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Small Indigenous Fish (SIF): Status and Contributions in Nutrition and Livelihood Security of India: A Review

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ABSTRACT

The small indigenous fish (SIF), having length of about 25 cm is locally available in the small water resources *viz.* wetlands, canals, streams *etc.* and affordable to the poor people also. These are important food item as animal protein, vitamins and minerals sources in the diet of human beings. The objective of this review is to investigate the availability and importance of SIF in nutritional security and income generation of the community. Published and unpublished sources were used to obtain appropriate data. This study interprets actual availability of different species of SIFs, capture and culture resources, consumption pattern and marketing channels *etc.* A literature review was conducted to highlight the research attempt made to enhance the socio-economic condition of rural sector and as a result it offers important guidelines to popularize SIFs for nutritional security. In India a total of 765 native freshwater fish species documented, out of which about 450 are categorized as small indigenous fish species. The maximum diversity of the SIF's has been recorded from the North East region followed by Western Ghat and Central India. Review indicates an ardent need of focused research efforts towards the development and conservation of these fishes before they become extinct.

Key words: Health, Livelihood security, Nutritional security, Small indigenous fish.

According to the Food and Agriculture Organisation (FAO) of the United Nations (1997) fish is a vital source of food for people. It is important single source of high-quality protein, providing ~16% of the animal protein consumed by the world's population, fish constitute the major source of dietary protein after cereals and milk for human beings and are the sole source of animal protein for majority of the people. The Small Indigenous fish species are those which attain a length of about of 25 cm or 6 inches at maturity (Felts *et al.* 1996) and rich source of nutrients. Kongsback *et al.* 2008 studied the consumption of nutrient rich freshwater small indigenous fish by human beings and stated that SIFs provides better nutrition since generally eaten as whole including head, bone and eyes and thus all available nutrients including the micronutrients get utilized. These fishes are important equally well known for rich source of proteins, fatty acids, vitamins and minerals. It has been reported that some species such as mola (*Amblypharyngodon mola*), dhela (*Osteobrama cotio cotio*), darkina (*Esomus danricus*) and kaski (*Corica soborna*) contain high amount of vitamin A and other micronutrients and minerals (Thilsted *et al.* 1997). It is reported that vitamins and minerals available in one kg of SIFs are equal to those available in approx fifty kilograms of big fishes, such as Indian Major Carps (Mohanty 2010). In Bangladesh, it is reported that the small fish is the only source of vitamin A and calcium as dietary source for rural masses (Roos *et al.* 2003). SIFs play important role in preventing malnutrition due to protein deficiency and more specifically the micronutrient deficiency thereby safe guarding both nutritional as well as livelihood security of the rural population (Mohanty *et al.* 2013). It is well opined that the availability of self-recruiting species (SRS) in both natural and managed habitats is important for livelihood of the rural poor (Roos *et al.* 1999; Mazumdar and Lorenzen 1999). Extensive carp culture along with small indigenous species is certainly a source of additional income and dietary protein to the rural families, incurring no additional cost besides being environment friendly (Bayen *et al.* 2020). The role of SIF in providing micronutrients is very critical especially where micronutrient deficiency is a big problem (Zafari and Ahmed 1981). The aim of this review mainly focuses on the important nutritional component available in fish. Therefore, diversification of aquaculture with high valued small fish species of regional importance holds great promises in Indian economy.

To review the paper, Google *Scholar* search engine was the primary source to collect literature and perform sequential online searches for traditional knowledge and similar identified sections. A systematic evaluation of all the papers, reports and books on the related subject was done to document the information. The available data was categorised under different heads and presented accordingly.

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Availability of different species of SIFs

India is endowed with a total of about 2,246 species of finfish, out of which 765 are freshwater fish recorded from inland water bodies like wetlands, ponds, rivers, ditches and paddy fields (Lakra *et al.* 2010). Out of recorded 765 freshwater fish species, about 450 were small Indigenous fishes (SIFs), having maximum length of 30 cms. Felts *et al.*, 1996 enlisted 45 fish species as SIFs including 18 species of carps and minnows, 9 species catfishes, 9 species perches and others in Bangladesh. Further they sub-categorized SIS into three main groups based on the maximum length of the fish up to 7.5 cm, 15 cm and 25 cm. These species do not get any score in national statistics that are largely based on catches reported from major landing centres in high quantity and these fishes tend to be sold and consumed locally (Halwart 2008; Roos, 2007a). The high demand SIF species are identified by Sarkar and Lakra 2010.

Capture and culture resources

These fish species inhabit widely diverse natural ecosystems ranging from rivers, tributaries, streams, flood plains, wet lands, lakes, low lying paddy fields, swamps and seasonally inundated low lying areas. Maximum diversity of SIFS has been recorded from North East Region of India followed by Western Ghats and Central India. Fish-cum-paddy culture is also well known from these water rich areas. Suresh *et al.* 2007 studied the biology of a SIF (*A. mola*) from a floodplain wetland of West Bengal, India and reported as a good source of income generation for the community. Small sized fishes are usually considered as obnoxious weed fishes and these are subject to eradication from the culture system. Kumari *et al.* 2021 studied the food selectivity and reproductive biology of small indigenous fish Indian river shad, *Gudusia chapra* in a large tropical reservoir of India and observed a new trend of reproductive pattern. The qualitative estimation of the stomach contents revealed herbi-omnivorous feeding behavior of these fish species. The absolute fecundity of the individuals ranged from 749 to 15044 and ova diameter ranged from 0.10-2.00 mm. The gonadal indices (GSI, MGSI and DI) indicated that spawning extended throughout the year with peak reproductive activity in October, March-April and July (mean absolute fecundity ranged from 4000 to 6000).

Loss of SIFs

Freshwater aquatic environments are experiencing serious threats to both biodiversity and ecosystem stability and many strategies and priorities have been proposed to solve this crisis. The major threats to the SIF's are as: loss of natural habitats, use of small mesh sized gears, dewatering, use of insecticides and pesticides, industrial and domestic pollution, siltation of water bodies, invasion of exotics and disease. Under several schemes announced by the Government for fisheries enhancement programme and culture based fisheries had intensified by regular stocking of water bodies with Indian Major Carps (IMC). In this process, small native fish species are being affected and their population is declining fast. Small fishes are known as weed fish in aquaculture management practices. These are mostly eradicated using rotenone and other pesticides. Therefore, a drastic shift in the species composition and diversity is marked in favour of major carps' at the cost of the prized native fish species (Sugunan *et al.* 2000). This is one of the undesirable practices which greatly affect the biodiversity of indigenous species in inland water bodies. The environmental degradation and loss of existing wetlands are also a major constraint and adversely affect SIFs in turn. Overexploitation of species by local inhabitants reduces population size and disturbances in age structure and sex composition. Damming, deforestation, diversion of water for irrigation and conversion of marshy land and small water bodies are also the reasons for physical modifications of habitat of SIFs (Tewari and Bisht 2014). This affects the breeding ground and cause gill clogging of native small fishes. Use of pesticide in paddy fields is rampant all over India. Agrochemicals, metals, acids and phenol in high concentration cause mortality and affect the breeding process of fish (Kime 1995). Ambient temperature increases due to thermal pollution and reduces dissolved oxygen concentration leading to death of some sensitive fish species. SIFs are being caught before their maturity and considered as a major constraint in loss of SIFs (Suresh, 2010).

Consumption pattern

About 250 million children worldwide are estimated to be at the risk of vitamin A deficiency and an almost the same number are at the risk of deficiencies of minerals like iron, zinc, calcium *etc.* SIFs form a major component of food of those living around such water resources. Local people have knowledge about the health benefits of such species, for example, mola (*A. mola*), commonly found in eastern and North Eastern India. Those living in urban/suburban areas often expect variety of fish in addition to only carp species availability mainly for providing formidable amount of critical food source of very high biological value in the form of fresh fish for day to day consumption and offering larger benefits in terms of nutritional security particularly provision of household nourishment with regard to micronutrient availability so vital for healthy growth of children (Mukhopadhyay 2019).

Marketing channels

It usually passes through a number of levels. Each level contains a set of middlemen who perform the functions with the intention to bring the product closer to the point of consumption (Sinha, 2020). Nurullah *et al.* (2005) reported that the processors in consumer market received higher marketing profit followed by the primary market and secondary market, respectively. But, the availability of SIFs in the market is far below the demand and there is no specific marketing chain. There is a great seasonal and regional variation in the supply and type of SIFs. The peak harvest

season of riverine SIFs is November-December. SIFs from the floodplain comes to the markets between May and December with a peak in October-December. SIFs from other water bodies are harvested between January and April. Fish price depended on size, season, availability and quality. Low income, lack of capital, very poor or no handling preservation and processing facilities are the uncertainty in SIF marketing and pricing system, very poor educational background and ill health are also among the main problems in the livelihood of SIFs retailers. Ahmed and Hossain 2000 portray a bottleneck in the livelihood approach of fish farming and marketing system due to lack of access to livelihood assets for the poorer section of the community. Retail marketing of SIFs is preferred by the fishermen. Sometimes small fishes are vending door to door by the fishermen and women.

Nutritional value of SIFs

Food Security is the "adequate access to food for all people at all times for an active, healthy life" (Gross *et al.* 2010). Based on the ICMR-National Institute of Nutrition (Hyderabad) norm more than two-thirds of population in rural households in India was undernourished during 2009-10 (Chand and Jumrani 2013). Majority of the Indian rural women face nutritional deprivation since their childhood which is the major cause of malnutrition and under-nourishment of the women (Roy *et al.* 2015). Socio-cultural values are also biased against women (Anonymous, 1997) which are one of the major reasons of the malnutrition. The importance of mola (*A. mola*) has been highlighted as the richest source of vitamin (Alam, 1985). Consumption of these fish may be a simple and easy way to meet the vitamin-A deficiency and thus may be used as in curing the night blindness. Small fish are very rich in Zinc compared to food from other animal sources. Calcium absorption from small fish was comparable that from skimmed milk and that these fish may represent a good source of Ca (Hansen *et al.* 1998). The proximate biochemical composition of some small indigenous fish species were analyzed by Mazumder *et al.* 2008. Even the low market-value small species *Esomus longimanus*, contains 20.3 mg of zinc/100 g raw edible parts is commonly consumed by poor people in Cambodia, (Roos *et al.* 2007). SIF can serve as natural supplements for combating and preventing micronutrient deficiency as well as protein calorie malnutrition (Mahanty *et al.* 2014). Stansby 1954; Salam 1995 and Jacquot 1961 found variation in proximate composition of fish flesh with species variation, season, age and the feeding habit of the fish. The same observation was reported by Piska and Waghray 1989. Gopakumar 1997 studied the amino acid composition of some SIFs (Table 1). The successful linking of human nutrition and fisheries to address micronutrient deficiencies has relevance for other countries with rich fisheries resources, such as Cambodia and countries in the Lake Victoria region of Africa (Roos *et al.* 2007b).

The nutrient content of some common SIF is mentioned in Table 2.

Small fish as alternate livelihood

A livelihood comprises of capabilities and assets required for means of living. SIFs found in the vast inland water resources, provide not only nutrition but also livelihood

Table 1: Amino Acid Composition of some SIFs (Gopakumar, 1997).

Species ⇒ *Amino* Acids ⇓ (g 100 g^{-1} Protien)	*A. mola*	*P. sarana*	*H. fossilis*	*Ambassis spp.*	*P.stigma*	*C. striatus*	*G. chapra*
Asparagine	9.82	9.63	6.33	9.52	2.80	10.74	3.53
Threonine	5.72	4.79	4.29	3.23	1.68	4.24	1.93
Serine	6.68	3.48	2.41	2.34	1.30	3.60	1.43
Glutomine	16.31	20.31	10.79	14.88	5.76	21.6	6.72
Proline	0.38	4.61	3.86	3.29	2.31	4.0	2.30
Glycine	13.74	4.47	4.74	3.31	3.22	3.75	3.22
Alanine	10.50	6.47	4.47	4.39	2.88	5.49	3.03
Valine	0.84	5.21	4.07	4.48	2.24	5.54	2.64
Cysteine	3.15	0.80	0.50	0.74	0.24	2.40	0.26
Methionine	1.72	1.83	1.34	2.05	1.22	2.47	1.49
Isoleucine	5.45	3.07	4.56	4.22	2.02	4.50	2.31
Leucine	9.62	8.05	6.92	7.05	3.00	8.76	3.48
Tyrosine	1.39	2.58	1.84	4.81	1.60	1.90	1.81
Histidine	4.41	1.21	4.86	3.30	1.11	3.16	1.08
Lysine	5.17	11.17	10.98	11.30	3.36	13.26	4.10
Arginine	1.87	5.66	2.78	6.21	2.71	4.87	3.17
Tryptophan	1.73	1.13	1.38	1.12	-	-	-
Phenylalanine	1.50	-	3.84	-	1.85	2.91	2.13

opportunities and income to a large number of fishers. Studies in India have shown that the profit accruing to fishers is actually higher in the case of SIFS when compared to those from large cultured species. SIFs are also available in creeks, water channels, wetlands, paddy fields of coastal Sundarbans (Sinha 2017). Thus, if SIF is conserved properly, sustainable fisheries based on small indigenous fishes can provide an additional income or a source of alternate income to the people. Thus, food and nutritional security can also be ensured. SIF has the potential to increase the income of the fishermen community, which will empower the community to access education, health, nutrition and better living standards which ultimately can ensure food and nutritional security of the people. Mondal *et al*. 2020 recommended poly-culture of carps with mola for additional nutritional and economic benefits; field level household culture is highly suggested in Bangladeshi pond. Mola is very rich in micronutrients and high potential for polyculture with carps. It is compatible for production in all type of ponds, inundated water bodies, rice field connected ponds, beels. It also breeds in ponds and other water bodies, it is highly fecund fish species (1,000-20,000), breed several times in a year and matured at three months of age. It is not required further stocking if once stocked and conserved it properly. Saha and Barman 2020 promoted production and marketing of Mola and other Small Indigenous Species of fish in Bangladesh. They opined that many people partly or fully maintain their livelihoods through harvesting and selling of fish most importantly the SIFs by harvesting from the natural resources.

Integration of high priced small indigenous fish with conventional carp culture

SIF based aquaculture technology packages are developed for: Carp-mola polyculture, Mola-punti-carp polyculture, Carp-prawn-mola culture *etc.* (Wahab *et al.* 2010). In an experiment it was reported that, when *A. mola* along with carp species was cultured has increased overall pond fish production (Roos *et al.* 2007). It was observed that the prices of these species were high, often higher than the prices of Indian Major Carps (Ahmed 2009), providing a source of supplementary income to rural households. Analysing the local demand for freshwater small indigenous fish species, the FAO (1999) also indicated the possibility of integration of polyculture system with such indigenous fish species. Sinha and Santra 2016 observed the better total fish production from culture of carps with mola than carps with chela. The same result was also observed by Roy *et al.* 2003 and Kohinoor *et al.* 1998. Dewan *et al.* 1991 and Kohinoor 2000 observed a severe competition for food between planktivorous native and exotic carps. In polyculture of carps while phytoplankton grazer mola was added, it reduced the food availability for rohu. Catla feeds in the upper layers of the water column, mainly capturing zooplankton (Miah and Siddique 1992; Jhingran and Pulin 1985). The addition of mola, puntius or chela which also grazes on phytoplankton but mainly feeds on the bottom and on detritus, indirectly reduced food availability for catla reducing algal food of zooplankton and puntius also by removing benthic stages of zooplankton (Kohinoor 2000). The addition of highly efficient grazer silver carp in Indian Major carp culture system reduced food availability for all fish grazers (Milstein 1992). The fishes living in the aquatic ecosystem have specific feeding habit and preference for the food (Ahmed *et al.* 2010). They have feeding interrelationship among them and therefore, the knowledge of feeding ecology of the fishes must be studied for the individual integration. Wahab *et al.*, 2011 proved that manipulation of species composition is one of the useful tools towards improving fish yield and corresponding income. Nandi *et al.* 2012 opined that there is need to study the feeding ecology of SIFs to understand food partitioning and habitat preference within and between the fish species for better culture cum conservational approach.

Commercially important SIFs of ornamental value

The top ten groups of ornamental fishes are the livebearer fish like guppy, molly, platy, swordtail and egg layers like goldfish, catfish, gourami, tetra, loach, cichlid and the barb. Of the 30-35 species that are the favorites of aquarists, only a few are of Asian origin-*Brachydanio rerio* and *Pethia conchonius* being the most common. About 30 species of

Table 2: Nutrient content of some SIF (Mohanty *et al.* 2011).

SIFs	Calcium (g)	Iron (mg)	Zinc (mg)	Vitamin A (mg)
Amblypharyngodon mola	0.853	5.7	3.2	>1500
Gudusia chapra	1.063	7.6	2.1	NA
Chanda nama	0.955	1.8	2.3	100-500
Esomus danricus	0.891	12	2.1	500-1500
Mystus vittatus	NA	NA	1.5	100-500
Channa punctatus	0.766	1.8	3.1	100-500
Puntius chola	1.171	3.0	NA	<100
Heteropneustes fossilis	0.042	4.86	NA	<100
Clarias batrachus	NA	NA	NA	<100
Channa striatus	82.20	1.88	NA	NA
Oreochromis nilotics	585.20	1.5	NA	NA

highly priced ornamental fishes were identified for culture including *Pethia denisoni*. The hill stream fishes belonging to the genera *Balitora*, *Barilius*, *Garra*, *Homaloptera*, *Lepidocephalus*, *Nemacheilus* and *Psilorhynchus* are considered to be coldwater species. Some of the other endemic species from the south are known to have an immense potential for export. Sinha (2017) could enlist small indigenous fish as exportable ornamental fish (Table 3). A few of the indigenous freshwater ornamental fish are bred in captivity.

Conservation

SIF has the potential to increase the income of the fishermen community, which will empower the community to access education, health, nutrition and better living standards which ultimately can ensure food and nutritional security of the people (Roy *et al.* 2020). The loss of aquatic biodiversity due to anthropogenic activities is continuing at an alarming rate (Moyle and Moyle, 1995). About 20 per cent of the world's ichthyofauna is already extinct or going to be extinct (Moyle and Leidy 1992). Lakra *et al.* (2010) has compiled a list of 120 freshwater threatened fish species in India including 5 species of Channa and 14 species of Puntius. Dubey *et al.* 2014 suggested that *A. mola* and *P.ticto* can potentially be used as the candidate species for aquaculture diversification in slightly saline water of Sundarbans. The majority of SIFs are caught before their maturity. Sinha *et al.* 2014 reported that there is a significant reduction in availability of native small fish *Amblypharyngodon mola*, *S. bacalia*, *Mystus vittatus*, *Puntius sarana*, *Nandus nandus* in the water channels of Sundarbans. Patra *et al.* 2005 reported that SIFs like *H. fossilis*, *A. gagora*, *Mystus. vittatus*, *P. canius*, *Ailia coila*, *Clarias batrachus* are vulnerable species in Sundarbans.

Table 3: Some indigenous fishes identified as exportable ornamental fishes (Sinha, 2017).

Common name	Scientific name
Spotted moray eel	*Lycodontis tile*
Devil catfish	*Chaca chaca*
Topaz pusser	*Chelenodon spelenodachneri*
Red green dwarf puffer	*Monotetrus travancoricus*
Jaguar loach	*Somileptus gongota*
Spiny green eel	*Mastacembelus pancalus*
Dwarf gourami	*Colisa fasciata*
Jewel glass fish	*Chanda ranga*
Mourala	*Amblypharyngodon mola*
Techokho	*Aplocheilus panchax*
Chang	*Channa gachua*
Lata	*Channa punctatus*
Nandas	*Nandus nandus*
Panther loach	*Lepidocephalus guntea*
Leopard loach	*Noemacheilus corica*
Indian glass barb	*Chela labuca*
Zebra Loach	*Botia striata*
Putti	*Puntius sophore*
Botya	*Botia dario*
Tengra, Golsha-tengra	*Mystus bleekeri*
Tengra	*Mystus vittatus*
Pabda	*Ompok bimaculatus*
Doya, Potasi	*Pseudentrpius atherinoides*
Baghari	*Bagarius bagarius*
Batasio, Bajori	*Batasio batasio*
Botsinghi	*Olyra longicaudata*
Kaikya	*Xenentodon cancila*
Cheng	*Channa orientalis*
Chanda	*Chanda nama*
Chanda	*Pseudambassis baculis*
Bhedo, Darhi	*Badis badis*
Golchi, Bime	*Macrognathus caudiocellatus*

In situ conservation can be done through their maintenance within natural or man-made ecosystem in which they occur. A trial was conducted for initiating in-situ conservation in Sundarbans for ensuring the community participation in conserving the small indigenous fishes and observed encouraging results (Sinha and Roy 2016).

Eco-restoration can be done by ranching of SIFs through active people's participation in the fresh water canals or water channels. Enforcement of laws and regulation to protect SIFs particularly in breeding, regulation of small meshed nets, selection of water bodies as sanctuaries, intensive aquaculture and introduction of exotic fishes must be reduced, mass awareness generation about nutritional benefit of SIF, institutional mechanism to popularize SIF for nutritional security as well as alternative livelihood needs attention.

Awareness and capacity building

Sensitizing the community to include SIFs in their diet attracts small scale entrepreneurs to culture SIF for their nutritional security and livelihood was attempted by Sinha *et al.* 2017. Awareness and capacity building programme are the need to contribute in developing policies and legislative measures to ensure the conservation and promotion of SIFs, both in capture and culture systems, as well as access of disadvantaged groups, particularly women. It is important to mention that traditional conservation ethics could still protect much of the country's valuable biodiversity, if local community actively involve themselves in such measure with a share in financial benefit (Deb and Malhotra 2001). Public awareness is the necessity of conservation of indigenous fish diversity and wise management of habitats needs to be created through mass media.

CONCLUSION

The study concludes that there is an urgency of proper documentation of SIFs, both from culture and capture fisheries to project them in the Fish Production Statistics. Presently, there is no organised and regulated / voluntarily regulated SIFs fishery sector in India. Mass awareness and

capacity building programmes related to SIF is demanded by fish farmers and it needs urgent attention. To save these fish there should be law in place for unauthorised fishing and catching of brooders and juvenile fishes, which will help them to establish their population in the ecosystem and directly help in restoration and conservation of small fishes. As this sector is purely based on traditional culture and capture methods, the sector needs documentation and protection of the traditional knowledge and farmers' innovation to protect SIF resources. A number of researchers documented the nutrient availability in SIFs, however, nutrient profiling studies of SIFs by Research and Academic Institute need encouragement to fill the technological gaps. In addition, the literature state that more research work is required in respect of the diversification, culture practices and also to know the breeding potential of small indigenous fish of India.

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REFERENCES

Ahmed, N., Hossain M.A.R. (2000). A study on marketing of freshwater prawn, *Macrobrachium rosenbergii* (De Man, 1879) from Bagerhat to international markets. Bangladesh J. Fish. 23(2): 25-31.

Ahmad, S.A.S., Bart, A.N., Yi, Y., Rakocy, J.E., Diana, J.S. (2010). The effect of the introduction of *Nile tilapia* (*Oreochromis niloticus* L.) on small indigenous fish species (mola, *Amblypharyngodon mola*, Hamilton; Chela, *Chela cachius*, Hamilton; punti, *Puntius sophore*, Hamilton). Aquac Res. 41: 904-912.

Ahmed, V.I., Babu, V.S., Chandra, V., Nambi, K.S., Thomas, J., Bhonde, R., and Hameed, A.S. (2009). A new fibroblastic-like cell line from heart muscle of the Indian major carp (*Catla catla*): Development and Characterization. Aquaculture. 293(3-4): 180-186.

Alam, A.K.M.A. 1985. Mini pond. CARITAS Bangladesh, Dhaka. Anonymous. (1997). Harmful traditional practices affecting the health of women and children: A report from DESA, united nations high commissioners for human rights, Geneva, Switzerland. P-16.

Bayen, S., Sinha, A., Aftabuddin, M., Roy, A., Parida, P.K., Das, B.K. (2020). Developing mola (*Amblypharyngodon mo*la) based fish culture practices for addressing livelihood and nutritional security of rural populace of Indian Sundarbans, Journal of Entomology and Zoology Studies. 8(6): 359-364.

Chand, R., Jaya, J. (2013). Food Security and Undernourishment in India: Assessment of Alternative Norms and the Income Effect. Policy Brief 38, National Centre for Agricultural Economics and Policy Research, New Delhi. pp. 6.

Deb, D. and Malhotra, K.C. (2001). Conservation ethos in local traditions: The West Bengal heritage. Society and Natural Resources. 14: 711-724.

Dewan, S., Wahab, M.A., Beveridge, M.C.M., Rahman, M.H., Sarker, B.K. (1991). Food selection, electivity and dietary overlap among planktivorous Chinese and Indian major carp fry and fingerlings grown in extensively managed, rain fed ponds in Bangladesh. Aquaculture and Fisheries Management. 22: 277-294.

Dubey, S.K., Trivedi, R.K., Rout, S.K., Chand, B.K., Choudhury, A. (2014). Median lethal salinity (MLS_{96h}) of two small indigenous fish species *Amblypharyngodon mola* and *Pethia ticto* from Indian Sundarbans. J. Aquac Res Development. 5(5): 249.

FAO. (1997). Review of the State of World Aquaculture. FAO Fisheries Circular No. 886, Rev. 1. Rome, Italy. [PubMed].

Felts, R.A., Fajts, F., Akteruzzaman, M. (1996). Small Indigenous Fish Species culture in Bangladesh (Technical brief), IFADEP Sub Project 2, Development of Inland Fisheries, p. 41.

Gopakumar, K. (1997). Biochemical composition of Indian food fish. Revised ed. Central Institute of Fisheries Technology (ICAR), Cochin, India. p. 44.

Gross, R., Schoeneberger, H., Pfeifer, H., Preuss, H.A. (2010). The four dimensions of food and nutrition security: Definitions and concepts. Nutrition and Food Security, In Went (FAO): 1-17.

Halwart, M., and Settle, W. (2008). Participatory training and curriculum development for Farmer Field Schools in Guyana and Suriname. A field guide on Integrated Pest Management and aquaculture in rice. 116.

Hansen, M., Thilsted, S.H., Sandstrom, B., Kongsback, K., Larsen, T., Jensen, M., Sorensen, S.S. (1998). Calcium Absorption from Small Soft-boned Fish. J. Trace Elements Med. Biol. 12 :148-154.

Jacquot, R. (1961). Organic constituents of fish and other aquatic animals: Fish as food. Borgstorm Academic Press, N.Y. and London. pp. 145-209.

Jhingran, V.G., Pulin, R.S.V. (1985). A hatchery manual for the common, Chinese and Indian major carp. ICLARM Contribution. Vol.252. ADB and ICLARM Publication. 191p.

Kime, D.E. (1995). The effects of pollution on reproduction in fish. Reviews in Fish Biology and Fisheries. 5(1): 52-55. DOI: 10.1007/BF01103366.

Kohinoor, A.H.M. (2000). Development of culture technology of three small indigenous fish mola (*Amblypharyngodon mola*), punti (*Puntius sophore*) and chela (*Chela cachius*) with notes on some aspects of their biology. Ph.D. thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 263 p.

Kohinoor, A.H.M., Islam, M.L., Wahab, M.A., Thilsted, S.H. (1998). Effect of mola (*Amblypharyngdon mola* Ham.) on the growth and production of carps in polyculture. Bangla. J. Fish. Res. 2: 119-126.

Kongsback, K., Thilsted, S.H., Wahed, M.A. (2008). Effect of consumption of the nutrient-dense freshwater small fish, *Amblypharyngodon mola* on biochemical indicators of vitamin A status in Bangladeshi children: A randomized controlled study of efficiency. J Nutr. 99:581-597.

Kumari, S., Sarkar, U.K., Karnatak, G., Mandhir, S.K., Lianthuamluaia, L., Kumar, V., Panda, D., Puthiyottil, M., Das, B.K. (2021). Food selectivity and reproductive biology of small indigenous fish Indian river shad, *Gudusia chapra* Hamilton, 1822) in a large tropical reservoir. Environ Sci Pollut Res Int. 28(9): 11040-11052. DOI: 10.1007/s11356-020-11217-w. Epub 2020 Oct 27. PMID: 33111225.

Lakra, W.S., Sarkar, U.K., Gopalakrishnan, A., Kathirvel, Pandian, A. (2010). Threatened Freshwater Fishes of India. NBFGR Publ., ISBN: 978-81-905540-5-3.

Mahanty, A., Ganguly, S., Verma, A., Sahoo, S., Mitra, P., Paria P., Sharma, A.P., Singh, B.K., Mohanty, B.P. (2014). Nutrient profile of small indigenous fish *Puntius sophore*: Proximate composition, Amino acid, fatty acid and micronutrient profiles. Natl. Acad. Sci. Lett. 37(1): 39-44.

Mazumder, D. and K. Lorenzen. (1999). Developing aquaculture of small native species (SNS) in Bangladesh: village level agroecological change and the availability of SNS. NAGA ICLARM Quarterly. 22(3): 20-23.

Mazumder, M.S., Rahman, M.M., Ahmed, A.T.I., Begum, M., Hossain, M.A. (2008). Proximate composition of some small indigenous fish species (SIS) in Bangladesh. Int. J. Sustain. Crop Prod. 3(4): 18-23.

Miah M.J.U. and Siddique, W.H. (1992). Studies on the food and feeding habits of mola, *Ambly pharyngodon mola*. Bangladesh Journal of Agricultural Science. 19: 165-170.

Milstein, A. (1992). Ecological aspects of fish species interactions in polyculture ponds. Hydrobilogia. 231: 177-186.

Mohanty, B.P., Behera, B.K., Sharma, A.P. (2010). Nutritional Significance of Small Indigenous Fishes in Human Health. Central Inland Fisheries Research Institute (ICAR), Barrackpore, India, Bulletin No. 162, ISSN: 0970-616X, p.63.

Mohanty, B.P., Pati, M.K., Bhatacharjee, S., Hajara, A., Sharma, A.P. (2013). Small indigenous fishes and their importance in human health. Advances in Fish Research. V: 257-278.

Mondal, S., Wahab, A., Barman, B.K., Asif, A.A. (2020). Enhance the Contribution of Small Indigenous Fish Production: Emphasis Mola (*Amblypharyngodon mola*) with Carps in North-West of Bangladesh. Singapore Journal of Scientific Research. 10: 308-316. DOI: 10.3923/sjsres.2020.308.316URL: https://scialert.net/abstract/?doi=sjsres.2020.308.316.

Moyle, P.B., Leidy, R.A. (1992). Loss of biodiversity in aquatic ecosystems: Evidence from fish faunas. In: Conservation Biology: The Theory and Practice of Nature Conservation. [Fiedler, P.L. and Jain, S.K. (eds.)]. Preservation and Management, pp.127-169. Chapman and Hall, New York.

Moyle, P.B., Moyle, R.A. (1995.) Endangered fishes and economics: International obligations. Environmental Biology of Fishes. 43: 29-37.

Mukhopadhyay, P. (2019). Small indigenous freshwater fish biodiversity and their aquatic biodiversity conservation for nutrition security. Agriculture World. 68-75.

Nandi, S., Majumder, S., Saikia, S.K. (2012). Small freshwater fish species (SFFs) culture: Issues from nutrient security, carp-SFF integration and feeding ecology. Rev Fish Biol Fisheries. DOI 10.1007/s11160-012-9294-2.

Nurullah, M., Kamal, M., Wahab, M.A., Islam, M.N., Yasmin, L., Thilsted, S.H., Mazid, M.A. (2005). Present status of harvesting, transportation and marketing fresh water small indigenous species of fish (SIS) of Bangladesh. Bangladesh J. Fish. Res. 9(2): 2005: 159-168.

Patra, M.K., Acharjee, S.K., Chakraborty, S.K. (2005). Conservation categories of siluroid fishes in North-East Sundarbans, India. Biodiversity and Conservation. 14: 1863-1876.

Piska, R.S. and Waghray, S. (1989). Biochemical variations of reproductive tissues of *Ambly pharyngodon mola* (Ham.) with reference to spawning cycle. Indian J. Fish. 36(4): 335-336.

Roos, N., Islam, M., Thilsted, S.H. (2003). Small Fish is an important dietary source of vitamin A and calcium in rural Bangladesh. Int. J. Food Science Nutr. 54(5): 329-339.

Roos N., Islam M.M., Thilsted S.H., Ashrafuddin M., Murshedu zzaman, M., Mohan D.M. and Shamsuddin, A., B.M. (1999). Culture of Mola (Amblypharyngodon mola) in polyculture with carps-experience, a field trial in Bangladesh. NAGA, ICLARM Quarterly. 22(2): 16-19

Roos, N., Thorseng, H., Hamnan, C., Larsen, T., Gondolfu, B., Thilsted, S.H. (2007a). Iron content in common cambodian species: Perspective for dietary iron intake in poor rural households. Food Chem. 104(3): 12226-1235.

Roos, N., Wahab, M.A., Hossain, M., Thilsted, S.H. (2007b). Linking human nutrition and fisheries: Incorporating micronutrient-dense, small indigenous fish species in carp polyculture production in Bangladesh. Food and nutrition bulletin 28(2 Suppl): S280-93. DOI: 10.1177/15648265070282S207.

Roy, A., Aftabuddin, M., Parida, P.K., Sinha, A., Das, B.K., Adhiguru, P. (2020). Small indigenous fishes to boost nutritional security: A roadmap for nutri-smart village in deltaic sunderbans. In Book Agricultural Extension: Socio-economic Imperatives. 63-67.

Roy, A., Pandit, A., Sharma, A.P., Bhaumik, U., Majunder, S., Biswas, D.K. (2015). Socioeconomic status and livelihood of fisher women of hooghly estuary. Journal of Inland Fisheries Society of India. 47(1): 49-56.

Roy, N.C., Wahab, M.A., Khatoon, H., Thilsted, S.H. (2003). Economics of carp-SIS polyculture in rural farmer's pond. Pak. J. Biol. Sci. 6(1): 61-64.

Saha, M.K. and Barman, B.K. (2020). A strategy on increase production and marketing of mola and other small indigenous species of fish (SIS) in Bangladesh' under the project 'Aquaculture: Increasing income, diversifying diets and empowering women in Bangladesh and Nigeria'. Penang, Malaysia: World Fish. Technical report.

Salam, M.A., Alam, N., Nasiruddin, M., Nabi, R., Howlader, M.Z.H. (1995). Biochemical composition of body muscles and its caloric contents of tawes (*Puntius gonionotus*, Bleeker). Bangladesh J. Sci. Res. 13(2): 205-211.

Sarkar, U.K. (2010). Diversity and conservation of small indigenous fresh water Fish Species of India. Workshop on "Small Indigenous Fresh water Fish Species: Their role in Poverty Alleviation, Food Security and Conservation of Biodiversity". Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal.

Sarkar, U.K. and Lakra, W.S. (2010). Small Indigenous Freshwater Fish Species of India: Significance, conservation and utilization. Aquaculture Asia Magazine. 15(3): 34-35.

Sinha, A. (2017). Evolution, trend and status of ornamental fisheries in India and their commercialization. In Social Entrepreneurship in Aquaculture, Edited by: V.R.P. Sinha, Gopal Krishna, P. Keshavanath and Nalini Ranjan Kumar. Copyright © 2016, Narendra Publishing House, Delhi, India. 225-240.

Sinha, A. (2020). Culture of Small Indigenous Fishes (SIF) in India. In: Indian Aquaculture 2020. [V.V. Sugunana, V.R. Suresh and C.K. Murthy, Eds]. Published by The Society for Indian Fisheries and Aquaculture, Hyderabad. 108-115.

Sinha, A. and Roy, A. (2016). Sunderban me Ajibika abam poshakiya suraksha hetu chhoti deshi machhlika utpadan abam sangrakhan (In hindi). Central Inland Fisheries Research Institute, Barrackpore, Bulletin no: 195, 24p.

Sinha, A. and Santra, S. (2016). Integration of high priced small indigenous Fish with conventional carp culture for nutritional security and rural livelihood. International Journal of Agriculture Innovations and Research. 4, ISSN (Online) 2319-1473:960-963.

Sinha, A., Das, S.K., Roy, A., Mitra, A., Mukherjee, C.N., Sengupta, A. (2014). Small indigenous fish an alternate source to improve rural livelihood and nutritional security in coastal zone of Sunderbans, India. In Extended Abstract of National conference on mitigation and adaptation strategies in wetlands-A Community Leadership Perspective: 73-74.

Sinha, A., Roy, A., Das, B.K., Mohanty, B.P. (2017). Small Indigenous Fish (SIF) for livelihood and nutritional security awareness and sensitization initiative by ICAR- Central Inland Fisheries Research Institute, Barrackpore, India. Report number: ISSN: 0970-616X.

Stansby, M.Z. (1954). Composition of certain species of fresh water fish. Food. Res. 19: 231- 234.

Sugunan, V.V., Vinci, G.K., Bhattadrarjya, B.K., Hassan, M.A. (2000). Ecology and fisheries of beels in West Bengal. Central Inland Fisheries Research Institute, Barrackpore, Bull. No. 103:1-53.

Suresh, V.R. (2010). Fishery of wetlands in West Bengal and contribution of Wild Fish stocks to production and fisher's income (Abstract). Workshop on "Small Indigenous Fresh water Fish Species: Their Role in Poverty Alleviation, Food Security and Conservation of Biodiversity". Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal.

Tewari, G. Bisht, A. (2014). Aquatic Biodiversity: Threats and Conservation. Aquafind The World Fish Centre. Fish and Human Nutrition. http://www.worldfishcenter.org/sites/default/files/fish_human_nutrition_1.

Thilsted, S.H., Roos, N., Hassan, N. (1997). The role of small indigenous fish species in food and nutrition security in Bangladesh. NAGA WorldFish Centre Quarterly, July-December (Supplement). 82-84.

Wahab, M.A., Kadir, A., Milstein, A., Kunda, M. (2011). Manipulation of species combination for enhancing fish production in polyculture systems involving major carps and small indigenous fish species. Aquaculture. 321: 289-297.

Wahab, M.A., Thilsted, S.H., Milstei, A. (2010). Small fish production through aquaculture and conservation measures for HH nutrition security.Workshop on "Small indigenous fresh water fish species: Their role in poverty alleviation, food security and conservation of biodiversity", 23-25, February 2010, CIFRI, Barrackpore.

Zafri, A. and Ahmed, K. (1981). Studies on the vitamin A content of fresh water fish:content and distribution of vitamin A in mola (*Amblypharyngodon mola*) and dhela (*Rohte ecotio*). Bangla. J. Biol.Sci.10: 47-53.