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ORIGINAL ARTICLE

Population parameters and reproductive biology of the streaked gurnard, *Chelidonichthys lastoviza* (Bonnaterre, 1788) in the Egyptian Mediterranean waters (GFCM-GSA 26)

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Abstract

The population dynamics and reproduction of the streaked gurnard, *Chelidonichthys lastoviza* (Bonnaterre 1788), has been studied based on collected data between January 2020 and December 2021 from the Egyptian Mediterranean waters. In this study, age, growth, mortality, critical lengths, sex, gonadal maturation and spawning season were determined. A total of 1215 specimens ranged between 7.9 and 26.6cm TL and 5 to 220g total weight were sampled. Total lengths of males ranged from 11.5 to 24.4cm (n= 474), and of females from 11.0 to 26.6cm (n=553). The maximum observed age based on otolith readings was 4 and 5 years for males and females respectively. The length-weight relationship was estimated as $W= 0.0093L^{3.0487}$ for males and $W= 0.0089L^{3.0673}$ for females indicating an isometric growth. The von Bertalanffy growth equation was $L_t= 27.56(1-e^{-0.433(t+0.62)})$ for males and $L_t= 30.92(1-e^{-0.299(t+0.92)})$ for females. The growth performance index was computed as 2.52 (males) and 2.46 (females). Males mature at smaller lengths and younger ages ($L_m= 15.2$cm, $T_m= 0.61$ years) than females ($L_m=15.8$cm, $T_m= 0.71$ years). The male: female ratio was 1:1.17. The gonado-somatic index (GSI) values defined a protracted spawning season starting in November till February with a peak in January and December for males and females respectively.

Keywords: Triglidae, *Chelidonichthys lastoviza*, Mediterranean, Growth, Reproduction.

INTRODUCTION

Fishery resources in Egypt are one of the greatest food resources and have been extensively contributed in the food security and the economy of the country. The fisheries in Egypt constitute a variety of commercially important marine and freshwater species that support both the artisanal and industrial fleets. Also, the growing seafood trade and fisheries related industries help to sustain the income for a wide sector of Egyptian.

The streaked gurnard, *Chelidonichthys lastoviza*, is an important commercial demersal marine fish species belonging to the family Triglidae, which can be commonly found in the north-eastern Atlantic, in the Mediterranean Sea and in the Black Sea. The Mediterranean triglids include 5 genera and 8 species (Hureau 1986). In the Egyptian Mediterranean (GFCM GSA 26), gurnard species (Triglidae) are usually taken in multispecies catches (4 or more species) so there are no separate landings statistics. Within the gurnards, streaked gurnard, *Chelidonichthys lastoviza* is one of the greatest economic value species and one of the most abundant in the Egyptian coast contributing over 50% of gurnard landings. Streaked gurnard lives mostly over rocks and on sand bottoms at depths ranging from 10 to 200m, often forming shoals (Ben Othmen 1973; Fischer et al. 1981&1990; Mehanna et al. 2011). The biological characteristics and growth of streaked gurnard, *C. lastoviza* was rarely investigated (Papaconstantinou 1986 in the Saronikos Gulf; Faltas 1996; Faltas & Abdallah 1997 and Farrag 2015 for the Egyptian Mediterranean water off Alexandria).

Effective fisheries management requires an understanding of the stock status and population dynamics of the targeted fish species, where the growth parameters (asymptotic length and curvature

Fig.1. Egyptian Mediterranean coast with the mail landing sites.

parameter) are among the crucial inputs (Isley & Grabowski 2007; Katsanevakis & Maravelias 2008). Accurate estimates of growth parameters are important for monitoring the stock status as well as for assessing management actions that have been applied to maintain the integrity of the fish stock (Zhang et al. 2020). Reproductive behavior, spawning time and size at sexual maturity (L_m) are also fundamental requirements for managing the fisheries (Jennings et al. 2001).

The present study was undertaken to provide information on age and growth, length-weight relationship, first maturity and reproduction of *Chelidonichthys lastoviza* in the Egyptian Mediterranean waters GSA 26. This information is considered as a prerequisite for an effective fisheries management of the species stock in the area.

MATERIAL AND METHODS

Study area: The study focused on the eastern coastline of Egyptian Mediterranean (GSA 26) which comprises of seven fishing grounds namely; eastern harbor, Abo Qir, Rashid (Rosetta), El-Burullus, Damietta, Port Said and El-Arish (Fig. 1). Three fishing grounds were selected where the bulk of triglid catch was landed, Rashid, El-Burullus and Damietta (Ezbet El-Borg). The selection criteria for the present study sites were based on the level and type of fishing activity for the studied species.

Data collection and measurements: Fish samples were obtained from local fishers at the selected landing sites for two years from January, 2020 to December, 2021 operating mostly with bottom trawl fishing gear. Samples obtained were preserved on ice in ice chest and transported to the Fish Population Dynamics laboratory at National Institute of Oceanography and Fisheries NIOF, Suez Branch. Identification of the species was done to the species level using identification keys by Fischer et al. (1981) and Froese & Pauly (2022). During the two years, four gurnard species were identified and a total of 1322 individuals of *Chelidonichthys lastoviza* were separated. Fish species were weighed using an electronic scale to the nearest 0.1g while the total and standard lengths were measured to the nearest 0.1cm using a measuring board. Weights of gonads were recorded to the nearest 0.01g. The sex and maturity stages of each fish were detected. Sagittal otoliths were removed, cleaned and stored dry in small laboratory envelops for later age determination.

Methods: Age was read from the whole otoliths immersed in glycerin and viewed with a stereomicroscope (Carl Zeiss Discovery v20 connects to AxioCam ERc5s camera with software) with reflected light and black background with a magnification of 16x. Opaque and transparent rings were counted and one opaque zone together with one transparent zone has been considered as annual growth. The growth rings on the otoliths were counted twice by two readers to minimize the bias and to be sure about the number of annual rings. The

coefficient of variation (CV) for the two readings for each otolith was calculated using the method described in Kimura & Lyons (1991) and Campana (2001). Also, Absolute Percent Error (APE) and Percent Agreement (PA) were used to estimate the reading precision (Beamish & Fournier 1981).

The allometric growth equation, $W=aL^b$ was used to describe the length-weight relationship (Ricker 1979) of *C. lastoviza* where *W* is the gutted weight (g), and *L* is the total length (cm) and *a* and *b* are constants whose values were estimated by least square method. The 95% confidence limits of *b* were estimated to show if the *b*-value was significantly different from 3.

The growth parameters of the Von Bertalanffy growth model (L_∞ and *K*) were computed by using Ford (1933)-Walford (1964) plot, while t_0 was estimated by the equation: $t_0=t+(1/K)xLn((L_\infty-L_t)/L_\infty)$. Growth was expressed in terms of the von Bertalanffy equation as $L_t=L_\infty(1-e^{-k(t-to)})$ for growth in length and $W_t=W_\infty(1-e^{-k(t-to)})^b$ for growth in weight where L_t and W_t are the fish length and weight at age t; L_∞ and W_∞ represent the asymptotic length and weight, *k* is a relative growth coefficient and t_o the theoretical age when the fish length is zero.

Maturity stages of *C. lastoviza* were classified according to Nikolsky (1963) into six maturity stages; immature stage (I and II), Stage III was considered as mature. Stages IV and V were considered as mature/ripe (running). The length at first sexual maturity was obtained as the length of which 50 percent of all individuals are sexually mature (Pitt 1970). Gonado-somatic index was estimated as GSI=Gonad weight/Gutted weightx100. Sex ratio was determined as the percentage of males to females (M:F). According to Moreau et al. (1986), the following equation was adopted to estimate the growth performance index for length: $\Phi_L=\log k+2 \log L_\infty$.

The ascending left arm of the length-converted catch curve was used to analyze the probability of capture of each length class. By plotting the cumulative probability of capture against mid-length a resultant curve was obtained from which the length at first capture (L_c) was taken as corresponding to the cumulative probability at 50%.

While the Length at maturity (L_m), the size at which 50% of the individuals were mature, was estimated by means of a logistic function that was fitted to the proportion of sexually mature individuals by size class using a nonlinear regression (King 2007) as follows: $P=1/(1+\exp[-b(L-L_m)])$, where *P* is the proportion of mature fish in each length class, *b* is a parameter determining the slope of the maturity curve, and L_m is the total length at which 50% of the fish are mature.

RESULTS

Length composition: Of the 1215 specimens measured, 474 were male (39.01%), 553 female (45.51%) and 188 unsexed (15.47%). The total length of males ranged from 11.5cm to 24.4cm with a mean of 16.07±2.56cm. The range was higher for females, from 11.0cm to 26.6cm with a mean of 16.47±2.58cm. The most abundantly captured specimens ranged 13.0-19cm for males and females (Fig. 2). For the whole sample, the length range was 7.9 and 26.6cm TL with a mean of 15.66±2.92cm.

Length-weight relationship: The total weight of males ranged between 14.5 and 155 g with a mean value of 47.79±24.35g, while females ranged from 10.5 to 220 g with a mean value of 52.02±25.19g. For the whole sample, the total weight varied from 5.0 to 220g with a mean value of 45.62±23.18g. An isometric growth was observed for both males and females (Fig. 3). The relationships obtained were, $W=0.0093L^{3.0487}$ for males, $W=0.0089L^{3.0673}$ for females and $W=0.0103L^{3.0125}$ for the whole sample.

Age composition and growth in length: The maximum life span of *C. lastoviza* was four years for males and five years for females, age group II was the most frequent group in the catch, constituting 40.73% for males and 42.57% for females. Age groups and growth in length (average back

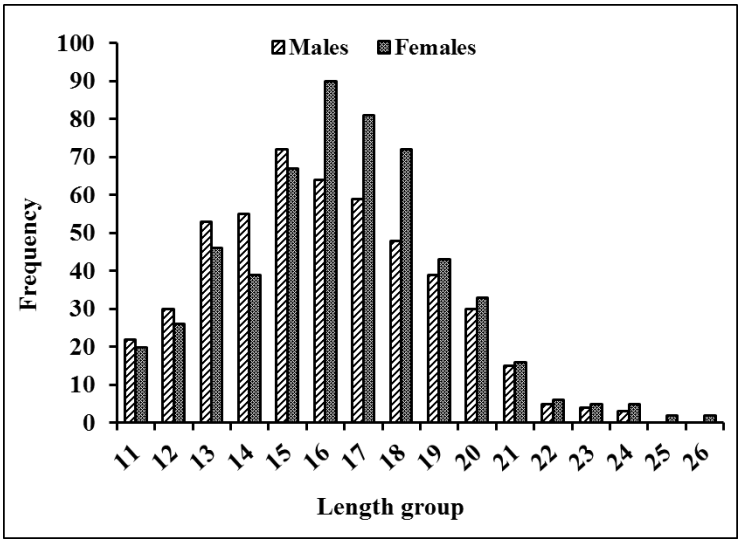
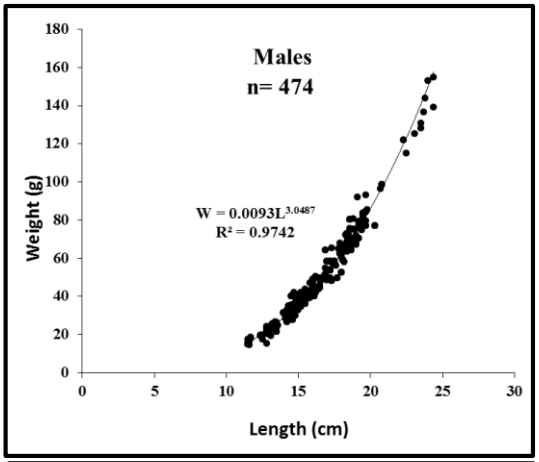
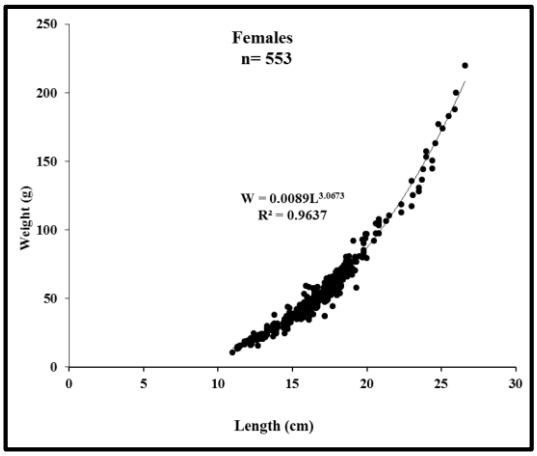


Fig.2. Length frequency distribution of *C. lastoviza* from the Egyptian Mediterranean waters.





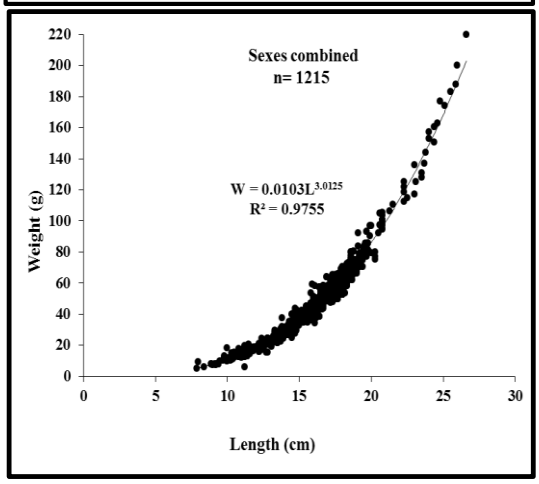


Fig.3. LWR of *C. lastoviza* from the Egyptian Mediterranean waters

calculated lengths) were identified as 13.91, 18.71, 21.82 and 23.84 cm for 1st, 2nd, 3rd and 4th years for males and 13.86, 18.31, 21.49, 23.95 and 25.77 cm for 1st, 2nd, 3rd,4th and 5th years for females. The growth rate of *C. lastovisa* is high during the first year of life, after which the annual growth rate rapidly decreased (Fig. 4).

Growth parameters and performance index: The estimated Von Bertalanffy growth parameters for the tub gurnards were; L_∞= 27.56cm, K=0.433 and t_o=-0.62 for males and L_∞=30.92cm, K=0.299 and t_o=-0.92 for females. The growth performance (Φ)

for length was found to be 2.52 and 2.46 for males and females respectively (Table 1).

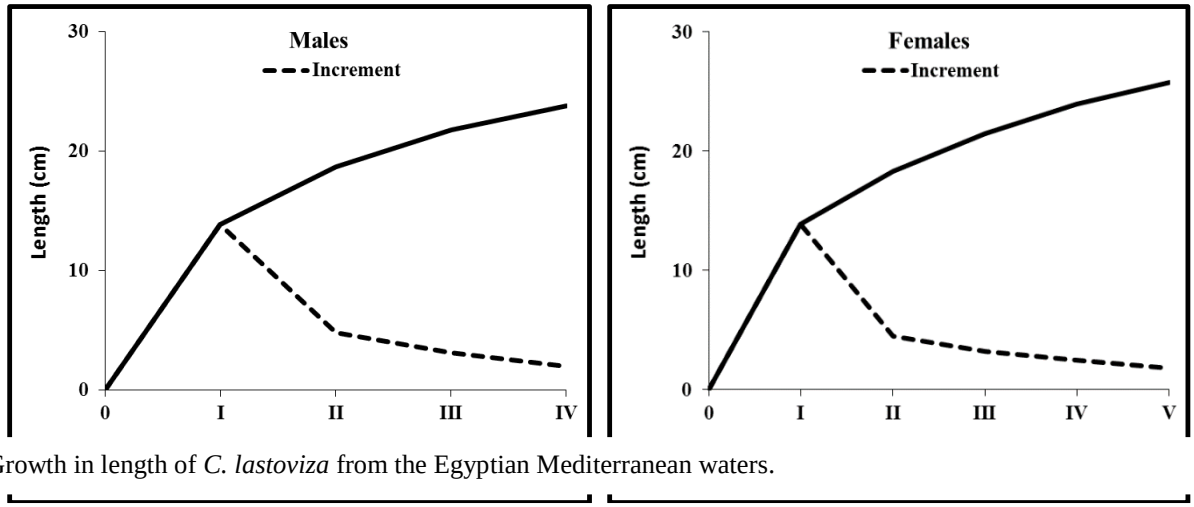


Fig.4. Growth in length of *C. lastoviza* from the Egyptian Mediterranean waters.

Table 1. von Bertalanffy growth parameters and Φ values of *C. lastoviza* (No= number of specimens, L_∞= the asymptotic length, K=a relative growth coefficient, t_o= theoretical age, Φ= growth performance index).

Sex	No	L_∞	K	t_o	W_∞	Φ_L
Males	474	27.56	0.433	-0.62	220.45	2.52
Females	553	30.92	0.299	-0.92	222.01	2.46
Combined	1215	29.62	0.35	-0.98	280.93	2.48

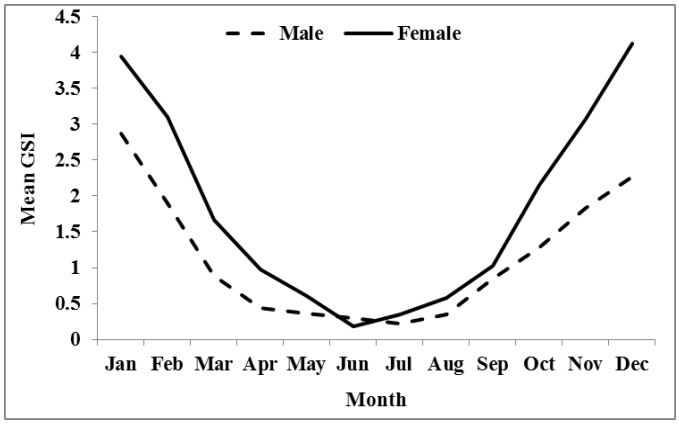


Fig.5. Gonado-somatic index value by sex in different months of *C. lastoviza* in GSA 26.

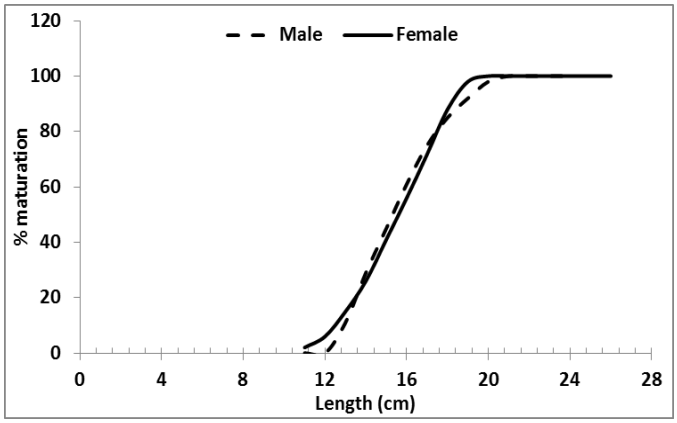


Fig.6. Percentage of mature male and females with total length of *C. lastoviza*.

Gonado-somatic index: Figure 5 shows the monthly variation of the Gonado-somatic index values, the lower values were recorded in July (0.22) for males and in June (0.19) for females. Meanwhile the higher values which coincide with the spawning season were recorded in October, November, December, January, February and March with a peak in January and December (2.87 and 4.12) for males and females respectively. Generally, the values of gonado-somatic index of females were much higher than those of males during the different months of the year except for June (Fig. 5).

Length at first maturity L_m and at first capture L_c: Both males and females less than 13cm length are collectively immature. Larger fishes show an increasing in the frequency of mature specimens in both male and female until 20cm where all fishes longer than this length are fully mature. It is clear that, 50% of maturity for males and females takes place at the total length of 15.2cm and 15.8cm respectively (Fig. 6). The length at first capture was estimated at 14.48 and 14.75cm for males and females, respectively.

Sex ratio: The fluctuation in the sex ratio was

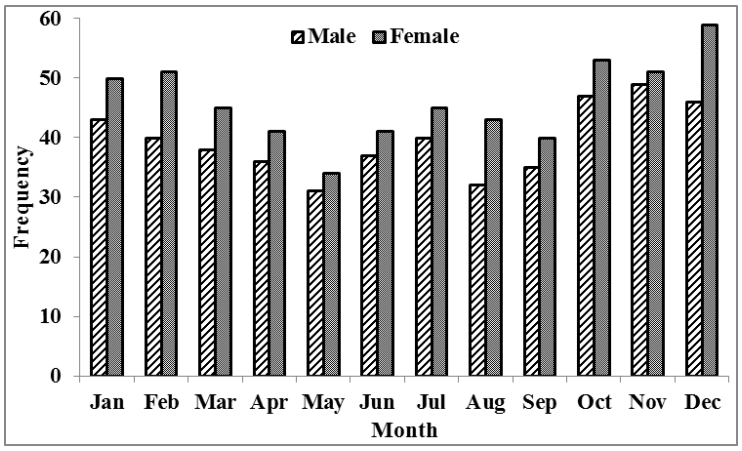


Fig.7. Monthly sex ratio of *C. lastoviza* from the Egyptian Mediterranean water

examined in the different months of the year and the data available are given in Figure 7, it is concluded that, the percentage occurrence of females was higher than that of males throughout the whole period of investigation. The overall females were accounted 53.8% of the total sample with sex ratio (M/F=1:1.17).

DISCUSSION

The length-weight relationship in fish is affected by several factors including gonad maturity, sex, diet, stomach fullness, differences in the observed length ranges of the caught specimen, and health as well as season and habitat (Froese 2006; Abbasi et al. 2019; Eagderi et al. 2020). In the present study, an isometric growth is observed for male and female where the *b*-values were not significantly different from 3 (Table 2). The *b* value could be an indicator of the physiological condition of the fish and vary seasonally in response to seasonal variations in environmental condition and changes in the fish wellbeing (Biswas 1993). The length-weight relationship and the b value can also be influenced by fishing pressure that excessively catch the adults. However, the present values were still within the expected range (2.5-3.5).

The observed total length of *C. lastoviza* specimens varied between 7.9 to 26.6cm in the Egyptian Mediterranean. In comparison with the previous studies, the observed maximum length differs from those given before (Table 2). This may be due to their sampling method, fishing gear used, fishing intensity, and fishing characteristics in different geographical areas. Females of *C. lastoviza* from the Egyptian Mediterranean waters reach greater lengths than males. This difference is the most common pattern found in other localities (Table 2).

The length at age and Von Bertalanffy parameter estimates showed that *C. lastoviza* is a relatively fast-growing and moderately long-living species, like other triglid species (Boudaya et al. 2010). The oldest fish recorded in this study was 4 years old for male and 5 years for female. Also, females seem to have a slower growth rate and larger maximum length and age than males. Taking the geographical distribution of the species into consideration, the maximum observed life span was in the range of the previous studies. The maximum observed life span was five years for combined sexes from Lion Bay (Kartas 1971) and in Catalane Sea and Douarnenez Bay (Baron 1985). Papaconstantinou (1986) determined six year groups for males and eight age groups for females in Saronikos Bay. Uçkun (2005) gave six and five age groups for males and females respectively from Edremit Bay (Aegean Sea). Akalin & İlhan (2013) reported five and six years for males and females respectively in İzmir Bay. El-Serafy et al. (2015) found that the maximum life span of *C. lastoviza* was four years for male and female in Alexandria, Egypt. The differences between age determinations from place to another

Table 2. Maximum length, LWR parameters of *C. lastoviza* in different locations.

Location	Sex	Max TL (cm)	a	b	r	Authors
	M+F	29.3	0.0128	2.963	0.994	
Saronikos Gulf	M+F	42.0	0.00002	3.003	0.980	Papaconstantinou (1986)
Bay of Biscay	M+F	35.0	0.0145	2.892	0.985	Dorel (1986)
Adriatic Sea	M+F	25.1	0.023	2.79	0.984	Dulcic & Kraljevic (1996)
Aegean Sea	M+F	14.4	0.0166	2.885	0.963	Moutopoulos & Stergiou (2002)
Alexandria, Egypt	M	19.7	0.0114	3.033	0.970	Abdallah (2002)
Aegean Sea	F	22.1	0.0122	3.004	0.969	Uçkun (2005)
	M+F	22.1	0.008	3.100	0.995	
	M	27.4	0.004	3.300	0.985	
Portugal	F	22.4	0.007	3.120	0.990	Olim and Borge (2006)
	M+F	27.4	0.0123	3.006	0.974	
	M	18.2	0.0136	2.973	0.969	
İzmir Bay	F	19.8	0.0124	3.007	0.974	Akalin & Ilhan (2013)
	M+F	19.8	0.0088	3.069	0.98	
	M	23.0	0.0085	3.084	0.98	
Alexandria, Egypt	F	24.0	0.0106	3.006	0.98	El-Serafy et al. (2015)
	M+F	24.0	0.0111	2.986	0.97	
	M+F	25.0	0.0111	2.986	0.97	
Mediterranean, Egypt	M	24.4	0.0093	3.0487	0.97	Mehanna & Farouk (2021)
Mediterranean, Egypt	F	26.6	0.0089	3.0673	0.96	Present study
	M+F	26.6	0.0103	3.0125	0.97	

Table 3. Growth parameters and growth performance of *C. lastoviza* from different localities.

Authors	Localities	Sex	L∞	K	to	Φ
		M+F	35.6	0.133	1.12	2.23
Papaconstantinou (1986)	Saronikos Gulf	F+M	38.2	0.254	0.639	2.57
Campillo (1992)	Mediterranean waters	M+F	34.68	0.372	--	2.65
Faltas&Abdallah (1997)	Egyptian Mediterranean	M	26.9	0.184	1.586	2.13
Uçkun (2005)	Edremit Bay (Aegean Sea)	F	26.3	0.190	1.554	2.12
		M+F	26.4	0.186	1.613	2.11
		M	26.80	0.152	2.822	2.04
Akalin & İlhan (2013)	İzmir Bay (Aegean Sea)	F	19.59	0.361	1.370	2.14
		F+M	23.28	0.235	1.887	2.11
		M	27.17	0.347	-1.01	2.41
El-Serafy et al. (2015)	Egyptian Mediterranean	F	27.0	0.370	-0.93	2.43
		F+M	26.92	0.370	-0.92	2.43
		M	27.56	0.433	-0.62	2.52
This study	Egyptian Mediterranean	F	30.92	0.299	-0.92	2.46
		M+F	29.62	0.35	-0.98	2.48

may be due to the method used, sample size, timing of sample collection, environmental conditions, and fishing pressure (Mehanna 1997).

The von Bertalanffy growth function (VBGF) parameter L_∞, is a major parameter in evaluating the status of the population. The asymptotic length value ($L\infty$) is related to the size of the largest individual sampled in the area. The differences in growth rates between areas (Table 3) were probably related to different bio-ecological conditions, methodological differences in the age determinations and sampling depths and also fishing mortality. A comparison of growth performance for male and female values of (Φ=2.52 and 2.46, respectively) shows that *C. lastoviza* of the Egyptian Mediterranean waters had a slow growth performance compared with the study of Baron (1985) in Douarnenez Bay and Faltas & Abdallah (1997) in Alexandria, Egypt. In contrast, *C. lastoviza* in the present study showed a higher growth performance than the studies of

Papaconstantinou (1986), Campillo (1992), Uçkun (2005), Akalin & İlhan (2013), El-Serafy et al. (2015). Our data concerning the growth performance and growth parameters values were compared with those observed by other studies in Table 3.

The overall sex ratio is in favor of females and no males were found in a size class higher than 24.5cm TL. The population of *C. lastoviza* was composed of 46.2% males and 53.8% females from Egyptian Mediterranean. Papaconstantinou (1986) and Abdallah & Faltas (1998) reported that the overall sex ratio was 1:1 and 1:1.01 in the Saronikos Bay and the Egyptian Mediterranean waters, respectively. The overall sex ratio is close to 1:1 in many species, but may vary from species to species, even from population to population of the same species, and may change from year to year in the same population (Nikolsky 1963). However, variation in size of the sexes can be explained by differences in growth and mortality (Turner et al. 1983; Kartas & Quignard 1984).

Concerning reproduction, the gonado-somatic index values computed in the present study revealed that the reproduction of this species took place from November to February with a peak in January and December for males and females respectively. Serena et al. (1998) reported that there is a clear shift of timing for the reproductive processes of triglid species between the Mediterranean and North Atlantic waters. These differences in spawning season may reflect different temperature regimes among these areas (Kashiwagi et al. 1987).

Lengths at first maturity of *C. lastoviza* was 15.2 cm and 15.8cm for male and female respectively. Generally, triglid males mature at a younger age and smaller size than females (Papaconstantinou 1984; Baron 1985; McPhail et al. 2001). This can be attributed to the average size of maturation being directly related to the population density and environmental conditions, particularly temperature, that stimulate sexual maturation (Nikolsky 1963; Kashigawa et al. 1987).

In conclusion, it clears that a considerable amount of *C. lastoviza* susceptible to the exploitation method are juveniles or immature individuals. From the management point of view, the mesh sizes of the gear used in the species exploitation should be increased to allow escape of young individuals and it should to decrease the fishing pressure. This would enable more females participate in the reproductive activity and also to allow the young recruits to grow and reproduce in order to assure resource availability and sustainability.

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مقاله کامل

پارامترهای جمعیتی و زیست‌شناسی تولید مثل خروسک ماهی *Chelidonichthys lastoviza* (Bonnaterre, 1788) در در آب‌های مدیترانه مصر (GFCM-GSA 26)

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چکیده:

پویایی جمعیت و تولید مثل *Chelidonichthys lastoviza* (Bonnaterre 1788)، براساس داده‌های جمع‌آوری‌شده بین ژانویه ۲۰۲۰ و دسامبر ۲۰۲۱ از آب‌های مدیترانه، مصر مورد مطالعه قرار گرفته است. در این مطالعه پارامترهای سن، رشد، مرگ و میر، طول‌های حیاتی، جنس، بلوغ غدد جنسی و فصل تخم‌ریزی تعیین شد. در مجموع ۱۲۱۵ نمونه با دامنه طول کل ۷/۹ و ۲۶/۶ سانتی‌متر و وزن کل ۵ تا ۲۲۰ گرم نمونه‌برداری شد. طول کل نرها بین ۱۱/۵ تا ۲۴/۴ سانتی‌متر (۴۷۴ نمونه) و ماده‌ها از ۱۱ تا ۲۶/۶ سانتی‌متر (۵۵۳ نفر) متغیر بود. حداکثر سن مشاهده شده براساس خوانش اتولیت برای نر و ماده به‌ترتیب ۴ و ۵ سال بود. رابطه طول و وزن برای جنس نر به‌صورت $W= 0.0093L^{3.0487}$ و برای جنس ماده $W= 0.0089L^{3.0673}$ بود که نشان‌دهنده الگوی رشد ایزومتریک است. معادله رشد ون برتالانفی برای جنس نر به‌صورت $L_t = 27.56(1-e^{-0.433(t+0.62)})$ و برای جنس ماده به صورت $L_t= 30.92(1-e^{-0.299(t+0.92)})$ بود. شاخص عملکرد رشد ۲/۵۲ (نر) و ۲/۴۶ (ماده) محاسبه شد. نرها در طول‌های کوچکتر و سنین کمتر ($L_m= 15.2$ cm, $T_m= 0.61$ years) نسبت به ماده‌ها بالغ می‌شوند ($L_m= 15.8$cm, $T_m = 0.71$ years). نسبت نر به ماده ۱/۱:۱۷ بود. مقادیر شاخص گنادوسوماتیک (GSI)، یک فصل تخم‌ریزی طولانی مدت را که از نوامبر تا فوریه شروع و به‌ترتیب در ماه‌های ژانویه و دسامبر برای نرها و ماده ها به اوج می‌رسد، را بیان می‌کند.

کلمات‌کلیدی: خروسک ماهیان، *Chelidonichthys lastoviza*، مدیترانه، رشد، تولید مثل.