WATER QUALITY ANALYSIS AND FOOD PREFERENCE OF *Sarotherodon galilaeus* IN THE GOLINGA COMMUNITY RESERVOIR IN THE NORTHERN REGION OF GHANA

Abdul-Aziz Issah[1] and Tayari Salifu[2]
[1]Zamse Senior High School, Bolgatanga, Ghana
[2]Department of Agricultural Engineering, Bolgatanga Polytechnic, Bolgatanga, Ghana
E-Mail: sahakpema@yahoo.com

ABSTRACT

The study investigated the water quality and food preference of *Sarotherodon galilaeus* (*S. galilaeus*) in the Golinga Community Reservoir in the Northern Region of Ghana from November, 2011 to April, 2012. Analysis of stomach contents in the laboratory found seven different food items (detritus, filamentous blue green algae, diatoms, green algae, blue green algae, undigested items and xamthophyceae) in 216 stomachs sampled. The food preference was in the order of detritus (43.5%), filamentous blue green algae (23.9%), diatoms (13.0%), green algae (11.4%), blue green algae (8.9%), undigested items (1.2%) and xamthophyceae (0.4%). The ranges for the water quality parameters in the reservoir were 23.8 -31.3^{o}C, 43.1-61.1 µcm^{-1}, 6.85-7.65, 1.8 -18.8 NTU, 23.3-29.3 mg/l, 0.04 mg/l-1.80 mg/l and 0.006-0.007 mg/l for temperature, conductivity, pH, turbidity, total alkalinity, nitrates and phosphates, respectively. These were within the optimum range for plankton production and culturing of *S. galilaeus.*

Keywords: *Sarotherodon galilaeus*, water quality, algae, detritus, plankton.

INTRODUCTION

Sarotherodon galilaeus is a tilapia species within the family Cichlidae. It lives in fresh water or brackish water environments at a depth of 5m (Bailey, 1994). Climatically, it survives in a subtropical temperature of 22°C-28°C (Baebsch and Riehl, 1991; Huet, 1990). This temperature range stimulates growth, oxygen demand, food requirements and food conversion efficiency in fresh water bodies (Aquaculture, 2003). Also, *S. galilaues* in fresh and brackish waters requires pH of 6.5-9.0 (Stone and Thomforde, 2005; Boyd, 1998). Therefore, total alkalinity (a measure of the concentration of bases-typically carbonate and bicarbonate) in freshwater should be maintained at 20-300mg/l to provide buffering capacity to keep pH at 6.5-9.0 (Stone and Thomforde, 2005; Boyd, 1998). Furthermore, freshwater streams ideally should have conductivity between 30-500 µS/cm to maintain osmotic balance in fishes (Stone and Thomforde, 2005). Nutrients such as nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) in fresh water maintain healthy plankton growth as food for aquatic vertebrates as well as keep turbidity levels at 75 NTU. Hence, the acceptable concentrations of 0.2-10 mg/l for nitrite (NO_3^-) and 0.005mg/l -0.2mg/l for PO_4-P (Aquaculture, 2003; Boyd, 1998) are desirable for aquatic vertebrates.

The study of tilapia feeding ecology and food consumption follow two approaches: stomach content analysis of fishes captured in the field and direct quantification of algal ingestion by fish in the laboratory (Hartnell, 1996). Various experiments on stomach content analysis among the Cichlids have shown a diversity of feeding adaptations and behaviour that enable them to utilise virtually different kinds of food items, suggesting a high degree of opportunistic feeding behaviour (Lever, 1996). Among these species are the tilapiines of the genera *Oreochromis species* and *Sarotherodon species*. According to Bailey (1994), *S. galilaeus* is associated with beds of submerged vegetation and often feed on algae and fine organic debris. Similarly, Lever (1996) and Christian (1997) found that, algae and algae-derived detritus comprised the bulk of gut content in adult *Sarotherodon*. In terms of length relationship to feeding, Bowen (1982) and Lever (1996) found that *S. galilaeus* with standard length (SL) of 6-7 cm filter feed on phytoplankton and algae derived detritus respectively. Furthermore, the total length of *S. galilaeus* found in the Volta Lake in Ghana was 19.8 cm (FishBase, 2010).

In northern Ghana, dugouts and reservoirs abound and serve as sources of fish habitats and food supply. Also, *S. galilaeus* is widely fished in the wild in Ghana and has good market value. Unfortunately, very little information is known about its water quality requirement and food to facilitate its rearing in constructed fish ponds. The study therefore sought to find out the types of food preference and the water quality requirement of *S. galilaeus* in the Golinga community reservoir in the Northern Region of Ghana. Such information is not only for academic and scientific interests but may help to improve yields from aquaculture to help alleviate the plights of resource poor fishing communities.

MATERIALS AND METHODS

The study area

The study was conducted in the Golinga community reservoir in the Tolon-Kumbungu District of the Northern Region of Ghana (Figure-1). Golinga is about 12 km north-west of Tamale, the regional capital. The dugout has an area of about 192 ha (Abubakari, 1998). It is in the Guinea Savannah agro-ecological zone

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characterized by short trees with grass undergrowth. The economic trees are the shea and dawadawa. It experiences a unimodal rainfall regime which greatly influences the water level of the dugout. The average rainfall ranges between 900 mm to 1100 mm. The average wet and dry season temperature ranges between 20°C to 30°C and 32°C to 40°C with means of 28°C and 32°C, respectively. Farming is the main occupation of the people.

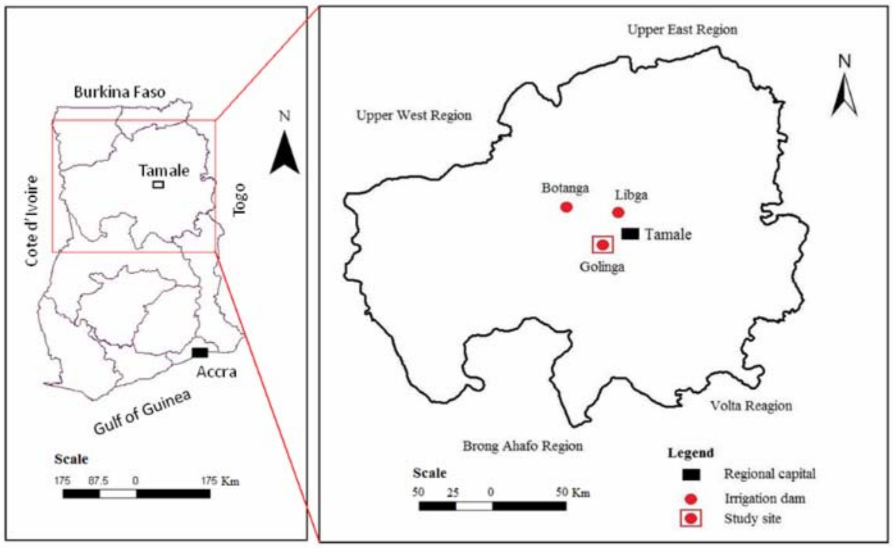

Figure-1. Location map of the study area.

Data collection

Water samples and stomachs of *S. galilaeus* were taken monthly from the reservoir from November, 2011 to April, 2012. The water samples were taken from three different points to analyze for turbidity, conductivity, pH, alkalinity, nitrates and phosphates. Thirty-six (36) *S. galilaeus* were also taken from the landings of fishermen to determine the types of food in their stomachs as well as their standard length, total length and weight.

Water quality sampling and analysis

In the field, plastic bottles were lowered at three different points at a depth of 30 cm from a canoe. The water samples were put in an ice chest to prevent any growth of algae and other micro-organisms. These were then transported to the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) laboratory for analysis of conductivity, nitrates, total alkalinity and phosphates. Turbidity, temperature and pH, were done in the field.

Turbidity was analyzed using a 2100p turbid meter. This was done by immersing the glass electrode into the reservoir at three different points and values read directly from the screen and the average of the three readings taken and recorded. Conductivity was determined using WPACMD200 Conductivity Meter in the laboratory. Also, the pH was determined in the field using the Wagtech pH Meter. Temperature was determined in the field using a mercury-in-glass thermometer. The thermometer was placed at a depth of 15-30 cm from the surface at three different points and the average taken.

Alkalinity and Phosphate-phosphorus (PO_4-P) were determined in the laboratory as outlined in APHA (1998; 1995) and AWWA (1998; 1995). Nitrate-nitrogen (NO_3-N) was also determined in the laboratory using Jenway spectrophotometer model 6505 UV/VIS based on the procedure outlined in APHA (1998) and AWWA (1998).

Analysis of stomach contents

In the field, fishes sampled were dissected individually and stomachs removed and preserved in separate plastic containers with 10% buffered formalin solution. In the laboratory, stomachs of individual fishes were dissected and emptied into Petri dishes, dissolved with distilled water and examined under a microscope. Individual food items were identified to the family level based on a procedure outlined by Belcher and Swale (1976).

Measurement of standard length, total length and weight

In the field, each *S. galilaeus* was first placed on a weighing scale and the body weight read to the nearest 0.01g. The standard and total lengths of individual fishes were taken with a meter rule to the nearest 0.1 cm.

Data analysis

Means, Standard Deviation and Percentages were computed for all the parameters using Microsoft Excel and SPSS. The Percentage Occurrence of each food item was computed using equation (1).

Percentage Occurrence = (Total monthly occurrence of each food item / TFI) x 100 (1)

RESULTS AND DISCUSSION

Water quality of the reservoir

Table-1 presents the mean values of conductivity, pH, turbidity, alkalinity, nitrate, phosphate and temperature from Nov. 2011 to April, 2012. Conductivity of the reservoir increased from 43.1µcm^{-1} in November, 2011 to 61.1µcm^{-1} in April, 2012. This range did not change the performance of *S. galilaeus* in the reservoir since it was within the acceptable limit of 30-5, 000 µ /cm to maintain osmotic balance of the fish in the reservoir as reported by Stone and Thomforde (2005).

Table-1. Mean analyzed physicochemical data for the Golinga community reservoir.

Parameter	Nov., 11	Dec., 11	Jan., 12	Feb., 12	Mar., 12	Apr., 12
Conductivity (u/cm)	43.10±0.58	43.40±0.22	43.50±1.22	54.2±1.34	57.70±0.31	61.10±4.50
pH	7.15±0.11	7.18±0.23	7.43±0.01	6.85±0.10	7.51±0.23	7.65±0.22
Turbidity (NTU)	1.80±1.52	2.70±0.38	3.60±1.53	4.50±1.91	15.50±3.71	18.80±3.50
Alkalinity (mg/l)	23.70±0.82	23.30±1.03	24.30±1.93	25.30±1.15	25.00±1.10	29.30±2.07
Nitrate (mg/l)	0.04±0.08	0.13±0.03	0.14±0.02	0.14±1.19	1.10±1.92	1.80±2.80
Phosphate (mg/l)	0.006±0.00	0.006±0.00	0.006±0.00	0.006±0.00	0.006±0.00	0.007±0.00
Temperature (^{o}C)	23.80±0.17	23.80±0.53	25.80±0.80	25.8±0.88	31.20±0.45	31.30±0.42

Also, the study found surface water temperature in the reservoir within the range of 23.8-31.3 which is similar to the results reported by Baebsch and Riehl (1991) and Huet (1990) to be suitable for culturing *Sarotherodon* in a reservoir. Also pH range of the reservoir was 6.85-7.65 which falls within the recommended range of 6.5 - 9.0 as suitable for photosynthetic activities in a reservoir (Boyd, 1998).

Turbidity of the reservoir was generally lower than the Ghana Environmental Protection Agency limit of 75 NTU. There was an increase in turbidity from 1.8 NTU in November, 2011 to 18.8 NTU in April, 2012 (Table-2). Nevertheless, this level of increase did not interfere with light penetration in the water column to limit photosynthesis. This was because there was continuous growth in SL, TL and W from January, 2012 to April, 2012 (Table-3), suggesting high plankton production in November, 2011 and subsequent decomposition of the plankton in March and April, 2012 as a result of recession in the water level of the reservoir coupled with high temperatures.

Alkalinity values in the reservoir ranged from 23.7 mg/l in November 2011 to 29.3 mg/l in April, 2012. This range falls within the acceptable range of 20-300 mg/l to maintain neutral pH and provide carbon dioxide (CO_2) in a reservoir for plankton production as reported by Boyd (1998) and Stone and Thomforde (2005).

Phosphate (PO_4-P) in the reservoir was not in limited supply. It remained fairly constant throughout the study period (November 2011 to April, 2012) with a range of 0.006 - 0.007 mg/l which falls within the acceptable range of 0.005-0.2mg/l for fish habitation (Boyd, 1998) and could thus stimulate algae bloom as food for *S. galilaeus.* Nitrates level of the reservoir increased throughout the study period (November 2011 to April, 2012) with a minimum value of 0.04 mg/l in November, 2011 to a maximum of 1.80 mg/l in April, 2012 which falls within the acceptable range of 0.2 - 10 mg/l for plankton production in a reservoir (Boyd, 1996). However, the increase in nitrates in April, 2012 might be due to the onset of the rainy season resulting in inflow of minerals into the water body from nearby irrigated farmlands.

Analysis of stomach contents

Table-2 shows the number and percentage occurrence of food items (in parenthesis) in the stomachs of *S. galilaeus* sampled in the Golinga Community Reservoir. Out of 216 stomachs sampled, each stomach had more than one food item, totalling 246.

Table-2. Number and percentage of occurrence of different food items in the stomachs of *S. galilaeus* in Golinga reservoir.

Months	N	Monthly number of occurrence of food items						
		DT	FA	BG	G	DA	X	UM
November, 20 11	36	9	6	4	3	3	–	–
December, 2011	36	15	13	3	12	10	–	–
January, 2012	36	20	15	1	6	6	–	3
February, 2012	36	22	10	1	6	3	1	–
March, 2012	36	25	8	10	–	10	–	–
April, 2012	36	10	7	3	1	–	–	–
Total	216	108 (43.9)	59 (23.9)	22 (8.9)	28 (11.4)	32 (13.0)	1 (0.41)	3 (1.2)

DT: detritus; FA: filamentous blue-green algae; BG: blue green-algae; G: green algae; DA: diatom; X: xamthophyceae; UM: unidentified plant material; N: sample size of the fish; DT: detritus; FA: filamentous blue-green algae; BG: blue green-algae; G: green algae; DA: diatom; X: xamthophyceae; TFI: total number of food items

The study results revealed seven different food items eaten by *S. galilaeus* (Table-2). These include: detritus, filamentous blue green algae, blue green algae, green algae, diatoms, xamthophyceae and unidentified plant material. Out of the 246 food items, detritus was found in the stomachs of 108 *S. galilaeus* representing about 43.9 %, filamentous blue green algae was found in 59 stomachs representing 23.9% and diatoms was found in 32 stomachs representing 13.0%. The rest were, 28 green algae representing 11.4%, 22 blue green representing 8.9%, 3 undigested items representing 1.2% and 1 xamthophyceae representing 0.41%. The results showed that *S. galilaeus* is a euryphagous and therefore exploit a wide range of organisms. This makes it an opportunistic feeder as reported by Lever (1996), Christian (1997) and Bowen (1982). Nonetheless, detritus constituted the most preferred food item eaten by *S. galilaeus* as reported by Boyd (1996). Also, filamentous blue-green algae were favoured more than diatoms. The preference of filamentous blue green algae over diatoms was consistent with the findings of Lauzanne (1972).

Standard length, total length and weight

Table-3 presents the standard length (SL), total length (TL) and weight (W) of *S. galilaeus* in the Golinga community reservoir. All three parameters (SL, TL and W) were observed to increase throughout the period of the study (November, 2011 to April, 2012).

Table-3. Mean monthly values of standard length (SL), total length (TL) and weight (W) of *S. galilaeus* in golinga reservoir.

Months	N	**Mean SL** (cm) $\pm$ **SD**	**Mean TL** (cm) $\pm$ **SD**	**Mean W** (g) $\pm$ **SD**
November, 11	36	7.9 $\pm$ 2.38	10.7$\pm$2.34	44.0$\pm$0.02
December, 11	36	9.6 $\pm$ 2.65	13.0$\pm$3.50	67.0$\pm$0.04
January, 12	36	8.8 $\pm$ 2.32	13.0$\pm$2.73	69.0$\pm$0.04
February, 12	36	10.1$\pm$ 1.99	14.2$\pm$2.70	89.0$\pm$0.04
March,12	36	10.9$\pm$ 2.29	15.5$\pm$3.10	107.0$\pm$0.04
April,12	36	11.7 $\pm$1.36	15.5$\pm$1.78	69.0$\pm$.003
Total	216			

N: sample size of the fish; SL: standard length; TL: total length; SD: standard deviation; Wt: weight; SD: standard deviation

The study found an increase in SL from 7.9 cm-11.7 cm from November, 2011 to April, 2012, and TL from 10.7 cm-15.5 cm for the same period. The increase in SL and TL from November, 2011 to April, 2012 occurred during the period when detritus and filamentous blue green algae were high (Table-2). However, body weight increased progressively from 44.0 g in November, 2011 to 107.0 g in March, 2012 but decreased drastically to 69.0 g in April, 2012. This could be due to a reduction in the amount of detritus and filamentous blue green algae. This presupposes that, increase in SL, TL and W of *S. galilaeus* is a function of the amount of detritus and filamentous blue green algae production in a reservoir as reported by Lever (1996) and Bowen (1982).

CONCLUSIONS

The study of water quality and the food preference of *S. galilaeus* in the Golinga community reservoir showed that *S. galilaeus* is a detritus herbivore but also has the ability to feed on different types of phytoplankton. This makes it an opportunistic feeder. The results of the study also showed that *S. galilaeus* could grow to a SL of 11.0 cm, TL of 15.5 cm and body weight of 107.0 g within five months if a natural surface water body could be stimulated to produce about 43.9% detritus, 23.9% filamentous blue green algae, 13.0% diatoms, 11.4% green algae and 8.9% blue green algae. The ranges for temperature, conductivity, pH, turbidity, total alkalinity, nitrates and phosphates were 23.8 - 31.3^{o}C, 43.1- 61.1 µcm^{-1}, 6.85-7.65, 1.8 -18.8 NTU, 23.3- 29.3 mg/l, 0.04 - 1.80 mg/l and 0.006- 0.007 mg/l, respectively. These values were all within the acceptable limits of water quality for culturing of *S. galilaeus.*

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