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# Age and Growth of the Silver Grunt *Pomadasys argenteus* (Forsskal, 1775) in Jizan Fisheries, Saudi Arabia

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*Abstract*. The silver grunt *Pomadasys argenteus* is one of the commercial fish species in the family Haemulidae widely distributed in the Indo-West Pacific (from Red Sea to Fiji). The age of this species was determined using scales. The back-calculated lengths-at-ages were estimated using the body proportional hypothesis (BPH) based on the relation between the body length and scale measurements. The relationship between the scale radius (S) and total length (L) could be described by the linear form: L = 4.632 S - 4.813 ($R^2$ = 0.93) for males, L = 4.37 S - 2.761 ($R^2$ = 0.94) for females, and L = 4.39 S - 3.28 ($R^2$ = 0.95) for pooled sexes. Seven age groups were determined for females ($I^+$ to $VII^+$), and five groups for males ($I^+$ to $V^+$). Growth parameters were estimated from the growth rates and found to be $L_\infty$ (asymptotic length) = 52.33 cm, K (growth coefficient) = 0.197 $yr^{-1}$, and $t_o$ (supposed age at zero length) = -0.74 yr for males; $L_\infty$ = 57.39 cm, K = 0.174 $yr^{-1}$, and $t_o$ = -0.82 yr for females; and $L_\infty$ = 56.07 cm, K = 0.181 $yr^{-1}$, and $t_o$ = -0.79 yr for pooled sexes. The length-weight relationship was described by the nonlinear power equation: $W = 0.0130\ L^{3.014}$ ($R^2$ = 0.99) for males, $W = 0.0146\ L^{2.98}$ ($R^2$ = 0.99) for females, and $W = 0.0138\ L^{3.00}$ ($R^2$ = 0.99) for pooled sexes. The growth of this species is isometric where the regression slope for both sexes does not differ significantly from the value ' 3 ' of the isometric growth. The life span (maximum age) was estimated to be 16.4 yr for females, 14.5 yr for males, and 15.8 yr for combined sexes, indicating that the silver grunt in Jizan fisheries is a moderate sized fish species (between 10 to 20 yrs).

*Keywords*: *Pomadasys argenteus*, age determination, Growth parameters, life span, Jizan fisheries.

## 1. Introduction

Fishes of the family Haemulidae are commonly known as grunts due to their ability to produce sound by grinding their teeth. This family has 136 species in 19 genera (Fricke *et al.*, 2021). These fishes are found in tropical marine, brackish and rarely fresh waters in the Indo-West Pacific region (from Red Sea to Fiji). They are found mainly in inshore waters, particularly in mangroves and soft-bottom habitats, feeding mainly on benthic invertebrates such as bivalves, shrimps and polychaetes (Sheaves and Molony, 2000, Kulbicki *et al.*, 2009).

Some species of Grunts are highly priced food fishes and represent one of the major components of the fish biomass in the coastal waters in the Indo-Pacific. The silver grunt *Pomadasys argenteus* is one of the larger species of grunts, reaching 60 cm SL (McKay, 1998). It is a major food fish targeted in both commercial and recreational fishing (Ley *et al*., 2002).

Life history parameters of fishes estimated based on age studies (Choat and Robertson, 2002) are necessary in investigating the effect of fishing on fish populations and how they respond to their exploitation (Jennings *et al.*, 2001), and in assessment of the status of fish stocks (Grandcourt, 2005). Several studies have been conducted on the growth of silver grunt from different fisheries (Brothers and Mattews, 1987; Bade, 1989; Mathews and Samuel, 1991; Salman *et al.*, 2005; Kulbicki *et al*., 2009).

In Jizan Fisheries, this species is one of the important food fish caught mainly in the commercial trawl and artisanal gillnet fishing. However, little is known about the growth and biology of this species in the Red Sea. The aim of the present study is to determine age and growth parameters of the silver grunt *P. argenteus* in Jizan fisheries.

## 2. Materials and Methods

Monthly samples of the silver grunt *Pomadasys argenteus* (a total of 338 specimens) from Jizan fisheries were collected randomly during the period from September 2019 to March 2020 from the fish landing site of Jeddah, where most of the trawl catch is being marketed at early morning. The total fish length was measured to the nearest 0.1 cm and total body weight to the nearest 0.1 g. To describe the length-weight relationship, the following power equation was used:

$$W = a\, L^b \qquad \text{(Le Cren, 1951)}$$

The constants a and b were estimated by the linear regression analysis between the Ln L (independent variable) and Ln W (the dependent variable) through the linear form:

$$\text{Ln } W = \text{Ln } a + b \text{ Ln } L$$

To determine if the growth is isometric or not, the Pauly's t-test (Pauly, 1984) was used to test if the slope b is different from the value ' 3 ' of the cubic law.

For age determination, scales were removed and cleaned in water, dried and mounted between two microscope glass slides. The scales were examined under a stereo-zoom microscope (AmScope) using a digital video camera (AmScape18 MP) connected to a computer. The pictures of scales were saved for later measurements.

The relationship between the body length (L) and scale radius (S) was described using the linear regression of total length (L) on the scale radius (S) according to the linear form:

$$L = c + d\, S$$

Where 'c' is the intercept, and 'd' is the slope. The back-calculated lengths-at-ages were estimated using Body proportional hypothesis (BPH) as described in Francis (1990):

$$L_i = [(c + dS_i) / (c + dS)]\, L$$

Where, $L_i$ is the back-calculated length at the time of annulus ' i ' formation, $S_i$ is the radius of the annulus ' i '. The average calculated lengths at ages were estimated and the annual rates of growth in length and in weight were determined. The growth parameters of von Bertalanffy (1938) growth equation (VBGE):

$$L_t = L_\infty\, [1 - e^{-K\,(t - t0)}]$$

The asymptotic length ($L_\infty$) and the growth coefficient (K) were estimated using Ford (1933) and Walford (1946) method, by fitting the method to the average back-calculated lengths-at-ages for males, females and sexes combined. The hypothetical age at zero length ($t_0$) was estimated using the following empirical equation suggested by Pauly (1980):

$$\text{Log } (-to) = -0.3922 - 0.2752 \log L\infty - 1.038 \log K$$

The formula suggested by Pauly and Munro (1984): $\Phi' = \text{Log } K + 2 \text{ Log } L_\infty$ was used to estimate the growth in length performance index (phi-prime, Φ') for this species in Jizan fisheries. The maximum life span of *P.*

*argenteus* in Jizan fisheries was estimated using the following form suggested by Taylor (1958):

$$t_{max} = t_0 + 3 / K$$

## 3. Results and Discussion

### *3.1 Age Determination*

Depending upon the characteristic pattern recognized on the scales (Fig. 1), and the annual time scale (Williams and Bedford, 1974) assigned for each annulus (annual check mark), the scales of *P. argenteus* were used for age determination. The time scale assigned for the annual check marks has been confirmed in previous studies on this species used scales (Bade, 1989), and otolith (Salman *et al*., 2005, Kulbicki *et al*., 2009) for age determination. The number of annuli formed on the scales was counted and the age (in years) could be assigned to each specimen. Seven age groups ($I^+$ - $VII^+$) and 5 age groups ($I^+$ - $V^{+)}$ were determined for females and males, respectively.

### *3.2 Body Proportional Hypothesis (BPH)*

Figure 2 shows the relationship between the total fish length and scale radius for pooled data. This relationship was found to be linear based on the following equation:

For males, $L = 4.63\ S - 4.81$ $(R^2 = 0.93)$

For females, $L = 4.37\ S - 2.76$ $(R^2 = 0.94)$

For sexes combined, $L = 4.39\ S - 3.28$ $(R^2 = 0.95)$

The individual back-calculated lengths-at-ages were calculated using the body proportional hypothesis (BPH) formula for sexes combined:

$$L_i = [(3.28 + 4.39\ S_i) / (3.28 + 4.39\ S)] \times L$$

The average back-calculated lengths at ages estimated for males, females and sexes combined are illustrated in Table 1 and Fig. 3. The analysis of variance showed no significant difference between the average calculated lengths at ages for males and those at corresponding ages for females and sexes combined (ANOVA: $F = 0.2974$, $P = 0.827$). This indicates that both sexes of *P. argenteus* in Jizan fisheries have similar growth pattern that agrees with previous studies on the same species (Brothers and Mathews, 1987; Bade, 1989; Salman *et al.*, 2005; Kulbicki *et al*., 2009)

### *3.3 Growth in Length*

As shown in Table 1 and Fig. 4, the maximum growth rate in length occurred through the first year (15.5 cm). During the second year, the growth rate decreased to 6.7 cm. The growth rates during the first and the second year of life was 22.3 cm, collectively, which is equivalent to 51% of the maximum observed length 44 cm. This conclusion agrees with the observations of Legendre and Albaret (1991) for wild fish populations. The growth in length displayed gradual decrease during the next years, reaching the minimum in the $7^{th}$ year of age (2.2 cm).

However, similar results were recorded in previous research on this species at different localities. Based on the otolith microstructures of *P. argenteus* in the Persian Gulf, Brothers and Mathews (1987) estimated the length at the fifth year of life to be 358 mm total length which is also very close to our calculated length of 364 mm total length at the end of fifth year. Bade (1989) used scales for age determination of *P. argenteus* in North Queensland waters and reported that the largest fish sampled was 430 mm total length and from the marks observed on the scales he suggested that its age was between 5 and 6 years old. Also, Salman *et al*. (2005) used otoliths for age determination of *P. argenteus* in Red Sea fisheries of Yemen (very close to Jizan Fisheries) and recorded six age groups for fish ranging in total length from 130 to 440 mm. Similarly, Kulbicki *et al.* (2009) used fish otoliths for age determination and reported similar growth pattern for *P. argenteus*

in New Caledonia, where fish can attain 341 mm (Fork length) by the end of fifth year of life which is very close to our findings (if the fork length converted to total length).

### *3.4 Growth Parameters and Performance Index*

The von bertalanffy growth curve for *P. argenteus* (for sexes combined) in Jizan fisheries is shown in Fig. 5. Listed in Table 2 are the results obtained compared to the results estimated for the same species by different authors at different localities.

The following equation is the von Bertalanffy Growth Function (VBGF) used to estimate the growth curve of *P. argenteus* in Jizan fisheries shown in Fig. 5:

$$L_t = 56.07\ [1- e^{-0.181\ (t + 0.79)}]$$

Based on the results obtained for the asymptotic length and the growth coefficient, the performance index of growth in length (phi-prime, Φ') of the silver grunt in Jizan fisheries was estimated to be 2.73, 2.76 and 2.75 for males, females and pooled sexes, respectively.

However, the results in Table 2 show considerable variability among growth parameters and performance index. This might be due to using different methods and techniques to determine age and estimate back-calculated lengths at ages. For example, different sites of scales used, scales measuring at different angles and poor representation of all size groups, in addition to different geographical distribution can result in a wide variation in the parameters of the regression analyses used in the back-calculation methods (Carlander, 1982; Hirschhorn & Small, 1987 and Taylor *et al.*, 2020).

### *3.5 Length-weight Relationship*

The length-weight relationship for males, females and combined sexes of *P. argenteus* in Jizan fisheries could be described by the following equations:

For males,

$$W = 0.0130\ L^{3.01} \quad (R^2 = 0.986,\ n = 155)$$

For females,

$$W = 0.0146\ L^{2.98} \quad (R^2 = 0.987,\ n = 183)$$

For combined sexes,

$$W = 0.0138\ L^{3.00} \quad (R^2 = 0.986,\ n = 338)$$

The observed and predicted weights for 338 specimens of *P. argenteus* (combined sexes) displayed total length range from 15.5 – 44.0 cm and total weight from 41 – 1127 gm (Fig. 6).

The Pauly's t-test, indicates isometric growth for males and females of *P. argenteus* in Jizan fisheries, where the exponent 'b' values for both sexes were not significantly different from the value '3' of the isometric growth (for males: t = 0.342, critical t = 1.96 for *P* = 0.05; for females: t = 0.576, critical t = 1.96 for *P* = 0.05). These results are comparable with other previous studies (Table 3).

The values of the exponent b during the present study (2.74 to 3.138), fall within the range (2.5 to 3.5) suggested by Carlander (1969) and reported by Froese (2006). The variability of b values may be due to different factors such as food availability and water temperature which differs among seasons and regions, in addition to sex, length type and range of the specimens used in the regression analysis (Tesch, 1971; Pitcher and Hart, 1982)

### *3.6 Growth in Weight*

One of the benefits of the length-weight relationship in fish is converting the lengths at ages to weights at ages. So, the weights-at-ages corresponding to the length-at-ages were calculated by using this relationship described for *P. argenteus* in Jizan fisheries. Results are represented in Fig. 7 showing the growth in weight and annual increment. The maximum growth in weight was attained during the sixth

year of life (221.6 gm). The maximum asymptotic weight corresponding to the asymptotic length ($L_\infty$ = 56.07 cm) was estimated to be 2403 gm.

### *3.7 Maximum Age (Life span)*

Taylor (1958) suggested the following form to estimate the maximum life span of fish:

$$t_{max} = t_0 + 3 / K$$

Where, $t_{max}$ is the maximum life span (longevity) of fish having a length equal to 95% of the maximum asymptotic length $L_\infty$. K and $t_0$ are the estimated growth parameters. This form was used to estimate the longevity of *P. argenteus* in Jizan fisheries. Females were found to have longer life span (16.4 yr) than males (14.5 yr), and the longevity for pooled sexes was estimated to be 15.8 yr. It has been supposed that fish having a life span of more than 20 years are long-lived species (King & McFarlane, 2003; Martinez-Andrade, 2003 and Newman *et al*., 2016). Accordingly, *P. argenteus* in Jizan fisheries is a moderate sized fish having a maximum life span lower than 20 yrs. In North Queensland, this species was reported as a moderate sized fish attaining the maximum asymptotic length (481 mm) in approximately 10 years (Bade, 1989).

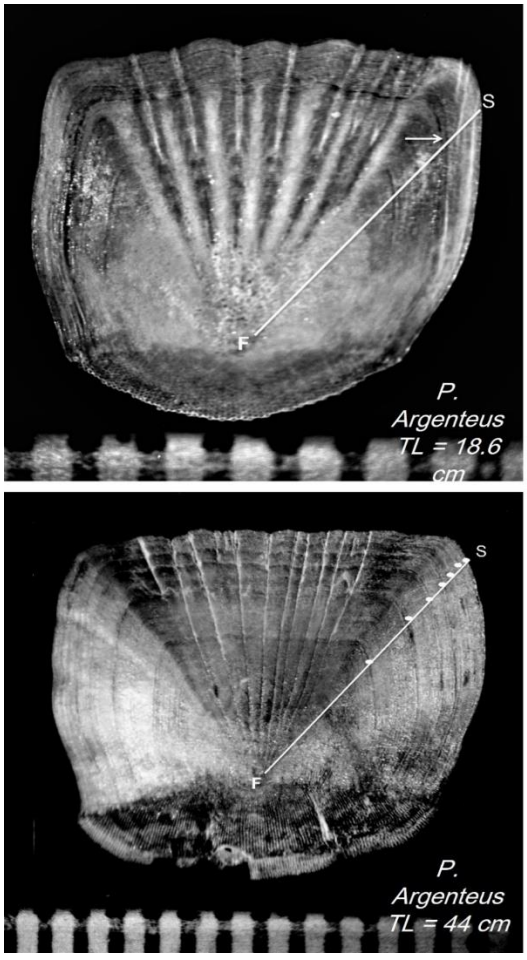


**Fig. 1. A scale of 18.6 cm (top: age group I+) and 44 cm (bottom: age group VII+) total length specimens of *P. argenteus* in Jizan fisheries showing the annual check marks (F is the focus, and S is the scale radius).**

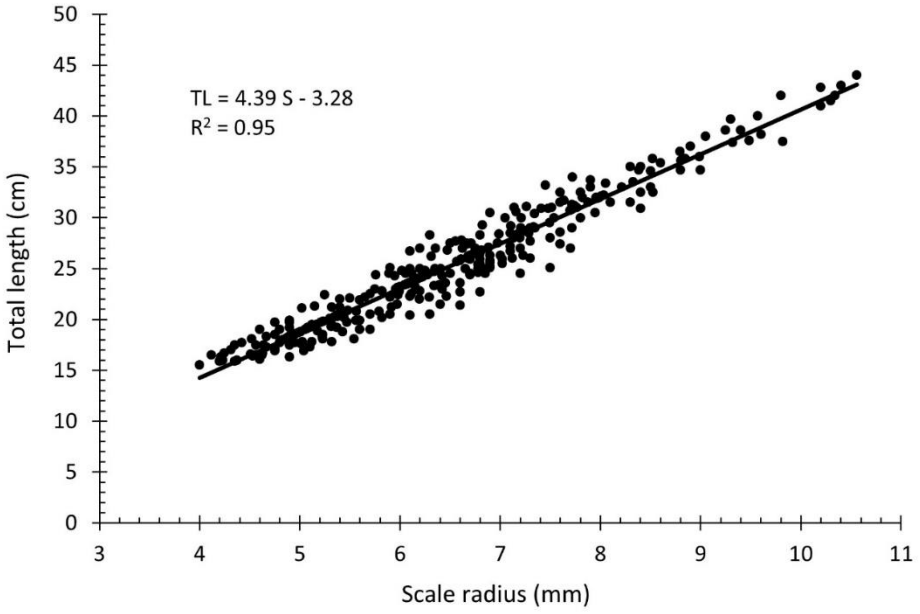


**Fig. 2. Total length–Scale radius relationship of *P. argenteus* (combined sexes) in Jizan fisheries.**

**Table 1. The average back-calculated lengths at ages for males, females and sexes combined of *P. argenteus* in Jizan fisheries.**

| Age | Average back-calculated length | | | Annual increment (pooled) | VBGF (pooled) |
|---|---|---|---|---|---|
| | Males | Females | Combined sexes | | |
| 1 | 15.6 | 15.7 | 15.5 | 15.5 | 15.5 |
| 2 | 22.1 | 22.3 | 22.2 | 6.70 | 22.2 |
| 3 | 27.6 | 2 7.8 | 27.6 | 5.40 | 27.8 |
| 4 | 32.0 | 32.6 | 32.4 | 4.80 | 32.5 |
| 5 | 35.6 | 37.0 | 36.4 | 4.00 | 36.4 |
| 6 | | 40.1 | 40.1 | 3.70 | 39.7 |
| 7 | | 42.7 | 42.3 | 2.20 | 42.4 |

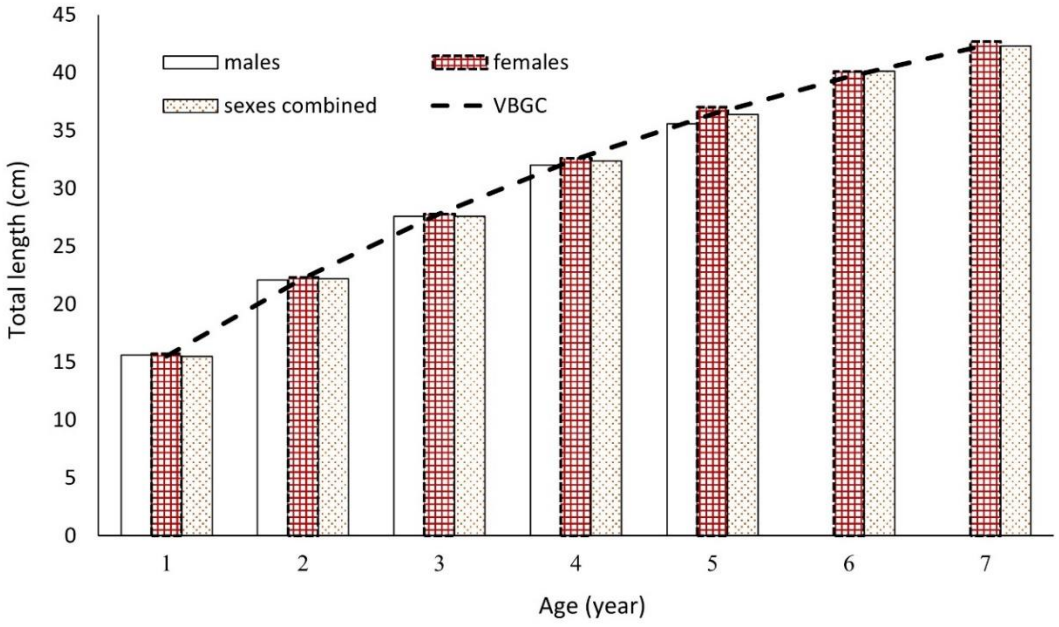


**Fig. 3. The mean back-calculated lengths at ages estimated by body proportional hypothesis (BPH) for males, females and sexes combined of *P. argenteus* in Jizan fisheries.**

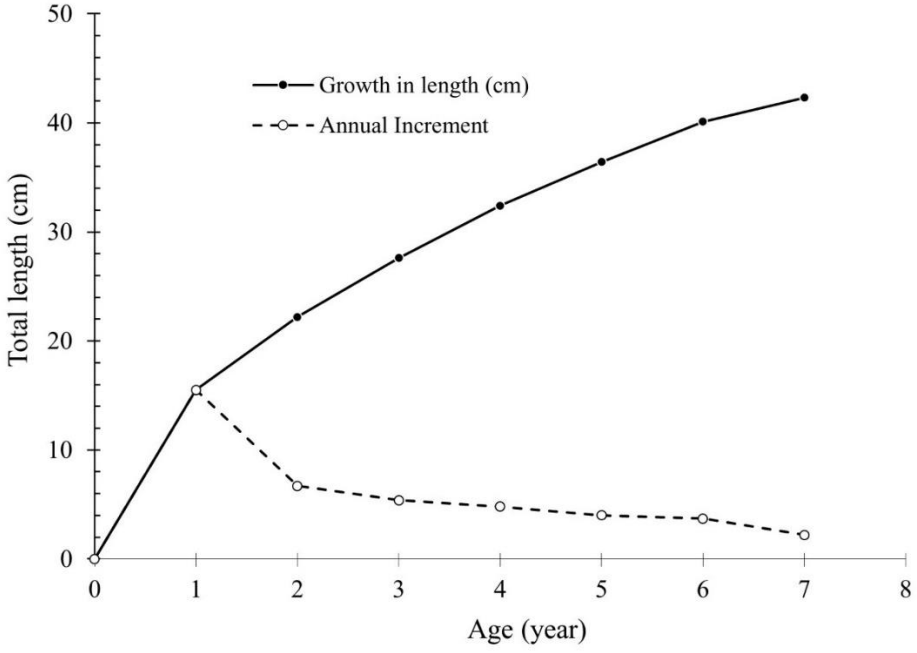


**Fig. 4. Growth in length and annual increment of *P. argenteus* in Jizan fisheries.**

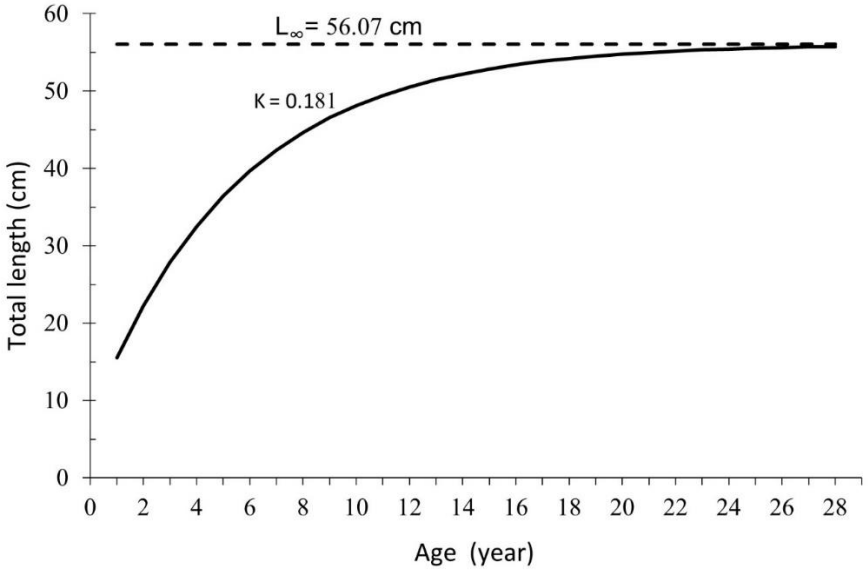


**Fig. 5. von Bertalanffy growth curve for *P. argenteus* (sexes combined) in Jizan fisheries.**

**Table 2. Growth parameters and Growth performance index (Φ') of *P. argenteus* at different locations estimated by different authors.**

| Author (Locality) | Method | Sex | $L_\infty$ (cm) | K ($yr^{-1}$) | $t_o$ (yr) | Φ' |
|---|---|---|---|---|---|---|
| The present study (Red Sea- Jizan) | Scales TL | M | 52.33 | 0.197 | -0.738 | 2.73 |
| | | F | 57.39 | 0.174 | -0.816 | 2.76 |
| | | C | 56.07 | 0.181 | -0.791 | 2.75 |
| Kulbicki *et al*. (2009) (New Caledonia) | Otoliths FL | C | 42.00 | 0.346 | 0.161 | 2.79* |
| Mathews and Samuel (1990) (Kuwait) | Otoliths TL | C | 67 | 0.238 | NA | 3.03 |
| Bade (1989) (North Queenland) | Scales TL | C | 48.1 | 0.384 | 0.012 | 2.95* |
| Brothers and Mathews (1987) (Iran) | Otoliths TL | C | 55.1 | 0.210 | NA | 2.80 |

M is Male, F is Female, C is combined sexes, TL is the Total Length, FL is the Fork Length
* Estimated from K and L∞ values.

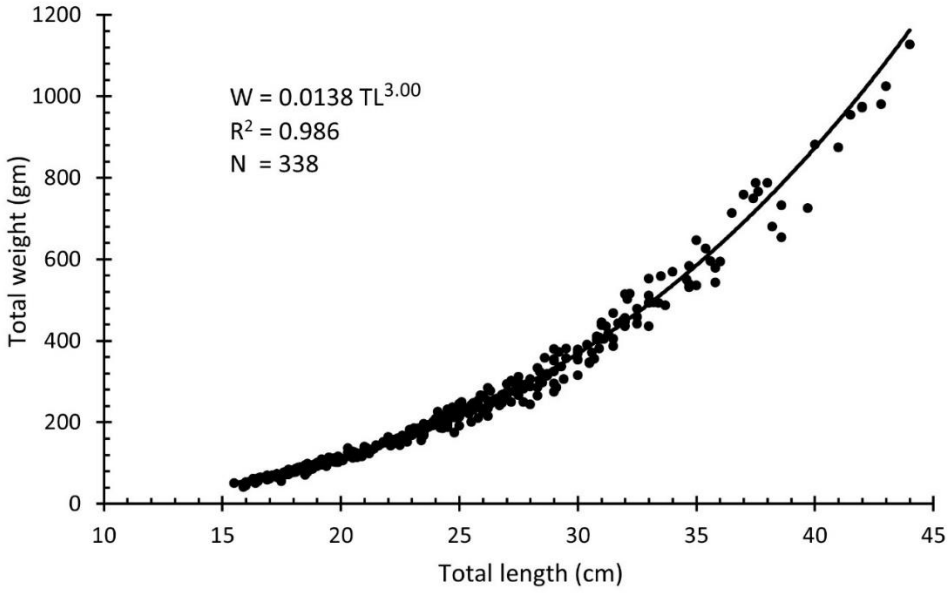


**Fig. 6. Length-weight relationship of *P. argenteus* (sexes combined) in Jizan fisheries.**

**Table 3. Length-weight relationship parameters of *P. argenteus* estimated by different Authors at different localities.**

| Authors | Sex | a | b | $R^2$ | N | Size range (cm) |
|---|---|---|---|---|---|---|
| The present study (Red Sea, Jizan) | M | 0.0130 | 3.01 | 0.986 | 155 | 15.5 – 36.0 TL |
| | F | 0.0146 | 2.98 | 0.987 | 183 | 15.9 – 44.0 TL |
| | C | 0.0138 | 3.00 | 0.986 | 338 | 15.5 – 44.0 TL |
| Karna *et al*. (2020) (Chilika Lagoon, India) | C | 0.0140 | 3.01 | 0.984 | 23 | 5.0 – 16.2 TL |
| Kulbicki *et al*. (2009) (New Caledonia) | C | 0.0229 | 2.937 | 0.994 | 869 | 14.0 – 44.0 FL |
| Salman *et al*. (2005) (Red Sea, Yemen) | C | 0.032 | 2.74 | NA | 166 | 13.9 – 44.2 TL |
| Al Sakaff and Esseen, (1999) (Yemen) | M | 0.0090 | 3.138 | 0.891 | 214 | 13.5 – 39.2 TL |
| | F | 0.0150 | 2.999 | 0.873 | 200 | 14.5 – 38.4 TL |

M is Male, F is Female, C is combined sexes, TL is the Total Length, FL is the Fork Length

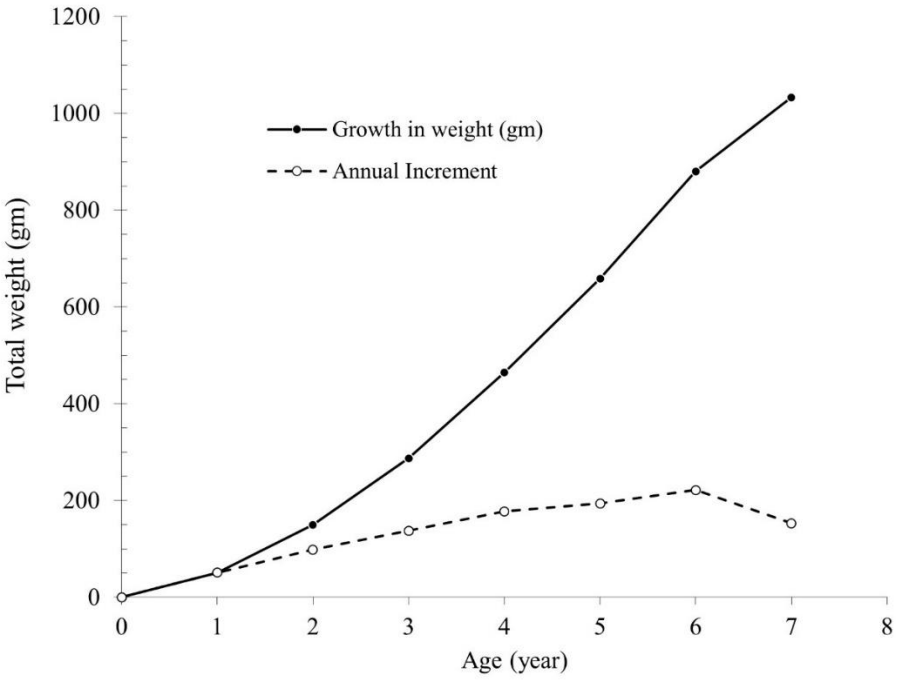


**Fig. 7. Growth in weight and annual increment of *P. argenteus* (sexes combined) in Jizan fisheries.**

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# تحديد العمر والنمو لأسماك الناقم (*Pomadasys argenteus*) في مصايد جيزان – المملكة العربية السعودية

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*المستخلص.* أسماك الناقم (*Pomadasys argenteus*) هي أحد أنواع الأسماك التجارية في عائلة (Haemulidae) المنتشرة على نطاق واسع في المحيط الهندي وغرب المحيط الهادئ (من البحر الأحمر إلى فيجي). تم استخدام القشور فى تحديد الأعمار لهذا النوع. كما تم احتساب الأطوال المقابلة للأعمار باستخدام العلاقة التناسبية للجسم (BPH) اعتمادًا على العلاقة بين طول الجسم وقياسات القشرة. وقد أمكن وصف العلاقة بين نصف قطر القشرة (S) والطول الكلي (L) بالمعادلة الخطية: $L = ٤,٦٣٢\ S - ٤,٨١٣$ ($R^2 = ٠,٩٣$) للذكور، و$S = L - ٤,٣٧$ ٢,٧٦١ ($R^2 = ٠,٩٤$) للإناث، و$L = ٤,٣٩\ S - ٣,٢٨$ ($R^2 = ٠,٩٥$) للجنسين معا. وأمكن تحديد سبع فئات عمرية للإناث ($I^+$ إلى $VII^+$)، وخمس فئات عمرية للذكور ($I^+$ إلى $V^+$). وتم حساب معاملات النمو من معدلات النمو وتبين أنها $L_\infty$ (أقصى طول) = ٥٢,٣٣ سم، و$K$ (معامل النمو) = ٠,١٩٧ في السنة، و$t_o$ (العمر المفترض عند طول صفر) = –٠,٧٤ سنة للذكور؛ $L_\infty$ = ٥٧,٣٩ سم، $K$ = ٠,١٧٤ في السنة، و$t_o$ = –٠,٨٢ سنة للإناث؛ و$L_\infty$= ٥٦,٠٧ سم، $K$ = ٠,١٨١ فى السنة، و$t_o$ = –٠,٧٩ سنة للجنسين معا. وأمكن وصف علاقة الطول بالوزن بواسطة معادلة الطاقة غير الخطية: $W = ٠,٠١٣٠\ L^{3.014}$ ($R^2 = ٠,٩٩$) للذكور، $W = ٠,٠١٤٦\ L^{2.98}$ ($R^2 = ٠,٩٩$) للإناث، و $W = ٠,٠١٣٨\ L^{3.00}$ ($R^2 = ٠,٩٩$) للجنسين معًا. ويعتبر نمو هذا النوع مثاليًا، إذ إن معامل الانحدار لكل من الذكور والإناث لا يختلف اختلافا معنويا عن قيمة '٣' للنمو المثالي. وقدر أقصى عمر (مدى الحياة) بـ ١٦,٤ سنة للإناث، و١٤,٥ سنة للذكور، و١٥,٨ سنة للجنسين معًا، مما يشير إلى أن أسماك الناقم في مصايد جيزان هو من الأنواع متوسطة الحجم.

*الكلمات المفتاحية:* أسماك الناقم، تحديد العمر، معايير النمو، مدى الحياة، مصايد جيزان.