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Research Article

Macro and trace mineral elements of five small indigenous fishes of Manipur, India

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ABSTRACT

Proximate composition and concentration of macro (Ca, K, Na and Mg) and trace elements (Mn, Cu, Zn and Fe) of five different Small Indigenous Fishes of Manipur viz *Devario acquipinnatus*, *Glossogobius giuris*, *Hypsibarbus myitkyinae*, *Puntius chola* and *Tariqilabeo burmanicus* was analyzed. Significantly higher ($P<0.05$) moisture (76.21±1.11) was recorded in *G. giuris*. Concentration of protein (21.00±0.00) was found highest in *D. acquipinnatus*. In *T. burmanicus*, significantly higher lipid (10.76±0.03) and ash (4.00±0.12) were recorded among the small fishes studied. Macro and trace mineral elements were recorded in all the fishes. Results from the analysis revealed that Ca, Mg and K were 2244.0±3.77 mg/100g, 125.8±1.09 mg/100g and 149.8±1.1 mg/100g respectively which shows significantly ($P<0.05$) higher in *G. giuris* among the fish species studied. Significantly higher ($P<0.05$) Na (102.4±1.7 mg/100g), Mn (1.26±0.04 mg/100g) and Zn (1.77±0.013 mg/100g) respectively were recorded in *P. chola* Higher concentration of Cu (0.35±0.007 mg/100g) and Fe (25.3±0.36 mg/100g) were observed highest in *T. burmanicus* and *D. acquipinnatus* respectively. From the above study, it was revealed that Small Indigenous Fishes are good sources of essential mineral elements which are indispensable for the maintenance of human health and various physiological abnormalities of the human body. Thus consumption and conservation of small fishes should be encouraged.

INTRODUCTION

Small Indigenous Fishes are those fishes which grow to a maximum size of 25 cm or 9.8 inches in the mature or adult stage in their life cycle (Felts *et al.*, 1996). However, many SIS are less than 10 cm or 3.9 inches in length and they are consumed as a whole. These fishes have a short life cycle and can be grown in all types of inland water bodies. North East India owing to its topographical features provides an ideal habitat for various endemic small fishes. As many as 47 genera of small fishes are recorded from North East India out of this 40 genus are found in Manipur (Vishwanath *et al.*, 2007). In Manipur, these small fishes are abundant in river, beels, streams, canals and ponds. Due to overfishing, destruction of their habitats and feeding ground, some of the small fishes are on the verge of extinction. So, there is an urgent need for the conservation and proper management to increase the productivity of these small fishes.

Fish are the good sources of animal protein as well as rich in vitamins and minerals (Moghaddam *et al.*, 2007 and Singh *et al.*, 2017). The nutritional value of fish comprises of moisture, protein, lipid, vitamins, minerals and caloric value of the fish (Steffen, 2006). Fish meat contains essential amino acid as well as having high energy depot in the form of lipid and contains the high amount of polyunsaturated fatty acid which prevents a number of coronary heart diseases (Palani *et al.*, 2014). Besides, fish meat is also a rich source of minerals and the most abundant micro-elements are zinc, Iron and copper (Saadattin *et al.*, 1999). The human body usually contains a small number of minerals and the deficiency of these principal nutritional elements indices a lot of malfunction and causes various diseases such as the inability of the blood clot, osteoporosis, anaemia, etc (Mill, 1980).

Fish can be considered “the poor man’s food” (Kent, 1997) and for large population groups, fish is an irreplaceable animal food source. Most fish species are consumed but small fishes are generally being less preferred than larger fish species and therefore having less market value, this means that small fish species are more accessible to poor particularly in the season of high production (Roos *et al.*, 2007). However, these small fishes have high market value as well as highly esteemed among the people of Manipur. Moreover, micronutrient deficiency, sometimes termed “hidden hunger” since it is difficult to see, and is a big problem in south and Southeast Asia. About 250 million children worldwide are at risk of vitamin A deficiency, and an equal number are at risk of deficiencies of other minerals like iron, zinc and calcium (Sakuntala, 2010). Small fishes are important sources of micronutrients and play an important role to provide essential nutrients. They are consumed in small qualities but these small fishes are consumed as a whole which are particularly rich in micronutrients such as iron, zinc and their bone are excellent sources of calcium (Roos *et al.*, 2006). In addition to the nutritional values, it is crucial to say that Small Indigenous Fishes also plays a vital role in the life and economy of the vast majority of the fisherman community and poor rural people.

There are some reports on biochemical composition and nutritional qualities of small fishes (Larsen 2000, Saronalini, 2010, Abdul and Sarojnalini, 2012, Sarojnalini and Sarjubala, 2014). However, there is no such report on essential mineral elements content of Small fishes. Many Small fishes endemic to Manipur are highly esteemed among the people for their distinctive taste and flavour. These fishes are consumed either in fresh or process forms (Sarojnalini 2010). These fishes are abundant in the markets of Manipur during 1980’s but it is now scarce due to overfishing, destruction of their habitats and feeding ground and also this small fishes are on the verge of extinction. Thus this paper is largely focused on the importance of essential mineral elements which can combat micronutrient deficiency and to fill the gap of records on nutritional values of small fishes.

MATERIALS AND METHODS

Sample collection

Five Small indigenous Fishes viz. *Devario yuensis* (Arunkumar and Tombi Singh 1998) *Glossogobius giuris* (Hamilton1822), *Hypsibarbus myitkyinae* (Parshad and Mukherji 1929), *Puntius chola* (Hamilton 1822) and *Tariqilabeo burmanicus* (Hora 1936) respectively were selected for various analyses. The respective collection sites and total length and weight of fish species were shown in Fig. 1a, 1b, 1c, 1d and Table 1 respectively. The fish sample was brought fresh with proper caring using the cold chain to the Manipur University fishery laboratory and washes immediately in tab water and undergoes various analyses.

Proximate composition

Moisture content was determined by hot air oven method (AOAC 2000) at 60˚C till a constant weight is obtained. The loss in weight was expressed in percentage in dry weight of the sample. Total Nitrogen content was determined by the modified micro- Kjeldahl method (AOAC 2000). The samples were subjected to digestion in Pelican – Keplus-KES 12LVA, Nesslerization and finally measured by using UV-1800 UV-Spectrophotometer, Shimadzu. Total protein value was obtained by multiplying the total nitrogen value by 6.25. Total lipid was also extracted by following the modified method of Singh *et al.*, 1990 by extraction with chloroform and methanol in the ratio of 2:1. For the determination of ash content, moisture free sample was ignited at 550˚C in a muffle furnace for about 2-3 hours to obtained carbon free white ash as described by AOAC 2000.

Mineral analysis

Sample for mineral analysis was done by following the method of Perkin Elmer’s (1996). 2gm muscle tissue of each fish sample was taken and dried at 135ºC for 2 hours and weighed. It was heated up to 500-550ºC in a muffle furnace for 2 hrs cooled to room temperature, added 2 ml H_2NO_3 and evaporated to dryness. It was transferred to a volumetric flask (50ml) and added HCl as necessary and diluted to volume with deionized distilled water (Millipore). All care was taken for cleanness and non-contamination

Atomic absorption spectrometer analysis

Analysis of mineral elements Ca, Mg, Na, K, Mn, Ni, Cu, Zn and Fe were done by Atomic Absorption Spectrometer 203 following the methods of Perkin-Elmer (1996). Most of the mineral elements Na, K, Ca etc. were done with hollow cathode lamps (HCL). Na and K were analysed through Flame Photometer – 121,122,125.

Statistical analysis

Three samples were used for determination. The data were subjected to one way-ANOVA and the significance mean were compared by Duncan’s multiple range tests ($P<0.05$). The relationship between proximate composition and length-weight and essential mineral elements and length-weight were identified using Pearson’s correlation coefficients. Differences and correlations were considered significant when $P<0.05$ and $P<0.01$ were obtained. Species were grouped and classified in a cluster by their similarities produce in the data. The linkage in dendrogram shows the order of dissimilarities designated as a distance index (Krzanowski, 1995). All the statistical analyses were performed using SPSS version 16.0.

RESULTS AND DISCUSSION

Proximate composition of Small indigenous fishes

Proximate composition of small fish species of Manipur was depicted in Fig. 4. The highest moisture content was 76.21mg/100g which was observed in *G. giuris* among the fishes studied, the concentration is followed by *P. chola* (76.18mg/100g) and the lowest was found in *D. yuensis* (71.18mg/100g). However, moisture content was negatively correlated with crude lipid content which shows highest at 10.76±0.83 mg/100g in *T. burmanicus* and the lowest in G. *giuris* (2.23mg/100g). Moreover, moisture content was also negatively correlated with crude protein. Higher concentration of protein was found in *D. yuensis* (21.00 mg/100g) and the lowest was observed in *G. giuris* (9.42 mg/100g) which show significant different ($P<0.05$) among the fishes studied. The concentration of ash ranges from 2.91mg/100g to 4.00mg/100g, which show highest in *T. burmanicus* and lowest in *P. chola* among the fishes studied.

Accumulation of essential mineral elements in Small indigenous fishes

Macromineral elements {Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)} and Trace mineral elements {Manganese (Mn), Zinc (Zn) and Iron (Fe)} of Small fishes studied are depicted in Table 2. Analysis of variant (ANOVA) of the concentration among the fishes studied shows significantly difference ($P<0.05$). Highest concentration of Ca (2244.0 mg/100g), Mn (125.8 mg/100g) and K (149.8 mg/100g) were recorded in *G. giuris* among the fish studied. However, *P. chola* shows higher concentration of Na (102.4 mg/100g), Mg (1.77 mg/100g) and Zn (1.77 mg/100g). Higher concentration of Cu (0.35 mg/100g and Fe (25.3 mg/100g) were recorded in *T. burmanicus* and *D. yuensis* respectively. It can be deduced that the accumulation of essential mineral within the whole body of small fishes are in the decreasing order as Ca>Mg>K>Na>Fe>Zn>Mn>Cu..

The relationship between proximate composition and Length-weight of the fishes studied

The relationship of moisture, lipid, protein and ash content was stratified by the total length and weight of the fishes (Table 3). In these analyses, moisture content was negatively correlated with ash content (-0.223). Whereas, crude lipid was negatively correlated with total length (-0.184), weight (-0.357) and moisture content (-0.673). Moreover, protein content was also negatively correlated with total length (-0.479), weight (-0.493) and moisture content (-0.979). However, ash content shows positively correlated with total length (0.555), weight (0.306), crude lipid (0.551) and protein (0.318) except moisture (-0.223) respectively. The correlation coefficient (r^2) of moisture, crude lipid, protein and ash with total length were 0.489, -0.184, -0.479 and 0.555 respectively. Whereas, correlation coefficient (r^2) of moisture, crude lipid, protein and ash with weight were 0.433, -0.357, -0.493 and 0.331 respectively.

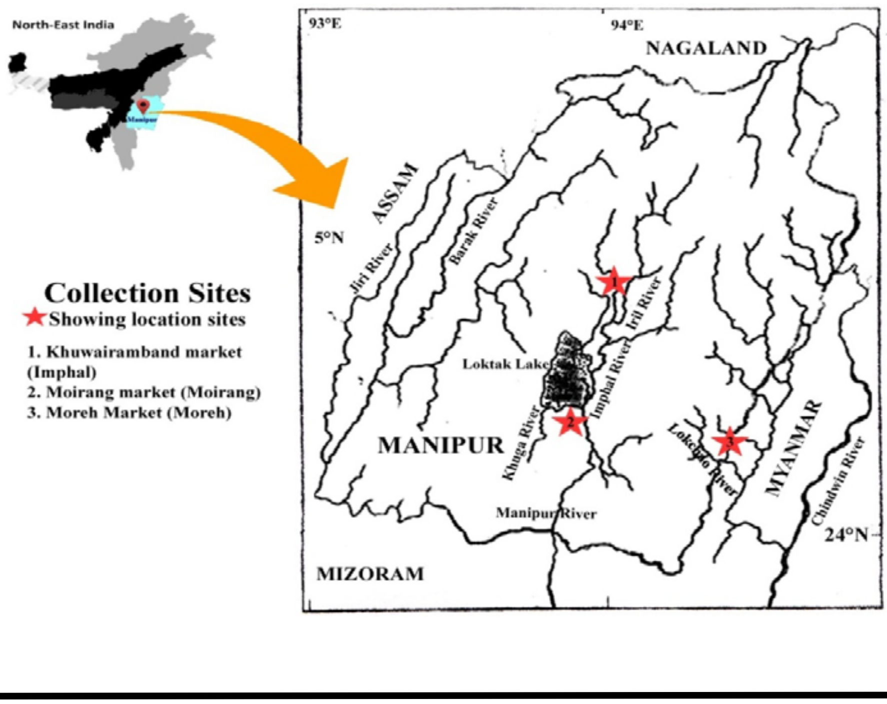
The relationship between essential mineral elements and Length-weight of the fishes

The relationship between essential mineral elements and total length and weight of small fishes studied were presented in Table 4. In these analyses, it is revealed that total length is positively correlated with Cu (0.727) which is followed by K (0.280) and Ca (0.087) respectively. These same elements viz Cu (0.442), K (0.030) and Ca (0.122) were also positively correlated with the weight of the fishes. However, Mg, Na, Mn, Zn and Fe were negatively correlated with total length (-0.306, -0.488, -0.403, -0.684 and -.849) and weight (-0.455, -0.345, -0.394, -0.778 and -0.682) of the small fishes suggesting that higher total length and weight may accumulate lower concentration of Mg, Na, Mn, Zn and Fe.

Table 1: The respective collection sites and length- weight of five Small Indigenous Fishes of Manipur.

Species	Local name	Collection site	GPS Location	Total Length (cm)	Weight (gm)
Devario yuensis	Ching-nga	Moreh Market	24˚14'57.34''N 94˚18'07.50''E	6.73±0.25	2.81±0.54
Glossogobius giuris	Nilon ngamu	Moirang Market	24˚30'05.03''N 93˚46'34.21''E	13.56±0.81	19.86±2.83
Hipsibarbus myitkyinae	Heikak nga	Moreh Market	24˚14'57.34''N 94˚18'07.50''E	12.86±0.6	23.58±0.72
Puntius chola	Phabou nga	Khuwairamban Market, Imphal	24°48'28.48''N 93°56'01.45''E	8.30±0.17	6.42±0.14
Tariqilabeo burmanicus	Ngaroi	Moreh Market	24˚14'57.34''N 94˚18'07.50''E	10.86±0.40	8.76±0.39

Values are mean of three replicate.



1a

1b

1c

1d

Fig 1: Map showing the collection sites of the fish samples 1a) Complete map of collection sites1b) Khuwairamband Market (1c) Moirang Market and (1d) Moreh Market.

Table 2: Mineral composition of five Small Indigenous Fishes of Manipur

	Nutrient content mg/100g raw edible parts					
	Devario yuensis	***Glossogobius giuris***	***Hypsibarbus myitkyinae***	***Puntius chola***	***Tariqilabeo burmanicus***	***RDA (mg/day)***
Macro elements						
Calcium (Ca)	2077.0±2.0[d]	2244.0±3.77[e]	1864.3±1.28[b]	1932.8±4.16[c]	1759.0±2.17[a]	500-600†
Magnesium (Mg)	112.6±2.5[c]	125.8±1.09[d]	67.25±1.98[a]	115.7±1.29[c]	96.00±0.25[b]	30-340†
Sodium (Na)	87.5±0.13[c]	84.99±0.14[b]	85.0±0.09[b]	102.4±1.7[d]	79.56±0.68[a]	1100-3300†
Potassium (K)	54.9±0.01[b]	149.8±1.14[e]	47.49±0.10[a]	124.9±0.04[d]	104.9±0.15[c]	1875-5625†
Trace elements						
Manganese (Mn)	0.53±0.01[b]	0.42±0.01[a]	0.65±0.01[c]	1.26±0.04[e]	0.77±0.008[d]	2-5†
Copper (Cu)	0.16±0.016[a]	0.314±0.008[d]	0.26±0.017[c]	0.24±0.01[b]	0.35±0.007[e]	2†
Zinc (Zn)	0.90±0.016[c]	0.36±0.01[b]	0.29±0.015[a]	1.77±0.013[e]	1.19±.006[d]	12†
Iron (Fe)	25.3±0.36[e]	11.88±0.13[c]	10.39±0.13[b]	17.6±0.14[d]	8.61±0.21[a]	5-35†

Values are mean of three replicate.
Mean (±SD) followed the same latter are not significantly different ($P \leq 0.05$).
†National Institute of Nutrition

Table 3: Pearson's correlation between proximate composition and total length-weight

	Total Length	**Weight**	**Moisture**	**Lipid**	**Protein**	**Ash**
Total Length	1					
Weight	0.928*	1				
Moisture	0.489	0.433	1			
Lipid	-0.184	-0.357	-0.673	1		
Protein	-0.479	-0.493	-0.979**	0.800	1	
Ash	0.555	0.306	-0.223	0.551	0.318	1

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level

Table 4: Pearson's correlation between Essential mineral elements and total length-weight

	Total Length	Weight	Ca	Mg	Na	K	Mn	Ni	Cu	Zn	Fe
Total Length	1										
Weight	0.928*	1									
Ca	0.087	0.122	1								
Mg	-0.306	-0.455	0.695	1							
Na	-0.488	-0.345	0.105	0.349	1						
K	0.280	0.030	0.373	0.704	0.226	1					
Mn	-0.403	-0.394	-0.510	0.010	0.763	0.192	1				
Ni	0.790	0.548	0.328	0.283	-0.360	0.761	-0.315	1			
Cu	0.727	0.442	-0.258	-0.096	-0.460	0.559	-0.038	0.825	1		
Zn	-0.684	-0.778	-0.381	0.329	0.641	0.260	0.862	-0.349	-0.115	1	
Fe	-0.849	-0.682	0.388	0.438	0.467	-0.290	0.044	-0.691	-0.918*	0.295	1

*Correlation is significant at the 0.05 level

DISCUSSION

Proximate composition of Small Fishes

From the above results, it was revealed that moisture concentration was within the acceptable level (60-80%) in all the fish sample studied which could be due to the stable water level in the environment. Omolara *et al.,* 2008 have reported that high moisture content increases susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and consequently decrease in quality of the fishes for longer preservation. Relatively high to moderate protein content was found, which may be considered as high dietary quality sources of animal protein. The differences observed in the present values might be due to the fishes consumption or absorption capability and conversion potential of nutrients from their diet or local environment into such biochemical attribute needed by the organisms' body (Adewoye 1997). Lipid serves as a source of energy during starvation and fasting. The mean lipid content of the fishes studied ranges from 2.23±0.15 mg/100g to 10.76±0.83 mg/100g which shows significant different (P<0.05) among the fishes. According to Ackman 1989 fishes studied can be grouped under low fat fish (2% - 4%), medium (4% - 8%) and high fat fish (>8%). In the present finding, *T. burmanicus* can be categorised under the high-fat fish. Ash content ranges from 2.91 mg/100g to 4.00 mg/100g which show a positive correlation with mineral elements content of the fishes. Higher content of ash may be due to higher bony consistency and highly scaly nature (Sarojnalini *et al.*, 1994). Furthermore, the cluster analysis dendrogram of proximate composition (Fig 2) shows that *G. giuris* and *P.chola* show good similarities, whereas least similarity with *H. myitkyanae*. However, *D. yuensis* and *T. burmanicus* show good similarities between the fishes. But *G. giuris* and *P. chola* have no similarity with *T. burmanicus* as well as *D. yuensis*. As reported by Deka *et al.,* (2012) variation in the proximate composition of fish flesh may vary with species variation, season, age and quality of food. Besides this, some physiological reasons and change in environmental condition might also greatly affect the proximate composition in fishes.

Macro and Trace mineral elements of Small Fishes

Concentration of mineral elements were detected in decreasing order as Ca>Mg>K>Na>Fe>Zn>Mn>Cu. In the previous report of Jassica *et al.,* (2015) mineral elements were detected in the decreasing order of Ca>P>K>S>Mg>Se>I>Fe>Zn>Mn>Cu in important small fishes of Bangladesh. Abdul 2012 reported in the decreasing order of K>P>Mg>Na>Ca> Fe>Co>Cu>Ni>Mn>Cu>Cr in smoke dried hill stream fishes of Manipur. Many researchers did not observe any definite order in the magnitude of the elements. This variation in concentration of elements is due to the chemical forms of the elements and their concentration in the local environment (Window *et al.,* 1987).

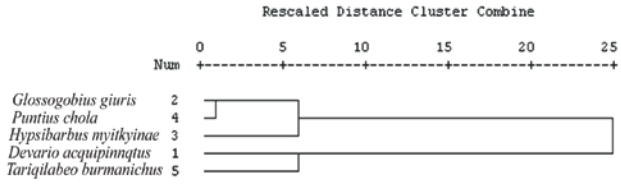


Fig 2: Dendrogram of five small fishes using Ward's method with respect to proximate composition.

Macro elements of small fishes

As reported by John *et al.,* 2012 deficiencies of Ca can lead to osteoporosis, lower bowel (unabsorbed Ca) which can increase vulnerability to colon cancer and stone kidney. Failure to maintain extracellular Ca concentration may increase the risk of hypertension, premenstrual syndrome, obesity, polycystic ovary syndrome and hyperparathyroidism. Higher concentration of Ca was recorded than the previous report of Abdul and Sarojnalini (2012) and Jassica *et al.,* (2015) as well as the concentration of Ca content in Indian major carps viz *C. catla*, *C. mirgla* and *L. rohita* respectively (Table 6). Higher concentration of Ca be due to these small fishes are consumed as a whole including scales, bones and skin. The absorbed Ca was deposited in the skin (John E.H. 2013), thus these small fishes can be highly recommended as a source of good bioavailability dietary Ca. RDA according to by National Institute of Nutrition 2009 is 500-600 mg/day.

Mg plays a primary role in controlling nerve transmission cardiac excitation, neuromuscular conduction, muscular contraction, vasomotor tone and blood pressure. However, deficiency of Mg has linked to metabolic syndrome, insulin resistance and diabetes mellitus (John *et al.,* 2012). The concentration of Mg shows higher than the concentration of the previous report of Jassica *et al.,* 2015. Higher concentration of Mg accumulation might be due to the uptake of Mg-rich food from the environment. National

Institute of Nutrition 2009 recommended RDA for proper Mg balance of Indian is 30-340 mg/day.

The concentration of Na and K of fishes studied were shown lower than the previous concentration reported by ICAR in Indian Major Carps (Table 5). However, the values were consistent with the previous report of Abdul 2012 and Jassica *et al.,* 2015. Na regulates the electrolyte and acid-base balances, the conductive capacity of adrenaline and amino acids (Pirestani *et al.,* 2009). According to WHO 2012 intake of K in both adult and children has specific health outcome in maintenance of normal blood pressure, cardiovascular disease, coronary heart disease, stroke, renal function, blood lipid level, catecholamine level and potential adverse effect, moreover it also regulates the normal functioning of the nerves and muscles, the sugar metabolism, acid-base balance and oxygen metabolism in the brain. Intake of high Na and low K was also associated with increased risk of hypertension (Quanhe Y. *et al.,* 2011). The human Na and K requirement are 1100-3300 mg/day and 1875-5625mg/day respectively (National Institute of Nutrition 2009).

Trace mineral elements of small fishes:

The concentration of Mn content in the present study shows slightly higher than the previous report which was in the ranges of 0.13 mg/100g to 0.5 mg/100g in smoke dried hill stream fishes of Manipur (Abdul 2012), 0.021 mg/100g to 2.3 mg/100g in important small fish species of Bangladesh (Jassica *et al.,* 2015) and 0.3 mg/100g to 0.5 mg/100g in Indian major carp (ICAR). Higher concentration of Mn of the present study might be due to the analysis of fishes as a whole body, where the higher concentration of Mn was found in bone, liver, muscle, kidney, gonadal tissue and skin (John E. H., 2013). According to National Institute of Nutrition, 2009 the required RDA for proper balance of Mn is 2-5 mg/D. Mn activates various enzyme including oxidoreductases, ligase, hydrolase, kinases, decarboxylases and transferases. Moreover, deletion of Mn metalloenzymes manganese superoxide dismutase (MnSOD) found in human and animal may exhibit myocardial injury, neurodegeneration, lipid peroxidation, fatty liver, anaemia and severe mitochondrial damage (John *et al.,* 2012). The deficiency of Mn leads to growth failure, skeletal abnormalities and impaired reproductive function (National Institute of Nutrition 2009).

The concentration of Cu was within the range of RDA recorded by National Institute of Nutrition, 2009. All the small fishes studied can provide the Cu content to some extent to the diet. Cu content in the literature of Abdul 2012 have been reported in the range of 0.5 mg/100g - 0.87 mg/100g respectively in smoke dried hill stream fishes of Manipur. The concentration of Cu was recorded in the range of 0.73 µg/g – 1.26 µg/g in fishes of the Black and Aegean Seas of Turkey (Ozgur *et al.,* 2007). RDA of Cu according to National Institute of Nutrition, 2009 is 2 mg/day. Intake of Cu is essential for good health, but very high intake of Cu cause health problem such as liver and kidney damage (ATSDR 2004). Deficiencies of Cu in human may lead to hypochromic anaemia (refractory to iron supplementation), neutropenia, thrombocytopenia, hypopigmentation, plus anatomical and functional abnormalities in the skeletal, cardiovascular, and immune systems (John *et al.,* 2012).

The concentration of Zn was slightly lower than as reported by Abdul 2012. Jassica *et al.,* 2015 reported the concentration of Zn was in the range of 1.1 mg/100g to 4.7 mg/100g. However, the concentration of Zn content in the present study can significantly contribute to the uptake of Zn. Zn reduces childhood illness, enhance physical growth and decrease morbidity and mortality in poor children. Supplementation with Zn was also found to lower frequency and severity of infections like diarrhoea and pneumonia and reduce mortality. Deficiency of Zn manifested with symptoms like growth failure, depressed immunity, anorexia, diarrhoea, altered skeletal function and reproductive failure. The RDA of Zn for proper balancing in human is 12 mg/day according to National Institute of Nutrition 2009.

The deficiency of iron is coexisting with the causes of anaemia in India. Iron deficiency occurs when the demand for Fe is high during growth, high menstrual loss and pregnancy and the intake quantity is inadequate or contains elements that render the Fe unavailability for absorption (Lynch 1996). The concentration of Fe was recorded higher than the previous literature in the range of 0.46 mg/100g to 19.0 mg/100g (Jassica *et al.,* 2015), 1.71 mg/100g to 8.37 mg/100g (Abdul 2012) and 1.6 mg/100g to 2.2 mg/100g in Indian Major Carp (ICAR). These differences might be due to the species distributed in the different environment and the higher concentration of Fe might be due to the abundance of phytoplankton in the environment. The concentration of Fe indicates that small fish species may contribute significantly to dietary Fe intake which is of high bioavailability as an animal food source (FAO and WHO 2004). This may reflect the public health significance of Fe deficiency in India with prevalence estimation of 24% in men age more than 20 yrs. The RDA of Fe in India is in the range of 5-35 mg/day (National Institute of Nutrition 2009).

Moreover, the result of the cluster analysis with respect to mineral elements as shown in Fig 3. The dendrogram was classified into groups by randomly rescale distance cluster Ward's method. The cluster analysis result shows that *H. myitkyinae* and *P. chola* shows good similarity and least similarity with *T. burmanichus*. Whereas, *D. yuensis* and *G. giuris* shows a similarity between the fishes. However, *T. burmanicus* has no similarity with *G. giuris* and *D. yuensis* respectively.

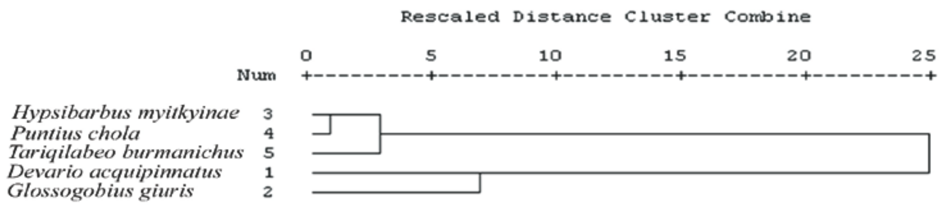


Fig 3: Dendrogram of five small fishes using Ward's method with respect to mineral content.

Table 5: Essential mineral elements (mg/100g) of some fishes

	*Catla catla**	*Cirrhinus mrigala**	*Labeo rohita**	*Lebeo pangusia†*	*Ompok bimaculatus†*	*Semiplotus manipurensis†*
Macro elements						
Calcium (Ca)	161.1±4.4	222.5±15.7	205.7±4.8	9.70±0.55	24.25±0.54	10.75±0.25
Magnesium (Mg)	Nd	Nd	Nd	68.75±0.25	106.75±1.86	81.00±0.66
Sodium (Na)	198.3±31.9	205.7±31.6	202.1±44.5	60.87±1.32	103.12±1.36	65.82±0.88
Potassium (K)	283.9±6.9	273.4±24.0	267.5±32.9	236.25±2.15	121.05±1.26	284.24±0.79
Micro elements						
Manganese (Mn)	0.3±0.0	0.5±0.3	0.4±0.2	0.5±0.00	0.13±0.00	ND
Nickel (Ni)	Nd	Nd	Nd	1.8±0.00	2.5±0.00	1.5±0.00
Copper (Cu)	Nd	Nd	Nd	0.5±0.00	ND	0.87±0.01
Zinc (Zn)	1.3±0.3	1.1±0.6	1.9±0.6	3.75±0.00	0.92±0.01	2.06±0.00
Iron (Fe)	1.6±0.4	1.9±0.5	2.2±0.5	5.969±0.53	1.71±0.36	8.37±0.03

*Nutrient profiling and evaluation of fish as dietary component (NUTRIFISHIN, ICAR)

† Abdul Hei, 2012; Smoke-dried Hill Stream Fishes from Manipur

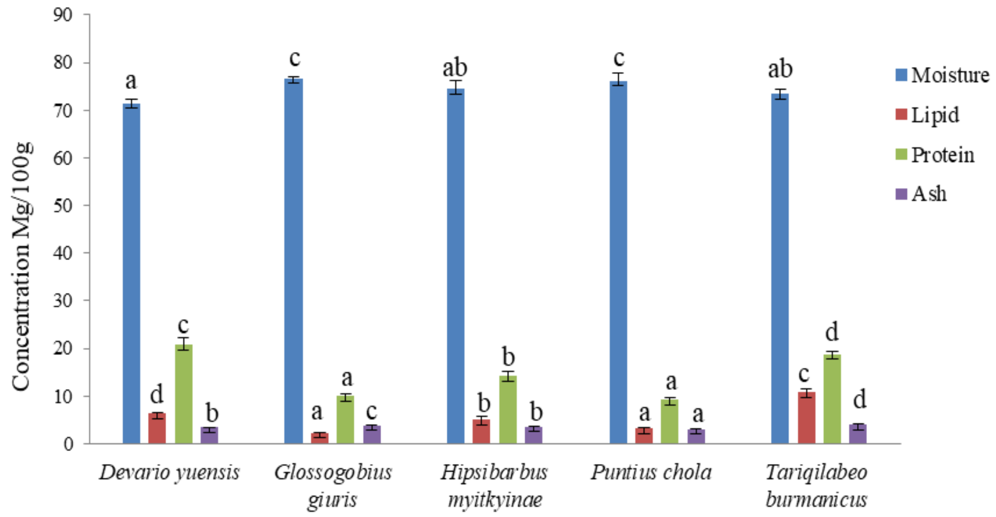


Fig 4: Proximate composition of Five SIS of Manipur. Means with different superscript shows on the bars are the significant difference by Dancan's multiple range test (p<0.05)

CONCLUSION

From the above analysis, it was revealed that small fishes of Manipur are good sources of essential elements especially Ca and Fe. However, other elements like Mg, K, Na, Mn, Cu and Zn may contribute to the various health benefit, growth and development, as well as can, contributes to overcoming various mineral deficiencies when consumption. Higher concentration of Ca would increase the concentration of the Mg, Na, K and Fe which were supported by the Pearson's correlation. Thus, this paper can contribute to some extent about the nutritional aspect with special reference to essential mineral elements of Small Indigenous fishes of Manipur.

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