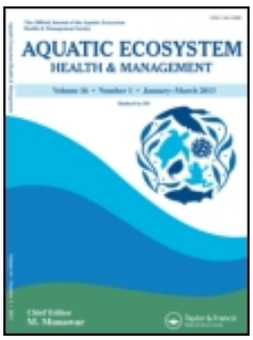

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Invasion and impacts of alien fish species in the Ganga River, India

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*In this study, we document an increasing trend of catches of alien fish species from the Ganga River system. The changing fishery during 1980 to 2011 and the fish yield rate (kg km^{-1}) are positively correlated with an invasion coefficient index (I_{xi}) of alien species within the river. The reproductive propagule pressure (PPP) of alien fishes (*Cyprinus carpio, Oreochromis niloticus, Aristichthys nobilis, Ctenopharyngodon idella, Hypophthalmichthys molitrix and Clarias gariepinus) *was determined and found to be 19.45×10^6 for* C. carpio*, 0.33×10^6 for* O. niloticus *and 0.82×10^6 for* A. nobilis *at confluences suggesting that these alien species may be migrating into new habitats. Further, these invaded species exhibited all reproductive stages, indicating their likely establishment within the river. The trophic spectrum of alien fishes spanned all levels and the gut repetitive index (GRI) indicated that that food items in most of the fishes were similar showing early trends of food-web alteration and biotic homogenization. The results of this study suggested a continuous decline in the catch of local fishes by wet weight, particularly Indian major carps (IMC) from 128.91 kg km^{-1} to 38.58 kg km^{-1} owing to increased catches of alien species from nil to 384.27 kg km^{-1}. Invasion of alien species in the Ganga River represented one of many possible causes of the decline in river health and overall loss of native aquatic communities.*

Keywords: aquatic biodiversity, risks and impacts, aquatic health

Introduction

The Ganga River harbors a rich fish diversity, with 34 commercially important species, including Gangetic Carps, Large Catfishes, Featherbacks, and Murrels (Rao, 2001; Vass et al., 2010; Singh et al., 2010). Recent studies of Central Inland Fishery Research Institute (CIFRI), Barrackpore, Kolkata, India revealed the presence of 79 native fish species belonging to seven orders and 25 families in the stretch between Kanpur to Farakka (Vass et al., 2010). The Ganga River supports fishery resources and contributes to the riparian communities and the national economy (Rao 2001; Vass et al., 2010). Commercial fishing activity in the Ganga River is mainly observed in downstream of the river in the State of Uttar Pradesh, Bihar and West Bengal (Vass et al., 2010).

In India, inland aquaculture though predominantly carp farming is rapidly changing, mainly due to famers wishing to diversify their operations by using fast growing alien species (Singh and Lakra, 2011). Alien fishes are favoured because of higher production (fishery yield) and the need to meet the demands of changing market patterns. Cultured alien fishes such as Thai-pangus

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(*Pangasianodon hypophthalmus*), African Catfish (*Clarias gariepinus*), Red-Tilapia (*Oreochromis niloticus*), Red-Bellied-Pacu (*Piaractus brachypomus*) and Bighead (*Aristichthys nobilis*) are raised commercially both for domestic consumption and export (Singh and Lakra, 2011). Many of these species were originally introduced illegally for aquaculture purposes, but have subsequently spread to many other watercourses, presumably due to natural dispersal and human activity. These species have the ability to establish, invade and compete with native fishes leading to high abundance in the new environments following their introduction (Lakra et al., 2008; De Silva et al., 2009). Given their wide ecological niche, they also have potential to establish within most ecosystem types (De Silva et al., 2009). Impacts attributed to these species appear to be diverse. Potential confounding factors have been considered to influence the likelihood of successful establishment of alien species which have potential to disrupt the biological integrity of the Ganga River (Singh et al., 2010; Singh and Lakra, 2011). Many of the species affect biological diversity and strongly influence surrounding native fishes; thus, they are considered invasive in Indian waters (Garcia-Berthou, 2007; Singh and Lakra, 2011). Given the significant irreversible environmental and socio-economic damages at the genetic, species and ecosystem levels caused by invasive fishes (De Silva et al., 2009; Singh and Lakra, 2011), quantifying their incidence and impacts is an utmost fisheries management priority. Therefore, our aim is to document the distribution of alien fish species in the Ganga River, to assess their ecological impact as reflected by potential declines in native fishes, and to identify proposed actions for effective management.

Status of freshwater fishes in the Ganga River

Current state of knowledge of freshwater fish diversity

The study was conducted in lower Ganga from Kanpur to Ballia, which covers a river reach of approximately 250 Km (Figure 1). The river in this reach is wide with extensive flood plains. In the headwater areas, human population density is low. As river order increases, so do human populations and anthropogenic activities near the watercourse.

The fish fauna in this middle stretch of the Ganga River is dominated by Indian major carps, catfishes, and other miscellaneous fishes (Vass et al., 2010); however, the mainstays of the fisheries in this region are species belonging to the family Cyprinidae and Siluridae. Overall, 140 fish species have been documented in the river (Sinha, 2006; Lakra et al., 2010). However, we have documented that a total of over 69 fish species exists in the relatively small stretch between Kanpur to Ballia of the Ganga River through our filed surveys and sampling works. In this study, we have calculated different taxonomic groups of food items in the gut of fishes, identified, counted, and the food richness, diet breadth, and gut repetative index (GRI%) was determined using the Simpson's diversity index (Singh et al., 2010). The trophic chain appears to be significantly disturbed since the gut repetitive index (GRI) of local and alien species were found to be more or less similar. Trends in fishery landings also indicate the increased distribution and abundance of invasive fishes and confirm catches during commercial operations (Figure 2).

Current status of alien fish species in Ganga River

The middle stretch of River Ganges flows through the states of Uttar Pradesh and Bihar before draining into the Bay of Bengal (Vass et al., 2010). In the present study, results of sampling from the river region between Kanpur to Ballia recorded an increased yield of alien species in the River. The highest yield of alien species was found 384.27 kg km^{-1} between Allahabad to Varanasi (Figure 3). The invasion coefficient index of alien species at different sampling stations along the river was further recorded. Based on the location specific fish diversity and the total number of exotic fish species observed, the invasion coefficient index (I_{xi}) was calculated using the formula:

$$I_{xi} = \frac{En}{N}$$

Where I_{xi} was invasion coefficient index; *En* was number of exotic fish species captured at each study site and *N* was number of all the fish species caught at the sampling site. I_{xi} represents the level to which local fish species have been invaded by alien species. Index 0 shows minimum level of loss to the fish

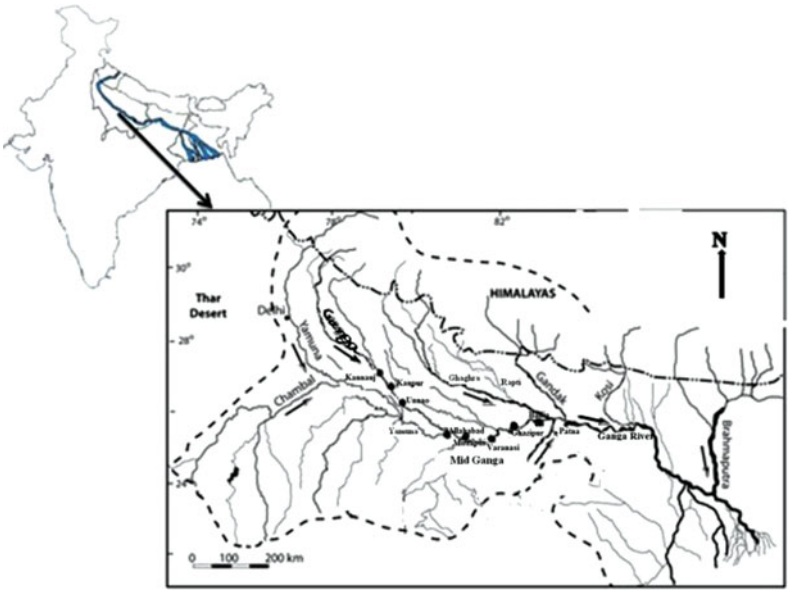

Figure 1. Location of mid Ganga where data was collected. (Color figure available online.)

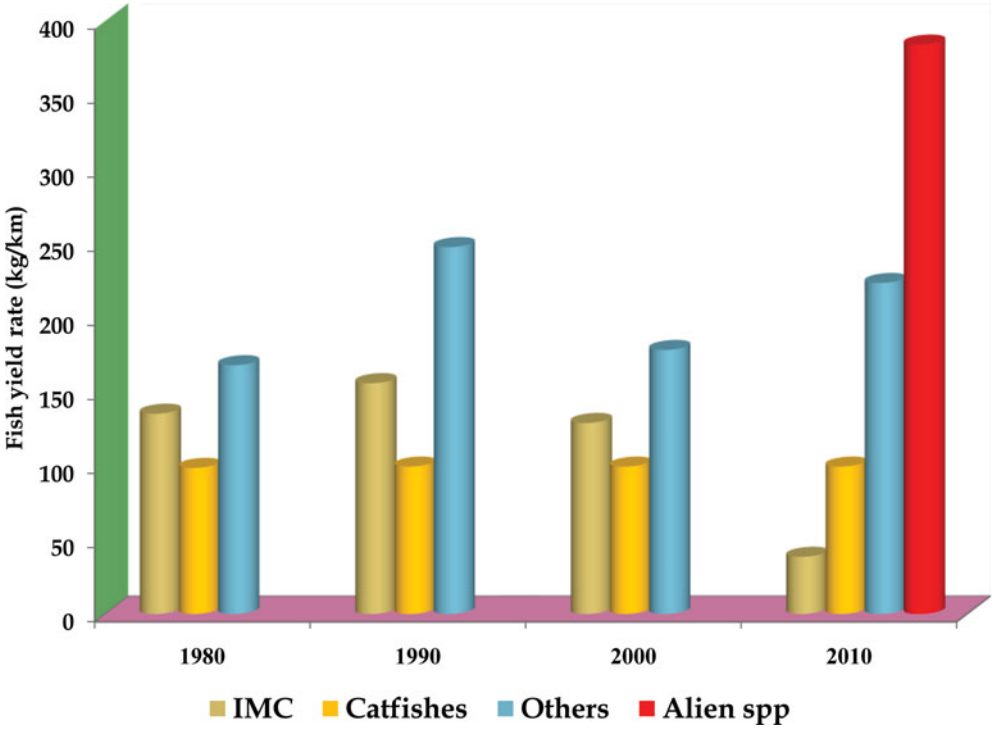

Figure 2. Fish yield rate (kg km^{-1}) in the middle stretch of the Ganga River between 1980 and 2010 (IMC = Indian major carps). (Color figure available online.)

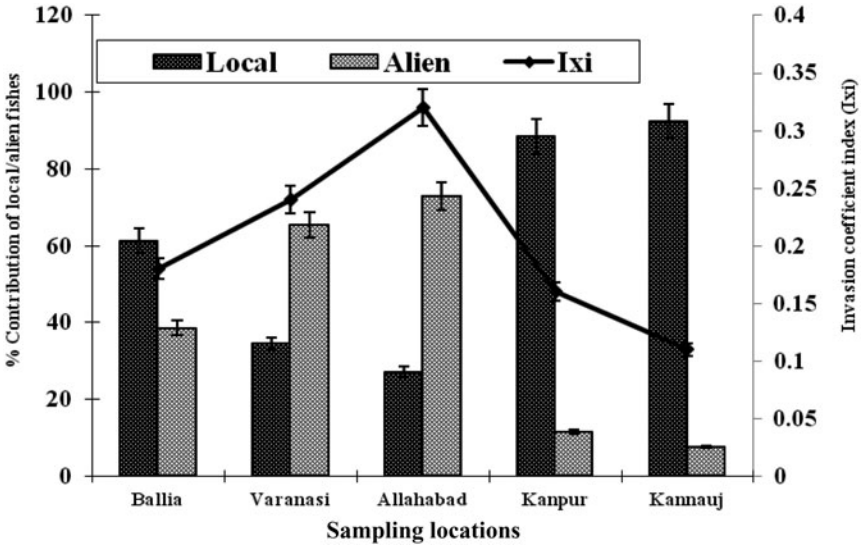

Figure 3. Fisheries contribution of local and alien fish species at different sampling locations in the Ganga River.

diversity and 1 represents the highest degree of invasion consequently loss to the biodiversity.

The propagule pressure of invaded alien species was determined as the number of mature female alien fishes captured and the absolute fecundity. The reproductive propagule pressure of six alien fishes (*Cyprinus carpio, Oreochromis niloticus, Aristichthys nobilis, Ctenopharyngodon idella, Hypophthalmichthys molitrix* and *Clarias gariepinus)* has been high, mostly at confluences of the river stretches such as Ganga and Yamuna at Allahabad suggesting that these alien species prefer to migrate into new habitats (Table 1). The reproductive staging of these six alien species has also been determined in the Ganga River and we have found that all reproductive stages (Singh et al., 2010) along with incidence of fry and juveniles have been present confirming their establishment in the river.

Further, to assess the link between propagule pressure and aquaculture, we have conducted a bench mark survey at fish seed markets to collect information on availability of fry and fingerlings of invasive fishes. These results indicate that that over 34.6% fish seed markets have been saturated with fry and fingerlings of alien fish species. The rapid expansion of culture of alien species is likely to have facilitated the escapement of these alien fishes into natural water bodies, including the Ganga River system in large areas. While aquaculture promises economic and social benefits, aquaculture escapee poses strong ecological risks to their recipient aquatic environments (Singh and Lakra, 2011).

Invasion, risks and impacts of alien species

The impact of introduced fishes in the middle stretch of the Ganga River was assessed with the Fish Invasiveness Screening Test (FIST; Singh and Lakra, 2011). The FIST includes factors contributing to invasiveness, such as the ability of the alien fish to reproduce naturally, dispersal ability, rapid growth, phenotypic plasticity (tolerance of range of salinity and temperature), breadth of food niche,

Table 1. Reproductive propagule pressure (PPP) of invasive fish species in the Ganga River.

Exotic fish Species	Reproductive propagule pressure (PPP) $\times 10^6$ in the Ganga River	
	At confluences	Main river stream
Cyprinus carpio	19.458	11.19
Oreochromis niloticus	0.33	0.09
Aristichthys nobilis	0.82	0.27
Ctenopharyngodon idila	0.56	0.17
Hypophthalmichthys molitrix	0.342	0.11
Clarias gariepinus	0.03	0.013

Table 2. Impact summary of alien fishes in the Ganga River.

Fish species	Potential impacts
Aristichthys nobilis	Banned species in India. Has initiated displacement of *Catla catla* leading to declining commercial catches. Possibility of natural hybridization of *A. nobilis* with *Catla catla.*
Cyprinus carpio	Naturalized population has led to declines of Indian major carps from the Ganga River contributing to increased production of *C. Carpio* from the river.
Oreochromis niloticus	Naturalized breeding population of tilapia in rivers is causing declined catches of Gangetic carps but positively contributing towards overall production of the Ganga River.
Clarias gariepinus	Highly carnivorous causing loss to biodiversity. Naturalized in some small streams connecting rivers, Ganga River.
Hypophthalmichthys molitrix	Naturalized population is adversely competing with *Catla catla*.
Gambusia affinis	Its presence has reduced natural zooplankton population thereby likely displacing many local fish species.
Pterygoplichthys perdalis and *P. disjunctivus*	Breeding has been documented. Known invader as determined by FIST.

and other characteristics (Singh and Lakra, 2011). The invasiveness and level of risks have been determined by marking score on a scale of 1 to 5 as per available prior information (i.e., through literature searches) and through data collected in the field (Figure 4). These data have been analysed in a FIST modules developed for Microsoft Excel to determine the threat levels (Figure 4). African Catfish has been found to score highest (105) showing high risks, followed by Common Carp which has scored 88 while Silver Carp and Bighead have scored 79 points; Gambusia 77 points and Tilapia 70 points.

The impact assessment of the alien species has documented a continuous decline in the catch of local fishes, particularly Indian major carps and some others (Figure 2). The plasticity of the introduced fish species to thrive in degraded aquatic habitats or otherwise has been documented since the water quality of the Ganga River has been deteriorating over the past couple of decades (Rao, 2001; Vass et al., 2010). Potential confounding factors such as declining water quality and increased trend of aquaculture diversification with alien fish species have been identified as important reasons possibly influencing the likelihood of successful establishment of alien species and consequently disrupting the biological integrity (Table 2). Impact assessment of alien fish has been considered as one of the core elements for protecting fish biodiversity and food safety. The risk assessment results through FIST revealed a high level of threats for African Catfish, however its low incidences in the Ganga River still leaves scientists with opportunity to take eradication or control measures and appropriate management action. On the other hand, high incidences of invasion and considerable commercial catch of Tilapia and Common Carp were noted. These catches are alarming because tilapia exhibit sparse culture prevalence in the region of interest, but despite low abundances, the fish has become important pest.

Management implications

With the development of aquaculture in India during last few decades, it has been difficult to avoid introduction of alien species since they often command a higher market price than native fishes in international markets (De Silva et al., 2009). At present the aquaculturists prefer alien fish species because basic information and culture techniques are available for them and it is easy to adopt them to

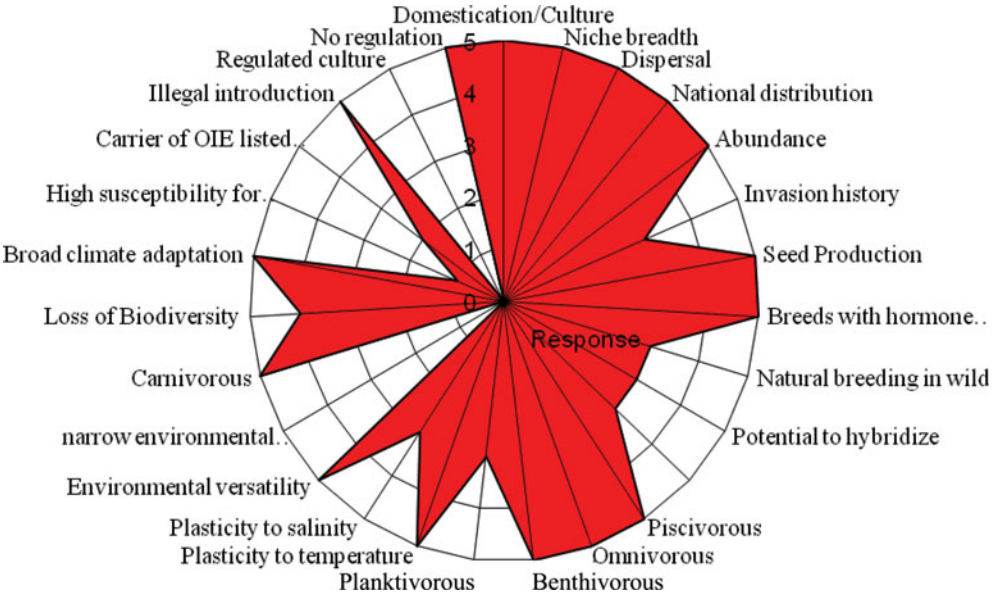

Figure 4. Risk assessment model based on scoring system, values from 0 to 5 represent ranked threats for each categorical assessment. Higher proportions of dark colouration within the graph represent higher threat assessment. Results shown represent FIST scores for African Catfish. (Color figure available online.)

be competitive within international markets. Over the last two decades, the aquaculture entrepreneurs and farmers have been demanding importation of many new fish strains and varieties for improved production and competition in global markets. However, environmental, socio-economic and biodiversity issues have been the important considerations for authorities when determining the impact of these activities. There is a National Committee for Introduction of Exotic Aquatic Species in Indian Waters under the Union Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries,

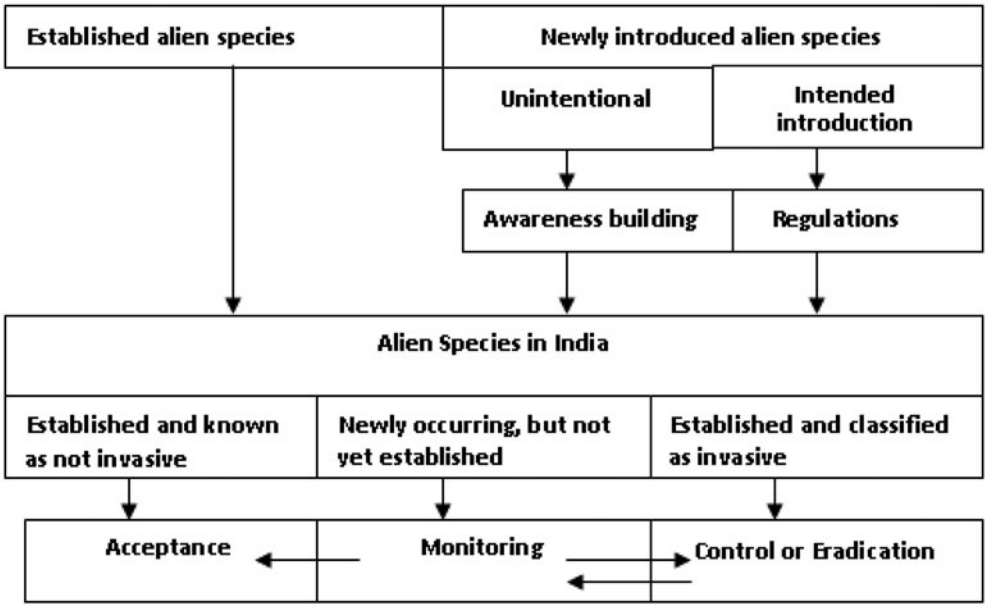

Figure 5. Modality to handle the issues of alien fish introductions.

New Delhi to check and regulate importation of alien fishes in India. However, there is no legislation or policy to deal with the invasive species other than the Strategic Guidelines and National Plan on Introduction of Aquatic Exotics in India developed by the National Bureau of Fish Genetic Resources, India. Here, we propose one method to manage the import, and management of introduced fishes in India (Figure 5).

At the national level, quarantine and health certification programmes have been initiated as an integral part of much broader strategies aimed at protecting the natural environment and natural faunas from the deleterious impact of alien fish species. Species-specific guidelines have also been developed particularly for introduction of *O. niloticus, P. hypophthalmus* and *Litopenaeus vannamei*. The quarantine facility required for alien fish species introduction has also been designed and can be adopted under public–private partnership mode. Considering the negative impacts of alien fishes on biodiversity, stringent regulations are imperative and all introductions must pass through the National Committee on Introduction of Aquatic Species in Indian waters after risk assessment before import. The aquaculturists and farmers have been advised to comply with the available regulatory mechanisms for all alien fish species along with strict conditions of sanitary and phyto-sanitary standards.

Conclusions

The threats and the ecological impacts due to the rapid spread of alien fishes in the Ganga River are especially alarming given global concerns about the conservation of the fish biodiversity (Garcia-Berthou, 2007; De Silva et al., 2009; Singh and Lakra, 2011). Introduced alien fish have caused strong community changes in aquaculture (Garcia Berthou, 2007; Singh and Lakra 2011) and elsewhere within naturalized communities. The role of alien species in aquaculture has been dealt on global and regional scales (De Silva et al., 2006, 2009) and a number of invasions by freshwater alien fishes have been reported including India (Singh and Lakra, 2011) suggesting a precautionary approach during the import and introduction of additional species for aquaculture. Introduced fishes represent both a symptom and a cause of decline in river health and the integrity of native aquatic communities. This study indicates that future management actions are warranted to reduce the social and ecological impacts of invasive fishes in India.

Acknowledgements

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References

De Silva, S.S., Nguyen, T.T.T., Abery, N.W., Amarasinghe, U.S., 2006. An evaluation of the role and impacts of alien finfish in Asian inland aquaculture. Aquaculture Research 37, 1–17.

DeSilva, S.S., Nguyen Thuy, T.T., Turchini, G.M., Amarasinghe, U.S., Abery, N.W., 2009. Alien species in aquaculture and biodiversity: a paradox in food production. Ambio 38, 24–28.

Garcia-Berthou, E., 2007. The characteristics of invasive fishes: what has been learned so far? Journal of Fish Biology 71(Suppl D), 33–55.

Lakra, W.S., Singh, A.K., Ayyappan, S., (Eds) 2008. Fish Introductions in India: Status, Potential and Challenges. Narendra Publishing House, New Delhi.

Lakra, W.S., Uttam Kumar, Sarkar, Rupali Sani, Kumar, Ajay, Pandey, Vineet Kumar, Dubey, and Om Prakash, Gusain, 2010. Fish diversity, habitat ecology and their conservation and management issues of a tropical River in Ganga basin, India. The Environmentalist 30(4), 306–319.

Rao, R.J., 2001. Biological resources of Ganga River, India. Hydrobiologia 458, 159–168.

Singh, A. K., Lakra, W. S., 2011. Risk and benefit assessment of alien fish species of the aquaculture and aquarium trade into India. Reviews in Aquaculture 3, 3–18.

Singh, A.K., Pathak, A.K., Lakra, W.S., 2010. Invasion of exotic fish-common carp, *Cyprinuscarpio* L. (Actinopterygii: Cypriniformes: Cyprinidae) in the Ganga river and its impacts. Acta ichthyologica et piscatorial 40, 11–19.

Sinha, M., 2006. Riverine Fisheries of India. In: S. Ayyappan, J. K. Jena, A. Gopalakrishnan, A. K. Pandey (Eds.), *Handbook of Fisheries and Aquaculture*, p 142–157. ICAR Publication, New Delhi.

Vass, K. K., Mondal, S. K., Samanta, S., Suresh, V. R., and Katiha, P. K., 2010. The environment and fishery status of the River Ganges. Aquatic Ecosystem Health and Management 13(4), 385–394.