 2). The transition stage was found in February, April, October and December.

Table 2. Morphometric and reproductive parameters of redbreasted wrasse Cheilinus fasciatus in Stage I – Transition.

| N=8 | Total Length (mm) | Body Weight (g) | Gonad Weight (g) | GSI |
|-----|------------------|-----------------|------------------|-----|
| Mean| 273              | 283.98          | 0.02             | 0.01|
| SD  | 49               | 114.18          | 0.01             | 0.00|

3.1.2. Macroscopic characteristics of Stage II - Early Maturation. In the redbreasted wrasse, the maturation stage was divided in two, namely early maturation (Stage II) and maturation (Stage III). This distinction was made because the maturation process is quite long. In specimens at Stage II, it was still difficult to distinguish between testes and ovaries, both of which were light brown in colour (Figure 4). Gonad weight ranged from 0.01 to 0.49 g (0.05±0.05) with mean ± standard deviation (SD) GSI of 0.05±07. Specimens in Stage II were found throughout the year, except in November.

Table 3. Morphometric and reproductive parameters of redbreasted wrasse Cheilinus fasciatus in Stage II - Early Maturation.

| N=222 | Total Length (mm) | Body Weight (g) | Gonad Weight (g) | GSI |
|-------|------------------|-----------------|------------------|-----|
| Mean  | 204              | 135.49          | 0.05             | 0.05|
| SD    | 40               | 77.65           | 0.05             | 0.07|
3.1.3. **Macroscopic characteristics of Stage III - Maturation**. The gonad colour was milky white for males, orange amber or brown for females (Figure 5). The gonad weight range was 0.04-0.88 g (0.22±0.20), with a mean GSI of 0.19±0.30 (Table 4). Stage III specimens were found in most months throughout the year, the exceptions being January and May.

| N=57 | Total Length (mm) | Body Weight (g) | Gonad Weight (g) | GSI |
|------|-------------------|-----------------|------------------|-----|
| Mean | 222               | 162.06          | 0.22             | 0.19|
| SD   | 43                | 78.67           | 0.20             | 0.30|

3.1.4. **Macroscopic characteristics of Stage IV - Maturity (Ripe)**. The gonad colour was milky white in males, orange amber to reddish brown in females (Figure 6). The gonads were larger and firmer in texture. Gonad weight range was 0.08-3.50 g (0.82±0.65) (Table 5). The weight of the gonads varied with the size of the fish. At this stage, the Gonadosomatic Index increased rapidly, reaching 0.82±0.66. If the gonad was slashed with a scalpel, sperm and ova flowed out. Stage IV specimens were found throughout the year, except in November.
Table 5. Morphometric and reproductive parameters of redbreasted wrasse *Cheilinus fasciatus* in Stage IV – Maturity.

| N=118 | Total Length (mm) | Body Weight (g) | Gonad Weight (g) | GSI  |
|-------|-------------------|-----------------|------------------|------|
| Mean  | 198               | 144.13          | 0.86             | 0.82 |
| SD    | 49                | 85.33           | 0.62             | 0.66 |

Figure 6. Macroscopic characteristic of testes (left) and ovaries (right) of Stage IV redbreasted wrasse *Cheilinus fasciatus* (Scale line = 1 cm).

3.1.5. Macroscopic characteristics of Stage V – Post Spawning (Spent) or Resting. The size of the gonads in males and females has decreased in Stage V specimens. The gonad appears shrunken, flat and wrinkled, and the colour has turned brown. In males, remnants of sperm were sometimes still present in the testes. In stage V, gonad size and weight have decreased dramatically compared to Stage IV, with an average weight of $0.21 \pm 0.21$ g, and a diameter of 0.3-0.6 mm (Table 6). Stage IV specimens were found throughout the year, except in November.

Table 6. Morphometric and reproductive parameters of redbreasted wrasse *Cheilinus fasciatus* in Stage V – Post Spawning (Spent) or Resting.

| N=11  | Total Length (mm) | Body Weight (g) | Gonad Weight (g) | GSI  |
|-------|-------------------|-----------------|------------------|------|
| Mean  | 206               | 141.64          | 0.21             | 0.19 |
| SD    | 40                | 72.27           | 0.21             | 0.23 |

Figure 7. Macroscopic characteristic of testes (left) and ovaries (right) of stage V redbreasted wrasse *Cheilinus fasciatus* (Scale line = 1 cm).
3.2. GSI Curve
The GSI curve shows a progressive increase from stage I to stage IV, followed by a sharp decrease between stage IV and stage V. In stage IV, the standard deviation was very large (Figure 8).

![Figure 8](image_url)

**Figure 8.** Changes in the Gonadosomatic Index of redbreasted wrasse *Cheilinus fasciatus* from gonad maturity stage I to stage V.

4. Discussion
The five maturity stages distinguished based on macroscopic characteristics were quite effective in describing gonad development. In practice, maturity stages III, IV and early Stage V, the maturity stage and sex of each specimen were readily identifiable. The determination of maturity stages I, II and late Stage V was more challenging. In these stages, the gonads were so small that caution was needed in determining the stage, and male and female gonads could not be clearly differentiated. In these three phases, sex determination was therefore difficult because redbreasted wrasse do not exhibit sexual dimorphism (e.g. colouration), so there were no secondary sex-related characters that could be used in sex determination. Male and female redbreasted wrasse can only be distinguished when entering Stage III.

Based on the macroscopic structure of the gonads during the spawning period, it appears that the redbreasted wrasse is a total spawner. In organisms with this reproductive strategy, any remaining gametes and the walls of the testes and ovaries are absorbed after spawning. The next reproductive cycle begins with the formation of new testicles and ovaries. This reproductive pattern generally occurs in organisms with "r" type reproduction strategies [18]. This reproductive strategy also occurs in other marine organisms such as sea cucumbers [19,20].

The description of the maturity stages for redbreasted wrasse based on macroscopic characters aligned well with the GSI, which increased progressively during gonad development from Stage I to IV. This increase reflects the increase in gonad mass during the formation of gametes in the gonads. The increase in standard deviation in Stages III and IV can be considered normal because the reproductive capacity of each group was different [21,22]. Such variation is common in aquatic organisms [9,23]. Standard deviation was also quite large in Stage V; this variation reflects the amount of gametes remaining in the spent testes and ovaries.

Organisms with a total spawner reproductive strategy or pattern tend to have a sharper post-spawning decrease in GSI compared to fish with a partial spawner strategy [16,24]. Partial spawning fishes have a long spawning period, so that for certain species there are two gonad maturity stages over the spawning period, namely spawning and post spawning [25]. But for some partial spawning fish it is considered that there is only one spawning stage (stage V), for example *Thunnus albacores* [16]. In *T. albacores* the maturation process continues after spawning for the gametes that have not yet been spawned.
5. Conclusion
This study identified five gonad maturity stages in the redbreasted wrasse *C. fasciatus*, namely: Stage I (Immature or transition), Stage II (Early maturation), Stage III (maturation), stage IV (maturity) & Stage V (post spawning. These maturity stages were identified based in the macroscopic structure and morphometric parameters of the gonads. The five classifications were compatible with the observed pattern of change in the Gonadosomatic index (GSI). This good fit with GSI indicates that the five stages are valid and can be used as a practical reference for the identification of gonad maturity stages and to describe the reproductive cycle of the redbreasted wrasse *C. fasciatus*.

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