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ORIGINAL ARTICLE

Growth and stock assessment of three species of the family Carangidae from the Red Sea, Hurghada, Egypt

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Abstract
This study highlighted the Stock assessment of three Carangid species *Carangoides ferdau*, *Carangoides malabaricus* and *Gnathanodon speciosus* from the Hurghada, Red Sea, Egypt. A total sample of 192 specimens (125-542mm SL) of *C. ferdau,* 279 specimens of *C. malabaricus* (145-460mm SL), 193 specimens of *G. speciosus* (110-503mm SL) investigated items included the length- weight relationships, condition factor, growth and mortality, exploitation ratios, and annual recruitment patterns. The results showed that the correlation of total length and standard length is best described by linear regression, while the length-weight analyses showed best described by the power function equations for three species. The weight of the fish increased as the fish length increased for *C. ferdau*, *C. malabaricus* and *G. speciosus* giving the best correlation coefficient (R=0.98) for the third one. The variations of condition factors (Kc and Kn) according to length groups and the monthly variations seemed to be weak. The age composition as estimated from otolith readings. It was noticed that *C. ferdau* and *G. speciosus* attained 9 age groups from I to IX years old, while the age composition of *C. malabaricus*, was 7 age groups from 0 to VII years old. The most dominant age group in the catch was the second age group for *C. malabaricus* and *G. speciosus* forming 26.91%, 20.96% respectively of the total catch. While in C. *ferdau* most dominant age group in the catch was the third (III) age group forming 36.26% of the total catch. The growth parameters were estimated as L∞= 747.13, 676.42, 525.2mm SL, K=0.12, 0.13, 0.18 and to=-0.82, -1.00, -1.08 years for *C. ferdau, C. malabaricus* and *G. speciosus*, respectively. The estimated growth performance index (Ø) was 2.91, 2.93, 3.23 for three species respectively. Total mortality (Z) was calculated as 2.09, 2.13 and 2.21 year-1 respectively. Natural mortality (M) was estimated as average 0.405, 0.465 and 0.460 year-1 respectively. The Exploitation ratio of the three species exceeded the optimum exploitation (E=0.5), indicating that overfishing is occurring. From the maturity observation, the spawning season extended from June to September with a peak in July for *C. ferdau* and *G. speciosus* while for *C. malabricus*, the spawning season started in May to September with a peak in August. This study recommends the reduction of the fishing efforts considering the length at sexual maturity doesn't exceed the length at first capture.

Keywords: Fish growth, stock assessment, Carangidae, Red Sea, Egypt

INTRODUCTION

Fisheries play an important role in development, food security, and providing incomes to the nations and their people, directly for food support or indirectly in other applications, worldwide. Fish is highly nutritious and a valuable supplement in diets lacking essential proteins, vitamins and minerals. The main threat facing fisheries as a food resource is ineffective management with poor conservation of habitats. To enhance the contribution of fisheries to food and livelihood security, a transition towards more people-centered governance approaches is needed. The involvement of the public, civil society and private sector is required to develop incentives for sustainable ecosystem management and to ensure that the role of fisheries in reaching global food production is taken into account. Fisheries statistics, biological data and population dynamics studies are a basis for assessing the fishery resources and can provide the appropriate scientific advice for sustainable exploitation (Mohammad 2016; Farrag 2016; Mehanna 2018).

The Carangidae are a large family of open-water carnivorous fishes, with about 32 genera and approximately 140 species in the world's oceans. Being well represented in all tropical and subtropical seas, they are important as food fish, and the larger species are highly regarded by anglers (Randall et al. 1997; Smith-Vaniz 2003; Nelson 2006). The Red Sea is one of the most important fishing grounds in Egypt. The important fish families among the Red Sea fisheries, Carangidae or Jacks (Mohammad 2016), form 4.09% of Red Sea catch (GAFRD 2018).

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The relationship between body length and weight of fish presents great importance in fisheries biology and population dynamics, where many stock assessment models require the use of length-weight parameters (Richter et al. 2000, Ndimele et al. 2010; Farrag 2014). Knowledge of length-weight relationships is useful for predicting weight from length values, condition of fish, stock assessment, and biomass estimation (Bolger et al. 1989; Valset et al. 2008; Mouludi-Saleh & Keivany 2018; Mouludi-Saleh et al. 2022). In addition, they are used in growth pattern or age determination and fishery assessment (Stevenson et al. 2006), applicable in population dynamics and aquatics ecology science. Also, length-weight data are useful for fishery biologists to monitor the state of health of a population (Paul et al. 1993). The condition factor compares a fish's well-being and is based on the hypothesis that heavier fish of a given length are in better condition (Bagenal & Tesch 1978). The present study aims to provide information regarding the length-weight relationship, condition factor (Kn), and population parameters to evaluate the current status of three species of family Carangidae viz. *Carangoides ferdau, C. malabaricus and Gnathanodon speciosus* from the hurghada, Red Sea Egypt by proposing some reference points for its sustainability.

MATERIALS AND METHODS

Study area and sampling: Specimens were randomly collected from the commercial catch of the artisanal fishery landed in the southern Red Sea at Hurghada fishing port, which is located at latitudes 26°55'N-27°30'N and longitudes 33°58'E-33°35'E (Fig. 1). The sampling procedure was done each month during the period from December 2018 to November 2019.

A total 192 specimens of *C. ferdau, C. malabaricus* (No. 279) and 193 specimens of *G. speciosus* were collected from the artisanal fleet working in this area. Total length (TL) and standard length (SL) were measured to the nearest mm, total body weight (W) to the nearest 0.01g, and the otoliths were removed from the fish (Figs. 2 and 3). Length-length (L-L) and Length-weight relationship is considered throughout

Fig.1. Map of the Red Sea showing the study area at Hurghada, Red Sea, Egypt.

the whole period of investigation, were described by the linear regression analysis of TL= a + b×SL, TL= a + b×FL and FL= a + b×SL (mm). The length-weight relationships are described by the power function equation of $W = a\ SL^b$ (Hile 1936; Le Cren 1951) and its logarithmic form of Log W = log a + b×Log SL/TL. Condition factor measures the well-being of fish, was calculated from the following equations as proposed by Bagenal & Tesch (1978).

$$Kc = (W \times 100) / SL^b$$

Where: W= fish weight in g., SL= standard length in mm and b is the exponent of the power function equation or b= 3. The relative condition factor (Kn) Le Cren (1951) is calculated with the formula: Kn= W/W', where: W is observed weight, and W' is calculated weight derived from length weight relations. The age composition was estimated from otolith readings for the *C. ferdau, C. malabaricus* and *G. speciosus.*

Population parameters different method: The length at different ages was bback-calculated based on Lee (1920). Growth parameters were estimated by fitting Ford (1933) and Walford (1946) plot and by using the Von Bertalanffy Growth function, 1938 fitted in FISAT II. According to VBGF, individual fishes grow on average towards the asymptotic length at an

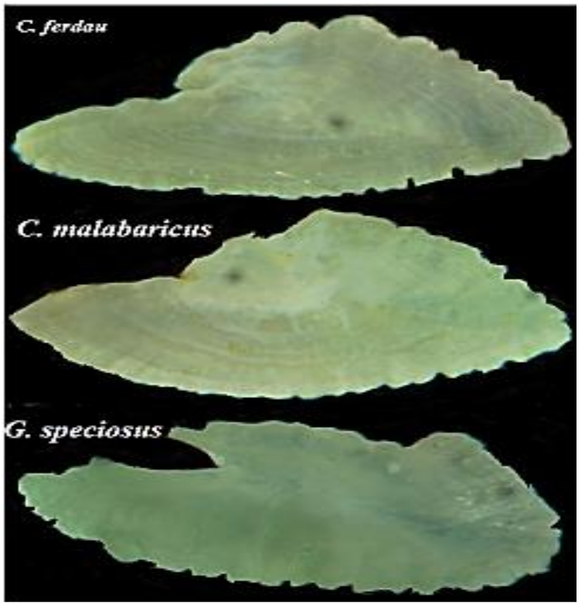

Fig.2. Sagittal otoliths of the three Carangid species.

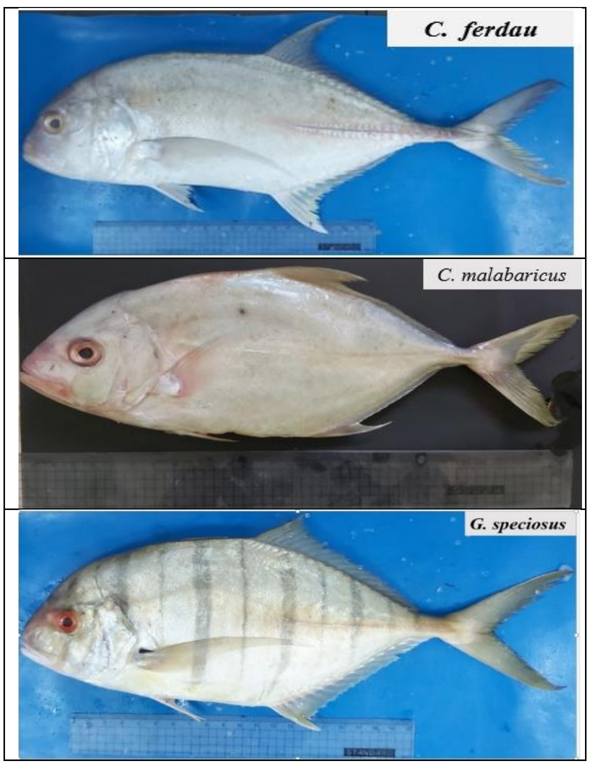

Fig.3. Photographs illustrating the external features of *C. ferdau, C. malabaricus* and *G. speciosus* from the Hurghada, Red Sea, Egypt.

instantaneous growth rate K with length at time t following the expression:

$$L_t=L_\infty*1-\exp-k\ (t-to)$$

Where L_t is the total fish length at age t, L_∞ is the asymptotic length, k is the growth coefficient and to is the hypothetical age at zero length and was estimated by employing the equation of Pauly (1980): Log (-to)=-0.3922-0.2752LogL_∞-1.038LogK.

The longevity T_{max} was estimated as T_{max}=3/K+ to (Beverton 1992). The mean asymptotic length, growth coefficient and age at length zero were estimated to the following calculation. The overall growth performance index for *G.speciosus* was calculated using the formula of Pauly & Munro, (1984) Ø=Log10K+2LogL_∞.

The total mortality coefficient (Z) was estimated as the average of two different methods; linearized catch curve method of Pauly (1983b) and Hoenig's model (1982). While the natural mortality coefficient (M) was calculated as the geometric mean of three different methods; Ursin (1967), Rikhter & Efanov (1976) and Pauly (1980). Accordingly, the fishing mortality coefficient (F) was estimated as F= Z – M. The exploitation ratio (E) was estimated using the formula of Gulland (1971) as E = F /Z.

The length at first capture L_c was estimated by the analysis of catch curve using the method of Pauly (1984), while the length at first sexual maturity Lm was estimated using the empirical formula Log Lm= 0.8979 Log L_∞ - 0.0782 (Froese & Binohlan 2000). The length at first sexual maturity (Lm); the length at which 50% of Carangid reach their sexual maturity was estimated by fitting the percentage maturity against mid lengths. Lm was estimated as the point on X-axis corresponding to 50% point on Y-axis, while the corresponding age at first sexual maturity (Tm) was computed by converting Lm to age using the von Bertalanffy growth equation as follows:

$$T_m = t0 - (1/k * \ln [1- (Lm/L_\infty)])$$

RESULTS

The present collected samples were measured as 125-542mm SL of *C. ferdau, C. malabaricus* (145-460mm SL), and *G. speciosus* (110-503mm SL). The linear regression analysis of the length-Length data allowed the estimation of the constants, a and b of the length–weight relationship. Table 1 and Figure 4 explained by the equations provided a good fit to length and weight data for species. The growth in weight relative to fish size in both species is isometric i.e. b is not statistically

Table 1. Different length Relationship of *C. ferdau*, *C. malabaricus* and *G. speciosus*, from the Hurghada Red Sea, Egypt, and their constants (a, b, R) (SL: Mean Standard Length; Wt: mean body Weight in g).

(L-L)	*C. ferdau*			*C. malabaricus*			*G. speciosus*		
	a	b	R	a	b	R	a	b	R
TL-SL	1.079	-0.306	0.99	1.073	-0.290	0.99	1.050	-0.239	0.99
TL-FL	1.025	-0.12	0.99	1.019	-1.06	0.99	1.028	-0.133	0.99
FL-SL	1.049	-0.169	0.99	1.048	-0.169	0.99	1.021	-0.103	0.99

(SL-Wt)	Min SL (mm)	Max SL (mm)	Min-Max. (Wt in g)	a	b	R
C. ferdau	125	542	599.22-2800.4	0.0007	2.4005	0.95
C. malabaricus	145	460	104.55-1808.9	0.0007	2.4251	0.97
G. speciosus	110	503	39.14-2680.4	0.0002	2.639	0.98

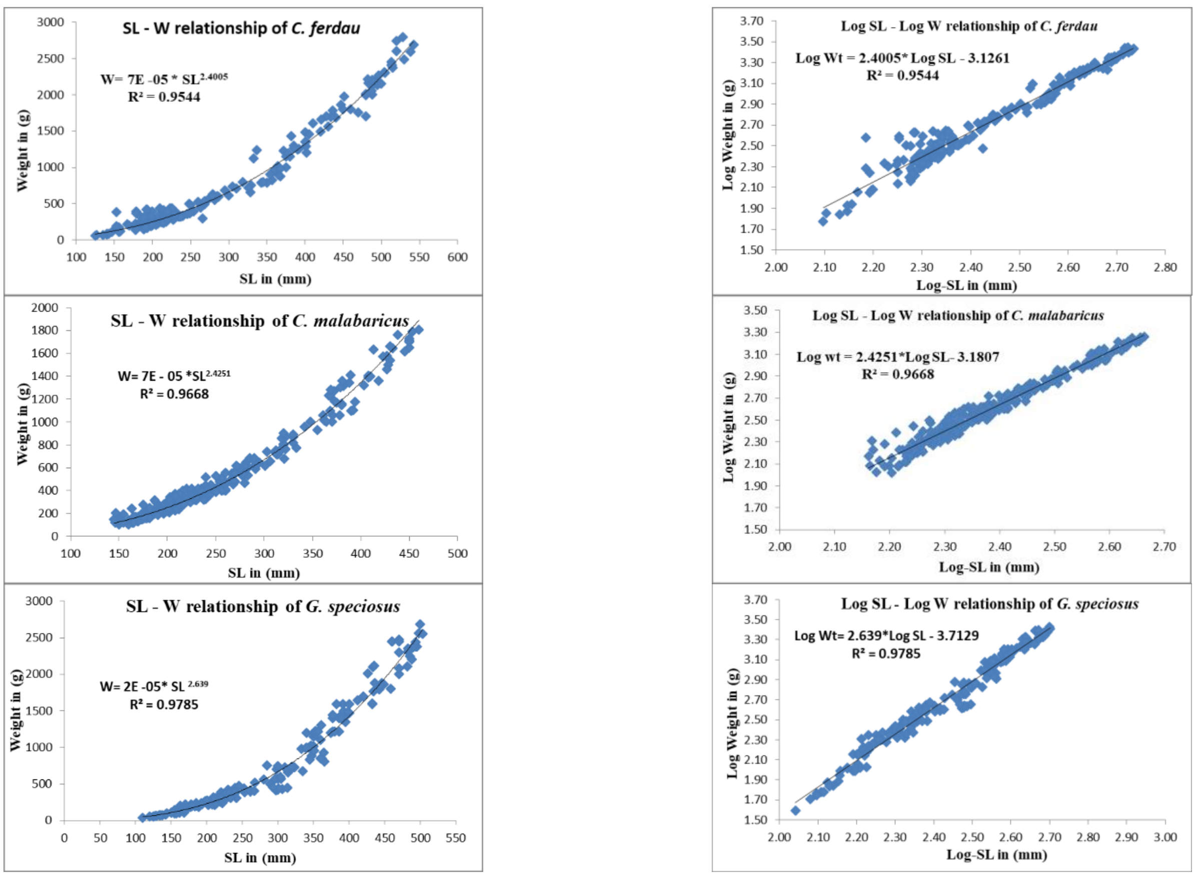

Fig.4. Standard length (SL)–weight relationship and its logarithmic form for *C. ferdau*, *C. malabaricus* and *G. speciosus* from the Hurghada, Red Sea, Egypt.

significant differs from 3. The Length-Length (L-L) relationship through the whole period of investigation were described by the linear regression equations analysis for the three Carangid species Table. 1.

Condition factor: The variations in Kc and Kn according to length groups and the monthly variations in the condition factors seemed to be weak, the condition factor was found to be size-free for the three species studied, (Figs. 5 and 6), Accordingly, the highest value of Kc was recorded in February, January and December for *C. ferdau*, *C. malabaricus* and *G. speciosus*, respectively. While the highest value of Kn was recorded in January, April and March for *C. ferdau*, *C. malabaricus* and *G. speciosus*, respectively.

Age composition: The age composition as estimated from otolith readings, given in Figure 7. It was noticed that *C. ferdau* and *G. speciosus* attained 9 age groups from I to IX years old, while the age composition of *C. malabaricus*, was 7 age groups from 0 to VII years old. The most dominant age group in the catch was the second age group for *C. malabaricus* and *G. speciosus*

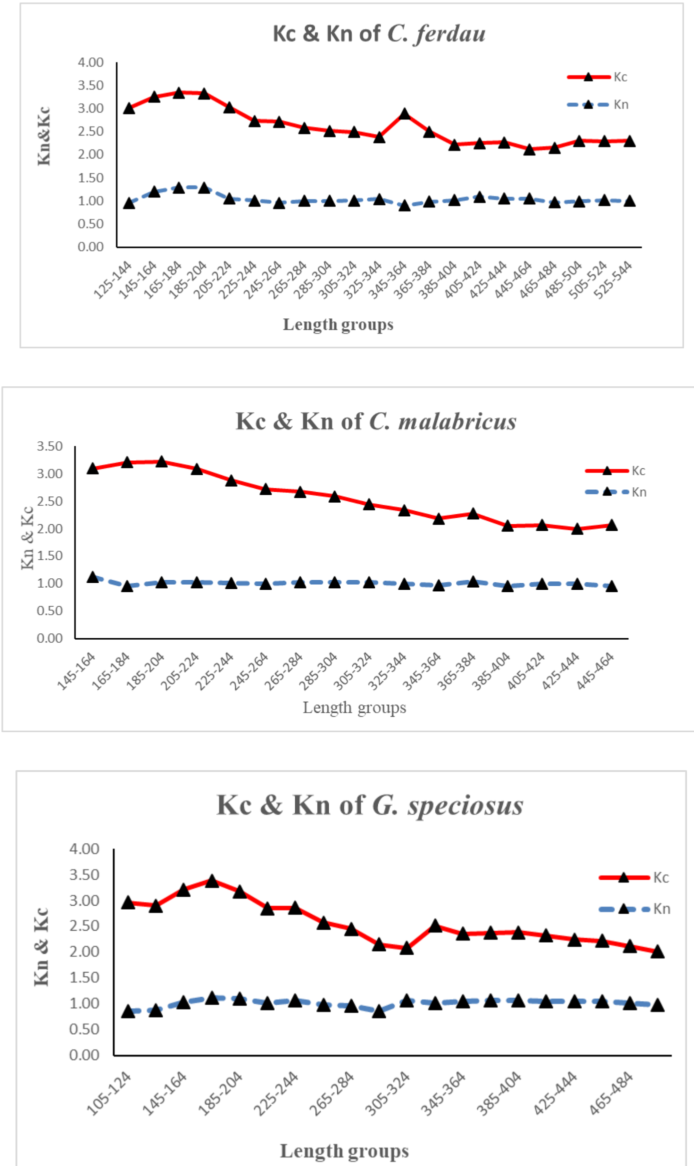

Fig.5. Conditions factor (Kc & Kn) of *C. ferdau*, *C. malabaricus* and *G. speciosus* based on length variations

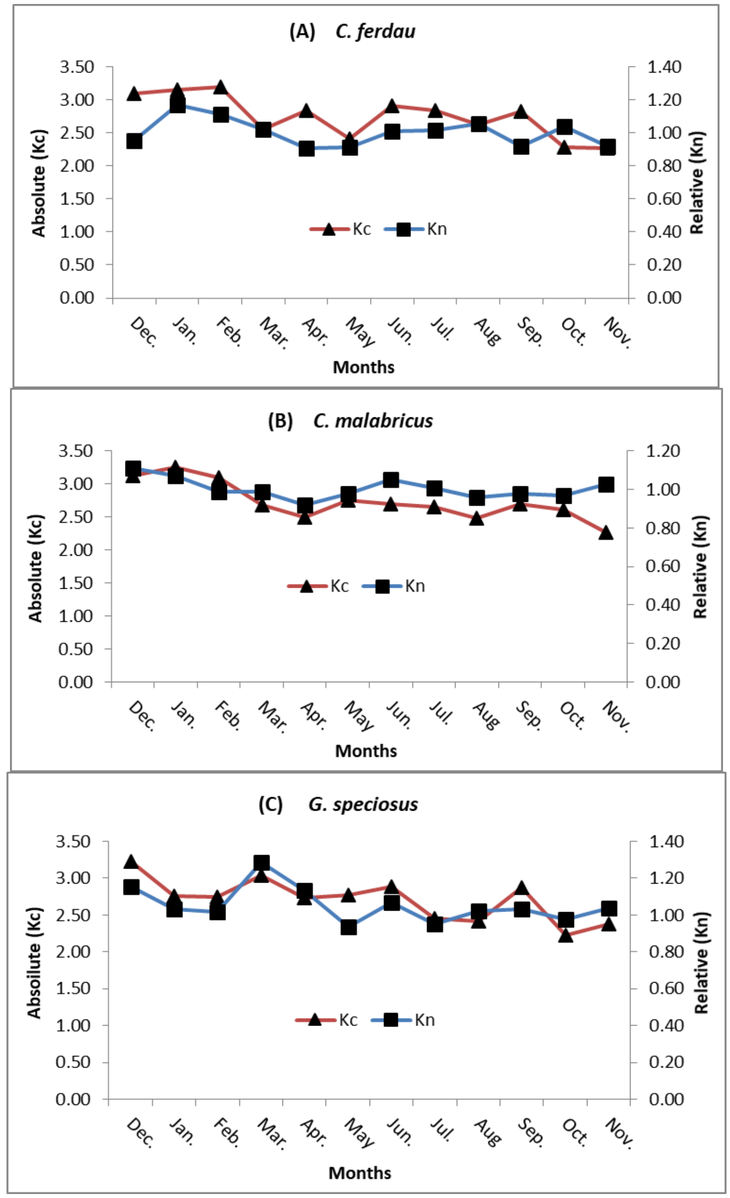

Fig.6. Monthly variations in condition factors (Kc & Kn) of (A *C. ferdau*, (B) *C. malabaricus* and (C) *G. speciosus*

forming 26.91%, 20.96% respectively of the total catch. While in C*. ferdau* most dominant age group in the catch was the third (III) age group forming 36.26% of the total catch.

Theoretical growth in length and Weight: The theoretical growth in length and Weight estimated by applying the von Bertalanffy growth equation for *C. ferdau, C. malabaricus* and *G. speciosus* is shown in Tables 2, 3 and Figure 8. In all age groups the mean back calculated lengths to some extent, confirm with the corresponding observed ones. From the result, we can show that there are close agreements between the estimated and calculated values.

Growth models and population structures

The Von Bertalanffy Growth Model: Table 5 demonstrated the values of the constants of the von Bertalanffy growth model, estimated for *C. ferdau, C. malabaricus* and *G. speciosus* while (Fig. 9) represented the plot of these methods for *C. ferdau, C. malabaricus* and *G. speciosus* (Table 4).

As the growth parameters are nearly the same from the three methods, the values obtained from Ford-Walford plot were used for subsequent analysis.

Growth performance index (Ø'): The values obtained

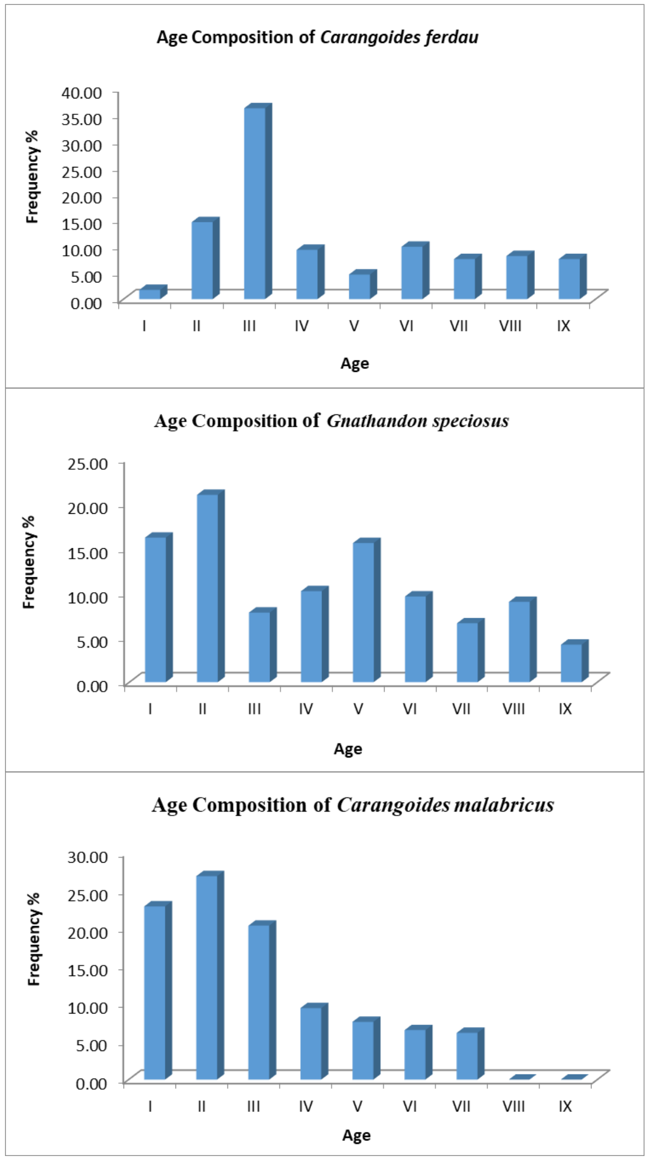

Fig.7. Species variations in age composition of *C. ferdau*, *C. malabaricus* and *G. speciosus* from Hurghada, Red Sea, Egypt.

for the computed growth performance index (Ø') for *C. ferdau, C. malabaricus* and *G. speciosus* were 2.91, 2.93 and 3.23, respectively.

Length (Lc) and age (Tc) at first capture: According to the resultant curve derived from catch curve, the estimated Lc was 154.33, 160.05 and 165.34mm SL for *C. ferdau, C. malabaricus* and *G. speciosus*, respectively, these lengths were corresponding to ages Tc of 0.90, 0.92 and 1.3 year, for *C. ferdau, C. malabaricus* and *G. speciosus*, respectively.

Length (Lr) and age (Tr) at recruitment:

The length at recruitment (Lr), which refers to the smallest fish in the catch, was 135,145 and 219.8 for both of *C. ferdau, C. malabaricus and G. speciosus, respectively*. The corresponding age at recruitment (Tr) was 0.571, 0.669 and 0.139 year for *C. ferdau, C. malabaricus* and *G. speciosus*, respectively.

Total Mortality Coefficient (Z) estimated from Jones and Van Zalinge (1981) and the length converted catch curve of Pauly (1983) are shown in Table 5. The obtained values from these methods were very close for both species. The mean total mortality was 1.86 for *C. ferdau* and 2 for *C. malabaricus* and *G. speciosus*, from results, it is clear that the total mortality rate of *C. ferdau* is higher than that of *C. malabaricus* and *G. speciosus.*

Natural mortality coefficient (M): The values of natural mortality coefficients for *C. ferdau, C. malabaricus* and *G. speciosus* estimated from three different methods are given in Table 6. The values

Table 2. Theoretical growth in length of *C. ferdau, C. malabaricus* and *G. speciosus*, from Hurghada Red Sea of Egypt.

Age	*C. ferdau*			*C. malabaricus*			*G. speciosus*		
	Back-calc.	Theoretical Length	Increment	Back-calc.	Theoretical Length	Increment	Back-calc.	Theoretical Length	Increment
I	186.12	135.6	135.6	179.4	168.7	168.7	170.63	147.9	147.9
II	214.26	200.4	64.8	218.5	229.5	60.8	219.8	208.7	60.8
III	265.19	264.2	63.8	257.5	287.2	57.7	244.7	267.3	58.6
IV	304.13	322.4	58.2	299.7	340.4	53.2	298.8	313.3	46.0
V	355.74	372.4	50.0	347.8	387.9	47.5	341.4	351.5	38.2
VI	387.73	412.4	40.0	285.3	424.5	36.6	385.6	382.2	30.7
VII	434.21	454.6	42.2	436.2	451.2	26.7	422.7	405.4	23.2
VIII	482.23	487.6	33.0	--	--	--	478.1	425.8	20.4
IX	517.69	512.5	24.9	--	--	--	479.7	441.3	15.5

Table 3. Theoretical growth in weight of *C. ferdau, C. malabaricus* and *G. speciosus*, from Hurghada Red Sea of Egypt.

Age	*C. ferdau*			*C. malabaricus*			*G. speciosus*		
	Back-calc.	Theoretical Weight	Increment	Back-calc.	Theoretical Weight	Increment	Back-calc.	Theoretical Weight	Increment
I	186.12	127.8	127.8	179.4	180.9	180.9	170.63	108.2	108.2
II	214.26	277.8	150.0	218.5	311.3	130.4	219.8	243.4	135.2
III	265.19	462.8	185.0	257.5	486.9	175.6	244.7	405.8	162.4
IV	304.13	732.9	270.1	299.7	772.3	285.4	298.8	606.3	200.5
V	355.74	1002.6	269.7	347.8	1118.5	346.2	341.4	847	240.7
VI	387.73	1342.2	339.6	285.3	1588.6	470.1	385.6	1132.3	285.3
VII	434.21	1682.8	340.6	436.2	1942.1	353.5	422.7	1452.9	320.6
VIII	482.23	1982.6	299.8	--	--	--	478.1	1718.8	265.9
IX	517.69	2240.1	257.5	--	--	--	479.7	1939.1	220.4

Table 4. Growth parameters of *C. ferdau, C. malabaricus and G. speciosus*, from the Hurghada, Red Sea, Egypt.

Growth Model	Ford- Walford		Chapman		Gulland	
Parameter	$L\infty$	K	$L\infty$	K	$L\infty$	K
C. ferdau	747.13	0.12	743.91	0.19	745.43	0.12
C. malabaricus	676.42	0.13	670.84	0.12	673.42	0.13
G. speciosus	525.2	0.18	524.24	0.15	524.68	0.19

were 0.125, 0.333 and 0.65 for *C. ferdau*, 0.205, 0.428 and 0.763 for *C. malabaricus* and 0.289, 0.333 and 0.763 for *G. speciosus* so the natural mortality of *G. speciosus* is higher than from *C. ferdau, C. malabaricus,* the mean values of natural mortality were 0.405, 0.465 and 0.460 for *C. ferdau, C. malabaricus* and *G. speciosus*, respectively.

Fishing mortality coefficient (F): So the fishing mortality of *C. ferdau* is higher than that of *C. malabaricus* and *G. speciosus* and the values of F were high for both species indicating the high level of exploitation.

Exploitation Rate the exploitation level is very high and exceed the optimum one (E= 0.5) for *C. ferdau, C. malabaricus* and *G. speciosus.*

Length (Lm) and age (Tm) at first maturity: Based on the maturation curve (Fig. 9), the estimation of L_m was 305mm for sexes combined *C. ferdau*, which corresponding to age 3.55, years, while for the *C. malabaricus* was165mm with age 1.15 years. In the case of *G. speciosus* was 285mm for combined sexes, which length corresponding to the age of 3.33 years (Table 7).

These provided that the spawning season extended from June to September with a peak in July for *C. ferdau* and *G. speciosus* while, the spawning season started in May to September for *C. malabaricus* with a peak in August.

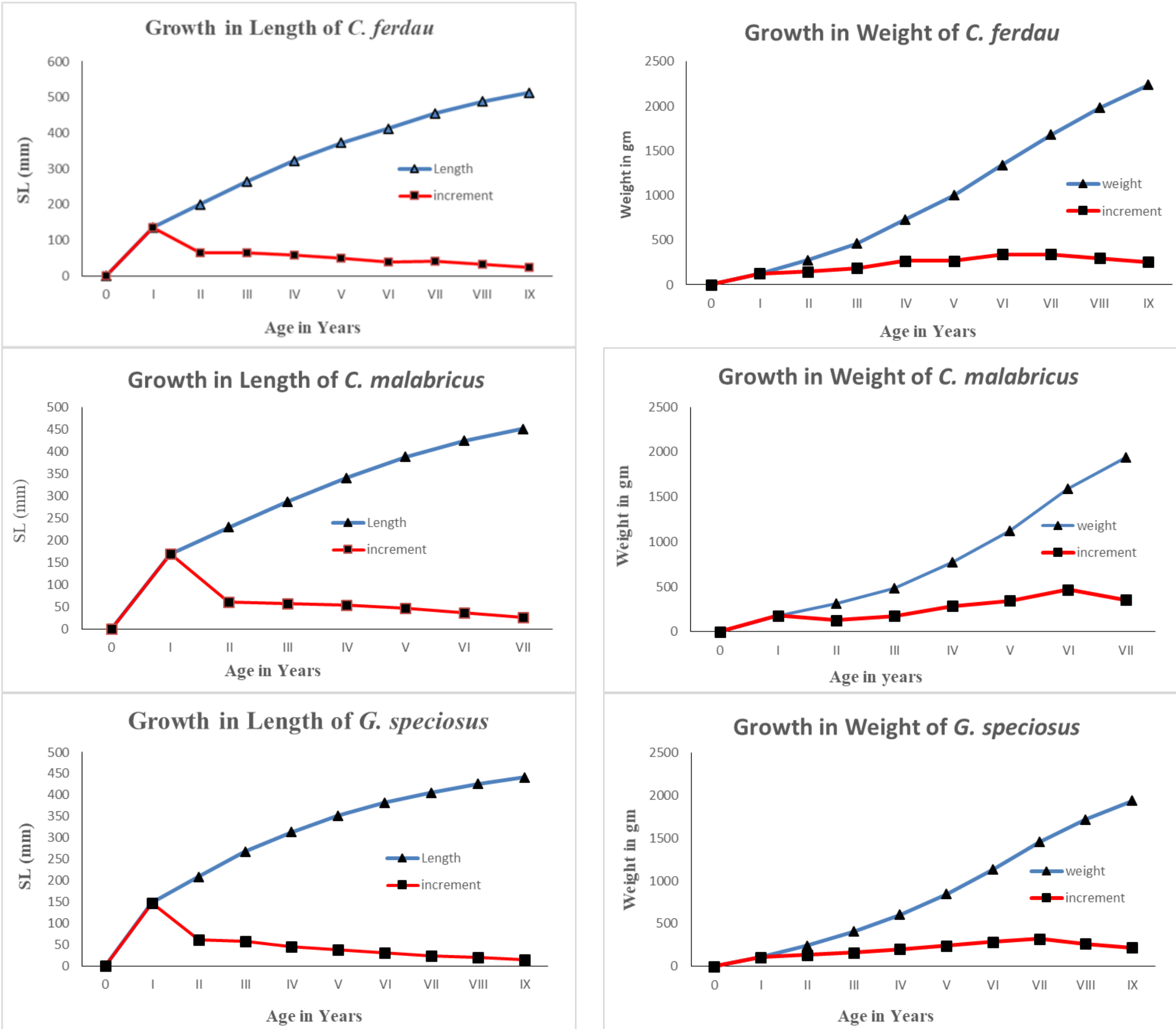

Fig.8. The theoretical growth in length (mm) and weight (g) and annual increment of *C. ferdau, C. malabaricus* and *G. speciosus*, from Hurghada Red Sea of Egypt.

Table 5. Total mortality coefficients for *C. ferdau, C. malabaricus* and *G. speciosus.*

Species/ Method	Jones –Van Zalinge	Length- converted catch curve	Mean
C. ferdau	3.51	0.68	2.09
C. malabaricus	3.546	0.71	2.128
G. speciosus	1.75	2.66	2.205

DISCUSSION

Egyptian fisheries are under pressure at the moment as all commercially important fish stocks are declining. At the same time, the management and regulation of the fisheries become more complicated every year. In fisheries management, the reliability of scientific advice is highly dependent on the quantity and quality of data that are available for stock assessment.

Marine fisheries management is a complex process required to studying fisheries biology and stock assessment. The purpose of this study was to explain the fisheries biology, stock assessment and fisheries management for three Carangid species. This is important for fishermen and other stakeholders interested in fisheries management issues. In the light of this issue, the all biological and dynamical parameters of three species of Family Carangidae from the Red Sea, Hurghada, Egypt, were estimated to

Table 6. The natural mortality coefficient for *C. ferdau, C. malabaricus* and *G. speciosus*.

Method Species	Pauly (1980)	Taylor1960	Rikhter and Efanov	Mean
C. ferdau	0.125	0.33	0.65	0.405
C. malabaricus	0.205	0.428	0.763	0.465
G. speciosus	0.289	0.333	0.763	0.460

Table 7. Population parameters of the *C. ferdau, C. malabaricus* and *G. speciosus* from Hurghada, Red Sea, Egypt.

Parameters	*C. ferdau*	*C. malabaricus*	*G. speciosus*
L_{max}	542	460	503
$L\infty$	747.13	676.42	525.2
K	0.12	0.13	0.18
t_o	-0.82	-1.00	-1.01
L_r	125	145	110
T_r	0.84	0.86	0.37
T	2	2	2
L_t	214.26	218.51	219.8
W_t	275.75	330.04	304.3
$W\infty$	5529.5	5112.77	3019.72
a(mm)	0.0007	0.0007	0.0002
a(cm)	0.1881	0.1755	0.0844
b	2.4005	2.4251	2.639
L_{25}	447.36	145.05	146.84
$L_{50}(L_c)$	154.33	160.05	165.34
L_{75}	583.46	177.53	183.67
T_c	1.11	1.08	1.3
L_m	305	165	285
t_{max}	9	7	9
M	0.405	0.465	0.460
E	0.815	0.650	0.791
Ø	2.91	3.05	3.23
F	2.86	1.663	1.745
A	0.625	0.912	0.722
Z	3.51	3.546	2.205

assess its current status and to suggest some precautionary reference points for its sustainability.

Over a wide range of length-length and length-weight relationship of fishes may be described by (Osman 2000; Obady 2003; Basmidi 2004, Mohammad 2007; Hossain et al. 2009; Freire et al. 2009; Daliri et al. 2012; Alam et al. 2013; Al-Rasady et al 2013; Farrag 2014; Guo, et al. 2014; Osman 2018). In the presents study, the growth in weight of Carangid species relative to length was best described by the power function equation. Such growth was isometric in the three Carangid species under investigation. For applied ichthyological studies, 'b' seems to be important as a key parameter in estimating population growth through length-weight relationship (Kimmerer et al. 2005; Simon & Mazlan 2008; Farrag 2014, Mohammad 2016; Osman, 2018).

The results of the present work on *C. ferdau, C. malabaricus* and *G. speciosus* were compared with other results for the same species and same family collected from different localities (Table 8). The present results indicated that, the value of the exponent "b" 2.4005, 2.4251 and 2.639 for *C. ferdau, C. malabaricus* and *G. speciosus* respectively. This mode of growth was nearly the same as those recorded by (Grandcourt et al. 2004; Farrag et al. 2019) for *Gnathanodon speciosus* estimates the b value of length-weight relationship as 2.867, 2.8613 respectively for an allometric pattern of growth.

Condition factor has been used as an indicator of health in fishing biology studies since the beginning of the 20 centuries, such as growth and feeding intensity (Froese, 2006). Condition factor was decrease with an increase in length (Mohammad 2016). The condition factor provides information on the variation of fish physiological status and may be

Table 8. Length weight relationship parameters for Family Carangid from different locations.

Species	SL mm	Wt (g)	A	b	Author
Carangoides ferdau	125-542	59.2-2800.4	0.0007	2.4005	Present study
Carangoides malabaricus	145-460	104.5-1808.9	0.0007	2.4251	Present study
G. speciosus	110-503	39.1-2680.4	0.0002	2.639	Present study
Gnathanodon speciosus	24.85-74.40	6000	0.0195	2.8613	Farrag et al. (2019) (Southern Arabian Gulf off The United Arab Emirates)
Carangoides bajad	145-515	87.2-3032.9	0.00005	2.8827	Mohammad (2016) (Southern Red Sea, Egypt)
Caranx melampygus	145-631	631-6009	0.00004	2.9333	Mohammad (2016) (Southern Red Sea, Egypt)

used for comparing populations living in certain feeding, climate and other conditions (Gomiero et al. 2008). Such factor may increase, decreases or shows no particular trend as supported by many authors; (Osman 2000; Obady 2003; Basmidi 2004; Froese 2006; Mohammad 2007; Kumolu-Johnson & Ndimele 2010; Šantić et al 2011; Alam et al. 2013; Farrag 2014; Osman 2018; Saber et al. 2020). In the present study, the condition factor of the three Carangid species showed no particular trend with the variation of fish size. The difference between present results and those of other authors may be attributed to the difference in the recorded maximum length and to the different environmental conditions, and the difference in the collection period. There are few studies were estimated the condition factors (absolute and relative) for the Carangid species.

Age determination is very important to evaluate fisheries stock and management, so the present study estimated the life span for three Carangid species by using sagittal otoliths from Hurghada, Red Sea, Egypt. Otolith reading is reliable and valid method for determining the age Carangid fishes (Metin & ILkyaz, 2008; Farrag et al. 2019; Mohammad et al. 2020).

The age composition as estimated from otolith readings revealed that *C. ferdau* and *G. speciosus* attained 9 age groups from I to IX years old, while the age composition of *C. malabaricus* was 7age groups from I to VII years old. The most dominant age group in the catch was the second age group for *C. malabaricus* and *G. speciosus* forming 26.91% and 20.96% of the total catch, respectively. While for *C. ferdau* was the third age group representing 36.26% of the total catch. In previous studies in other Carangid species, the most dominant age group was (II) of *C. bajad* and (III) of *Caranx melampygus* (Mohammad 2016). This difference may be due to different habitats, methods used and number of specimens.

The growth study of the three Carangid species (the present work) attained their highest growth rate in length during the first year of life then this increment sharply decreased by the end of the second year. Similar trends in length increment have been recorded on *Siganus* species (Obady, 2003), on *Lutjanus* species (Basmidi 2004), on *Lethrinus* species (Mekkawy et al. 2005), on *Epinepheline* species (Mohammad 2007) and on *Carangoides bajad* and *Caranx melampygus* (Mohammed 2016).

The annual increments in weight of some fishes decrease gradually with increase of age (Mekkawy 1990; Obady 2003; Basmidi 2004, Mohammed 2016). By contrast, in some other fishes, as age group increases, such increments generally increase (Ezzat et al. 1984; Yoakim et al. 1993; El-Okda 1998; Mekkawy et al. 2005). In the present study the annual increments in weight of the three Carangid species studied showed fluctuation with increase in fish age. Similar result was recorded in *Lutjanus* species (Basmidi 2004) and *Carangoides bajad* and *Caranx melampygus* (Mohammad 2007).

Population parameters: In the present study, Estimation of mathematical description of growth is

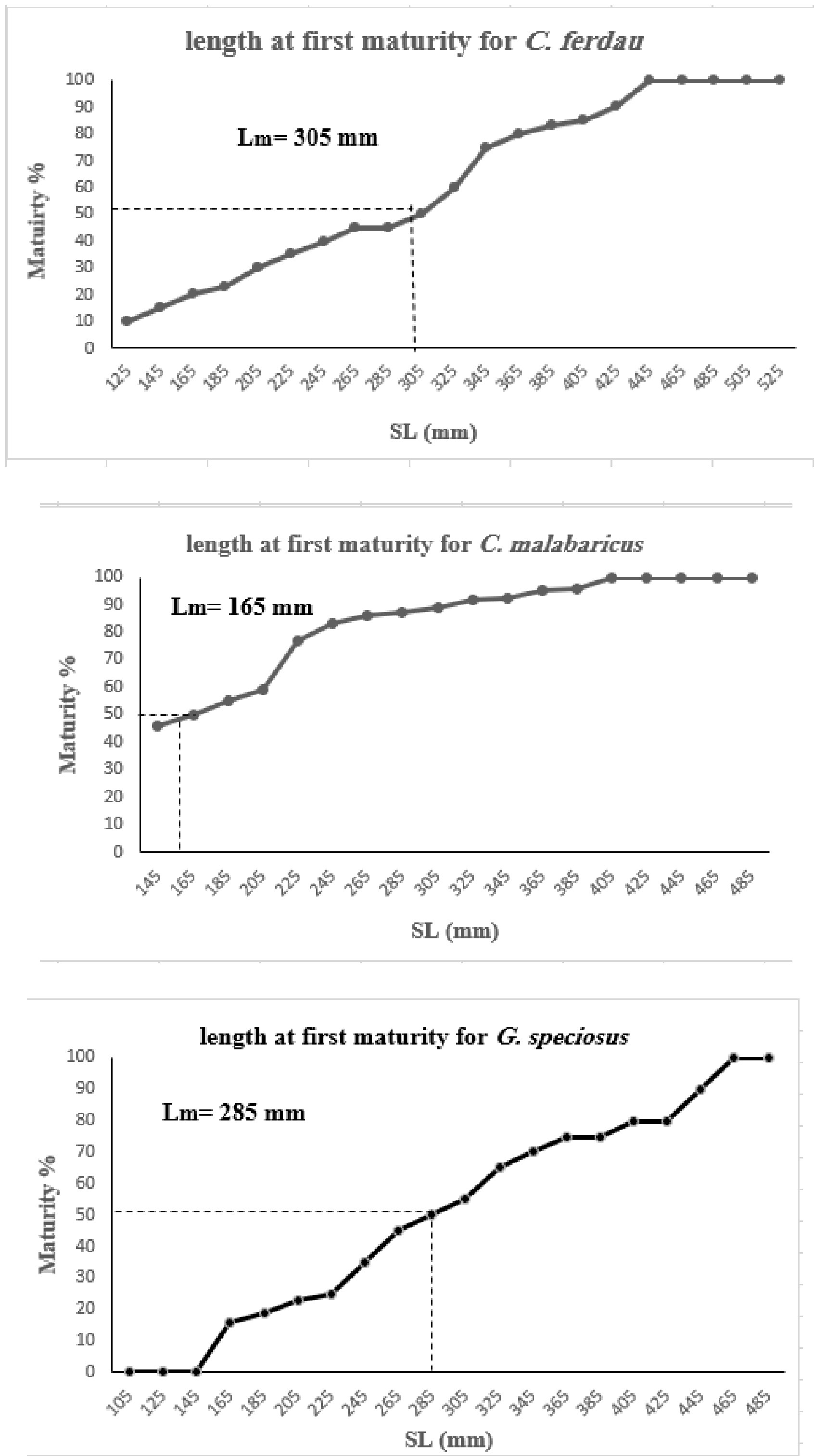

Fig.9. length at first maturity for *C. ferdau, C. malabaricus* and *G. speciosus*, from the Hurghada Red Sea, Egypt.

of a great importance in the field of fisheries management and fish stock assessment. The obtained growth population parameters (L_∞, K and t_0) are the basic input data into various models used for managing and accessing the status of the exploited stocks. Besides, it facilitates the comparison between growths of individuals belonging to different species or to the same species at different times and different localities the rate of exploitation was found to be relatively high with high total mortality for the three Carangid species studied. Such result was similar with that found in *Lutjanus* species (Basmidi 2004);

Table 9. Von Bertalanffy growth parameters (L_∞, K and t_0) of *C. ferdau*, *C. malabaricus* and *G. speciosus* of the present study and those of the previous studies.

Species	Author	L∞	K	t_0	Ø'	Region
Carangoides ferdau	Present study	747.13	0.12	-0.82	2.91	Red Sea, Egypt
Carangoides	Present study	676.42	0.13	-1.00	2.93	Red Sea, Egypt
Gnathanodon	Present study	525.2	0.18	-1.08	3.23	Red Sea, Egypt
Carangoides bajad	Mohamed (2016)	576.88	0.24	-0.86	2.91	Red Sea, Egypt
Caranx melampygus	Mohamed (2016)	701.08	0.17	-1.013	2.93	Red Sea, Egypt
Carangoides. bajad	Grandcourt et al. (2004)	40.38	0.59	-0.25	2.99	The Southern Arabian Gulf
Gnathanodon speciosus	Grandcourt et al. (2004)	72.33	0.51	-0.70	3.13	The Southern Arabian Gulf
Carangoides	Ahmad et al. (2003)	38.1	0.77	-0.2	2.86	Malaysia
Carangoides	Al-Rasady, et al. (2013)	73.3	0.3	-0.52	3.13	The Arabian Sea
Carangoides ferdau	Edwards et al. (1985)	93.1	0.21	-0.59	3.26	Gulf of Aden
Carangoides equula	Ahmad, et al. (2003)	30.5	0.4	-0.4	2.57	Malaysia

Table 10. Mortality parameters (Z, M, F and E) of *C. ferdau, C. malabaricus* and *G. speciosus* of the present study and those of the previous studies.

Species	Z	M	F	E	Author and Site
Gnathanodon speciosus	1.01	0.68	0.33	0.32	Farrag, et al. (2019) United Arab Emirates
Carangoides bajad	1.86	0.34	1.5	0.82	Mohammad (2016) Red Sea
melampygus Caranx	2	0.25	1.75	0.88	Mohammad (2016) Red Sea
Gnathanodon speciosus	1.834	0.896	0.94	--	Grandcourt et al. (2004) Coast of the Emirate of Abu-Dhabi
Carangoides ferdau	2.09	0.405	2.86	0.815	Present Study, Red Sea
Carangoides malabaricus	2.128	0.465	1.663	0.78	Present Study, Red Sea
Gnathanodon speciosus	2.205	0.460	1.745	0.791	Present Study, Red Sea

Epinepheline species (Mohammad 2007) and *Carangoides bajad, Caranx melampygus* (Mohammad 2016) in habiting the Red Sea. In contrast, it disagrees with that found in *Siganus species* (Shiekh-Eldin 1988; Obady 2003) inhabiting the Red Sea.

The growth Performance index (Ø) is used to compare the growth rate of fish species with other species (Pauly & Munro 1984). As reflected by the growth Performance Index (Ø') value, the pattern of growth varies with time and locality to different regions (Table 9). These variations may be attributed to the different techniques used in the age determination and the maximum recorded length in the different areas of study or difference may be due to variations in environmental conditions

In the present study, the length at recruitment (L_r) was represented by the smallest length in the catch, was 125, 145 and 110mm-SL for *C. ferdau, C. malabaricus* and *G. speciosus* respectively. These small lengths indicate an overfishing situation where they are caught before they grow large enough to contribute substantially to the stock biomass. Additionally, the estimated length at first capture (L_c) was 154.33, 160.05 and 165.34mm-SL for *C. ferdau, C. malabaricus* and *G. speciosus* respectively was found to be less than the estimated length at first sexual maturity (L_m) (322, 220 and 390mm-SL for *C. ferdau, C. malabaricus* and *G. speciosus* respectively which was further evidence of over-fishing that prevent them from spawning at least once before being fished.

The Mortality, Exploitation rates have their importance as population parameters used in estimating fish stock to date whether there in over fishing, since any population of species is maintained by the equilibrium between its birth and death rates (Soliman 2005; Farrag 2008; Mustafa 2015; Mohammad 2016; Osman 2018).

The total mortality is defined as the total number of fishes missed by death from a given population during a certain time interval. The total mortality can be distinguished into two components; the first is called the natural mortality coefficient (M) and the second is the fishing mortality coefficient (F). There are several methods for the estimation of the total mortality coefficient (Z). In the present study, the instantaneous total mortality coefficient (Z) for *C. ferdau, C. malabaricus* and *G. speciosus* where estimated by the analysis of catch curve, based on length composition (Pauly 1983). The estimated value of Z was 2.09, 2.128 and 2.205 year-1 respectively, for sexes combined represented the high value of *G. speciosus*. The values recorded by (Farrag et al. 2019), 1.01 /yr-1 was lower than the value of the present study for *G. speciosus* in United Arab Emirates. The revealed that favorable environmental conditions as well as high fishing effort prevailed in Hurghada Port, Red Sea. The natural mortality M of *C. ferdau, C. malabaricus* and *G. speciosus* calculated by empirical methods of pauly, Rikhter and Efanov and Hoeing's were average 0.405, 465 and 0,460 yr-1 respectively. Therefore, the computed instantaneous fishing mortality coefficient F was estimated as 2.86, 1.663 and 1.745 yr-1 respectively for *C. ferdau, C. malabaricus* and *G. speciosus*.

Total, natural and fishing mortalities were calculated according to (Grandcourt et al. 2004) as: 1.834, 0.896 and 0.94yr-1 respectively in the Coast of the Emirate of Abu-Dhabi for *G. speciosus*, and (Farrag *et al*., 2019) as: 1.834, 0.896 and 0.94 yr-1 respectively in the Coast of the Emirate of Abu-Dhabi for *G. speciosus*. While in habit Red Sea by (Mohammad 2016) for *Carangoides bajad* as: 1.86, 0.34 and 1.5 yr-1 respectively and *Caranx melampygus* as: 2, 0.25 and 1.75 yr-1 respectively (Table 10).

In Conclusion, the results of the present analysis revealed that the stock of carangid species in the Egyptian Red Sea appears to be overexploited since the current exploitation is higher optimum (0.5), where estimated the yield per- recruit at 0.81, 0.65 and 0.79 for M *C. ferdau*, *C. malabaricus* and *G. speciosus*, respectively, thus an exploitation reduction is necessary in order to avoid future loss in stock productivity and landings.

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مقاله کامل

ارزیابی رشد و ذخیره سه گونه از خانواده Carangidae از دریای سرخ، غورغاده، مصر

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چکیده: این مطالعه ارزیابی ذخایر سه گونه *Carangoides ferdau*، *Carangoides malabaricus* و *Gnathanodon speciosus* از غورغاده، دریای سرخ، مصر را نمایان کرد. ۱۹۲ نمونه از *C. ferdau* (۵۴۲-۱۲۵ میلی‌متر SL)، ۲۷۹ نمونه از *C. malabaricus* (۴۶۰-۱۴۵ میلی‌متر SL)، ۱۹۳ نمونه از *G. speciosus* (۵۰۳-۱۱۰ میلی‌متر SL) برای مواردی از جمله روابط طول و وزن شاخص وضعیت، رشد و مرگ و میر، نسبت‌های بهره‌برداری، و الگوهای بازگشت شیلاتی مورد بررسی قرار گرفتند. نتایج نشان داد که همبستگی طول کل و طول استاندارد به بهترین شکل با رگرسیون خطی توصیف می‌شود، در حالی‌که تحلیل‌های طول وزن بهترین توصیف را با معادلات تابع نمایی برای سه گونه نشان دادند. وزن ماهی با افزایش طول ماهی برای *C. ferdau*، *C. malabaricus* و *G. speciosus* افزایش یافت که بهترین ضریب همبستگی (R=۰/۹۸) را برای ماهی سوم نشان داد. تغییرات فاکتور وضعیت (Kc و Kn) براساس گروه‌های طولی و تغییرات ماهانه ضعیف به‌نظر می‌رسید. ترکیب سنی که از خوانش اتولیت تخمین زده می‌شود. مشاهده شد که *C. ferdau* و *G. speciosus* در ۹ گروه سنی از ۱ تا ۹ سال قرار گرفتند، در حالی که ترکیب سنی *C. malabaricus*، ۷ گروه سنی از ۰ تا ۷ سال بود. غالب‌ترین گروه سنی در صید، گروه سنی دوم برای *C. malabaricus* و *G. speciosus* بود که به‌ترتیب ۲۶/۹۱ و ۲۰/۹۶ درصد از کل صید را تشکیل می‌دادند. در حالی‌که در *C. ferdau* بیشترین گروه سنی در صید، گروه سنی سوم (III)۱ بود که ۳۶/۲۶ درصد از کل صید را تشکیل می‌داد. پارامترهای رشد به‌ترتیب L∞ ۷۴۷/۱۳، ۶۷۶/۴۲ و ۵۲۵/۲ میلی متر و مقادیر K نیز به‌ترتیب ۰/۱۲، ۰/۱۳ و ۰/۱۸ و مقادیر t0 نیز به ترتیب ۰/۸۲، ۱ و ۱/۰۸- سال برای *C. ferdau*، *C. malabaricus* و *G. speciosus* برآورد شد. شاخص عملکرد رشد تخمینی (Ø) برای سه گونه به‌ترتیب ۲/۹۱، ۲/۹۳ و ۳/۲۳ بود. کل مرگ و میر (Z) به‌ترتیب ۲/۰۹، ۲/۱۳ و ۲/۲۱ در سال محاسبه شد. میانگین مرگ و میر طبیعی (M) به‌ترتیب ۰/۴۰۵، ۰/۴۶۵ و ۰/۴۶ در سال برآورد شد. نسبت بهره‌برداری از سه گونه بیش از بهره‌برداری بهینه (E=۰/۵) است که نشان می‌دهد صید بی‌رویه در حال وقوع است. از مشاهدات بلوغ، فصل تخمریزی از ژوئن تا سپتامبر با یک اوج در ژوئیه برای *C. ferdau* و *G. speciosus* در حالی‌که برای *C. malabricus*، فصل تخمریزی در ماه می تا سپتامبر با اوج در اوت آغاز شد. این مطالعه کاهش تلاش‌های صیادی را با در نظر گرفتن طول در بلوغ جنسی از طول در اولین صید توصیه می‌کند.

کلمات‌کلیدی: رشد ماهی، ارزیابی ذخایر، Carangidae، دریای سرخ، مصر.