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Some biological aspects and population dynamics of the five-lined snapper, *Lutjanus quinquelineatus* (Family: Lutjanidae) from Red Sea off Hurghada, Egypt

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Abstract
Age and growth, reproductive strategy, mortality and yield per recruit analysis are essential to evaluate the fishery status of fish stocks. The fishery status of five-lined snapper *Lutjanus quinquelineatus* in Hurghada fishing area was assessed based on the monthly representative samples covered 12 months from January to December 2016. The von Bertalanffy equation for the growth in length was: $L_t = 35.5\ [1 - e^{-0.35(t + 1.3)}]$. The total mortality coefficient 'Z', natural mortality coefficient 'M', and fishing mortality coefficient 'F' were estimated at 1.84, 0.69, and 1.15 year^{-1}, respectively. The current exploitation rate 'E' was 0.62 year^{-1}. The spawning season was found to extend from March to July, and the maximum absolute fecundity was estimated to be 389880 eggs. The yield and biomass per recruit were analysed using the Beverton and Holt's yield per recruit Model (1957). Results indicated that there is an opportunity to expand the fishery of *Lutjanus quinquelineatus* stock in Hurghada fishing area. But before any recommendation, the current status of different target species needs to be analysed as the fishery in Hurghada is multispecies.

Keywords: Red Sea, Egypt, snappers, age and growth, fecundity, population dynamics.

1. Introduction

Family Lutjanidae, which known as snappers, is composed of 17 genera and 112 species (Fishbase, 2017). All of them are marine fishes and most of them inhabiting the coral reefs ecosystems [1]. Snappers are mainly confined to tropical and subtropical marine water. These fishes are essentially predators, usually active at night and feeding on demurral organism including fishes, crustaceans, small echinoids and mollusks. Snappers are an important component of the local artisanal catch throughout their geographic range [1] and up to 15 species were recorded in the Red Sea [2].

A proper understanding of the biology and dynamics of fish is very necessary for the future management of the fisheries and exploitation of the fish stock. The biology and dynamics of snappers have been studied in different localities [3-18].

Despite the economic importance of Lutjanid species, there are very few studies dealing with their biology and population dynamics in the Egyptian Red Sea [19-24]. So, the present study is the first to evaluate the biology and dynamics of the five-lined snapper *L. quinquelineatus* in the Egyptian Red Sea, Hurghada fishing area. The information gained from this study will help in construct a scientific plan for rational exploitation of this important species in Red Sea.

2. Material and methods

Monthly random samples of about 800 fish of *L. quinquelineatus* ranging from 14 to 31.7 cm TL were collected from the commercial catch landed at Hurghada (Fig. 1) from January to December 2016. The total length to the nearest millimeter, total weight to the nearest 0.l g, sex and maturity stage were taken for each individual.

Fig 1: Main landing sites along Egyptian Red Sea

The constants of Length (L) - Weight (W) relationship were estimated using the linear version of the power function $W = aL^b$ and the confidence intervals (CI) were calculated for the slope to see if it was statistically different from 3 and the growth parameters were derived from [24].

The length at first capture (L_c) was estimated from the catch curve analysis [25, 26], while the length at first sexual maturity (L_m) was estimated by the empirical relationships of [27] as $\text{Log } L_m = 0.8979 * \text{Log } L\infty - 0.0782$, and the corresponding age at first sexual maturity (T_m) was computed by converting L_m to age using the von Bertalanffy growth equation.

Total mortality rate (Z) was estimated using two different methods: the linearized length-converted catch curve analysis [28] and cumulated catch curve analysis [29] method. Instantaneous natural mortality rate (M) was derived as the mean of three different formulae**.** Empirical formula of [30] as: $\log M = -0.0066 - 0.279 \log L\infty + 0.6543 \log K + 0.4634 \log T$ where $L\infty$ and K are the VBG parameters, and T is the mean water temperature. The Rikhter and Efanov equation [31] based on the estimated length at first sexual maturity, as well as, the formula of Taylor [32]. Fishing mortality rate (F) was estimated by $F = Z-M$ [33], while the exploitation ratio (E) was calculated as $E = F/Z$ [34].

The yield per recruit (Y/R) analysis was performed by applying the model of Beverton and Holt [35] using the formula suggested by Gulland [36] as:

$Y/R= F\, e^{-K\,(Tc-Tr)}\, W_\infty\, [(1/Z) - (3S/Z+K) + (3S^2 /Z+2K) - (S^3/ Z+3K)]$

Where $S = e^{-K\,(Tc - to)}$, T_c is the age at first capture, T_r is the age at recruitment, W_∞ is the asymptotic weight, F is the fishing mortality rate, M is the natural mortality coefficient and Z is the total mortality coefficient.

Fecundity

A total of 34 ripe ovaries of *L. quinquelineatus* were collected during the spawning season and used for the estimation of the absolute fecundity. Six weighed subsamples, three from each lobe of the ovary were crushed in petri-dish and the eggs of each were counted. Then the absolute fecundity (F) was obtained from the following formula $F = W/W_1 * X$ where F is the absolute fecundity, W is the total gonad weight in gram, W_1 is the subsample weight in gram and X is the number of ripe eggs in the subsample.

3. Results and discussion

During the field surveys and monitoring process in this study, eight species belonging to the family Lutjanidae [1, 2, 37] were recorded in Hurghada: *Lutjanus ehrenbergii*, *L. quinquelineatus*, *L. bohar*, *L. argentimaculatus, L. gibbus*, *L. fulviamma, L. Lutjanus,* and *L. monostigmus*. *Lutjanus ehrenbergii*, *L. quinquelineatus*, *L. bohar* and *L. argentimaculatus* are common with large amounts of wide range of sizes, while the rest of the species were recorded with lesser amounts during the study period. *Lutjanus quinquelineatus* was chosen for this study because there is no any previous works about it in the area.

3.1 Length frequency distribution

The smallest fish noted in the catch of *L. quinquelineatus,* was 14 cm TL, while the biggest length was 31.7 cm TL. Most fish represented in the catch of this species lie within the length range 19 and 23 cm TL (Fig. 2). It is clear that the length frequency distribution of *L. quinquelineatus* showed four modal lengths which coincide with the fact that this species attained 4 years old based on otolith reading [24].

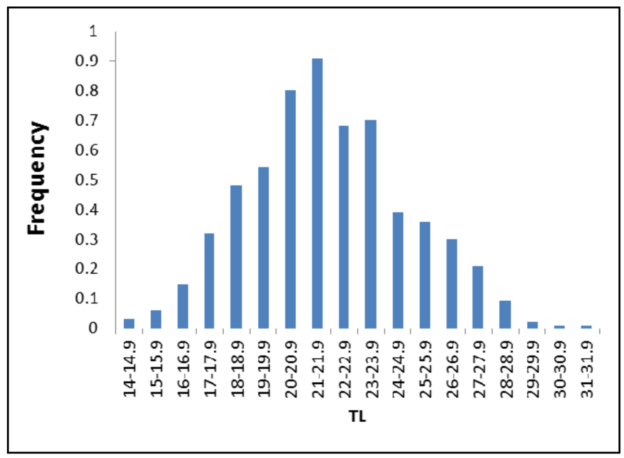

Fig 2: Length frequency distribution of *L. quinquelineatus* from Hurghada, Red Sea

3.2 Length-weight relationship

The total length of *L. quinquelineatus* ranged between 14 and 31.7 cm, while the total weight varied from 40 to 520 g. The calculated length- weight equation (Fig. 3) was $W = 0.0118\, L^{3.0986}$ with $r^2 = 0.95$. The 95% confidence interval for b was 3.1069 - 3.0903 indicating that *L. quinquelineatus* grows isometrically. The same result was recorded in the work of Loubens [38a] in New Caledonia and Newman [39] in the Central Great Barrier Reef of Australia. They used both fork FL and standard SL length to estimate the length-weight relationship of *L. quinquelineatus* and gave the following equations:

$W= 0.00002\, SL^{3.076}$ [38a]

$W= 0.00001\, FL^{3.0663}$ [39]

$W= 0.00004\, SL^{2.9476}$ [39]

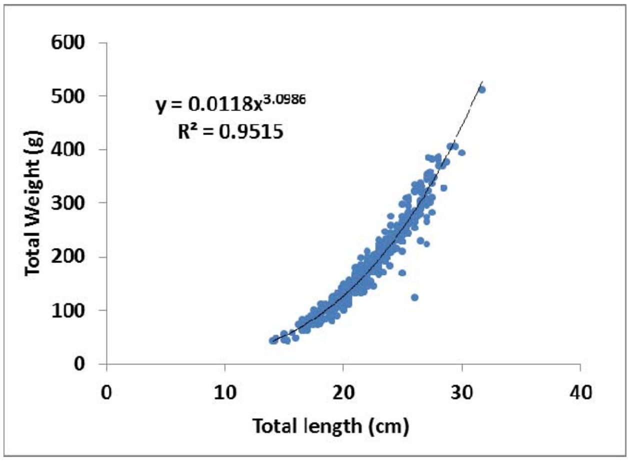

Fig 3: Length-weight relationship of *L. quinquelineatus* from Hurghada, Red Sea

3.3 Spawning season

According to the monthly variations in GSI, maturity stages and egg diameter, spawning occurred from March to the end of July. There is only one breeding season per year for *L. quinquelineatus*, which takes place in spring and summer, where the highest values of GSI and the highest percentages of ripe gonads were recorded. This agrees with the previous studies which mentioned that spawning activity of lutjanid species occurs during the spring and summer months in the Great Barrier Reef waters with a single summer spawning peak [40]. Similarly, [38b] indicated that lutjanids in New Caledonia also have a single midsummer spawning peak.

3.4 Fecundity

Absolute fecundity was calculated as the actual total number of ripe eggs produced by one female in a spawning season or in one year. The average number of eggs for *L. quinquelineatus*, increased from 162360 to 389880 eggs for length range from 22-28 cm. The relation between the absolute fecundity and length (Fig. 4) was linear and represented by the following equation:

$F = 40963\ TL - 781987$ ($r^2 = 0.93$)

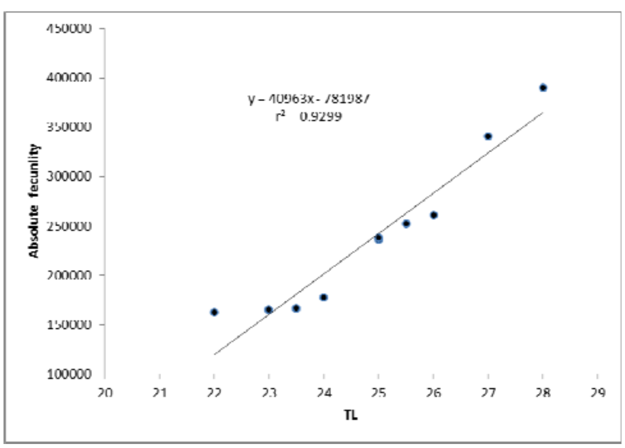

Fig 4: Length-absolute fecundity relationship of *L. quinquelineatus* from Hurghada, Red Sea

3.5 Length (L_m) and age (T_m) at first sexual maturity

The determination of length at first sexual maturity, which refers to the length at which 50% of the fish reach its sexual maturity, has its practical application in the estimation of the minimum legal size that will conserve the spawning stock biomass and to ensure that the fish will undergo at least one spawning in its life. The length at first sexual maturity (L_m) of *L. quinquelineatus* from Hurghada fishing area was estimated at 20.6 cm, while its corresponding age (T_m) was 1.18 year.

From the previous studies, length at maturity was estimated for *L. quinquelineatus* using the empirical equation and the mean estimate was 36.5 cm with a minimum value of 10.3 cm. This is corresponding to an ages of 2.9 years with a minimum of one year [41].

3.6 Length (L_c) and age (T_c) at first capture

According to the resultant curve derived from catch curve, the estimated L_c was 20.4 for *L. quinquelineatus*, this length is corresponding to age T_c of 1.12 (Fig. 5). It is evident that the estimated L_m is nearly the same as L_c indicating that the current minimum legal length is appropriate for this species.

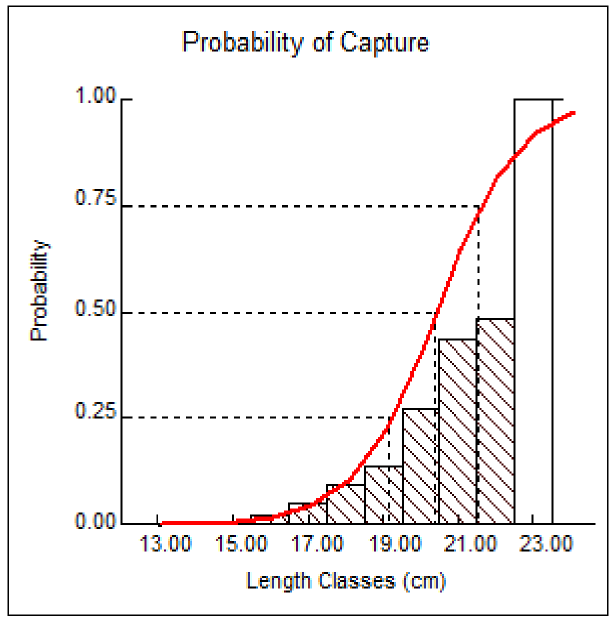

Fig 5: Length at first capture of *L. quinquelineatus* from Hurghada, Red Sea

3.7 Growth parameters

The mathematical description of growth is of vital importance in the field of fisheries management, since the obtained growth parameters ($L\infty$, K and t_o) are the basic inputs of various models used for assessing the status of an exploited stock. The growth parameters of von Bertalanffy growth model for *L. quinquelineatus* from Hurghada fishing area were derived from [24]. The obtained equations for growth in length and weight were:

For growth in length $L_t = 35.5\ [1 - e^{-0.35(t + 1.3)}]$

For growth in weight $W_t = 750.62\ [1 - e^{-0.35(t + 1.3)}]^{3.0986}$

3.8 Mortality estimates and exploitation rate

3.8.1 Total Mortality Coefficient (Z)

The values of total mortality coefficient Z for *L. quinquelineatus* estimated from Jones and Van Zalinge (1981) and the length converted catch curve of Pauly (1983) were 1.78 and 1.90 yr^{-1} respectively with a mean value of 1.84 yr^{-1}.

3.8.2 Natural mortality coefficient (M)

The natural mortality coefficient M was estimated as 0.78, 0.76 and 0.53 yr^{-1} from Pauly, Rikhter and Efanov and Taylor methods respectively with a mean of 0.69 yr^{-1}.

3.8.3 Fishing mortality (F) and exploitation rate (E)
By subtracting mean M from mean Z, the obtained fishing mortality coefficient F was 1.15 yr^{-1}. Accordingly, the exploitation rate which is an indication to the state of the stock was estimated at 0.62. The current exploitation level is higher than the optimum one (E_{opt} = 0.5 that given by Gulland, 1971 and E_{opt} = 0.4 that given by Pauly, 1984).

3.9 Yield per recruit
The effect of fishing pattern on the abundance of *L. quinquelineatus* stock in Hurghada fishing ground, Red Sea was investigated through the catch - age composition by applying the model of Beverton and Holt (1957) as modified by Gulland (1969). Table (1) demonstrated the input values used in this model that applied to assess the fishery status of *L. quinquelineatus* from Hurghada, Red Sea.
The plot of (Y/R) against F was shown in figure (6). It was obvious that, the (Y/R) was increased by the increase of fishing mortality. The results indicate also that, at the present level of fishing mortality coefficient (F= 1.15), age at first capture (T_c = 1.12 year) and natural mortality coefficient (M= 0.69), the yield per recruit was estimated to be 69 g.
Based on the obtained results, the present fishing effort along the Red Sea coast off Hurghada can be increased, so that higher catch could be achieved. But, under the present conditions, such an increase in fishing effort may not adversely affect the stock of five lined snapper in Hurghada fishing area but will affect the other commercial stocks of demersals in the area which are already overexploited [42-53].

Table 1: Population parameters of *Lutjanus quinquelineatus* from the Hurghada fishing area, Red Sea, Egypt.

Parameter	Value
L∞	35.5 cm TL
K	0.35/ year
t_0	-1.3 year
M	0.69/year
F	1.15/year
Lc	20.4 cm
Tc	1.12 year
Lr	14 cm
Tr	0.2 year
E	0.62
W∞	750.62 g

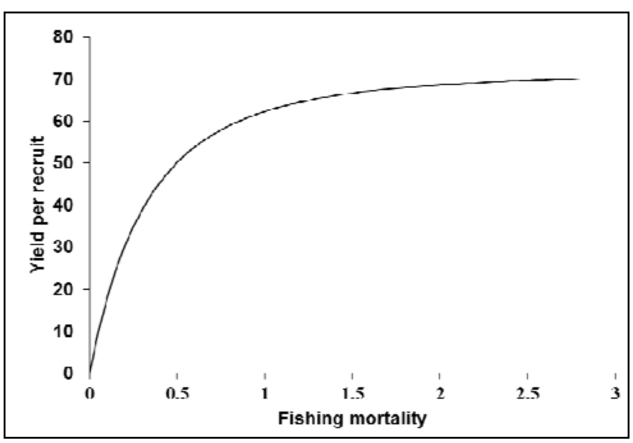

Fig 6: Yield per recruit analysis of *L. quinquelineatus* from Hurghada, Red Sea

4. Conclusion and recommendations
In the light of the above findings and with the fact that all target species in the Egyptian Red Sea fisheries are in a situation of overexploitation, the five lined snapper fishery in Hurghada fishing area can become more profitable and can achieve more economic returns if it given more attention and due care. So, a detailed knowledge on behavior, biology and population dynamics of the all fish stocks in the area is a vital step and should be done to put a full concept for how to exploit and expand this promising resource that will achieve the desired sustainable development of the lutjanid fishery in Hurghada.

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