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Original research article

Abundance and biomass of assorted small indigenous fish species: Observations from rural fish markets of West Bengal, India

Dibyendu Saha [a], Santanu Pal [a], Supratim Mukherjee [b], Gargi Nandy [c], Anupam Chakraborty [c], Sk Habibur Rahaman [a], Gautam Aditya [a, c, *]

[a] Department of Zoology, The University of Burdwan, Golapbag, Burdwan, 713104, India
[b] Department of Zoology, Government General Degree College, Singur, Hooghly, 712409, India
[c] Department of Zoology, University of Calcutta, 35 Ballygunge Circular Road, Kolkata, 700019, India

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A B S T R A C T

The small indigenous fish species (SIS) are harvested as ensemble of different fish species of varying size and shape. An appraisal of the abundance and biomass of fish species constituting such ensemble was carried out with samples collected from fish markets of West Bengal, India. The data revealed that at least 22 different fish species were present varying in numbers and species combinations. The abundance and biomass of the individual fish species was negatively correlated, indicating numerical dominance of small sized species. Logarithmic regression showed a good fit of the relative abundance (y) with the species richness (x) in the samples of SIS ($y = 55.72\ln(x) - 77.27$; $r^2 = 0.940$), while power regression was best fit for the relative biomass of individual fish (y) with the species richness (x) in the samples of SIS ($y = 24.58x^{-1.54}$; $R^2 = 0.831$). In overall both species specific and individual based biomass and abundance relationships were negatively correlated. In order to ascertain the harvest and marketability of the SIS in a judicious manner, monitoring of the fish assemblages in natural habitats is recommended.

1. Introduction

The small indigenous fish species (SIS) are characterized by small size (<25 cm standard length) with indigenous in origin, commonly found in freshwater wetlands (Nandi, Majumder, & Saikia, 2013). In West Bengal and Assam, India, the SIS are found in the rice fields and associated trap ponds, irrigation canals and rivers (Aditya, Pal, & Saha, 2010; Baishya et al., 2016). These fish are generally excluded from commercial culture fisheries and the exploitation is dependent mostly on the capture using traditional knowledge and tools (Nandi et al., 2013; Samajdar & Saikia, 2014). In India and many other Asian countries several SIS are considered as cheap sources of proteins, minerals and vitamins (Roos, Islam, & Thilsted, 2003b, 2007a, 2007b, 2003a; Fiedler, Lividini, Drummond, & Thilsted, 2016; Nandi et al., 2013; Thilsted et al., 2016) and they contribute to enrich the quality of the ecosystems of the wetlands and rice fields(Aditya, Pal, Saha, & Saha, 2012; Chandra et al., 2008; Halwart, 2006; Halwart & Gupta, 2004). The contribution to the for food security (Roos et al., 2003b, 2007a, 2007b, 2003a; Fiedler et al., 2016; Thilsted et al., 2016)and the livelihood (Gupta & Banerjee, 2008) are valued ecosystem services attributable to the SIS. Inland water fisheries involving intensive culture systems uses limited number of fish species (Naylor et al., 2000; de Silva, 2016) but they have the potential to yield greater biomass per fish unit. In contrast, with the exception of few species such as the *Amblypharyngodon mola, Chela cachiux* and *Puntius sophore* (Kohinoor, Wahab, Islam, & Thilsted, 2001; Wahab, Kunda, Azim, Dewan, & Thilsted, 2008) little importance are given to SIS in commercial fisheries. Nonetheless, SIS form a common component of the culture fisheries involving harvest from wetlands and rice field associated trap ponds and irrigational canals (Aditya et al., 2012; Chandra et al., 2008; Fiedler et al., 2016; Halwart, 2006; Halwart & Gupta, 2004).

Although SIS are commonly found in both rural and urban market places, their exploitation is not extensively documented particularly in India(Keskar, Raghavan, Kumkar, Padhye, & Dahanukar, 2017; Nandi et al., 2013; Saha et al., 2017). The

* Corresponding author. Department of Zoology, University of Calcutta, 35 Ballygunge Circular Road, Kolkata, 700019, India.
E-mail addresses: dibyendusaha012@gmail.com (D. Saha), s.pal.bu@gmail.com (S. Pal), supratimm7@gmail.com (S. Mukherjee), nandygargi@gmail.com (G. Nandy), anu12.1515@rediffmail.com (A. Chakraborty), rahamanzoology@gmail.com (S.H. Rahaman), gazoo@caluniv.ac.in (G. Aditya).

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importance of gathering information about SIS can be associated to sustainability, such that these fish resources are exploited in a manageable way for the future generations. In India, empirical studies document that SIS are commonly found in rice fields and associated canals (Aditya et al., 2010),rivers (Baishya et al., 2016), with possible utility in rice-fish culture (Baruah, Bhagowatp, & Talikdar, 2000). Similar information on the fish species associated with the rice fields are known from other Asian countries such as China (Li, 1988; Lu & Li, 2006), Thailand (Little, Surintaraseree, & Innes-Taylor, 1996), Vietnam (Berg, 2002; Berg, Berg, & Nguyen, 2012) Cambodia (Gregory, 1997; Hortle, Troeung, & Lieng, 2008) and Bangladesh (Dey et al., 2005; Wahab et al., 2008). Rice fields and associated habitats including trap ponds and irrigation canals are enriched with valuable animal food resources including fish, prawns, crabs and snails (Halwart, 2006; Nurhasan et al., 2010). Natural colonization and establishment of taxonomically diverse fish species is the basis for promoting rice fish cultures which may be considered a sustainable source of secure food production andprotein supplement (Dey et al., 2008; Halwart & Gupta, 2004). The link between river, canals and trap ponds of the rice agro-ecosystem facilitate fish colonization and the production of diverse SIS. Consequently, the harvested fish species are diverse in taxonomic composition and sizes, and are sold as an assortment of multiple species (Saha et al., 2017).

As an extension to the recent findings (Fiedler et al., 2016; Saha et al., 2017; Thilsted et al., 2016), the biomass-abundance relationship of the SIS available in the fish market may enable justifying the heterogeneity of the harvested fish species (Saha et al., 2017). Thus the objective of the present study was to highlight the extent of variations in the relative abundance and the biomass of the SIS in the assorted samples sold in the markets. The results of the present study will provide the necessary information for sustainable exploitation of resources and selection of the most appropriate fish species for rice-fish culture (Kohinoor et al., 2001; Kunda et al., 2008). Assessment of species specific abundance and biomass will provide an overview of the population structure that exists in the natural water bodies. The present information will also justify the dependence on the capture fisheries (Thilsted et al., 2016) and the role of SIS in food security and livelihood (Roos et al., 2003b, 2007a, 2007b, 2003a) in Asian countries including India.

2. Materials and methods

In order to characterize the abundance and biomass of the small indigenous fish species (SIS) as food resource, a survey and collections were performed in the fish markets of Burdwan, Birbhum and Howrah districts of West Bengal, India. The study on the SIS availability was carried out between 2009 and 2016 (Saha et al., 2017) and 86 samples were used to assess the abundance-biomass relationship of the representative fish species. The vendors of the fish market sold the SIS in assortments of multiple species, mostly captured in combinations of multiple species using indigenous fishing gears such as *ghuni* (Samajdar & Saikia, 2014) and *mugri* (Manna & Bhattacharjya, 2009)from the rice fields, trap ponds and irrigation canals. The SIS samples originating directly from the rivers of the concerned geographical areas (River Ajay, River Damodar) were excluded either due to the assortment being made separately from different collections, or the harvested fish were sold as individual species. No samples were considered from the vendors selling SIS as segregated units of single species. A sample of 200 g of assorted multiple fish species were purchased from the local vendors and brought to the laboratory for assessment of biomass and relative abundance. In the laboratory, each sample was segregated on the basis of the constituent species

Table 1
Relative abundance (n_i) and body weight (BW, in gm) of the small indigenous fish species (SIS) sold in assorted form in the fish markets of West Bengal, India. Data of 86 different samples of 200gm each were used for the analysis. A - acronym for the species name used.

No.	Fish name	A	n_i	BW
Family- Cyprinidae				
1	*Puntius sophore* (Hamilton, 1822)	PSO	23.51 ± 1.64	2.36 ± 0.13
2	*Puntius terio* (Hamilton, 1822)	PTE	8.27 ± 1.61	1.39 ± 0.08
3	*Pethia ticto* (Hamilton, 1822)	PTI	8.72 ± .99	1.64 ± 0.12
4	*Pethia phutunio* (Hamilton, 1822)	PPH	10.75 ± 1.88	1.51 ± 0.07
5	*Amblypharyngodon mola* (Hamilton, 1822)	AMO	69.51 ± 4.05	1.61 ± 0.08
6	*Esomus danrica* (Hamilton, 1822)	EDA	40.59 ± 7.34	1.27 ± 0.06
7	*Laubuka fasciata* (Silas, 1958)	LFA	18.00 ± 2.74	1.38 ± 0.05
8	*Laubuka laubuca* (Hamilton, 1822)	LLA	10.69 ± 2.16	1.33 ± 0.02
Family- Aplocheilidae				
9	*Aplocheilus panchax* (Hamilton, 1822)	APA	7.33 ± 2.01	1.52 ± 0.14
Family- Ambassidae				
10	*Chanda nama* Hamilton, 1822	CNAM	47.61 ± 3.63	1.32 ± 0.13
11	*Parambassis ranga* (Hamilton, 1822)	PRA	45.02 ± 6.04	1.07 ± 0.1
Family- Osphronemidae				
12	*Trichogaster fasciata* Bloch & Schneider 1801	TFA	17.47 ± 6.85	1.31 ± 0.07
13	*Trichogaster lalius* (Hamilton, 1822)	TLA	13.50 ± 4.06	1.55 ± 0.08
Family- Bagridae				
14	*Mystus vittatus* (Bloch, 1794)	MVI	61.76 ± 11.95	4.03 ± 0.32
15	*Mystus tengara* (Hamilton, 1822)	MTE	25.45 ± 5.67	3.76 ± 0.90
Family- Mastacembelidae				
16	*Macrognathus pancalus* Hamilton 1822	MPA	11.50 ± 9.50	6.85 ± 0.75
17	*Macrognathus aculeatus* (Bloch, 1786)	MAC	22.50 ± 5.50	7.28 ± 1.07
Family- Gobiidae				
18	*Glossogobius giuris* (Hamilton, 1822)	GGI	10.03 ± 1.91	2.13 ± 0.42
Family- Cobitidae				
19	*Lepidocephalichthysguntea* (Hamilton, 1822)	LGU	12.11 ± 4.65	2.14 ± 0.32
Family- Badidae				
20	*Badis badis* (Hamilton, 1822)	BBA	3.00 ± 1.00	0.81 ± 0.50
Family- Channidae				
21	*Channa punctata* (Bloch, 1793)	CPU	3.33 ± 1.09	4.08 ± 0.72
22	*Channa striata* (Bloch, 1793)	CST	13.67 ± 3.38	6.22 ± 1.92

(Jayaram, 2010; Khanna & Singh, 2003; Talwar & Jhingran, 1991) species composition and the relative numbers per species were recorded. Here, the term relative abundance (n_i) was meant to represent the number of individuals of the *i*th species per sample(200 g). For each sample, the individual of a particular fish species was weighed to the nearest 0.01 g in a pan balance (Citizen®, India) and the data were recorded for further analysis. For all samples, the selling price (in Indian Rupee, Rs.), species richness, relative abundance and total abundance were recorded. A Pearson's correlation coefficient (r) analysis was used to compare the relative number and biomass against species richness in the samples ($n = 86$). The relation between the relative abundance and biomass of the SIS was represented by regression analysis. The best fit model of the regression equation was selected on the basis of the coefficient of determination value (R^2) and the regression equations were framed both on a species specific manner as well as individual within a sample (Zar, 1999)using the *XL*STAT software (Addinsoft, 2010).

3. Results

The survey carried out on the fish markets revealed that SIS were commonly sold by 3–4 people, mostly women vendors. A total of 27 fish species were observed of which 22 were within the

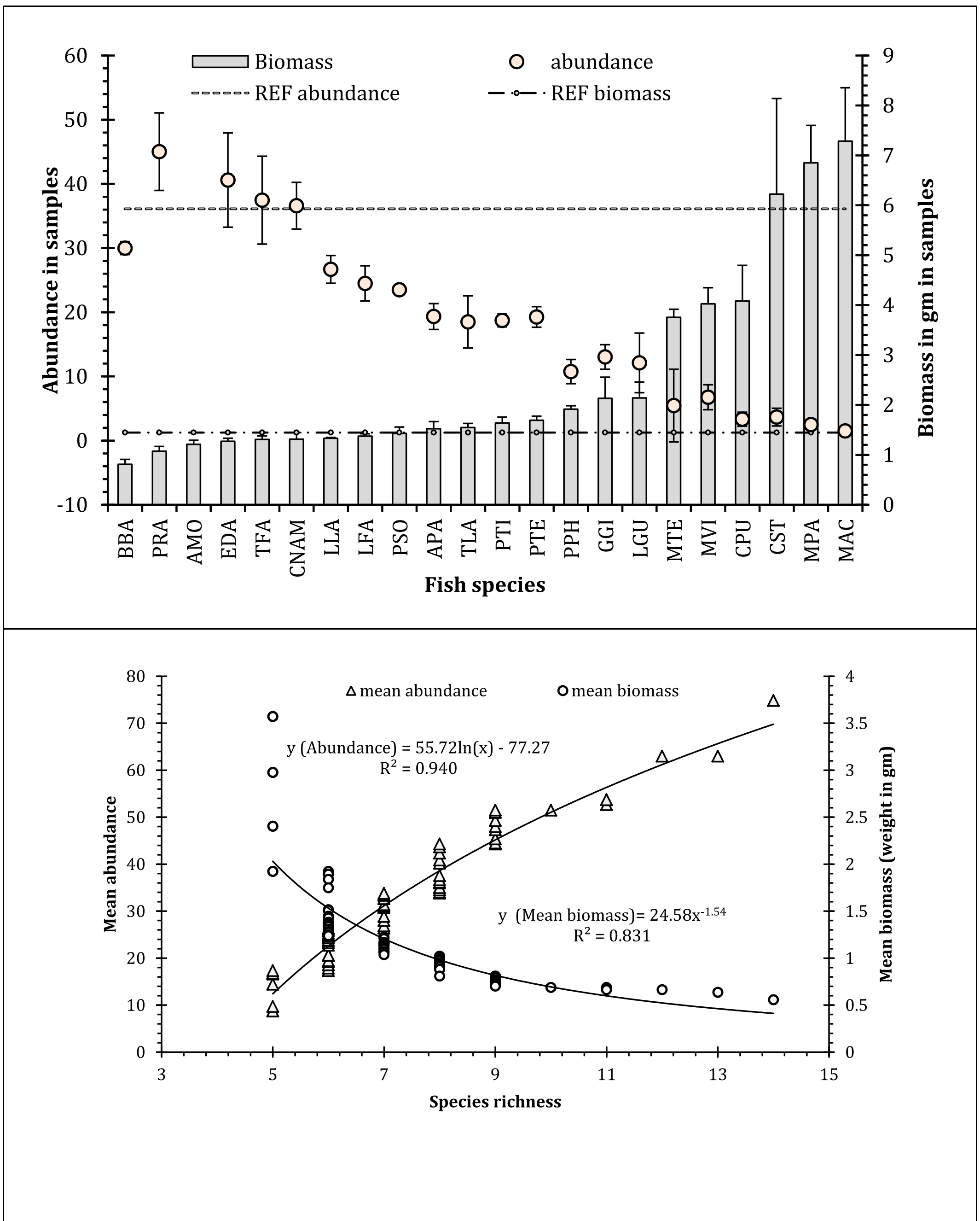

Fig. 1. (a)The biomass and abundance of the different small indigenous fish species observed in samples from selected fish markets of West Bengal, India. Data of 86 assorted samples of 200 g each were considered. The mean values of the abundance and biomass are shown as dashed lines (REF). (b) The species richness of the SIS as explanatory variable against the relative abundance and biomass as observed in the samples concerned.

SIS category. Juveniles of magur, *Clarias magur* (Hamilton, 1822) (Siluriformes: Clariidae) and Asian stinging cat fish, *Heteropneustes fossilis* (Bloch, 1794) (Siluriformes: Heteropneustidae), Asiatic knife fish, *Notopterus notopterus* (Pallas, 1769) (Osteoglossiformes: Notopteridae) bata, *Labeo bata* (Hamilton, 1822) (Cypriniformes: Cyprinidae) and climbing perch, *Anabas testudineus* (Bloch, 1792) (Perciformes: Anabantidae) were observed in less than three samples. Among the SIS, darikana (*Esomus danrica*), glassy perchlet (*Chanda nama*), glassy fish (*Parambassis ranga*) and banded gourami (*Trichogaster fasciata*) were numerically dominant while snake head murrel (*Channa striata*), lesser spiny eel (*Macrognathus aculeatus*) and barred spiny eel (*Macrognathus pancalus*) were dominant in terms of individual biomass. At least five fish species were (spot fin swamp barb, *Puntius sophore;* mola carplet, *Amblypharyngodon mola, C. nama; P. ranga* and stripped dwarf catfish, *Mystus vittatus*) sold as both separate and single species.

The data of 22 species were considered for the biomass-abundance relationship, which were consistently present in all samples. On an average 229 (range 70–300; mean 229 ± 8.4 SE) individuals of 7.39 different species (5–14; 7.39 ± 0.19 SE) were present in a sample of 200 g of assorted SIS that were sold at the rate of Indian Rupee, Rs.110.11 ± 1.4/kg (range Rs. 80 to Rs.130/kg). Considerable variations in the abundance and biomass composition of fish species were observed (Table 1) (Fig. 1). The relative numbers and relative biomass of the fish species were opposite related when plotted against the species richness in the assorted samples (Fig. 1b). The species richness in the samples were positively correlated with the relative number of individuals ($r = +0.962$; df = 84; $P < 0.001$) but negatively correlated with the relative biomass of individual fish ($r = -0.716$; df = 84; $P < 0.001$). Thus in samples with increased species richness, the individual biomass were low, while the relative abundance of the species was high.

The relative abundance of fish species per sample of assorted SIS was a decreasing function of the biomass for both species-specific and based observations (Fig. 2). On the whole, SIS samples were considerably diverse in terms of species composition, relative biomass and relative abundance.

4. Discussion

The small indigenous fish species (SIS) are common to abundant in varied type of freshwater wetlands and rivers in the Indian subcontinent. Although diverse in terms of taxonomic, shape and size, the SIS are rarely included in traditional aquaculture with the exception offew species. Despite being least considered for the traditional culture fisheries, the SIS play animportant role in food security and livelihood in India, Bangladesh, Vietnam, Laos and many other Asian countries (Belton & Thilsted, 2014; Berg et al., 2012; Dey et al., 2008; Nurhasan et al., 2010). Apart from the protein value and the vitamin and mineral content of several SIS qualify them as valued food resources (Roos et al., 2003b, 2007a, 2007b, 2003a; Thilsted et al., 2016). Availability of the SIS at the

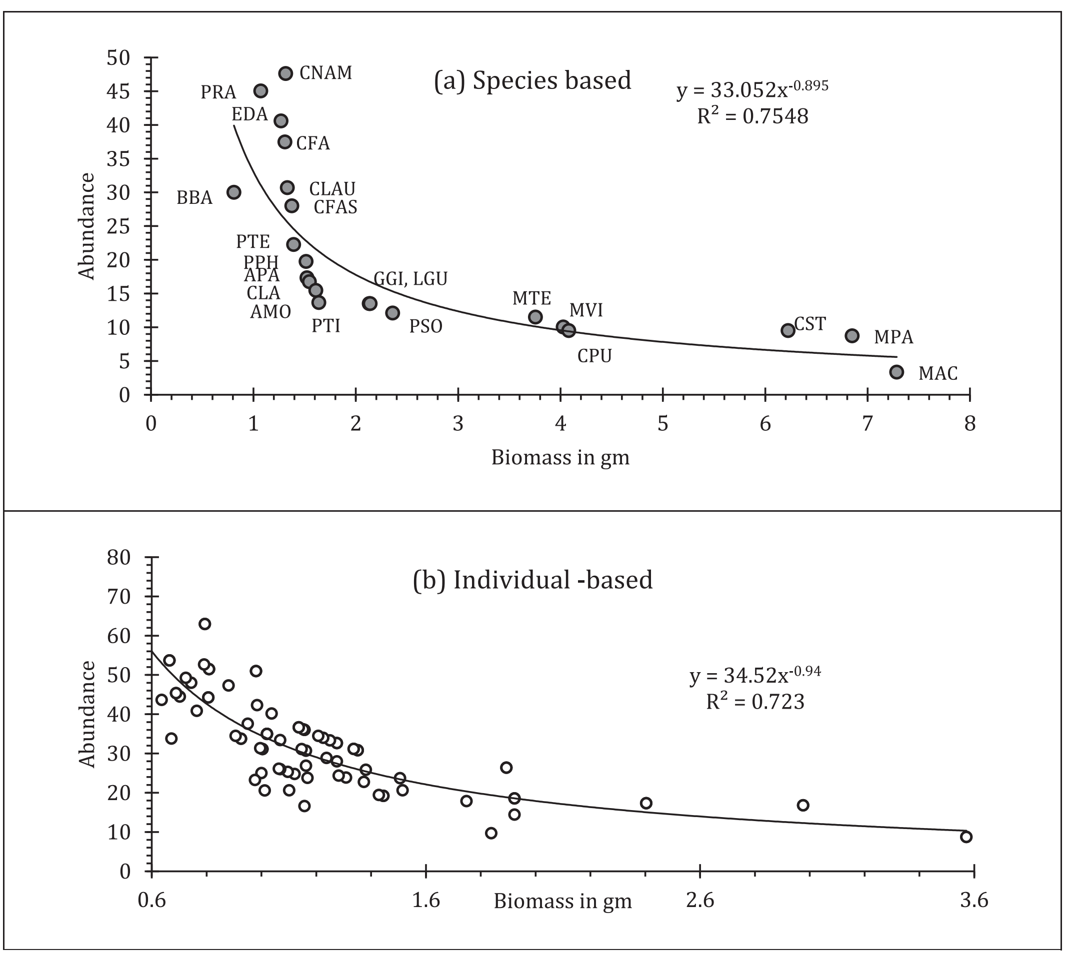

Fig. 2. The relation between abundance and biomass of the small indigenous fish species in the samples collected from fish markets of West Bengal, India. ($n = 86$ samples of 200 g of assorted fish species). (a) Species based – the mean value of the abundance and biomass were used as input data. (b) Individual based – the mean value of abundance and biomass of the assorted fish species.

local scale is considered as a beneficial factor, particularly for the rural poor regions, where the dietary protein, vitamin and mineral requirements are acquired through the consumption of SIS.

Although a wide variety of animals are associated with the rice field ecosystem, including snails, crustaceans, amphibians and other fish species (Halwart, 2006; Nurhasan et al., 2010), the SIS are comparatively rich in terms of nutrient quality (Roos et al., 2003b, 2007a, 2007b, 2003a) and high in diversity and abundance (Aditya et al., 2010; Baishya et al., 2016). The observations of the present study substantiates that a diverse variety of SIS are sold in the fish markets following harvest from the local rice field and associated ecosystems. The species richness observed in the assorted samples complies with the observations on the diversity of the SIS reported from the rice fields and associated canals and rivers of West Bengal (Aditya et al., 2010) and Assam (Baishya et al., 2016). The relative abundance and biomass relationship of the constituent species were opposite related with the species richness. Thus an assortment of the SIS was observed to be either species rich with low biomass of each individual or species low with relatively high biomass of species individual. As shown in Fig. 1b, a sample of 200gm of assorted SIS comprised of a relatively higher abundance of individuals with low biomass and high species richness or relative low abundance of individuals with high biomass. Few species such as *A. mola, C. nama, P. ranga, P. sophore, E. danrica* and *M. vittatus*, featured by low biomass constituted the bulk of the samples purchased from the fish markets. The relative abundance of these species is in parity with the observation made from the rice fields and associated trap ponds in the concerned area (Aditya et al., 2010). Generally traditional fishing gears are employed to harvest SIS from rice fields and allied trap ponds. Owing to the structural features of the gears (for figures see, Manna & Bhattacharjya, 2009, Samajdar & Saikia, 2014), fish with smaller biomass are more prone to such traps than higher biomass fish, resulting in the species size and composition as observed in the samples of the assorted SIS sold in the market. The species composition, biomass and abundance features of the SIS in the present study were similar to the observations obtainedfrom the river Brahmaputra in India (Baishya et al., 2016)2, as well as from Mathabhanga river (Hossain et al., 2006) and Padma river (Hossain, 2010) in Bangladesh. Perhaps the links between the rivers, irrigation canals and the rice fields provide a continuity of the freshwater habitats facilitating movements of fish species across varied landscape space. Fish species specific choice for the habitats (canals, rivers or rice fields) may contribute to the differences in the encounter rate and capture in the three different systems. Monitoring of the three habitats for the small indigenous fish species composition can further substantiate the meta-population characteristics of the fish species considered in the present study. Nonetheless, the present study provides a primary description of the variations in the biomass and abundance of the SIS in the rural fish markets of West Bengal, India.

The diverse ecosystem services attributable to the SIS qualify them as a valuable aquatic living resources requiring sustainable exploitation. Owing to the abundance and food value of SIS, continued exploitation is essential, particularly at local scale. Strategies to augment the abundance of the SIS through polyculture (Kohinoor et al., 2001) or rice fish culture (Kunda et al., 2008; Wahab et al., 2008) can be a feasible alternative to sustain the demand at the local scale of the concerned geographical areas. Apart from the role in food security, various species of SIS are in high demand in ornamental fish trade (Raghavan, Dahanukar, Tlusty, Rhyne, & Kumar, 2013) and in the biological control of mosquitoes (Aditya et al., 2012). Incorporation of SIS in rice fish culture (Berg, 2002; Berg et al., 2012; Nhan et al., 2007; Rothuis, Nhan, Richter, & Ollevier, 1998) will enhance the population and ensure the sustenance of the ecosystem. However, further studies on the regional scale variations in species composition and the relative exploitation rate is essential to frame the strategies to enhance SIS population in India.

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