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COMPARITIVE REPRODUCTIVE BIOLOGY OF THE NILE TILAPIA *OREOCHROMIS NILOTICUS* (L.), BLUE TILAPIA, *Oreochromis aureus* (Steind.) AND THEIR HYBRIDS IN LAKE EDKU, EGYPT

Shnoudy A. Bakhoum
National Institute of Oceanography and Fisheries, Alexandria, Egypt

Key words: Reproductive biology, *O. niloticus*, *O. aureus*, hybrids, Lake Edku.

ABSTRACT

The reproductive biology of *Oreochromis niloticus*, *O. aureus* and their hybrids from Lake Edku was examined. Female and male sex ratio is 1:1.07 for Nile tilapia (*O. niloticus*), 1:1.20 for blue tilapia (*O. aureus*) and 1:1.37 for hybrids. Length at first sexual maturity is 9.4cm (TL) for males and 10.3 cm (TL) for females of *O. niloticus*. The corresponding values for males and females of *O. aureus* are 8.2 and 9.2 cm respectively, while for hybrids these values are 8.2 cm for males and 8.4 cm for females. The breeding season of Nile tilapia extended from April to September with a peak of gonadosomatic index (GSI) in May, whereas in case of blue tilapia and hybrids, it extended from February until November with a maximum value in May. For all fish groups, the fecundity showed curvilinear relationship to fish length, body weight and ovary weight. The present study revealed that blue tilapia and hybrids are markedly less fertile than Nile tilapia.

INTRODUCTION

Tilapias have a great economic importance in the Egyptian fisheries; constituting about 26.71% of the total catch of the country, 88.40 % of total annual inland catch and representing 78.46% of the fish catch in Lake Edku (GAFRD, 1999).

Congeneric species of fish often hybridize in nature (Hubbs, 1955 and Schwartz, 1972). Numerous examples of this phenomenon have been documented for the genus *Salmo* (Payne *et al.*, 1972; Soloman &Child, 1978 and Beland *et al.*, 1981) and for tilapias (Welcomme, 1964; Fryer & Iles, 1972 and Agnese *et al.*, 1998). In all Egyptian brackish Lakes some specimens of tilapias were found with external appearance, intermediate to Nile tilapia (*Oreochromis niloticus*) and blue tilapia (*Oreochromis aureus*), the morphological features of these specimens agree with features of artificial hybrids which were obtained from crossing between *O. niloticus* and *O. aureus* (Haroun, 1999). However, Bakhoum (2002) in his study on this phenomenon in Lake Edku confirmed the hybrid nature of tilapias.

Therefore, the aim of the present work was to compare the reproductive biology of Nile tilapia (*O. niloticus*), blue tilapia (*O. aureus*) and their hybrids from Lake Edku. This has been achieved by determining the differentiation in sex ratio, monthly distribution of maturity stages, length at first sexual maturity, gonadosomatic index, oocyte diameter and fecundity.

MATERIAL AND METHODS

Lake Edku is situated in the northern part of the Nile Delta. It lies at about 30 km to the northern east of Alexandria, at latitude 30° 25́ N and longitude 31° 15́ E. It has a susface area of about 12,600 hectares (30,000 feddan) (Philips, 1994). A total of 451, 596 and 1028 specimens of *Oreochromis niloticus, Oreochromis aureus* and their hybrids respectively were collected by trammel nets from Lake Edku during the period from January to December 1999.The total length (TL) and gutted weight for each fish were recorded to the nearest mm and 0.1g respectively. Gonads were weighed at an accuracy of 0.01g. Samples of gonads were preserved in 10% formalin for fecundity and ova diameter studies. Maturity for each fish was assessed by six stages: immature, maturing, nearly ripe, ripe, spawning and spent (Sakun and Butskaya, 1968). Fecundity was estimated as the number of mature ova that are likely to be spawned, using ripe ovaries of the highest gonadosomatic index according to the method of Batts (1972). Oocyte diameter was measured using an eyepiece micrometer at 16x magnification and all measurements were then converted to millimeters.

RESULTS

Sex ratio

The overall ratio of females to males was 1:1.07 for *Oreochromis niloticus*, 1:1.20 for *Oreochromis aureus*, and 1: 1.37 for their hybrids (Table 1). Statistical analysis by chi-square test indicated that sex ratio was significantly different from the expected ratio of 1:1 in case of blue tilapia ($X2 = 4.868$, $p < 0.05$) and hybrid fish ($X2 = 8.418$, $p < 0.01$), but the sex ratio was not significant in case of Nile tilapia ($X2 = 0.517, p > 0.05$).

The sex ratio for the various fish groups showed significant difference between parental species ($X2 = 20.720, p < 0.01$). Furthermore the statistical analysis revealed significant differences between Nile tilapia and their hybrids ($X2 = 186.999, p < 0.01$) and blue tilapia and their hybrids ($X2 = 87.289, p < 0.01$).

Monthly distribution of maturity stages

Maturing individuals of both sexes for *O. niloticus* first appeared in November till the following July, while nearly ripe stages made their appearance from February to August. Ripe stages of males and females of this species were detected throughout the period from March to September, and the spawning stage was recorded from April to November for females and to October for males. The spent females and males were represented throughout the period from May to February (Figs. 1and 2).

For *O. aureus*, maturing gonads for females and males were found from November to the following August and nearly ripe stages were recorded from January to October. The first sign of ripe females and males was found in February and became dominant in May, decreased until August then increased in September-October, while the last sign of the ripe stage were recorded in November. Spawning and spent stages of both sexes appeared through the period from March and April to December, respectively (Figs.3 and 4).

It is obvious that individuals of the maturing stage for females and males of hybrid fish were represented throughout the period from November to the following August, while nearly ripe stages were found from January to October. Ripe ovaries and testes of hybrid fish showed the same representation such as blue tilapia. Also spawning and spent stages for both sexes appeared through the periods from March and April to December, respectively (Figs.5 and 6).

Length at first sexual maturity

The length at first maturity was estimated for the mature individuals of both sexes for each size group of the parental species and hybrid fish group as the total length at which 50% of the fish are mature (Figs.7, 8 and 9). The sizes of fish at first sexual maturity of Nile tilapia are 9.4 for males and 10.3cm (TL) for females, while the corresponding values for males and females of blue tilapia are 8.2 and

9.2 cm (TL) respectively. In case of hybrids, the sizes at first sexual maturity were 8.2 for males and 8.4 cm (TL) for females.

Gonadosomatic index (GSI)

The values of gonadosomatic (GSI) index for both sexes of *O. niloticus* began to increase from April, expressing the beginning of the breeding season, These values increased progressively to attain a majority of 1.02 for males and 2.78 for females in May. It dropped during June, then fluctuated and decreased in September, indicating the end of spawning season.

It seems that the breeding season of *O. aureus* extends from February until November, where two peaks are identified. The first peak extends from February to June with a peak in GSI values of 2.17 for males and 6.27 for females in May. The average (GSI) decreases in August to 0.71and 1.46 for males and females respectively. The second peak extends from August to November with maximum GSI values of 1.95 for males and 3.86 for females in October.

As the parental species, GSI values for hybrid fish groups were mostly higher for females than males. The results suggest that the breeding season of hybrids have the same spawning season of *O. aureus*, whereas it extends from February, until November, including two peaks. Gonadosomatic index attains its maximum values of 2.25 for males and 5.65 for females in May. There is a decline in GSI values for both sexes from June until August, then increases again to reach maximum values for the second peak of 1.67 for males and 3.04 for females in October, then declines indicating the end of spawning season in November (Figs.10).

Oocyte diameter

The frequency distribution of oocyte diameter in ripe ovaries of *O. niloticus, O.aureus* and hybrid fish groups in the pre spawning period are shown in Fig.11. The results indicate that *O. niloticus* and their hybrids have the same oocyte range from 0.3 to 3.0 mm, while the size of oocyte for *O. aureus* is larger, ranging in diameter from 0.3 to 3.1 mm. The frequency distribution of oocyte diameter of parental species and hybrids shows three batches of ova. The first one includes oocytes with a diameter ranging from 0.3 to less than 0.8 mm for Nile tilapia and blue tilapia and ranges from 0.3 to 1.0 mm for their hybrids. These are immature ova that represent the oocyte stock. The second batch contains the maturing oocytes ranging from 0.8 to less than 1.8 mm for *O. niloticus* and to less than 1.9 mm for *O. aureus*, while ranging from 1.0 to less than 2.0 mm in case of their hybrids. The third peak comprises well-developed transparent oocytes varying from 1.8 to 3.0 mm for *O. niloticus* and ranging from 1.9 to 3.1 mm for *O. aureus*, while it ranges from 2.0 to 3.0 mm for hybrids fish group.

Fecundity

The absolute and relative fecundities of parental species and their hybrid, groups are represented in Tables (2,3,4). The Nile tilapia was the most fertile, having the higher number of oocytes, ranging from 378 to 1324 eggs for fish of total length ranging between 9 to 21 cm, while blue tilapia was markedly less fertile, having absolute fecundity ranging from 310 to 976 eggs (9-18 cm TL). The absolute fecundity of hybrid specimens has intermediate values, ranging from 353 to 1369 eggs for total length ranging from 9 to 22cm.

To find the comparative relationship of fecundity with total length, body weight, and ovary weight, also between both of ovary weight and oocyte diameter, regression analyses were conducted and observed to be curvilinear. Analysis of covariance was employed to test if the regressions are significantly different for these fish groups, the logarithmic equations and significance levels are given in Table 5.

DISCUSSION

Species fertility is considered as an indicator of the reproductive strength of any fish species. It is defined as the number of eggs spawned in a year. This is controlled by several factors, such as length of the spawning period and its frequency, batch fecundity of individuals, number of females and length or age composition of the females (Ebisawa, 1997). The preponderance of males to females in *Oreochromis niloticus* and *Oreochromis aureus* in the present study is in agreement with the same species in Lake Borollus (El-Haweet, 1991), in Lake Mariut (EL-Shazly, 1993) and in Lake Edku for Nile tilapia (Philips, 1994). In case of the hybrid specimens, males were more abundant, and this may be attributed to that hybrid fish can be obtained mainly by two crosses, *O. niloticus* females X *O. aureus* males or *O. niloticus* males X *O. aureus* females and backcrosses. The first cross results in 80-90% males and is used commercially in Israel fish farms (Mires, 1977). It seems that this cross is responsible for males preponderance in Lake Edku. According to Wohlfarth and Hulata (1981), crossing females of Nile tilapia with males of different *Oreochromis* species produces hybrids containing high percentage of males, reaching 100% in some crosses. Badawy (1993) proved that the percentage of hybrid males obtained from the crossing between *O. aureus* males and *O. niloticus* females brought from the Nile was 89.5%, being higher than that obtained from the same crossing of El-Serow fish Farm (85.5%). The author attributed that to the effect of the relative genetic purity of these species.

Estimation of length at first sexual maturity is very important; Iles (1968) found that in any fish population, the mortality rate and the size at which maturity is achieved determine the proportion capable of reproduction and the relative reproductive potential. For many fish species, males attain their sexual maturity at smaller sizes than females (Cooper, 1983; Fouda *et al.*, 1993 and Philips, 1994). In the present study, the sizes at which males and females of *O. niloticus* attain their sexual maturity are 9.4 and 10.3 cm respectively. These values agree with finding of El-Haweet (1991) in Lake Borollus, while it agrees only for males with the results of Bishara (1973) in Lake Manzalah and Philips (1994) in Lake Edku. The males and females of *O. aureus* reach their first maturity at smaller sizes than *O. niloticus*. Similar results were reported in Lake Brollus (El-Haweet, 1991) and in Lake Manzalah (Shalloof, 1991). The size at first sexual maturity for hybrid males has the same value of blue tilapia males, while it was noticed that hybrid females become mature earlier at shorter lengths than parental species females.

The spawning season, can be defined by observing the mean monthly variation in the gonadosomatic index, whereas during spawning season, GSI reaches its maximum value. In the present study, the spawning season of *O. niloticus* extended from April to September with a peak during May. This finding is in agreement with those given by Maclaren (1981) and Philips (1994) in Lake Manzalah and Lake Edku respectively. They mentioned that it extended from April to September, while it starts from April to August in the middle region of Lake Manzalah (Shalloof, 1991) and from March to November in Lake Mariut (El-Shazly, 1993). *O. aureus* and hybrid specimens have the same spawning seasons which extend from February until November, including two peaks.

Maturation is directly related to the population density and ecological conditions particularly temperature, which stimulates sexual maturity (Kashiwagi, *et al.*, 1987). In the present study, the differences in spawning period between Nile tilapia and both of blue tilapia and their hybrid groups may be caused by differences in optimum species temperature. This finding agrees with Chervinski and Lahav (1976) who found that the hybrid between *O. niloticus* females and males of *O. aureus* has temperature limits similar to that of *O. aureus.*

Hickling and Rutenberg (1963) pointed out that measurements of ova diameter approaching spawning might give evidence to the spawning nature of the fish species. In the present study, the ova diameter of *O. aureus* was larger than that of both *O. niloticus* and hybrid specimens. The succession of maturity stages in this work indicates a continuous process of egg ripening, while the presence of three peaks of ova diameter for parental species and hybrid fish groups indicates that they are fractional spawners. The same finding has been noted by Shallof (1991) in his study on *O. niloticus*, *O. aureus* and *Tilapia zillii* from Lake Manzalah, who confirmed the fractional spawning of these cichlid species. This finding goes parallel with that of Nikolsky (1963), who pointed out that fractional and prolonged spawning is mainly characteristic of tropical and subtropical fish species.

The absolute fecundity of parental species and hybrid specimens was positively correlated to fish length, weight and ovary weight, while negative relationship was found between relative fecundity and the length and weight of these fish groups. The fecundity of parental species was more or less similar to those obtained by El-Haweet (1991) in Lake Burullus and EL-Shazly (1993) in Lake Mariut.

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Table (1): Seasonal sex ratio of *O. niloticus*, *O. aureus* and their hybrids from Lake Edku.

Season	Species	Number		Percentages %		Sex ratio	
		Female	Male	Female	Male	Female: Male	Chi-square
Spring	*O. niloticus*	63	65	49.22	50.78	1:1.03	0.0313
	O. aureus	76	88	46.34	53.66	1-1.16	0.8780
	Hybrid	125	152	45.13	54.87	1:1.15	2.6318
Summer	*O. niloticus*	25	31	44.64	55.36	1:1.24	0.6429
	O. aureus	23	34	40.35	59.65	1:1.48	2.1228
	Hybrid	88	98	47.31	52.69	1:1.11	0.5376
Autumn	*O. niloticus*	65	66	49.62	50.38	1:1.02	0.0076
	O. aureus	138	126	52.27	47.73	1:.91	0.5455
	Hybrid	173	213	44.82	55.18	1:1.23	4.1451*
Winter	*O. niloticus*	57	63	47.50	52.50	1:1.11	0.3000
	O. aureus	41	52	44.09	55.91	1:1.27	1.3011
	Hybrid	40	52	43.48	56.52	1:1.05	1.5652
Total	*O. niloticus*	210	225	48.28	51.72	1:1.07	0.5172
	O. aureus	262	315	45.41	54.59	1:1.20	4.8683*
	Hybrid	426	515	45.27	54.73	1:1.37	8.4176**

* Significant at 5% level   ** Significant at 1% level

Table (2): Fecundity of O. *niloticus* at different lengths and weights.

Fish length (cm)	Average weight (g)	Absolute fecundity	Relative fecundity (egg/ g)
9	15.75	378	24.00
10	22.13	467	21.10
11	24.89	506	20.33
12	30.33	547	18.03
13	40.57	583	14.37
14	50.00	628	12.56
15	60.16	763	12.68
16	79.31	795	10.02
17	88.04	918	10.43
18	114.63	1088	9.49
19	131.08	1183	9.03
20	158.09	1262	7.98
21	169.50	1324	7.81

Table (3): Fecundity of *O. aureus* at different lengths and weights.

Fish length (cm)	Average weight (g)	Absolute fecundity	Relative fecundity (egg/ g)
9	11.52	316	27.43
10	15.55	408	26.24
11	21.67	485	22.38
12	27.85	514	18.46
13	35.16	569	16.18
14	44.91	583	12.98
15	54.59	735	13.46
16	68.00	771	11.34
17	75.57	882	11.67
18	91.80	976	10.63

Table (4): Fecundity of hybrid specimens at different lengths and weights.

Fish length (cm)	Average weight (g)	Absolute fecundity	Relative fecundity (egg/ g)
9	12.16	353	29.03
10	18.40	445	24.18
11	22.14	514	23.22
12	27.80	521	18.74
13	34.78	532	15.30
14	43.76	609	13.92
15	62.13	742	11.94
16	73.50	786	10.69
17	90.50	873	9.65
18	109.66	1026	9.36
19	132.33	1164	8.80
20	161.90	1238	7.65
21	179.00	1297	7.25
22	206.67	1369	6.62

Table (5): Comparative relationship of ovary weight and fecundity parameters of *O. niloticus* (n.) ; *O. aureus* (a.) and their hybrids (H)

Type of comparison	Species	a	b	r^2	F-value		
					(n.)-(a.)	(n.)-(H)	(a.)-(H)
Total length and ovary weight	*O. niloticus*	1.2275	0.3151	0.9261	9.0324 **	0.004	5.8670*
	O.aureus	1.1349	0.3035	0.8542			
	Hybrid specimens	1.2241	0.5258	0.9696			
Ovary weight and absolute fecundity	*O. niloticus*	-5.8799	1.9795	0.9244	14.4160**	0.4312	7.9405*
	O.aureus	-4.6689	1.6681	0.8747			
	Hybrid specimens	-3.2458	1.0964	0.9490			
Total length and absolute fecundity	*O. niloticus*	-0.7155	0.6537	0.9759	6.9310*	1.093	2.0674
	O.aureus	-0.6823	0.6503	0.9794			
	Hybrid specimens	-0.6613	0.6384	0.9751			
Body weight and absolute fecundity	*O. niloticus*	-3.7078	1.9062	0.9858	0.6788	2.1233	0.6501
	O.aureus	-3.8441	1.9514	0.9741			
	Hybrid specimens	-4.1627	2.0654	0.9869			
Total length and relative fecundity	*O. niloticus*	1.9368	-0.7009	0.9803	1.4854	1.702	0.1269
	O.aureus	1.8979	-0.6442	0.9677			
	Hybrid specimens	1.8231	-0.5901	0.9925			
Body weight and relative fecundity	*O. niloticus*	4.0192	-2.0378	0.9837	0.0001	0.6732	0.3497
	O.aureus	3.9128	-1.9452	0.9743			
	Hybrid specimens	3.8585	-1.8942	0.969			
Total length and oocyte diameter	*O. niloticus*	0.9479	1.1256	0.9815	28.9026***	29.7423***	0.0805
	O.aureus	0.8928	1.2175	0.9796			
	Hybrid specimens	0.9049	1.1681	0.9855			

a= intercept b= slope r^2= coefficient of determination * Significant at 5% level
** Significant at 1% level *** Significant at 1%° level.

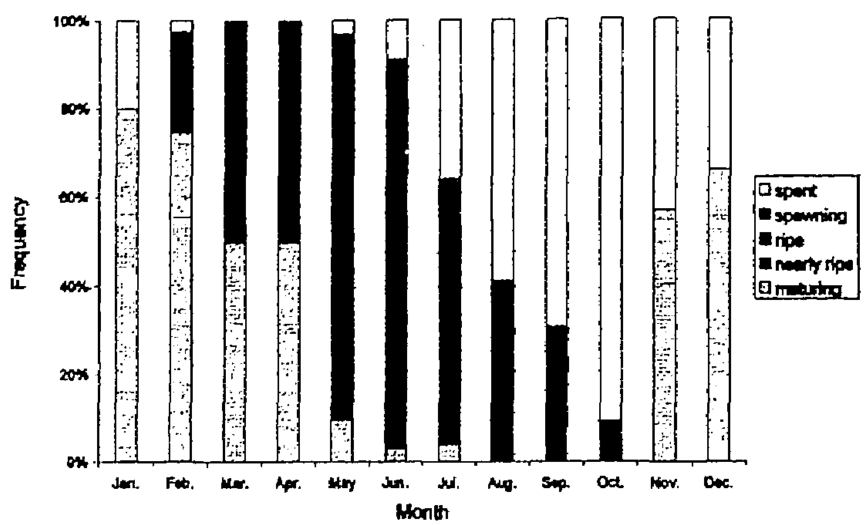

Fig. (1): Monthly distribution of maturity stages for female *O. niloticus*

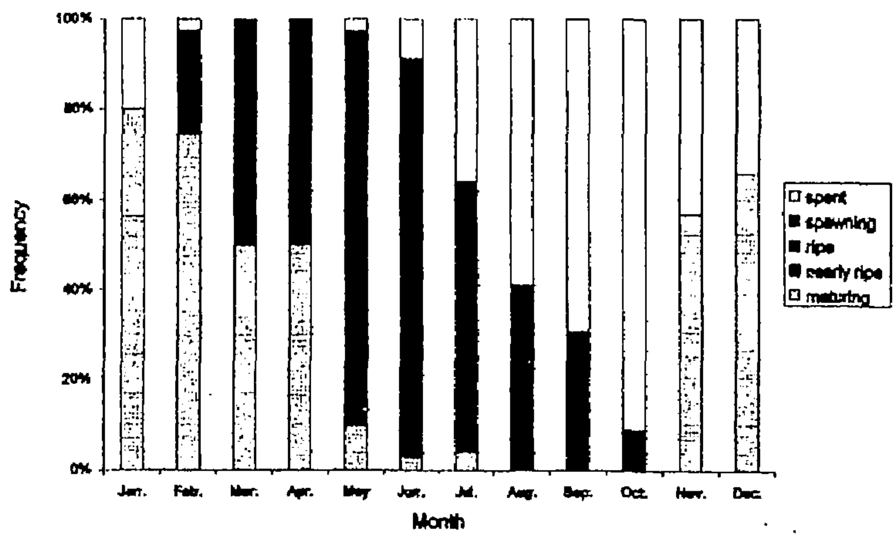

Fig. (2): Monthly distribution of maturity stages for male *O. niloticus*

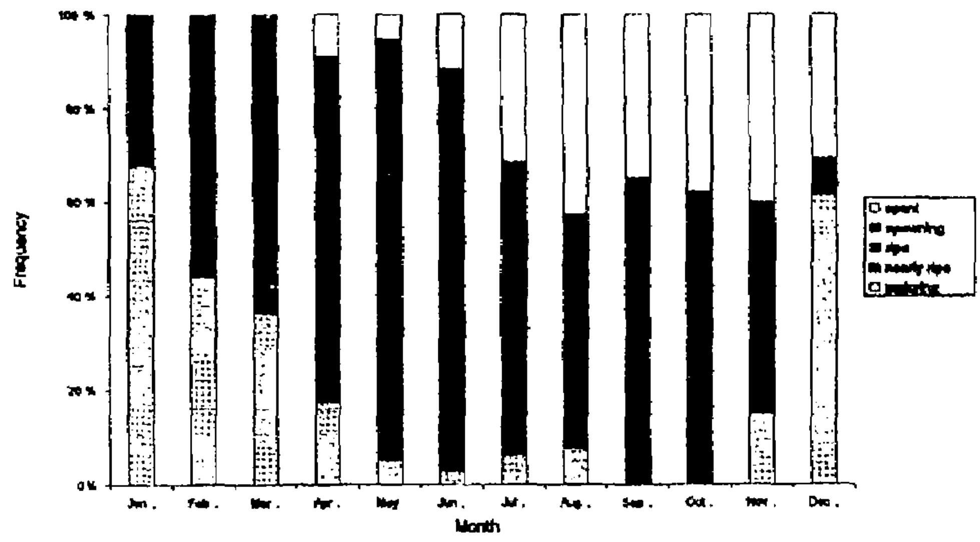

Fig. (3): Monthly distribution of maturity stages for female *O. aureus*.

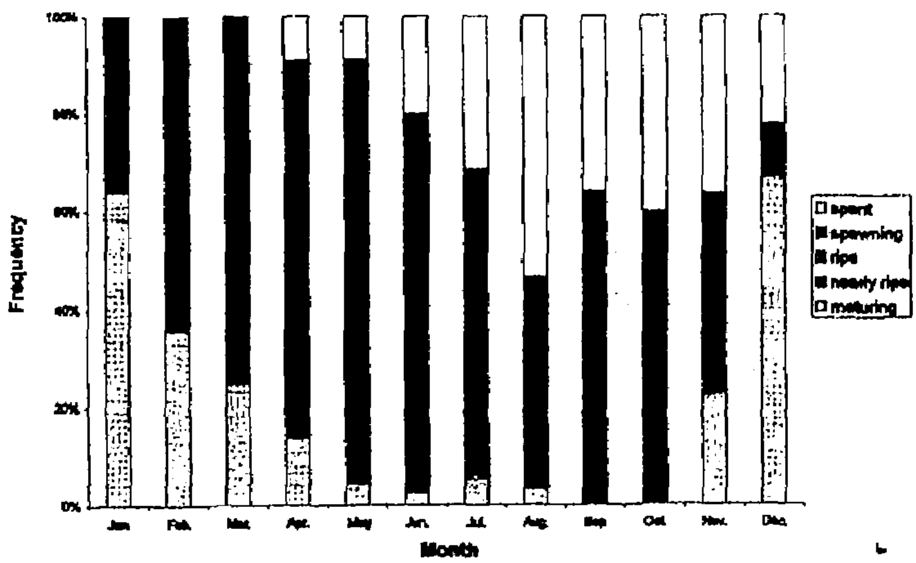

Fig. (4): Monthly distribution of maturity stages for male *O. aureus*.

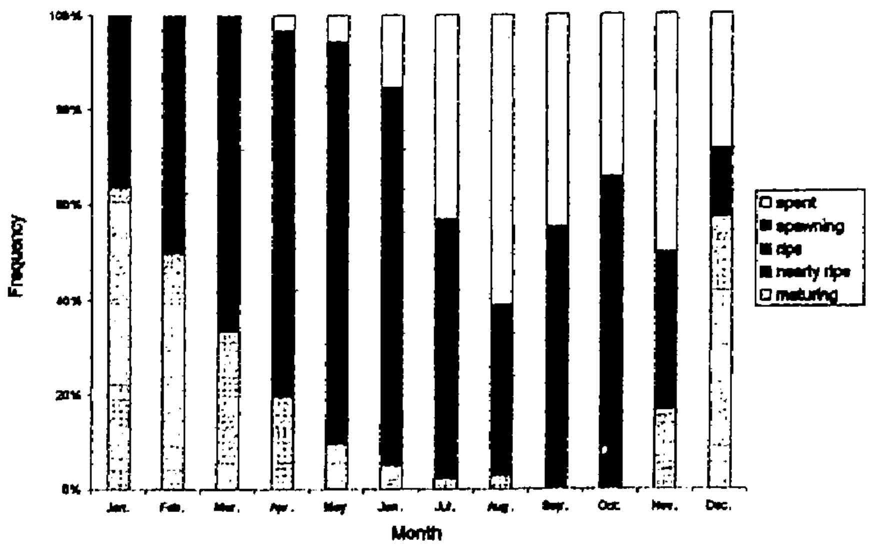

Fig. (5): Monthly distribution of maturity stages for females of the hybrid specimens

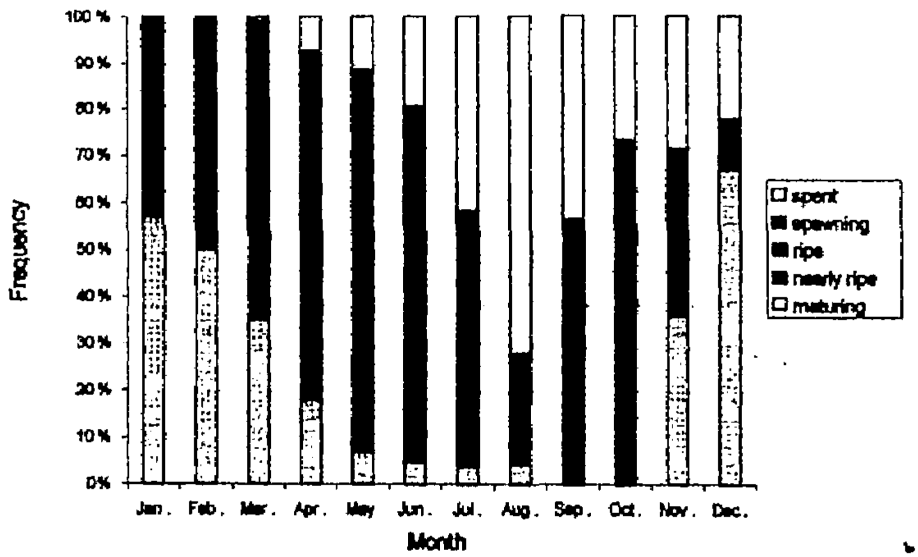

Fig. (6): Monthly distribution of maturity stages for males of the hybrid specimens

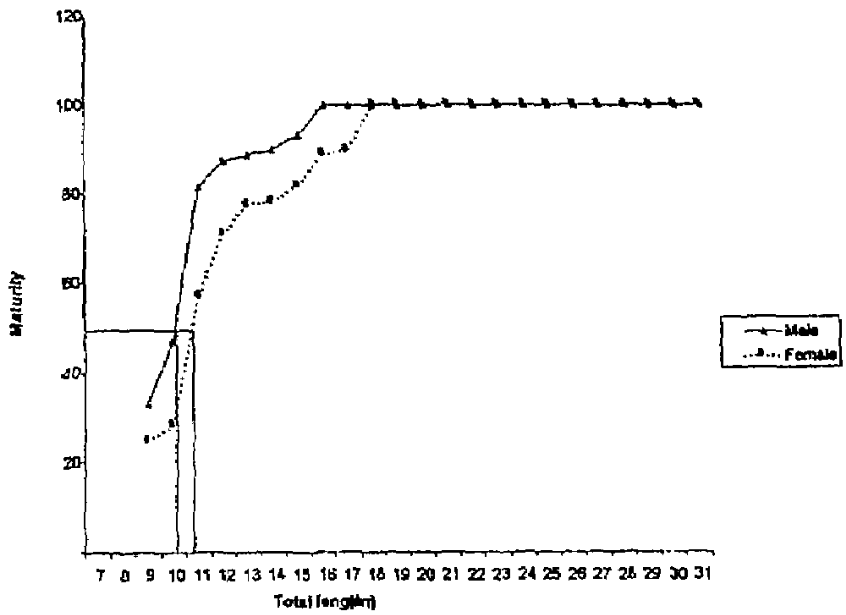

Fig. (7): Length at first sexual maturity for males and females of *O. niloticus*.

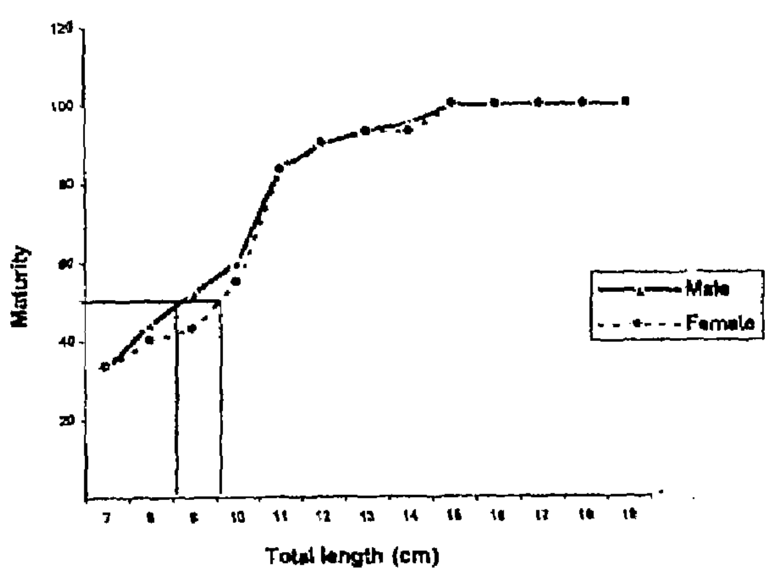

Fig. (8): Length at first sexual maturity for males and females of *O. aureus*

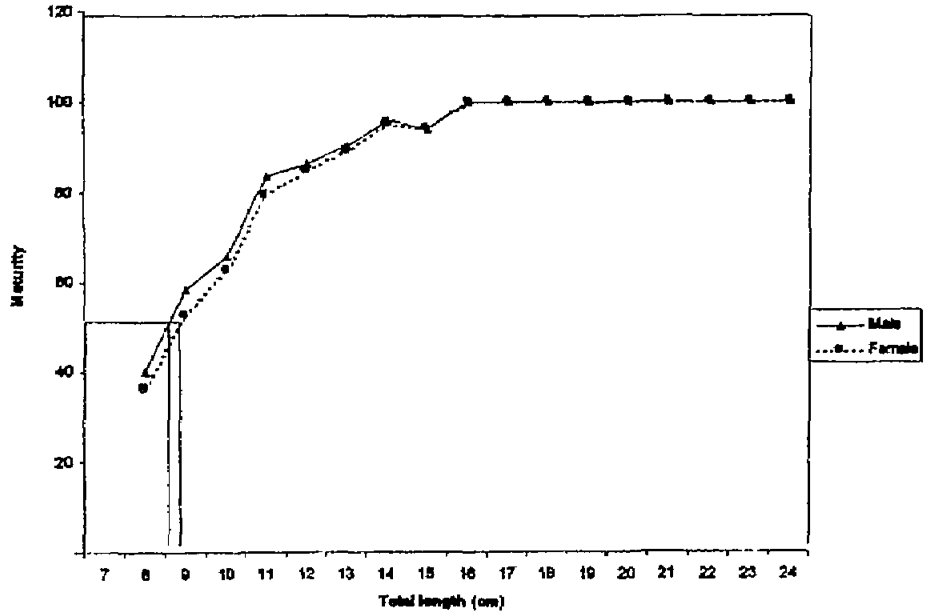

Fig. (9) : Length at first sexual maturity for males and females of the hybrids

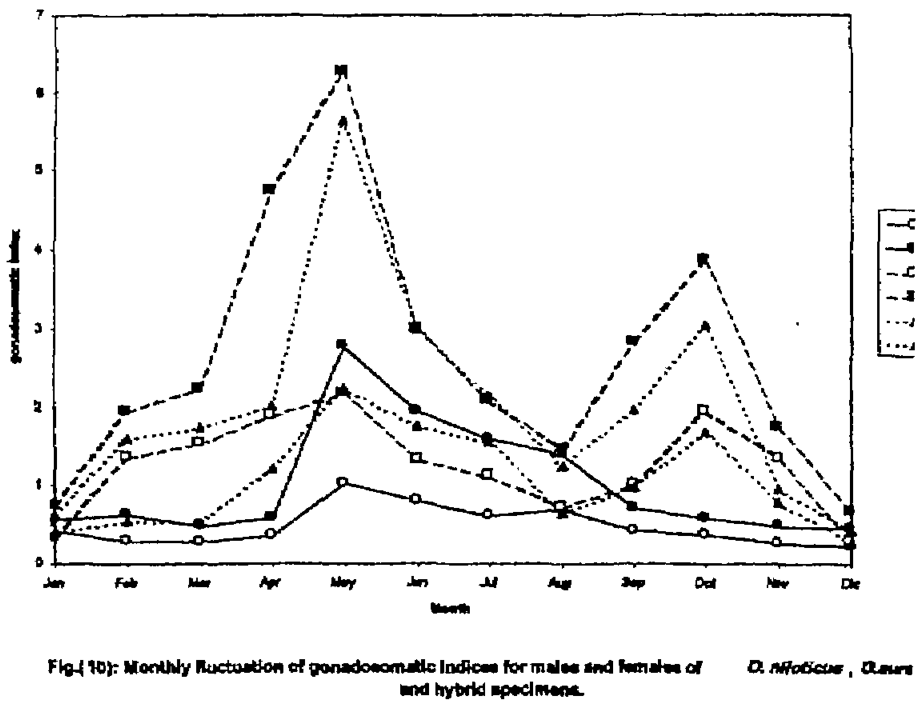

Fig.(10): Monthly fluctuation of gonadosomatic indices for males and females of *O. niloticus* , *O.aurs* and hybrid specimens.

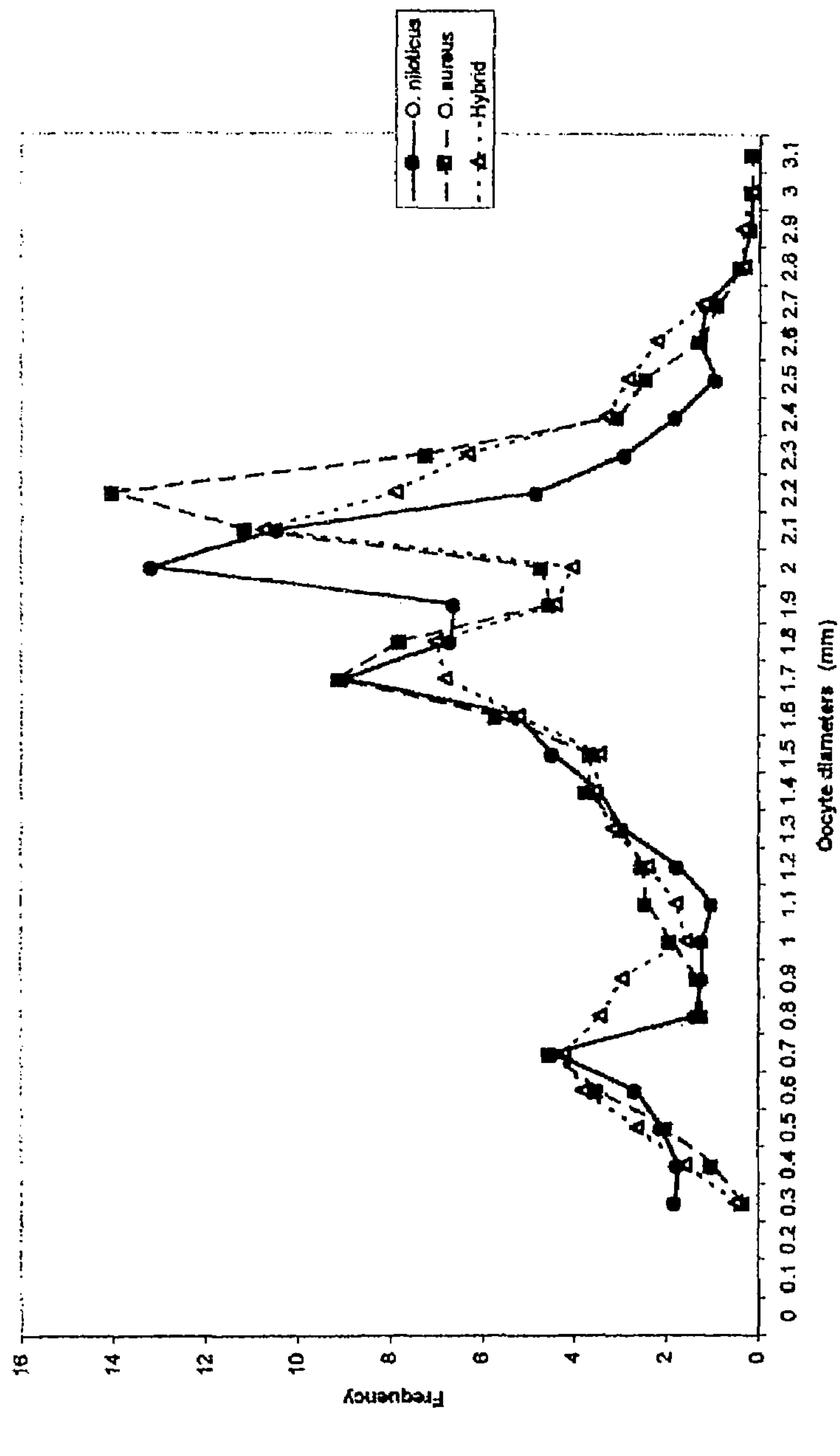

Fig. (11) Frequency distribution of oocyte diameters for ripe ovaries of *O. niloticus* ; *O. aureus* and their hybrids.