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Full Length Research Paper

Seasonal variations in the mineral composition of some commercially important fish species of Lake Victoria-Tanzania

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Seasonal variations in the mineral compositions of three commercial fish species; *Lates niloticus*, *Oreochromis niloticus*, *Rastrineobola argentea* from Lake Victoria were determined using standard method and procedures. Calcium, potassium, phosphorus, sodium and magnesium were significantly higher (p<0.05) during the wet season, while zinc was significantly (p<0.05) higher during the dry season and no significant differences (p>0.05) in the contents of manganese, copper and iron were observed in *L. niloticus*. Calcium was higher in the wet season but not significantly different. Potassium, phosphorus, sodium, magnesium and zinc were significantly higher (p<0.05) during the wet season, while manganese and iron were significantly (p<0.05) higher during the dry season and copper was unaffected by the seasons in *O. niloticus.* Calcium, potassium, phosphorus, magnesium, zinc and iron were significantly higher (P<0.05) in wet season, while sodium, manganese and copper were unaffected by seasons in *R. argentea.* The three species were found to be good sources of dietary minerals such as calcium, phosphorus, iron, copper and zinc which could be recommended to pregnant women, lactating mothers and infants for normal growth and good health. The high levels of the essential minerals during the wet season indicated that the species could be desirable during this period.

Key words: Fish species, Lake Victoria, mineral composition, seasonal variations, Tanzania.

INTRODUCTION

Fish is high in digestible protein and an important source of minerals (Abdullahi, 2002). The most important minerals in the fish and shell fish are potassium and calcium followed by phosphorus which is important for proper functioning of the nerves and bone formation (Karakolitsidis *et al.,* 1985; Elfaer *et al.,* 1992). These minerals, although occurring in small quantities are important as enzyme-cofactors, maintenance of colloidal system and regulation of acid- base equilibrium (Halver, 1989).

Calcium and phosphorus are necessary to maintain an optimal bone development (Cruz and Tsang, 1992) more of these minerals being required during childhood and growing stages to prevent rickets and osteomalacia (NRC, 1990). Moreover, it is known that several aberrations in bone mineral homeostasis and bone metabolism result as a consequence of severe magnesium deficiency. These include reduced bone growth, bone volume and increased skeletal fragility (Wallach, 1990; Carpenter, *et al.,* 1992). Although Ca, P and Mg are important in bone metabolism and development, other minerals such as Fe, Cu, Zn and Mn are considered essential for normal growth and for avoiding several pathologies (Prassad, 1991; Sherman, 1992).

Phosphorus also plays a central role in energy and cell metabolism. Inorganic phosphates serve as important buffers to regulate the normal acid-base balance (pH) of the animal body fluids (Abisoye *et al.,* 2011).

Fish is an essential source of all nutrients in desirable concentrations (Qyvind*, et al.,* 1994). However, climatogical differences between two seasons may affect the nutrient composition of the fish species. Such variations occur in the chemical composition of fishes of same species, different species at different geographical locations and in different seasons (Balogun and Talabi, 1986).

Lates niloticus (Linn.), *Oreochromis niloticus* (Linn.), *Rastrineobola argentea* (Pelleg.) are economic important fish species from one of the Great Lakes of Africa i.e. Lake Victoria. These fish species were chosen because of their abundance, ease of recognition by the fishermen, availability throughout the seasons, public acceptance as food items and their respective trophic levels.

Although these three fish species are readily available in all seasons and geographical locations there has been few or little reports on their mineral contents. However, Shulman (1984), Balogun and Talabi (1986), Abdullahi and Abolude (2000), Abdullahi (2005), Abdulkarim *et al.,* (2011) and Mine *et al.,* (2014) reported variations in the nutrient contents of marine and fresh water fishes at different seasons and locations. Reports of such changes in these fish species and in this Great Lake is lacking.

This study therefore attempts to provide data on the mineral compositions of these fish species from Lake Victoria with special reference to rainy (wet) and dry seasons. This objective was addressed by testing the hypothesis that there are significant seasonal variations in the minerals composition of the three fish species (*L. niloticus, O. niloticus* and *R. argentea*) from Lake Victoria.

MATERIALS AND METHODS

Study Area

Lake Victoria, covering an area of 68,000 km² is the second largest lake in the world after Lake Superior in North America. It is shared by the three East African countries with Tanzania occupying the largest portion as follows, Tanzania (51 %), Uganda (43%) and Kenya (6%) (Fig. 1). The lake lies between latitude 0.7 º N - 3 º S and Longitude of 31.8 º E - 34.8 º E (Witte and Van Densen, 1994).

Samples Collection and Processing

A total of 5,328 samples of the three fish species consisting of 226 *L. niloticus,* 237 O*. niloticus* and 4,865 of *R. argentea* were purchased randomly from the commercial catches of fishermen at the three sampling sites (i.e Mwanza, Magu and Sengerema) of Lake Victoria. (Fig.1). The fishes were purchased in the early morning between 06:30–08:30 hours of December 2012, January, February, March, 2013 (wet season) and June, July, August and September 2013 (dry season). Each time the fishes were purchased from the fishermen they were iced and transported in insulated cool boxes to the Department of Aquatic Sciences and Fisheries, University of Dar es salaam, Tanzania and prepared for further laboratory analysis.

The samples were washed with de-iodized water, filleted, de- boned for the larger species (*L. niloticus* and *O. niloticus*), oven-dried at 105-109^{o}C for 20 hours or to a constant weight before being milled into homogenous powder using 8” Lab. milling machine (Christy Hunt Engineering Essex, England Serial number 19911). Powdered samples were put in polythene bags, labelled and kept in a dry place before being transported to the Department of Animal Sciences and Production (DASP), Sokoine University of Agriculture (SUA), Morogoro where the analyses were carried out. Triplicate determinations were carried out on each sample.

Mineral analyses

The minerals in the ash (samples) powder were brought into solution by wet digestion using concentrated nitric acid (63%), concentrated hydrochloric acid (60%) and concentrated sulphuric acid in the ratio 4:1:1 (Harris, 1979). These were digested slowly at moderate heat in a fume cupboard. Digestion continued for 15 minutes. After the appearance of white fumes, the solution was cooled and filtered with whatman filter paper No. 44 and further diluted with distilled water. Blank digestion was also carried out.

Metals were determined by a Flame Atomic Absorption Spectrophotometer (UNICAM 919, Cambridge, England) machine with an air acetylene flame, flow spoiler and a corrosion resistant nebulizer, using a mono-elemental hollow cathode lamp for each element. Na and K were determined by digital flame photometer (Model number 265500, Cole Palmer Instrument Company, Chicago, Illinois 60061). Phosphorus determination was carried out by Visible - Ultraviolet Spectrophotometer (BIO-MATE 6, Thermo-scientific Inc. Madison W1, 2008) using Ascorbic acid Colometric Method of the Association of Official analytical Chemists (AOAC, 1990).

Statistical analyses

The data obtained were subjected to a t-test and Wilcoxon matched- paired signed rank test using Graph Pad Prism Statistical Software Version (6.04) at a significant difference level of $P \leq 0.05$.

RESULTS

The mean calcium content of *L. niloticus* was significantly higher in wet season than dry season (t- test, t= 2.533, df = 11, p= 0.0278) (Fig. 2A). The mean potassium content during the wet season was 504.7mg/100g and was 387.4mg/100g during the dry season. The content was significantly higher in wet season than dry season (t- test, t= 3.812, df= 11, p= 0.0029) (Fig. 2B). Phosphorus

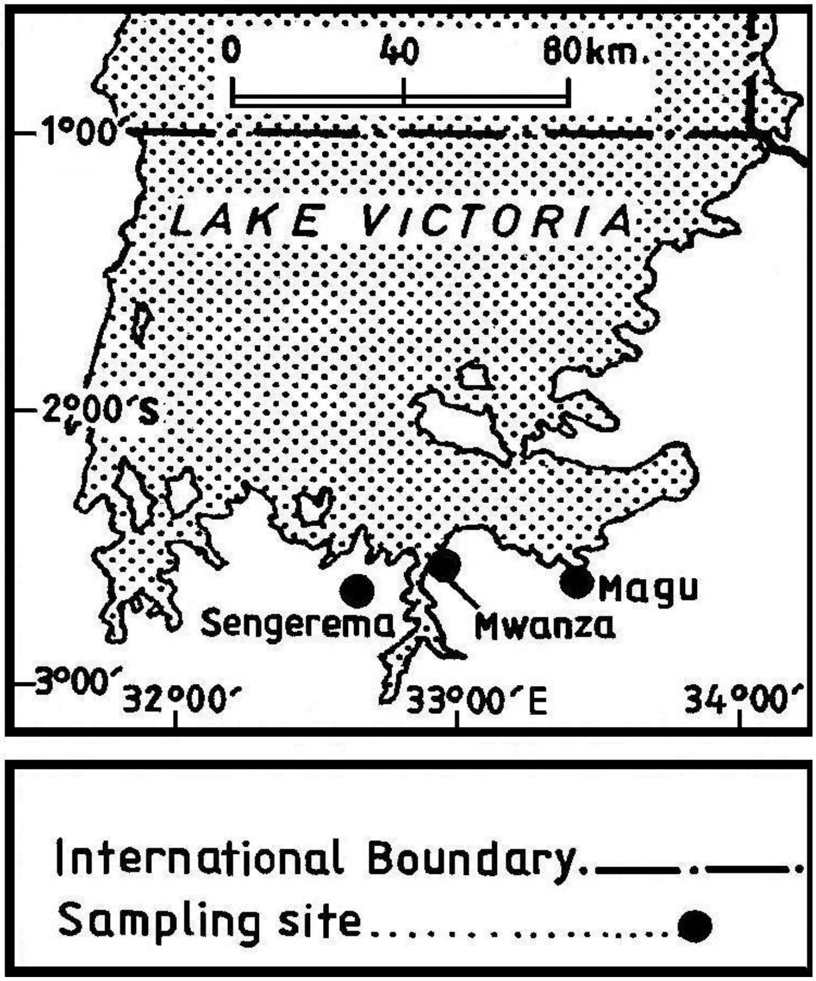

Figure 1. Map of Lake Victoria showing the sampling sites. (Source: Cartographic Unit, Geography Dept., University of Dar es salaam).

content was significantly higher in wet season than dry season (t- test, t= 3.163, df= 11, p= 0.0090) (Fig. 2C). Sodium content was significantly higher in wet season than dry season (t- test, t= 3.510, df= 11, p= 0.0049) (Fig. 2D). Magnesium content was significantly higher in wet season than dry season (t- test, t= 3.026, df= 11, p= 0.0115) (Fig. 2E). The mean content during the wet season was 36.16mg/100g and was 23.60 mg/100g during the dry season.

There was no significant difference in the content of manganese between the seasons (t- test, t= 0.000, df= 11, p> 0.999) (Fig.3A). The mean contents of both wet and dry seasons were 0.05mg/100g each. Zinc content was significantly higher in dry season than the wet season (t- test, t= 3.741, df= 11, p= 0.0033) (Fig. 3B). There was no significant difference in the contents of copper between the two season (t=0.00, df= 11, p>0.999) (Fig. 3C). Similarly, There was no significant difference in iron contents between the two seasons (wilcoxon matched pairs ranked test, W= 18, df= 11, p= 0.5029) (Fig. 3D).

The mean calcium content of *O. niloticus* during the wet season was 133.3mg/100g and was 104.4mg/100g during the dry season. The content was higher in wet season but not statistically significant (W= -48, df= 11, p= 0.0610) (Fig. 4A). The mean potassium content was significantly higher in wet season than dry season (t- test, t= 2.865, df= 11, p= 0.0154) (Fig. 4B). The mean phosphorus content during the wet season was 578.5mg/100g and 330.6mg/100g during the dry season. The content was significantly higher in wet season than dry season (W= -78, df = 11, p= 0.0005) (Fig. 4C). The mean sodium content during the wet season was 124.7mg/100g and 90.66mg/100g during the dry season. The content was significantly higher in wet season than dry season (t- test, t= 3.048, df= 11, p= 0.0111) (Fig. 4D). The mean magnesium content during the wet season was

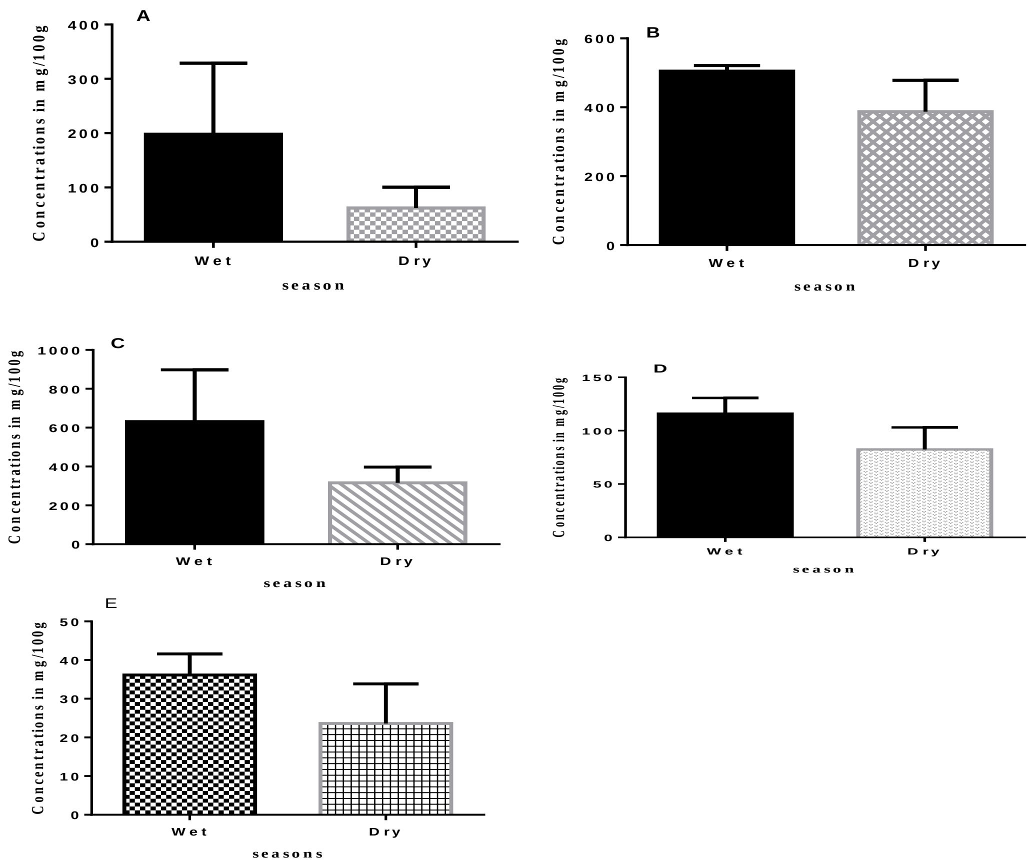

Figure 2. Seasonal variations in Calcium (A), Potassium (B), Phosphorus (C), Sodium (D) and Magnesium (E) of *L. niloticus.*

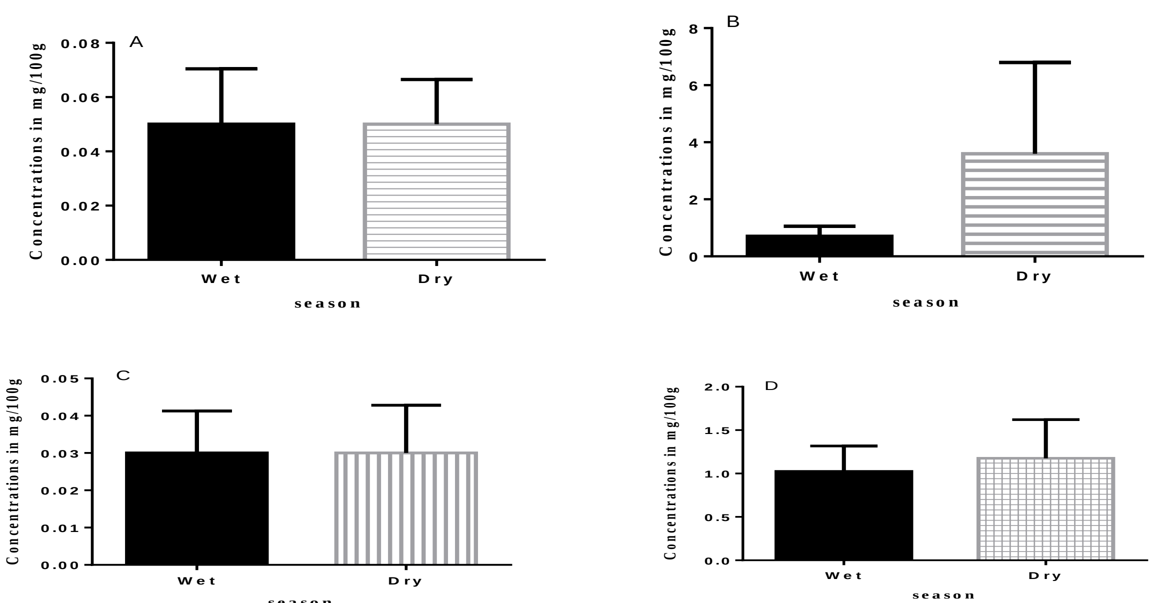

Figure 3. Seasonal variations in Manganese (A), Zinc (B), Copper (C) and Iron (D) of *L. niloticus.*

33.89mg/100g and was 26.82mg/100g during the dry season. The content was significantly higher in wet season than dry season (t- test, t=3.453, df= 11, p= 0.0054) (Fig. 4E).

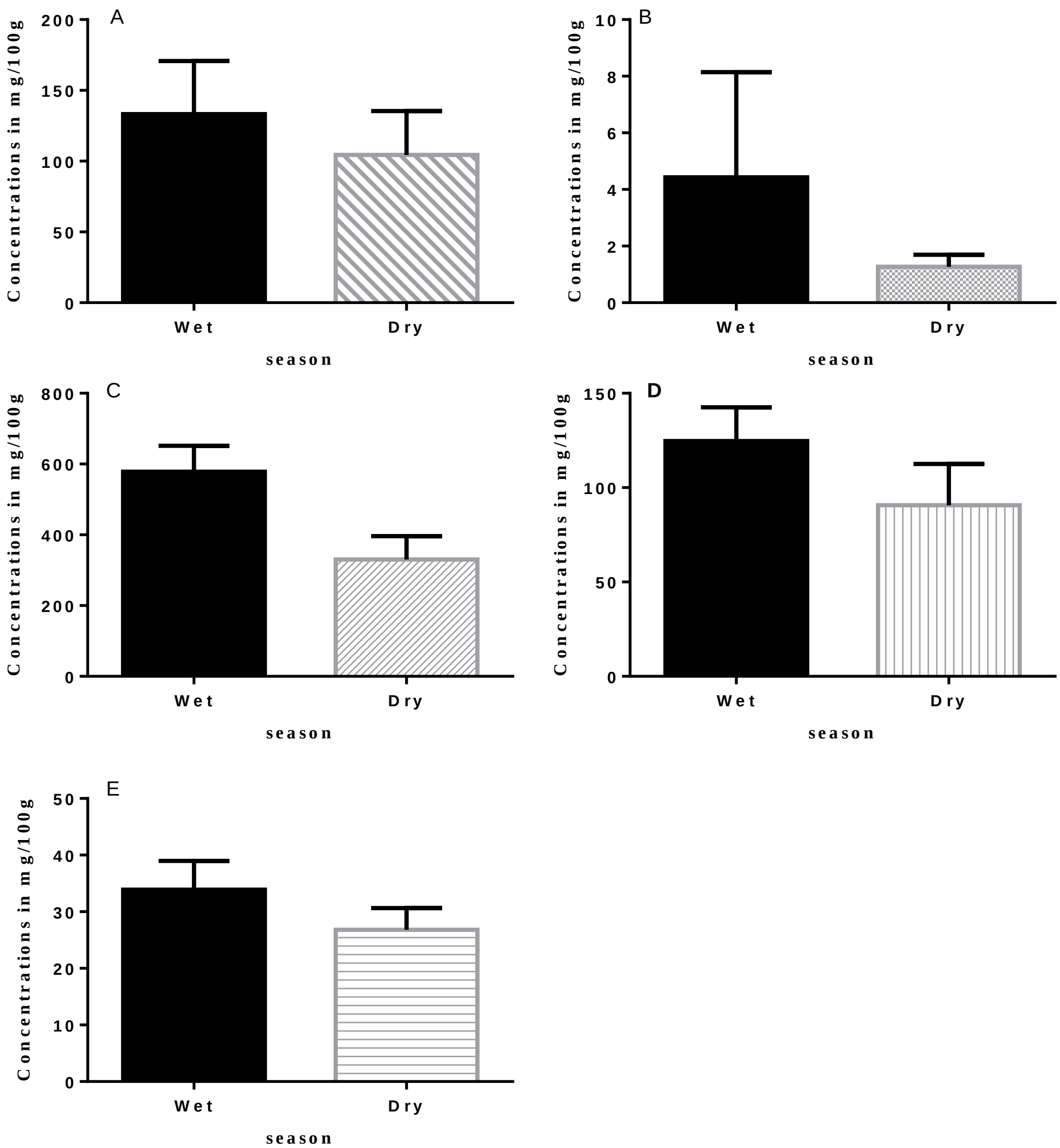

Figure 4. Seasonal variations in Calcium (A), Potassium (B), Phosphorus (C), Sodium (D) and Magnesium (E) of *O. niloticus.*

There was no significant difference in manganese contents between the two seasons (t- test, t= 1.340, df= 11, p= 0.2074) (Fig. 5A). Zinc contents was significantly higher in wet season than dry season (t- test, t= 3.027, df= 11, p= 0.0115) (Fig. 5B). There was no significant difference in copper contents between the two season (Wilcoxon matched paired rank test, W= 11, df= 11, p= 0.6523) (Fig.5C). The mean contents were 0.095mg/100g during the wet season and 0.1308mg/100g during dry season. The content of iron was significantly higher in dry season than wet season (t- test, t= 2.333, df= 11, p= 0.0397) (Fig. 5D).

The mean calcium content of *R. argentea* for wet season was 2041mg/100g and was 1475mg/100g for dry season. The content was significantly higher in wet season (t – test, t= 4.237 df= 11, p= 0.014) than dry season (Fig. 6A). The mean potassium content was significantly higher in wet season than dry season (Two sample t- test, t= 2.468, df= 11, p= 0.0312) (fig. 6B). The mean phosphorus content during the wet season was 2902mg/100g and 2042mg/100g during the dry season. The content was significantly higher in wet season than dry season (t- test, t=4.031, df = 11, p= 0.0020) (Fig. 6C). There was no significant difference in the mean sodium

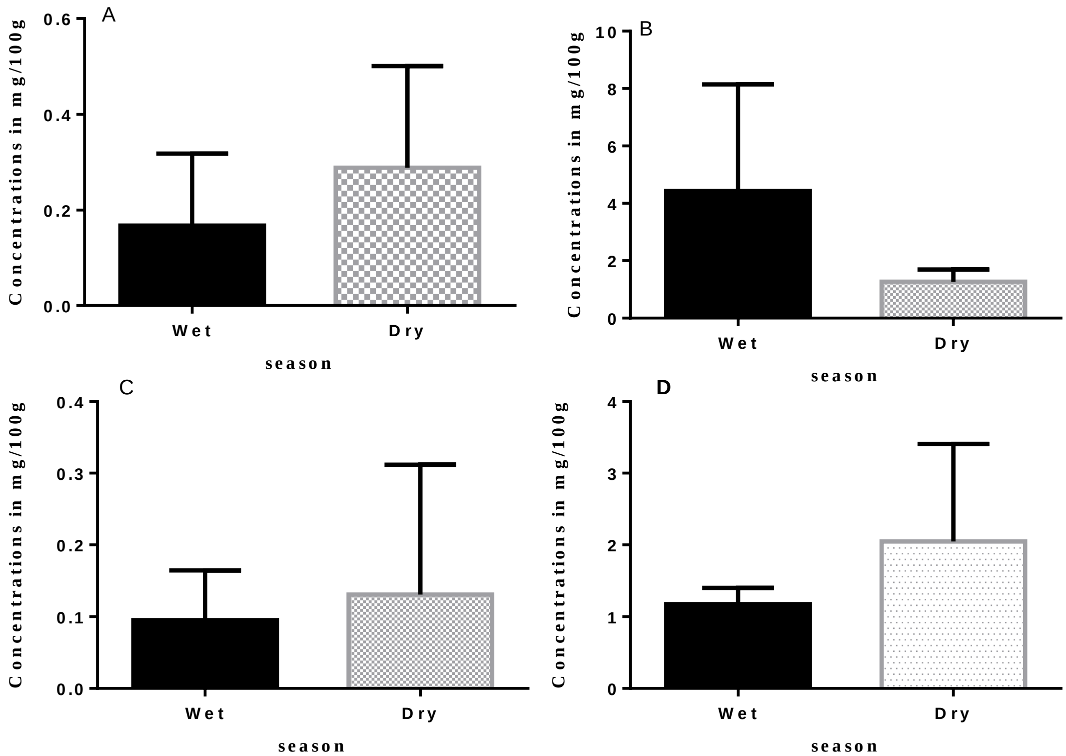

Figure 5. Seasonal variations in Manganese (A), Zinc (B), Copper (C) and Iron (D) of *O. niloticus.*

content of the species between the two seasons (t- test, t= 1.850, df= 11, p= 0.0914) (Fig. 6D). Magnesium content was significantly higher in wet season than dry season (Wilcoxon matched paired rank test, W= -54, df= 11, p= 0.0342) (Fig. 6E). The mean magnesium content during the wet season was 72.96mg/100g and was 54.73mg/100g during the dry season.

There was no significant difference in manganese contents between the two seasons (t- test, t= 0.2053, df= 11, p= 0.8411) (Fig.7 A). The mean content was 0.91mg/100g during the wet season and was 0.88mg/100g during the dry season. Zinc content was significantly higher in wet season than the dry season (t-test, t= 2.984, df= 11, p= 0.0124) (Fig.7 B). There was no significant difference in copper contents within two seasons (t= 0.00, df= 11, p> 0.999) (Fig.7C). The content of iron was significantly higher in wet season than the dry season (t- test, t=4.079, df= 11, p= 0.0018) (Fig.7D). The mean content during the wet season was 2.55mg/100g and was 1.40 mg/100g during the dry season.

DISCUSSION

Fish is a potential source of minerals such as calcium, phosphorus, sodium, potassium, iron, zinc, magnesium etc. These minerals are important in the metabolic and physiological activities and subsequent growth and development of living organisms. According to Haard, (1992) consumers are interested in mineral composition of fish because of a concern of the presence of heavy metals in fish flesh. There is also an interest in the delivery of essential minerals (Ca, P, K, Na, Mg, Mn, Zn, Cu, and Fe). Minerals also may have an influence on fillet flavour, increasing the level of importance on mineral determinations and comparisons among fishes.

Lates niloticus

A season is an important factor that could affect considerably the chemical composition of fish and consequently the quality of fish species. Phosphorus dominated the pool followed by calcium and the least recorded was copper for the two seasons. Phosphorus, calcium, potassium, sodium and magnesium were significantly ($p<0.05$) higher in rainy (wet) season. Zinc was significantly ($p<0.05$) higher during the dry season. However, copper, iron and manganese were statistically the same (($p>0.05$) in both dry and rainy seasons. Similar results were obtained by Abdullahi and Abolude (2005) in Bagridae:*Chrysichthys auratus*, *Bagrus docmac* and *Clarotis laticeps* from Tiga dam and Niger-Benue confluence from Nigeria. Abdulkarim *et al.,* (2011) also reported that calcium, potassium, iron, sodium, phosphorus and zinc were significantly higher during the rainy season while copper and magnesium were unaffec-

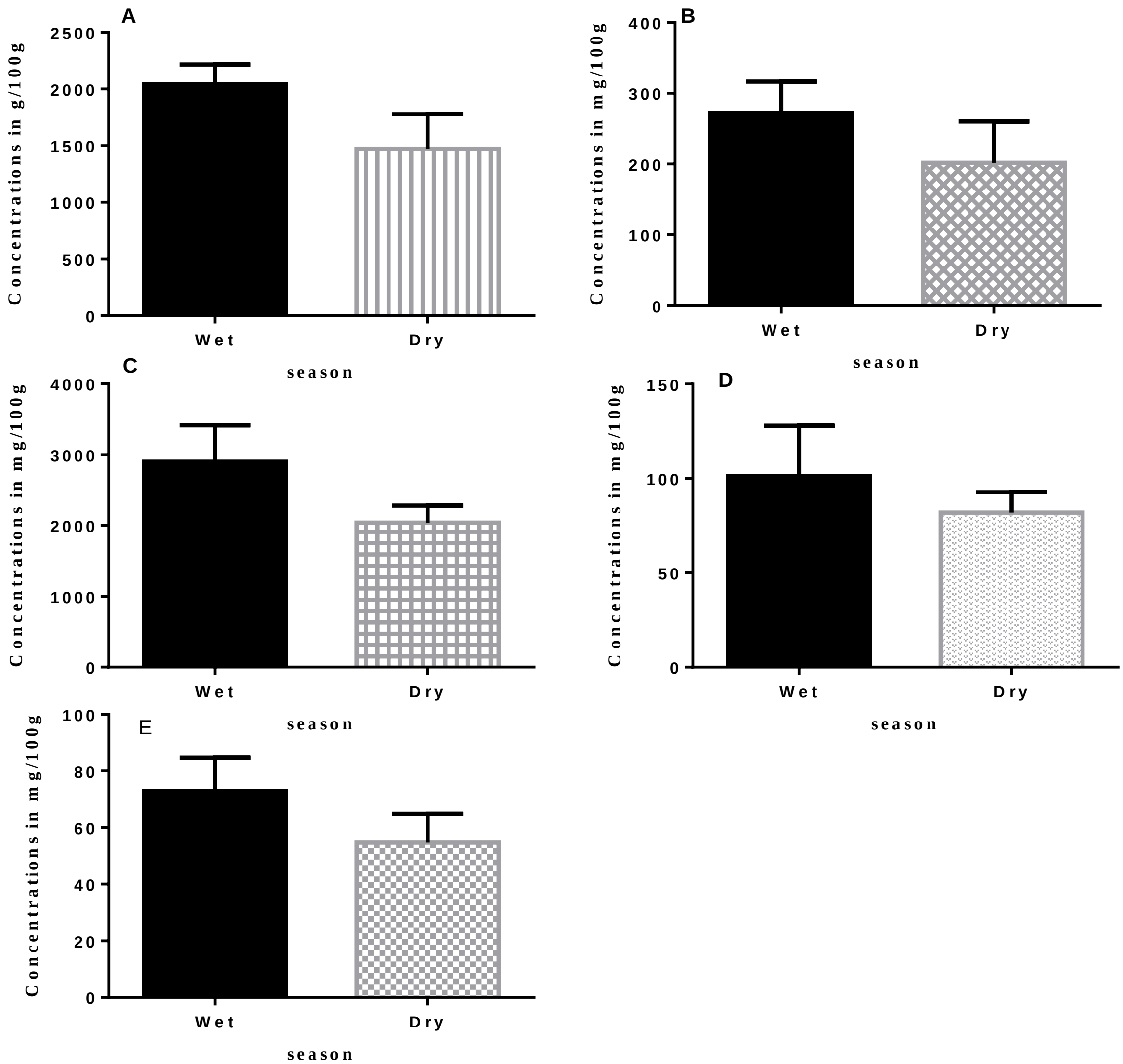

Figure 6. Seasonal variations in Calcium (A), Potassium (B), Phosphorus (C), Sodium (D) and Magnesium (E) of *R. argentea.*

ted by the seasons in the family's Mochokidae, Mormyridae and Schilbedae. This finding also concurs well with the findings of Ilhem *et al.,* (2014) who reported that Ca, K, Mg and Na were higher in *Liza aurata* (golden grey mullet) during the spring season in Tunisia. Higher contents of minerals in this study during rainy season might be attributed to the availability of more nutrients and dietary materials as well as increase in minerals washed into the natural habitats during the rainy season (Abdulkarim *et al.,* 2011). This study reported copper and manganese to be constant in both the two seasons. This was comparable to the findings of Effiong and Mohammed, (2008) who reported no significant differences in all the mineral contents of *Citharinus citharus*, *Clarias anguillaris* and *Hemisynodontis membranaceus* from Kainji Dam, in Nigeria. The reason for this might be because the elements are needed by the fish in small quantities hence excess may not be absorbed, and that their concentrations in the water bodies might also be little.

Oreochromis niloticus

Calcium, phosphorus, potassium, magnesium, sodium and zinc were significantly ($p<0.05$) higher in rainy season, while iron was significantly ($p<0.05$) higher during the dry season. Manganese content remained constant in both two seasons. These results agreed with the findings of Balogun and Talabi (1986) who reported higher mineral contents in Skipjack tuna in rainy season and in locations with higher inlets emptying into water bodies and Abdullahi (2005) who reported higher contents of minerals during the rainy season in *Malapterus electricus* from Nigeria. The content of minerals were higher during the rainy season because during this period, runoffs carry dissolved minerals from

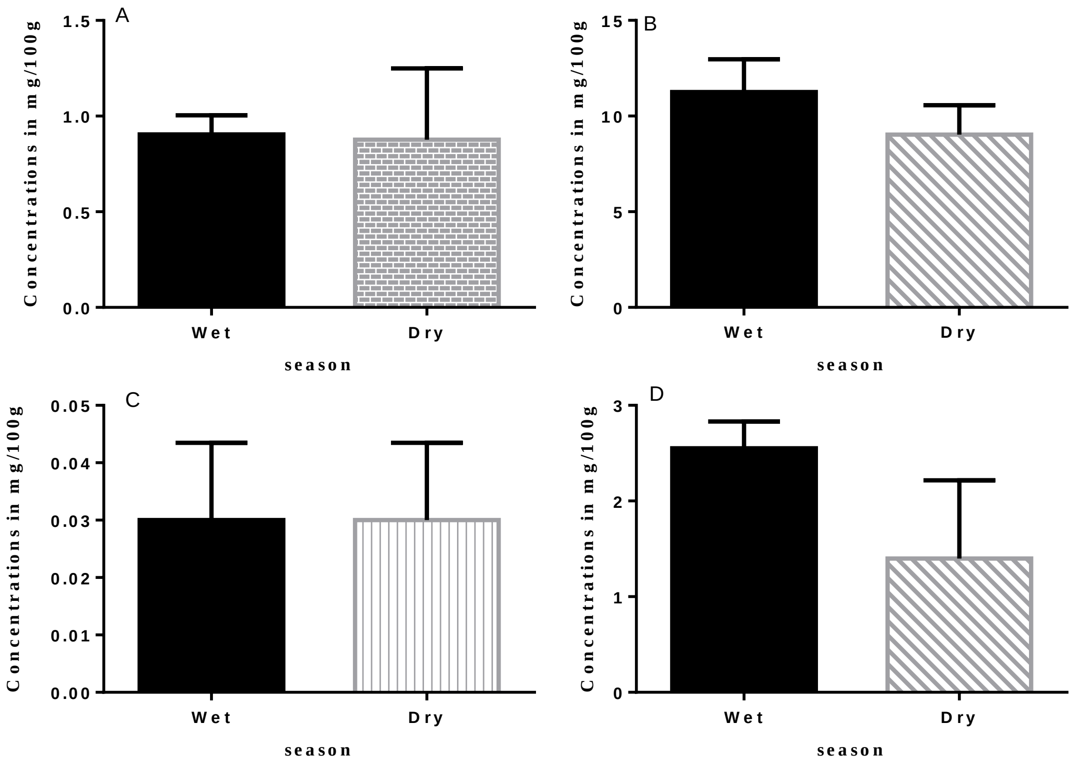

Figure 7. Seasonal variations in Manganese (A), Zinc (B), Copper (C) and Iron (D) of *R. argentea.*

adjacent land into the larger water bodies and therefore made them readily available to the fish. More, so the essential minerals were also in higher demand for utilization during metabolic and other physiological processes. This necessitates their bio- accumulation. However, during the dry season the minerals were homeostatically regulated to the level required by the fish (Koda *et al.,* 1995).

Rastrineobola argentea

Calcium, potassium, phosphorus, magnesium, sodium, zinc and iron were more concentrated in the rainy season. However, the contents of manganese and copper remained constant during both seasons. This is similar to that obtained by Abdullahi (2002) in *Lates niloticus*, *Heterotis niloticus* and *Gymnarcus niloticus*. The contents were higher because essential elements are in higher demand for metabolic and physiological activities. These essential nutrients are homoestatically regulated by the species metabolism and the concentrations reflect their physiological requirement rather than their level of exposure in the environment (Koda *et al.,* 1995). Phosphorus, zinc and calcium are required for enzyme activities and breeding processes of the fish (Connell, 1980). This explains the higher concentrations in the species during the rainy season which is the peak of breeding period (Quayam, 1984). Similar seasonal variations were earlier reported in Skipjack tuna (Balogun and Talabi, 1986), Cichlidae and Claridae (Abdullahi, and Abolude, 2000) and Bagridae (Abdullahi and Abolude, 2001).

Large variations occur in the chemical compositions of fishes of same species or different species, of different geographical locations and in different seasons (Balogun and Talabi, 1986). Standby (1982) suggested that these variations often ascribed to geographical and seasonal factors are in fact primarily due to the feed ingested, the metabolic rate and the mobility of the fish. The mineral compositions of the fish species based on seasons indicated that the major mineral elements (Ca, K, P, Mg, and Na) were highly concentrated during the rainy season.

The micro- elements such as copper, iron and zinc were found to be higher during the dry seasons or remained constant throughout the seasons. This is important to the consumers as they now have information on the best time or season to obtain some particular minerals from the fish species. The variations recorded in the concentration of the mineral in the fish examined could-have been a result of the rate at which they are available in the water bodies and the ability of the fish to absorb these inorganic elements from their diets and the water bodies where they live (Adewoye and Omotosho, 1997).

CONCLUSION

These fresh water fish species *L. niloticus*, *O. niloticus* and *R. argentea* have great potentials as health food and sources of therapeutic substances. The levels of the essential and non essential minerals presence in them indicate that the species could be used as supplements in remedy of health and nutritive problems among the Tanzanian populace. In addition, the higher levels of essential minerals during the rainy season make the three species highly desirable for consumption during this period.

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