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Age, Growth, Mortality and Yield per Recruit of the Filefish *Stephanolepis diaspros* (Fraser-Brunner, 1940) (Pisces: Monacanthidae), in the Gulf of Suez, Egypt

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Abstract: The filefishes Monacanthids have a relatively high occurrence in the trawl landings of the Gulf of Suez, representing about 7% of the total trawl catch. The leasarjaket filefish *Stephanolepis diaspros* is the most abundant filefish in the area. In the present work the population structure of *S. diaspros* was studied. Samples were collected from the commercial trawl catches during the period from November 2004 till March 2007. The anterior dorsal spine was used for age determination. Validation of the ageing method was carried out by analyzing the monthly length frequency distributions. The life span was found to be four years. The estimated von Bertalanffy growth parameters from the dorsal spine age reading were L_∞ = 27.83 cm, K = 0.350 year^{-1} and t_0 = -0.499. The values of natural mortality (M), total mortality (Z) and fishing mortality rates were 0.702, 1.88 and 1.18 year^{-1}, respectively. Results of the exploitation rate (E = 0.628) and relative yield per recruit showed that the filefish resource in the Gulf of Suez is overexploited and that juvenile individuals are the target of the fishery. Some implications for the fishery management were proposed.

Key words: Filefish, *Stephanolepis diaspros*, population dynamics, Gulf of Suez

INTRODUCTION

The filefishes Monacanthids are widely distributed in the Indo-west Pacific (Assadi and Dehghani, 1997) they are migrated to the Eastern Mediterranean via Suez Canal and became an important food fish in the Levant Basin (Taskavak and Bilecenoglu, 2001; Dulcic and Pallaoro, 2003). Monacanthids are represented in the Gulf of Suez by two species namely the leasarjaket filefish *Stephanolepis diaspros* and the unicorn filefish *Aluterus monoceros*. Filefishes were discarded species (El-Ganainy *et al*., 2005) till the 1990s, but currently they have a relatively high occurrence in the trawl landings, representing about 7% of the total trawl catch (GAFRD, 2005). *Stephanolepis diaspros* is the most abundant, biological information on this species is very scarce, although there are some data for relative monacanthid species in other regions. So, the growth of the juveniles of Rudarius ercodes and *Paramonacanthus japonicus* were studied by Ishida and Tanaka (1983) and Kawase and Nakazono (1994) of Japan while that of adults by Peristiwady and Geistdoerfer (1991) in Indonesia and by Mancera-Rodriguez and Castro-Hernandez (2004) in the Canary Islands.

The objective of this study is to provide information on age and growth, mortality rates, exploitation rates and effect of fishing on the stock of the filefish *Stephanolepis diaspros* in the Gulf of Suez for the proper management of this resource.

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MATERIALS AND METHODS

Monthly random samples of the filefishes *Stephanolepis diaspros* were collected from the commercial trawl catches landed at Attaqa fishing harbor during the period from November 2004 till March 2007. Total length in cm, total weight in gram and sex were recorded for each specimen. The sagitta otoliths and anterior dorsal spine were collected. Otoliths were not appropriate for age determination due to their small size, complex and diffuse growth marks. The anterior dorsal spine was used by applying the burning technique (Chrestensin, 1964). This technique involved broken each spine transversely by a blade and the broken surfaces were ground smooth, before burning, with the help of a polishing paper of p 320 c model. Then, burning involved holding the spine near a naked flame for several seconds. The smoothed burned surface was then 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 monthly length frequency distributions. 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_0) of fish, which would have at zero length.

To establish the length weight relationship, the commonly used relationship $W = a L^b$ (Ricker, 1975) was applied, where W is the weight (g), L is the total length (cm) and a and b are the equation constants.

The monthly length frequency distributions were analyzed by using the appropriate routines and subroutines of the FiSAT program (Gayanilo *et al*., 1998). For the separation of the length frequency composition into its component distributions, the Bhattacharya (1967) method was used. A prime estimate of the asymptotic length ($L\infty$) and the growth coefficient (K) were obtained by applying the method of Wetherall (1986). The estimated (K) was ascertained by the equation of Pauly *et al*. (1998). The resultant growth estimates were then used as seed values in ELEFAN I program (Pauly and David, 1981) for estimation of the best combination of (L_∞ and K).

The instantaneous rate of total mortality (Z) was estimated by the length converted catch curve method described by Pauly (1983). The instantaneous rate of natural mortality (M) was computed using the following three methods: (1) Pauly (1980) empirical equation, (2) Ralston (1987) regression method and (3) King (1995) method: $M = -\ln [0.01]/t_{max}$ where t_{max} is the time required for a fish to reach 95% of the species $L\infty$, or the maximum age.

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 effect of fishing was explained using the Beverton and Holt (1957, 1966) relative yield per recruit model.

RESULTS

Length-Weight Relationship

The total length measurements of the filefish *Stephanolepis diaspros* specimens ranged from 7.0-26.1 cm with an average of 14.59±3.61 cm, while the total weight measurements varied from 7.0-261.2 g with an average of 61.49±41.95 g. The length weight relationship was computed and the obtained equation was in the form of $W = 0.0262 L^{2.8393}$, it is shown in Fig. 1.

Age and Growth

Anterior dorsal spines of 550 specimens were used for age determination. The reading showed 5 age classes from 0 to 4 years, with a predominance of age class one in the catch (42.7% individuals).

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

	Age reading			Bhattacharya method			
Age	No. of fish	Length	SD	Population	Mean length	SD	SI
0	64	8.90	1.821	51	9.00	2.40	-
I	235	13.65	1.770	385	14.89	1.96	2.74
III	181	18.74	1.230	113	18.17	1.33	2.99
III	63	23.06	0.920	35	22.00	0.98	3.32
IV	7	25.65	0.509	4	25.55	0.81	3.97

SD = Standard deviation, SI = Separation index

Table 2: Parameters of von Bertalanffy equation of *S. diaspros* from the dorsal spine age reading and length frequency distribution

Method	L_∞	K	t_0
Age reading Prager *et al.* (1989)	27.83	0.35	-0.499
Wetherall (1986)	28.19		
Pauly and David (1981)	27.92	0.34	

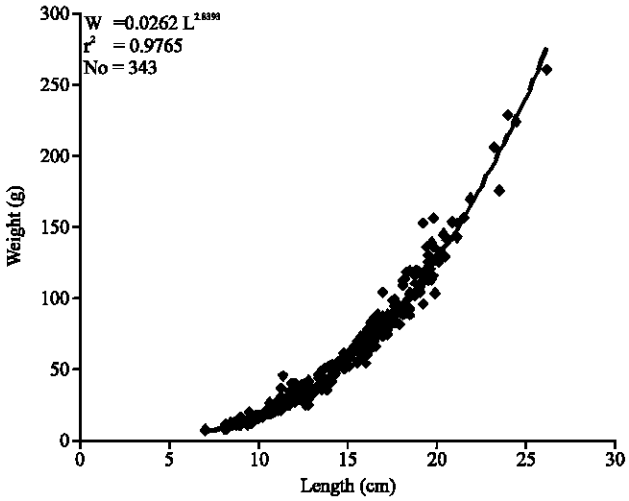

Fig. 1: Length weight relationship of the filefish *S. diaspros* in the Gulf of Suez

The mean estimated lengths at age (Table 1) indicated rapid growth in the 1st year of life with the fish attaining almost 50% of its maximum size, whereas in the following years the rate of growth slows down. The mean lengths at age for all aged specimens were used for fitting the growth curve (Fig. 2) and estimating the von Bertalanffy growth parameters by the non linear least squares method (Prager *et al.*, 1989). The resulting VBGF parameters are L_∞= 27.83 cm (SE = 0.431), K = 0.350 year^{-1} (SE = 0.130) and t_0 = -0.499 (SE = 0.359) (Table 2).

Length Frequency Distribution

The seasonal length frequency distributions (Fig. 3) show that the smallest fishes (<13 cm) younger than one year old represented by about 23% of the total catch. Mot of these individuals was caught during winter, referring that recruitment to the fishery occurs during this season.

The pooled length frequency distributions were analyzed by Bhattacharya (1967) method as incorporated in FiSAT software (Fig. 4). Five components could be identified which were considered as distinct age groups with mean modal lengths of 9.0, 13.98, 18.17, 22.89 and 25.55 cm. The first

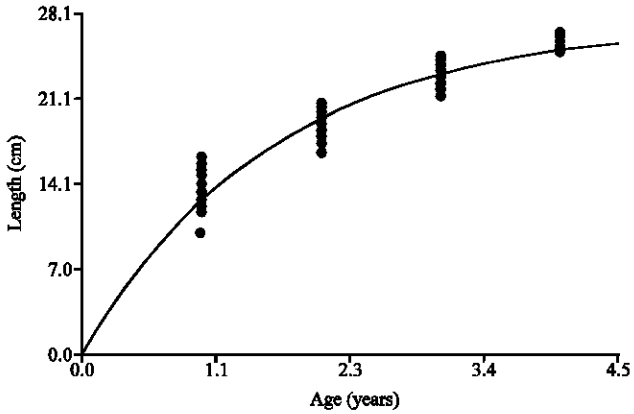

Fig. 2: Length at age and von Bertalanffy growth curve of *S. diaspros* based on age estimated from sectioned anterior dorsal spine

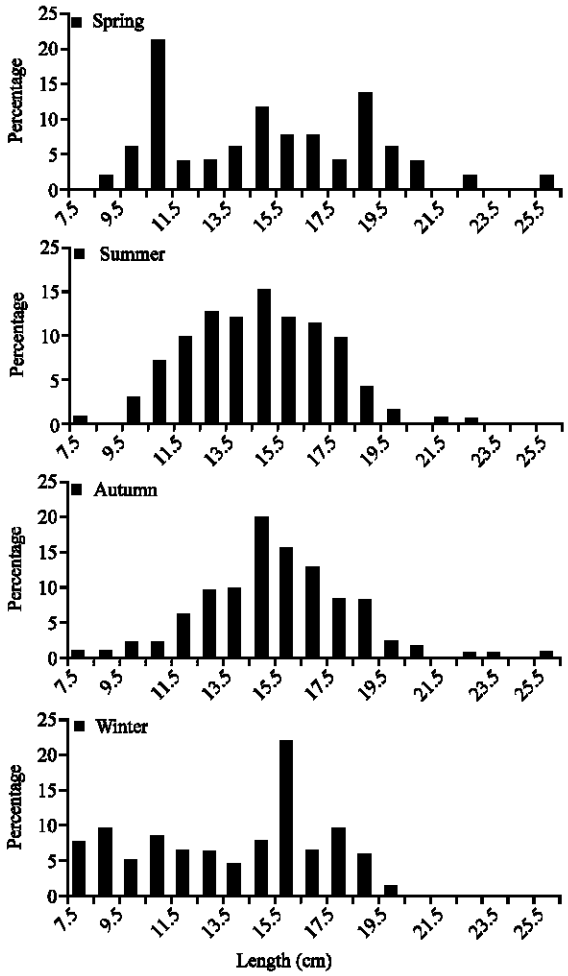

Fig. 3: Seasonal length frequency distribution of the filefish *S. diaspros* from the Gulf of Suez

Table 3: Estimated values of Natural mortality (M) and subsequent estimations for the different models used

Parameters	Pauly (1980)	Ralston (1987)	King (1995)	Mean M
M	0.824	0.740	0.543	0.702
Z	1.880	1.880	1.880	1.880
F	1.056	1.140	1.337	1.178
E	0.561	0.606	0.711	0.627
M/K	2.350	2.114	1.551	2.006

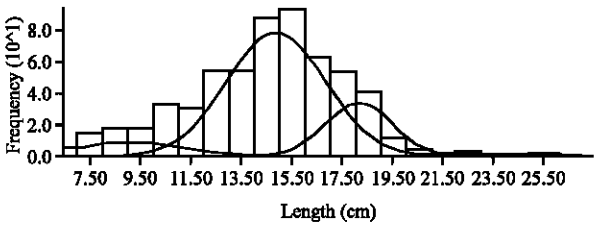

Fig. 4: Composite distributions of the pooled length frequency composition of *S. diaspros* identified by Bhattacharya (1967) method

component was considered as age group zero. These groups are almost well discriminated according to the values of the separation index, which must be over 2 to allow an objective separation of the adjacent groups (Rosenberg and Beddington, 1988) (Table 1).

The asymptotic length (L_∞) of the von Bertalanffy equation, obtained through Wetherall (1986) was 28.19 cm. This length was used as an input value for the Pauly and David (1981) equation and the obtained growth parameters are shown in Table 2.

Mortalities and Exploitation Rate

The total mortality rate was estimated using the length converted catch curve (Pauly, 1983) and the estimated (Z) value was 1.88 year^{-1} with a CI of 0.62-3.14 and $r^2 = 0.9678$. Figure 5 represents the catch curve utilized in the estimation; the black dots represent the used points through least squares linear regression, while open dots represent the points either not fully recruited or close to $L_\infty$and hence discarded from the calculation.

The von Bertalanffy growth parameters (L_∞ = 27.83 cm and K = 0.35 year^{-1}) and the mean annual water temperature of the Gulf of Suez (T = 22.2°C) were used in Pauly's empirical equation (1980) and the resultant natural mortality coefficient was M = 0.824 year^{-1}. The estimated natural mortality coefficient from the three applied methods ranged between 0.543 and 0.824 (Table 3). The mean of M (0.702) was used in the subsequent calculations. The reliability of the estimated natural mortality rate was ascertained using the M/K ratio, as Beverton and Holt (1957) reported that the M/K value for most of the fishes lies in the range 1.12-2.5. The value of M/K ratio was 2.006. The fishing mortality coefficient was calculated directly as F = 1.178 year^{-1} and the exploitation rate was computed as E = 0.627 year^{-1}.

The length at first capture (Lc) was estimated from the left ascending part of length-converted catch curve, the method derived by Pauly (1984) has been found to provide reasonable estimates of mean size at first capture, Lc = 8.5 cm.

Relative Yield per Recruit

Prediction of the yield and future state of *S. diaspros* fishery in the Gulf of Suez was studied by applying the analytical relative yield per recruit (Y`/R) model derived by Beverton and Holt (1957, 1966). The effect of fishing on the stock was examined by changing the Lc value. The Y`/R was

Table 4: Exploitation rates at different sizes at first capture

Item	$L_c = 7.5$	$L_c = 8.5$	$L_c = 9.5$
$E_{0.1}$	0.419	0.457	0.463
$E_{0.5}$	0.295	0.305	0.314
E_{max}	0.510	0.541	0.572

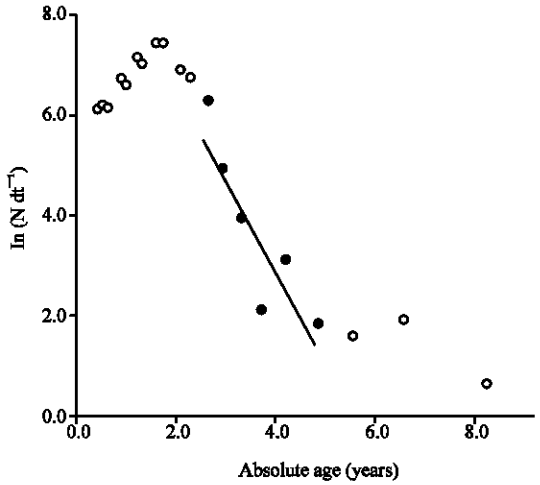

Fig. 5: Length converted catch curve of *S. diaspros* from the Gulf of Suez

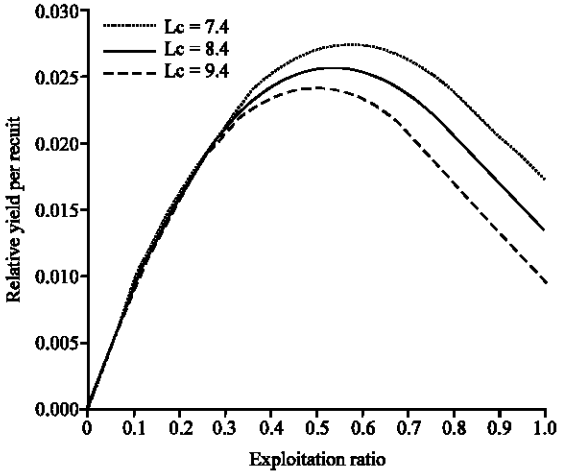

Fig. 6: Relative yield per recruit of the filefish S. diaspros as a function of exploitation rate and length at first capture

computed as a function of different values of exploitation ratio (E) and length at first capture Lc. The results (Fig. 6) indicate that at the present value of length at first capture (Lc = 8.5) and the current natural mortality (M = 0.702), the present value of the exploitation ratio is higher than that associated with the maximum relative yield per recruit (Emax = 0.541) by about 16% (Table 4), indicating that the fishing pressure exerted in the Gulf of Suez has exceeded the critical level.

DISCUSSION

This research is the first to study the demographic parameters of age, growth, mortality and yield per recruit of the file fish *S. diaspros* in the Gulf of Suez. The anterior spine of the first dorsal fin was found to have a distinct pattern of alternating hyaline and opaque bands. Five annuli could be distinguished in the sectioned spines representing age classes from 0 to 4. Many authors have proved that spines are favorable for age determination of filefishes (Manooch and Drennon, 1987; Mancera-Rodriguez and Castro-Hernandez, 2004). The alternating bands of hyaline and opaque zones considered as annuli in this study are analogous to those reported by Mancera-Rodriguez and Castro-Hernandez (2004), although they recorded 4 age classes from 0 to 3 for *S. hispidus* in the Canary Islands.

In general, there was a good agreement between length at age determined through direct observation on sectioned spines and those from the length-based method ($p = 0.985$) which validates the age readings.

Age at length observations showed that the most rapid growth prevails in the first year of life, thus, approximately 50% of growth to asymptotic length (L_∞) is achieved within the first year of lifespan. The asymptotic length estimated from both direct observations and length based methods are very close to the maximum length recorded from the sampled fish (26.5 cm) and it is in accordance with that (27.4 cm) recorded by Mancera-Rodriguez and Castro-Hernandez (2004). The estimated growth parameter K obtained through age reading on the dorsal spine ($K = 0.35$ year^{-1}) is lower than that reported for other monacanthid species. Thus, Peristiwady and Geistdoerfer (1991) recorded a $K = 0.86$ year per for *M. tomentosus* off Indonesia, Kikuchi (1966) suggested a $K = 1.2$ year^{-1} for *R. ercodes* caught off Japan. However, the growth rate of *S. diaspros* is somewhat similar to that given for *Balistes vetula* (Balistidae) off the Virgin Island ($K = 0.30$ year^{-1}) (Manooch and Drennon, 1987) and that given for *S. hispidus* caught from the Canary Islands ($K = 0.40$) (Mancera-Rodriguez and Castro-Hernandez, 2004). The difference in environmental conditions and ecosystem characteristics in the different areas may explain the variation in the estimates.

The estimation of mortality coefficient of a fish stock is an essential step for the calculation of the potential yield, the optimum yield per recruit and the optimum fishing effort. The natural mortality coefficient (M) estimated from Pauly's (1980) empirical equation ($M = 0.824$ year^{-1}) is higher than that calculated from the other two methods. Using the mean natural mortality of the three applied methods and the longevity-based relationship of Alagaraja (1984), a lifespan of 7.1 years was estimated, this value compares well to the estimated maximum age of 8.6 years. Thus the M value of 0.702 appears to be fairly realistic. Data on the mortality of this species is not available from previous studies, so comparisons could not be made.

The assessment of the present state of the filefish resource indicates an overexploitation. The current exploitation rate ($E = 0.627$) is higher than the estimated maximum exploitation level Emax. The estimated length at first capture ($Lc = 8.5$ cm) is close to the length at first sexual maturity 9.0 cm (Sabra and El-Ganainy, in press). This implies that juvenile individuals are the target of the fishery and the stock dynamics of this species would be seriously affected. The high vulnerability of juvenile fish to capture by trawling would result in the reduction of the future yield of this species. Thus, the protection of juveniles is probably the key factor for the sustainability of the resource; through periodic spatial closure of the spawning and nursery areas. This may be achieved through the establishment of certain reserves in the Gulf of Suez to protect the spawning stock biomass and then monitoring their effects as a management strategy. In this context, a map for the spawning and nursery grounds of the filefishes in the Gulf of Suez should be prepared on the basis of sound biological research.

CONCLUSION

The leasarjaket filefish *Stephanolepis diaspros* is the most abundant filefish in the Gulf of Suez. This species was discarded till the 1990s, but currently it has a relatively high occurrence in the trawl landings of the Gulf. Age readings of the sectioned anterior dorsal spine showed five age classes. The assessment of the present state of the filefish resource indicates that the fishing pressure exerted in the Gulf of Suez has exceeded the critical level, the present value of the exploitation ratio is higher than that associated with the maximum relative yield per recruit by about 16% and juvenile individuals are the target of the fishery.

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