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ASPECTS OF THE REPRODUCTIVE BIOLOGY OF THE AFRICAN BUTTER CATFISH *SCHILBE MYSTUS (*TELEOSTEI: SCHILBEIDAE*)* IN AN ARTIFICIAL LAKE IN SOUTH WESTERN NIGERIA

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Abstract
Reproductive features of *Schilbe mystus* were studied in Oyan Lake, (the first man-made lake in Ogun State, Nigeria) from January to December, 2001 in order to establish its reproductive biology. Gonad maturation was determined macroscopically and microscopically, fecundity by gravimetric method and gonadosomatic indices calculated. Six maturity stages occurred in the species in the lake. Histological structures of the ovaries revealed that the diameter of oocytes of immature / stage I ranged from 0.03 to 0.09mm (mean= 0.06mm ± 0.031). Maturation took place after the oocytes have attained a maximum diameter of 0.66mm in ripe/ stage IV gonad of fish with a total length of 24.9cm. Fecundity of *S.mystus* in the lake ranged from 3,500 - 9,700 for fish with a total length of 13.4-24.9cm. The species is a total spawner as there was one major peak on the frequency polygon distribution of egg diameters. There was a high correlation between gonadosomatic index (GSI) and amount of rainfall (r = 0.7807) as well as between the percentage of female with ripe gonads and amount of rainfall (r = 0.5566) in the lake. These indicate that the species bred during the rainy season. The females were significantly more numerous than males ($p<0.05$) during sampling period.

Keywords: *Schilbe mystus*, gonad maturation, egg diameter, fecundity, Oyan Lake.

Introduction
The reproductive traits of the individuals are influenced by various environmental factors. Hence, each species strategically regulates its reproductive traits, through the size and age of first reproduction, maturity stages, breeding time and frequency, breeding habits, egg size and egg production potential in relation to their environment.

Oyan Lake is a man made lake located in south-western Nigeria (Fig. 1). The lake was constructed by damming River Oyan in 1981. Impacts of damming river on fisheries have been discussed by various authors (Hora 1940, 1942; Marchetti and Moiyle 2001; Freeman *et al*., 2001; David and Gloss 2002; Arthington *et a*l., 2003). According to these studies, dams modify flow regimes of rivers and flow variability directly affects many life history stages of fish. Flooding and subsequent receding flood water serves as a cue for migration and spawning (Gopal, 2006).

Studies on aspects of reproductive biology of African butter catfish populations have been carried out by Imevbore (1970), who reported the sex ratio and fecundity of the species in River Niger. Olatunde (1978), studied sex, reproductive cycle and fecundity of the Family Schilbeidae in Kainji Lake and Elliot (1986), determined reproductive features of *S.mystus* in Asejire Lake.

This study reports the reproductive biology of African butter catfish, *Schilbe mystus* in Oyan Lake. The results will enable rational management and sustainable exploitation of this commercially important species in the lake.

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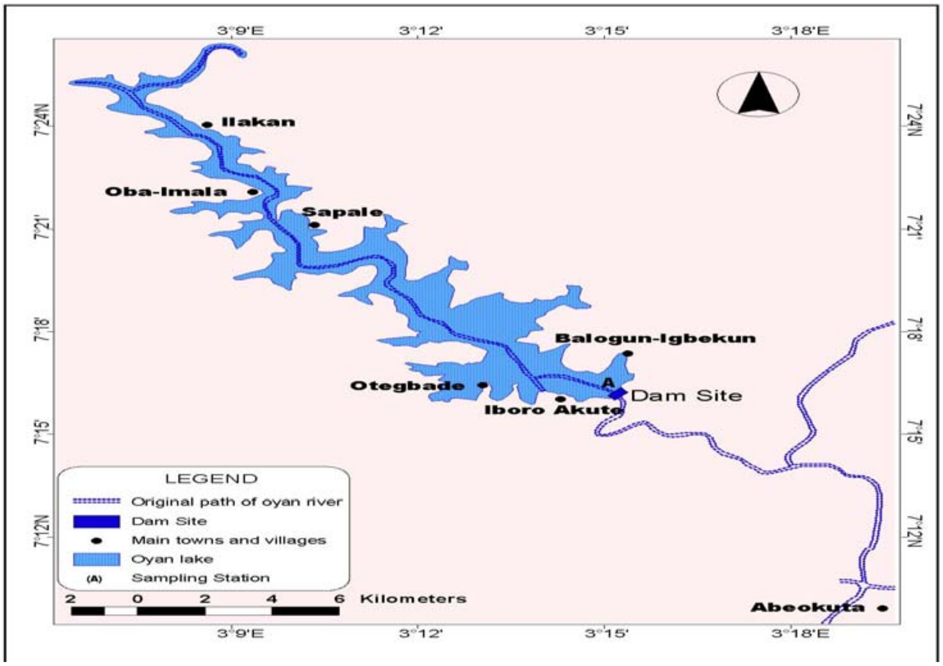

Fig. 1. Map of Oyan Lake showing original path of Oyan River, main towns and Villages and sampling station.

Materials and methods

The geography, topography, and limnological features of Oyan Lake have been described elsewhere (Ayoade *et al*., 2006). A total number of 1540 *Schilbe mystus* were collected from January to December, 2001 at landing centre on the lake from catches of artisanal fishermen that used cast nets and gill nets of mesh size 50-55mm.

The sex of each specimen was determined externally by the presence or otherwise of genital papillae which are cone - like projections of the genital apertures of the males and are absent in females. Internally, sex was determined by the testes having fingerlike lobes, while ovaries were ovoid and granular. Maturity of gonads were determined macroscopically by internal examination of the gonads. Male and female gonads were classified according to a maturity scale modified after Kesteven (1960) and Nikolsky (1963).

Ovaries and testes selected as being representative of each maturity stage were fixed in Bouin's fluid for 24hrs and then transferred to 70 % alcohol. These were then embedded in paraffin wax and sections of 5-10µm were cut from the forepart and stained with haematoxylin and eosin. The stained sections were observed under a binocular microscope and the type of oocytes that dominated was noted. Measurements of oocytes diameter were made from the stained sections using a calibrated eyepiece micrometer to the nearest 0.01mm. Twenty oocytes were selected at random from each gonad development stage and their diameters measured on the horizontal axis irrespective of shape. Only those oocytes sectioned through the nucleus were measured and the mean was taken as egg diameter for that gonad development stage.

Ripe ovaries in stage IV were removed, weighed and preserved in Gilson's fluid (Bagenal and Braum, 1978) for at least two months. The specimen bottles were agitated at intervals to ensure the ova were released from adhering connective tissue. Preserved eggs were washed with water to drain excess preservative and left on filter paper for about 5-10 minutes after removing any remaining ovarian tissue left. Fecundity was determined by sub-sampling using the gravimetric method reviewed by Lagler (1956), Kesteven (1960), Ricker (1968) and Bagenal and Braum (1978). The linearity of the fecundity-length and fecundity-weight relationship was determined using the equation:

$$Y = a + bX$$

Where Y = Fecundity estimated, X = length (cm) or weight (gm) of fish depending on the relation, *a* and *b* are constants. The logarithmic transformation of the equation is

$$\text{Log } Y = \log a + b \log X$$

Relative fecundity i.e. the number of eggs produced per unit kilogram fresh body weight was determined (Adebisi, 1987).100 ova each were randomly selected from three Gilson's fluid-preserved ripe ovaries (stage IV) and diameters were measured with a graduated micrometer in the eyepiece of a binocular microscope. Percentage frequencies of occurrence of eggs in different size classes were plotted. Ova diameter-frequency distributions were determined with the view to confirming the spawning rhythm and the spawning type.

Index of maturity (measured as the percentage of mature fish with ripe gonads and ready for spawning) was calculated for each month over a year (January to December, 2001) providing an index of reproductive activity (Reardon and Chapman, 2008). The relationship between the weight of gonad and body weight of fish i.e. Gonadosomatic index (GSI) was calculated for all stages of gonad maturity as follows:

$$GSI = \frac{\text{Gonad weight}}{\text{Fish weight}} \times 100 \quad \times 100$$

The smallest size at which the males and females attained maturity was established. Records of monthly rainfall were collected from Oyan dam Meteorological Department. Data collected were analyzed using Pearson correlation, regression and Chi-square test.

Results

Gonad maturity stages and reproductive cycle

The maturity stages for the ovaries and testes of *S.mystus* were classified as immature/virgin, immature developing, matured, ripe/fully matured, running/spawning and spent (Table1). Mean oocyte diameter showed progressive increase in size from stage I to stage V.

Table 1. External and histological features of each stage of gonad development of *Schilbe mystus*

	Maturity Stage	External and Histological Appearances	
		Female	Male
I	Virgin/immature	Ovaries were small, thread-like and colorless. No oocytes visible through ovary walls. Histological section (H.S) showed dominance of oogonia and primary oocytes. Mean ovarian wall thickness (MOWT) and mean oocyte diameter (MOD) were 0.07mm±0.1and 0.06mm±0.02mm respectively	Testes were very small, not easy to identify. H.S showed a large number of spermatogonia surrounding an empty lumen.
II	Immature developing	Ovaries were oblong. Both left and right ovaries were visible to the eyes. No egg could be seen with naked eye. Primary vitellogenic oocytes and primary oocytes occurred. Primary vitellogenic oocytes formed 23-30%. MOD = 0.09mm± 0.023mm.	Testes could be seen with eye and had fingerlike outgrowth giving it a lobed appearance. H.S is similar to stage Ì
III	Matured/developed	Tiny oocytes were visible through the ovary walls. The two ovaries occupied about 50% of the abdominal cavity. Secondary vitellogenic oocytes appeared and formed 10-15% of cell. Primary vitellogenic oocyte dominated. MOD= 0.21mm±0.41mm.	Fingerlike outgrowths are more pronounced and swollen. H.S showed spermatocytes at different stages of development filled the testis at this stage. Spermatids were also present.
IV	Ripe/fully matured	Ovaries were swollen and occupied about 70% of abdominal cavity. Vascularization is heavy. Most of the oocytes were tertiary oocytes and constituted 70-75% of entire cells. MOWT=0.01mm. Oocyte diameter ranged from 0.21 to 0.66mm.	Testes were white and swollen. Histologically, testis was filled with lobules containing spermatids and formed 75-85%of cells. Spermatocytes were also present.
V	Running/Spawning	Eggs were shed with slight pressure on the abdomen. Ovaries occupied about 75% of the abdominal cavity. Ovary colour was yellow and eggs were translucent. Similar histologically to stage ÌV with yolk globules more prominent in mature oocytes.	Running testes were not encountered in samples.
VI	Spent	Ovaries looked like empty sacs. Eggs have been shed.	Spent testes looked like an empty sac.

Immature females (Stages I and II) were found in samples every month except May while immature males were encountered regularly in the year (Fig. 2). Maturing females (stage III) occurred in samples from May to December, while maturing males were encountered in July and August. Specimens with mature and gravid gonads were caught from June to September while those with spent gonads were present from September to November.

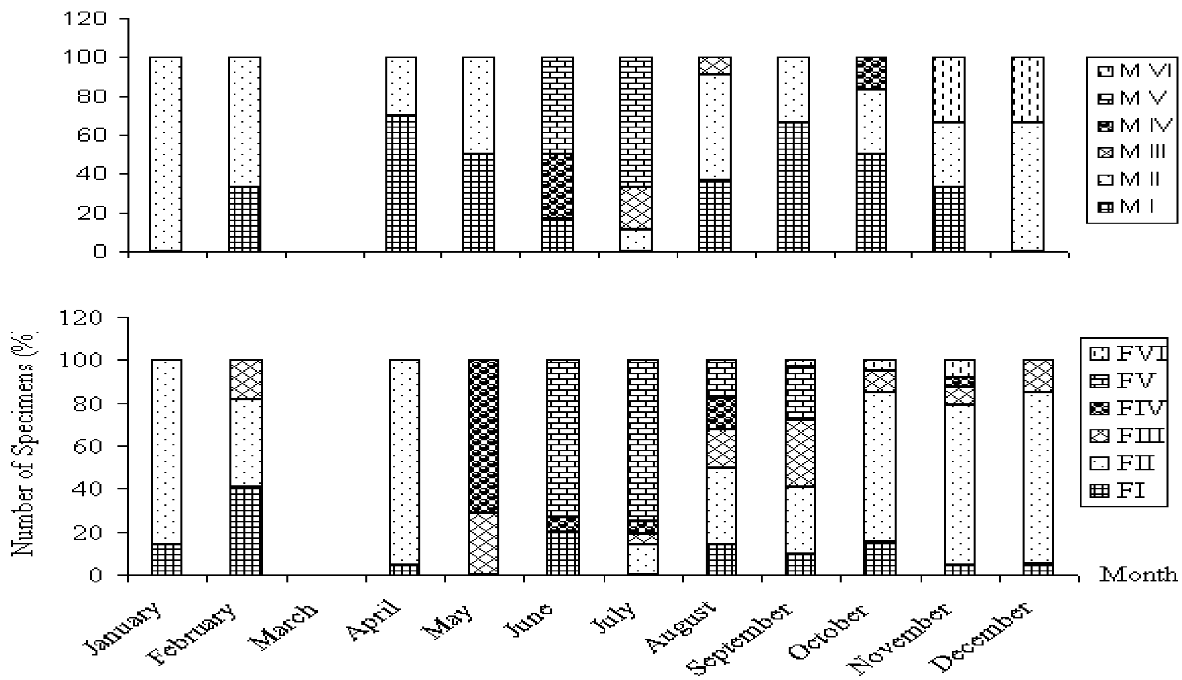

Fig. 2. Monthly distribution of different stages of gonads in samples of *Schilbe mystus* in Oyan Lake (M-Male, F-Female)

Sex ratio

Out of the 1540 specimens of *S.mystus* collected, 923 had observable gonads. 793 were females, and 130 were males giving a sex ratio of 1:6 (male: female). Females were significantly more than males ($p < 0.05$). The monthly sex ratio values (Fig. 3) show that the females were more numerous than the males throughout the study period. Sex ratio was found to show some seasonal variations. During the raining season, the sex ratio (1:1.4 to 1:8.57) was less than in dry season (1:12 to 1:35).

Fecundity

The absolute fecundity fluctuated between 3500 and 9700, with mean relative fecundity of 137,197 eggs/ kg of fish. There was a slight increase in fecundity with increase in length and weight of fish. The logarithmic transformation of the relationship between fecundity (F) and total length (L)/total weight (W) of fish are

Log F = 2.5342 + 0.9443 Log L (r = 0.5170)

Log F = 3.3636 + 0.2193 log W (r = 0.4392)

Egg diameter

The mean egg diameter of *S.mystus* in Oyan Lake was 0.66mm ± 0.07. The frequency polygons for the egg diameters of three specimens in stage IV are shown in Fig. 4. Most of the figures show two peaks, a major and minor one.

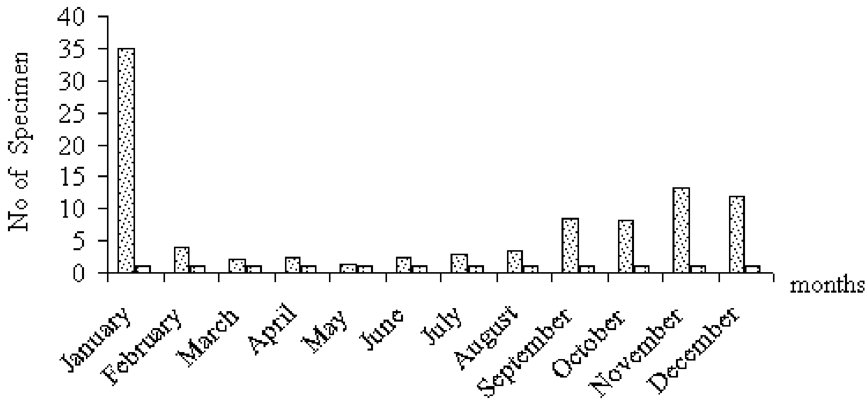

Fig. 3. Monthly sex ratio of Schilbe mystus in Oyan Lake

female male

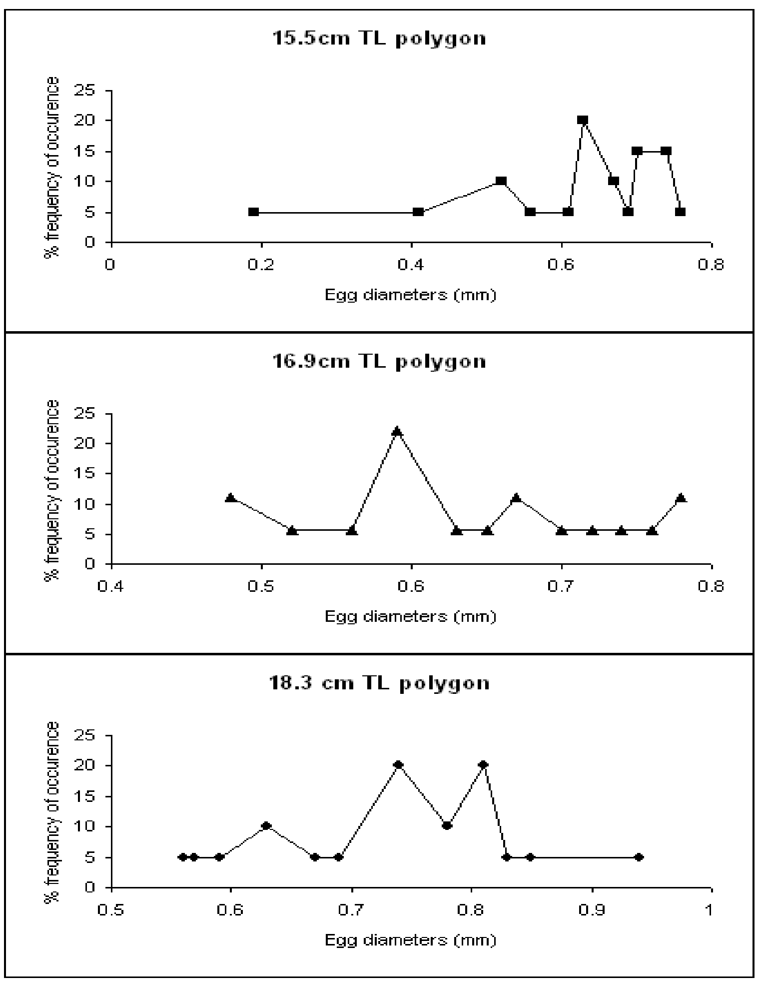

Fig. 4: Frequency polygons of egg diameters of *Schilbe mystus* in Oyan Lake

Gonadosomatic index and index of maturity

There were monthly variations in the values of GSI and Index of maturity (Fig. 5). Rainy season months recorded higher GSI (3.15% – 10.5%) and Index of maturity (71.43% – 81.08%) compare to dry season months with GSI (0.4% – 0.96%) and Index of maturity (0 – 4%). There was significant correlation between index of maturity and rainfall (r = 0.56, p>0.05); GSI and rainfall(r = 0.78, p>0.05), and also, between mean GSI and percentage of mature females with ripe gonads(r = 0.88, p>0.05)

Size at maturity

The males attained maturity at a lower length than the females. The smallest mature male was 12.2 cm and female was 14.6 cm total length.

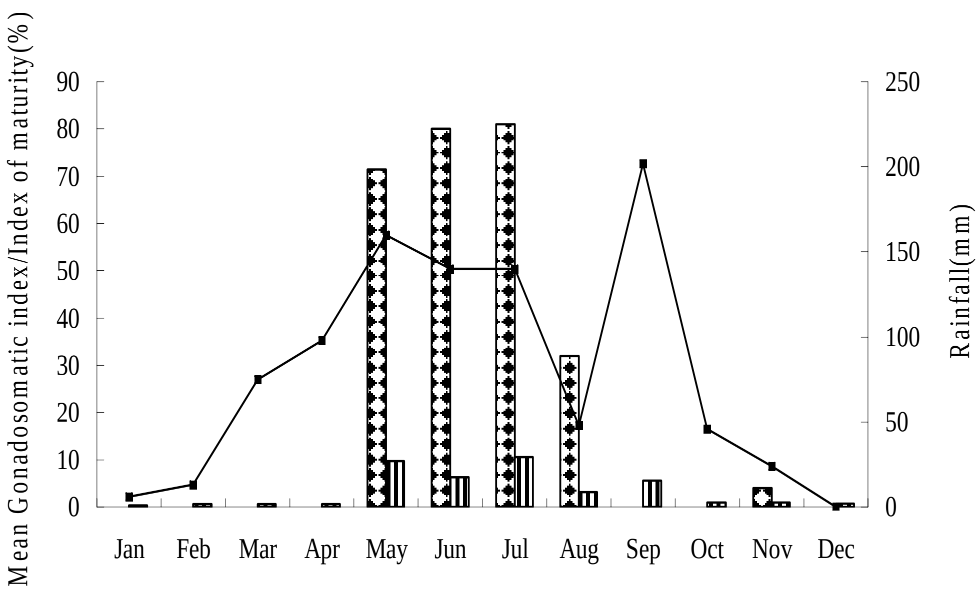

Fig 5: Monthly variations in mean gonadosomatic indices (gsi) and indices of maturity (%M.fe) of *Schilbe mystus* in Oyan Lake.

Discussion

The cellular type's oogonium, primary oocyte, primary vitellogenic oocyte, secondary vitellogenic oocyte, tertiary vitellogenic oocyte and hyaline oocyte found in the ovaries of *S. mystus* are as in most teleosts. This observation is similar to that of Ugwumba (1984) on *Elops lacerta* off Lagos coast, Nigeria. Elorduoy-Garay and Ramirez-Luna (1994) also reported six cellular types during ovarian developments of *Caulolatilus princeps* in the Bay of La faz. Oben (1995) encountered similar cells in ovaries of *Hyperopisus bebe*, *Mormyrus rume* and *Mormyrops deliciosus* in Lekki

Lagoon. The gradual increase and growth of oocytes with various maturity stages of gonadal cycle shows distinct shifting of modes of egg sizes with the advancement of each stage.

The process of spermatogenesis observed in *S. mystus* is similar to that of other teleosts, where spermatogonia divide to produce spermatocytes and these later develop into spermatids which are released into the lumen of the seminiferous tubule where final maturation into spermatozoa takes place (Ruby and McNillan, 1970; de Viaming, 1972a; Vander Horst 1970; Coetzee, 1983; Omotosho, 1984). Few spermatogonia were observed in maturing and mature gonads and this may suggest the fish shed its milt once. However, Dadzie (1969) observed cells at all stages of maturation in the testis of *T. mossambica* and associated this with the polycyclic nature of the species. Omotosho (1984) also reported germ cells occurred at different stages of spermatogenesis and suggested that spermatogenesis does not commence simultaneously in all of the lobules of *T. zillii* and *S. niloticus*.

Sex ratio studies can be helpful in detecting differential fishing, if any, in different periods of the year and thus the abundance of a sex at a particular time (during spawning season) or throughout the year (Natrajan and Reddy, 1980).Thus, knowledge of sex ratio can enhance fishery management and allow the movement of sexes in relation to season to be known (Somvanshi, 1980). According to Nikolsky (1963), sex ratio varies considerably from species to species, but in majority of species, it is close to one. The obtained sex ratio (1:6) for *S.mystus* in this study indicated that more females than males were caught from Oyan Lake, with a higher female biased sex ratio during non breeding season generally. This preponderance of females could be an adaptation for the survival of this species in this man made lake. The increase in number of females which ensures greater population fecundity could be the reproductive strategy developed by this species in this artificial lake to ensure its continuity. A similar result of more females than males was obtained for members of Family Schilbeidae in Lake Kainji by Olatunde (1978). However, Imevbore (1970) noted more males than females in *S.mystus* collected from the coffer dam area of River Niger. From these observations, it can be inferred that the sex ratio of the species vary with habitat The general trend in monthly sex ratio of *S. mystus* in Oyan Lake show that during the breeding season, the number of females to males is less and this may suggest that this species migrate to adjacent floodplain to spawn. Floodplains provide benign spawning environment and bountiful food for juveniles, adults and larvae.

The absolute fecundity, 9073 – 9088 was recorded for *S. mystus* of standard length 16.5cm and 16.6cm in Lake Kainji (Olatunde,1978), while Adebisi (1987) recorded 35,460 – 75,670 (24.6 – 26.7cm total length) for the same species with mean relative fecundity of 437,109eggs/Kg. The absolute fecundity 3500 – 9700 and mean relative fecundity 137,197eggs/Kg obtained for specimens with total length 13.4cm and 24.9cm in Oyan Lake indicate that the species is less fecund in this lake. The mean egg diameter (0.66mm) in this study was smaller than 0.87mm and 0.82mm obtained by Adebisi (1987) and Imevbore (1970) for *S. mystus* in Ogun River and Kainji Lake respectively. This may be due to differences in body size of female and amount of food consumed as reported by Fryer and Iles (1972), and Springate *et al*. (1985).

The major peak obtained from the egg sizes frequency polygon represents fully matured eggs to be shed during the spawning period that year and the minor peak represents small immature eggs which will not be shed but will be reabsorbed (Olatunde,1978). Thus *S. mystus* is a total spawner.

Monthly variations occurred in gonadosomatic indices and high GSI values were obtained during the peak period of gonad development which was between May and September. The higher percentage of mature females of *S.mystus* encountered during rainy season further points to seasonal reproduction in Oyan Lake. The study revealed that the males of *S. mystus* matured earlier than females in Oyan Lake. Olatunde (1977) also observed that males of *S. mystus* (13.2cm total length) in Kainji Lake matured earlier than female of 14.9cm total length. According to Kolding *et al*. (1992), male *S. mystus* matured at 15.00cm total length and female at 16.00cm total length in Lake Kariba. The differences in size at maturity at different locations could be due to the fact that size at which a fish matures depends on a number of factors which include asymptotic length (Beverton and Holt, 1966), its life span (De Silva, 1973), shortage of food supply and intensive predation (Fryer and Iles, 1972; Ricker, 1975).

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