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GROWTH, MORTALITY AND YIELD PER RECRUIT OF THE AFRICAN CATFISH *Clarias gariepinus* INHABITING THE RIVER NILE IN EGYPT

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ABSTRACT

The study was performed on *C. gariepinus* population inhabiting the river Nile main stream with emphasis on the stock assessment and population dynamics. The objectives of this study were to assess the growth rate, abundance and age composition, age at first sexual maturity, size and age at recruitment, size and age at first capture, mortality, exploitation level and yield per recruit, and to discuss the observations to reach optimum exploitation of the African catfish stock in the river Nile stream in Egypt. The back calculated lengths at the different age groups of *C. gariepinus* show that the longevity of fish extends to five years in the river Nile main stream with a total length of 51 cm and 48 cm for males and females, respectively. The spawning stock biomass represents about 48 % of the *C. gariepinus* population. The results indicate that the stock of *C. gariepinus* is exposed to a slightly overfishing under the current level of fishing effort. The catch curves for fully recruited fishes were used to estimate the total mortality coefficients (Z). Its computed values were -1.07 and -1.04 per year with a total mortality rate (A) equals 66 % and 65 % for males and females, respectively. Yield per recruit was estimated using Thompson-Bell and Ricker model at the current level of fishing mortality and under the different simulation levels of Nile fishery exploitation. The present work recommends to prohibit catch-

ing the small fish sizes (less than 33 cm total length) by regulating the minimum mesh sizes of the gears that are still used in the river Nile. In addition, the fishing efforts as the number of boats and fishermen need to be reevaluated on scientific basis to protect and develop the Nile fishery.

Key words: *African catfish, Clarias gariepinus, fisheries, river Nile.*

1. INTRODUCTION

The African catfish *Clarias gariepinus* belongs to family Clariidae and is one of the most important freshwater fishes in Africa and Egypt. *C. gariepinus* constitutes a major portion of the inland fish catch in Africa and is considered an important source of protein for human consumption (Hyslop, 1986). In Egypt, the total production of *C. gariepinus* is about 21,815 tons, and contributes about 4% of the total fish production in 1998. Its yield from the river Nile only is about 11.613 tons, which constitutes about 17 % of the river Nile catch in Egypt (GAFRD, 1998). On the other hand, this species occupies an important position in the trophic chain as predator on tilapias offspring (Viveen *et al.*, 1986 and Khallaf and Gaber, 1991). It is also known that *C. gariepinus* is well adapted and can survive in a wide range of environmental conditions even with low oxygen content and gives good yield in aquaculture (EL-Bolock 1972, Bishai 1976, and Hogendoorn 1980 & 1983). Some earlier studies were conducted on this species in ponds and dealt with the age and growth (EL-Bolock and Koura 1960, EL-Bolock 1972, and Bishai 1976). Other studies were carried out on the fishes caught from the inland fisheries such as Baher Shebeen Nile canal and Rosetta Branch of the River Nile, which dealt with growth and morphology (Khallaf *et al.*, 1993 a & b) and fecundity (Khallaf and Gaber1993, and Shenouda *et al.*, 1995).

Although, the economic importance of the African catfish *C. gariepinus* which inhabiting the river Nile main stream, their population dynamics or fishery management have not been studied. Therefore, the present work dealt with the stock assessment of *C. gariepinus* population inhabiting the river Nile main stream. The objectives of this study were to assess the growth rate, abundance and

age composition, age at first sexual maturity, size and age at recruitment, size and age at first capture, mortality, exploitation level and yield per recruit, and to discuss the observations to reach optimum exploitation of the African catfish stock in the river Nile stream in Egypt.

2. MATERIALS AND METHODS

Samples of the African catfish *Clarias gariepinus* were collected monthly from the professional fishermen using the common trammel gill nets in the area extending from Giza to Assuit (about 500 Km, with a representative sample from each governorate) of the main river Nile stream during 1999. Fish total length was measured to the nearest millimeter, and body weight was recorded to the nearest 0.1 gram for each fish (330 males and 391 females). The fifth vertebra behind the head were removed, cleaned, dried and kept in an envelope, with records of date, sex, fish length and fish weight for later examination. Vertebrae were cleared with ethanol and examined using a research microscope aided with an ocular micrometer at 20 X magnifications for measuring the radius of annual rings and vertebrae (mm) according to EL-Bolock (1972) and Tharwat (1998). The constant parameters (a & b) of the length-weight relationship for *C. gariepinus* which inhabits the river Nile (Tharwat, 2000) were used to convert fish lengths to weights. Back-calculated lengths at the different age groups were computed by Lee method for annual rings (Carlander, 1981). To determine total instantaneous mortality (Z) of the fully recruited portion of fish stock, Z was estimated as the slope of the descending limb of the catch curve, a plot of the natural logarithm of the number of harvested fishes in each age-class versus age (Gulland, 1969), and the linearized catch curve method (Pauly, 1983). Simple annual mortality (A) of this portion of the stock was estimated as $A = 1 - e^{-Z}$ (Ricker, 1975). The natural mortality coefficient (M) was estimated using Pauly equation (1980). The yield per recruit was computed for the fish stock under the current mortality rate using the yield model of Thompson-bell and Ricker (Ricker, 1975). Instantaneous rate of growth (G) was estimated for each age-class by the equation: $G = \log_e W_2 - \log_e W_1$; where W_1 and W_2 are mean weights of successive age-classes. Age at first sexual maturity " tm_{50}"

was calculated by the commonly used equation of von Bertalanffy (Bertalanffy, 1938) as follows: $t_{(L)} = to - 1/K \text{ Ln } (1 - L/L\infty)$, where $t_{(L)}$ is the age at length L ; to, K and $L\infty$ are population growth parameters.

2.1. Statistical methods

The regression analysis was used to determine the relationship between vertebrae radius and the fish total length for both sexes (SAS, 1985). The significance of differences between sexes was tested ($P < 0.05$) with analysis of variance for back-calculated lengths at the different age groups, age frequency, and to estimate the total instantaneous mortality (Z). Differences among slopes and intercepts were determined with ANOVA (Schaffer and Elson, 1975).

3. RESULTS AND DISCUSSION

3.1. Age and growth

The relationship between fish total length and vertebra radius is logarithmic and differs significantly ($P < 0.05$) between the males and females. These relationships were found to be as follows:

Log L = 1.0972 + 1. 0124 Log Vr , with r = 0.9832 for males and

Log L = 1.0484 + 1.1693 Log Vr , with r = 0.9867 for females,

where L = total length of fish (cm) , Vr = vertebra radius (mm) , and r = correlation coefficient of the regression equation. Consequently, these relationships were used to predict the back-calculated lengths at successive annuli. The back calculated lengths and weights at the different age groups for males and females of the Nile catfish *Clarias gariepinus* and their annual increments are shown in Table (1). It is obvious that the African catfish *Clarias gariepinus* lives about five years in the river Nile main stream with an average total length of 51 and 48 cm for males and females, respectively. The percentage of length increment gradually decreases as fish becomes older for both sexes. However, the percentage of weight increment follows a reverse pattern for both sexes, where it increases gradually from age group I to reach its maximum values at age group IV. The von Bertalanffy growth model for males and females of the African catfish *Clarias gariepinus* was estimated as follows:

$L_t = 76.7[1 - e^{-0.21\ (t + 0.1981)}]$, for males and
$L_t = 64.6[1 - e^{-0.26\ (t + 0.2736)}]$, for females,
where L_t = back calculated of fish length at age t (years).

3.2. Age at first sexual maturity

The estimated length at first sexual maturity (Lm50) for the African catfish *Clarias gariepinus* which inhabits the river Nile stream was 33 cm for males and 32 cm for females (Tharwat, 2000). Converting these lengths to the corresponding age at first sexual maturity (tm_{50}) using the Bertalanffy formula gave 2.48 and 2.36 years for males and females, respectively. Both of Lm50 and tm50 are the necessary parameters for fish stock assessment and spawning stock biomass of the fish population (Hegge *et al.*, 1991).

Table (1): Back calculated lengths and weights at the different age groups for males and females of the Nile catfish *Clarias gariepinus* and their annual increments.

Items	Age groups (years)					Total
	1	2	3	4	5	
Frequency:						
Males	25	66	145	77	17	330
Females	29	82	169	90	21	391
Total length (cm):						
Males	17.8	28.7	37.9	45.2	51.0	-
Females	18.3	29.0	36.9	43.2	48.2	-
Increment (cm):						
Males	17.8	10.9	9.2	7.3	5.8	51.0
Females	18.3	10.7	7.9	6.3	5.0	48.2
% Increment:						
Males	34.9	21.4	18.0	14.3	11.4	100
Females	38.0	22.2	16.4	13.0	10.4	100
Total weight (gm):						
Males	64.0	221.8	457.3	723.2	990.1	-
Females	72.6	258.1	501.1	773.6	1046.1	-
Increment (gm):						
Males	64.0	157.8	235.5	265.9	266.9	990.1
Females	72.6	185.5	243.0	272.5	272.5	1046.1
% Increment:						
Males	6.5	15.9	23.8	26.9	26.9	100
Females	6.9	17.7	23.2	26.1	26.1	100

3.3. Size and age at recruitment and at first capture

The shortest length of *C. gariepinus* that was represented monthly in the catch is selected to be the length at recruitment (Lr) and it was found to be 15 cm in total length for both sexes. Its calculated weight equals 41 and 42 gm for males and females, respectively. The corresponding age at recruitment (tr) is estimated from the Von Bertalanffy equation as 0.84 and 0.74 year for males and females, respectively.

The length at first capture (Lc) is the size at which 50 % of the fish retained by the gear. Lc was computed, using the length selection catch curve method of Lee and Baddar (1989) and its estimated values were 31 and 30 cm total length for both males and females, respectively (Fig. 1). Converting these lengths (Lc) to the age at first capture (tc) gave tc about 2.27 and 2.13 years for both males and females, respectively.

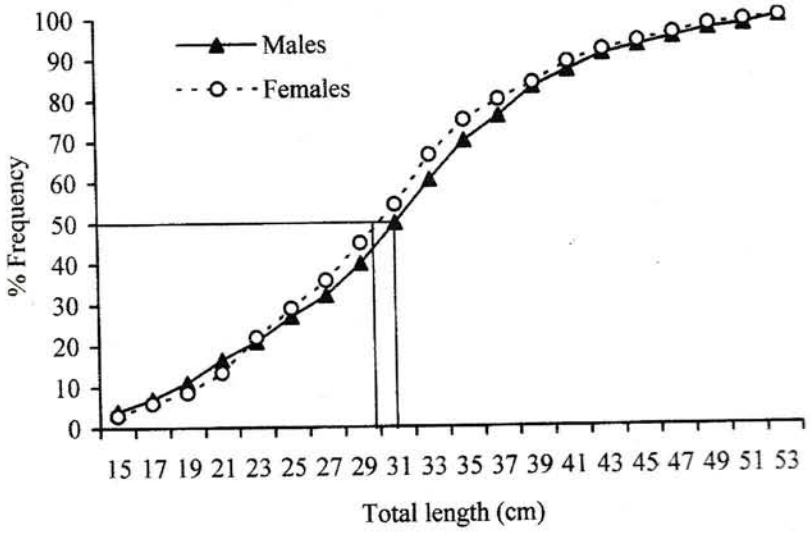

Fig (1): Gear selection curve of the African catfish *Clarias gariepinus* harvested from the river Nile to estimate the length at first capture (Lc).

3.4. Age composition

The age composition of *C. gariepinus* was investigated and the percentage of fishes of each age group was examined (Fig. 2). The data revealed that age group (0) is not represented in the catch. The immature fishes that belong to age groups I and II constitute about 33.6 and 31.8 % for males and females, respectively. However, fishes of age group III are dominant in the catch and constitute about 40.9 and 40.2 % (which including tm_{50} , about 50 % of them is mature) for males and females, respectively. Moreover, fish frequency of age groups IV and V including fully mature fishes in the catch are represented about 25.5 and 28 % for males and females, respectively. Hence, the spawning stock is representing about 47 and 48 % of the *C. gariepinus* population. These results indicate that the stock of *C. gariepinus* is exposed to a slightly overfishing under the current level of fishing effort, and illustrate the high relative abundance of *C. gariepinus* at a relatively small fish size in the Nile fishery.

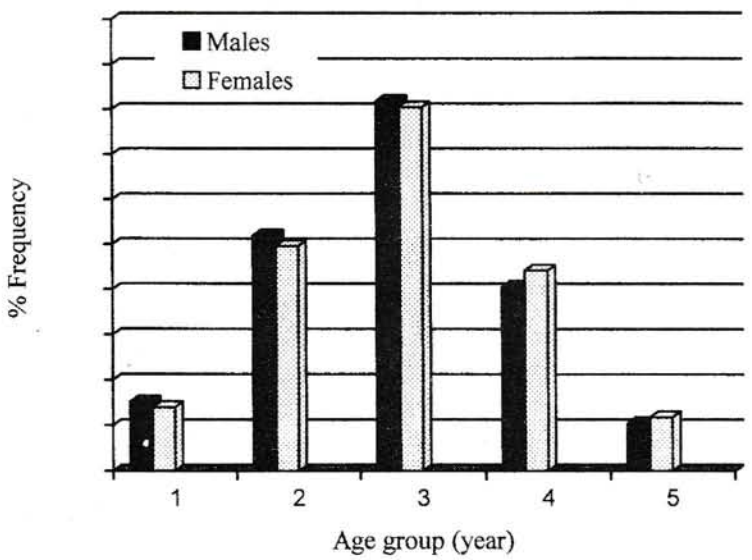

Fig (2): Age composition for males and females of the African catfish *Clarias gariepinus* inhabiting the river Nile main stream.

3.5. Mortality and exploitation rate

The catch curves for fully recruited males and females of the African catfish *Clarias gariepinus* are represented graphically in Figures (3 & 4) and were used to estimate the total mortality coefficients (Z). It is obvious that the slope of the descending limb of the catch curve occurs for the age ranging between 3 and 5 years (adult fishes). The computed total mortality coefficients (Z) were -1.07 and -1.04 per year for males and females, respectively. The figures reflect that the total mortality rate (A) equals to 66 % and 65 % with a survival rate of 34 % and 35 % for the adult individuals in the fish population. The mean surface water temperature (22.6 ^{0}C) of the river Nile (Tharwat, 1995) was used to estimate the natural mortality coefficient (M) of *Clarias gariepinus*, which was found to be 0.45 and 0.54 per year for males and females, respectively. On the other hand, the value of fishing mortality coefficient (F) was obtained from the difference between the total and natural mortality coefficients and it was equal to 0.62 and 0.50 per year for males and females, respectively. The exploitation ratio of fish stock under the current fishing effort represented 0.58 and 0.48 yearly for males and females, respectively, Table (2). It is well known that the exploitation ratio (E) allows one to roughly assess whether the stock is overexploited or not, on the assumption that the optimal value of E is equal to 0.50. Consequently, the present results indicate that the males of *C. gariepinus* are exposed to a relatively overfishing in the river Nile under the current fishery exploitation than females. This result may be explained by the more active behaviour of males than females, which increases the probability of males to fall in the fishing gears than females. The natural mortality rate of females is higher than in males that may be attributed to the reproductive behaviour, which include spawning, hatching and nursing the offspring for a relatively long period of time in the nests by females. This exposes the females to the higher probability to natural mortality causes than males. All estimated population parameters for males, females and combined sexes are shown in Table (2).

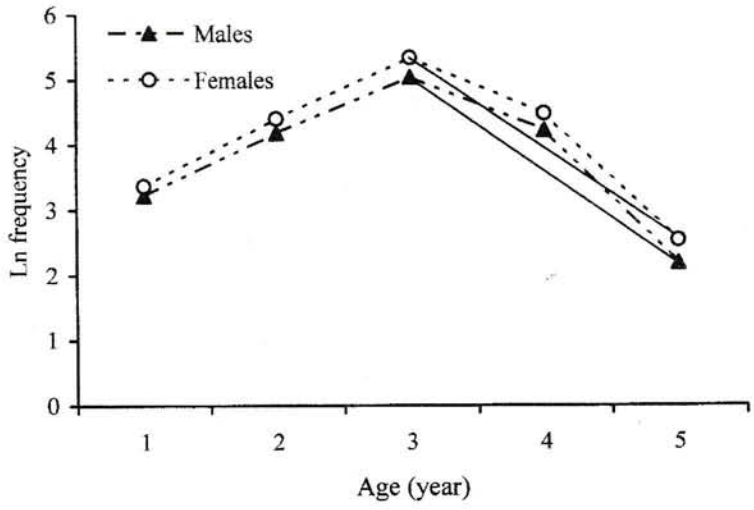

Fig. (3): Catch curve for the males and females of the African catfish *Clarias gariepinus* inhabiting the river Nile.

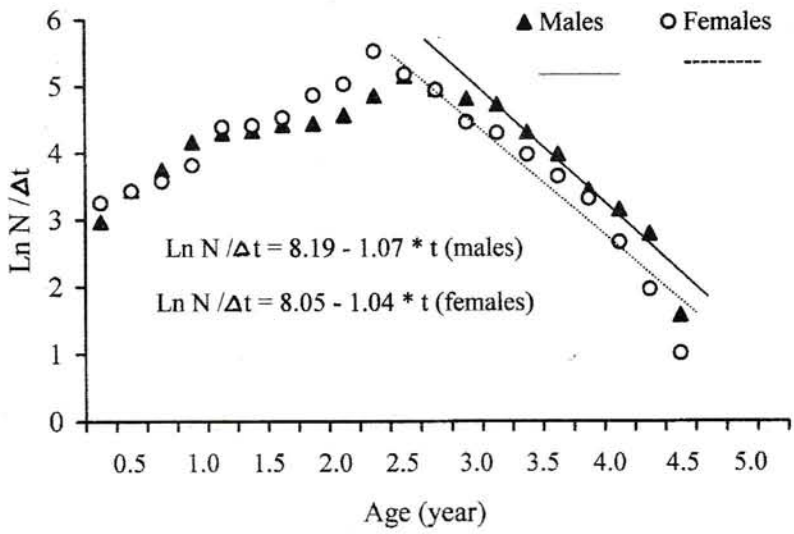

Fig. (4): Lineared catch curve based on length-age composition data to estimate total mortality coefficient (Z).

Table (2): Population parameters for the males and females of the African catfish *Clarias gariepinus* inhabiting the river Nile.

Parameters		Males	Females	(♂ & ♀)
Length at first sexual maturity,cm	(Lm_{50})	33	32	33
Age at first sexual maturity, yr	(tm_{50})	2.48	2.36	2.5
Length at recruitment, cm	(Lr)	15	15	15
Age at recruitment, yr	(tr)	0.84	0.74	0.79
Length at first capture, cm	(Lc)	30	31	31
Age at first capture, yr	(tc)	2.27	2.13	2.2
Asymptotic length, cm	($L\infty$)	76.7	64.6	71
Asymptotic weight, gm	($W\infty$)	2862.7	2343.8	2603.0
Age at which length is nil, yr	(t_o)	-0.1981	-0.2736	-0.2358
Growth coefficient	(K)	0.21	0.26	0.23
Total mortality coefficient, yr^{-1}	(Z)	-1.07	-1.04	-1.06
Natural mortality coefficient, yr^{-1}	(M)	0.45	0.54	0.50
Fishing mortality coefficient, yr^{-1}	(F)	0.62	0.50	0.56
Total survival rate	($S = e^{-Z}$)	0.34	0.35	0.35
Total mortality rate	(1-S)	0.66	0.65	0.65
Exploitation ratio	(E = F/Z)	0.58	0.48	0.53

3.6. Yield per recruit

Yield per recruit estimates for males and females of the African catfish *Clarias gariepinus* based on the Thompson-Bell and Ricker model (Ricker, 1975) are shown in Table (3). The yield per recruit at the current level of fishing mortality is significantly higher in males (2560 Kg) than in females (1945 Kg) of the fish population. On the other hand, the yields per recruit model were computed for the combined sexes under the different levels of Fishing mortality rates (F), and are graphically represented in figure (5). It was noticed that the yield per recruit increased with the increase of fishing rate and its values ranged between 1820 and 2754 Kg. However, the high rate of this increase occured by increasing fishing mortality up to F = 0.6 then it decreased gradually. Yield per recruit is estimated to be 2321 kg for combined sexes of *C. gariepinus* under the current fishing mortality rate (F = 0.56).

Table (3): Yield per recruit for males and females of the African catfish *Clarias gariepinus* harvested from the river Nile.

Age (year)	Mean length (cm)	Mean weight (gm)	Log_e (wt)	G	M	F	G-M-F (G-Z)	Weight change factor e^{G-Z}	Weight stock (kg)	Average weight (kg)	Yield (kg)
Males:											
1	17.8	64.0	4.159						1000		
2	28.7	221.8	5.402	1.243	0.45	0.62	+0.173	1.189	1189	1095	679
3	37.9	457.3	6.125	0.723	0.35	0.72	-0.347	0.707	841	1015	731
4	45.2	723.2	6.584	0.459	0.25	0.82	-0.611	0.543	457	649	532
5	51.0	990.1	6.898	0.314	0.15	0.92	-0.756	0.470	215	672	618
Total											**2560**
Females:											
1	18.3	72.6	4.285						1000		
2	29.0	258.1	5.553	1.268	0.54	0.50	+0.228	1.256	1256	1128	564
3	36.9	501.1	6.217	0.664	0.44	0.60	-0.376	0.687	863	1060	636
4	43.2	773.6	6.651	0.434	0.34	0.70	-0.606	0.546	471	667	467
5	48.2	1046.1	6.953	0.302	0.24	0.80	-0.738	0.478	225	348	278
Total											**1945**

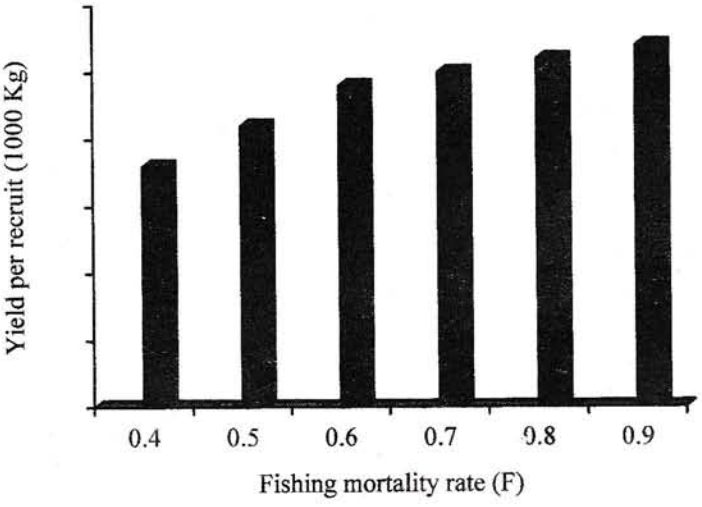

Fig (5): Yield per recruit estimates for the African catfish *Clarias gariepinus* (combined sexes) harvested from the river Nile.

CONCLUSION

After investigating all population parameters for *Clarias gariepinus* , which inhabits the river Nile stream (Table 2), age composition (Fig. 2) and yield per recruit (Fig. 5), it could be concluded that the stock of *C. gariepinus* is slightly overexploited under the current level of fishing effort (F = 0.56) or the current level of exploitation (E = 0.53). These results may be confirmed by those found that the spawning stock biomass is representing about 48 % of the *C. gariepinus* population and may illustrate the high relative abundance of *C. gariepinus* at a relatively small fish size in the Nile fishery. The present study shows that the fishery resources in the River Nile in Egypt are overexploited with a total mortality rate (65 %). The results of this study imply that a decrease in fish abundance and the break-down of the reproductive cycle will occur as a result of increasing the number of the fishing fleet in the river Nile above the current level. The decrease in the abundance of fish by heavy exploitation will be followed by a decrease in the average size of fish in the catch.

The present study has demonstrated the need to predict the strength of year-classes recruiting to *C. gariepinus* fishery before setting a total allowable catch (TAC) which is in accordance with Walker *et al.*, (1993). Therefore, it is suggested to prevent the fishing for *Clarias gariepinus* fishes of the river Nile until they complete 2.5 year of their life at a length not less than 33 cm. Since the percentage of weight increment increases gradually from age group I to reach its maximum values at age group IV. Therefore, it is recommended to prohibit catching the small fish sizes (less than 33 cm total length) by regulating the minimum mesh sizes of the gears that are still used in the river Nile. In addition, the fishing efforts as the number of boats and fishermen need to be reevaluated on scientific basis to protect and develop the Nile fishery.

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معدل النمو والنفوق والمحصول السمكي السنوي للفئات العمرية لسمكة القرموط الأفريقي *Clarias gariepinus* فى نهر النيل بمصر

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ملخص

تضمن العمل الحالي دراسة وتقييم المخزون السمكي وديناميكية العشيرة لسمكة القرموط الأفريقي *Clarias gariepinus* فى المجرى الرئيسي لنهر النيل. وتهدف هذه الدراسة إلى تقدير معدل نمو الأسماك ، الوفرة النسبية والتركيب العُمرى للمخزون السمكي ، عمر الأسماك عند بداية النضج الجنسي (tm50) ، حجم وعمر الأسماك عند بداية تمثيلها فى القطيع (Lr , tr) ، معدل نفوق الأسماك ، تحديد مستوى الإستغلال الحالي ومحصول الأسماك السنوي للفئات العمرية المكونة للقطيع. تم مُناقشة النتائج بهدف الوصول إلى مستوى الإستغلال الأمثل للمخزون السمكي لهذه الأسماك فى نهر النيل بمصر. تم تحديد أعمار الأسماك من خلال الفحص الميكروسكوبي لحلقات النمو السنوية على الفقرات العظمية (الفقرة الخامسة الأمامية) و حَسبتْ أطوال الأسماك للمجموعات العُمريةِ المختلفةِ بطريقة الحساب العكسي . ووجد أن فترة حياه أسماك القرموط الأفريقي في المجرى الرئيسي لنهر النيل تمتدُ إلى خمس سنوات عندما يصل الطول الكلى للسمكة إلى 51 سنتيمتر للذكور و 48 سنتيمتر للإناث ، وأن الأسماك الناضجة جنسيا تمثل حوالي 48 % من المخزون السمكي ، وأن قِيَم معامل النفوق الكلى المَحْسُوب (Z) هى – 1.07 و – 1.04 سنوياً بمعدل وفيات كلى (A) قدره 66 % للذكور و 65 % للإناث . تم استخدام نموذج بيل–ثومبسون و ريكير لتقدير محصول الأسماك السنوي للفئات العمرية المكونة للقطيع عند مستوى الصيد الحالي ، كما تم استخدامِ نظام المحاكاة بزيادة أو خفض مستوياتِ الصيد للتنبأ بالمحصول السمكي للفئات العمرية لأسماك القطيع عند كل مستوى . وتشير نتائج البحث إلى أن المخزونَ السمكي لأسماك القرموط الأفريقي تحت المستوى الحالي لجهدِ الصيد يتعرض إلى معدل إستغلال (E = 0.53) يزداد قليلا عن مستوى الاستغلال الأمثل. وتوصى الدراسة الحالية بمنع صيد الأسماك التي يقل طولها عن 33 سم وذلك من خلال تَنظيم فتحات عيون شباك الصيد المستخدمة في نهر النيل . كما

يوصى البحث أيضا بضرورة دراسة وتقييم جهد الصيد الحالي وكفاءة حرف الصيد المستخدمة على إمتداد نهر النيل وعددِ المراكبِ والصيادين على أسس علمية تستهدفُ حماية وتنمية الثروة السمكية والوصول إلى الاستغلال الأمثل للمخزون السمكي.

المجلة العلمية لكلية الزراعة -جامعة القاهرة - المجلد (51) العدد الرابع (أكتوبر 2000): 393 - 410 .