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Length-based population parameters of Indian Snapper, *Lutjanus madras* (Valenciennes 1831) off Madras coast along southeast coast of India

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Abstract
This study estimates some of the population parameters of Indian snapper, *Lutjanus madras* off Madras coast along southeast coast of India based on length-frequency data. A total of 776 specimens in the length range of 120-280 mm total length were collected from the trawl catches of the vessel *M.F.V. Samudrika* (OAL: 28.8m, GRT: 151T, BHP: 650) from January 2007 to June 2009 between the area Lat.12°30' N to 13° 32' N and Long. 80° 12'E to 80°30'E. The samples were also collected from Royapuram fish landing centre.The length frequencies collected were analysed with the help of electronic package FiSAT.
The parameters L∞ and K were 294.0 mm, 0.52/year. The von Bertalanffy growth equation for *L. madras* is $L = 294[1-e^{-0.52(t-t_0)}]$. The recruitment pattern is unimodal and the period of recruitment was from January to July with peak during April and May. The longevity of the species was calculated as 6 years. After 1st, 2nd, 3rd, 4th 5th and 6th year the length attained by the species is 119.2, 190.1, 232.2, 257.3, 272.2 and 281.0 mm respectively. The mortality parameters were Z=0.89, M =0.61, F=0.28 and the exploitation ratio was 0.32. The virtual population analysis for *L. madras* indicated that the natural morality due to natural cause was upto 140 mm mid-length, however the fishing pressure was observed at 160 mm size and it increased thereafter.

Keywords: indian snapper, lutjanidae, length based analysis, age, growth

1. Introduction
The snappers (family: Lutjanidae) are large apex predators and highly esteemed for their flavour and command high prices. Hence, they are important targets for fisheries in several regions worldwide. These small to medium sized fishes are of high commercial value throughout the world and are regularly taken in artisanal, recreational and commercial fisheries. Due to their high fisheries demand, concerns are being raised about the level of harvest and sustainability of fishing lutjanid populations. Their aggregative behavior and reef based distribution make snappers particularly vulnerable to exploitation. Tamil Nadu state in India is one of the major contributor of perch (snappers, groupers and emperors) landings in India. Snappers formed 0.6% of the total landings in Tamil Nadu (6.6 lakh tonnes) and was mainly landed by trawlers (64%) [1]. There is no separate statistics available for individual snapper species.
Determination of age and growth of commercially important fish is significant as it contributes in understanding the age class structure of the stock and role played by various year classes in the fluctuations of the fishery. Mortality estimates like total mortality, natural mortality and fishing mortality are highly required in the exploited fish stocks for better understanding on the optimum levels of exploitation. Bensam [2] opined that most fisheries researches in tropical countries are using length frequency data for estimating growth parameters since it is difficult to determine the periodicity of formation of growth rings in most marine fishes in tropical environment due to the absence of wide variation in environmental condition like in the temperate waters.
Growth rates of Lutjanidae from Gulf of Aden was studied by Druzhinin and Filatova [3]; Population dynamics of *L. lineolatus* (=*L. lutjanus*) from Gulf of Suez, Egypt was studied by Mehanna [4]; Bitter Lakes, Suez Canal, Egypt by Amin [5]; Philippines [6]; Eastern Malaysia [7] and Indo-Pacific [8]. The studies on the *L.madras* are very few like first report of *L.madras* from Iriomote Island, Japan [9] and Phylogenetic relationships of some common Indo-Pacific snappers (Perciformes: *Lutjanidae*) based on mitochondrial DNA sequences [10].
From Indian waters, publications are mainly on commercial fishery [11, 12, 13]. The biological aspects like food and feeding of *L. lineolatus* of Madras coast was studied by Job [14]. Length–weight relationship of *L.rivulatus* off Tutucorin, Gulf of Mannar was studied by Ameer Hamsa *et al.* [15]. Ramachandran *et al.* [16] studied the age and growth of *L. vitta* from the southwest coast of India (Arabian Sea). Pradeep [17] studied the age, growth mortality of *L.vitta* along Madras coast. The present study the population parameters like age, growth and mortality of *L.madras* along the Madras coast based on the length frequency parameters is attempted for the first time.

2. Materials and Methods
The monthly samples of the Indian snapper, Indian Snapper, *Lutjanus madras* (Valenciennes 1831) were collected from January 2007 to June 2009 from the Madras coast along the southeast coast of India, Fig.1(Lat.12°30' N to 13° 32' N and Long. 80° 12'E to 80°30'E) in the depth range of 20 to 100 m during the exploratory surveys of the stern trawler, *M.F.V. Samudrika* (OAL: 28.8 m, GRT: 151T, BHP: 650) of Fishery Survey of India, Chennai using fish trawl net (27.5 m; coded mesh size:30 mm). The samples were also collected from Royapuram fish landing centre and the fishing gears employed by the local fishermen for harvesting these resources are mainly bottom trawl and hook & line. In the present study the

length–frequency based methods was preferred because in tropical waters the growth rings which are formed in hard parts of the fish's body may not necessarily be annual, as various external factors like seasons and other environmental factors affect the formation of growth rings. A total of 776 specimens of *L. madras* between the length range of 120-280 mm were taken for studies. Length frequency data collected were grouped into 20 mm class intervals were used for the estimation of growth parameters and was analysed using FISAT II(FAO-ICLARM Stock Assessment Tools). The von Bertalanffy [18] growth parameters, L∞ and annual growth coefficient K were computed by ELEFAN I (Electronic Length Frequency Analysis) method [19]. The age at nil (t_0) known as "the initial condition parameter" is the age of the fish when it's length is zero. But the growth begins after hatching as the larva already has a certain length, which may be called $L_{(0)}$ and hence t_0 was taken as 0. In addition to this the L∞, K and Z/K were also estimated by Shepherd's [20] and Powell –Wetherall method [21, 22] (this method was developed by Powell and later improved by Wetherall). The length at first recruitment (L_r) was taken as the smallest length in the length frequency distribution. The length at first capture L_{50} (the length at which 50% of the fishes are vulnerable to capture) was estimated as a component of the length converted catch curve analysis. This was carried out by the probability of capture method of FiSAT software. Longevity was calculated by the formula tmax = 3/K+ t_0 [23]. Natural mortality (M) was calculated from Pauly's [24] empirical formula (ln (M) = -0.0152 - 0.279 ln (L∞) + 0.6543 ln (K) + 0.463 ln (T)) and the total mortality (Z) from length converted catch curve by taking the mean habitat temperature as 27°C [23]. The fishing mortality was calculated as F= Z-M. The exploitation rate E was obtained by dividing F by Z. The length structured Virtual Population analysis (VPA) was carried out to ascertain the loss due to natural causes, the fishing pressure at different length class, catches as well as the survivors. The identification of the specimen was confirmed based on the description by Allen [8].

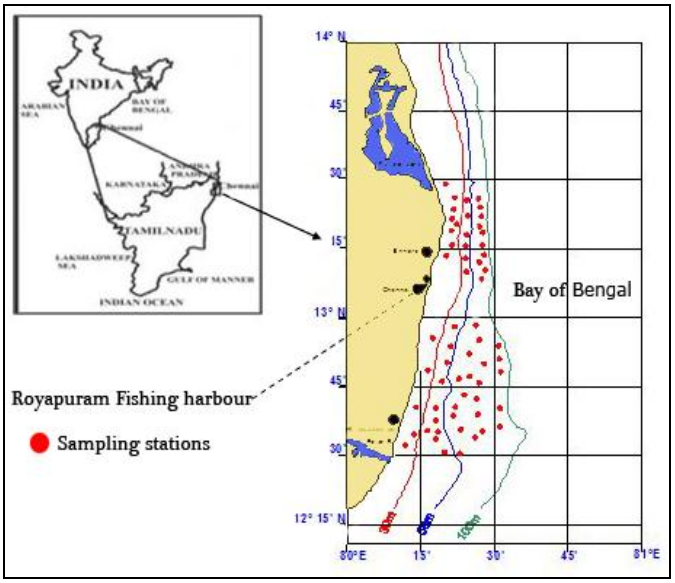

Fig 1: Sampling stations.

3. Results

3.1 Growth Parameters

The growth parameters estimated for *L. madras* by using the length frequency data in ELEFAN I programme gave the best fit for L∞ = 294.0 mm and K = 0.52/year. The same data was analyzed by the Shepherd's method and the L∞ and K values obtained were 294.0 mm and 0.58/year respectively. The L∞ and Z/K values obtained by Powell and Wetherall method were 308.5mm and 2.2 respectively. All these values show a uniform growth pattern without much deviation. By observing the maximum length (280.0 mm) in the sample and estimated extreme length (297.2 mm) in the population the values obtained by the ELEFAN I appears to be best. The growth curve generated by ELEFAN I for *L. madras* is shown in Fig.2.

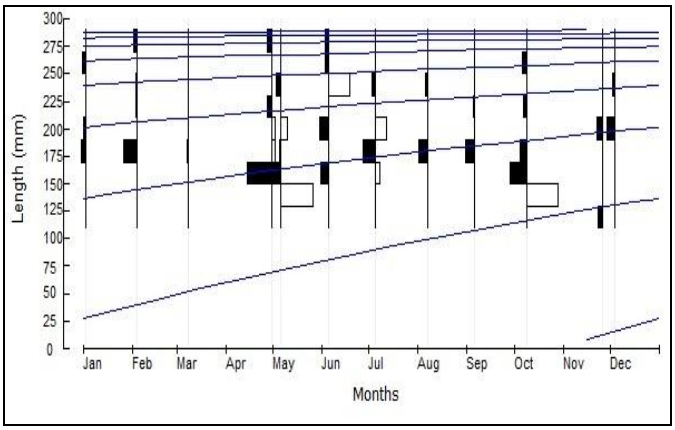

Fig 2: ELEFAN I growth curve of *Lutjanus madras* from Madras coast.

3.2 Recruitment Patterns

The recruitment pattern of the species *L. madras* is unimodal as shown in Figure.3. The period of recruitment was from January to July with peak during April and May. During April and May the percentage of recruitment was 17.9% and 17.2% respectively.

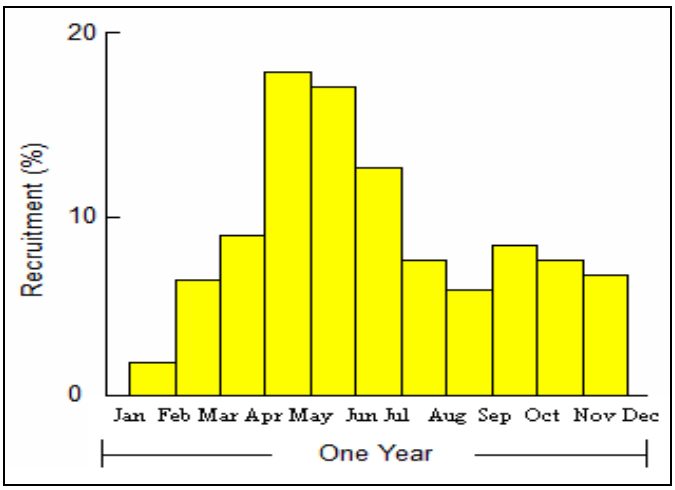

Fig 3: Recruitment pattern of *Lutjanus madras* from Madras coast

3.3 Length at first capture (L_c) and length at recruitment (L_r):

The length at first recruitment(L_r) was taken as the smallest length in the length frequency distribution and the length at first capture(L_c) was obtained by probability of capture analysis (the length at which 50% of the fish are vulnerable to capture). The length at first recruitment (L_r) for the species *L.*

madras was 115.0 mm and the length at first capture (L_{50}) was 178.3 mm. The length at which 75% fish are retained in the gear was estimated as 221.1mm.

3.4 Longevity

Taking t_0 as 0 the longevity of *L. madras* was calculated as 6 years. The species *L. madras* attained a length of 119.2, 190.1, 232.2, 257.3, 272.2 and 281.0 mm after 1st, 2nd, 3rd, 4th 5th and 6th year (Figure. 4). The growth pattern indicated that the maximum growth was in the first two years itself. In the first year the growth rate was 9.9mm per month followed by 5.9 mm /month and 3.5 mm/month respectively. The fish grows to length of 119.2 mm in the first year and 70.9 mm in the second year. The growth pattern shows a decreasing trend in the subsequent months.

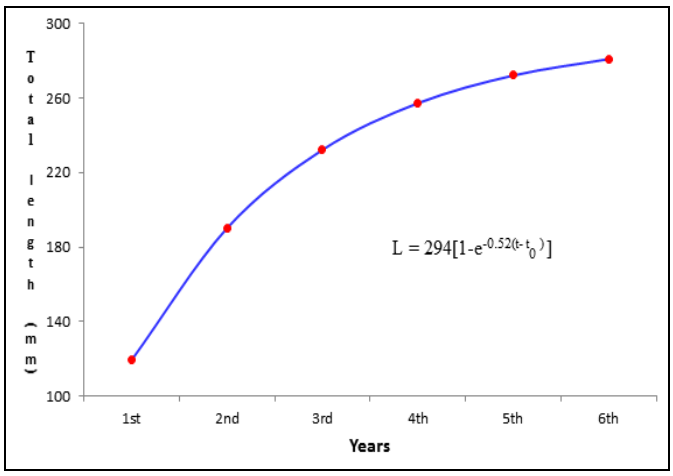

Fig 4: Von Bertalanffy growth curve of *Lutjanus madras* from Madras coast

3.5 Mortality

The natural mortality (M / year) as per Pauly's empirical formula keeping the habitat temperature as 27°C was found to be 0.61 for *L. madras.* Total mortality coefficient (Z) was estimated from the length converted catch curve (Figure 5) as 0.89. The fishing mortality (F) was found to be 0.28. The exploitation ratio E was found to be 0.32.

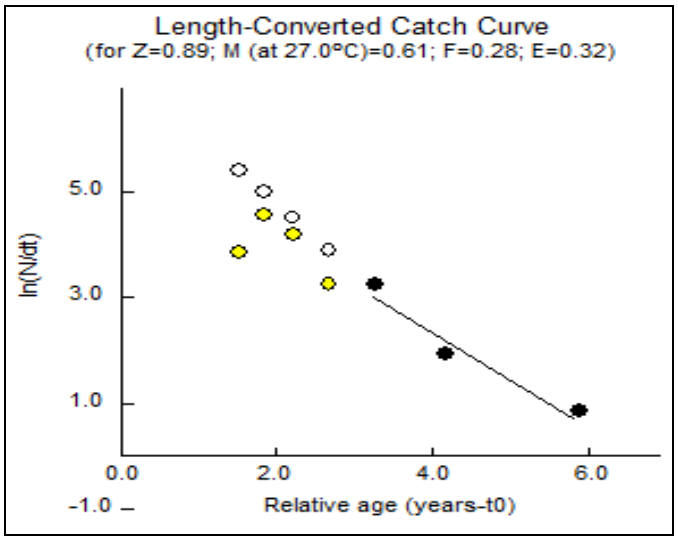

Fig 5: Length converted catch curve for the estimation of mortality parameters of *L. madras* in the Madras coast.

4. Discussion

Lutjanids are known to be fast growing in their first year of life [25-28]. In peninsular India the work done on the growth and population parameter of the family Lutjanidae are limited to a few species. The earlier works include mainly the catch records carried out in the Indian waters by Chacko and Rajendran [11]; Alagaraja *et al.* [12]; James *et al.* [13]. The Length–Weight relation of *L.rivualtus* from Gulf of Mannar was studied by Hamsa *et al.* [15]; Age, growth and maturity of *L.vitta* from southwest coast of India was studied by Ramachandran *et al.* [16] and from southeast coast by Pradeep [17]. Some notable observations were made on the biology of the species in their studies. Studies on the Indian snapper, *L. madras* is very less rather than few reports [9] and from Indian waters mainly in the checklist of the species, Ramesh *et al.* [32] from Tamil Nadu and Varghese *et al.* [33] from Gulf of Mannar. Recently Iwatsuki *et al.* [31] redescribed *L.madras* from the Indo-west Pacific. For a similar sized species *Lutjanus lineolatus* synonym of *L. lutjanus*, Mehanna [4] reported the $L\infty$ as 24.45 cm, K = 0.4/year and t_0 = -0.6 for the species *Lutjanus* in the Gulf of Suez. Amin [5] reported the $L\infty$ as 22.92 cm and t_0 as - 0.27 in the Gulf of Suez. Mohammad *et al.* [29] studied the growth parameters of *Lutjanus lineolatus* in the west coast of peninsular Malaysia (off Sarawak) and reported the $L\infty$ as 22.50 cm and K as 0.33/year. In east coast of peninsular Malaysia the $L\infty$ value was 27.6 cm and K value was found to be 0.54/year. Corpuz *et al.* [6] estimated the $L\infty$ and K value as 252 mm and 0.75/year from Philippines waters. Allen [8] recorded the $L\infty$ and K values were 315 mm and 0.27/year from the Indo-Pacific. Mansor *et al.* [30] reported the size of the species in between 73-170mm from the east coast of peninsular Malaysia. Pradeep [17] studied the age, growth and mortality of *L.vitta* off Madras coast along southeast coast of India, the estimated $L\infty$ = 351.8mm and annual K= 0.34. The recruitment pattern of the *L.vitta* was unimodal which is similar to the species of present study. The recruitment period is from January to July and peak during February to April. The length at first recruitment was found to be 74 mm and the length at first capture (L_{50}) was 304.3 mm. The longevity of *L.vitta* was calculated as 9 years. The growth rates of *L.vitta* during the 1st and 2nd year were 8.5 and 6 mm/month and subsequently declined. The mortality estimates M= 0.44, Z= 1.27 and F= 0.83 with the exploitation ratio E= 0.66. The virtual population analysis the mortality in the population due to natural causes alone was up to 230 mm later the fishing mortality started at 235 mm mid-length and it increased thereafter. The population parameters estimates of the present species (*L. madras*) are $L\infty$ =294.0 mm and K= 0.52/year. The recruitment pattern is also unimodal similar to the above studies and the period of recruitment was from January to July which also falls within the range mentioned for *L. vitta* along Madras coast. The longevity of the species was calculated as 6 years. After 1st, 2nd, 3rd, 4th 5th and 6th year the length attained by the species is 119.2, 190.1, 232.2, 257.3, 272.2 and 281.0 mm respectively and very well agree with the above studies that growth rates will be more for first two years and gradually reduces. The virtual population analysis for *L. madras* indicated that the natural morality due to natural cause was upto 140 mm mid-length, however the fishing pressure was observed at 160 mm size and it increased thereafter. The mortality parameters were Z=0.89, M =0.61, F=0.28 and the exploitation ratio was 0.32, which shows the fishing pressure

on the species is less. These observations alone cannot give a thorough picture on the status of *L. madras* fisheries along Madras coast as a lot of other factors such as biomass, MSY and total landings needs to be taken into consideration. Periodic reassessment of the *L. madras* stocks is required with adequate inputs from exploratory surveys as well as commercial landings to prevent any unsustainable trends in the development of its fisheries along Madras coast. There is a need to study the population parameters, Biomass and MSY for all the snappers along Madras coast for sustainable management of the stocks.

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