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Research Article

An Aspect of Reproductive Potential of *Sarotherodon galilaeus* and *Oreochromis niloticus* in the Golinga Reservoir in Northern Region, Ghana

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Abstract

The study looked at the reproduction potential of *Oreochromis niloticus* and *Sarotherodon galilaeus* in the Golinga reservoir between November 2006 and April 2007, by assessing the stages of gonad development, fecundity, condition and physico-chemical parameters including temperature, pH, dissolved oxygen and turbidity. For *Oreochromis niloticus*, a total of 115 fishes were obtained during the study period, 42 males (36.52%) and females 73 (63.58%). Out of the 73 females 14 were gravid with the following stages of gonad development, expressed as percentages: immature (White) = 7.14% maturing (yellow) =7.14% , ripe (deep green) = 50% and spent (red, flaccid) = 35.7% . The total number of *Sarotherodon galilaues* that were encountered during the study period were 191, with 74 males (35%) and 117 females (65%). Off the 117 females 35 were gravid of which 7 have immature gonads (20%), 15 maturing gonads (43%) and 13 ripe gonads (37%). The study showed a preponderance of females in both cichlids with sex ratios (male:females) for both cichlids were 1:1.7 and 1:1.5 for O. niliticus and S. galaeus respectively. The monthly Gonado-Somatic Index (GSI) of females ranged from 0.24 to 4.49 with higher GSI values recorded in April. The pattern of gonad development for females indicated that the spawning was not synchronized in both cichlids

In spite of the variation in the gonadal stages of females, the periodicity of spawning for *O. niloticus* and *S. galilaeus* at Golinga indicates that the breeding season and the reproductive cycle begins around January and reaches its peak in April-May where there is increase in food abundance from run-off during the onset of the rains. The fecundity range from 162 to 874 for *O. niloticus* and 299 to 1768 for *S. galilaeus*. The above fecundity statistics for *O. niloticus* and *S. galilaeus*, shows that, *S. galilaues* is more fecund than *O. niloticus*. Also with the biparental mouth brooding nature of *S. galilaeus* it suggest that more offspring could be raised than in the case of *O. niluticus*.

The condition factor (K) was higher in *S. galilaeus* than in *O. niloticus* as 2.81 – 4.07 and 5.0- 9.7 respectively. This suggest that *S. galilaeus* are in a better condition that *O. niloticus*, nevertheless both cichlids were in good condition. The physico-chemical parameters generally are optimal and do not have any effects on the survival, growth and reproduction of *O. niloticus* and *S. galilaeus*.

Keywords: Fecundity; Gonad development; *Orochromis niloticus*; Reproduction; *Sarotherodon galilaeus*; Sex ratio

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Introduction

Fish production, processing and trade generate income to over 10 million Africans. Ghana is the leading consumer of fish in Sub-Saharan Africa and about 70% of the dietary animal protein of Ghanaians comes from fish [1-4].

About 80 species of fish are referred to by the common name Tilapia which belongs to the tribe *Tilapiini* an exclusive African group of fish within the family Cichlidae. The three main genera are: *Oreochromis* (maternal mouth-brooders), *Sarotherodon* (paternal or biparental mouth-brooders) and Tilapia (substrate spawners). The grouping is based largely on differences in their reproduction, feeding habits and biogeography [5,6].

In Northern Ghana fishing is done mainly in rivers, dug-outs, dams and reservoirs. Fish is used as food and some sold in the local markets for income. The two most prominent species that are of economic importance in the capture fisheries of Ghana are the *Oreochromis niloticus* and *Sarotherodon galilaeus*. Fish farming of *Oreochromis niloticus* has been promoted for over three decades by the Ministry of Food and Agriculture. The choice of *O. niloticus* is based widely on the recognized attractive cultural attributes and its importance in world aquaculture rather than the local experience conditions [7]. *Sarotherodon glilaeus* appears to fit best in pond culture as both sexes can be hand sorted and raised in monosex culture due to their equal growth potential. Hand sorting is an inexpensive appropriate technology that an ordinary small scale fish farmer can easily apply.

Sarotherodon galilaeus is also the most predominant cichlid species in freshwater bodies [8].

As economically important species commonly exploited in dugouts, reservoirs, lakes and rivers in both northern and southern Ghana, there is the need to research into the reproductive potential in order to design exploitation and conservation strategies. This will enhance aquaculture development in the country particularly northern Ghana to meet the increasing demand for fish. Over the years consumer's perception about fish has increased favourably because the mind set of consumers encompasses attributes such as healthiness, naturalness and convenience of the use of fish.

A number of preliminary studies have been carried out in many water bodies in Northern Ghana of which Golinga is not exclusive. The species composition, sex ratios, length-weight relationship and gonad assessment have been researched into and documented on *Sarotherodon glilaeus* and *Oreochromis niloticus* in the Golinga reservoir [9,10]. This study examined the reproductive potential of these cichlids by looking at the stages of gonad development, fecundity and the condition factor. Some physico-chemical parameters such as temperature, pH, conductivity and transparency which affect the reproduction of fishes were monitored within the study period.

Materials and Methods

Golinga is the study area and it is about 12km north-west of Tamale, located on 9° 23' 23.04'' N and 0° 59' 33.7604''W, of Tamale Nyankpala road. The total surface area of the reservoir is 80 ha. Golinga is located within the Guinea savannah zone of Ghana and it is boarded by three communities namely Gbulaligu, Golinga and Galinkpegu (Figure 1).

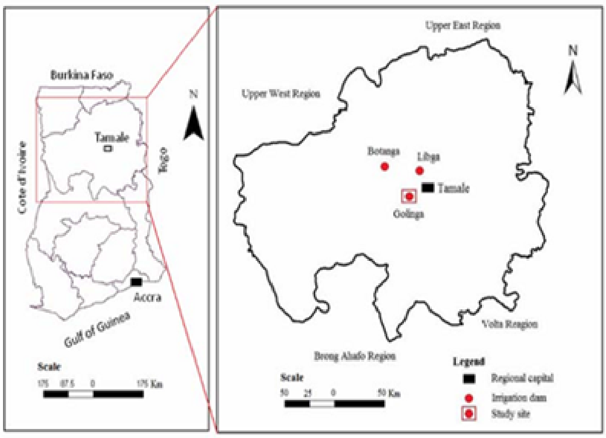

Figure 1: Location map of the study area.

Species Identification

The study was conducted from November 2006 to April 2007 (i.e 6 months) with fortnightly visits in each month. The species were identified by closely examining the shape and position of the mouth parts and mouth respectively, the body colour, and by counting the number of rays and fins [11,12].

Sexing

The identified fish species with weights > 20g, having visible reproductive organs for easy identification were sorted into males and females by observing the shape of the genital papillae with the help of a hand magnifying glass.

Gonad Study

Fish that were above 20g were dissected and inspected for the presence of gonads. The colours of the ovaries and eggs present were recorded for determination of the stage of maturity of the eggs [13]. They were then placed into plastic containers with tight fitting lids and then taken to the laboratory. In the laboratory, they were weighed to the nearest 0.1g using an electronic scale. Matured (deep green) gonads were dissociated into single (individual) eggs for easy counting using five (5%) formalin solution to determine the fecundity.

Gonadosomatic index (GSI)

Gonado-somatic Index (GSI) was calculated using the formula:

$$Gonado - somatic\ index = \frac{Gonad\ weight}{Total\ body\ weight}\ x\ 100;$$

Gomez-Marquez et al. (2003)

Condition factor (K)

The mean monthly Condition Factor (K) was computed using the Fulton condition from the relation:

$$Condition\ factor\ \frac{Total\ weight\ of\ fish\ (g)}{Total\ lenght\ (Tl)^3\ (cm)}\ x\ 100;$$

Gomez-Marquez et al. [14]

Physico-chemical data

Temperature, conductivity and pH were measured using a Wagtech meter and Dissolved Oxygen (DO) using an oxymeter (model: OXI 45). Three (3) sampling sites were established across the reservoir thus at the southern end, the middle and the northern end. The probe of each instrument was immersed 20-30cm deep at various locations into the water and the readings taken after 2-3Minutes when the values on the screens of the instruments had stabilized on each visit. Water samples were also collected in 5ml bottles and tested for turbidity using a turbidimeter (model: 2020). A graph was used to show the relationship between the mean monthly temperatures, turbidity and dissolved oxygen as these were closely related.

Data Analysis

Data recorded during the study were captured and analysed with Microsoft Excel (2007). A Chi-square analysis was performed to test for the significance of deviation from the expected 1:1, male: female sex ratio at a 5% probability level for each monthly sample, as well as the pooled data for the study period.

Results

Sex rations of fish

The sex ratios of the two fishes are shown in (Table 1). For *Oreochromis niloticus*, a total of 115 fishes (Table 1) were obtained during the study period, males were 42 (36.52%) and females 73 (63.58%). Females were more in January' 07 and April' 07, whilst mores males in November' 06 and December' 06. *Sarotherodon galilaues* that were encountered during the study period were 191, 74 were males forming 35% and 117 females (65%). There were more females (27) and males (16) in the month of February '07 and January '07 respectively.

Stages of gonad development

Out of the 73 females of *Oreochromis niloticus* sampled, 14 were gravid. With that of *Sarotherodon galilaues* out of the 117 females, 35 were gravid. Gonads encountered were in different stages as shown (Table 2).

	Months													
	Nov'06		Dec '06		Jan '07		Feb '07		Mar '07		Apr '07		Total	
	On	Sg	On	Sg	On	Sg	On	Sg	On	Sg	On	Sg	On	Sg
Total No	13	16	10	38	39	42	16	42	13	28	24	25	155	191
Males	10	9	4	17	14	16	8	15	1	9	8	10	42	74
Females	3	9	6	21	25	26	8	27	13	19	42	15	73	117
Sex Ratio M:F	3:01	1:01	1:05	1:01	1:08	1:02	1:01	1:02	1:01	1:02	1:02	1:02	1:1.7	1:1.5
χ^2(P<0.05) χ^2=11.070	9.14	1.17	0.052	2.499	0.01	7.38	1.26	4.88	5.206	0.513	2.254	6.28	17.92	22.73
χ^2(P<0.05) χ^2=3.841	S	NS	NS	NS	NS	S	NS	S	S	NS	NS	S	S	S

Table 1: S=significant and NS not significant at p<0.05, χ^2=11.070 at a degree of freedom (df) = 5 for the whole study period and χ^2=3.814 at a degree of freedom (df) = 1 for each month.

Stages of Gonad development	% Gravid females of *Oreochromis niloticus*	% Gravid females of *Sarotherodon galilaues*
Immature (white)	7.14	20
Maturing (yellow)	7.14	43
Ripe (deep green)	50	37
Spent (red, flaccid)	35.72	0

Table 2: Stages of gonad development of Oreochromis niloticus and Sarotherodon galilaues (November 2006 to April, 2007).

Gonadosomatic index (GSI)

As illustrated in (Figure 2), for *Oreochromis niloticus* there were zero (0) records of Gonado Somatic Index (GSI) for the months of Nov' 06, Dec' 06 and Feb' 07. In Mar' 07 and Apr' 07 the GSI ranged from 2.16 to 4.49. For *Sarotherodon galilaues* GSI ranged from 0.65 to 4.01, with the highest recorded in Apr' 07 and the lowest in Nov' 06.

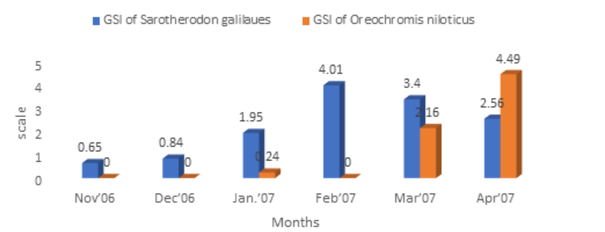

Figure 2: Mean monthly gonadosomatic index (GSI) of Oreochromis niloticus and Sarotherodon galilaues (November 2006 to April, 2007).

Fecundity (F) and Condition factor (K)

(Table 3) is the fecundity and condition factor of the two cichlids. In *Oreochromis niloticus,* there were zero (0) records of fecundity from November' 06–February' 07, however, in March, 162 matured (deep green) oocytes/eggs were counted from a single female. Most of the remaining females had their gonads still forming (white coloured). About 874 matured (deep green) oocytes were counted from five (5) females with lengths ranging from 13-15.00cm for the total lengths and 10.0-12.5cm for the standard lengths in the month of April. Oocytes number increased with ovarian weight in fishes that had eggs which could be counted. The condition index (K) was high in March' 07 (4.07), lower in April' 07 (2.81). For *Sarotherodon galilaues,* the total fecundity was 3694 and it ranged from 299-1768. The month of February'07 recorded the maximum with 1768 oocytes followed by March with 1075 oocytes. November'06 and December'06 recorded no fecundity. The total condition was 43.4 with the mean being 7.2. The highest condition factor occurred in December '06 (9.7) and the least in January '07 (5.0).

Months	*Oreochromis niloticus*		*Sarotherodon galilaues*	
	Condition factor	Fecundity	Condition factor	Fecundity
Nov'06	3.42	0	6.5	0
Dec.'6	3.86	0	9.7	0
Jan.'07	3.46	0	5.0	552
Feb'07	3.54	0	5.6	1768
Mar'07	4.07	162	8.0	1075
Apr'07	2.81	874	8.6	299

Table 3: Monthly Condition index (K) and Fecundity (F) of Oreochromis niloticus and Sarotherodon galilaues (November 2006 to April, 2007).

Physico-chemical parameters

(Figure 3) below shows the relationship between the mean monthly temperature, dissolved oxygen and turbidity, for the study period as these parameters are directly related. Maximum temperatures of 29.15 ^{o}C were recorded in the months of November' 06 and April' 07. That of the minimum temperatures of 24.0^{o}C occurred in January' 07. Conductivity kept rising from 0.14 to 0.29 µS/cm and that of pH remained relatively constant throughout the study period (6.2 to 6.8). Turbidity also increased from 9.68NTU-24.00NTU from November' 06 to April' 07.

Discussion

Sex ratio

The reproductive potential of *Oreochromis niloticus* and *Sarotherodon galilaeus* in the Golinga reservoir was studied from samples collected every month for a period of six (6) months, November 2006 to April 2007. The critical χ^2 value from the chi-square (χ^2) distribution table is 11.070 tested at 5 degrees of freedom. Since the χ^2 calculated for both species (Table 1) is greater than the critical χ 2 value, then it could be concluded that there is significant differences between the sex ratio of *Oreochromis niloticus* and *Sarotherodon galilaeus*.

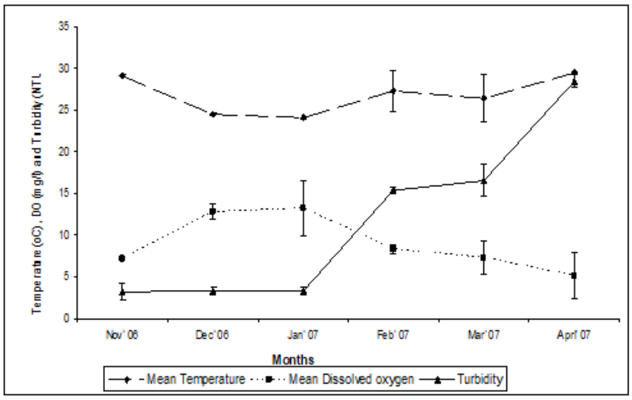

Figure 3: Mean monthly variation of temperature, dissolved oxygen and turbidity, (November 2006 to April 2007).

Hence the sex ratio of 1:1.7 and 1:1.5 for *Oreochromis niloticus* and *Sarotherodon galilaeus* respectively is significant. This indicates that, males and females are different in numbers and the deviation from the expected 1:1 (male:female) was significant. The reason for the predominance of females over the males in the reservoir could be as a result of differential sexual movement prior to spawning and geopgraphical disparity. This is an indication of reproductive efficiency in the reservoir as corroborated by Olopade *et al.* [15], however this contradicts the general unity of 1:1 [8,14,16]. In both species, catches increased from January' 07 to April' 07 and females were always more than males, the reason being that seine nets of fishermen were often observed set in the vegetation (i.e. where there were aquatic weeds such as water lily) where spawning was believed to take place. In attempts to avoid the fishermen, they get entangled by their gills in the nets. Increase in turbidity from Ferbuary'07 to April' 07 gave these nets a councealing colour, so were not easily seen by the fishes. This made visibility and differentiation of the nets from the water very difficult. This is supported by Inuwa [17] who did indicate that spatial sexual segregation may occur in the environment with males and females inhabiting different areas, and also the fishing gears utilized could have also contributed to this slight disparity.

In choosing fishes for culture and reproduction,an important consideration should be the sex ratios. EI-Kasheif *et al.* [18] reported more males to females for Tilapia spp, and attributes it to the reason that males exhibit more higher growth than females. Although this may be true for *O. niloticus*, because the males grow bigger and faster than females, in the case of *S. galilaeus* both sexes growth is almost the same. This gives *S. galilaeus* an advantage over *O. niloticus,* this is because there would be no need for sex reversal which comes with an additional cost to farmers and having to even deal with incomplete sex reversed fish which later may concentrate on reproduction [19].

Gonado-somatic index, fecundity and environmental conditions

The monthly Gonado-Somatic Index (GSI) of females ranged from 0.24 to 4.49. Higher GSI values were recorded in April. This pattern of gonad development for females indicated that the spawning of *Oreochromis niloticus* was not synchronized since females had different reproductive cycles (i.e. from November'06- April'07). In *Sarotherodon galilaeus,* the GSI was high in the months of February and higher in March, which therefore depicts that the gonads were ripe hence spawning was most and more likely to occur in these periods as they marked the peak of the dry season when temperature were of the best maximum which influence gonad maturation. This finding conforms to that of Abban *et al.* [20] who stated that for most species, the GSI builds up gradually from the dry season till it peaks up just before the peak of the flood and maturation of gonads needs a certain amount of temperature in hour grades or day grades. November '06-January'07 recorded low GSI which could be that reproductive activity just started and the gonads were in the state of formation and developing.

In (Figure 2), GSI values were consistently recorded for *S. galilaeus* throughout the study period whiles that of *O. niloticus* started showing up in the month of March and April. These differences in GSI among species and localities could be explained by different environmental factors such as water temperature, day length, light intensity and water level which influenced spawning (breeding) period [18]. Following the above explanation it seems that the present conditions favour the growth and reproduction of *S. galilaeus* than that of *O. niliticus*. Although *O. niloticus* is widely cultured, *S. galilaeus* will be better suited for the environment in Northern Ghana, but with some effort to improve upon its growth. There was also an observed increase in GSI from immature to ripe gonads in the months of March and April. The increase in GSI could be attributed to an increase in food availability and increased metabolism as temperature increases, hence supports Mark *et al*., [21]. Duponchelle and Legendre [22], mentioned that most of the breeding activity of *O. niloticus* was spread over a period from January to September, with a peak between April-May and July. This could have been the reason for the high proportion of resting females between July and December. The periodicity of spawning for *O. niloticus* and *S. galilaeus* at Golinga indicates that the breeding season and the reproductive cycle begins around January and reaches its peak in April-May where there is increase in food abundance from run-off during the onset of the rains.

Gomez-Marquez et al. [14] had a fecundity range of 104 to 373 and Pena-Mendoza *et al.* [16] reported a fecundity range of 243 to 847 for *O. niloticus*. In Fawole and Arawomo [8] the total fecundity in the ovary of *S. galilaues* ranged from 604 eggs in a fish of total length 15.6cm, standard length 10. 9cm and weight 115g to 2 173 eggs in a fish of total length 31.0cm, standard length 24.2cm and a weight of 578g. In this study, the fecundity range from 162 to 874 for *O. niloticus* and 299 to 1768 for *S. galilaeus* (Table 3). The variation in fecundity may be attributed to differential abundance of food within the members of the population, and fish species exhibit wide fluctuations in fecundity among fish of the same species, size and age as explained by Fawole and Arawomo [8], EI-Kasheif et al. [18] and Inuwa [17]. In addition, fecundity is largely dependent on environmental factors such as temperature, altitude and latitude and these factors vary from one location to the other. An early sexual maturity of individual fish population represents an adaptive response of the population to environmental changes where an increase in the fecundity ensure the preservations and not extermination of the species, it ensures its relative stability both in space and in time, in the event of wide fluctuations in the environmental conditions [17]. The fecundity of the fish evaluated in this study is believed to have been lower than that seen and documented in previous studies because they sexually matured earlier.

Variations in fecundity between the species under study could be attributed to the difference in their reproductive habits. It was mentioned that, in mouth brooding cichlids; where limited space available for incubation of eggs and rearing of alevins in the buccal cavity; the fecundity is considerably low because the parents ensure the survival of the offspring and in consequence less mortality [18]. Clearly, in the above fecundity statistics for *O. niloticus* and *S. galilaeus,* it is obvious that *S. galllaeus* is more fecund than *O. niloticus.* Also with the biparental mouth brooding nature of *S. galilaeus* [23] it suggest that more offspring could be raised than in the case of *O. niluticus.*

There was insignificant variation in the conditions index for both cichlids for study period. *S. galilaeus* recorded higher condition index than *O. niloticus.* This suggest that *S. galilaeus* are in a better condition that *O. niloticus,* nevertheless both cichlids were in good condition. When the condition index (K) is greater than 1 is implies good conditions [15]. Wootten [24] explained further that such conditions indicates the suitability of the environment for growth; this can also be influenced by availability of food Abban *et al* [20]. However, K for *S. galilaeus* varied widely in the months of study, this may suggest an interplay water quality and availability of food. The mean condition factors for *O. niloticus* and *S. galilaeus* are higher compared to the report of Nehemia *et al*., [25] where K for *T. zillii* was less than 1.

Sexual maturity is a function of size and may be influenced by the abundance and seasonal availability of food, temperature and by other environmental factors (Gomez-Marquez *et al,* [14]). The physico-chemical parameters (temperature, pH, conductivity and dissolved oxygen) were relatively good compared it findings of Mohl Jr. *et al* [26]. However, turbidity, which measured up-to a mean of 23.45 NTU, exceeded the ideal standard (< 20 NTU)) for the good health of the fish. This might have posed problems with breeding and feeding activities, so accounting for the low numbers (total sample size) and smaller sizes of *Oreochromis niloticus* and *Sarotherodon galilaeus* in the reservoir. The increase in turbidity was as a result of the increase in the concentration of suspended particles from fine soil deposit from the hamattan winds (i.e. in the months of December '06 - January '07) coupled with a decrease in water volume (i.e. fetching of water for domestic use and for the 'irrigation of crops). Continues stirring of the water by fishermen during their fishing activities made the water turbid at all times.

In (Figure 3), increase in temperature corresponded with a decrease in dissolved oxygen because warm water holds less oxygen that cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life. Increase in temperature exerts a major influence on the biological activity and growth of aquatic organisms. The higher the water temperature, the greater the biological activity changes in the growth rates of cold-blooded aquatic organism. Growth rates doubles if temperature increases by 10°C. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity (feeding and breeding) hence more demand for oxygen. This is the reason why in (Figure 2) increase in temperature corresponds with a decrease in oxygen. Cornish and Smit [27], reported that water temperature acts to trigger the unset of reproduction (increase in GSI) in female of *Oreochromis mossambicus.* In this study, mean temperature was fairly constant throughout the study period. GSI for both cichlids almost peaked in the months of February for *S. galilaeus* and April for *O. niloticus.* There seems to be no relationship between temperature and the GSI of the cichlids under this study. Rather GSI is believed to be related much to the abundance of food. Also there seems to be an inverse relationship in the GSI for *S. galilaeus* and *O. niloticus*. The reason for this inverse relationship is beyond the scope of this investigation. Increase in turbidity reduces sunlight penetration in the water due to the presence of the suspended particles. This limits the photosynthetic activity of aquatic micro and macrophytes, so reduces the amount of oxygen been released into the water. This also gave the reason why oxygen decreased with an increased in turbidity.

Conclusion

The sex ratio (1:2) of *O. niloticus* and *S. galilaeus* is a good indication that the population will increase with time since females are more. Spawning begins around April for *O. niloticus* but for *S. galilaeus* from November through to April. The physico-chemical parameters generally are optimal and do not have any effects on the survival, growth and reproduction of *O. niloticus* and *S. galilaeus*.

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