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Growth, mortality and relative yield per recruit of the sharptooth catfish *Clarias gariepinus* (Clariidae) in Lake Manzalah, Egypt

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ABSTRACT

Clariid catfishes are of great economic importance as protein food in adequate prices. For several years, species of the genus *Clarias* (Scopoli, 1777) have been used in local fish culture, where they proved to be a fast growing protein source. Age, growth, mortality and relative yield per recruit of *Clarias gariepinus* in Lake Manzalah, Egypt, were investigated. The maximum life span based on otoliths' readings was 8 years, while the von Bertalanffy growth parameters were $L\infty$= 86.88cm, K= 0.31/year and t_0= -0.39 year. The mean annual instantaneous total, natural and fishing mortality coefficients were 0.98, 0.37 and 0.61/year, respectively. Accordingly, the exploitation ratio was 0.62, which was higher than the optimum one. Relative yield per recruit analysis revealed that *C. gariepinus* is over exploited in Lake Manzalah where the $E_{0.5}$ was lower than the current one ($E_{0.5}$ = 0.35). Some recommended management actions should be applied to strengthen the ban of fishing in the spawning season or in the nursery ground and to adopt a legal minimum size to protect the young and small-sized fish. In addition, to make any regulation more effective, all stakeholders (fishermen, scientists, non-governmental organizations and policy makers) should work together to establish a co-management plan to conserve this valuable stock.

INTRODUCTION

Fisheries contribute to food security and nutrition and play a vital role in global, national and rural economies. Fisheries in Egypt classified into two sectors; natural and artificial resources. Recently, the natural resources are seriously declined due to many reasons from which the over fishing, illegal fishing practices and pollution. El Manzalah Lake is considered one of the most important sources of inland fishery in Egypt and it is the largest lake of the four brackish coastal lakes fringing the Nile Delta (Fig. 1). Lake Manzalah is separated from the Mediterranean Sea by a strip of sand and connected to the Mediterranean in the north and to the Suez Canal in the east. The lake served as a significant source of inexpensive fish for human consumption in Egypt with a mean annual production of 60,000 ton. It represents 32% of the lakes' fish production in Egypt and 44% of the Northern lakes. Many challenges are facing the lake productivity from which the pollution and water quality are the most important.

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The lake receives annually about 4000 million cubic meters of untreated industrial, domestic and agricultural drainage water, through several drains; Bahr El-Bakar Drains (sewage and industrial), Hadous, Ramsis, El-Serw and Faraskour Drains (agricultural effluents) (Ali, 2008). Also, the decreasing of the lake's area from about 720,000 feddan to less than 80,000 Feddan today is another big challenge affected the productivity of the lake.

The lake produces a number of fish and crustacean species from which the clariid species come in the second degree after tilapia species. Clariid species production fluctuated between 5445 ton in 2007 and 16513 ton in 2012 forming 21% of the total production of the lake (GAFRD annual statistical book, 2007-2016). Clariid Catfishes are air breathing fishes naturally occurring in freshwater bodies in Africa, South East Asia where they constitute significant component of catches. The Clariid catfishes are of great importance as food and vital in the sustainability of the aquaculture (Venden Bossche and Bernacsek, 1990). African sharptooth catfish *Clarias gariepinus* is one of the most readily acceptable species in Egypt because they grow to large sizes and has a good taste with reasonable prices. The African sharptooth catfish was introduced all over the world in the early 1980s for aquaculture purposes, so is found in countries far outside its natural habitat, such as Brazil, Vietnam, Indonesia, and India. Many studies were undertaken on this species in the artificial ponds but in the wild it is rarely studied in Egypt. The present study will provide the basic parameters acquired for assessing its abundance and its current status in Manzalah lake as well as will propose some reference points for its sustainability.

MATERIALS AND METHODS

Collection of Samples

A total of 1241 of *Clarias gariepinus* were monthly collected from the commercial catch at different sites along the lake Manzalah (Al Kabouty, El-Gammalyia and El-Mataryia) during two seasons from 2015 to 2017. In the laboratory, date and place of capture, total length to the nearest cm, total weight to the nearest 0.1g, and sex were taken for each specimen. Otoliths were removed, cleaned and kept in special envelopes with full information for subsequent examination relevant to age determination.

Length-weight relationship

Length L-weight W relationship was determined according to the power equation $W = aL^b$ where a & b are constants whose values are estimated by the least square method.

Population parameters

The von Bertalanffy growth model was applied to describe the theoretical growth of *C. gariepinus.* The constants of the von Bertalanffy model ($L\infty$ and K) were estimated by using Ford (1933) - Walford (1946) plot. While t_0 was calculated according to experimental formula of Pauly (Froese and Binohlan, 2000) as $Log(-t_0) = -0.3922 - 0.2752\ Log(L_\infty) - 1.038\ Log(K)$. The growth performance index Φ' which is used to compare growth indices in the studied area was computed as $\Phi' = Log(K) + 2Log(L_\infty)$ (Pauly and Munro, 1984).

The total mortality coefficient (Z) was estimated as the geometric mean of two different methods; linearized catch curve method of Pauly (1983), Hoenig formula (1982) and Ricker plot (1975). While the natural mortality coefficient (M) was calculated as the geometric mean of three different methods; Taylor (1960), Ursin

(1967) and Pauly (1980). Accordingly, the fishing mortality coefficient (F) was estimated by subtracting the value of natural mortality (M) coefficient from the value of total mortality coefficient (Z) as F = Z-M. The exploitation ratio (E) was estimated using the formula E = F / Z (Gulland, 1971).

Critical lengths and ages

The length at first capture L_c was estimated by the analysis of catch curve using the method of Pauly (1984) and the corresponding age at first capture T_c was obtained by converting L_c to age using the von Bertalanffy growth equation as $T_c = -1/K \ln (1- L_c/L_\infty) + t_0$. While the length at first sexual maturity L_m was estimated using the empirical formula $\text{Log } L_m = 0.8979 \text{ Log } L_\infty - 0.0782$ (Froese and Binohlan, 2000) and the corresponding age at first sexual maturity (T_m) was computed by converting L_m to age as $T_m = -1/k \ln (1- L_m/L_\infty) + t_0$

Relative yield per Recruit (Y'/R)

The model of Beverton and Holt (1966) was applied to analyze the relative yield per recruit (Y'/R) of *C. gariepinus* as follows:

$(Y'/R) = E\, U\, (M/K)\, [1- 3U/(1+m) + 3U^2/(1+2m) - U^3/(1+3m)]$

Where: M = 1- E /(M/K) = K/Z and U =1– (L_c/L_∞).

Resource status

Resource status was evaluated by comparing estimates of the fishing mortality rate with target (F_{opt}) and limit (F_{limit}) biological reference points (BRP) which were defined as: $F_{opt} = 0.5M$ and $F_{limit} = 2/3M$ (Patterson 1992).

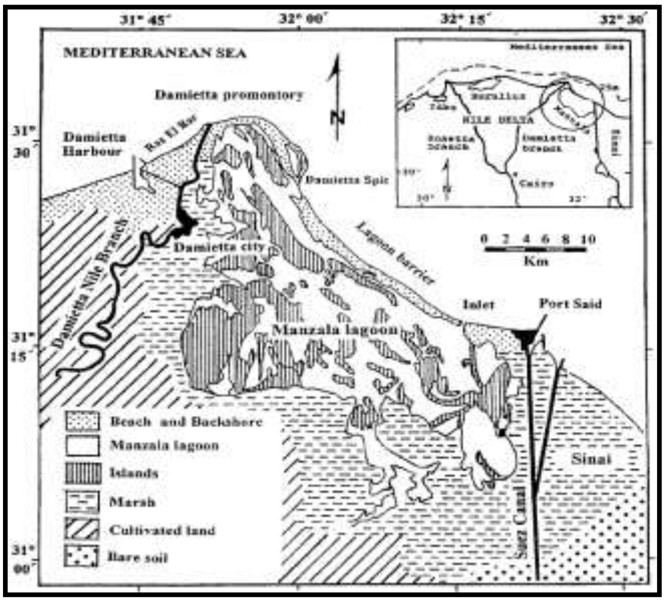

Fig. 1: Lake Manzalah

RESULTS AND DISCUSSION

Length frequency distribution

A total number of 1241*C. gariepinus* were sampled (540 male and 701female) during two years survey along the Manzalah lake. Mean length in males was 41.19 (20.5-79.9) cm, whereas in females it was 40.19 (18.3-80) cm. Mean weight in males was 790.9 (55-4125) g, whereas it was 712.4 (40-4225) g in the females. The population structure of *C. gariepinus* in Manzalah lake indicates that over 75% of the catch was between 28 and 48 cm of length (Fig. 2). For a fish that grows up to

170 cm under ideal conditions (Idodo-Umeh 2003), this is an indication of over exploitation.

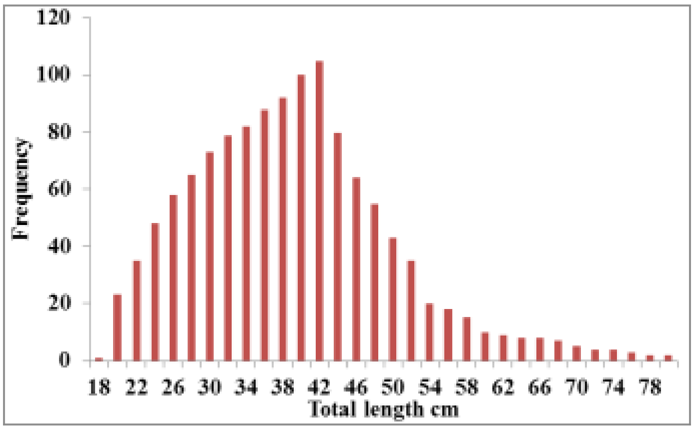

Fig. 2: Length frequency distribution of *Clarias gariepinus* from Lake Manzalah

Length- weight relationship

The non-linear regression analysis of length-weight relationship (R^2 = 0.99 for males and 0.98 for females) showed that the relationship between length (L) and weight (W) was $W= 0.0037L^{3.1802}$ for males and $W= 0.0045L^{3.133}$ for females (Fig. 3). The b value was significantly greater than 3 ($p<0.001$), which indicates positive allometric growth of *C. gariepinus* in Manzalah lake. The b value could be an indicator of the physiological condition of the fish and vary seasonally in response to seasonal variations in environmental condition and changes in the fish wellbeing (Biswas 1993). The length-weight relationship and the b value can also be influenced by fishing pressure that excessively catch the adults.

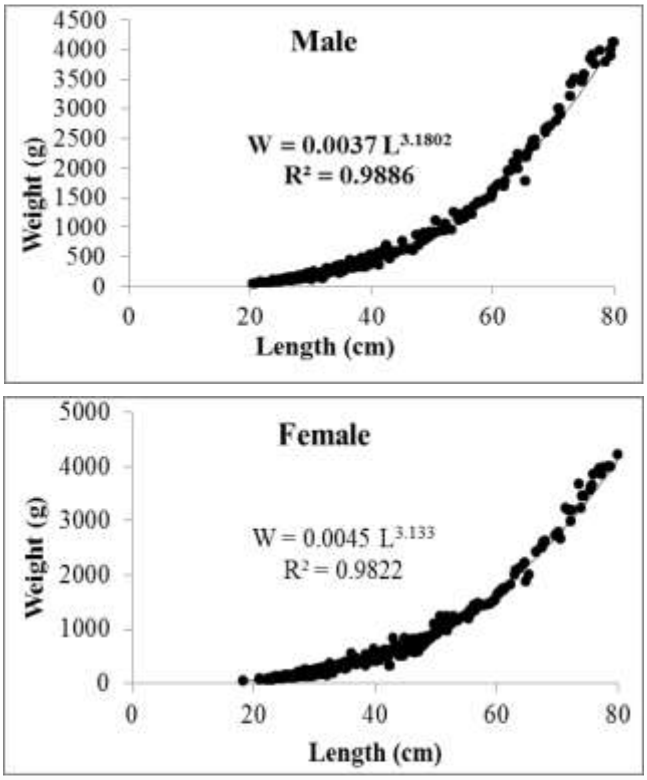

Fig. 3: Length-weight relationship of *Clarias gariepinus* from Lake Manzalah

Age composition

Sagittal otoliths were used for age determination of *C. gariepinus* from Manzalah lake and the maximum life span of this species not differ between sexes and reaches 8 years old. It is found that the age groups one and two were the most dominant age groups forming 64% of the total samples (27% for age group one and 37% for age group two). The dominance of young fishes in the catch is an additional indication for over exploitation.

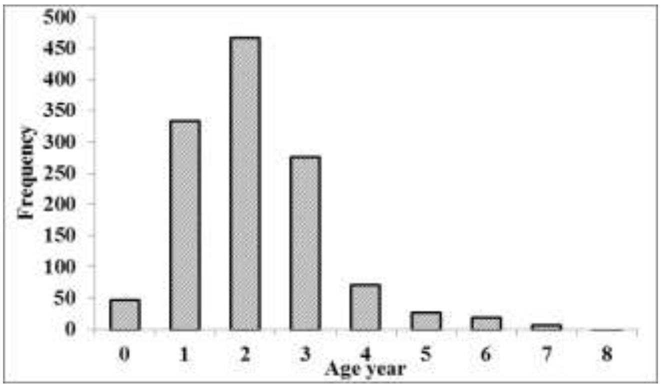

Fig. 4: Age composition of *Clarias gariepinus* from Lake Manzalah

Population parameters

The estimated growth parameters are $L\infty$= 86.88 cm, K= 0.31/year, t_0= -0.39 year and Φ' =3.37. The Φ' tends to show little variation between stocks of the same species and serves as an indicator of the reliability or otherwise of the estimated growth parameters. The estimated instantaneous rate of mortality and exploitation rate for *C. gariepinus* was very high. Using the Powell-Wetheral plot, a Z/K ratio≈2 indicates over exploitation (Etim *et al.*, 1999), in this study, the Z/K ratio was 3.14 which attest to the gross over exploitation of the species.

The mortality rates were estimated as Z= 0.98, M= 0.37 and F= 0.61 per year. The estimated exploitation rate was 0.62, which is higher than the optimum exploitation rate (E_{opt}) of 0.5 according to Gulland (1971) and of 0.4 according to Pauly (1987) which further evidence to the fact that *C. gariepinus* is under sever fishing pressure in the lake Manzalah.

Critical lengths and ages

Estimation of length at maturation, length at first capture and spawning time is important for determination of fishing prohibition time and optimum length for catch. The length at first capture L_c (the length at which 50% of the fish at that size are vulnerable to capture) was estimated from the catch curve of Pauly (1984). The resultant curve gave an estimate of L_c at 38.9 cm TL which is corresponding to an age of 1.6 year. On the other hand the length at first sexual maturity (L_m) of *C. gariepinus* was estimated at 46 cm TL and consequently the age at first maturity was 2.12 year. It is obvious that the estimated L_c was smaller than L_m. This means that the exploited *C. gariepinus* must be protected in order to share the spawning activities at least once before being fished.

Relative yield per recruit

The Beverton and Holt relative yield per recruit estimated using the knife-edge method (Fig. 5), gave the optimum exploitation rates as; E_{max} = 0.62, $E_{0.1}$ = 0.51 and $E_{0.5}$ = 0.35. The current E is nearly equal the E_{max} but much higher than $E_{0.5}$ which conserve 50% of the spawning stock biomass. The yield isopleth diagram is shown in Fig. 6. The yield contours predict the response of relative yield-per-recruit of the fish to changes in Lc (length at first capture) and E (exploitation rate). Comparing the yield isopleth diagram in this study with that of Pauly & Soriano (1986), the Lc/L∞ of 0.45 and exploitation rate of 0.62 falls within quadrant D which implies that the smaller fish are caught at higher effort level.

Stock status

Resource status was evaluated by comparing estimates of the fishing mortality rate with target (F_{opt}) and limit (F_{limit}) biological reference points (BRP) which were defined as: F_{opt} = 0.5M so that E =0.5 (King, 2007) and F_{limit} = 2/3M. The present F was much higher than F_{opt} and F_{limit} revealing that the sharptooth catfish in lake Manzalah is overexploited. The reason for the over exploitation of *C. gariepinus* is due to the fact that as the different fish stocks in the lake are declined, the fishers tend to reduce the mesh size of nets as well as double their efforts to catch more.

In conclusion, there is an urgent need to protect the fish stocks in lake Manzalah through the concerted effort of all stakeholders; fishers, local communities, researchers and government. The present study suggested some management regulations, including reduction of fishing pressure especially on spawners and juveniles, increasing the length at first capture, defining and protecting specific critical areas such as nursery and spawning grounds. As well as monitoring and improving the water quality of the lake.

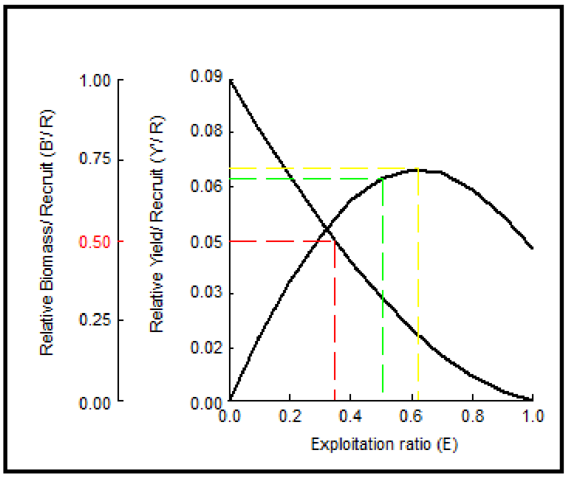

Fig. 5: Yield per recruit analysis of *Clarias gariepinus* from Lake Manzalah

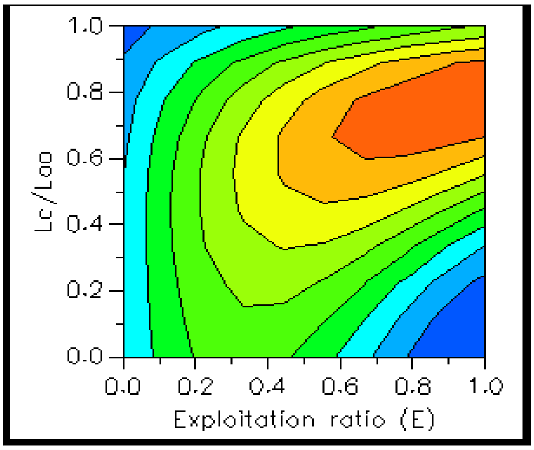

Fig. 6: Isopleth diagram of *Clarias gariepinus* from Lake Manzalah

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