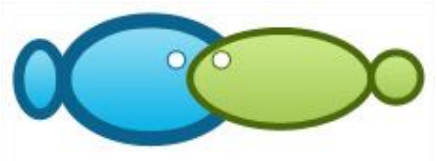

Exploitation pattern of mola carplet, *Amblypharyngodon mola* (Hamilton, 1822), a small indigenous fish: observations from fish markets of rural West Bengal, India

[1]Dibyendu Saha, [1]Santanu Pal, [2]Gargi Nandy, [1,2]Sk H. Rahaman, [2]Anupam Chakraborty, [1,2]Gautam Aditya

[1] Department of Zoology, The University of Burdwan, Golapbag, Burdwan, India;
[2] Department of Zoology, University of Calcutta, Kolkata, India. Corresponding author: G. Aditya, gautamaditya2001@gmail.com

Abstract. The mola carplet, *Amblypharyngodon mola* is a representative small indigenous fish species, rich in vitamin and mineral contents. As a common fish in different freshwater habitats, *A. mola* is often harvested and sold as an assortment of Small Indigenous fish Species (SIS) consisting of multiple fish. A survey of the rural fish markets was made to characterize the exploitation pattern of *A. mola* as a component of assorted SIS, highlighting the biomass, abundance as parameters influencing the pricing pattern. A sample size of 168 assorted SIS from different fish markets indicated the presence of *A. mola* in varying proportions and biomass in 159 such samples. A logistic regression revealed that the pricing pattern of the assortment of SIS was strongly influenced by both the abundance and biomass of the representative *A. mola* in the samples. The species richness in the samples of SIS was negatively related, while the price was an increasing function to the proportional abundance of *A. mola* in the samples. The biomass of *A. mola* in the assorted SIS was significantly different from those that were sold as single species. The observations on the fish *A. mola* provide evidence about the food resource potential as well as the preference at the local scale. Further studies including monitoring of the habitats and the fish markets should be initiated to justify the sustainable use of the fish *A. mola* as a food resource.
Key Words: small Indigenous fish species (SIS), price-biomass, assorted fish species, food security.

Introduction. The small indigenous fish species (SIS) are featured by small size with their abundance in inland freshwater habitats including rice fields and associated irrigation canals. Different species of fish qualifying as SIS are biocontrol agents of mosquitoes (Chandra et al 2008; Manna et al 2011; Aditya et al 2012), some of them are exploited in ornamental fish trade (Gupta & Banerjee 2008; Raghavan et al 2013) and used in ethno-medicine (Dey et al 2008). Above all, different SIS are harvested for human consumption to meet the dietary requirement, particularly in rural areas of India and Bangladesh (Nandi et al 2013; Roos et al 2003a; Roos et al 2003b; Thilsted et al 2016). Apparently, the functional roles and the contribution to the food security qualify SIS as a natural resource providing valuable ecosystem services. In many parts of India and Bangladesh, the SIS are harvested as a part of capture fisheries in the form of an assemblage of multiple species. Apart from the protein content, varied types of SIS are rich sources of vitamin and minerals, adding value as a food resource. As a consequence, the consumption of the SIS is promoted as a cheap food resource with high nutritive value.

Among the various SIS, the mola carplet, *Amblypharyngodon mola* (Hamilton, 1822) (Cypriniformes: Cyprinidae) is a source of vitamin A and minerals in addition to the protein content (Roos et al 2003a; Roos et al 2003b; Roos et al 2007a; Roos et al 2007b; Belton & Thilsted 2014; Thilsted et al 2016). The fish *A. mola* is endemic to Oriental realm and occurs as common to abundant numbers in almost all type of inland waters of India, Bangladesh and other Asian countries (Mookherjee & Basu 1946; Afroze et al

1991; Suresh et al 2007; Mondal & Kaviraj 2013). Owing to the nutritive value and the preference among the consumers, *A. mola* is considered for the rice-fish integrated culture to harvest in desired quantity (Wahab et al 2008). The ecological and economic importance of *A. mola* is reflected in the studies related to the distribution, morphometry (Hossain et al 2009; Hossain 2010; Gupta & Banerjee 2015), food consumption and morphometry (Nandi & Saikia 2015), abundance (Suresh et al 2007; Mondal & Kaviraj 2013) and food value (Roos et al 2003a; Roos et al 2003b; Belton & Thilsted 2014). In view of the significance of *A. mola* as a food resource, information on the harvest and consumption pattern is essential to justify compliance with the principles of sustainable use of resources.

In India, particularly in West Bengal, *A. mola* is a common constituent of the SIS sold as an assortment of multiple species in rural areas (Aditya et al 2010). An appraisal on the availability of *A. mola* in the fish markets will justify the importance as food resource to the consumers as well the exploitation pattern and economic value. As a food resource, the information obtained from the fish markets provide insights about the preferences by the consumers, pricing factors and the harvested size classes, which are crucial to determine the sustainable exploitation of the resource (Dey et al 2008). The value of the fish species in commercial scale can also be judged from the information obtained from fish markets, which is evident from the studies on several of the marine and freshwater aquaculture resources (Béné et al 2016). Thus the present study was focused on the assessment of the relative abundance, price and the size class of the fish *A. mola* from the fish markets of rural West Bengal, India. The results are expected to bridge up the gap between the information on the biology and ecology with that of the economic value of *A. mola* as a food resource.

Material and Method. The fish markets of the rural areas of Birbhum (23.646235N, 87.704745E), Burdwan (23.487453N, 87.733108E), Hooghly (23.046164N, 88.317850E) and Howrah (22.523829N, 87.901922E) districts of West Bengal, India were considered for procurement of *A. mola* in samples of assorted small indigenous fish species. Observations from a total of 168 samples collected from different fish market for one year between January and December 2014 were considered in the present study. After selection of the fish vendors selling assorted multiple species of SIS, samples of 200 g were purchased and brought to the laboratory. In the laboratory the assorted SIS were segregated according to species and the relative numbers were counted. The identification of the fish species was made following appropriate key (Jayaram 1981; Talwar & Jhingran 1991; Khanna & Singh 2003) and the information available in www.fishbase.org (Froese & Pauly 2016). Further for *A. mola,* the body weight of the individuals was recorded up to the nearest 0.01 g (Citizen®, India) along with the relative abundance in each of the samples. The number of fish species in the samples and the proportional presentation of *A. mola* were also estimated. In few instances, the fish *A. mola* were sold as a single species, and were collected (n = 15 samples) for the comparison with the individuals present in the assorted SIS in terms of biomass and price, justified using a paired t-test (Zar 1999). The data on the price of the fish were standardized as a function of the maximum price to avoid the expression in Indian Rupee (INR). Thus the standardized price, SP = (Price in INR/ Maximum price in INR) X 100; where the prices are unit (kg) of the SIS sold by the vendors.

The data on the relative abundance and biomass of *A. mola* in the samples were estimated and subjected to regression analysis (Zar 1999) to highlight the biomass and abundance relationship. A binomial generalized linear model with logit link (logistic regression) was applied to justify the influence of *A. mola* on the unit price of the SIS. The binomial logistic regression was of the form $(y) = 1/(1+ \exp(-(a + b_1x_1)))$, where, y is the dependent variable (price) and x_1 is the explanatory variable (abundance or biomass of *A. mola* in assorted SIS). In this regression model, the price of the assortment of SIS was assumed to follow the binomial distribution (n,p) with n replicates (samples of SIS) for each level of abundance (and biomass) of *A. mola* (explanatory variable). The probability parameter p represents the linear combination of the abundance (and biomass) of *A. mola* in the samples explanatory variables. Relation

between the species richness in the assortment of SIS and the abundance of *A. mola* in the sample was also justified using the logistic regression. Significant contribution of the parameters of the equations (intercepts and the explanatory variables) was judged through the Wald's chi-square value. The analyses were carried out using *XL*STAT software (Addinsoft 2010).

Results. The fish species *A. mola* was consistent in almost all the samples of assorted SIS sold in the fish markets. In the 168 samples of assorted SIS, an average of 7 different fish species (range 3–14; 6.9±0.14) including *A. mola* were present with a relative abundance of 33 individuals (range 8.75–78.33; 33.73±1.03) per sample. Although not elaborated in the present instance, the SIS samples consisted of at least 20 other fish species like *Puntius sophore, P. terio, Pethia ticto, Trichogaster fasciata, T. lalius, Parambassis ranga, Chanda nama, Mystus vittatus,* and *Lepidocephalicthys guntea* in different proportions and combinations.

The price (in Indian Rupee, INR) of the SIS ranged between 56 and 130 in (mean Rs. 93±1.7 or ~1.45 USD/kg) for an average of 215 individuals/200 g (range 70 to 300 individuals/200 g), of varying biomass. In 159 of these samples, the representation of AMO was between 9 and 148 individuals (70.51±3.08) with a proportion of 0.06 to 0.8 (0.34±0.01) of the total assorted fish species. A negative correlation ($r = -0.369$; $P<0.001$; $n = 157$) was observed between proportion of *A. mola* in the samples with the total number of individuals of assorted SIS. The biomass of *A. mola* individuals in the assorted SIS samples ranged between 0.6 and 3.5 g per individual (1.51±0.06). In the samples of assorted SIS, the higher the relative abundance of *A. mola* the lower was the biomass, fitting with a power regression equation (Figure 1a). The relative abundance (proportion) and the mean biomass complied with the power equation for *A. mola* appearing in the assorted SIS samples (Figure 1b). The logistic regression between proportional abundance and biomass of the fish *A. mola* (AMO) was: unit biomass of AMO (y) = 1 / (1 + exp(-(0.69 - 0.61*(x)AMO prop))), with the parameters of the model being statistically significant (intercept = 0.69±0.32; Wald's $\chi2 = 4.588$; $P<0.032$; Proportion of AMO = -0.61±0.16; Wald's $\chi2 = 15.07$; $P<0.0001$). The samples with higher proportion of *A. mola* had relatively low species richness in comparison to the conditions where the proportion of *A. mola* was lower (Figure 1c). A logistic regression represented the relation as: species richness of SIS(y) = 1 / (1 + exp(-(0.54 - 0.25*(x)AMOprop))) with the parameters of the model being significant at $P<0.001$ (intercept = 0.54±0.12; Wald's $\chi2 = 20.462$; Proportion of AMO(AMOprop) = -0.25±0.05; Wald's $\chi2 = 25.822$).

The price per individual *A. mola* reduced as a function of increase in the relative abundance ($r = -0.732$; $df = 79$; $P<0.001$) in the samples complying with a power regression equation (Figure 1d). When portrayed as a function of individual biomass of *A. mola* in the assorted SIS samples, the biomass obtained per unit price increased in a linear fashion (Figure 1e). This reflects that in the samples where *A. mola* was present in higher number, the biomass of each individual was less, and in samples where the numbers were less, the unit biomass was higher. In respect to these analyses and considering the relations in Figure 1d,e, it was apparent that in assorted SIS samples where *A. mola* with higher biomass was present, the yield of biomass per unit price remained higher, benefiting the consumers. Similarly, in low biomass and higher abundance samples, the consumers may benefit in terms of number of *A. mola* present. The logistic regression indicated significant contribution of the relative abundance as well as biomass to the pricing of the assortment of SIS sold in the markets. For the relative abundance the logistic regression was: Price of SIS (y) = 1 / (1 + exp(-(1.26 - 0.15*AMO_{ab}))) with the intercept and the explanatory variable (*A. mola* relative abundance, AMO_{ab}) being significant at $P<0.001$ (intercept = 1.26±0.04; Wald's $\chi2 = 826.717$; Relative abundance of AMO = -0.15±0.02; Wald's $\chi2 = 71.17$). Considering the unit biomass of *A. mola* (AMO_{bw}) in the sample of the assorted SIS, the price stands as: Price of SIS (y) = 1 / (1 + exp(-(1.0 - 0.04*AMO_{bw}))); the parameters being statistically significant (intercept = 1.00±0.03; Wald's $\chi2 = 863.57$; $P<0.0001$; AMO_{bw} = -0.04±0.01; Wald's $\chi2 = 8.41$; $P<0.004$). In comparison with the biomass (range 1.6 –

6.8; 3.81±0.16) of individuals of *A. mola* sold as a single species, the individuals in the assorted SIS samples were significantly smaller ($t_{(2),\ 63}$ = 13.333; P<0.001) (Figure 1f). Although in few instances (n = 15 vendors selling *A. mola* as a single species), the price were almost twice that of the condition when *A. mola* was sold as an assorted SIS.

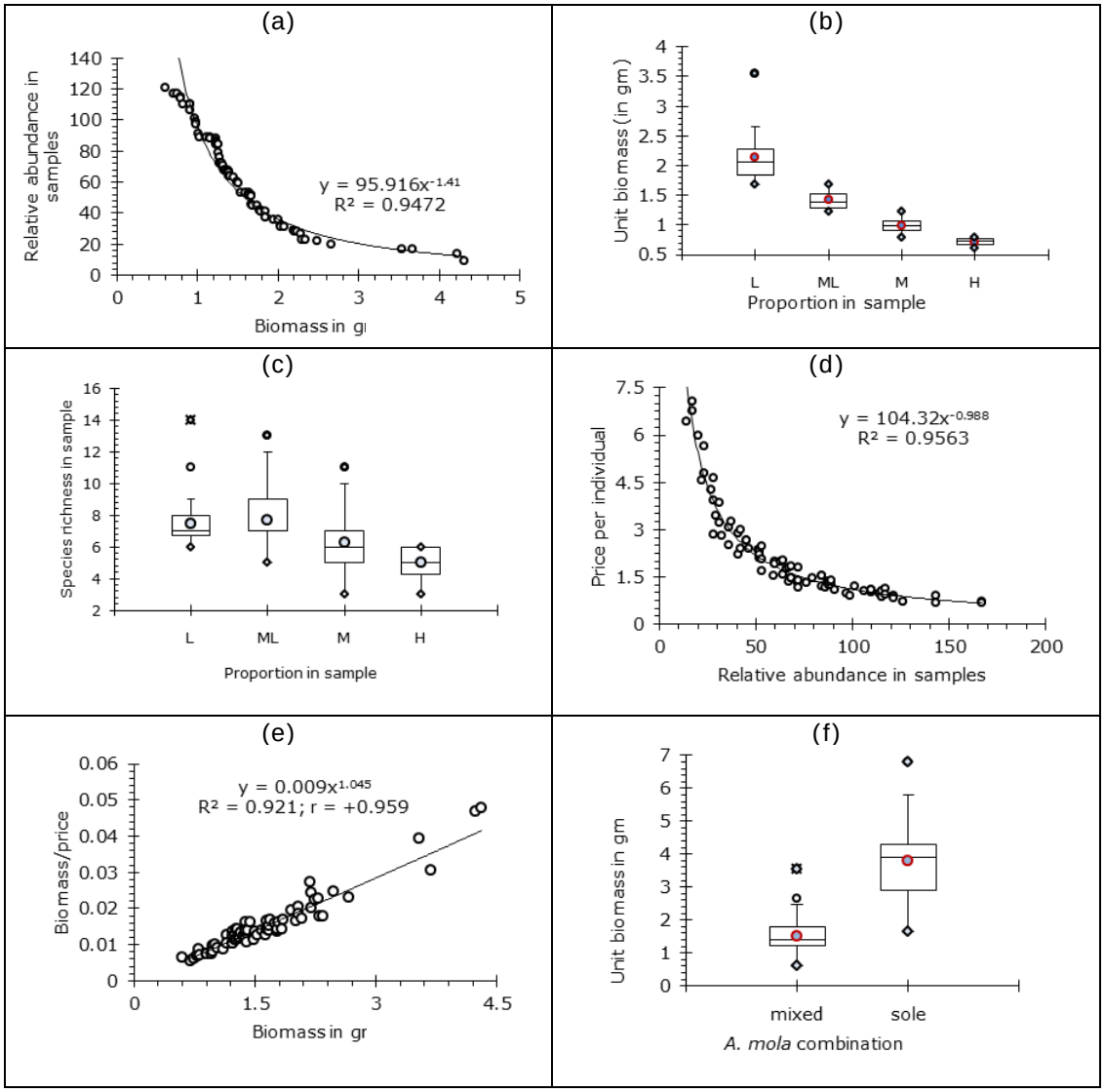

Figure 1. The various parameters of *Amblypharyngodon mola* as a part of the assortment of SIS sold in the fish markets of selected places of West Bengal, India. (a) The relationship between biomass of individual *A. mola* with the relative abundance in the assorted SIS samples; (b) Box-plot representation of the individual biomass as a relation of proportion of *A. mola* in the samples; (c) Box-plot representation of the species richness of other fish in relation to the proportion of *A. mola* in the assorted SIS samples; (d) The price of *A. mola* individual as a function of the relative abundance in the assorted SIS samples; (e) The price per unit biomass as a function of the biomass of *A. mola* in the samples; (f) The comparison of the biomass of *A. mola* sold in assorted samples and as single species. (N – 159 samples of assortment of SIS where *A. mola* was present out of 168 samples). In the graphs (b) and (c), the proportions in sample are represented as Low L = 0.01 – 0.2; Moderate low, ML = 0.21–0.4; Moderate, M = 0.41-0.6, and High, H = 0.61-0.8. The filled circles within the box plot represent the mean value with the diamond signs representing the extreme value. Filled circle outside the box plot represents the outliers.

Discussion. The small indigenous fish species are common commodity in the rural fish markets of West Bengal, India, being mostly sold by women vendors as an instantaneous catch from different water bodies. Particularly relevant is the abundance of the SIS during the period of paddy rice cultivation in the different districts of West Bengal, India. However, the composition of the assortment of SIS varies considerably in terms of species richness and the relative abundance of each species. Perhaps, the composition is linked with the fish species assemblages present in the water bodies from where the harvest is made. The species richness in the assorted samples of SIS were similar to those observed in rice fields and associated canals (Aditya et al 2010), beels (billabong or lake like wetland) and haors (backswamps) (Mondal et al 2006) and riverine systems (Baishya et al 2016) of eastern India as well as Bangladesh (Hossain et al 2009; Hossain 2010). In all these instances, *A. mola* is a common fish species, generally present in varying relative abundance in the water bodies in Indian subcontinent. Even being a redundant species in the SIS assemblage, the consumption pattern and marketability is not widely explored for the SIS in Indian context. As observed in the present instance, the variability of the biomass and the relative abundance contributed to the pricing pattern of the assortment of SIS samples sold in the rural fish markets. In the assorted samples, *A. mola* was represented in two forms: a) larger biomass but less in proportion, and b) smaller biomass but with high proportion, and influencing the composition and price of the assortment of the SIS sold in the market. A gain in the biomass of fish per unit price was obvious for the consumers when the fish with higher biomass was present in the assorted samples. Such discrepancy in biomass and abundance and the link to the pricing pattern reflect the relative value of *A. mola* as a saleable commodity. When sold as a single species, the biomass of *A. mola* remained considerably higher than those present in the assorted samples, providing further evidence of preference for the species to the sellers as well as consumers. In both forms, assorted or single species, the influence of the biomass of *A. mola* on the price was evident, thereby substantiating the resource value as a preferred fish species in the concerned region. The observations also comply with the general trends in the marketable SIS documented from the same area (Saha et al 2017).

Keeping in view the food value of *A. mola* (Roos et al 2003a; Roos et al 2003b; Roos et al 2007a; Roos et al 2007b; Fiedler et al 2016; Thilsted et al 2016), and the exploitation pattern, it is evident that the fish is in demand for the consumption at the local scale, which can influence overexploitation, if the harvest in continued without scientific basis. Monitoring of the availability of the fish in the natural habitats and the fish markets may be initiated to regulate the capture in a sustainable pattern. Alternatively, initiation to incorporate the fish in culture as a single species or in combination with other fish species may be adopted (Kohinoor et al 2001; Kohinoor et al 2005; Kunda et al 2008; Wahab et al 2008) to provide sufficient supply to the market in parity with the demand of the fish species. Inclusion of *A. mola* as a part of the rice-fish culture (Baruah et al 2000; Halwart & Gupta 2004) can also be considered to provide ample supply to the local fish markets. With the background knowledge on the biology and reproduction of the *A. mola* (Hossain et al 2009; Hossain 2010; Mondal & Kaviraj 2013; Gupta & Banerjee 2015; Nandi & Saikia 2015), as well as its availability in the varied type of wetlands of West Bengal, India, (Mondal et al 2006; Suresh et al 2007), commercial culture of the fish is a feasible option. In the context of diversifying aquaculture and promoting the fish for the food value, strategies to incorporate the *A. mola* in commercial aquaculture should be encouraged for food security. As observed in the present instance the fish *A. mola* is a common fish species sold in aggregate with other fish species or as a sole species in the rural fish markets. Incorporation of this fish species or other SIS in the commercial aquaculture will enable propagation and thus sustainable use of a nutrient rich food resource. Further studies should be initiated to identify the factors that favor the population growth and abundance of the fish in the natural system.

Conclusions. *A. mola* is a common small indigenous fish species (SIS) exploited as a food resource in Indian subcontinent. In assortments of SIS sold in the markets of West

Bengal, the proportion of *A. mola* varied considerably, and showed negative correlations with the species richness and individual biomass. A higher abundance of *A. mola* in the samples was negatively correlated with price indicating individuals with smaller biomass were present. However, the biomass of *A. mola* in assorted samples remained low in comparison to the situations where sold as a sole species. Future studies emphasizing the availability in the natural habitats and the exploitation pattern should be carried out to substantiate the compliance with sustainability principles.

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Authors:
Dibyendu Saha, The University of Burdwan, Department of Zoology, India, Golapbag, Burdwan 713104, e-mail: dibyendusaha012@gmail.com
Santanu Pal, The University of Burdwan, Department of Zoology, India, Golapbag, Burdwan 713104, e-mail: s.pal.bu@gmail.com
Gargi Nandy, University of Calcutta, Department of Zoology, India, 35 Ballygunge Circular Road, Kolkata 700019, e-mail: nandygargi@gmail.com
Sk Habibur Rahaman, The University of Burdwan, Department of Zoology, India, Golapbag, Burdwan 713104; University of Calcutta, Department of Zoology, India, 35 Ballygunge Circular Road, Kolkata 700019, e-mail: rahamanzoology@gmail.com
Anupam Chakraborty, University of Calcutta, Department of Zoology, India, 35 Ballygunge Circular Road, Kolkata 700019, e-mail: anu12.1515@rediffmail.com
Gautam Aditya, The University of Burdwan, Department of Zoology, India, Golapbag, Burdwan 713104; University of Calcutta, Department of Zoology, India, 35 Ballygunge Circular Road, Kolkata 700019, e-mail: gautamaditya2001@gmail.com

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