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Some Biological Characteristics of *Sardinella aurita* in the Egyptian Mediterranean Water (Abu Qir Bay)

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ABSTRACT

This study investigated the growth, reproductive maturity, and condition of *Sardinella aurita* in Abu Qir Bay, Egyptian Mediterranean waters, based on 2,400 specimens collected over 12 months in 2023. Key findings included an average total length of 12.14cm (±1.85cm) and an average total weight of 15.23g (±7.52g). The length-weight relationships were robust with r^2 values of 0.956 for gutted weight and 0.946 for total weight, with the fitted equations $W = 0.0070 \times L^{3.012}$ (gutted weight) and $W = 0.0073 \times L^{3.030}$ (total weight) indicating an isometric growth pattern overall. However, when analyzed by sex, both males and females exhibited negative allometric growth with exponent values of 2.787 and 2.762, respectively, and no significant difference between them. The study also found that the average annual condition factor (K) was 0.727, with notable seasonal fluctuations, lowest values were recorded in July (0.622 for males and 0.654 for females) during the spawning period and a peak value of 0.787 was recorded for combined sexes in October during the post-spawning phase. Logistic regression analysis estimated the length at first sexual maturity (L_{m50}) at 12.27cm, while the length at first capture (L_C) was determined to be 11.22cm. The gonado-somatic index (GSI) also revealed a bimodal spawning pattern with a major peak in May–June and a secondary peak in August–September. These findings underscore the vital role of biological monitoring in sustainable fisheries management while shedding light on the reproductive strategy of *S. aurita* in Abu Qir Bay. To protect spawning stocks during peak periods and support long-term sustainability, we recommend implementing seasonal fishing restrictions and establishing a minimum landing size to ensure individuals reach maturity before capture.

INTRODUCTION

Sardinella aurita (Clupeidae), commonly known as round sardinella, is a key small pelagic fish (SPF) species widely distributed in tropical and subtropical waters of the Atlantic Ocean, Mediterranean Sea, and adjacent seas **(Whitehead, 1985)**. SPFs, including *S. aurita*, play a vital role in marine ecosystems, serving as essential prey for higher trophic levels and facilitating energy transfer within pelagic food webs **(Cury *et al.*, 2000; Ruzicka *et al.*, 2024)**. Beyond their ecological significance, SPFs are crucial to global fisheries, contributing over 18% of the total marine capture production and supporting the livelihoods of millions worldwide **(FAO, 2022)**.

In the Egyptian Mediterranean, SPFs, including *S. aurita*, are primarily targeted by night light and daylight purse seine fishing gear **(El-Haweet, 2001; Akel, 2009; WGSASP, 2022, 2023)**. Five Clupeidae species contribute to the sardine catch in Egyptian Waters (GSA 26), namely *S. aurita*, *Sardina pilchardus*, *Sardinella maderensis*, *Dussumieria acuta*, and *Etrumeus teres*, all of which are officially recorded under the general term "sardines" in the national statistics books **(WGSASP, 2022, 2023)**. *S. aurita* holds considerable commercial importance, accounting for approximately 40% of the total sardine landings, which collectively represent 15.6% of the national marine fish catch **(LFRPDA, 2022; WGSASP, 2022, 2023)**.

Abu Qir Bay is one of the primary fishing areas for sardines in the Egyptian Mediterranean, contributing 1266 tons in 2022, constituting around 15% of the total sardine catch from the Egyptian Mediterranean fisheries **(LFRPDA, 2022)**. Research on *S. aurita* in Abu Qir Bay dates back to the 1960s, with early studies focusing on its biology, growth, and fisheries **(El-Maghraby *et al.*, 1970; Soliman *et al.*, 1970)**. Between 1976 and 1978, a large-scale project examined the sardine fishery along the Egyptian Mediterranean, providing significant insights into the species' biology and exploitation. Subsequent research addressed key biological parameters, such as length-weight relationships (LWRs), age and growth, maturity, and spawning patterns **(Soliman *et al.*, 1982; Wassef *et al.*, 1985)**. However, scientific interest in *S. aurita* declined after the 1980s, with only one study conducted in the late 1990s by **Abdallah and El-Haweet (2000)** and additional assessments done in the early 2000s by **Akel (2005, 2009)**. Since then, research efforts have stagnated, leaving critical knowledge gaps in the species' biology and fisheries management.

The collection and analysis of biological data are fundamental to sustainable fisheries management, as they provide essential insights into fish population dynamics **(Hilborn & Walters, 1992; Froese, 2006; King, 2013)**. Key biological parameters, such as the length-weight relationship, condition factor, Gonado somatic index (GSI), and size at first sexual maturity, are critical for understanding growth, reproductive cycles, and fishery sustainability. Additionally, estimating the length at first capture (L_C) is crucial for assessing fishing pressure and its impact on population dynamics **(Froese, 2004)**.

This study aimed to address existing gaps in recent information on *S. aurita* in the Egyptian Mediterranean waters by analyzing some of its biological parameters in Abu Qir Bay over 12 months. Specifically, it examined the length-weight relationship, condition factor, gonadosomatic index, and length at first sexual maturity to evaluate growth and reproductive biology. Additionally, the study assessed the length at first capture to understand fishing impacts. The findings will contribute to a comprehensive understanding of *S. aurita*'s population status and provide science-based recommendations for sustainable fisheries management in the Egyptian Mediterranean.

MATERIALS AND METHODS

1. Area of study

The study area of Abu Qir Bay extended from Alexandria to Rosetta in the Egyptian Mediterranean. Abu Qir Bay is a semi-circular aquatic basin situated 35km east of Alexandria at 31° 16'-31° 28' N and 30° 03'-30° 22' E (Fig. 1). The bay's depth gradually increases toward its center, reaching a maximum of approximately 22m with an average depth of less than 10m. Its coastline extends along a roughly 50-kilometer stretch from Rosetta in the northeast to the Abu Qir mouth in the southwest **(Abdallah *et al.*, 2006)**. Abu Qir Bay is a crucial fishing area, accounting for approximately 20% of the total fish catch from Egypt's Mediterranean fisheries, with a total landed catch of 10,077 tons in 2022 **(LFRPDA, 2022)**. The bay fisheries support coastal communities by providing thousands of jobs and serve as a vital cornerstone for livelihoods and food security in the region **(Pinello *et al.*, 2020; Samy-Kamal, 2021)**.

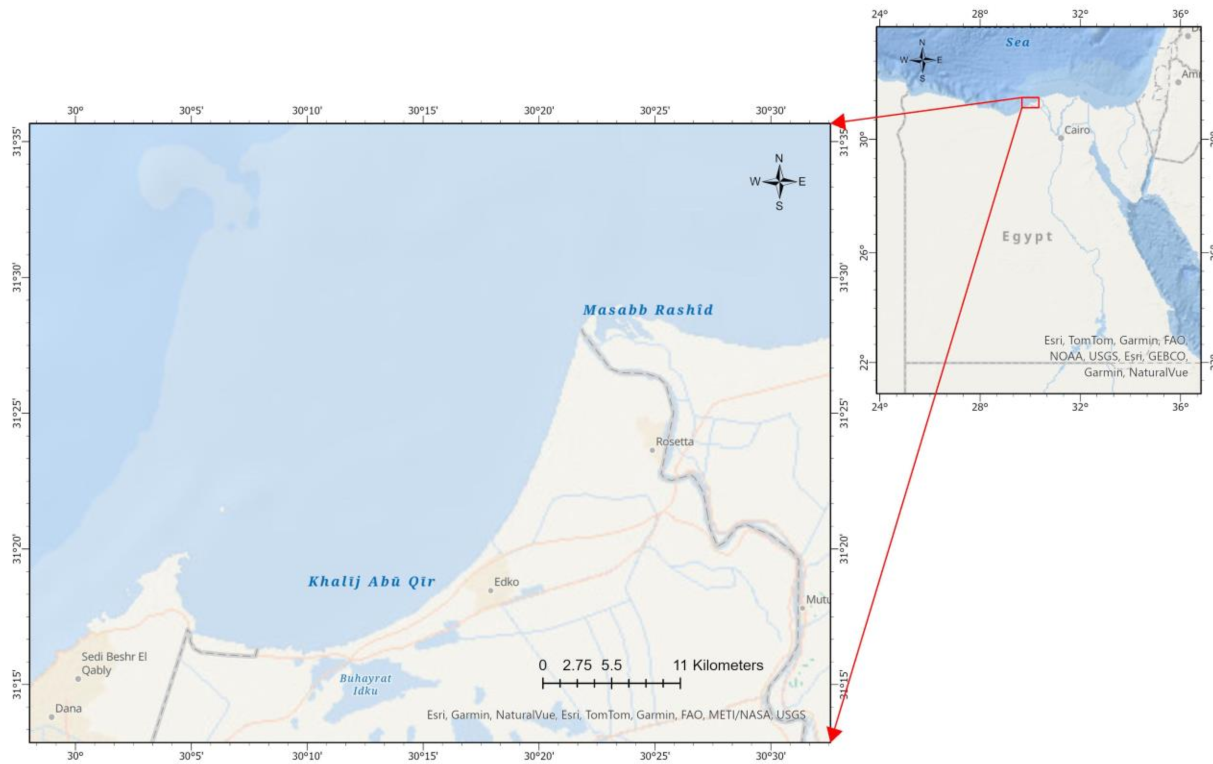


Fig. 1. Map of Abu Qir Bay and its location on the Egypt Mediterranean

2. Sampling

A total of 2,400 *S. aurita* specimens were collected during the first week of each month from Abu Qir Bay during the period from January to December 2023. Samples were collected directly from purse-seine fishing vessels and also from the fish market at the Maadia fishing port, ensuring a comprehensive representation across various size ranges.

In the laboratory, length measurements were recorded at 1cm intervals to construct a length-frequency dataset. From this sample, 1,555 specimens were selected for detailed biological investigation. Total length (TL) and total weight (TW) were measured to the nearest 0.01cm and 0.01g, respectively. Gutted weight was also recorded to minimize biases associated with gonad and stomach content weights. Additionally, gonad weight was measured to the nearest 0.01g. Sex and maturity stages were determined where applicable, following the six-stage maturity scale described by **Nikolsky (1976)**, as reported by **Dimech *et al.* (2012)**.

3. Biological studies of *S. aurita*

3.1. The length-weight relationship (LWR)

The LWR of *S. aurita* was determined using the **Le Cren (1951)** equation: $W = a * L^b$, Where W is the total weight (g); L is the total length (cm); *a* is the intercept, and *b* is the slope of the regression line. A linear regression analysis was conducted using the least squares method to estimate the parameters *a* and *b*, along with the coefficient of determination (r^2). The analysis was performed separately for total weight and gutted weight, as well as for males and females.

The growth exponent (*b*) was tested for statistical significance following **Ricker (1973)** to evaluate whether growth was isometric ($b \approx 3$) or allometric. A t-test was conducted to assess whether b significantly differed from 3, using the car package in R software **(R Core Team, 2025)**. The test computes an F-statistic and associated *P*-value for the null hypothesis $H_0 : b = 3$.

Scatter plots were generated using the ggplot2 package to visualize the relationship, with fitted regression lines superimposed. The estimated LWR equations and corresponding r^2 values were directly annotated on the plots for interpretation. Additionally, to evaluate potential sex-based differences in the LWR, a t-test was performed to determine whether *b* values for males and females were significantly different. A one-sample t-test was applied to assess whether the growth pattern deviated from isometric growth, and 95% confidence intervals for *b* were calculated for each sex. Furthermore, an analysis of covariance (ANCOVA) was conducted to test whether males and females followed significantly different LWRs, incorporating an interaction term between sex and length. All statistical analyses were performed using R software **(R Core Team, 2025)**, ensuring robust estimation and validation of the LWRs.

3.2. Condition factor calculation and monthly variations

The condition factor (*K*) of *S. aurita* was calculated according to **Bagenal and Tesch (1978)**, using the formula: ($K = 100 * W_{gut} \backslash L^3$), where *Wgut* is the gutted weight in grams (g) and L is the total length in centimeters (cm). This index provides an indication of the fish's well-being and variations in energy reserves over time.

Monthly variations in K were analyzed to identify seasonal trends and differences between sexes. The dataset was processed using R **(R Core Team, 2025)**, employing the dplyr package for data manipulation and the ggplot2 package for visualization. The data were grouped by month and sex, and mean K values along with standard deviations were computed.

3.3. The length at first capture (L_C).

The length at first capture (L_C) was estimated using a logistic selectivity model following **Sparre and Venema (1999)**. The length-frequency dataset was used to calculate cumulative frequency and capture probability at each length class. A logistic function $S(L) = 1/(1+e^{-(a+bL)})$ was fitted to the data, and a logit transformation was applied to linearize the relationship. The parameters a and b were estimated using linear regression, and L_C was determined as: $L_C = -a/b$, representing the length at which 50% of fish are retained. The logistic selectivity curve was visualized, marking L_C at a 50% probability of capture. This approach follows established methods in fish stock assessment **(Sparre & Venema, 1999)**.

3.4.Gonado-somatic index (GSI) calculation

The gonado-somatic index (GSI) was calculated for each individual (N = 611) using the formula reported by **Philips and Ragheb (2013)** as follows: GSI = (Gonad Weight (g)×100)/Gutted Weight (g), where gonad weight and gutted weight were measured in grams. The dataset was processed in R **(R Core Team, 2025)**. To identify and remove outliers in GSI values, the interquartile range (IQR) method was applied **(Tukey, 1977)**. For each month, the first quartile (Q1) and third quartile (Q3) were computed, and the interquartile range was determined as: IQR = Q3 − Q1. Any value greater than Q3 + 1.5 × IQR was considered an outlier and removed from the dataset. Summary statistics, including mean, standard deviation, minimum, and maximum GSI values, were then computed for each month using the dplyr package.

3.5. The length at first sexual maturity (L_{m50})

The length at first sexual maturity (L_{m50}) was estimated using logistic regression, a standard approach for modeling maturity ogives in fish populations **(King, 2013)**. The total length of maturity (L_{m50}) was calculated based on the shortest length at which 50% of individuals were in the mature state **(Bagenal & Tesch, 1978)**. The analysis was conducted in R software **(R Core Team, 2025)**. A generalized linear model with a binomial family and logit link function was applied to describe the probability of maturity as a function of fish length: $P(M) = 1/(1+e^{-(\alpha+\beta L)})$, Where $P(M)$ is the probability of being mature at length L, and α and β are model parameters. The length at which 50% of individuals reach maturity (L_{m50}) was computed as: $L_{m50} = -\beta/\alpha$. Predicted probabilities were generated across the observed length range, and a logistic curve was plotted along with the observed proportions of mature individuals. A vertical dashed line was added at L_{m50} to indicate the estimated value.

RESULTS

1. Descriptive analysis of *S. aurita* sample

The *S. aurita* length class sample (n = 2,400) histogram (Fig. 2) reveals an unimodal distribution, with the highest frequency centered on the 11–12cm length class. Most individuals fall within the 9–13cm range, and the frequency declines after 14cm, reaching a maximum length of approximately 20cm. This right-skewed distribution suggests that smaller fish (under 13cm) dominate the sample, with relatively few larger individuals present.

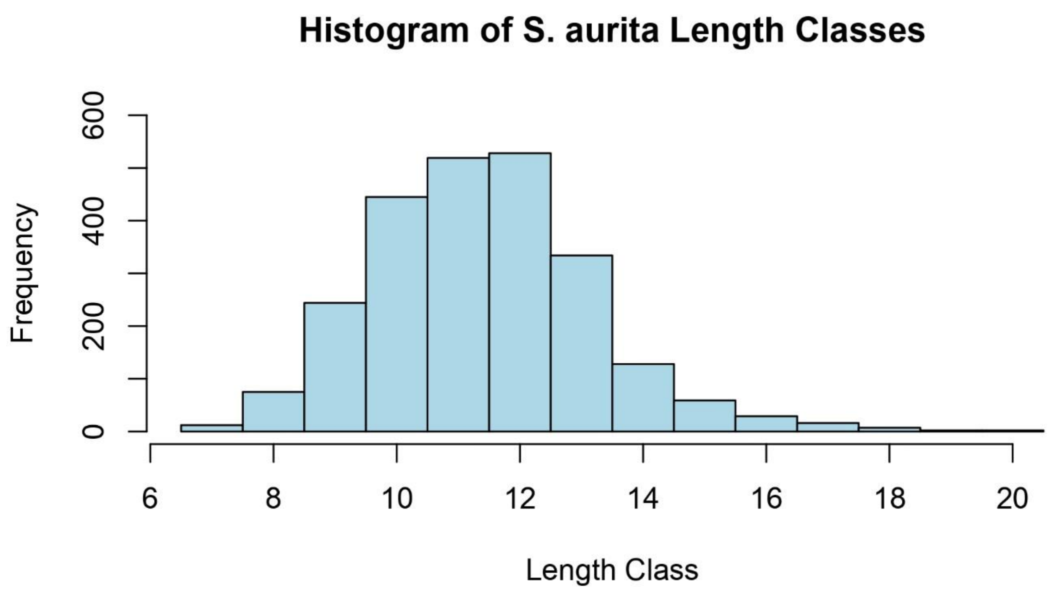


Fig. 2. The histogram of the total length of *S. aurita* samples collected from Abu Qir Bay during 2023

The detailed *S. aurita* sample (n = 1,555) exhibited an average length of 12.14cm (SD = ±1.85cm), with a median of 12cm and a range from 7.8 to 20.2cm. The average total weight was 15.23g (SD = ±7.52g), with a median of 13.92g and values extending from 3.5 to 56.77g, indicating greater variability in weight compared to length. Gutted weight averaged 13.90g (SD = ±6.79g), with a median of 12.72g and a range of 3.25 to 52.26g.

2. The length-weight relationship (LWR)

The LWR of *S. aurita* (n = 1,555) was analyzed for both total weight and gutted weight using the following equations:

- For gutted weight: $W = 0.0070 \times L^{3.012}$ ($r^2 = 0.956$)
- For total weight: $W = 0.0073 \times L^{3.030}$ ($r^2 = 0.946$)

Both equations indicate a strong positive correlation between length and weight, with r^2 values exceeding 0.94, suggesting a reliable fit to the data. The exponent *b* values (~3.0) indicate an isometric growth pattern, meaning weight increases proportionally with length. Fig. (3) illustrates the LWR of *S. aurita* for both total weight and gutted weight.

To assess whether the observed growth pattern deviates from isometry, the slope (*b*) was tested against the null hypothesis $H_0 : b = 3$ using Student's t-test. For total weight, the test yielded an F-statistic of 2.81 and a *P*-value of 0.09407. Since the *P*-value exceeded the significance level ($P \leq 0.05$), H_0 was not rejected, indicating no statistically significant difference from 3. Similarly, for gutted weight, the test produced an F-statistic of 0.52 with a *P*-value of 0.4703, again supporting the conclusion that *b* does not significantly differ from 3. Together, these results confirm that *S. aurita* exhibits an isometric growth pattern in both total and gutted weight analyses.

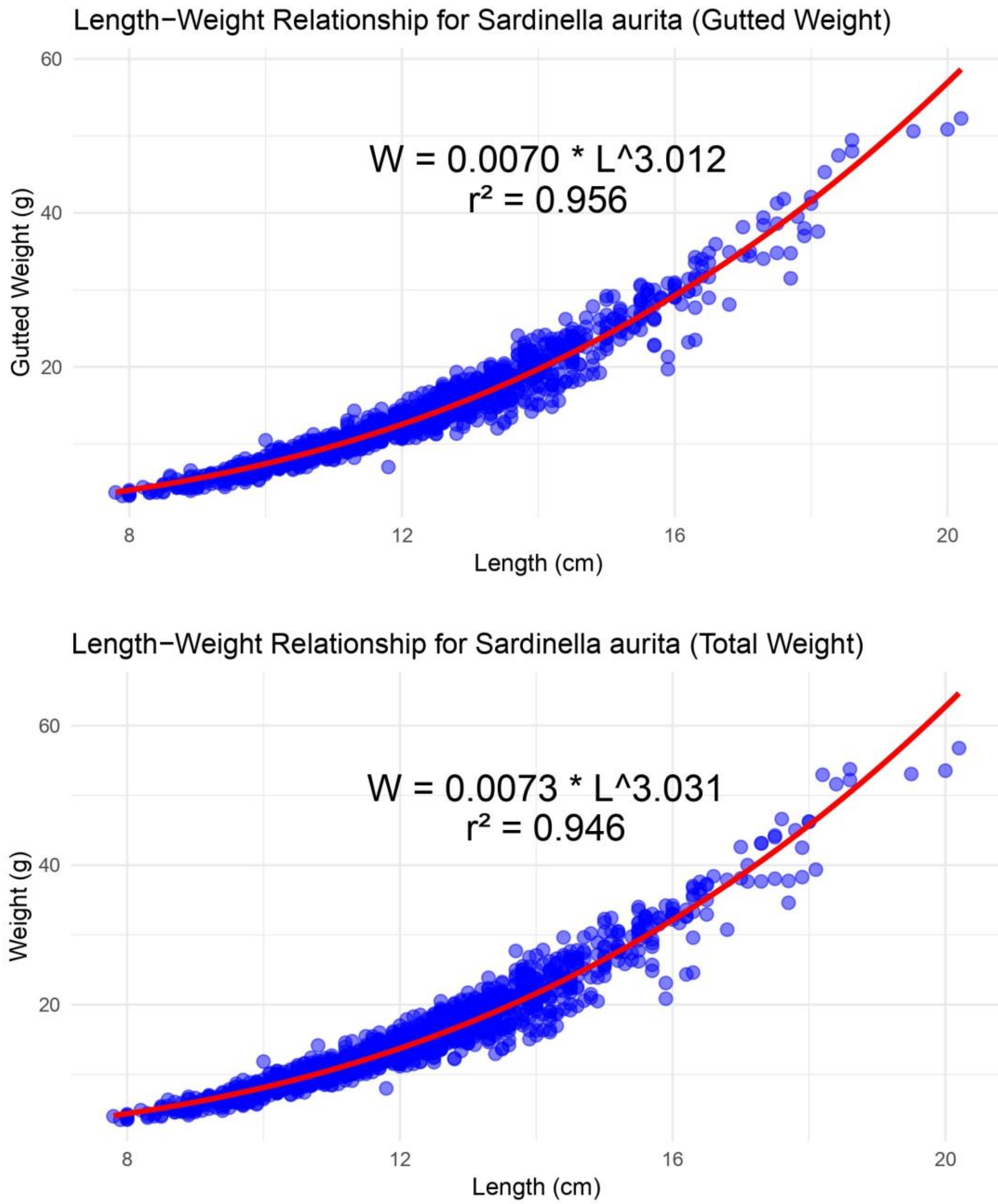
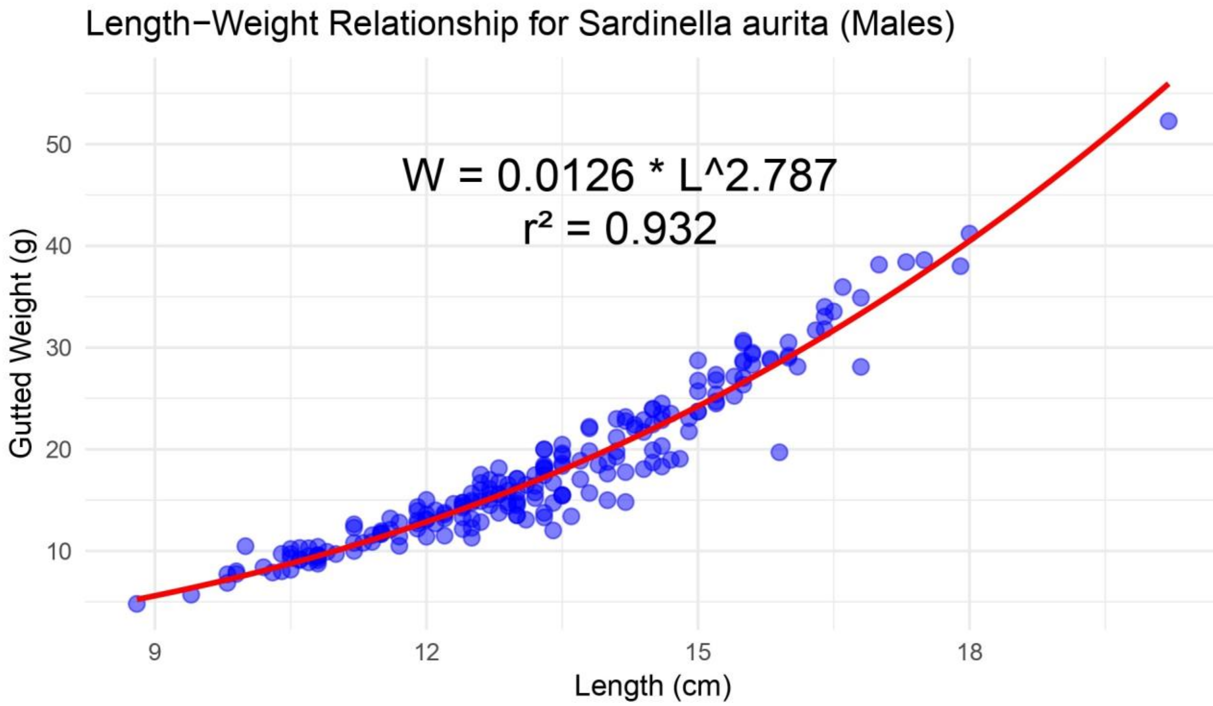


Fig. 3. The LWR using total weight (down) and gutted weight (up) of *S. aurita* samples collected from Abu Qir Bay during 2023

Additionally, the LWR of *S. aurita* was analyzed separately using gutted weight for males (n = 209) and females (n = 351). Fig. (4) illustrates the LWR of *S. aurita* for males and females, according to the following equations:

- For Males: $W = 0.0126 \times L^{2.787}$ ($r^2 = 0.932$)

- For Females: $W = 0.0138 \times L^{2.762}$ ($r^2 = 0.933$)



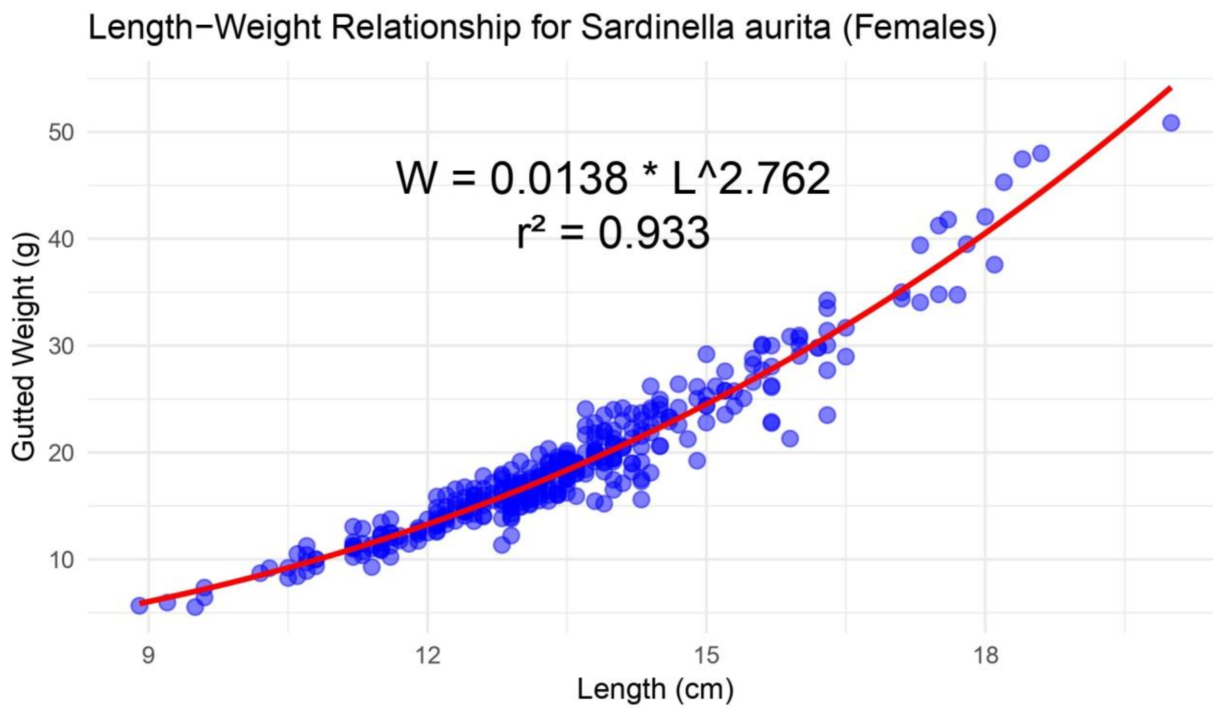


Fig. 4. The LWR for males (up) and females (down) of *S. aurita* samples collected from Abu Qir Bay during 2023

3. The condition factor

The average annual condition factor (*K*) of all *S. aurita* samples was 0.727 (SD ± 0.057). The annual averages were similar for males (0.734 ± 0.051) and females (0.733 ± 0.052), with males showing slightly higher values.

The condition factor exhibited seasonal variations, reflecting changes in the fish's overall condition throughout the year (Fig. 5). Monthly trends showed that from January to March, *K* remained relatively stable in the combined-sex group, ranging between 0.709 and 0.747. During April to June, the condition factor remained consistent, fluctuating between 0.728 and 0.749. A significant decline was observed in July, where the lowest values were recorded (*K*=0.622 for males, 0.654 for females, and 0.669 for the combined sexes). This drop likely corresponds to the spawning season, during which energy reserves are depleted. From August to October, a notable recovery occurred, with the highest *K* values recorded in October (0.796 for males, 0.797 for females, and 0.788 for combined sexes), suggesting a post-spawning period characterized by increased feeding and energy storage. However, a gradual decline in *K* values was observed from November to December, with December showing the lowest values for combined sexes (0.665 ± 0.050), possibly due to the reduced food availability during the winter season.

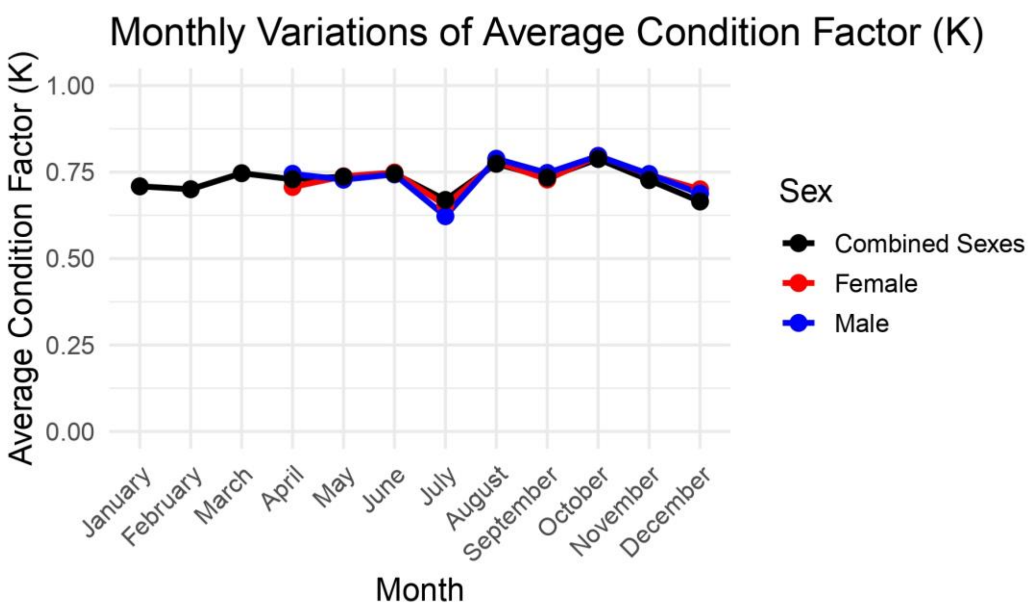


Fig. 5. Monthly variations of average condition factor (*K*) of *S. aurita* samples collected from Abu Qir Bay during 2023

4. The length at first capture (L_C)

Based on the analysis, the estimated length at first capture (L_C) for *S. aurita* was 11.22cm, indicating that individuals of this length or less cumulatively represent 50% of the catch and are retained by the fishing gear. The logistic selectivity curve (Fig. 6) shows a gradual increase in catch probability with length, with smaller fish having lower retention probabilities and larger fish approaching full selectivity ($S(L)$ = 1). The fitted logistic function closely follows the observed data, confirming a good model fit.

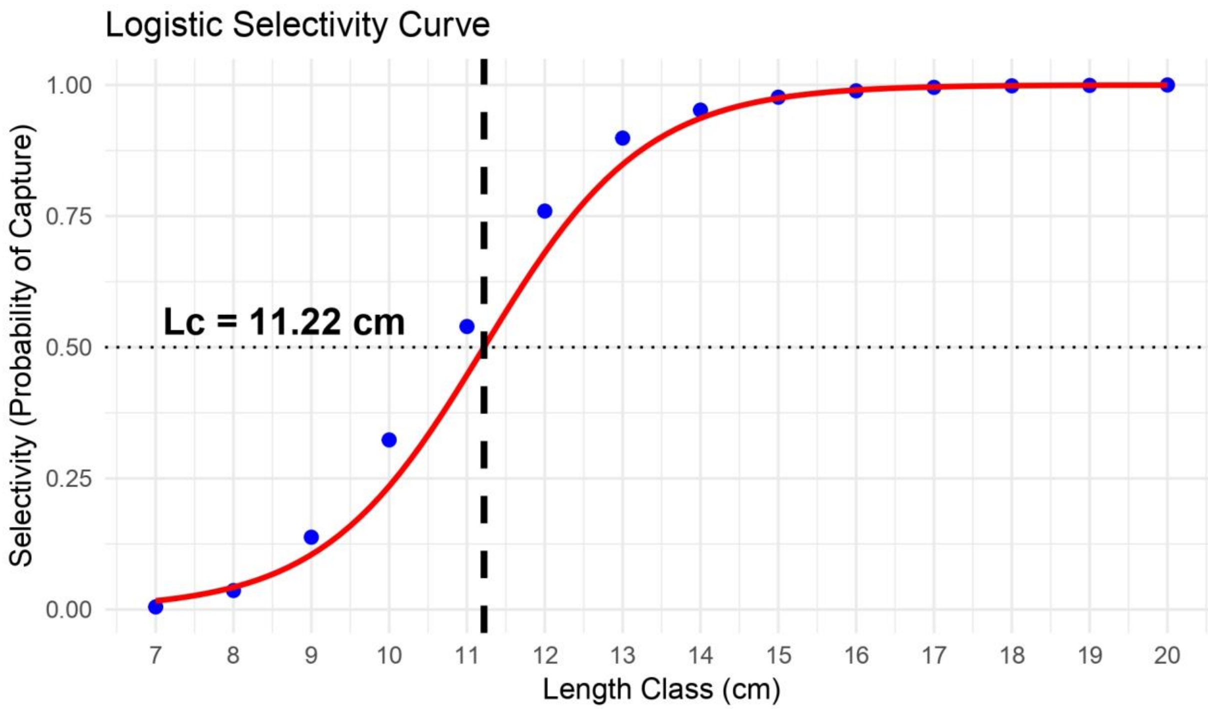


Fig. 6. The estimated length at first capture (L_C) for *S. aurita* samples collected from Abu Qir Bay during 2023

5. Gonado-somatic index (GSI) results

The results indicate that the reproductive season of *S. aurita* extends from early April to the end of October, characterized by two distinct spawning peaks (Fig. 7). The first and most pronounced peak occurs in May and June, where the mean GSI values reach 5.32 ± 1.93 (N = 109) and 5.50 ± 1.63 (N = 71), respectively. These high values suggest a period of intense reproductive activity. This is followed by a brief resting phase in July, where the mean GSI drops significantly to 0.88 ± 0.38 (N = 59), indicating a marked reduction in spawning effort.

The second spawning peak, observed in August and September, is less intense than the first but still signifies a secondary reproductive phase. During this period, the mean GSI rises to 2.79 ± 2.06 (N = 89) in August and 2.50 ± 1.36 (N = 90) in September. The gradual decline in GSI values from October (1.45 ± 0.90, N = 103) onward, reaching 0.65 ± 0.29 in November (N = 51) and 0.59 ± 0.36 in December (N = 8), marks the end of the spawning season. The low GSI values in these later months indicate a post-spawning period, likely associated with energy recovery and preparation for the next reproductive cycle.

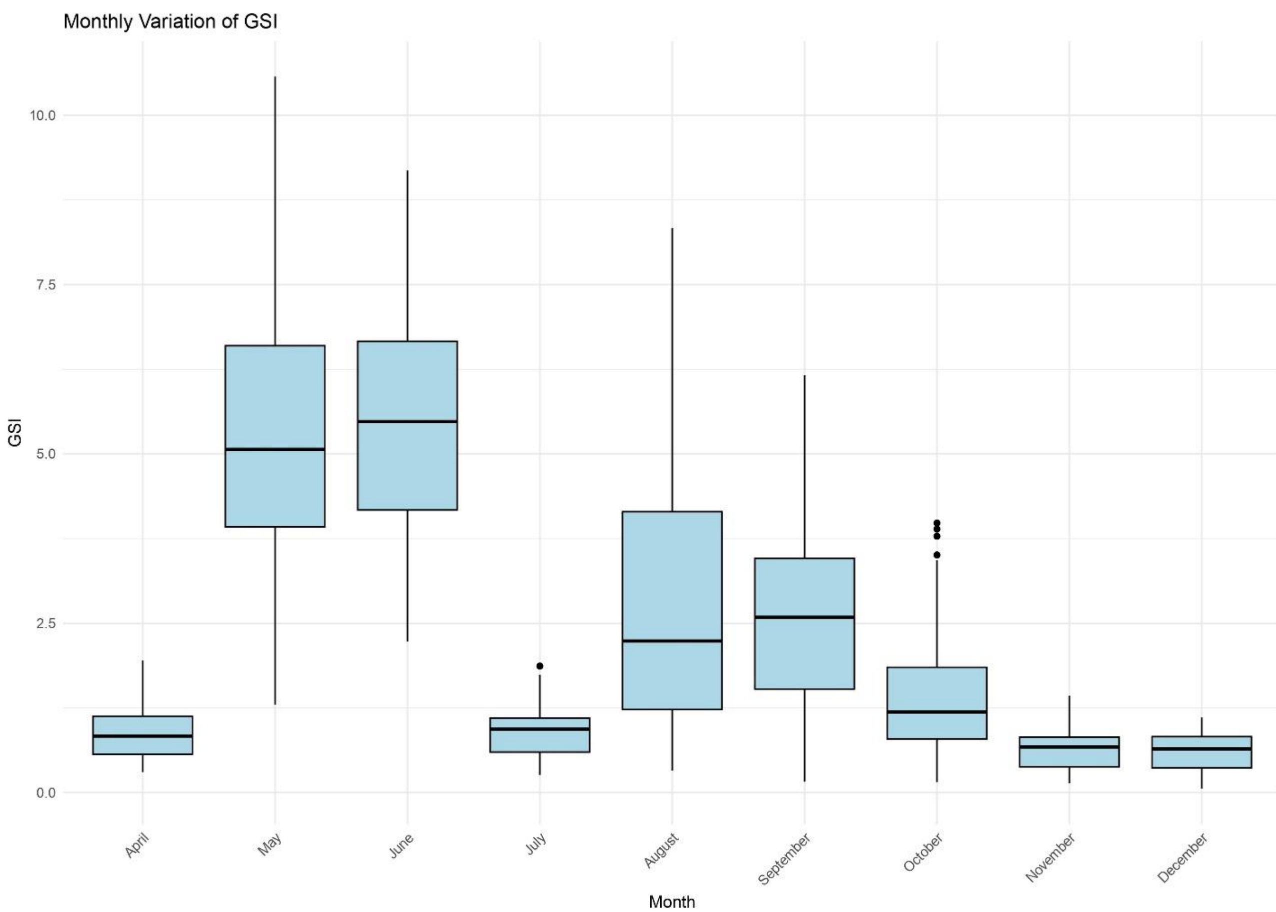


Fig. 7. Monthly variation of GSI of *S. aurita* samples collected from Abu Qir Bay during 2023

6. The length at first sexual maturity (L_{m50})

The results of the maturity analysis for *S. aurita* indicate that the estimated length at first sexual maturity (L_{m50}) is 12.27cm (Fig. 8). This value represents the length at which half of the population reaches reproductive maturity. The logistic regression model fitted to the maturity data shows a sigmoidal relationship between fish length and the proportion of mature individuals, with a gradual increase in maturity probability as length increases. The observed maturity proportions align well with the predicted logistic curve, confirming the model's robustness. The vertical dashed blue line at (L_{m50}) in the graphical output highlights this threshold, emphasizing its importance for fisheries management.

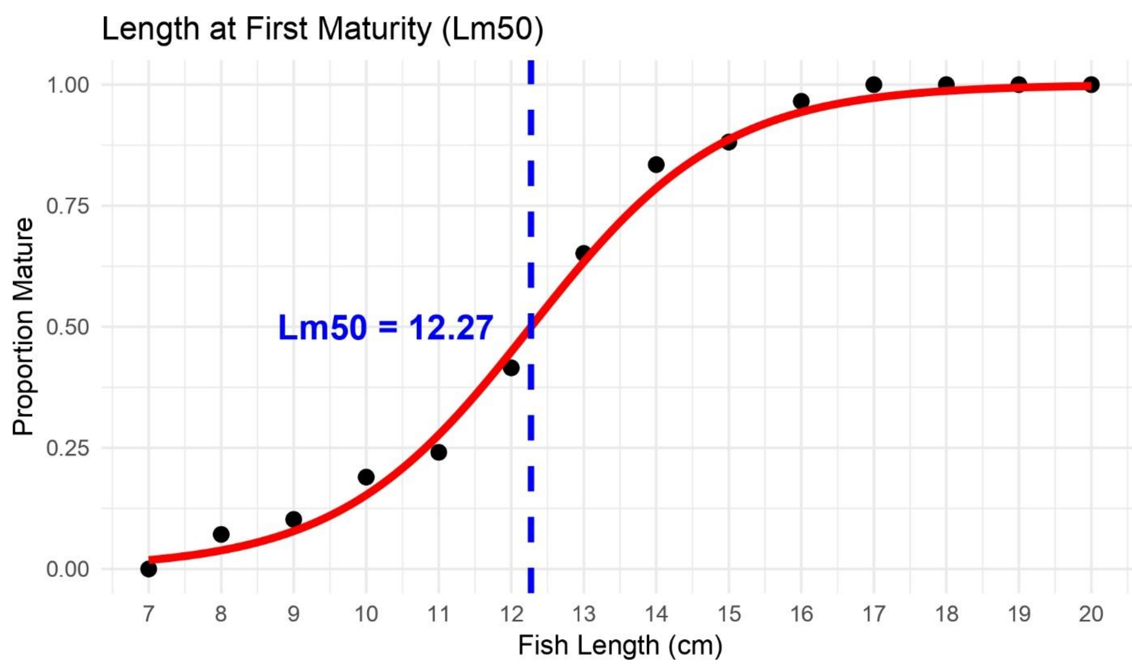


Fig. 8. The results of the maturity analysis for *S. aurita* samples collected from Abu Qir Bay during 2023 indicate the estimated length at first sexual maturity (L_{m50})

DISCUSSION

The length range of *S. aurita* in the present study varied from 7.8 to 20.2cm, with an average length of 12.14 ± 1.85cm, a value slightly lower than those reported in previous studies in Abu Qir Bay. For instance, **Soliman *et al.* (1982)** documented lengths between 7 and 28cm, **Abdallah and El-Haweet (2000)** recorded a range of 6.5 to 28.5cm, **Akel (2009)** observed lengths from 10 to 26cm with an average of 14cm. While **Mehanna and Farouk (2021)** reported a range of 8.1 to 23cm with an average of 12.9 ± 2.5cm in the Egyptian Mediterranean Waters (Table 1).

The gradual decline in maximum body length observed over the past 25 years, coupled with a decrease in average length, may indicate increased fishing pressure on the stock. Such reductions in size structure are often interpreted as signs of intense exploitation, where larger individuals are selectively removed, leading to a shift toward smaller, younger fish in the population **(Shin *et al.*, 2005)**.

Table 1. Comparison of *S. aurita* growth parameters from historical and present studies

Source	Sampling area	Collecting method	Year collected	Sample size (No.)	Length range	Mean length (cm)	a	b
(Soliman *et al.*, 1982)	Abu Qir Bay and El-Alamein	Purse seine	1977	1867	7 - 28	NA	0.000005	3.086
(Abdallah & El-Haweet, 2000)	Alexandria and Abu Qir Bay	Landing sites and Purse seine	1997	54927	6.5 - 28.5	NA	0.0052	3.179
(Akel, 2009)	Alexandria to Rosetta	Purse seine	2007	663	10 - 26	14.5	0.01701	2.689
(Mehanna & Farouk, 2021)	Egyptian waters of the Mediterranean Sea	Bottom trawl surveys	2017-2018	870	8.1 - 23	12.9 ±2.5	0.0149	2.745
(Mehanna & Salem, 2011)	North Sinai	Purse seine	2008-2009	4870	7.8 - 22.7	NA	0.0149	2.745
(Abd EL Hakim *et al.*, 2012)	North Sinai	Landing site	2010	4450	6 - 23.9	NA	0.016	2.641
Present study	Abu Qir Bay	Landing sites and Purse seine	2023	1555	7.8 - 20.2	12.14 ±1.85	0.007	3.012

The LWR obtained in this study for *S. aurita* indicates an isometric growth pattern ($b \approx 3$) when considering combined sexes **(Froese, 2006)**. However, separate analyses of males and females revealed a negative allometric growth ($b < 3$) **(Froese, 2006)**. This suggests that as individuals mature, energy allocation shifts from somatic growth to reproductive investment **(Sparre & Venema, 1999)**. The isometric growth observed in the combined-sex analysis can be attributed to the predominance of younger individuals in the dataset, whereas the male and female groups contained a higher proportion of older fish. This pattern suggests that growth is relatively faster during early life stages but slows down as individuals mature, reflecting a physiological shift from somatic development to reproductive processes **(McBride *et al.*, 2015)**.

In Table (1), which compares *S. aurita* growth parameters from historical and present studies, the variation in the b value of the LWR is evident and can be attributed to differences in geographic location, sampling methods, and environmental conditions. Studies conducted in Abu Qir Bay by **Soliman *et al.* (1982)**, **Abdallah and El-Haweet (2000)** and **Akel (2009)** recorded *b* values of 3.086, 3.179, and 2.689, respectively, whereas **Mehanna and Farouk (2021)** recorded a *b* value of 2.745 for the entire Egyptian Mediterranean. While studies of samples from Al-Arish, located at the far eastern end of the Egyptian Mediterranean, **Mehanna and Salem (2011)** and **Abd EL Hakim *et al.* (2012)** reported *b* values of 2.641 and 2.745, respectively. The present study in Abu Qir Bay recorded a *b* value of 3.012, which is closer to isometric growth.

The higher *b* values observed in Abu Qir Bay compared to those in Al-Arish and the broader Egyptian Mediterranean may reflect localized differences in environmental conditions, food availability, and fishing pressure. Moreover, the influence of sampling techniques—such as purse seines versus bottom trawl surveys—on the size structure of the specimens further contributes to these variations. These observations are consistent with existing literature that emphasizes the role of environmental factors, including habitat complexity and water temperature, in shaping LWRs **(Froese, 2006)**, genetic diversity **(Chlaida *et al.*, 2008)**, climate change **(Tsikliras, 2008)**, ecological dynamics **(Costalago, 2015)**, and nutrient availability **(Baldé *et al.*, 2019)**.

The Gonado-somatic index (GSI) confirms a distinct reproductive cycle in *S. aurita*, characterized by two spawning peaks: a primary peak in May–June and a secondary, less intense peak in August–September. This bimodal reproductive pattern aligns with previous studies on the species' reproductive dynamics in the region. **Soliman *et al.* (1982)** and **Abdallah and El-Haweet (2000)** reported that recruitment of *S. aurita* occurs in two cohorts of unequal strength. The first and more dominant cohort originates from spawning in early spring, while the second results from late summer spawning, creating two overlapping recruitment pulses with a time lag between them.

El-Aiatt (2004) observed a similar pattern for *S. aurita* along the Sinai coast in the eastern Egyptian Mediterranean, where ripe individuals first appeared in April, dominated from May to August, and disappeared by November. This indicates that the spawning season extends from May to August, with a pronounced peak in July.

Akel (2009) reported an average condition factor (*K*) of 0.7 for the *S. aurita* in the same study area, slightly lower than our result of 0.727 ±0.057. Seasonal variation in *K* suggests a physiological cycle linked to reproductive activity, with the lowest values in July—coinciding with the peak spawning season—and the highest in October, reflecting a post-spawning recovery period. This inverse relationship with GSI trends supports the hypothesis that spawning imposes a high energetic cost, leading to temporary declines in body condition, followed by recovery as feeding activity increases. Notably, the similar *K* values between males and females indicate that both sexes adopt comparable energy allocation strategies.

Our findings indicate that the length at first sexual maturity (Lm50) for *S. aurita* in Abu Qir Bay is 12.27cm, which is slightly higher than values reported in the same region by **Wassef *et al.* (1985)** who reported an L_{m50} of 11.5cm. On the other hand, **El-Aiatt (2004)** and **Al-beak (2016)** recorded 11.5 and 11.71cm, respectively, along the Sinai coast.

These variations in L_{m50} may be influenced by several environmental factors, including sea surface temperature, food availability, and water currents within the bay **(Sabatés *et al.*, 2006; Baldé *et al.*, 2019)**. Warmer temperatures can accelerate growth and can affect maturation size, while differences in food availability may influence energy allocation toward growth and reproduction. Additionally, water circulation patterns inside the bay can impact larval dispersal and recruitment dynamics, potentially leading to localized differences in maturation size.

Based on our analysis, the estimated length at first capture (L_C) for *S. aurita* in Abu Qir Bay was 11.22cm. In comparison, **El-Aiatt (2004)** and **Al-beak (2016)** recorded 11.1 and 11.17cm, respectively, along the Sinai coast, while **Akel (2009)** reported a higher L_C of 13.25cm.

These differences in L_C may be attributed to variations in fishing pressure, gear selectivity, and environmental conditions across different regions. A higher L_C, such as that reported by **Akel (2009)**, could indicate the use of fishing gear with larger mesh sizes or differences in fishing intensity, allowing fish to grow longer before being captured. Conversely, lower L_C values suggest that smaller individuals are being retained, which may have implications for stock sustainability and recruitment dynamics **(Froese, 2004)**.

These findings provide valuable insights into the reproductive strategy of *S. aurita* in Abu Qir Bay, underscoring the need for targeted fisheries management measures to protect the species during peak spawning periods **(Van Overzee & Rijnsdorp, 2015)**. Seasonal closures and gear restrictions could help safeguard spawning stocks **(Yıldız *et al.*, 2020)**, while the implementation of a minimum legal size for landed fish has proven effective in protecting juvenile fish, maintaining spawning biomass, and regulating catch sizes **(Graham *et al.*, 2007; Mohamed *et al.*, 2014; Yildiz & Ulman, 2020)**. **El-Haweet (2001)** recommended such measures, specifically for daylight purse seine fisheries.

CONCLUSION

The findings of the current study provide crucial insights into the biological status of *S. aurita*, highlighting that while overall growth is isometric, sex-specific analyses reveal negative allometric trends. The identified values for L_{m50} and L_C, along with the seasonal variations in the condition factor and GSI, underscore the impact of fishing pressure and reproductive cycles on the stock. These results are pivotal for informing sustainable fisheries management and potential regulatory measures in the Egyptian Mediterranean region. Future research should continue to monitor these parameters in response to environmental and fisheries-induced changes to guide adaptive management strategies.

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