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Biological aspects and exploitation of *Plectorhinchus gaterinus* (Forsskal, 1839) (F: Haemulidae) from the northern Red Sea, El-Tor, Egypt

Amal M. Amin*, Azza A. El-Ganainy and, Manal M. Sabrah
National Institute of Oceanography and Fisheries, Suez, Egypt.
*Corresponding Author: aminamal30@yahoo.com

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ABSTRACT
This investigation is considered to be the first analysis involving the most useful parameters for the management purposes of *Plectorhinchus gaterinus* from El-Tor, Egyptian northern Red Sea coast. Age was estimated by using two methods, the fish otolith reading and the length-frequency analysis (LF) of 248 samples collected through the fishing season 2015/2016. The length-weight relationship was determined for all samples, that ranged from 11.0 to 39.0 cm. The "b" value exhibits an isometric growth pattern (b ≈ 3.0). Eight age groups were recorded by the two methods. Growth parameters were estimated by applying the plager method's, 1983 where the asymptotic length (L_∞) and the growth rate (K) were computed as 41.02 cm and 0.28 year^{-1} respectively from the otolith reading, while that resulted from (LF) analysis were 43.78 cm and 0.21 year^{-1} respectively. The total mortality rate (Z) was 0.66/Y, natural mortality (M) was 0. 34/Y then the fishing mortality (F) was 0.32/Y. Length at first sexual maturity was estimated to be in the length group of 23.0-23.9 cm for males while it was in the range of 25.0-25.9 cm in females. The results indicated that the current fishery status of *Plectorhinchus gaterinus* from El- Tor, Egyptian Red Sea is in the optimum exploitation rate (E = 0.48) and any additional fishing effort will cause an over-exploitation and destroy the fish stock.

INTRODUCTION

Family Haemulidae has a broad geographic distribution living in tropical fresh, brackish, and salt waters around the world. Haemulids are bottom-feeding, carnivorous, and use the reefs for shelter, usually congregate during the day and then spread out to forage at night (Randall, 1992). It is representing one of the valuable and economical fish families in the Red Sea. It's divided into two subfamilies, Haemulinae and Plectorhynchinae including about (132) valid species in (19) genera (Eschmeyer, 2014).

Plectorhinchus gaterinus known as Grunts**.** It is a reef-associated and may also occur in the sand near estuaries and in coral and rocky areas, inhabiting depths between 3 and 55m. It found in the western Indian Ocean, from the Persian Gulf and the Red Sea to Natal, South Africa, Mauritius, Madagascar and Comoro Islands. It found singly or in large groups in coastal waters and reef flats often sheltering during the day under ledges. *P. gaterinus* commonly reaches a length of 30 cm, with a maximum size of 50 cm. No studies would be found about this species around the world except Amer *et al*., (2006) recorded that Family Haemulidae including three species**,** throw light on the length at first sexual maturity and length-weight relationship. Yet, there are no other papers that analyze the parameters of the population dynamics of this species.

Although Haemulidae fishes are of great economic importance to fisheries throughout the world there are no previous reports or information on the biological study of *P. gaterinus* in the world. Therefore, the aims of this study is to get the vital information of *P. gaterinus* at the Egyptian northern Red Sea, on the population's structure, composition and age information, the length-weight relationship, growth rate, length at maturity, spawning period, mortality and the exploitation rate as a tool for management and preservation applies.

MATERIALS AND METHODS

Study area:

The northern Red Sea is an important area both for its unique and often spectacular marine environment as coral reefs, mangroves, and seagrass beds. The delicate area of the Red Sea coast of Egypt has about 66 % of hard coral reefs species existing within the Red Sea including some endemic species. Also; coral reefs provide protection and shelter natural zone for many species of fish. (PERSGA, 2010).

The El-Tor fishing port is located on the Red Sea coast of Egypt at the south Sinai zone. El-Tor port capacity is about 77 fishing boats, most of the fishing crafts are long lines, and artisanal. There are a variety of gears used by the traditional subsistence fishery resting at the west of the port. Furthermore, the port receives three fishing vessels of trawl craft every day for unloading their stocks, and these vessels leave the port just after unloading. The port has one berth (76 m) length, and the depth of the port is about to 4.0 m. The land area is (12,600 m^2) while the water area is (25,200 m^2) (Sharaan *et al*., 2017). Fig. (1).

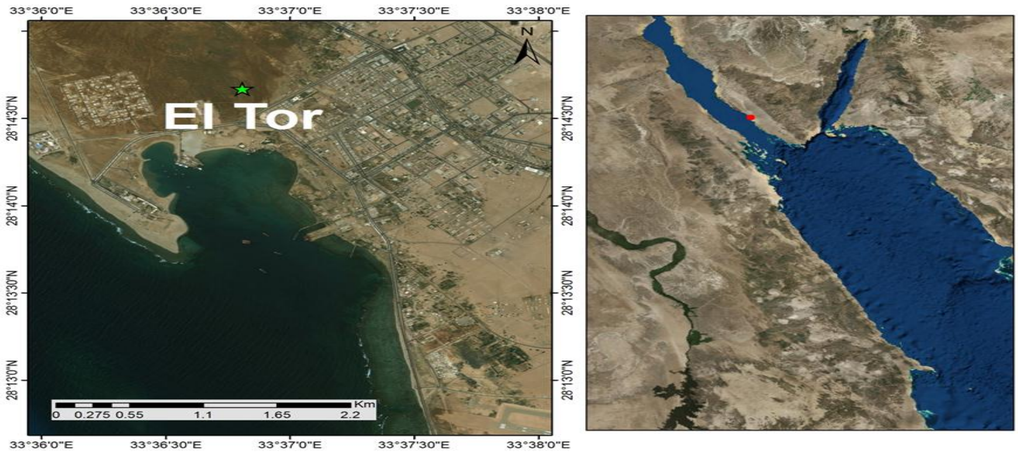

Fig. 1: Sampling area at El-Tor fishing port.

Sampling analysis:

P. gaterinus samples (248 specimens) were collected seasonally during 2015/2016 from the El-Tor fishing port. The length-weight relationship was estimated according to Le Cren (1951): $W = a L^b$, where (W) is the total weight, (L) is the total length, while (a) and (b) are constants.

Aging: Age determination was computed by two methods, directly by counting the rings in the fish otolith and indirectly by analyzing the length-frequency data to validated the age determination from otolith since it is the first time to determine the age and growth of this species in the Egyptian waters. The length-frequency data was separated into its component distributions according to the method of Bhattacharya (1967), using the befitting computing of the FISAT II program (Gayanilo et al, 1998).

Growth parameters, the asymptotic length (L_∞) and growth rate coefficient (K) were detected through a non-linear least squares technique (Prager *et al*, 1989) method.

The growth performance index (φ') was calculated according to the formula of Pauly and Munro (1984) based on the L_∞ and K as the following: $\varphi' = 2 \log 10\ L_\infty + \log 10 K$.

Longevity (t_{max}) the initial values of the lifespan was obtained from the equation: $t_{max} = 3 / K$, Taylor (1958).

Length at maturity (L_m): The length at first sexual maturity (L_{50}) was determined for both sexes by analyzing the maturation curve between mature and immature fish at the1-cm interval.

Mortality methods: The total mortality rate (Z) was estimated by Pauly's (1984) length converted catch curve method. The natural mortality rate (M) was estimated by pauly, 1980 modified by Amy, *et al* (2015) equation. Fishing mortality (F) was expressed as $F = Z - M$.

The exploitation rate (E) was estimated as F/Z according to (Gulland, 1971) and resultant from length converted catch curve.

Length at first capture (L_c): The length at first capture was estimated by the analysis of the catch curve using the method of Pauly, 1984.

The optimum length at capture was calculated by Beverton (1992) formula:
$L_{opt} = 3L_\infty / (3 + M/K)$.

RESULTS AND DISCUSSION

Length composition

A total of 248 specimens of *P.gaterinus* were collected seasonally from El-Tor fishing port, the Egyptian Red Sea during the fishing season 2015/2016. Samples were ranged in length from 11.2 to 39.2cm with a mean length and standard deviation of 23.36 ± 6.1. It is clear (Fig. 2), that the length groups from 14.0 to 18.0 cm were dominating the study period, while the length groups from 35.0 to 39.0 cm were constituting a small number in the catch.

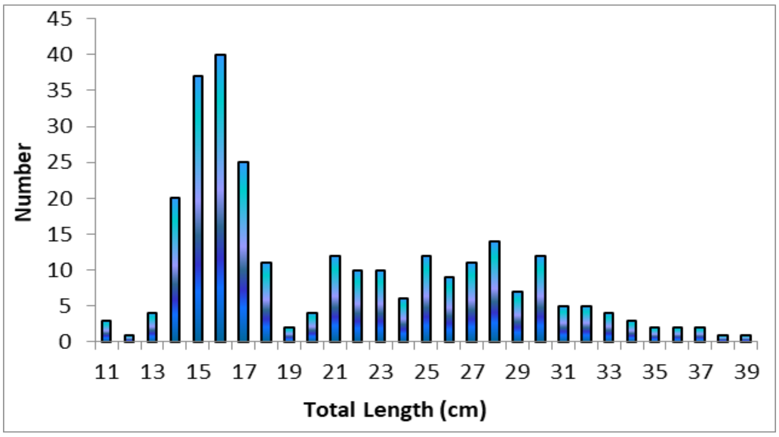

Fig. 2: Length composition of *P. gaterinus* from, El- Tor port, the Egyptian northern Red Sea.

Amer *et al*. (2006) studied the fishery traps of *P. gaterinus* from Saudi territorial waters of the Arabian Gulf and concluded that it reached a mean maximum length of 39.0±3.2 cm in the large trap harvested, while with the small traps harvested the mean total length were noted as (27 ± 3.1cm).

In contrast through our study, a decline in the mean total length (23.36 ± 6.1) and in the large group individuals (35.0 to 39.0 cm) were observed indicated that intensive fishing occurred by removing the largest individuals in El-Tor region. The differences in length-frequency distribution may be due to many factors such as differences in the fishing sites, fishing method used or the sample collection method. Also, may be due to the fishermen that tend to harvest the large fish, which results in a decrease in the density, average sizes and relative abundance of exploited species (Russ, 1985).

Length-weight relationships have been used widely in fisheries biology to give information on the conditions of fish stock. These parameters are also required to calculate growth rates, length, age structures and other biological characteristics of fish population dynamics. Furthermore, Length-weight relationships are useful for comparing life history and morphological aspects of populations inhabiting different regions (Stergiou, 1995). The total length of *P. gaterinus* ranged from 11.2 to 39.2 cm and their total weight ranged from 21.0 to 900 g with an average of 251.1 ± 172.3 g. Values of exponent *'b'* provide information on fish growth patter and indicating the type of growth; isometric ('*b*' =3.0), positive allometric (b > 3.0) or negative allometric (b < 3.0). In the present study (Fig. 3), the '*b*' value of *P. gaterinus* was estimated at 2.975 (b≈3) indecating the isometric growth pattern of *P. gaterinus* in the Egyptian Red Sea water. The relation was expressed by the power equation for all samples as follows: $W=0.0182\ TL^{2.975}$ ($R^2 = 0.98$) No= 248

This result is different from that obtained by Ontomwa, et al (2018) who studied the seasonal variation in length -weight relationship of *P. gaterinus* and observed that the value of '*b*' = 4.3 was characterized by positive allometric growth on the south coast of Kenya during the northeast monsoon (NEM), while in the southeast monsoon (SEM) '*b*' value estimated as 2.9, indicating the negative allometric growth. The value of '*b*' was affected by a number of factors including gonad maturity, sex, diet behaviour, stomach fullness and the fish healthy (Petrakis *et al.*, 1995).

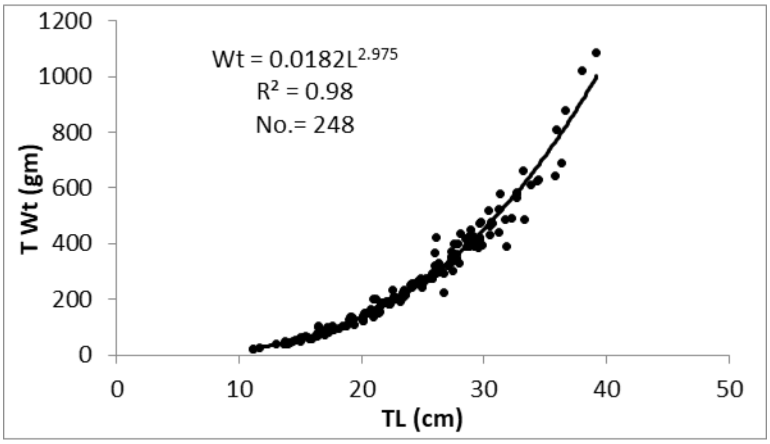

Fig. 3: Length-weight relationship of *P. gaterinus* from, El- Tor port, the Egyptian northern Red Sea.

Age determination and growth parameters

Direct aging of *P. gaterinus* was estimated by a reading of 248 otoliths using a stereoscopic zoom microscope under reflected light against a black background. Eight age groups were detected and the lengths at the different age groups were 15.8, 22.6, 25.6, 29.5, 33.4, 35.3, 36.6 and 37.5 cm for age groups I, II, III, IV, V, VI, VII and VIII respectively.

The indirect age determination of *P. gaterinus* was computed by the length-frequency data analysis using the method's of Bhattacharya (1967). Eight components were identified and were considered as clear age groups, Table (1) and Fig. (4). It is shown that the *P. gaterinus* attained 16.3, 21.87, 25.72, 28.43, 31.0, 33.07, 35.5 and 37.32 cm at the end of the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th year respectively.

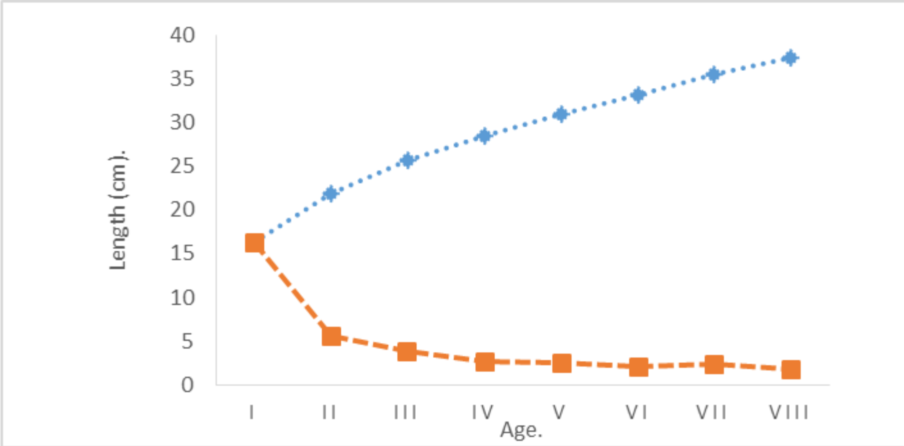

Fig. 4: Mean lengths at ages and growth increment of *P. gaterinus* from, El- Tor port, the Egyptian northern Red Sea.

Table 1: Mean length at age, standard deviation (SD), separation index (S.I.) for each age group of *P. gaterinus* as estimated from the Bhattacharya method.

Age group (Yr.)	Computed Mean Lengths (cm)	S.D.	Population	S.I.
1	16.31	1.28	140.15	n.a
2	21.87	0.86	28.76	2.39
3	25.72	0.99	31.23	2.18
4	28.43	0.92	32.69	2.06
5	31.00	1.14	17.16	1.97
6	33.07	2.70	21.96	1.89
7	35.50	1.90	16.30	1.99
8	37.32	1.01	4.15	2.09

Fig. (4) indicated the fast growth increment in the first year of life where the fish attained about 45% of its maximum length, then a gentle decrease in the growth increment was observed as the fish gets older.

Aging in the present study was carried out by two methods, reading otoliths and the length frequency analysis of *P. gaterinus*. It is clear that there was a good agreement between length at age determined through otoliths and length frequency analysis as the two methods tended to give the same results (8 years) and approximately gave the same mean length at the end of each age group, that indicated the validation of the age deterimination of *P. gaterinus*.

Geographic location and environmental conditions such as temperature, organic matter, food quality, time of capture, stomach fullness and disease, parasitic could be affected the growth rate and the longevity of the fish (Wootton, 1992).

Growth parameters

The growth parameters

The asymptotic total length (L_∞) of *P. gaterinus* was estimated as L_∞ = 41.02 cm, while the growth rate coefficient (K) was 0.28/year that resulted from the otolith reading. L_∞ and K from the length-frequency analysis were 43.78 cm and 0.21/Y respectively. There were no previous recorded data dealing with the growth parameters of *P. gaterinus*. A trade-off between growth rate (K) and (L_∞) is often found, they influenced by many factors, like temperature, mortality or food availability. The increased food availability causes a shift towards a larger maximum size, but may not increase the growth rate (Tserpes and Tsimenides, 2001). The growth performance index of *P. gaterinus* assessed as Φ = 2.67 for all samples.

Longevity

The maximum observed age of *P. gaterinus* was eight years, while the calculated theoretical longevity was more than the maximum observed age by about 34%. Longevity was estimated by Taylor's (1958) as 10.7 years. The variation of longevity among fishes could be due to geographic latitude, predation and fishing activities(Kovačić, 2007).

Mortalities and exploitation rates

The total mortality coefficient (Z) was estimated as 0.66 $yr^{-1}$and the natural mortality (M) was 0.34 yr^{-1}. Fishing mortality (F) was 0.48 yr^{-1} (Fig. 5). Beverton and Holt (1959) noted that the natural mortality coefficient is directly related to the growth coefficient (K) and inversely related to the asymptotic length (L_∞) and the life span. They suggested that the normal range of M/K ratios within of 1 – 2.5, in the present study this ratio estimated as (1.214), within the range suggested.

The exploitation rate of *P. gaterinus* was estimated as E = 0.48 which indicated that the stock of *P. gaterinus* is in the optimum status according to Gulland (1971), where he concluded that the suitable optimum yield is obtained when the exploitation rate (E = 0.50). So, our study suggested the fishery of *P. gaterinus* is in the optimum exploitation and any excessive fishing effort will cause overexploitation and destroy the fish stock.

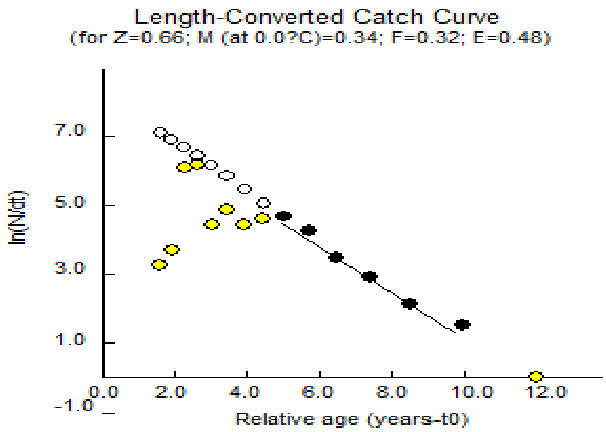

Fig. 5: Length converted catch curve, estimated the annual total, natural, fishing mortalities and the exploitation rate of *P. gaterinus* from, El- Tor port, the Egyptian northern Red Sea

Sex ratio

Information on sex ratio is vital for understanding the relationship between individuals, the environment and the state of the population (Vicentini and Araújo (2003)). The sex ratio may differ from the expected 1:1 from species to species, or even in the same population at different times, being influenced by many factors such as an adaptation of the population, reproductive behavior, food availability and environmental conditions {Vandeputte et al., (2012)}. The overall sex ratio (males: females) was 1:1.35 for *Plectorhinchus gaterinus*. During the study period, there is a trend of a predominance of females, Chi-square test showed no significant difference (x^2 =2.842, df =1 and p > 0.05 Asymp. sig 0.092).

The length at first capture (L_c) and length at first sexual maturity (L_{50})

The length at first capture (L_c) was investigated to be 23.0 cm (Fig. 6). L_c corresponds to the length at which 50% of the fish became vulnerable to the fishing gear. Fig. (7) shows the mean size at first sexual maturity L_{50} which was estimated at 23.0± 2.520 cm for females and 25.0+2.75 cm for males. Results revealed that the size at first capture (L_c) in females is within and related to the size at first sexual maturity (L_{50}), indicating that the present level of L_c is the suitable length at first capture for *P. gaterinus*.

On the other hand, the optimum length at capture was found to be 29.2cm according to Beverton (1992), so the *P. gaterinus* is fished at length smaller than the optimum one.

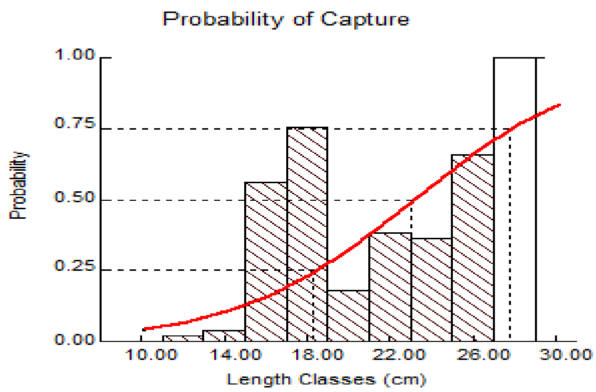

Fig. 6: Probability of capture (L_c) for each length class of *P. gaterinus* from, El- Tor port, the Egyptian northern Red Sea.

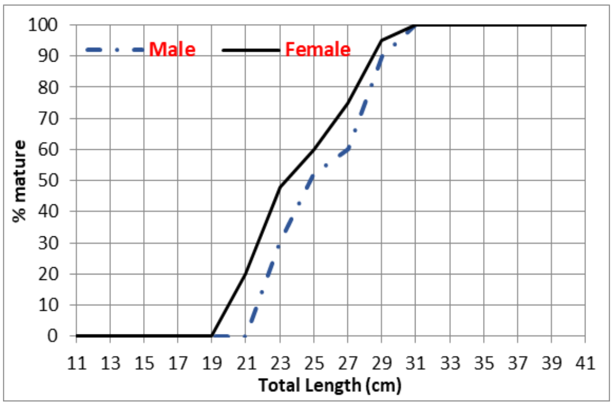

Fig. 7: Length at sexual maturity for *P. gaterinus* from El- Tor port, the Egyptian northern Red Sea (males and females)

Gonado-Somatic index (GSI)

Gonado-Somatic index (Fig. 8) was determined the spawning period for males and females of *P. gaterinus*. The minimum values of GSI were observed in Autumn and winter, while it increased gradually until it reached its maximum ratio in spring, then it decreased again in summer. It is clear that the spawning peak of *P. gaterinus* occurs during the spring.

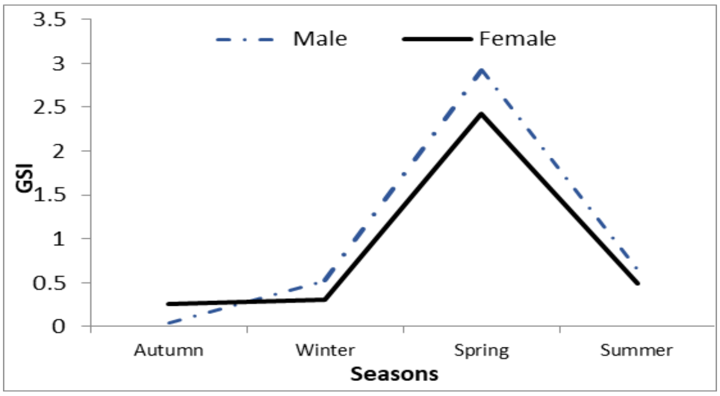

Fig. 8: Seasonal variations in Gonado-somatic index (GSI) (males and females) of *P. gaterinus* from El- Tor port, the Egyptian northern Red Sea

CONCLUSION

Otolith measurements can be used for age determination for *P. gaterinus* as the use of length-frequency distribution validated the results of age determination using otolith.

The age and growth of *P. gaterinus* was used to determine the proper size of fish at catch (optimum size at capture= 29.0 cm) and manage the sustainable fishery of *P. gaterinus*.

the current fishery status of *P. gaterinus* from El-Tor, Egyptian Red Sea is in the optimum exploitation rate (E = 0.48<0.5) and any excessive fishing effort will cause an over-exploitation and destroy the fish stock.

The coral reefs area must be preserved, which provide the spawning grounds and recruitment for *P. gaterinus* stock.

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