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Mineral Accessibility of Small Indegenous Fishes of Manipur, North-East India

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Abstract
The Small Indigenous Fishes (SIFs) available in the wild habitat are preferred for consumption. Fish, a high-protein and low-fat food, provides various health benefits. The present study highlights the analysis of macro and micro elements of the indigenous fish species Pangio pangia (*nganap achouba)*,Lepidocephalichthys irrorata(*nganap macha*), *and* Lepidocephalichthys berdmorei(*ngakijou)using Energy Dispersive X-ray Spectroscopy (EDS).*
The results of the present study revealed that the macro elements, namely Ca, Na, Mg, P, and K, and microelements, such as Mn, Fe, Cu, and Zn, were detected in varying concentrations. The macro element viz, Mg (83.80 ±0.52mg/100g), P (756.00 ± 0.88 mg/100gm), and microelement Fe(8.70 ±0.68 mg/100gm), Cu (0.97±0.38 mg/100g) were found significantly higher (p<0.05) in Pangio pangia. *On the other hand, Na (158.10 ±0.63mg/100g) and K(85.70 ± 0.46 mg/100g) were significantly higher(p<0.05) in* Lepidocephalichthys berdmorei *among the fish studied. Ca (1725.00 ±0.38mg/100g) content was recorded as significantly higher (P<0.05) than other macro elements and found highest in* Lepidocephalichthys irrorata. *From the above analysis, it has been observed that all the fishes were good sources of minerals. This elemental profile study will impact the future study of their roles in cellular metabolism, growth, and development in addition to their nutritive, detoxification, immune functions, and antioxidant activity.*
Keywords: *Biodiversity, Conservation, Habitat, Health, Nutrients,*

1.NTRODUCTION

Various biochemical processes in the biological function of all organisms are controlled and regulated by the enzymes, hormones, vitamins, and minerals present in them. Though minerals are present in small quantities, they play an important role in the proper functioning of the body, particularly in the regulating mechanism of the vitamins and enzymes (Hegsted BM,1976; S.H Thilsted et al.1997), nerve transmission, regulation of pH, muscle contraction, digestion and other metabolisms (Harris ED, 2001). Besides, they have their nutritive role and perform profound antioxidant activities. Many of the elements are indispensable to all living things. The functions of each element must be specific and cannot be replaced by another. Imbalances of the mineral elements may negatively affect the biological processes and are associated with many fatal diseases (Prasad AS, 1995). In fact, they are essential components of biological activities and can be toxic if consumed at excessive levels, which may lead to many fatal diseases, such as cancer. Elements like Ca, Cu, Mn, Zn, Fe, Cl, etc., are also required in trace amounts, and the deficiency of these elements induces many malfunctions and might cause bone demineralization and poor growth in children, anorexia, loss of appetite, anemia, etc. (Neilsen FH, 2012; Roos et al., 2007). As per the recommended daily allowance (RDA), every organism has its recommended dietary dose to maintain a physically and chemically fit body, but for human beings, it is essential to have a balanced meal so that everyone can be mentally and physically fit. However, everyone may not have the ability to consume a balanced diet at each serving, which may be because of unawareness, unavailability of resources due to increasing demands, poverty, decreased productivity, etc., despite having many economic developments. Malnutrition is certainly a problem in underdeveloped and developing countries such as Southern Asia and sub-Saharan Africa (Webb et al., 2018; Afshin et al., 2019). The burden of malnutrition has been unacceptably high across the globe. It was reported that there are about 800 million undernourished people, and undernourishment is responsible for six of the top 11 ill health-causing global risk factors (Afshin et al., 2019). Many workers reported the various effects on children and women in many ways, causing diseases (UNICEF, WHO, WBG, 2020; Development Initiatives, 2018; Setboonsarng, 2005).

Therefore, the inadequate balanced diet can be overcome by using the available dietary supplements in the wild and by enhancing knowledge of traditional food with high nutritional value.One such dietary supplement could be the Small Indigenous Fishes (SIF_s). These fishes grow to a maximum size of 25 cm or 9.8 inches (Felts et al., 1996). However, many SIFs are less than 10 cm or 3.9 inches in length and are consumed as a whole. They are available in the wild, i.e., in lakes, rivers, wetlands, etc. (S.H.Thilsted et al., 1997). In fact, the SIFs are a good source of protein, micro-nutrients, and essential fatty acids. Besides, they are rich in vitamins, particularly vitamins A, D, and E, as well as vitamins B1, B2, and B3. They are also rich in calcium and phosphorus and are a great source of essential minerals such as iron, zinc, iodine, magnesium, potassium, etc., and other microelements (Roos et al., 2002).
There are various reports on the biochemical composition and nutritional qualities of small fishes by different workers. Sakuntala et al. 1997 studied the role of small indigenous fish species in food and nutrition security in Bangladesh. Larsen et al. 2000 reported on small fishes as a rich source of calcium. Roos et al. 2007 reported the role of fish in food-based strategies to combat vitamin A and mineral deficiencies in developing countries. The nutritive value of two indigenous Cobitid fishes of Manipur and various aspects of fresh and cooked small indigenous fishes of Manipur were reported by several workers (Sarojnalini et al., 2010; Sarojnalini& W. Sarjubala,2014). Nearly 47 genera of small fishes are found in North East India, out of which 40 are found in Manipur (Vishwanath et al., 2007). SIFs are culturally associated with and very much desirous food by the different ethnic communities in Manipur.Two SIFs, P.pangia and L.irrorata, can play an essential part in the tradition of the Meitei community in Manipur. The preparation of these fish curry is consumed on the wedding night by the newly married couple. It is believed that the couple could be inseparable in their life. Besides their food values, they play an essential role in sustaining the livelihood of the fishing community and helping the rural economy. Although these fishes are currently listed under the most minor concern category in the IUCN Redlist, their nutritional and aesthetic values make them suitable for conservation and mass production to improve livelihood and ecological and cultural significance. In the present investigation, an analysis of the mineral profile of the three SIFs is done. There is a necessity for documenting the mineral profile of these fish species.Therefore, the current study focuses on the importance of essential mineral elements that can combat various mineral deficiency diseases. Also, it can provide knowledge to the locals about the importance of Small Indigenous Fishes for their high nutritive value.

2.MATERIALS AND METHODS

2.1 Sample collection:

The three cobitid fishes were purchased from different localities, i.e., Pangio pangia (Lepidocephalichthys irrorata (Hora, 1921) Hamilton, 1822)from Churachandpur market, Manipur, and Lepidocephalichthys berdmorei (Blyth, 1860) from Nambol market, Manipur in May 2022 (Fig.1a, 1b,1c.) The collected fish samples were acclimatized to laboratory conditions in a large aquarium with tap water for 15 days at room temperature. During acclimatization, fish were fed daily with commercial dry feed pellets (Tetrabits). Individual fish's length (in cm) and weight (in gm) were measured and recorded. Ten fish were pooled separately for each species for sample preparation and analysis. The samples were oven-dried at 60^0 C till a constant weight was obtained. Economic Importance and present status of the three Small indigenous fishes of Manipur are represented in Table 1. All the experiments were performed in triplicates, representing the results as mean ±SD.

2.2 Sample Preparation:

The dried sample was ground into powder, and the sample was placed on the sample holder using a double tap carbon. It was then placed inside the sputter coater and coated with gold.

2.3 Instrumentation: The elemental composition of the sample is analyzed using AMETEK EDAX, which is an indispensable part of the SEM QUANTA 250. The electrons emitted from the tungsten filament, using thermionic emission, are made to hit the target (sample), thereby knocking out the inner shell or core electron. The vacant site created is subsequently filled in by an electron from the outer shell, and the difference in energy is released in the form of an X-ray. The X-ray emitted is unique for each element and also for the transition. They are collected using a silicon drift detector and then interpreted using software (EDAX Genesis). EDX can be used for both semi-qualitative and semi-quantitative analysis, enabling users to identify the type of elements and also the percentage of each element present

in the sample. The energy of the electron beam we used to hit the target sample is 20KV, and pressure inside the vacuum chamber is set to ESEM (Environmental SEM).

3. Statistical analysis

Data were analyzed by one-way analysis of variance (ANOVA), and the significant differences among the three different fishes were determined by Duncan's Test. The level of significance employed was $p<0.05$. All the statistical analyses were performed using SPSS version 21.

4. RESULT

In our study, the mineral content was found in varied concentrations among the studied SIF_s. Ca was found to be highest in all three fish samples studied compared to the other elements studied. The concentration of macro and microelements in decreasing order is as follows: Ca> P> Na>K> Mg and Mn> Fe >Zn > Cu in L.berdmorei, Ca>P>Mg>K>Na and Fe>Zn>Mn>Cu in P.pangia and Ca>P>K>Mg>Na and Mn>Zn>Fe>Cu in L.irrorata. The comparison of the three fishes by Duncan's one-way ANOVA revealed that there were significant differences ($P<0.05$) in concentration in all the elements. The highest Ca content was found in L.irrorata (1725±0.38mg/100g). P concentration of the fish studied varies from 254.7±0.60mg/100g to 756±0.88 mg/100g. The content of Na and K in all the fish studied ranges from 29±0.60 mg/100g to 158.1± 0.63 mg/100g and 57.72± 0.64 mg/100g to 85.7± 0.46 mg/100g, respectively. The highest concentration of Mg (83.8±0.52 mg/100g) was found in P.pangia, and the lowest was recorded in L.irrorata (42.8±0.44 mg/100g). The highest Fe content (8.7± 0.68 mg/100g) was found in P.pangia, and the lowest concentration was recorded in L.irrorata (6.5± 0.38 mg/100g). The highest concentration of Mg (83.8±0.52 mg/100g) was found in P.pangia, and the lowest was recorded in L.irrorata (42.8±0.44 mg/100g). The highest concentration of Mn was found in L.irrorata(16.57± 0.28mg/100g), and the lowest concentration was recorded in P.pangia (1.28±0.49 mg/100g). The Cu content was found to be highest in P.pangia (0.97±0.38 mg/100g), and the lowest concentration was found in L.irrorata (0.56±0.042 mg/100g). In the present study, Zn was recorded to be present in varying concentrations with the range from 2.7±0.073mg/100g to 7.13±0.73mg/100g, with the highest content recorded in L. irrorata. The concentration of the macro and micro elements studied in the present investigation is represented in Table 2.

The concentration of P in P.pangia shows the highest value among the species. The highest Na and K content were found in L.berdmorei, and the lowest were found in L.irrorata species. The variability in the distribution of minerals was observed between the studied fishes. Ca & P were more dispersed while some data were skewed positively or negatively and dispersed in different way and some have symmetrical ranges (Figure 2).

5. DISCUSSION

5.1: Small Indegenous Fishes (SIF_s) and Mineral Nutrients:

Fishes could be an essential source of minerals, and the same also is concomitant with the previous reports, irrespective of whether the species belongs to the large, medium, or small sized fishes. Mineral elements such as Ca, P, Na, K, Fe, Zn, Mn, etc, are required in large quantities as well as in trace amounts in the human body to perform several physiological functions. As per the RDA, the mineral content of the studied SIF_s was categorically included as the observed value is in the range of the minimum nutrient requirements of a balanced meal for healthy people. However, the varied concentrations observed among the studied minerals were due to differences in their metabolism and environmental factors like habitat quality, age, size of the fish, etc. (Abdullahi, 2001; Effiong & Mohammed, 2008). The concentration of Ca was higher than in the previous reports of Santosh and Sarojnalini (2018) and Abdul and Sarojnalini (2012). P.pangia is within the range compared to the previous report by Mohanty P et al., 2016 in Puntius sophore (944.6±55.4mg/100g). Ca is an important component for various metabolic functions and intracellular regulation for bone, muscle, and nerve, while low dietary intake, associated with the risk of certain diseases like blood pressure, increases hypertension. (Allender PS et al.1996; Bucher HC et al. 1996) It is recommended to have an average intake of Ca per the RDA for people of different age groups. The consumption of small fishes as a whole plays an important role as a source of Ca, whereas the amount of Ca content in the small fishes has a higher value than the milk (Lersen et al., 2000), which was also consistent with the present finding.

It was observed that the concentration of P and K was also found collateral with other minerals sources. In the present study, the Phosphorus content is lower than that of the concentration reported by the

previous workers, in Ailia coila,1880±45.2mg/100g, Gudusia chapra 2490± 32.1mg/100g (Mohanty P et al. 2016). Likewise, the concentration of Na and K is much higher than in the previous report (Santosh et al., 2018) and lower than in Nolle N et al., 2021, and Mohanty P et al. 2016). In their report, they found the content of Na in the Small Indigenous Fishes in the range of 45.0± 0.20mg/100g to112.5± 0.06mg/100g and K in the range of 57.5±10.15mg/100g to 90.81±1.41mg/100g. the concentration of Mg in Ailia coila is (160.0± 12.3mg/100g) (Mohanty P et al., 2016) Gudusia chapra (170± 9.8mg/100g) (Mohanty P et al. 2016), Lepidocephalichthys guntea is (87.33±0.29mg/100g) Santosh et al. 2018 respectively which was also agreed with that of the concentration of Mg in P.pangia and it was lower in L.irrorata and L.berdmorei.

In the previous literature, the Fe content has been reported in the ranges of 3.77mg/100g to 8.57mg/100g in fresh hill stream fishes of Manipur (Abdul, 2013).In the present study, it was within the range. However, in small fishes of Bangladesh and Cambodia, the concentration of Fe was recorded in the ranges of 1.8± 0.7 mg/100g) to 12.0mg /100g and 0.7 ± 0.1mg/100g to 11.3 ± 3.4mg/100, respectively (Roos et al., 2007). The highest concentration of Mn was found in L.irrorata(16.57± 0.28mg/100g), and the lowest concentration was recorded in P.pangia (1.28±0.49 mg/100g). Mohanty. P et al.2016 has reported in some Small indigenous fishes such as Anabas testudineus and Gudusia chapra are in the ranges of 0.8± 0.4mg/100g to 4.61± 1.3mg/100g. However, in our findings, P.pangia was within the range, and as compared to the previous record, the concentration was found to be higher in L. irrorata and L. berdmorei. Abdul, 2013 reported that the concentration of copper in hillstream fish was in the range of 0.299mg/100g to 1.50mg/100g. However, in the present finding, it was comparatively higher than that of the reported range of 0.226±0.01 mg/100g to 0.47±0.007 mg/100g by Santosh and Sarojnalini, 2018. The concentration of zinc was also comparatively higher than the study reported by Nolle N et al.2021 and Abdul, 2013 and lower than the fish species Gudusia chapra,12.3 ±2.3mg/100g (Mohanty et al., 2016).The comparative statement of the nutritional profile of the SIFs are also represented in table (2) & table (3) along with their RDA values. Therefore, this study clearly suggests that the selected species could be granted as an essential source of minerals. People can have such species as a source of balanced nutrients. People Living in remote areas where they can depend on naturally available food can also overcome the hidden hunger of several mineral deficiency diseases like anaemia, infant mortality, ovarian and testicular degeneration, Alzheimer's disease, anorexia, loss of appetite, smell and taste failure, arteriosclerosis, etc.Being small in size and all the parts edible, one can consume the whole body, including the head and bones, whereas in large fish, only the flesh is consumed, and different inner parts of the body are discarded. So, eating small fish has some advantages (Nolle et al., 2021; Kawarazuka&Béné, 2011). In our investigation, the consumption of these fishes could meet the RDA recommendation for a balanced meal. We can easily regulate the consumption rate needed for children, lactating mothers, pregnant women, adult men and women, etc. Therefore, quantifying the mineral composition of the SIFs is essential to enhance the knowledge about the importance of SIFs.

5.2 SIF$_s$ and Habitat Crisis:

Habitat is an important criterion for the sustainable resources of fish, particularly the SIFs. In Manipur, Historical records confirmed that they had been abundantly found in the wild in diverse habitats such as paddy fields, small streams, canals, wetlands, hillock streams etc. However, advanced technology and the widespread use of pesticides have led to the loss of their habitat. Apart from this, indiscriminate fishing exploits the sustainable way of capturing of the fish and the introduction of exotic species has put these fishes on the verge of extinction. Many workers find out that many species of indigenous fish were becoming locally endangered, and some are extinct in the wild due to obstruction in their migratory route because of dam construction, changes in land use pattern, siltation, overexploitation, inculcating of toxic substances, chemical fertilizers etc. and it might be reason for the decrease in their abundance in the wild ((Dudgeon et al., 2006; Khatri et al., 2014.).There is an urgent need for proper management and conservation otherwise the species might be extinct due to the loss of equilibrium of hardy weinberg population genetics that leads to inbreeding which disturbs the genetic structure (Parmaksiz et al., 2024) and could not be adapt to the existing natural geographical habitat . Despite the limitations, the study of the SIFs of Manipur is indeed necessary for the promotion of the studied fishes by expanding their roles as an alternative source of minerals, expanding the horizon for choosing the fishes for consumption on the basis of palatability, efficient storage, etc.Therefore adequate strategies should be taken up to increase the abundance in the wild through the use of modern techniques of breeding and high tech

culture techniques and captivating them in the natural habitat (Wahab et al., 2008; Kunda et al.,2008) by developing innate adaptability and genetic diversity. It could meet the demands of the locals when they have been abundantly found in the wild.

5.3 SIF$_s$ and Economy:

People living in a developing country like India, which faces an ever-increasing population growth and where there is an economic crisis for having a balanced diet for a healthy body, can look for such foods present in the wild habitat. People could look for small fish as most small fish usually contain higher minerals than large and medium fish (Nolle et al., 2021). Several studies reported the production ofSIFs through culture and capture techniques (Mohanty and Parida, 2017;Paul L et al.,2013;Sarma D et al., 2012) However, no such evidences of successful production for the studied fishes using the high tech aquaculture techniques have been reported so far from the region. It was also evident from the cultural and historical perspective of the region that the studied fishes have been culturally associated in different ritual ceremonies. Even the dried body of the studied fishes sell in the market at high prices in different markets of Manipur. It is aged old tradition that reconnecting the people of Manipur to have the urge to taste the delicacy of the SIFs in the wild habitat of Manipur. Because of its high demand both for consumption and ritual processes, there is a chance of earning and improving the economy if produced in large quantities by introducing induced breeding and rearing of such small fishes. People who cannot afford to buy large fish can buy small fish in small quantities. The accessibility of SIF is also easier than that of large fish. In the Manipuri Society, women have been facing the problem of food insecurity and economic crisis. To fulfil their needs, women are actively involved in search of food and other marketable resources from different habitat to support their families. Therefore,SIFs could be a source to increase the economy of the fishermen community by increasing productivity (Saha and Barman, 2020; Sinha, 2017; Sinha et al., 2021).It is indeed possible for a healthy and balanced life when such locally available nutritious food is abundantly found in their villages.

CONCLUSION

From the above study, it can be concluded that the SIFs are rich sources of essential mineral elements. They provide most of the essential minerals important in human nutrition as they are consumed in whole with the bones, which are extremely Ca-rich. Each element has a definite role, viz. copper, manganese, and zinc are enzymatic antioxidants. Moreover, trace elements like iron, zinc, copper, and manganese activate numerous enzymes involved with either catalytic or regulatory functions. Besides their food values, they play a vital role in preserving the rich culture and tradition of the state. They play an essential role in sustaining the livelihood of the fishing community and helping the rural economy. Besides, it occupies a specific niche in the food chain. However, the widespread utilization of chemical fertilizers, habitat changes, overexploitation, invasion of exotic species, etc., adversely impact these species, gradually reducing their numbers. So, it is extremely important to conserve these species by creating awareness about their value in socio-economic improvement and can combat various diseases. Further, it adds scientific information related to its well-known demand in the market for centuries and for consumption by the locals, providing a linkage between traditional and scientific knowledge. This research will help in creating awareness to the farmers as well as to the policymaker to integrate the SIFs in the wild with the aquaculture system to bring sustainable fisheries and to conserve gene pool. This information will provide a platform for further studies on the introduction of high tech culture techniques to increase abundance and conservation of locally endangered SIFs.

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Table.1: Economic Importance and present status of the three Small indigenous fishes of Manipur. (Chaudhry, S. 2010; Duarah and Das, 2019; Mohanty et al., 2022)

Sl.no.	Fish species	Family	IUCN Red List Status	Habitat (source)	Economic Importance
1	Pangio pangia (Hamilton, 1822)	Cobitidae	LC	Fresh water (capture)	Fd
2	Lepidocephalichthys irrorata (Hora, 1921)	Cobitidae	LC	Fresh water (capture)	Fd
3	Lepidocephalichthys berdmorei (Blyth, 1860)	Cobitidae	LC	Fresh water (capture)	Fd, Or

Abbreviations: LC, Least Concern; Fd, Food; Or, Ornamental.

Table 2: Mineral composition of the three Small Indigenous Fishes

Minerals	Pangio pangia(Hamilton, 1822)	Lepidocephalichthys irrorata (Hora, 1921)	Lepidocephalichthys berdmorei (Blyth, 1860)	RDA in adult Human(mg/d)
Na	57.83 ± 0.44^{b}	29.00 ± 0.60^{c}	158.10 ± 0.63^{a}	2000®
Mg	83.80 ± 0.52^{a}	42.80 ± 0.44^{c}	66.10 ± 0.12^{b}	340®
P	756.00 ± 0.88^{a}	254.70 ± 0.60^{c}	567.00 ± 0.88^{b}	600®
K	69.30 ± 0.66^{b}	57.72 ± 0.64^{c}	85.70 ± 0.46^{a}	3500®
Ca	993.00 ± 0.57^{c}	1725.00 ± 0.38^{a}	1316.00 ± 0.55^{b}	600®
Mn	1.28 ± 0.49^{c}	16.57 ± 0.28^{a}	9.03 ± 0.60^{b}	4®
Fe	8.70 ± 0.68^{b}	6.50 ± 0.38^{c}	6.90 ± 0.64^{c}	21®
Cu	0.97 ± 0.38^{c}	0.56 ± 0.55^{c}	0.82 ± 0.34^{c}	2®
Zn	6.60 ± 0.83^{b}	7.13 ± 0.73^{b}	2.70 ± 0.43^{c}	13®

The values are expressed as mg/100g dry weight. Samples were analysed in triplicates and values are reported as mean± standard deviation. Values in columns not sharing same superscripts differ significantly at 0.05 level of significance.
* P values was considered to be significant at 0.05 level of significance
®ICMR (Nutrient Requirements and RDA for Indians-A report of the expert group of the ICMR,2010)

Table 3: Comparative Mineral profile data of different fish species.

Fish species	Macromineral					Micromineral				References
	Na	K	Ca	Mg	P	Fe	Cu	Zn	Mn	
Pangio pangia (Hamilton, 1822)	45.0 ±0.20	57.5±0.15	905.0± 3.12	73.5±0, 66	nd	20.53± 0.03	0.29± 0.02	1.59±0 .011	0.27 ±0.0 08	Santos h et al., 2018
Ailia coila ((Hamilton, 1822)	270. 0±50 .2	120.±21 .2	2410.0 ±14.7	160.0±1 2.3	1880 ±45.2	10.9±1 .3	nd	10.2±2 .1	1.3± 0.9	Mohan ty et al., 2016
Syncros sus berdmo rei (Blyth,1 860)	64.9 9±0. 08	90.81±1 .41	680.33 ±2.28	77.0±0. 66	nd	28.61± 0.10	0.22± 0.01	1.40±0 .01	1.26 ±0.0 1	Sarojn alini et al., 2018
Lepidoc ephalic hthys guntea (Hamilton, 1822)	112. 5±0. 06	87.33±0 .29	2150.0 ±8.71	131.7±2 .05	nd	13.55± 0.26	0.47± 0.007	3.05±0 .014	1.15 ±0.0 05	Santos h et al., 2018
Puntius chola (Hamilton, 1822)	102. 4±1. 7	124.9±0 .04	1932.8 ±4.16	115.7±1 .29	nd	17.6±0 .14	0.24± 0.01	1.77±0 .013	1.26 ±0.0 4	Santos h et al., 2019
Gudusi a chapra (Hamilton, 1822)	220± 15.2	1140±7. 9	3440± 10.4	170±9.8	2490 ±32.1	36.5±4 .91	nd	12.3±2 .3	4.61 ±1.3	Mohan ty et al., 2016
Anabas testudin eus (Bloch, 1794)	236. 8±69 .4	178.3±8 .8	252.6± 45.7	nd	159.8 ±3.5	2.3±0. 8	nd	0.9±1. 0	0.8± 0.4	Mohan ty et al., 2016
Amblyp haryngo don mola(H amilton , 1822)	52.7 ±6.5	211.3±2 0.1	841.7± 40.2	40.2±2. 9	nd	11.9±3 .4	0.2±0. 0	3.9±1. 3	1.1± 0.4	Mohan ty et al., 2016
Puntius sophore (Hamilton, 1822)	nd	860	1171	100	nd	3.00	1.16	3.1	7.39	Bogard et al., 2015

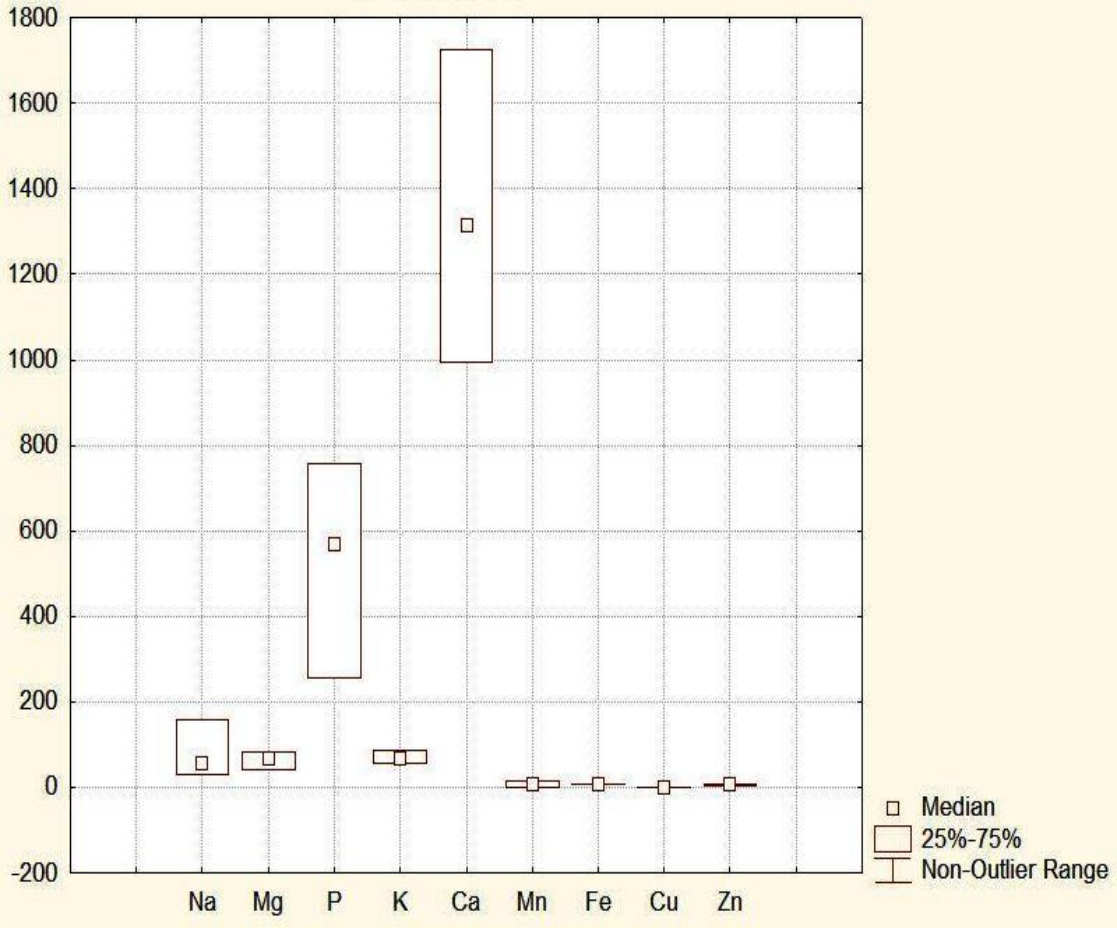
Bangana devdevi (Hora, 1936)	70.00±0.24	137.50±0.29	164.38±1.95	58.10±0.96	nd	21.74±0.06	0.32±0.01	2.18±0.07	0.32±0.01	Sarojnalini et al., 2019
Gagata dolichonema (He,1996)	110.00±0.29	137.50±0.22	2302.5±4.95	93.00±1.52	nd	38.04±0.03	0.30±0.02	2.43±0.02	0.51±0.02	Sarojnalini et al., 2019
Garra abhoyai (Hora, 1921)	80.00±0.34	95.00±0.24	1473.5±2.21	96.50±1.75	nd	30.71±0.01	0.20±0.01	0.17±0.02	1.99±0.02	Sarojnalini et al., 2019
Opsarius barnoides(Vinciguerra, 1890)	92.50±0.11	120.00±0.23	1612.50±1.21	311.00±1.32	nd	8.65±0.03	0.24±0.02	2.59±0.01	0.77±0.02	Sarojnalini et al., 2019
Clarias magur (Hamilton, 1822)	201.49	262.09	222.36	nd	129.42	2.20	nd	0.68	0.21	Paul et al., 2015
Cabdio ukhrulensis (Selim &Vishwanath, 2001)	87.50±0.19	100.00±0.25	860.94±1.33	120.60±0.92	nd	18.03±0.03	0.26±0.01	3.74±0.02	1.29±0.02	Romharsha & Sarojnalini, 2018
Raiamas guttatus (Day,1870)	107.60±0.08	120.00±0.15	2023.94±4.24	97.75±1.73	nd	24.69±0.07	0.23±0.03	1.44±0.02	0.81±0.02	Romharsha & Sarojnalini, 2018
Salmostoma sladoni (Day,1870)	90.00±0.27	112.56±0.23	1861.00±2.60	114.80±1.04	nd	11.68±0.03	0.37±0.02	1.91±0.02	1.01±0.02	Romharsha & Sarojnalini, 2018
Schistura khugae(Vishwanath & Shanta, 2004)	89.17±1.40	24.92±0.38	1598.50±4.00	91.00±1.75	nd	7.91±0.01	0.20±0.01	0.68±0.02	0.37±0.01	Romharsha & Sarojnalini, 2018
Systomus clavatus (	100.00±2.46	132.50±0.29	1405.20±3.18	74.25±2.00	nd	19.36±0.71	0.19±0.60	1.99±0.17	0.86±0.16	Romharsha & Sarojn

McClelland,1845)										alini, 2018
Tot tor (Hamilton, 1822)	100.00±2.39	75.00±0.52	220.00±1.41	81.50±1.14	nd	21.23±0.05	0.41±0.15	0.23±0.02	0.45±0.01	Romharsha & Sarojnalini, 2018

Figure 1a: Pangio pangia

Figure 1 b: Lepidocephalichthys irrorate **Figure 1c: Lepidocephalichthys berdmorei**

Figure 2: The variability in the distribution of Minerals in the studied SIFs



Highlight

- Overexploitation and obstruction of migratory routes can lead to genetic loss of SIFs.
- Mineral accesibility could enhance through proper conservation.
- SIFs have significant contribution in sustainable livelihoods and economy enhancement.