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Age Estimation and Growth Pattern of Common Pandora, *Pagellus erythrinus*, on the Coast of Benghazi - Eastern Libya

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Abstract

The aim of this study was to estimate the age and growth pattern of the common pandora *(Pagellus erythrinus)* from the coast of Benghazi, eastern Libya. We collected 102 samples of these fish during the winter season using nets and fishing lines. Age was determined by analyzing their scales, which ranged from one to four years. Total weight ranged from 31.58 to 189.7 grams, and total length ranged from 13.2 to 25.0 cm. The mean total length calculated inversely was estimated to be 8.5 cm at the end of the first year, 13.4 cm in the second year, 16.2 cm in the third year, and 17.4 cm in the fourth year. Growth in length was most pronounced in the first year, with an average increase of 4.9 cm representing 57.6% of the fish's size at that age. In the second year, growth slowed to 2.8 cm (20.9%), and by the third year it declined further to 1.2 cm (7.4%). These data show that *P. erythrinus* reaches a large fraction of its final size within the initial year of existence, after which its growth rate slows significantly. The statistical analysis, using a one-way ANOVA, revealed highly significant differences in the mean total length among the different age groups ($p<0.001$), confirming that age is a crucial factor influencing the size of this species. The von Bertalanffy model was used to determine the growth parameters, which included a theoretical age at zero length (t_0 = -1.51 years), an asymptotic length ($L\infty = 27.51$ cm), and a growth coefficient ($K= 0.34 year^{-1}$). These findings provide a valuable baseline for understanding the population dynamics of *P. erythrinus* in the region and highlight the importance of localized data for sustainable fisheries management. These results promote sustainable fisheries management throughout the Libya coast and advance our knowledge of *Pagellus erythrinus* population dynamics.

Keywords: *Pagellus erythrinus*, Age Estimation, scales, Growth Pattern, von Bertalanffy model, Eastern Libya.

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تقدير العمر ونمط النمو لسمكة الباندورا الشائعة (*Pagellus erythrinus*) في ساحل بنغازي – شرق ليبيا.

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الملخص

هدفت هذه الدراسة إلى تقدير عمر ونمط نمو سمكة البندورة الشائعة (Pagellus erythrinus) من ساحل بنغازي، شرق ليبيا. جمعنا 102 عينة من هذه الأسماك خلال فصل الشتاء باستخدام الشباك وخيوط الصيد. حُدد عمرها بتحليل قشورها، التي تراوحت أعمارها بين سنة وأربع سنوات. تراوح الوزن الإجمالي بين 31.58 و189.7 غرامًا، وتراوح الطول الإجمالي بين 13.2 و25.0 سم. قُدّر متوسط الطول الإجمالي المحسوب عكسيًا بـ 8.5 سم في نهاية السنة الأولى، و13.4 سم في السنة الثانية، و16.2 سم في السنة الثالثة، و17.4 سم في السنة الرابعة. كان النمو في الطول أكثر وضوحًا في السنة الأولى، بمتوسط زيادة بلغ 4.9 سم، أي ما يعادل 57.6% من حجم السمكة في ذلك العمر. في السنة الثانية، تباطأ النمو إلى 2.8 سم (20.9٪)، وبحلول السنة الثالثة انخفض أكثر إلى 1.2 سم (7.4٪). تُظهر هذه البيانات أن *P. erythrinus* يصل إلى جزء كبير من حجمه النهائي خلال السنة الأولى من عمرها، وبعد ذلك يتباطأ معدل نموه بشكل كبير. كشف التحليل الإحصائي، باستخدام تحليل التباين أحادي الاتجاه، عن اختلافات كبيرة في متوسط الطول الإجمالي بين الفئات العمرية المختلفة ($p < 0.001$)، مما يؤكد أن العمر عامل حاسم يؤثر على حجم هذا النوع. تم استخدام نموذج فون بيرتالانفي لتحديد معلمات النمو، والتي تضمنت عمرًا نظريًا عند الطول الصفري ($t_0 = -1.51$ سنة)، وطولًا مقاربًا ($L_\infty = 27.51$ سم)، ومعامل نمو ($K = 0.34$ سنة$^{-1}$). تُوفر هذه النتائج أساسًا قيّمًا لفهم ديناميكيات أعداد سمكة *P. erythrinus* في المنطقة، وتُبرز أهمية البيانات المحلية للإدارة المستدامة لمصايد الأسماك. تُعزز هذه النتائج الإدارة المستدامة لمصايد الأسماك على طول الساحل الليبي، وتُعزز معرفتنا بديناميكيات أعداد سمكة *P. erythrinus*.

الكلمات المفتاحية: *Pagellus erythrinus*، تقدير العمر، القشور، نمط النمو، نموذج فون بيرتالانفي، شرق ليبيا.

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1. Introduction

Fish growth is the process of increasing length and weight through food metabolism over time. Fish continue to develop as they age, but their growth rate slows or ceases once they reach a particular size. Age and growth are important characteristics for assessing fish populations' responsiveness to management techniques (Mayank and Dwivedi, 2015); (Pathak *et al*., 2015).

Assessing age and growth is a prerequisite for gathering information on recruitment, longevity, mortality, and fishery fluctuations caused by different year classes. This knowledge contributes to the development of sustainable fish stock exploitation strategies. Studies incorporating proper statistical refinements provide valuable insights into both the current status and historical trends of fish populations. The von Bertalanffy growth model corresponds closely to measured fish growth. (Gulland, 1983), (Pauly, 1984), and (Pauly and Morgan, 1987). It is a length-at-age model, which is widely employed in more sophisticated fisheries models. The major role is to estimate fish length or weight at a certain age, or vice versa, based on four parameters: L∞, K, and t0, which are unique to each fish species in its habitat. Values for these characteristics are typically computed using individual fish lengths at age from a random sample indicative of the original population at sea. The common pandora *(Pagellus erythrinus*), which belongs to the family Sparidae and inhabits the Mediterranean Sea, the Black Sea, and the Atlantic Ocean. This species is valuable for both aquaculture and fisheries. The fish range in length from 10 to 30 cm and can reach up to 60 cm (Bauchot & Hureau, 1986). Common Pandora fish are found at depths ranging from 10 to 100 meters and can be found at depths of up to 320 meters (Bauchot, 1987). The common pandora, *Pagellus erythrinus* (Linnaeus, 1758), is a seabream from the family Sparidae that lives on the continental shelf waters of the northeastern and central-eastern Atlantic Ocean, from Norway (Bauchot & Hureau., 1986) to Guinea Bissau (Sanches, 1991). It can also be found on the Madeira, Canary, and Cape Verde islands (Reiner, 1996). (Jardas ,1996) reports that it can be found on sandy-muddy bottoms in the Adriatic Sea, usually up to 100m. According to (Benli *et al*., 2001), the common pandora feeds primarily during the day. Common pandora is a carnivorous fish in the Tyrrhenian Sea and Greek waters, according to (Ardizzone and Messina, 1983) and (Caragitsou and Papaconstantinou.,1985). In the western and Egyptian Mediterranean waters, the diet of *Pagellus erythrinus* is primarily based on zoobenthic invertebrates (Rosecchi *et al*., 1983), (Rizzkalla

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et al., 1999). In Greek waters and the Tyrrhenian Sea, (Caragitsou and Papaconstantinou, 1985) and (Ardizzone and Messina,1983) outline typical the pandora is a fish that eats meat. In both the Egyptian and western Mediterranean waters, zoo benthic invertebrates make up the majority of *Pagellus erythrinu*ٰ *s* diet. (Rizzkalla *et al*., 1999); (Rosecchi *et al*., 1983). The demersal fish known as the common pandora *P.erythrinus*ٰ is found throughout the Black Sea, the Mediterranean Sea, and the western coasts of Africa and Europe in According to (Papacons *et al*., 1988), the Atlantic Ocean.

2. Materials and Methods

2.1. Area of study (Benghazi Coast, eastern Libya)

The study was carried out along the eastern coast of the Libyan Mediterranean Sea, specifically covering the entire coastline of Benghazi and its surroundings, which is located between 32°36'N and 20°03'E (Figure 1). This coastal region is distinguished by sand dunes and lagoon marshes (Al-Hassan and Silini, 1999). The fishing area is approximately 20 meters deep and stretches for 5 kilometers in front of the city. The region is home to seven fishing associations and numerous fishing businesses. This area has approximately 1200 fishermen who use a variety of fishing methods, including trammel nets and gill nets. Because of its ecological and economic importance, as well as its ease of access to fish samples, this area was chosen for sample collection and analysis in the current research.

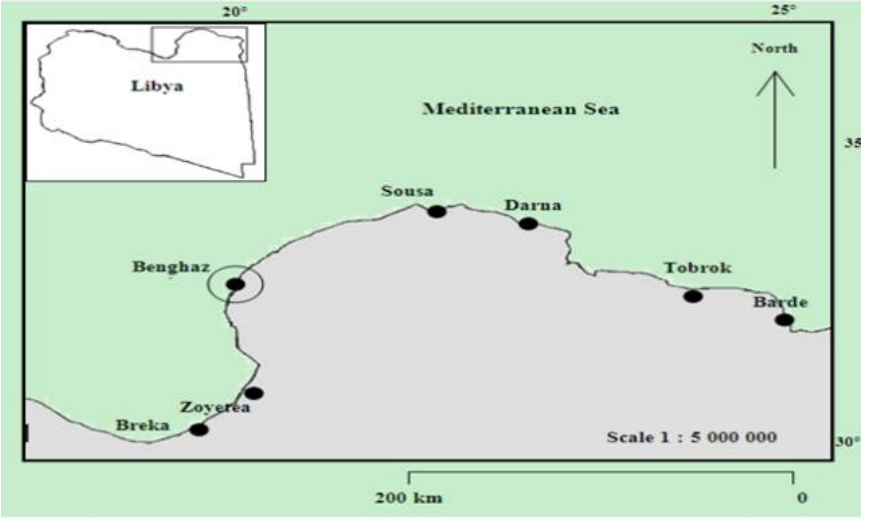

Figure 1: The study area (Coast of Benghazi, eastern Libya).

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Pagellus erythrinus (samples were obtained in the winter months (December, January, and February)). From fishermen operating in various locations along Benghazi's coastline. These fishermen typically use small motorized boats to fish with nets, hooks, and lines. The samples were brought to the laboratory, where the following measurements were taken for each specimen: total length "TL" (cm) and total weight "W" (g). A total of 102 specimens were examined to assess age and growth. Scales were sampled from the area behind the pectoral fin, with six scales taken from each individual for age determination using growth ring counts. Each scale was read three times by separate observers under a compound microscope at 10×–20× magnification, using reflected light and a black background. Disturbance rings were identified and excluded from counts based on their irregular shape, discontinuity across the scale, and increased thickness. Marginal increment analysis, following (Panfili *et al*., 2002), was used to confirm the annual nature of ring formation. All measurements were taken along the longest axis of the scale. Once annual deposition was verified, individuals were assigned to year classes according to capture date, annuli counts, formation periods, and the reproductive cycle of the local population (Panfili *et al*., 2002).

2.2. Age Determination:

The age was calculated only by inspecting and counting the annual growth rings on fish scales.

The link between scale radius (S) and total fish length (TL) was calculated using the formula TL = a + b (S). The back-calculated lengths at the end of each year of life were estimated by (Lee, 1920) equation as follows: Ln = (L - a) Sn / S + a where “Ln” is the calculated length at the end of nth year, “L” is the length at capture, “Sn” is the scale radius to nth annulus, “S” is the total scale radius and “a” is the intercept of the regression line with the Y-axis.

2.3. Growth Parameters and the Performance Index

Lt = L∞ (1 – e-k (t-to)) (von Bertalanffy, 1938) was the formula used to characterize the growth of *Pagellus erythrinus*. **Lt** = predicted length at time t; **L∞**= asymptotic length or maximum attainable length; **e** = Base of the natural log t; **t** = Time; **to** = the age at zero length; **K** = growth coefficient.

Using the (Chapman, 1961) approach, the von Bertalanffy growth

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parameters "L∞ and K" were computed. The following rearranged von Bertalanffy equation formula was used to estimate "to**": -**

ln[1-(Lt/L∞)]=-k*to+k*t.

The growth performance index was estimated using the following (Pauly and Munro., 1984) formula: where **φ = log K + 2 log L∞. φ** = Phi-prime, or a growth performance index based on length.

2.4. Statistical Analysis

To compare the variations between the fish's age groups, analysis of variance (ANOVA) was used. All statistical analyses were performed using IBM SPSS Statistics 26 with a significance level of $p < 0.05$.

3. RESULTS

3.1. Age and Growth

An examination of the scales of the common Pandora (*Pagellus erythrinus*) from the Benghazi shore in eastern Libya found that this population has a maximum age of four years. Back-calculated mean total lengths were assessed as 8.5 cm, 13.4 cm, 16.2 cm and 17.4 cm at the first, second, third and fourth years, respectively. Figures 2 and 3 show how length and weight change across these age divisions.

Growth in length was most pronounced in the first year, with an average increase of 4.9 cm representing 57.6% of the fish's size at that age. In the second year, growth slowed to 2.8 cm (20.9%), and by the third year it declined further to 1.2 cm (7.4%). These data show that *P. erythrinus* reaches a large fraction of its final size within the initial year of existence, after which its growth rate slows significantly.

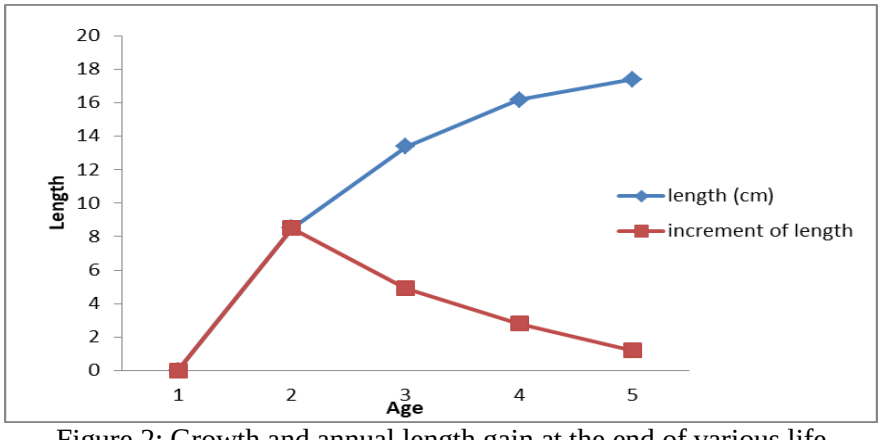

Figure 2: Growth and annual length gain at the end of various life stages combined sexes of *P. erythrinus* in 2025.

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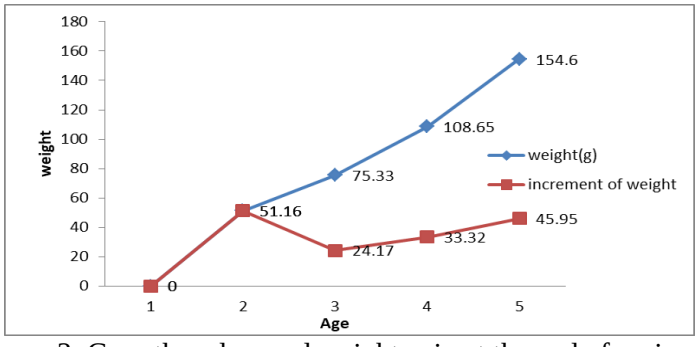

Figure 3: Growth and annual weight gain at the end of various life stages combined sexes of *P. erythrinus* in 2025.

3.2. Growth Parameters and the Performance Index

The Chapman (1961) method (Figure 4) was used to estimate growth parameters (L∞ & K) for *P. erythrinus*, and the Von Bertalanffy plot (Figure 5) was used to estimate t0. The results for all individuals were as follows: 27.51 cm, 0.34 per year-1, -1.51 years, and 2.411 for L∞, k, t0, and φ′ (Table 2).

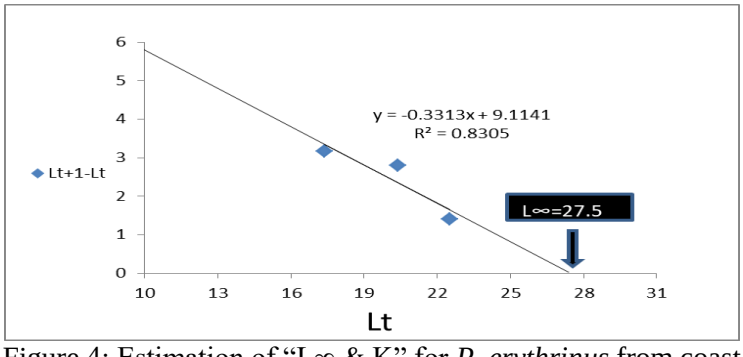

Figure 4: Estimation of "L∞ & K" for *P. erythrinus* from coast Benghazi, Libya.

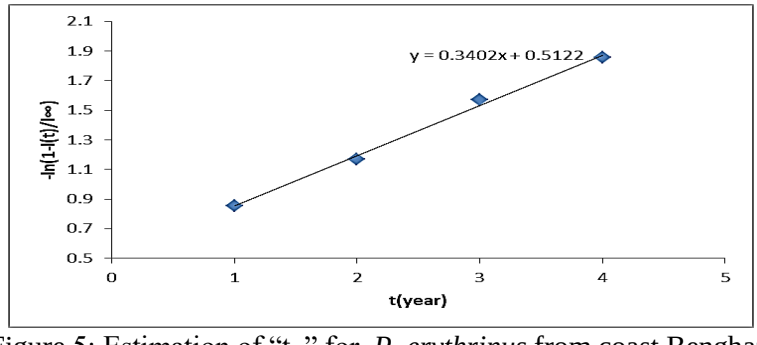

Figure 5: Estimation of "t_0" for *P. erythrinus* from coast Benghazi, Libya.

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The dimensions of the growth curves that fit the Von Bertalanffy growth equation for both sex samples were: Lt = 27.51(1-e (0.34*(t+1.51)) (Figure 6).

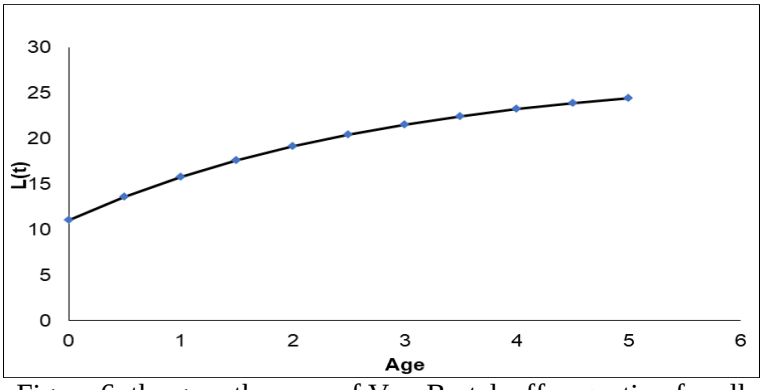

Figure 6: the growth curve of Von Bertalanffy equation for all indefinitely of *P. erythrinus* from coast Benghazi, eastern Libya.

3.3. Statistical Analysis of the Relationship between Age and Total Length

We assessed how body size changed with age by applying one-way ANOVA of variance to compare the mean total length (TL) of *Pagellus erythrinus* across the four age classes obtained. Age was treated as the independent factor, while total length was the dependent variable.

Table. 1. Descriptive statistics for the average total height (cm) according to age groups.

Age	N	Mean ± SD	Min	Max	p-value
1	32	15.9 ± 1.50	13.2	21.5	P < 0.001
2	24	17.5 ±2.7	13.5	23.2	P < 0.001
3	30	20.5 ± 2.3	15.7	23.6	P < 0.001
4	14	23.44 ± 1.51	19.5	25	P < 0.001

Notes:

- Mean Length: Calculated for each age group.
- Standard Deviation (SD): Reflects variation in fish lengths at each age.
- P - Value: Indicates the statistical significance of the results.
- Min: Minimum length for each age group.
- Max: Maximum length for each age group.

As shown in Table 1, average length increased steadily with age. The youngest group (age 1) had the smallest mean length at 15.90 cm, while fish aged four years reached an average of 23.44 cm. The ANOVA test confirmed that these differences were highly

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significant ($p < 0.001$), indicating that age plays a central role in determining the growth pattern of this species.

4. Discussion

The individuals examined in this study showed total lengths ranging from 13.2 to 25.0 cm, and body weights between 31.58 and 189.7 g. While these values differ slightly from those reported in previous studies, the overall findings remain largely consistent.

For example, (Taylan and Yapici, 2021) observed lengths between 10.2 and 28.5 cm in Marmaris Bay, whereas (Lteif *et al*., 2021) found a wider range from 7.5 to 40.0 cm along the Lebanese coast. In Tunisia, (Fassatoui *et al*., 2019) recorded sizes from 14.0 to 27.0 cm, and (Ayyidiz *et al*., 2019) reported a span of 18.5 to 34.5 cm around Gökçeada Island in Turkey.

Comparable growth patterns have also been reported in other Mediterranean populations, reflecting a consistent regional trend. (Mahdi *et al*., 2018) reported lengths between 12.0 and 38.0 cm off the Algerian coast, while (Saleh, 2018) documented ranges from 16.0 to 28.0 cm along the Telmethah Coast near Benghazi. In the Central Mediterranean, (Busalacchi *et al*., 2014) observed fish measuring between 5.5 and 48.0 cm, and (Metin *et al*., 2011) reported sizes from 4.1 to 27.8 cm in the Aegean Sea. Additional data from (Mehanna and Fattouh, 2009) noted lengths between 6.0 and 30.0 cm in Egyptian waters, while (Coelho *et al*., 2010) reported 12.0 to 44.8 cm in southern Portugal. (Hoşsucu and Cakir, 2003) recorded 7.0 to 22.8 cm in Edremit Bay.

The scarcity of smaller individuals in the present sample is likely related to local environmental conditions and the selectivity of the fishing gear used. Regarding growth, *P. erythrinus* exhibited a marked increase during its first year of life, gaining an average of 4.9 cm, which represented nearly 58% of its total annual growth. In the following years, growth slowed considerably, with increments of 2.8 cm (20.9%) in the second year and 1.2 cm (17.3%) in the third.

The pattern of rapid early growth followed by a gradual slowdown is common among many fish species and is generally linked to the reallocation of energy from somatic growth to reproduction as individuals mature. Observations from several studies across the Mediterranean corroborate these developmental patterns. The growth patterns observed in the present study are not unique to the Benghazi coast but are consistent with findings reported from other areas of the Mediterranean. Similar developmental trajectories have been

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reported elsewhere in the Mediterranean. For instance, (Fassatoui *et al*.,2019) documented a marked slowdown in growth following the initial rapid phase among populations in Tunisia. Likewise, (Somarakis and Machias, 2002), studying the Cretan Shelf, noted comparable declines in growth rates with advancing age.

In Egyptian waters, both (Mehanna and Farouk, 2021) and (Hegab *et al*., 2025) confirmed the persistence of this trend, suggesting it may be a common feature of *Pagellus erythrinus* across different ecological contexts. Such findings are consistent with established biological principles, where fish typically experience accelerated growth during early life stages, followed by a tapering off as energy demands shift toward reproduction and maintenance. The statistically significant variation in size across age classes observed in our data reinforces the notion that age plays a central role in determining body dimensions. Beyond their biological implications, these results offer practical value: they can inform stock assessment models, support age estimation from length data in future research, and assist in designing more effective size-based regulations for sustainable fisheries management.

Table. 2. Shows the growth parameters for *Pagellus erythrinus* in different locales.

$L\infty$ (cm)	K (year^{-1})	T0 (years)	φ	Locality	Authors
47.1	0.08	-4.42	2.25	Portugal	Erzini *et al*. (2001)
27.8	0.32	-0.74	2.40	Cretan Shelf	Somarakis and Machias (2002)
24.0	0.16	-2.6	1.96	Edremit Bay	Hoşsucu and Çakır (2003)
33.4	0.37	-0.23	2.62	Egyptian Medit.	Mehanna and Fattouh (2009)
54.3	0.12	-1.12	2.54	Tyrrhenian Sea	Abella *et al*. (2010)
40.1	0.17	0.75	2.44	South Levant Sea	El_Haweet *et al*. (2011)
34.1	0.153	-1.922	2.25	Northern Tunisia	Fassatoui *et al*. (2019)
28.02	0.150	-3.961	2.07	southern Tunisia	Fassatoui *et al*. (2019)
29.98	0.38	-0.958	2.538	North Sinai Egypt	Hegab *et al*. (2025)
27.51	0.34	-1.51	2.411	Coast Benghazi, eastern Libya	Present study

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The Von Bertalanffy Growth Function (VBGF) von (Bertalanffy, 1930) was used to assess the growth characteristics and population status of *Pagellus erythrinus* along the Benghazi coast. The calculated parameters for this population were: $L\infty = 27.51$ cm, $k = 0.34$ year^{-1} and $t_0 = -1.51$ year. These values suggest that the *P. erythrinus* population in this region grows at a relatively faster rate compared to populations from several other areas.

When compared with findings from previous research, our results reveal noticeable regional variation in growth dynamics. For instance, (Erzini *et al*., 2001) documented a markedly slower growth rate in Portuguese waters, with a larger asymptotic length ($L\infty = 47.1$ cm) but a much lower growth coefficient ($k = 0.08$ year^{-1}). A similar trend was observed by (Abella *et al*., 2010) in the Tyrrhenian Sea, where a high $L\infty$ (54.3 cm) was accompanied by a low k value (0.12 year^{-1}).

On the other hand, the parameters observed in this study are more in line with those reported from other parts of the Mediterranean basin. For example, Egyptian studies by (Mehanna and Fattouh, 2009) and (Hegab *et al*., 2025) yielded comparable estimates ($L\infty = 33.4$ cm, $k = 0.37$ year^{-1} and $L\infty = 29.98$ cm, $k = 0.38$ year^{-1}, respectively). A broader look across the region also shows variation. In Edremit Bay, (Hoşsucu and Çakır, 2003) reported a smaller asymptotic length ($L\infty = 24.0$ cm) with a low growth coefficient ($k = 0.16$ year^{-1}). Interestingly, the results from the present study closely mirror those from the Cretan Shelf, where (Somarakis and Machias, 2002) recorded $L\infty = 27.8$ cm and $k = 0.32$ year^{-1}.

Additional variability is evident from other Mediterranean locations. (El-Haweet *et al*., 2011), for instance, reported $L\infty = 40.1$ cm and $k = 0.17$ year^{-1} in the South Levant Sea. In Tunisia, (Fassatoui *et al.*, 2019) presented two sets of values from different regions: $L\infty = 34.1$ cm, $k = 0.153$ year^{-1} and $L\infty = 28.02$ cm, $k = 0.150$ year^{-1}. These differences underscore the influence of environmental, ecological, and possibly genetic factors on the growth patterns of *P. erythrinus* across its range.

The evident regional differences in growth parameters suggest that *Pagellus erythrinus* inhabiting the Benghazi coast may benefit from more favorable growth conditions. The accelerated growth of this fish could be due to a mix of factors, like higher sea temperatures, more available food, and different levels of fishing pressure. Scientists (Benetti & Fagundes , 1991) and (Kraiem, et al., 2001) have previously shown that these environmental and human influences play a big role in the growth of marine fish.

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These findings highlight the importance of conducting localized studies rather than relying solely on broad, region-wide growth models. Generalized approaches may fail to capture site-specific dynamics and lead to inaccurate assessments of population status. A localized perspective is therefore essential to ensure effective management strategies that reflect the unique ecological and fisheries contexts of each area. Tailoring management efforts in this way contributes directly to the long-term sustainability and resilience of fish stocks.

5. Conclusions

The findings of this study contribute meaningfully to addressing gaps in knowledge related to the distribution and biological performance of *Pagellus erythrinus* in the Benghazi coastal waters. Based on the observed results, several recommendations are proposed to support future research efforts and enhance fisheries management in the region.

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