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Age and Growth of *Epinephelus fasciatus* from northern Red Sea

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ABSTRACT

Age and Growth of the fish *Epinephelus fasciatus* (n=443) from Northern Red Sea were investigated, during the period from June 2006 to May 2007. The t-test analysis for the length-weight relationships showed a significant difference between b values, where male are positive allometric while female and sexes combined are isometric. The "K_c" and (K_n) factor was studied monthly and according to size classes, where females usually outnumbered males. The total average of K_c for sexes combined was 1.428 (SE.± 0.4134), this value is indication of a good condition. The value for both K_c and K_n increased in line with increased fish size until the size 31.4, and then decreased in value. On the other hand, both condition factors showed fluctuations among months, where the lowest value was recorded during August (within spawning season). The back calculation method was used to determine the age and growth for *E. fasciatus*. According to Bhattacharya method eight age group were verified growth parameters $L\infty$=36.75 cm (TL), K= 0.35 year -1 and t_0= -0.41121 were derived from Ford and Walford method. The highest range of growth recorded in the first year as it grows about 14.32 cm. Then the rate of growth either slowed down slightly or get closer to being steady.

Keywords: Age, Epinephelinae, *Epinephelus fasciatus*, Groupers, growth, length-weight relationships, Northern Red sea, Serranidae, South Sinai

INTRODUCTION

The fishes create important components of the demersal fishery resources that are the primary targets of commercial fisheries in both tropical and sub-tropical waters worldwide (Ogongo *et al.,* 2015). However, a recently UNEP and WIOMSA (2015) reported that an estimated 1,900 bony fish species including some *Epinephelus* genus (groupers) are threatened within the region (Esseen and Richmond, 2011) The current global threaten rate of grouper exploitation and mortality that will lead to, some species become effectively extinct (Hossain *et al.,* 2009) and make shifts in the biological communities with resultant biodiversity losses (Jennings and Kaiser, 1998). Thus, given the sensitivity of the fishes even with little fishing efforts due to their slow growth rates, delayed maturity, low fecundity and long lifespans, potential recovery of their populations to overharvesting can take decades (Myers *et al.,* 2007)

A fish Length Weight Relationship is an essential fishery management tool Fisheries biology and fish stock assessments, as it enables the determination of fish age, structure and health by providing many facts about its seasonal cycles and influencing aspects of the biotic and abiotic factors (Ayoade and Ikulala, 2007). That relation given chance to study the life history and morphological comparisons between different fish species, or between fish populations from the different habitats and/or regions (Goncalves *et al.,* 1997).

Growth in weight is more important than growth in length, because the rate of increase in weight reflect the suitability of the environment around the fish, particularly the amount of food available as well as the assimilation on efficiency of this food (Ahmed, 1999). Lagler (1956) discussed the uses of the relationship between length and weight in the field of fisheries management. In general, length of fish is easier, rapid and accurate parameters to be measured than weight which show great variability within the food amount in the external environment. However, the fish weight measurement is an important parameter in fishery biology, hence, it is essential to find the relationship between the fish length and fish weight. Such a relation can be used to convert lengths into weights and consequently the estimation of growth in weight.

Condition factor is another application in age and growth studies required to fishery biologists to describe the condition plumpness, or well-being of fish (Ogongo *et al.,* 2015). It is used to express fish condition with regard to the degree of wellbeing, fatness or relative robustness in numerical terms.

On the other hand, age determination of fishes can be seen by counting and interpretation of rings, which made along the hard structures of fishes such as scales, otoliths, operculum bone, vertebrae, FM spines and rays (Moyle and Cech, 1982; Sharaf, 1987).

Scales reading is perhaps the most widely used methods because they are easily and rapidly moved without harm to fishes, which may be returned alive to the water (Fouda, 1989). Scales reading is based on two assumptions: the firstly, the cyclical changes in the growth rate as seasonal or annual rings on the scales, and the secondly, the spacing between these marks accurately monitors the growth of the whole population during the elapsed period of time. If these assumptions are correct, it is possible to age a fish from the number of rings and back calculated the extent of growth over the previous years by relative spacing of seasonal rings (Tesch 1968).

The present research aims to study the growth of the *Epinephelus fasciatus*, from Northern Red Sea by age determination, length-weight relationship, and the condition coefficient.

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MATERIALS AND METHODS

A total of 443 fish specimens was collected for a period of one year from June 2006 through May 2007. All specimens were collected from local fishermen in Nabq protected area and Al Tur city. All the catch carried out by fishing line and fishing net. Total lengths and total weights were used to computation of the length-weight relationship and coefficient of condition "Kc" and "K_n" between males, females and whole population. The length-weight relationship is derived from the equation $\mathbf{W=a\ L^b}$ (Hile, 1936 and Beckman, 1948). According to Fulton (1902), the calculation of condition factor (K) is expressed by the equation

$$\mathbf{Kc = W/L^3 * 100}$$

While, the relative coefficient of condition (K_n), calculated by using equation of Le cren (1951)

$$\mathbf{K_n=W/a\ L^b}$$

For age determination, 4-5 scales of *E. fasciatus* were removed from the left side of each fish behind the tip of pectoral fin below the lateral line. Theoretical growth in length was expressed in terms of the equation of Bertalanffy (1938), the Von Bertalanffy growth curve was fitted to the observed length at correct age data for the resulting age-length key by means of non-linear least method. The form of the growth curve is: $\mathbf{L_t = L\infty\ [1 - exp^{\{-k\ (t-to\}}]}$ **(**Bertalanffy**,** 1938**).** While, the theoretical growth in weight can be obtained by applying the length-weight relationship ($W = \mathbf{aL^b}$**)** to the Von Bertalanffy growth equation, so the equation become as follow:

$\mathbf{W_t = W\infty[1\ exp^{\{-K(t-to)\}}]^b}$ **(**Bertalanffy**,** 1938)

RESULTS

Length – weight relationship

Of 443 specimens of *Epinephelus fasciatus were* used to estimate the length weight relationship (399 females and 34 males). In spite of the low number of males, we applied the length-weight relationship. As a result of low naturally occurring, the male sex ratio of the *E. fasciatus* had limited ability to collect representative sample size. Whereas, that male low ratio recognized in many literatures (Pear, 2005; Mishina *et al.,* 2006; Ogongo *et al.,* 2015).

The relationship between fish total length and total weight of male, female and sexes combined was derived respectively as $W = 0.0082L^{3.1707}$; $W = 0.016L^{2.9789}$ and $W= 0.0132L^{3.0378}$. The t-test analysis showed a significant difference in (b) value of male growth pattern, indicating that the growth pattern is positively allometric (P- value = 0.047) while, for females (P- value = 0.373) and sex combined (P- value = 0.286) indicating a non-significant difference, which reflect that growth is isometric. Paired t-test showed that there is an agreement between the observed and the calculated weight, no significant differences were found for males (P- value = 0.8), females (P- value = 0.979) and sexes combined (P-value = 0.589) (Table 1).

Table (1): Length-weight relationship of *E. fasciatus* for males, females and sexes combined of *E. fasciatus* from Northern Red Sea.

Sex	n	TL range (cm)	TW range (g)	a	b	R^2
Male	34	16.5 - 26.5	70.4 - 297.6	0.0082	3.1707	0.9158
Female	399	15.5 - 36.5	52.7 - 575	0.016	2.9789	0.9679
Total sexes combined	433	15.5 - 36.5	51.1 -575	0.0132	3.0378	0.9685

Condition coefficient "K"

The results of "K_c" and "K_n" for *E. fasciatus* with interval 1.5 cm fish length are represented graphically in figures (1 A and B). It is clear that Kc was generally higher than K_n. For males, Kc was less than that of females and sexes combined. The lowest value for males was in size class of 18-19.4 cm with value 1.12 and highest recorded values of 1.6 was observed in size class of 25.5-26 cm with a mean 1.428 (SE. ± 0.4134). Whereas, the values of K_n varied from 0.95 to 1.123, in size class 22.5-23.9 cm and 16.5-17.9 cm respectively with a mean 1.032 (SE. ± 0.2801). For females, K_c and K_n showed the lowest and highest values in correspondence to the same size classes of 34.5-36.5 cm and 19.5-20.9 cm. K_c varied between 1.215 to 1.549 (mean: 1.455, SE.±0.2179), whereas K_n fluctuated between 0.818 and 1.031 (mean: 0.973, SE. ± 0.01436). For sexes combined, K_c ranged from 1.215 to 1.533, in size classes 34.5-36.5 cm and 30-31.4 cm respectively with a mean of 1.451 (SE. ± 0.029). While K_n varied from 0.804 to 1.029 in size classes, 34.5-36.5 cm and 19.5-20.9 cm respectively with a mean 0.974 (SE. ± 001462).

The calculated of K_c and K_n in different months are presented in figures (1 C and D), for males, females and sexes combined. During different months, usually the values of K_c and K_n for females are higher than that for males. On the other hand, the results shown in the both figures that the values of K_c and K_n of *E. fasciatus* fluctuated significantly during different months. For males, the lowest value of the K_c was recorded during August and the highest one during September (1.2776 and 15.194 respectively). The lowest values of K_c for female was recorded during November (1.42) and the highest value of 1.55 was observed during March. Concerning sexes combined, the lowest (1.42) and highest (1.55) value was recorded during November and March respectively. The annual average values of condition factor (K_c) for males, females and combined sexes were 1.40 (SE. ± 0.182), 1.5 (SE. ± 0.0234) and 1.49 (SE. ± 0.0224) respectively. It has been found that the highest value of K_n in males was found in April (1.09), while in females and combined sexes the highest values were recorded in March (1.04 and 1.045 respectively). The minimum value of K_n for males was recorded in August (0.925). While for females and combined sexes the lowest values were recorded in November (0.953 and 0.9508 respectively).

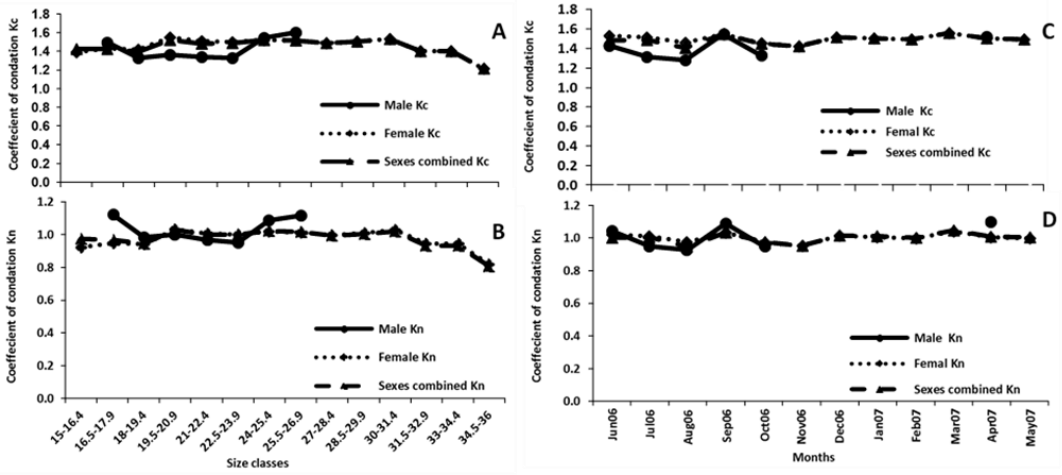

Figure (1): Shows the Condition factor K_c and Relative condition factors K_n in different size classes (A and B) and months (C and D) for males, females, and sexes combined of *E. fasciatus* from Northern Red Sea.

Age determination by scales

Scales of *E. fasciatus* are of ctenoid type and tightly embedded in the skin with its posterior short conical cteni. The attempt to determine the growth layers in scales of *E. fasciatus* was unsuccessful. It was observed that, as the fish grows and increase in length, increase in the scale radius as well and the number of annual rings. However, the existence of alternatively wide and narrow zones, which characterizes the rapid and slow growth during summer and winter respectively, were not obviously detected and could easily identified by their discontinuity on the lateral sides.

Growth Estimation

As a consequence in inability to determine age from reading the scale rings, it was used the back calculation as a tool to define the age groups. The length frequency method of Bhattacharya (1967) was used for age determination. Age groups and mean length of whole population were estimated and shown in table (2). The theoretical growth in length (Von Bertalanffy equation) of the whole population of *E. fasciatus* could be written in the following form:

$$L_t = 36.75[1 - \exp^{\{-0.35\ (t\ +\ 0.41121)\}}]\}].$$

On the other hand the theoretical growth in weight (the combination between Von Bertalanffy equation and length-weight relationship equation) of the whole population of *E. fasciatus* was expressed as the following: $W_t = 750.7[1 - \exp^{\{-0.35\ (t\ +\ 0.41121)\}}]^{3.0378}$. Paired t-test, for both computed length (t = -1.117, p = 0.301 and df = 7) and weight (t = -1.289, df = 7 and p = 0.866), confirm that there was no significant difference between them and calculated length and weight (Figures 2 A and B).

Table (2): Age determination by length frequency distribution of the E. fasciatus for sexes combined from the northern Red Sea

Age group	Population Number	Computed Mean length (Bhattacharya)	Standard deviation	Separation index
1	76	18.28	1.6	n.a.
2	66	20.98	0.57	2.49
3	186	23.2	1.61	2.04
4	75	25.96	0.74	2.35
5	46	28.51	0.82	3.27
6	14	30.77	0.53	3.35
7	4	32.79	0.73	3.21
8	6	34.93	1.17	2.25

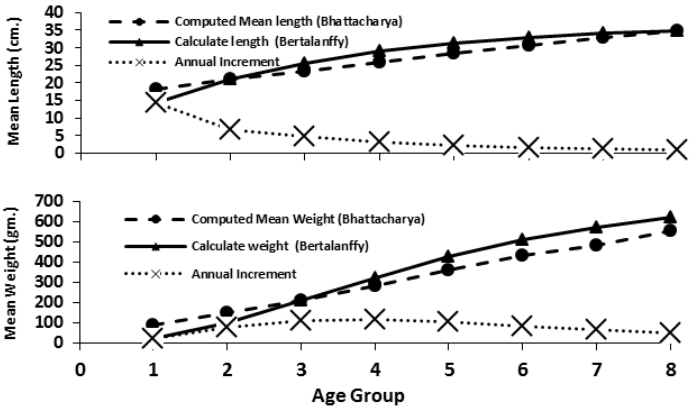

Figure (2): Theoretical growth in length (A) and weight (B) for sexes combined of the *E. fasciatus* from the Northern Red Sea.

DISCUSSION

Life history features of fish, such as age, size and growth, are important in understanding population boiology and managing exploited species (Choat and Robertson, 2002). These parameters have spatial variations recorded for many taxa including several species of groupers (Manickchand-Heileman and Phillip 2000; Mapstone *et al.*, 2004). Consequently, it is essential to consider such variations when comparing characteristics of different species (Pear, 2005; Ohta *et al*. 2017).

One limitation of this study was the unavailability of smaller size-classes of *Epinephelus fasciatus*, since the sampling strategy was primarily dependent on fishery catch, who used selective fishing gears which favored bigger sizes. This research obstacle has been affirmed by several researchers who studied groupers, such as Caballero-Arango *et al*., (2013) in Gulf of Mexico, Burton *et al.,* (2015) in Southeastern United States and Freites *et al*., (2017) in SW Atlantic. Many attempts were made to overcome that limitation using nets or spears to capture the smaller sizes. Unfortunately, these attempts were not successful.

The (b) value in the present study was 3.1707 for males, indicating positive allometric mode of the growth, this value is higher than the value calculated by Wahbeh (2005) in the Jordanian Gulf of Aqaba (b value= 2.7851), indicating negative allometric growth mode. While In females (b) value was 2.9789 indicating isometric mode, which is in harmony with Wahbeh (2005) who reported female isometric growth with (b) value at 3.0372 (Table 3).

On the other hand, the b value for the whole population was 3.0378 (t = 0.666, P-value = 0.286) indicating isometric growth mode. This finding is not in accordance with other studies in other regions of the world (Table 3), where it was recorded as a negative allometric growth (Letourneur *et al*., 1998; Agembe *et al.,* 2010; Ogongo *et al.,* 2015). However, the (b) value obtained in this study for the whole population turned out to be more comparable with other grouper species, like yellow mouth grouper in the Southern United States, which was recorded at 3.010 (Michael, *et al.,* 2014). And Kandula *et al.* (2015) recorded the length-weight relationship as isometric off eastern Indian coasts for *E. chlorostigma* as (b = 3.04), *E. tauvina* (b = 3.07), *E. coioides* (b = 3.00) and *E. malabaricus* (b = 3.06). Also for *Epinephelus areolatus* In Gulf of Suez, the b value for combined sexes was calculated at 2.9947 and 3.0171 using total weight and gutted weight, respectively (Abd-Allah *et al*., 2015). Moreover, the b value for *Cephalopholis argus, Epinephelus coioides, Epinephelus fuscoguttatus* and *Epinephelus tauvina* in Kenya were calculated as 3.081, 3.041, 3.091 and 3.051 respectively (Agembe *et al.,* 2010).

The *E. fasciatus* showed significant difference between the regression coefficient (b-values for males, females and combined sexes), and the hypothetical b value (b = 3). This reflects the difference in the body proportions and specific gravity for both males and females of *E. fasciatus* along its life span. This result is in harmony with Pear (2005), Waheba (2005), Agembe *et al*., (2010) and Michael (2014). This difference was clarified by Pear (2005) and Ohta *et al*. (2017) as which referred it to the fact that groupers species are mostly protogynous hermaphrodites, they mature only as females and have the ability to change sex after sexual maturity.

Table (3): The length-weight relationship parameters of *E. fasciatus* collected from different regions

Author	sex	LWR* constant		Growth type	R^2	Location
		a	b			
Letourneur *et al*. (1998)	WP**	0.0229	2.877	-A	---	New caledoina lagoon
Wahbeh (2005)	Male	0.0286	2.7851	-A	0.9974	Aqaba, Jordon
	Female	0.0103	3.0372	I	0.9957	
Agembe *et al.* (2010)	WP**	-1.77	2.931	-A	0.93	Kenya coast
Ogongo *et al.* (2015)	WP**	0.462	2.696	-A	0.7048	Kenya coast

*LWR= length weight relationship, **WP= Whole population, A= Allometric, and I= Isometric

Table (4) shows the difference between (b) values and R^2 for the same *Epinephelus* species studied by Agemba *et al.,* (2010) and Ogongo *et al.,* (2015). The difference in regression coefficient (b) may be a result of selective sampling and/or population length structure that may strongly influenced the estimated parameters of length-weight relationship, (a and b values) (Godinho, 1997; Dulcic *et al.,* 2000). However, Turkmen, (2003) and Tsoumani *et al.,* (2006) mentioned that the coefficient b of length-weight relationship was influenced by growth phase, season, degree of stomach fullness, gonad maturity, sex, size range, health, general fish condition, geographical location, environmental conditions, population density, and fishing impact. Bagenal and Tesch (1978) asserted that the (b) value is not only inconsistent among different species, but sometimes among stocks of the same species, depending on the sex, season and maturity stage.

The length-weight relationship for *E. fasciatus*, in the present work clearly demonstrated that, weight increase isometrically with length. The almost perfect agreement between the observed and the calculated weight. This finding mostly agreed with Wahbeh (2005) in Gulf of Aqaba and Agema (2010) in Kenya (Table 3), while the low determination coefficient (R^2) was recorded by Ogongo *et al.* (2015) in kenya (R^2= 0.7048) and Pear (2005) in Great barrier reef (R^2 ranging between 0.488 and 0.898) and in Seychelles (R^2 ranging between 0.803 and 0.834).

The obtained results of K_C and K_n indicated that there is a significant trend between the values during different months and across different size classes for males, females and sexes combined. K_c and K_n There are a few literatures that investigate the condition factors (K_n and

K_c) of groupers, and none have investigated for *E. fasciatus*. So difficulties were founded in comparing the obtained results with others. In such cases, where no literature exists we instead opted for comparing our results with other groupers or other carnivore species. Maguire and Mace (1993) demonstrated the importance of K_c measurement, where it gives an indication of the well-being of the fish. Low K_c values indicate poor food conditions, while high values indicate a good condition. In light of such evidence, "K_c" of *E. fasciatus in* Northern Red Sea was prospering.

The average K_c throughout the years was 1.45. The values obtained from the study showed that *E. fasciatus* was in good condition. This finding was consistent with Ezzat (1982), Ekpo (2013) and Waly *et al.,* (2015) who studied the white grouper and reported a high conditions factor K_C ranging between 1.24 to 1.361, confirming that these values indicate a good environmental conditions. Le Cren (1951) reported that environmental factors, food supply and parasitism have great influence on the health of the fish. Mbaru *et al.,* (2011), studied the relation between condition factor K_c and the different size classes for *Epinephelus anderson* and other three carnivorous fishes in Kenya. He reported that K_c increased with the increase in length before decreasing again in bigger size classes. The condition factor K_c in the present work is in harmony with previous studies, where K_c values followed diverse trends for males, females and whole population, showing positive relationship with size up until the medium fish size (19.5 - 20.9 cm), then fluctuated until the size 30-30.4 cm, followed by an inverse relationship with sizes up to 36.5cm. Maguire and Mace, (1993) and Angelescu *et al.,* (1958) explained this finding by the accumulation of fat and sometimes gonadal development, especially after the maturation stage, when fish possesses higher reproductive potentiality. The highest value of condition factor K_c was recorded before and after the spawning season in the present work, during March and September, and was calculated as 1.55 and 1.54 respectively. Conversely, K_c values decreased during spawning season and immediately in the wake of it. The K_c value differed slightly after the spawning season, where the condition factor may be affected by feeding activity, status of sampling and environmental factors rather than the condition of the gonads. This finding run parallel with Mbaru *et al*., (2011) and Waly *et al.,* (2015) who recorded generalized low value of K_c for both *Epinephelus anerson* in Kenya and *Epinephelus aeneus* in Senegal during the spawning season and slightly increased before and after spawning. The same finding was recorded for *Sphyraena chrysotaenia* in Gulf of Suez by Osman (2016) who recorded the highest estimated values of condition factor prior to the spawning season and just after the spawning season. While the lowest estimated, values were recorded during the spawning season. This may be a result of the exhaustion suffered by fish during its long spawning season. Vazzoler (1996) confirmed that lowest K_c values during the more developed gonadal stages might reflect re-allocation of resources to the gonads during the reproductive period. Braga (1986), showed that values of the condition factor vary according to seasons and are influenced by environmental conditions. Similarly, Sossoukpe *et al.* (2016) confirmed that it might be related to sexual cycle or feeding intensity.

Age determination takes an important role in the stock assessment of fisheries resources and fisheries management. It is necessary to be informed about life span and both growth and mortality (El-Ganainy, 1997; El-Okda, 1998). The published information about age and growth of *Epinephelus fasciatus* in the Red Sea are rare (Wahbeh, 2005). Available studies provided observations on the diet, habitat, behavior, and classification (Smith, 1965; Randall and Ben-Tuvia, 1983; Shpigeland Fishelson, 1989, 1991). Since few studies were concerned with age determination of *E. fasciatus*, the current study determined the ages at the end of successive years of fish life for sexes combined of *E. fasciatus* using the length based method of Bhattacharya (1967). The results were then compared with the finding presented by Rathacharen *et al.,* (1999) in Mauritius, Pear (2005) in the Great Barrier reef, Seychells and Wahaba (2005) in Aqaba, Jordon.

Several studies on age determination and growth in fishes using hard structures have been reported in the literature. The validity of this method for tropical fishes, however, is still a matter of controversy (Ricker, 1971). Menon (1953) and Geraldo *et al*., (2011) reported that determination of age and growth is difficult in tropical and sub-tropical regions because the scales may show rings that are not necessarily annual. In addition, and as a result of little seasonal and environmental changes fishes developed clear annual rings. In contrast, Nekrasov (1979) reported that annulus formation occurs once a year in tropical fishes and is linked to spawning. However, Laban (2008) found it is difficult to determine the age of *Solea aegyptiaca* in the Mediterranean Sea through annual ring method, and instead he adopted the length-based technique. In the present study, it has been attempted to determine age using scales of *E. fasciatus*, but a distinct annulus was not seen, so it is concluded that the scales of *E. fasciatus* cannot be used for age determination. This observation is consistent with the finding of Rajaguru (1992) who failed to find the annual markings in scales, otoliths, operculum bone and the supra-occipital crests of flatfishes *Cynoglossus arel*, and *C. lida* from the southeast coast of India.

The length-based Bhattacharya method (1967) available in the FISAT software (Gayanilo *et al.,* 1993) was used to determine the age and growth of *E. fasciatus*. Eight distinct modes with high separation indices were detected, indicating eight years of life. According to Bhattacharya method (1967), the lengths assigned to the different years of life were 18.28, 20.98, 23.2, 25.96, 28.51, 30.77, 32.79 and 34.93 cm, corresponding to age groups I, II, III, IV, V, VI, VII, and VIII years respectively for the combined sex.

Table (4): Comparison between (b) value and R^2 for the same species in the same location with five years' time interval between the two studies.

Species	(b) Value		R^2	
	Agembe *et al.*, (2010)	Ogongo *et al.*, (2015)	Agembe *et al.*, (2010)	Ogongo *et al.*, (2015)
E. caeruleopunctatus	2.92 I	1.2671	0.95.1	0.9388
E. coioides	3.04 I	2.4781	0.993	0.7574
E. fasciatus	2.93 I	1.2671	0.93	0.7048
E. fuscoguttatus	3.09 I	2.8039	0.979	0.7286
E. malabaricus	2.90 I	1.1826	0.977	0.891
E. merra	2.99 I	0.0108	0.976	0.9439
E. multinotatus	2.93 I	1.2377	0.898	0.8299
E. tauvina	3.05 I	0.3352	0.978	0.4947
E. tukula	3.17 I	0.3752	0.984	0.2313

The longevity of *E. fasciatus* was recorded by Wahbeh (2005) in Aqaba Jordon being seven years, but the estimated total length for each age was lower than that recorded in the present study. This variation may be because the smaller size-classes which were not collected in this work, which is attributed to the dependence of the sampling on the fisher's catch and the selectivity of their fishing gears. Furthermore, these observed differences, may have appeared due to the effect of the different nature and method used in determining the age where, Wahbeh (2005) determined the age using annual rings of the scales. Pear (2005) confirmed that longevity varied significantly on the regional scale for *E. fasciatus*, where at the Lizard region it was significantly greater than other broad regions of the Great Barrier Reef and in the Seychelles, the longevity estimate for the Southern Amirante Isles was lower than that of the Northern Amirante in Great Barrier Reef. Pears (2005) estimate of the *E. fasciatus* longevity in the Southern Amirante Isles was 7 years, which is lower than that of the Northern Amirante Lsles. The longevity of 5 to 8 years is lower than those of any region in the Great Barrier Reef. Thus, relatively high turnover is expected for *E. fasciatus* in the southern Amirante Isles, which in turn may give higher regional productivity. Conversely, individual fecundity may be lower for *E. fasciatus* when fish reach minimum sizes, since fecundity typically increases with body size (Roff, 1992).

Study of the growth in length and growth parameters is very important for fishery management (Ahmed, 1999; Osman, 2016), where it reflect not only the genetic capability of the fish species but also the type of the environment in which it occurs (Manooch and Huntsman, 1977). Temming and Herrmann (2001) and Moumita DE *et al.*, (2016) found that water temperature is one of the most important factor affecting fish growth. Theoretical growth parameters (K, t_o and $L\infty$) are the basic input data into various models used for managing and assessing the status of the exploited fish stocks (Ahmed, 1999; Farrag, 2008). In the present study, the theoretical growth in length and weight of *E. fasciatus* were estimated. Growth parameters ($L\infty$, K and t_0) were derived from Ford (1933) - Walford (1946) method. The theoretical maximum length value (L = 36.75 cm (TL).), maximum weight (W. = 750.7 gm.) which was close to the largest fish recordrd. The prenatal ages (t_0 = -041121) and the growth coefficient value (K = 0.35 year -1).

Table (5) shows the von Bertalanffy growth parameters of *E. fasciatus* from different localities. From the table 5, it is evident that the growth coefficient value (K) in the present work, was generally lower than those given by Pears (2005), except it was higher than that recorded in Townsiville and slightly higher than that recorded in Pompey in the Great Barrier Reef. Where the age of *E. fasciatus* in the Great Barrier Reef ranged between 4 and 16 years and in Seychelles ranged between 2 and 11 years. However the growth coefficient (K) in the present study is higher than that was recorded by Wahbeh (2005) in Aqaba, Jordon, with age ranging between 1 and 7 years. Furthermore, the growth coefficient (K) in the present study is higher than that of *Epinephelus areolatus* that studied in the Gulf of Suez by Abd-Allah *et al.*, (2015) were calculated as 0.154 yr^{-1}. Kasim & Balasubraman (1990) and Pajuelo & Lorenzo (1998) referred to the effect of the sample size on estimates of L_∞, K and t_0. In the present study the maximum age determined by Bhattacharya method (1967) was 8 years which is lower than that estimated by Pears (2005). This may be as a result of the lack of small samples in the present work, where the smallest sample size was 15cm (TL) and the largest was 36 cm (TL), while the smallest and largest samples studied by Pears (2005) were 5cm (FL) and 29cm (FL) respectively. On the other hand, the results obtained by this study approach those of Wahbeh (2005), with the size assigned for each age is smaller than what estimated in the present study. This may be due to geographical effect and food availability in different sites.

The prenatal ages (t_0) of the present work were different from those given by other authors (Table 5). The observed high t_0 value can be attributed to the absence of the youngsters of 1 year old in the samples or otherwise the length at first year was high (Murad, 2007). From the above table, the asymptotic length (L_∞) for *E. fasciatus* in the present results was nearly in agreement with that value given by Pears (2005) and higher than that recorded by Wahbeh (2005), however smaller than that estimated by Rathacharen *et al.*, (1999) in Mauritius, and such difference may be due to variations in habitats. Beverton and Holt (1957) Asserted that L_∞ values may be affected by factors such as population

density and food availability. In the current work, calculated length using Bertalanffy growth equation of *E. fasciatus* showed the highest growth in length in the first year of life as it grows about 14.32 cm. Then the rate of growth in length slowed down gradually during the next years. The annual increments were found to be 6.6, 4.6, 3.3, 2.2, 1.6, 1.2 and 0.8 cm during second, third , fourth, fifth, sixth, seventh and eighth years of life respectively. These observations are in close agreement with those recorded by Rajaguru (1992) who studied *Cynoglossus arel*, and *C. lida* from Indian water, Laban (2008) who studied *Solea aegyptiaca* in the Mediterranean Sea, Abd-Allah *et al*. (2015) who studied *Epinephelus areolatus* in Gulf of Suez, and Osman (2016) and ElGanainy *et al.* (2017) who studied *Sphyraenia chrysotaenia* in the Gulf of Suez. All of them described the increment in growth as very rapid growth rate during the first year of life

Table (5): Growth parameters (Loo, K and t_0) estimated for *E. fasciatus* by various authors in different localities.

Author	Region	L ∞	*K*	t_0
Pears (2005)	Great barrier reef (Whole population)	28.2 cm (FL)	0.469	-0.198
	Lizard (Whole population)	26.8 cm (FL)	0.536	-0.183
	Townsville (Whole population)	28.5 cm (FL)	0.308	-0.298
	Mackay (Whole population)	28.5 cm (FL)	0.443	-0.207
	Pompey (Whole population)	29.7 cm (FL)	0.383	-0.230
	Seychelles (Whole population)	27.5 cm (FL)	0.450	-0.212
	Northern Amirante (Whole population)	28.8 cm (FL)	0.441	-0.206
	Southern Amirante (Whole population)	26.1 cm (FL)	0.483	-0.208
Wahbeh (2005)	Aqaba Jordon (Female)	29.9 cm (TL)	0.173	-1.002
	Aqaba Jordon (Male)	31.2 cm (TL)	0.132	-1.287
Rathacharen et al. (*1999*)	Mauritius (Whole population) 1990	41.29(TL)	0.254	-0.23
	Mauritius (Whole population) 1991	41.21(TL)	0.283	-0.01
	Mauritius (Whole population) 1992	42.17(TL)	0.257	-0.1
	Mauritius (Whole population) 1993	41.14(TL)	0.25	-0.06
	Mauritius (Whole population) 1994	41.27(TL)	0.254	-0.06
	Mauritius (Whole population) 1995	40.47(TL)	0.177	-0.04
Present work	Northern Red Sae	36.75 (TL)	0.35	-0.4112

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دراسة تحديد عمر ونمو سمكة إبنيفليس فشياتس من شمال البحر الأحمر

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الملخص العربى

تعتبر دارسة العمر والنمو ذات أهمية كبيرة في إدارة موارد مصائد الأسماك. في هذه الدراسة تم تحديد العلاقة بين الطول والوزن للذكور والإناث (كلٌ على حدة) ولكلا الجنسين معاً لأسماك إبنيفليس فشياتس و قد اعتُمد الطول الإجمالي و الوزن الإجمالي كمعايير قياسية في هذه الدراسة وقد مُثلت النتائج في المعادلات التالية: للإناث (الوزن = 0.016الطول$^{2.9789}$ R^2=0.9679) و الذكور (الوزن =0.0082 الطول$^{3.1707}$ R^2=0.9158) و كلا الجنسين معا (الوزن = 0.0132الطول$^{3.0378}$ R^2=0.9685). دلت الدراسة الإحصائية على وجود فروقات هامة بين قيمه (b) لكل من الذكور والإناث (كلٌ على حدة) و كلا الجنسين معاً لأسماك إبنيفليس فاشياتس حيث أظهر مقياس النمو للذكور تفاوتاً ايجابياً بينما كان متساوياً لدى الذكور و لكلا الجنسين معا. تم حساب معامل الحالة "K_C" و معامل الحالة النسبي"K_n" على مدار الشهور والأحجام المختلفة للذكور والإناث (كلٌ على حدة) ولكلا الجنسين معاً. ولوحظ أن معامل الحالة النسبي للإناث عادة ما يكون أعلى من الذكور. وبلغ متوسط مجموع "K_C" لكلا الجنسين 1.428 (SE ± 0.4134) هذه القيمة تعبّر عن حالة بيئة جيدة بالنسبة لأسماك إبنيفليس فاشياتس. لوحظ أن قيمة كل من "K_C" و"K_n" تزداد بزيادة الحجم و ذلك حتى حجم 31.4 سم، ثم تنخفض في الأحجام الأكبر. من ناحية أخرى سُجل عاملا الحالة بقيم متفاوتة على مدار الشهور، ولكن أقل قيمة سجلت كانت خلال شهر أغسطس أثناء موسم التزاوج. نتيجة لعدم إمكانية تحديد العمر عن طريق قراءة الحلقات العمرية المتواجدة على القشور لهذا النوع. تم الاستعاضة عنها باستخدام طريقة الحسابات التراجعية. وفقا لطريقة باتشريا (1967) المتوفرة ببرنامج FISAT، و أسفرت الدراسة عن تحديد ثمانية مجموعات عمرية لأسماك إبنيفليس فاشياتس، حيث كان الطول في نهاية كل سنة من الحياة كالآتي: 18.28، 20.98، 23.2، 25.96، 28.51، 30.77، 32.79 و 34.93 سم. للفئات العمرية I، II،III،IV،V،VI،VIIو VII سنوات على التوالي لكلا الجنسين معاً. وقد تم استخدام طريقه فورد (1933) والفورد (1946) لتحديد معدل أقصى طول نظري و($L\infty$= 36.75 cm)، و أقصى وزن نظري ($W\infty$= 750.7 gm) وقيمة معامل النمو (K = 0.35) وحساب العمر عندما كان الطول نظرياً يساوى صفر.(t_0= -0.41121). سُجل أعلى معدل للنمو في أسماك إبنيفليس فاشياتس في السنة الأولى بحوالي 14.32 سم. وبعد ذلك بدأ النمو في التباطؤ إلى الحد الذي اقترب فيه أحياناً من الثبات.