Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(5): 1189 – 1209 (2025)
www.ejabf.journals.ekb.eg


# Reproductive Biology of *Nemipterus nemurus* (Bleeker, 1857) and *Nemipterus furcosus* (Valenciennes, 1830) in the North Coast Waters of East Java

**Amar Noor Hidayat, Anisah Luthfi Purboasih, Tony Budi Satriyo, Ratih Ida Adharini, Eko Hardianto, and Eko Setyobudi***

Fisheries Department Faculty of Agriculture Universitas Gadjah Mada Jl. Flora Gedung A-4 Bulaksumur Yogyakarta 55281

***Corresponding Author**: setyobudi_dja@ugm.ac.id

**ARTICLE INFO**

**Article History:**
Received: June 6, 2025
Accepted: Aug. 30, 2025
Online: Sep. 22, 2025

**Keywords**:
Condition factors,
Fecundity,
Gonadal histology,
Gonad maturity stage,
*Nemipterus* spp.

**ABSTRACT**

Reproductive biology plays a fundamental role in fisheries management, since it provides essential insights into reproductive strategies and the characteristics of fish populations. Studies on fish reproductive biology are important for the effective planning of conservation and management strategies. Successful reproduction is a critical factor in the growth of fish populations in aquatic environments. This study aimed to analyze reproductive aspects of threadfin breams (*N. nemurus* and *N. furcosus*) in the North Coast waters of East Java. Fish sampling was conducted at Brondong Fishing Port in Lamongan, from September to October 2023. The samples comprised two different species: *N. nemurus* with 111 individuals (63 males and 48 females), and *N. furcosus* with 154 individuals (80 males and 74 females). A balanced ratio of males to females was identified in the reproductive traits (1:1). The relationship between length and weight is negative allometrically. The gonads of both species reached a similar level of maturity. The t-test showed that fecundity and egg diameter were significantly different between the two species ($P < 0.05$). The majority of the captured threadfin bream exhibited immature gonads (Lc < Lm), which could have implication for the ecosystem conditions in the North Coast waters of East Java.

## INTRODUCTION

The threadfin bream (*Nemipterus* spp.) is a member of the family Nemipteridae and is commonly found in tropical and subtropical regions **(Innal *et al*., 2015)**. The distribution of the threadfin bream in Indonesia includes the waters of Java, Sumatra, Sulawesi, and Papua **(Srihari *et al*., 2020)**. It possesses a slender, elongated body shape that facilitates efficient movement in water **(Mohamed *et al*., 2022)**. The threadfin bream is predominantly pink, while the underside is silver. The head is golden and has no scale, and the body is covered with ctenoid scales **(Bilecenoglu & Russell, 2008)**.The threadfin bream's habitat is typically found at the depths of 5 – 80 meters, characterized by a sandy or muddy substrate. Is is commonly observed schooling in such habitat. This fish plays an important role in maintaining ecological balance and marine ecosystems, as it is a carnivorous fish that preys on marine organisms at the trophic level below it **(Imtiaz 7 Naim, 2018)**.

The threadfin bream is a demersal fish that is commonly found in the Fisheries Management Area (FMA) 712 or the Northern Java Waters. The annual potential yield for demersal fish in the Northern Java Waters is estimated at 358,832 tons, with a total allowable catch (TAC) of 179,416 tons, while the exploitation rate reaches 1.10. An exploitation rate of 1 is considered overexploited, consequently fishing efforts in FMA 712 must be reduced **(Ministry of Marine Affairs and Fisheries, 2022)**. Fisheries management is important to ensure sustainable fisheries by maintaining a balance between the exploitation of fish resources and the biological reproduction of fish. Good management is based on data and information on all aspects, including the biological aspects of fish **(Erdoğan *et al*., 2021)**. Fisheries and Maritime Affairs Office of Lamongan Regency reported that the threadfin bream has the second highest catch productivity value after the red bigeye (*Priacanthus* spp.) among 52 other fishery commodities, which is 9,173.71 tons/year (2021). These data illustrate that the threadfin bream is an important commodity in the North Coast waters of East Java. Even in Peninsular Malaysia, efforts to cultivate threadfin bream have not been successful, primarily due to a lack of understanding of its reproductive biology, especially with regard to gonadal maturity, gonadal changes, and spawning periods **(Rahman & Samat, 2021)**.

Reproductive biology plays a fundamental role in fisheries management, as it provides fundamental insights into the reproductive strategies and fish population characteristics. Studies on fish reproductive biology are important for planning effective conservation and management strategies **(Erdoğan *et al*., 2021)**. The increase in fish populations in waters is influenced by reproductive success **(Lambert, 2008)**. In addition to its role in species survival, reproduction is also a contributor to genetic variation within a population **(Farias *et al*., 2014)**. Understanding of reproductive biology is an important consideration in the assessment of management strategies for exploited populations **(Kantun & Moka, 2022)**. The study of reproductive biology helps determine the optimal time and location for implementing fishing regulations such as closed seasons or protected areas. These measures can help protect spawning individuals and ensure reproductive success **(Yi *et al*., 2021)**.

Several studies on the reproductive biology of the threadfin bream have been conducted in various locations, demonstrating that the threadfin bream is an important commodity in fisheries. **Rahman and Samat (2021)** studied *N. furcosus* on the East Coast of Peninsular Malaysia and found that the male population was larger than the female population, with an average fecundity of 102,477 ± 43,580. Research on *N. japonicus* on the Northeast Coast of India **(Rao *et al*., 2017)** also showed a male-dominated population, with first gonadal maturity sizes recorded at 15.4cm for males and 14.9cm for females. Other studies have focused on reproductive aspects such as sex ratio, gonadal maturity level, gonadal maturity index, size of first gonadal maturity, and fecundity, which are crucial for understanding population dynamics and assessing the impact of exploitation on fish population **(Tari *et al*., 2015)**. This study provides new information on size at first capture, size at first gonad maturity, and gonad histology, which have not been previously studied in the waters of the North Coast of East Java. These data are essential for the management of the threadfin bream as a species of significant economic value in East Java, Indonesia. The aim of this study was to provide data on the reproductive biology of threadfin bream, which can serve as a foundation for sustainable management of this species.

## MATERIALS AND METHODS

### 1. Sampling and fish samples

A total of 265 fish samples were collected from Brondong Fishing Port, Lamongan, East Java, during September-October 2023, comprising two species: *N. nemurus* with 111 individuals (63 males and 48 females) and *N. furcosus* with 154 individuals (80 males and 74 females). Fish samples were caught using Danish seine with a mesh size of 1 inch at a depth of 50-60 meters. The sampling locations are shown in Fig. (1).

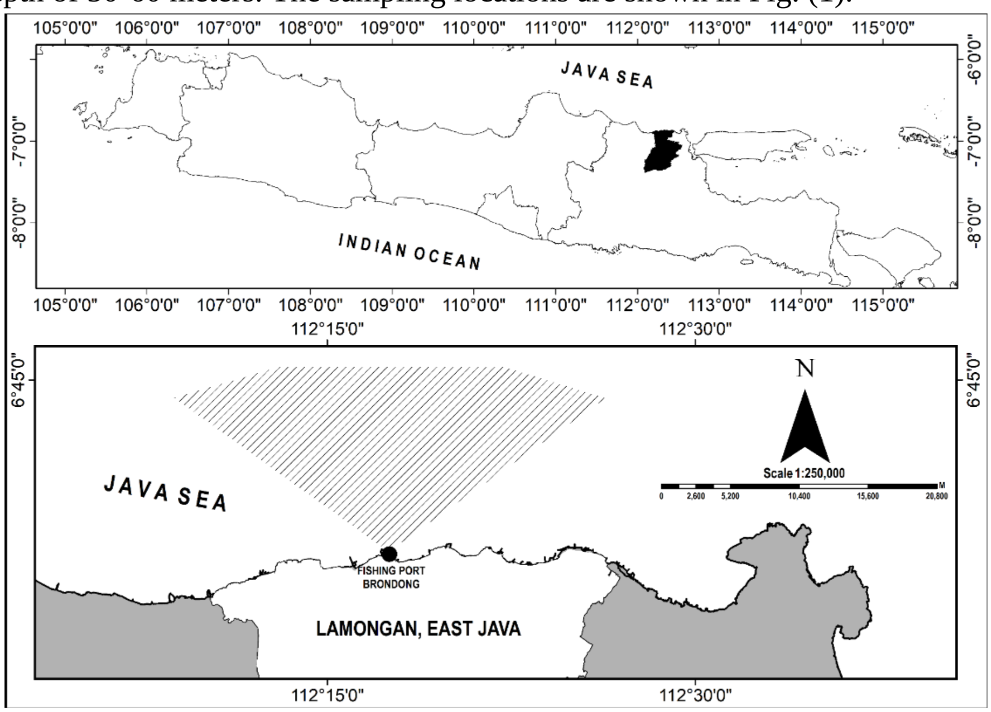



**Fig. 1**. Sampling location of *Nemipterus* spp. in North Coast waters of East Java

## 2. Methods

Samples that had been separated by species according to **Russell (1990)** were then measured for length and weight. Total length was measured using a ruler with an accuracy of 0.1cm, while fish weight was measured using a digital scale with an accuracy of 0.01g. Data were then separated between males and females in each species.

Sex ratio = number of male fish/number of female fish, followed by a chi-square test to see the proportion of the threadfin bream population, with a 95% confidence interval and a significance level ($\alpha$) of 0.05. The equation $\chi 2 = \sum(oi - ei2)/ei$, where $oi$ is the number of male and female fish frequencies and $ei$ is the expected frequency of male and female fish.

Length-weight relationship (W), sex ratio, condition factor, fecundity, histology, egg diameter, size at first maturity (*Lm*), and size at first capture (*Lc*) were calculated using the following equations:

$$W = aL^b \ (Eq.1)$$

Where, W = fish weight (g), L = total length (cm), *a* = intercept, and *b* = regression coefficient. The value of b was interpreted as isometric growth (b=3), negative allometric growth (b<3), and positive allometric growth (b>3). The coefficient of determination (R2) and parameters a and b were estimated by linear regression analysis after logarithmically transformed equations **(Amira *et al*., 2016)**.

The relative condition factor (*Kn*) was calculated using the following equation:

$$K_n = \frac{W}{aL^b} \ (Eq.2)$$

Where, *Kn* = condition factor, W = fish weight (g), L = total length (cm), *a* and *b* from Eq. (1). According to **Lloret-Lloret *et al*. (2022)**, the condition factor is classified into three parameters, namely <0.95 for fair, 0.95-1.05 for good, and >1.05 for excellent.

Fish samples were dissected, and then the gonads were removed and observed to determine the sex of fish based on morphological characteristics. Fish gonads were used to determine the gonadal maturity stage, fecundity, egg diameter, egg histology, and size at first gonadal maturity (Lm). Gonadal maturity level is classified based on **Effendie (2002)**, as shown in Table (1).

**Table 1.** Classification of the gonadal maturity stages according to **Effendie (2002)**

| Gonad Maturity Stage | Female | Male |
|---|---|---|
| I | The ovary is small, extends to the front of the body cavity, and has a smooth surface. | Testes are small, clear in color, and the tip is visible in the body cavity |

| | | |
|---|---|---|
| II | Ovary size is larger. Ovary color is yellowish, and eggs are not yet clearly visible | Larger testes size, white |
| III | Ovaries are yellow in color and morphologically the eggs begin to appear | The surface of the testes appears jagged, the color gets whiter and the size gets bigger. |
| IV | Ovary gets bigger, egg is yellow, easy to separate. Oil grains are not visible, filling 1/2 to 2/3 of the abdominal cavity | The appearance is more obvious, with the testes becoming more solid. |
| V | Ovary wrinkled, thick wall, residual eggs found near the release | The testes at the back are deflated and the ones near the discharge are still full. |

Fecundity was calculated only on female fish in the GMS III and IV, using the gravimetric method according to **Effendie (2002)**. We then preserved the gonads in a 4% formalin solution to maintain their shape. Gonad subsamples were taken from three parts, namely anterior, median, and posterior, then weighed and counted for fecundity determination. Fecundity (*F*) was determined following **Effendie (2002)** using the following equation:

$$F = \frac{G}{Q} \times n_t \; (Eq.3)$$

Where, F = fecundity, G = total gonad weight (g), Q = partial gonad weight (g), and *nt* = number of eggs in the subsample.

Ten eggs from each of the parts of the gonads were observed under a compound binocular microscope with a magnification of 4x and an ocular micrometer of 10 μ, which was equipped with OptiLab.

Histological observation using the Harris hematoxylin-eosin method involves seven stages: fixation, dehydration, clearing, embedding and blocking, sectioning, staining, and mounting. Gonads were cut with a thickness of 5-8 µm and then stained using hematoxylin and eosin. Each oocyte development was photographed and classified based on the categorization set in the study of **Wu *et al*. (2008)**.

The differences in fecundity and egg diameter were analyzed using an independent t-test. Previously, the Kolmogorov-Smirnov normality test and Levene's homogeneity test were conducted. When the significance value obtained from Levene's test exceeds 0.05, the data meet the assumptions for a parametric t-test; meanwhile, the significance value is less than 0.05, and the Mann-Whitney test (non-parametric t-test) is performed using the SPSS application.

The size at first gonadal maturity (*Lm*) was estimated using the Spearman–Karber method **(Udupa, 1986)**, as follows:

$$m = \left[x_k + \left(\frac{x}{2}\right)\right] - \left(x \sum p_i\right) \; (Eq.4)$$

Where, *m* = log length at first maturity, *xk* = log midpoint of the last length class, *x* = log interval, and *pi* = proportion of mature fish.

The size of the fish at first capture (Lc) was calculated using the equation **(Sparre & Venema, 1999)**:

$$SL = \frac{1}{1 + EXP(S1 - S2xC)}$$

And

$$LC = \frac{S1}{S2}$$

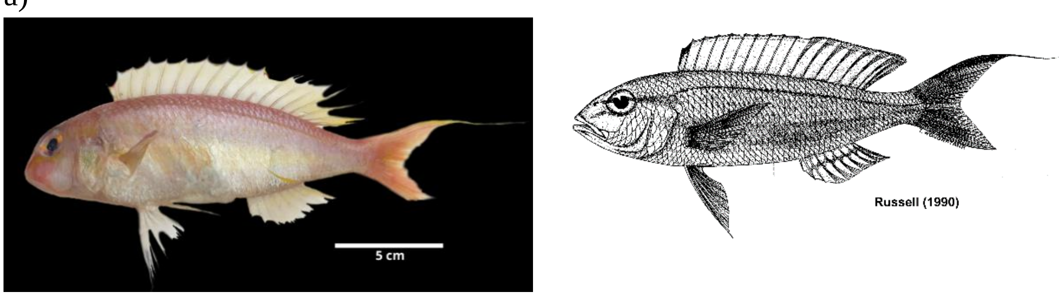
Where, *SL* = estimated value, *SLc* = relative cumulative frequency, *L* = midpoint of the length class, and *S1* and *S2* = constants from the logistic curve formula.

## RESULTS

### 1. Morphological comparison of *N. nemurus* and *N. furcosus*

*Nemipterus nemurus* species has a pinkish body coloration on the dorsal side and a silvery-white coloration on the ventral side. On the side of the body, there are two similar yellowish lines from behind the eyes to the base of the tail. The dorsal fin of *N. nemurus* is pale yellow with yellow edges. The membrane on the first and second rays is bright red; the anal fin is white; the forked caudal fin has a red base with the upper lobe producing long filaments; the pectoral fin is pink; and the pelvic fin is white. The upper jaw consists of two to five pairs of canine teeth. The dorsal part has six vertical patterns. Meanwhile, *N. furcosus* has a pale pink coloration on the dorsal side and a silvery-white coloration on the ventral side. The morphology of both species can be seen in Fig. (2).

a)



b)

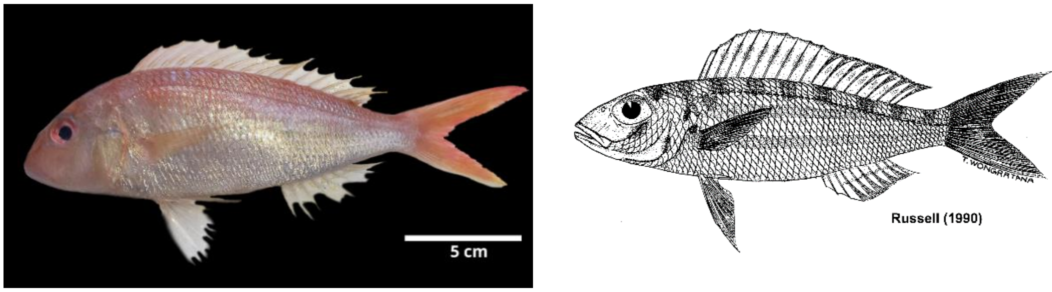



**Fig. 2.** Morphological differences between (a) *N. nemurus* and (b) *N. furcosus*

Fig. (3) shows the length distribution of both species. For *N. nemurus*, the highest proportion is in the 15.6– 16.5cm class (28%), and the lowest in the ≥ 18.6cm class (3%). In *N. furcosus*, the highest distribution occurs in the 16.6– 17.5cm class (29%), while the lowest is in the ≤ 13.5cm class (1%).

a) b)

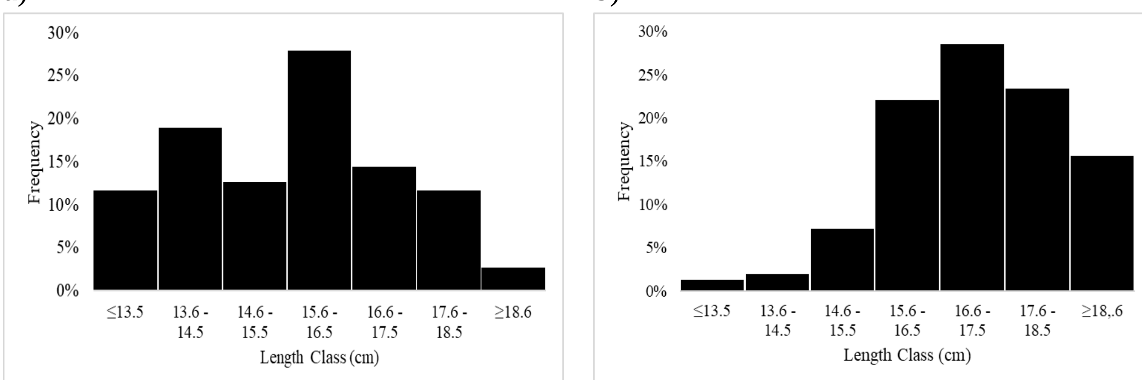



**Fig. 3.** Length distribution between (a) *N. nemurus* and (b) *N. furcosus* in the North Coast waters of East Java

## 2. Sex ratio

The sex ratio of *N. nemurus* and *N. furcosus* in the North Coast waters of East Java shows a difference of 1:0.76 and 1:0.93, respectively, which indicates that both species of threadfin bream have a balanced sex ratio (α=0.05). The sex ratio can be seen in Tables (2, 3).

**Table 2.** Sex ratio of *N. nemurus*

| Sex | Frequency ($o_i$) | Expected frequency ($e_i$) | $X^2$ calculated | M/F | Ratio |
|---|---|---|---|---|---|
| Male | 63 | 55.5 | 1.01 | 1.31 | 1:0.76 |
| Female | 48 | | 1.01 | | |
| Total | 111 | | 2.02 | | |

**Table 3.** Sex ratio of *N. furcosus*

| Sex | Frequency ($o_i$) | Expected frequency ($e_i$) | $X^2$ calculated | M/F | Ratio |
|---|---|---|---|---|---|
| Male | 80 | 77 | 0.12 | 1.08 | 1:0.93 |
| Female | 74 | | 0.12 | | |
| Total | 154 | | 0.24 | | |

Explanation:

$X^2$calculated = $X^2$ 0.05(2-1) = 3.841

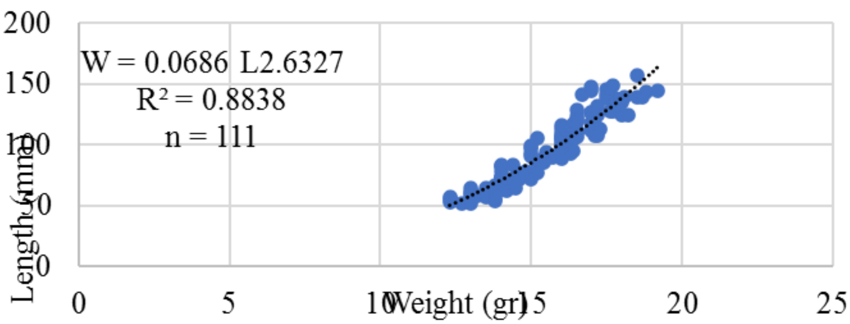
Result: Since $X^2$calculated < $X^2$table, the null hypothesis (Ho) is accepted, indicating a balanced sex ratio.

M/F = Male/Female

## 3. Length-weight relationship

The length-weight relationships of *N. nemurus* and *N. furcosus* are 0.0686 $L^{2.6327}$ and 0.0553 $L^{2.778}$, respectively. The growth patterns of *N. nemurus* and *N. furcosus* show negative allometric values, with b values of 2.63 and 2.77, respectively (Fig. 4).

a)



b)

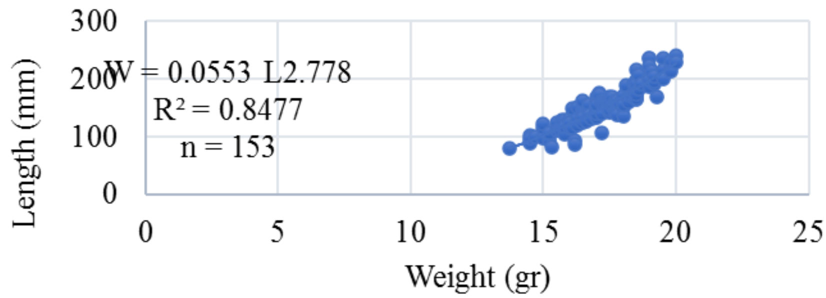
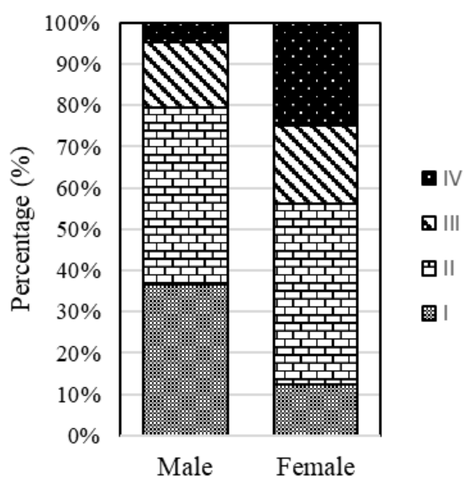



**Fig. 4.** Length-weight relationship of threadfin bream a) *N. nemurus* and b) *N. furcosus* in the North Coast waters of East Java

## 4. Gonadal maturity stage

The composition of the gonadal maturity stages of the threadfin bream (*N. nemurus* and *N. furcosus*) is classified into stages I, II, III, and IV. The proportion of gonadal maturity stages of the threadfin bream can be seen in Fig. (5).

a)




b)

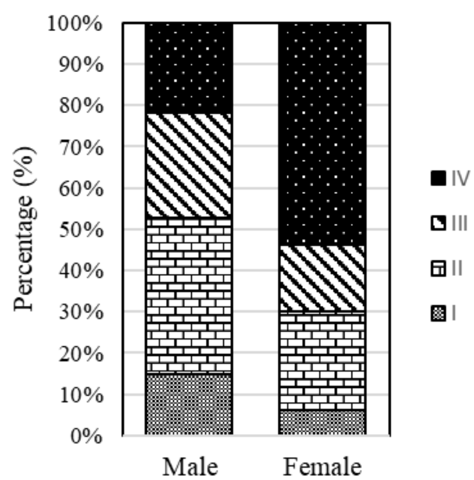


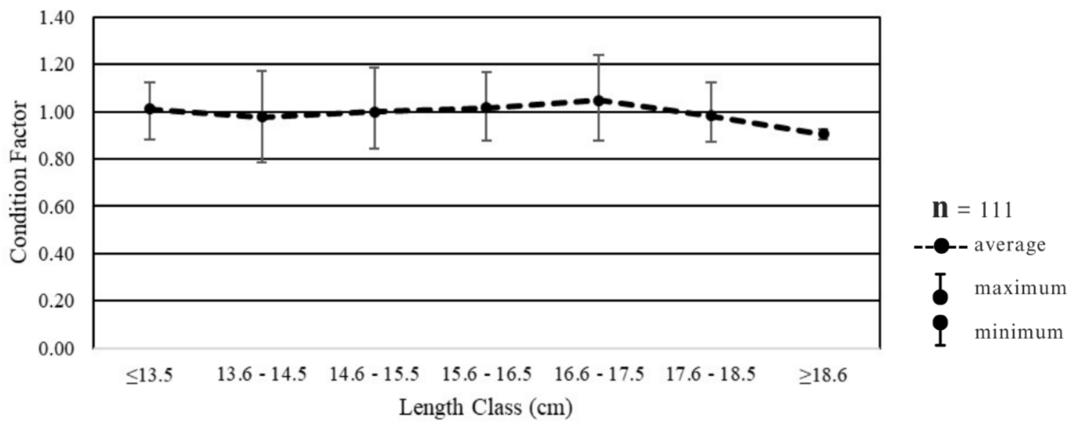

**Fig. 5.** Gonadal maturity stage of male and female threadfin bream (a) *N. nemurus* and (b) *N. furcosus* in the North Coast waters of East Java

The highest gonadal maturity stage value in male and female of *N. nemurus* is at stage II, while male *N. furcosus* has the highest proportion at stage II (38%) and female at stage IV (54%). The lowest proportion in *N. nemurus* is at stage IV (5%) and female at stage I (13%), while both male and female *N. furcosus* are at stage I with 15% and 6%, respectively.

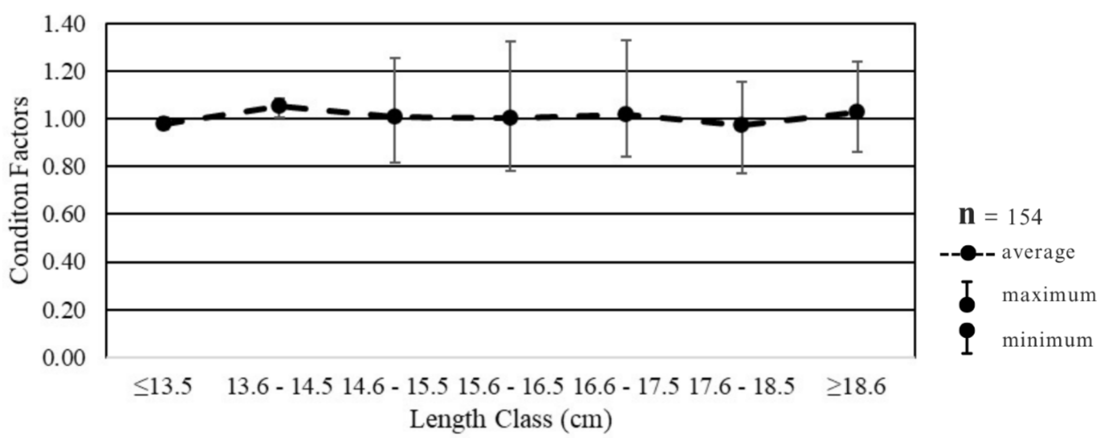
## 5. Relative condition factor (Kn)

The average relative condition factor (Kn) value across all class ranges is around 1. The Kn values for both species show similar results, with *N. nemurus* having a Kn of 0.78-1.24 with an average of 1±0.09 and *N. furcosus* 0.67-1.22 with an average of 1±0.09. The highest Kn value for *N. nemurus* is at a length of 16.5- 17.5cm, which is 1.05, and the lowest at a length of ≥18.6 cm, which is 0.90 (Fig. 6.).

The Kn values of both species within the class intervals show quite different results. For *N. nemurus*, the class interval with the highest percentage is the size of 15.6- 16.5cm, and the lowest is the size of ≥ 18.5cm. The highest proportion of *N. furcosus* is in the size of 16.6- 17.5cm, and the lowest is in the size of ≤ 13.5cm (Fig. 7.).




a)




b)

**Fig. 6.** Condition factor of threadfin bream (a) *N. nemurus* and (b) *N. furcosus* in the North Coast waters of East Java

a) b)

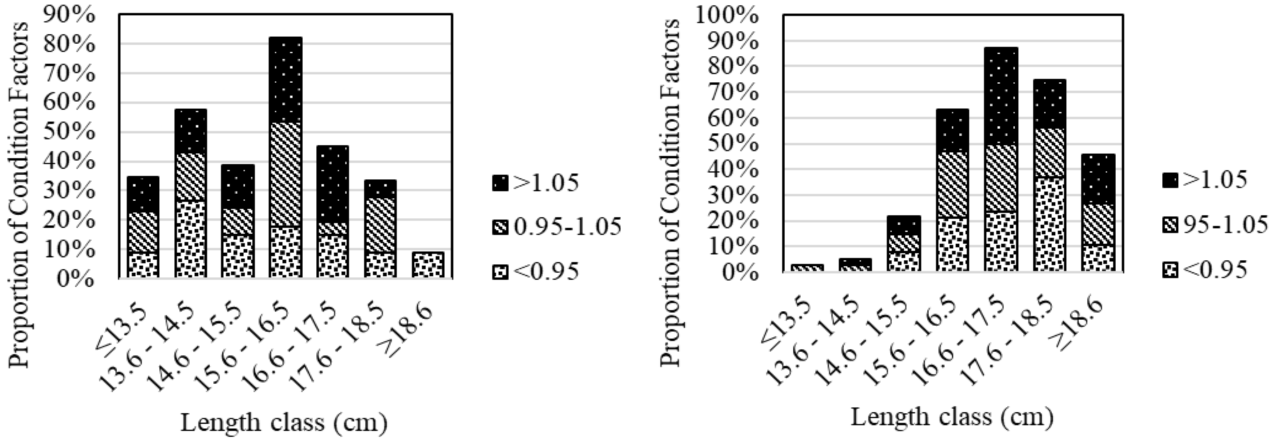
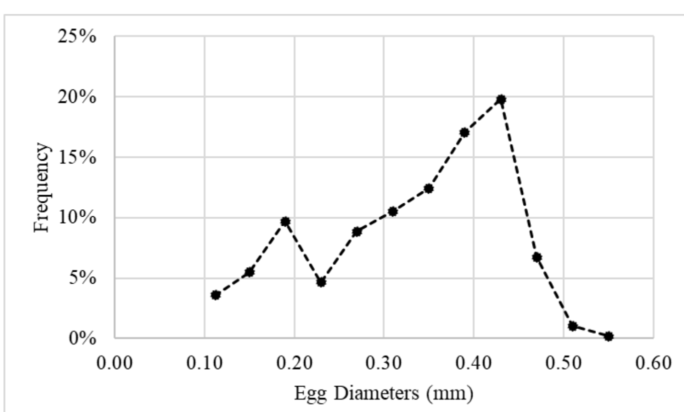



**Fig. 7.** Proportion of condition factor of (a) *N. nemurus* and (b) *N. furcosus* in the North Coast waters of East Java

## 6. Distribution of egg diameters

The distribution of egg diameters of the two species shows a difference. Based on the independent t-test, the significance was *P*= 0.003, which is less than 0.05, indicating a significant difference between the two species. The diameter of the eggs of both species ranges from 0.11 mm to 0.55 mm, with an average egg diameter of 0.32 ± 0.09 mm for *N. nemurus* and 0.36 ± 0.08 mm for *N. furcosus*. *N. nemurus* has the highest number at the size of 0.43 mm (20%) and the lowest at the size of 0.55 mm (0.21%). *N. furcosus* has the highest number at the size of 0.43 mm (24%) and the lowest at the size of 0.11mm (0.23%). The distribution of egg diameters can be seen in Fig. (8).

a)



b)

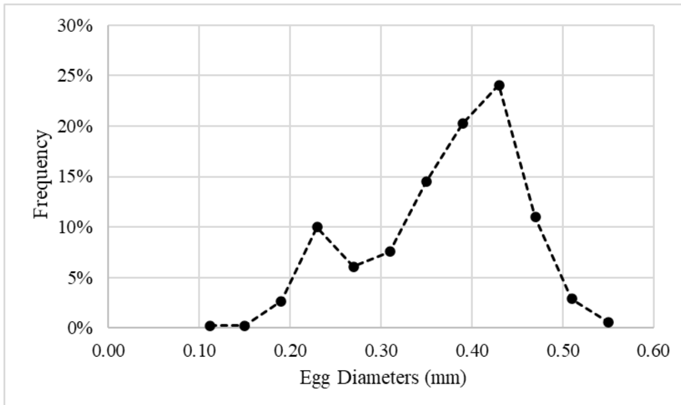



**Fig. 8.** Distribution of egg diameter (a) *N. nemurus* and (b) *N. furcosus* in the North Coast waters of East Java

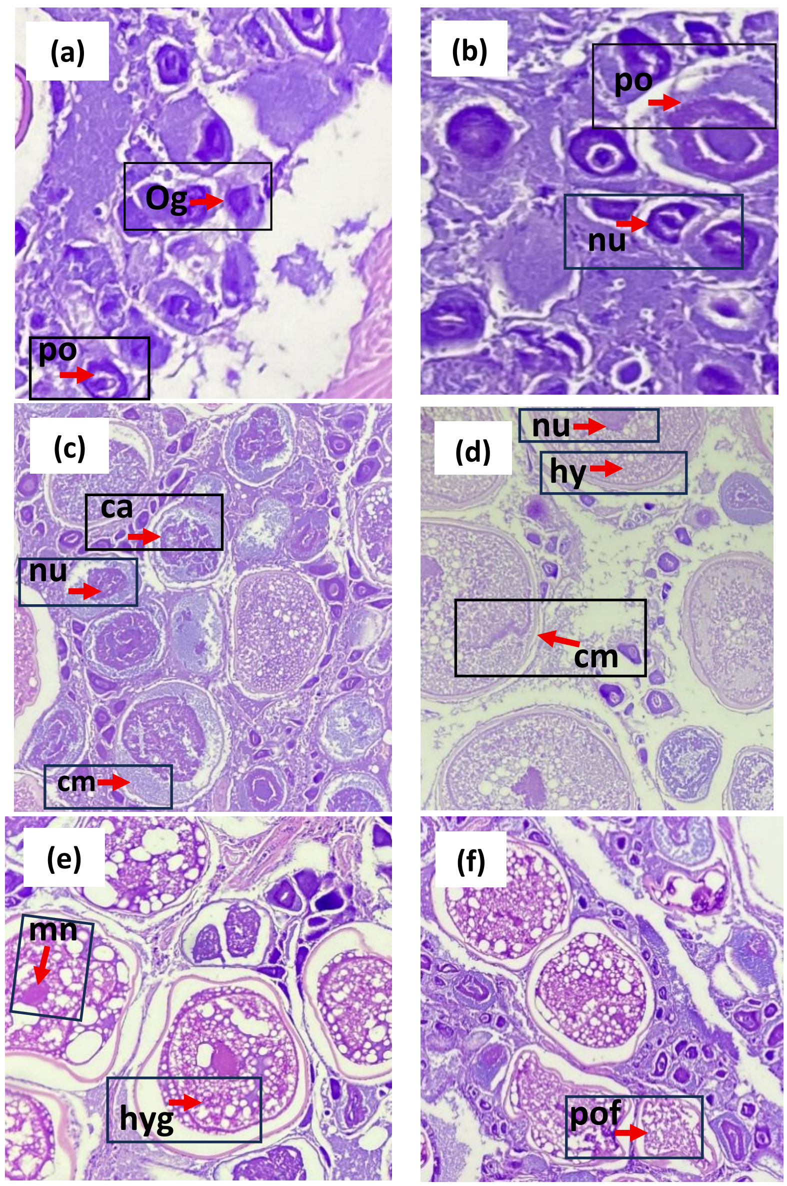
The results of the egg diameter distribution in both species show the presence of two peaks. The egg distribution of *N. nemurus* forms peaks at sizes of 0.19 and 0.43mm, while *N. furcosus* forms peaks at sizes of 0.23 and 0.43mm. The formation of these two peaks indicates that the eggs of the threadfin bream are not released in a single spawning, due to the varying sizes or maturity levels of the eggs.

## 7. Fecundity

The fecundity of the two species of threadfin bream shows a difference; *N. nemurus* has a fecundity ranging from 10,147 to 86,944 eggs with an average of 37,689 eggs, while *N. furcosus* has a fecundity ranging from 16,038 to 108,649 eggs with an average of 60,153 eggs. Based on the t-test, *P*= 0.000 (< 0.05), indicating a significant difference in the fecundity values of the two species.

## *8. Gonad histology*

Gonad histology is observed to examine development in detail (Fig. 9.). In Stage I, ovaries contain clusters of oogonia and oocytes that remain in the chromatin nucleolus phase (Fig. 9a.). Stage II is the early maturation, where the secondary growth oocyte is located in the cortical alveoli (ca), the oocyte enlarges, and the nucleus shrinks. At this stage, the nucleus still occupies a central position and is surrounded by cytoplasm. (Fig. 9b.). Stage III shows the gonads reaching mid-maturity. Secondary growth in the form of yolk granules (yg) is accompanied by the growth of oocytes and oogonia. This stage of oocyte development is quite significant (Fig. 9c.). Stage IV is the final maturation, where the growth of the oocyte is at the stage of nuclear migration. At this stage, the oocyte is filled with yolk, the nucleus begins to migrate towards the micropyle, and the cortical alveoli adhere to the cell membrane (Fig. 9d.). Stage V is the spawning preparation stage, where the nucleus has disintegrated and is no longer visible, and there are hydrated yolk granules (hyg), primary oocytes (po), and oogonia (Fig. 9e.). Stage VI is the post-ovulation follicle stage (pof), the final growth oocyte with hydrolyzed yolk granules, oogonia, and oocytes in the primary growth condition (po) (Fig. 9f.). Stage VII is the resting stage, with primary growth oocytes and oogonia. This stage has many empty follicles and there are unfertilized yolk granules that undergo resorption (atresia) (Fig. 9g.).



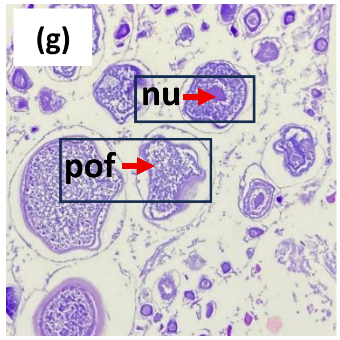



**Fig. 9**. Histological observation of the *Nemipterus* ovary, a) immature; b) early maturation; c) mid-maturation; d) final maturation; e) spawning prepared; f) active spawning; g) spent. Notes: Oogonia (og), primary oocyte (po); nucleus (nu), cortical alveoli (ca), yolk granule (yg), cell membrane (cm), hydrated yolk granule (hyg), post ovulatory follicle (pof)

### 9. Size at first maturity (Lm) and size at first caught (Lc)

The size at first gonadal maturity in Table (4) shows that both species have similar values, with the first gonadal maturity of *N. nemurus* at 18.42cm and *N. furcosus* at 17.34cm. The size at first capture for *N. nemurus* and *N. furcosus* is 15.02 and 16.75cm, respectively.

**Table 4.** Size at first maturity (Lm) and size at first capture (Lc) of *N. nemurus* and *N. furcosus* in the North Coast waters of East Java

| Species | Frequency (ind) | Lm (cm) | Lc (cm) |
|---|---|---|---|
| *N. nemurus* | 111 | 18.42 | 15.02 |
| *N. furcosus* | 154 | 17.34 | 16.75 |

The size at first capture value in Table (4) shows that both species are smaller than the size at first gonad maturity value (Lc<Lm). This calculation shows that the threadfin bream in the North Coast waters of East Java are caught before reaching maturity or still in their productive age.

## DISCUSSION

The average lengths of *N. nemurus* and *N. furcosus* in the North Coast waters of East Java are 15.7 ± 1.7cm and 17.3 ± 1.3cm, respectively. In comparison, *N. japonicus* from the northeast coast of India has an average length of 17.3 ± 0.19cm **(Rao *et al.*, 2017)**. The average length of *N. randalli* in the central Aegean Sea of Turkey is 16.01 ± 2.35cm **(Yapici & Filiz, 2019)**. Different results were obtained for *N. furcosus* on the East Coast of Peninsular Malaysia, which ranged from 9- 27cm **(Rahman & Samat, 2021)**. Another study on *N. japonicus* in the Makassar Strait showed that the length of males ranged from 15.0 to 27.3cm and females ranged from 15.0 to 23.0cm. Variations in length differences are influenced by the sampling period and different habitat conditions, such as food availability, temperature, and genetic differences at specific locations. For example, fish with high food availability and optimal temperature may have better growth compared to fish with lower food availability and optimal temperature **(Carlotti *et al*., 2007)**.

The length-weight relationship of *N. nemurus* and *N. furcosus* showed values of $_{0.0686}L^{2.6327}$ and $_{0.0553}L^{2.778}$, respectively. This indicates that both species have negative allometric values, meaning that the increase in length is faster than the increase in weight. Other research shows that *N. furcosus* in Kuantan, Pahang, Malaysia, has negative allometric growth **(Rahman & Samat, 2021)**. *Nemipterus randalli* from Antalya Bay shows positive allometric growth **(Innal *et al*., 2015)**. This difference may be due to genetic factors of the different species. Other causes can be influenced by habitat, and one of the factors with a significant effect is temperature. Temperature will affect physiology and metabolism. The availability of food is also an important factor that determines fish growth **(Viadero, 2019)**. Previous studies reported b values ranging from 2.7 to 2.9 for *Nemipterus* species found in Terengganu waters, Malaysia, which is similar to those recorded in this study **(Habib *et al*., 2021)**.

The sex ratio of *N. nemurus* and *N. furcosus* were 1:0.76 and 1:0.93 respectively, which means that the population of the threadfin bream in the North Coast waters of East Java is in a balanced state. A balanced sex ratio, where males and females are equal (1:1) or females outnumber males, is generally considered to be the ideal population for maintaining recruitment and population stability **(Hosny & Al-Jaber, 2017)**. The study by **Innal *et al*. (2015)** shows that *N. randalli* in Antalya Bay, Turkey has a male-to-female ratio of 0.9:1. *N. japonicus* in Sarawak, Malaysia shows a significantly male-dominated sex ratio **(Nettely *et al*., 2016)**. The female-to-male sex ratio of *N. japonicus* on the Saurashtra Coast of Gujarat is 1.08:1 **(Sarman *et al*., 2018)**. The sex ratio of *N. furcosus* landed at Sungailiat Fishing Port is 1.1:1 **(Persada *et al*., 2016)**. Calculating the sex ratio of the same species at different times and places can also yield different values. Sex ratio are influenced by environmental conditions, including temperature, habitat quality, food competition, and predation pressure **(Vandeputte *et al*., 2012)**. Variations in sex ratios can fluctuate throughout the year, influenced by factors such as seasonality, maturation periods, differences in growth rates between males and females, differences in mortality rates for each sex, and the selectivity effects of fishing gear size **(Innal *et al*., 2015)**.

Relative condition factor (Kn) in *N. nemurus* and *N. furcosus* has an average around 1 in all classes. *N. nemurus* has Kn values of 0.78-1.24 with an average of 1±0.09, while *N. furcosus* has Kn values of 0.67-1.22 with an average of 1±0.09. The Kn values of male *N. furcosus* in Kuantan, Malaysia, is 1.26-1.39 and female 1.25-1.39 **(Amira *et al*., 2016)**. Another study on *N. japonicus* in the Gulf of Suez, Egypt, had Kn values of 0.95-

1.72 and 1.01-1.62 for males and females, respectively **(Amine, 2012)**. The average Kn of both species in this study is in good condition, as they have values of 0.95-1.05. Kn values are influenced by external factors, namely water quality and food availability. Ecosystem productivity is a contributing factor to the value of the condition factor **(Amira *et al*., 2016)**. Internal factors that can affect the value of Kn are the gonad maturation process, which requires energy to be allocated to the reproductive process. Condition factors can describe the fish's reproductive cycle **(Effendie, 2002)**.

Gonad maturity stage shows that *N. nemurus* and *N. furcosus* have different results. This difference may be caused by competition for food resources and the same spawning location. The same habitat can cause competition, thereby affecting the gonad maturity level. Other factors that influence differences in GSI are environmental differences, reproductive strategies, and species differences **(Chattopadhyay, 2017)**.

The diameter of *N. nemurus* eggs ranges from 0.05 to 0.6mm, while *N. furcosus* eggs range from 0.1 to 0.52mm, both showing two modes (Fig. 8.), which means that the eggs of the threadfin bream do not mature simultaneously. The threadfin bream spawn by releasing their eggs gradually or partially. Based on the independent t-test, the egg sizes of the two species were significantly different ($P< 0.05$). The size of the eggs will increase with the increase in gonad maturity due to the deposition of yolk during the process of vitellogenesis. Genetic factors and food availability in the environment determine egg size. The size of the egg will produce a large larva at hatching **(Bone and Moore, 2008)**. The large size of the egg has negative impacts, namely longer development time, higher oxygen requirements, and greater visibility to predators **(Hart & Reynolds, 2002)**.

The fecundity of *N. nemurus* and *N. furcosus* in the North Coast waters of East Java differed significantly based on the t-test results, with the fecundity values of the two species ranging from 10,147-86,944 with an overall average of 35,576±22,518 and 16,038-108,648 with an overall average of 59,508±26,041, respectively. Another study on the fecundity of *N. japonicus* and *N. furcosus* in the East Coast of Peninsular Malaysia varied between 54,970-236,938 with an average of 102,477 ± 43,580 **(Rahman & Samat, 2021)**. *Nemipterus japonicus* in the North-east Coast of India has a fecundity ranging from 13,176 to 123,875 **(Rao *et al*., 2017)**. A similar study in Indonesia found that *N. furcosus* from Jakarta Bay had a fecundity range of only 39,728 to 40,921 **(Persada *et al*., 2016)**. According to **Rahman and Samat (2021)**, fecundity increases during the spawning season. This difference may be due to different collection periods and variations in fecundity that depend on several factors. Influencing factors include species, size, and age **(Rahman & Samat, 2021)**.

Histological observations were conducted to examine the development of the ovaries in the threadfin bream (*Nemipterus* spp.). The results of the histological study of the female gonad are similar to the previous study of the threadfin bream from Malaysian waters **(Nettelly *et al*., 2016)**, where ovarian development was classified into seven growth stages: (I) immature, (II) early immaturity, (III) intermediate maturity, (IV) final maturity, (V) spawning preparation, (VI) spawning active, and (VII) spent stage.

The size at first gonad maturity (Lm) of *N. nemurus* and *N. furcosus* has different values, namely 18.4 and 17.3cm, respectively, while the size at first capture (Lc) is 15 and 16.7cm. This study shows that *N. nemurus* and *N. furcosus* have Lc<Lm values, meaning that most of the captured fish have not yet reached gonad maturity. The difference in Lm between the two indicates competition within the same habitat, whether for food or shelter. Another study of *N. japonicus* in the waters of Banten Bay reported Lm value of 19.6cm **(Oktaviyani *et al*., 2016)**. This difference may be caused by variations in water quality, genetic characteristics of the population, regional differences, and fishing pressure **(Leet *et al*., 2011)**. Fish that experience pressure from overfishing tend to mature their gonads more quickly at smaller sizes, as a form of reproductive strategy to sustain their generation **(Cardoso & Haimovici, 2014)**. The value of Lm can vary due to climatic conditions, food availability, fishing, and changes in growth rates **(Nair *et al*., 2021)**.

Information regarding the initial size of gonadal maturity is an important parameter in determining the minimum size of fish caught **(Meshram *et al*., 2021)**. This study reveals that most of the fish caught have not yet reached gonadal maturity, which threatens the sustainability of species.

This study presents important basic information about the reproductive biology, growth and condition of male and female of *N. nemurus* and *N. furcosus* in the North Coast waters of East Java. The maturity result would help determine the minimum acceptable catch size to ensure the sustainability of these species. In order to prevent the overfishing, it is necessary to implement mesh size regulation with strict management.

## CONCLUSION

*Nemipterus nemurus* and *N. furcosus* in the North Coast waters of East Java have a balanced sex ratio (1:1). The fecundity of *N. furcosus* is higher compared to *N. nemurus* with average values of 37,689 and 60,153. The size at first gonadal maturity of *N. nemurus* is reached at a length of 18.42 cm, while the size at first gonadal maturity of *N. furcosus* is 17.34cm. The size at first capture is smaller than the size at first gonadal maturity (Lc < Lm), indicating that the fish are caught before reaching reproductive age. As a result, overfishing could threaten the sustainability of threadfin bream population in the North Coast waters of East Java.

## ACKNOWLEDGEMENT

This research was funded by Universitas Gadjah Mada through the RTA Scheme (Grant Number: 5075/UN1.P.II/Dit-Lit/PT.01.01/2023).

## REFERENCES


**Amine, M. A.** (2012). Biology and assessment of the thread fin bream *Nemipterus japonicus* in Gulf of Suez, Egypt. Egypt. *J. Aquat. Biol. & Fish*, 16(2): 47-57.

**Amira, F. S.; Rahman, M. M.; Kamaruzzaman, B. Y.; Jalal, K. C. A; Hossain, M. Y. and Khan, N. S.** (2016). Relative Abundance and Growth of Male and Female *Nemipterus furcosus* Population. *Sains Malaysiana*, 45(1): 79-86.

**Bilecenoglu, M. and Russell, B. C.** (2008). Record of *Nemipterus randalli* Russell, 1986 (Nemipteridae) from Iskenderun Bay, Turkey. *Cybium*, 32(3): 279–280.

**Bone, Q. and Moore, R.** (2008). Biology of fishes third edition. Taylor & Francis Group, US.

**Cardoso, L. G. and Haimovici, M.** (2014). Long term changes in the sexual maturity and in the reproductive biomass of the southern king weakfish *Macrodon atricauda* (Günther, 1880) in Southern Brazil. *Fisheries Research*, 160: 120–128. https://doi.org/10.1016/j.fishres.2014.05.012

**Carlotti, F.; Bonnet, D. and Halsband-Lenk, C.** (2007). Development and growth rates of *Centropages typicus*. *Progress in Oceanography*, 72(2–3): 164–194. https://doi.org/10.1016/j.pocean.2007.01.011

**Chattopadhyay, N. R.** (2017). Reproductive Cycle, Maturation, and Spawning. In Induced Fish Breeding (pp. 15–42). Elsevier. https://doi.org/10.1016/B978-0-12-801774-6.00002-X

**Erdoğan, Z.; Koç, H. T. and Özdemir, F.** (2021). Reproductive Biology of the Tigris Scraper, *Capoeta umbla* (Heckel, 1843) Population Living in Solhan Creek of Murat River (Bingöl, Turkey). *Transylvanian Review of Systematical and Ecological Research*, 23(2): 39–50. https://doi.org/10.2478/trser-2021-0013

**Farias, I.; Figueiredo, I.; Janeiro, A. I.; Bandarra, N. M.; Batista, I. and Morales-Nin, B.** (2014). Reproductive and feeding spatial dynamics of the black scabbardfish, *Aphanopus carbo* Lowe, 1839, in NE Atlantic inferred from fatty acid and stable isotope analyses. *Deep-Sea Research Part I: Oceanographic Research Papers*, 89: 84–93. https://doi.org/10.1016/j.dsr.2014.04.010

**Habib, A; Hanizar, M. I. A; Kamal, M. S; Azmi, M. A. S and Seah, Y. G.** (2021). Length-Weight Relationship of Four Demersal Species from Chendering, Terengganu. Malaysia. *Thalassas: An International Journal of Marine Sciences*, 37: 205-207.

**Hart, P. J. B. and Reynolds, J. D.** (2002). Handbook of fish biology and fisheries. Blackwell Publishing, USA.

**Hosny, C. F. H. and Al-Jaber, A. M.** (2017). Reproductive biology of *Gerres longirostris* Lacepede, 1801 (Perciformes: Gerreidae) in the western Arabian Gulf. *Indian Journal of Fisheries*, 64(2): 10–16. https://doi.org/10.21077/ijf.2017.64.2.58421-02

**Imtiaz, A. and Naim, D.** (2018). Geometric morphometrics species discrimination within the genus *Nemipterus* from Malaysia and its surrounding seas. *Biodiversitas*, 19(6): 2316–2322. https://doi.org/10.13057/biodiv/d190640

**Innal, D.; Aksu, M.; Akdoganbulut, D.; Kisin, B. and Can, M.** (2015). Age and growth of *Nemipterus randalli* from Antalya Gulf-Turkey. *International Journal of Fisheries and Aquatic Studies*, 2(4): 299–303.

**Kantun, W. and Moka, W.** (2022). Some Aspects of the Reproductive of Japanese Threadfin Bream (*Nemipterus japonicus* Bloch, 1791) caught in the Area Around the Artificial Reef In the Pitu Sunggu Waters of the Makassar Strait. *Jurnal Perikanan Universitas Gadjah Mada*, 24(2): 147. https://doi.org/10.22146/jfs.73629

**Lambert, Y.** (2008). Why Should We Closely Monitor Fecundity in Marine Fish Populations ? Journal of Northwest Atlantic Fishery Science, 41: 93–106. https://doi.org/10.2960/J.v41.m628

**Leet, J. K.; Gall, H. E. and Sepúlveda, M. S.** (2011). A review of studies on androgen and estrogen exposure in fish early life stages: Effects on gene and hormonal control of sexual differentiation. *Journal of Applied Toxicology*, 31(5): 379–398. https://doi.org/10.1002/jat.1682

**Lloret-Lloret, E.; Albo-Puigserver, M.; Giménez, J.; Navarro, J.; Pennino, M. G.; Steenbeek, J.; Bellido, J. M. and Coll, M.** (2022). Small pelagic fish fitness relates to local environmental conditions and trophic variables. *Progress in Oceanography*, 202, 102745. https://doi.org/10.1016/j.pocean.2022.102745

**Meshram, M. M.; Rajesh, M.; Rajesh, K. M. and Suyani, N. K.** (2021). Sexual Maturity, Spawning Periodicity and Fecundity of Obtuse Barracuda *Sphyraena obtusata* (Cuvier, 1829) along Karnataka Coast, Southeastern Arabian Sea. *Indian Journal of Animal Research*, 55(12): 1409–1415. https://doi.org/10.18805/IJAR.B-4505

**Ministry of Marine Affairs and Fisheries**. (2022). Fisheries Production. https://statistik.kkp.go.id/home.php?m=prod_ikan_prov&i=2#panel-footer

**Mohamed, A. A.; Ismail-Fitry, M. R.; Rozzamri, A. and Bakar, J.** (2022). Effect of foam-mat drying on kinetics and physical properties of Japanese threadfin bream (*Nemipterus japonicus*) powder. *Journal of Food Processing and Preservation*, 46(3). https://doi.org/10.1111/jfpp.16376

**Nair, P. G.; Joseph, S.; Kripa, V. and Pillai, V. N.** (2021). Population growth and maturity characteristics of Commerson s anchovy (*Stolephorus commersonnii* Lacepède, 1803) along the southwest coast of India. **Indian Journal of Geo-Marine Sciences**, 50(2): 141–147. https://doi.org/10.56042/ijms.v50i02.66089

**Nettely, T.; Rajaee, A. H.; Denil, N. A.; Idris, M. H.; Nesarul, M. H.; Amin, S. M. N. and Hena, M. K. A.** (2016). Reproductive biology of *Nemipterus japonicus*

(Bloch, 1791) from the coastal waters of Bintulu (South China Sea), Sarawak, Malaysia. *Journal of Environmental Biology*, 37(Special issue): 715–724.

**Oktaviyani, S.; Boer, M. and Yonvitner, Y.** (2016). Biological Aspects of Threadfin Bream (*Nemipterus japonicus*) in Banten Bay Waters. *BAWAL Widya Riset Perikanan Tangkap*, 8(1): 21. https://doi.org/10.15578/bawal.8.1.2016.21-28

**Persada, L. G.; Utami, E. and Rosalina, D.** (2016). Reproductive Aspects of Fork-tailed Threadfin Bream *(Nemipterus furcosus*) Landed at Sungailiat Archipelago Fishing Port. *Akuatik*, 10(2): 46–55.

**Rahman, M. M. and Samat, A. F.** (2021). Reproductive cycle, sexual maturity and fecundity of *Nemipterus furcosus* (Valenciennes, 1830). *Aquaculture and Fisheries*, 6(4): 424–431. https://doi.org/10.1016/j.aaf.2020.07.006

**Rao, M. V. H.; Ghosh, S.; Sreeramulu, K.; Mahesh, V. U.; Kumar, M. S. and Muktha, M.** (2017). Reproductive biology of *Nemipterus japonicus* (Bloch, 1791) in the trawl grounds along the north-east coast of India. *Indian Journal of Fisheries*, 64(4). https://doi.org/10.21077/ijf.2017.64.4.62693-03

**Russell, B. C.** (1990). FAO species catalogue. Vol. 12. Nemipterid Fishes of the World. (Threadfin breams, Whiptail breams, Monocle breams, Dwarf monocle breams, and Coral breams). Family Nemipteridae. An Annotated and Illustrated Catalogue of Nemipterid Species known to Date. (Vol. 12). FAO.

**Sarman, V.; Hitesh, K.; Mahendra, P. and Piyush, V.** (2018). Biological aspects of threadfin bream *Nemipterus japonicus* (Bloch 1791) along coast of Saurastra, Gujarat. *Journal of Fisheries and Life Sciences*, 3(1): 34-38.

**Sparre, P. and Venema, S. C.** (1998) Introduction to tropical fish stock assessment, Part I: Manual. FAO Fisheries Technical Paper, 306, 1.

**Srihari, M.; Silpa, S.; Pavan-Kumar, A.; Tikochinski, Y.; Golani, D.; Nayak, B. B.; Bushan, S. and Abidi, Z. J.** (2020). Characterization of genetic diversity of an invasive Lessepsian Migrant, *Nemipterus randalli* Russell, 1986 from its native and non-native regions using mitochondrial DNA marker. *Mediterranean Marine Science*. https://doi.org/10.12681/mms.23507

**Tari, F.; Namin, J. I.; Abdolmalaki, S. and Hadavi, M.** (2015). Reproductive biology of Caspian vimba, *Vimba vimba* (L.), in the coastal waters of the southwestern Caspian Sea. *Archives of Polish Fisheries*, 23(3): 171–180. https://doi.org/10.1515/aopf-2015-0020

**Udupa, K. S.** (1896). Statistical method of estimating the size at first maturity of fishes. *Fishbyte*, 4(2): 1-3.

**Vandeputte, M.; Quillet, E. and Chatain, B.** (2012). Are sex ratios in wild European sea bass (*Dicentrarchus labrax*) populations biased? *Aquatic Living Resources*, 25(1): 77–81. https://doi.org/10.1051/alr/2012002

**Viadero, R.** (2019). Water Quality Factors Affecting Fish Growth and Production. Encyclopedia of Water: Science, Technology, and Society, John Wiley & Sons, USA, pp.1-8.

**Wu, C.C.; Weng, J.-S.; Liu, K.-M. and Su, W.-C.** (2008). Reproductive Biology of the Notchedfin Threadfin Bream, *Nemipterus peronii* (Nemipteridae), in Waters of Southwestern Taiwan. *Zoological Studies*, 47(1): 103–113.

**Yapici, S. and Filiz, H.** (2019). Biological aspects of two coexisting native and non-native fish species in the Aegean Sea: *Pagellus erythrinus* vs. *Nemipterus randalli*. *Mediterranean Marine Science*, 20(3): 594–602. https://doi.org/10.12681/mms.19658

**Yi, M.R.; Hsu, K.-C.; Wang, J.-X.; Feng, B.; Lin, H.-D. and Yan, Y.-R.** (2021). Genetic Structure and Diversity of the Yellowbelly Threadfin Bream *Nemipterus bathybius* in the Northern South China Sea. *Diversity*, 13(7): 324. https://doi.org/10.3390/d13070324