Age, growth, mortality rates and corresponding yield estimates of the snubnose emperor *Lethrinus borbonicus* from south Sinai coast, Gulf of Suez, Egypt

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ABSTRACT

Age-based demographic analysis were conducted to assess the current status of fished stock of the snubnose emperor *Lethrinus borbonicus* in South Sinai coast, Gulf of Suez, Red Sea. *L. borbonicus* is one of the most abundant emperors in the area, representing about 10% of the total artisanal fishery in south Sinai coast. Seasonal samples were collected from the commercial small scale fishery during the period from June 2005 until April 2007. The otoliths were used for age determination. Validation of the ageing method was carried out by analyzing the seasonal length frequency distributions. The life span was found to be four years. The estimated von Bertalanffy growth parameters from otolith age reading were L_∞= 36.76 cm, K= 0.344 year^{-1} and t_o= -0.321. Instantaneous rates of fishing mortality (F) were beyond the limit reference point compared with estimated instantaneous rates of natural mortality (M), indicating that there is currently a risk to the sustainability of that stock. Results of the exploitation rate (E=0.583) and relative yield per recruit showed that the snubnose resource in the Gulf of Suez is overexploited and that small 16 individuals are the target of the fishery referring to recruitment overfishing also. Some implications for the fishery management for decreasing fishing effort are required.

Keywords: *Lethrinus borbonicus*, age, growth, mortality, Gulf of Suez, Red Sea.

INTRODUCTION

The artisanal fishery in South Sinai coast (Gulf of Suez, Red Sea) is one of the most important small scale fisheries in the Egyptian Red Sea. Emperors constitute one of the most commercial fish groups of this fishery; they contribute by about 25% of the total annual catch (GAFRD, 2010). The economically dominant emperor species in the investigated area are *Lethrinus nebulosos, L. mahsena*, *L. borbonicus* and *L. lentjan*. The snubnose emperor *L. borbonicus* represents the second most abundant emperor species in Sinai coast; it is prevalent in the catch of commercial and recreational fisheries in the Gulf of Suez in the vicinity of coral reefs (El Ganainy and Ahmed, 2002). It is also caught by gill nets and lines in southern coastal areas in depths shallower than 20 m, near shore at Gabal Elzeit, Abu Kafas, Laira, Abu Darba and further offshore near Ras Ghareb. The annual commercial catch of *L. borbonicus* during 2006-2011 since separate catch statistics have been gathered for the species ranged between 63 and 72 ton (Fig. 1).

Despite the commercial exploitation of the snubnose emperor *L. borbonicus* in south Sinai coast of the Gulf of Suez, information on the biology and population structure of the species are scarce. Salem (1990 a, b, c) studied the age and growth, population dynamic and reproduction of *Lethrinus bungus* (synonym) in the Red Sea. Gaudian *et al.* (1995) estimated the population size of the species in the coral reefs around Tanzania. Amin (2002) studied the biology and population dynamics of *L.*

bungus in the Gulf of Suez. Grandcourt *et al.* (2010) studied the life history parameters of this species in the southern Arabian Gulf.

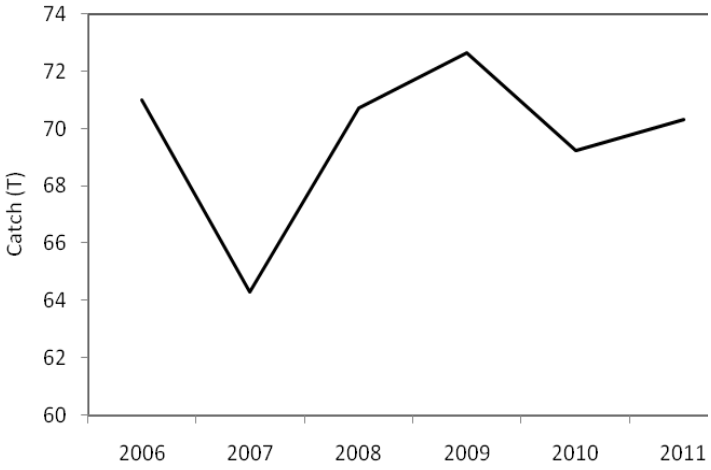

Fig. (1). Annual total catch of *Lethrinus borbonicus* from south Sinai coast in the Gulf of Suez.

The aim of this study is to estimate the growth, mortality parameters and the level of exploitation of the snubnose emperor *Lethrinus borbonicus* in south Sinai coast of the Gulf of Suez based on the otolith age determination as well as the length frequency distribution analysis. The results will provide the basic information necessary for the assessment and management of the stock of this species in the investigated area.

MATERIAL AND METHODS

Seasonal random samples of the snubnose emperor *Lethrinus borbonicus* were collected from the landing sites of the artisanal fishery along South Sinai coast between Qud Ibn Haddan region and El-Tur city. Sampling was carried out for two years, from June 2005 to April 2007. Total length in cm, total weight in gm and sex were recorded for each specimen. The otoliths were removed, cleaned and kept in special envelopes for using in age determination, and then they were viewed with incident light of a stereo microscope at a magnification of 40 X while immersed in a clearing fluid of equal volumes of glycerol and alcohol. Validation of the ageing method was carried out by analyzing the pooled monthly length frequency distributions using the Bhattacharya (1967) method incorporated in the FiSAT program (Gayanilo *et al*., 1998).

The estimation of growth parameters was performed through a non-linear least squares technique (Prager *et al.*, 1989); the mean square error was used as an index of goodness of fit. The empirical equation of Pauly (1979) was used to estimate the hypothetical age (t_o) of fish, which would have at zero length. A prime estimate of the asymptotic length (L_∞) and the growth coefficient (K) were obtained by applying the method of Wetherall (1986).

To establish the length weight relationship, the commonly used relationship

$$W = a\ L^b \text{ (Ricker 1975)}$$

was applied, where W is the weight (gm), L is the total length (cm) and a and b are the equation constants.

The instantaneous rate of total mortality (Z) was estimated by the catch curve method described by Pauly (1983). The instantaneous rate of natural mortality (M)

was computed by applying Pauly (1980) empirical equation. The instantaneous rate of fishing mortality (F) was extracted as F = Z-M. The exploitation ratio (E) was calculated as equal to the fraction of death caused by fishing (E = F/Z). The length at which 50% of the catch retains in the net (Lc) was obtained by plotting the curve for probability of capture by length (Pauly, 1984). The size that generates maximum yield per recruit and the length at first sexual maturity was estimated by Froese and Binohlan (2000) empirical equations. The effect of fishing was explained using the Beverton & Holt (1957 and 1966) relative yield per recruit model.

RESULTS AND DISCUSSION

Length-weight relationship:

The total length measurements of the snubnose emperor *L. borbonicus* specimens ranged from 11.4 cm. to 30.1 cm. with an average of 20.73 ± 5.21 cm, while the total weight measurements varied from 23 to 452 gm with an average of 167.67 ± 114.96 gm. The length weight relationship (Fig. 2) was computed and the obtained equation was $W= 0.0185\ L^{2.9509}$ (ANOVA, $F = 11048.21$, $P < 0.01$) by: ($r^2 = 0.9901$, $SE_a = 0.084$, $SE_b = 0.028$). The growth of weight relative to length was almost isometric ($b = 2.9509$; 95% CI: 2.895-3.006) as the obtained isometric index value (b) was not significantly different from 3 (Student's t-test; $P = 0.453$).

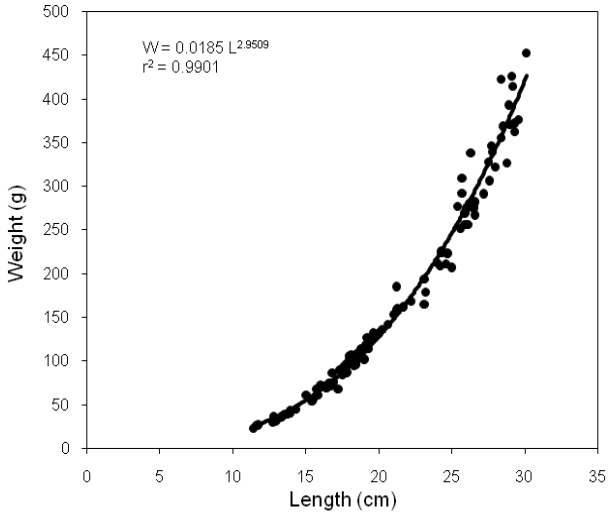

Fig. (2). Length weight relationship of *L. borbonicus* from south Sinai coast in the Gulf of Suez.

Age and growth

Otoliths were used in age determination. The validity of the annulus as a true year mark was tested by the decomposition of the pooled length frequency distribution into its normal distributions. There was a good agreement between length at age determined through direct observation on otoliths and those from the length-based method ($P = 0.962$) which validates the age readings (Table 1).

The otolith age readings showed 4 age classes with mean lengths of 14.48, 20.79, 26.15 and 28.84 cm for age groups I, II, III and IV respectively. Age group II constituted the bulk of the catch with 50.4% of the aged individuals (Fig. 3). The mean estimated lengths at different age groups (Table 1) indicated rapid growth in the 1st year of life with fish attaining almost 50 % of its maximum size, whereas in the following years the rate of growth slows down.

Table 1: Mean length at age estimated for *L. borbonicus* from direct age reading and from length frequency distribution (Bhattacharya, 1967 method).

Age	Age reading				Bhattacharya method		
	Number of fish	Length	SD	Population	Mean Length	SD	S.I.
I	68	14.73	0.30	42	14.48	1.51	-
III	132	20.79	0.29	96	19.48	1.57	3.25
III	38	26.15	0.27	86	27.27	1.95	4.43
IV	24	28.84	0.17	50	29.00	1.51	2.00

SD = standard deviation
S.I. = separation index

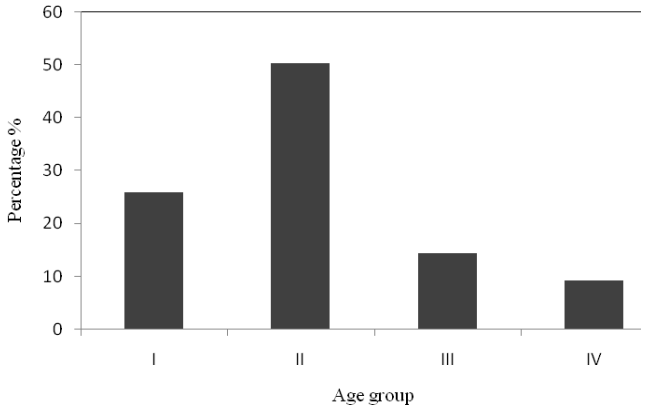

Fig. (3). Age composition of *L. borbonicus* from the Gulf of Suez, SouthSinai coast.

The available age studies for *L. borbonicus* from the Gulf of Suez and Red Sea (Salem, 1990; Amin, 2002) showed that its life span is 4-5 years. Salem (1990) recorded an age of 4 years for *L. bungus* in the Red Sea (Hurghada) with lengths of 13.28, 17.21, 19.72 and 21.65 cm for the age groups from 1 to 4. Amin (2002) recognized five age groups in the scales of *L.borbonicus* in the Gulf of Suez with mean lengths of 15.99, 22.42, 26.79, 29.55 and 31.51 cm. These records are relatively different than that of the present study, which may be attributed to the difference in the length composition and the maximum recorded length in each study.

In the present study the mean lengths at age for all aged specimens were used for fitting the growth curve (Fig. 4) and estimating the von Bertalanffy growth parameters. The resulting VBGF parameters were L_∞= 36.76 cm (SE= 2.97 and C.V. = 0.095), K= 0.344 year^{-1} (SE= 0.302 and C.V. = 0.523) and t_o= -0.321 (SE= 0.156) (Table 2).

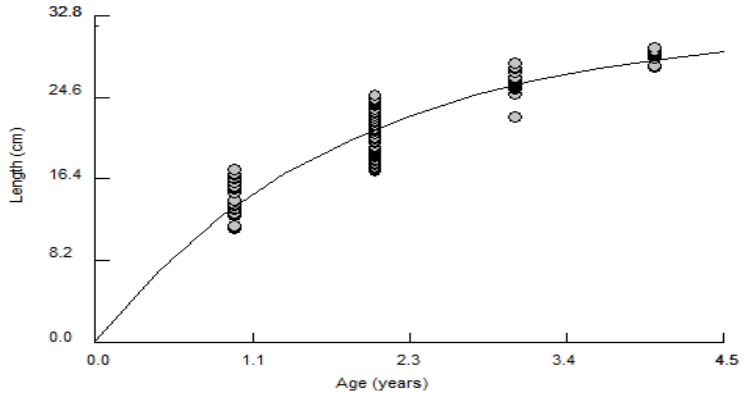

Fig. 4: Growth curve estimated from age reading data of *L. borbonicus* from the Gulf of Suez, South Sinai coast.

Table 2: Parameters of von Bertalanffy equation of *L. borbonicus* estimated for lengths from the otolith age reading and length frequency distribution.

Method	L_∞	K	t_o
Otolith reading	36.756	0.344	-0.321
Wetherall (1986)	33.261	0.512	-0.283
Bhattacharya (1967)	36.478	0.36	-0.356

The asymptotic length and growth coefficient estimated from both direct observations and length based methods were very close, and in accordance with that recorded by Amin (2002) but higher than that reported by Salem (1990) who estimated the growth parameter as L_∞ = 25.59 an K= 0.378 y^{-1}.

Mortalities and Biological reference points

The estimated total annual mortality rate (*Z*) was 1.82 $year^{-1}$ with a CI of -0.83-3.26 and r^2 = 0.8453 (Fig 5).

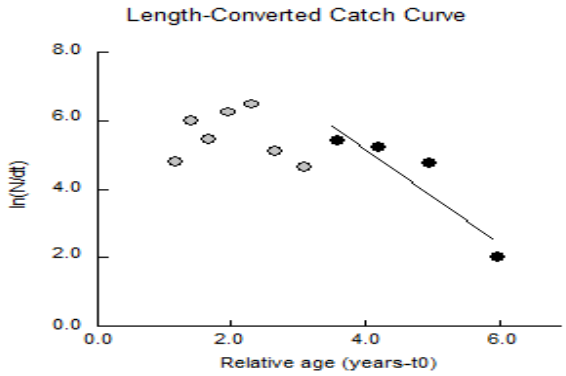

Fig. 5: Length converted catch curve for estimation of total mortality coefficient of *L. borbonicus.*

The estimated growth parameters and the mean annual water temperature of the Gulf of Suez (T= 22.5 C°) as recorded by Yassien (1998) were used in Pauly's empirical equation (1980) and the resultant natural mortality coefficient was M = 0.758 $year^{-1}$. The estimated fishing mortality (F = 1.062/yr) was much greater than both the target (F_{opt} = 0.379/yr) and limit (F_{limit} = 0.505/yr) biological reference points (Table 3).

Table 3: The estimated population parameters of *L. borbonicus*

Parameters	Value
Natural mortality coefficient (M)	0.758
Total mortality coefficient (Z)	1.820
Fishing mortality coefficient (F)	1.062
Exploitation rate (E)	0.583
Optimum fishing mortality F_{opt}	0.379
Limited fishing mortality F_{lim}	0.505
M/K	2.210

The calculated length that generates the maximum possible yield (L_{opt}) was 22.8 cm (s.e. of 19.2-26.9); this value is greater than the mean size at first capture (L_c = 16.4 cm) and the mean size at first sexual maturity L_m = 21.2 cm (s.e. 15.9-28.5).

Selectivity and recruitment pattern

The selectivity range derived from the probability of capture at size plot was 4.5 cm (11.7-15.0) (Fig.6). Values of the sizes where the probability of capture was 50% (L_{50}), 75% (L_{75}) and 100% (L_{100}) are 12.7, 16.4, and 18.0 respectively.

The recruitment pattern of *L. Borbonicuc* in the Gulf of Suez was plotted in relation to the percentage of recruitment vs. time (projecting a set of length frequency backward onto 1-year time axis). There was continuous recruitment throughout the year, with a peak during May (Fig. 7). This result coincides with that recorded by Salem (1990), who studied the reproduction of *L. bungus* in the Red Sea and reported that the species has long spawning season with a peak during May and June.

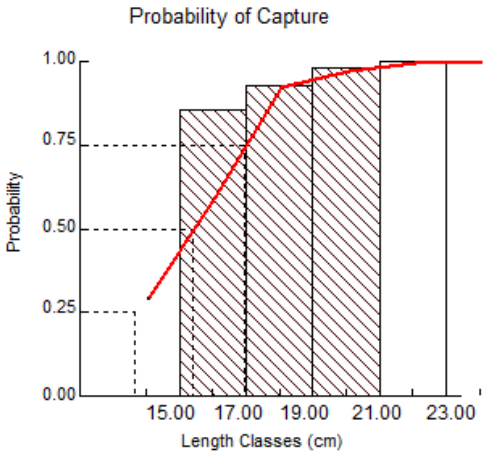

Fig. 6: Probability of capture of *L. borbonicus* from the Gulf of Suez, South Sinai coast.

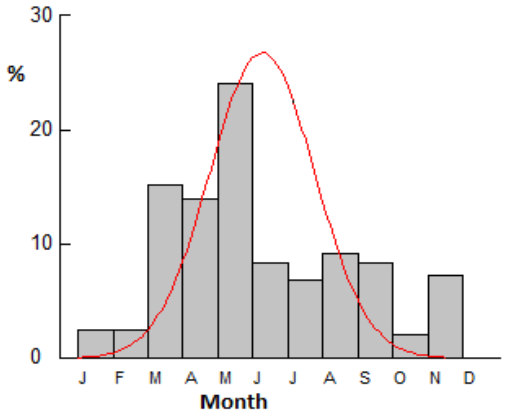

Fig. 7: Recruitment pattern of *L. borbonicus* from the Gulf of Suez, SouthSinai coast.

Assessment of the fishery

Assessment of *L. Borbonicus* stock in the Gulf of Suez was studied by examining the effect of fishing through changing the L_c value. The relative yield per recruit (Y`/R) was computed as a function of different values of exploitation ratio (E) and length at first capture L_c. The results (Fig. 8) indicated that at the present value of length at first capture (L_c = 16.4 cm) and the current natural mortality (M = 0.758y^{-1}), the maximum Y'/R occurs at a value of exploitation rate E_{max}= 0.713 which is higher than the current exploitation rate E_{cur} = 0.583.

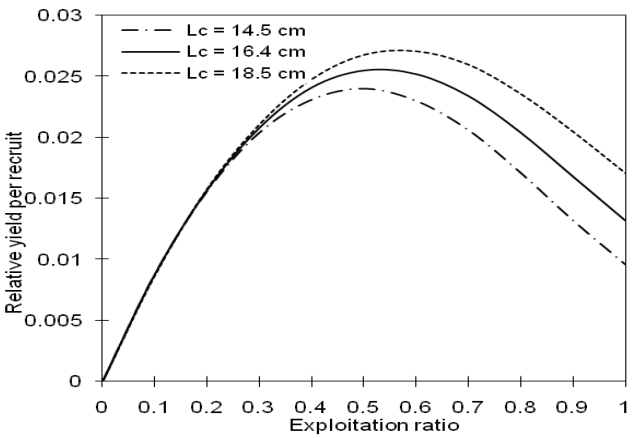

Fig. (8). Relative yield per recruit of *L.borbonicus* as a function of exploitation rate and length at first capture

However, the value of E_{cur} is very close to the optimum exploitation rate $E_{0.1}$= 0.619 which corresponds to a point on the yield per recruit curve where the slope is $1/10^{th}$ of the value at the origin of the curve, this provides an estimate of $E_{opt} = E_{0.1}$ which is lower than E_{MSY} but generates the economic yield per recruit.

CONCLUSION

The results of the present study revealed that there is a marked effect of fishing on the snubnose *L. borbonicus* stock in the Gulf of Suez, South Sinai coast and there is a risk on the sustainability of this resource. It is suggested that further management intervention to decrease fishing effort is required through reducing the number of fishing trips and changing the gear characteristics (mesh size) to catch larger fish to maintain the stock productivity and its sustainability. For the proper management of the multispecies resource in this area, further studies must be undertaken on the other species inhabiting the present investigated region.

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ARABIC SUMMARY

العمر و النمو و معدلات النفوق والانتاج لاسماك البنقذ (ليثرينس بوربونيكس) من ساحل جنوب سيناء على خليج السويس ، مصر

عزة الجنايني - امل امين
المعهد القومى لعلوم البحار والمصايد فرع السويس، مصر

تعتبر سمكة البنقذ من أهم اسماك عائلة الامبراطور التى تصاد عن طريق الشباك الخيشومية أو السنار بالقرب من الشعاب المرجانية فى منطقة جنوب سيناء شرق خليج السويس. تم فى هذه الدراسة تجميع عينات موسمية من سمكة البنقذ على مدار عامين من يونيو 2005 حتى ابريل 2007 من منطقة الانزال فى مدينة الطور وتم قراءة أعمار الاسماك بأستخدام كل من عظمة الأذن و التردد الطولى ووجد ان عمر السمكة يصل الى اربعة سنوات. . كما انه امكن فصل التردد الطولى للمجموع الكلى للعينات الى اربعة مجاميع عمريه لها اطوال مقاربة تماما لما تم تسجيله من قراءة عظمة الاذن. واتضح ان سمكة البنقذ تصل الى اقصى طول نظرى (36.756 سم) بمعدل نمو 0.344 فى السنة. واثبتت الدراسة ان معدلات نفوق اسماك البنقذ فى خليج السويس عالية حيث وصل معدل النفوق الطبيعى الى 0.758 فى السنة بينما كان معدل النفوق الكلى 1.82 فى السنة. و اوضحت نتائج معدل الأستغلال لاسماك البنقذ فى خليج السويس (= 0.583E) ان المخزون من هذه الاسماك معرض لصيد جائر و للحفاظ على هذا المخزون يجب تخفيض جهد الصيد.