Full Length Research Paper

Investigation on Food Ecology of three Cichlid Species in the Mankessim Reservoir, Central Region of Ghana

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The Mankessim Reservoir supports a thriving cichlid fishery that provides both financial gain and nutritional value to the people. Fish samples of *Hemichromis fasciatus*, *Tilapia zillii* and *Sarotherodon melanotheron* were obtained from artisanal fishermen by gill nets (10 m long and 1.5 m deep, 3, 6 and 12 mm mesh) and cast nets (25 mm mesh and 2.5 m radius) in the reservoir ($5^0$18"52.08"'N $1^0$01"45.08"'W) from September 2011 to August 2012. Physicochemical parameters were measured *in situ* and nutrients level determined by the spectrophotometric method. Stomach contents were analyzed using the frequency of occurrence and "points" method and condition was evaluated by means of Fulton condition index. As a result, food resources exploited by *T. zillii* and *S. melanotheron* were highly similar. *T. zillii* fed more on plant material and benthic invertebrates with diatoms *(Navicula* spp*., Pinnularia nobilis, Frustulia rohomboides, Stephanodiscus cymbella, Melosira* spp*., Gyrosigma* spp*., Tabellaria* sp. and *Diatoma* sp.) blue green (mainly *Ulothrix* sp. *Oscillatoria* spp., *Anabaena* spp*.,* and *Microspora* sp.) and desmids being the most preferred algae. *S. melanotheron* ingested more of debris, and fed on considerable amount of algae and benthic invertebrates mainly chironomid larvae and oligochaetes showing a high level of trophic flexibility. The three cichlids showed very good condition (1.75 ± 0.11 - 1.98 ± 0.40). This could probably be as a result of the observed favourable environmental conditions as all physicochemical parameters were within acceptable limits for their sustenance except for phosphates (1.68 ± 0.04 mg/L to 5.37 ± 0.02 mg/L).

Key words: *Hemichromis fasciatus*, *Tilapia zillii*, *Sarotherodon melanotheron*, Cichlids, Physicochemical parameters, Condition factor

INTRODUCTION

There is an increasing interest in cichlids for aquaculture purposes. They are extensively cultured and perhaps the most economically important fishes of tropical African freshwater. For all these reasons, the knowledge on their biology is really important (Soyinka et al., 2013). According to Abowei et al. (2009), the wellbeing of fish is partly determined by the food they exploit and other environmental factors.

A study of the stomach contents can be used to determine its food habits. And this knowledge on food habits could further serve as basis for the development of successful capture and culture fisheries world-wide (Blay and Eyeson, 1982). Ndome and Victor (2002) emphasized that information on the feeding ecology of fish species is a prerequisite to the use of the fish for culture, exploitation and rationale management. Alot of studies have been done in other systems (Ugwumba, 1988; Ugwumba and Adebesi, 1992; Atindana et al., 2014) but little documented work has been carried out in the Mankessim Reservoir.

The three species have over the years grown and survived well to big sizes as compared to their counterparts from surrounding water bodies. This study is aimed at documenting reliable scientific data on their food habits and general wellbeing and possibly highlight reasons for their distinctly thriving ability in the water required for their culture while offering some clues into fisheries policy and regulations.

MATERIALS AND METHODS

Study area

Mankessim Reservoir is situated about 30 km North – East of Cape Coast in the Central Region of Ghana and lies on latitude 5˚18''N and longitude 1˚01''W (Figure 1). The study was conducted first week of every month from September 2011 to August 2012 between 6:00 GMT and 9:00 GMT.

Measurement of environmental factors

Nutrient levels were measured using a HACH D2800 spectrophotometer by employing the Cadmium Reduction Method for determining nitrates and Molybdovonadate Method for phosphates (APHA, 1998).

Fish sampling and data collection

A minimum of 30 specimens comprising both males and females for each of the species were collected each month from artisanal fishermen. Standard length measurements were taken using a measuring board to the nearest 0.01 cm and the weight estimated to the nearest 0.01 g using an electronic scale and hand held balance (for heavier fish).The guts of the fish were removed, weighed (to the nearest 0.01 g) and preserved in 10% formalin. Stomachs of specimens were removed and contents of stomachs were examined under a microscope.

Physicochemical parameters

Monthly means of the physicochemical parameters for the period were calculated using Minitab (Version 15) and statistically tested for any differences using a paired student's t - test (Zar, 1999).

Analysis of data on fish species

Condition factor (K) of the experimental fish was estimated from the relationship:

$K = 100W/L^3$(Fulton's index)

Where K = condition factor (CF)W = weight of fish (g); L = Length of fish (cm).The value of the condition factor is around 1 (no unit) the closer the value is to 1 implies very good, the farther it is away from 1or closer to 0 is poor.

Stomach contents were analyzed using the frequency of occurrence and "points" method (Bagenal, 1978; Hyslop, 1980; Lima and Goitein, 2001). The frequency of occurrence method estimates the percentage of stomachs in a sample containing a given food item whereas the "points" method gives the bulk contribution of each food item to the total food consumed. Points were awarded to each stomach according to its degree of fullness; 10 points for full stomach, 5 for half stomach and 2.5 for quarter filled stomach. Empty stomachs were excluded from the analysis. The total number of points awarded to each stomach was subdivided among the food items present according to their relative contribution to the total stomach content. The percentage composition of each of the food items was determined by summing up the points awarded to the item and dividing it by the total points awarded to all stomachs containing food, and the resulting value expressed as a percentage.

RESULTS

Physicochemical parameters

All water parameters were within acceptable ranges for sustenance of aquatic life (WHO, 1993) except for phosphates (Table 1).

Food habits of the cichlids

The percentage frequency of occurrence and composition of the various food items consumed by *Hemichromis fasciatus*, *Tilapia zillii* and *Sarotherodon melanotheron* are illustrated in Figures *2*, 3 and 4, respectively.

Hemichromis fasciatus

Of the 325 stomachs examined, 96 stomachs representing 29.54% contained food. Algae, fish/fry, fish parts, benthic invertebrates, blue green algae and desmids were also frequently found in the stomach of the fish. The species preyed more on benthos and fish fry which constituted greater than 30% of the total food consumed and occurred in not less than 80% of all the stomachs examined. It preferred benthic invertebrate species such as the *Chaoborus* sp., chironomid and caddis fly larvae. Insect parts, fish fry and detritus formed less than 15% composition and occurred in not more than 85% of the stomachs.

Tilapia zillii

Of the 78 stomachs containing food, plant Material, material, debris, sand grains and algae were the main contents (Figure 3). Plant material and algae constituted 30% and occurred in greater than 70% of the food
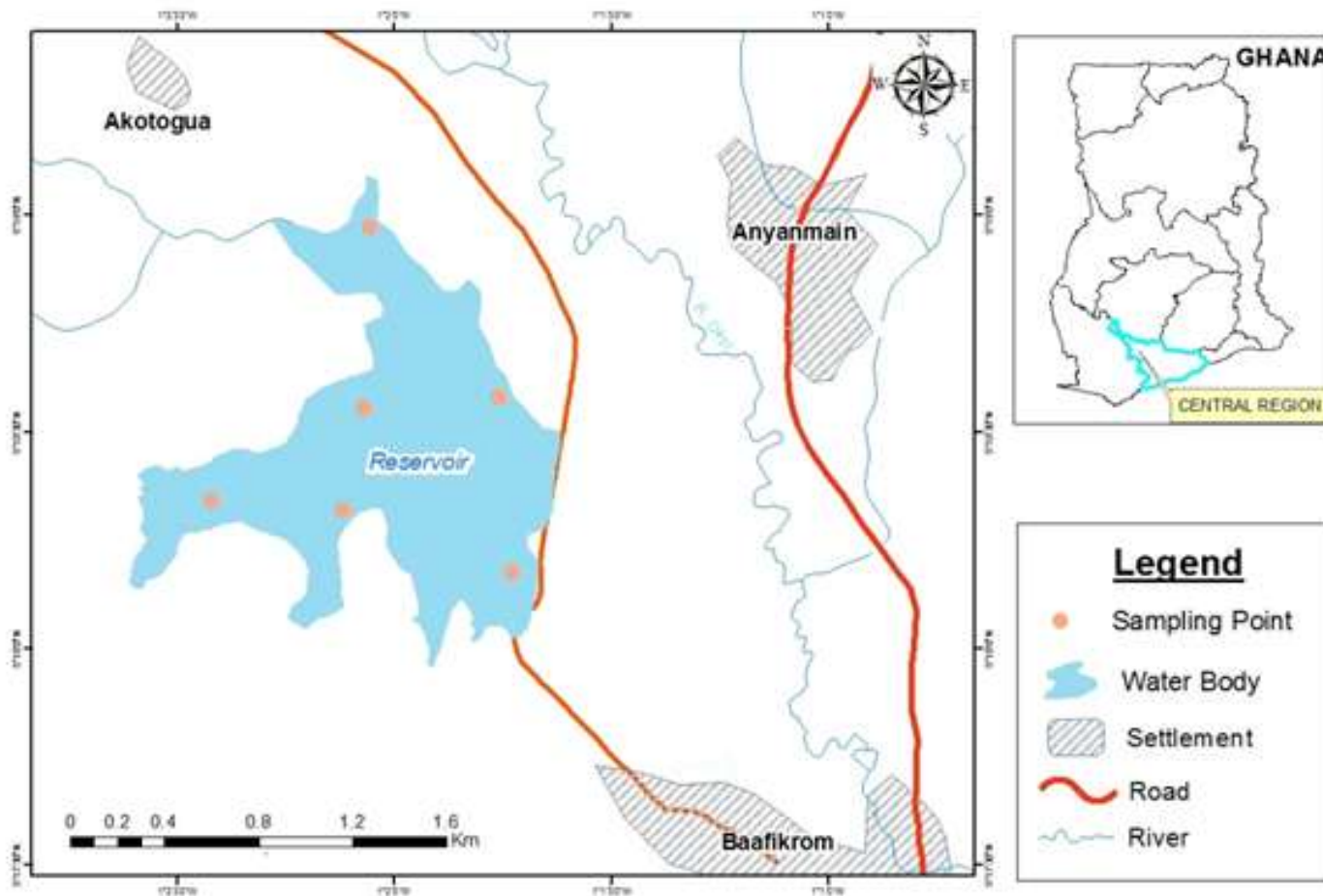
Figure 1. Mankessim Reservoir (Department of Fisheries and Aquatic Sciences, UCC).

eaten.

Algae constituted 30.68%, benthic invertebrates 9.32%, fish scales 3.65 %, debris 2.66%, and stones/sand 2.43 % of the stomach contents and all occurred in more than 5.26 % of the food ingested. Diatoms in the stomachs of *T. zillii* were mainly *Navicula* spp.*, Pinnularia nobilis, Frustulia rohomboides, Stephanodiscus cymbella, Melosira* spp.*, Gyrosigma* spp.*, Tabellaria* sp.and *Diatoma* sp.

The blue green algae were made up of *Ulothrix*sp.*Oscillatoria* spp., *Nostoc* sp., *Anabaena* spp.*, Eucapsis* sp.*, Spirulina* sp. and *Polycystis* sp. *Microspora* sp. was the filamentous form

encountered.

The desmids encountered were *Closterium* spp., *Cosmarium* spp.*, Gonatozygon mougeotia, Pleurutaenium trochistum, Staurastrum* sp., *Micrasterias* sp., *Protococcus* sp. and *Pediastrum* spp. Benthic invertebrate organisms like chironomids (*Chironomus* sp. and *Nilodorum* sp.),

Table 1. Mean values of physicochemical parameters in the Mankessim Reservoir measured from September 2011 to August 2012 (S.Edenotes standard error).

Parameter	Mean ± S.E.
Temperature(^{o}C)	29.16 ± 0.46
Dissolved oxygen(mg/L)	5.15 ± 0.48
PH	6.94 ± 0.13
Conductivity((µS/cm)	16.60 ± 0.56
Transparency(m)	1.01 ± 0.09
Turbidity(mg/L)	3.27 ± 0.39
Nitrates(mg/L)	0.39 ± 0.15
Phosphates (mg/L)	3.45± 0.76
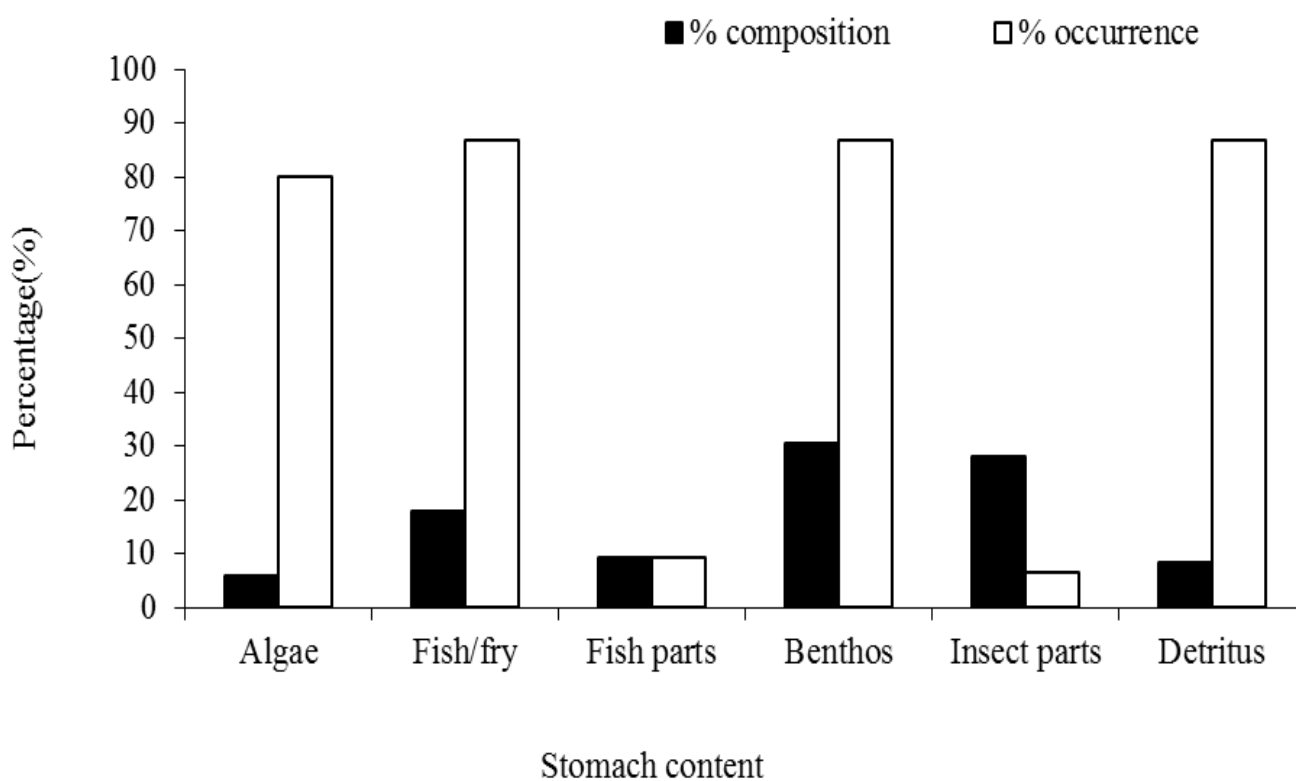
Figure 2. Composition and frequency of occurrence of stomach contents of *Hemichromis fasciatus* in the Mankessim Reservoir from November 2011 to August 2012.

Chaoborus sp., caddisfly larvae (*Setodes* sp.) coleopteran and hemipteran larvae and some crustaceans were found in the stomachs of some specimens.

Sarotherodon melanotheron

The stomach contents of 114 specimens measuring 10 to 22.7 cm standard length, and weighing 47.36 - 500 g were examined. As shown in Figure 4, in terms of composition debris, diatoms and blue green algae were

the most important items ingested by the fish followed by green algae, others, stones and benthic invertebrates accounting for 55.65, 17.22, 8.52, 6.87, 5.74, 3.74 and 2.26% of the stomach examined. Similarly, in terms of occurrence all items occurred in more than 20 % of the food eaten. *Synedra* sp., *Tabellaria* spp., *Diatoma* spp., *Melosira* spp. were the main diatoms eaten on by the fish.

Spirulina spp. was commonly found than the other blue green algae like *Oscillatoria* spp., *Microcystis* sp., *Microspora* sp., *Protococcus* sp. and *Zygnaema* sp. The green algae found were mostly filamentous types such as
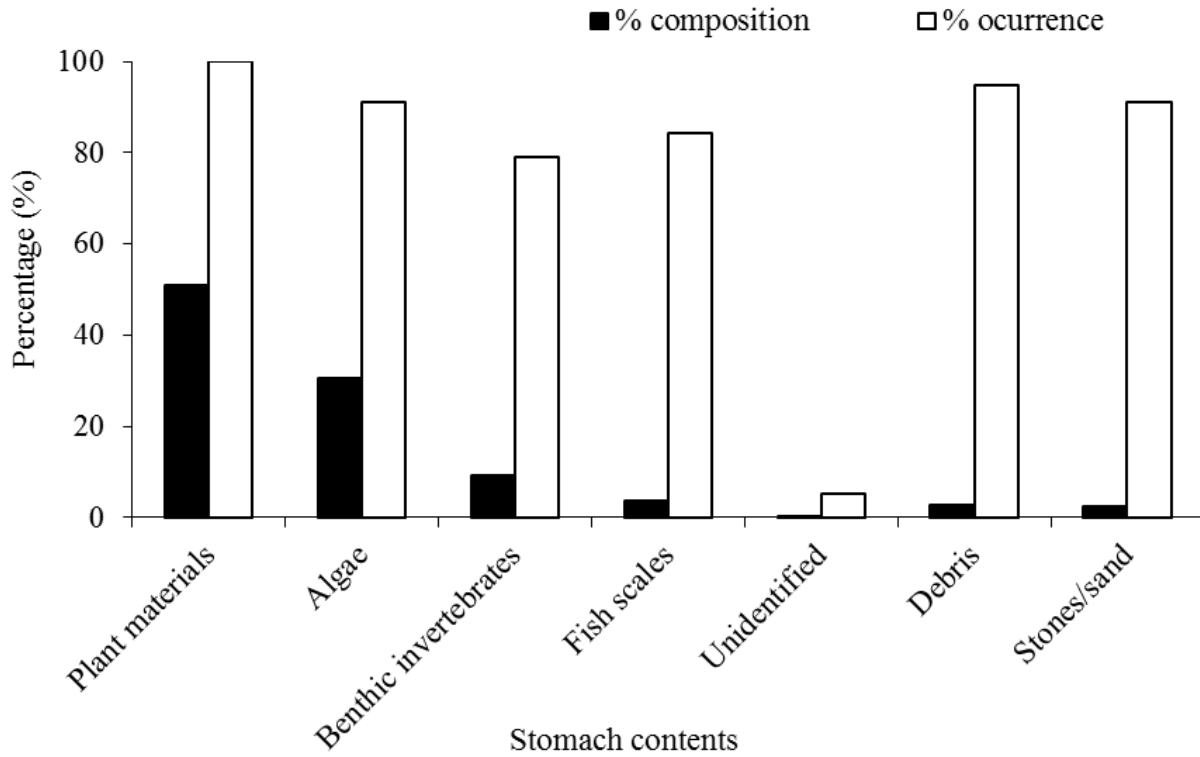
Figure 3. Composition and frequency of occurrence of stomach contents of *Tilapia zillii* in the Mankessim Reservoir from November 2011 to August 2012.
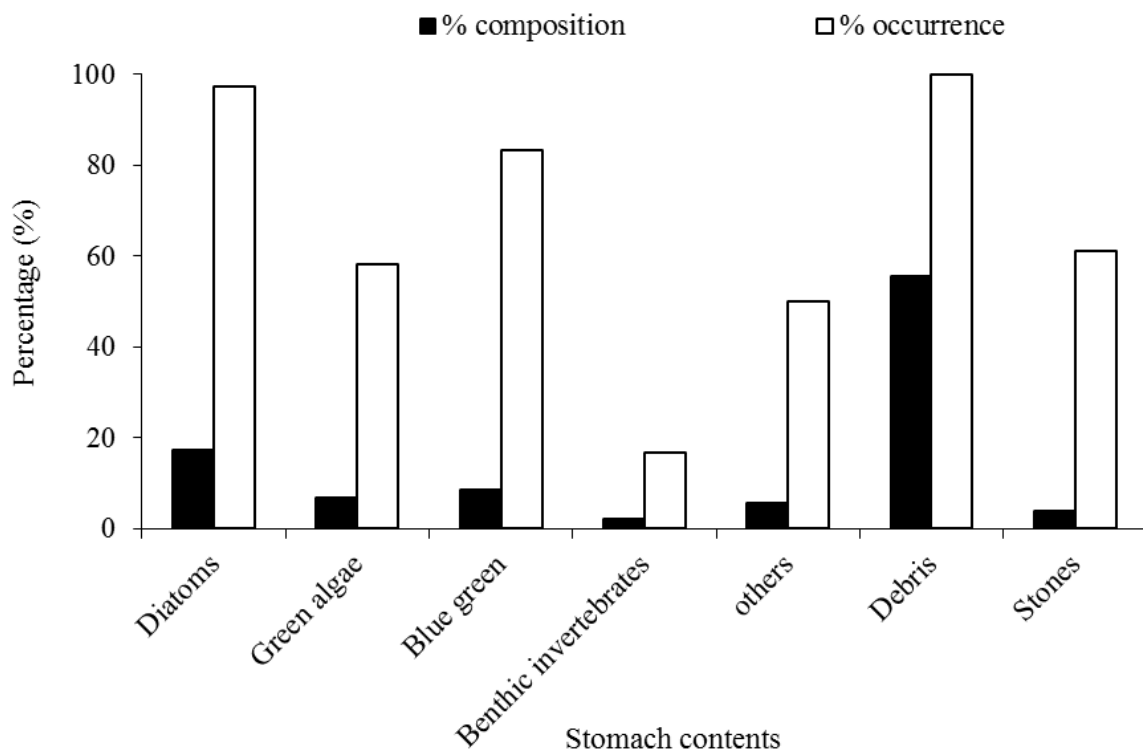

Figure 4. Composition and frequency of occurrence of stomach contents of *S. melanotheron* in the Mankessim Reservoir from November2011 to August 2012.

Table 2. Table 2. Condition factor of the three cichlids of the Mankessim Reservoir from November 2011 to August 2012 (*s.e = Standard error of means).

Species	N	K
Hemichromis fasciatus	325	1.75± 0.11*
Tilapia zillii	333	1.98± 0.40*
Sarotherodon melanotheron	251	1.91± 0.38*

Spirogyra sp. and the desmids *Micrasterias fimbriata, Closterium* spp, *Cosmarium* spp., *Pediastrum* spp., *Gonatozygon* spp. and *Tetrame bresbissonii*.

Condition factor of the three species

All three species were found to be in very good condition (Table 2).

DISCUSSION

All water parameters were within acceptable ranges for sustenance of aquatic life except phosphates (WHO, 1993). Generally the reservoir showed higher concentrations of phosphate than nitrate with overall mean concentration of nitrate and phosphate ranging from 0.38 to 0.49 mg/L and 1.68 mg/L to 5.37 mg/L respectively. With the exception of nitrate which was found to be within the acceptable range for lentic ecosystems (0.003 to 7.00 mg/L), phosphate was above the recommended level (<0.05 mg/L) (Wetzel, 2001).Through personal observations and interviews with some farmers, the higher levels of phosphate compounds could be attributed to the use of a high phosphate containing fertilizer (Root developer) with Nitrogen, Phosphorous and Potassium (N P K) ratio of 10: 50: 10 in vegetable farms along the banks of the reservoir. This result corroborates the observation of Antwi and Ofori-Danson (1993), who observed the existence of nearby agricultural farms as responsible for the increase in nutrients in reservoirs.

Food habits

The well-being of fish could be determined partly by the quality and quantity of food it eats. According to Bagenal (1978) the maximum size that a fish can reach may possibly be affected by the various food resources and their availability in its environment. In comparison with a previous study on the reservoir by Avortri (1989) there was similarity in observations made on food items eaten by each of the three cichlids except for *S. melanotheron*. The diet of *H. fasciatus* in this study however revealed a wide spectrum than populations in the Golinga Reservoir

in Ghana (Atindana et al., 2014). Insect parts and benthic invertebrate species such as coleopterans, chironomids, *Chaoborus* sp. and caddis fly larvae were the other stomach contents from specimens in the Mankessim Reservoir. Such a relatively wide variation in food exploited by the two populations, suggests the availability of these food items in the Mankessim Reservoir. This could be due to high nutrient levels in the water triggering the abundant growth of algae and other primary producers required for the sustenance of the aquatic food chain. Also, the findings of Dankwa et al. (1999) suggests the species is a minor piscivore which is similar to this study due to the range of dietary prey consumed by the species.

There was a high similarity in food resources exploited by *T. zillii* and *S. melanotheron*. Both species showed a high level of trophic flexibility in that *T. zillii* fed more on plant material and benthic invertebrates (mainly *Chaoborus* sp., caddisfly larvae, coleopteran and hemipteran larvae) with diatoms, blue green and desmids being the algae preferred. Conversely, *S. melanotheron* ingested more of debris, considerable amount of algae and benthic invertebrates mainly chironomid larvae and oligochaetes. This might be a means of minimizing interspecific competition and ensuring their coexistence. Considering the observed food habits of the three dominant species in the reservoir, *H. fasciatus* can be classified as an invertevore – piscivore and the tilapia species: *T. zillii* and *S. melanotheron* microherbivore – detritivore according to the trophic guilds used in Wooton (1998) and Esteves et al. (2008). Condition factor has been used as an index of growth and feeding intensity and influences the reproductive cycle in fish. The high condition index of the species during the study is possibly due to the availability of their food resources and favourable environmental conditions in the reservoir.

CONCLUSION AND RECOMMENDATION

The broad spectrum of food items eaten by the species and their preference for different food items could be strategies adopted to avoid interspecific competition and ensure their coexistence. The observed environmental conditions of the water could be possible reasons for the thriving abilities of the cichlids. However considering the high levels of phosphates in the water which is an

indication of some level of pollution, it is important for farmers to farm away from the banks of the system to help prevent future deterioration of the quality of water and sustain aquatic life.

A further study should be conducted on the biochemical oxygen demand of the water to ascertain the possible state of health of the water for future use.

Conflict of Interests

The authors have not declared any conflict of interest.

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