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Age and Growth Based on the Scale Readings of the Two Carangid Species *Carangoides bajad* and *Caranx melampygus* from Shalateen Fishing Area, Red Sea, Egypt

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ABSTRACT

The study of the age and growth of fish is fundamental for understanding the general biology of the species and in particular its population dynamics. The age and growth of two Carangid species *Carangoides bajad* and *Caranx melampygus* from the Egyptian Red Sea, Shalateen region (Elba National Park) were studied based on the scale readings using a non-linear back-calculation method. A total of 1103 specimens (145–515 mm in SL) of *C. bajad* and 795 specimens (145–631 mm in SL) of *C. melampygus* were aged and their maximum life span was 8 and 12 years, respectively. The most dominant age group in the catch was age groups II (45.36%) for *C. bajad*, and age group 0for *C. melampygus* (21.6%). The von Bertalanffy growth parameters were L∞ = 576.88 and 701.08 mm for *C. bajad* and *C. melampygus* respectively, while K = 0.24 and 0.17 $year^{-1}$ for the two species respectively. It was found that *C. melampygus* was heavier and characterized by a higher growth rate than *C. bajad* for the same length and age. These data are the inputs of the analytical models used to achieve the wise management of this potential fishery.

INTRODUCTION

The determination of age and growth is of great importance to both fisheries biology and management as it provides some information pertaining to the growth rate. In addition, it forms the basic knowledge required for the estimation of mortality, recruitment and yield. Also, these parameters constitute the basic information needed for the construction of a management strategy for any exploited stock **(Mehanna, 1996)**. For age Determination in fishes, age can be estimated directly by the examination and interpretation of annuli which are found on the different hard structures such as scales, otoliths, vertebrae, spines, opercula, etc. The age can also be estimated indirectly by the analysis of length frequency data using one of many available standard statistical methods such as **(Peterson, 1892; Harding, 1949; Cassie, 1954; Tanaka, 1962; Bhattacharya, 1967** and **Pauly, 1983)**.

The family *Carangidae* comprises four subfamilies with 32 genera and 148 species in the world oceans. The members of this family are commonly known as horse mackerels, trevallies, yellowtails, queenfishes, jacks, scads and pompanos. It is a large family, which includes many important commercial species worldwide and often supports important fisheries **(Nelson, 1994; Randall, 1995; Al-Marzouqi *et al*., 2013** and **Mehanna *et al*., 2013)**.

In the Egyptian sector of the Red Sea, Shalateen fishing area, at least 10 Carangid species were recorded from which *Carangoides bajad* and *Caranx melampygus* are the most common. *C. bajad* and *C. melampygus* represent an important component of local artisanal catch. Despite of the economic importance of carangids, there are little studies dealing with their biology and population dynamics in the Egyptian Red Sea. The present study is aimed to provide growth data of the common carangid species (*Carangoides bajad* and *Caranx melampygus*) in the Egyptian Red Sea sector at Shalateen fishing area, which could serve as a guide for their future management.

MATERIALS AND METHODS

1. Study area:

In the southern Red Sea, Shalateen fishing port lies at 520 Km south of Hurghada, Egypt **(Fig.1)**. The fishing landing site location latitude (N: 23° 09' 07.31") and longitude (E: 35° 36' 51.14"). Shalateen port is considered as one of the productive fishing grounds along the Egyptian coast of the Red Sea.

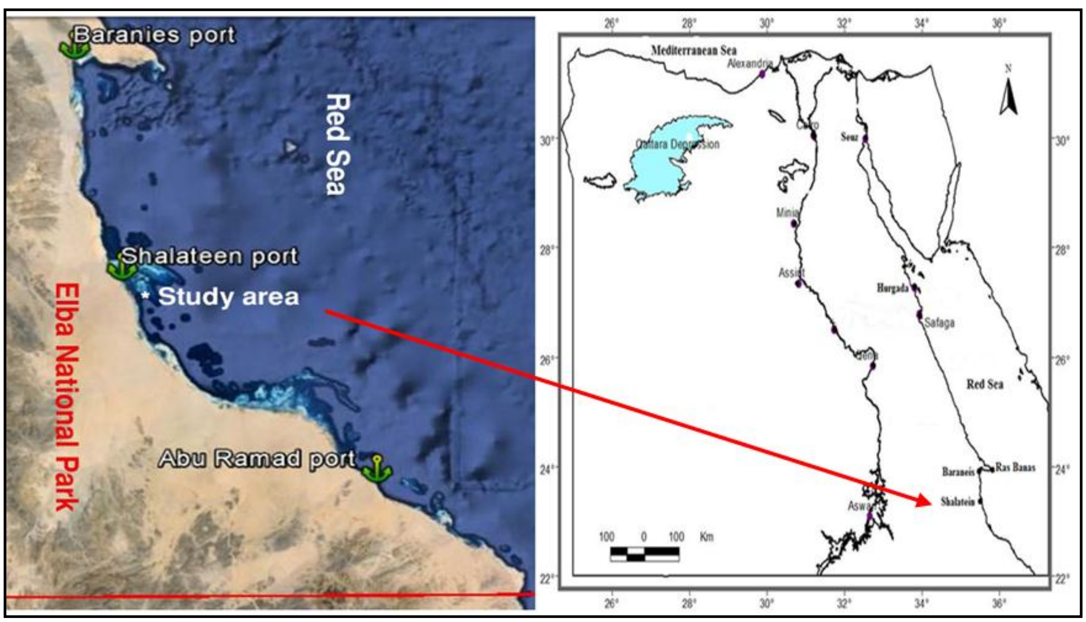


Fig. 1: Egyptian Red Sea map showing the study area

2. Collection of samples:

A total of 1103 specimens (145–515 mm in SL) of *Carangoides bajad* and 796 specimens (145–631 mm in SL) of *Caranx melampygus* were randomly collected monthly from the commercial landings at Shalateen fishing port in Shalateen city during the period from November 2013 to October 2014.

3. Biological Studies:

The following measurements were taken for the two species under study:

- **Standard length** "**SL"** (to the nearest mm) from the anterior border of head to the posterior caudal fin.
- **Total body weight "W"** in grams (to the nearest 0.01 g).
- **Scales** for age determination.

Standard length SL was used for all analysis in this study as the most accurate measurement.

4. Age determination:

For age determination, the scales of 480 specimens of *C. bajad* and 400 specimens of *C. melampygus* were prepared and examined. Scales were taken from the area below the lateral line at a level behind the pectoral fin on the left side of the fish. Using scale projector, the examination and measurement of growth annuli were carried out. The relationship between the scale radius (R) and the standard length (SL) was studied to estimate the necessary correction factor for back calculation. On the bases of scatter diagrams, such a relationship is represented by the following equation:

$$SL = a + b\,R$$

Where "a" (the correction factor) and "b" are constants estimated by the least square method. The calculated growth in length was determined by the calculation of length at the end of each year of life using the following formula.

$$SL_n = a + R_n / R * SL - a \qquad \text{(Lee, 1920)}$$

Where SL_n is the calculated length at the end of n^{th} year, SL is the standard length of fish at capture, R_n is the scale radius corresponding to n^{th} year, R is the scale radius at the time of capture and "a" is the correction factor.

5. Length-weight relationship:

The length–weight relationships of *C. bajad* and *C. melampygus* considered through the whole period of investigation were described by the power function equation:

$$W = a\,SL^b \qquad \text{(Hile, 1936 and Le Cren, 1951)}$$

$$\text{Log } W = \log a + b * \text{Log } SL$$

Where: **W** is the weight of fish in g. **SL** is the standard length of fish in mm.

(**a** & **b**) are constants whose values were estimated by the least square method.

6. Growth parameters:

The von Bertalanffy growth model was applied to describe the theoretical growth of *C. bajad* and *C. melampygus.* The constants of the von Bertalanffy model ($L\infty$ and K) were estimated by using the methods of **Ford (1933)-Welford (1946)** plot as the follows:

$$L_{t+1} = L_\infty (1- e^{-k}) + e^{-k} L_t$$

Where: L_t and L_{t+1} are the fish length at age t and t+1 respectively. This method was applied by fitting L_t against L_{t+1} which gives a straight line with a slope (b) equal to e^{-k} and an intercept (a) equal to $L_\infty (1-e^{-k})$.Thus, the value of K and L_∞ can be estimated as the follow:

$b = e^{-k}$ then $k = -Ln\ b$, $a = L_\infty (1- e^{-k})$

i.e. $a = L_\infty (1-b)$ then $L_\infty = a / (1-b)$

While the constant "t_0" was estimated from the following rearranged formula of the von Bertalanffy equation:

$$- \ln [1 - (L_t/L_\infty)] = - k*t_0 + k*t$$

7. Growth Performance Index (Ø'):

Growth performance index was computed to compare the von Bertalanffy growth of carangid fish with other fish species according formula of **Pauly & Munro (1984)** as follow:

$$Ø' = Log_{10} K + 2 Log_{10} L_\infty$$

Where: Ø' = Phi-prime, i.e. a length-based index of growth performance.

RESULTS & DISCUSSION

1. Age composition:

From the direct examination of the scales of the two species under investigation; *C. bajad* and *C. melampygus*, it was found that they are a reliable tool for age determination of these species **(Fig. 2)**. Body length–scale radius relationship **(Fig. 3)** showed a strong correlation between the body length and scale radius (r = 0.90 for *C. bajad* and 0.91 for *C. melampygus*). Based on the number of annuli on the scales, the oldest individuals were 8 and 12 years old for *C. bajad* and *C. melampygus* respectively.

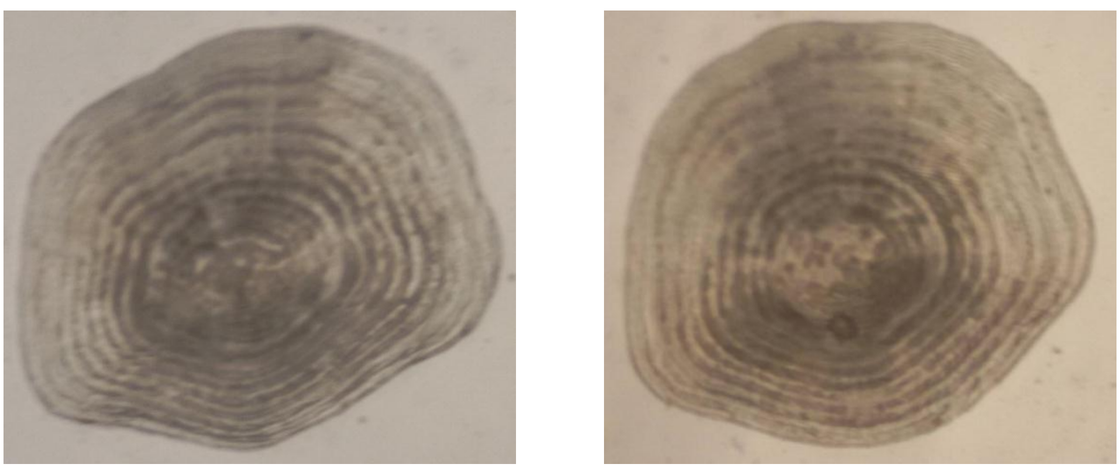


Fig. (2): Shape of scales for the two Carangid species as an age determination tool. **A:** Shape of scale of *Carangoides bajad* **(SL= 465 mm; Age 6 years); B:** Shape of scale of *Caranx melampygus* (**SL= 490 mm; Age 6 years**)

The growth study of the present study revealed that the two Carangid species attained their highest growth rate in length (annual increment) during the first year of life, then this increment sharply decreased by the end of the second year **(Fig. 4)**. *C. melampygus* attainted its highest growth rate in length (35.7%) in age group I while that of *C. bajad* was 41.5%.

Similar trends in length increment have been reported on all carangid species studied before **(Sudekum *et al*., 1991; Mehanna, 1999a&b; Smith & Parrish, 2002; Grandcourt *et al*., 2004; Mehanna *et al*., 2005; Yankova *et al*., 2010; Mehanna *et al*., 2013** and **El-Sherbeny, 2015)**.

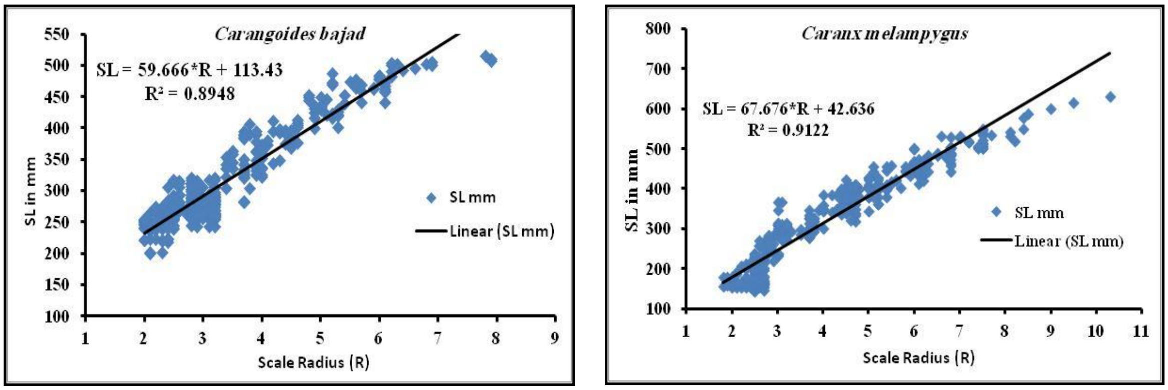


Fig. (3): Standard length (SL)–scale radius relationships of *Carangoides bajad* and *Caranx melampygus*, from the southern Red Sea of Egypt.

2. Time of annulus formation:

Figure 4 shows the mean values of the monthly increments of distance between the last annulus and the scale margin for the age group (II) of *C. bajad* and age group (III) of *C. melampygus* through the period of investigation. The minimal increment occurred in December for *C. bajad* and November for *C. melampygus*; whereas the maximal increments were in June for *C. bajad* and May for *C. melampygus*. This means that the time of annulus formation on the scales takes place in December for *C. bajad* and in November for *C. melampygus*.

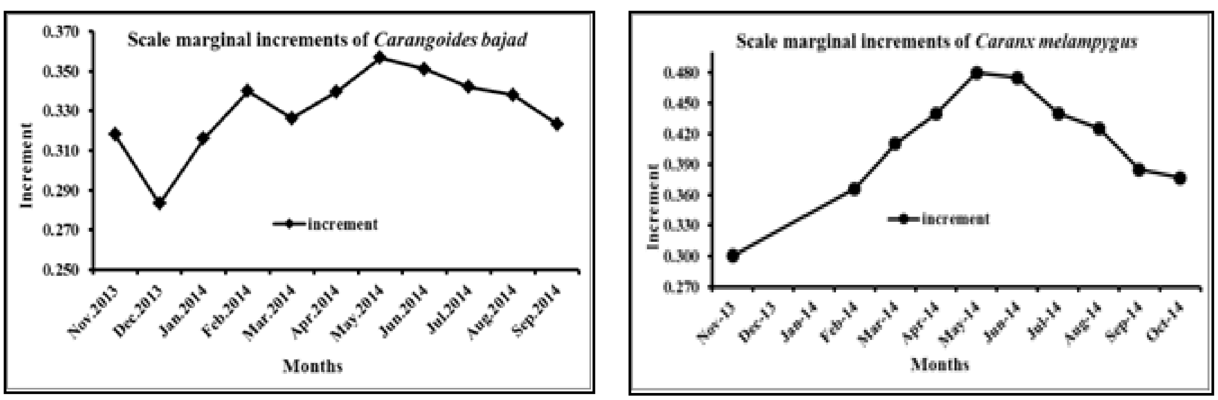


Fig. (4): Monthly average of scale marginal increments of *Carangoides bajad* and *Caranx melampygus*, from the southern Red Sea of Egypt.

3. Length-weight relationship:

The length-weight relationship is considered as an essential tool in the studies of fish stock assessment and management of fisheries resources **(Haimovici & Velasco, 2000; Ilkyaz *et al.*, 2008; Rodriguez-Romero *et al*., 2009** and **Rojas-Herrera *et al*. 2009)**.

The length and weight measurements of 1103 and 796 specimen of *C. bajad* and *C. melampygus* were used to estimate the length-weight relationships. The length-weight relationships of the two Carangid species are best described by the following power equations **(Fig. 5)**:

Carangoides bajad: $\mathbf{W = 0.00005 * SL^{2.8827}}$ $\mathbf{R^2 = 0.98}$ SL in mm

Caranx melampygus: $\mathbf{W = 0.00004 * SL^{2.9333}}$ $\mathbf{R^2 = 0.99}$ SL in mm

It is obvious that the growth in weight for both species is isometric i.e. b is not statistically significant differ from 3 (b= 2.883; CI = 2.860-2.9057 for *C. bajad*) and (b= 2.933; CI = 2.9168-2.9496 for *C. melampygus*).

Tables (1 & 2) showed the length-weight relationship constants obtained from the present study compared to those obtained from previous ones for different carangid species.

Based on the L-W relationship, the back calculated lengths were transformed to weights **(Fig. 6)**. The growth rate in weight exhibited its higher values in age groups IV for *C. bajad* and VII for *C. melampygus*.

Table 1: The length – weight relationship constants (a & b) of *Carangoides* spp.

***Carangoides* species**	**b**	**a**	**Reference**
Carangoides armatus	3.126	0.0115	**Corpuz *et al*., 1985** (Philippine)
Carangoides bajad	2.869	0.0199	**Grandcourt *et al*., 2004** (The southern Arabian Gulf)
Carangoides bartholomaei	2.908	0.0259	**Cervigón, 1993** (Venezuela)
Carangoides chrysophrys	2.902	0.0267	**Al-Rasady *et al*., 2013** (Arabian Sea)
Carangoides coeruleopinnatus	2.902	0.0321	**Paxton *et al*., 1989** (Australia)
Carangoides equula	3.01	0.016	**Ahmad *et al*., 2003** (Malaysia)
Carangoides ferdau	2.85	0.0414	**Edwards *et al*., 1985** (Gulf of Aden)
Carangoides fulvoguttatus	2.705	0.0461	**Paxton *et al*., 1989** (Australia)
Carangoides gymnostethus	2.747	0.0463	**Paxton *et al*., 1989** (Australia)
Carangoides hedlandensis	2.864	0.0381	**Paxton *et al*., 1989** (Australia)
Carangoides humerosus	2.939	0.0222	**Allen & Swainston, 1988** (Western Australian Museum)
Carangoides malabaricus	2.92	0.019	**Ahmad *et al*., 2003** (Malaysia)
Carangoides orthogrammus	3.026	0.0156	**Paxton *et al*., 1989** (Australia)
Carangoides talamparoides	3.319	0.0114	**Paxton *et al*., 1989** (Australia)
Carangoides bajad	**2.88**	**0.0349**	**The present work**

Table 2: The length – weight relationship constants (a & b) of *Caranx* spp.

species	b	a	Reference
Caranx bucculentus	3.033	0.023	**Brewer, *et al*., 1994** (Gulf of Carpentaria, Australia)
Caranx caballus	2.91	0.0325	**Gallardo-Cabello *et al*., 2007** (Colima, Mexico)
Caranx caninus	2.957	0.038	**Espino-Barr *et al*., 2008** (Colima, México)
Caranx crysos	2.949	0.0318	**Erzini, 1991** (University of Rhode Island)
Caranx heberi	2.856	0.0386	**Fricke, 1999** (Mascarene Islands)
Caranx hippos	2.855	0.0329	**Reuben *et al*., 1992** (Indian seas)
Caranx ignobilis	2.978	0.0282	**Sudekum *et al*., 1991** (Oceanic communities)
Caranx latus	2.97	0.021	**Robins & Ray, 1986** (Boston, U.S.A.)
Caranx lugubris	2.9	0.0187	**Erzini, 1991** (University of Rhode Island)
Caranx melampygus	2.941	0.0242	**Longenecker & Langston, 2008** (Hawaii)
Caranx papuensis	2.91	0.0249	**Paxton *et al*., 1989 (**Australia)
Caranx rhonchus	2.88	0.02	**CECAF, 1979** (Mauritania to Liberia)
Caranx ruber	2.99	0.018	**Palomares & Pauly, 1989** (Australia)
Caranx sexfasciatus	3.005	0.0265	**Munro & Williams, 1985** (Tahiti)
Caranx tille	3.163	0.0088	**Fry *et al*., 2006** (Papua, New Guinea)
Caranx melampygus	**2.9333**	**0.0329**	**The present work**

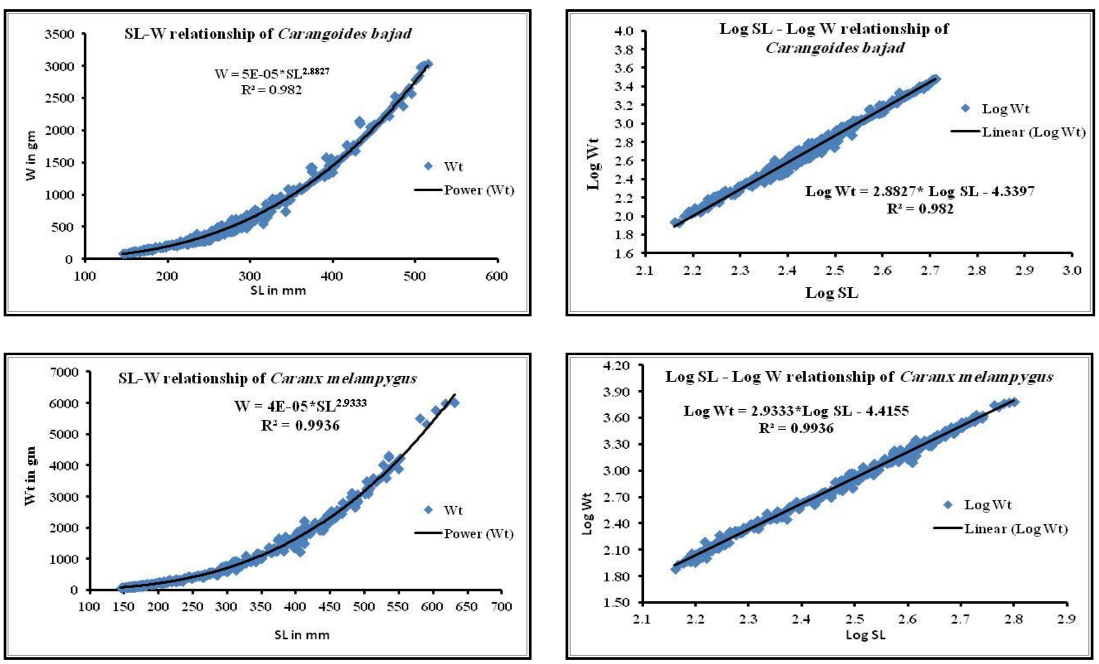
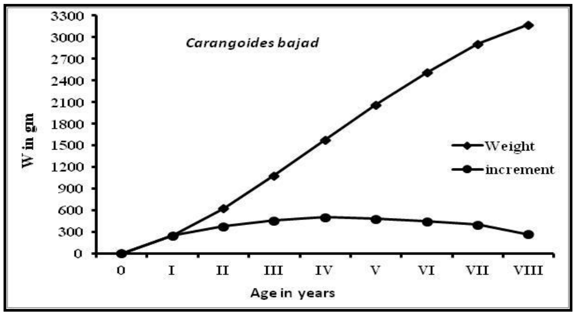


Fig. (5): Standard length (SL)–weight relationship and its logarithmic form for *Carangoides bajad* and *Caranx melampygus* from the southern Red Sea of Egypt.



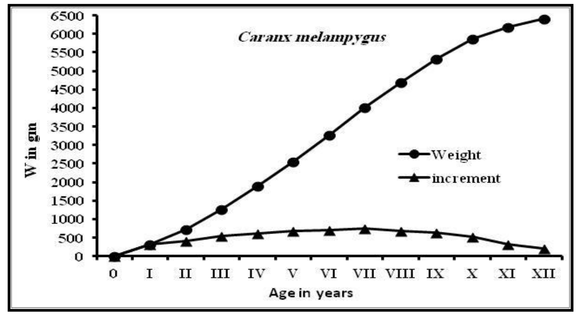


Fig. (6): Growth in weight (W in g) and annual increment of *Carangoides bajad* and *Caranx melampygus*, considered from the southern Red Sea of Egypt.

4. Growth parameters:

The growth parameters "L∞, K, W∞ and t_0" for *Carangoides bajad* and *Caranx melampygus* were given in **Table (3)** and **Fig. (7)**.

Table 3: Growth parameters for *Carangoides bajad* and *Caranx melampygus*, from Shalateen fishing area, Red Sea, Egypt

Species	L∞	K	W∞	t_o
C. bajad	576.88	0.24	4553.56	-0.86
C. melampygus	701.08	0.17	8903.28	-1.013

The only study dealing with the growth parameters of those species is those of **Smith & Parrish (2002)** from Hawaii and **Grandcourt *et al*. (2004)** from the Southern Arabian Gulf Abu Dhabi, United Arab of Emirates. In Hawaii, L∞ = 97.3 cm; K = 0.19 $year^{-1}$; t_0 = -0.20 years for *C. melampygus*, while in Abu Dhabi, L∞ = 40.38 cm; K = 0.598 $year^{-1}$; t_0 = -0.35 years for *C. bajad*. Von Bertalanffy growth parameters for a number of local species are given in **Tables (4 & 5)**.

Accordingly, the estimated von Bertalanffy growth equations in both length and weight were as follows:

***Carangoides bajad*:** for growth in length $\mathbf{L_t = 576.88\ (1 - e^{-0.24\ (t + 0.86)})}$

For growth in weight $\mathbf{W_t = 4553.56\ (1 - e^{-0.24\ (t + 0.86)})^{2.8827}}$

***Caranx melampygus*:** for growth in length $\mathbf{Lt = 701.08\ (1 - e^{-0.17\ (t + 1.013)})}$

For growth in weight $\mathbf{Wt = 8903.28\ (1 - e^{-0.17\ (t + 1.013)})^{2.9333}}$

5. Growth performance index:

The values obtained for the computed growth performance index (Ø') for the two Carangid species under investigation were 2.91 and 2.93 for *Carangoides bajad* and *Caranx melampygus*, respectively.

Table 4: Von Bertalanffy (1938) growth parameters of *Carangoides* species

Species	L_∞	K	T_o	Ø'	Reference
Carangoides armatus	60.2	0.34	-0.4	2.58	**Corpuz *et al.*, 1985** (Philippine)
Carangoides bajad	40.4	0.6	-0.25	2.99	**Grandcourt *et al.*, 2004** (The southern Arabian Gulf)
Carangoides bartholomaei	102.8	0.2	-0.6	3.33	**Cervigón, 1993** (Venezuela)
Carangoides chrysophrys	73.3	0.3	-0.52	3.13	**Al-Rasady, *et al.*, 2013** (The Arabian Sea)
Carangoides coeruleopinnatus	42.8	0.46	-0.32	2.93	**Paxton *et al.*, 1989** (Australia)
Carangoides equula	30.5	0.4	-0.4	2.57	**Ahmad, *et al.*, 2003** (Malaysia)
Carangoides ferdau	93.1	0.21	-0.59	3.26	**Edwards *et al.*, 1985** (Gulf of Aden)
Carangoides fulvoguttatus	123.1	0.16	-0.72	3.38	**Paxton *et al.*, 1989** (Australia)
Carangoides gymnostethus	92.7	0.22	-0.56	3.28	**Paxton *et al.*, 1989** (Australia)
Carangoides hedlandensis	33.5	2.86	-0.05	2.98	**Paxton *et al.*, 1989** (Australia)
Carangoides humerosus	26.3	0.73	-0.23	2.70	**Allen & Swainston, 1988** (Western Australian Museum)
Carangoides malabaricus	38.1	0.77	-0.2	2.86	**Ahmad *et al.*, 2003** (Malaysia)
Carangoides orthogrammus	77.5	0.27	-0.48	3.21	**Paxton *et al.*, 1989** (Australia)
Carangoides talamparoides	53	0.38	-0.37	3.03	**Paxton *et al.*, 1989** (Australia)
Carangoides bajad	**57.7**	**0.24**	**-0.86**	**2.91**	**Present study**

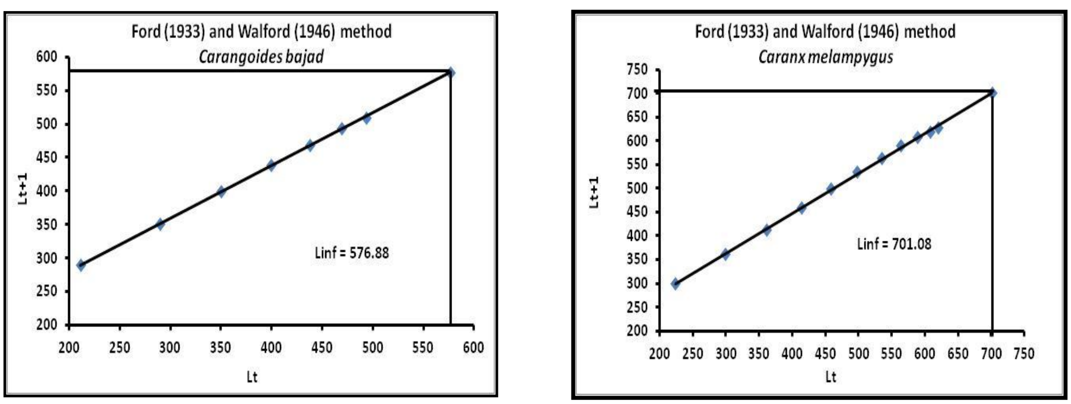


Fig. (7): Von Bertalanffy (1938) growth model of *Carangoides bajad and Caranx melampygus*, from the southern Red Sea of Egypt.

Table (5): Von Bertalanffy (1938) growth parameters of *Caranx* species

Species	L_∞	K	T_o	Ø'	Reference
Caranx bucculentus	54	0.3	-0.42	2.95	**Brewer *et al*., 1994** (Gulf of Carpentaria, Australia)
Caranx caballus	52	0.4	-0.39	2.99	**Gallardo-Cabello *et al*., 2007** (Colima, Mexico)
Caranx caninus	112	0.2	-1.57	3.15	**Espino-Barr *et al*., 2008** (Colima, México)
Caranx crysos	42	0.3	-0.4	2.75	**Erzini, 1991** (University of Rhode Island)
Caranx heberi	90.7	0.23	-0.54	3.28	**Fricke, 1999** (Mascarene Islands)
Caranx hippos	44.4	0.7	--	3.11	**Reuben *et al*., 1992** (Indian seas)
Caranx ignobilis	184	0.1	0.1	3.57	**Sudekum *et al*., 1991** (Oceanic communities)
Caranx latus	103.9	0.18	-0.67	3.29	**Robins & Ray, 1986** (Boston, U.S.A.)
Caranx lugubris	82.2	0.1	-0.47	2.91	**Erzini, 1991** (University of Rhode Island)
Caranx melampygus	97.3	0.2	-0.2	3.26	**Longenecker & Langston** (2008, Hawaii)
Caranx papuensis	90.7	0.58	-0.2	3.68	**Paxton *et al*., 1989** (Australia)
Caranx rhonchus	48.6	0.2	-0.8	2.58	**CECAF, 1979** (Mauritania to Liberia)
Caranx ruber	56	0.1	-1.73	2.65	**Palomares & Pauly, 1989** (Australia)
Caranx sexfasciatus	80	0.2	-0.51	3.19	**Munro & Williams, 1985** (Tahiti)
Caranx tille	57.5	0.3	-0.48	2.98	**Fry *et al*., 2006** (Papua New Guinea)
Caranx melampygus	**70.1**	**0.17**	**-1.013**	**2.93**	**Present study**

RECOMMENDATIONS

This study should be completed to assess the fishery status of both species and propose a future plan for their management and how to conserve and exploit them rationally.

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