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Age and growth of red toothed triggerfish *Odonus niger* (Ruppell, 1836) (Family: Balistidae) off Thoothukudi, Southeast coast of India (08° 53.6'N 78° 16'E and 08° 53.8'N 78° 32'E) – (36 M)

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Abstract
Fishery resources, being renewable, have to be exploited in such a way that reaping of maximum sustainable yield (MSY) is possible without affecting the stocks. For such an effective exploitation, size of stocks is to be determined for obtaining their MSY. Its distribution was recorded up to 36 m depth between 08° 53.6'N lat. 78° 16'E long and 08° 53.8'N lat. 78° 32'E long, 38 miles from Thoothukudi fishing harbour, southeast coast of India. The regression equation calculated for female was Log W = -2.8161 + 2.2508 Log L, and for male was Log W = -2.6605 + 2.1601 Log L by[40]. The slope value (b) estimated for *Balistoides viridescens* of both sexes was found to be 1.0541. The slope value (b) estimated for *Balistoides viridescens* male was found to be 1.4070 and for female 1.2257. The asymptotic length (L∞) of *O. niger* was higher for females 283.90 and the value of K was 0.75. The t0 value was estimated at 0.002. The summer point ts value was 0.30. The length base index of growth performance index (Phi prime) Pφ was 4.781. The regression equations calculated for female was Log W = -0.4394 + 1.2257 Log L, and for male Log W = -0.7044 + 1.4070[41]. The natural mortality (M), fishing mortality (F) and total mortality (Z) were estimated at 0.80, 0.27 and 1.07, respectively. The present level of exploitation rate and exploitation ratio (F/Z) is estimated at 0.25. Heavy fishing pressure on the length group 6 to 31.5 cm revealed that *O. niger* in Thoothukudi waters suffer due to recruitment overfishing. The total stock, average annual stock and maximum sustainable yield were estimated at 1,25,392.028 tonnes, 3134.8007 tonnes and 1,161.3730 tonnes respectively. This red toothed was found to have two recruitment seasons, one major season, during November and a minor season during April. The estimated life span appears to be 2.5 years.

Keywords: Odonus Niger, Age and Growth, Mortality Parameters- Recruitment pattern -Thoothukudi coast- Southeast coast of India

1. Introduction
The fishes of the family Balistidae popularly known as trigger fishes (locally called Klathi in Tamil) are cosmopolitan in distribution. The triggerfish family (Balistidae) is a highly modified and advance group of fish and is well represented throughout the world's ocean with approximately 11 genera and 40 species described [16].

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This 412 extant species in the 10 families of living Tetraodontiformes, with the allocation of species and genera as follows: Triacanthodidae including 23 species in 11 genera, Triacanthidae seven species in four genera, Balistidae 37 species in 12 genera, Monacanthidae 102 species in 27 genera, Aracanidae 13 species in six genera, Ostraciidae 22 species in five genera, Triodontidae monotypic, Tetraodontidae 184 species in 27 genera, Diodontidae 18 species in seven genera, and Molidae five species in three genera [16]. The red-toothed trigger fish *Odonus niger* is one of the commercially non-conventional fishes available along the southeast coast of India. Except studies on population dynamics of red-toothed triggerfish *Odonus niger* was estimated by [29]. A few studies of length-weight of relationship of *Odonus niger* were calculated the slope value by [40, 36, 4]. There is no information on distribution and population dynamics of *O. niger* from Indian waters. I have been an attempt to find out distribution and estimate asymptotic length (L∞), growth coefficient (K), natural mortality(M),

fishing mortality (F), total mortality (Z), exploitation ratio (E) and recruitment pattern (Lc/L∞); where Lc is length at first capture) and M/K and length-weight relationship of *O. niger* off Thoothukudi coast of Gulf of Mannar, southeast coast of India.

2. Materials and Methods

Samples of *Odonus niger* (Family: Balistidae) were collected from bottom trawl, Off Thoothukudi fishing harbour, southeast coast of India. Its distribution was recorded up to 36 m depth between 08° 53.6'N lat. 78° 16'E long and 08° 53.8'N lat. 78° 32'E long, 38 miles from Thoothukudi fishing harbour, southeast coast of India. The total-length was measured from (range: 8 to 31.5 cm) the tip of the snout to the tip of the upper lobe of caudal-fin mm and weight was recorded to the nearest 0.1 gm. The Specimen where the tails are broken is rejected. The von Bertalanffy growth parameters, namely, L∞ and K were estimated by length frequency (in discrete series) analysis using computer program ELEFAN I as suggested by [6, 7, 23, 35].

The natural mortality (M) was estimated using the empirical relationship derived by [25] as follows:

Log 10 M = -0.0066-0.279 Log 10 L∞ +0.6543 Log 10 K+ 0.4634 Log 10 T

Where, L is expressed in cm and T (28ºC) is the mean annual environmental temperature. The t0 was estimated following the empirical formula derived by [24] as given below:

Log 10 (-t0) = -0.3922-0.2752 log 10 L∞ -1.038 log 10 K.

The total mortality (Z) was estimated by the length-converted catch curve method [26]. Fishing mortality (F) was estimated by subtracting M from Z and exploitation rate (E) from $E = F/Z^8$. Relative yield-per-recruit (Y/R) was obtained from the estimated growth parameter and probability of capture by length[27]. All other calculations were made using ELEFAN program developed by ICLARM. Length-weight relationship was estimated by least square method using the formula of $W = aL^b$.

3. Results and Discussion

In general, small to medium sized fish are characterized by fast growth, shorter life span, young age-at-maturity, and serial spawning periodicity, which are characteristic of r-selected species. As a result, these species are able to display faster turnover rates. On the other hand, K-selected species display slower growth, older age-at-maturity, large size, longer life-span, and infrequent spawning periodicity. The conservative life history characteristics of these species make them more vulnerable to overfishing.

3.1 Growth parameters

Fig.1 shows restructured length distribution for the computed growth curve. The von Bertalanffy growth equation for *Odonus niger* was estimated as L∞ = 283.90 and K= 0.75. However, some species such as the grey triggerfish (*Balistes capriscus)* growth parameters obtained from all back-calculation including end-points (derived data) of *Balistes capriscus* were L∞ = 485.88±19.17 mm and K = 0.22 (1/year) and *Balistes punctatus* were L∞ = 275.76±3.38 mm and K = 0.48 (1/year) [21, 22]. The present species is relatively moderate in growth K = 0.75. According to [39] fishes with moderate K are characteristic with moderate natural mortality, and it is related to age and size of the fish. The M value is 0.80 and the M/K ratio of *O. niger was* 1.06. The estimated life span appears to be 2.5 years (Fig 8). The M/K ration is found to be in close proximity limit among the closely related species [3]. The M/K ration is fishes generally falls within the range of 2.0 – 3.0. The von Bertalanffy parameters K and L∞ can be plotted to provide summaries of growth performance in variety of taxa [28]. has presented such a summary based on 4826 sets of parameter estimates of the von Bertalanffy growth function. This generated the familiar negative relationship, confirming the conclusion of [28] that fishes either tend to remain small and have high K values or become large or have low K values. Thus although the parameters K and L∞ allow comparison of growth patterns they do not capture the important life history features that arise from differences in life-span.

The total mortality (Z) and fishing mortality (F) were 1.07 and 0.27, respectively. Fig.2 represents the catch curve constructed for estimation of Z. The darkened quadrilateral represents the points used for estimating Z through least square. The open circles represent points either not fully recruited of nearing L∞ or hence not considered for calculation. Good fit to the descending right hand limits of the catch curve was considered.

Considering fishing (F), natural (M) and total (Z) mortalities of a fisheries resource which is collapsed, for instance, triggerfish resource in Thoothukudi coast of Gulf of Mannar, southeast coast of India. Z is supposed to be the sum of *M* and *F*, so at least for negligible *F* (since the fisheries had collapsed), *Z* should have been equal to *M*. But in nature, 1 + 1 ≠ 2 meaning that natural causes of mortality may be varying from time to time to either increase or decrease *M*, and hence the relation:

F + M = Z

When F = 0, or F ≈ 0 (in collapsed fisheries scenario) does not necessarily imply the M = Z. Rather, either M ≤ Z, or M ≥ Z. Bur *M* and *Z* can be very close in the case of collapsed fisheries. *M* can also be was higher than *Z* since the derivation of *Z* is independent of *M* (for instance), *Z* obtained from length-converted catch model). This is because in collapsed fisheries *Z* was obtained from sparse length-frequency data due to absence of specimen.

In the present study deal with exploitation ratio (E) was estimated 0.25. As the E is <0.5, it appears that the stock of *O. niger* along southeast coast is under much fishing pressure. The values of the asymptotic length (L∞) and the growth coefficient (K) calculated from the Ford-Walford plot was L∞ = 283.90 cm and K = 0.75. The value of t0 calculated from the plot L^ L∞ -Lj) = aj + b is: t0= -0.47 year. Total mortality (Z = F + M) was estimated using the method of[3] and natural mortality (M) using Pauly's formula [24]. The size at first capture Lc observed is close to the calculated figure of 0.02 cm which gives maximum yields per recruit. According to [9], if the E is >0.5 the stock may be considered as overfished.

3.2 Age and Growth

The size range of *O. niger* in the trawl fishery recorded was 8.0 to 31.5 cm. A preliminary estimate of asymptotic length (L∞) was obtained by Powell and Wetherall (Was L∞ = 283.90 cm and K = 0.75. The month wise data on size distribution of *O. niger* was collected during January 2011-December 2012 and was utilized for the estimation of growth parameters through ELEFAN I programme. A preliminary estimate of K was obtained with an input of L∞ of 283.90 cm, which gave the value of K as 0.75 (Fig 2). There have been relatively few age and growth studies on *Balistes capriscus*; however, they are estimated to live up to 11 years, with 16 being the maximum age recorded [9, 42, 10]. *Balistes capriscus*

are estimated to grow rapidly within the first year of life (K = 0.39), then growth slows and is estimated at K = 0.152-0.183 year-1 for both sexes combined [9, 10, 42, 37]. *Balistes capriscus* spawn as early as May and as late as August, with peak spawning in June and July in the Gulf of Mexico and South Atlantic Bight [42, 9, 10, 17, 12, 38]. Both sexes were reproductively mature by age-2, 10 inches FL (250 mm FL). At this size (~10 inches FL), some males were age-1 and all females were [42, 10]. Average back-calculated lengths-at-age calculated as weighted means were presented in [11] as 11.3 cm, 23. 7 cm, 30.6 cm, 35.4 cm, and 39.3 cm for age 1, II, III, IV and V respectively. [1]gave estimated values of 14.8 cm and 20.3 cm, and 20.3 for age I and II for fish off southwest Africa. [5]gave range values from 9-15.3 cm, 17.0-23.1 cm, 23.8-28.5 cm, 29.0-32.2 cm, and 32.4-34.8 cm for ages 1, II, III, IV, and V years, respectively for Senegal [21, 22]. present length-at-age estimates of 14.4 cm, 23.6 cm, 29.3 cm and 33.0 cm for age groups 1, II, III, and IV. From these, estimates of L = 0.43 year[1] were obtained for *Balistees capriscus* from Ghana. Approximate average lengths for fish aged 1, 2, 3, 4, 5, 10, and 12 years are 10.9 cm, 22.6 cm, 30.2 cm, (0.59 kg), 35.6 cm (1.45 kg), 54.6 cm and 55.9 cm[13]. The studies above indicated that size-at-age for African fish are different than the Gulf of Mexico. These differences may be the result of different environments, biology, methods of capture, or ageing [11].

The ELEFAN I programme exercise produced the following growth parameters. L∞: 283.90 cm and K = 0.75 (annual). The M arrived by the equation is 0.80. However, being pelagic species the same is multiplied with 0.8 as suggested by[26]. Most studies indicate gray triggerfish, *Balistes capriscus* reach sexual maturity at 2 years, but may mature at 1 year [42, 21], 1.5 years [22], to up to 3 years [13]. *Balites vetula* (Queen triggerfish) from Puerto Rico and the Virgin Islands, estimated growth rate to be K = 0.30 with fish being 16 cm in length after[14.] Off the east coast of Brazil, growth of the Queen triggerfish was estimated to be K = 0.76[19], while off the central coast of Brazil growth was found to be much slower, with K = 0.14[2].

Total mortality coefficient (Z) was estimated by the catch curve method for the period 2011-2012. The average Z during the last seven years was 1.07 (Fig.2). Natural mortality was 0.80 (M) and fishing mortality was 0.27. The exploitation rate (F/Z) estimated was 0.25 (Fig.5). This red toothed was found to have two recruitment seasons, one major season, during August and a minor season during July (Fig.4). The recruitment of this species were February – April, and the peak was in March by [29] (Fig. 3). Keeping in view of the above; the present estimates of K 0.75 and L∞ 283.90 cm appears to be reasonable estimate. The resource appears to be under exploited from Thoothukudi coast of Gulf of Mannar.

Length calculated for different years using von Bertalanffy's growth equation was plotted along with the observed length of the same period which showed a general agreement in the growth pattern. This also showed high degree of agreement with other methods employed. Ford-Warlford graph was constructed for *O. niger* by plotting Lt + 1 against Lt where Lt is the height of the animal at a particular age. Lt + 1 when intersected by a 45º diagonal from the origin, L (length at infinity) was obtained and it was found to be 283.90 cm for this species. In the present study, age and growth were studied through different methods. However, von Bertalanffy's equation showed agreement and gave reliable results. This red toothed trigger fish was found to have two recruitment seasons, one major season, during August and a minor season during January to March (Fig.4).

3.3 Length-weight relationship

The smallest length recorded for *Odonus niger* species was 80 mm while the largest being 310 mm and the body weight between 15 g and 620 g. The length-weight relationship of *O. niger* was W = 0/0002 L [2.2]. *Odonus niger* increased in weight by a power of cube and less than cube of length. The calculated slope value was 2.16 for males and 2.25 for females by [40]. The slope value (b) estimated for *Balistoides viridescens* of both sexes was found to be 1.0541. The slope value (b) estimated for *Balistoides viridescens* male was found to be 1.4070 and for female 1.2257. The regression equations calculated for female was Log W = -0.4394 + 1.2257 Log L, and for male Log W = -0.7044 + 1.4070 [41].

[30] studied the length-weight relationship of *Odonus niger* and *Balistapus undulates* and reported the slope value of 3.0 and 3.6 for both the sexes. In the present study, slope value was higher in females compared to males [34]. reported a slope value of 2.87 and 2.93 for both the sexes of *Balistes vetula* and *Xanthichthys ringens*. A good correlation was consistently observed between length and weight by [16] for *Rhinecanthus rectangulus* [18]. studied more length gain and the recorded a slope value of 2.96 for both sexes. Thus comparing the slope of *Odonus niger* with other species of the balistids, it could be concluded that the slope value is less than 3 for both the sexes of *Odonus niger* [36]. reported b value of 2.08 from Gulf of Mannar, whereas [40] reported 'b' value for male and females was 2.1 – 2.2 of this species, southeast coast of India. [29]have obtained 'b' value was 2.5 of this species, southwest coast of India. The length-weight relationship of *S. fraenatus* obtained by[4] from the fish landing at Tuticorin fisheries harbour had 'b' value of 2.43 and *Z. niger* had 'b' value of 2.73. [20] obtained 'b' value of 2.950 for *S. fraenatus* and 'b' value of 2.69 for *Abalistes stellatus* from New Caledonia. According to [15] the value of the exponent 'b' in the parabolic equation usually lies between 2.5 and 4.

3.4 Yield per recruit and biomass per recruit

The estimated length at first capture (Lc) was 0.025 cm. The relative yield per recruit and biomass per recruit were determined as a function of Lc/L∞ and M/K ratio, which are 0.03 and 1.06 respectively. The plot of yield per recruit (Y/R) against E is shown in Fig 6. The maximum Y/R was at E = 0.25. The present E (0.25) has not exceeded the optimum exploitation rate (Emsy = which maintain the 50% of the stock biomass). It is suggested that for attaining the maximum yield per recruit the fishing pressure may be increased for *O. niger* (Fig 7). There is increasing recognition of the need to conserve reef fish stocks and to gather the information necessary to identify levels of vulnerability based on life history features. [31]identified extended life-spans, slow growth rates, and low natural mortality rates as characteristics that will render marine species vulnerable to extinction through human acidities, including overexploitation. Research on the biology of balistids, particularly in terms of demographic and reproductive studies, is urgently needed to support efforts in conservation and management of exploited balistids species. Although marine reserves offer a precautionary approach by allowing management or conservation to occur without detailed technical and scientific capacity, their effectiveness is also dependent on education, awareness and as [32, 33] point out, local fishing community support and the response of fish populations to reduced exploitation. Hence, the integral role

stakeholders must play in order to achieve a successful outcome.

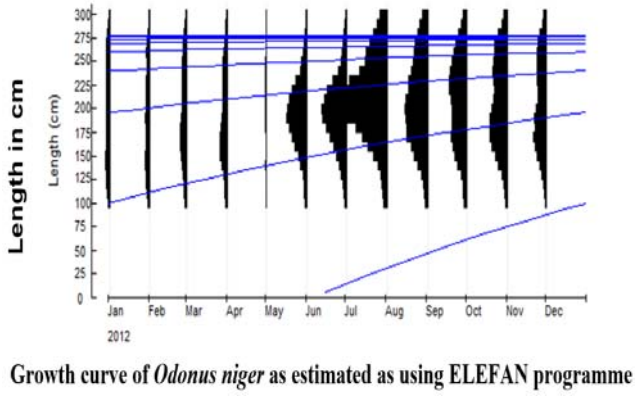

Fig 1: Estimation of growth parameter through ELEFAN I programme of *Odouns niger*

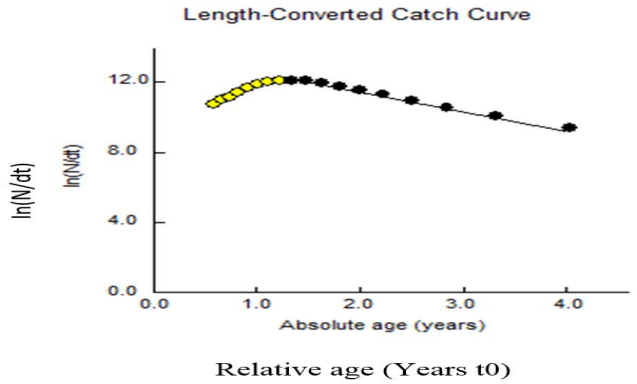

Fig 2: Total mortality estimates by-catch curve method during Jan 2011 – Dec 2012 of *Odonus niger*

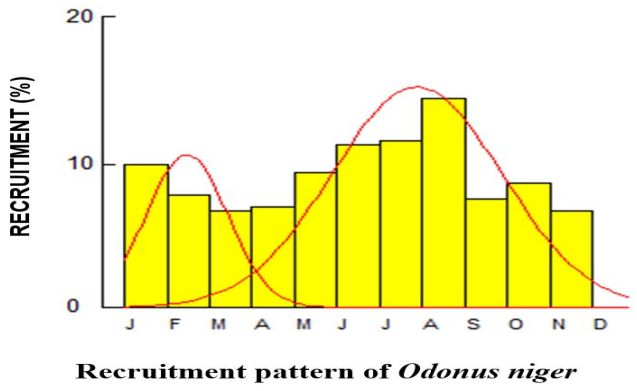

Fig 3: Recruitment pattern of *Odonus niger*

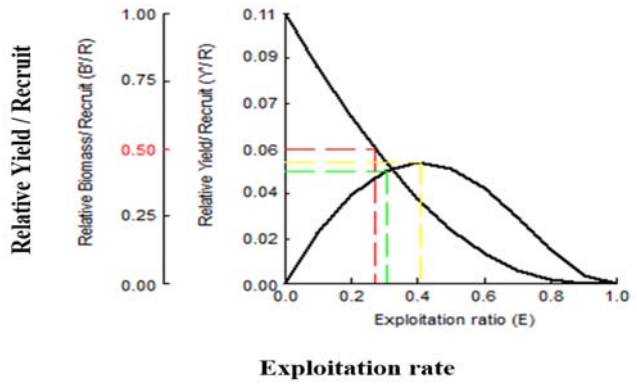

Fig 4: Relative yield-per-recruit and biomass-per-recruit *Odonus niger* (Lc /L∞ = 0.025, M/K = 1.06

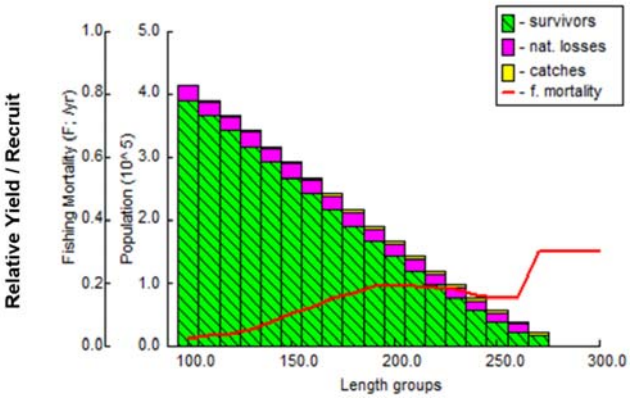

Fig 5: Yield/Recruit and Biomass/Recruit of *Odonus niger*

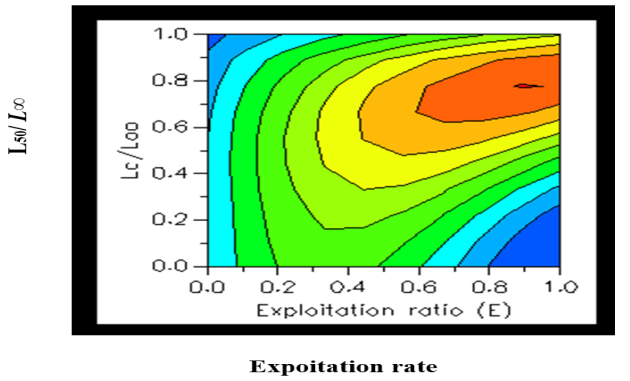

Fig 6: Yield isopleth of *Odonus niger*

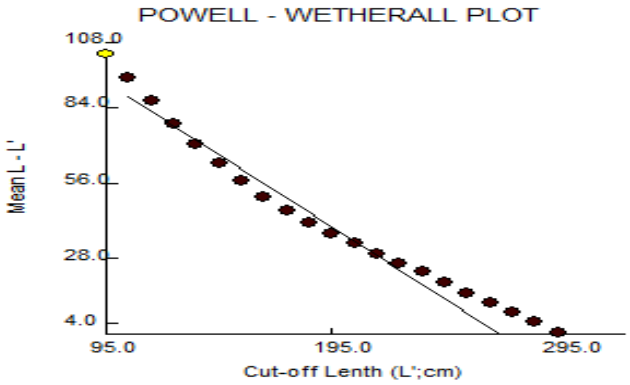

Fig 7: Estimation of Lα and Z/K of *Odonus niger* (Sexes pooled) using Powell-Wetherall Plot

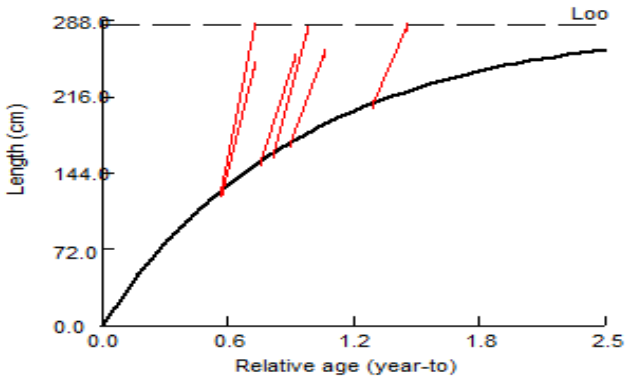

Fig 8: von Bertalanffy growth curve of *Odonus niger* (Growth parameter from observed data)

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