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Full Length Research Paper

Some aspects of the reproductive biology of *Tilapia mariae* (Boulenger 1901) in a small lake in south-eastern Nigeria

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Some aspects of the reproductive biology of *Tilapia mariae* of Umuoseriche man-made lake such as fecundity of female fishes was determined gravimetrically after the sex had been established. The ratio of male to female *T. mariae* of Umuoseriche Lake was 1:1.56. The numbers of female fishes were greater in 110 – 145 mm and 185 – 195 mm size groups. Males dominated the 135 – 175 mm size group. Gonadosomatic index ranged between 1.4 and 3.4 with a mean of 2.25 ± 0.7. Mean ovarian weight was 1.7 ± 0.3 g and a mean fecundity of 1705 ± 629 eggs/ clutch.

Key words: *Tilapia mariae*, gonadosomatic index, fecundity.

INTRODUCTION

Cichlid fishes have a worldwide distribution but are known to have originated from Africa and Madagascar where they are important to the economy and ecology of the ecosystems, which they inhabit. The reason for their wide distribution is probably connected with their prolific reproductive habits (Fryer and Iles, 1972; Barker and Ibrahim, 1979). Cichlids namely, *Chromidotilapia guentheri* (Sauvage, 1882), *Tilapia mariae* (Boulenger, 1901), *Tilapia zilli* (Gervais, 1848), *Tilapia cabrae* (Boulenger, 1899), and *Tilapia guineensis* constitute 92% of the fishery of Umuoseriche Lake. *T. mariae* particularly accounts for about 37% by number and 35% by weight to total catch of cichlid fishes (Anene, 1998).

The reproductive biology of cichlids has been widely reported for East African species (Welcomme, 1967; Hyder, 1970; Fryer and Iles, 1972; Schwanck, 1987). Within Nigeria, studies on the reproductive biology of cichlids have been concentrated in the southwest (Fagade, 1978, 1983; Adebisi, 1987). The conception, construction and commissioning of Kainji Lake evoked interest on the cichlids of the newly formed lake in the Northern region (Akintunde and Imevbore, 1979; Oni et al., 1983; Omotosho, 1987). There is a dearth of information on the reproductive ability of cichlid fishes in southeast Nigeria. The only exception is a report on the reproductive biology of a number of cichlid fishes in Sombreiro River (Nwadiaro, 1987), and *Chromidotilapia guentheri* (Sauvage, 1882) of Umuoseriche Lake (Anene, 2004).

This study, amongst other objectives, seeks to investigate the reproductive potentials of *T. mariae,* information that is required for the commercial production of the fish.

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METHODS

Study area

The Umuoseriche is a man-made lake, located in Oguta, Imo State, southeast Nigeria (5^0 30'N and 50 38' E) (Figure 1) (Anene, 1999). The mean monthly physico-chemical characteristics of the lake have been published (Anene, 2001) and include water level of 1.91 ± 0.32 m, transparency of 0.54.0 ± 0.07 m, conductivity of 8.84 ± 4.91 µS and pH of 6.42 ± 0.81. The level of dissolved oxygen, biological oxygen demand and alkalinity were 6.12 ± 1.41 O_2/l, 0.94 ± 0.22 O_2/l and 5.78 ± 1.4 $CaCO_3$/l respectively.

Sampling strategy

Sampling was routinely done monthly between April 2001 and March 2002. Sampling time was between 0900 and 1800 h. A cast

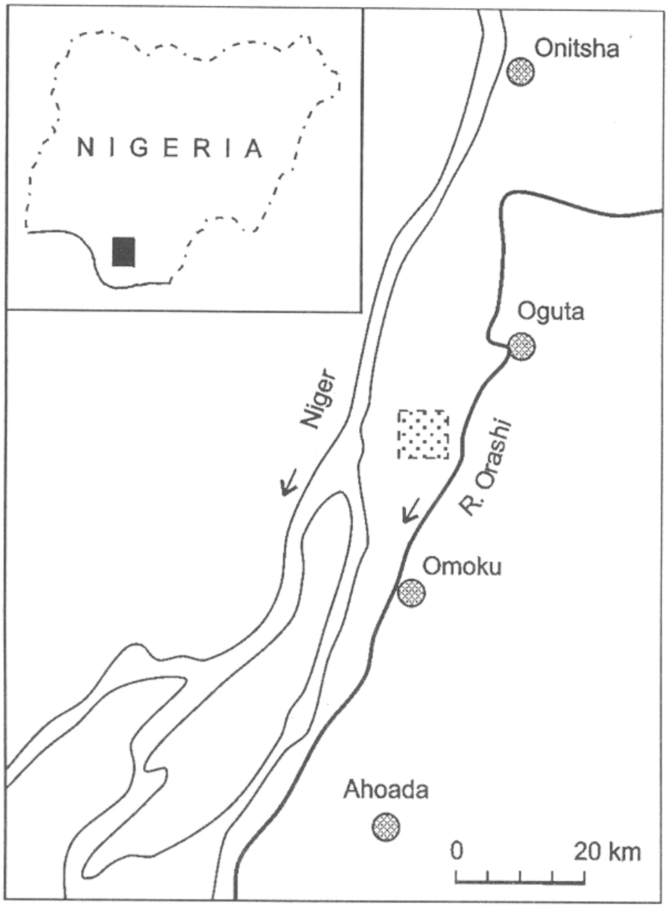

Figure 1. Location of the Umuoseriche lake (dotted area).

net (15 mm stretched mesh size) and four gillnets with various stretched mesh sizes (20.2, 25.3, 30.4 and 40.1 mm) each measuring 12 by 2 m was used for sampling. During each sampling trip, five sampling operations were made using each of the nets on the shallow margins characterized by submerged and emergent vegetation, while the same number of operations was made in the open deeper waters bringing the total number of operations to 10 operations per trip. Sampling in the shallow margins and the deeper open waters was simultaneously done. The procedure used for the sampling operation was a four-man active seining methodology which is a similar to the experimental trawl fishing technique described by Schroeder (1984) and the one-man active seining methodology described by Wingate and Schupp (1985). In the four man active seining technique, one end of the net is tied to a pole with the lead end as close as possible to the bottom. One of the men was positioned at this end of the net to help keep the pole in position. One other man then stretched the loose end of the net with the net in position to a distance equal to its length. The same man then moved around an imaginary circle whose circumference is about 12 m in order to enclose a volume of water and all the fish therein. Two other men were positioned in between both ends of the net to help keep the net in position as well keep the lead end as close to the bottom of the lake as possible. When the loose end touches the fixed end, the net is slowly pulled. The float line is pulled faster than the lead line so that it rolls over to form a crib. The operation is completed when all the net converges at the fixed end and all the entrapped fish removed. This operation lasts for 40 - 45 min.

Parameters studied

Six hundred and forty five mature females of *T. mariae* were used for the study. Fish samples were differentiated into separate sexes using both the naked eye and a microscope. The numbers of specimens in each sex were recorded. Temporal changes in the sex ratio were analyzed using the chi-square statistics. The sex ratio was compared with an expected ratio of 1:1.

Measurements of total length (TL), standard length (SL), were made to the nearest 0.1 mm using a measuring board. Fish specimens were segregated into various size groups and the ratio of male to female fish in each size group was also analyzed using the contingency chi-square statistics. Body weight (BW), ovarian weight (OW) and gutted weight (GW) were made to the nearest 0.1 g using an electronic weighing balance.

Gonads were preserved in 5% formalin for 2 - 3 months during which period they were periodically agitated to separate ova from ovarian tissue. Later, the formalin was decanted and the ovaries washed three times by running clean water through a funnel and filter paper in which they were placed. Clumps of eggs were gently teased with dissecting needle. Gentle shaking the eggs on a dry filter paper absorbed excess moisture. The ovaries were then weighed on an electronic weighing balance to the nearest 0.001 mg and were then thoroughly mixed in small transparent polyethylene bags from where two sub-samples were obtained and weighed. The number of eggs in each sub-sample was counted. The fecundity (F) of each fish was estimated from the relationship according to Babiker and Ibrahim (1979).

$$F = \tfrac{1}{2}(N_1/W_1+N_2/W_2)\ W \qquad (1)$$

Where N_1 = number of eggs in the first sub-sample with weight W_1; N_2 = number of eggs in the second sub-sample with weight W_2; and W = total weight of the pair of ovary from which the sub-samples were obtained. Gonadosomatic index (GSI) was estimated as the ratio of gonad weight to body weight of fish.

The relationship between fecundity (F) with the independent variables (X) total length (TL), standard length (SL), gutted weight (GW), body weight (BW) and ovarian weight (OW) were expressed according to Bagenal and Braum (1978) as:

$$F = ax^b \qquad (2)$$

Where a is a constant and b the regression co-efficient. The constants a and b were empirically determined using a calculator after a logarithmic transformation of raw data. The co-efficient of correlation (r) between fecundity (F) and other variables was tested at the appropriate degree of freedom (d. f.) at 0.001 and 0.05 probability levels of significance. Fertility co-efficient (FC) was estimated according to the equation of Riedel (1969):

$$FC = E/TL^3 \qquad (3)$$

Where E = number of eggs produced and TL = total length of female fish (mm).

RESULTS

Sex

A total of five hundred and eighteen samples of *T. mariae* with observable gonads were used for the study. There were 202 (39%) males and 316 (61%) were females (Table 1). This gives a male/female ratio of 1:1.56 in favour of the females (χ^2 = 3.976, df = 1, p ≤ 0.01). Males

Table 1. Monthly proportion (%) of Male and Female *T. mariae*.

Month	Males		Females		Male : Female ratio	χ^2 ratio
	Number (N)	%	Number (N)	%		
April	16	20	64	80	1: 4	28.8*
May	18	56	14	44	1: 0.8	0.5^{ns}
June	18	25	54	75	1: 3	18.0*
July	16	50	17	50	1: 1	-
August	18	35	34	65	1: 1.9	4.92*
September	16	50	16	50	1: 1	-
October	16	50	16	50	1:1	-
November	20	50	20	50	1: 1	-
December	16	50	16	50	1: 1	1.2^{ns}
January	18	60	12	40	1: 0.6	1.2^{ns}
February	14	44	18	56	1: 1.2	0.5^{ns}
March	16	30	36	70	1: 2.3	7.6*

*Significantly different; ns = no significant difference.

Table 2. Percentage composition of male and female *T. mariae* in the different size groups.

Size Group (mm)	Males		Females		Male : Female ratio	χ^2 ratio
	Number (N)	%	Number (N)	%		
110 – 125	19	25	57	75	1: 3	19.0*
125 –135	24	23	80	77	1: 3.3	30.1*
135 – 145	21	30	49	70	1: 2.3	11.2*
145 – 155	45	50	45	50	1:1	-
155 – 165	40	80	10	20	1: 0.25	18.0*
165 – 175	30	70	13	30	1: 0.4	6.7*
175 – 185	28	50	28	50	1:1	-
185 – 195	15	30	35	70	1: 2.3	8.0*

*Significantly different.

occurred more in the months of May (2001) and January (2002). There were more females in April, June, August (2001) and February and March (2002).

There is a significant difference (χ^2 = 122. 79, df = 7, p ≤ 0.01) in the proportion of both male/females in the four different size groups of *T. mariae* (Table 2). Females dominated the three lowest (110 – 125 mm, 125 – 135 mm and 135 – 145 mm) and the largest (185 – 195 mm) size group. Males dominated two middle size groups namely 155 – 165 mm and 165 – 175 mm.

Gonadosomatic index (GSI) and breeding cyclicity

The gonadosomatic index (GSI) of *T. mariae* was 2.25 ± 0.67 ranging between 1.4 and 3.4. Mean ovarian weight was 1.7 ± 0.3 g. Peak GSI values occurred in the months of April, June, August, December (2001) and February (2002) (Figure 2). These months, which can be interpreted as peak-breeding periods occurred in alternate months and this probably indicates that the cycle of ovarian maturation and spawning takes about sixty days.

Fecundity

The number of eggs per clutch of *T. mariae* ranged from 424 to 2781 with a mean of 1705 ± 629 eggs/clutch. The number of eggs produced varied greatly even within the same size group. The fertility co-efficient for the fish under study was 0.49 ± 0.11. Fertility co-efficient did not have any correlation with the weight. Fecundity was positively correlated with total length (TL), standard length (SL), body weight (BW), gutted weight (GW) and ovarian weight (OW) (Table 3). It is worthy to note that fecundity varied with total length by a factor of 2.49 and standard length of 2.11 (Table 3).

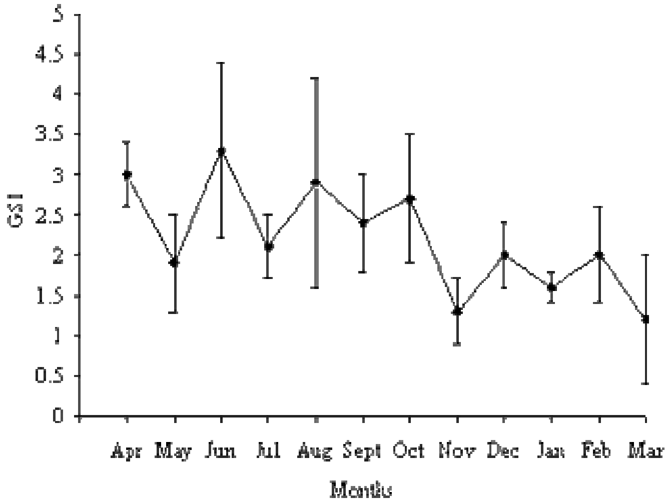

Figure 2. Monthly variation in gonadosomatic index of *T. mariae* of Umuoseriche lake.

DISCUSSION

The overall male : female ratio of *T. mariae* of Umuoseriche Lake was in favour of the female, an observation which is consistent with that made for the same species of fish in a tropical rain forest stream (King, 1994). The observed predominance in the number of female fishes in this study may also result from the fact that females were more susceptible to exploitation than the males. The dominance in the number of females in the relatively small and large size groups may be either due to sex reversal or differences in the rate of activity between male and female fishes. However, there is no apparent morphological evidence to suggest that sex reversal accounted for the dominance in number in particular sex groups of *T. mariae.*

The monthly values of gonadosomatic index (GSI) and the presence of ripe ovaries of *T. mariae* throughout the duration of this study indicate a polycyclic breeding habit with peak periods of breeding occurring in alternate months. The time it takes for spawning to reach its peak is interpreted to mean the time it takes for the ovaries to mature prior to spawning. Dadzie (1969) and Dadzie and Wangila (1980) have reported a polycyclic nature of spawning in *T. mossambica* and *T. zilli*. Observations of this study reveal ovarian maturation/spawning duration of about sixty days. This falls within the record of 1–3 months for the same species of fish (King, 1994). Schwanck (1987) was more specific and reported that *T. mariae* in Ethiope River showed a clear lunar synchronization in breeding. Transparency in Umuoseriche Lake was 54.0 $\pm$ 0.7 cm (Anene and Nwachukwu, 2001) as against the situation in Ethiope River where the bottom of the river was visible from a distance of up to 2.0 m (Schwanck, 1987). This singular environmental factor may be responsible for the difference in duration of ovarian maturation/spawning. The description of *T. mariae* of Umuoseriche pond points to the fact that it belongs to another sub-species (Anene, 1999) and this provides another possible reason for the difference in the duration of ovarian maturation/spawning.

Table 3. Functional equation showing the relationship between fecundity (F) and other variables (X).

Functional equation (F = a X ^{b})	r	df	p
FC = 0.858 $(BW)^{-0.15}$	- 0.303	68	0.001
F = 0.006 $(TL)^{2.49}$	0.952	68	0.001
F = 0.071 $(SL)^{2.11}$	0.744	68	0.05
F = 18.499 $(BW)^{1.02}$	0.817	68	0.05
F = 20.99 $(GW)^{1.01}$	0.872	68	0.05
F = 448.81 $(OW)^{629.44}$	0.872	68	0.05

Moonlight improves guarding efficiency and enhances survival of broods in fishes that show parental care (Schwanck, 1987). The case of *T. mariae* in this study is particularly intriguing because gas is flared in an oil location within 400 m from the lake. The gas flare provides an all round supply of light with an intensity which may equal (or surpass) that of the full moon and should similarly impact on the duration of ovarian maturation/spawning. Insofar as light may be important in determining breeding periodicity, turbidity or some other environment variable specific to the locality may constitute a more important factor.

The fecundity of *T. mariae* in this report compares favourably with literature value of other cichlid fish (Fryer and Iles, 1972; Nwadiaro, 1987; King, 1994). *T. mariae* used for this study were in relatively good condition (Anene, 2005) and this may account for the observed fecundity. As expected, fecundity was positively and linearly correlated with total length, standard length, body weight, and ovarian weight (Bagenal and Braum, 1978; Fagade, 1983). The fecundity-length relationship produced regression co-efficient of 2.11 with respect to total length and the value of 2.11 can be approximate to equal 2.0 while the same cannot be said for the value of 2.49 which is intermediate between 2.0 and 3.0. The exponent of 2.49 of fecundity, total length relationship in *T. mariae* confirms that their reproductive characteristic is intermediate between substrate and mouth breeding, an observation which has also been reported by Whitehead (1962). The estimate for fertility co-efficient of *T. mariae* is similar to the same estimate for *T. mossamica* (Riedel, 1965), which provide the only data for comparison. This co-efficient was negatively correlated to body weight, probably indicating that smaller, lighter fish invest more energy in egg production than bigger, heavier fish.

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