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Age and Growth of the Areolate Grouper *Epinephelus areolatus* from the Gulf of Suez

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Abstract: Age and growth of the associated coral reef grouper, *Epinephelus areolatus*, were estimated for samples collected from the artisanal fishery in the Gulf of Suez during November 2013 and October 2014. Otoliths of 597 specimens ranged in length from 11.2 to 50.5 cm were used in age determination. The otoliths showed alternating opaque (light) and translucent zones when seen by reflected light against a dark background, a translucent zone plus the opaque zone immediately around it formed an annulus. According to the otolith examination, the maximum life span of *E areolatus* was eight years with mean lengths of 16.9, 24, 29.9, 35.7, 39.7, 43.4, 46.6 and 49.7 cm for the age groups from one to eight respectively. Individuals belong to age group two constituted the bulk of the catch with more than 60% of the population. The results showed that the *E. areolatus* is a relatively slow growing species and the values of the von Bertalanffy growth function was estimated as K = 0.154, L_∞ = 66.55 cm (LT) and t_0 = −0.91 years. The estimated growth performance index is 2.83. The length weight relationship was estimated as a = 0.0135 and b = 2.9947, r^2 =0.981 indicating an isometric growth of the weight relative to the length.

Keywords: Age and Growth, *Epinephelus areolatus,* Gulf of Suez

1. Introduction

Groupers (Serranidae: Epinephelinae) are major targets of artisanal, recreational and commercial fisheries in the Red Sea. Groupers are being subjected to increasing fishing pressure for food, ornamental display and medical purposes globally [1, 2].

Groupers are widespread in the Red Sea from a few meters to even 200 meters depth and are famous for high commercial value. The members of Serranidae family which comprises a large number of species; at least 31 of which are found in the Red [3] are among the most commercially important fishes in the Red Sea. Worldwide, chronic overfishing has depleted populations of large predatory reef fishes and caused unexpected, top-down changes in coral reef ecosystems. Groupers are especially susceptible to overexploitation, because they aggregate to reproduce at specific locations and times. An understanding of the spatial dynamics of these fishes is critical for fisheries management and conservation [4].

The areolate grouper Epinephelus areolatus is a sea fish that inhabits coral reefs in the Indo-Pacific region, whitish to gray in color with rounded brownish spots. It is a very common species in the Red Sea. Biological studies on E. areolatus is very scarce, thus [5, 6] conducted some biological and fisheries studies on the Serranidae Epinephelus areolatus from the Red Sea. [7, 8] studied the reproductive biology of E. areolatus from the Arabian Gulf, while [9] investigated the reproductive biology and life history of the species from the central eastern coast of India. This study aims to investigate the age, growth and length weight relationship as a seed information for the population structure and management studies of Epinephelus areolatus in the Gulf of Suez

2. Material and Methods

The samples used in this study were collected monthly (during the period from November 2013 to October 2014 from the catches of the artisanal fishery operating in the Gulf of Suez and landed in the Attacka landing site. The total

length of each sampled areolate grouper was measured to the nearest centimeter above and weighted to nearest 0.1 gm. All the fish collected, irrespective of sex, were grouped into size classes of 1.0 cm intervals according to the month of capture. The mean lengths and weights of each size class were also recorded.

Otoliths were removed from these fishes, for subsequent examination relevant to age determination. Before aging, otoliths were cleaned by 8 % Hcl, and dried. The otoliths were cleared in a mixture of 50 % alcohol and 50 % glycerin and examined using a stereo microscope at a magnification of 40 X. Age was determined by interpreting growth rings on the otoliths. The length weight relationship was applied as $W=a\ L^{b}$ where W is the total weight, L is the total length, and a, b are constants.

Growth was described by the von Bertalanffy growth model [10]. The length at age data were used for the estimation of the parameters of the von Bertalanffy growth model (L_∞, K and t_o) by applying three methods [11][12][13]-[14]. The empirical equation of [15] was used to estimate the hypothetical age (t_o) of fish, which would have at zero length. The growth performance index Q' was estimated to compare growth parameters obtained in the present work with those reported by other authors, it was obtained from the equation of [16].

$$Ø = \text{Log } K + 2 \text{ Log } L\infty$$

3. Results and Discussion

3.1. Length- weight Relationship

A total of 597 specimens of *Epinephelus areolatus* (76 males, 518 females and 3 unsexed) were used for the calculations of the length weight relationship. Samples of male *E areolatus* lengths ranged from 18.7 to 48.6 cm with average of 28.14 cm (SD=6.09), corresponding to weights of 83.1 to 1610 and 345.87 g (SD= ±284.5) for minimum, maximum and average lengths respectively. On the other hand, samples of female lengths ranged from minimum length 11.2 cm (17.1 g) to maximum length 50.5 cm (1944.3 g) with an average of 25.79 cm (256.65 g), (SD= ±5.06 and SD= ± 194.28 for length and weight respectively) (Table 1).

Table 1. *Descriptive statistics of mean for Epinephelus areolatus from Gulf of Suez during the period from November, 2013 to October, 2014.*

Descriptive statistics	Male		Female		Combined sex	
	Length	Weight	Length	Weight	Length	Weight
Fish No.	76		518		597	
Minimum	18.7	83.1	11.2	17.1	11.2	17.1
Maximum	48.6	1610.7	50.5	1944.3	50.5	1944.3
Mean	28.14	345.67	25.79	256.65	26.05	267.03
SD	6.092	284.505	5.067	194.281	5.259	209.176
SE	0.708	33.073	0.222	8.520	0.215	8.561
Variance	37.113	80943.07	25.673	37745.29	27.658	43754.76

*SD, Standard deviation and *SE, Standard error.

The length- weight relationships were calculated for each sex and for the combined sexes for the total weight and also for the gutted weight and the estimated b constant indicated an isometric growth of the weight relative to the length. The relationships are expressed in the following equations:

The total length- total weight represented by power equations (Fig 1):

W= 0.0112L3.0509 for males (No. = 74 and r2 = 0.986).

(SEa= 0.145, SEb= 0.044, CIb= 2.964-3.138)

W= 0.0139L2.9842 for females (No. = 518 and r2 = 0.979).

(SEa= 0.061, SEb= 0.0.19, CIb= 2.947-3.022)

W= 0.0135L2.9947 for all samples (No. = 597 and r2 = 0.981).

(SEa= 0.056, SEb= 0.017, CIb= 2.958-3.026)

Total length- Gutted weight represented by power equations (Fig 2).

$Wg= 0.0101L^{3.0686}$ for males (No. = 74 and $r^2= 0.988$).

($SE_a= 0.137$, $SE_b= 0.041$, $CI_b= 2.985\text{-}3.151$)

$Wg= 0.0123L^{3.0085}$ for females (No. = 518 and $r^2= 0.982$).

($SE_a= 0.061$, $SE_b= 0.019$, $CI_b= 2.971\text{-}3.045$)

$Wg= 0.0119L^{3.0171}$ for combined sexes (No. = 597 and $r^2= 0.983$).

($SE_a= 0.056$, $SE_b= 0.017$, $CI_b= 2.983\text{-}3.050$)

Hassan [5] calculated the length weight relationship for combined sexes of *Epinephelus areolatus* from the Red Sea as $W=0.016449*L^{2.9359}$. Sujatha [9] estimated the relationship for *E. areolatus* from the central eastern coast of India as $W = 0.00133*L^{2.946}$. These results are in close agreement with the present study.

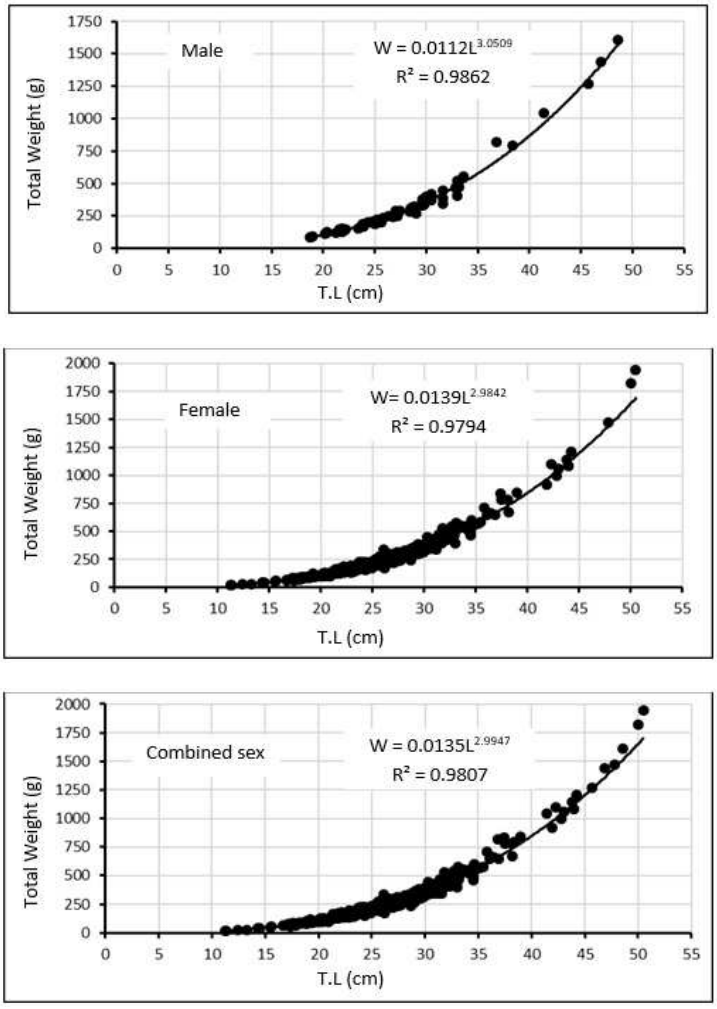
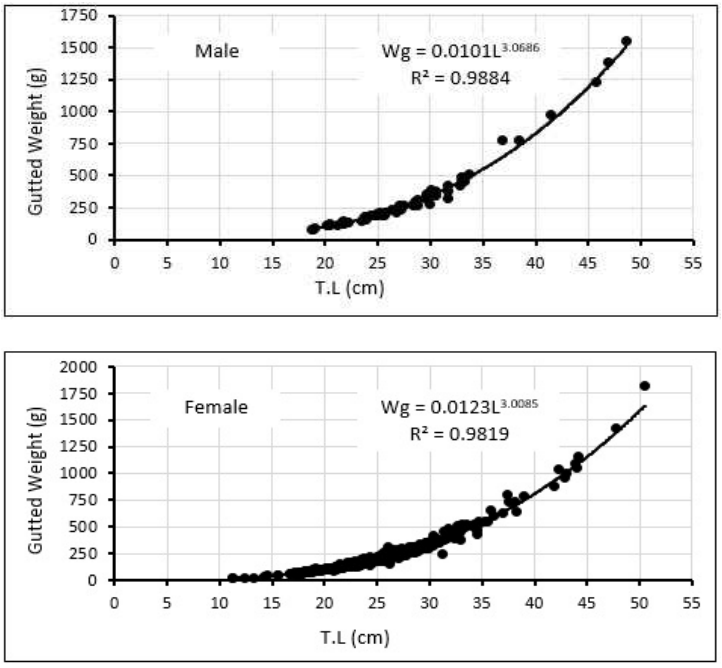


Fig. 1. *Total length-total weight relationship for males, females and combined sexes of E areolatus from the Gulf of Suez during the period of study (2013-2014).*



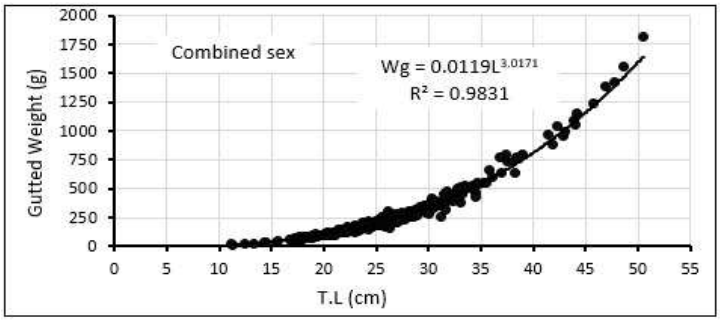


Fig. 2. *Total length-gutted weight relationship for males, females and combined sexes of E areolatus from the Gulf of Suez during the period of study (2013-2014).*

3.2. Age Determination

The otoliths of *Epinephelus areolatus* are laterally compressed, oval structures which has a concave and a convex surface, the latter having a ridge down the center. The posterior edge is blunt and rounded while the margins are irregularly indented. The focus is surrounded by a wide opaque zone, the core. When seen by reflected light against a dark background, the otolith show alternating opaque (light) and translucent zones. Under transmitted light, the opaque zone becomes dark while the translucent zone becomes light. A translucent zone plus the opaque zone immediately around it are together defined as "growth ring" or "annulus". The beginning of the second ring is translucent and separated from the former opaque zone, Fig. (3).

Fig. 3. *Otolith of areolate grouper Epinephelus areolatus collected from the Gulf of Suez (35.2 cm total length, 4 years old).*

Table 2. *Mean lengths and increment at each age group of Epinephelus areolatus estimated by otolith reading.*

Age group	No. ofFish	Range of Length (cm)		Average Length	Increment (cm)	± SD
		Min.	Max.			
I	34	11.2	19	17.0	16.96	2.19
II	376	18.3	27.6	24.0	7.064	2.22
III	153	27.1	34.5	30.0	5.96	1.70
IV	14	34.2	37.5	35.7	5.74	1.14
V	8	38.1	42.3	39.7	3.95	1.85
VI	4	42.8	44	43.4	3.7	0.59
VII	5	44.2	48.4	46.6	3.2	1.68
VIII	3	48.6	50.5	49.7	3.1	0.98

The otoliths of 597 specimens were used in age determination of *Epinephelus areolatus*. According to the otolith examination, the maximum life span of *E areolatus* was eight years with mean lengths at age of 16.9, 24, 29.9, 35.7, 39.7, 43.4, 46.6 and 49.7 for the age groups from one to eight respectively (Table 2).

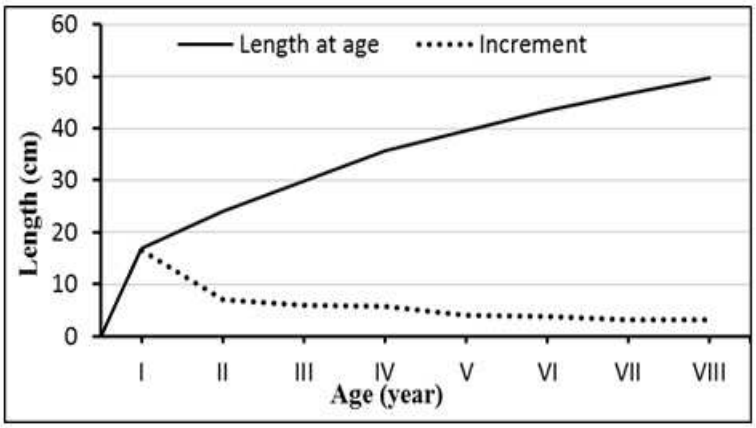


Fig. 4. *Growth in length and increment of Epinephelus areolatus from the Gulf of Suez.*

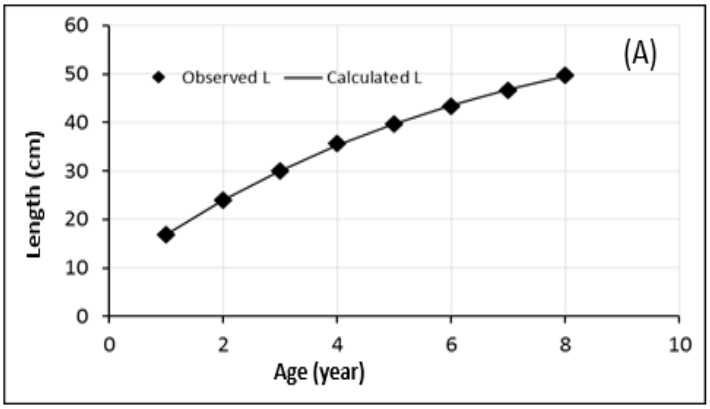
3.3. Growth in Length and Weight

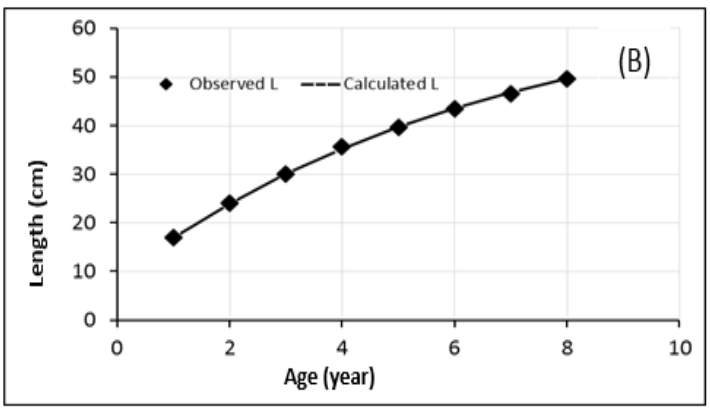
The mean calculated length at age of *Epinephelus areolatus* were used for the estimation of the parameters of the von Bertalanffy growth model (L_{∞}, K and t_o) by applying three methods [11][12][13]-[14] (Table 3).

Table 3. *The parameters of the von Bertalanffy growth model of Epinephelus areolatus.*

Constant	Ford-Walford	Gulland and Holt	Chapman
L_{∞}	66.55	66.65	66.55
K	0.154	0.153	0.133
T_o	- 0.91	- 0.92	- 1.35

The mean estimated lengths at age indicated rapid growth in the 1st year of life then the rate of growth slows down. The estimated growth parameters showed that the areolate grouper is a relatively long lived species with slow growth rate and age group two was the most predominant in the catch represented by more than 60.0 % of the individuals. Hassan [5] recorded the values of the von Bertalanffy growth function as K = 0.13, L∞ = 78.92 cm (LT) and t0 = −1.102 years. The result of the growth coefficient K is comparable to the result of the present study while the result of L∞ is higher than ours which may be attributed to the higher recorded maximum length from the Red Sea than that from the Gulf of Suez.





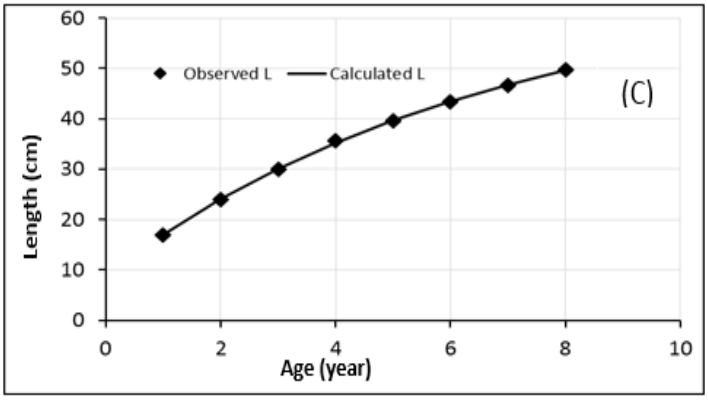


Fig. 5. *Growth in length of Epinephelus areolatus from the Gulf of Suez by (A) Ford-Walford fitting method, (B) Gulland and Holt fitting method and (C) Chapman fitting method.*

3.4. Growth Performance Index (φ)

The results showed that the growth performance (φ) of *E. areolatus* is 2.83, 2.77 and 2.83 according to [13]-[14][12][11] respectively. These results are in accordance with that estimated from [5] growth parameters (φ = 2.9).

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