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Reviewing Nutritional Quality of Small Freshwater Fish Species

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Abstract Small freshwater fish species (SIFFs) constitute one of the major sources of nutritious food for human being as they provide balanced nutrition; subsistence and supplementary income to the rural population in India. The nutritive values of them depend upon their biochemical composition, such as protein, amino acids, lipid, fatty acids, carbohydrate, vitamins and minerals. This review addresses motivating interest in this attractive group of SIFFs by summarizing what little we do know about them comparing with other freshwater fish species found in India as well as different parts of the world. It is observed that SIFFs with a high content of MUFA (mono unsaturated fatty acid), PUFA (poly unsaturated fatty acid) as well as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid); which makes them curative diet also. Until recently, possibilities of culturing them in combination with the IMC (Indian major carp) are unexplored. This study also exposed that the small and shallow water bodies may open-handedly be used for SIFFs culture and indicates the feasibility of attaining a good production of the same along with IMCs. Conservation strategy should be undertaken and taking SIFFs in every day diet may result in better and advanced protection against coronary heart disease (CHD) and other lifestyle related disease. Exploration of the nutritional eminence of them will encourage fish farmers to promote mixed culture of SIFFs in India in proper scientific way.

Keywords: *SIFFs, nutrition, fatty acids, fish culture, disease, conservation*

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1. Introduction

Freshwater fish is an excellent and cheaper resource of animal protein with high biological value for a large section of the inhabitants in India [1]. In general, fish constitutes almost one-half of the total number of recognized vertebrate species [2]. Normally, worldwide freshwater fish production is mainly dependent on carps. Hence, India is regarded as a 'carp country' due to its prosperous diversity of carps in its freshwater ecosystem as it is blessed with at least 15-20 varieties of minor and medium carps that have a high potential for freshwater aquaculture, which has yet to be exploited [3]. With declining fisheries worldwide [4], still now aquaculture produces an escalating proportion of fish/seafood in the human food basket amounting to around 50% in 2008 to till recent year [5]. India, one of the 17 global mega biodiversity hotspots, is inhabitant to 2246 fin fish species out of which 838 are from fresh water [6]. Among them, total 450 fish species could be categorized as small indigenous freshwater fish species (SIFFs) out of 765 native freshwater species, and 239 of them are from West Bengal. In West Bengal the total production of inland fish was 15.30 lakh ton and marine fish was 2 lakh ton [7]. Regarding inland fish production, India ranks second, next to China [8]. Knowledge of these indigenous fish species and communities reveal crucial facts indispensable for the arrangement of ecosystem and habitats as well as to the preservation of important genomes and genes [9].

2. Prospective Cultivable Indigenous Small Fishes

It has been detailed that some species such as mola (*Amblypharyngdon mola*), dhela (*O. cotio cotio*), darkina (*E. danricus*) and kaski (*C. soborna*) traditionally occupy an unenviable position and an inseparable link in the life, livelihood, health and the general well being of the rural mass, especially the poor [7]. Two species from the genus *Esomus*(*E. danricus* and *E. longimanus*), *A. mola*, *A. microlepis*, *Notopterus notopterus*, *Puntius sarana*, *P.ticto*, *P. chola*, *P. sarana*, *Labeo bata*, *Cirrhinus reba*, *Salmo stomabacaila*, *Nandus nandus*, *Anabas testudineus*, *Glossogobius giuris*, *Danio devario*, and *Chanda nama*, etc. can be introduce as a candidate species in freshwater aquaculture system [10]. Other potential species for aquaculture diversification includes *Labeo gonius*, *L. bata*, *L. boggut*, *L. dussumeri*, *L. fimbriatus*, *Barbo descarnaticus*, *P. pulchellus*, *P. kolus*, *P. Sarana* and *Cirrhinus cirrhosa*. Some of these species are being cultured at minimum scale, mostly based on wild seed collection [11].

3. Nutritional Value of SIFFs

So far, in India, available documents show that lipids of fresh water fishes are analyzed mostly on major carps or large commercial fishes [12,13,14]. Additional data on lipid and fatty acid composition of tropical freshwater fishes have recently become accessible for evaluation [15,16,17]. However SIFFs are remaining unnoticed still today so the status of fresh water minor carps in India is at stake as if they have no commercial/nutritional value except some works had been done by Roos *et al.*, [18,19,20,21]; Mazumder *et al.*, [22]; Mohanty *et al.*, [23]; Mahanty *et al.*, [24]; Dey *et al*., [25,26] etc. In India, major effort need to aware about the role of SIFFS in poverty alleviation, food security and conservation of biodiversity. If the commercial value of SIFFs is properly acknowledged, then it would be helpful to design the conservation strategy of those fish species. Thus in order to meet the demand of the society there is the need to investigate the spatial distribution of lipids and fatty acids of these species [27].

Expanding earnings and high consumer inclination for fish, especially in Asia, have caused global fish consumption to double in the past 30 years to 15 kilograms per person per year, according to the Food and Agriculture Organization of the United Nations (FAO). This development is mainly attributable to demand from growing urban populations in China and other Asian countries [28]. Rural populations living in riparian and coastal areas are some of the poorest countries in the world. These communities not only consume fish, but also depend on it for their income and livelihoods. Fish caught by household members or bought in local markets are eaten daily by all members of all households, especially in the fish production season. Small fish species are particularly important for these groups. Studies in rural Bangladesh and Cambodia show that small fishes support between 50 and 80 percent of all fish eaten during the production season [29]. High content of PUFA (poly-unsaturated fatty acid), especially the ω-3 [mainly DHA (Docosahexaenoic acid) and EPA (Eicosapentaenoic acid)] in SIFFs- have a range of health benefits on cardiac diseases by: a) increasing HDL2 (High density lipid-2)-cholesterol concentrations (b) reducing TAG (Triacylglycerol) rich lipoprotein concentrations(c) decreased apoprotein B synthesis (d) depression of LDL (Low density lipid) synthesis (e) reduction of postprandial lipemia [30]. Substantial evidence from epidemiological and clinical trial studies indicates the low incidence of breast cancer observed in Greenland Inuits even though eating a relatively high-fat diet, and also in Japanese women on their traditional diet, which contains fats-rich in ω-3PUFAs [31,32]. The ratios of ω 6/ω3 found in these SIFFs are lower than the value (4.0 at maximum) recommended by UK Department of Health [33]. Furthermore, elevated DHA concentration in SIFFs may help to fulfill the optimal pregnancy length because EPA and DHA decrease prostaglandin E_2 and prostaglandin $F_{2\alpha}$ production, therefore reducing inflammation within the uterus, which could be associated with preterm labor [34]. Interest grew even more when it was documented that, the high calcium content and vitamin A bioavailable in these SIFFs as found in milk, commonly regarded as the best source of calcium [35,36]. That is why they are crucial for development of the fetal brain [34] and the eye retina [35]. In addition, Large fish do not contribute to calcium intake because their bones are discarded as plate waste and not eaten but SIFFs are eaten whole with bone, head and eye thereby providing a rich source of calcium and other micronutrients [24].Hence it can be concluded, that these SIFFs are crucial for the mental health, including prevention of schizophrenia and bipolar disorders [37]. Several report have shown that cardiovascular diseases, inflammatory bowel disease (IBD), cancer, rheumatoid arthritis and autoimmune disorders may be reduced by increasing the ratio of ω-3 to ω-6 fatty acids in the diet, and consequently favor the production of EPA and DHA through consumption [38]. A very low ω3/ω6 in IMC may increase the thrombogenicity through increased production of ARA and thromboxanes [39]. Additionally, in the SIFFs beneficial content of EPA and DHA, make them a prophylactic diet in prevention of allergy by to increased secretion of adiponectin, an anti-inflammatory adipokine [40]. Large commercial fishes with high ω-6 PUFA diets may have link between atherosclerosis, gynecological tumors of the ovary or endometrium; carcinogenesis and non-insulin dependent diabetes mellitus (NIDDM) and obesity-all are associated with hyperinsulinaemia and insulin resistance, and grouped together as the insulin resistance syndrome or syndrome X [39,41]. In this point, SIFFs can be preferred more by the nutritionists as a balanced diet because of plenty ω-3 PUFA than ω-6 [42]. The category of PUFA is beneficial on the lipid and immune abnormalities secondary to chronic renal failure (CRF) and may have a useful effect on progression of proteinuria [41]. The ratio among SFA: MUFA: PUFA shows that these small fishes can serve as excellent local sources of PUFA as it plays an important role in slowing down the occurrence of breast cancer by decreasing blood pressure, regulate IL-12 production, inhibits the production of ROS and plasma rigidity [42]. In agreement with Lie [43], MUFA rich SIFFs are has advantageous role in lowering of insulin resistance and diabetes. So a matching of SIFFs in the diet would be more efficient in avoiding CAD (coronary artery disease) amongst Indians who have a high occurrence of this metabolic syndrome and diabetes [24] .According to Bogard *et al.* [44], high EPA+DHA ethyl esters as found in these fishes raises the "EPA+DHA level" to approximately greater than 6% that is associated with a marked protection from sudden cardiac death, so they can be recognized as curative diet for decreasing pro-inflammatory eicasanoids and cytokines [45]. According to Khan *et al.*, [46] SIFFs can be recommend as an element for maintaining proper homeostasis inside the body as PUFA content of SIFFS is less than 10% which assists to lower serum LDL cholesterol. Recent studies have also shown that EPA and DHA can reverse cystic fibrosis related fatty acid abnormalities (36).On the other hand, DHA can be used for therapy of children who experience asthma, attention deficit hyperactivity disorder (ADHD), dyspraxia (motor skills disorder), dyslexia, aggression, autism, depression [47] and in geriatric nutrition for dementia, age-related macular degeneration (AMD), alzheimer's disease (AD), obsessive compulsive disorder (OCD) [48].

In this article, total lipid (TL) content of some edible freshwater fishes is considered (Table 1) and it is found

that the content of TL is very low in SIFFs relatively to other freshwater fishes, which can be make them an ultimate supplement for low fat to the patients suffering from the complications of digestive system and also obesity. Table 2 portrays major lipid classes and ω-3 and ω-6 fatty acids composition in diverse freshwater species distributed worldwide to make a clear idea that how far SIFFs are nutritionally attractive in consideration with different parameter in the previous studies. After Roos *et al*. [20,21] and Mahanty *et al.*, [24] a comparative analysis also have been done of the micro-nutrient contents of selected SIFFs with other major cultured fish species in India (Table 3). Comparison of the distribution of EPA+DHA content in the Indian small indigenous fish species with some other Indian food fishes are depicted in Figure 1 respectively.

Table 1. Comparison of Total lipid fraction in the different freshwater fish species from various parts of the India

	Species name	TL%	References
Five Indian freshwater carps	*Labeo rohita*	1.05	13
	Labeo bata	2.55	
	Labeo calbasu	1.11	
	Catla catla	0.6 0	
	Cirrhinus mrigala	1.15	
Indian freshwater fish species	*Catla ctla*	1.2	14
	Oreochromis mossambicus	0.8	
	Labeo rohita	2.9	
	Cirrhinus mrigala	1.8	
	Cyprinus carpio	3.8	
Some selected Indian Fishes	*Catla catla*	1.2	16
	Labeo rohita	2.9	
	Clarius batrachus	7.9	
	Pangasianodon hypophthalamus	4.98	
Two Selected SIFFs	*Amblypharyngodon mola.*	0.6	25,26
	Puntius sophore	0.58	

Table 2. Comparison of major fatty acid classes in the different freshwater fish species from various part of the world

	Species name	SFA	MUFA	PUFA	ω3	ω6	ω3/ω6	EPA +DHA	References
Five indian freshwater carps	*Labeo rohita*	42.5	34.1	16.8	10.5	10.1	1.03	3. 0	13
	Labeo bata	42.2	26. 0	26.8	16. 0	8.7	1.83	7.1	
	Labeo calbasu	45.5	23.8	14.4	5.2	9.5	0 .547	2.01	
	Catla catla	37.5	25.5	18.9	9.7	0 .9	1.077	4.9	
	Cirrhinus mrigala	41. 0	31.4	19.9	10.9	9.4	1.15	3.6	
Tropical freshwater fish from Nigeria	*Clarias anguillariass*	73.51	26.48	--	--	--	--	--	97
	Lates niloticus	20.63	14.46	64.91	12.62	16.61	0.76	_	
	Mormyrops anguilloides	33	16.34	50.66	8.83	25.82	0.34	_	
	Mormyrus ruma	11.77	88.23	-	-	-	-	-	
	Hydrocynus forskali	10.43	ND	89.57	-	-	-	-	
	Heterobranchus bidorsalis	50.28	22.58	27.14	10.48	-	10.48	-	
	Hyperopisus bebe	8.79	89.9	1.31	0.98	-	0.98	-	
	Clarias gariepinus	40.49	46.91	12.6	2.22	8.4	0.26	-	
	Clarihetero branchus	50.41	9.63	39.96	-	8.02	0	-	
	Sarotherodon galilaeus	59.21	22.42	18.37	8.64	7.61	1.14	3.98	
	Oreochromis niloticus	64.04	21.76	14.2	8.16	4.53	1.8	3.02	
Indian freshwater fish species	*Catla ctla*	38.5	22.9	23.5	-	-	4.5	11.6	14
	Oreochromis mossambicus	35	20	35.5	-	-	6.4	12.1	
	Labeo rohita	34.6	33.6	25.1	-	-	0.8	7	
	Cirrhinus mrigala	39.4	34.7	12.1	-	-	4	5.2	
	Cyprinus carpio	23.2	18.6	38.2	-	-	2.9	12.7	
Some selected Indian Fishes	*Catla catla*	60.92	15.26	12.5	-	--	6.544	7.3	16
	Labeo rohita	52.28	29.55	15.84	-	-	1.046	5.03	
	Clarius batrachus	39.85	31.75	25.56	-	-	0.706	5.86	
	Pangasianodon hypophthalamus	47.15	33.47	23.37	-	-	0.74	6.41	
Selected freshwater Malaysian fishes	*Channa striatus*	34.11	16.2	-	8.32	8.71	-	0.74	98
	Pangasius hypothalamus	32.9	41.68	-	8.45	11.54	-	1.55	
	Clarias macrocephalus	26.24	15.51	-	5.57	9.53	-	1.23	
Freshwater fish from Pakistan	*Labeo calbasu*	30.67	41.68	27.65	10.52	17.13	-		99
Two selected SIFFs From India	*Amblypharyngodon mola*	53.0	25.5	17.67	16.3	20.7	11.89	13.2	25,26
	Puntius sophore	51.52	20.2	22.9	1.37	2.2	9.40	16.5	

Table 3. Comparative analysis of micro-nutrient contents of small Indigenous with cultured fish species (After Roos *et al.* [20,21], Mahanty *et al.* [24])

TYPE OF FISH	Vitamin A (RAE/100 g raw, cleaned parts) (RAE, retinol activity equivalent)	Calcium (mg/100 g raw, cleaned parts)	Iron (mg/100 g raw, cleaned parts)	Fat (g/100g raw, cleaned parts)	Zn (mg) mineral content per 100 g raw, cleaned parts—mean value
Small indigenous fish species					
1.Mola (*Amblypharyngodon mola*)	2680	776	5.7	4.4	5.7
2.Puti (*Puntius sophore*)	60	784	3.0	7.1	3.0
Cultured fish species					
1.Mrigal (*Cirrhinus cirrhosus*)	< 30	< 10	2.5	2.9	2.5
2.Rui (*Labeo rohita*)	< 30	86	NA	NA	NA
3.Silver carp (*Hypophthamichthys molitrix*)	< 30	36	4.4	2.7	4.4
4.Tilapia (*Oreochromis niloticus*)	< 30	NA	5.0	NA	NA

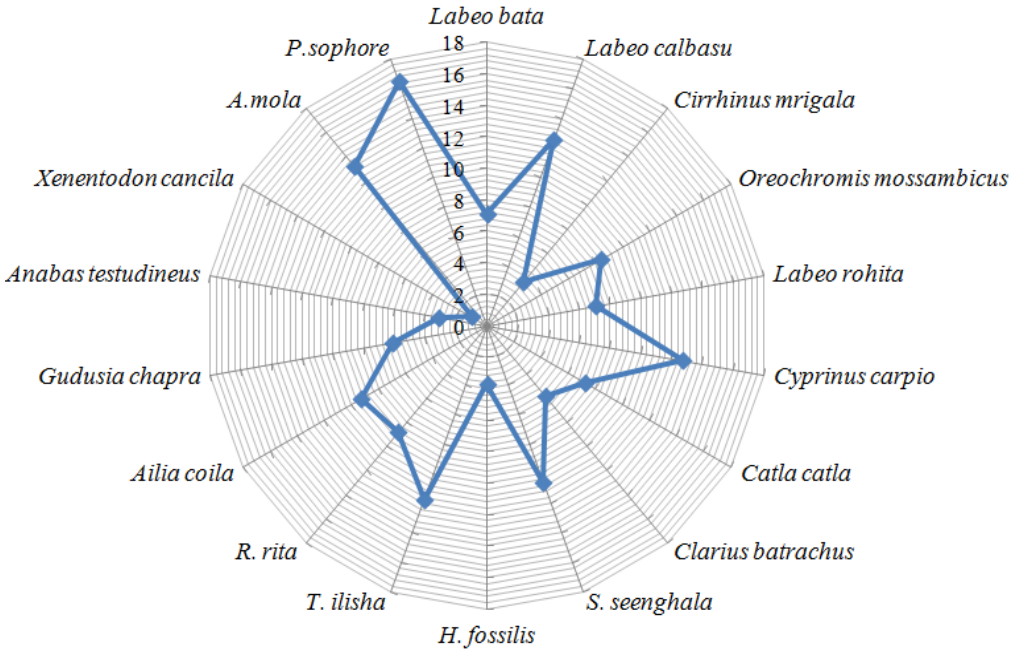

Figure 1. Comparison of the occurrence of EPA+DHA content in the body flesh samples of some small indigenous fish species in India with other Indian food fishes (Refs. [13,14,25,26,69,78,97])

Cook and McMaster [49] stated that the lipids apart from being a source of energy act as a transport for the lipid soluble vitamins like vit–A and vit–D. In India, blindness in children is the most common symptom. In the above mentioned study from Bangladesh, small fish contributed 40 percent and 31 percent of the total recommended intakes of vitamin A and calcium, respectively, at household level; in the peak fish production season. SIFFs have high content of vitamin A(2680 retinol equivalent(RE)/1000g raw edible parts commonly cultured carp species have low content <100µgRE/100g raw edible parts [29] . Changes in the organization of lipids can have strong effects on cellular function, such as signal transduction and membrane trafficking [50]. Jacobson *et al*. [51] consider that these membrane effects can cause disease in humans as a result of genetic alterations or such environmental effects like diet or both. The essential fatty acid (EFA) like linoleic (18:2ω-6) and α- linolenic acid (ALA) (18:3ω-6) is required for the body for healthy development and is termed essential because without them the animals will die [52]. Dietary DHA is known to modulate a number of neurotransmitter systems including the cholinergic system which is known to play a key role in memory and learning [53]; up regulating effect on myelination and synaptogenesis [54]. Cao *et al*. [55] also demonstrated a role for cholinergic neurotransmission in the regulation of the neurovascular coupling of brain activity and local cerebral blood flow in aged monkeys and subsequently demonstrated that the age-impaired regional cerebral blood flow (rCBF) response to tactile stimulation is positively modulated following four weeks dietary supplementation with 150 mg/kg/day DHA. The non-conjugated PUFA are converted by enzymatic per-oxidation into oxygenated fatty acid (eicasanoids), which have a variety of physiological effects at minute concentrations [56].

For maintaining normal vascular functions, proper balance between the biosynthesis of eicasanoids from the ω-3 and ω-6 PUFA families in the body, is important [57]. SIFF Oil Supplementation (FOS) potentiates muscle protein synthesis (MPS) in response to a

hyper-aminoacidemic–hyper-insulinemic infusion [58]. Previous data suggest that fish oil had a beneficial effect for LDL/HDL cholesterol ratio [59]. Plasma TAG seems to be a major determinant of the LDL (low density lipid) and HDL (high density lipid) subclass [60].LDLs are mostly derived from VLDL by a series of degradative steps that remove TAG [61,62]. HDL_2 and HDL_3 are two subclasses of which, the former has a stronger inverse relationship with cardiovascular diseases [63,64]. Dietary DHA has the largest and most consistent effect in down-regulating the hepatic expression of fatty acyl desaturase (FADS) 2a (Δ6), FADS2b (Δ5), elongation of very long-chain fatty acid (ELOVL) 5 and ELOVL 2 [65,66]. SIFFs like *P. sophore*, *Amblypharyngodon mola*, *Parambassis ranga* and *Esomus danricus* have significantly higher level of zinc, calcium and potassium content in comparison to Indian major carps (IMCs) like *L. Rohita*, *C. catla*, and C. *mrigala* [67].

4. Importance of SIFFS in Aquaculture

Studies in India have shown that the profit accruing to fishers is actually higher in the case of SIFFS when compared to those from large cultured species.Current epidemiological and clinical evidence show that there is successful link between human nutrition to fisheries to address public health problems by documenting and disseminating data on the importance of SIFFs as a commonly consumed, nutrient-dense food in the everyday diet of the poor rural Indian population.So consumption of SIFFs is better recommended to boost health since other animal foodstuffs such as pork, lamb and beef provide little-to-no contribution as they have high AI(atherogenicity index) and TI(thrombogenicity index) values [17]. Asia accounts for 90 percent of the world's aquaculture, most of which targets the fast-growing demand of urban populations at various parts of the South and South-east Asia. For small-scale farmers, however, semi-intensive pond aquaculture is one of many farming activities, contributing only a 10 percent increase in annual household income. [23,29,68]. These fishes easily breed in local ponds and partial harvesting can be done frequently in small amounts for favored home consumption. Among traditional communities, indigenous knowledge about the health benefits of such species exists, for example, Mola(*Amblypharyngodon mola)*, commonly found in Eastern and Northeast India, is often included in the diet of pregnant and lactating mothers, for its nutritive value [69]. These SIFFs has prospective to combat micronutrient deficiencies as because these small fishes are eaten as a whole with head, bones, viscera; rich in essential micronutrients (vitamins and minerals); e.g. vitamin A, iron, zinc, and calcium with high bioavailability [70]. For this reason, SIFF powder can be used as an excellent source of essential nutrients in feeding programmes for pregnant and lactating women, young children, school children, the sick and elderly [71]. Alternatively, Freshwater capture fisheries in India are under great pressure due to human population growth, reduced access to common water resources, environmental changes related to rice production, embankment construction for flood control, the filling up of open water areas, and also the use of irrigation, pesticides, and fertilizers [72]. Agricultural systems silently eradicate small fish species from the diet or replace small fish with large fish, such as silver carp (*Hypophthamichthys molitrix*), in which the edible parts are mainly the muscles [73].

4.1. Fish-related Health Risks

In Southeast Asia, small freshwater fish due to its high food and nutritional value can be recommended as potent species which is being tried for domestication and aquaculture. The health benefits of habitual consumption of fatty fish are threatened by environmental contaminants and fishborne zoonotic parasites and have a detrimental effect on the micronutrient intakes of the rural poor [72]. The accumulation of mercury in fatty fish muscle, like Tuna, is a potential global health risk, as canned tuna is widely exported and consumed. Some developed countries have issued guidelines for restricted intake of fatty fish by pregnant women and children, to avoid toxic exposure to mercury [75]. Accumulation of arsenic, lead, chromium and cadmium in fish stocks in septic environments may also pose a health hazard which is easily accessible in fatty fishes. Also, accumulation of polychlorinated biphenyls (PCBs), caused by industrial pollution, in fish from coastal and inland waters is identified as a health risk factor [20,21]. Consumption of raw or inadequately cooked fish infected with fishborne zoonotic parasites also poses threats to health. Inadequate cooking of fish in poor households is primarily due to fuel shortages. In Southeast Asia, diseases such as bile duct cancer, gallstones, diarrhea, and peptic ulcers caused by these parasites are emerging as public health issues [76]. Fish borne zoonotic parasites affect more than 60 percent of the workforce in Northeast Thailand and 15 to 20 percent of the population in certain areas in Vietnam. Moreover, population pressure, water pollution, and dams create favorable environments for the snails and fish that transmit parasites. At a same time, consumption of raw or inadequately cooked fish due to fuel shortages in meager households infected with fishborne zoonotic parasites also poses threats to health [77]. In many developing countries, high prevalence and vulnerability to HIV/AIDS in fisherfolk have been reported by the FAO. Because of the poverty, insecurity, malnutrition and marginalization of fishing communities, they are neglected in terms of basic services like education and health care, and thus HIV/AIDS prevention, care, and mitigation efforts do not reach them. Moreover, micronutrient deficiency as well as protein calorie malnutrition has become a major cause of concern in these groups. The utilization of fat has been found to be lower in developing countries, that is, 49 g/person/day in comparison to 128 g/person/day in the developed countries [78]. In this scenario, SIFFs can be serving as natural remedy to them. Low fat intake and associated chronic energy deficiency have been the major nutritional problem of developing countries [79]. After the trigger of Blue revolution (1970), the production of freshwater SIFFs is stagnating for years due to the overlooked attitude towards minor carps, lack of interest about species diversification, poor strategies of replenishment and stock enhancement [80]. These consequences became more devastating for the health and livelihoods of fishing communities, as well as of other

groups in the fisheries sector, as they are dependent vastly on these SIFFs vastly [9]. Additionally In terms of resilience, 62 percent of SIFFS are highly resilient (in which the population doubling time is two years or less), while 38 percent have medium resilience (with a population doubling time of over five years), making it important to consider conservation measures for these species [79].

5. Conservation, Management and Aquaculture Opportunity for SIFFs

There is no comprehensive policy or legislation for the conservation and management of SIFFs. However, there are elements in existing policies that are relevant to SIFFs and fisheries and to the dependent socio-economic systems [81]. In 1987, the Bangladesh Fisheries Research Institute (BFRI) initiated programs to develop breeding and culture techniques for some small indigenous fish species but without focus on the commonly consumed and nutrient-dense species [29]. The Indian Fisheries Act of 1897 prohibits destructive fishing practices like poisoning and dynamite fishing. The provision to prohibit the use of certain fishing gears indirectly helps in the conservation of SIFFs. Under the United Province Fisheries Act of 1948, no polluted water was to be released into water bodies. The West Bengal Inland Fisheries Act makes a reference to "proper management" of inland fisheries [3]. In West Bengal, there are more than 150 floodplain wetlands, locally called beels. These wetlands, spread over an estimated area of 42,000 ha, harbor a large number of small native fish species [82]. In recent years, under fisheries enhancement programme, culture based fisheries has been intensified in most of these beels and are regularly being stocked with Indian major carps. In this process, small native fish species are being removed as 'Eradication of unwanted fishes' [83]. As a result, a drastic shift in the species composition and diversity in favor of major carps, at the cost of some of the prized native fish species has been noticed in these wetlands. Although most of these small species are considered as low value and referred as 'weed fishes', have high nutritional value [84]. NBFGR (National Bureau of Fish Genetic Resources) has prioritized a list of 100 SIFFs that are important for their food value and that need to be conserved [85]. Out of 104 important SIFFs also documented by NBFGR, Lucknow, 6 species have been listed under endangered and 16 species under vulnerable category [86]. Recent few initiatives such as the CGIAR (Consultative Group on International Agricultural Research) Research Programmes; USAID(United States Agency for International Development) funded Feed the Future; Scaling Up Nutrition (SUN) Framework and Roadmap provides new possibilities to focus on management and culture of SIFFs for linking between agriculture, human nutrition and health. At present in Cambodia and Kenya the WINFOOD project (For alleviating childhood malnutrition by improved utilization of traditional foods) being conducted, complementary foods for new-born and young children with powdered, nutrient-rich small fish species have been developed, and effectiveness studies are being carried out [71]. Innovative approaches to fish conservation programme has been done on polyculture of IMCs, catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) and some exotic species such as silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*) and Thai Silver Barb (*Barbodes gonionotus*) with mola (*Amblypharyngodon mola*), punti (*Puntius sophore*) and chela (*Chela cachius*) to evaluate the production potential under low cost management system [87,88,89]. Hossain *et al.* [90] recorded an average production from polyculture of carps with chapila (*Gudusia chapra*) as 890 kg/ha while, Kohinoor *et al.* [91] got a production of 1,126 kg/ha/4 months from polyculture of carps with mola where the contribution of mola was 58.67kg only. Akhteruzzaman *et al.* [92] obtained a production of 3,728.40 kg/ha/8 months from the polyculture of mola, *L. bata* and bhangna (*C. reba*). The highest production (2103 kg) was obtained when cultured with punti [93]. The Indian Fisheries Act of 1897 prohibits destructive fishing practices like poisoning and dynamite fishing. The State of Madhya Pradesh has extended the lease period to 10 years. Tamil Nadu reservoir licensing policy allows fishers a 1:2 (fisher: government) share of larger fishes and a 1:1 share of smaller fishes. Intensive carp cultures in wetland areas to increase fish production put pressure on indigenous varieties [94]. The all result proved that stocking SIFFs in the polyculture of carps could increase the fish production. In addition, these studies also revealed that the small and shallow water bodies may open-handedly be used for SIFFs culture and specifies the feasibility of attaining a superior manufacture of the similar along with Indian major carps [95]. Seed production technology must be standardized to supply sufficient seeds to the farmers desirous of culturing these species on commercial scale and research on low-cost feed formulation for these species needs immediate attention, as no attempts has been made so far. For conservation purposes, non-natural reproduction methods are applied to set up an Endangered Fish Species Breeding agenda. The two main sections of this agenda are a) a live gene bank and b) gamete/embryo bank. The project is started under the programme "Breeding and culture of high valued food fish" sponsored by the NBSFRA at the lead institute CIFRI (Central Inland Fisheries Research Institute), Barrack pore from 1st November, 2012 to 30th November, 2017. Except CIFRI, 6 other institutes are also involved viz. NBFGR, CIFE (Central Institute of Fisheries Education), CIBA (Central Institute of Brackish water Aquaculture), CIFA (Central Institute of Freshwater Aquaculture), CMFRI (Central Marine Fisheries Research Institute) and VBU (Vinoba Bhave University) [96]. Women role in inland fisheries and fish marketing need to be recognized and to insist 33% membership of women in newly formed State cooperatives.

6. Conclusion

Among the fish populations, the SIFFs are now attracting awareness, due to their wide range of distribution, easy access to rural people. Knowledge on indigenous fish species and communities reveals crucial facts necessary to the arrangement of ecosystem and habitats as well as to the identification of important genomes and genes. The above discussion has generated important reasoning .To

prioritize SIFFs for conservation and restoration or enhancement programmes for their pleiotropic nature. Furthermore SIFFs are now included in the polyculture practice which yield the higher production as well as cost effective. It is observed that partial harvesting of SIFFs from polyculture of Indian major carps yields better productivity for both SIFF and IMC. However, appropriate scientific management of SIFFs is still a virgin area of enormous importance and therefore requires a lot of dedicated approach to thrash out problems and issues relating to their promotion and conservation. It is important to update the Inland fishery policy of each state through a stake holder based approach and shift priority to bringing more water resources under fish production with equal importance to indigenous species, from just increasing production and productivity of major carps and exotic carps. Economic evaluation may also afford a very constructive statistics about ω-3 essential fatty acids content, their oil-value which opened a new door-designed for advance research in pharmacology and food industries. While the river basin is undergoing severe corrosion as a result of anthropogenic interference, the conservation strategies must be innovative and amalgamated. The commercialization SIFFs based food products depend at the output of FEIP (Farmer, Entrepreneur, Individual and people) chain for the nutritional safety of the underprivileged population of rural areas. Achievement will also depend on the extent at which conservationists, water commissions, municipalities and corporate, work together in these positions to sustain and reestablishment in natural water habitats of the country.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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