Small Indigenous Fishes as a Potent Bioresource of Northeast India

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ABSTRACT

Fishes achieving an utmost length of 25–30 cm at maturity and are easily locally found are known as small indigenous fishes (SIF). Among eight hundred and seventy seven local freshwater fish species of India, about four hundred fifty are cataloged as small indigenous fish and Northeast India is home to 216 species of them. The peaking diversity of these is recorded in Northeast Indian area followed by Western Ghat and Central India. They possess a lofty nutritional content of micro and macronutrients. Since they are easily available, hence is first hand choice for the poor and middle-class people to fill up the protein craving. The present piece of work reviews the occurrence of the small indigenous fishes and their function in defending malnutrition and more explicitly the deficiency caused due to micronutrients, which directly influences both standard of nutrition and economic security of the rural populace. It also reviews the threats to its diversity loss and improvement of conservation strategies. It attempts to create sensitization of food benefits of the SIF and create mass awareness to protect this bioresource for nutritional and livelihood security for the poor rural people of Northeast India.

Keywords: Conservation, Fish, Livelihood, Nutrition

AN OVERVIEW OF SMALL INDIGENOUS FISH

Fish as a whole is composed of almost half of the vertebrate group of animals and proved as the rich source of food (Begum *et al*., 2012) even for poor man, enriched with simple proteins and free amino acids, beneficial lipids along with the striking amount of minerals and vitamins (Balami *et al*., 2019; Bezbaruah and Deka, 2021) and is used against many of the ailments (Li *et al*., 2019; Jan *et al*., 2021). Small indigenous fish (SIFs) are frequently consumed whole (Mayanglambam and Tongbram, 2022; Pegu *et al*., 2023), reaching an utmost size of 25 cm during the full-grown or mature phase of their life cycle and many are even less than 5 cm long (Felts *et al*., 1996). Their short life cycle and proliferative breeding habit seldom require any form of management approaches. They used to survive in all possible types of inland water bodies (Duarah and Das, 2019).

India ranked third among the top fish producing countries of the world (Ngasotter *et al*., 2020). Being one of the 17 global mega biodiversity hotspots harbor nearly 2,319 species of finfish species amongst which, 838 belongs to inland water bodies as reported by National Bureau of Fish Genetic Resources, NBFGR ICAR, Lucknow, India (Lakra *et al*., 2010). India has contributed 27.85% of native fish fauna, followed by China, Indonesia and Myanmar. About 450 species of them are classified as SIFs. NorthEast India being an ideal habitat for various endemic small fish supports as many as 216 species which are abundant in all forms of inland water bodies (Mayanglambam and Tongbram, 2022). Culturing of small indigeneous fishes is more challenging than culture of Indian Major Carps. Moreover, they get little or no attention either from the public or private stack holders due to their no export demand. However, limited information on the Aquaculture of Indigenous Mekong Species (AIMS) (Mayanglambam and

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Tongbram, 2022) as well as culture of indigenous *Puntius* species in the polyculture (Kohinoor *et al*., 2005) is available.

SIFs are prolific breeder (Mohan *et al*., 2010), common in the rural areas and rich in micronutrients compared to the larger fish groups, earn the distinction of being nutritional resources. As many as 104 species out of 450 species of SIFs are highly important as food and 62 species are used for aquarium trade, provide local livelihood security (Baishya *et al*., 2021). These small fishes have occupied enviable and inseparable relation in the life, livelihood, health and extend economical support especially to the poor people (Mayanglambam and Tongbram, 2022). Besides, SIFs are also rich sources of micronutrients essential elements or vitamins. Apart from these, SIF species serves a profound source of dietary calcium since they are consumed along with bones and also supply many important minerals and is Vit. A enriched (Larsen *et al*., 2000). By composition the live weight of majority of fish consists of 70–80% water, 20–30% protein and 2–12% of lipid (Roos *et al*., 2003). Its oil has the innate resource of important polyunsaturated fatty acids like Eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA). It has been reported that certain group of SIFs add to valuable Ayurvedic and Unani medicines for the treatment of many ailments like night blindness, appetite loss, cold, cough, bronchitis, asthma, tuberculosis etc (Kotpal, 2006; Duarah and Das, 2019).

The consumption of fish has achieved recognition in latest years (Supartini *et al*., 2018; Lee and Nam, 2019; Krešić *et al*., 2022) and India occupied a pivotal position in terms of fish consumption. The apparent per capita fish consumption in India lies between a range of 5 to 10 kg per annum, while the monthly consumption stand at 0.266 kg (26%) and in urban India 0.252 kg (21%) during the survey period of 2011–2012 as per the NSSO report (FAO, 2018). Increasing income as well as the easy availability of fishes influences the fish consumption rate (Shyam *et al*., 2015). Interestingly the 80–90% people of the Northeast India are the regular fish eaters (Table 1; Barman *et al*., 2012). India showed an increasing curve during the period 1983–2000. The Northeastern people represent the ethnic diversity along with its enormous bioresources in the eight states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim have been highlighted (Kaushik and Bordoloi, 2016). The rich biological diversity and favourable climate of the region is enough for fulfilling the basic needs of food, shelter and medical care of the people (Sarkar *et al*., 2017). The SIFS have a good demand as ethnic food item of Northeast because of their food value, availability and easy accessibility. These fishes are easily caught by the traditional fishing gears made of bamboo or cane, also sold in local markets; or used by the ethnic people for their day to day consumption. Since they are consumed both in their fresh and dried or fermented form, it provides a continuous supply of nutrition throughout

Table 1. Fish consumption pattern in Northeastern States (Barman *et al*., 2012; Singh *et al*., 2017).

States	Regular fish eating population (%)	Occasional fish consumers (%)	Non fish eating population (%)	Total population
Assam	90	0	10	31,169,272
Arunachal Pradesh	97	2	1	1,382,611
Nagaland	99	0.5	0.5	1,980,602
Mizoram	10	90	0	1,091,014
Tripura	95	0	5	3,671,032
Meghalaya	90	0	10	2,964,007
Sikkim	10	70	20	607,688
Manipur	80	10	10	2,721,756
Northeast (average)	87.6	3.7	8.8	45,587,982

the year. The tribal communities of Northeast India have their own traditional ways of fish preservation which are basically done by sun drying, smoke drying or fermentation process. However, the process of fermentation varies among allied communities. There are many popular local delicacies which are made from either dried or fermented fishes, named as Shidol, Hukoti, Hentak, Ngari etc. (Jeyaram *et al*., 2009; Muzaddadi and Basu, 2012; Muzaddadi *et al*., 2013). In fact, the people of this region consume fishes without having awareness about its nutritional status, especially the SIF group. Therefore, it is enough relevant to evaluate the proximate composition (Hantoush *et al*., 2015) in order for their preservation in various forms. The proximate composition of any organism including fish decodes the quality and quantity of nutrition and their health status, which also signifies the expression of calorific value of food (Qasim, 1972), and the fish physiology is indicated by the proximate composition analysis (Cui and Wootton, 1988).

However, food and feeding habits, age, size, sex, habitats, genetic features and season/migration directly influences the proximate composition (Daniel, 2015; Begum *et al*., 2016). In addition to protein the SIFs are rich source of omega ω-3 polyunsaturated fatty acid (PUFA) and the micronutrients (Mohanty *et al*., 2019). Therefore, their production must be boosted up, so that the society can get an ease to fight with malnutrition. The SIFs are micronutrient dense and play a pivotal role in the eradication of their deficiency related diseases as prevalent among the rural populace (Roos *et al*., 2003). Meanwhile many of the original works on the nutritional status of SIFs have well been recorded in the country including the northeast region (Mohanty *et al*., 2010; 2013; 2019; Goswami *et al*., 2012; Duarah and Das, 2019; Mayanglambam and Tongbram, 2022; Pegu *et al*., 2023). Based on these works an attempt has been made to highlight the rich nutritional rank of SIFs, which could be a comprehensive benchmark point for their culture and preservation, in turn may attribute in the process of livelihood and rural economy. Moreover, their diversity and conservation are also to be understood. Further, this will enhance the prospect of augmentation in the economic status in the form of basic needs like health and education of the poor fisherman as a community.

ABUNDANCE OF SIF IN NORTHEAST INDIA AND ITS POTENTIAL THREATS

As recorded, India has 2,319 species of finfish, out of which 838 are found in various types of tiny inland water bodies and also in paddy fields (Lakra *et al*., 2010). SIFs are diverse group that stands at 450 species in India, out of which 216 species have been distributed in the Northeast Indian region (Goswami *et al*., 2012; Duarah and Das, 2019; Mohanty *et al*., 2022; Pegu *et al*., 2023). Earlier Felts *et al*. (1996) segregated 45 SIFs species into carps and minnows, catfish group and perches as 18, 9, and 9 species respectively. Further they were categorized with three main groups, based on their maximum length as 7.5 cm, 10 cm and 25 cm respectively. However, these groups could not get gain in national statistics score because of their enumeration which occurs only on catches in the landing sites only, which are either sold or consumed locally (Roos *et al*., 2007; Halwart, 2008).

The high demand of SIF species and their rich diversity has already been mentioned by various workers in the NE region (Duarah and Das, 2019; Mayanglambam and Tongbram, 2022; Mohanty *et al*., 2022; Pegu *et al*., 2023). Duarah and Das (2019) classified that SIFs belongs to 5 orders with 33 genera of 15 families, with 55 species collected from the River Brahmaputra and its tributaries in its upper stretch. Cyprinidae family was the most plentiful with 22 SIF species followed by Bagridae 9 species and Cobitidae family with 4 species. Some of the important SIF of India has been produced in (Table 2) as ready reference. Records of SIF diversity, especially the Cyprinid group presented 25 number of total strengths of 39 species, which were obtained from an Oxbow Lake, Dhir Beel from the lower part of the Brahmaputra basin (Das *et al*., 2021; Das and Sharma, 2022).

Despite of such rich diversity, the present status of the SIFs existence appears dark. Because the most undesirable effect, mostly the anthropogenic pressure in various forms like habitat shrinkage, fragmentation, over exploitation, pollution, introduction of exotic species etc. have eventually altered the SIFs habitat (Tewari and Bisht, 2010). Fishing of the SIFs at their premature stage is another major

Table 2. List of some common SIF of North East India. (Goswami *et al*., 2012; Duarah and Das, 2019; Mohanty *et al*., 2022).

Scientific name	Local name	Fishbase name
Ailia coila	Kajuli, Baspata	Gangetic ailia
Amblypharyngodon mola	Mola, Moa	Mola carplet
Anabas testudineus	Koi	Climbing perch
Badis badis	Napit koi	Badis
Badis assamensis	Randolnee	Assamese Chameleon fish
Batasio batasio	Batasimas	Tista batasio
Botia dario	Bou, Rani	Bengal loach
Botia lohachata	Bou, Rani	Reticulate loach
Chanda nama	chanda	Elongate glass-perchlet
Chanda ranga	Chanda	Indian glassy fish
Channa orientalis	Gachua	Walking snakehead
Channa punctuates	Taki	Spotted snakehead
Clarias batrachus	Magur	Walking catfish
Colisa fasciata	Khalisa	Banded gourami
Colisa lalia	Lal khalisha	Dwarf gourami
Corica soborna	Kachki	Ganges river sprat
Ctenops nobilis	Kholihona	Indian paradise fish
Danio devario	Chap chela	Dind danio
Esomus danricus	Darkina	Flying barb
Glossogobius giuris	Bele	Tank goby
Glosogobius gutum	Patimutura	Bar eyed gobi
Gudusia chapra	Chapila	Indian rivershad
Heteropneustes fossilis	Shingi	Stinging catfish
Labeo bata	Bata	Bata
Lepidocephalus guntea	Gutum	Guntea loach
Macrognathus aculeatus	Tara Baim	Lesser spiny eel
Mastacembelus pancalus	Guchi	Barred spiny eel
Mystus tengara	Tengra	–
Mystus vittatus	Tengra	Striped dwarf catfish
Nandus nandus	Meni	Gangetic leaffish
Notopterus notopterus	Pholi	Bronze featherback
Ompok pabda	Pabda	Pabdah catfish
Ompok pabo	Pabo	Pabo catfish
Parambassis lala	Lal chanda	Highfin glassy perchlet
Puntius conchonius	Kanchan punti	Rosy barb
Puntius phutunio	Phutani punti	Spotted sail barb
Puntius sarana	Sarpunti	Olive barb
Puntius sophore	Jat punti	Pool barb
Puntius ticto	Tit Punti	Ticto barb
Rohtee cotio	Dhela	–
Salmostoma bacaila	Chela	Large razorbelly minnow
Xenentodon cancila	Kakila	Freshwater garfish

cause in loss of SIFs (Suresh and Manna, 2010). To prevent this loss, it has to be counterbalanced with increased production by innovative techniques of aquaculture. One such easy and low cost method is composite culture of economically important small native fishes with major carps. Successful trials have been carried out with *Amblypharyngodon mola* and *Ompok pabda* by Wastewater Aquaculture Centre of Central Institute of freshwater Aquaculture, Rahara, Kolkata (India). Observations also revealed that since these species are auto breeders, they increased their production by 50–60% more than the initial stock (Datta, 2010). It is also observed that mola-carp-prawn polyculture too gives lucrative yields in successful trials in Bangladesh (Kunda *et al*., 2010).

NUTRITIONAL PACKAGE IN SIF

Micronutrients

Indispensible dietetic elements as micronutrients are required in trace amount, serve as cofactor or coenzymes in many of the biochemical reactions that govern the growth and survival. SIFs are a huge repository of many important micronutrients (Mahanty *et al*., 2014; Mayanglambam and Tongbram, 2022), which mostly consist of lipophilic vitamins namely Vitamin A, D, E, and K. In addition the hydrophilic vitamins like B1, B2, B3 and provitamin A1, A2 etc. in their isomeric form of retinol and 3,4-dehydroretinol are found in high amount in four commonly consumed SIFs, namely *Ambylopharyngodon mola, Parambassis ranga, Osteobrama cotio* and *Esomus danricus* (Roos *et al*., 2002; Mohanty *et al*., 2013). Interestingly the vitamin A richness could be established in *A. mola*, since the eye of this group contain 62,200 RE·100 g^{-1}. Detailed analysis showed that >50% (approx) of Vit. A present in the eye of *A. mola* consists of 2% of its weight (Roos *et al*., 2002). The viscera and the eye contain 90% of Vit A. Again less than 2% of *A. mola's* total vitamin A content is found in 100 g of raw *Labeo rohita* (Roos *et al*., 2002). The undeniable role of vitamins in human health subject, specifically in growing children and young women is well understood (West, 2002).

Moreover, many of the microelements like Zn, Se, I, Fe, Co, Na, K, Mg and many more are detected in SIFs and due to this, their whole body consumption appeared as profound nutriresource (Mahanty *et al*., 2014). For example, SIF like *Mystus tengra* (17.0), *Mystus vittatus* (11.0), *Osteobrama cotio* (13.6), *Chanda ranga* (14.6), *Chela bacalia* (12.8) are very rich in Zn per 100 g raw edible parts (Table 3, Figure 1). Further the mentioned groups of SIF were also found to be enriched with trace elements like Fe, K, Mn, Mg and Cu (Table 3, Figure 1) (Gopakumar, 1997; Roos *et al*., 2003). Even other SIFs like *Gudusia chapra*, *Channa punctatus, Chela cachius, Osteobrama cotio, P. ranga, Esomus danricus, Parambassis baculis, Botia dario,Chanda nama* and *M. vittatus* (Bogard *et al*., 2015; Islam *et al*., 2023) were identified with the richness of Vit. A quantum validated the presence of nutriresources. Data obtained from the dietary analysis in rural Bangladesh established that 90% of Ca and Vit. A intake in human are contributed by the SIFs (Roos *et al*., 2003; Kongsbak *et al*., 2008; Mohanty *et al*., 2013). The amount of Calcium obtained from small fish is alike to that of skimmed milk (Hansen *et al*., 1998). Among the commonly edible SIF *Puntius sophore* holds a very good score of Calcium, i.e. 1,170 mg·100 g^{-1} (Table 3). SIF can supplement as natural nutrients to put off nutrient insufficiency (Mahanty *et al*., 2014). However, the difference in composition of nutrient quantum of SIFs was estimated at variance due to species variation, habitat, age, feeding habit and seasons (Jacquot, 1961; Piska and Waghray 1989; Salam *et al*., 1995).

Macronutrients

Such nutrients that our body needs in large amounts are called macro nutrients. It includes fats, carbohydrates and proteins. Freshwater fish are rich in high-quality protein and polyunsaturated fatty acids (PUFA) (Memon *et al*., 2010; Volpe *et al*., 2015; Acharya *et al*., 2018). However, they are poor suppliers of carbohydrate.

Table 3. Mineral content of some small indigenous fishes (Gopakumar, 1997; Roos *et al*., 2003; Mohanty *et al*., 2010).

Sl.No	SIF	Ca	Fe	Zn	Na	K	P	Mu	Cu	Mg
1.	*Chanda nama*	955	1.8	2.3	-	750	-	4.24	1.82	110
2.	*Gudusia chapra*	1,063	7.6	2.1	-	860	-	4.76	1.97	120
3.	*Esomus suratensis*	315.30	1.80	-	126.90	296.70	251	-	-	-
4.	*Esomus danricus*	891	12.0	2.1	-	-	-	-	-	-
5.	*Amblypharyngodon mola*	853	5.7	3.2	-	630	-	4.21	2.67	120
6.	*Puntius sophore*	1,171	3.0	3.1	-	860	-	7.39	1.16	100
7.	*Channa punctatus*	766	1.8	1.5	-	-	535	-	-	-
8.	*Mystus vittatus*	1,093	4.0	3.1	-	-	-	-	-	-
9.	*Puntius sarana*	30.32	2.55	-	34.36	121.28	268.20	-	-	-
10.	*Heteropneustes fossilis*	42.61	4.86	-	57.58	247.29	135.94	-	-	-
11.	*Barbus spp*	47.96	0.84	-	76.98	244.93	118.48	-	-	-
12.	*Clarius batrachus*	76.52	2.21	-	76.52	280.44	122.29	-	-	-
13.	*Osteobrama cotio*	140	39.7	13.6	-	920	-	4.42	2.82	110
14.	*Mystus vittatus*	120	33.0	11.9	-	830	-	6.02	5.83	100
15.	*Mystus tengra*	190	14.5	17.0	-	840	-	5.31	3.20	110
16.	*Chela bacalia*	160	33.2	12.8	-	880	-	4.32	1.20	110
17.	*Chanda ranga*	150	24.7	14.6	-	610	-	6.34	1.25	200

Note: All values are mg·100 g^{-1} of tissues.

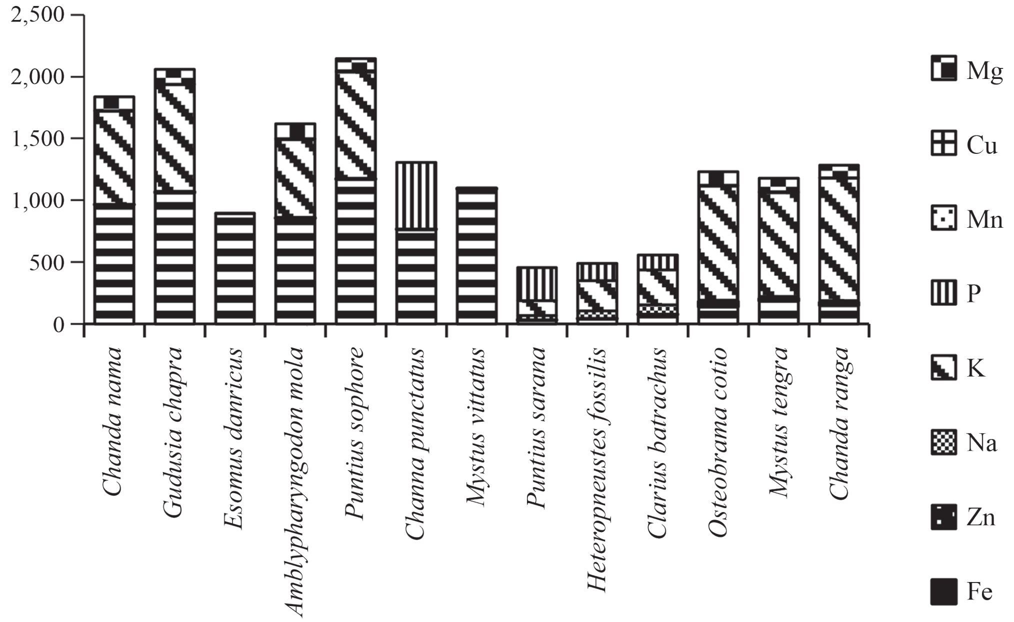

Figure 1. Bar chart showing the abundance of different micronutrients in small indigenous fishes (Mazumder *et al*., 2008; Mohanty *et al*., 2010; 2013).

Lipids in SIF

Relying on the amount of fat content, fishes are divided into four groups a) lean fish, with minimal fat <2%, b) low–fat fish (2–4%), c) medium fat (4–8%) and d) high fat (6-8%) (Ackman, 1989). The SIFs usually have low–medium fat (Table 4). The metabolism of fat reserves during spawning period and the poor storage mechanism of fat in the bodies are regarded as the cause of their low lipid content (Osibona *et al*., 2009). Polyunsaturated fatty acids (PUFAs), especially ω3 and ω6 fatty acids have an admirable contribution in health and prevention of disease (Calder and Yaqoob, 2009). Researchers have supported that ω3 fatty acids reduce the threat of heart attacks (Golanski *et al*., 2021). At least two servings of fish per week are recommended by American Heart Association (AHA) Dietary Guidelines for sustaining good health (Kris-Etherton *et al*., 2002). It might be helpful treatment and improvements in extensive array of ailments and disorders, including rheumatoid arthritis, allergies, Alzheimer's disease, gout, endometriosis and other recurring inflammatory disorders. It has already been evidenced that the fish is very rich in EPA (Eicosapentanoic acid and DHA Docosahexaenoic acid) essentially needed to reduce eicosanoid and proinflammatory cytokines. They are very important for fetal growth and development, as they impact on the neuronal, immune and retinal function. It was found in research that the synthesis of interleukin 1b declined by 20 percent after the consumption of a diet high in omega-3 fatty acids for two weeks and was decreased further at the end of one month (Mantzioris *et al*., 2000). Omega-3 fatty acids even augment insulin secretion and bind into the plasma membrane that compete with amino acid production and thus lessens sugar in blood (Ajiro *et al*., 2000).

Since these essential components are not synthesized in human body, they need to be obviously dependent on dietary source and the SIFs appear as one of them. However, the 20-carbon EPA and 22 carbon DHA, both of which are n-3 fatty acids can be derived from 18 carbon alpha linolenic acid. This DHA and EPA now fight for the enzyme cyclooxygenase with arachidonic acid. Platelet Cyclooxygenase then converts EPA to thromboxane A3, which is a milder form of vasoconstrictor as compared to thromboxane A2, which is generated by the action of cyclooxygenase on arachidonic acid (Choo *et al*., 2018). Hence, an elevated dietary ratio of Eicosapentanoic acid: arachidonic acid ratio contributes to relative vasodilation and inhibits aggregation of platelets (Nelson and Raskin, 2019).

Fatty acid profile of SIFs especially *Amblypharyngodon mola, Puntius sophore* and *Systomus sarana* were estimated by Mustafa *et al*. (2015). The fish oil extracted from these fishes contained twenty-one types of fatty acids (Table 4). The principal saturated fatty acids (SFA) were C16:0 and C18:0 the main monounsaturated fatty acids (MUFA), C16:1 ω7 and C18:1 ω9, while the main PUFAs were found as C22:6:4 ω3 (DHA), C20:5 ω3 (EPA). The range of total ω 3 is 4.28%–17.86% and the total ω6 was between 4.08% and 23.12%. The ω3/ω6 ratio was between 0.35% and 1.50%. Thus, it is apparent from research that these three fishes- *A. mola, P. sophore* and *P. sarana* are efficient resource of good fats, i.e. ω3 and ω6 and their inclusion in normal diet can ascertain sound health.

Attempts have been made to project the presence of saturated, monosaturated and polysaturated fatty acids (Figure 2–4) of different SIFs as one of the major good lipids (Gopakumar, 1997; Mohanty *et al*., 2010).

Protein in SIF

Like the big fishes, SIF are ample sources of protein. The protein percent in SIF is generally 14–22% of live body weight (Table 4). A humble dose of only 0.8 $g \cdot kg^{-1}$ of body weight is regarded as the recommended dietary allowance (RDA), which can easily be met by intake of SIF in daily diet plan. Comparative evaluation of the protein quantum of SIFs was at its maximum of 22.50% in *Etroplus suratensis* (Mohanty *et al*., 2010) against its minimal level at 14.08% in *Puntius chola* (Chakraborty and Goyal, 2015). The protein quality is expected to be better possibly due to higher amount of sulphur containing amino acids like methionine

Table 4. Fatty acids composition of the lipids of some small indigenous fishes (Gopakumar, 1997; Mohanty *et al*., 2010).

Fatty acid	*Amblypharyngodon mola*	*Channa punctatus*	*Etroplus maculatus*	*Heteropneustes fossilis*	*Etroplus suratensis*	*Macrognathus armatus*	*Puntius sophore*
Saturated							
C11:0	0.01	0.0	0.0	0.0	-	-	-
C12:0	0.32	0.0	0.0	1.2	0.0	2.1	-
C13:0	0.15	0.3	0.2	1.4	1.0	0.7	-
C14:0	6.91	0.7	3.4	3.3	3.8	3.6	7.56
C15:0	1.95	2.1	1.1	2.2	2.8	-	3.35
C16:0	36.75	24.0	24.7	17.6	19.9	-	1.04
C17:0	1.56	3.0	2.8	2.5	0.4	-	4.24
C18:0	7.77	13.7	12.0	9.4	15.7	-	-
C19:0	0.00	1.3	0.9	1.6	0.0	-	-
C20:0	0.22	0.0	0.0	0.0	-	-	-
C22:0	0.14	0.0	0..0	0.0	-	-	-
Total	55.86	45.1	45.1	39.2	43.6	41.3	-
Mono unsaturated							
C16:1 n7	0.61	5.8	6.3	16.5	11.1	7.5	4.43
C17:1 n7	0.37	2.0	1.2	0.0	0.4	1.1	1.55
C18:1 n9 (OA)	18.1	14.0	13.7	15.3	20.3	20.4	28.64
C20:1 n9	0.81	0.7	0.9	0.0	1.6	1.0	1.45
C22:1 n9	0.04	0.3	0.7	0.9	1.0	0.5	-
Total	20.19	24.6	23.0	35.2	34.5	33.5	-
Poly unsaturated							
C18:2n6	4.86	3.8	2.1	4.1	7.6	8.2	1.14
C18:3n3	9.36	0.5	0.6	0.9	5.5	1.9	16.39
C18:3n6	1.00	-	-	-	-	-	0.17
C18:4n3	0.00	1.8	3.6	1.7	2.4	1.6	-
C20:2n6	0.36	0.2	1.0	1.0	0.0	0.0	-
C20:3n6	1.30	0.2	0.7	2.1	0.0	1.5	-
C20:3n9	0.64	-	-	-	-	-	2.07
C20:4n6	3.5	6.1	3.0	6.3	3.5	7.1	9.80
C20:5n3	4.50	6.0	2.2	3.8	0.5	1.2	6.19
C21:n6	0.35	-	-	-	-	-	1.18
C22:4n6	0.00	2.4	5.9	0.9	0.0	1.3	-
C22:5n3	0.00	2.2	5.1	0.5	1.0	0.3	-
C22:6n3	0.00	6.7	8.0	0.3	1.0	2.2	3.27
Others	0.021	0.0	0.0	1.3	0.5	0.0	-
Total	23.94	29.9	32.2	22.9	22.0	25.3	-

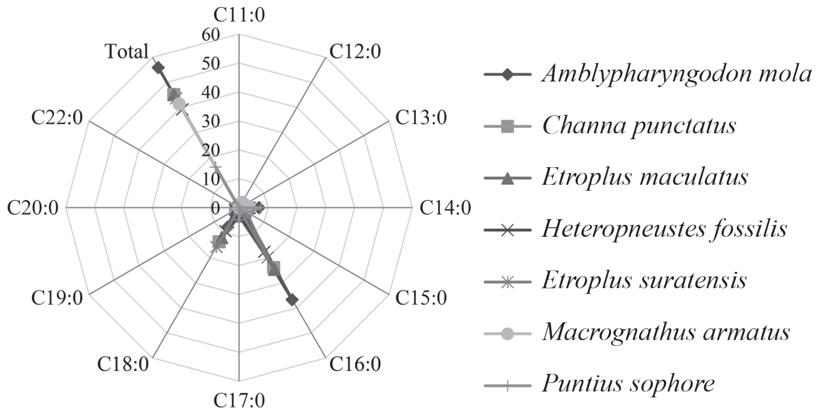

Figure 2. Data base analysis of saturated fatty acids among certain common small indigenous fishes of Northeast India.

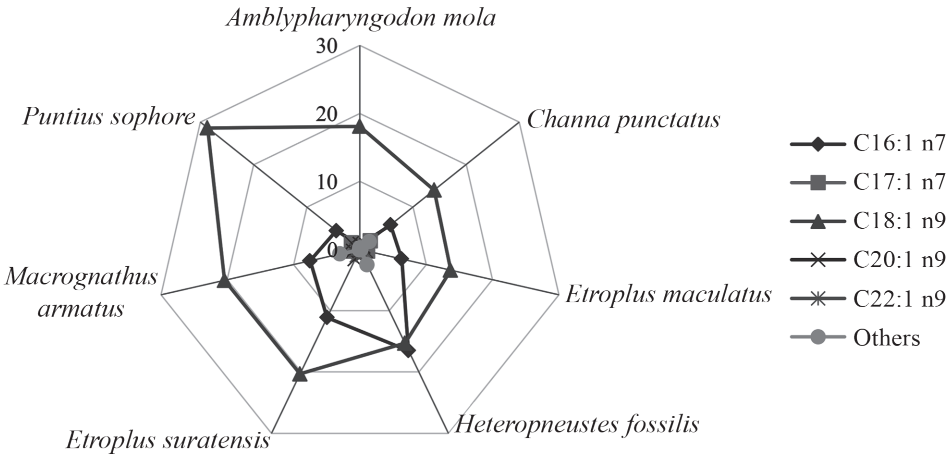

Figure 3. Data base analysis of mono unsaturated fatty acids among certain common small indigenous fishes of Northeast India.

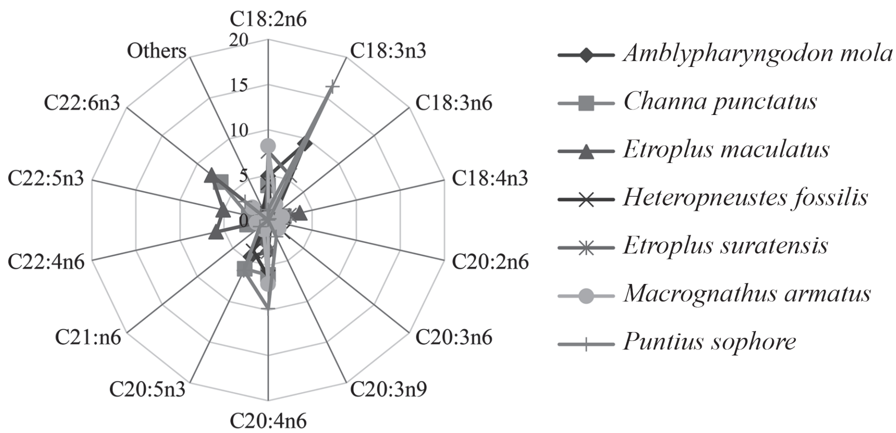

Figure 4. Data base analysis of poly unsaturated fatty acids among certain common small indigenous fishes of Northeast India.

and cysteine (Gopakumar, 1997). Protein in SIF (98–96%) being the major constituent of proximate composition (Ahmed *et al*., 2022) has been able to be major source of nutrient supplementation to human diet, particularly to the rural populace of this region. The proximate composition including the moisture (highest quantity 81.03% *Heteropneustes fossilis*), crude fats (6.27% in *P. stigma*). Crude protein (22.50% in *E. suratensis*) and ash (3.29% in *Pseudoeutropius atherinoids*) have already been evaluated in SIFs (Mohanty *et al*., 2010; Mahanty *et al*., 2014; Chakraborty and Goyal, 2015) and thus validated the view of higher quality of animal protein. Twenty number of SIF of the region are presented with their proximate composition in Table 5. Furthermore, the review of the proximate composition are being highlighted from time to time and as such, the species like *P. nama, P. sophore, P. ranga, T. fasciata, A. mola, B. dario, E. danricus, Mastacembelus pancalus, M. vittatus* and *Lepidocephalus guntea* were subjected to analysis (Chalamaiah *et al*., 2012; Jena *et al*., 2018; Manoharan *et al*., 2019; Ahmed *et al*., 2022; Pegu *et al*., 2023). These researchers have highlighted the range variation of protein (12–23%), lipids (0%–6.5%) and moisture (60–82%) in different SIF species depending upon the seasonality and breeding period. Other nutrients like ash have consistently been presenting the discrepancy with range variation of 0.9% to 3.5% in different fishes. Interestingly all fishes, especially the SIFs are very poor in carbohydrate quantum (Islam *et al*., 2023), although Pegu *et al*. (2023) have reviewed the presence of carbohydrate quantity at a range variation of 20.68% (*P. ranga*) to 7.13% (*Chanda nama*). Therefore, it is ample clear that the SIF group being rich in protein and omega 3 fatty acids and low in carbohydrate content might well be used by the diabetic patients.

Table 5. Proximate composition of small indigenous fishes (Mohanty *et al*., 2010; Chakraborty and Goyal, 2015).

Name of SIF	Crude protein (%)	Crude Fat (%)	Ash (%)	Moisture (%)
Amblypharyngodon mola	18.46	4.10	1.64	76.38
Gudusia chapra	15.23	5.41	1.55	75.07
Chanda nama	18.26	1.53	3.92	65.88
Pseudoeutropius atherinoides	15.84	2.24	3.29	73.32
Ailia coila	16.99	3.53	1.98	78.62
Puntius chola	14.08	3.05	1.19	74.43
Channa punctatus	19.84	3.15	1.00	75.80
Puntius sarana	20.84	3.15	1.17	74.84
Heteropneustes fossilis	16.43	0.40	1.30	81.03
Barbus spp.	18.81	0.19	1.12	79.67
Mystus vittatus	18.90	1.63	1.19	77.50
Clarias batrachus	18.20	1.42	0.97	78.70
Ambassis sp.	18.63	21.70	1.12	79.72
Glossogobius giuris	16.35	0.25	1.25	79.10
Osteobrama cotio	16.90	5.96	3.06	74.58
Puntius stigma	18.95	6.27	0.98	72.97
Mystus tengara	16.81	6.28	2.82	73.67
Xenontodon cancila	21.70	2.82	1.11	73.90
Puntius sophore	16.20	3.55	5.36	72.02

THERAPEUTIC DOMAIN OF SIFs

Since the fishes are nutritionally rich, they are believed to have medicinal values (Neog and Konwor, 2023). The people of Northeast India also use the fishes in traditional medicines (ethnozoology), especially the small indigenous fishes. The biochemical study of these fish species by different workers provides affirms on the traditional acceptation of the application of these fish species (Duarah and Das, 2014). Some of the important SIFs used as medicines are cited in Table 6.

Besides, the rich content of omega 3 fatty acids in all the SIFs makes it an incredible means to fight with conditions like fatigue, poor memory, dry skin, heart issues, mood swings or sadness, and poor circulation manifested in human body, due to its insufficiency.

Table 6. Some common small indigenous fishes used in different ailments with their justification to indigenous technical knowledge (ITK) (Adopted from Duarah and Das, 2019).

Scientific name	Ailments	Validation
Channa punctatus	Inflammatory problems, wound healing, postpartum conditions	The quantity of moisture, ash, protein and lipid in *C. punctatus* is 81.93%, 1.25%, 15.22%, and 1.60% respectively (Ahmed *et al*., 2012). It has good wound healing properties owing to excellent combination of amino acid and fatty acid content (Zuraini *et al*., 2006). It has high arachidonic acid level, which is a precursor of prostaglandin (Jais *et al*., 1994).
Clarias batrachus	For healing the infected of measles and chicken pox.	Easily digestible high-grade protein, high concentration of iron and beneficial lipid content indicates its high acceptance as medicinal fish (Debnath, 2011). Polyunsaturated fatty acid (PUFA) was estimated to be 25.56% in magur (Jakhar *et al*., 2012).
Ambylopharyngdon mola	Night blindness and vitamin A deficiency diseases.	Contains a very rich profile of vitamins, specially Vit. A (Roos *et al*., 2003; Mohanty *et al*., 2013).
Heteropneustes fossilis	Anemia and weakness	Highest antioxidant activity and has very rich content of Fe and other nutritional elements (Mazumder *et al*., 2008; Ray *et al*., 2014).
Channa gachua	Weakness and joint pains.	Non-essential amino acids that appear to be in abundance in *Channa* sp. extracts are glutamic acids and aspartic acid (Saiga *et al*., 2003; Ahmad *et al*., 2005; Zakaria *et al*., 2007).

CONSERVATION

The SIFs are a biodiversity rich group in the NE region of India and elsewhere. But even then, the biodiversity of these fishes is at risk due to various anthropogenic activities which is still expanding enormously (Lakra *et al*., 2010). SIF has the potential to bring fortune to the poor fisherman community and reach up to their basic needs (Roy *et al*., 2015; 2020). *Amblypharyngodon microlepis, A. mola, Notopterus notopterus, Puntius sarana, Labeo bata, P. ticto, Cirrhinus reba, Salmostoma bacaila, Nandus nandus, Anabas testudineus, Esomus danricus, P. chola, P. sarana, Glossogobius giuris, Danio devario,* and *Chanda nama* are species for aquaculture diversification (Roy *et al*., 2003; Wahab *et al*., 2011). A polyculture of such species along with Indian major carps is highly demandable (Nandi *et al*., 2012; Mondal *et al*., 2020). Besides, *in situ* conservation and ecorestoration can be carried out by maintaining them within natural or man-made ecosystems. Hence people's awareness must be boosted up through various agencies at different levels. It is necessary to understand the feeding ecology of SIFs, so as to know food partitioning and habitat preference within and between the fish species, for better culture and so that the ecological semblances could well be maintained and sustained (Nandi *et al*., 2012). Laws and regulations to protect SIFs chiefly in breeding season are entailed. Use of small webbed nets, up gradation of water bodies to sanctuaries, an intensive aquaculture and outlawing of introduction of exotic fishes, educating the general people about nutritional advantage of SIF and the initiative role of institutions to popularize SIF for nutritional safety as well as alternative livelihood must be focused (Sinha and Santra, 2016; Sinha *et al*., 2017; Sinha, 2020)

CONCLUSIONS

Thus, the study wind ups that SIF are a potent source of nutrition and revenue generation. Among the designated SIF's, certain species like *Ambylopharyngodon mola*, Dhela (*Osteobrama cotio*), Darikina (*Esomus danricus*) and Kaski (*Corica soborna*) are of special demand due to their high nutrient quality. Species like *O. cotio, E. danricus* and *C. soboma* are very rich in Vit. A. Besides, few other small fishes are also reported to have rich iron content such as *O. cotio* (39.7 mg·100 g^{-1}), *Mystus vittatus* (33.0 mg·100 g^{-1}) and *C. bacalia* (33.2 mg·100 g^{-1}). Therefore, a polyculture of such species along with Indian major carps is highly demandable. Moreover, the fish farmers should be acquainted with mass awareness and capacity building programmes related to SIF. So, as to restore their population in the ecosystem and as a step towards their conservation all illegal fishing and catching of juveniles and brooders must be lawfully banned. The ethnic knowledge and farmers' innovation to protect SIF resources must be accurately documented. Although researchers could successfully highlight the nutritional value of SIFs, but the technical gaps are yet need to be filled. Moreover, more prominence should be given in developing the breeding capacity, diversification and innovative cultural practices to save and propagate this excellent bioresource.

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