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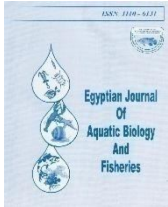

SomeBiologicalAspectsandPopulationParametersoftheSlenderEmperor*Lethrinus variegatus* (Family Lethrinidae) from the Gulf of Aqaba, Egypt

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ABSTRACT

Egyptian fisheries including the aquaculture represent an important sector in the national economy,and it is asource of employment. All studies dealing with the stock assessment and fisheries management in Egypt confirmed the over- exploitation situation for most commercial stocks leading to a serious decrease in domestic fish production from natural resources.This situation made the fisheries managers in Egypt explore new fishing areas to enhance fish production in Egypt. The present work was undertaken as a part of NIOF scientific plan about the Gulf of Aqaba fisheries and how rationally it can be exploited Fish biology and population dynamics are fundamental for fish stock assessment and its management. Some biological and dynamical parameters of *Lethrinus variegatus* from the Gulf of Aqaba, Egypt were investigated to assess its exploitation status. Comparisons of age and growth characteristics recorded no significant differences (P> 0.05) between the sexes. The von Bertalanffy growth parameters for pooled data were K= 0.51/ year, $L\infty$= 25.79cm TL and t_0= -0.387 year. The mean size at which the fish attained sexual maturity for *L. variegatus* was 16.33cm TL.The mean size at first capture was 17.31cm,which was greater than the size at first sexual maturity, indicating the healthy status of *L. variegatus* stock in the Gulf of Aqaba. The fishing mortality rate for *L. variegatus* (0.80/ yr) was substantially greaterthanthetargetF_{opt}(0.51/yr)andlimitF_{limit}(0.67/yr)estimates.Theslender emperor stock was in its optimum situation as the current exploitation rate was 0.44/ yr. The results of the study are important to fisheries management authorities intheregionsincetheywillcontributetoplanningtheregionalfishery managementpoliciesinEgypt.

INTRODUCTION

Fishery resources in Egypt play an important role in the country economy since fish are considered one of the most important food sources for human, which can contribute to bridging part of the nutritional gap of animal protein in Egypt. Besides, fish represent a good source of vitamins, minerals and amino acids necessary for the human health.

Therefore, there is a global and regional care about the fishery resources. In addition, there is a need to pay attention to fisheries as one of the productive activities that can contribute to the development or increase of the national income on one hand, and as one of the most important sources of protein that must be available in human food on the other hand **(Mehanna, 2021)**.

Many of those interested in Egyptian fisheries activities have supported fish farming with all the available capabilities of the country in addition to the strong support of the private sector in this field. Remarkably, all natural Egyptian fisheries suffer from several difficulties and problems that lead to a serious decline in their fish production. It is not possible to close the food gap with aquaculture alone, according to the study. Instead, maintaining capture fisheries should be the focus of attention. In order to protect wild fish stocks from threats like overfishing, pollution, illegal fishing, climate change, and habitat loss, combined efforts are required to develop practical solutions. These elements reduce the quantity and quality of fish that are caught.

Fish of the family Lethrinidae are indigenous to the tropical and subtropical Indo-Pacific region, from the South African Kwa Zulu Natal to the coast of Japan including Australian waters **(Aldonov & Druzhinin, 1978)**. Only *Lethrinus atlanticus*, which is found in the Atlantic off the coast of West Africa, is one of the five genera and 42 species that have been identified thus far **(Carpenter & Allen, 1989)**. Lethrinids are commonly known as emperors or scavengers and are one of the most commercially important group of fish in many nations **(El-Gammal, 1988)**. In Egypt, the lethrinids together with groupers, mullids, siganids and tunas are the most important component of artisanal marine fisheries in the Red Sea, constituting about 29% of the total reef fish landings over the last ten years. *Lethrinus variegatus* (localy known as Deriny) is a common marine, reef associated and demersal species and one of the most abundant and commercially important species among lethrinid fish in the Gulf of Aqaba. Intensive studies on the biological and dynamical aspects of the family Lethrinidae, including age, growth, reproduction, mortality and exploitation, in addition to food and feeding habits, have been carried out in the Pacific, the Red Sea, and the Arabian Gulf **(Walker, 1975, 1978; Aldonov & Druzhinin, 1978; Kuo & Lee, 1986a, b, 1990; Al-Sayes *et al.,* 1988; El-Gammal, 1988; Morales-Nin, 1988; Sharma, 1990; Wassef & Bawazeer, 1990; Wassef, 1991 ; Ezzat *et al.,* 1992; Mehanna, 1997; Brown & Sumpton, 1998; Mehanna, 2011, 2023; Mehanna *et al.,* 2017; Mehanna *et al.,* 2022; El- Mahdy *et al.,* 2022)**. Despite these studies, very rare studies were done on the Gulf of Aqaba **(Mehanna, 2023)**, and the present work is the first to study the biology and dynamics of *L. variegatus* in the Gulf of Aqaba, Egypt.

MATERIALSANDMETHODS

1. Study site

Gulf of Aqaba, Egypt (Fig. 1) is located in the northeastern arm of the Red Sea, penetrating between Saudi Arabia and the Sinai Peninsula at an altitude of 28°45′N 34°45′E. It varies in width from19 to 27 km and it extends to 177 km long. It reaches a maximum depth of 1,850 metres in its central area, with a surface area of about 239Km2. The gulf is characterized by its high diversity where more than 800 fish species, 100 coral species, several crustaceans and mollusks species, dolphins, whales, dugongs and sharks are found. The present annual fish yield of the Egyptian coast of the Aqaba Gulf is reported with 46 tons (GAFRD,2020), which is very low in respect to the fishing area of the Gulf. The commercial fish populations in the Egyptian sector of the gulf showed a seasonal variation in terms of dominant species and catch composition. The fishing fleet in the Aquaba Gulf is of smallscale with wooden small boats not exceeding 12m in length. Avarietyof gears, such as gills, trammel nets and lines were used by the fishermen. There is no definite landing site for the Gulf fisheries, however the fishermen were scattered in the area from the south of Taba until Dahab through Newibaa City. They have their own landing points opposite to their residence along this area.

2. Collection of samples

The samples were monthly collected from landing points along the fishing area from south Taba to Nuwaibaa, covering the period from May 2022 to June 2023. Boats were randomly selected at the landing points along the studied area, and all catch of these boats was taken. The catch was sorted to species le, and the studied species was selected and separated for further analysis.

For each specimen of *L. variegatus*, total length was measured to the nearest 0.1cm, and the total body weight was recorded to the nearest gram. Sagittal otoliths were surgically extracted from each specimen for age determination. Otoliths were cleaned with ethanol and stored dry in individually labeled vials.

Methods

Growth was investigated to size-at-age data using standard nonlinear optimization methods, following the von Bertalanffy growth function (**von Bertalanffy, 1938**). The model was fitted to each sexseparately and to sexes combined.The von Bertalanffy growth function is defined as follows: $Lt= L\infty\ (1-e^{-K(t-t_0)})$, where, Lt is the length at time t; $L\infty$ is the asymptotic length; K is the instantaneous growth coefficient, and t_0 is the hypothetical time at which length is equal to 0.

Growth curves were compared between sexes by using the analysis of residual sums of squares, following the method of **Chen *et al.* (1992)**. The growth performance index (ø') is calculated as per the formula provided by Gayanilo *et al*. (2005) since it serves as a metric to compare growth characteristics, particularly in terms of length, as follows ø'= LogK + 2Log $L\infty$.

Parameters of the length-weight relationship were obtained by fitting the power function ; $W = aL^b$ to length and weight data, where W is the total weight; L is the total length, and a and b are constants determined empirically.

The annual instantaneous rate of total mortality (Z) was determined by two methods,the linearized catch curve based on age composition data, following the method of **Ricker (1975)**, as follows: ln $C(t_1, t_2) = q-z*t$, where slope= -Z,and the cumulative catch curve method, following the method outlined by **Jones and van Zalinge (1981)**,asfollows:ln(CN)=a+(Z/K)*ln($L\infty$L),whereCN=cumulativefrequency.Naturalmortality coefficient(M) was determined using the empirical equation derived by **Hoenig (1983)** and the formula of **Lorenzen (1996)**. The annual instantaneous rate of fishing mortality (F) was calculated as: F= Z-M.

The exploitation rate (E) was calculated as the proportion of the fishing mortality in relation to total mortality (E= F/Z). Precautionary target (F_{opt}) and limit (F_{limit}) biological reference points were calculated as 0.5 and 2/3M, respectively, and they were used to assess the resource status by direct comparison with the current fishing mortality rates established for the studied species.

The length at first capture Lc was estimated using catch curve analysis, following the method outlined by **Pauly (1984)**, while the length at first sexual maturity was estimated using the formulas of both **Froese and Binohlan (2000)** and **Hoggarth *et al.* (2006)**.

The length at maximum yield-per-recruit(L_{opt}) was estimated using the method of **Beverton(1992)**, as follows:$L_{opt} = L\infty*(3/(3 + M/K))$.

The analysis was conducted in Rusing package LBSPR, according tothe guide lines of **Hordyk(2019)**.

Fig. 1. The Gulf of Aqaba showing the sampling area

RESULTS ANDDISCUSSION

Knowledge about the life history and status of the exploited species is an important starting point for developing a management plan for its population and is fundamental to improve its status. The slender emperor is one of the common fish species that are captured in the Gulf of Aqaba, Egypt. The population dynamics and status of the slender emperor (*L. variegatus*) in the Gulf of Aqaba, Egypt were assessed using the size at-age data.

1. Age and growth in length

Fish growth is an important factor that shapes the population structure of juvenile and adult fish **(Sogard, 1992; Gamito, 1998)**. The study of fish age and growth is essential in population dynamics and fishery management **(Longo *et al.,* 2021)**. Since, there is no significant difference observed between sexes in respect to age, growth and length distribution; all calculations in this study were conducted for combined sexes. The maximum age estimates determined from counts of opaque and translucent bands on the slender emperor otoliths were 4 years for males and females. A comparison of the growth characteristics between sexes revealed that there werenosignificantdifferencesinparameter estimates for the studied species (*P*> 0.001). The respective mean lengths at different ages were 15.23, 19.31, 22.20, and 23.45cm at 1st, 2nd, 3rd, and 4th year, respectively, while the age of full recruitment was the age group II representing about 60% of the total sample (Fig. 2). The growth in length was very rapid in the first year of life and decreasing gradually with increasing of age. determined the age of *L. variegatus* from the Egyptian Red Sea using both length frequency and scales readings, and found that this species attained three and four years for male and female, respectively. The length range in his study was 10- 22.5cm TLfor male and 9- 24.2cm TL for female. It is clear that the Gulf of Aqaba fisheries seem to be better than the other Egyptian Red Sea fisheries, since the small sized fish were not represented in the catch of the Aqaba Gulf. Additionally, the *L. variegatus* in the Aqaba Gulf attain bigger sizes and heavier weights for the same age group.

Length-weight relationship LWR

The LWR has many applications in fish stock assessments, biomass estimations, ecological studies and modeling aquatic ecosystems.The LWR provides valuable information on the habitat where the fish lives, condition, reproduction history, life cycle and the general health of fish species **(Froese, 2006; Froese *et al.*, 2011; Mehanna & Farouk, 2021)**. The LWR of the slender emperor was estimated using 430 individuals ranging in their lengths between 14.1 and 23.7cm TL (mean 18.68± 2.51cm) and in their weights between 35 and 185g (mean 90.05± 33.1g). The resultant equation for the combined sexes was $W= 0.0086L^{3.1394}$ with a high correlation coefficient $R^2 = 0.966$ (Fig. 3). The obtained b-value is significally different from 3 indicating positive allometric growth (b> 3; t-test, *P*> 0.05) for the slender emperor in the Gulf of Aqaba. The positive allometric growth revealed that this species have a relatively fast growth rate and tend to be heavier. The present results differ from that of **El-Gammal (1988)** who found that, *L. variegatus* in the Red Sea had negative allometric growth (b= 2.85 for male and 2.65 for female). This variation is acceptable due to the variation in the habitat and ecological parameters.

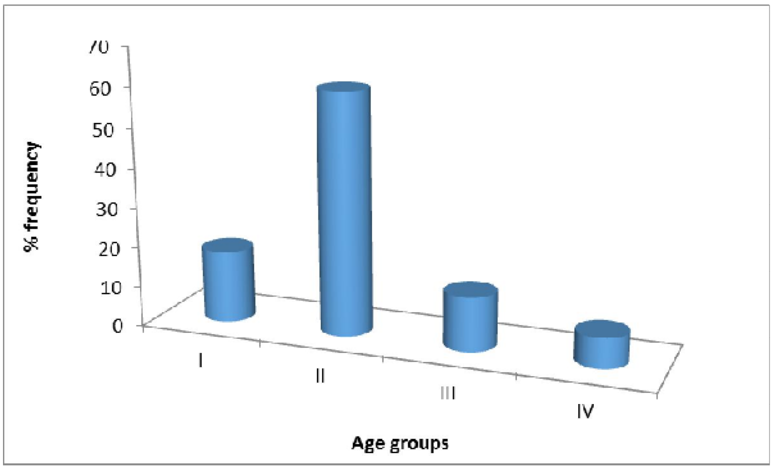

Fig.2. Age composition of *Lethrinus variegatus* from the Gulf of Aqaba

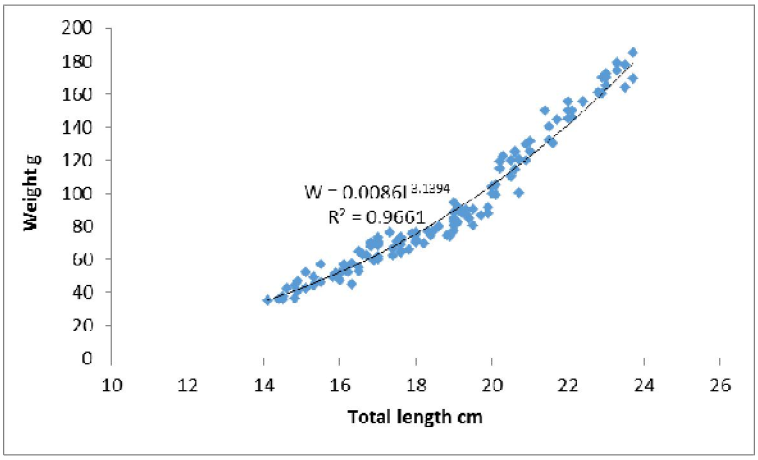

Fig.3. Length-weight relationship of *Lethrinus variegatus* from the Gulf of Aqaba

3. Growth parameters

The asymptotic length ($L\infty$) and growth constant (K) were estimated at 25.79 cm and 0.51 $year^{-1}$, respectively. The growth performance index (Φ) and theoretical age at birth (t_0) were estimated at 2.88 and -0.387 years, respectively. Using the growth parameters ($L\infty$, K and t_0), the VBGF for length at time (t) was expressed as:

$$Lt = 25.79 \ (1\text{-}e^{-0.51(t+0.387)}).$$

The asymptotic length in the present study is greater than that reported by **El-Gammal (1988)**, who gave $L\infty$= 24.19 and 25.68cm for male and female, respectively.This difference could be attributed to factors like the selectivity of the gears,the sampling methods and geographical locations. The estimated growth rate (K= 0.51 $year^{-1}$) from this study was higher than the estimates of **El-Gammal (1988)**, which is possibly a result of variation in the geographical locations, and suitability of the Aqaba Gulf conditions rather than the rest of the Egyptian Red Sea. Furthermore, the growth performance indicates the important availability of food and other favorable environmental conditions in theGulf of Aqaba.

4. Mortality coefficients and current exploitation rate index

The mean instantaneous total mortality coefficient (Z) was estimated as 1.81 $year^{-1}$. The mean natural mortality (M) and fishing mortality (F) wereestimatedtobe1.01$year^{-1}$and 0.80 $year^{-1}$, respectively. The current exploitation rate was estimated as E= 0.44. Both of fishing mortality and exploitation rate revealed that this fishery is operating around its optimum situation. The natural mortality (M= 1.01 $year^{-1}$) was greater than the fishing mortality (F= 0.80 $year^{-1}$), which could be due to the fact that the *L. variegatus* stock in the Aqaba Gulf, Egypt is more vulnerable to natural mortality circumstances than to fishing efforts and gears.

5. Length at first capture (Lc) and length at first maturity (Lm)

The probability of capture of *L. variegatus* is at 25, 50, and 75% which provides a clear indication of the estimated real size of fish in the fishing area that are being caught by specific gear were estimated as: L_{25}=16.01cm, L_{50}=17.31cm, and L_{75}=18.56cm (Fig. 4). Therefore, the length at first capture (L_c) was 17.31cm. The mean value of length at first maturity (L_m)was estimated at 16.33 cm. It is obvious that$L_c$was greater than L_m, indicating the healthy status of this fishery and demonstrating that the *L. variegatus* stock is harvested after sharing in the reproduction process.

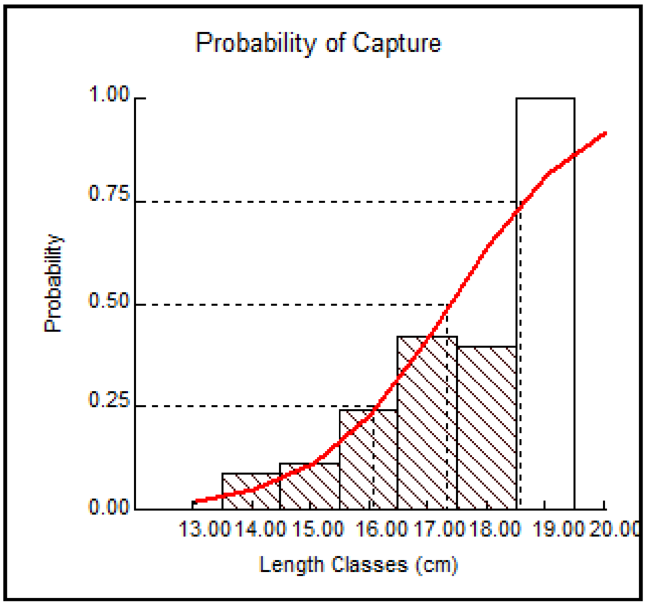

Fig.4. Probability of capture of *Lethrinus variegatus* from the Gulf of Aqaba

In addition, from the present study, the ratio L_c/L_∞ was estimated as 0.67,relatively higher than 0.5, which implied that the harvested catch is mostly made up of moderate and large sized *L. variegatus.*

The length at maximum yield-per-recruit (L_{opt}) was estimated using the method of **Beverton (1992)**, as 15.7cm TL which is smaller than L_c and L_m in an indication for the healthy status of the slender emperor in the Gulf of Aqaba, Egypt.

A critical and essential step for the development of management policies for any fishery resource is to determine the reference points since these are parameters that both scientistsandmanagersusetocomparethecurrentstatusofapopulationorafisherywiththe desirable or undesirable status. The F_{opt} and F_{limit} which are regarded as biological reference points were estimated at 0.51 and 0.67 per year, respectively. The current F (0.8/ year) was higher than both F_{opt} and F_{limit} in an indication that the fishing gears in the area need a detailed study about their characters and selectivity.

CONCLUSION

This study assessed the status of *L. variegatus* species in the Gulf of Aqaba, Egyptand the results revealed that the *L. variegatus* population is not in the risk of overfishing until now. Caution is needed in the management of the *L.variegatus* stock to prevent population decline in the future. It is clear that some fishermen in the Gulf of Aqaba are not following the gear size restrictions and proposed fisheries regulations. Hence, some recommendations are proposed, including the improved implementation of fisheries regulation and contineous monitoring of illegal gear used, as well as educating fishermen about gear selectivity and minimum support sustainability of fishery resource. Addtionally, further analysis based on more biological informationaboutthismult ispecies fishery is recommended before drawing any strategic management conclusions.

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