

E-ISSN: 2708-0021  
 P-ISSN: 2708-0013  
[www.actajournal.com](http://www.actajournal.com)  
 AEZ 2025; 6(1): 95-99  
 Received: 28-12-2024  
 Accepted: 30-01-2025

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## Spawning season of Indian mackerel (*Rastrelliger kanagartha*) in Massawa coastal waters, Southern Red Sea, Eritrea

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DOI: <https://www.doi.org/10.33545/27080013.2025.v6.i1b.194>

### Abstract

Indian mackerel, *Rastrelliger kanagartha* (Cuvier, 1817) is a group of small pelagic schooling fish that belongs to Scombridae family and that has high economic value and ecological importance. Spawning season and sexual maturity of *Rastrelliger kanagartha* was studied in Eritrean Red Sea around Massawa coast studied from June 2022 to May 2023. Monthly data were collected from artisanal (footfishermen) who caught the fish using hook and line. A total of 638 individuals comprising 64.6% females, 33.5% males and 1.9% unsexed were sampled and analyzed. The morphometric measurements including total length, fork length and standard length of fish in each sample were measured using a ruler to the nearest centimeter, and the total body weight and gonad were also measured using digital balance to the nearest gram. The length weight relationship for female was analyzed and expressed as:  $TW = 0.0566TL^{2.4538}$  ( $r^2 = 0.72$ ,  $n = 412$ ) and for male as:  $TW = 0.0225TL^{2.7656}$  ( $r^2 = 0.684$ ,  $n = 214$ ). The spawning season was prolonged period extending from July to November with a peak during September for female and October for male. The first sexual maturity size ( $L_{50}$ ) of female was 19.56 cm TL and 19.29 cm TL for male *Rastrelliger kanagartha*.

**Keywords:** Gonadosomatic indices, length at maturity, *Rastrelliger kanagartha*, Red sea, Eritrea

### 1. Introduction

Indian mackerel, *Rastrelliger kanagartha* (Cuvier, 1817) is a small pelagic schooling fish widely distributed in the Indian Ocean, Indo-West Pacific region <sup>[1]</sup> and in the Red Sea that plays important role in food supply and fish meal for the Red sea bordering countries such as Eritrea and Egypt <sup>[2]</sup>. Eritrea possesses a variety of fish resources as per their natural habitats and the Small pelagic, such as Sardines, Anchovies and herrings and Indian mackerel that are targets for beach-seines and purse-seines comprise 55% of the maximum sustainable yield (MSY) of the Eritrean marine fish resources. Small pelagic sardines and anchovies including Indian mackerel are a major fishing resource in Eritrean waters, forming schools of various sizes that can usually be found near the surface. These small pelagic are migratory species moving through the Southern Red Sea, approaching inshore areas during the winter season and moving further offshore during the warm summer season <sup>[3]</sup>.

Although Indian mackerel is important in Eritrea, limited studies have been done about Indian mackerel such as gut content analysis <sup>[4]</sup>. Comprehensive biological studies of Indian mackerel have not done so far in Eritrean Red Sea waters. Therefore this species should be studied in order to understand its status and ensure its sustainable exploitation through effective management. An understanding of the reproductive biology of a species is important for management of fisheries resources <sup>[5]</sup>. This present study intended to study the length-weight relationship and condition factor, reproductive biological aspects such as sex ratio, gonad maturity level, gonadosomatic index (GSI) and length at first maturity that enrich the biological information of Indian mackerel around Massawa, Eritrean Red Sea waters under Fisheries Resources management program (FRMP) funded by International fund for Agricultural Development (IFAD).

### 2. Methods and Materials

The specimens for the study of spawning season were collected from the artisanal fishermen (footfishermen) from around Massawa over a period of one year from June 2022 to May

2023. Every month except for the month of February samples of individuals were obtained for processing and analyzing in the laboratory. The morphometric measurements such as total length, fork length and standard length of fish in each sample were measured using a ruler to the nearest centimeter, and the total body weight and gonad were also measured using digital balance to the nearest gram. The samples of individual fish were dissected, sexed and classified into stages of gonad development based on macroscopic observation.

In the analysis of the data, length-weight relationship of Indian mackerel was analyzed using Microsoft excel in the form of cubic equation [6] as:  $W=aL^b$

The degree of correlation ( $r^2$ ) that describes the degree of association between the length and weight was computed from the length-weight analysis.

Condition factor of the fish was calculated using the formula:  $K= W \times 100 / TL^3$

Where

K= condition factor, W= fish weight in grams, TL= total length of fish in cm.

Normally GSI was calculated as the percentage ratio of gonad weight to body weight [7].

$$GSI = (\text{gonad weight} / \text{total body weight}) \times 100$$

1. GSI data from each month for one year were analyzed and the analysis was done for males and females separately as the following steps.
2. GSI value of every fish in a sample was calculated.
3. Average monthly GSI value was calculated.
4. Finally the monthly mean GSI values were graphed against the months to estimate the spawning season of the species.

The maturity stage of gonad was classified in to five stages (immature/inactive I, developing II, ripe/mature III, spawning IV and spent V stages) based on macroscopic observation of the gonads. Gonads in stage III and above were considered as mature and used to determine the length at 50% maturity ( $Lm_{50}$ ). The cumulative frequency of samples having mature gonads were plotted against the length class of 1 cm interval and the  $Lm_{50}$  was calculated from the size class at which the cumulative maturity percentage was 50% mature [8].



Fig 1: Mature translucent female gonad

### 3. Results

In the present study which was carried out from June 2022 to May 2023, a total of 638 individuals comprising 412 (64.6%) females, 214 (33.5%) males and 12 (1.9%) unsexed were sampled and analyzed. The length frequency of Indian mackerel varied among length classes during the study period. The length classes for female ranged from 15.6 to 23.5 cm with mean length 19.5 cm TL and the lowest observed length frequencies (samples occurrence) were 15.6-18.5 cm and 21.5-23.5 cm, while the most frequent lengths (75%) ranged between 18.5 and 21.5 cm TL. For the male, the length classes ranged from 15.5 to 22.5 cm with mean length 19.2 cm TL and the lowest observed length frequencies (samples occurrence) were 15.5-17.5 cm and 20.5-22.5 cm, while the most frequent lengths (78%) ranged between 17.5 and 20.5 cm TL (figure 2). Totally 626 individuals of Indian mackerels were used for sex ratio analysis in which the male (n = 214) to female (n= 412) sex ratio male to female was 0.52 for the entire collected sample during the study period. The sex ratio result indicated that females are almost twice more dominant than males. Females are found to dominate males in the length classes between 20.5 and 23.5 cm TL and males dominate females in the length classes range 15.5-16.5 cm and 17.5-18.5 cm TL while in the remain length classes (75%) the sex ratio is almost 1:1 (figure 2).

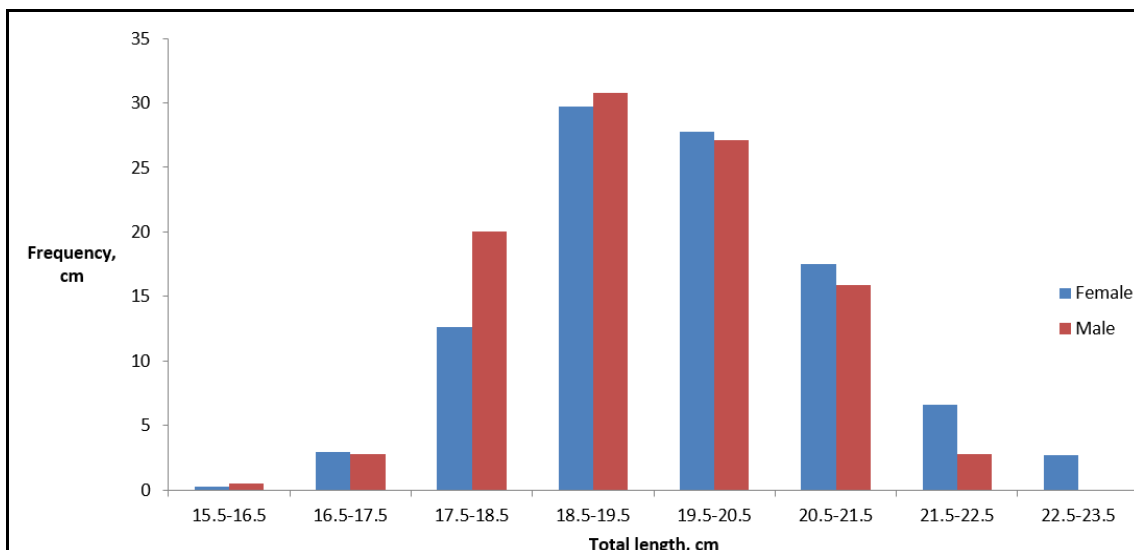
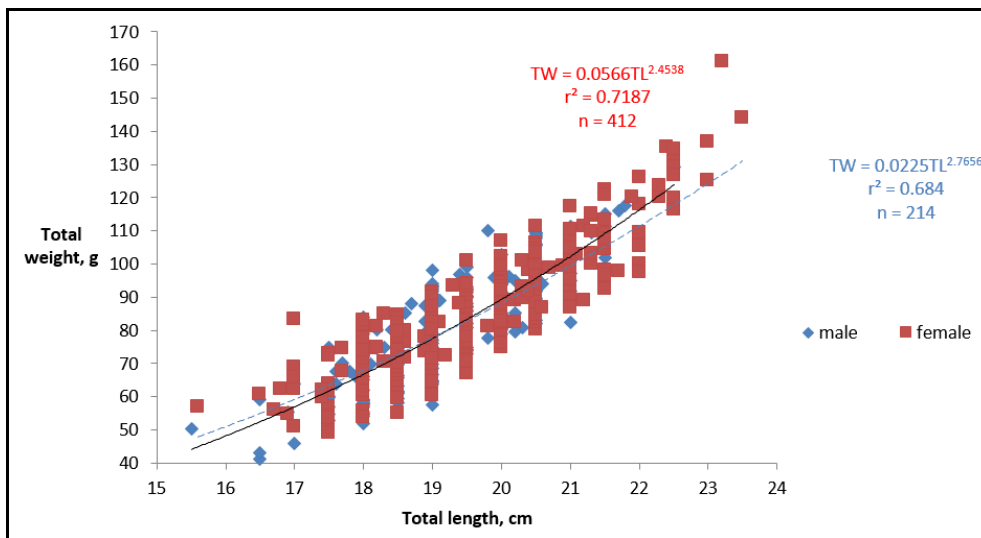


Fig 2: Length frequency distribution of Indian mackerel

The weight of females ranged between 49 and 161.1 gram with the mean 84.4 gram while for males ranged between 41.2 and 129.4 gram with the mean 81.1 gram, indicating that females are heavier than males in the entire samples of this study. The length weight relationship analysis was done separately for males and females in entire sample and for combined sex monthly. The allometric coefficients (b) in the present study for combined sex were between 2.366 and 3.421. The lowest b-values was found in June, whereas the highest values were found in March. The monthly length

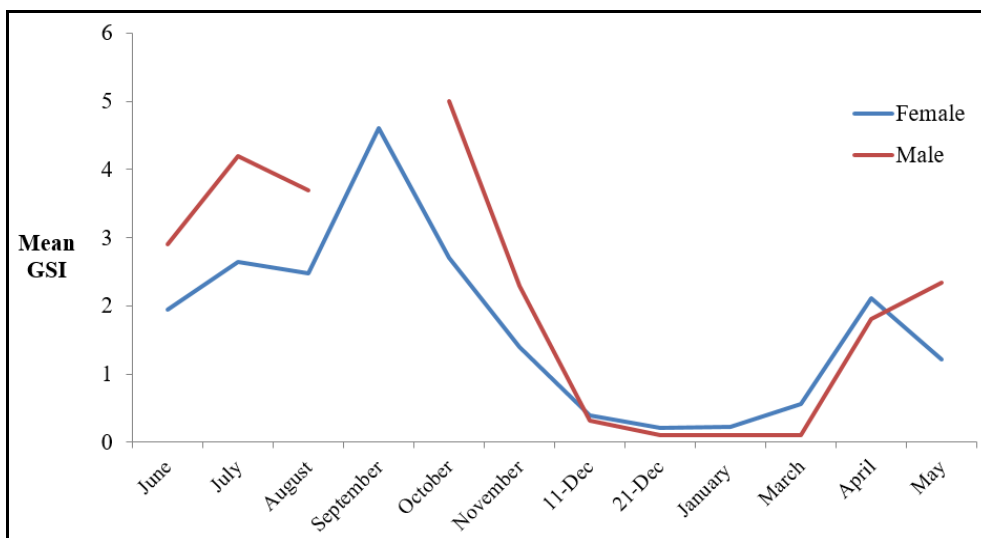
weight relationships were observed with  $R^2$  values that range between 0.5616 and 0.8913. Based on the entire sample during the study period, length weight relationship for female was analyzed and expressed as:  $TW = 0.0566TL^{2.4538}$  ( $r^2 = 0.72$ ,  $n = 412$ ) and for male as:  $TW = 0.0225TL^{2.7656}$  ( $r^2 = 0.684$ ,  $n = 214$ ) (figure 3). The condition factor (K) ranged from 0.8 to 1.1. The lowest value was recorded in the month of July and the highest values were recorded in the months from March to May. In the remain months the value was recorded 1.



**Fig 3:** Length weight relationship of Indian Mackerel

The monthly mean GSI values ranged from 0.21 to 4.6 for female and the lowest was recorded in the month of January and the highest was recorded in the month of September while for male the monthly mean GSI values ranged between 0.1 and 5. The lowest value was recorded in the month of January and highest value was recorded in

October. The spawning season was only once in a year for prolonged period extending from July to November with a peak during September for female and October for male (fig 4). The first sexual maturity size of female was 19.56 cm TL (fig 5) and 19.29 cm TL for male in this present study (fig 6).



**Fig 4:** Monthly distribution of mean gonosomatic index (GSI) of Indian Mackerel

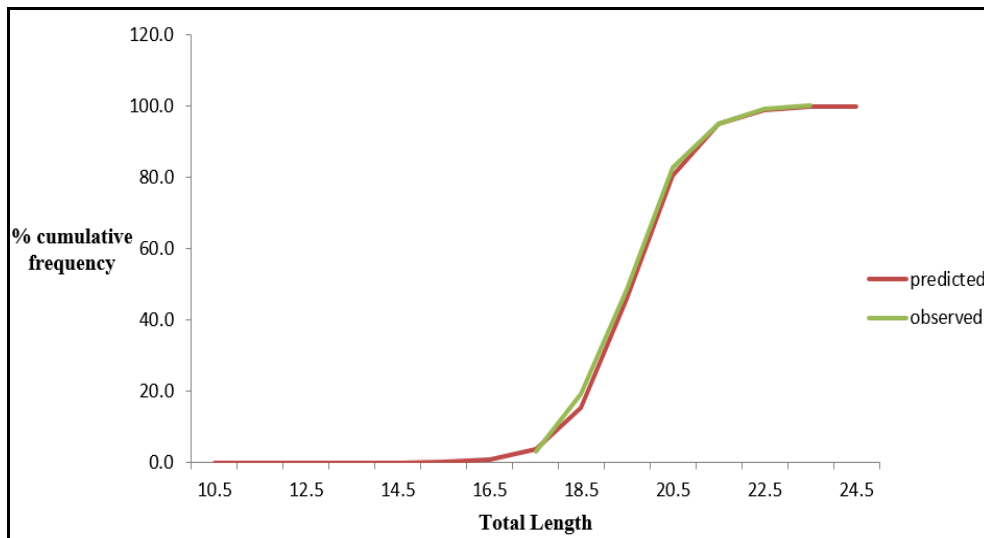


Fig 5: The size at first sexual maturity ( $L_{m50}$ ) of female Indian Mackerel

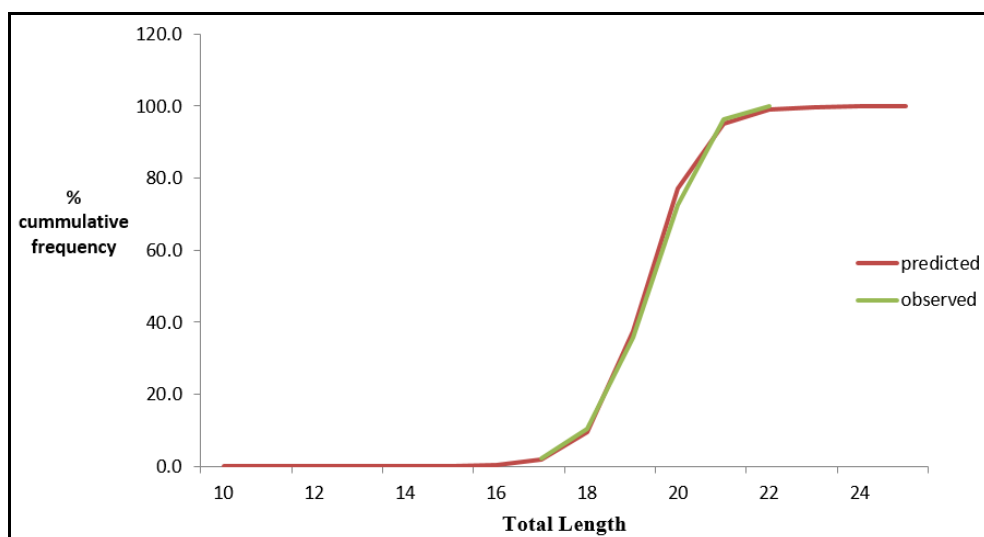


Fig 6: The size at first sexual maturity ( $L_{m50}$ ) of male Indian Mackerel

#### 4. Discussion

This present study provides important insight about the spawning season and the size at first sexual maturity ( $L_{m50}$ ) about Indian mackerel, *Rastreliger kanagaruta* around Massawa along the Eritrean Red Sea coast. The observed length-weight relationship was with  $R^2$  values ranging between 0.5616 and 0.8913 and the coefficient of determination indicated increase in length with increase in weight. If the value of " $R^2$ " is higher than 0.5, then the length-weight relationship is positively correlated. The power equation describing the length-weight relationship of *R. kanagaruta* in this present study shows a "b" value between those found in the previous studies [9, 10, 11]. Difference in b values in each month can be attributed to the combination of factors such as : number of specimens examined, effect of area/season, habitat, degree of stomach fullness, gonad maturity, sex, health and general fish condition, preservation technique and differences in the observed length ranges of the specimens caught [12]. The condition factor is also affected by certain factors such as pulling data, sorting into classes, sex, stages of maturity and state of the stomach [13].

The gonado-somatic index (GSI) showed one spawning season of *Rastreliger kanagaruta* extended from July to

November around Massawa along the Eritrean Red Sea coast. Several studies similarly support the present result and suggested the spawning season such as: August-November in the coast of Oman [14], January-March and July-October in Aceh waters [9], July and August in Mangalore Region [15], September and November in Mayalibit Bay, Raja Ampat, West Papua [16], July to September in in Makassar coastal waters, South Sulawesi, Indonesia [17]. Differences in spawning seasons attributed to environmental conditions such as feeding availability, water quality, and the influence of seasons [18]. Shifts in spawning seasons occur if the environmental conditions are not favored [19].

The length at first maturity ( $L_{50}$ ) was estimated at 19.56 cm TL for females and 19.29 cm for males in the present study which was similar to those estimated in other studies. It was reported that length at first maturity of female was 19.58 cm (TL) from the Western Waters of Aceh [9]. Other Studies estimated length at first sexual maturity ( $L_{50}$ ) at 20.39 cm for males and 20.53 for females [10] and 20.42 cm for combined sex [20] in Egypt Red Sea and analysis of size at first maturity using cumulative frequency method showed that male attained first maturity at 20.5 cm TL while the female at 21.0 cm TL in Mangalore Region [15]. Studies



from Indian coast indicated that *R. kanagurta* attained sexual maturity at a size of 18.86 cm along northern region and 18.32 cm along southern region <sup>[21]</sup> and 17.85 cm for female and 16.65 cm for male <sup>[11]</sup>. Further the estimated length at first maturity values ( $L_{50}$ ) of male and female were at 19.55 cm and 20.71 cm, respectively in Mayalibit Bay, Raja Ampat, West Papua <sup>[16]</sup>. However, estimates of this study are lower than results of some studies reported from the coast of Oman for male at 27.75 cm and for females 26.75 cm <sup>[14]</sup>. The size of the first gonad mature fish caused by several factors, such as the environment pressure, age, and other factors. The suitable climate is related to the abundance of natural food and good water quality, so the size of the first gonad maturity in good environmental conditions will be larger than the poor environmental conditions with limited feed. Fishing pressure affects the stock size of fishes and the average size of the fish. Fish populations that get high fishing pressure will respond to spawn quickly on a small average fish size <sup>[22]</sup>.

### 5. Conclusion

The present study indicated that the samples were dominated by female during study period. The size at first maturity calculated by cumulative percentage method for male was at 19.29 cm and 19.56 cm for female. The gonado-somatic index (GSI) was used to estimate the period of gonad development and spawning season. The monthly gonado-somatic index showed that the spawning season was between July to November with a peak during September-October for both sex. This information of spawning season could be integrated in management plan to achieve sustainable management of Indian mackerel through restricting fishing activities during spawning season when it is needed.

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