Biological Aspect of Indian Scad (*Decapterus russelli*) Caught by Purse Seine in North Coast of Sumenep Waters, East Java

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Abstract. An Indian scad (*Decapterus russelli*) is one of the dominant catch in Java Sea. Sustainability of Indian scads resources need to be maintained due to its important role and fisheries economic value especially in purse seine fisheries. This research was conducted in Sumenep Regency from February until July 2018 which aimed to determine the biological aspects and food composition of Indian scads (*Decapterus russelli*). The method in this research is descriptive and using random sampling method. A total of 1,078 fish samples obtained with Total Length (TL) range between 13.5-23.7 cm and body weight between 21.23-132.3 grams. The Indian Scads growth pattern was negative allogmetric with equation W = 0.02L^{2.736}. Male and female ratio was 1:1.08. The value of Gonado Somatic Index (GSI) was 1.76%. The Lm value was 19.3 cm. That was higher than the Lc value (18.6 cm). Growth parameters of Indian Scads indicated that asymptotic Length (L∞) was 25 cm, K was 0.58 and t0 age was -0.29 years and age of t max was 4.9 years. It was found that the main food of the Indian scads was phylum Ochrophyta (IP> 72%). The Indian scads growth pattern was negative allometric. Gonad Maturity Level (GML) analysis indicated that the samples were dominated by immature fish. Lm value of 19.3 cm was higher than the value of Lc (18.6 cm). The Indian scads were categorized as plankton feeder types.

Keywords: Length and weight relationship, Purse seine, Length at first mature, Plankton feeder, Sustainable resources

1. Introduction

Indian scads (*D. russelli*) are one of small pelagic resources in Java Sea which has important economic value. Furthermore the Indian scads resource was categorized as one of the biggest production among pelagic fisheries resource in Indonesia. While in East Java, the Indian scads (*D. russelli*) has an important economic role and value especially in Sumenep Regency [1].

The utilization of an aquatic resource potential must be based on the principle of natural resource management which is about how to utilize these natural resources by paying attention to their sustainability in order to be maintained so that they can be utilized continuously and can be enjoyed by future generations. Fisheries management need a fundamental analysis and information, well planned correctly and a structured decision-making so that management can be more effective and efficient. Optimizing the utilization of fish resources requires a management strategy based on scientific data and information. Important information needed is about the biological aspects of fish [2]. Given the importance of the Indian scads (*D. russelli*) role in the field of fisheries, its sustainability needs to be
maintained in the basis that it is necessary to have information about biological aspects and food consumption of the Indian scads resources.

2. Methods

2.1. Research Method

This research was done using descriptive and random sampling method. The research was conducted from February until July 2018 in north coast of Sumenep waters, Sumenep Regency, East Java. Primary data is obtained from taking samples of fish caught by purse seine in north coast of Sumenep waters landed in Pasongsongan fish landing site (FLS) Sumenep and carried out for approximately 6 months. Other primary data include identification of fish and the types of plankton in fish stomach. While secondary data consist of information obtained from fisheries official and fisheries journals to support primary data. In this research, biological aspect of Indian scads (D. russelli) to be analyzed consisted of length and weight relationship, sex ratio, Gonad Maturity Level (GML), Gonado Somatic Index (GSI), length at first capture (Lc), length at first mature (Lm), and the food composition. In addition, two growth parameters were also assessed, namely theoretical maximum length or asymptotic length (L∞) and growth rate coefficient (K). Estimation of both L and K would be assessed using Electronics Length Frequency Analysis (ELEFAN I) in the Fish Stock Assessment Tools (FISAT II) application program introduced by Food Agriculture Organization (FAO) and International Centre for Living Aquatic Resource Management (ICLARM).

2.2. Data analysis

2.2.1. Length and Weight Relationship

Length and Weight Relationship data are assessed based on [3] allometric growth model with mathematical formula as follow:

\[ W = aL^b \]  

where W is weight (gr), L is the total length (mm), a is the intercept and b is the constant. The equation is then transformed into linear equations so that the form of the equation becomes: \( \ln W = \ln a + b \ln L \). Justification whether relationship is allometric or isometric is analyzed by the T-Test [4]. If \( t_{count} \) is higher than \( t_{table} \) then the value of \( b \neq 3 \) or allometric. While if \( t_{count} \) is smaller than \( t_{table} \) then the value \( b = 3 \) or isometric [5].

2.2.2. Sex Ratio

Sex ratio was determined by looking at the frequency ratio of male and female fish. To find out the balance of the sex ratio, the following formula is used [6]:

\[ X = \frac{J}{B} \]

where \( X \) is the sex ratio, \( J \) is the number of male fish (the number of fish); \( B \) is the number of female fish (the number of fish). Comparative ratio of sex is predicted using the formula proposed by Zar (2010) [7] as follow:

\[ X^2 = \sum \frac{(O_i - E_i)^2}{E_i} \]

where: \( O_i = \) value of observation; and \( E_i = \) Expected value

2.2.3. Gonado Somatic Index (GSI)

Gonado Somatic Index (GSI) can be analyzed using the formula described by [6] is:

\[ \text{GSI} = \frac{W_g}{W} \times 100\% \]

where: GSI = Gonado Somatic Index; \( W_g \) = Gonad Weight; and \( W \) = body weight.
2.2.4. **Length at first capture (Lc)**

Lc is used to foresee the first maturity of gonads using the Sparre and Venema formula [4], as follows:

\[
Q = \frac{1}{1 + e^{-a(L - L_m)}}
\]

where:

- \( Q \) = fraction of the long class which is gonad ripe
- \( I \) = maximum value that shows 100% mature
- \( E = 2.718 \)
- \( A \) = constant
- \( L \) = class length interval
- \( L_m \) = length of fish when 50% mature gonads

The above equation is converted to linear form as below:

\[
L_m = -\frac{a}{b}
\]

where \( a \) is intercept and \( b \) is slope.

2.2.5. **Length at first mature (Lm)**

Length at first mature (Lm) is used to predict the length at the first mature using the formula, as follows [4]:

\[
y' = \ln Fc(x + dL) - \ln Fc(x)
\]

Where \( Fc(x) \) is a normal distribution curve

\[
Fc(x) = \frac{n.dl}{\sqrt{\pi}} \times \left[ \frac{(x-x)^2}{2s^2} \right]
\]

Where: \( Fc = \) the calculated frequency; \( n = \) number of observations; \( dL = \) class interval; \( s = \) standard deviation; \( x = \) average count; and \( \pi = 3.14 \)

2.2.6. **Growth Parameters**

Estimation of growth parameters is calculated using the Von Bertalanfy formula as follows:

\[
L_t = L_\infty \left( 1 - e^{-K(t-t_0)} \right)
\]

Where \( L_t \) is the length of the fish at age of \( t \) (unit of time), \( L_\infty \) is the maximum length theoretically (asymptotic length), \( K \) is the growth coefficient (per unit of time), \( t_0 \) is the theoretical age when the length equals zero. After obtaining the \( L_\infty \) and \( K \) values, the \( t_0 \) value is calculated using [8] formula as follows:

\[
\log (-t_0) = -0.3922 - 0.2752 \log (L_\infty) - 1.038 \log K
\]

2.2.7. **Type of Plankton, Food Composition and Index of Preponderance**

Type of plankton is identified using Verlencar and Desai (2004) [9] and Reynolds (2006) [10] methods. While food composition in the stomach of fish is assessed using Effendie method [11] with equation as follows:

Phytoplankton (a):

\[
\% X_a = \frac{a}{a+b} \times 100\%
\]

Zooplankton (b):

\[
\% X_b = \frac{b}{a+b} \times 100\%
\]

where: \( X_a = \) Phytoplankton composition (%); \( X_b = \) Zooplankton composition (%); \( a = \) the number of phytoplankton founded; and \( b = \) the number of zooplankton founded

While Index of preponderance or the largest portion of the index largest part is a combination of volumetric methods and frequency of occurrence and expressed in percent. Index of preponderance can be calculated using a formula [3] as follows:

\[
IP = \frac{\sum v_{i}o_{i}}{v_{i}} \times 100\%
\]
where: IP = Index of Preponderance (%); \( Vi \) = Percentage of volume of a food (%); \( Oi / FKM \) = Percentage of frequency of occurrence of a type of food (%); and \( \sum Vi \times Oi \) = Total \( Vi \times Oi \) and all kinds of food.

Based on the value of Index of Preponderance (IP), food is divided into 3 categories namely main food (> 25%), complementary food (4 - 25%), and additional food (<4%).

3. Results and Discussion

The sample of fish obtained was 1078 fish and was used for measurement of the length and weight relationship and length at first capture. Then for the observation of GML, GSI and Length at first mature (Lm) using 638 sample fish and for observing the food composition was used 173 fish samples. Fish length ranged from 13.5 to 23.7 cm and fish weight ranged from 21.23 to 132.32 gram.

3.1. Length and Weight Relationship

The equation of \( W = 0.02 L^{2.736} \) is obtained with \( R_{\text{square}} \) value of 0.838 which means that the length affects the fish's body weight by 84% (Figure 1). T-test results (T-test) showed a \( t_{\text{count}} \) was 7.1901 and \( t_{\text{table}}0.05 \) was 1.962. It meant that \( t_{\text{count}}> t_{\text{table}}0.05 \) where \( b \neq 3 \) obtained the growth pattern of Indian scads (\( D. russelli \)) was negative allometric which means that growth of body length was more dominant than that of body weight.

![Figure 1. Length and Weight Relationship of Indian scad (D. russelli) in the northern waters of Madura Island](image)

The analysis of length and weight relationship of Indian scads sample (Figure 1) obtained a negative allometric growth pattern. There are several factors affected fish body shape. They are the prey behaviour, availability of food, and the condition of waters [12]. If environmental conditions support the growth of fish, then other factors that can also affect the difference in \( b \) value are food availability and gonad maturity level [13].

3.2. Sex Ratio

The sex ratio is used to find out the comparison of the number of male and female fish in a population. Fish samples obtained during the study consisted were 307 male fish and 331 female fish. The percentage of male and female fish is 48%: 52%. The results of the total chi square analysis (Table 1) obtained a ratio of male and female 1 : 1.08 with an \( x_{\text{count}}^2 \) is 0.006672 < \( x_{\text{table}}^2 \) 3.850 which means that the ratio of male and female fish is balanced, while monthly sex ratio were varied. They were 1:1.1 (February), 1:1.04 (March), 1:1 (April), 1.02:1 (May), and 1:1.2 (June and July).
3.3. Gonad Maturity Level (GML)
Male or female fish have a variety of GML (I-V). From the observations of the frequency of male and female GML fish (Table 3) shows that in February-July 2018 dominated by fish with GML II (immature fish) (Figure 2).

![Figure 2. Gonad maturity Level Frequency of male and female fish](image)

In this research was found that the proportion of Mature fish is 42% (265 fish) and Immature fish is 58% (373 fish). Fish spawning season is influenced by environmental conditions (temperature, salinity, and climate) that benefit the fish to do spawning. The differences in spawning season in fish are caused by annual fluctuations in rainy season, geographical location and fish condition [14].

3.4. Gonado Somatic Index (GSI)
The Gonado Somatic Index (GSI) generally describes Gonad Maturity Levels in fish. The value GSI of Indian Scads (*D. russelli*) in the northern waters of Madura Island is quite varied in each month. The highest GSI was obtained in March 2018, while the lowest GSI was obtained in April 2018 (Figure 3). Average of Gonado Somatic Index (GSI) of Indian Scads (*D. russelli*) (Figure 3) obtained in February, March, April, May, June and July were 1.77%, 2.27%, 1.76%, 1.41%, 1.24% and 1.06% respectively. The smallest GSI value occurred in April with a value of 0.17%, while the largest value was in March with a value of 6.70%. Gonad weight was also followed by an increase in body weight [15]. The GSI value would decrease if the fish has spawned as a result of the decreasing weight of the gonad because the contents have been removed [16].

![Figure 3. Gonado Somatic Index (GSI) of Indian Scads (*D. russelli*)](image)

3.5. Length at first mature (Lm)
Length at first mature (Lm) is used to estimate the length of the fish at first mature. Based on data analysis, it was found that male fish matured faster than female fish with Lm values of 18.3 cm for male fish and 21.5 cm for female fish (Figure 4). Differences in the size and age of fish when length at the first mature between one species and another species are very likely. In fact, fish in the same
species can have different Lm values depending on the condition and geographical location where the fish lives [17].

![Length at the first Mature](image)

Figure 4. Length at first mature (Lm) of Indian scads (*D. russelli*)

Total of 635 samples were used for GML analysis. The overall Lm was 19.3 cm. Fish caught with a length higher than 19.3 cm were 144 numbers of fish while fish with a length of less than 19 cm were 494 numbers of fish.

The value of Lm male fish > the value of Lm female fish meant that the growth of female fish is focused on the growth of the body compared to the growth of the gonad, so that male fish was mature faster. Differences in the size and age of fish when gonads first mature between one species and another species are very likely. In fact, fish in the same species may have different Lm values. This happen because it depends on the condition and geographical location where the fish lives [7].

3.6. Length at first capture (Lc)

Length at first capture (Lc) is used to predict the first time the fish was catch. From the analysis of the data calculation, it was found that Lc was 18.8 cm (Figure 5). The value of Lc was smaller than that of Lm. It means that the Indian Scads was catch in the Northern waters of Madura Island are not suitable to catch because that fishes (Indian scads) are still in a growing stage and still immature fish.

Value of Lc in several research locations was varied. One of the factors of the difference in Lc value is from the catchment area as well as awareness of the surrounding fishermen. The prohibition of fishing under a predetermined size, at least one time spawning. Catchable fish is defined as a fish that has a length that is larger than the length of the first gonad ripe (length at first mature) [17]. That is, fishing activities in the north of Madura Island that are landed in Pasongsongan Fish landing Site have been overfishing. Growth overfishing occurs when the catch is dominated by small fish or young fish (immature fish) [18].

![Length at first capture](image)

Figure 5. Length at first capture Indian scads (*D. russelli*)
3.7. Growth Parameters

It was obtained that asymptotic length ($L_\infty$) and growth rate coefficient (K) were 25 cm and 0.58 per year respectively. The fish growth rate coefficient can be said to be high if it is in the range of 0.5-1. Based on the acquisition of K value, it can be assumed that the Indian scads ($D. russelli$) have a fast growth of 0.58 per year and short-lived because to reach the asymptotic length requires a short time. The higher the K value, the faster the fish will reach $L_\infty$ and the fish will die faster [4].

3.8. Food Composition

Assessment of stomach content of Indian scads ($D. russelli$) found that food consisted of phylum Ochrophyta, Arthropoda, Charophyta, Bacillariophyta, Annelida, Cnidaria, Cyanobacteria, Mollusca, Chlorophyta, Protozoa and small fish. While index of preponderance analysis indicated that of the main food of Indian scads in northern waters Madura island consisted of phylum Ochrophyta (IP > 72%), supplementary food (IP 6-9%) from phylum Arthropoda, Charophyta and Chlorophyta, while complementary foods (IP <2.2%) from phylum of Cyanobacteria, Bacillariophyta, Annelida, Cnidaria, Mollusca, Protozoa and small fish. Based on the type of food obtained, it can be expected the Indian scads ($D. russelli$) is a Plankton feeder types because food at this stomach are dominated by plankton species.

![Figure 6. Growth Curve of Indian scads ($D. russelli$)](image)

![Figure 7. Index of Preponderance of Indian scads ($D. russelli$)](image)

The calculation of Index of Preponderance (Figure 7) indicated that the fish was plankton feeder type because it found that plankton species dominated the food composition. The assessment of prey behaviour is closely related to the availability of food in their environment [6]. Many fish species can adapt to the food supply in their environment according to the prevailing season. In a wide geographical area for one species of fish that lives separately, there can be different eating habits. This difference is not for one size but for all sizes of fish species. So for one fish species of the same size in different areas, eating habits can be different. Changes in the environment can change the eating habits.
of fish; where in the event of changes in the environment can cause changes in the availability of food in the aquatic environment, thus forcing the fish to change the eating habits of fish in order to survive.

Fish growth parameters produced a value of $L_\infty = 25$ cm, $K = 0.58$ per year, and $t_0 = -0.29$ years. Based on these three parameters, the growth equation $L_t = 25 (1-e^{-0.58(t+0.29)})$ is obtained (Figure 6). The growth of Indian scads ($Decapterus russelli$) has a high growth rate at a young age and its growth rate then decreases with age. When approaching asymptotic length ($L_\infty$), fish will experience growth stagnation. The value of the growth coefficient ($K$) can also affect the speed of the fish to reach its asymptotic length.

4. Conclusion

1. The length and weight relationship of Indian scad is negative allometric with equation $W = 0.02L^{2.736}$. Sex ratio is 1: 1.08. Gonad Maturity Level (GML) is 58% immature and 42% mature. Gonado Somatic Index (GSI) obtained the lowest mean value where the GSI in April with a value was 0.17% and the highest average value in March was 6.70%. The Lc value of the Indian Scad ($D. russelli$) was 18.8 cm. Estimation of the length at the first mature (Lm) based on the analysis obtained 19.3 cm. The Lc value < Lm. Most of fish was caught at immature stage.
2. Several growth parameters of Indian scad are $L_\infty = 25$ cm, $K = 0.58$, and $t_0 = -0.29$ year.
3. Observation on the stomach contents found that the food of Indian Scad ($D. russelli$) consisted of phylum Ochrophyta, Arthropoda, Charophyta, Bacillariophyta, Annelida, Cnidaria, Cyanobacteria, mollusca, Chlorophyta, Protozoa and small fish. The fish is a plankton feeder types because the food was dominated by plankton species.

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