Population structure of *Octopus defilippi* (Verany, 1851) from the Gulf of Suez, Red Sea, Egypt.

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ABSTRACT

Octopuses are relatively abundant in the trawl landings of the Gulf of Suez; though they were considered discarded species till 1990's, but currently they have a commercial importance. The population structure and level of exploitation of the *Octopus defilippi* were studied using the length frequency distribution of samples collected from the Gulf of Suez. Some morphometric relationships were estimated where the mantel length, total weight potential equation was found to be $W = 0.7087 L^{2.646}$ for males and $W = 0.9118 L^{2.3629}$ for females. The length distribution pattern showed that females reach larger lengths than males. The population appeared to be structured in two cohorts for males and three for females. Growth of both sexes was fast and could be described well by the von Bertalanffy growth formula. The estimated asymptotic length for combined sexes was $ML_\infty = 9.0$ cm and the growth coefficient was $K = 0.94 \ y^{-1}$. The overall sex ratio of males to females was 1: 0.5. The total and natural mortality rates were high for both sexes, where the estimated values were $Z = 3.341 \ y^{-1}$ and $M = 1.43 \ y^{-1}$. The current exploitation ratio ($E = 0.57$) indicates that the Octopus population in the Gulf of Suez is overexploited.

Key words: population structure**,** *Octopus defilippi ,* Suez Gulf

INTRODUCTION

There is a significant worldwide commercial interest in cephalopods for human consumption, where world catches have increased steadily throughout the last 50 years, with annual landings increased from 0.5 million tons in 1950 to 03.3 million tons in 2001 (FAO, 2003). The Atlantic longarm Octopus *Octopus defilippi* is characterized by extremely long arms; it is a typical inhabitant of littoral waters taken on sandy to muddy bottoms from 6 to 60 m depth. Octopuses are relatively abundant in the trawl landings of the Gulf of Suez; they were considered as discarded species till 1990's (El-Ganainy *et al.* 2005), but currently they have a relatively high occurrence and commercial importance in the trawl landings, representing about 2.74 % of the total trawl catch (GAFRD, 2005). They are represented in the Gulf of Suez by two species namely *O. vulgaris* and *O. defilippi*.

Biological information on Octopuses in the Gulf of Suez is very scarce; only Riad and Gabr (2007) studied some morphometric relationships and natural

mortality of *O. vulgaris*. There are some previous studies on the biology of relative Octopus species in other regions (Mangold, 1983; SaÂnchez and Obarti, 1993; Quetglas, *et al.* 1998; Hernandez-Garcia, *et al.* 2002; Katsanevakis and Verriopoulos 2006; Rueda and Fl´orez, 2007).

This study is the first attempt to investigate the growth, population structure and level of exploitation of *Octopus defilippi* in the Gulf of Suez to help in the proper management and sustainability of this species.

MATERIALS AND METHODS

Samples of *Octopus defilippi* were collected from the commercial trawlers operating in the Gulf of Suez during the fishing season of 2004. Specimens were sorted by sex and measured for dorsal mantel length DML (cm) and weighed for total and gutted weight (g).

The length frequency data were grouped at 0.5 cm intervals. The Bhattacharya (1967) method was applied to the pooled size distributions by sex, in order to identify the different cohorts and split the length distributions into normal components. The parameters of the Von Bertalanffy growth equation L_∞ and k were estimated by applying the method of Wetherall (1986). The resultant growth estimates were then used as seed values in ELEFAN I program (Pauly, 1984) for estimation of the best combination of (L_∞ and k). The reliability of these growth parameters were tested using the Munro's phi prime index (Φ) computed from the equation derived by Pauly & Munro (1984)

The total mortality rate (Z) was estimated for each sex separately and also for combined sexes by Jones and van Zalinge (1981) method. The natural mortality rate (M) was estimated after King (1995) method as:

$$M = -\ln [0.01] / t_{max}$$

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 size that generates optimum yield per recruit (L_{opt}) was estimated by Froese & Binohlan (2000) empirical equation, and then it was compared with the length at first maturity (L_m) and length at first capture (L_c).

RESULTS AND DISCUSSION

Growth

Some morphometric relationships were investigated for each sex separately by fitting regressions to total length on total weight, mantel length on total weight and total length on mantel length (Fig.1) and Table (1). The slopes of the length weight regressions were statistically significant (Ps<0.001), where females of this species reached larger sizes and gained more weights than males. The growth in weight was found to be allometrically negative in all three cases

(*P*>0.5). The negative allometry found in the length-weight relationship agrees with results obtained by other authors for Octopus species in other areas (Guerra and ManrõÂquez, 1980; Smale and Buchan, 1981; SaÂnchez and Obarti, 1993; Quetglas *et al*., 1998 ; Riad and Gabr, 2004).
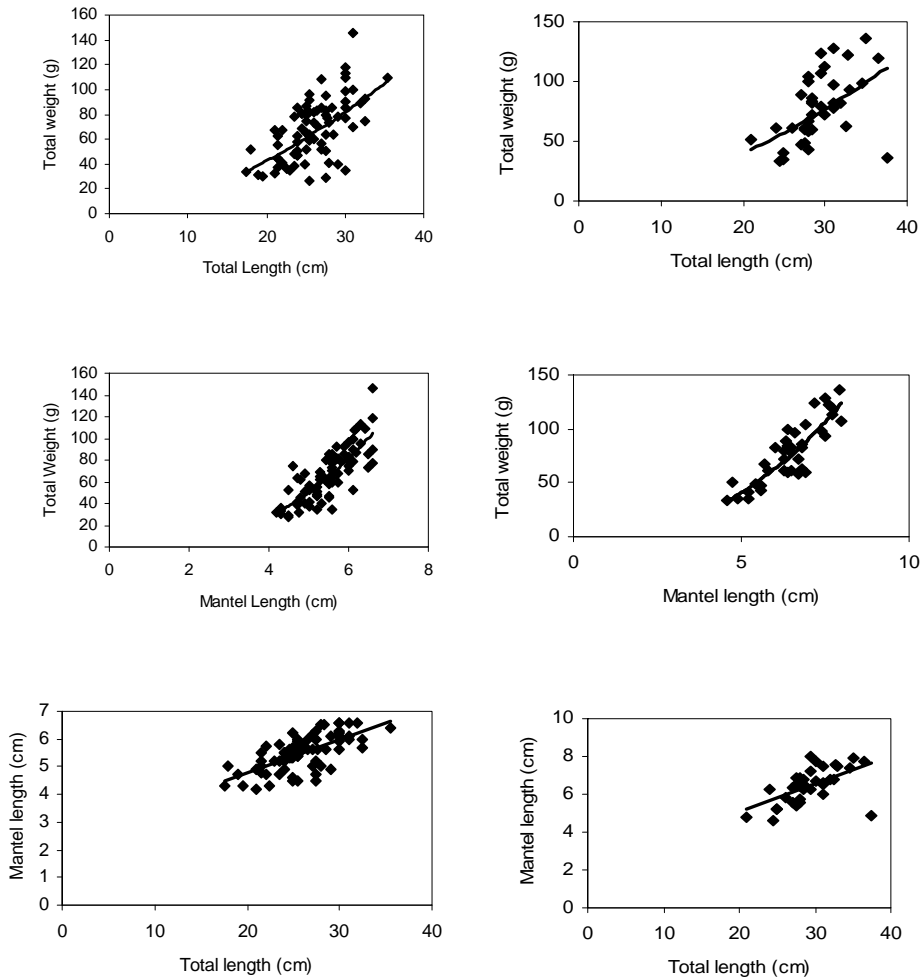

Fig (1) Different morphometric relationships for males and females *Octopus defilippi* collected from the Gulf of Suez

Table (1): Different morphometric relationships of the Octopus *O. defilippi* from the Gulf of Suez (r^2 is the correlation coefficient).

Parameters	Relationship	r^2	Variance of b
Males			
Total length against total weight	$W = 0.3482\ TL^{1.6048}$	0.3428	0.0024
Mantel length against total weight	$W = 0.7087\ ML^{2.646}$	0.6544	0.0025
Total length against Mantel length	$ML = 0.1208 + 2.379\ TL$	0.4618	0.00017
Females			
Total length against total weight	$W = 2.857\ TL^{1.648}$	0.2520	0.0027
Carapace length against total weight	$W = 0.9118\ ML^{2.3629}$	0.7683	0.0030
Total length against Mantellength	$ML = 0.1465 + 2.1738\ TL$	0.9705	0.00017

Size composition

Sampled Octopus ranged in size from 4.2 to 8.0 cm DML with an average of 5.81 ± 0.84 cm, and weighed between 27.0 to 146.0 g with an average of 71.39 ± 25.89g. The lengths of females ranged from 4.6 to 8.0 cm with an average of 6.46 ± 0.89 cm and the weight from 33.0 to 136.0 g with an average of 78.28 ± 28.17 g. The length of males ranged from 4.2 to 6.6 cm DML with an average of 5.51 ± 0.62 cm, and the weight from 27.0 to 146.0 g with an average of 68.09 ± 24.22 g. The monthly length frequency distributions of 0.5 cm class intervals (dorsal mantel length) were pooled and presented in (Fig. 2). The smallest size fully recruited to the fishery was 4.2 cm for males and 4.6 cm for females.
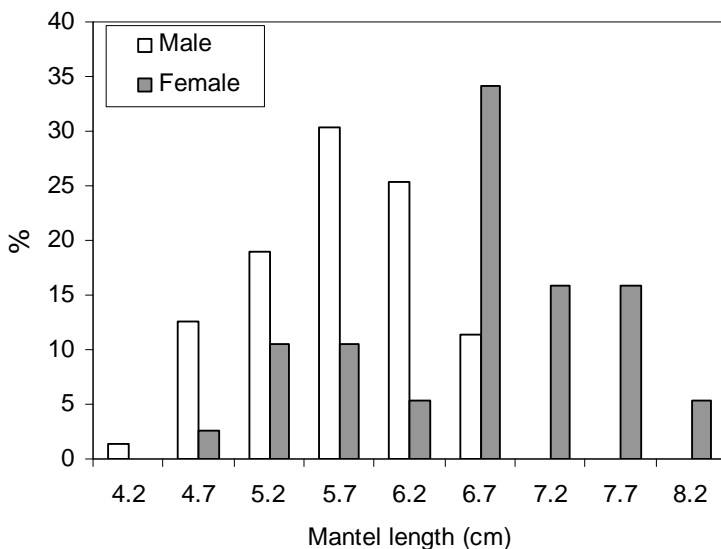

Fig (2) Mantel length frequency distribution of *O. defilippi* in the Gulf of Suez.

Sex ratio

The variation in both the numbered and percentage of males and females in different length groups (Fig. 3) show that females reach larger sizes. The overall sex ratio of males to females was 1: 0.5 and the proportion of females was significantly lower than males (χ^2 48.1; P< 0.001). Fig. 3 shows that males largely outnumbered females up to the length interval 4.2- 6.2 cm, while females dominated the catch in the following length intervals. The same trend of sex ratio was recorded by Quetglas *et al.* (1998); Hernandez-Garcia *et al.* (2002) and Rueda and Fl´orez (2007) for *O. vulgaris* in the Mediterranean Sea.
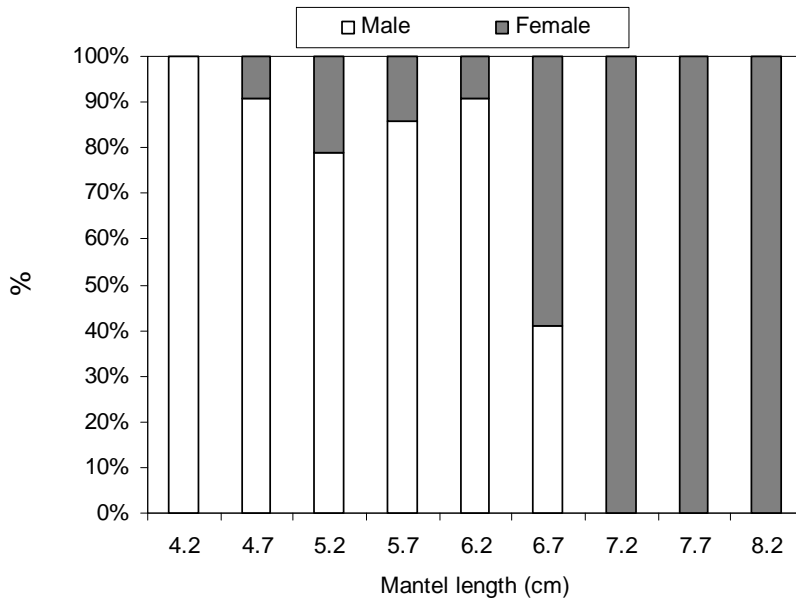

Fig (3) sex ratio by length group of *O. defilippi* from the Gulf of Suez.

Population parameters

The seasonal length distributions by sex were analyzed into normal components using Bhattacharya (1967) method. Two cohorts were identified for males with mean modal lengths of 5.0 and 6.1 cm (Fig 4a). For females three cohorts could be separated with modal lengths of 5.53, 6.88 and 7.45 cm (Fig 4b). The evolution of the population structure examined suggests a life-span of about 2 years and a maximum age of about 3 years for combined sexes. Herna´ndez-Lo´pez *et al.* (2001) estimated a lifespan of 12-13 months for *O. vulgaris* in the Canary Island waters, by counting the number of concentric rings on the upper beaks of 275 Octopuses. Katsanevakis and Verriopoulos (2006) stated that the lifespan of the common Octopus would be between 12 and 15 months. Several hypotheses have been made about longer-lived individuals (Mangold, 1983).
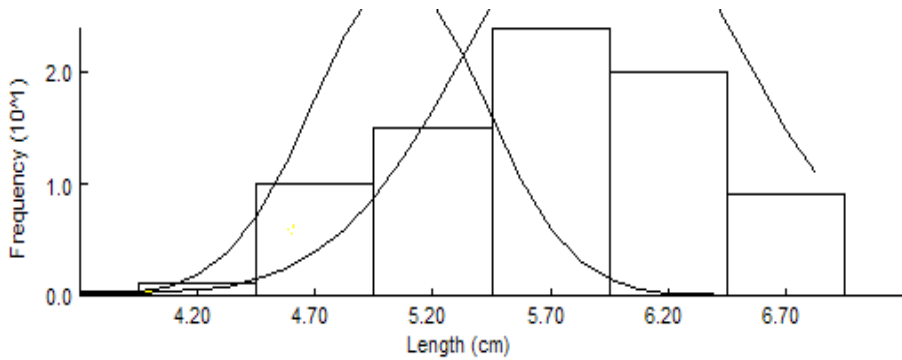
(A)
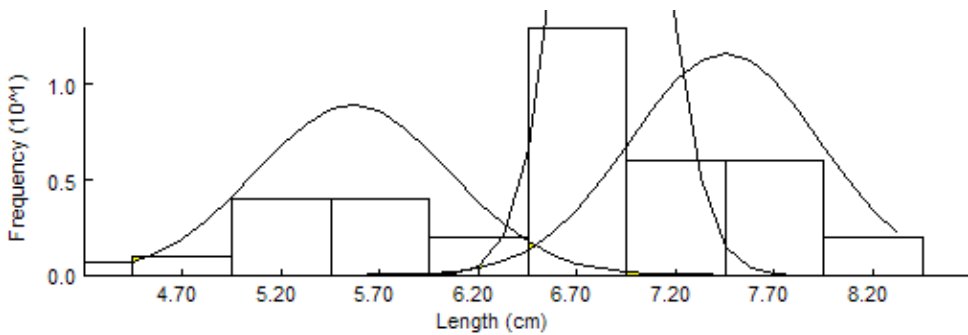
(B)

Fig. (4): Bhattacharya plots for Male (A) and Female (B) *O. defilippi* from the Gulf of Suez.

The estimated von Bertalanffy growth parameters that describe growth in length and weight (L_∞, W_∞ and K) and the derived growth performance index (Φ) are presented in Table (2). These results indicate that males have a relatively higher "K" value than females and they reach their asymptotic length faster than females.

Table (2) Estimated values of the population parameters of *Octopus defilippi* from the Gulf of Suez.

Parameter	Males	Females	Sexes combined
Asymptotic length "L_∞"cm	7.70	9.10	9.00
Growth coefficient "K"	1.10	0.93	0.94
Growth performance index "Φ"	1.81	1.89	1.88
Total mortality rate "Z"	2.78	3.11	3.34
Natural mortality rate "M"	1.69	1.43	1.43
Fishing mortality rate "F"	1.09	1.68	1.91
Length at first maturity "L_m"cm	4.90	5.50	6.00
Optimum length 'L_{opt}"cm	4.70	5.50	5.50
Exploitation rate "E"	0.39	0.54	0.57

The pooled length frequency distribution by sex was used for the estimation of the total mortality rate by applying the method of Jones and van Zalinge (1981) (Fig 5). The results show that the estimated total mortality (Z) for both sexes was nearly similar, while the estimated natural mortality rate (M) was higher for males than females and the fishing mortality (F) was accordingly higher for males (Table 2).
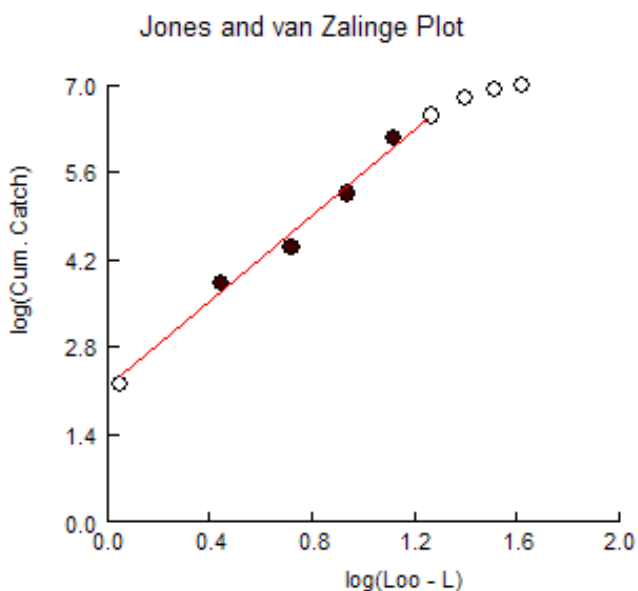

Fig (5) Jones and van Zalinge plot for the estimation of total mortality rate of *O. defilippi* from the Gulf of Suez.

The estimated values of the exploitation rate were E = 0.39 for males, 0.54 for females and 0.57 for combined sexes. According to Gulland (1971), the present estimated values of exploitation rate of *O. defilippi* indicated an overexploitation of this species in the Gulf of Suez.

Optimum length

The optimum length (L_{opt}) for a given stock is defined as the intermediate length class, where the product of individuals times their average weight reached a maximum. L_{opt} and its 95% confidence intervals were estimated from the asymptotic length (L_∞) using the empirical relationship of Froese and Binohlan (2000). The fishery would reach the maximum possible yield if it were to catch only fish of the optimum size (Beverton, 1992). The derived estimate of this optimum length for *O. defilippi* was 4.7 cm for males and 5.5 cm for females and 5.5 cm for combined sexes. It has been used with the length at first maturity (Lm = 6.0 cm for combined sexes as derived from the empirical equation of Froese and Binohlan (2000) to evaluate the length frequency diagram (Fig. 6) for signs of growth overfishing, The figure indicates growth and recruitment overfishing, where the smallest fully recruited size to the fishery was 4.2 cm for males and 4.6 cm for both females and combined sexes, and the mean size of the catch calculated from the smallest fully recruited size was smaller than the estimated optimum size. It can be seen that the length at first capture (Lc = 4.2 cm) is smaller than the length at first maturity and the optimum length, the length at first capture for this population should be increased to obtain the maximum possible yield and to maintain the sustainability of the species.
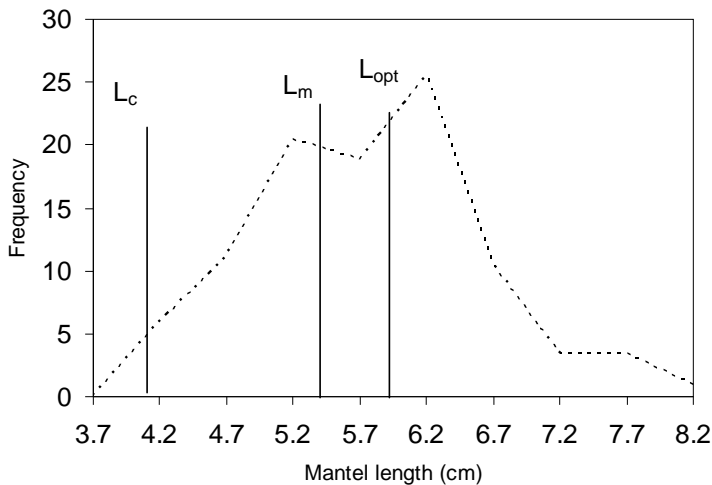

Fig (6) Length frequency diagram showing the optimum length, lengthat first maturity and length at first capture of *O. defilippi* from the Gulf of Suez.

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