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Evaluation of Fishery Status and Some Biological Aspects of Striped Piggy, *Pomadasys stridens* from Gulf of Suez, Red Sea, Egypt

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ABSTRACT
The study was conducted to assess the fishery status of the most common species of the family Haemulidae, *Pomadasys stridens* in the Gulf of Suez. This species lives mainly in marine waters and is associated with coral reefs worldwide. The von Bertalanffy growth coefficients $L\infty$, K and t_0, as well as the instantaneous annual rates of total, natural and fishing mortality were estimated, and thus the exploitation rate was determined and compared with the optimal one to assess the status of the striped piggy fishery in the Gulf of Suez, Red Sea, Egypt. *P. stridens* samples were collected monthly from commercial fishing vessels at the Ataqa landing site and the local fish market in Suez city. The present results revealed that the stock of striped piggy in the Gulf of Suez appears to be overexploited since the current fishing mortality is higher than the biological reference points F_{opt} (0.5 M) and F_{limit} (2/3 M). Thus a fishing mortality reduction is necessary in order to avoid future loss in stock productivity and landings.

INTRODUCTION

The Egyptian marine fisheries have an area of more than 11 million acres, comprise the Red Sea and the Mediterranean, and despite the large area they occupy, their fish production is still low compared to their area. The fisheries grounds in the Red Sea is 4.4 million acres, and its beaches extend a thousand kilometers long, including the areas of the Gulf of Suez in Suez Governorate, El-Tur, Dahab and Newibaa in South Sinai Governorate, and Hurghada, Safaga, El—Quseir, Berenis, Shalatein and Abo Ramad in the Red Sea Governorate.

The Gulf of Suez is considered as one of the major sources of fish production in the Egyptian sector of the Red Sea as well as in Egypt. Its importance as a fish resource can be attributed to the shallowness and sandy bottom which make it suitable for trawling. Also, it is characterized by the presence of a great diversity of highly economic fish and invertebrate species (**Sanders and Kedidi, 1984; Sanders and Morgan, 1989; Mehanna, 1997 & 2021**).The fisheries resources in the Gulf were exploited by three main fishing methods; trawling “caught demersal fishes”, purse seining “caught pelagic fishes” as well as long and hand lines “caught demersal and pelagic fishes” (**Mehanna and El-Gammal, 2007; Mehanna, 2021**). The exploitation of fisheries resources in the

Gulf of Suez has greatly contributed to the development of the fisheries and national economy; however, the status of fisheries resources and the ecosystem structure in the Gulf have substantially changed. It is appeared that, the fisheries resources in the Gulf are depleted, and the ecosystem is switching from large-size and high-value demersal fisheries to a small-size and low-value pelagic fisheries dominated ecosystem (**Mehanna *et al.*, 2015; Mehanna, 2021**).

Family Haemulidae includes about 20 genera and 133 species inhabiting the world oceans (**Froese and Pauly, 2023**). It is a large one, which includes many important commercial species worldwide and often supports important fisheries (**Al-Kiyumi *et al.*, 2014**). The members of this family are commonly known as grunts.

In the Gulf of Suez, *Pomadasys stridens* is the most common, abundant and distributed haemulid species; it is mainly exploited by the trawl fishing gears and constitute 20% of its total catch. It is a marine reef associated and it most commonly found at about 20 -100 m depth with maximum length of 25.0 cm. This species inhabits coastal waters (**Sommer *et al.*, 1996; Akyol and Çoker, 2018**) and feeds on crustaceans and fishes (**Fischer *et al.*, 1990**). In spite of the importance of striped piggy to the economy of the Egyptian fisheries, they have been infrequently studied. Accordingly, the present study is aimed at determination of biological and dynamical parameters of the striped piggy in the Gulf of Suez including age determination, length-weight relationship, von Bertalanffy growth parameter (K, $L\infty$ and t_0), mortality rates, age composition, length distribution, age length key, and critical lengths. These critical information will help in evaluation the fishery status of *P. stridens* in the Gulf of Suez, Red Sea, Egypt to assess the sustainability and management of this particular fish species.

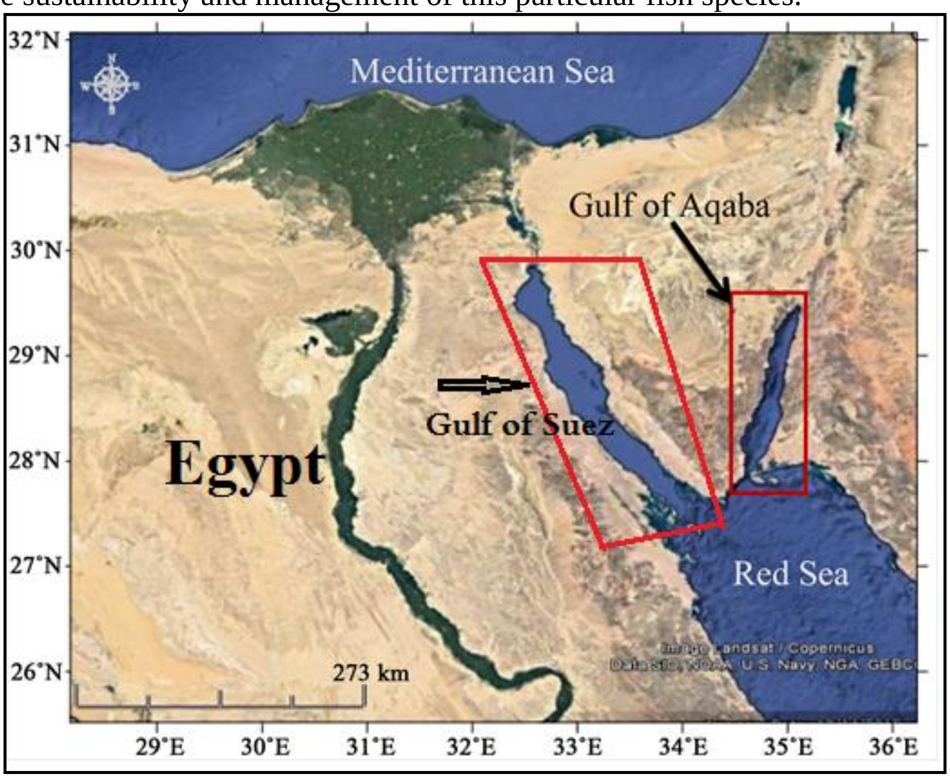


Fig. 1. Red Sea with the Gulf of Suez (study area)

MATERIALS AND METHODS

1. Sampling and biological studies

Pomadasys stridens samples were collected monthly from the commercial landings of trawlers at Ataka landing site and local fish market in Suez city during the fishing season (2021-2022) from September, 2021 to May, 2022. Total length TL for each specimen was measured to the nearest millimeter and sorted afterwards in successive length groups of one centimeter interval. Total body weight "W" was taken to the nearest 0.01 g, after this each individual was dissected to determine sex and maturity stage, then the otoliths were extracted for age determination

2. Methods

2.1. Age Determination

The age was determined directly by the examination of growth rings formed on the otolith (ear stones). The whole otolith immersed in glycerol was examined using a compound microscope and amplifications between 10 and 40x, with a black background and under reflected light. Distance between the focus and the successive annuli were measured to the nearest 0.001 mm. The relationship between otolith radius (S) and TL was determined by least square method. The back-calculated lengths at the end of each year of life were calculated by Lee's equation as follows:

$L_n = (L_t – a)\, S_n/S + a$ (**Lee, 1920**)

2.2. Growth parameters

The von Bertalanffy growth model (1938) $L_t = L_\infty\, [1 - e^{-k\,(t - to)}]$ was applied to describe the growth of striped piggy expressed where L_t is the mean length at age t, L_∞ is the asymptotic length, K is the growth coefficient and t_0 is the age at which the length is theoretically equals zero. $L\infty$ and K were estimated using the equation of **Ford (1933) - Walford (1946)** as $L_{t+1} = L\infty\,(1 - e^{-k}) + e^{-k}\, L_t$, where L_t and L_{t+1} = mean length at age t and t+1 respectively .

2.3. Growth Performance Index (Ø')

The growth performance index was computed according to the formula of **Pauly and Munro (1984)** as Ø' = Log10 K + 2 Log10 L∞

2.4. Critical lengths

The length at recruitment (Lr) was determined as the smallest striped piggy specimen in the catch, the length at the first capture (Lc) was estimated by the analysis of catch curve using the method described in **Sparre and Venema (1992),** while the length at first sexual maturity (Lm) was estimated as the point on X-axis corresponding to 50% point on Y-axis on the maturation curve.

2.5. Mortality and Exploitation Rates

Three different methods were applied to estimate the total mortality coefficient Z; **Jones and Van Zalinge, 1981** (Analysis of the cumulative catch curve), **Pauly, 1983**

(Analysis of the length converted catch curve), the both are depending on length frequency data, and Hoeing model, 1983 which based on the age.

The natural mortality coefficient M was estimated as the geometric mean of four methods; **Taylor's method (1960)**, **Ursin formula (1967), Rikhter & Efanov (1976)** and **Pauly (1980).**

The fishing mortality coefficient F was estimated by subtracting the value of natural mortality coefficient from the value of total mortality coefficient as F = Z – M. While the exploitation rate E was estimated by the formula suggested by **Gulland (1971)** as E= F/Z. Precautionary target (F_{opt}) and limit (F_{limit}) biological reference points were calculated as 0.5 and 2/3 M, respectively, and they were used to assess the resource status by direct comparison with the current fishing mortality rates established for the studied species.

RESULTS AND DISCUSSION

1. Study area

The Gulf of Suez extends about 250 km from Suez in the north (Lat. 29° 56' N) to Shadwan Island in the south (Lat. 27° 36' N). Its width varies between 20 and 40 km, and its depth throughout its axis is fairly constant with a mean depth of 45 m (Fig. 1). The Gulf is one of the most productive fishing areas along the Egyptian sector of Red Sea. Three main fishing methods are operated in the Gulf; trawl, purse-seine and artisanal fisheries especially long and hand lines (**Mehanna and El-Gammal, 2007**). Many fishing ports are found along the Gulf of Suez; Ataka, El Salakhana, Ras Gharib and El Tour from which Ataka is the most important where about 65% of the total Gulf production landed on it (**GAFRD, 2020**). Also, mostly the trawl catch was landed in Ataka fishing port. The trawl fishery is seasonal, generally from September or October to May. The trawl fishery contributed about 19.85% of the total fish production from the Gulf. This being about 56% of the gross revenue of the Gulf due to the high price of large shrimp and cephalopod in the local markets (**Mehanna and El-Gammal, 2007; Mehanna, 2021**). The most economically important fish categories represented in the catch of the trawl are the lizard fish (family: Synodontidae), striped piggy (family: Haemulidae), the large shrimp (family: Penaeidae), threadfin bream (family: Nemipteridae), red mullet (family: Mullidae), horse mackerel and scads (family: Carangidae), cuttlefish and small shrimp (**Mehanna, 2000, 2021 & 2022**).

2. Age determination and age composition

Age determination is one of the most important elements in the field of fisheries management. It forms the basic knowledge required for the evaluation of longevity, growth rate, mortality rate and yield. These parameters are the basic information needed for the construction of a management strategy for a rational exploitation of any exploited fish stocks (**Mehanna, 1997**). Age and growth data also permit the determination of population changes due to fishing rates (**Morales-Nin, 1992**). By investigating the otoliths of *P. stridens* specimens from the Gulf of Suez (Fig. 2), it was found that, the maximum life span of this species is 3 and 4 years for males and females respectively. The age composition of *P. stridens* from Gulf of Suez (Fig. 3) showed that the percentages frequencies of age groups II and III were the most dominant age groups in the catch contributing about 25 and 66.4% in males, 24.5 and 50% in females, and 25.1 and 57.1% for sexes combined respectively. On the other hand, the terminal age groups (0, III and IV) were represented by low percentages for the species.

Fig. (2). Otolith of *Pomadasys stridens* (TL: 18 cm; 4 years old)

3. Back-calculations and growth in length

The back calculated lengths were 10.2, 13.8, and 15.9 cm for ages 1, 2, and 3 years respectively for males and 10.6, 14.2, 16.7 and 18.3 cm for ages 1, 2, 3 and 4 respectively for females (Fig. 4). It was clear that the highest growth rate in length for both males and females occurred at the first year of life after which the annual increment decreases with further increase in age.

The sample of striped piggy consisted of 587 males, 732 females and 54 undetermined fish with an overall sex ratio of 1:1.25 which is significantly different from the expected 1:1 ratio (Chi square= 5.38, *P*= 0.023). Monthly sex ratio (Fig. 5) showed that females were dominant in all months of the fishing season except for November 2021 where males were the dominant in this month.

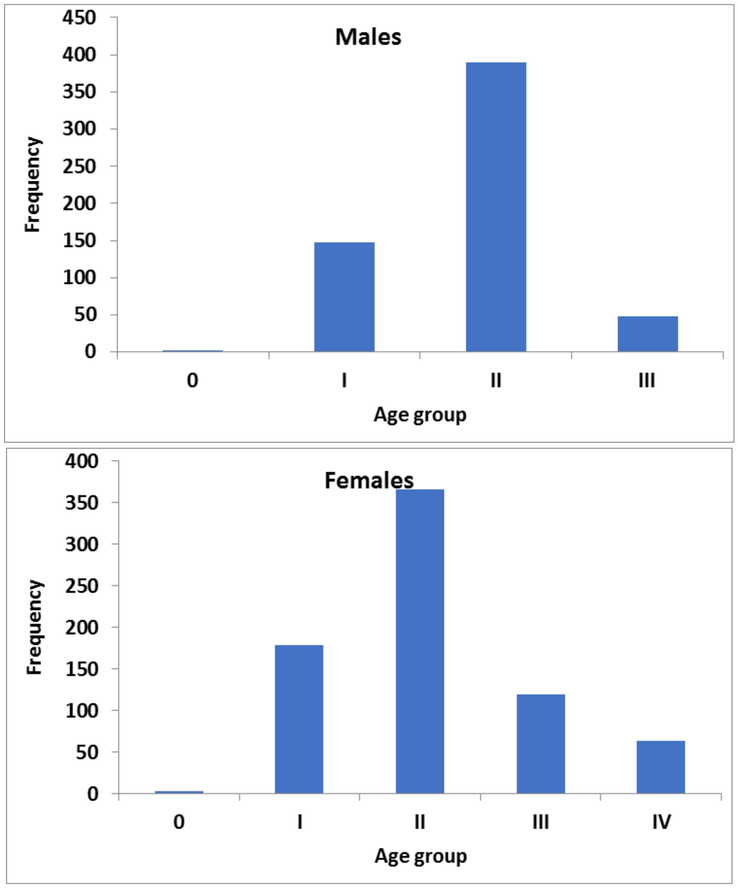
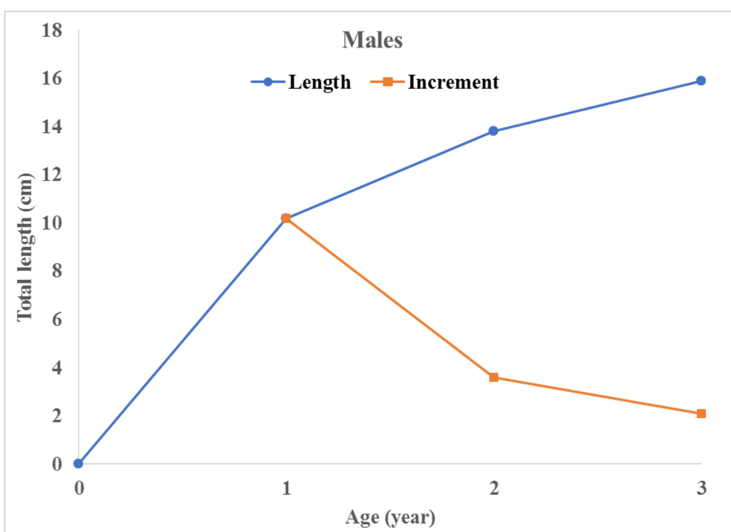


Fig. (3). Age composition of *Pomadasys stridens* from Gulf of Suez



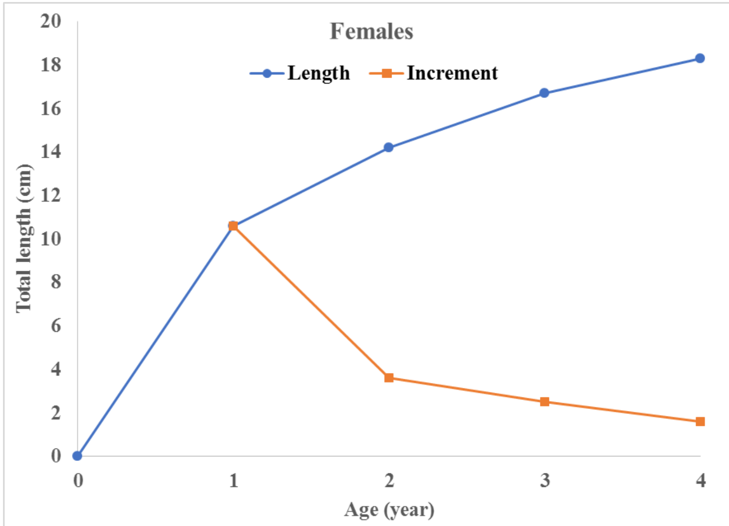


Fig. 4. Growth in length and growth increment of *Pomadasys stridens* from Gulf of Suez

4. Sex ratio

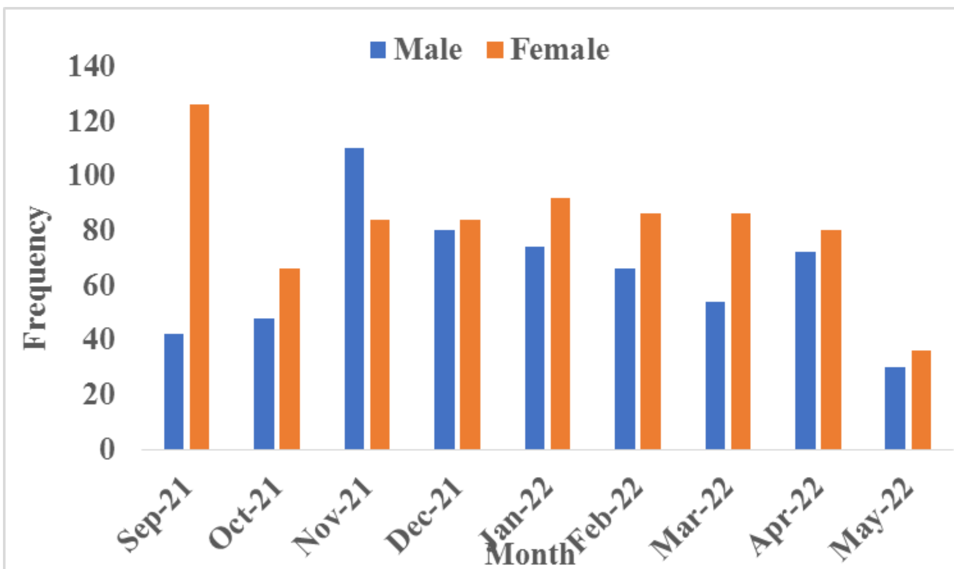


Fig. 5. Monthly sex ratio of *Pomadasys stridens* from Gulf of Suez

5. Growth parameters

Growth parameters ($L\infty$, K and t_o) are the basic input data into various models used for managing and evaluate the status of the exploited fish stocks, these parameters facilitate the comparison between the growth of fishes belonging to different species or to the same species at different times and different localities. The growth parameters of males and females of *P. stridens* in the Gulf of Suez showed that there is a difference in the age and growth rate between males and females (K= 0.539 and 0.395 for males and females respectively). K-values mean that males reach their asympotitic length faster than females and also that males have shorter life span than females. The lower of $L\infty$ may be due to the short longevity or/and the unsuitability of environments for growth such as salinity and temperature ($L\infty$= 18.94 and 21.70 cm for males and females respectively). Growth parameters of striped piggy varied in a wide range in both native and introduced distribution area. **Abd El-Azim *et al* (2017)** reported $L\infty$ value as 23.15 cm, K= 0.51/year and t_0= –0.29 year in the Bitter lakes, Suez Canal. In the Gulf of Iskenderun, **Uyan *et al.* (2018)** estimated $L\infty$ as 32.7 cm and K as 0.096/year in females of the striped piggy population. **Avsar *et al.* (2021)** estimated $L\infty$ as 21.6 cm and K as 0.23 year^{-1} in females.

6. Growth performance Index (Ø')

Growth performance index (Ø') was used to compare the growth rate of fish species in different localities or/and with other species in the same area (**Pauly and Munro, 1984**). The computed growth performance index (Ø') for the striped piggy was 2.28 and 2.27 for males and females respectively. Growth performance values calculated in **Avsar *et al.* (2021)** study and **Uyan *et al.* (2018)** were very close (2.01 and 2.03 respectively). Since the both studies performed in the same area, the Gulf of Iskenderun, this was an expected outcome. Moreover, the growth performance values calculated from the Gulf of Suez in the present study were greater than those values given in Iskenderun Gulf. This variation may be explained due to the ecological conditions, particularly temperature. The striped piggy populations inhabit the Suez Canal lakes seem to have better growth performance with 2.44 (**El-Azim *et al.*, 2017**) than in the Mediterranean and the Gulf of Suez.

7. Critical lengths

The length at recruitment of males and females striped piggy in the Gulf of Suez were 9.8 and 9.4 cm respectively. These small values of L_r indicate small mesh sizes that prevent them from escaping. The estimated length at first capture of males and females was 11.21 and 11.32 respectively (Fig 6), while the length at first sexual maturity was 12.51 and 12.85 cm respectively. It was clear that L_c of striped piggy was less than L_m. This means that the stock of striped piggy in the Gulf of Suez must be protected in order to give them a chance to spawn at least once before being fished.

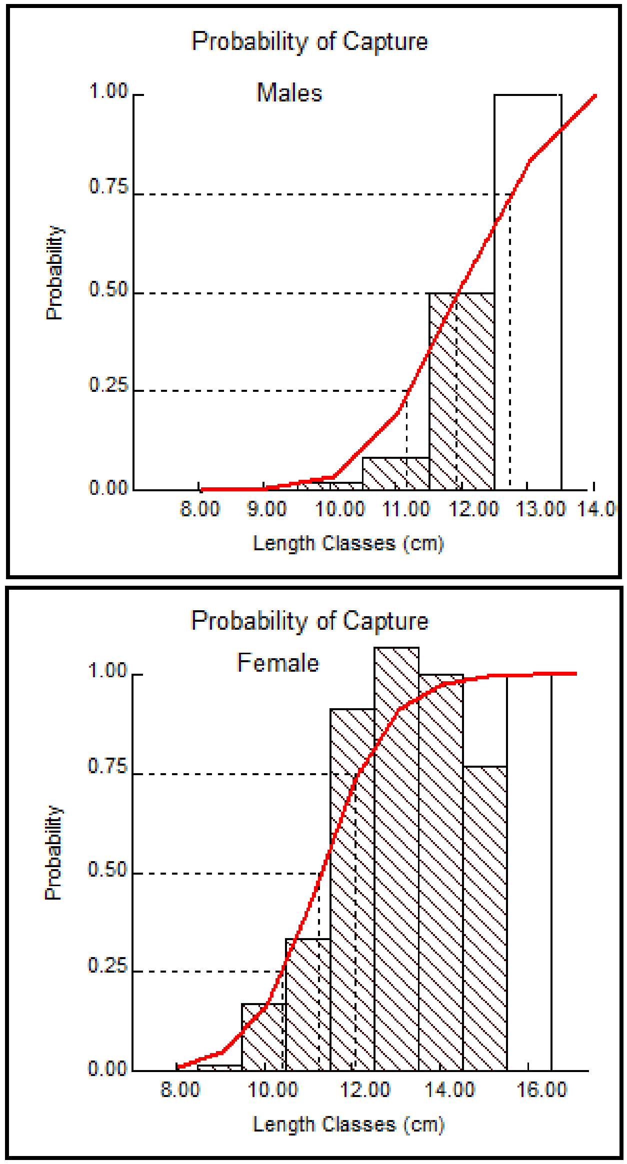


Fig. 6. Probability of capture analysis of *Pomadasys stridens* from Gulf of Suez

8. Mortality and exploitation rates

Mortality means the loss of fish by death from a population due to natural causes (diseases, predation, etc.), or by fishing (capture). The former being referred to as natural mortality (M) and the latter as fishing mortality (F). The values of total mortality coefficients "Z" for males, females and sexes combined of *P. stridens* estimated are showed in table (1). While the values of natural mortality coefficients "M" for males, females and sexes combined of *P. stridens* estimated are given in table (2). Accordingly, the estimated fishing mortality coefficients "F" for males, females and sexes combined of *P. stridens* were 1.99, 1.3 and 1.76/year respectively. From the mortality estimates, it is noticed that, the values of fishing mortalities are high, reflecting an overfishing condition for the striped piggy stock in the Gulf of Suez. Also, the fishing mortality of males was higher than that of females. The current F was also higher than both F_{opt} and F_{limit} indicating the high level of exploitation.

The estimated exploitation rate "E" for males and females of *P. stridens* were 0.69 and 0.64 respectively. Gulland (1971) suggested that the optimum exploitation rate for any exploited stock is about 0.5, at F = M. From results of the present study, it is obvious that the estimated exploitation rates were higher than the optimum value given by Gulland indicating that the striped piggy stock in the Gulf of Suez is being overexploited.

Table (1). Total mortality coefficients of *Pomadasys stridens* from different methods

Method / Sex	Jones – Van Zalinge	Hoeing's	Pauly	Mean
Sexes Combined	2.48	2.35	2.67	2.50
Males	2.77	2.82	3.06	2.88
Females	2.01	2.04	2.07	2.04

Table (2). Natural mortality coefficients of *Pomadasys stridens* from different methods

Method / Sex	Taylor	Ursin	Rikhter& Efanov	Pauly	Mean
Sexes Combined	0.75	0.37	0.92	0.90	0.74
Males	1.00	0.38	0.94	1.22	0.89
Females	0.75	0.35	0.91	0.96	0.74

CONCLUSION

Striped piggy, *P. stridens* has an economic importance in the Egyptian Red Sea fisheries and is suitable for human consumption. Beside its importance in its native areas, the striped piggy is an invasive species, spreading throughout the Mediterranean coasts of Egypt and many Mediterranean countries and also became an important source for food. It constitutes one of the most dominant fish in the shallow coastal waters in the Gulf of Suez and caught mainly by trawlers. This study assessed the growth patterns, stock status and exploitation levels of the striped piggy population in the Gulf of Suez, the northern Red Sea. The results presented here will constitute an important baseline for the fishery status of the studied species. The present results revealed that the stock of striped piggy in the Gulf of Suez, Red Sea, Egypt appears to be overexploited since the current fishing mortality is higher than $F_{0.1}$ and F_{max}. Thus a fishing mortality reduction is necessary in order to avoid future loss in stock productivity and landings.

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