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*Review Article*

# Nutritional composition of small indigenous species of fishes of Northeast India: A systematic review

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**Abstract**
Northeast India has various water bodies including the tributaries of the Brahmaputra and Barak river systems, wetlands, lakes and beels. These water bodies support the diversity of many fish species. Seasonal changes in the number of fish species in the SIS category were also observed and they are most abundant during the winter and least abundant during the monsoon season. Many researchers collected fish data from Assam's rivers and wetlands, particularly small indigenous species (SIS). Small Indigenous Species (SIS) of fish are a vital and conveniently accessible source of rare protein, vitamins, and minerals in traditional diets. The present study aimed to review Assam's small indigenous fish species and their nutritional worth. The sources of the review article were Google Scholar, Web of Science, ScienceDirect, and PubMed for SIS nutrition composition, fish nutritional profile, and fish proximate composition. Northeast India's rural inhabitants get their sustenance from fish SIS. The SIS of Northeast India fish species contain proteins, lipids, vitamins, minerals, and vital macro- and micronutrients. The protein content of SIS range from 12.49% to 18.30% (12.49–18.30g/100 g), lipid content from 0.7% to 19.63% (0.7–19.63g/100 g), moisture content from 65.88% to 82.8% (65.88–82.8g/100 g), and ash level from 2% to 6.8% (2–6.8g/100 g). This review suggests SIS has adequate nutritional benefits because it is an excellent source of proteins, lipids, vitamins, minerals, and omega-3 fatty acids necessary for optimal health. Northeast India's impoverished region might achieve their nutritional demands by eating more SIS of fish.

**Keywords:** Nutritional profile, Northeast India, Proximate composition, SIS fish

## INTRODUCTION

Fish is a nutritious diet high in micronutrients, high-quality animal proteins, and polyunsaturated fatty acids, particularly omega-3 eicosapentaenoic and docosahexaenoic acids. Moreover, compared to other sources of animal proteins, fish is more readily available and less expensive in tropical nations (Mohanty *et al*., 2019; Mohanty *et al*., 2022; Sinha *et al*., 2022). More than half of India's population eats fish, and in certain areas, such as Assam, Arunachal Pradesh, Goa, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tripura, and West Bengal more than 90% of the population eats fish (Sankar *et al*., 2010; Debnath *et al*., 2014; Sobczak *et al*., 2021). Fish contain proteins and nitrogenous substances other than protein, minerals, iodine, selenium, taurine, vitamin D, and a small quantity of carbohydrates (Chen *et al*., 2007; Sankar *et al*., 2010; Achionye-Nzeh *et al*., 2011; Moniruzzaman *et al*., 2021). Fish is also a known source of such amino acids, which are not produced by the human body itself, specifically lysine, which is also found in less amounts in cereals (Jabeen and Chaudhry, 2011; Abdulkarim *et al*., 2017). Therefore, protein from fish can be used to supplement a mixed diet's amino acid profile and overall protein quality (FAO, 2005). When compared to other protein sources such as goat and chicken meat, it is also known to be a safer, healthier, and higher quality protein in terms of both amino acid content and ease of digestion (Ogundiran, *et al*., 2014). Unsaturated fatty acids, fat-soluble vitamins, and energy are all made from fats (Sarkar *et al*., 2017). Fish consumption has gained popularity in recent years (Supartini *et al*., 2018; Lee and Nam, 2019; Krittanawong *et al*., 2021; Krešić *et al*., 2022) due to its high level of polyunsaturated fatty acids, particularly omega-3 fatty acids such as docosahexaenoic acid (C22:6) and eicosapentaenoic acid (C20:5), as they cannot be synthesis by human body (Alam *et al*., 2016). These acids have been shown to have a role in the formation of nerve cells in developing children, as well as having antithrombic and atherosclerosis actions. Vitamins A, D, and E, as well as Thiamin, Riboflavin, and Niacin, are abundant in fish. Vitamin A obtained from fish is more easily absorbed by the body than vitamin A obtained from plant sources (Sankar *et al.,* 2010).

Northeastern India comprises eight states: Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Tripura, Nagaland, and Sikkim. These states are known for their many different ethnic groups and bioresources (Kaushik and Bordoloi, 2016; Borah, 2019). The region's rural and tribal peoples rely heavily on biological resources for their food, shelter, medical care, and cultural needs because of the area's favourable climate and a wide variety of plants and animals, many of which have their own biological benefits (Sarkar *et al*., 2017). This review article aimed to review the diversity of Small Indigenous Species (SIS) of fish and their nutritional and nutraceutical significance.

This study analysed the literature with a focus on fish species that are underrepresented in global databases to fill the knowledge gap regarding the nutrient composition data of fish and other aquatic species (Byrd *et al*., 2021). A systematic literature survey was conducted using ScienceDirect, Web of Science, PubMed, Scopus, Google Scholar, and other online sources. The information on the nutritional make-up of Small Indigenous Species of fish found in various parts of the globe was from the articles surveyed.

## DIVERSITY OF SMALL INDIGENOUS FISH OF NORTHEAST

Rivers, beels (wetlands), and other bodies of water, as well as wetlands, are abundant in Assam. Assam has a variety of wetlands, including lakes, ponds, Ox-Bow Lakes, marshy areas, etc. These freshwater bodies' fish populations are seriously threatened by environmental degradation and other issues (Taran *et al*., 2023). It is now widely accepted that environmental deterioration has harmed biodiversity, including plants and animals (Duarah and Das, 2019; Mohanty *et al*.,

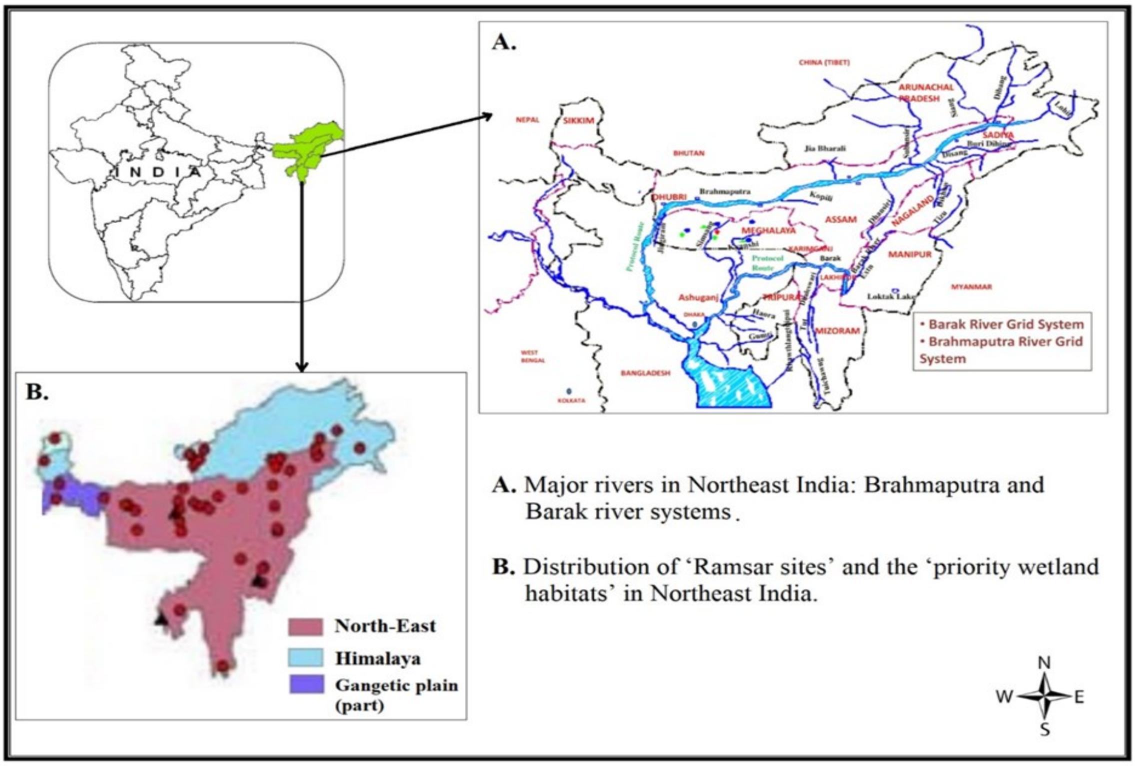

**Fig. 1.** *Map of North-east India showing water bodies. A. Major rivers in Northeast India; B. Distribution of "Ramsar sites" and the conservation "priority wetland habitats" in Northeast India (Vijayan et al., 2004; Nagabhatla et al., 2010)*

2022; Sinha *et al*., 2022).

Locally available in tiny water resources like wetlands, canals, streams, etc., the small indigenous fish (SIF), with a length of around 25 cm, is also cheap to the poor (Sinha *et al*., 2022). Diverse fish species, including SIS, have been found in rivers and wetlands, according to a number of workers. Two hundred sixteen species of Small Indigenous fishes have been found in Northeast India (Goswami *et al*., 2012; Duarah and Das, 2019; Mohanty *et al*., 2022) (Table 1). In another study, 18 species of fish belonging to 15 genera and 10 families were in the Brahmaputra River and its tributaries in Assam. Most of the species they studied and recorded were economically important for food, medicine, leisure, and aesthetics. (Das & Antoney, 2010). From Jorhat, Assam, approximately 27 SIS from 5 orders, 17 genera, and 13 families were reported. (Duarah and Das, 2019). Fifty-two SIS fish in total, representing 15 families and 33 genera, were found over the entire upper side of the Brahmaputra River. With 22 species (42.31%), the Cyprinidae family was reported to be the most abundant, followed by the Bagridae family with 9 species (17.31%) and the Cobitidae family with 4 species (7.69%). They also recorded *Botia lohachata* from this area, which had not before been recorded (Bora and Sarma, 2014; Duarah and Das, 2019). Another study conducted in Dipalibeel, Kokrajarh, Assam, identified 67 fish species, including 4 exotic species, in 49 genera, 25 families, and 8 orders (Singha *et al*., 2017).

## NUTRITIONAL PROFILE OF SMALL INDIGENOUS FISH

Due to an increase in consciousness of human health, an increase in food security in developing countries (India, Bangladesh, Pakistan, Nepal) and restoration of the ecological diversity of the various species of fish around the world, there has been an increase in the interest of research in biochemical composition and extensive studies in the impact of fish for health and diseases of the mankind when consumed.

One of the best sources of nutrients, including the proteins, lipids, carbohydrates, vitamins, and minerals needed to maintain a healthy human body, is fish (Sarkar *et al*., 2017). Protein, fat, and carbohydrate, which are known as macronutrients and are present in large amounts, make up the high energy-yielding component among these compositions. while vitamins and minerals, which do not produce energy, are known as micronutrients (Fig. 2).

### Proximate composition of small indigenous species (SIS) of fish

Determining the moisture, protein, fat, and ash concentrations of fish is part of determining its "proximate composition," which accounts for 96%–98% of the total components of the fish's body (Ahmed *et al*., 2022). The small indigenous fish *Puntius sophore*'s proximate composition, amino acid, fatty acid and micronutrient profiles have been studied (Mahanty *et al*., 2014). The moisture, crude fat, crude protein, and ash with values of 72.02, 3.55, 16.2, and 5.36%, have been estimated, respectively. They also stated that compared to other food fishes like large catfish and Indian major carps, small indigenous species (SIS) of fishes provided higher-quality animal protein for human nutrition.

The mean value of protein, moisture, fat and ash content in C*. batrachus, H. fossilis, A. testudineus, N. notopterus, C. punctatus* and *M. vittatus* was found in the range of 14.87±0.63 to 19.63 ± 0.5 (protein) , 69.27 ± 1.04 to 76.06 ±2.24 (moisture), 3.45 ± 0.92 to 7.90 ± 1.91 (fat) and 3.15 ± 0.25% to 6.81 ±0.94% (ash) respectively (Kamal *et al*., 2007; Sinha *et al*., 2022). Considering the result of their studies, they concluded that all the species are rich in food value.

The proximate composition of ten small indigenous species (SIS) viz., *Parambassis nama, Puntius sophor, P. ranga, Trichogaster fasciata, Amblypharyngodon mola, Botia dario, Esomus danricus, Magrognathus pancalus*, *Mystus vittatus*, *Lepidocephalichthys guntea* were analysed to evaluate their nutritive value (Chalamaiah *et al*., 2012; Jena *et al.*, 2018; Manoharan *et al*., 2019). They reported that the protein content varied between 12.89% and 16.75%, with *A. mola* and *M. pancalus* having the highest protein content and *E. danricus* and *Parambassis nama* having the lowest. In the same way, the lipid content ranged from 1.84% (*A. mola*) to 6.19% (*P. sophore*). Other nutrients such as moisture content show a discrepancy from 70.65% (*P. sophore*) to 76.95% (*P. ranga*), carbohydrate content from 0.68% (*P. ranga*) to 7.13% (*C. nama*) whereas, the ash content varied from 1.93% (*A. mola*) to 4.29% (P*. sophore*) indicating that the SIS are the good sources of macronutrients thereby safeguarding both nutritional as well as livelihood security.

The proximate composition of some small indigenous fish species i.e., *Gudusia chapra, A. mola, P. chola, Pseudeutropius atherinoides, P. nama and Ailia coila* have been reported (Mazumder *et al.*, 2008). Different species were reported to have different proximate compositions. The reported protein content of *A. mola* is 18.46 %, *G. chapra* is 15.23 %, P. *chola* is 14.08%, *Parambassis nama* is 18.26%, *Pseudeutropius atherinoides* is 15.84% and A*. coila* is 16.99% respectively. Likewise, the fat content of those SIS was reported as 4.10%, 5.41%, 3.05%, 1.53%, 2.24% and 3.53%, respectively. A. *coila* had the lowest moisture content (65.88%), while *P. nama* had the highest (78.62%) and ash content ranged from 1.55 percent in *G. chapra* to 3 .92 percent in *P*. *nama* as per their report (Table 2). Theses findings revealed that A. *mola* had the highest protein content (18.46%), but *G. chapra* had the high-

**Table 1.** Understudied SIS fish diversity in Northeast India (Goswami *et al*., 2012; Duarah and Das, 2019; Mohanty *et al*., 2022)

| | Species | Family | Economic Importance | Present Status |
|---|---|---|---|---|
| 1 | *Notopterus notopterus* (Pallas, 1769) | Notopteridae | Fd | EN |
| 2 | *Gonialosa manmina* (Hamilton, 1822) | Anguillidae | Fd | VU |
| 3 | *Gudusia chapra* (Hamilton, 1822) | Anguillidae | Fd | VU |
| 4 | *Gudusia variegata* (Day, 1870) | Clupeidae | Fd | DD |
| 5 | *Nematalosa nasus* (Bloch, 1795) | Clupeidae | Fd, Or | DD |
| 6 | *Setipinna phasa* (Hamilton, 1822) | Engraulidae | Fd, Or | LC |
| 7 | *Amblypharyngodon mola* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 8 | *Aspidoparia jaya* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 9 | *Aspidoparia morar* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 10 | *Aspidoparia ukhrulensis* (Selim & Vishwanath, 2001) | Cyprinidae | Fd, Or | DD |
| 11 | *Barilius bakeri* (Day, 1865) | Cyprinidae | Fd, Or | VU |
| 12 | *Barilius bendelisis* (Hamilton, 1807) | Cyprinidae | Fd, Or | VU |
| 13 | *Barilius barnoides* (Vinciguerra, 1890) | Cyprinidae | Fd | LC |
| 14 | *Barilius vagra* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 15 | *Barilius chatricensis* (Selim & Vishwanath, 2002) | Cyprinidae | Fd, Or | VU |
| 16 | *Barilius dimorphicus* (Tilak & Husain, 1990) | Cyprinidae | Fd | VU |
| 17 | *Barilius dogarsinghi* (Hora, 1921) | Cyprinidae | Fd, Or | VU |
| 18 | *Barilius gatensis* (Valenciennes, 1844) | Cyprinidae | Fd | LC |
| 19 | *Barilius ngawa* (Vishwanath & Manojkumar, 2002) | Cyprinidae | Fd, Or | VU |
| 20 | *Barilius radiolatus* (Günther, 1868) | Cyprinidae | Fd, Or | DD |
| 21 | *Barilius tileo* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 22 | *Barilius barila* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 23 | *Barilius barna* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 24 | *Barilius shacra* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 25 | *Barilius lairokensis* (Arunkumar & Tombi Singh, 2000) | Cyprinidae | Fd | LC |
| 26 | *Crossocheilus latius* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 27 | *Danio rerio* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 28 | *Devario aequipinnatus* (McClelland, 1839) | Cyprinidae | Fd, Or | LC |
| 29 | *Esomus danricus* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 30 | *Garra annandalei* (Hora, 1921) | Cyprinidae | Fd, Or | NT |
| 31 | *Garra gotyla* (Gray, 1830) | Cyprinidae | Fd, Or | VU |
| 32 | *Garra lamta* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 33 | *Chela laubuca* (Hamilton, 1822) | Cyprinidae | Fd, Or | DD |
| 34 | *Oreichthys cosuatis* (Hamilton, 1822) | Cyprinidae | Fd, Or | DD |
| 35 | *Osteobrama cotio* (Hamilton, 1822) | Cyprinidae | Fd | NT |
| 36 | *Puntius chola* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 37 | *Puntius conchonius* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 38 | *Dawkinsia filamentosus* (Valenciennes, 1844) | Cyprinidae | Fd, Or | VU |
| 39 | *Puntius fraseri* (Hora & Misra, 1938) | Cyprinidae | Fd, Or | VU |
| 40 | *Puntius gelius* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 41 | *Puntius guganio* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 42 | *Puntius jayarami* (Vishwanath & Tombi Singh, 1986) | Cyprinidae | Fd | EN |
| 43 | *Pethia ornatus* (Vishwanath & Laisram, 2004) | Cyprinidae | Fd, Or | LC |
| 44 | *Puntius javanicus* (Bleeker, 1855) | Cyprinidae | Fd | NE |
| 45 | *Pethia khugae* (Linthoingambi & Vishwanath, 2007) | Cyprinidae | Fd, Or | NE |
| 46 | *Pethia phutunio (Hamilton, 1822)* | Cyprinidae | Fd, Or | NK |
| 47 | *Pethia yuensis* (Arunkumar & Tombi Singh, 2003) | Cyprinidae | Fd | VU |
| 48 | *Systomus sarana* (Hamilton, 1822) | Cyprinidae | Fd | VU |
| 49 | *Puntius shalynius* (Yazdani & Talukdar, 1975) | Cyprinidae | Fd, Or | VU |
| 50 | *Puntius puntio* (Hamilton, 1822) | Cyprinidae | Or | NK |
| 51 | *Puntius sophore* (Hamilton, 1822) | Cyprinidae | Fd, Or | NK |
| 52 | *Puntius terio* (Hamilton, 1822) | Cyprinidae | Fd, Or | NK |
| 53 | *Pethia ticto* (Hamilton, 1822) | Cyprinidae | Fd, Or | NK |
| 54 | *Rasbora daniconius* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |

Contd…….

**Table 1.** Contd…….

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|---|---|---|---|---|
| 55 | *Chela cachius* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 56 | *Laubuka fasciata* (Silas, 1958) | Cyprinidae | Fd, Or | LC |
| 57 | *Chela khujairokensis* (Arunkumar, 2000) | Cyprinidae | Fd | LC |
| 58 | *Danio dangila* (Hamilton, 1822) | Cyprinidae | Or | VU |
| 59 | *Danio jaintianensis* (Sen, 2007*)* | Cyprinidae | Or | VU |
| 60 | *Devario annandalei* (Chaudhuri, 1908) | Cyprinidae | Or | LC |
| 61 | *Devario acuticephala* (Hora, 1921) | Cyprinidae | Or | EN |
| 62 | *Devario aequipinnatus* (McClelland, 1839) | Cyprinidae | Or | LC |
| 63 | *Devario assamensis* (Barman, 1984) | Cyprinidae | Or | LC |
| 64 | *Devario devario* (Hamilton, 1822) | Cyprinidae | Or | NT |
| 65 | *Devario horai* (Barman, 1983) | Cyprinidae | Or | NT |
| 66 | *Devario naganensis* (Chaudhuri, 1912) | Cyprinidae | Or | VU |
| 67 | *Devario regina* (Fowler, 1934) | Cyprinidae | Or | LC |
| 68 | *Devario yuensis* (Arunkumar & Tombi Singh, 1998) | Cyprinidae | Or | LC |
| 69 | *Esomus danrica* (Hamilton, 1822) | Cyprinidae | Fd, Or | VU |
| 70 | *Garra rupecula* (McClelland, 1839) | Cyprinidae | Fd, Or | LC |
| 71 | *Garra annandalei* (Hora, 1921) | Cyprinidae | Or | LC |
| 72 | *Garra compressus* (Kosygin & Vishwanath, 1998) | Cyprinidae | Or | LC |
| 73 | *Garra flavatra* (Kullander & Fang, 2004) | Cyprinidae | Fd, Or | DD |
| 74 | *Garra gotyla* (Gray, 1830) | Cyprinidae | Fd, Or | VU |
| 75 | *Garra kempi* (Hora, 1921) | Cyprinidae | Or | VU |
| 76 | *Garra kalpangi* (Nebeshwar, Bagra & Das, 2012) | Cyprinidae | Or | NK |
| 77 | *Garra mcclellandi* (Jerdon, 1849) | Cyprinidae | Or | LC |
| 78 | *Garra notata* (Blyth, 1860) | Cyprinidae | Or | LC |
| 79 | *Garra lissorhynchus* (McClelland, 1842) | Cyprinidae | Fd, Or | VU |
| 80 | *Garra litanensis* (Vishwanath, 1993) | Cyprinidae | Or | NT |
| 81 | *Garra manipurensis* (Vishwanath & Sarojnalini, 1988) | Cyprinidae | Or | NK |
| 82 | *Garra naganensis* (Hora, 1921) | Cyprinidae | Or | VU |
| 83 | *Garra nasuta* (McClelland, 1838) | Cyprinidae | Or | LC |
| 84 | *Horalabiosa joshuai* (Silas, 1954) | Cyprinidae | Fd | VU |
| 85 | *Megarasbora elanga* (Hamilton, 1822) | Cyprinidae | Fd | VU |
| *86* | *Neolissochilus blythii* (Day, 1870) | Cyprinidae | Fd | LC |
| 87 | *Oreichthys cosuatis* (Hamilton, 1822) | Cyprinidae | Or | DD |
| 88 | *Osteobrama cotio* (Hamilton, 1822) | Cyprinidae | Fd | NT |
| 89 | *Rasbora ornata* (Vishwanath & Laisram, 2005) | Cyprinidae | Or | LC |
| 90 | *Rasbora rasbora* (Hamilton, 1822) | Cyprinidae | Or | LC |
| 91 | *Salmostoma bacaila* (Hamilton, 1822) | Cyprinidae | Fd, Or | DD |
| 92 | *Salmostoma sardinella* (Valenciennes, 1844) | Cyprinidae | Fd | DD |
| 93 | *Salmostoma sladoni* (Day, 1870) | Cyprinidae | Fd | DD |
| *94* | *Salmostoma phulo* (Hamilton, 1822) | Cyprinidae | Fd, Or | LC |
| 95 | *Psilorhynchus arunachalensis* (Nebeshwar, Bagra & Das, 2007) | Psilorhynchidae | Or | NK |
| 96 | *Psilorhynchus balitora* (Hamilton, 1822) | Psilorhynchidae | Or | VU |
| 97 | *Psilorhynchus gracilis* (Rainboth, 1983) | Psilorhynchidae | Fd | NK |
| 98 | *Psilorhynchus homaloptera* (Hora & Mukerji, 1935) | Psilorhynchidae | Fd | VU |
| 99 | *Psilorhynchus microphthalmus* (Vishwanath & Manojkumar, 1995) | Psilorhynchidae | Fd | NK |
| 100 | *Psilorhynchus sucatio* (Hamilton, 1822) | Psilorhynchidae | Or | LC |
| 101 | *Aborichthys garoensis* (Hora, 1925) | Balitoridae | Or | NK |
| 102 | *Aborichthys elongatus* (Hora, 1921) | Balitoridae | Or | LC |
| 103 | *Aborichthys kempi* (Chaudhuri, 1913) | Balitoridae | Or | VU |
| 104 | *Acanthocobitis botia* (Hamilton, 1822) | Balitoridae | Or | VU |
| 105 | *Paracanthocobitis zonalternans* (Blyth, 1860) | Balitoridae | Or | DD |
| 106 | *Balitora brucei* (Gray, 1830) | Balitoridae | Or | VU |
| 107 | *Balitora burmanica* (Hora, 1932) | Balitoridae | Or | VU |
| 108 | *Homalopteroides modestus* (Vinciguerra, 1890) | Balitoridae | Or | NK |
| 109 | *Schistura reticulofasciata* (Singh & Banarescu, 1982) | Balitoridae | Or | DD |
| 110 | *Neonoemacheilus assamensis* (Menon, 1987) | Balitoridae | Or | DD |
| 111 | *Neonoemacheilus labeosus* (Kottelat, 1982) | Balitoridae | Or | VU |
| *112* | *Physoschistura elongata* (Sen & Nalbant, 1982) | Balitoridae | Or | EN |

Contd…….

**Table 1.** Contd…….

| | | | | |
|---|---|---|---|---|
| 113 | *Schistura beavani* (Günther, 1868) | Balitoridae | Or | EN |
| 114 | *Schistura cincticauda* (Blyth, 1860) | Balitoridae | Or | EN |
| 115 | *Schistura corica* (Hamilton, 1822) | Balitoridae | Or | LC |
| 116 | *Schistura devdevi* (Hora, 1935) | Balitoridae | Or | EN |
| 117 | *Schistura kangjupkhulensis* (Hora, 1921) | Balitoridae | Or | LC |
| 118 | *Schistura manipurensis* (Chaudhuri, 1912) | Balitoridae | Or | VU |
| 119 | *Schistura minuta* (Vishwanath & Shanta Kumar, 2006) | Balitoridae | Or | NK |
| 120 | *Schistura multifasciata* (Day, 1878) | Balitoridae | Or | VU |
| 121 | *Schistura nagaensis* (Menon, 1987) | Balitoridae | Or | EN |
| 122 | *Schistura prashadi* (Hora, 1921) | Balitoridae | Or | LC |
| 123 | *Schistura reticulata* (Vishwanath & Nebeshwar Sharma, 2004) | Balitoridae | Or | EN |
| 124 | *Schistura savona* (Hamilton, 1822) | Balitoridae | Or | LC |
| 125 | *Schistura scaturigina* (McClelland, 1839) | Balitoridae | Or | LC |
| 126 | *Schistura sikmaiensis* (Hora, 1921) | Balitoridae | Or | EN |
| 127 | *Schistura vinciguerrae* (Hora, 1935) | Balitoridae | Or | EN |
| 128 | *Acantopsis multistigmatus* (Vishwanath & Laisram, 2005) | Cobitidae | Fd, Or | LC |
| 129 | *Botia dario* (Hamilton, 1822) | Cobitidae | Or | VU |
| 130 | *Botia histrionica* (Blyth, 1860) | Cobitidae | Or | VU |
| 131 | *Lepidocephalichthys berdmorei* (Blyth, 1860) | Cobitidae | Or | EN |
| 132 | *Lepidocephalichthys guntea* (Hamilton, 1822) | Cobitidae | Or | VU |
| 133 | *Lepidocephalichthys annandalei* (Chaudhuri, 1912) | Cobitidae | Or | LC |
| 134 | *Neoeucirrhichthys maydelli* (Bănărescu & Nalbant, 1968) | Cobitidae | Or | LC |
| 135 | *Pangio pangia* (Hamilton, 1822) | Cobitidae | Fd | VU |
| 136 | *Somileptus gongota* (Hamilton, 1822*)* | Cobitidae | Or | VU |
| 137 | *Batasio batasio* (Hamilton, 1822) | Bagridae | Or | NK |
| 138 | *Batasio fasciolatus* (Ng, 2006) | Bagridae | Fd, Or | LC |
| 139 | *Batasio niger (Vishwanath & Darshan, 2006)* | Bagridae | Fd, Or | NT |
| 140 | *Batasio spilurus* (Ng, 2006) | Bagridae | Fd, Or | LC |
| 141 | *Batasio tengana* (Hamilton, 1822) | Bagridae | Fd, Or | LC |
| 142 | *Chandramara chandramara* (Hamilton, 1822) | Bagridae | Fd, Or | VU |
| 143 | *Mystus armatus* (Day, 1865) | Bagridae | Fd | VU |
| 144 | *Mystus bleekeri* (Day, 1877) | Bagridae | Fd, Or | VU |
| 145 | *Mystus falcarius* (Chakrabarty & Ng, 2005) | Bagridae | Fd, Or | LC |
| 146 | *Mystus montanus (Jerdon, 1849)* | Bagridae | Fd, Or | VU |
| 147 | *Mystus pulcher* (Chaudhuri, 1911) | Bagridae | Fd, Or | LC |
| 148 | *Mystus rufescens* (Vinciguerra, 1890) | Bagridae | Fd, Or | LC |
| 149 | *Mystus tengara* (Hamilton, 1822) | Bagridae | Fd, Or | LC |
| 150 | *Mystus vittatus* (Bloch, 1794) | Bagridae | Fd, Or | LC |
| 151 | *Olyra kempi* (Chaudhuri, 1912) | Bagridae | Or | VU |
| 152 | *Olyra longicaudata* (McClelland, 1842) | Bagridae | Or | VU |
| 153 | *Olyra burmanica* (Day, 1872) | Bagridae | Fd | LC |
| 154 | *Rama rama* (Hamilton, 1822) | Bagridae | Fd | LC |
| 156 | *Ompok bimaculatus* (Bloch, 1794) | Siluridae | Fd | EN |
| 157 | *Ompok pabda* (Hamilton, 1822) | Siluridae | Fd | VU |
| 158 | *Ompok pabo* (Hamilton, 1822) | Siluridae | Fd | EN |
| 159 | *Pterocryptis berdmorei* (Blyth, 1860) | Siluridae | Fd | LC |
| 160 | *Pterocryptis indica* (Datta, Barman & Jayaram, 1987) | Siluridae | Fd | LC |
| 161 | *Pterocryptis gangelica* (Peters, 1861) | Siluridae | Fd | NK |
| 162 | *Ailia coila* (Hamilton, 1822) | Schilbeidae | Fd | VU |
| 163 | *Ailiichthys punctata* (Day, 1872) | Schilbeidae | Fd | VU |
| 164 | *Pachypterus atherinoides* (Bloch, 1794) | Schilbeidae | Fd | LC |
| 165 | *Amblyceps apangi* (Nath & Dey, 1989) | Amblycipitidae | Or | VU |
| 166 | *Amblyceps arunachalense* (Nath & Dey, 1989) | Amblycipitidae | Or | VU |
| 167 | *Amblyceps laticeps* (McClelland, 1842) | Amblycipitidae | Or | LC |
| 168 | *Amblyceps cerinum* (Ng & Wright, 2010) | Amblycipitidae | Or | NE |
| 169 | *Amblyceps mangois* (Hamilton, 1822) | Amblycipitidae | Or | EN |
| 170 | *Exostoma berdmorei* (Blyth, 1860) | Sisoridae | Or | LC |
| 171 | *Exostoma labiatum* (McClelland, 1842) | Sisoridae | Or | LC |
| 172 | *Exostoma stuarti* (Hora, 1923) | Sisoridae | Or | LC |
| 173 | *Exostoma vinciguerrae* (Regan, 1905) | Sisoridae | Or | LC |
| 174 | *Gagata cenia* (Hamilton, 1822) | Sisoridae | Or | NT |
| 175 | *Gagata dolichonema* (He, 1996) | Sisoridae | Or | LC |
| 176 | *Gagata sexualis* (Tilak, 1970) | Sisoridae | Or | NT |
| 177 | *Glyptothorax botius* (Hamilton, 1822) | Sisoridae | Or | LC |

Contd…….

**Table 1.** Contd…….

| | | | | |
|---|---|---|---|---|
| 178 | *Glyptothorax conirostris* (Steindachner, 1867) | Sisoridae | Or | LC |
| 179 | *Glyptothorax platypogonides* (Bleeker, 1855) | Sisoridae | Or | VU |
| 180 | *Glyptothorax chindwinica* (Vishwanath & Linthoingambi, 2007) | Sisoridae | Or | VU |
| 181 | *Glyptothorax granulus* (Vishwanath & Linthoingambi, 2007) | Sisoridae | Or | LC |
| 182 | *Glyptothorax manipurensis* (Menon, 1955) | Sisoridae | Or | LC |
| 183 | *Glyptothorax ngapang* (Vishwanath & Linthoingambi, 2007) | Sisoridae | Or | LC |
| 184 | *Glyptothorax striatus* (McClelland, 1842) | Sisoridae | Or | VU |
| 185 | *Glyptothorax telchitta* (Hamilton, 1822) | Sisoridae | Or | VU |
| 186 | *Glyptothorax ventrolineatus* (Vishwanath & Linthoingambi, 2006) | Sisoridae | Or | VU |
| 187 | *Glyptothorax indicus* (Talwar, 1991) | Sisoridae | Or | NT |
| 189 | *Glyptothorax gracilis* (Günther, 1864) | Sisoridae | Or | LC |
| 190 | *Glyptothorax chimtuipuiensis* (Anganthoibi & Vishwanath, 2010) | Sisoridae | Fd | NK |
| 191 | *Gogangra viridescens* (Hamilton, 1822) | Sisoridae | Or | LC |
| 192 | *Nangra assamensis* (Sen & Biswas, 1994) | Sisoridae | Or | LC |
| 193 | *Nangra nangra* (Hamilton, 1822) | Sisoridae | Or | NK |
| 194 | *Nangra robusta* (Mirza & Awan, 1973) | Sisoridae | Or | LC |
| 195 | *Parachiloglanis hodgarti* (Hora, 1923) | Sisoridae | Or | LC |
| 196 | *Aplocheilus panchax* (Hamilton, 1822) | Aplocheilidae | Or | LC |
| 197 | *Microphis deocata* (Hamilton, 1822) | Syngnathidae | Or | VU |
| 198 | *Monopterus hodgarti* (Chaudhuri, 1913) | Synbranchidae | Fd | LC |
| 199 | *Macrognathus pancalus* (Hamilton, 1822) | Mastacembelidae | Fd,Or | NK |
| 200 | *Heteropneustes fossilis* (Bloch, 1794) | Clariidae | Fd | VU |
| 201 | *Xenentodon cancila* (Hamilton, 1822) | Belonidae | Or | VU |
| 202 | *Chanda nama* (Hamilton, 1822) | Chandidae | Or | LC |
| 203 | *Parambassis baculis* (Hamilton, 1822) | Chandidae | Or | LC |
| 204 | *Parambassis lala* (Hamilton, 1822) | Chandidae | Or | LC |
| 205 | *Parambassis ranga* (Hamilton, 1822) | Chandidae | Or | LC |
| 206 | *Parambassis tenasserimensis* (Roberts, 1995) | Chandidae | Or | LC |
| 207 | *Johnius coitor* (Hamilton, 1822) | Scianenidae | Fd | NK |
| 208 | *Badis assamensis* (Ahl, 1937) | Nandidae | Or | NK |
| 209 | *Badis badis* (Hamilton, 1822) | Nandidae | Or | NK |
| 210 | *Badis blosyrus* (Kullander & Britz, 2002) | Nandidae | Or | LC |
| 211 | *Badis kanabos* (Kullander & Britz, 2002) | Nandidae | Or | NK |
| 212 | *Badis tuivaiei* (Vishwanath & Shanta, 2004) | Nandidae | Or | LC |
| 213 | *Nandus nandus* (Hamilton, 1822) | Nandidae | Or | NK |
| 214 | *Anabas testudineus* (Bloch, 1792) | Anabantidae | Fd | VU |
| 215 | *Trichogaster fasciata* (Bloch & Schneider,1801) | Osphronemidae | Or | NK |
| 216 | *Trichogaster lalius* (Hamilton, 1822) | Osphronemidae | Or | LC |
| 217 | *Trichogaster labiosa* (Day, 1877) | Osphronemidae | Or | NK |
| 218 | *Channa bleheri* (Vierke, 1991) | Channidae | Fd | EN |

Abbreviations: LC, Least Concern; EN, endangered; VU, vulnerable; NK, not known; NT, Near Threatened, DD; data deficient; Or, Ornamental; Fd, Food

est fat content (18.46%). They concluded that the overall nutritional content of the small native fish they examined was comparable to or even greater than that of larger fish species.

SIFs were reported to contain moisture 75-81%, Ash 1.95-4.31%, protein 13-15%, fat 1.18-5.78%, energy 52.14-114.02 Kcal/g, Potassium 78.29-501.47mg/100g, Sodium 124.85-581.92mg/100g, Calcium76.59-1984.32 mg/100g, Magnesium 81.55-148.16 mg/100g, iron 0.31 -15.95 mg/100g, zinc13.15-27.06mg/100g, Manganese -0.02.6.34mg/100g. Since the ethnic people of the region typically consume these fish along with their head, bones, and viscera, they can be a convenient source of important nutrients, including vitamins, calcium, iron, and other minerals (Borah, 2019).

**Amino acid composition of small indigenous species of fish**

Amino acids are organic molecules with side chains (R groups) unique to each amino acid as well as amine (-NH2) and carboxyl (-COOH) functional groups. The main constituents of an amino acid are carbon (C), oxygen (O), nitrogen (N), and hydrogen (H), though some amino acids also contain other elements in their side chains. There are around 500 naturally occurring amino acids, but only 20 of these, known as proteinogenic amino acids, are found in proteins.

Mohanty *et al.* (2014) had reported on amino acid compositions of 27 food fishes out of which 4 food fishes, i.e., *Amblypharyngodon mola, Anabas testudineus, Puntius sophore* and *Heteropneustes fossilis* are small indigenous fish. They reported that lysine and glutamic acid is the most abundant amino acid in *Heteropneustes fossilis* in comparison to other SIS. They further reported that Histidine is present in significant proportions in the SIS *Puntius sophore* and *Amblypharyngdon mola.* According to their analysis, marine fishes have leusine, small indigenous fishes contain histidine, and carps and catfishes contain glutamic acid and glysine.

The amino acid composition of 10 SIS fishes (*A. mola, Macrognathus pancalus, Trichogatser fasciata, Xenentodon cancila, Channa punctatus, Barilius vagra, N. maydelli, Parambassis nama, C. gachua, Rasbora daniconius*) was recorded by Chakraborty in (2018). They showed that *Barilius vagra* had a fair amount of gl utamic acid. *T. fasciata* had the greatest concentration of the essential amino acid (EAA) hist idine (10%), while C. *nama* had the second-highest concentration (8.36%). Methionine, another EAA was highly quantified in C. *gachua* (9.42%), followed by *N. maydelli* (6.8%) and X. *cancila* (5.75%), in that order. Another NEAA (non-essential amino acid), threonine was present in high concentration in *C. gachua* (8.67%), *M. pancalus* (7.07%), *R. daniconius* (6.51%) and *X. cancila* (5.18%), respectively. According to data from Romharsha *et al.* (2014), S. *manipurensis* has the greatest quantity of glutamic acid (20.04%) compared to the other two investigated fish species, L. *pangusia* and N. *stracheyi*. Some researchers have estimated the amino acid composition of Systomus clavatus, Gagata dolichonema, Garra abhoyai and Opsarius barnoides (Ambily and Nandan, 2017; Singh, 2020). All the EAA—Histidine, Isoleucine, Lysine, Leucine, Methionine, Phenylalanine, Threonine, and Valine—are found in the highest concentration in *Systomus clavatus* (Table 3).

**Fatty acid composition of Small Indigenous Species of fish**

The ability of fatty acids to minimize a wide range of medical conditions, including cancer, cardiovascular disease, and many others, is broadly established. Additionally, it plays a significant role in many facets and newborn brain development. Due to their role in supplying high-energy molecules and the necessary nature of particular fatty acids, lipids are a vital part of a fish's diet. As a result of the presence of polyunsaturated fatty acids (PUFAs), fish oil is essential for maintaining human health.

There are primarily three groups of fatty acids, namely SFAs (saturated fatty acids), MUFA (monounsaturated fatty acids) and PUFA (poly-unsaturated fatty acids). SFAs and MUFAs can synthesized by the human body, but PUFAs cannot be produced by humans; as a result, it must be received from food. Fish oils are substantial sources of essential fatty acids including alpha - linolenic acid, eicosapentaenoic acid, and docosahexaenoic acid, which are the significant n-3 polyunsaturated fatty acids. These fatty acids may be found in fish eggs from small and big fish as well as oily fish. These omega -3 fatty acids are another name for these n-3 fatty acids.

Mohanty *et al.* (2019) reported that most of the fatty acids in the SIS viz, *Amblypharyngodon mola, Anabas testudineus, Puntius sophore* and *Heteropneustes fossilis,* were unsaturated fatty acids (UFA) like oleic acid and linolenic acid. They also reported a high ω-3 fatty acid content in *P, sophore* and a high ω-6 fatty acid content in *Amblypharyngodon mola*. The ω-3 / ω-6 ratio indicates the fat's quality since higher levels of -6 fatty acids enhance the pathogenesis of many diseases, including cancer, inflammatory diseases, and autoimmune diseases, whereas higher levels of -3 PUFA exert inhibitory effects (Simopoulos, 2002). Therefore, it is preferable to have more omega-3 fatty acids and a higher ratio of omega-3 to omega-6 (Mohanty *et al.*, 2019). A recent study has reported that seasonal variations can affect fatty acid composition and nutritional profiles of fish (Souza *et al*., 2020).

**Vitamin contribution of Small Indigenous Species of fish**

Vitamins are chemical compounds that organisms require in little amounts for normal metabolic processes. In all forms of life, these molecules have virtually identical tasks. Higher animals have lost their ability to synthesise them and must thus receive them through eating. Vitamins are categorized as either water-soluble or fat-soluble based on their solubility. Vitamin C and the vitamin B series are water-soluble vitamins. Vitamin deficiency is a serious public health issue in many underdeveloped countries, particularly in children and women of reproductive age (West, 2002). According to studies, children under five with a high vitamin A level had a lower death rate. Some regularly consumed small indigenous freshwater fish species have greater levels of preformed vitamin A in retinol and dehydroretinol isomers, with the relative quantities varying between species (Roos *et al.,* 2002). *Amblypharyngodon mola* is an SIS fish that is nutritional dense; it is high in vitamin A and also high in haemi, zinc, and, notably, calcium (Kongsbak *et al.,* 2008). Other small indigenous species with high vitamin A content include *Gudusia chapra, Botia dario, Chela cachius Osteobrama cotio cotio, P. ranga, Esomus danricus, Parambassis baculis, Channa punctatus, P. nama and Mystus vittatus* (Islam *et al*., 2023; Bogard *et al*., 2015). In order to determine the dietary contribution of calcium and vitamin A from fish in rural Bangladesh, Roos *et al.* (2003) conducted research. There were 44 fish species reported in the diet and 84% of the entire fish intake came under small indigenous fish.

**Table 2.** Gross chemical composition of important food fish species from India (in %) (Duarah and Das, 2019; Mohanty *et al*., 2022)

| Sl No | Species | Moisture (g/100 g) | Crude Protein (g/100 g) | Crude Fat (g/100 g) | Ash (g/100 g) | Reference |
|---|---|---|---|---|---|---|
| 1 | *Ailia coila* (Hamilton, 1822) | 82.8 ± 0.2 | 12.9 ± 0.5 | 1.8 ± 0.0 | 2.0 ± 0.0 | Mohanty *et al*., 2017 |
| 2 | *Amblypharyngodon mola* (Hamilton, 1822) | 76.2 ± 1.1 | 16.3 ± 0.8 | 4.3 ± 0.0 | 4.0 ± 0.9 | Mohanty *et al*., 2017 |
| 3 | *Anabas testudineus* (Bloch, 1792) | 68.0 ± 0.7 | 16.9 ± 0.5 | 6.9 ± 0.6 | 5.3 ± 0.2 | Mohanty *et al*., 2017 |
| 4 | *Gudusia chapra* (Hamilton, 1822) | 76.7 ± 0.3 | 14.1 ± 0.1 | 5.7 ± 0.0 | 2.9 ± 0.0 | Mohanty *et al*., 2017 |
| 5 | *Heteropneustes fossilis* (Bloch, 1794) | 76.7 ± 1.1 | 16.3 ± 0.4 | 2.7 ± 0.5 | 2.6 ± 0.1 | Mohanty *et al*., 2017 |
| 6 | *Puntius sophore* (Hamilton, 1822) | 75.7 ± 1.9 | 16.3 ± 0.9 | 4.9 ± 0.5 | 3.4 ± 0.1 | Mohanty *et al*., 2017 |
| 7 | *Xenentodon cancila* (Hamilton, 1822) | 78.2 ± 0.7 | 15.7 ± 0.3 | 0.7 ± 0.0 | 3.6 ± 0.1 | Mohanty *et al*., 2017 |
| 8 | *Nandas nandas* (Hamilton, 1822) | 75.75±0.78 | 16.09±2.66 | 7.34 ±0.49 | 5.19±.029 | Kamal *et al.*, 2007 |
| 9 | *Mystus vittatus* (Bloch, 1794) | 73.99±3.13 | 15.62± 0.32 | 7.53±1.10 | 6.50±0.63 | Kamal *et al*., 2007 |
| 10 | *Channa puncta-tus* (Bloch, 1793) | 70.55±1.89 | 19.13±2.40 | 4.55±1.18 | 6.81±0.94 | Kamal *et al.*, 2007 |
| 11 | *Notopterus notopterus* (Pallas, 1769) | 72.68±1.08 | 18.30± 0.79 | 4.98 ±1.71 | 5.82±0.82 | Kamal *et al.*, 2007 |
| 12 | *Parambassis nama* (Hamilton, 1822) | 74.19±0.27 | 13.23±0.23 | 2.87±0.09 | 2.58±0.01 | Jena *et al*., 2018 |
| 13 | *Parambassis ranga* (Hamilton, 1822) | 76.95±0.21 | 14.24±0.20 | 5.06±0.26 | 2.58±0.01 | Jena *et al*., 2018 |
| 14 | *Trichogaster fasciata* (Bloch & Schneider, 1801) | 73.18±0.17 | 13.86±0.09 | 4.79±0.18 | 3.14±0.04 | Jena *et al*., 2018 |
| 15 | *Botia dario* (Hamilton, 1822) | 72.92±0.71 | 14.59±0.26 | 6.15±0.17 | 3.13±0.03 | Jena *et al*., 2018 |
| 16 | *Esomus danrica* (Hamilton, 1822) | 75.58±0.19 | 12.89±0.14 | 3.83±0.19 | 2.43±0.10 | Jena *et al*., 2018 |
| 17 | *Lepidocephalichthys guntea* (Hamilton, 1822) | 72.80±0.27 | 14.10±0.14 | 5.81±0.10 | 3.29±0.18 | Jena *et al*., 2018 |
| 18 | *Macrognathus pancalus* (Hamilton, 1822) | 75.12±0.40 | 16.53±0.06 | 3.02±0.13 | 3.58±0.05 | Jena *et al*., 2018 |
| 19 | *Puntius chola* (Hamilton, 1822 | 65.88±3.00 | 18.26±2.50 | 1.53±0.25 | 3.92±0.54 | Mazumder *et al*., 2008 |
| 20 | *Pachypterus atherinoides* (Bloch, 1794) | 73.32±2.98 | 15.84±1.50 | 2.24±0.40 | 3.29±0.68 | Mazumder *et al*., 2008 |
| 21 | *Setipinna phasa* (Hamilton, 1822) | 69.31±0.54 | 15.65±0.78 | 13.23±0.25 | 3.46±0.06 | Sarma *et al*., 2019 |
| 23 | *Aspidoparia morar* (Hamilton, 1822) | 77.42±0.36 | 16.71±0.70 | 4.96 ± 0.39 | 2.36±0.15 | Sarma *et al*., 2019 |
| 23 | *Mystus tengara* (Hamilton, 1822) | 74.27±.07 | 16.96±.07 | 6.04±.06 | 2.67±.08 | Farid *et al*., 2015 |

Over 99% of the calcium and vitamin A intakes from all fish were contributed by SIS. They also stated the availability and accessibility of SIS for the population in rural Bangladesh should be prioritised because it is a crucial and perhaps irreplaceable dietary source of calcium and vitamin A. (Mohanty *et al.,* 2013).

The concentration of vitamin A in the mola's eyes was staggeringly high, at 62,200 RE/100 g (Roos *et al.,* 2002). More than 50% of the vitamin A in the mola's eyes made up 2% of its wet weight. The viscera and eyes contain 90% of the vitamin A in mola. They also reported that Less than 2% of mola's total vitamin A content per 100 g of raw fish was present in *Labeo rohita*. Additionally, compared to bodily tissue and viscera, the eyes of *L. rohita* contain the highest concentration of vitamin A; however, this concentration is less than 2% of that of *mola.* This study explored the nutritional value of small indigenous species of fish that are found in Northeast India. Food fish have predominantly fulfilled the nutritional needs of human beings. Due to the declining fish population and rising demand for fish as food, production in the area requires additional study on the growth of technology for enhancing water quality, preventing sickness and producing wholesome stock. Campaigns to raise awareness of the SIS of fishes' abundance in fish protein, vital minerals, and n-3 polyunsaturated fatty acids like docosahexaenoic acid and eicosapentaenoic acid are being widely conducted. Additionally required for increasing the usefulness of fish are vitamins and amino acids, both in clinical and community nutrition. The conservation and sustainable use of the SIS of fish resources required environmental initiatives.

**Therapeutic potential of SIS fishes**

Omega-3 fatty acids are essential for proper growth and development as well as cognitive function. They minimize the chance of developing heart disease. Omega-3 fatty acids are also said to decrease inflammation and may minimise the chance of developing chronic illnesses, including cancer, arthritis, and heart disease. Omega-3 fatty acids are important for cognitive (brain memory and performance) and behavioral function because they are heavily concentrated in the brain. In fact, babies who do not receive adequate amounts of omega-3 fatty acids from their mothers throughout pregnancy continue to risk developing visual and nervous system issues. Fatigue, poor memory, dry skin, heart issues, mood swings or sadness, and poor circulation are all omega-3 fatty acid insufficiency symptoms. The human body cannot generate these nutritionally essential n-3 fatty acids from scratch. Still, it can convert the eighteen-carbon n-3 fatty acid alpha-linolenic acid into 20-carbon unsaturated n-3 fatty acids (EPA) and 22-carbon unsaturated n-3 fatty acids (DHA). DHA and EPA compete for the enzyme cyclooxygenase with arachidonic acid. Platelet cyclooxygenase converts EPA to thromboxane A3, a relatively mild vasoconstrictor, as opposed to thromboxane A2, which is generated by the action of cyclo-oxygenase on arachidonic acid and is a significant vasoconstrictor (Choo *et al*., 2018). However, prostacyclin I3, generated from eicosapentaenoic acid (EPA) in the endothelium, is just as effective as prostacyclin I2, produced from arachidonic acid. As a result, an elevated dietary eicosapentaenoic acid: arachidonic acid ratio results in relative vasodilation and platelet aggregation inhibition (Singleton *et al.,* 2000). *Channa punctatus* is a species of air-breathing fish native to different Asian nations. This species is popularly thought to have healing properties for wounds, postpartum depression, and various skin ailments. It has excellent amino acid and fatty acid contents, which are thought to be active components in the induction of wound healing (Zuraini *et al.,* 2006). *Channa* spp. has a unique fatty acid composition in that it has extremely low quantities of eicosapentaenoic acid and relatively high levels of arachidonic acid, a precursor of prostaglandin. (Jais *et al.,* 1994). *Monopterus cuchia* is a freshwater eel mostly found in Northeast India and Bangladesh. In recent years, there has grown in market demand and consumption of *Monopterus cuchia.* It is also thought to be an important part of the diet of anaemic and feeble persons. Traditional healers think consuming this species raises blood haemoglobin content and improves physical strength in sick people. Fish is excellent in nutritional content and has been believed to be a significant element in traditional therapies. (Neog and Konwor, 2023). Enhancement of the nutritional value of fish is now possible using an artificial intelligence approach (Sadhu *et al*., 2021).

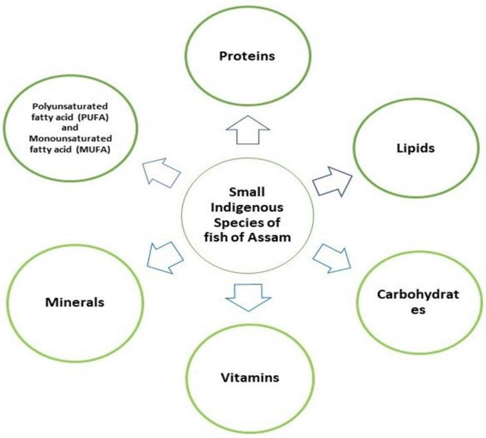


**Fig. 2.** *Nutrients in SIS fish of Northeast India (Adopted from Acharya et al., 2018 with modifications)*

**Conclusion**

Despite some variances in nutrient levels, SIS in Northeast India are nutrient-rich and can provide excellent

**Table 3**. Amino acid composition of SIS fishes from North east India

| Amino acids (g/100g) | *Amblypharyngodon mola* | *Macrognathus pancalus* | *Trichogatser fasciata* | *Xenentodon cancila* | *Channa punctatus* | *Barilius vagra* | *N. maydelli* | *Parambassis nama* | *Channa gachua* | *Rasbora daniconius* |
|---|---|---|---|---|---|---|---|---|---|---|
| L-Ala | 0.37 | 0.09 | 1.43 | 0.30 | 0.26 | 1.13 | 1.34 | | 0.14 | 0.88 |
| L-Arg | ND | 1.33 | 0.21 | ND | 0.72 | 0.39 | 3.76 | 0.16 | ND | 0.23 |
| L-Asn | 0.89 | 1.59 | 1.46 | 1.08 | 0.78 | 0.74 | 0.10 | 1.06 | 0.96 | 0.59 |
| L-Asp | ND | ND | 0.74 | 1.01 | ND | 1.56 | 2.11 | 0.08 | 1.05 | 0.96 |
| L-Glu | 0.43 | 1.19 | ND | 0.27 | 0.31 | 0.06 | ND | ND | 0.29 | 0.24 |
| L-Cys | 1.66 | 0.16 | 0.39 | 0.73 | 0.31 | 5.25 | 0.18 | 0.28 | 0.67 | ND |
| L-Gln | ND | ND | ND | 0.06 | ND | 0.45 | 0.77 | ND | 0.12 | 0.06 |
| L-Gly | 0.43 | ND | ND | 0.42 | 0.14 | 0.23 | 0.07 | ND | 0.36 | 0.28 |
| L-Pro | 1.66 | 0.11 | 0.24 | ND | 0.12 | ND | ND | 0.20 | ND | ND |
| L-Ser | ND | 0.41 | 0.11 | 0.58 | 0.47 | ND | ND | 0.65 | 0.54 | 0.35 |
| L-Tyr | ND | 0.75 | 0.47 | 0.33 | ND | 0.28 | ND | 0.33 | 0.62 | 0.86 |
| L-His | 0.16 | ND | 10.0 | 0.08 | 0.18 | 0.15 | 0.23 | 8.36 | 0.08 | 0.09 |
| L-Ile | ND | 0.19 | 0.51 | ND | 0.24 | 0.40 | 0.13 | 0.47 | ND | ND |
| L-Leu | ND | 0.73 | 0.45 | 0.75 | 2.68 | 0.99 | 0.57 | 0.29 | 0.72 | 0.54 |
| L-Met | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| L-Lys | 0.29 | 1.03 | 1.49 | 5.75 | 9.42 | 4.90 | 6.80 | 1.15 | 4.59 | 2.71 |
| L-Phe | ND | 0.46 | 0.15 | 0.60 | 0.30 | 0.10 | ND | 0.10 | 0.37 | 0.49 |
| L-thr | 0.17 | 7.07 | ND | 5.18 | 3.27 | ND | ND | ND | 8.67 | 6.51 |
| L-Trp | 0.07 | ND | 0.48 | 0.37 | 0.06 | ND | 0.63 | 0.37 | 0.20 | 0.21 |
| L-Val | 0.31 | 1.03 | 0.58 | ND | 0.23 | 0.56 | 0.70 | 0.39 | 0.27 | 0.21 |

Adopted from Chakraborty (2018), with modifications. ND= Not Detected nutritional security. Small Indigenous fish species are the main food item among the rural population of the Northeast and have long been known to have medicinal uses for treating a variety of illnesses. SIS fish give the rural fishermen in those areas access to food, nourishment, and extra revenue. For the poor in rural areas, they provide a source of vitamins, proteins, calcium, and iron. Because even the poor can afford the purchase of little fish, they are the main source of necessary animal protein in rural and urban environments. The Northeast region of India is shown to have the highest SIS fish diversity. The SIS fish species more diverse in NE India are *Anabas testudineus, Amblypharyngodon mola, Gudusia chapra, Puntius sophore, P. chola, P. conchonius, Systomus sarana, Pethia ticto, Xenentodon cancila, Barilius barila, B. barna, Rasbora daniconius, Esomus danricus, Lepidocephalicthys guntea, Mystus bleekeri, M. cavasius, M. tengara, M. vittatus, Macrognathus aral, M. pancalus, Parambassis nama*, *Nandus nandus*. The threatened species of SIS fish are *B. dimorphicus, P. jayarami, Physoschistura elongata, Schistura beavani, S. cincticauda, S. devdevi, S. nagaensis, S. reticulata, S. sikmaiensis, S. vinciguerrae* and *Lepidocephalichthys berdmorei. Ompok bimaculatus, O. pabo,* and *Channa bleheri*.Various biochemical and nutritional studies on these freshwater fish species reveal that they contain four basic components—water, protein, fat, and ash in varying proportions, as well as other powerful elements such as vitamins and minerals, which are also abundant. Therefore, it is suggested that small indigenous fish species might be a good alternative for most of Northeast India's poor people to meet their daily nutritional needs.

### Conflict of interest

The authors declare that they have no conflict of interest.

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This investigation was conducted as part of an Institute's internal initiative. The authors affirm that there were no financial or commercial ties that might be viewed as having a potential conflict of interest.

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