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Reproductive Biology and Sustainable Management of Round Scad (*Decapterus ruselli*) in the Sunda Strait

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ABSTRACT

The round scad (*Decapterus russelli*) is a commercially valuable fish species in the Sunda Strait, requiring sustainable management to prevent overexploitation. This study examined its reproductive biology, including first gonadal maturation size, gonadal maturation index, fecundity, and spawning patterns, to support conservation efforts. Findings indicate that female round scad reach gonadal maturity at 187mm, while males mature at 19mm. The species follows a partial spawning pattern, with peak spawning activity observed in May and July. The fecundity of round scad varies significantly, ranging from 1,774 to 196,031 eggs, influenced by body weight. The gonadal somatic index (GSI) fluctuates, with females exhibiting higher values than males, peaking in May. Sustainable management strategies include implementing a minimum catch size of 187mm, adjusting fishing net mesh sizes to 1.4 inches, and enforcing seasonal closures during peak spawning months. Effective fisheries management requires collaboration between local authorities, fisheries officers, and fishing communities. By adopting science-based conservation measures, the long-term sustainability of round scad resources in the Sunda Strait can be ensured.

INTRODUCTION

Small pelagic fish are a diverse group of species that form schools and exhibit free-swimming behavior, engaging in both vertical and horizontal migrations toward the surface. They are characterized by relatively small body sizes and often constitute the largest portion of fish biomass in marine ecosystems **(Fréon *et al*., 2005; Pennino *et al*.,**

2020). These fish play a vital role in Indonesia's fishing economy, accounting for approximately 75% of the total fish stock, equivalent to 4.8 million tons per year **(Hendiarti *et al*., 2005; Sadiyah *et al*., 2012)**. The Sunda Strait, a key marine region in Indonesia, holds significant potential for small pelagic fish, contributing to 30% of the fisheries production in the Banten Province **(Boer & Aziz 2007; Irnawati *et al*., 2021)**. Within this region lies Pandeglang District, home to PPP Labuan, a coastal fisheries port. PPP Labuan is a crucial fish landing site, with one of the most prominent small pelagic species caught being the round scad (*Decapterus russelli*). Round scad is a primary target of purse seine fisheries in the Java Sea, constituting 60% of the total catch of small pelagic fish species **(Aziz *et al*., 2000)**.

The high economic value and utilization potential of round scad have led to intensive fishing activities, prompting stakeholders in the fishing industry to maximize exploitation, often without sufficient consideration for fishery sustainability. According to **Octoriani (2015)**, growth overfishing affects 35% of female and 37% of male round scad. Growth overfishing occurs when fish are caught before reaching maturity, preventing them from contributing to the population. As defined by **Caillouete *et al*. (2009)**, growth overfishing happens when fishing pressure is too high, leading to the harvest of individuals before they reach the size required for maximum sustainable yield. Similarly, **Diekert (2010)** describes growth overfishing as the excessive and inefficient harvesting of small fish. The high exploitation rate, declining stock conditions, and limited knowledge of round scad reproductive biology raise serious concerns about the sustainability of this fishery. Therefore, this study aimed to examine the reproductive biology of round scad, focusing on key parameters such as the length-weight relationship, condition factor, sex ratio, gonadal maturity stage, gonadosomatic index, fecundity, and egg diameter. The findings of this study will provide valuable insights for designing effective fisheries management strategies to ensure the optimal and sustainable utilization of round scad resources.

MATERIALS AND METHODS

1. Study site

The fish used in this study were obtained from the catches of local fishermen in the Sunda Strait Waters and landed at the PPP Labuan, Pandeglang, Banten. The round scad fishing area was located in the vicinity of the Sunda Strait (Fig. 1). Fish samples were analyzed at the Fisheries Biology Laboratory, Department of Natural Resource Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University.

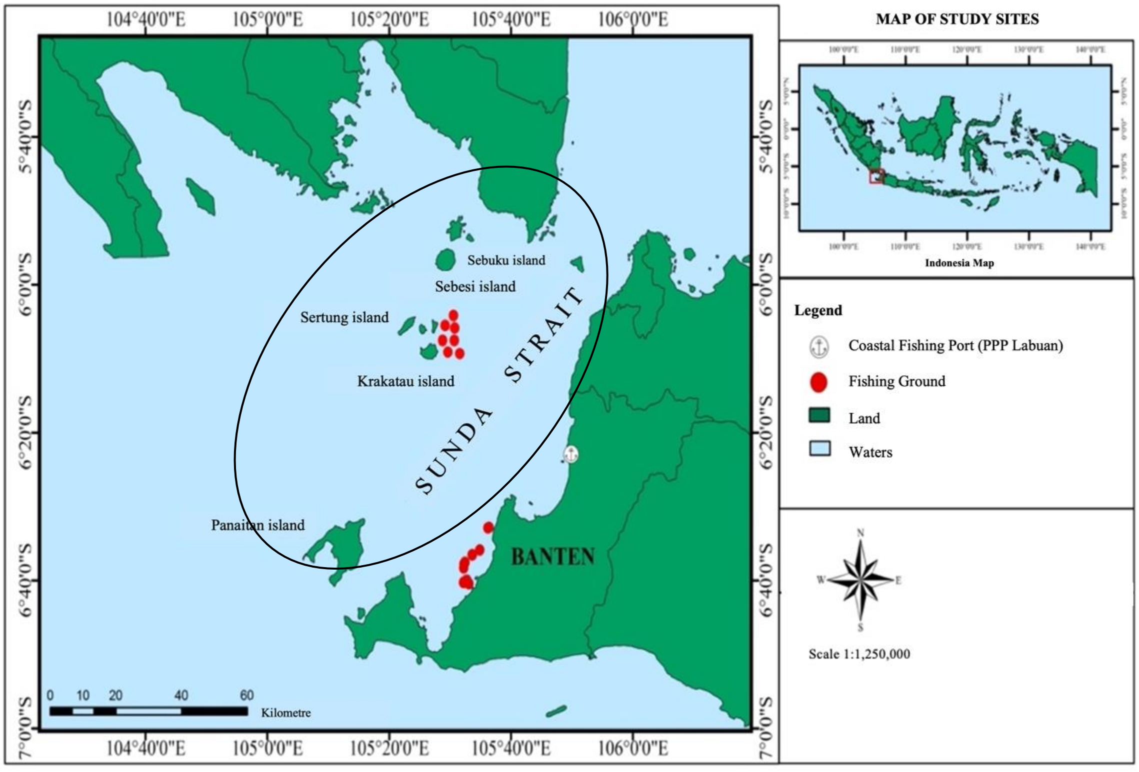

Fig. 1. Map of round scad catch locations in the Sunda Strait Waters

2. Data collection

This study employed a field survey method to assess the reproductive conditions of round scad in the Sunda Strait. Data were collected using a stratified random sampling technique over a period of five months, with a sampling interval of 30 days. A maximum of 200 individual fish were sampled per collection period and transported to the laboratory for analysis.

3. Laboratory analysis

In the laboratory, round scad samples were analyzed monthly. Total length (mm) was measured from the tip of the head to the end of the rearmost fin ray, while body weight (grams) was recorded. The fish were dissected to examine their reproductive organs, and gender was determined through morphological observation of the gonads. The gonadal maturation stage was determined based on a modified Cassie method **(Effendie, 2002)**. Gonads were extracted, weighed using a high-precision balance (accuracy: 0.0001g), and preserved in 4% formalin. The preserved gonads were divided into three sections (anterior, middle, and posterior), with each section weighed separately. Subsamples were taken from each section, diluted with 10ml of distilled water, and used to estimate fecundity. Egg diameters were measured in three regions (anterior, middle, and posterior) using a microscope with an ocular micrometer calibrated against an objective micrometer.

4. Data analysis

4.1. Length-weight relationship

The relationship between length and weight was modelled using an exponential equation **(Effendie, 1979)**:

$$W = a L^b$$

Where:
W = weight (g), L = length (mm), a and b = constants.

A linear transformation of this equation is:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

The parameters a and b were estimated via linear regression, with log L as the independent variable and log W as the dependent variable. The coefficient of determination (R^2) and correlation coefficient were calculated. A t-test **(Walpole, 1993)** was used to test for isometric (b = 3) vs. allometric (b ≠ 3) growth, using the hypotheses:
H_0: b=3 (isometric growth: proportional weight-to-length increase)
H_1: b≠3 (allometric growth: disproportionate length or weight increase)
If:
b<3 → Negative allometric growth (length increases faster than weight)
b>3 → Positive allometric growth (weight increases faster than length)

4.2. Condition factor

The condition factor (K) assesses fish health and reproductive potential. It was calculated using:
For isometric growth **(Effendie, 2002)**:

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

For allometric growth:

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

Where:
K = condition factor, W = weight (g), L = total length (cm), a and b = constants obtained from regression.

4.3. Sex ratio

The sex ratio was determined based on gonad observation. It was calculated as:

$$SR = \frac{M}{F}$$

Where:
SR = sex ratio, M = number of male fish, F = number of female fish

A Chi-square test (X^2) **(Steel & Torrie, 1997)** was used to assess whether the sex ratio significantly deviated from the expected 1:1 ratio:

$$\chi^2 = \frac{\sum (O_i - e_i)^2}{e_i}$$

X^2= the value of the random variable with a chi-square distribution, O_i = observed frequency of males and females, e_i = expected frequency. Significance was determined at α=0.05.

4.4. First maturation size

The first maturation size (length at which 50% of fish are mature) was estimated using the Spearman-Karber method **(Udupa, 1986)**:

$$m = x_k + \frac{x}{2} - x\sum Pi$$

Where:
m = log-transformed first maturation size, x_k = log midpoint of last length class with mature gonads, x = log-transformed length increment, Pi = proportion of mature fish in length class i. The final maturation size was obtained using the antilogarithm of m.

4.5. Gonadal maturity stage (GMS)

The gonadal maturity stage was assessed using the modified Cassie method **(Effendie, 2002)**, based on gonad morphology (size, color, texture, weight).

4.6. Gonadosomatic index (GSI)

The gonadosomatic index was calculated to assess gonad development in relation to body size:

$$GSI = \frac{GW}{BW} x100\%$$

Where:
GSI = gonadosomatic index (%), GW = gonad weight (g), BW = body weight (g).

4.7. Fecundity

Fecundity (total egg count in maturity gonads) was calculated using the **Effendie (2002)** method:

$$F = \frac{G \text{ x } V \text{ x } X}{Q}$$

Where:
F = fecundity, G = gonad weight (g), V = dilution volume (ml), X = eggs per 1ml, Q = weight of egg subsample (g).

4.8. Egg diameter

The egg diameters of stage III and IV gonads were measured microscopically. 50 eggs per region (anterior, middle, and posterior) were sampled at 4x10 magnification. Egg diameter data were analyzed to determine spawning patterns (total vs. partial spawning). A frequency distribution was created, with diameter length classes determined using a conversion factor of 0.025.

RESULTS AND DISCUSSION

Length-weight relationship

The analysis of the length-weight relationship was employed to elucidate the growth pattern of fish. In this study, the length-weight relationship of round scad was analyzed using data from 779 individuals, comprising 340 males and 439 females. Fig. (2) presents the length-weight relationship of round scad. Based on this analysis, the *b* value was calculated as 3.0791 for males and 2.8587 for females. Thus, the equations for the length-weight relationship for males and females are $W=0,000006L^{3,0791}$ and $W=0,00002L^{2,8587}$, respectively. The coefficients of determination obtained for males and females were 94.43 and 85.32%, respectively.

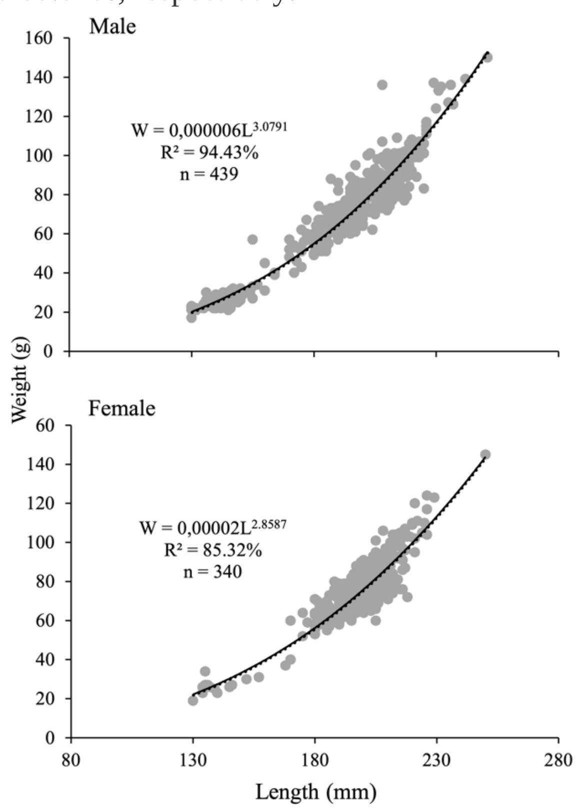

Fig. 2. Length-weight relationship of round scad fish

Based on a t-test at a 95% confidence interval, the growth pattern of male round scad is isometric, meaning that the rate of length increase is proportional to the rate of weight increase. In contrast, female round scads exhibit negative allometric growth, where body length growth is faster than body weight growth. Similar findings of isometric growth patterns were reported in previous studies. **Prihartini (2006)** conducted research in the Eastern Waters, obtaining a value of *b*=3.027, and in the Northwestern Java Waters, with *b*=2.910, both indicating isometric growth. Conversely, **Manik (2009)** observed positive allometric growth in the waters around Teluk Likupang, with *b* values ranging from 2.9334 to 3.3882. Measurements of the same species in Gorontalo Waters also indicated positive allometric growth, with *b* values of 3.1972 for males and 3.0613 for females **(Olii *et al*., 2022)**. Moreover, **Lawadjo *et al*. (2021)** recorded 3.2202 for males and 3.5323 for females. On the other hand, **Agista *et al*. (2019)** conducted a study in North Sumatera that revealed negative allometric growth, characterized by *b* value of 2.39. **Desmawanti *et al*. (2013)** also reported negative allometric growth in the Tanjung Pinang area, with a length-weight relationship represented by $W=0{,}00005L^{2{,}698}$. The variation in growth patterns across studies is likely attributable to differences in fish habitats and variability in fish sizes. In general, the *b* value depends on physiological conditions, sampling techniques, variations in the number and size of observed fish, habitat, environmental factors, sex, age, gonadal maturity, and differences in the time of observation **(Sinovcic 2000; Mulfizar *et al*., 2012; Febrianti *et al*., 2013; Osman *et al*., 2022)**.

Condition factor

The condition factor indicates the well-being of fish in terms of their physical capacity for survival and reproduction. Fig. (3) displays the condition factor of round scad observed in this study, ranging from 0.9200 to 1.0893.

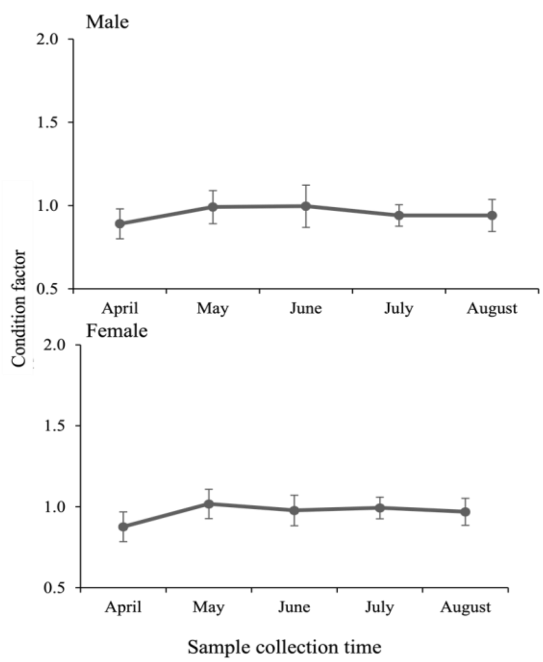

Fig. 3. Condition factors of round scad fish

The analysis of the condition factor suggests that round scad is generally in good condition. This aligns with **Effendie (1979)**, who stated that condition factor (K) values ranging from 1 to 3 indicate good conditions. In a separate study by **Desmawanti (2013)**, minimal temporal variations in condition factor values were observed across different months, with values remaining consistently between 0.98 and 1.08. Condition factor values vary across aquatic environments and are influenced by factors such as habitat, food availability, age, gender, and gonadal maturity **(Morato *et al*., 2001; Effendie, 2002)**. The observed discrepancies in condition factor values are likely influenced primarily by spawning activities and differences in fish age. In this study, the highest condition factor for round scad was observed in May, suggesting a possible correlation with the spawning season. According to **Lizama and Ambrósio (2002)** and **Tzikas *et al*. (2007)**, during the spawning season, fish reduce their feeding activity and utilize stored fat reserves as an energy source. The decrease in the condition factor is attributed to the fact that a significant portion of the consumed food is diverted toward the development of reproductive cells.

Sex ratio

The gender of male and female round scad was determined based on morphological observations of gonad shape and color. Fig. (4) presents the gender proportions of round scad observed during the study, with a total of 779 individuals, comprising 340 females (44%) and 439 males (56%), resulting in a sex ratio of 1.29:1 in favor of males.

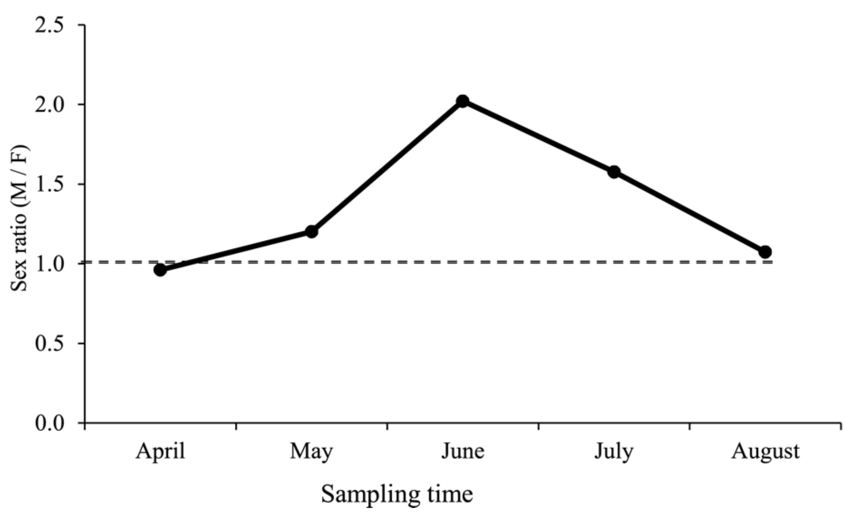

Fig. 4. Sex ratio of round scad fish during the observation period

The sex ratio, which represents the proportion of males to females in a population, ideally remains balanced at 1:1 to maintain species stability. However, in this study, round scad exhibited varying sex ratios across different sampling periods, with males consistently outnumbering females. A chi-square test confirmed that the overall sex ratio of round scad in the Sunda Strait was imbalanced, deviating from the expected 1:1 ratio.

The observed disparity in the number of male and female round scad may be attributed to differences in schooling behavior and reproductive cycles. According to **Thanh (2011)**, variations in the numbers of male and female fish captured by fishermen are influenced by behavioral patterns related to both mating and feeding. Similarly, **Nikolsky (1963)** explained that sex ratios may fluctuate before and during the spawning season. During the initial stages of mating, populations tend to be dominated by males, while females become more prevalent later in the reproductive cycle. Comparable findings have been reported in previous studies. **Aprilianty (2000)** analyzed a sample of 350 *D. russelli* and found a male-to-female sex ratio of 1:1.6, indicating a higher proportion of females. Similarly, **Ajub *et al*. (2023)** found a male-to-female sex ratio of *D. ruselli* of 1:1.23 based on a sample of 49 individuals. Meanwhile, **Zamroni and Suwarso (2011)** reported sex ratio disparities in *D. russelli* within the 14- 21.6cm size range, where 51 individuals (48%) were female and 55 individuals (52%) were male, yielding a ratio of 1.08:1 in favor of males. Such imbalances may be influenced by factors beyond distribution, including food availability. **Ernawati *et al*. (2009)** suggested that the monthly distribution of male and female fish is influenced by environmental conditions, behavioral differences, and fishing factors. Furthermore, **Nikolsky (1963)** noted that an abundance of food often correlates with a higher proportion of females, while food scarcity may lead to male-dominated populations.

Gonadal maturation stage

The gonadal maturation stages of round scad observed during the sampling period are presented in Fig. (5). Overall, the distribution of female gonadal maturation stages was as follows: Stage I - 8.6% (41 individuals), Stage II - 13.3% (65 individuals), Stage III - 44.2% (128 individuals), and Stage IV - 34% (106 individuals). Meanwhile, the gonadal maturation stages for male round scad were: Stage I - 15% (72 individuals), Stage II - 43.7% (192 individuals), Stage III - 32% (137 individuals), and Stage IV - 9.5% (38 individuals).

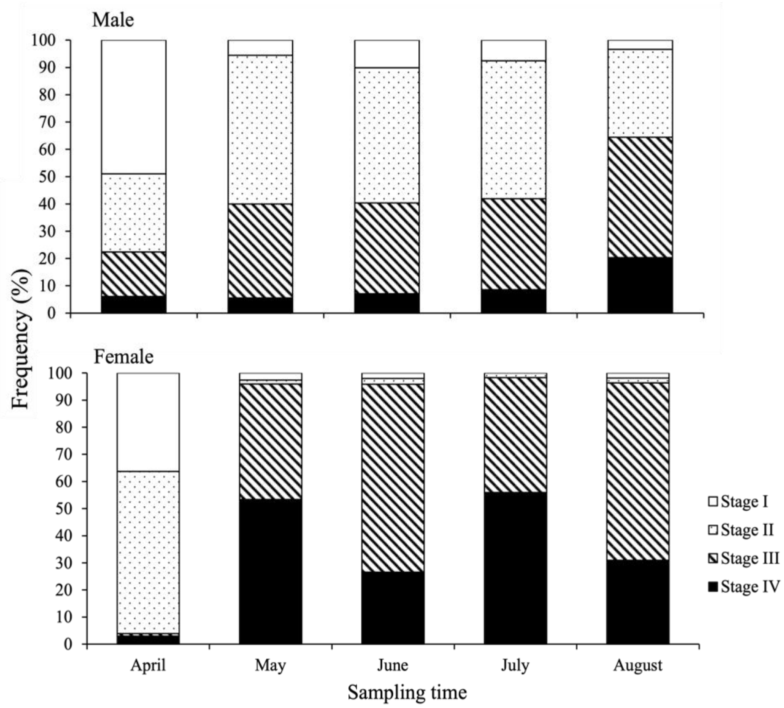

Fig. 5. Gonadal maturity stage of round scad fish

The results indicate that the majority of round scad collected during the study were in mature gonadal stages (Stage III and IV). Mature females were predominantly found in May and July, while mature males were more prevalent in May and August. These findings align with those of **Destha (2015)**, who reported that *Decapterus* spp. in the maturity stage IV was most abundant in August. Similarly, **Aprilianty (2000)** observed that round scad in Teluk Sibolga reached peak gonadal maturity in August. Comparatively, this study, conducted from April to August, revealed that stage I (immature gonads) was most frequently observed in April, whereas stages III and IV (mature gonads) were more prevalent in May and July. **Retnoningtyas *et al*. (2024)** focusing on the population dynamics, including gonad maturity levels of *Decapterus* spp in the Sulawesi sea, reported that the species exhibit continuous spawning with a peak in January, March, May and September. These findings suggest that round scad in the Sunda Strait likely spawn in May and July. The presence of mature fish during these months supports the hypothesis that the spawning season occurs within this period.

First gonadal maturation size

The first gonadal maturation size of round scad, determined using the Spearman-Karber method, was 195mm for males and 187mm for females, indicating that female round scad reach gonadal maturity at a smaller size compared to males. Based on the relationship between gonadal maturation stage and total length, both male and female round scad first reach gonadal maturity within the size range of 131- 140mm (Fig. 6). The estimated gonadal maturation size (L50) based on logistic regression for males and females falls within the range of 191- 200mm (Fig. 7). The frequency distribution of round scad by size group during the sampling period is presented in Fig. (8).

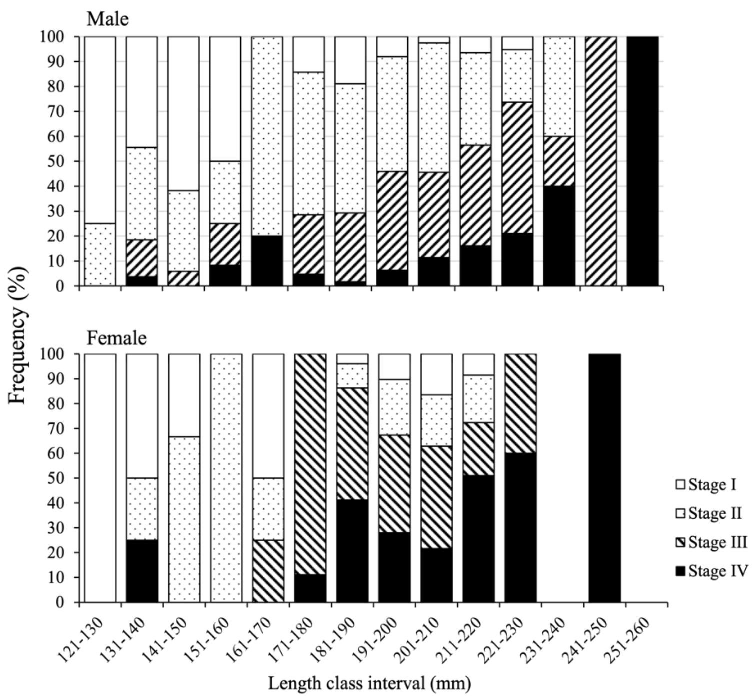

Fig. 6. Gonadal maturity stage of round scad fish based on length class intervals

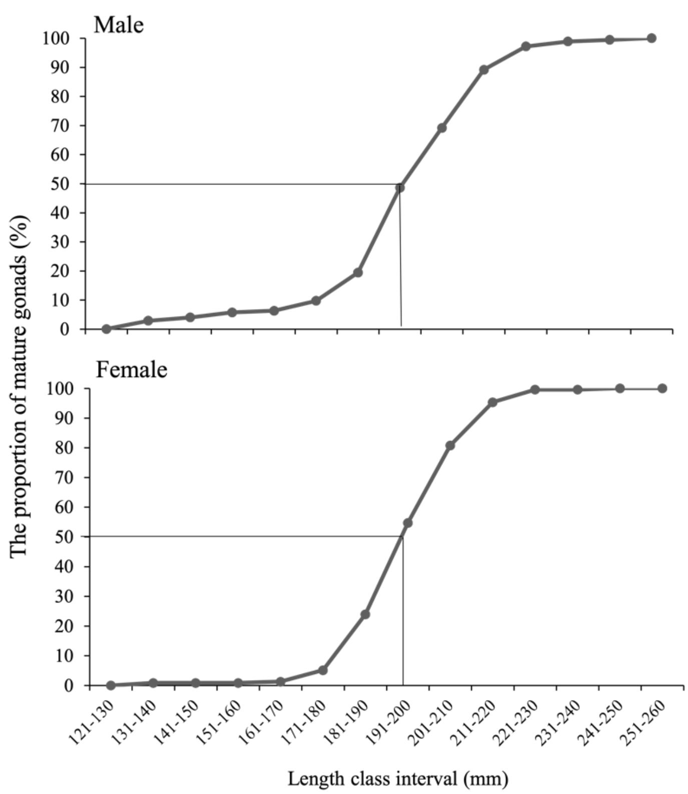

Fig. 7. The proportion of mature gonads in round scad

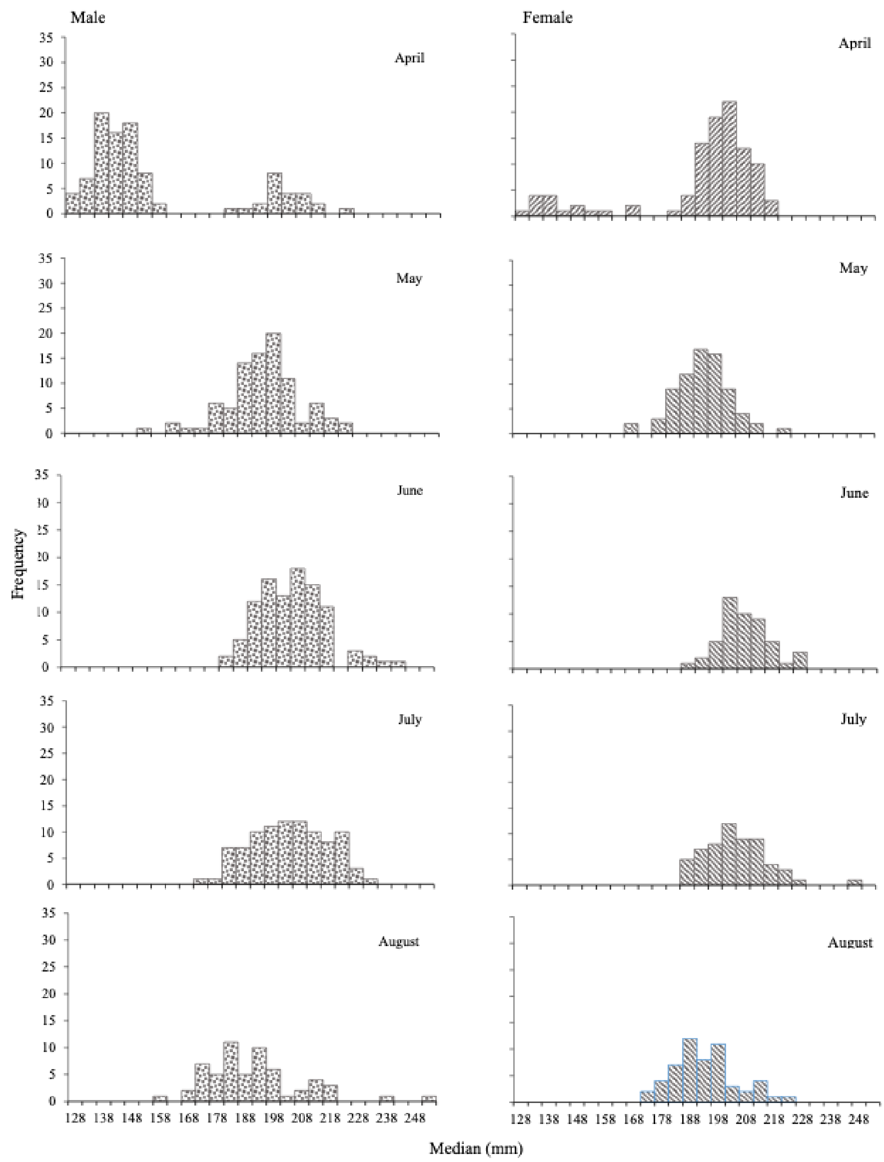

Fig. 8. Frequency distribution of round scad by size class

The length-class analysis suggests that both male and female round scad in the Sunda Strait begin their gonadal maturation at approximately 131– 140mm (Fig. 6). However, based on the Spearman-Karber method, the length at which 50% of individuals reach gonadal maturity (L50) is estimated at 187mm for females and 195mm for males. These findings indicate that female round scad attain reproductive maturity at a smaller size than males, which may contribute to sustaining population dynamics. Furthermore, immature fish dominated the smaller size groups mostly during April, while the proportion of mature individuals increased within the larger size groups in subsequent months (Fig. 8). The distribution shows recruitment of immature fish at the beginning of the observation period, followed by a greater relative abundance of larger mature individuals, particularly in size groups exceeding 190mm. This temporal shift reflects seasonal reproductive dynamics in the population **(Retnoningtyas *et al*., 2024)**.

Previous studies have reported variations in the first gonadal maturation size of round scad across different habitats. **Zamroni and Suwarso (2011)** observed that round scad reached their first gonadal maturity at 203mm and **Yonvitner *et al*. (2015)** recorded it at 217,4mm, a value slightly higher than the findings of this study. Most recent data from **Priatna *et al*. (2024)** stated that most analyzed *D. ruselli* belong to adult size with SL50 under current fishing pressure of 162,2mm and L50 of 152,4mm. These differences may be attributed to environmental conditions, population density, and food availability. **Sulistiono *et al*. (2009)** emphasized that the size at which fish first attains gonadal maturity varies even within the same species across different locations due to ecological factors. Additionally, sample size variations, the range of observed fish lengths, and differences in the proportion of mature individuals can also influence the reported size at first gonadal maturity **(Sivakami *et al*., 2001)**. The variation in gonadal maturation size highlights that not all individuals within the same age or size group reach reproductive maturity simultaneously **(Udupa, 1986)**. This discrepancy is influenced by genetic factors, food availability, environmental stressors, and reproductive cycles, which collectively impact the timing and size at which round scad become reproductively active **(Yonvitner *et al*., 2015; Priatna *et al*., 2024)**.

Gonadal maturation index

Effendie (2002) stated that as gonads develop, they increase in size and weight until reaching their maximum just before spawning. The gonadal maturation index (GSI) for round scad during the study period is presented in Fig. (9). The GSI values for female round scad ranged from 0.2816% to 3.7049%, while those for males ranged from 0.1343 to 1.0797%.

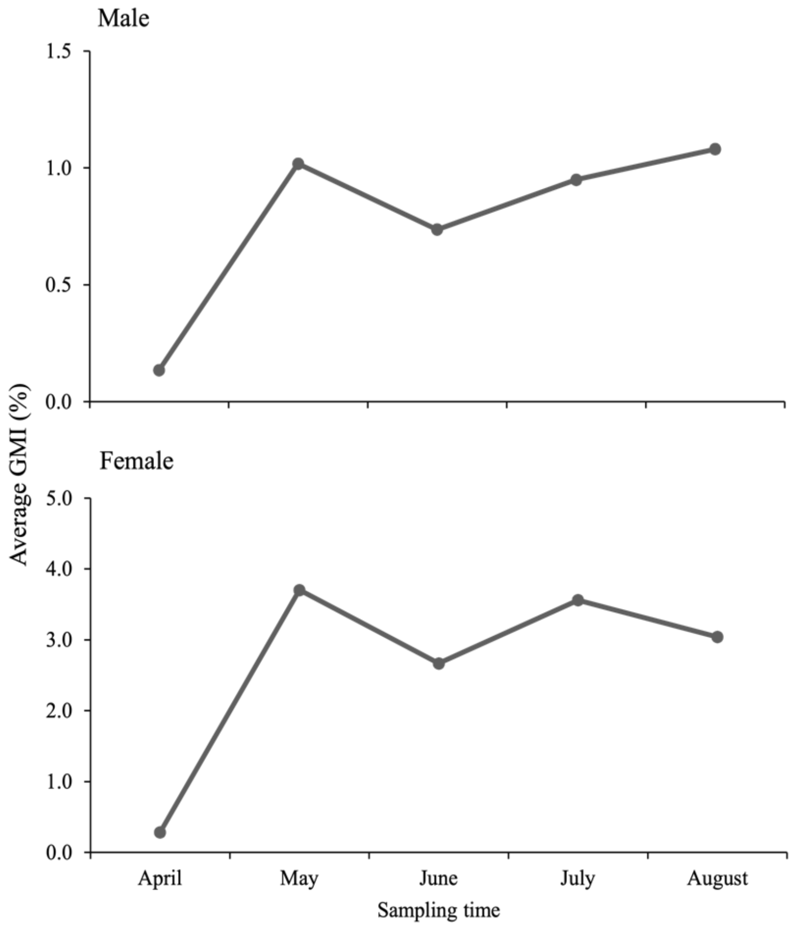

Fig. 9. Gonadal maturity index of round scad

The gonad somatic index (GSI) values fluctuated over the sampling period, with female round scad consistently exhibiting higher GSI values than males, peaking in May. This trend show that male gonadal maturity indices are generally lower than those of females **(Sulistiono *et al*., 2001a; Bintoro *et al*., 2019; Khasanah *et al*., 2020)**. Female gonadal weight increases by 10-25% of body weight, whereas male gonadal weight increases by only 5-10% of body weight **(Effendi. 2002; Sululu *et al*., 2022)**. The observed peak in GSI values in May suggests a significant rise in the gonadal maturation stage (GMS). As the GMS increases, the gonadal weight also rises, leading to a higher GSI. This pattern is consistent with the observations of **Sjafei and Saadah (2001)** and **Khasanah *et al*. (2020)**, who reported that an increase in GMS is correlated with higher GSI values. Additionally, **Sulistiono *et al*. (2001b)** emphasized that GSI values are closely linked to maturity levels, reinforcing **Effendie (2002)** claim that gonadal weight reaches its peak just before spawning, resulting in the highest GSI values. Similar findings were reported by **Apriliantу (2000)**, who found that the average gonadal maturity index of female round scad was highest in maturity stage IV. This increase in GSI is attributed to gonadal growth, where an increase in gonadal weight is accompanied by an increase in gonad size and reproductive activity.

Fecundity

Fecundity in fish is often correlated with body weight rather than total length, as weight provides a more accurate representation of the fish's physiological condition. However, weight fluctuations due to environmental and physiological factors can influence fecundity estimates. The relationship between fecundity and total length of round scad in the Sunda Strait is illustrated in Fig. (10), while the relationship between fecundity and body weight is shown in Fig. (11).

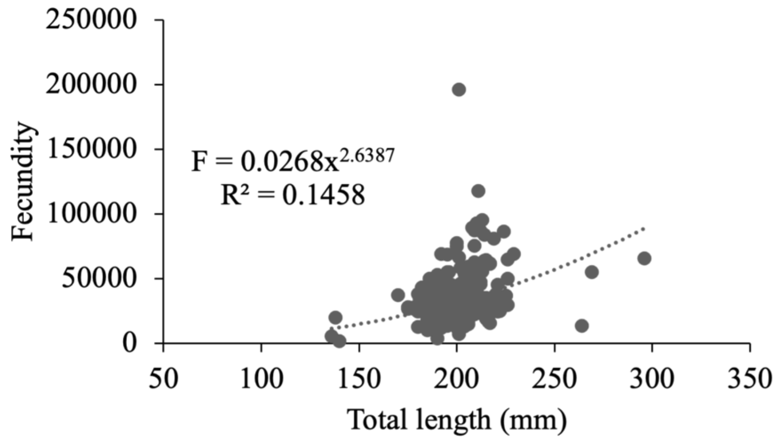

Fig. 10. The relationship between total length and fecundity of round scad

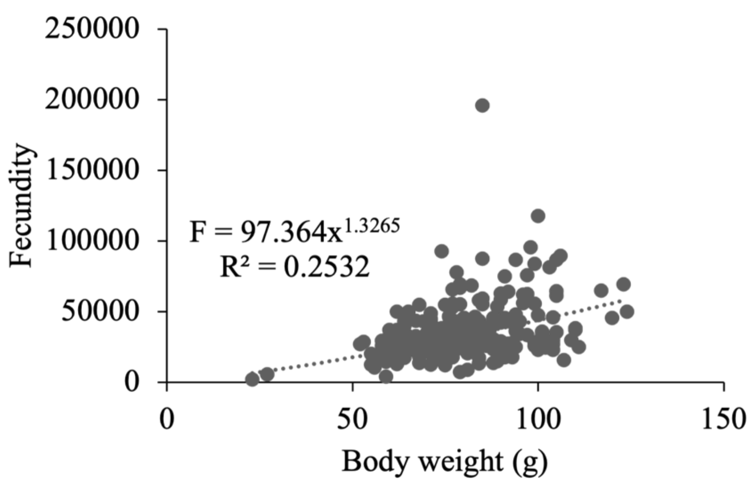

Fig. 11. The relationship between body weight and fecundity of round scad

The fecundity of round scad in this study varied widely, ranging from 1,774 to 196,031 eggs among 237 individuals at gonadal maturation Stages III and IV, with body weights between 23 and 124 g. The relationship between fecundity and total length (Fig. 10) resulted in a coefficient of determination (R^2) of 0.1458, whereas the relationship between fecundity and body weight (Fig. 11) yielded a slightly higher R^2 value of 0.2532.

These findings indicate that fecundity is only moderately influenced by body weight and length, suggesting that other biological or environmental factors, such as nutrition, reproductive strategy, and environmental conditions, contribute significantly to reproductive output. The body size contributes disproportionately to fish reproductive cause they allocate the energy not only fecundity but total reproductive energy **(King 2003; Barneche *et al*., 2018)**. Previous studies present the comparison between body size ranges of *D. russelli* and the number of eggs produced. For example, **Aprilianty (2000)** found that *D. russelli* in Teluk Sibolga, with a total length range of 161– 220mm, produced between 8,190 and 47,130 eggs, and during dry season and wet season in Pasongsongan, Sumenep reported fecundity values of 5.929 to 25.470 eggs within TL 180 – 185mm and 364 to 23.216 eggs (TL 172– 213mm), respectively **(Maskuriyah & Zainuri, 2021)**. The relatively low coefficient of determination values in this study (14.58% for length-fecundity and 25.32% for weight-fecundity) highlights that fecundity in round scad is influenced by multiple factors beyond just body size, such as spawning season, age, and environmental conditions.

Egg diameter distribution

The egg diameter sizes of female round scad at gonadal maturation Stages III and IV were observed in 126 and 101 individuals, respectively, with the distribution presented in Fig. (12).

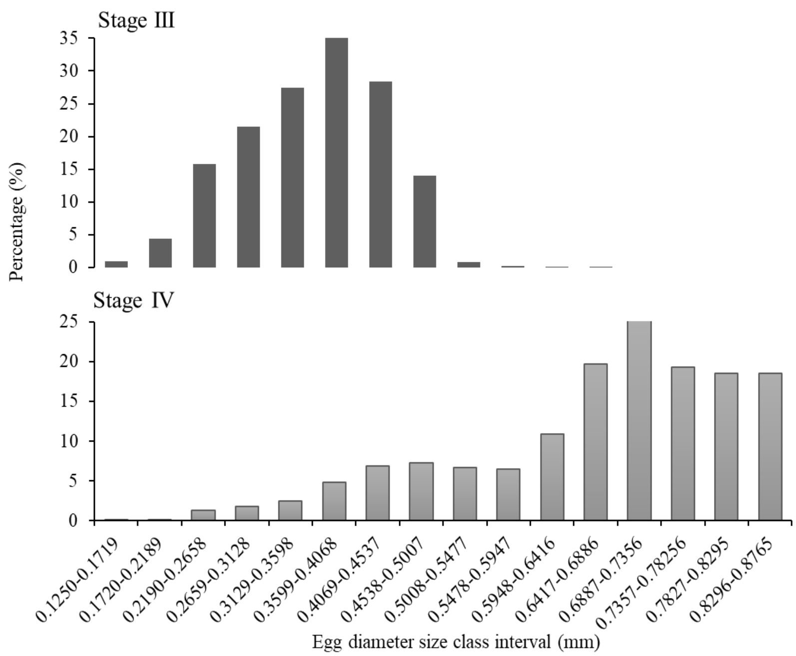

Fig. 12. Distribution of egg diameter in round scad

The distribution of egg diameters exhibited two distinct peaks, with egg sizes ranging between 0.3599–0.4068 and 0.6887–0.7356mm. This bimodal distribution suggests that round scad may be partial spawners, meaning they release eggs gradually over the spawning period rather than all at once. The presence of two dominant egg size groups indicates that spawning occurs in multiple stages within a short spawning period. Egg size distribution varies according to the gonadal maturity stage, which aligns that higher gonadal maturity levels correspond to larger egg diameters **(Effendie, 2002)**, and driven by the season **(Maskuriyah & Zainuri, 2021)**. The duration of spawning in fish can be inferred from egg diameter variation. When a species has a short spawning period, mature eggs within the ovaries tend to be of uniform size. However, species that spawn over extended periods exhibit a wider range of egg diameters, as mature and developing eggs coexist within the ovaries **(Hoar, 1957)**, while temperature and photoperiod have affected the ovarian histology **(Mokhtar, 2025)**. Environmental conditions, particularly food availability, play a crucial role in determining egg size. Previous studies presented that egg development and fecundity can be influenced by several factors such as the quantity and quality of food resources **(Nikolsky, 1963)**, individual variations including length, weight, and age of the fish, season, and environmental factors **(Ochokwu *et al*., 2015)**. A higher abundance of food generally results in larger egg sizes and increased reproductive output, whereas food scarcity can lead to smaller eggs and reduced reproductive success.

Management of round scad resources

The sustainable utilization of marine fisheries resources is essential to preserving fish populations and ensuring long-term ecological and economic benefits. Although marine fisheries resources are renewable, they are not inexhaustible. Effective fisheries management follows a structured approach, such as (1) monitoring and collecting related data, (2) policies based on scientific approach, (3) balancing the fisheries needs and socio-economic development, (4) collaboration and coordination among stakeholders, those are crucial to help assess the fishery conditions and better management strategies **(Widodo & Suadi, 2006; Xia & Mai, 2024)**. Fisheries management can be achieved through technical regulations, including restrictions on catch sizes, fishing locations, fishing seasons, and quota-based fishing **(Holland, 2003; Trenggono, 2023)**.

In this context, the management of commercially important species becomes a critical aspect of sustaining marine resources. Among these, round scad represents a key pelagic fishery resource whose ecological and economic significance necessitates management strategies informed by biological and ecological knowledge. Round scad is one of the pelagic fish resources with considerable economic importance, not only in Pandeglang but also thorughout Indonesian Waters **(Lawadjo *et al.*, 2021; Pasisingi *et al.*, 2021; Olii *et al*., 2022)**. Sustainable management of this species requires a focus on reproductive biology, which directly impacts fish stock sustainability in the Sunda Strait. Environmental conditions also play a crucial role, providing food sources (e.g., plankton and small fish) for round scads. A deteriorating environment can lead to food shortages, negatively affecting fish growth and reproduction.

This study found that female round scad first reaches gonadal maturity at 187mm, while males mature at 195mm. The size at first maturity is a key parameter in fisheries management, as it helps define minimum catch sizes, fishing gear regulations, and conservation strategies. To prevent overfishing and stock depletion, fishing should be restricted to individuals larger than 187mm. Sustainable management measures include: (1) legally permitting the capture of only round scad above 187mm, ensuring they spawn at least once before being caught **(Sudirman *et al*., 2008; Alnanda *et al*., 2020)**, and (2) adjusting fishing net mesh sizes to 1.4 inches to allow immature fish to escape and reproduce. In addition to the previously mentioned measures, (3) limiting the capture of smaller fish to maintain a balanced sex ratio is crucial for reproductive success **(Sluka *et al*., 2001; Aprilla *et al*., 2022)**.

The reproductive cycle of round scad is closely linked to population sustainability. Successful reproduction depends on individuals reaching reproductive age and having sufficient food for gonadal development **(Sjafei & Saadah, 2001; Pralampita & Chodriyah, 2010)**. Based on gonadal maturity stage, gonadal somatic index (GSI), and egg diameter distribution, this study found that round scad exhibits peak spawning activity in May and July and follows a partial spawning pattern. Implementing seasonal closures during May and July can protect spawning stocks and enhance population sustainability.

Effective fisheries management requires collaboration among key stakeholders. Local governments (e.g., The Department of Marine and Fisheries of Banten Province) should enforce regulations and promote awareness campaigns. Fisheries officers must monitor compliance with minimum catch sizes, gear restrictions, and seasonal closures. Fishing communities and industry stakeholders need to be educated on sustainable practices to ensure long-term fishery viability. By adopting science-based management strategies and fostering cooperation among stakeholders, the long-term sustainability of round scad fisheries in the Sunda Strait can be effectively safeguarded.

CONCLUSION

Round scad (*D. russelli*) exhibits an isometric growth pattern, an unbalanced sex ratio, and a partial spawning pattern, peaking in May and July. Many are caught before maturity, threatening stock sustainability. Regulating catch sizes, mesh sizes (1.4 inches), and seasonal closures can help protect the population, requiring cooperation from government and fisheries stakeholders.

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