Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(4): 1115 – 1132 (2024)
www.ejabf.journals.ekb.eg

Age and Growth of the Blackspot Snapper *Lutjanus ehrenbergii* (Family: Lutjanidae), from the Red Sea and the Arabian Gulf

Hamdy E. Hasieb, Ezzat Mohammed-AbdAllah, Rashad E.M. Said*, Alaa G.M. Osman
Zoology Department, Faulty of Science, Al-Azhar University, Assiut Branch (71524), Egypt
***Corresponding author: banjawy@yahoo.com**

ARTICLE INFO

Article History:
Received: June 14, 2024
Accepted: Aug. 1, 2024
Online: Aug. 9, 2024

Keywords:
Indo-Pacific snappers,
Lutjanus ehrenbergii,
Growth data,
Otolith,
Age measurements

ABSTRACT

The present study is an integral part of our ongoing investigation on the snapper fish (Family: Lutjanidae) and their distribution between the Red Sea, Egypt, and the Arabian Gulf, Qatar. In 2022, the blackspot snapper *Lutjanus ehrenbergii* was collected from the catch landings of the two countries concurrently, and it was identified using a previously employed DNA barcoding technique. A total of 221 and 210 specimens of *L. ehrenbergii* collected from the catch landings of the Red Sea, Egypt, and the Arabian Gulf in Qatar, respectively, were employed for the purpose of the current study. Fish were dissected to determine their sex after measuring the total length (TL) for each specimen to the nearest 0.1cm and calculating the total weight to the nearest 0.1g. Ages were calculated through the reading of otolith growth rings. For *L. ehrenbergii* from the Red Sea, the results of the von Bertalanffy growth parameters were L_∞ = 35.6cm, K = 0.32y^{-1}, and t_o = - 1.30 year for *L. ehrenbergii* from the Red Sea, and L_∞ = 34.8cm, K = 0.32y^{-1}, and t_o = - 1.40 year for *L. ehrenbergii* from the Arabian Gulf. Otolith growth rings revealed a maximum lifespan of 4 years. Kc values for *L. ehrenbergii* samples from the Arabian Gulf ranged from 1.30 to 1.47, whereas samples from the Red Sea exhibited values between 1.28 and 1.48. *L. ehrenbergii* exhibits a negative allometric growth, reflected by the weight of pooled sexes increasing in proportion to less than the cube of their body length (b= 2.926 to 2.942 in fish from the Red Sea and 2.876 to 2.881 in fish from the Arabian Gulf. The current study indicates that geographical or sex-specific variations in growth should be considered upon assessing the significance of growth studies for managing fish stocks.

INTRODUCTION

Previously, we compared the ecological variables and regional variations in the snapper fish distribution between the Arabian Gulf and the Red Sea. The results suggested mapping the primary gradients in the abundance of marine fish species and communities, as well as projecting their future distribution, using extensive, fisheries-independent data **(Said *et al.*, 2024)**. As a part of our continuous research on the snapper fish from the Red Sea and the Arabian Gulf **(Galal-Khallaf *et al.*, 2024; Said *et al.*, 2024)**, the current work shed light on *L. ehrenbergii*, a common species of the snapper fish (Family: Lutjanidae), being highly and commercially valuable in Egypt and the Gulf region. The primary habitat of the snapper fish is tropical and subtropical marine waters. Their catch, therefore, is essential for both artisanal and commercial purposes worldwide. Lutjanid snappers are a commercially valuable fishery resource due to their abundance and marketability **(Randall, 1995; Teixeira *et al.*, 2010)**, making a proper identification and management of concern. However, their populations are highly vulnerable to global exploitation **(Randall, 1995; Luo *et al.*, 2009; Cowan *et al.*, 2011; Freitas *et al.*, 2011; Allen *et al.*, 2013; Guardia *et al.*, 2018; Bezerra *et al.*, 2021)**. For this reason, it is important to properly identify them, determine their age & growth and manage them. The need for reliable seafood monitoring systems has led to the documentation of numerous fish species identification methods during the last few decades **(Galal-Khallaf *et al.*, 2017)**. Marine fish subpopulations that are widely distributed often display variance in life-history traits, including asymptotic length, growth rate, reproductive effort, sex change, lifespan, and demographic rates viz. mortality and recruitment **(Trip *et al.*, 2014; Lowe *et al.*, 2021)**. Still, no research has been conducted to find and contrast the growth parameters of related species of the lutjanid snappers between the Arabian Gulf and the Red Sea. The age-based demographics and status of some commercially significant demersal species in the southern Arabian Gulf, including *Plectorhinchus sordidus, Rhabdosargus sarba, Lethrinus lentjan,* and *L. ehrenbergii,* were evaluated **(Grandcourt *et al.*, 2011)**. The two main topics of fisheries biology research are growth and aging. Thus, assessing regional differences of the same fish species or population as well as growth traits is necessary when comparing geographic variability and stock management studies. For example, recreational catches from six Gulf of Mexico locations were compared to determine the size, age distribution, and growth rates of the red snapper *L. campechanus* **(Saari *et al.*, 2014)**. Reliable age determination is necessary to build the biological variables that are the base of population estimates **(Newman *et al.*, 2000)**. Scales, vertebrae, otoliths, and other hard tissues of the fish body will all have visible markings due to seasonal variations in the aquatic environment, which includes the biological and nonbiological conditions **(Chen *et al.*, 2022)**. In this regard, **Dos Santos *et al.* (2022)** elucidated that oceanographic and environmental conditions are major drivers of stock separation. **Sadighzadeh *et al.* (2014)** investigated the otoliths of John's snapper (*L. johnii*) from the Persian Gulf and the Oman Sea to compare if they are varied among the two regions.

Typically, von Bertalanffy parameters are computed for a species in a certain geographic area, sometimes based on sex. Since sample length-at-age data are usually used to estimate parameters, von Bertalanffy growth parameters have traditionally been thought of as population parameters **(Seber & Wild, 1989; Ahmed & Mohammed-AbdAllah, 2023)**. Furthermore, the condition factor indicates the degree of the fish's well-being, relative stoutness, and fatness; it also communicates how well the living conditions are suited for a particular type of fish. The otoliths of commercially significant species are often collected for the purposes of biological research, fisheries tracking, and evaluations **(Takahashi *et al.*, 2023)**. The otolith width and length are assessed as reliable measures of fish length **(Al-Busaidi *et al.*, 2017)**. Furthermore, along the central Brazilian coast, three simple fishing indicators were developed utilizing otolith-based methodologies and catch lengths to assess the status of the stock of *L. synagris* **(Aschenbrenner *et al.*, 2017)**. Numerous studies were carried out using the age and growth characteristics of fish living in a certain area. For example, combining biological and size-at-age data, the population dynamics, and the reproductive biology of *L. fulviflamma* in the Arabian Gulf were examined **(Grandcourt *et al.*, 2006)**. **Jawad *et al.* (2018)** utilized color patterns in addition to meristic and morphometric traits to identify expansion range of the blubberlip snapper *L. rivulatus* into the Arabian Gulf. Also, **Soliman *et al.* (2018)** identified the five-lined snapper, *L. quinquelineatus*, from the Red Sea, Egypt. Furthermore, **Soliman *et al.* (2020)** used meristic and morphometric traits as well as SDS-PAGE for muscle proteins to determine the morphological and genetic relationship of two species of *L. quinquelineatus* and *L. ehrenbergii* in the Red Sea. Recently, **Griffiths *et al.* (2024)** presented the phylogeography of *L. ehrenbergii*, which is found in the coastal waters of the Arabian Peninsula. One of the interesting lutjanids is the species *L. ehrenbergii*, which is usually found on rocky substrates and coral reefs, moreover it is widespread across the Indo-Pacific area. The distribution of the snapper fish between the Red Sea, Egypt, and the Arabian Gulf water in Qatar has been precisely determined **(Galal-Khallaf *et al.*, 2024)** using the DNA-barcoding approach. However, their comparative age and growth variation between the two regions is lacking. The primary goal of the current work was to use otolith increment counts to compare biological measurements and fishery status to provide the first age-based demographic parameter estimates for *L. ehrenbergii*, a common snapper identified between the Arabian Gulf and the Red Sea.

MATERIALS AND METHODS

1. Study area

Two geographic water bodies (the Egyptian Red Sea and the Arabian Gulf), both semi-enclosed basins in the western Indo-Pacific, were chosen to carry out the current investigation (Fig. 1).

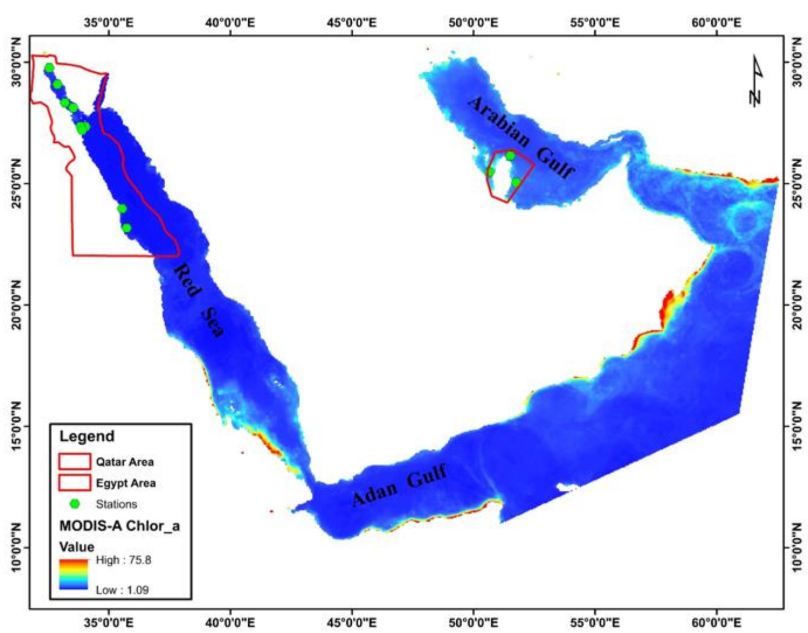


Fig. 1. Map showing the studied areas and the catch sites of *L. ehrenbergii* from the Egyptian Red Sea and the Arabian Gulf **(Said *et al*, 2024)**

2. **Studied snapper species,** L. ehrenbergii

A total of 221 and 210 specimens of *L. ehrenbergii* (Fig. 2) were monthly collected from the catch landings of the Red Sea, Egypt, and the Arabian Gulf, Qatar, respectively, during 2022. The total length (TL) of each specimen was measured to the nearest 0.1 cm, and the total weight was recorded to the nearest 0.1 g. Each specimen was then dissected to determine its sex. The otoliths of samples were removed and examined under the microscope for age determination.

Fig. 2. The blackspot snapper *Lutjanus ehrenbergii*

3. The length-weight relationship

The length-weight relationship was estimated using Le Cren's formula **(Le Cren, 1951)** as follows:

$$W = aTL^b$$

Where, W is the total weight; a is the intercept, and b is the slope or exponent. Student's t-test was used to ascertain statistically significant differences between the current b values and the hypothetical value ($H_o = 3$).

The absolute condition factor (Kc) was estimated according to **Bagenal and Ricker (1978)**:

$$Kc = W/TL^3 * 100$$

To estimate the growth parameters of the von Bertalanffy model **(von Bertalanffy, 1938)**, the length-at-age data of *L. ehrenbergii* was analyzed using the non-linear least-squares regression in the FiSAT II software **(Gayanilo Jr, Sparre, & Pauly, 1996)**, including the asymptotic length (L_∞), growth coefficient (K), and theoretical age at which the length is zero (t_o). The von Bertalanffy equation, $L_t = L_\infty{}^{(1 - e{-}K(t - to)})$, was used to model the relationship between length (L_t) and age (t) of the fish. To compare the growth rate of *L. ehrenbergii* between the two regions, the growth performance index was used **(Pauly, 1979)** as follows:

$$\varphi = \log K + 2 \log L_\infty$$

Where, L_∞ and K are the growth parameters of the von Bertalanffy.

Longevity (t_{max}) was estimated according to **Beverton (1963)** as:

$$t_{max} = 3/K$$

Where, K is the VBGE growth coefficient.

RESULTS

A total of 221 *L. ehrenbergii* specimens (3 unsexed, 98 males and 120 females) ranged in length from 15.0 to 29.0cm TL and in weight from 44.7 to 320.5g, collected from the Red Sea, Egypt, and 210 *L. ehrenbergii* specimens (4 unsexed, 89 males and 117 females) ranged in length from 12.2 to 28.4cm TL and in weight from 28.5 to 316.3g, collected from the Arabian Gulf, Qatar (Table 1).

1. Length-weight relationships

Table (1) shows the equations describing the TL–total weight relationship of males, females, and combined sexes of *L. ehrenbergii* from the Red Sea and the Arabian Gulf, and they are graphically illustrated in Figs. (3, 4), respectively. The LWR exponent (b) values for males, females, and combined sexes of *L. ehrenbergii* from the Red Sea, Egypt were 2.926, 2.942 and 2.929, respectively, and from the Arabian Gulf in Qatar, values were 2.881, 2.876 and 2.876, respectively. The significance deviated from the expected value of b = 3 for *L. ehrenbergii* for both sexes and combined sexes by using the t-test, which revealed a negative allometric growth for separated and combined sexes.

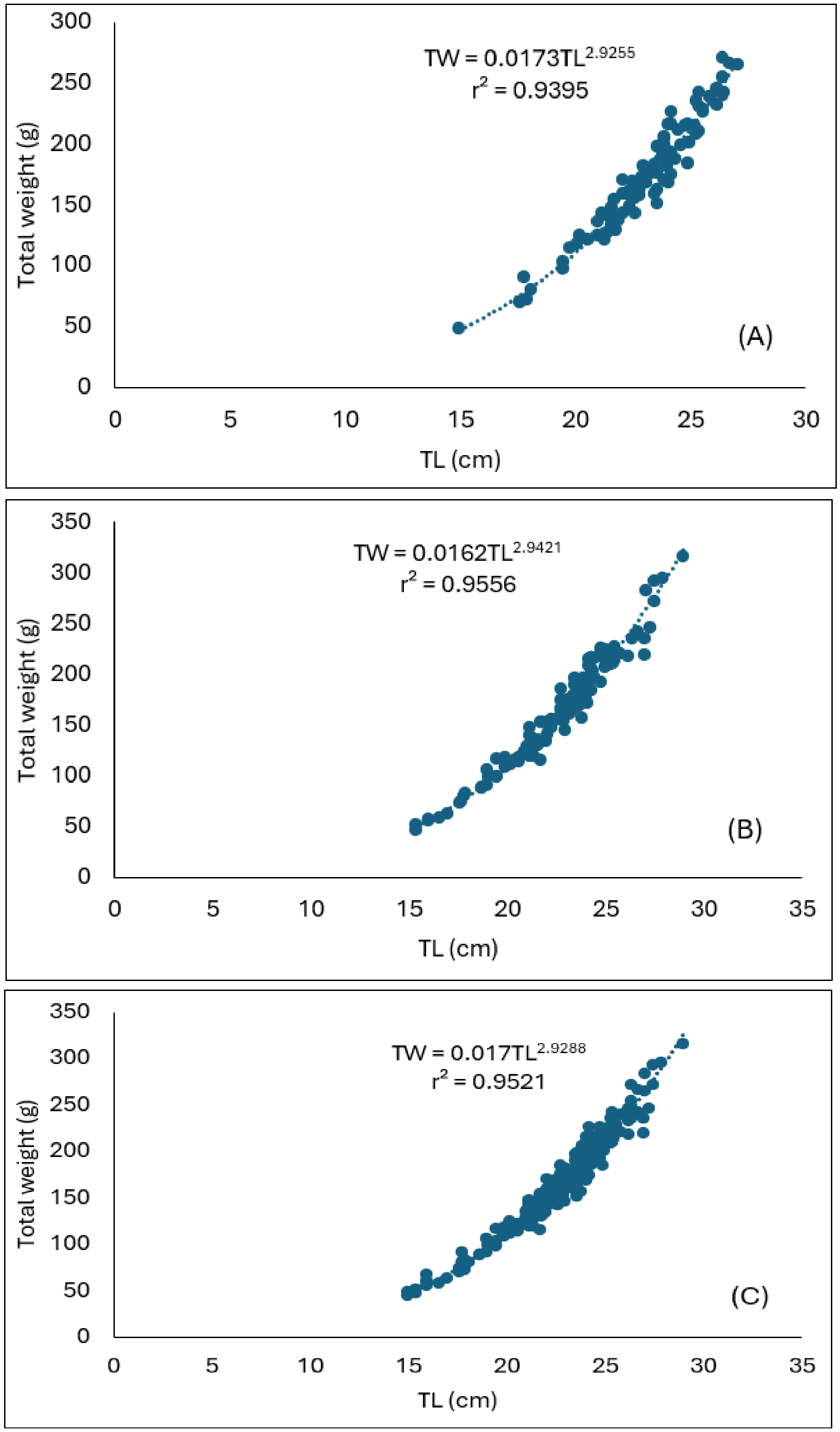


Fig. 3. TL–total weight relationship for (A) males, (B) females, and (C) combined sexes of *L. ehrenbergii* from the Red Sea, Egypt in 2022

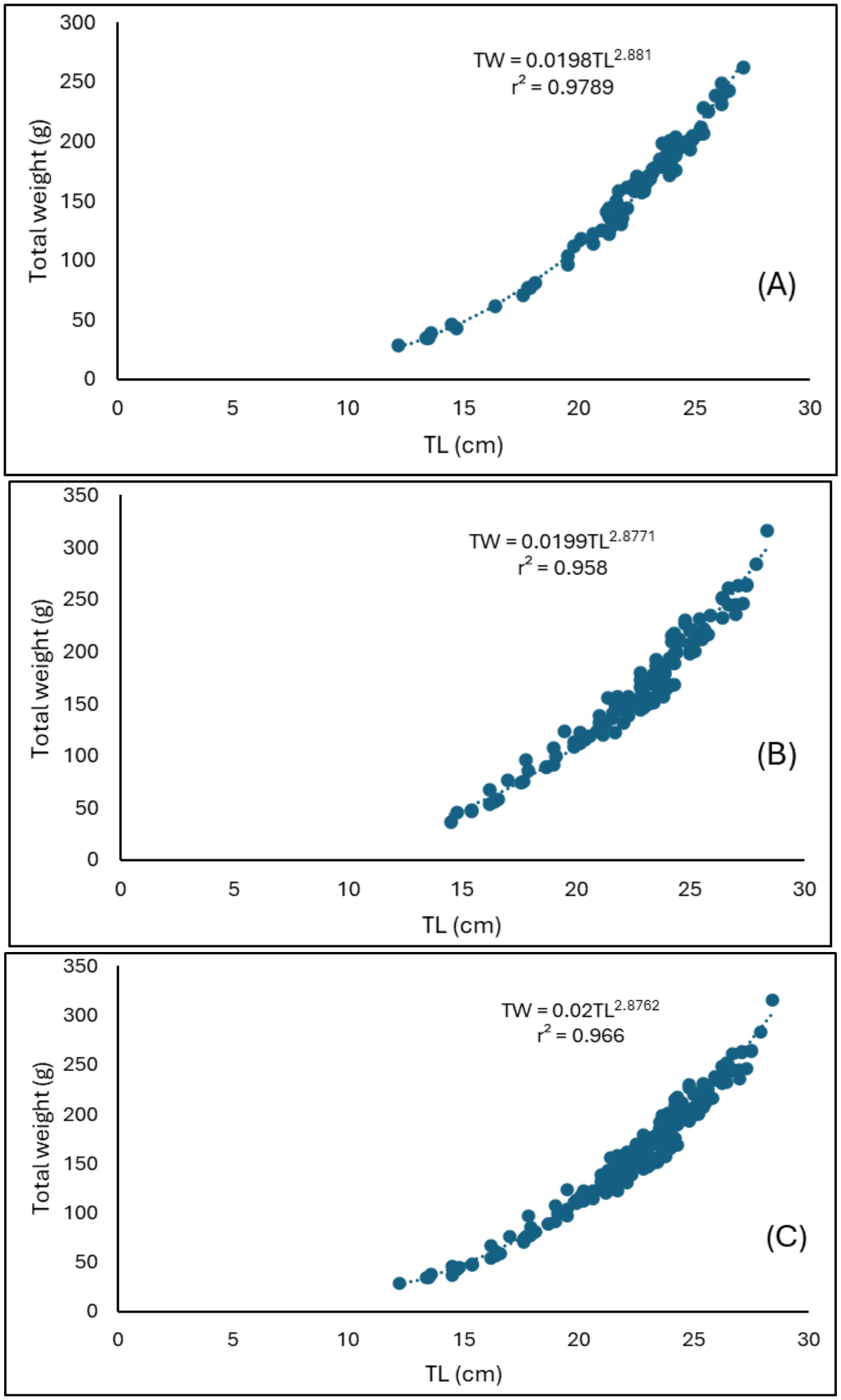


Fig. 4. TL–total weight relationship for (A) males, (B) females, and (C) combined sexes of *L. ehrenbergii* from the Arabian Gulf, Qatar in 2022

Table 1. Descriptive statistical and parameters of TL–total weight relationship for males, females, and combined sexes of *L. ehrenbergii* from the Red Sea, Egypt and from the Arabian Gulf, Qatar in 2022

Region	Sex	n	Total length			Total weight			Parameter of LWRs		
			Min.	Max.	Mean± SD	Min.	Max.	Mean± SD	a	b	r^2
Red Sea	Unsexed	3	15.0	16.0	15.7±0.6	44.7	66.0	56.7±11.4	-	-	-
	Males	98	15.0	27.1	23.1±2.2	48.6	270.2	172.9±45.8	0.0173	2.926	$r^2 = 0.939$
	Females	120	15.4	29.0	22.7±2.7	46.0	320.5	165.1±53.8	0.0162	2.942	$r^2 = 0.956$
	Combined sexes	221	15.0	29.0	22.8±2.6	44.7	320.5	167.1±51.7	0.017	2.929	$r^2 = 0.952$
Arabian Gulf	Unsexed	4	12.2	14.7	13.5±1.0	28.5	42.5	34.9±5.8	-	-	-
	Males	89	13.6	27.1	22.7±2.5	38.5	262.6	165.5±45.3	0.0198	2.881	$r^2 = 0.979$
	Females	117	14.5	28.4	22.7±3.0	36.5	316.3	165.3±56.9	0.0199	2.877	$r^2 = 0.958$
	Combined sexes	210	12.2	28.4	22.5±3.1	28.5	316.3	162.9±54.6	0.020	2.876	$r^2 = 0.966$

SD: standard deviation, n: number of fish, a: intercept; b: slope, r^2: correlation of determination.

2. The condition factor (Kc)

The monthly absolute condition factor (Kc) values of separated and combined sexes of *L. ehrenbergii*, collected from the Red Sea and the Arabian Gulf are shown in Fig. (5A, B), respectively. The Kc values of *L. ehrenbergii* collected from the Red Sea ranged from 1.28 to 1.45 in males, from 1.31 to 1.48 in females, and from 1.31 to 1.46 in combined sexes, while, values ranged from 1.30 to 1.44 in males, from 1.33 to 1.47 in females, and from 1.32 to 1.45 in combined sexes of *L. ehrenbergii* collected from the Arabian Gulf. The results showed that Kc attained higher values during May for males, females, and combined sexes of *L. ehrenbergii* collected from the Red Sea, and during April for males, females, and combined sexes of *L. ehrenbergii* collected from the Arabian Gulf. The lower Kc values were found in October for separated and combined sexes of *L. ehrenbergii* from the Red Sea and were found in September for separated and combined sexes of *L. ehrenbergii* from the Arabian Gulf.

3. Aging, growth parameters, and theoretical growth

A total of 221 otoliths of *L. ehrenbergii* from the Red Sea and 210 otoliths of *L. ehrenbergii* from the Arabian Gulf were examined and revealed that the maximum lifespan was 4 years. The mean lengths of *L. ehrenbergii* at each age group (I, II, III, and IV) were 19.3, 23.2, 25.9 and 28.2cm, respectively, from the Red Sea and they were 19.2, 22.9, 25.5 and 27.6cm, respectively, from the Arabian Gulf (Table 2). The growth in length of *L. ehrenbergii* from the Red Sea and the Arabian Gulf are illustrated in Fig. (6A, B), respectively. The growth in weight from the two regions are illustrated in Fig. (7A, B), respectively. The non-linear least squares revealed the following VBG parameters: L_∞ = 35.6cm (SE = 4.2206 & CV = 0.1181), K = 0.32 y^{-1} (SE = 0.103 & CV = 0.324), and t_o = - 1.30 year for *L. ehrenbergii* from the Red Sea, and L_∞ = 34.8cm (SE = 3.493 & CV = 0.1004), K = 0.32 y^{-1} (SE = 0.088 & CV = 0.274), and t_o = - 1.40 year for *L. ehrenbergii* from the Arabian Gulf. For *L. ehrenbergii* from the Red Sea, the VBG equation of length was $L_t = 35.6 [1 - e^{-0.32(t + 1.3)}]$ and that for weight was $W_t = 595.2 (1 - e^{-0.32(t + 1.3)})^{2.929}$. The

Φ was 2.61, and the t_{max} was 8.08 years. For *L. ehrenbergii* from the Arabian Gulf, the VBG equation of length was $L_t = 34.8\ [1 - e^{-0.32(t + 1.4)}]$ and that for weight was $W_t = 542.8\ (1 - e^{-0.32(t + 1.4)})^{2.976}$. The Φ was 2.59, and the t_{max} was 7.98 years. Fig. (8A, B) illustrates the growth curve of *L. ehrenbergii* from the Red Sea, Egypt and the Arabian Gulf, respectively.

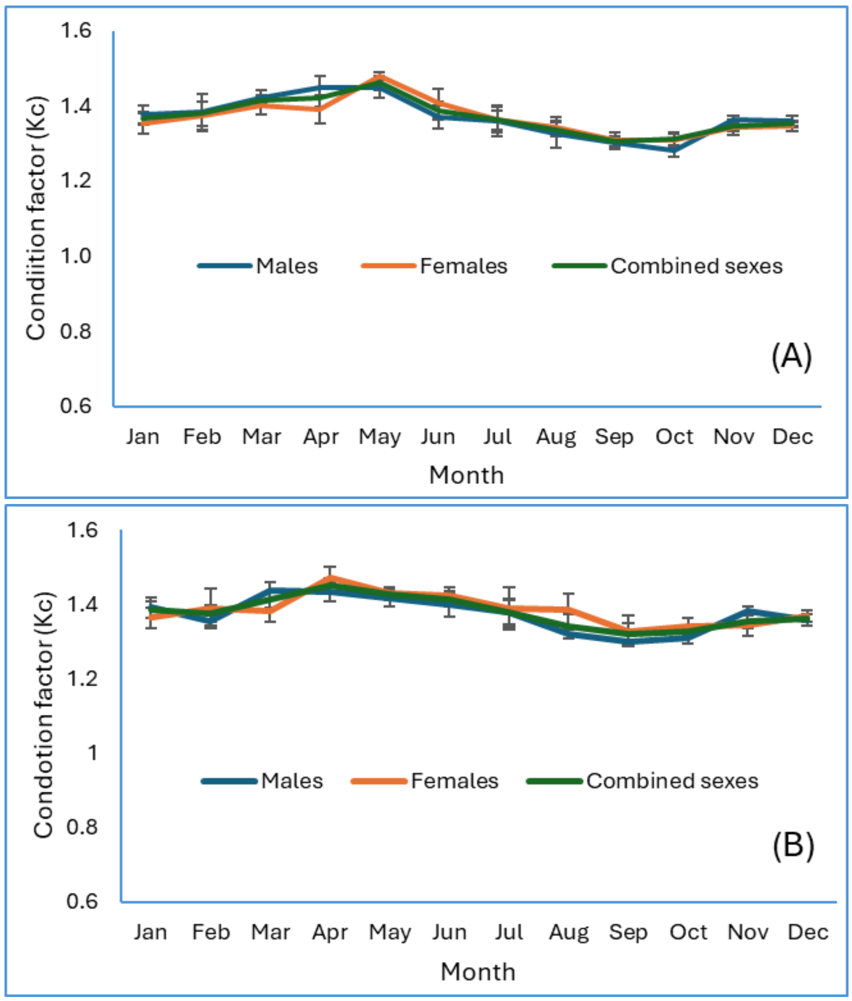


Fig. 5. Monthly average absolute condition factor for males, females, and combined sexes of *L. ehrenbergii* from the Red Sea, Egypt (A) and from the Arabian Gulf, Qatar (B) in 2022

Table 2. Mean lengths and weights and increment at each age group of *L. ehrenbergii* from the Red Sea, Egypt and from the Arabian Gulf, Qatar in 2022 estimated by otolith reading

Region	Age group	n	Total length				Total weight			
			Min.	Max.	Mean ± SD	Increment	Min.	Max.	Mean ± SD	Increment
Red Sea	I	57	15.0	21.7	19.3±2.0	19.3	44.0	152.2	94.1±29.6	94.1
	II	117	21.6	25.0	23.2±0.9	3.9	129.0	225.4	168.3±22.2	74.2
	III	44	24.4	27.5	25.9±0.8	2.6	184.0	291.7	241.9±22.9	73.6
	IV	3	27.1	29.8	28.2±1.4	2.3	284.7	315.0	312.4±25.3	70.5
Arabian Gulf	I	56	12.2	21.6	19.2±1.9	19.1	28.5	150.0	93.6±34.8	93.6
	II	97	20.8	24.8	22.9±0.8	3.8	122.2	215.3	162.5±19.7	69.0
	III	51	24.2	27.5	25.5±0.8	2.5	168.8	263.5	227.3±20.9	64.8
	IV	6	27.1	28.4	27.6±0.5	2.2	256.3	316.3	292.8±24.4	65.5

SD: standard deviation, n: number of fish.

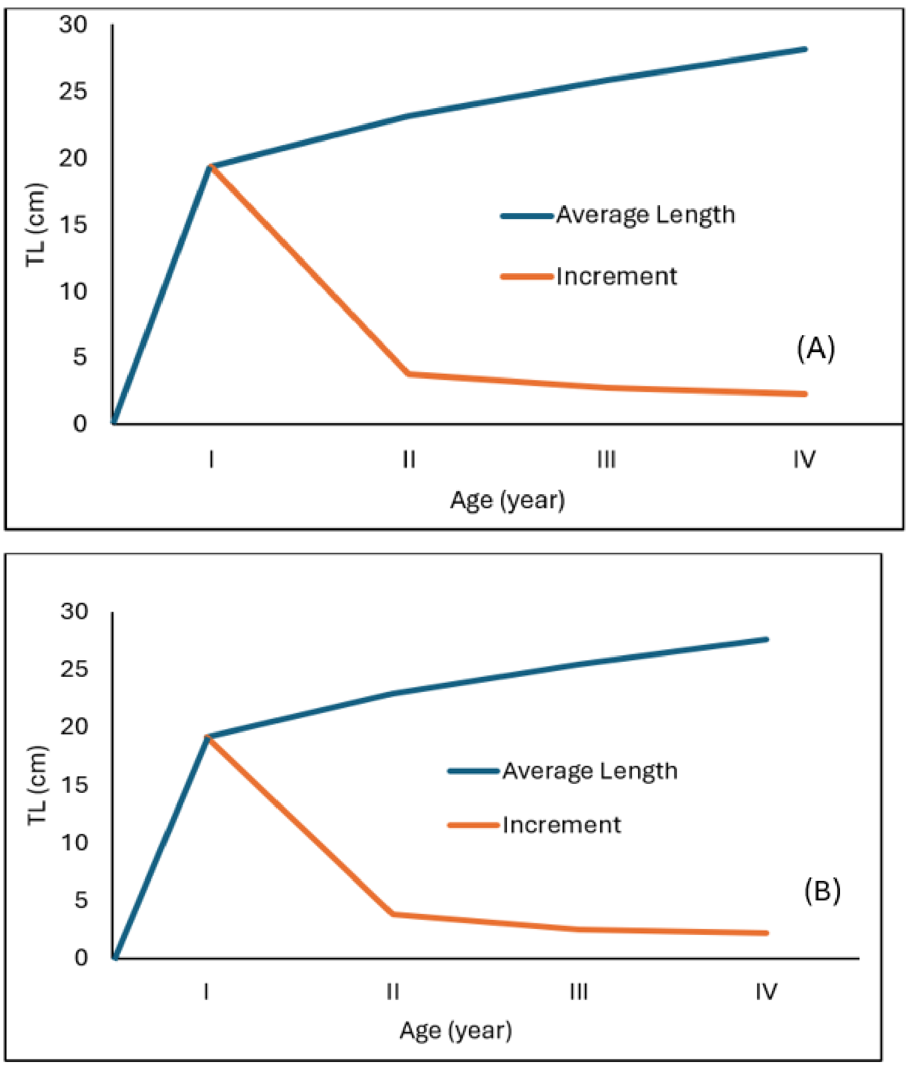


Fig. 6. Growth curve in lengths and annual increment of *L. ehrenbergii* from the Red Sea, Egypt (A) and the Arabian Gulf, Qatar (B) in 2022

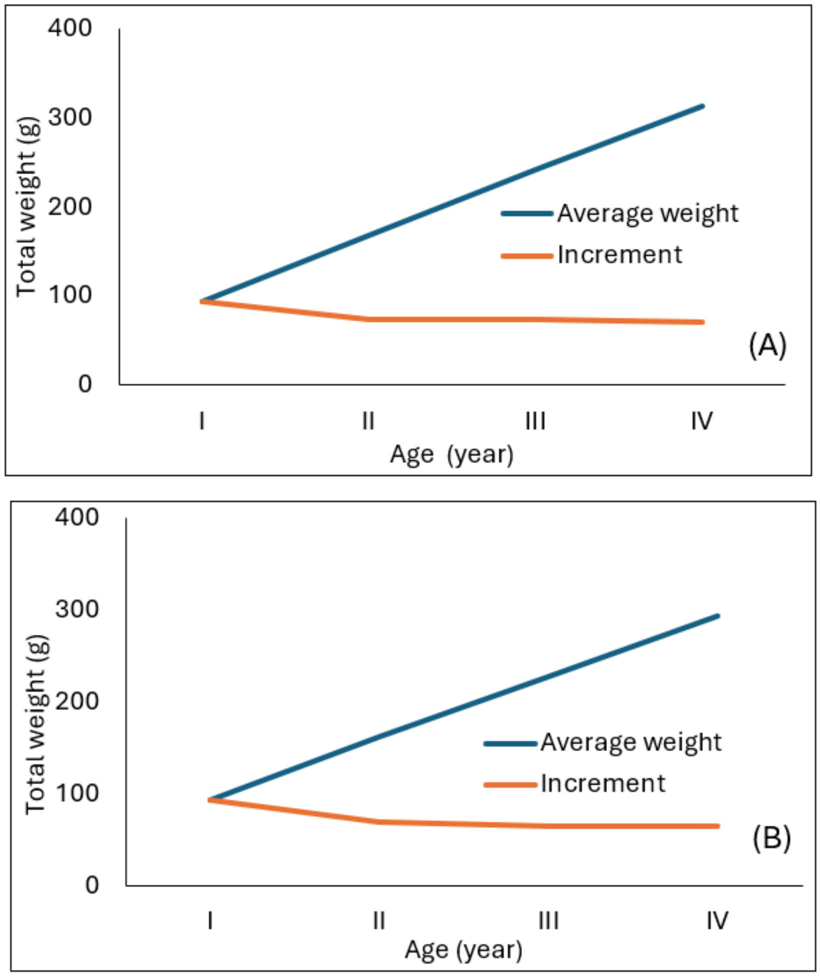
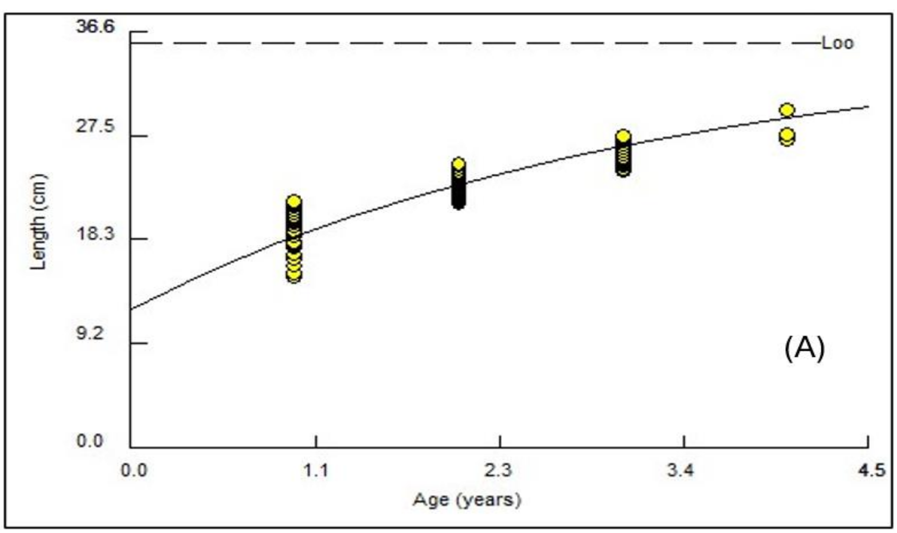


Fig. 7. Growth curve in weights and annual increment of *L. ehrenbergii* from the Red Sea, Egypt (A) and the Arabian Gulf, Qatar (B) in 2022



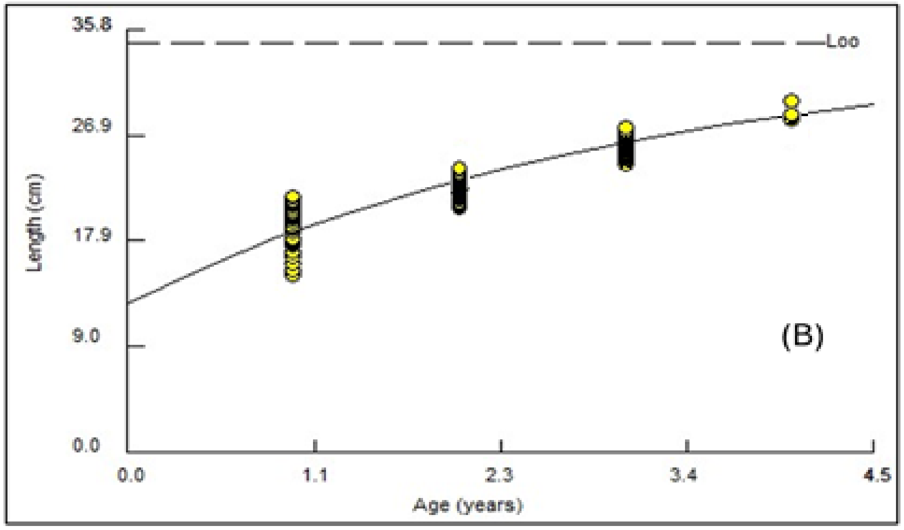


Fig. 8. Growth curve estimated from length-at-age data of *L. ehrenbergii* from the Red Sea, Egypt (A) and the Arabian Gulf, Qatar (B) in 2022

.

DISCUSSION

The slight variation in *L. ehrenbergii's* growth traits and age between the two regions is most likely due to multivariate factors. Accordingly, three sites along the northeast coast of Kodiak Island, Alaska, were shown to have significantly different growth rates of the rock sole *Lepidopsetta polyxystra* **(Hurst & Abookire, 2006)** . A related study **(Saari *et al.*, 2014)** found significant demographic differences in the size, age, and growth of the red snapper (*L. campechanus*) sampled from six distinct places along the Gulf of Mexico, as well as a drastically shorter age structure, which may be attributed to environmental differences, fishing pressure, and habitat preference. The authors attributed this fluctuation to changes in site temperatures. Indeed, our former work revealed regional variability and anomaly in term of SST and Ch-*a* between the Red Sea and the Arabian Gulf **(Said *et al.*, 2024)**. On the other hand, the availability of food, the condition of the coral reef, and pollution are important variables that influence fish size as well as population diversity. Interannual variations in growth can also occur as a result of outside influences such as fishing pressure and environmental changes **(Burton & Potts, 2017)**. One argument is that primary production is lower in more tropical seas, like the Caribbean, which results in a smaller food base and slower fish growth **(Garcia *et al.*, 2003)**. In consistence, differences in size-at-age of white grunt, *Haemulon plumieri*, from south Florida and the Caribbean were reported **(Potts, 2023)**.

We noticed a relationship between fish production and time series study of specific marine conditions within the Red Sea basin, Egypt **(Khaled *et al.*, 2023)**. **Boehlert and Yoklavich (1983)** combined these variables early and concluded that fish under starvation experienced an increase in weight loss as temperature increased. Differences in the growth performance of the notothenioid fish from the seasonal pack-ice zone and the high Antarctic zone could be explained by food availability and physiological changes **(Mesa & Vacchi, 2001)**. Similar to the current study, age, and growth of the red snapper *L. campechanus* in the western Gulf of Mexico were compared in artificial and natural habitats **(Streich *et al.*, 2017)**. Their results indicated that, in comparison to standing platforms or artificial reefs, the size and age frequencies of the snappers inhabiting natural banks supported a higher proportion of large and quite elderly fish, even though the mean age did not differ significantly among habitat types. Consequently, the influence of environmental changes on fish ecosystems can be evaluated by comparing fisheries status and fish characteristics across different regions or time periods, providing crucial environmental surveillance knowledge **(Santana *et al.*, 2020; Khaled *et al.*, 2023; Said *et al.*, 2024)**. The VBG L_∞ parameter **(Grandcourt *et al.*, 2011)** of *Lutjanus ehrenbergii* from the southern Arabian Gulf (off the coast of the Emirate of Abu Dhabi in the United Arab Emirates), had comparable values (L_∞= 24cm) compared to the current results (L_∞= 34.8cm) for those from Qatari waters. Similar to the current study, **Sadighzadeh *et al.* (2014)** investigated the morphology of the snapper *L. johnii* otoliths from the Persian Gulf and the Oman Sea to determine if it could be used to differentiate between populations. They noted a strong correlation between otolith weight and fish length in both areas, even if the two populations differed significantly. Fish length and weight, which are the typical measurable variables in the field, are good indicators of the environmental conditions of the habitat in which the fish live, especially the availability of food. Thus, the calculated growth in length to the matching growth in weight is reflected in the relationship **(Abu El-Nasr, 2017)**. The significance of length-weight relationships (LWRs) and condition factor in fishery assessment studies lies in its ability to offer insights into fish growth, overall health, and suitability in marine environments **(Jisr *et al.*, 2018)**. The findings demonstrated that males, females, and combined sexes of *L. ehrenbergii* obtained from the Red Sea and the Arabian Gulf in April and May, respectively, attained greater values of Kc. The lower Kc values was found in September for the separated and combined sexes of *L. ehrenbergii* from the Arabian Gulf and in October for the separated and combined sexes from the Red Sea. These results are in line with those of **De Giosa *et al.* (2014)**, concluding that the seasonality indicated by the growth curve and condition factor may be attributed to different environmental variables as well as different spawning, breeding, and feeding activities across the seasons. With LWR exponent (b) fluctuating from 2.926 to 2.942 in fish from the Red Sea and 2.876 to 2.881 in fish from the Arabian Gulf, no positive allometry was detected for any of the sampled fish. These results are consistent with previous regional and international research on fish biometrics. For example, *Gerres filamentosus* from the Red Sea, Egypt, exhibited negative (2.9) allometry **(Abu El-Nasr, 2017)**. Additionally, **Abdellatif *et al.* (2022)** reported a negative allometric (2.79 to 2.87) growth of *Chrysichthys auratus*. The current finding allometry strongly agrees with the outcome of the study of **Grandcourt *et al.* (2011)** on *L. ehrenbergii, L. lentjan*, *Plectorhinchus auratus* and *R. sarba* from the southern Arabian Gulf, which gave a negative allometry as 2.97, 2.88, 2.75 and 2.94, respectively. On the other hand, other studies reported a positive allometric growth from different fish species for *Schizothorax eurystomus* **(Karimov *et al.*, 2024)** and *Sardinella melanura* **(Kunlapapuk *et al.*, 2024)**. When a fish gains length, weight, and a deeper body, this is known as a positive allometric growth. Conversely, the negative allometric growth occurs when a fish grows longer during its development but significantly lighter or slenderer as it matures **(Famoofo & Abdul, 2020)**. **Jisr *et al.* (2018)** demonstrated that for *Liza ramada*, *Oblada melanura*, and *Epinephelus costae*, there was a substantial difference in the b values during the warm and cold periods. Totally, understanding variations in stock demography at the regional or even habitat level is the last factor affecting the overall stock productivity **(Streich *et al.*, 2017)**.

CONCLUSION

Fisheries research will benefit from the age and growth study of *L. ehrenbergii* from the Arabian Gulf and the Egyptian Red Sea, as well as from earlier research on the Lutjanidae family. The species under investigation, *L. ehrenbergii*, shares the same Indo-Pacific origin, and their growth data were expected to vary significantly due to the higher temperature of the Arabian Gulf compared to that of the Red Sea. However, the two populations exhibited similar measurements in growth and age data between the Red Sea and the Arabian Gulf. Despite this, geographic or sex-specific growth deviations and adaptation, all should be considered when evaluating the significance of growth studies for managing fish stocks.

REFERENCES

Abdellatif, M; Mohammed-AbdAllah, E; AbouelFadl, K. Y. and **Osman, A. G. M.** (2022). Age and growth of Chrysichthys auratus (Geoffroy 1809) (Family: Claroteidae) from Lake Nasser, Egypt. Egyptian Journal of Aquatic Research, *48*(4), **:** 417-424.

Abu El-Nasr, T. M. A. (2017). **Age and growth of the fish, Gerres filamentosus (Cuvier, 1829)** from Hurghada Red Sea, Egypt. Egyptian Journal of Aquatic Research, *43*(3), 219-227.

Ahmed, A. S. and **Mohammed-AbdAllah, E.** (2023). Assessing fishery status and sustainable exploitation of spotted seabass (*Dicentrarchus punctatus*) in Bardawil Lagoon, Eastern Mediterranean, Egypt. Egyptian Journal of Aquatic Research, *49*(3), 353-359.

Al-Busaidi, H. K; Jawad, L. A. and **Al-Balushi, A. H.** (2017). Relationships between fish and otolith size of the blackspot snapper *Lutjanus ehrenbergii* (Peters, 1869) collected from the coast of Muscat City, Sea of Oman. International Journal of Marine Science, *7*.

Allen, G. R; White, W. T. and **Erdmann, M. V.** (2013). Two new species of snappers (Pisces: *Lutjanidae: Lutjanus*) from the Indo-West Pacific. Journal of the Ocean Science Foundation, *6*, 33-51.

Aschenbrenner, A; Freitas, M. O; Rocha, G. R. A; Moura, R. L. d; Francini-Filho, R. B; Minte-Vera, C. and **Ferreira, B. P.** (2017). Age, growth parameters and fisheries indices for the lane snapper in the Abrolhos Bank, SW Atlantic. Fisheries Research, *194*, 155-163.

Bagenal, T. B. and **Ricker, W. E.** (1978). *Methods for assessment of fish production in fresh waters / edited by Timothy Bagenal* (Third edition.. ed.): Oxford [England] Philadelphia: Oxford England : Blackwell Scientific.

Beverton, R. J. H. (1963). *Maturation, growth and mortality of clupeid and engraulid stocks in relation to fishing. Rap. P. V. Réun. Cons. int. Expl. Mer 154:44-6*.

Bezerra, I. M; Hostim-Silva, M; Teixeira, J. L. S; Hackradt, C. W; Félix-Hackradt, F. C. and **Schiavetti, A.** (2021). Spatial and temporal patterns of spawning aggregations of fish from the Epinephelidae and Lutjanidae families: An analysis by the local ecological knowledge of fishermen in the Tropical Southwestern Atlantic. Fisheries Research, *239*, 105937.

Boehlert, G. W. and **Yoklavich, M. M.** (1983). Effects of temperature, ration, and fish size on growth of juvenile black rockfish, *Sebastes melanops*. Environmental Biology of Fishes, *8*(1), 17-28.

Burton, M. L. and **Potts, J. C.** (2017). Age, growth, and natural mortality of cubera snapper, *Lutjanus cyanopterus*, from the southeastern United States. Bulletin of Marine Science, *93*(3), 815-828.

Chen, X; Liu, B. and **Fang, Z.** (2022). Age and Growth of Fish. In X. Chen and B. Liu (Eds.), *Biology of Fishery Resources* (pp. 71-111): Singapore: Springer Nature Singapore.

Cowan, J. H; Grimes, C. B; Patterson, W. F; Walters, C. J; Jones, A. C; Lindberg, W. J; Gibson, H.T. and Rose, K. A. (2011). Red snapper management in the Gulf of Mexico: science- or faith-based? Reviews in Fish Biology and Fisheries, *21*(2), 187-204.

De Giosa, M; Czerniejewski, P. and **Rybczyk, A.** (2014). Seasonal Changes in Condition Factor and Weight-Length Relationship of Invasive *Carassius gibelio* (Bloch, 1782) from Leszczynskie Lakeland, Poland. Advances in Zoology, *2014*(1), 678763.

Dos Santos, J. B. Q; Chiessi, C. M; Crivellari, S; Vasconcelos Filho, J. E. d; Pereira, N. S; Freitas, M. O. and **Ferreira, B. P.** (2022). Identification of western South Atlantic stocks of the Lane snapper (*Lutjanus synagris*) from an otolith based multi-proxy approach. Fisheries Research, 253, 106356.

Famoofo, O. and **Abdul, W.** (2020). Biometry, condition factors and length-weight relationships of sixteen fish species in Iwopin fresh-water ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria. Heliyon, *6*(1).

Freitas, T. M. d. S; Almeida, V. H. d. C; Valente, R. d. M. and **Montag, L. F. d. A.** (2011). Feeding ecology of *Auchenipterichthys longimanus* (Siluriformes: Auchenipteridae) in a riparian flooded forest of Eastern Amazonia, Brazil. Neotropical Ichthyology, *9*, 629-636.

Galal-Khallaf, A; Elberri, A. I; Mohammed-Geba, K; Hasieb, H. E; Said, R. E. M; Mohammed-AbdAllah, E. and **Osman, A. G. M.** (2024). DNA barcoding for different Egyptian and Qatari common snappers reveals unexpected cryptic lineages in the blackspot snapper *Lutjanus ehrenbergii*.

Galal-Khallaf, A; Mohammed-Geba, K; Osman, A. G. M; AbouelFadl, K. Y; Borrell, Y. J. and **Garcia-Vazquez, E.** (2017). SNP-based PCR-RFLP, T-RFLP and FINS methodologies for the identification of commercial fish species in Egypt. Fisheries Research, *185*, 34-42.

Garcia, E. R; Potts, J. C; Rulifson, R. A. and **Manooch, C. S.** (2003). Age and growth of yellowtail snapper, *Ocyurus chrysurus*, from the southeastern United States. Bulletin of Marine Science, *72*(3), 909-921.

Gayanilo Jr, F; Sparre, P. and **Pauly, D.** (1996). The FAO-ICLARM stock assessment tools (FiSAT) user's guide. FAO computerized information series (Fisheries), *8*, 1-126.

Grandcourt, E; Al Abdessalaam, T. Z; Francis, F. and **Al Shamsi, A.** (2011). Demographic parameters and status assessments of *Lutjanus ehrenbergii*, *Lethrinus lentjan*, *Plectorhinchus sordidus* and *Rhabdosargus sarba* in the southern Arabian Gulf. Journal of Applied Ichthyology, *27*(5), 1203-1211.

Grandcourt, E. M; Abdessalaam, T. Z. A. and **Francis, F.** (2006). Age, growth, mortality and reproduction of the blackspot snapper, *Lutjanus fulviflamma* (Forsskål, 1775), in the southern Arabian Gulf. Fisheries Research, *78*(2), 203-210.

Griffiths, M. H; Wade, C. M; D'Agostino, D; Berumen, M. L; Burt, J. A; DiBattista, J. D. and **Feary, D. A.** (2024). Phylogeography of a commercially important reef fish, *Lutjanus ehrenbergii*, from the coastal waters of the Arabian Peninsula. Biological Journal of the Linnean Society.

Guardia, E. d. l; Giménez-Hurtado, E; Defeo, O; Angulo-Valdes, J; Hernández-González, Z; Espinosa–Pantoja, L; Gracía-López,L. and Arias-González, J. E. (2018). Indicators of overfishing of snapper (Lutjanidae) populations on the southwest shelf of Cuba. Ocean and Coastal Management, *153*, 116-123.

Hurst, T. P. and **Abookire, A. A.** (2006). Temporal and spatial variation in potential and realized growth rates of age-0 year northern rock sole. Journal of Fish Biology, *68*(3), 905-919.

Jawad, L; Al-Marzouqi, A; Al-Anbory, I. and **Al-Senaidi, R.** (2018). Range extension of Blubberlip Snapper *Lutjanus rivulatus* (Teleostei: Lutjanidae) to the Arabian Gulf. J ocea sci found, *30*, 78-81.

Jisr, N; Younes, G; Sukhn, C. and **El-Dakdouki, M. H.** (2018). Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. Egyptian Journal of Aquatic Research, *44*(4), 299-305.

Karimov, E; Zeiringer, B; Coeck, J; Verhelst, P; Karimov, B; Omonov, O; Schletterer, M. and **Hayes, D. S.** (2024). Length-Weight-Age Relationship of *Schizothorax eurystomus* Kessler, 1872 and Comparison to Other Snow Trout Species in Central Asia. Fishes, *9*(3), 94.

Khaled, M. A; Al-Jamali, F. H; Said, R. E. M; Mohammad, A. S; Ahmed, M. H. and **Ahmed, H. O.** (2023). Analysis of SST and Chl-a data from MODIS-Aqua in the Major Egyptian Fishing Zones of the Red Sea. Egyptian Journal of Aquatic Research, *49*(4), 520-529.

Kunlapapuk, S; Boonnom, S; Klangrahad, C; Siriwong, P. and **Kongchum, P.** (2024). Length–weight relationship and reproductive biology aspects of *Sardinella melanura* caught from the coastal waters of Phetchaburi, the Inner Gulf of Thailand. Fisheries Science, *90*(2), 191-200.

Le Cren, E. D. (1951). The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in the Perch (*Perca fluviatilis*). Journal of Animal Ecology, *20*(2), 201-219.

Lowe, J. R; Payet, S. D; Harrison, H. B; Hobbs, J. P. A; Hoey, A. S; Taylor, B. M; Sinclair-Taylor, T. H. and **Pratchett, M. S.** (2021). Regional versus latitudinal variation in the life-history traits and demographic rates of a reef fish, Centropyge bispinosa, in the Coral Sea and Great Barrier Reef Marine Parks, Australia. Journal of Fish Biology, *99*(5), 1602-1612.

Luo, J; Serafy, J. E; Sponaugle, S; Teare, P. B. and **Kieckbusch, D.** (2009). Movement of gray snapper *Lutjanus griseus* among subtropical seagrass, mangrove, and coral reef habitats. Marine Ecology Progress Series, *380*, 255-269.

Mesa, M. L. and **Vacchi, M.** (2001). Age and growth of high Antarctic notothenioid fish. Antarctic Science, *13*(3), 227-235.

Newman, S. J; Cappo, M. and **Williams, D. M.** (2000). Age, growth, mortality rates and corresponding yield estimates using otoliths of the tropical red snappers, *Lutjanus erythropterus*, L. *malabaricus* and L. *sebae*, from the central Great Barrier Reef. Fisheries Research, *48*(1), 1-14.

Pauly, D. (1979). Gill size and temperature as governing factors in fish growth: a generalization of von Bertalanffy's growth formula.

Potts, J. C. (2023). *Age and growth of vermilion snapper, Rhomboplites aurorubens, from the southeastern United States.* East Carolina University,

Randall, J. (1995). Coastal fishes of Oman. University of Hawaii Press: Honolulu.

Saari, C. R; Cowan Jr, J. H; and **Boswell, K. M.** (2014). Regional differences in the age and growth of red snapper (*Lutjanus campechanus*) in the US Gulf of Mexico. *Fishery Bulletin*.

Sadighzadeh, Z; Valinassab, T; Vosugi, G; Motallebi, A. A; Fatemi, M. R; Lombarte, A. and **Tuset, V. M.** (2014). Use of otolith shape for stock identification of John's snapper, *Lutjanus johnii* (Pisces: Lutjanidae), from the Persian Gulf and the Oman Sea. Fisheries Research, *155*, 59-63.

Said, R. E. M; Hasieb, H. E; Khaled, M. A; Mohammed-AbdAllah, E. and **Osman, A. G. M.** (2024). Regional variability in remotely sensed data with respect to the distribution of some snapper fishes (Family: Lutjanidae) between the Red Sea and the Arabian Gulf. Scientific African, *23*, e02104.

Santana, H. S. d; Dei Tos, C. and **Minte-Vera, C. V.** (2020). A review on the age and growth studies of freshwater fish in South America. Fisheries Research, *222*, 105410.

Seber, G. and Wild, C. (1989). Nonlinear Regression John Wiley and Sons New York. *NY;* 325-335.

Soliman, F. M; Mehanna, S. F; Soliman, H. A. and **Baker, T. S.** (2018). Meristic and Morphometric Characteristics of five-lined snapper, *Lutjanus quinquelineatus* (Bloch, 1790) from the Red Sea, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, *22*(1), 41-48.

Soliman, H. A. M; Soliman, F. M. and **Baker, T. S.** (2020). Morphological and Genetic Relationship of two Closely-Related Species of Snappers (Family: Lutjanidae) from *Egyptian Red Sea. Sohag Journal of Sciences, 5*(3), 15-21.

Streich, M. K; Ajemian, M. J; Wetz, J. J; Williams, J. A; Shipley, J. B. and **Stunz, G. W.** (2017). A Comparison of Size Structure, Age, and Growth of Red Snapper from Artificial and Natural Habitats in the Western Gulf of Mexico. Transactions of the American Fisheries Society, *146*(4), 762-777.

Takahashi, M; Wakefield, C. B; Newman, S. J; Hillcoat, K. B; Saunders, B. J. and **Harvey, E. S.** (2023). Utility of body and otolith morphometry to discriminate cryptic juveniles of two sympatric red snappers (Perciformes: Lutjanidae). Journal of Fish Biology, *103*(6), 1312-1320.

Teixeira, S; Duarte, Y. and **Ferreira, B.** (2010). Reproduction of the fish *Lutjanus analis* (mutton snapper; Perciformes: Lutjanidae) from Northeastern Brazil. Revista de biología tropical, *58*, 791-800.

Trip, E. D; Clements, K. D; Raubenheimer, D. and **Choat, J. H.** (2014). Temperature-related variation in growth rate, size, maturation and life span in a marine herbivorous fish over a latitudinal gradient. Journal of Animal Ecology, *83*(4), 866-875.

von Bertalanffy, L. (1938). A quantitative theory of organic growth (inquiries on growth laws. II). Human Biology, *10*(2), 181-213.