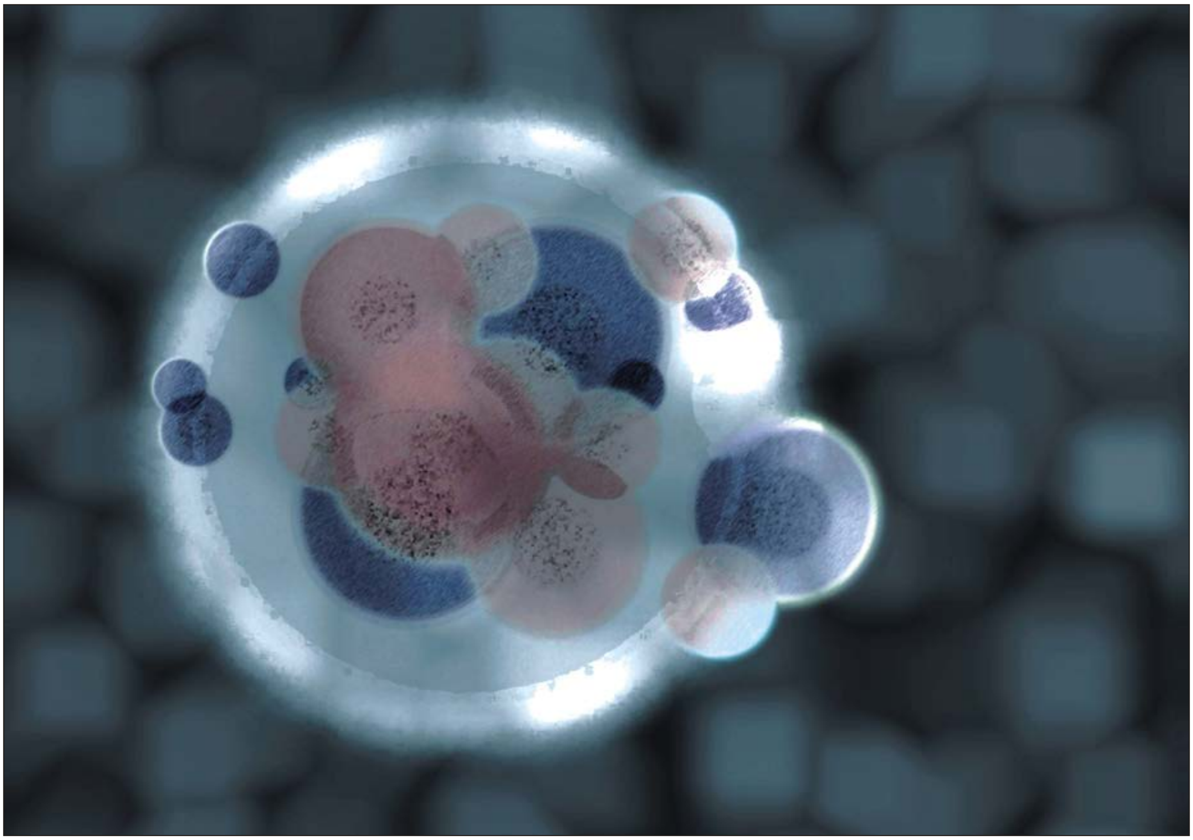

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Reproductive Characteristics of the Elephant-snout Fish *Mormyrus kannume* Forsskål, 1775 from the Nile, Egypt

[1,2]Imam A.A. Mekkawy and [2]Arafa A. Hassan
[1]Department of Biology, Faculty of Science, Taif University, Taif, Saudi Arabia
[2]Depatment of Zoology, Faculty of Science, Assiut University, Assiut, Egypt

Abstract: In the present study, some reproductive parameters including sex ratios, maturity stages, length and age at first maturity gonadosomatic and gonad indices, egg diameter and fecundity of *Mormyrus kannume* from the Nile, Egypt, were estimated in relation to standard length, weight, age and months. Other population parameters describing such population were also estimated. Different patterns of variations were recorded in these parameters. Overall sex ratio was significantly balanced in the Nile but not in the lacustrine locality: Lake Nasser. The females and males of *M. kannume* reached maturation at 31.7 and 31.5 cm with reproductive load of 0.754 and 0.748, respectively. Monthly variations in ED were evident with similar variability in GSI and GI. ED has its highest values in April and May and its lowest values in November and December (corresponding to highest fecundity). No association between ED and age groups whereas ED showed variability among maturity stages. Fecundity exhibited variability with age, length and months in the same locality. Fecundity highest average value was recorded in December (12623±6811).There is no association between fecundity and maturity stages and fish condition factor. The fecundity increased with age groups and has its highest values in age group I and II and lowest one in age VI. Fecundity also showed variations with time and locality when compared with other studies. In spite of estimation of its relation with other variables in univariate term, fecundity and variables controlling it were best modeled by stepwise multiple linear regression which isolated fish size, egg diameter and gonad index to be the best significant factors influencing fecundity and valid for prediction. In conclusion, *M. kannume* is a fecund fish with variations in time and localities.

Key words: Reproductive load, sex ratios, fecundity, maturity, *Mormyrus*

INTRODUCTION

Estimation of reproductive potential (RP) and recruitment of different species is important and at the same time, difficult process (Hilborn and Walters, 1992). So, the reproductive parameters represent a powerful tool in fisheries management and the related modeling processes. Fishery scientists considered fecundity as one of the most interested reproductive biology aspects in stock assessment based on egg production methods (Saville, 1964; Koslow *et al*., 1995; Morgan, 2008; Mekkawy and Hassan, 2011). In addition, Wang *et al*. (2003) and Morgan (2008) stated that the size and age at sexual maturity and the sex ratio are fundamental biological parameters in stock assessments and fishery management modeling. In this respect, estimates of body size and /or age at first sexual maturity are also, necessary parameters for age- and size-structured models, such as the spawner biomass per recruit model (Gabriel *et al*., 1989), per recruit model (Foale and Day, 1997) egg and other size-or age-structured models (Derios *et al*., 1985; Quinnll *et al*., 1990). Morgan (2008) stated that reproductive biology play an important role in determining productivity and in turn a population's resiliency to exploitation by fisheries as well as perturbation caused by other human activities. These findings provide sound scientific advice for fisheries management

Estimation of the reproductive aspects in terms of fecundity, egg size, size and length at sexual maturity, sex ratio, gonadosomatic index are essentials in consideration of life history theory. The goal of current life history theory is to predict how an organism's finite resources, time and energy, are allocated towards growth, maintenance and reproduction (Cody, 1966). In this concern, Williams (1966), Pianka (1976) and Willbur (1977) emphasized on a compromise between the organism's immediate prospects of reproductive success versus lifelong future prospects.

Mormyrids are endemic to Africa represented by about 100 species in two subfamilies (Aly, 1993) and represented in Lake Naser, Egypt by 7 species. Twenty species under genus Mormyrus were recorded in Africa

Corresponding Author: Imam A.A. Mekkawy, Department of Biology, Faculty of Science, Taif University, Taif, Saudi Arabia

(Froese and Binohlan, 2000). *M. kannume* is the only economic species represented downstream in the Nile with few small sized species of other mormyrid species after the construction of the High Dam in 1969 at Aswan, Egypt. Reviewing literature at hand on *M. kannume* and /or *M. caschive* (Ashour *et al*., 1990a; Zaher *et al*., 1991; Aly, 1993), no detailed research has been done on the reproductive biology of these species in the Nile. However, the reproductive biology of many Nile fish species was the focus of many authors (Mekkawy and Hassan, 2011).

According to the scientific information on *M. kannume* species of the Egyptian sector of the Nile, at Assiut, Egypt, the present work aimed at estimation of some of the reproductive parameters of *Mormyrus kannume* including sex ratios, size/age at first maturity, maturity stages, gonadosomatic and gonad indices and different fecundity relationships which can be included in fishery and stock assessment models of that species.

MATERIALS AND METHODS

One hundred and sixty specimens of *M. kannume* (16-47 cm in SL) were collected from the Nile at Assiut, Egypt, dissected and examined. Fish and gonads were weighed to the nearest gram and standard length was measured to the nearest centimeter. Ovaries were preserved in 10% formalin for later estimation of fecundity. For age determination of specimens used in this study, the first five vertebrae of each fish were cleaned and examined using binocular microscope.

Sex ratio: Sex ratio was determined for the two species on fish size and monthly bases. Sex ratio departure from the expected 1:1 ratio was testified. Moreover, sex distribution through length groups and months was also considered.

Maturity stages: The maturity stages of ovaries and testes were identified and distinguished according to the following basis (Aly, 1993):

Stage I (immature): gonads are small, ovary is transparent. Eggs are small and cannot be detected by the naked eye. Testis is thread-like.

Stage II (resting stage): gonads are still small and extend along 1/3-1/2 the length of the abdominal cavity. The ovary is still transparent and not thick. The eggs still cannot be distinguished with the naked eye. Testis is still without well-defined side lobes.

Stage III (maturation): the gonad begins to develop and extend along ¾ of the abdominal cavity length. Ovary is yellowish. Eggs are distinguished to naked eye. Testis starts to have side lobes.

Stage IV (maturity): sexual products are clear. The gonads nearly extend along the whole length and reach their maximum weight. Ovaries are orange but the eggs still not extruded while the testis lobes are clear, finger-like and full of sperms.

Stage V (reproduction): Ovaries are voluminous with large viable eggs which could be seen through the thin ovarian wall. Testes are whitish in color with stout lobes which are distended with sperms.

Stage VI (Spent): The ovary is flaccid, reddish black in color and much reduced in size, the testes are yellowish, white in color, soft, empty and fleshy in its appearance.

In the analysis, the maturity stages I and II were together considered as immature, stage III as maturing, while stage IV and V are considered as mature/ripe. Length (Lm) and age (Tm) at first maturity were estimated for males and females.

Gonadosomatic (GSI) and Gonad Indices (GI): The gonadosomatic index (GSI) was predicted by the following formula (Khallaf, 1986): GSI = GW *100/W where GW is the gonad weight in g and W is body weight in g. The Gonad Index (GI) was predicted by the following formula (Scrimgeour and Eldon, 1989):

$GI = GW * 10^8 / SL^3$. Two condition Factors (Kn = W* 100/SL^n and Kc= W*100/SL^3; n=allometric coefficient) were estimated.

Fecundity: Fecundity (F) is the number of eggs per ovary of mature fish (Bagenal and Tesch, 1978), whereas relative fecundity is the number of egg per unit length (RFSL) or weight (RFW) of fish. Three pieces per ovary were cut and weighed, then the eggs were counted and fecundity and relative fecundity were calculated. Egg Diameter (ED) was measured to the nearest micron by an ocular micrometer fixed in the eye-piece of a light microscope.

Statistical analysis: Length and size at first maturity (Lm and Tm) were estimated using probit analysis. Length-weight power function equation parameters (a and n) and SL-TL linear equation (a and b) and Bertalanffy equation parameters ($L\infty$, K, T0) as well as reproductive load ($Lm/L\infty$) were estimated. Monthly and size variations in the reproductive parameters were analyzed with one way ANOVA and Post Hoc Tukey-test;

homogeneity of variance was evident by Levene's Test in most cases and assumed in few others since no transformations were valid. Fecundity relationships with size, age, weight maturity stages and egg diameters were analyzed and fitted. The fecundity in relation to SL, W, GW, ED, GSI, GI, Age, M (maturity stage), Kn and Kc was subjected to stepwise multiple linear regression (forward and backward) to determine the best variables that control fecundity in a multivariate sense. Correlation, multiple correlation and partial correlation coefficients were estimated. Sex ratio was analyzed and fitted by Chi-square test. All tests were considered at 0.05-level of significance. SPSS-package release 9 (SPSS, 1998), Statistica package release 5 (Statsoft, 1995) and FiSAT-II package (Gayanilo *et al*., 2005) were used in these statistical analyses and models.

RESULTS

Some biological parameters: The males and females of *Mormyrus kannume* population studied grow positively allometricly and isometricly respectively and are characterized by the following general biological parameters (Table 1).

Sex ratio: The sex ratio of *M. kannume* of Assiut (male: female) was 1: 0.84 and did not depart from the expected 1:1 rate (Table 2). However there was significant association between sex distribution and length groups (χ^2 = 21.28; p = 0.0034) (Table 3). On the contrary, no significant association between sex and months (χ^2 = 15.08; p = 0.1788). Sex ratio of March (1: 0.25) was the only ratio that departed from the expected ratio 1:1 (χ^2 = 5.4; $p<0.05$) whereas only in length groups 20 and 32, sex ratios (1: 0.16 and 1: 2.06, respectively) were significantly different from the expected one 1:1 (χ^2 = 11.64 and 5.56 at $p<0.05$). Such ratios were responsible for the significant association between sex distributions and length groups. In spite of these findings, fishes were numerically insufficient to permit a reliable conclusion in some length groups and some months.

Size and age at first sexual maturity (Lm and Tm): The age and size-distribution of the mature and immature *M. kannume* are given in Table 4 and 5. From such distributions, Lm and Tm of *M. kannume* were estimated to be:

Sex	Lm (cm) (Confidence limit)	Tm (year) (Confidence limit)
Male	31.5 (29.9-33.2)	3.26 (3.1-3.4)
Females	31.7 (31.0-32.3)	3.46 (3.3-3.6)
Combined	31.6 (30.8-32.3)	3.36 (3.25-3.5)

Reproductive load: The reproductive loads (Lm/L_∞) of males, females and combined sex of M. kannume from the Nile at Assiut were 0.748, 0.754 and 0.595, respectively.

Maturity stages: The distribution of maturity stage categories (i.e., I+II, III, IV+V) showed variations among length groups in both males and females. The maturity increases with increase of fish size (Table 6). On other hand, all maturity stages categories of females were represented in March and July-October period. However, IV+V category was represented along the period of study which means a long period of spawning (Table 7). These female findings were different from those of males (Table 7). Seasonal variations were evident ($p<0.0001$).

Table 1: Parameters and their standard errors of Bertalanffy and length-weight power function equations (coefficient of variation is in parenthesis; SL (cm) and W (g)

Characters	Males	Females	Combined sex
N	101	59	160
Bertalanffy equation parameters			
L_∞ (cm)	42.12±4.84 (0.12)	42.02±4.12 (0.10)	53.11±12.64 (0.24)
K (year^{-1})	0.40±0.16 (0.41)	0.40±0.14 (0.34)	0.27±0.12 (0.45)
T0 (year^{-1})	0.01±0.42 (42.1)	0.01±0.39 (39.0)	0.01±0.26 (26.0)
Length-weight power function equation parameters			
a	0.017906	0.012915	0.016183
n	2.8068±0.079265	2.9149±0.105505	2.8417±0.062378
Allometry	Positive	Isometric	Negative

Table 2: Sex ratio of *M. kannume* in different length groups from Assiut (2000-2001 periods)

Length	Male	Female	Sex ratio (M and F)	Female sex ratio
16	6	2	1:0.30	25.0
20	19	3	1:0.16	13.6
24	12	10	1:0.80	45.5
28	12	15	1:1.30	55.6
32	15	31	1:2.10	67.4
36	23	15	1:0.65	39.5
40	9	6	1:0.70	40.0
44	5	3	1:0.60	37.5

Table 3: Seasonal variations in sex ratio of *M. kannume* from Assiut (2000-2001 periods)

Months	Male	Female	Sex ratio (M and F)	Female sex ratio
Nov. 2000	25	16	1:0.64	39.0
Dec.	7	4	1:0.60	36.4
Jan. 2001	6	6	1:1.00	50.0
Feb.	4	6	1:1.50	60.0
Mar.	4	8	1:2.00	66.7
Apr.	6	6	1:1.00	50.0
May	12	3	1:0.30	20.0
Jun.	3	2	1:0.70	40.0
Jul.	12	6	1:0.50	33.3
Aug.	8	4	1:0.50	33.3
Sept.	3	7	1:2.30	70.0
Oct.	11	17	1:1.60	60.7

Table 4: Distribution of mature and immature individuals of *M. kannume* from the Nile at Assiut, Egypt. Among different age groups in the period November 2000-October 2001

	Female			Male			Comb.		
Age	No.	Mature	Mature (%)	No.	Mature	Mature (%)	No.	Mature	Mature (%)
I	2	0	0	11	0	0	13	0	0.0
II	4	1	25.0	14	6	42.8	18	7	38.9
III	30	24	80.0	26	14	53.8	56	38	67.9
IV	28	25	89.3	39	37	94.9	67	62	92.5
V	18	17	94.4	11	11	10.0	29	28	96.6
VI	3	3	100.0	00	00	00.0	3	3	100.0

Table 5: Distribution of mature and immature individuals of *M. kannume* from the Nile at Assiut, Egypt among different length groups in the period November 2000-October 2001

	Female			Male			Comb.		
Length group	No.	Mature	Mature (%)	No.	Mature	Mature (%)	No.	Mature	Mature (%)
16	1	0	0	3	1	33	4	1	25
20	4	1	25	18	5	28	22	6	27
24	7	4	57	14	6	43	21	10	48
28	13	10	77	10	7	70	23	17	74
32	26	22	85	13	10	77	39	32	82
36	20	20	100	22	20	91	42	40	95
40	11	11	100	16	16	100	27	27	100
44	3	3	100	5	5	100	8	8	100

Table 6: Length groups variations of different maturity stages of males and females of *M. kannume* from the Nile at Assiut, Egypt

	Males maturity stage				Females maturity stage			
Length groups	No.	I+II	III	IV+V	No.	I+II	III	IV+V
16	3	66.7	33.3	0.0	1	100.0	0.0	0.0
20	18	72.2	22.2	5.6	4	50.0	50.0	0.0
24	14	57.1	35.7	7.1	7	42.9	14.3	42.9
28	10	30.0	50.0	20.0	13	27.3	36.4	36.4
32	13	23.1	38.5	38.5	26	11.5	26.9	61.5
36	22	9.1	31.8	59.1	20	0.0	35.0	65.0
40	16	0.0	18.8	81.3	11	0.0	9.1	90.9
44	5	0.0	0.0	100.0	3	0.0	0.0	100.0

Table 7: Monthly variations of different maturity stages of females and males of *M. kannume*, from the Nile at Assiut, Egypt

	Females maturity stage					Males maturity stage				
Months	No.	SL	I+II	III	IV+V	No.	SL	I+II	III	IV+V
Nov. 2000	16	27-48	6.25	50.0	43.7	25	17-40	28.0	24.0	48.0
Dec.	4	26-38	0.00	50.0	50.0	7	23-46	14.3	14.3	71.4
Jan. 2001	6	27-38	0.00	33.3	66.7	6	19-46	33.3	66.7	0.0
Feb.	6	28-40	0.00	0.0	100.0	4	21-36	25.0	25.0	50.0
Mar.	8	21-35	12.50	12.5	75.0	4	20-44	25.0	0.0	75.0
Apr.	6	23-47	0.00	0.0	100.0	6	28-40	0.0	0.0	100.0
May	3	25-41	0.00	0.0	100.0	12	20-39	33.3	33.3	33.3
June	2	27-30	0.00	0.0	100.0	3	24-32	100.0	0.0	0.0
July	6	15-34	50.00	33.3	16.7	12	16-37	58.3	41.7	0.0
Aug.	4	18-30	50.00	25.0	25.0	8	17-31	37.5	62.5	0.0
Sept.	7	33-38	14.20	14.3	71.4	3	18-36	0.0	33.3	66.7
Oct.	17	24-45	29.40	23.5	47.1	11	21-40	0.0	36.3	63.6

Table 8: Gonadosomatic index and gonad index of males and females in different length groups of *M. kannume* from the Nile at Assiut, Egypt

	Males			Females		
		GSI	GI		GSI	GI
Length groups	No.	X±SD (min.-max.)	X±SD (min.-max.)	No.	X±SD (min.-max.)	X±SD (min.-max.)
16	3	0.87±0.46 (0.6-1.4)	7.1±2.8 (4.9-10.2)	1	3.30	148.00
20	18	0.61±0.4 (0.2-1.4)	6.3±3.4 (2.2-13.8)	4	2±0.8 (0.9-2.7)	54±26 (19.5-82)
24	14	0.77±0.3 (0.2-1.1)	7.5±3.1 (2.2-11.6)	7	1.2±0.4 (0.8-1.9)	20.7±8 (13-37)
28	10	0.4±0.3 (0.1-1)	4.1±3.1 (0.9-10.3)	13	3±1.8 (0.9-6.2)	40±24 (12.3-78)
32	13	0.47±0.4 (0.1-1.5)	4.1±3.7 (0.8-13.7)	26	2.7±2.8 (0.6-14.5)	28±30 (5.6-151)
36	22	0.26±0.2 (0.1-8.7)	2.3±1.6 (0.4-5.3)	20	3.4v2.8 (0.6-10.9)	28.9±24 (5.6-94)
40	16	0.22±0.17 (0.03-0.5)	2±1.4 (0.3-5.1)	11	2v1.1 (0.6-4.5)	13±6.7 (3.9-26.7)
44	5	0.34±0.3 (0.1-0.8)	3±3.4 (0.8-9.1)	3	1.7±1.4 (0.9-3.3)	8.2±7 (3.8-16.5)

Table 9: Monthly variation with gonadosomatic index and gonad index of males and females of *M. kannume* from the Nile at Assiut, Egypt

	Females				Males			
Months	No.	SL	GSI	GI	No.	SL	GSI	GI
Nov.2000	6	27-38	3.6±2.7 (0.9-8.6)	33.9±23.9 (12.7-69.9)	6	19-46	0.5±44 (0.2-1.3)	4.0±4.0 (1.9-11.6)
Dec.	6	28-40	4.4±2.0 (0.9-6.2)	48.0±28.7 (8.3-78.8)	4	21-36	0.4±0.3 (0.2-0.8)	4.0±3.0 (1.9-8.6)
Jan.2001	8	21-35	4.3±5.4 (0.5-14.5)	43.5±51.7 (5.6-151.1)	4	20-44	0.8±0.5 (0.4-1.4)	7.7±5.0 (2.1-13.8)
Feb.	6	23-47	1.5±1.0 (0.9-3.6)	17.5±14.4 (3.9-45.6)	6	28-40	0.5±0.3 (0.2-1.0)	4.8±3.2 (1.7-10.3)
Mar.	3	25-41	1.5±0.07 (1.5-1.4)	14.5±9.5 (9.6-8.7)	12	20-39	0.5±0.3 (0.2-1.1)	4.8±3.0 (0.8-10.3)
Apr.	2	27-30	1.5±0.5 (1.2-2.0)	19.0±8.8 (12.9-25.4)	3	24-32	0.7±0.1 (0.6-0.9)	6.9±1.8 (4.9-8.1)
May	6	15-34	2.3±0.6 (1.5-3.3)	55.6±48.7 (14.2-148.1)	12	16-37	0.5±0.2 (0.3-1.1)	5.4±2.5 (2.9-11.6)
Jun.	4	18-30	2.0±0.9 (0.8-2.8)	36.2±31.6 (13.4-82-3)	8	17-31	0.5±0.4 (0.1-1.1)	5.0±4.3 (1.0-11.3)
Jul.	7	33-38	3.3±2.6 (1.0-7.0)	27.6±22.6 (8.9-61.1)	3	18-36	0.35±0.4 (0.1-1.0)	4.1±5.4 (1.0-10.3)
Aug.	17	24-45	2.5±1.5 (0.9-6.5)	24.8±15.7 (6.2-67.1)	11	21-40	0.2±0.3 (0.03-1.1)	2.7±3.3 (0.3-11.6)
Sept.	16	27-48	1.9±1.3 (0.6-4.6)	17.0±14.2 (3.9-62.5)	25	17-40	0.35±0.4 (0.1-1.5)	3.2±3.5 (0.4-13.7)
Oct.	4	26-38	2.9±1.4 (0.9+4.2)	29.4±23.1 (7.9-61.5)	7	23-46	0.4±0.2 (0.1-0.8)	3.7±2.1 (0.8-6.6)

Table 10: Egg diameter, GSI and GI in different length groups of *M. kannume* from the Nile at Assiut, Egypt

		Egg diameter (µ)	GSI	GI
Length groups	No.	X±SD (Min-Max)	X±SD (Min-Max)	X±SD (Min-Max)
20	2	2040±1036 (1308-2773)	2.7±1.1 (1.9-3.5)	29±9.6(23-36)
24	4	2144±662 (1278-2841)	3.9±2 (1.7-5.9)	36±19(16-54)
28	9	1499±544 (723-2349)	3.0±2.3 (1.1-7.3)	28±25(9-73)
32	17	1409±541 (738-2526)	2.2±1.4 (1-5.5)	23±15(7.6-56)
36	18	1297±563 (692-2503)	2.2±2 (1-8.6)	20±15(9-70)
40	8	1577±760 (723-2715)	2.8±2.7 (0.5-7.1)	26±23(4.6-65)
44	1	2483	2.2	16.7

Gonadosomatic (GSI) and Gonad (GI) Indices: The basic statistics of GSI and GI are shown in Tables 8 and 9 for males and females of *M. kannume*. The distributions of GSI and GI categories (Table 8) show variability among length groups. For females (N = 85), GSI (ungrouped data) was significantly correlated with SL (R = 0.77) and insignificantly with body weight (W) (-0.16), whereas GI (ungrouped data) exhibited no significant correlation (R = 0.04) with SL and positive significant correlation with body weight (R = -0.42). GSI and GI were weakly correlated (R = 0.43). Gonad weight (GW) was significantly correlated with SL (R = 0.69) and insignificantly correlated with W (R = -0.06). For males (ungrouped data, N = 101), GW, GSI, GI were significantly correlated with SL (R = 0.38, -0.50 and -0.53, respectively) and W (R= 0.42, -0.46 and -0.46, respectively). GSI and GI were highly correlated (R = 0.97). The last categories with higher magnitudes of GSI and GI were represented by low or zero percent for females. Similar situation was recorded for males especially for GSI (Table 9). In addition to these findings, GSI and GI exhibited monthly variations with regards to their values ($p<0.0001$) and categories distribution.

Fecundity: Basic statistics of Egg Diameters (ED) of mature *M. kannume* females and the corresponding GSI and GI are given in Table 10. No significant variability in average Egg Diameter (ED) with increase of fish size (R^2 = -0.13) for ungrouped data (N = 59); ED was significantly correlated with GW, GSI and GI (R = 0.50, 0.62 and 0.62, respectively). Monthly variations in ED were evident ($p<0.0001$) with similar variability in GSI and GI (Table 11). ED has its highest values in April and May and its lowest values in November and December (corresponding to highest fecundity). No association between ED and age groups ($p<0.05$) whereas ED showed variability among maturity stages ($p<0.0001$).

Fecundity (F) and relative fecundity with Respect to Length (RFSL), were significantly correlated with SL for grouped (R = 0.995) and 0.984, respectively) and

Table 11: Monthly average with egg diameter of females of *M. kannume* from the Nile at Assiut, Egypt

Months	No.	Egg diameter (μ) X±SD (Min-Max)	GSI X±SD (Min-Max)	GI X±SD (Min-Max)
Nov. 2000	10	749±56 (692-848)	2±1.0 (1-3)	15±7 (10-34)
Dec.	3	800±46 (773-853)	2±0.10 (1-2)	16±3 (12-19)
Jan. 2001	6	1249±77 (1126-1314)	2±0.6 (0.5-3)	14±7 (4.6-21)
Feb.	6	1600±90 (1480-1743)	3±2.00 (2-5)	32±12 (14-47)
Mar.	6	1863±324 (1278-2132)	4±3.00 (1-8.6)	39±21 (8-70)
Apr.	6	2416±114 (2225-2526)	5±2.00 (2-7)	44±23 (17-73)
May	4	2754±68 (2688-2841)	5±2.00 (2-7)	50±19 (23-65)
Jun.	2	1980±609 (1549-2411)	1±0.20 (1.2)	10±1 (9-11)
Jul.	1	1278	2	16
Aug.	3	198±196 (1263-1623)	3±2.00 (1-4)	28±15 (11-37)
Sept.	6	1294±277 (848-1623)	1±0.02 (1-2)	11±2 (9-15)
Oct.	6	1275±376 (773-1623)	1.1±0.20 (1-1.3)	12±2 (9-15)

Table 12: Fecundity variation with Length groups of *M. kannume* from the Nile at Assiut, Egypt

SL	No.	F (X±SD)	RF (X±SD)
20	2	1878±608 (648-2860)	102.53±24 (32-80.8)
24	4	2528±968 (1540-4200)	105.62±41.9 (57-175)
28	9	4624±3001 (1550-9652)	164.56±102 (51.7-320)
32	17	5835±40449 (1750-16800)	184.39±116 (54.6-480)
36	18	8366±6451 (3700-19380)	241.50±169 (97.3-510)
40	8	10306±24789 (4912-15456)	261.86±65 (242-386)
44	1	13148	280

Table 13: Fecundity variation with weight groups of *M. kannume* from the Nile at Assiut, Egypt

Weight	No.	F	RFW
100	2	1878±1739.5 (648-3108)	29.3±31.8 (2.8-51.8)
200	9	2536.8±9.19 (1330-4200)	17±7.1 (7.7-32.3)
300	10	6006±2681 (1750-9000)	25±12.4 (7-42.9)
400	22	7438.2±4131 (1550-16800)	21±11.3 (4.7-48)
500	9	8672±5465 (3500-19380)	19±11.2 (7.8-38.8)
600	3	11052±4428.2 (6600-15456)	19.4±7.6 (11-25.8)
700	2	10356±628 (9912-10800)	15.4±1.7 (14.2-16.7)
800	1	13500	15

ungrouped data (R = 0.653 and 0.450, respectively, N = 59). Fecundity, also showed significant association with W for grouped and ungrouped data (R = 0.958 and 0.579, respectively) whereas the Relative Fecundity (RFW) exhibited no significant correlation (R = -0.887 and -0.135 for grouped and ungrouped data, respectively). SL-F, SL-RFSL, W-F and W-RFW relationships were estimated for the grouped and ungrouped data as follow:

Ungrouped data	Grouped data
$F = 0.2484\ SL^{2.8926}$ ($R^2 = 0.426$)	$F = 0.8867\ SL^{2.5421}$ ($R^2 = 0.99$)
$RFSL=0.2485\ SL^{1.8926}$ ($R^2 = 0.241$)	$RFSL = 8.2237\ SL -71.699$ ($R^2 = 0.97$)
$F = 17.11\ W+ 993.36$ ($R^2 = 0.335$)	$F = 1887.5\ W^{0.0027}$ ($R^2 = 0.98$)
$RFW= -0.0103W+24.06$ ($R^2 = 0.0183$)	$RFW = -0.0152\ W+ 26.857$ ($R^2 = 0.58$)

These findings referred to the correlation of fecundity with SL even after standardization but no significant correlation with W and RFW. For transformation, the relationship between SL and TL are given by the following Equations:

$$TL = 0.7392+ 1.092639\ SL \text{ and } SL= -0.19276 +0.091776\ TL \quad (N = 59)$$

Fecundity and relative fecundity showed variability among length groups (Table 12), weight groups (Table 13) and months (Table 14). Absolute fecundity has its lowest values in June and July and its highest value in December ($p<0.0001$). There are no association between fecundity and maturity stages and fish condition factor ($p<0.05$). The fecundity increased with age groups and has its highest values in age group I and II and its lowest one in age VI ($p<0.0001$) (Table 15).

Stepwise multiple linear equation of fecundity: The relationship between absolute fecundity and SL, W, Age, GW, M, ED, GSI, Kn, Kc and GI were best described in a multivariate sense. The backward stepwise multiple linear regression referred to SL, ED and GI to be the best factors controlling the fecundity. So, fecundity and relative fecundity (per cm) can be estimated by the following equation ($p<0.0001$ for all parameters):

$$F = -9699.3+514.7*SL-2.89*ED+174.3*GI \quad (\text{multiple } R2 = 0.657)$$

with partial correlations of 0.72, -0.49 and 0.69 for SL, ED and GI versus normal correlation of 0.59, -0.06 and 0.38, respectively.

Table 14: The relationship between the months and absolute and relative fecundities of *M. kannume*, from the Nile at Assiut, Egypt

Months	No.	SL	F X±SD (Min-Max)	RFSL X±SD (Min-Max)	RFW X±SD (Min-Max)
Nov. 2001	10	27-41	7722±4037 (3304-14760)	227±111.4 (122-447)	21.4± 8 (14-37.8)
Dec.	3	34-38	12623±6811 (5760-19380)	348±170.8 (169.4-510)	27±11.4 (16-38.8)
Jan. 2002	6	27-38	7259±5066 (2600-14280)	215.5±142.1 (92.9-420)	22.7±11.7 (7.8-37)
Feb.	6	28-40	8402±4307 (2170-15456)	257±103.8 (77.5-480)	24.9±8 (11-32)
Mar.	6	24-35	7628 ± 5109 (1750-16800)	2334±138.7 (54.7-278)	24.3±14 (7-48)
Apr.	6	23-47	8121±3719 (1860-13148)	2465±88.9 (80.8-320)	27.5±11.6 (16-43)
May	4	20-41	6317±5418 (648 -11100)	1715±119.6 (32-278)	15.8±6.3 (6.8-21.3)
Jun.	2	27-30	1545±7.1 (1540-1550)	55.0±3.74 (51.7-57)	6.2±2.1 (4.7-7.7)
Jul.	1	23	1330	57.8	12
Aug.	3	18-30	4069±2588 (2100-7000)	159±82.6 (70-233)	28.6±22.9 (23-52)
Sept.	6	33-38	4117±14487 (2800-6600)	1172±34.7 (82.3-174)	9.7±1.4 (8-11.7)
Oct.	6	31-38	5118±1395 (2450-6200)	1531±40.1 (79-188)	12.4±3.7 (7.3-15)

Table 15: Relationship between age and some characters of *M. kannume* from the Nile at Assiut, Egypt

Age	No.	F	RFSL	RFW	Egg diameter (μ)
I	2	2329±1102 (648-3108)	112±86 (65-173)	28±33 (4.7-51.8)	1860±780 (1308-2411)
II	5	2394±1344 (1840-4200)	91±55 (32-175)	17±10 (6.8-32.0)	2324±537 (1549-2841)
III	10	5182±2628 (2170-9000)	181±91 (78-320)	25±11 (11-42.8)	1430±569 (722-2349)
IV	26	7028±4267 (2330-16800)	210±123 (55-480)	20±11 (6 -48)	1319±457 (692-2526)
V	14	10544±6319 (3700-19380)	248±115 (97-510)	19±9.0 (7 - 38.8)	1527±733 (862-2715)
VI	2	11530±2288 (9912-13148)	261±27 (242-280)	15±2.0 (14-16.4)	1603±1245 (723-2483)

Table 16: Comparisons of fecundity and relative fecundity length and weight equation of *M. kannume* and *caschive* with Aly (1993) from Lake Nasser, Egypt

Locality	Equation
Present work (2007) (*M. kannume*)	$F = 0.2484\ SL^{2.8926}$ ($R^2 = 0.426$)
	$F = 17.11\ W + 993.36$ ($R^2 = 0.335$)
	$RFSL = 0.2485\ SL^{1.8926}$ ($R^2 = 0.241$)
	$RFW = -0.0103 + 24.055$ ($R^2 = 0.0183$)
Lake Nasser Aly (1993) (*M. kannume*)	$F = 0.06535\ SL^{3.8988}$
	$F = 0.8937\ W^{1.291}$
	$RF\ SL = 0.06313\ SL^{2.9246}$
	$RFW = 0.9133\ W^{0.2813}$
Lake Nasser Aly (1993) (*M. caschive*)	$F = 0.25182\ SL^{3.0642}$
	$F = 0.93196\ W^{1.2798}$
	$RF\ SL = 5.0836\ SL - 109.9$
	$RFW = 0.98128\ W^{0.2653}$

Table 17: The relationship between average fecundity with length groups of *M. kannume* and *M. caschive* from different locality

	M. kannume					*M. caschive*	
	Present work			Aly (1993)		Aly (1993)	
Length	No.	Mean	Range	No.	Mean	No.	Mean
16							
18							
20	2	1878	1648-2860				
24	4	2528	1540-4200	6	962		
28	9	4624	1550-9652	8	1810	4	1268
32	17	5835	1750-16800	27	4071	16	3208
36	18	8366	3700-19380	20	5390	18	3947
40	8	10306	4912-15456	6	7458	8	6303
44	1	13148	13148	6	9816	2	8969
46				3	5818	6	10362
48						3	14421

$$RFSL = -111.067+10.083*SL-0.098*ED+5.583*GI$$
(multiple R2 = 0.631)

with partial correlations of 0.70, -0.57 and 0.74, respectively. The other variables have no significant contribution in these models and so are excluded.

DISCUSSION

In the case of choosing a freshwater species for farming, sex ratio must be on the top of production considerations such as dividing resources between male and female reproduction in terms of sex allocation theory (Charnov, 1982). West *et al.* (2000) reported that

Individuals facultatively adjust their offspring sex ratios in response to local conditions. Such sex ratios are generally dealt with reproduction studies for identifying the sexual behaviour of the fish understudy during different months of the year (Shenouda *et al*., 1994). The ideal value of sex ratio is 1: 1 (Hashem, 1972, 1973). But such value may vary yearly (Latif and Shenouda, 1973), seasonally (Shenouda, 1985; Downs and White, 1997), monthly (Nural-Amin *et al*., 2005; Laleye *et al*., 2006), or according to gear types, species of the same family (El-Shafey and Selim, 1998), length group (Dulcic and Kraljevic, 1996; Dulcic *et al*., 2003) and environmental factors such as temperature (Bohlen *et al*., 2008). In general, male may prevail in some populations (Mckenzie, 1974; Downs and White, 1997; Bohlen *et al*., 2008) or females in other ones (Lukens, 1978; Salem and Mohamed, 1982; Dulcic and Kraljevic, 1996; Dulcic *et al*., 2003; Nural-Amin *et al*., 2005; Ilkyaz *et al*., 2006). Sex ratios are balanced in other fish species (Hashem, 1972, 1973; Bohlen *et al*., 2008). In an adaptive hypothesis, Fisher (1930) suggested that equal sex ratios may be the results of natural selection when the sexes cost the same to produce resulting in a balance of investment between males and females.

Some Mormyrus populations from two different Egyptian localities, the Nile at Assiut (present study) and a lacustrine one, Lake Nasser (Aly, 1993) show variability in sex ratio to a certain degree. *M. kannume* population of Assiut exhibited overall sex not departed from the expected ratio 1:1 whereas those of Lake Nasser departed significantly; significant association was recorded between sex ratio and length groups in both populations. Such association was recorded between sex ratio and months for Lake Nasser population ($p<0.05$) but not for Assiut population. Sex ratio of Lake Nasser ranged from 1: 0.12 to 1:1.58 with departure from expected value (1:1), >48. Such ratio ranged from 1:0.45 to 1: 1.09 with departure from expected value in May-June and Sept.-Oct. *M. caschive* of Lake Nasser reflected similar variability (1:0.58-1:3) with departure from expectation in length group >48 and May-June only with significant association between sex and both length groups and months; no deviation in the overall sex ratio (1:0.99) from the ratio 1:1. These patterns of variations between Assiut and Lake Nasser population reflect time and locality factors and referred to the action of natural selection on the overall sex ratio.

The assessment of fecundity is the corner stone of the reproductive biology since it is not a stable character due to changes in enviromental conditions and species specific factors (Nikolsky, 1963; Khallaf and Authman, 1991; Shenouda *et al*., 1995). Sometimes, there are variability in fecundity for the same species in the some fisheries and in different years (Latif and Shenouda, 1973). Reproductive biology of *M. kannume* show variability under the spectrum of variations in the ecological and environmental condition of the aquatic ecosystem. Some authors (e.g., Ashour *et al*., 1990a) studied the reproductive cycle of that species in terms of the seasonal histological analysis of its ovary. Scott (1974) referred to *M. kannume* to be monoestrous. Okedi (1970), Scott (1974), Ashour *et al*. (1990b), Zaher *et al*. (1991) and Aly (1993) referred to variability of spawning season length of *M. kannume*. Okedi (1970) considered Mormyrids as anadromous spawners and the stimuli for annually twice spawning periods to be flood-associated. In Lake Victoria, ripe gonads of *M. kannume* in all months except July and August (Okedi, 1970). Ashour *et al*. (1990b) stated that spawning season of that species is fractional and extend for a long period (from May to August with peaks in June and July) in the Nile at Beni suef, Egypt. Zaher *et al*. (1991) reported a spawning stage extending from May to July. Aly (1993) reported a summer spawning season for *M. kannume* and *M. cashive* (especially June-July) in Lake Nasser, Egypt. In the Nile at Assiut (present study), the spawning season of *M. kannume* extend allover the year as reflected by maturity stage distribution and gonadosomatic index with overall increasing magnitudes (Table 9).

Size at maturity (Lm) of *M. kannume* show variability among sex and localities. In Lake Nasser, Lm of that species was calculated by the author based on Aly (1993) data to be 46.6, 31.8 and 36.7 for males, females and combined sex, respectively. In the Nile at Assiut, Egypt (present study), Lm was 31.5, 31.7 and 31.6 for males, females and combined sex, respectively. Reviewing Lm recorded for different Mormyrus species in Fishbase web site data variability in size at first maturity was evident even for species of the same length range. Such variability in Lm may be affected by several physical and biological factors in time and fisheries in addition to the fishing efforts. Froese and Binohlan (2000) suggested that fish generally optimize their mean Lm to coincide with the length class of maximum fecundity. Binohlan (1998) also suggested that fishes of about 200 cm maximum size mature at about 100 m (i.e., reproductive load of Lm/L_∞ to be 0.5). In the present work, the reproductive load was 0.748, 0.754 and 0.595 for males, females and combined sexes which is relatively higher. Such reproductive load is suggested to be determined by the species-specific gill surface area (Pauly, 1998). The low area explains the slow growth and is correlated with breathing difficulties especially in warm waters.

The relationship between fecundity, relative fecundity and fish size and weight of *M. kannume* and *M. cashive* according to the present author and Aly (1993) may be described by a power function or a linear regression (Table 16). Fecundity-age relationships of *M. kannume* were: F = 1561.9 $A^{1.24}$ (R^2 = 0.99) and F = 2065.7 A-728.9 (R^2 = 0.95) from Lake Nasser and the Nile at Assiut.

Fecundity of *M. kannume* of the Nile at Assiut ranged between 648-19380 (6794±4339). The average means of fecundity within different length groups of Table 17 reflects the high fecundity of *M. kannume* at the Nile, in comparison with Lake Nasser. Aly (1993) recorded a fecundity mean of 1601 to 6363 corresponding to age groups of III to V, respectively in Lake Nasser in comparison to 2329 to 11530 for the groups I to VI, respectively for *M. kannume* of the Nile at Assiut.

The egg diameter of *M. kannume* exhibited monthly variability as well as variations with fish size and age (Tables 10, 11,15). The overall range of egg diameter of *M. kannume* of the Nile was 0.69 to 2.84 mm. El-Etriby (1985) reported a maximum egg diameter of 2.38 mm for the same species in Lake Nasser. Ashour *et al*. (1990a) and Zaher *et al*. (1991) refered to a maximum diameter of 1.03 mm with an average of 0.95 mm for mature egg of *M. kannume* from the Nile at Beni-Suef. Aly (1993) recorded a maximum egg diameter of 2.55 mm for *M. kannume* and of 2.46 mm for *M. cashive* from Lake Nasser. ED represents one of the important factors that influence fecundity. So, in multivariate sense, fecundity and relative fecundity are found to be affected by fish size, egg diameter and gonad index whereas other characters considered have insignificant effects on controlling fecundity of *Mormyrus kannume*; models are given for their future prediction.

REFERENCES

Aly, A.M., 1993. Biological Studies on Mormyrid Fishes of the High Dam Resrvoir. M.Sc. Thesis, Assiut Univ., Egypt.

Ashour, M.B., M.M. Zaher and S. Rida, 1990a. Ecological studies on the female reproductive cycle of some fishes of the River Nile, at Beni Suef Area. J. Egypt. Ger. Soc. Zool., 2: 347-360.

Ashour, M.B., M.M. Zaher and S. Rida, 1990b. Ecological studies on the female reproductive cycle of some fishes of the River Nile, at Beni Suef Aria. J. Egypt. Ger. Soc. Zool., 2: 273-286.

Bagenal, T.B. and F.W. Tesch, 1978. Age and Growth. In: Methods for Assessment of Fish Production in Freshwater, Bagenal, T.B. (Ed.)., Blackwell Scientific Publications, Oxford and Edinburgh, pp: 101-136.

Binohlan, C., 1998. The Maturity Table. In: FishBase 98: Concepts, Design and Data Sources, Froese, R. and D. Pauly (Eds.). ICLARM, Manila, pp: 176-179.

Bohlen, J., J. Freyhof and A. Nolte, 2008. Sex ratio and body size in *Cobitis elongatoides* and *Sabanejewia balcanica* (Cypriniformes; Cobitidae) from a thermal spring. Folia Zool., 57: 191-197.

Charnov, E.L., 1982. The Theory of Sex Allocation. Princeton University Press, New Jersy.

Cody, M.L., 1966. A general theory of clutch size. Evolution, 20: 174-184.

Derios, R., I.T. Quinn and P. Neal, 1985. Catch-age analysis with auxiliary information. Can. J. Fish. Aquat. Sci., 42: 845-854.

Downs, C.C. and R.G. White, 1997. Age at sexual maturity, sex ratio, fecundity and longevity of isolated headwater populations of westslope Cutthroat trout. North, Am. J. Fish. Manage., 17: 85-92.

Dulcic, J. and M. Kraljevic, 1996. Weight-length relationships for 40 fish species in the Eastern Adriatic (Croatian waters). Fish. Res., 28: 243-251.

Dulcic, J., A. Pallaroro, P. Cetinic, M. Kraljevic, A. Soldo and J. Jardas, 2003. Age, growth and mortality of picerel, *Spicara smaris* L. (Pisces: Centracnthidae), from the Eastern Adriatic (Croatian coast). J. Applied Ichthyol., 19: 10-14.

El-Etriby, S.G., 1985. Biological studies on *Mormyrus kannume* forsk. In: Lake Nasser. Proceedings of 1st International Conference on Applied Science, March 30-April 1, 1985, Zagazig. Univiversity, Zagazig, Egypt,.

El-Shafey, A. and F. Selim, 1998. Fecundity, sex ratio of some freshwater fishes in the Egyptian Mediterranean waters. Bull. Inst. Oceanogr. Fish. A.R.E., 11: 20-26.

Fisher, R.A., 1930. The Genetical Theory of Natural Selection. 1st Edn. Oxford University Press, Oxford, UK.

Foale, S. and R. Day, 1997. Stock assessment of trochus (*Trochus niloticus*) (Gastropoda: Trochidae) fisheries at West Nggela, Solomon Islands. Fish. Res., 33: 1-16.

Froese, R. and C. Binohlan, 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. J. Fish Biol., 56: 758-773.

Gabriel, W.L., M.P. Sissenwine and W.J. Overholtz, 1989. Analysis of spawning stock biomass per recruit: An example for Georges Bank haddock. N. Am. J. Fish. Manage., 9: 383-391.

Gayanilo, F.C., P. Sparre and D. Pauly, 2005. FAO-ICLARM Stock Assessment Tools II: FiSAT II: User's Guide. World Fish Center, 2005, Rome.

Hashem, M. T., 1972. The age, growth and maturity of *Labeo niloticus*, Forskal. from the Nozha Hydrodrome in 1968-1970. Bull. Ins. Oce. and Fish., A.R.E, 2: 1-22.

Hashem, M.T., 1973. The feeding and fatness of *Labeo niloticus* Forsk. Bull. Inst. Oceanogr. Fish. ARE., 3: 83-94.

Hilborn, R. and C.J. Walters, 1992. Quantitative Fisheries Stock Assessment, Choice, Dynamics and Uncertainty. Chapman and Hall, London, Pages: 570.

Ilkyaz, A.T., K. Firat, S. Saka and H.T. Kinacigil, 2006. Age, growth and sex ratio of Golden Grey Mullet, Liza aurata (Risso, 1810) in Homa Lagoon (Izmir Bay, Aegean Sea). Turk. J. Zool., 30: 279-284.

Khallaf, E.A. and M. Authman, 1991. Growth and mortality of *Bagrus bayad* (Forskal) in Bahr Shebeen Canal. J. Egypt. Ger. Soc. Zool., 4: 87-109.

Khallaf, E.A., 1986. Reproduction of *Tilapia nilotica* and *Tilapia zillii* in a Nile canal and its interaction with the environment. Delta J. Sc. Tanta Univ., 10: 724-747.

Koslow, J.A., J. Bell, P. Virtue and D.C. Smith, 1995. Fecundity and its variability in orange roughly: Effects of population density, condition, egg size and senescence. J. Fish Biol., 47: 1063-1080.

Laleye, P., A. Chikou, P. Gnohossou, P. Vandewalle, J.C. Philippart and G. Teugels, 2006. Studies on the biology of two species of catfish *Synodontis schall* and *Synodontis nigrita* (Ostariophysi: Mochokidae) from the Oueme River, Benin. Belg. J. Zool., 136: 193-201.

Latif, A.F.A. and T.S. Shenouda, 1973. Studies on *Saurida undosquamis* (Richadson) from the Gulf of Suez, Monthly peculiarities of gonads. Bull. Inst. Oceanogr. Fish. A.R.E., 3: 295-335.

Lukens, J.R., 1978. Abandance movements and age structure of adfluvial westslope cutthroat trout in the Wolf Lodge Creek drainage Idaho. M.Sc Thesis, Univ. Idaho. Moscow.

Mckenzie, R. A., 1974. Smelt life history and fishery in Miramachi River, New Brunswick. Fisheries Research Board of Canada, Canada, Pages: 77.

Mekkawy, I.A.A. and A.A. Hassan, 2011. Some reproductive parameters of *Synodontis schall* (Bloch and Schneider, 1801) from the River Nile, Egypt. J. Fish. Aquat. Sci., 6: 456-471.

Morgan, M.J., 2008. Integrating reproductive biology into scientific advice for fisheries management. J. North. Atl. Fish. Sci., 41: 37-51.

Nikolsky, G.V., 1963. The Ecology of Fishes. Academic Press, London and New York, pp: 352.

Nural-Amin, M.S., A. Arshad, C.G. Haldar, S. Shohaimi and A. Ara, 2005. Estimation of size frequancy distribution, sex ratio and length-weight relationship of Hilsa (*Tenulasa ilisha*) in the Bangladesh water. Res. J. Agric. Biol. Sci., 1: 61-66.

Okedi, J., 1970. A study of the fecundity of some Mormyrid fishes from Lake Victoria. East-Afr. Agric. For. J., 35: 346-442.

Pauly, D., 1998. The Gill Area Table. In: FishBase 98: Concepts, Design and Data Sources, Froese, R. and D. Pauly (Eds.). ICLARM, Manila, Philippines, Pages: 293.

Pianka, E.R., 1976. Natural selection of optimal reproductive tactics. Am. Zool., 16: 775-784.

Quinnll, I.T., R. Fagen and J. Zheng, 1990. Threshold management policies for exploited populations. Can. J. Fish. Aquat. Sci., 47: 2016-2029.

SPSS, 1998. SPSS for Windows, Release 9.0.0. SPSS Inc., USA.

Salem, S.A. and S.Z. Mohamed, 1982. Studies on *Mugil seheli* and *Mugil capito* in Lake Timsah 1-Age and growth. Bull. Inst. Oceanogr. Fish, ARE., 8: 29-48.

Saville, A., 1964. Estimation of the abundance of a fish stock from egg and larvae surveys. ICES Rapp. Proc. Verb., 155: 164-173.

Scott, D.B., 1974. The reproductive cycle of *Mormyrus kannume* Forskal. (Osteoglossomorpha, Mormyriformes) in Lake Victoria Uganda. J. Fish. Biol., 6: 447-454.

Scrimgeour, G.J. and G.A. Eldon, 1989. Aspects of the reproductive biology of torrentfish, Cheimarrichthys fosteri, in two braided rivers of Canterbury, New Zealand. N. Z. J. Marine Freshwater Res., 23: 19-25.

Shenouda, T.S., 1985. Sexual maturity, spawning and postspawning behaviour of *Mullus barbatus* (Linne) after building the high Dam. Delta. J. Sci., 9: 236-325.

Shenouda, T.S., A.A. Massoud and M.E. Mahfouz, 1995. Spawning indices and fecundity of *Clarias lazera* (CUV. and VAL.) in Rosetta Branch of the River Nile. J. Egypt Ger. Soc. Zool., 17: 65-92.

Shenouda, T.S., F.F. Abass, M.M. Rashid and F.M. Mokhtar, 1994. Food and feeding habits of two *Chrysichthys* sp. (Fam. Bagridae) from Aswan reservoir. J. Egypt. Ger. Soc. Zool., 13: 147-167.

Statsoft, 1995. Statistica for Windows. Stasoft, Inc., Tulsa, OH., USA.

Wang, S.P., C.L. Sun and S.Z. Yeh, 2003. Sex ratios and sexual maturity of swordfish (*Xiphias gladius* L.) in the waters of Taiwan. Zoolog. Stud., 42: 529-539.

West, S.A., E.A. Herre and B.C. Sheldon, 2000. The benefits of allocating sex. Science, 290: 288-290.

Willbur, H.M., 1977. Propagule size, number and dispersion pattern in *Ambstoma* and *Asclepias*. Am. Naturalist, 111: 43-48.

Williams, G., 1966. Adaptation and Natural Selection. Princeton University Press, Princeton, New Jersey, USA.

Zaher, M.M., M.B. Ashour and S. Rida, 1991. Ecological studies on the female reproductive cycle of some fishes of the River Nile, at Beni Suef Area. J. Egypt. Ger. Soc. Zool., 3: 313-334.