JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Changing scenario of fish diversity and contribution of small indigenous fishes as a potential fishery in river Yamuna.

[1]Shadab Masud*and [2]K.P.Singh
[1]Women Scientist-B, [2]K.P.Singh
Department of Zoology, Institute of Science,
Banaras Hindu University,
Varanasi-221005, India

Abstract

One of the largest rivers of India, the Yamuna and its innumerable tributaries together with favorable ecological conditions of the state bear immense scope for production of commercial fish and also conservation of some of the important fish fauna. For the present study fish samples were collected in and around the study area i.e., river Yamuna at Allahabad during the period Jan'07-Dec'08, to delineate the diversity and composition of freshwater fishes. Identification of the fish collected were based on morphological feature, information received about local name, and its economic value etc. was obtained from native fishermen as well as from the resource persons. The fishery from Allahabad stretch of river Yamuna is mainly represented by the species belonging to Cyprinidae and Siluridae families. On the basis of present study fish biodiversity were estimated as 77 species of 10 order and 27 families. First time measurable amount of small indigenous fishes was recorded, while earlier reports included them in miscellaneous group. The findings of the present study might be helpful in planning the fishery development programme of the Yamuna River. This would not only boost up the economy of the nation but may also save the fish genetic resources that are at the verge of extinction.

Keywords: Yamuna River, Fish bio-diversity, SIS, fish extinction.

Introduction

The Ganga River system is one of the largest river systems in the world. The river along with its tributaries has a combined length of 12,500 km River Yamuna is the major tributary of river Ganga, it originates from Yamunotri in the Uttarkashi district, Uttarakhand. Having total length of about 1,370 km, it flows through Haryana, Delhi and Uttar Pradesh.

Fisheries, apart from contributing to nutritional security component of the food basket of the country, are recognized for providing livelihood and employment to millions of native people. As a result of changes in the environment, the pattern of fisheries in the Yamuna River system at Allahabad, has considerably changed from the earlier reports of 1960s and 1970s.The prized fishery such as Indian major carp have either collapsed or is at the threshold of collapse (Tyagi, 2005; Vass et. al, 2008). During those years the major contributors to the catch were the major carps (*Cirrhinus mrigala, Catla catla, Labeo rohita*) and some other fishes like *Wallago attu*, *Mystus aor* and *M. seenghala*, etc. At many places the famous hilsa was also an important component of the catch. But, during recent years the trends in the fisheries were quite different. Changed hydrological conditions and impact of anthropogenic activities has badly hampered the breeding and recruitment processes of fishes in rivers, resulting in declined catches, especially for rheophillic and floodplain spawning species like Indian major carps that like flowing waters (Pathak and Tyagi, 2010). Somehow, the smaller species are able to maintained their production level and becomes the important component of fisher's livelihood basket (Masud, 2013).

Previous investigations of the Yamuna emphasized the species composition and abundance of commercially important fish from selected fish landing centers of the river (Jhingran, 1975; Khan et al., 1995; Moza and Mishra, 2001; 2003; Mishra and Moza, 2001; Mishra et al., 2007). Systematic information on the fish biodiversity and contribution of small fishes of the river is lacking. The main objectives of the present study were to assess the status of small indigenous fish species along with the Indian major carps in the Yamuna River at Allahabad.

Materials and Methods

To assess the current status of the fishery of the Yamuna River at Allahabad, the present study was conducted from Jan'07-Dec'08. Sampling for fish species was done by different net (cast net, drag net and gill net) in the main river. Data on fish landings were also collected from fish markets and landing centers at the sites which received fish catch from the river regularly. Sadiapur wholesale fish market, Gaughat and Karelabagh retail fish markets was the main markets to collect the data.

All the above three markets are near to river Yamuna bank. The markets receive catch from different sources; hence, all precautions were taken to record the catch only from river Yamuna.

Sadiapur landings are mainly formed by night fishing and rest two markets by day fishing. Landings were recorded species wise. For the purpose of collection of data, a stratified sampling design was adopted (Tyagi and Mandal, 2008). A month was divided in four strata of seven or eight consecutive days, depending upon the month. From each stratum data was collected for two randomly selected days. All the three markets were covered on the sampling days. The collected samples were preserved in 4% formalin and brought to the laboratory for further Study. The fishes were identified following Day (1878, 1889), Talwar & Jhingran (1991) and Jayaram (1999) and also with the help of taxonomic expertise from the Central Inland Fisheries Research Institute, Allahabad, India. The meristic and morphometric characters of collected fishes were measured and identified up to the species level.

Results

Fish catch statistics

The fishery from Allahabad stretch of river Yamuna is mainly represented by the species belonging to Cyprinidae and Siluridae families. During the investigation period, a total of 77 species of 10 order and 27 families were recorded (Masud & Singh, 2014). During the years 2007 and 2008, the total catch was estimated at 132.23t and 117.56t, respectively (Table -1).

In the year 2007, the major carps contributed 27.83t in total. *L. rohita* contributed the maximum (10.28t) followed by *C. mrigala* (8.15t), *C. catla* (7.33t). The contribution of *L. calbasu* was only 2.07t (Tab. 2). Among the large catfish dominant species was *S. seenghala* (5.28t) followed by *S. aor* (3.36t) and *W. attu* (1.76t). The landings of *T. ilisha* were almost negligible (0.14t). Among exotics landings *C. carpio* contributed 35.59t in total, forming about 1/4th of the total landings. Another exotic species *O. niloticus* - contribution was only 4.05t. The other group comprising of smaller species, mainly *C. garua, E. vacha, R. rita, G. chapra, G. manmina, A. morar, A. jaya, S. bacaila, J. gangeticus, A. coila, E. murius, L. pangusia, M. armatus, R. corsula, S. cascasia, O. cotio* shared about 41% in total and their contribution stood at 54.22t.

Table 1: Fish landings (tones) from river Yamuna at Allahabad

Species	2007		2008	
	t	%	t	%
C. catla	7.33	5.54	2.45	2.08
L. rohita	10.28	7.78	7.68	6.53
C. mrigala	8.15	6.17	8.07	6.87
L. calbasu	2.07	1.57	4.73	4.02
Major carps	**27.83**	**21.05**	**22.93**	**19.51**
S. aor	3.36	2.54	5.27	4.48
S. seenghala	5.28	3.99	3.86	3.29
W. attu	1.76	1.33	1.07	0.91
Large catfish	**10.40**	**7.86**	**10.20**	**8.68**
T. ilisha	0.14	0.10	0.02	0.02
C. carpio	35.59	26.92	21.65	18.42
O. niloticus	4.05	3.06	4.59	3.90
Exotics	**39.64**	**29.98**	**26.24**	**22.32**
Others	54.22	41.01	58.17	49.48
Total	132.		117.	

During year 2008, the major carps contributed 22.93t (19.51% in total), dominated by *C. mrigala* (8.07t), followed by *L. rohita* (7.68t), *L. calbasu* (4.73t) and *C. catla* (2.45t) as shown in Tab. 1. Among large catfishes *S. aor* stood at the top with a contribution of 4.48t and followed by *S. seenghala* (3.29t) and *W. attu* (0.91t). Again, the contribution of *T. ilisha* was very low (0.02t). Among exotics, *C. carpio* contributed 21.65t and *O. niloticus* 3.90t. The other groups formed the bulk (49.48%) of catches and their contribution stood at 58.17t.

During year 2008, the fishery showed a decline of 11.1%. Among major carps the main decline was in the catches of *C. catla*, which came down to 2.45 t in 2008 from 7.33t during 2007. However, *C. mrigala* maintained its level. Large catfish as a group did not reflect any appreciable change but within groups there were significant change (Tab. 1). The other groups fishery registered an improvement with a contribution of 49.48% in total landings (Tab. 1).

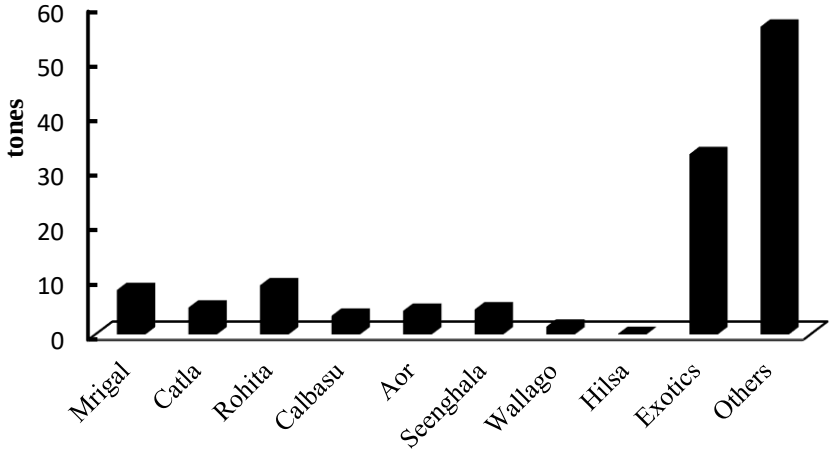

Figure 1: Average contribution (in tons) of various species landed at river Yamuna - Allahabad (Jan'07-Dec'08)

The average contribution (2007-08) of various fish species has been depicted in Fig. 1. It is obvious from the figure that other groups contributed maximum in total landings followed by exotics group.

The present work is mainly concerned with the contribution of four smaller species, their landings with other species have been presented in Tab. 2. During the year 2007, among selected species *G. manmina* contributed maximum (10.43t), followed by *A. morar* (9.42 t), *S. bacaila* (5.54 t) and *G. chapra* (1.29 t). Their contribution was almost equal to the rest of the species of others groups. In 2008 *G. manmina* contribution came down to 8.14t, but still it was the maximum contributor. The *A. morar* contribution also slipped down to 4.86 t. However, fishery of *G. chapra* showed some improvement and rose up to 3.99 t. During this period the rest of the species of others groups showed an improvement and increased by 38.6% over the landings in 2007. The fishery of selected species registered a further decline of 11.2% during the year 2008.

Table 2: Landings (tones) of considered smaller species and their percent contribution in total (Jan'07-Dec'08)

Species	2007		2008	
	t	%	t	%
G. chapra	1.29	0.97	3.99	3.39
G. manmina	10.43	7.89	8.14	6.93
A. morar	9.42	7.12	4.86	4.14
S. bacaila	5.54	4.19	2.99	2.54
Others-S.S.	27.54	20.83	38.18	32.48
Others	54.22	41.01	58.17	49.98
S.S.: studied species *G. chapra, G. manmina, A. morar, S.*				

The average percent contribution of selected species in others groups were depicted in Fig. 2. Their contribution to others group stood at 41.5%, *G. manmina* contributed 16.5%, followed by *A. morar* (12.7%), *S. bacaila* (7.6%) and *G. chapra* (4.7%).

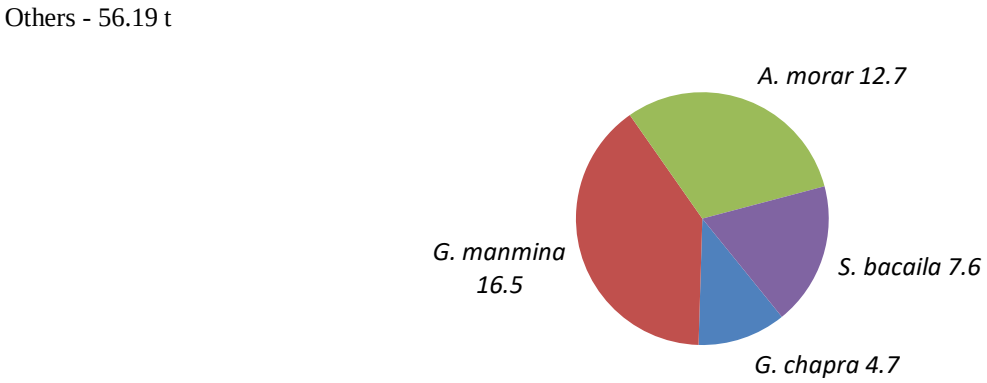

Figure 2: Average percent contribution of selected species in others group landings (Jan'07-Dec'08)

Average monthly contribution of various species is presented in Tab. 3. The maximum landings were recorded in the month of July (11.2%).

During post monsoon months (September-October) the fishery showed a sharp decline and contributed only 5.70-6.25t. However, in November fishery showed an improvement, contributing 11.95t (9.6%). Again, after a setback in December, it again revived. During winter and summer months, the landings were almost at same level (10.42 to 12.32t) except February (8.61t).

The group-wise monthly contribution has been depicted in Fig. 3. The maximum landings of *T. ilisha* were only 30 kg in the month of November and for that reason it could not be shown in the Fig. 3. It is evident from the figure that major Carps contribution was maximum in June and July, when they become sluggish due to final stage of maturation. Large Catfishes contribution was high from April to June and December-January months. Exotic species, *C. carpio* and *O. niloticus* were maximum during post monsoon months.

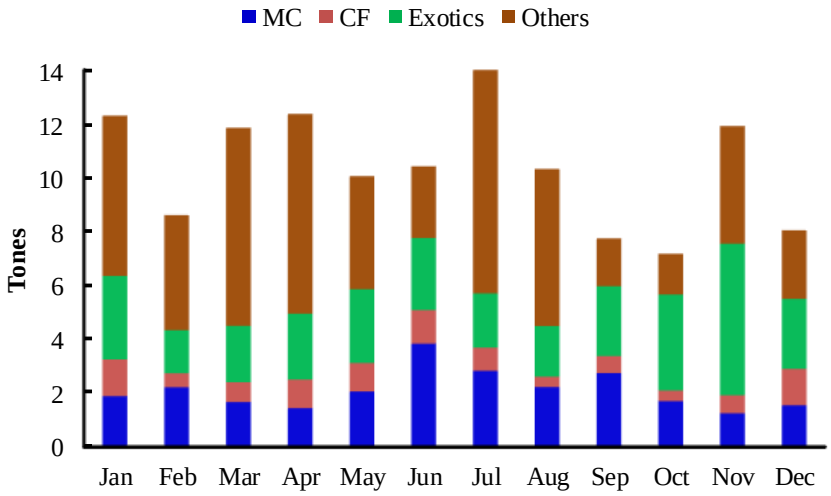

Figure 3: Monthly contribution (tones) of various groups in total landings

MC: major carps; CF: large size catfish

Table 3: Average monthly contribution (tones) of various species in landings from river Yamuna at Allahabad (Jan'07-Dec'08)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
C. catla	0.0	0.	0.0	0.1	0	0.	1.	0.	0.	0.	0.	0.	4.
L. rohita	1.0	0.	0.4	0.7	1	1.	0.	0.	1.	0.	0.	0.	8.
C.	0.7	1.	0.8	0.4	0	0.	0.	0.	0.	0.	0.	0.	8.
L.	0.0	0.	0.2	0.0	0	1.	0.	0.	0.	0.	0.	0.	3.
A. aor	0.8	0.	0.3	0.5	0	0.	0.	0.	0.	0.	0.	0.	4.
A.	0.3	0.	0.3	0.4	0	0.	0.	0.	0.	0.	0.	1.	4.
W. attu	0.1	0.	0.0	0.0	0	0.	0.	0.	0.	0.	0.	0.	1.
T. ilisha	0.0	0.	0.0	0.0	0	0.	0.	0.	0.	0.	0.	0.	0.
C. carpio	3.0	1.	1.6	2.1	2	2.	1.	1.	1.	3.	5.	2.	2
O.	0.0	0.	0.4	0.3	0	0.	0.	0.	0.	0.	0.	0.	4.

Others	5.9	4.	7.3	7.4	4	2.	8.	5.	1.	1.	4.	2.	5
Total	12.	8.	11.	12.	1	10	14	10	7.	7.	11	8.	1
%	9.9	6.	9.5	9.9	8	8.	11	8.	6.	5.	9.	6.	

Table 4: Average monthly contribution (tones) of selected species in landings from river Yamuna at Allahabad (Jan'07-Dec'08)

Species	J	F	M	A	M	J	J	A	S	O	N	D	To
G. chapra	0.	0.	0.	0.	0.	0.	0	0.	0.	0.	0.	0.	2.6
G.	0.	0.	0.	1.	0.	0.	4	0.	0.	0.	0.	0.	9.2
A. morar	1.	0.	1.	0.	0.	0.	0	1.	0.	0.	0.	0.	7.1
S. bacaila	0.	0.	0.	0.	0.	0.	0	1.	0.	0.	0.	0.	4.2
Total	2.	1.	2.	3.	1.	0.	5	3.	0.	0.	1.	0.	23.
%	8.	5.	1	1	8.	2.	2	1	0.	0.	4.	3.	

The others group fishery was maximum in July and after that it had a downward trend, reaching to its minimum in October 1.51t, (Tab. 3). After that it revived and remained at good level till April excepting the month of December.

The monthly contribution of selected species (*G. chapra, G. manmina, A. morar, S. bacaila*) has been presented in Tab. 4. The fishery of these species was of higher order in July and August (5.94t and 3.67t). Post monsoon months contribution was very low (0.14-0.15t). From November onwards with minor ups and down, it again showed another peak in April (3.24t).

Discussion

The decline of the major Indian carp species and dominance of small indigenous fish species (SIS) along with the exotic fishes reflects the ability of these species to colonise the altered habitat conditions prevailing in the river stretch. Previous researchers (Anonymous, 1994–2011; Mishra et al., 2007; Vass et al., 2011) stated that these species are gradually establishing themselves as a breeding population, replacing the major Indian carp species. Kolar and Lodge, 2002 have also indicated that reduced discharges alter the micro and macro habitat character, favoring the increase of non-indigenous species. The present studies revealed the presence of 77 fish species of 10 order and 27 families including six exotic species. Among exotics, four species viz. *C. idella*, *C. carpio specularis*, *H. molitrix* and *H. Nobilis* were rarely seen in catches. On the basis of an exploratory survey of river Ganga, Sinha et al (1998) reported 46 species from Kanpur – Patna stretch of Ganga. Vaas et al (2008) have reported 79 fish species from Kanpur – Farakka stretch of river Ganga. However, Payne et al (2003) stated the presence of only 30 species at Allahabad, this may be due to small number of sampling duration. Fish biodiversity from Allahabad stretch of river Yamuna were estimated with 75 species (CIFRI, 2010) and 62 species was recorded during the 2007-2010 at Allahabad by Sharma et al (2017), which is very close to the present studies. Although no earlier account is available about the ichthyo-biodiversity for Allahabad stretch of river Yamuna but earlier workers have stated it around 70 (personal communication, Ravish Chandra, Pr. Scientist; N.K. Srivastava, Technical Officer, CIFRI, Allahabad). Thus, it could be inferred that there is no loss in biodiversity over the years in qualitative terms, but quantitatively there are remarkable changes.

During different spells the fish landings at Allahabad from selected stretch of river Yamuna have been presented in Fig. 4.

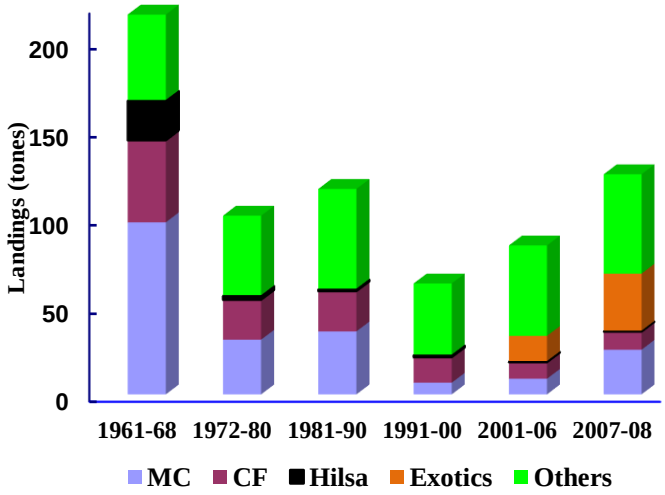

Figure 4: Landings at Allahabad from selected stretch of river Yamuna

It is obvious from the Fig. 4 that during 1961-68 the fishery from river Yamuna at Allahabad was of higher order with annual fish yield rate (Jhingran and Ghosh, 1978) as 46.77 kg ha yr^{-1}. From 1972 onwards fishery from river started declining with sharp changes in stock structure. The major carp fishery followed a constant declining trend till 2006 and their contribution came down to 8.88 t yr^{-1} during 2001-06 from 97.73 t yr^{-1} of 1961-68. However, during 2007-08 the major carp fishery rose to 25.38 t yr^{-1}. The increase may be due to diversion of catches from those areas which were not feeding Allahabad markets earlier or this may be a temporary increase which is a common phenomenon in natural populations. However, this may be studied further carefully. Jha et al (2017) also reported an increasing trend of IMC landing during 2005 to 2015 but landing of IMC had reduced to half in comparison to the time period of 1956-67. The reason for depletion could be attributed to construction of dam and barrages on river Ganga, Yamuna and its tributaries in the upstream, which ultimately led to reduction in volume of water into the Yamuna and Ganga rivers of at Allahabad and also create obstacles for migration of fishes in the river (Gupta and Tyagi, 1992; Vass et al., 2008)

The large catfish fishery also followed the trend of major carps and their contribution slipped to 10.29 t yr^{-1} in 2007-08 from 46.31 t yr^{-1} of 1961-68. *T. ilisha* which used to contribute about 10.4% in total, decline sharply from 1972 onwards and presently contributes only 0.08 t yr^{-1}. However, the others groups fishery fluctuated in a narrow range (40.99 to 56.19 t yr^{-1}) during the entire period and showed an increasing tendency. On the basis of fishing villages survey from Kannauj to Bhagalpur along river Ganga, Tyagi (2005) have shown that the contribution of others group fishery increased from 37.9% in 1960-70's to 80.9% during 2001-03. For Allahabad he has given an estimate of 74%.

From 2001 onwards exotic species started to appear in catches, first the *C. carpio* and then around 2005, *O. niloticus* also seen in catches. Their emergence was so fast that within a spell of eight years, their contribution in total reached to 32.94 t yr^{-1} (*C.* carpio – 28.62t; *O. niloticus* – 4.32t) in 2007-08 and together they formed about 26% of total catches. Masud and Tyagi (2007) have discussed about the emergence of Nile tilapia (*O. niloticus*) in lower stretch of river Yamuna.

As far as fishery of four studied species from the lower stretch of river Yamuna is concerned, no information is available, excepting little information for *G. Chapra* (Jhingran, 1966). He has estimated the landings of *G. chapra* at 2.88t per year for the period 1958-62 from the lower stretch of river Yamuna. The present estimate stood at 2.64t per year which is close to estimate given by Jhingran (1966). This may be the case with rest of the three species and it could be inferred that in spite of declining trend in fishery these species maintained their production level.

Vass et al (2008, 2010a, 2010b, 2011), Pathak and Tyagi (2010) have discussed the ecology, fish and fisheries of Indian rivers and discussed the probable reasons for declining fisheries. The measures to mitigate the situation have also been suggested. Vass et al (2008) have stated that due to heavy deforestation and other developmental activities in the catchment area silt load tremendously increased in Ganga at Allahabad and Varanasi. Such huge loading of silt resulted in severe hydrological degradation like in water holding capacity and volume in the river. As a result, many wetlands lost connection with the main channel and some of them even lost their existence due to choking. Although no such information is available for river Yamuna but situation remains almost same for Yamuna.

Another important reason for declining fishery may be water abstraction. The main decline in fishery started around 1965-70, the period when some of the important water abstraction projects were in final stage. Number of dams/barrages has been constructed on other important tributaries of Yamuna. Dams/barrages regulate the flow and due to regulated flow, the timing, extent and duration of floods is altered. The changed hydrological scenario badly hampers the breeding and recruitment process in rivers Vass et al, 2010a, 2010b, 2011). Spawn prospecting investigations in river Yamuna at Allahabad has shown a drastic decline in spawn quality index, which came down from 75.6% in 1976-80 to 37.6% in 1991-97. Index of quantity also declined from 1065 to 420 ml (Dwivedi and Tyagi, 1999).

Introduction of exotic fish have been reported to impact the fish biodiversity and cause various effects on environment, posing threats to community trophic structure disrupting biological integrity (Casal, 2006; De Silva et al, 2006; Rowe, 2007; Lakra et al, 2008). It has also been realized that the nature and extent of such changes being complex remains unpredictable. Exotic species may become invasive and are capable of spreading diseases, decreasing biodiversity through competition, predation and habitat degradation, genetic deterioration of wild populations through hybridization and gene introgression in short or long course of time (Casal, 2006; Lakra et al, 2008).

The domination of *C. carpio* and *O. niloticus* in catches from river Yamuna needs immediate attention as it has been identified as one of the most ecologically detrimental of all freshwater invasive fish species (Jha et al 2016). The dominance of common carp observed in present study leaves no place of doubt that they have occupied the natural habitat of our indigenous carps. To combat the situation multidiscipline program is need of hour and efforts may be made towards restoration and conservation of natural habitat of indigenous carps and other fishes of significance from river Yamuna.

The decline in fisheries is a common problem in almost all Indian rivers. The decline has put a serious impact on livelihood basket of fishers, up to the extent that they are forced to leave the fishing as an occupation. On the basis of socio-economic survey of fishers of Ganga, Tyagi (2005) have shown that around 75% riverine fishermen population was below poverty line and they were poorest among poor.

The small indigenous fish species may be potential species for the future fishery from the system. For the proper development of fishery of these species, they should be given a chance to breed at least once. For these restrictions should be imposed on use of smaller mesh sized gears. As all these species breeds mainly with the onset of monsoon, fishing may be restricted during the period.

Conclusion

The contribution of small indigenous fishes (SIS) towards the overall fish landing, are considered to be the major catch of the river Ganga. In addition to the numerous challenges that are being posed by the climate and the habitat changes, overexploitation of fish stocks through indiscriminate fishing operations creates a massive threat to these small indigenous fishes (SIS). SIS are highly nutritious (Masud and Haldar 2016,2017) and may be a potential and alternate source of IMCs and various potential fish products. High food value of SIS, may be developed with amalgamation of phyto-protein to uplift the socio-economic condition of fishermen community as suggested by Rizvi et al (2011).

The invasion of exotic fish species in the nutritional system may be detrimental to the studied species SIS. As both exotic species are omnivorous in nature and provides tough competition to the comfortable food. Further, these exotics fishes are destructive to the planktonic nature of water that provides continuous foods to the fishes for e.g. *C. carpio* uproots the aquatic vegetation of ponds. Thus, it will destroy the breeding grounds of studied species (SIS) which breeds mainly in marginal areas of river with its vegetation. Measures also should be taken to control the further development of exotic species in the system. Furthermore, the restriction of using small mesh-mosquito nets is required since these nets result in a significant reduction of the population of potential juvenile fishes before they reach to the full biological maturity. The findings of the present investigation might be very helpful in planning fishery development programme of freshwater river tribunes. This would not only boost up the economy of the nation but will also save the fish genetic resources from the verge of extinction. It is therefore need of the hour, that fish breed planners should look into the “particular water” requirement for the SIS fisheries sector while planning water requirement for other fishery sectors. Unfortunately, till date, it has almost been ignored.

Furthermore, sustainable exploitation of inland fisheries through effective resource management studies may contribute to overall improvement of SIS production, which can offer an integrated approach towards the future livelihood and nutritional status of fishermen.

References

1. Anonymous, 1994–2011. Annual Reports, Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India.
2. Casal, C.M.V. 2006. Global documentation of fish introductions: the growing crisis and recommendations for action. *Biological Invasions*, 8: 3-11.
3. CIFRI. 2010. Assessment of fisheries with regard to water quality in the river Ganga and Yamuna. Final Report Submitted to Central pollution Control Board, New Delhi.
4. Day, F. 1878. The fishes of India; being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon. Reprinted by Today and Tomorrow Publishing House, pages 778+ pls 195.
5. Day, F. 1889. The fauna of British India including Ceylon and Burma. London, 1: 375 pp.
6. De Silva, S.S., Nguyen, T.T.T., Abery, N.W. and Amarsinghe, U.S. 2006. An evaluation of the role and impacts of alien finfish in Asian inland aquaculture. *Aquaculture Research*, 37: 1-17.
7. Dwivedi, R.K. and Tyagi, R.K. 1999. Spawn prospecting and fisheries from river Yamuna - a case study, In: Sinha, M., Kumar, D. and Katiha, P.K. (eds.) Eco-Friendly Management of Resources for Doubling Fish Production - Strategies for 21st Century, Proc. of the National Seminar, Dec 22-23, 1999, Inland Fisheries Society of India, Barrackpore, 149-152.
8. Gupta, R. A., & Tyagi, R. K. 1992. Analytical approach to analysis of fish stocks of the Ganga River system. Journal of Inland Fish Society of India, 24(2), 20–27.
9. Jayaram, K.C. 1999. The freshwater fishes of the Indian region. Narendra Publishing House, Delhi: 551 pp.
10. Jha, D. N., Joshi, K. D., Alam, M. A., Das, S. C. S., Kumar, V. 2016. Dominance of exotic fishes in the River Ganga at Allahabad stretch. Journal of the Kalash Science,4 (2), 1-6
11. Jha, D. N., A. Alam, S. C. S. Das, V. R. Thakur, J. Kumar, Monika Gupta, Srivastava, R. S. and B. K. Das 2020. Chronological variation in landing of Indian Major Carp (IMC) of Ganga River. World Water Policy 6(1):142-151. DOI:10.1002/wwp2.12027.
12. Jhingran, A.G.1966. Studies on biology and fisheries of the clupeids Setipinnna phasa (Hamilton) and Gudusia chapra (Hamilton) in the Ganga river system. D. Phil. thesis, University of Allahabad.
16. Jhingran, V.G., 1975. Fish and fisheries of India, Hindustan Publication, New Delhi.
17. Jhingran, A.G and Ghosh, K.K. 1978. The fisheries of the Ganga River system in the context of Indian aquaculture. *Aquaculture*, 14: 141-162.
18. Jhingran, V.G. 1991. Fish and fisheries of India. Hindustan Publishing Corporation, India: 727 pp.
19. Khan, M.A., Panwar, R.S., Mathur, A.K., Rekha, 1995. Final Technical Report on "Investigations on biomonitoring and ecorestoration measures in selected stretches of the rivers-Ganga and Yamuna", Ganga Project Directorate, Ministry of Environment and Forests, New Delhi.
20. Kolar, C.S. and D.M. Lodge, 2002. Ecological predictions and risk assessment for alien fishes in North America. Science 298:1233-1236.
21. Lakra, W.S., singh, A.k. and Ayyappan, S. 2008. Fish introductions in India: Status, potential and challenges. Narendra Publishers, New Delhi, India.
22. Masud, S., 2013. Studies on biology and fishery of some carp minnows in lower stretch of river Yamuna, At Allahabad. D. Phil. Thesis, University of Allahabad.
23. Masud, S. and Haldar, C. 2017. Evaluation of nutrient composition and mineral content of traditionally dried small indigenous fishes. *Flora and Fauna*, Vol. 2 (2): 423-431.
24. Masud, S. and Haldar, C. 2016. Critical Appraisal of Nutritional Values of SIS. BHU Press, Varanasi, ISBN No. 81-85305-72-2, 125-138 pp.
25. Masud, S. and Singh, K.P. 2014. Assessment of fish biodiversity and their conservation from the lower stretch of the Yamuna River at Allahabad, Uttar Pradesh. J. Kalash Sci., 2 (1), 53-58.
26. Masud, S. and Tyagi, R.K. 2007. Emergence of Nile tilapia in lower stretch of river Yamuna. *National Seminar on Ecosystem Health and Fish for Tomorrow*, Barrackpore, 14-16 Dec'07. (Abstract).
27. Mishra, D.N., Moza, U., Lakra, C., Kumar, S. 2007. Time scale changes in fisheries of river Yamuna. J. Inland Fish. Soc. India 32(2), 48–52.
28. Moza, U., Mishra, D.N. 2001. Evaluation of fish biomass and community structure in the context of environmental modifications in upper stretch of river Yamuna. Appl. Fish. and Aquaculture 1(3), 17–21.
29. Moza, U., Mishra, D.N. 2003. Eco dynamics and fishery status of upper stretch of river Yamuna and associated canals. Bulletin No. 123. Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India
30. Pathak, V. and Tyagi, R.K. 2010. Riverine ecology and fisheries vis-à-vis hydrodynamic alterations: Impacts and remedial measures. *CIFRI Bull*, 161: 33 pp.
31. Payne, A.I., Sinha, R., Singh, H.R. and Huq, S. 2003. A Review of the Ganges Basin: Its fish and fisheries. Paper presented in the Second Large Rivers Symposium, Phnom Penh, Cambodia, 11-14 February, 2003: 229-251.

32. Rizvi, A.F., Singh, K.P. and Kumar, N. 2011. Population dynamics of non-commercial fishes in rivers around Allahabad and possibility of their commercialization to enhance socio-economic status of fisherman. Nat. Acad. Sci. Lett., 34 (11 & 12): 437-448.
33. Rowe, D.K. 2007. Exotic fish introductions and the decline of water clarity in small North Island, New Zealand lakes: A multi-species problem. Hydrobiologia, 583(1): 345-358.
38. Sharma, A. P., Das, M.K., Vass, K. K. and Tyagi, R. K. 2017. Patterns offish diversity, community structure and ecological integrity of River Yamuna, India. Aquatic Ecosystem Health & Management20(1-2), 30-42.
39. Sinha, M., De, D.K. and Jha, B.C. 1998. The Ganga – Environment and fishery. CIFRI publication, Barrackpore: 142 pp.
40. Tyagi, R.K. 2005. Final report on APCESS Scheme "Techno-socio-economic status of fishers of river Ganga. *CIFRI*: 83 pp.
41. Tyagi, R.K. and Mandal, S.K. 2008. Sampling methodologies for estimation of inland fish catch in India. CIFRI, Barrackpore, W.B.: 71 pp.
42. Vass, K.K., Das, M.K, Tyagi, R.K., Katiha, P.K., Samanta, S., Shrivastava, N.P., Bhattacharya, B.K., Suresh, V.R., Pathak, V., Chandra, G., Debnath, D. and Gopal, B. 2011. Strategies for sustainable fisheries in the Indian part of the Ganga – Brahmaputra basins. Int. J. Eco. and Env. Sc., 37: 157-218.
43. Vass, K.K., Mondal, S.K., Samanta, S., Suresh, V.R. and Katiha, P.K. 2010a. The environment and fishery status of the river Ganges. *Aquat. Ecosyst. Health Manag*., 13: 385-394.
44. Vass, K.K., Tyagi, R.K., Pathak, V., Singh, H.P. and Seth, R.N. 2008. The status of the river Ganges in the middle stretch. *CIFRI Bull*, 154: 25 pp.
45. Vass, K.K., Tyagi, R.K., Singh, H.P. and Pathak, V. 2010b. Ecology, change in fisheries, and energy estimates in the middle stretch of the river Ganges. *Aquat. Ecosyst. Health Manag*., 13: 374-384.