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Life Span, Maximum Age and Growth Pattern of the Blackspot Snapper *Lutjanus ehrenbergii* (Family: Lutjanidae) from Two Different Areas in the Red Sea, Egypt

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ABSTRACT

Since the ability of exploited populations to sustain harvests is influenced by their demographic characteristics, the present study aimed to investigate the longevity and growth patterns of the blackspot snapper (*Lutjanus ehrenbergii*) landed in Hurghada and Suez. A total of 356 and 345 specimens were regularly collected each month for one year during the active fishing season. These specimens were measured and dissected to determine their sex. The total length (TL) of each specimen was measured to the nearest 1mm, and the total weight was taken to the nearest 0.1g. Scales and otoliths were collected for age determination. The ages were calculated by counting the alternating translucent and opaque bands in sagittal otoliths and scales, which were validated as annuli. The maximum lifespan was found to be 5 years for both sexes and in both studied regions. For *L. ehrenbergii* collected from Suez, the von Bertalanffy growth function (VBGF) parameters were $L\infty$ = 32.81cm, K = 0.311 y^{-1}, and t_0 = -1.21 years, while for those collected from Hurghada, the parameters were $L\infty$ = 30.61cm, K = 0.359 y^{-1}, and t_0 = -1.91 years. The growth performance in length (ΦL) values were nearly identical, with values of 2.52 for Suez and of 2.53 for Hurghada. Furthermore, *L. ehrenbergii* exhibited negative allometric growth for males in Suez and positive allometric growth in Hurghada. Females showed isometric growth in both areas. The growth exponent (b) values were as follows: 2.67 for males, 2.97 for females, and 2.98 for combined sexes from Suez; and 3.26 for males, 3.02 for females, and 2.95 for combined sexes from Hurghada. This information should encourage fisheries managers to consider growth variations when implementing fishing regulations and management policies for *L. ehrenbergii* stocks from these two landing sites.

INTRODUCTION

Egypt has one of the most diverse combinations of waterbodies, including the unique marine ecosystem of the Red Sea. This sea encompasses two gulfs, one of which is the Gulf of Suez (Fig. 1), which is considered one of the most fundamental part of the Egyptian Red Sea fisheries. Snappers constitute an imperative component of both the local artisanal and industrial catch of the Gulf of Suez and Red Sea fisheries, and one of the significant lutjanids included in its catch is the blackspot snapper.

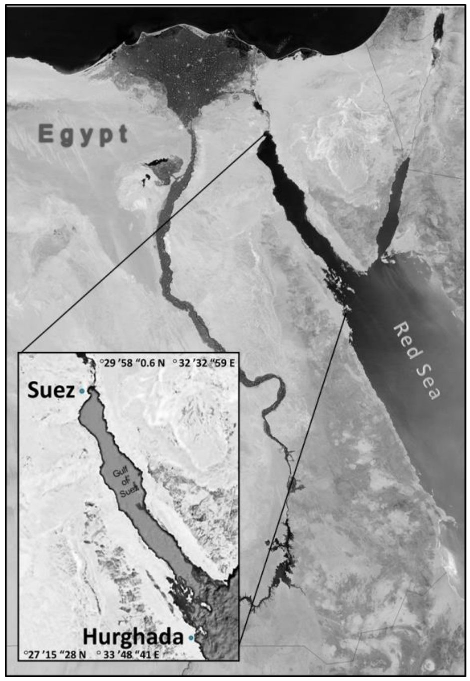

Fig. 1. Map of Gulf of Suez, Red Sea, Egypt

The blackspot snapper *Lutjanus ehrenbergii* is generally carnivore and mesopredator, feeding primarily on benthic invertebrates associated with turfing algae (i.e. amphipods, isopods) and small fish **(D'Agostino *et al.*, 2020; D'Agostino *et al.*, 2021; Griffiths *et al.*, 2024)**. *L. ehrenbergii* is also a small-sized, short-lived species that is characterized by its early maturation and rapid growth. This species can reach up to 12 years of age **(Grandcourt *et al*., 2011)**, with a maximum total length of about 35cm. The common total length is around 20cm, and the maximum juvenile size is 11.7cm, with maturation occurring at approximately 12cm **(Dunne *et al.*, 2023)**. It also has a single spawning season occurring in spring between March and June in the Arabian Gulf **(Grandcourt *et al.*, 2006, 2011; Vaughan *et al*., 2021)**.

The blackspot snapper is not only found in the Red Sea and its gulfs, but commonly distributed in the coastal areas of the Indo-West Pacific Ocean, covering the area from Solomon and Mariana Islands to East Africa **(Allen, 1985; Allen & Talbot, 1985)**. As a diurnal fish, the blackspot snapper is energetic during the day and can flourish in changeable levels of salinity. One of its noticeable features is the 5-6 lines on body, along with the ocellated black spot below anterior soft dorsal fin. The blackspot snapper is frequently found on coral reefs, at depths of about 5 and 20m, and rocky substrata all over its region of distribution **(Rooker & Dennis, 1991; Nagelkerken *et al.*, 2000; Dorenbosch *et al*., 2004; Luo *et al*., 2009; McMahon *et al.*, 2011)**. Juveniles are commonly found inshore over sand, silt, or coral rubble bottoms, and occasionally in mangrove-lined streams and estuaries **(Randall, 1983; Allen & Talbot, 1985)**. These types of habitats do exist in the Gulf of Suez, but they are not as extensive or as diverse as those that exist in the rest of the Red Sea, especially in the central and southern parts, due to shallower depth, higher salinity, temperature fluctuations, and sedimentation rates from shipping and industrial activities.

Blackspot snappers are primarily caught using handlines, gillnets, trawl nets, cast nets, traps, and fyke nets (called Sakhwa in Hurghada), and principally sold fresh. In Egypt, it is considered a communal in commercial Red Sea landings; the total catch of *L. ehrenbergii* was 3 tons in year 2021, and majority of that catch came from the Gulf of Suez; this is lower by half compared to the statistics of the previous year where *L. ehrenbergii* in 2020 contributed by 6 ton **(GAFRD, 2022; LFRPDA, 2023)**.

As the ability of exploited populations to sustain harvests depends on their demographic characteristics, such as longevity, growth functions, and mortality rates **(Musick, 1999)**, this study aimed to calculate the maximum lifespan, age, and growth pattern of *Lutjanus ehrenbergii* collected from two main landing sites in Suez and Hurghada. This research is part of a broader investigation into the population parameters of this species, which may contribute to its effective management.

MATERIALS AND METHODS

1. Sampling and biological measurements

Samples of the species under study (Fig. 2) were consistently collected every month during the active fishing season, from December 2022 to November 2023, at landing centers in Suez and Hurghada cities. Each individual was measured for total length (TL) to the nearest mm and was weighed to the nearest 0.1g. The specimens were then dissected to determine their sex, and otoliths and scales were collected and preserved for further age determination.

Fig. 2. Photograph illustrating the external features of *Lutjanus ehrenbergii*

2. Methods

2.1. Age determination

Ages were calculated through counting the growth bands of alternating translucent and opaque bands in sagittal otoliths and scales. Distances between the focus and the successive annuli were measured to the nearest micron (1µm). The relationship between otolith or scale radius (S) and TL was determined by the method of least squares. The back-calculated lengths at the end of each year of life were calculated by Lee's equation as follows:

$$L_n = (L_t – a) S_n/S + a$$ **(Lee, 1920)**

2.2. Length – body weight relationship

The relationship between total length (TL) and body weight (W) of the *L. ehrenbergii* specimens was expressed by the following power equation:

$$W = a\ TL^b$$ **(Beckman, 1948 and Le Cren, 1951)**

Where, a and b are constants and estimated by the method of least squares.

2.3 Growth parameters

The growth model proposed by **von Bertalanffy (1938)**, $L_t = L_\infty [1 - e^{-k(t - t_0)}]$, was used to designate the growth pattern of the blackspot snapper, where Lt is the mean length at age t; L∞ is the asymptotic length; K is the growth coefficient; and t_0 is the age at which the length theoretically equals zero. L∞ and K were predictable using the plot of **Ford (1933)** and **Walford (1946)**, as $L_{t+1}= L_\infty (1-e^{-k}) + e^{-k} L_t$, where L_t and L_{t+1} = mean length at age t and t+1, respectively.

2.4. Growth performance index (Ø')

The growth performance index in length ($Ø_L$) was calculated based on the formula of **Pauly and Munro (1984)**, as $Ø' = Log_{10} K + 2 Log_{10} L_\infty$.

2.5. Maximum age limit

Longevity (t_{max}) was estimated according to **Beverton (1963)**, as $t_{max}= 3/ K$, where K is the VBGE growth coefficient.

RESULTS AND DISCUSSIONS

1. Area description and catch statistics

The Red Sea is a long, narrow body of water located between Northeastern Africa and the Arabian Peninsula. It stretches from 30°N to 12°30’N and from 32°E to 43°E, with a length of about 2,250km and a maximum depth of 2,850m. The Red Sea has an average width of 208km, an average depth of 491m, and a surface area of 451,000km^2 **(Morcos, 1970)**. To the north, the area is divided into two gulfs: the Gulf of Suez, which is wide, shallow, and muddy, and the Gulf of Aqaba, which is narrow and deep **(Tesfamichael & Mehanna, 2012)**.

The Gulf of Suez extends about 250km from Suez in the north (Lat. 29°56' N) to Shadwan Island in the south (Lat. 27°36' N). Its width varies from 20 to 40km, and its depth along the axis remains fairly constant, with an average depth of 45m. The Gulf is one of the most productive fishing regions in the Egyptian sector of the Red Sea, where, according to **Mehanna and El-Gammal (2007)**, more than 64% of Egypt's Red Sea fish production was harvested. However, this percentage has dramatically decreased over the years, reaching just 36.2% in 2023 **(LFRPDA, 2023)**. Three key fishing techniques working in the Gulf are trawl, purse-seine, and long and hand lines **(Mehanna & El-Gammal, 2007)**. Many fishing ports are established along the Gulf of Suez; Ataka, El Salakhana, Ras Gharib and El Tour, from which Ataka is the most important where about 65% of the total Gulf production lands on it **(LFRPDA, 2023)**. Furthermore, mostly trawl catch lands in Ataka fishing port.

The total catch and Lutjanid catch (ton) from the Gulf of Suez and Red Sea in Egypt during the last six years (2017-2022) are given in Table (1). The total Red Sea catch varied between 45.2 and 51.5 thousand tons, with an annual mean of 49.3 thousand tons in the duration of six years. On the other hand, the Gulf of Suez catch fluctuated between 14 and 22.1 thousand tons, with an annual average of 18 thousand tons. The lutjanid catch in Egypt ranged between 209 and 731 tons, with an annual average of 428.9 tons. The percentage of lutjanid catch to the total Red Sea catch varied from 0.7 to 1.7%, while it ranged between 1.8 to 4.7% of the total catch from the Gulf of Suez.

Table 1. Egyptian fisheries production statistics (ton) between 2017 and 2022 **(CAPMAS, 2019, 2020, 2021, 2022, 2023; LFRPDA, 2023)**

	Year Statistics							
Country	**Species/ family/catch**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Mean**
Egypt	Blackspot snapper	2	1	--	6	3	6	3.6
	Lutjanidae	271	372	209	550	731	440.2	428.9
	Red Sea	50,838	47,965	50,935	51,496	45,243	--	49,295
	Gulf of Suez	17,255	14,002	22,134	20,070	16,376	--	17,967
	Hurghada	7470	7468	7404	7979	8154	--	7695
	Total natural fisheries production	370,959	373,285	397,042	418,683	425,769	--	397,148

2. Length – weight relationship

The length-weight relationship of fish is useful for estimating the condition of fish, determining biomass from length observations, converting growth-in-length equations to growth-in-weight, and comparing the life histories of species across different localities **(Binohlan & Pauly, 1998; Mehanna & Al-Mammry, 2012; Mehanna & Farouk, 2021)**. The length and weight measurements of 356 and 345 specimens of *L. ehrenbergii* that landed in Suez and Hurghada were used for the estimation of the length-weight relationship, and the LWR exponent (b) values for males, females, and combined sexes of *L. ehrenbergii* from Suez were 2.67, 2.97 and 2.98, respectively (Fig. 3), and from Hurghada, values were 3.26, 3.02 and 2.95, respectively (Fig. 4). The non-significant deviation from the expected value of b = 3 for *L. ehrenbergii* for sexes combined indicated an isometric growth in both areas (CI: 2.839-3.068 in Hurghada and CI: 2.912-3.052 in Suez). The t-test revealed negative allometric growth for males in Suez and positive allometric growth for males in Hurghada. Females exhibited isometric growth in both areas (CI: 2.891–3.151 in Hurghada and CI: 2.876–3.067 in Suez).

The positive allometric growth in Hurghada suggests that male *L. ehrenbergii* are gaining more mass relative to length, indicating that they may be growing under more favorable conditions compared to those landed in Suez, where food supply might be more limited. This also suggests that, in general, the fish stock may not be under an immediate stress from overfishing, habitat degradation, pollution, or other environmental pressures. The isometric growth of combined sexes of *L. ehrenbergii* landed in Suez and Hurghada differs from the results of **Mokhtar *et al*. (2014)** and **Hasieb *et al*. (2024)**. However, it is consistent with the findings of **Grandcourt *et al*. (2011)** and **Gumanao *et al.* (2016)** (Table 2).

Table 2. Length-weight relationship parameters of *L. ehrenbergii* in different study areas

Region			Sex	No.	LWRs Parameters		
					A	B	r^2
Current Study	Gulf of Suez	Suez	Male	69	0.037	2.67	0.89
			Female	269	0.014	2.97	0.93
			Combined	356	0.014	2.98	0.95
		Hurghada	Male	66	0.006	3.26	0.90
			Female	263	0.012	3.02	0.89
			Combined	345	0.016	2.95	0.88
Hasieb *et al.* (2024)	Red Sea		Male	98	0.017	2.93	0.94
			Female	120	0.016	2.94	0.96
			Combined	218	0.017	2.93	0.95
	Southern Arabian Gulf		Male	89	0.019	2.88	0.98
			Female	117	0.019	2.88	0.96
			Combined	206	0.020	2.88	0.97
Mokhtar *et al.* (2014)	Red Sea		Male	--	0.028	2.77	--
			Female	--	0.035	2.70	--
			Combined	--	0.031	2.74	--
Grandcourt *et al.* (2011)	Southern Arabian Gulf		Combined	--	0.018	2.97	0.96
Gumanao et al. (2016)	Davao Gulf		Combined	--	0.037	2.96	0.98

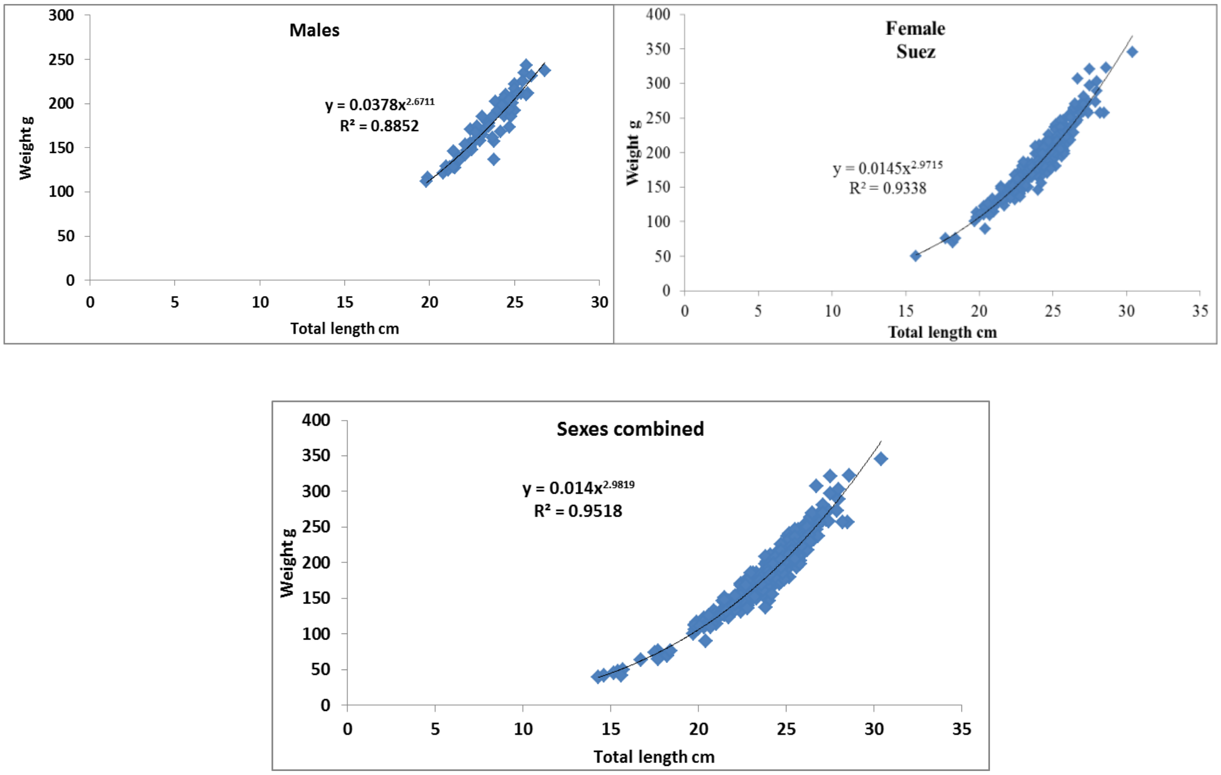

Fig. 3. Length-weight relationship of *L. ehrenbergii* landed in Suez

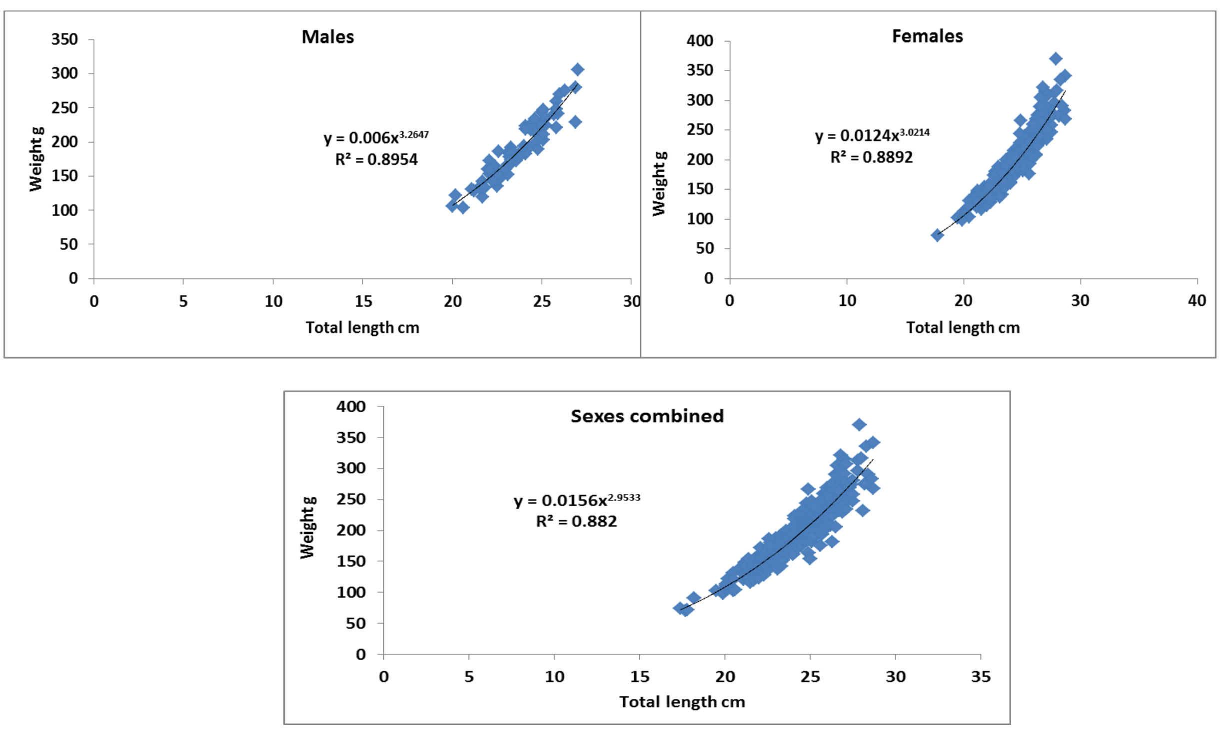

Fig. 4. Length-weight relationship of *L. ehrenbergii* landed in Hurghada

3. Age Determination

Age determination is one of the most essential components in the field of fisheries management. It forms the basic knowledge necessary for the evaluation of longevity, growth rate, mortality rate and yield. These parameters are the basic data required for the construction of a management strategy for a rational exploitation of any exploited fish stocks **(Mehanna, 1997)**.

In this study, both scales and otoliths were used for age determination. Examination of the otoliths and scales of *L. ehrenbergii* specimens from the Gulf of Suez (Figs. 5, 6) reveals that the maximum lifespan of the species is five years for both sexes in both regions.

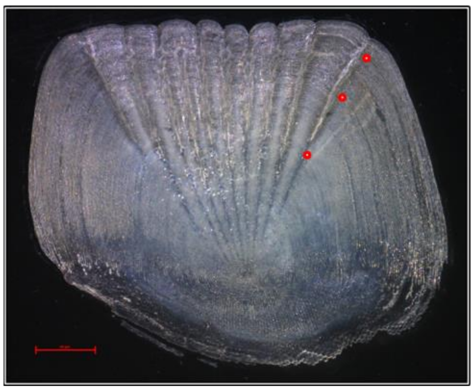

Fig. 5. Scale picture of a sample collected in Hurghada with T.L. 25cm

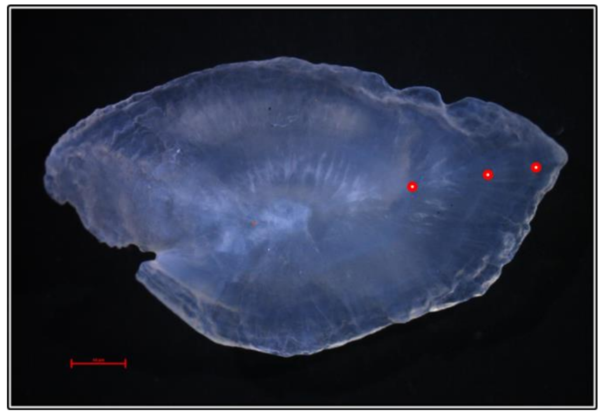

Fig. 6. Sagittal otolith picture of a sample collected in Hurghada with T.L. 23.4cm

Although there is variation between the *L. ehrenbergii* populations landed in Suez and Hurghada, with the maximum length in Suez being greater than in Hurghada, the longevity in both regions is relatively similar. Additionally, there is no significant difference in the maximum lifespan of the species between the two landing sites. The values obtained in this study were found to be somewhat different from those reported in previous studies (Table 3). These variations may be attributed to differences in sampling techniques, environmental factors, and water quality parameters, which can affect fish life expectancy and biological limits. However, the closest values to our study were those of **Hasieb *et al.* (2024)**, particularly for the Hurghada and Red Sea estimated longevity.

Moreover, the use of different fishery independent methods such as lines, traps alongside gillnets may have produced more representative size and age structures. Size selectivity could also have been the reason why the maximum observed sizes reported in other localities were considerably less than those of the current research, except for the values of **Allen (1985)** and **D'Agostino *et al.* (2021)** in Oman Sea (Table 3).

Table 3. Maximum observed length and age of *Lutjanus ehrenbergii* in different areas

Author	t_{max} (year) 3/K	L_{max} (cm)	Age (year)	Area
Allen (1985)	--	35 TL	--	Indo-West Pacific
Grandcourt *et al.* (2011)	12	26.5 FL		Southern Arabian Gulf
D'Agostino *et al.* (2021)	15 16	20 SL 24.6 SL	8.58 11	Southern Arabian Gulf Oman Sea
Hasieb *et al.* (2024)	8.08 7.98		4 4	Red Sea Southern Arabian Gulf
Current study	9.65 8.33	30.4TL, 28.5FL, 22.9 SL 28.7TL, 27FL, 21.9SL	5 5	Suez Hurghada

TL= total length, FL= fork length, SL= standard length

4. Age composition

The age composition of *L. ehrenbergii* from Suez and Hurghada is shown in Figs. (7, 8). The percentage frequencies of fish in the age 0 group are very low, representing only 2.21% in Suez and 3.22% in Hurghada. Age groups I, II, and III were the most dominant in the catch in both regions, contributing 15.23, 47.37, and 26.87% in Suez, respectively. In Hurghada, age groups II, III, and IV were the most dominant, representing 41.09, 27.59, and 20.40%, respectively. Therefore, the terminal age groups (0, I, and V) were represented by low percentages in both areas.

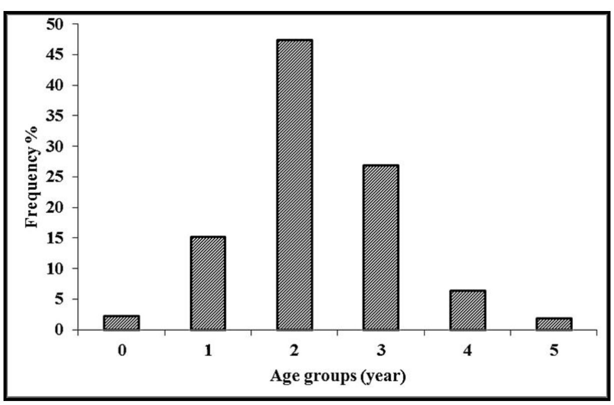

Fig. 7. Age composition of *Lutjanus ehrenbergii* from Suez

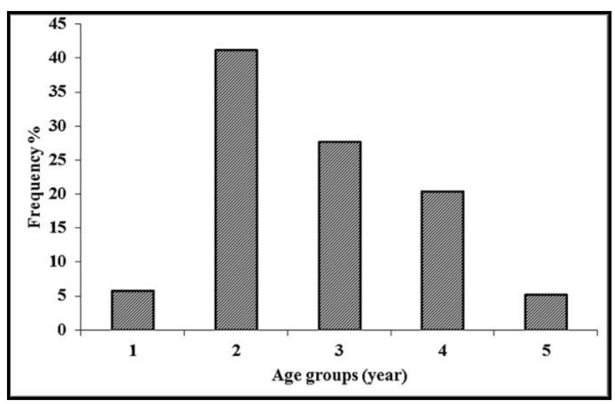

Fig. 8. Age composition of *Lutjanus ehrenbergii* from Hurghada

5. Body length-scale radius relationship

The relationship between TL and scale radius (R) of *L. ehrenbergii* was found to be linear, not passing through the origin (Figs. 9, 10), and could be described according to the least squares method by the following equations:

TL = 9.948 + 0.058R (R^2 = 0.8485) in Suez

TL = 11.334 + 0.055R (R^2 = 0.7941) in Hurghada

Accordingly, the equations used in back calculation were as follows:

TL_n = 9.948 + (R_n/R)*(TL - 9.948) in Suez

TL_n = 11.334 + (R_n/S)*(TL - 11.334) in Hurghada

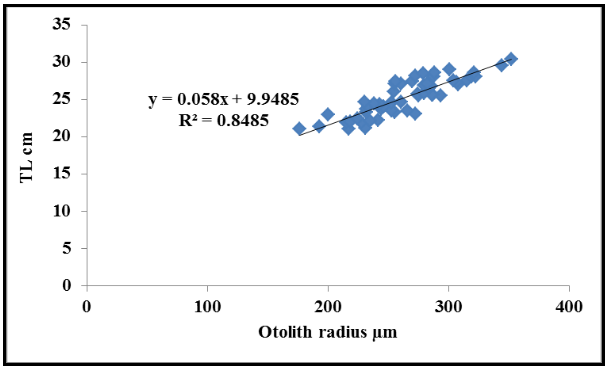

Fig. 9. Length-scale radius relationship of *Lutjanus ehrenbergii* from Suez

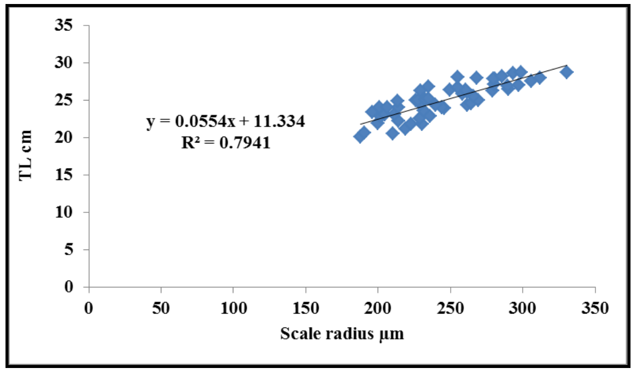

Fig. 10. Length-scale radius relationship of *Lutjanus ehrenbergii* from Hurghada

6. Back-calculations and growth in length

The back-calculated lengths for *L. ehrenbergii* were 19.89, 23.43, 25.85, 27.51, and 29.12cm for ages 1, 2, 3, 4, and 5, respectively, for the samples from Suez, and 19.79, 22.93, 25.06, 26.69, and 28.07cm for ages 1, 2, 3, 4, and 5, respectively, for those from Hurghada. It is clear that the highest growth rate in length for *L. ehrenbergii* occurred in the first year of life in both Suez and Hurghada, after which the annual increment decreased with the increasing age (Fig. 11).

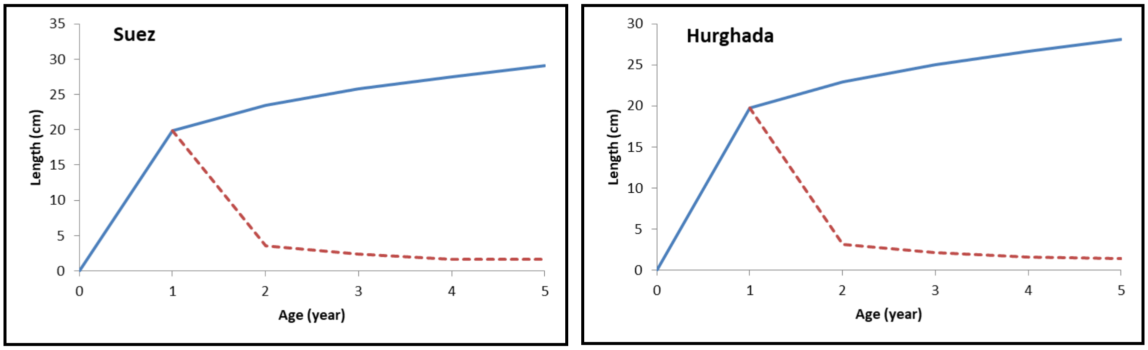

Fig. 11. Growth in length (solid line) and growth increment (dot line) of *L. ehrenbergii* from Suez and Hurghada

7. Growth in weight

The calculated weights at the end of each year of life for *L. ehrenbergii* from Suez and Hurghada were estimated by applying the length–weight relationship (Fig. 12). The results showed a successive increase in weight, reaching its maximum at age group five.

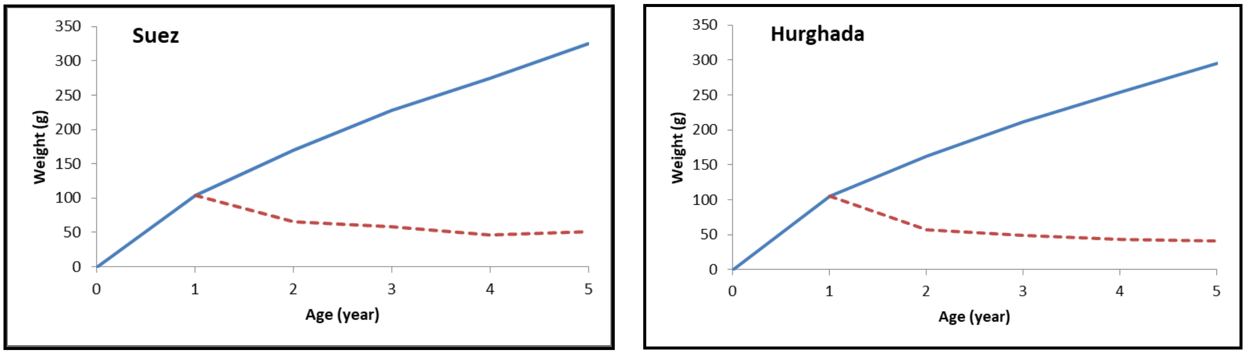

Fig. 12. Growth in weight (solid line) and growth increment (dot line) of *L. ehrenbergii* from Suez and Hurghada

8. Growth parameters

The obtained values of "L∞" for *L. ehrenbergii* were 32.81 and 30.61cm from Suez and Hurghada, respectively. While, the obtained values of "K" were 0.311 and 0.359 year^{-1} in Suez and Hurghada, respectively. It is obvious that *L. ehrenbergii* in Hurghada grow slightly faster than those landed in Suez and attained lower values of L∞. This may be due to the environmental conditions and the maximum observed length between the two fishing grounds. The values of von Bertalanffy constant "t_0" were -1.21 and -1.91 year from Suez and Hurghada, respectively.

Accordingly, the von Bertalanffy growth in length equations for *L. ehrenbergii* from Suez and Hurghada were as follows:

Suez $L_t = 32.81\ [1 - e^{-0.311\ (t + 1.21)}]$

Hurghada $L_t = 30.62\ [1 - e^{-0.359\ (t + 1.91)}]$

The values of W∞ for the *L. ehrenbergii* landed in Suez and Hurghada were obtained by applying the length-weight relationship by using the value of L∞ and were found to be 464.007 and 381.525g in Suez and Hurghada, respectively. Accordingly, the von Bertalanffy growth formula for ponderal growth, were as follows:

Suez $W_t = 464.0\ [1 - e^{-0.311\ (t + 1.21)}]^{2.982}$

Hurghada $W_t = 381.5\ [1- e^{-0.359\ (t + 1.90)}]^{2.953}$

The calculated asymptotic weight for *L. ehrenbergii* landed in Suez was greater than that in Hurghada, indicating that the species is slightly heavier in one region than the other.

The mean reported values of growth parameters (L∞ & K) of the present study along with those reported in the previous ones are given in Table (4). **Mehanna *et al.* (2017)** recorded similar results for *L. ehrenbergii* in Hurghada, with L∞ values matching our findings but a higher K value. Similarly, **Hasieb *et al.* (2024)** reported values for L∞ and K in both the Red Sea and the southern Arabian Gulf that were relatively close to those of our study. On the other hand, **Grandcourt *et al.* (2011)** presented L∞ and K values for *L. ehrenbergii* in the southern Arabian Gulf that differ significantly from our results, with a higher K value and a lower L∞. The t0 values estimated in the current study are also relatively close to those reported by **Hasieb *et al.* (2024)** for the Red Sea and southern Arabian Gulf, but much lower than the t0 value reported by **Grandcourt *et al.* (2011)** for the southern Arabian Gulf.

Table 4. Growth parameters "L∞, K and to" of *L. ehrenbergii* from different localities

Study			K/year	L∞ cm	t_0 year
Grandcourt *et al.* (2011)	Arabian Gulf		0.99	24.2	- 0.05
Mehanna *et al*. (2017)	Red Sea (Hurghada)		0.47	32.4	--
Hasieb *et al.* (2024)	Red Sea		0.32	34.8	- 1.40
	Arabian Gulf		0.32	34.8	- 1.40
Current Research	Gulf of Suez	Suez	0.31	32.8	- 1.21
		Hurghada	0.36	30.6	- 1.90

8. Growth performance index (Ø')

This index is used to measure the overall growth performance. The growth performance values in length (ΦL) for *L. ehrenbergii* were 2.52 for Suez and 2.53 for Hurghada. These values are nearly identical in the two regions, with only a slight advantage for those collected from Hurghada, which may have more favorable ecological factors for fish growth. This result is slightly lower than those reported by **Hasieb *et al*. (2024)**, suggesting that *L. ehrenbergii* in the southern Arabian Gulf (ΦL = 2.59) and the Red Sea (ΦL = 2.61) grow faster or achieve a larger asymptotic length than those in the current study.

CONCLUSION

This section presents the conclusions drawn from the findings on the blackspot snapper specimens collected from the two main landing sites in Suez and Hurghada, highlighting the key differences and their implications. While there are some similarities between the blackspot snapper populations from these regions, the differences stand out. The size range of Ehrenberg's snapper in Suez includes both smaller and larger individuals compared to Hurghada. However, the population from Hurghada gains more mass than length, suggesting that the fish in this region experience more favorable living conditions, likely due to an adequate food supply. This also implies that the stock in Hurghada may not be under immediate stress from overfishing, habitat degradation, or pollution. This is reflected in the growth rate, where fish from Hurghada grow slightly faster than those from Suez, but both populations achieve similar growth performance. Although the fish from Hurghada attain slightly lower values of L∞, both populations exhibit strong growth potential. Fisheries managers should consider these growth variations when managing stocks in different regions. Regular stock assessments are necessary to ensure that management plans and strategies are on track and to guide decision-making effectively. Authorities should also enforce strict fishing regulations to improve and maintain the health of this valuable fishery.

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