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Bioaccumulation of two macro-elements (Sodium and Potassium) in relation to body size and condition factor of *Notopterus chitala* from River Indus, Ghazi Ghat, Pakistan

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Abstract

Notopterus chitala is a member of the primitive teleost lineage and considered as commercially important food fish. In the present study, a total of 16 fish specimens of *N. chitala* were collected from the River Indus to assess the concentration of sodium and potassium and to determine the influence of fish size and condition factors on the bioaccumulation of these macro-elements in the fish. Mean (±SD) body weight, total length and condition factor was found 250.32±113.93 g, 32.93 ± 4.85 cm and 0.647± 0.094, respectively. Fish samples were oven dried, grinded, and burned to make ash and digested into 1M HNO_3 to make sample solution. Atomic absorption spectrophotometer was used to detect the concentration of sodium and potassium. The mean concentration of sodium was found 255.51± 32.45 μgg^{-1} with range values of 206.28-298.70 μgg^{-1}, while potassium was observed 1327.15 ± 234.71 μgg^{-1} with a range 815.08-1694.87 μgg^{-1} in wet body weight of wild captured *N. chitala.* Body weight, total length and condition factor represented insignificant correlations with the concentrations of sodium and potassium in *N. chitala*, indicating no dependence of fish size on the bioaccumulation of these essential minerals in the body of this fish species.

Keywords: Essential elements, Metal concentrations, Atomic absorption spectrometry, Fish size

Introduction

Notopterus chitala (Notopteridae) is carnivorous and predatory fish, and distributed in India, Bangladesh, Pakistan, Sumatra, Vietnam, Thailand and other parts of continent Asia (Day, 1878). It has annually breeding habit and is found in spawning grounds in rainy days and then moves back to its permanent habitat during dry season (Rainboth, 1996). It is a highly demanded fish species because of its special taste when cooked, so consumers demand this fish species in bulk (Samad et al., 2017; Jayaram, 1999).

Fish is widely consumed worldwide as it provides high-quality proteins, polyunsaturated fatty acids, vitamins and other essential nutrients (Javed and Hayat, 1999). Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life. Essential metals have a role in biological functions, but in higher concentrations they may become toxic by disrupting metabolic activities (Mallick et al., 2014).

The uptake rate, metabolism of the chemical, and excretion rate determine the accumulated amount (Heath, 1995). There are three ways for a substance to get entry into a fish body and these are food, gills, and skin. Due to being directly in contact with ambient water, the most important target of metals are gills (Playle, 1998). However, metal concentrations in fish tissue are influenced by different factors, such as fish size (Naeem et al., 2012) feeding behavior, species ecology, environmental variations (Martinez et al., 2010) and sex (Simionov et al., 2019).

Mineral elements are of great diversity uses in animal body. The mineral elements essential for fish body functioning are calcium, sodium, molybdenum, phosphorus, chlorine, iron, selenium, iodine, manganese, magnesium, copper, cobalt and zinc (Watanabe, 1997). Sodium and potassium are electrolytes that must be balanced in the body. Electrolyte balance is indispensable for function and bone composition, neuronal processes, muscular physiology, acid-base homeostasis, oxygen transport and for many other biological functions. Even small deviations in blood concentrations of electrolytes can lead to serious health problems and even increased mortality (Kear, 2017). Sodium (Na) is a cation in the extracellular fluid, critical in maintaining fluid balance. It also contributes to the cell membrane potential and enzymatic reactions in the intracellular fluid (Williams, et al., 2018). Potassium (K) is the most common cation of the intracellular fluid, where it is important for the maintenance of osmotic pressure, regulation of membrane potential, acid-base-balance and electrolyte homeostasis. It functions in protein biosynthesis, controlling nerve impulses, and conversion of blood sugar into glycogen. Potassium is also important for a healthy nervous system and a stay heart rate (Schiefermeier et al., 2020, Mallick et al., 2014).

The objective of this research was to analyze the of macro-elements (sodium and potassium) in relation to condition factors and body size in *Notopterus chitala* from River Indus, Ghazi Ghat, near Dera Ghazi Khan, Pakistan

Materials and Methods

Sampling of *Notopterus chitala* (Clown Knifefish) was done from the River Indus, Ghazi Ghat (30°3'48"N 70°48'51"E), near Dera Ghazi Khan, Pakistan. Samples were carried to the Applied Fisheries Research Laboratory, Institute of Zoology, Bahauddin Zakariya University, Multan, Pakistan, for further experimental process. Fish samples were washed thoroughly to remove sand, debris, etc. and dried on paper towel. Each of the fish specimen was weighed (in gram) and total length (in centimeters) was measured. Condition factor was calculated by following standard formula to analyze the relationship between condition factors and accumulation of macro elements (sodium and potassium).

Whole fish samples of *N. chitala* were dried in electric oven (Incucell, MMM Medcenter Einrichtungen GmbH) till constant weight. Dry weight of each sample fish was recorded for calculation of concentration in the whole dry fish weight. Each dried fish sample was grinded to homogenize and was packed in air tight plastic bottles for further analyses. One gram sub-sample of each specimen was burnt in muffle furnace (RJM-1.8-10A) at 500°C for overnight. Obtained ash was digested in 1% nitric acid to make 25ml solution. Concentration of sodium and potassium was analyzed by Atomic Absorption Spectrometer (Agilent 240 AA Series).

Log transformed regression equation in ($Log\ Y = a + b\ Log\ X$) was applied to assess the correlation between the fish size and concentration of sodium and potassium in the body of *N. chitala*, where "a" was regression coefficient, "b" was slope; "Y" is concentration of sodium and potassium; whereas total length (TL), body weight (W) or condition factor was taken on "X". Data were reflected significant at $P<0.05$.

Results

A total of 16 fish samples of *Notopterus chitala* were studied to detect the concentration of sodium and potassium. The Mean (±SD) total length of the studied fish samples was 32.93 ± 4.85 cm with a range of 25.30-39.6 cm, and mean body weight was found 250.32±113.93 g with a range value of 90.00-403.00 g, while mean condition factor value was found 0.647± 0.094 with range values 0.494-0.855.

It was determined from the obtained results that the pattern of the considered element in the *Notopterus chitala* was found as Potassium>Sodium on the basis of metal concentration in the fish's dry and wet body weight. Descriptive statistics of sodium and potassium concentration (μgg^{-1}) in wet as well as dry body weight of *N. chitala* are represented in **Table 1**.

Table 1. Mean values and range of elemental concentration in wet weight and dry weight of *Notopterus chitala* (whole fish).

Elem	*Conc. (μgg^{-1}) wet weight*		*Concentration (μgg^{-1}) dry weight*	
	Range	**Mean ± S.E.**	**Range**	**Mean ± S.E.**
Na	206.28-298.70	255.51± 32.45	768.75-1237.5	978.9063 ± 130.44
K	815.08-1694.87	1327.15 ± 234.71	3240.00-6420.00	5071.25 ± 847.39

Elemental Concentrations in relation to Fish Size

Results of regression analyses for log-transformed data represented that Sodium and Potassium concentration in *N. chitala* showed a non-significant correlation (P>0.05) with body weight (**Table 2**) and total length of the fish (**Table 3**). In metal concentration versus fish weight relations, values of correlation coefficient (r) were found 0.071 and 0.046; and slope (b) values were -0.017 and 0.017 for sodium and potassium, respectively (**Table 2**).

Table 2: Statistics of regression analysis between log wet body weight (g) and log body burden element (µg) for *N. chitala* (n = 16).

Elem	Correlation coef. (r)	Intercept (a)	Slope (b)	S.E of b	t value (b = 1)
Na	0.071 $^{n.s}$	2.444	-0.017	0.065	-15.401
K	0.046 $^{n.s}$	3.076	0.017	0.097	-10.292

ns = Non-Significant at P>0.05

In relationships between metal concentration and total length (TL) of *N. chitala*, the r-value was observed 0.109 and 0.051; and the b-value was -0.094 and 0.066 for sodium and potassium, respectively (**Table 3**).

Table 3: Statistics of regression analysis between log total length (cm) and log body burden element (µg) for *N. chitala* (n = 16)

Elem	Cor. Coef. (r)	Intercept (a)	Slope (b)	S.E of b	t value (b = 3)
Na	0.109 $^{n.s}$	2.546	-0.09	0.23	-13.194
K	0.051 $^{n.s}$	3.016	0.066	0.34	-8.655

Elements Concentration in relationship to Condition Factor

Concentration ($\mu g g^{-1}$) of sodium and potassium in wet weight of *Notopterus chitala* was also found non-significantly correlated (P>0.05) with condition factor, comprising r-value 0.145 and 0.047 for sodium and potassium, respectively (**Table 4**).

Table 4: Statistics of regression analysis between condition factor and metal concentration (wet weight, $\mu g g^{-1}$) for *N. chitala* (n = 16)

Elem	Correl. Coeffic. (r)	Intercept (a)	Slope (b)	S.E of b	t value (b = 0)
Na	0.145 $^{n.s}$	223.256	49.82	90.99	0.548
K	0.047 $^{n.s}$	1252.179	115.80	664.27	0.174

Discussion

Fish has great importance in a diet and also it is an easy way to get protein for people in underdeveloped countries (Burger and Gochfeld 2010). Fish is also a vital source of many essential (micro- and macro-) minerals including Sodium and Potassium. Both Sodium and Potassium are essential macro-elements in the human diet as these are needed for nerve transmission, muscle contraction and proper fluid balance. The findings of the present study showed that wild-captured *Notopterus chitala* contained reasonable concentrations of sodium and potassium minerals, hence representing that the studied fish species could serve as good sources of minerals.

Naeem et al. (2010) reported 339.42 ± 15.191 and 1470.07 ± 38.893 $\mu g g^{-1}$ of the wet weight of sodium and potassium in hatchery reared *Oncorhynchus mykiss*. Results for mineral concentrations in wild captured population of N. chitala were in general accordance with those reported by Naeem et al. (2010). The studied values of potassium are in accordance with the results of Salam et al. (1996) for *Oreochromis niloticus*. Findings of Salam et al. (1998) for *Catla catla* and Salam et al. (2002) for *Cirrhinus mirigala* are also in accordance with the aforementioned. However, Iqbal et al. (2019) have found q higher concentration of both sodium and potassium in hybrid fish (Catla catla♂ x Labeo rohita♀) by feeding experimental diets containing specific protein levels. The variations in the concentration of the different nutritional components could have been as a result of the rate in which these components are available in the water body (Yeannes, and Almandos, 2003), or may be dependent upon their feeding habitat (Ansari et al., 2006), season (Fawole et al., 2006) and size (Naeem et al., 2010; Iqbal et al., 2019; Ansari et al., 2006).

It was clear from the results that the concentration of potassium was found higher than that of sodium in wet as well as dry body weight of N. chitala. The relatively higher concentration of potassium would suggest that the fish was more capable of concentrating this mineral element in its body from the aquatic environment than sodium. Naeem et al. (2010) found the same order of accumulation of elements in these macro-elements in *O. mykiss*. Moreover, potassium was reported to be present most abundantly in the studies of Tsegay *et al*. (2016) in *Oreochromus niloticus*, which also supports the findings of the present work.

To assess the size dependence of sodium and potassium concentrations in *Notopterus chitala*, regression analyses were performed and parameters of

the relationships are provided in Tables 2 and 3. Insignificant correlations (P >0.05) of mineral elements concentrations with body weight and total length of wild *N. chitala* depicted no dependence of sodium and potassium on the fish size. Iqbal *et al.* (2019) also documented insignificant correlations of various metals concentrations including sodium and potassium with concentrations of total length of hybrid fish (*C. catla*♂ x *L. rohita*♀). Another study (Nasir et al., 2022) also reported a lack of correlation between metal concentrations and body weight of *Cirrhinus mrigala*. On the other hand, many researchers have reported that essential metals concentration generally increase in direct proportion to an increase in total length or body weight of fish. Naeem *et al*. (2010) found strong significant relationships (P<0.001) of sodium and potassium with body size of *O. mykiss*, with negative allometric pattern. Salam *et al*. (2002) also showed significant positive correlation (P<0.001) of sodium and potassium with body weight or total length in farmed *Cirrhinus mrigala*. These previously documented reports are contrary to the findings of the present study. The variation might be due to fact that concentration of some metals decrease or increase while others remain constant as fish grows, accumulation rate of some metals is greater than others (Naeem et al., 2010; Salam et al., 2002); and beside fish size, may also be influenced by some other biotic or abiotic factors like its foraging behavior, habitat, the metabolic rate of fish, seasonal changes, temperature, and physical and chemical changes of water (Iqbal et al., 2019; Burger and Gochfeld 2010; Naeem et al., 2010; Fawole et al., 2007; Ansari et al., 2006). Results of the present study also showed that sodium and potassium concentrations remained constant with condition factor of wild N. chitala. Similar results were also observed by Naeem et al. (2012) wild captured *Mystus bleekeri*.

Conclusions

It is concluded that *Notopterus chitala* contained reasonable concentrations of the studied macro-elements (sodium and potassium), hence the fish species from the collected habitat could serve as good sources of these minerals. Moreover, fish size and condition factor does not influence the bioaccumulation of sodium and potassium in wild captured *N. chitala.*

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