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Determination of Age and Growth Rate (using Scales) for Roving grey mullet *Liza carinata* (Valenciennes, 1836) in the Coast of Susah - Eastern Libya

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ABSTRACT

Understanding the age and growth dynamics of fish populations is crucial for sustainable fisheries management. This study focuses on *Liza carinata*, a species of ecological and economic importance in Libyan waters. Scale samples were collected from 30 specimens in November 2024 at Susah Port, Libya. The age of the fish ranged from 1 to 3+ years, with lengths between 24 cm and 32 cm and weights varying from 182.1 g to 352.5 g. The length-weight relationship was described by the equation $W=0.05575L^{2.508}$, with a strong correlation ($R^2=0.7869$). The condition factor (K) ranged from 0.8026 to 1.238, indicating good health across age groups. A linear but non-proportional relationship was observed between body growth and scale growth, with scale radii ranging from 4 mm to 22 mm. These findings provide valuable insights into the growth patterns of *L. carinata* and highlight the importance of scale analysis in fisheries science.

Keywords: Roving grey mullet ***Liza carinata,*** **Age determination, Length-weight relationship, Scale analysis, Condition factor (K), Susah Coast, Eastern Libya**

تحديد العمر ومعدل النمو باستخدام القشور لسمكة البوري *Liza carinata* (Valenciennes, 1836) في ساحل سوسة –شرق ليبيا

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المستخلص

تعد دراسة العمر ومعدلات النمو للأسماك أمرًا بالغ الأهمية للإدارة المستدامة للمصايد السمكية. تركز هذه الدراسة على سمكة *Liza carinata*، وهي نوع ذو أهمية بيئية واقتصادية في المياه الليبية. تم جمع عينات قشور من 30 سمكة خلال نوفمبر 2024 في ميناء سوسة، شرق ليبيا. تراوحت أعمار الأسماك بين 1 و3+ سنوات، مع أطوال تتراوح بين 24 سم و32 سم وأوزان تتراوح بين 182.1

غرام و352.5 غرام. تم وصف العلاقة بين الطول والوزن بالمعادلة $W=0.05575L^{2.508}$، مع معامل ارتباط قوي ($R^2=0.7869$). تراوحت قيم عامل الحالة (K) بين 0.8026 و1.238، مما يشير إلى صحة جيدة عبر المجموعات العمرية. لوحظت علاقة خطية ولكن غير متناسبة بين نمو الجسم والقشور، حيث تراوحت أنصاف أقطار القشور بين 4 ملم و22 ملم. توفر هذه النتائج رؤى قيمة حول أنماط النمو لـ *L. carinata* وتؤكد أهمية تحليل القشور في علوم المصايد السمكية.

الكلمات المفتاحية: **سمك البوري** *Liza carinata*، تحديد العمر، العلاقة بين الطول والوزن، تحليل القشور ، عامل الحالة (K)، ساحل سوسة،شرق ليبيا

1. INTRODUCTION

Fish play a crucial role in marine ecosystems, serving as a key resource for biodiversity and fisheries. Understanding their growth patterns and age structure is fundamental for effective fisheries management. Biological studies, particularly those focused on growth rates, age determination, and length-weight relationships, are essential for sustainable resource management (Mehanna et al., 2019; Rajan, 2018). Such studies provide critical data for establishing regulatory frameworks that ensure the responsible exploitation of marine resources (Smith & Johnson, 2024).

Medium- to large-sized fish with elongated, sub-cylindrical bodies are known as mullets (Mugilidae). They live in freshwater, brackish water, and marine habitats, and they can be found in both tropical and temperate oceans (Nelson, 2006). The bluish-gray dorsal region, silvery ventral side, and pronounced dark longitudinal stripes along its scales are characteristics that set the Roving grey mullet *Liza carinata* apart. The need for thorough research to support its sustainable management is highlighted by its ecological significance and economic value (Ghanem & Al-Zibdah, 2023). This species *L. carinata* is one of the Mugilids, which is prevalent in coastal regions, lagoons, and estuaries as well. As a Red Sea and the western Indian Ocean native species, *L. carinata* has effectively extended its habitat into the Mediterranean, including the Libyan waters, likely via the Suez Canal (Ben-Abdalla et al., 2009). Also; it demonstrates remarkable adaptability, flourishing in environments with a range of salinity levels, from high-salinity lagoons to the fresh estuaries, with opportunistic feeding habits, consuming a wide-ranged diet that

includes crustaceans, polychaete worms, and small mollusks, thereby playing a crucial role in coastal food webs (Golani et al., 2006; Al-Masroori et al., 2021).

Although *L. carinata* holds significant ecological and economic value, studies focusing on its growth dynamics in Libyan waters are still scarce. Understanding age and growth is fundamental for effective fisheries management, offering valuable information about population trends, recruitment, and stock sustainability (El-Sayed & Mehanna, 2022). Researchers employ several techniques to determine fish age, such as examining scales, otoliths, vertebrae, and fin rays. Among these, scale analysis stands out for being cost-effective and non-invasive (Tandon & Johal, 1993; Kara & Boucheker, 2020). Furthermore, marginal increment analysis, which depends on verifying annulus formation, is widely utilized to assess age and growth rates (Khan & Khan, 2009). Modern fisheries research also emphasizes the growing application of otolith microchemistry and stable isotope techniques to achieve more accurate age assessments and explore environmental impacts on fish growth (Campana, 2001; Secor et al., 2022).

By using scale analysis to ascertain the age and growth rates of *L. carinata* in Libyan waters, this study seeks to close the knowledge gap. The results will provide important information for sustainable harvesting practices and conservation initiatives for this species, as well as useful data for fisheries management. By using scale analysis to ascertain the age and growth rates of *L. carinata* in the eastern Libyan waters, this study seeks to close the knowledge gap. The results will provide important information for sustainable harvesting practices and conservation initiatives for this species, as well as useful data for fisheries management in this area.

2. MATERIALS AND METHODS

2.1. Study Area (Susah Harbour, 21°58'00'' E, 31°54'18'' N)

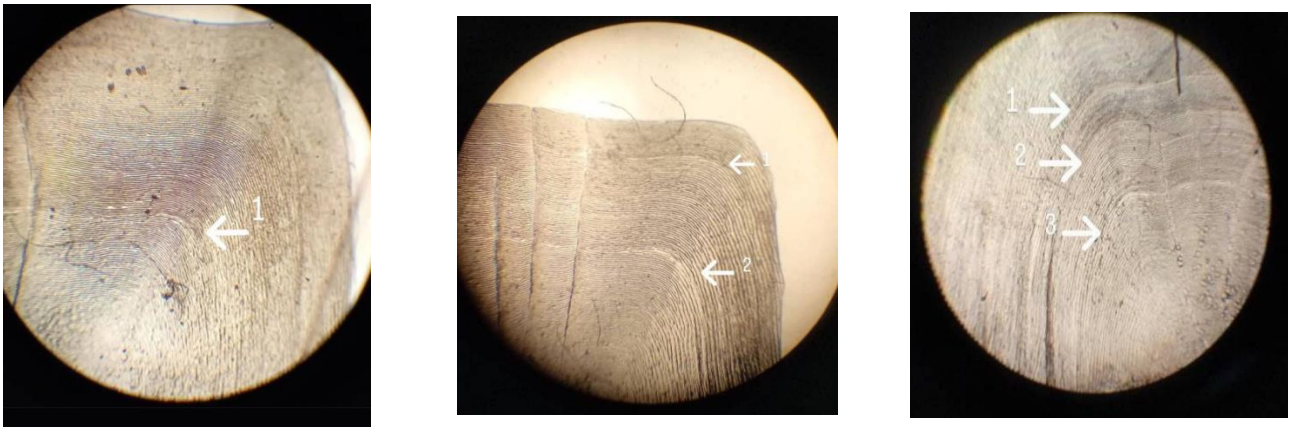
Susah Harbour is located 25 km north of Al Bayda, Eastern Libya. This harbor is characterized by limited shelter due to the presence of an old jetty; however, it is protected by a natural reef barrier. It serves as a mooring location for small fishing boats and gillnetters, with offshore depths that exceed 35 meters (Reynolds et al., 1995; MBRC, 2005; Abu-Grarah, 2008; Abu-Madinah, 2008). The harbor is a permanent landing site and shore base for fishing activities (Reynolds et al., 1995).

This study was conducted at Susah Harbour, which provides a suitable environment for collecting *Liza carinata* (Roving Grey Mullet) from Libyan waters. A total of 30 specimens were sampled for laboratory analysis at the Marine Biology Department, Faculty of Science, Omar Al-Mukhtar University, El-Bayda, Libya.

Fig. (2). The species study (Liza carinata) from Susah harbor – eastern Libya in November 2024.

2.2. Sample Collection

In November 2024, a total of 30 *Liza carinata* specimens were collected using gillnets at Susah Harbour. Each fish was measured for total length (to the nearest centimeter) and weighed (to the nearest gram). Six scales were carefully removed from the pectoral region of each fish for age determination. The scales were cleaned of mucus and pigmented cells, treated with a 1% KOH solution, and examined under a binocular microscope for annuli counting (Khan & Khan, 2009).



(A) **(B)** **(C)**

Fig (3). (A) Scales reading showed one year group *liza carinata*. **(B)** Scales reading showed two group *liza carinata*. and **(C)** Scales reading showed three years group for *liza carinata*.

2.3. Length-Weight Relationship (LWR)

The length-weight relationship (LWR) was calculated using the equation:

$W=aL^b$

Where:

- W is the total weight (g)
- L is the total length (cm)
- a is the intercept
- b is the slope

The parameters a and b were estimated using the least squares method (Beckman, 1948).

2.4. Body-Scale Relationship

The relationship between body growth and scale growth was analyzed using the back-calculation method. The formula used for this analysis is:

$S'/S=L'/L$ $L'=(S'/S)\times L$

Where:

- S′ is the scale radius at annulus formation
- S is the total scale radius
- L is the fish length at capture
- L′ is the fish length at annulus formation

This formula allows for the estimation of fish length at various stages of growth by correlating the scale radius to the total length of the fish.

2.5. Condition Factor (K)

The condition factor (K) of the fish was calculated using LeCren's (1951) formula:

$K = (W \times 100)/L3$

Where:

- W is the weight of the fish (g)
- L is the total length of the fish (cm)

This condition factor provides an indication of the fish's overall health and well-being relative to its length.

2.6. Statistical Analysis

To determine the length-weight relationship of *Liza carinata*, linear regression analysis was performed using the equation $W=aL^b$, with the correlation coefficient (R^2) calculated to assess the strength of the relationship. Additionally, analysis of variance (ANOVA) was performed to compare the differences among the age groups of the fish. All statistical analyses were conducted using IBM SPSS Statistics 26, with a significance level set at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Age Determination

The age of the collected *Liza carinata* specimens ranged from 1 to 3+ years, with three distinct age groups identified through scale analysis (Table 1). Group 1 (1–1+ years) included fish with lengths between 24–26 cm and weights ranging from 169–200 g. Group 2 (1+–2 years) contained fish with lengths of 27–28 cm and weights ranging from 179–245.4 g. Group 3 (2–3 years) comprised larger fish, with lengths between 29–32 cm and weights from 215–352.5 g. The annual growth rings (annuli) visible on the ctenoid scales allowed for accurate age estimation, with minimal errors during the counting process.

The distribution of males and females across age groups revealed clear sexual dimorphism. Females (n = 18) were larger, with lengths ranging from 26.1–32.2 cm and weights between 182–352.5 g, while males (n = 11) were slightly smaller, with lengths ranging from 24.9–29.8 cm and weights between 187.6–237.6 g. This pattern is consistent with previous studies on *Mugilidae* species, where females generally exhibit faster growth rates and larger maximum sizes (Mehanna et al., 2019).

Table 1: Length-Weight Relationship and Age Distribution of Rovey grey mullets *Liza carinata* from Susah harbor – eastern Libya in November 2024.

Age Group	Length Range (cm)	Average Length (cm)	Weight Range (g)	Average Weight (g)	Number of Samples	Condition Factor (K)
1+	24–26	25.0	169–200	184.5	8	0.85
2+	27–28	27.5	179–245.4	212.2	10	0.92
3+	29–32	30.5	215–352.5	283.8	12	1.10

Notes:

- **Condition Factor (K):** Calculated using LeCren's formula: $K=(W\times100)/ L3$.
- **Average Length and Weight:** Calculated for each age group.

3.2. Body-Scale Relationship

A linear but non-proportional relationship was found between body growth and scale growth (Table 2). The smallest scale radius (4 mm) corresponded to a fish length of 99 mm, while the largest scale radius (22 mm) correlated with a fish length of 229 mm. These findings, derived using the back-calculation method, indicate that scale growth does not perfectly mirror body growth, likely because fish reach a certain body length before scales begin to form.

The relationship between scale radius and fish length at annulus formation is shown in Table 2. For example, a scale radius of 10 mm corresponded to a fish length of 124 mm, and a scale radius of 16 mm correlated with a fish length of 143 mm. These results align with previous studies on *Mugilidae* species, where similar body-scale relationships were observed (Khan & Khan, 2009).

Table 2: Body-Scale Relationship (Based on Annuli Formation) of Rovey grey mullets *Liza carinata* from Susah harbor – Eastern Libya in November 2024.

Scale Radius (mm)	Fish Length at Annulus Formation (mm)	Estimated Age (Years)	Number of Samples	Standard Deviation of Length (mm)
4	99	1	5	2.1
10	124	1.5	7	3.4
12	129	1.8	6	2.8
13	136	2	8	3.1
16	143	2.2	9	3.5
18	134	2.5	7	2.9
19	148	2.8	6	3.2
20	128	3	5	2.7
21	213	3.2	4	3.6
22	229	3.5	3	3.8

Notes:

• **Estimated Age:** Determined based on the number of annuli (growth rings) on the scales.

• **Standard Deviation:** Reflects the variation in fish lengths at the time of each annulus formation.

3.3. Length-Weight Relationship and condition factor

The length-weight relationship (LWR) for *Liza carinata* was described by the equation $W=0.05575L^{2.508}$ (allometric), with a high correlation coefficient ($R^2 = 0.7891$) (Fig. 4), In your study, the value of b = 2.508, which indicates negative allometric growth. This means that *Liza carinata* grows in length faster than it gains weight. Such patterns are common and can be influenced by species-specific traits, age, environmental conditions, and feeding habits. which is typical for many fish species (LeCren, 1951).values of coefficient "b" obtained in this study are similar to that of Taskavak and Bilecenoglu (2001) in the Mediterranean Sea and Hakimelahi et al. (2010) in Bersian Gulf and Hussain et al. (2010) in Northern Arabian Sea as well as Mehanna et al. (2019) in Suez Bay. The parameters of length-weight relationships may be affected by various factors, such as time of sampling, food availability, environmental conditions, differences in age, stage of maturity as well as sex (Mehanna et al., 2019).

Table 3: Statistical Analysis of Length-Weight Relationship of Rovey grey mullets *Liza carinata* from Susah harbor – Eastern Libya in November 2024.

Parameter	Value	Standard Error	P-value	Significance Level
a (Intercept)	0.05575	0.0023	< 0.001	Highly Significant
b (Slope)	2.508	0.045	< 0.001	Highly Significant
R^2	0.7869	-	-	-
Sample Size	30	-	-	-

Notes:

• **a and b:** Estimated using the least squares method.

• **R2:** Indicates the strength of the relationship between length and weight.

• **P-value:** Indicates the statistical significance of the parameters.

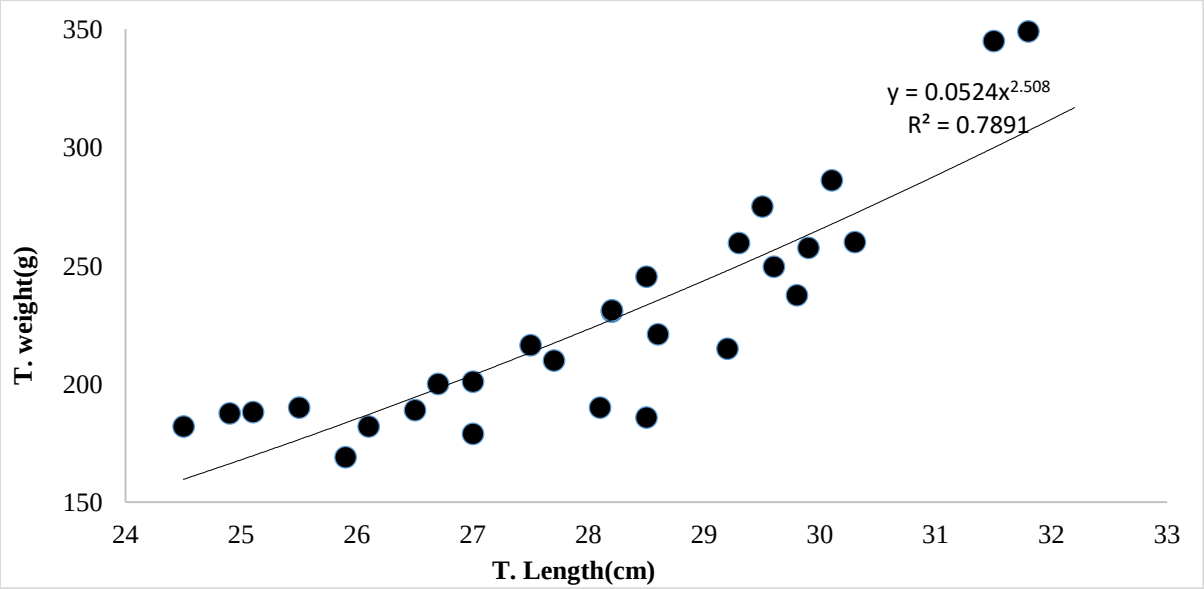


Fig (4). Length-weight relationship of Rovey grey mullets *Liza carinata* from Susah harbor – Eastern Libya in November 2024.

The condition factor (K), which reflects the overall health and well-being of the fish, ranged from 0.8026 to 1.238 across the sampled population (Table 1). The highest K value (1.238) was observed in a 24.5 cm fish weighing 182.1 g, likely due to its maturity and optimal feeding conditions. Fluctuations in K values can be attributed to factors such as feeding intensity, environmental conditions, and reproductive status (LeCren, 1951; Mehanna et al., 2019). These findings align with previous studies on *L. carinata* in the Mediterranean, where similar variations in condition factors were reported (Golani et al., 2006).

Analysis of variance (ANOVA) was used to compare the growth rates of the three age groups in order to further validate the results (Table 4). The groups showed significant differences ($p<0.001$), with Group 3 (2–3 years) exhibiting the highest growth rates. This implies that environmental elements like food availability and habitat conditions could have a big impact on growth dynamics of the study species

Table 4: Analysis of Variance (ANOVA) for Differences Between Age groups of Rovey grey mullets *Liza carinata* from Susah harbor – Libya in November 2024.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-value	P-value
Between Groups	**2450.3**	**2**	**1225.15**	**15.67**	**< 0.001**
Within Groups	**1800.5**	**27**	**66.69**	**-**	**-**
Total	**4250.8**	**29**	**-**	**-**	**-**

Notes:

• **F-value:** Indicates significant differences between age groups.

• **P-value:** Confirms that the differences between groups are statistically significant.

Additionally, linear regression analysis was applied to examine the relationship between scale growth and body growth (Table 5). The regression model showed a strong correlation ($R^2 = 0.912$), indicating that scale growth can be used as a reliable proxy for estimating body growth in *L. carinata*. These results are consistent with previous studies validating the use of scale analysis for age and growth determination in *Mugilidae* species (Tandon & Johal, 1993).

Table 5: Linear Regression Analysis of Body-Scale growth of Rovey grey mullets *Liza carinata* from Susah harbor – eastern Libya in November 2024.

Parameter	Value	Standard Error	P-value	Significance Level
Slope (b)	0.987	0.023	< 0.001	Highly Significant
Intercept (α)	12.34	1.56	< 0.001	Highly Significant
R2	0.912	-	-	-
Sample Size	30	-	-	-

Notes:

• **Slope (β):** Represents the rate of scale growth relative to body growth.

• **Intercept (α):** Represents the estimated fish length at the start of scale formation.

3.4. Implications for Fisheries Management

The findings of this study have important implications for the sustainable management of *Liza carinata* populations in Libyan waters. The strong relationship between length and weight, combined with observed variations in condition factors, suggests that this species is highly adaptable to its environment. However, further research is needed to explore the impact of environmental factors such as temperature and salinity on growth rates and overall population dynamics.

The use of scale analysis for age determination provides a valuable tool for monitoring fish populations and assessing the health of fisheries. By understanding the growth patterns and age structure of *L. carinata*, fisheries managers can develop more effective strategies for sustainable exploitation and conservation of this important resource

4. CONCLUSION

This study provides valuable insights into the age and growth dynamics of *Liza carinata* in the eastern Mediterranean, specifically on the Libyan coast. The results highlight the potential of scale analysis as a reliable tool for determining age and growth patterns in this species. Furthermore, the significant differences in growth rates and condition factors across age groups emphasize the importance of environmental factors in shaping the biological characteristics of *L. carinata*. Continued research is essential for optimizing fisheries management practices and ensuring the long-term sustainability of *Liza carinata* populations.

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