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Fisheries Management of *Oreochromis niloticus* and *Oreochromis aureus* Caught by Trammel Nets and Basket Traps in Lake Manzalah, Egypt

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Abstract: Cichlid fish species dominating Lake Manzalah (namely *Oreochromis niloticus* and *Oreochromis aureus*) were collected by trammel nets and basket traps. Analysis of the length-frequency using (FiSAT) computer program, estimated the Von Bertalanffy's growth parameters as: L_{∞} = 22.67 cm (asymptotic length); k = 1.1year^{-1} for *O. niloticus*; L_{∞} = 22.66 cm; k = 1.1 year^{-1} for *O. aureus* caught by trammel nets where it was found that L_{∞} = 18.52 cm (asymptotic length); k = 1.1 year^{-1} for *O. niloticus* and L_{∞} = 18.24 cm; k = 0.94 year^{-1} for *O. aureus* caught by basket traps. The estimated fishing mortalities of *O. niloticus* were nearly the same (2.54 and 3.05) in cases of trammel nets and basket traps, whereas that of *O. aureus* was 3.09 for fish caught by basket traps and 3.15 for that caught by trammel nets. The estimated exploitation rates "E" were 0.59, 0.64 for the two species caught by trammel nets and 0.62, 0.64 in respective for the two species caught by basket traps. To obtain the optimum level of exploitation rate, the fishing pressure exerted by these two fishing methods should be reduced to reach the optimum exploitation (0.5) level and the mesh size should be raised specially of the basket traps used. In addition, the usage of larger meshes will affectively reduce the risk of a stock collapse by a long-term increase of the spawning stock size.

Key words: Tilapia % Fisheries % Fishing gears % Lake manzalah % Egypt

INTRODUCTION

Lake Manzalah is considered as one of the most important sources of inland fishery in Egypt where it is estimated to yield about 38.02% of the northern Nile Delta lakes and is considered as the second major source of fish after Lake Burollus [1]. Importance of the lake fishery returns to to two main targets; as a source of animal protein for human consumption and as a source of employment.

Freshwater fish represent an essential and often irreplaceable source of high quality and cheap, animal protein. Four Cichlid species were identified in Lake Manzalah namely; *Oreochromis niloticus*, *Oreochromis aureus*, *Sarotherodon galilaeus* and *Tilapia zillii*. The two former species were found to be more abundant than the other two species in most areas of the lake [2].

Various aspects of the biology of Cichlid species have been studied in Egypt [3 - 9]. There is a considerable exploitation pressure on the different species of tilapia specially *O. niloticus* & *O. aureus*, which dominated the catch taken by the different gears used in the lake. The need for developing the inland fisheries must be taken into consideration. Information on fishing mortality and exploitation rates exerted by the different fishing methods are essentially required for sustainable management of the lake fishery.

MATERIALS AND METHODS

The trammel net (locally known as El-Daba) and basket traps (locally known as Gawabi) are of the main fishing methods used in lake Manzalah.

Trammel net consists of three layered walls of webbing and are hanged between corked rope and lead line. The two outer walls are made of nylon twines (Td 210/3 or 110/3). The inner wall with smaller mesh sized and slacked net made of nylon twines. The mesh size of both the inner and outer walls depends on the species and the size of the fish to be caught [3]. The average mesh size of the outer layer of the trammel net used in the present study was 6.6 cm (±0.430 cm), while that of the inner layer was of 2.8 cm (± 0.756 cm). Basket trap used in Lake Manzalah is fixed by three iron galvanized iron hoops and stretched by two bambo sticks in a perpendicular plane to the hoops. The trap is supplied

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with two cone-shaped entrance mouths which are kept opened by stretching them to the middle hoop by nylon filaments.

The length frequency data of the two cichlid species were seasonally collected from the catch of both trammel nets and basket traps (of different mesh sizes and from different localities) operated on commercial scale in Lake Manzalah during 2006-2007. After sorting the fish sample to the different species, The total length of individual fish was measured to the nearest 0.5 cm and the samples were grouped into 1.0 cm class intervals to estimate the length frequency distributions which were analyzed using the appropriate routines and subroutines of the "FiSAT" computer program [10]. An estimate of the asymptotic length (L_4) and the growth coefficient (K) were obtained by the method of Wetherall [11]. The parameters were then used as seed values in ELEFAN I routine [12, 13] for estimating the best combination of L_4 and K.

The instantaneous rate of total mortality (Z) was derived from the length converted catch curve method described by Pauly [14]. The instantaneous rate of natural mortality (M) was computed from the empirical equation of Pauly [12] considering the mean annual temperature of the lake as 20.75°C [15]. The instantaneous rate of fishing mortality (F) was extracted as F= Z-M. The exploitation rate was calculated as E = F/Z. The length at first capture "L_c" was determined from the catch curve according to Pauly [13, 14].

The relative yield per recruit $(Y/R)'$ and relative biomass per recruit $(B/R)'$ were estimated by using the model of Beverton and Holt modified by Pauly and Soriano [16] and incorporated in the FISAT software package as follows; $(Y/R)' = E\ U^{M/K}\ [1 - (3U/1+m) + (3U^2/1+2m) - (U^3/1+3m)]$ $(B/R)' = (Y/R)' / F$.

RESULTS

The annual fish catch from Lake Manzalah during the period 2000-2006 fluctuated between a maximum catch of 74132 tons in year 2000 and a minimum catch of 39857 tons in 2005 [1]. Tilapia catch fluctuated from 39573 tons in 2000 and 17364 tons in 2005, with an average of 27984.9 tons (Table, 1).

Tilapia formed the majority of fish catch from the lake (53.38, 50.83 %) in years 2000 and 2001, respectively. Recently, it showed signs of a decline in the landed catch in the last few years as it contributed only by 42.59 % in 2006. It was followed by the Catfish *Clarias gariepinus* (23.3 %).

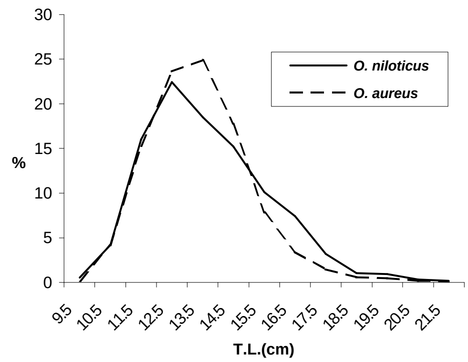

Fig. 1: Annual Length frequency of O. niloticus & O. aureus caught by different trammel nets at Lake Manzalah

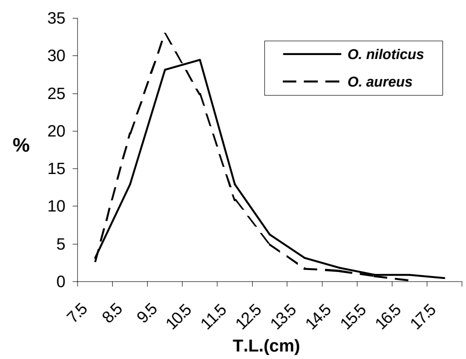

Fig. 2: Annual Length frequency of O. niloticus & O. aureus caught by different basket traps at Lake Manzalah

Table 1: Total catch and Tilapia production from Lake Manzalah during 2000 - 2006

Year	Total Catch (ton)	Tilapia Catch (ton)
2000	74132	39573
2001	68400	34767
2002	58400	29703
2003	65015	30054
2004	63772	26886
2005	39857	17364
2006	41193	17547

A total number of 4131 fish were collected from the trammel nets catch *O. niloticus* represented the majority by 52.3 % of that number. Their total lengths varied between 9.5 cm and 21.5 cm with a modal length of 12.5 cm. The other percentage was represented by *O. aureus* where its modal length shifted to correspond 13.5 cm (Figure 1). 2778 fish were collected from the catch of basket traps. It was found that *O. aureus* represented the majority by more than 75 % of numerical abundance with a modal length of 9.5 cm, while *O. niloticus* was represented by about 24% with a modal length of 10.5 cm (Figure 2). Very little proportions of other species were ignored.

Table 2: Mortality and exploitation rates of *O. niloticus* and *O. aureus* caught by two different fishing gears in Lake Manzalah

Fishing Method	Species	L_4	K	Z	M	F	E
Trammel	*O. niloticus*	22.67	1.1	4.33	1.79	2.54	0.59
	O. aureus	22.66	1.1	4.94	1.79	3.15	0.64
Basket traps	*O. niloticus*	18.52	1.1	4.94	1.89	3.05	0.62
	O. aureus	18.24	0.94	4.80	1.72	3.09	0.64

Table 3: Probability of capture of two tilapia species caught by two different fishing methods in Lake manzalah

Method	Trammel nets		Basket traps	
Species	*O.niloticus*	*O. aureus*	*O.niloticus*	*O. aureus*
L_{25} (cm)	10.70	10.80	8.04	7.85
L_{50} (cm)	11.45	11.66	8.89	8.60
L_{75} (cm)	12.27	12.47	9.73	9.38

Table 4: Relative exploitation parameters corresponding to yield per recruit (Y/R)' and relative biomass per recruit (B/R)' for *O. niloticus* and *O. aureus* caught by two different nets

Method	Trammel nets		Basket traps	
Species	*O.niloticus*	*O. aureus*	*O.niloticus*	*O. aureus*
E_{10}	0.66	0.657	0.621	0.621
E_{50}	0.37	0.367	0.357	0.355
E_{max}	0.75	0.755	0.719	0.723

An estimate of the total mortality coefficients (Z) for *O. niloticus* were found to be 4.33yG^{1} and 4.94yG^{1} for fish caught by trammel and basket traps respectively. Meanwhile, the natural mortalities of *O. niloticus* (M) were found as 1.79 yG^{1} and 1.89yG^{1} in relation to the two fishing methods.

The fishing mortalities (F) were computed as 2.54yG^{1} and 3.05yG^{1} for *O. niloticus* caught by trammel and basket traps respectively (Table 2).

The total mortality coefficients (Z) of *O. aureus* were estimated as 4.94yG^{1} and 4.80 yG^{1} for trammel and basket traps respectively. While the natural mortality rates (M) of *O. aureus* were computed as 1.79yG^{1} and 1.72yG^{1} for fish caught by trammel and basket traps respectively. Thus; their respective fishing mortality rates were calculated as 3.15yG^{1} and 3.09yG^{1} corresponding to the two fishing methods (Table 2).

The exploitation rates (E) were found to be nearly the same value (0.59&0.62) in case of *O. niloticus* caught by the two fishing methods. While those of *O. aureus* were of the same value 0.64 for trammel and basket traps (Table 2). Although the trammel nets are known to be selective to a definite fish size according to the mesh size used and the mode of net construction leading to the effect of entanglment, however this obstacle was overcomed by using different mesh sizes and from the commercial nets used by the fishermen to cover a wider range of the population size strucure and estimation of the different parameters is restricted to the the points which are almost on a straight line on the catch curve.

The length at first capture is strongly correlated with the mesh size of the net used. L_c at which 50% of the fish that become vulnerable to capture was estimated to be 11.45 cm and 11.66 cm for *O. niloticus* and *O. aureus*, respectively caught by trammel nets, while it was 8.89 cm and 8.60 cm, for the same species respectively caught by basket traps (Table 3).

The selection range fluctuated between 10.7 cm and 12.27 cm total length for *O. niloticus* caught by trammel nets, while it ranged between 10.8 cm and 12.47 cm for *O. aureus* caught by the same net. It was found to range between 8.04 and 9.73 cm for *O. niloticus*, while it recorded 7.85 and 9.38 cm for *O. aureus* caught by basket traps (Table 3).

As shown at Table 4, the relative yield per recruit and relative biomass per recruit of *Oreochromis niloticus* and *O. aureus* were estimated. It was found that the maximum exploitation rates of *O. niloticus* were 0.61 and 0.72 caught by trammel and basket traps respectively, while their values at 50% unexploited biomass were 0.34 and 0.36 respectively. The maximum rate of exploitation of *O. aureus* was 0.63 and shifted to 0.72 for both nets, respectively.

The value of exploitation ($E_{0.1}$) where its slope corresponds to 1/10th of the value at the origin of the yield per recruit curve was nearly equal to (0.66) for *O. niloticus* & *O.aureus* caught by trammel nets and were also of the same value (0.62) for those caught by basket traps.

DISCUSSION

As shown from Figure 3, both the total catch and tilapia catch showed a decreasing trend (r = ‑ 0.8739). This decrease may be due to many factors as reduction in lake's area, a progressive increase of eutrophication and pollution of lake water [17] as well as using illegal fishing gears in the lake [2]. A variety of factors are implicated including sea communication problems, reduction of the fresh water supply, over- fishing with a continuing increase of fishing effort units, contributes to fisheries decline [18].

It was found that *Oreochromis niloticus* and *Oreochromis aureus* dominated the catch of the seine net (El-Tara), seine/hand catching combination (El-Laffa),

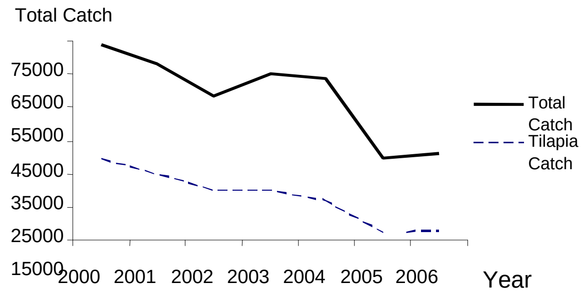

Fig. 3: Annual Total Catch and Tilapia Fish in Lake Manzalah, after GAFRD (2000-20006)

hand catching (Gatis), frame net (El-Gerba), trammel net (El-Daba) according to El-Bokhty [2]. Therefore, it can be concluded that *O. niloticus* and *O. aureus* dominated the lake tilapia catch.

The total mortality coefficients (Z) for *O. niloticus* calculated as shown in (Figure 4 a&b) caught by trammel nets and basket traps were higher than those estimated by El-Bokhty [19] as 3.38yG^{1} for fish caught by seine net from Lake Manzalah indicating that the species is subjected to high mortality levels.

The natural mortalities of *O. niloticus* (M) were computed as 2.52 yG^{1} and 1.89 yG^{1} for fish taken by the two fishing methods which were higher than that recorded by El-Bokhty [19] as 1.04 yG^{1}. The fishing mortalities (F) were computed as 2.54yG^{1} and 3.05yG^{1} for *O. niloticus* caught by trammel and basket traps respectively, whereas it was 2.34 yG^{1} for the same species caught by seine net, locally named El-Tara [19]. This difference may be due to the difference in efforts exerted by different fishing gears as well as the difference of mesh sizes of these nets.

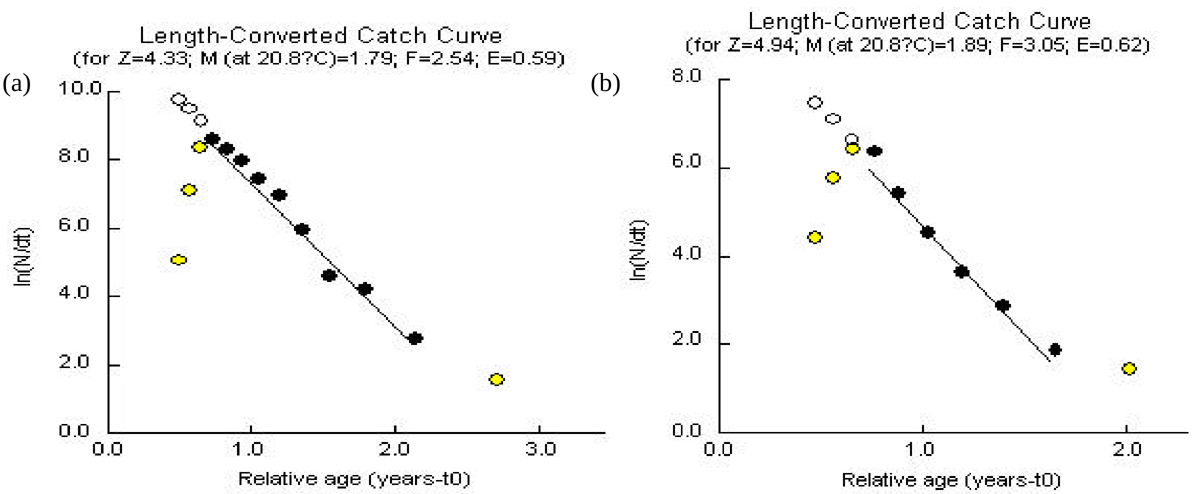

Fig. 4a,b: a: Length converted catch curve of *O. niloticus* caught by trammel nets, Lake Manzalah
b: Length converted catch curve of *O. niloticus* caught by basket traps, Lake Manzalah

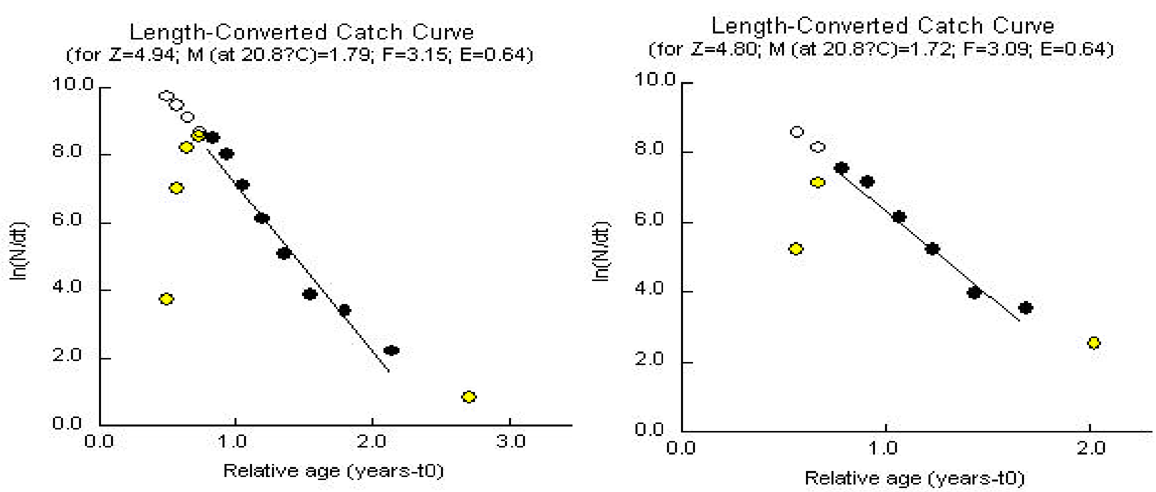

Fig. 5a,b: a:Length converted catch curves of *O. aureus* caught by trammel nets, Lake Manzalah
b: Length converted catch curve of *O. aureus* caught by basket traps, Lake Manzalah

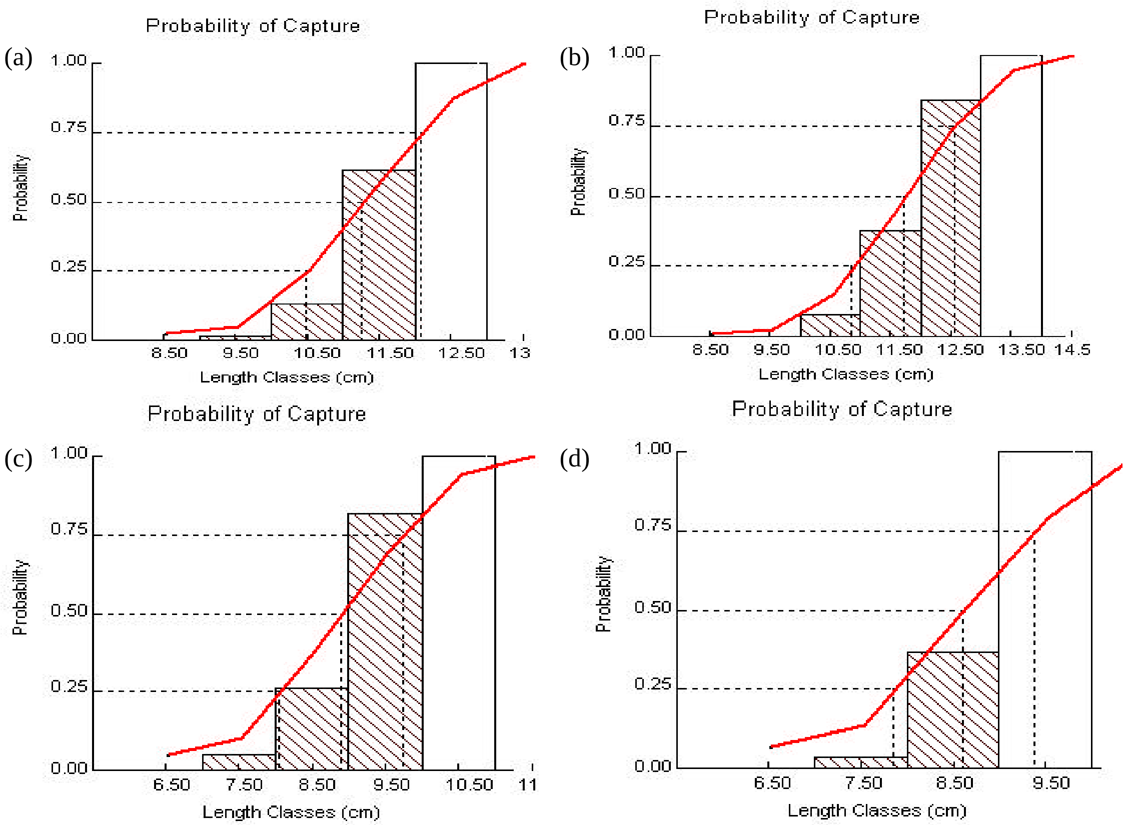

Fig. 6a-d: a: Probability of length at first capture for *O. niloticus* caught by trammel nets, Lake Manzalah
b: Probability of length at first capture for *O. aureus* caught by trammel nets, Lake Manzalah
c: Probability of length at first capture for *O. niloticus* caught by basket traps, Lake Manzalah
d: Probability of length at first capture for *O. aureus* caught by basket traps, Lake Manzalah

The total mortality coefficients (Z) of *O. aureus* were estimated as 4.94yG^{1} and 4.8 y G^{1} for trammel and basket traps, respectively. These values were found higher than that recorded by El-Bokhty [19] (2.94yG^{1}). While the natural mortalities (M) *O. aureus* were computed as 1.79yG^{1} and 1.72yG^{1} for trammel and basket traps, respectively. Therefore; their respective fishing mortality rates were calculated as 3.15yG^{1} and 3.09yG^{1} corresponding to the two fishing methods. It was recorded by El-Bokhty, [19] that the fishing mortality of *O. aureus* was 1.73yG^{1} caught by seine net. These findings indicate that *O. aureus* is subjected to the highest fishing mortality rates (Figure 5 a&b). Also, it was shown that the the fishing effort and and mesh size greatly affect the fishing mortality [20].

The exploitation rates (E) were found to be nearly the same value (0.60) in case of *O. niloticus* caught by the two fishing methods. Those of *O. aureus* attained the same value (0.64). for both nets. Although the trammel nets are known to be selective to a definite fish size according to the mesh size used and the mode of net construction affecting entanglment, however this obstacle was overcomed by using different mesh sizes and from the commercial nets used by the fishermen to cover a wider range of the population size strucure and estimation of the different parameters is restricted to the the points which are almost on a straight line on the catch curve. According to Gulland [21] the fishing mortality should equal to the natural mortality resulting in a fixed and optimal exploitation rate (0.50) to reach and ensure a sustainable yield. Therefore, it was found that the stock of *O. niloticus* and *O. aureus* are overexploited. This agrees with the findings achieved by El-Bokhty [19] for the species caught by seine nets.

Lengths at first capture (L_c) at which 50% of the fish become vulnerable to capture were estimated to be 11.45 and 11.66 cm for *O. niloticus* and *O. aureus*, respectively by trammel nets, while it was 8.89 and 8.60 cm, for the same species respectively by basket traps (Figure 6, a-d). The differences can be attributed to

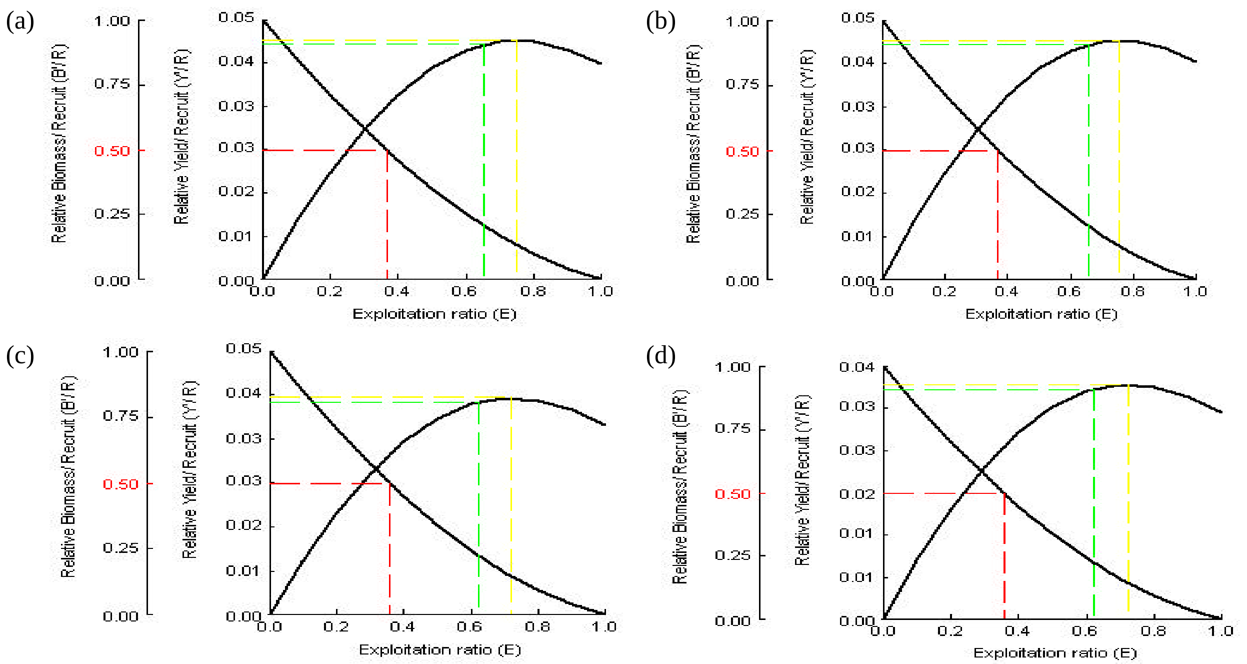

Fig. 7a-d: a: Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' of *O. niloticus*, (trammel nets), Lake Manzalah
b: Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' of *O. aureus*, (trammel nets),Lake Manzalah
c: Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' of *O. niloticus*, (basket traps), Lake Manzalah
d: Relative yield per recruit (Y/R)' and biomass per recruit (B/R)' of *O. aureus*, (basket traps), Lake Manzalah

the differences of mesh sizes of the two fishing nets in the lake. El-Zarka [5] reported that tilapia fish are caught at average length 11 cm. This sizes don't affect the breeding success of the fish because tilapia are known as fractional spawners and reach its first maturity and spawns at this size and even at smaller lengths. Also, Hosny [22] declared that the optimum size at first capture corresponding to the optimal yield in weight per each recruit for the four tilapia species (under the actual fishing and natural mortality rates) would be about 2^+ year which corresponds to a minimum size limit of 12 cm that would permit one whole season for the spawning process. This would not only prevent recruitment over fishing but will increase the total yield of the lake under the actual levels of the fishing effort.

Hence, L_c values are recommended to be raised to at least these minimum lengths by using wider mesh-sized nets for conservation of the stock and also to raise the sustainable yields of the different fish caught by basket traps and trammel nets at Lake Manzalah.

According to the equation $W = 0.01745\ L^{3.01043}$ recorded by El-Bokhty [19], the total weight by of *O. niloticus* will be 26.9 gm at 11.45 cm and 12.5 gm at length 8.89 cm caught by trammel nets and basket traps respectively. Raising these L_c values to 15 cm (which nearly corresponds to the optimum length) in total length will make a shift in weight reaching 60.58 gm. Also, applying the equation $W = 0.01332\ L^{3.0939}$ for *O. aureus*, an obvious shift in weight would reach 57.97 gm at 15 cm total length instead of 11.5 gm and 10.4 gm at the L_c values of *O. aureus* corresponding to trammel and basket traps respectively. Hence, this could increase the catch of both species caught by such gears based on the criterion of gaining extra-weight and lead to more economic returns. It was highly recommended to use trammel nets with inner layer mesh sizes of 6 cm stretched mesh and basket traps of not less than 5 cm or 2.5 cm mesh bar to achieve this goal [2].

As obvious from Relative yield per recruit $(Y/R)'$ and relative biomass per recruit $(B/R)'$ Figures (7,a-d), the exploitation rates of *Oreochromis niloticus* and *O. aureus* should be reduced from 0.60 to 0.35 (nearly 25%) through reducing the effort exerted by both trammel nets and traps to save the stock biomass or at least exploitation rates of the species *O. niloticus* and *O. aureus* (nearly 60% and 64%) should be reduced to the optimum level (E=50) to reach an optimally exploited stock [21]. To get this, the mesh sizes of nets used in basket traps should be increased in parallel with decreasing the effort exerted.

The elastic increase in the overall fishing effort resulted in reducing the CPUE in combination with reduction of mesh sizes in the used gears have led to the over-fishing problem and decline of the fish catch of Lake Manzalah beside the other environmental factors which should be considered. Fisheries management have hitherto targeted limiting gear types and mesh sizes which are difficult to be controlled in such lakes without enforcing laws.

In conclusion, results indicated that the stock of *O. niloticus*, *O. aureus* using both trammel nets and basket traps in Lake Manzalah are overexploited. For fishery management of this fishery resource the fishing pressure and the present level of exploitation should be reduced to the optimum level (0.50%). The use of illegal mesh sizes especially of basket traps used in the lake need to be urgently addressed by the authorities concerned and the effort exerted by both of trammel nets and basket traps should be reduced. In addition, the usage of larger meshes will affectively reduces the risk of a stock collapse by a long-term increase of the spawning stock size of tilapia fish and prevents recruitmen overfishing.

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