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Characterization and role of non-native fishes (*Cyprinus carpio, Oreochromis niloticus*) from the middle stretch of the Ganga river, India: Current knowledge and research needs

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Abstract

Riverine ecosystems are presently unique opportunity to employment of youth and fishers community in the Ganga basin, India. Present study was undertaken to fish catch from the middle stretch of the Ganga river at Allahabad (now Prayagraj), India during July 2014 to June 2016. In case of July 2014 to June 2015, annual fish landing demonstrated that the catch was dominated by miscellaneous group with 23.19% (22.16 kg day-^{1}) followed by *Oreochromis niloticus* with 13.36% (12.76 kg day-^{1}) and *Sperata seenghala* with 13.21% (12.63 kg day-^{1}). While in case of July 2015 to June 2016, the estimated annual catch was dominated by miscellaneous group followed by *Cyprinus carpio* and *O. niloticus*. They accounted for 19.09%, 15.50% and 14.56%, respectively. The landing of fishes fluctuated from year to year from the Ganga river at Allahabad, India. The landing of *C. carpio* and *O. niloticus* shared greater in 2015 to 2016 (19.22 kg day-^{1}, 18.05 kg day-^{1}) compared to in 2014 to 2015 (7.82 kg day-^{1}, 12.76 kg day-^{1}), respectively. In case of Indian Major Carps (IMC), *Cirrhinus mrigala* was shared maximum contribution in both years. Both species, *C. carpio* and *O. niloticus* are fully help in increasing of the total landing and also increase the income of the fishers from the Ganga river. For conservation point of view, *C. carpio* and *O. niloticus* species should be monitored in the Ganga river. Both species are very harmful for indigenous species especially commercially important fishes from the Ganga river ecosystem. Our results have implications for assessing the invasive fish species role and utility from the Ganga river system.

Keywords: *Cyprinus carpio, Oreochromis niloticus*, Ganga river, Ganga basin, fish landing

Introduction

Riverine fishery is sustaining nutrient food for poor human being and fisher community through especially trace fishes (Smith *et al*. 2005, Rizvi *et al.* 2010, Dwivedi *et al.* 2014). Human activities have powerfully changed productivity or landing and species richness of the freshwater ecosystems (Example streams, rivers, reservoirs) over the world (Argent *et al* 2003, Cooke *et al*. 2005, France & Duffy 2006, Pathak *et al* 2015, Toussaint *et al.* 2016, Nautiyal & Dwivedi 2019, Ujjania & Soni 2020, Choudhary *et al.* 2023, Kumar *et al.* 2023). The Ganga river is the largest river system in Asia that harbors richest fish diversity in Indian subcontinent (Bilgrami *et al.* 1992, Pathak *et al.* 2011a, Tripathi *et al.* 2015, Mayank *et al.* 2015a, Dwivedi *et al.* 2016a, Das *et al.* 2023). The Ganga river fishery resources also provide a wide range of other ecosystem services (Pathak *et al.* 2014a, 2014b, Dwivedi *et al.* 2016b, Dwivedi & Mayank 2017, Gopesh *et al*. 2021). The Ganga river also supports small aquatic ecosystem for their flora and fauna diversity. Tremendous alterations have been registered on the Ganga river due to multifarious stressor operating in the river (Jha *et al.* 2016, Gupta *et al.* 2022, Swain *et al* 2021).

The landing of the middle stretch of Ganga river has rapidly changed at Allahabad centre due to powerfully invasion of *Cyprinus carpio* (Common carp) and *Oreochromis niloticus* (Nile Tilapia). Indian major carp (IMC) *Catla catla, Labeo rohita, Cirrhinus mrigala*, catfishes such as *Sperata aor*, *S. seenghala*, *Wallago attu*, *Rita rita*, *Clupisoma garua*, *Eutropiichthys vacha* and two exotic fish species common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) are commercially exploited by fishers from the landing of the Ganga river at Prayagraj, Uttar Pradesh (Gupta & Tyagi 1992, Singh *et al.* 1998, Dwivedi 2009, Dwivedi & Mayank 2013,

Dwivedi & Nautiyal 2013, Tripathi *et al.* 2015, Mayank & Dwivedi 2015b, Tripathi *et al.* 2023) and its tributaries (Mayank & Dwivedi 2015a, Pathak *et al*. 2011a, Dwivedi *et al.* 2016c, Kumar *et al.* 2023).

C. carpio and *O. niloticus* are exotic\alien fish species for India. The exotic fishes have been introduced mainly for food aquaculture (Gozlan 2008, Pathak *et al.* 2011b, 2014a, Dwivedi *et al.* 2014). Biological invasions are now considered a major environmental issue of public and scientific apprehension (Gozlan *et al.* 2010, Yakubu *et al.* 2011, Dwivedi *et al.* 2014, Tiwari & Dwivedi 2014). The landing of fishes from the Ganga river has been observed to be declining order compared to earlier data (Pathak *et al* 2015). Inland fisheries and aquaculture in European country has been also altered rapidly (Cowx 2015).

In specific, *Cyprinus carpio* is a commonly considered to be one of the most ecologically damaging fish species globally (Zambrano *et al.* 2001, Nautiyal & Dwivedi 2019, Mishra *et al* 2021, Tessema *et al* 2020). It is commonly called an ecological pest because it can change ecological characteristics (Example feeding ground, food supply, breeding ground, Oxygen level, Total dissolved solid) of aquatic ecosystems (Dwivedi *et al.* 2017, Kottelat & Freyhof 2007, Mayank *et al.* 2021). In natural water bodies, *C. carpio* can survive in very low water temperature and it can tolerate low concentrations and supersaturation of dissolved oxygen (Bajer *et al.* 2009, Jackson *et al.* 2010). *C. carpio* is preferred larger and slow-moving water bodies with soft sediments (Balon 1995, Mishra & Dwivedi 2020). It is a tolerant and resilient fish species that thrive in a wide variety of aquatic habitats (Froese & Pauly 2002, Dwivedi *et al.* 2009, 2016d).

In general, *Oreochromis niloticus* (Nile tilapia) is eminent for their plasticity in survival (Example due to its ability to tolerate a wide range of environmental conditions and ability to feed at different trophic levels), feeding nature, fast growth, tolerance, high resistance to diseases, easiness of breeding and lowest size-at first maturity (Absar *et al.* 2015, Tripathi *et al* 2017a, Dwivedi *et al.* 2018). They have ability to invasion in any fresh water ecosystem and become powerfully established in non-native ecosystem or introduced ecosystem but also allow them an excellent aquaculture species with other indigenous carps, sport fishing and stock enhancement (Ishikawa *et al.* 2013, Abarike & Ampofo-Yeboah 2016, Mayank & Dwivedi 2017, Dwivedi & Mayank 2018). After introduction or invasion in any ecosystem, *O. niloticus* have a tendency to out-compete native species for habitat (Example space), dissolved oxygen, food especially natural food and spawning grounds (Absar *et al.* 2015, Mayank & Dwivedi 2015c, 2016, Mehak *et al*. 2017, Dwivedi *et al.* 2016d, Teferi *et al*. 2001, Tsungai *et al.* 2013, Johnson *et al.* 2020).

The fish species contributing significantly to fishery have always been assessed through landings, largely to explain the fishery trends well exemplified by the riverine landings monitored regularly for the Ganga river as well as Yamuna river at Allahabad by Gupta & Tyagi (1992), Singh *et al*. (1998), Vass *et al.* (2010), Pathak *et al.* (2011a, 2013, 2015), Mayank & Dwivedi (2015b), Jha *et al.* (2016) and Dwivedi *et al.* (2016c). The objective of the present study was to give recent landing data regarding the role of *Cyprinus carpio* and *Oreochromis niloticus* from Ganga river with especial reference of fitness of both species at Allahabad (now Prayagraj), Uttar Pradesh, India.

Material and method

Present study was undertaken during the period July 2014 to June 2016 from the middle stretch of the Ganga river, Allahabad, Uttar Pradesh. For the purpose of collection of data on fish landing Teliarganj fish market was chosen it is a major landing center for the Ganga river at Allahabad. Fishing was conducted by local fisherman with the help of using drag net, gill net, cast net, scoop net and hook and line. For collection of data Teliarganj fish market was visited evening time. The data was collected species wise in case of commercially important fishes viz., *Catla catla, Labeo rohita, Cirrhinus mrigala, L. calbasu, C. carpio, O. niloticus, Sperata aor, S. seengala, Clupisoma garua, Eutropiicthys vacha, Wallago attu, Rita rita, Bagarius bagarius* and *Mastacembelus armatus,* and rest recorded miscellaneous group. For the purpose of collection of data a stratified sampling design was adopted (Tyagi & Mandal 2008). A month was divided in four strata of seven or eight consecutive

days, depending upon the month and from each stratum data was collected for two randomly selected days. Data was collected day unit.

Catch structure: Catch is a suitable indicator of population size and dominance of species. Catch day-^{1} gives an estimate of the quantum of fish catch and its components. Catch composition provides a break-up of the landings and quantum contribution of different species to this commercial activity. Change in the relative numbers of the different species is one measure of the abundance for the total populations of all species in a water body.

Catch day-^{1}: Catch day-^{1} was hence, assessed to understand the exploitation patters (landings). In the present study day unit vendor was used to determine the Catch day-^{1}. The sampling day and pooled. The landings of that day were represented by pooled data. In order to obtain catch day-1, quantity of each fish species sold on that particular day by the vendors was obtained by weighing all fishes of one species. This was repeated for all vendors present on that particular day. Thus, the quantity of fishes from each vendors was added so as to obtain an estimate of the total catch on one day, hence forth termed as catch day-^{1}. A monthly value (Mean, SE, median and others) was obtained by computing descriptive statistics (MS Excel 5.0) from the catch day-^{1} recorded during the number of sampling days in the particular month.

Result

Fishes are very commonly used for freshwater bio-assessment as they help the delivery of various ecosystem services and reproduce delivery of other. The fish species contributing significantly to fishery have always been assessed through landings, largely to explain the fishery trends well exemplified by the riverine landings monitored regularly for the Ganga river, India. Present study was carryout in two years, July 2014 to June 2015 and July 2015 to June 2016 from the Ganga river at Allahabad, Uttar Pradesh, India.

In year 2014-2015

Analysis of annual data on fish landing confirmed that *Oreochromis niloticus* and *Cyprinus carpio* have powerfully invaded in the middle stretch of the Ganga river at Allahabad in a bigway. The estimated annual catch was dominated by miscellaneous group (22.16 kg day-^{1}) followed by *O. niloticus* (12.76 kg day-^{1}) and *Sperata seenghala* (12.863 kg day-^{1}) and they accounted for 23.19% 13.36% and 13.21%, respectively (Table 1). The landing data also indicated that the Ganga river at Allahabad region was most suitable and supporting for the miscellaneous group or mostly small size fishes. In case of Indian major carps (IMC), *Cirrhinus mrigala* showed maximum contribution (7.73 kg day-^{1}, 8.09%). *Catla catla* and *L. rohita* shared 1.45 kg day^{-1} and 2.35 kg day^{-1}, respectively (Table 1) in the total catch. The average catch was 5.89 kg day-^{1} for *Eutropiicthys vacha* (6.17%), 5.78 kg day^{-1} for *Clupisoma garua* (6.04%), 5.15 kg day-^{1} for *Wallago attu* (5.39%), 5.06 kg day-^{1} for *S. aor* 5.3% 3.42 kg day-^{1} for *Rita rita* (3.58%) and 1.97 kg day-^{1} for *Bagarius bagarius* (2.06%). The *Labeo calbasu* was contributed low amount (0.94 kg day-1, 0.99%) of the total catch. The contribution of *Mastacembelus armatus* was also very low quantity 0.44 kg day-1 (0.46%).

In year 2015-2016

The estimated annual catch was also dominated in year July 2015 to June 2016 by miscellaneous group (23.67 kg day^{-1}, 19.09%) followed by *C. carpio* (19.22 kg day-^{1}, 15.5%) and *O. niloticus* (18.05 kg day-1 , 14.56%). Annual estimates of landing data indicated that the Ganga river at Allahabad region was most suitable for the miscellaneous group (Table 1). Miscellaneous group of fishes are formed by small size fishes and irregular catch of fishes. In case of Indian major carp, *C. mrigala* shared maximum with contribution of 10.35 kg day-^{1} (8.35%). The stock of the Indian major carp has been recorded to be declining from the Ganga river. Indian major carp group is backbone of Indian culture fishery. Present condition of Indian major carp from the river also indicated that the inbreeding chances of Indian major carp (*C. catla, L. rohita, C. mrigala*) in culture fishery is becoming high. *C. catla* and *L. rohita* contributed 1.74 kg day-^{1} (1.41%) and 3.20 kg day-^{1} (2.58%), respectively. In case of important catfishes, *S. seenghala* shared maximum contribution 16.21 kg day-^{1} with 13.08%. The average catch was 8.07 kg day-^{1} for *C. garua* (6.5%), 6.78 kg day-^{1} for *S. aor* (5.47%), 5.06 kg day-^{1} for *W. attu* (4.08%), 2.91 kg day-^{1} for *R. rita* 92.355), 2.74 kg day-^{1} for

B. bagarius (2.21%) of the total catch. Among other important species from River Ganga were *Labeo calbasu* and *Mastacembelus armatus* which contribute very marginally to the total catch; *L. calbasu* 1.20 kg day-^{1} (0.97%) and *M. armatus* 0.67 kg day-^{1} (0.54%). The carnivorous and omnivorous fish species are strongly stable in the Ganga river and shared high proportions in the total landing from middle stretch of the Ganga river at Allahabad, Uttar Pradesh, India.

Table 1 Annual landing scenario of commercially important fishes from the Ganga river at Allahabad, Uttar Pradesh.

Groups/Fish species Average Total catch	Average catch day^{-1} (kg.)	Percentage	Average catch day^{-1} (kg.)	Percentage
	In Year July 2014 to June 2015		In Year July 2015 to June -2016	
Catla catla	1.45	1.51	1.74	1.41
Labeo rohita	2.35	2.46	3.20	2.58
Cirrhinus mrigala	7.33	8.09	10.35	8.35
Cyprinus carpio	7.82	8.18	19.22	15.50
Oreochromis niloticus	12.76	13.36	18.05	14.56
Sperata seenghala	12.63	13.21	16.21	13.08
S. aor	5.06	5.30	6.78	5.47
Clupisoma garua	5.78	6.04	8.07	6.51
Eutropiicthys vacha	5.89	6.17	4.09	3.30
Wallago attu	5.15	5.39	5.06	4.08
Rita rita	3.42	3.58	2.91	2.35
Bagarius bagarius	1.97	2.06	2.74	2.21
Labeo calbasu	0.94	0.99	1.20	0.97
Mastacembelus armatus	0.44	0.46	0.67	0.54
Miscellaneous	22.16	23.19	23.67	19.09

Discussion

Analysis of annual data on fish landing in both years (July 2014 to June 2015 and July 2015 to June 2016) confirmed that *Oreochromis niloticus* and *Cyprinus carpio* have powerfully invaded in the middle stretch of the Ganga river at Allahabad, Uttar Pradesh, India in a bigway. Both species, *C. carpio* and *O. niloticus* are fully help in increasing of the total landing and also increase the income of the fishers from the Ganga river. The *C. carpio* and *O. niloticus* have a well-known effect on the worldwide homogenization process due to ecological adaptation (Dwivedi *et al*. 2014, Pathak *et al.* 2015, Toussaint *et al*. 2016). Such exotic fish species have a harmful impact on the indigenous or native fish species throughout competition for breeding ground, habitat, basic food, predation on eggs and fish larvae (Savini *et al*. 2010, Vass *et al*. 2010, Ribeiro & Leunda 2012). Gupta & Tyagi (1992) recorded that the miscellaneous species comprised the major share about 50.50% while *Aaorichthys aor* and *A. seenghala* together accounted for 16.81% at Allahabad. Mishra & Moza (2001) reported that the overall fish population in the Yamuna river (Delhi to Etawah), showed dominance of large size catfishes (49.26%) followed by major carp (28.54%). The Ganga river system, India, however presently lacks monitoring and assessment of riverine circumstances in all important places (e.g. famous landing centres) that would allow detection of unexpected declines in river condition (e.g. habitat and breeding grounds) and timely remediation. *C. carpio* was as powerful invaders in the Ganga river at Allahabad with contributed 13.44% and 14.82% in 2008 and 2009, respectively (Pathak *et al*. 2013) and the Yamuna river (Dwivedi *et al.* 2016d).

Ray *et al.* (2023) stated that the river Ganga produces a substantial amount of its fish from small native species. Singh *et al.* (1998) reported that the *A. aor* and *A. Seenghala* were dominant fish species (45.2%) compared with miscellaneous (28.2%) and *L. calbasu* (14.6%) in the Ganga and Yamuna rivers at Allahabad. The *L. rohita, C. catla* and *C. mrigala* contributed small proportions 2.5%, 3.2% and 1.5%, respectively showing a decline in their fishery. The miscellaneous group, the share of which declined from 75.62% in 1985 to 48.33% in 1986, primarily dominated the fishery of the Ganga at Patna *A. aor*, *A. seenghala* and *W. attu* which contributed in sizeable amounts among catfish increased from 1985 to1986 (from around 10 to 15%, Kumar 1996).

Mishra & Moza (2001) reported that the *Aorichthys* spp. and *W. attu* contributed 29.38% and 19.87%, respectively. At Kanpur too the catfishes (42.2%) and others (29.6%) have dominated the Indian major carps (18.9%) and exotic carps 9.3% in the Ganga. Pathak *et al.* (2011a) also reported that the *O. niloticus* and *C. carpio* well stable in 2008 and 2009 from the Ganga river at Allahabad. Due to miscellaneous stressor operation on the Ganga river, remarkable alterations have been listed in its fisheries, landing pattern and abundance of non-native species (Jha *et al*. 2016, Dwivedi *et al.* 2016b, Tripathi *et al.* 2017b). Heavy metal concentration in water and different organs of fishes are creating negative impact in recruitment and stock maintenance especially in the river system, globally (Tiwari *et al.* 2013a, 2013b, Tiwari & Dwivedi 2014, 2015, Dwivedi *et al.* 2015, Tiwari *et al.* 2020). Due to pollution from the riverine ecosystem, the species composition, abundance and landing of fishes are frequently changed in huge degree.

Conclusion

It may be concluded that the Ganga river at Allahabad mainly roofed by miscellaneous fishes and two exotic fish species (*O. niloticus, C. carpio*). The landing data of the Ganga river also indicated that the ecological condition of the river is very suitable for small size of fishes including *O. niloticus* (upto 38 cm). The river Ganga is known as original adobe of the valuable Indian major carp. The landing of Indian major carp has significantly declined through step wise. The year variation is also highly monitored to the landing of fishes from the river. *C. carpio* and *O. niloticus* species are provide proper occupation and food security for fishermen community from the Ganga river at Allahabad. For the physical condition of the river and native fish stock restoration (Example habitat restoration, ranching) is very immediately require for Indian major carp and *Labeo calbasu* at Allahabad, India. Our results have implications for assessing the invasive fish species role and utility from the Ganga river system.

References

Abarike, E.D. & A. Ampofo-Yeboah 2016. Reproductive potential of Nile tilapia (*Oreochromis niloticus* Linnaeus, 1757) in the Golinga reservoir in Ghana. *Inter. J. Fish. Aqua. Stud.*, **4(5):** 279-283.

Absar, A., N.K. Chadha, K.D. Joshi, S.K. Chakraborty, P.B. Sawant, T. Kumar *et al.* 2015. Maturation profile and fecundity of the exotic *Oreochromis niloticus* in the River Yamuna, India. *J. Environ. Bio.*, **36(4):** 927-931.

Argent, D. G., J. A. Bishop, J. R. Stauffer, R. F. Carline & W. L. Myers 2003. Predicting freshwater fish distributions using landscapelevel variables. *Fish. Res.*, **60:** 17-32.

Bajer, P.G., G. Sullivan & P.W. Sorenson 2009. Effects of a rapidly increasing population of common carp on vegetative cover and waterfowl in a recently restored Midwestern shallow lake. *Hydrobiologia*, **632(1):** 235- 245.

Balon, E.K. 1995. The common carp, *Cyprinus carpio*: its wild origin, domestication in aquaculture and selection as colored nishikigoi. *Guelpd Ichthyology Review*, **3:** 1- 55.

Bilgrami, K. S., J. S. Datta Munshi & S. K. Verma 1992. Bioconservation and biomonitoring of river Ganga in Bihar. Final Technical Report, Ganga project Directorate, New Delhi.

Choudhary, M., K. Thakur, B. Brar, S. Kumar, D. Sharma, R. Kumar & D. Mahajan 2023. Status of fish assemblage structure in the Ganga and Indus riverine systems of the western Himalaya. *World Water Policy*, 1-26. https://doi. org/10.1002/wwp2.12116.

Cooke, S. J., C. M. Bunt & S. J. Hamilton 2005. Threats, conservation strategies, and prognosis for suckers (Catostomidae) in North America: insights from regional case studies of a diverse family of non-game species. *Biological Cons.*, **121:** 317-331.

Cowx, I. G. 2015. Characterization of inland fisheries in Europe. *Fish. Manage. Ecol.*, **22:** 78-87. doi: 10.1111/fme.12105

Das, B.K., A. Ray, C. Johnson, S.K. Verma, A. Alam, R. Baitha, R.K. Manna, S. Roy & U.K. Sarkar 2023. The Present status of Ichthyofaunal diversity of River Ganga India: synthesis of present v/s past. *Acta Ecol. Sin.* **43:** 307–332.

Dwivedi, A. C., A. Tiwari & P. Mayank 2015. Seasonal determination of heavy metals in muscle, gill and liver tissues of Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) from the tributary of the Ganga River, India. *Zoology and Ecology*, **25(2):** 166-171. **DOI:** 10.1080/21658005.2015.1020012.

Dwivedi, A. C., P. Nautiyal, A. F. Rizvi & P. Mayank 2016c. Landing scenario, size and age of commercially important fish species, *Labeo rohita*, *Tor tor* and *L. calbasu* response to need their restoration in the Vindhyan region (Paisuni river), India. *J. Kalash Sci.*, **4(1):** 27-40.

Dwivedi, A.C. & P. Mayank 2013. Studies on the age, growth pattern and sex ratio of *Cyprinus carpio* var. *communis* from the largest tributary of the Ganga river, India. *Journal of the Kalash Science,* **Special Volume:** 21-27.

Dwivedi, A.C. & P. Mayank 2017. Reproductive profile of Indian Major Carp, *Cirrhinus mrigala* (Hamilton, 1822) with Restoration from the Ganga River, India. *Journal of Fisheries & Livestock Production,* **5(1):** DOI: 10.4172/2332-2608.1000212.

Dwivedi, A.C. & P. Mayank 2018. Suitability of ecosystem determination through biology and marketing of exotic fish species, *Oreochromis niloticus* (Linnaeus, 1757) from the Ganga River, India. *J. Aquatic Res. Marine Sci.,* **1(2):** 69-75.

Dwivedi, A.C. & P. Nautiyal 2013. Alien fish species, *Cyprinus carpio* (common carp) as a invader in the Vindhyan region (Ken, Paisuni, Tons rivers), India. *Journal of the Kalash Science,* **1(2):** 133-139.

Dwivedi, A.C. 2009. Ecological assessment of fishes and population dynamics of *Labeo rohita* (Hamilton), *Tor tor* (Hamilton) and *Labeo calbasu* (Hamilton) in the Paisuni river. *Aquacult*, **10(2):** 249-259.

Dwivedi, A.C., A. S. Mishra, P. Mayank and A. Tiwari 2016a. Persistence and structure of the fish assemblage from the Ganga river (Kanpur to Varanasi section), India. *Journal of Geography and Natural Disasters*, **6:** 159. **Doi:** 10.4172/2167-0587.1000159.

Dwivedi, A.C., A. Tiwari & P. Mayank 2018. Environmental pollution supports to constancy and invader potential of *Cyprinus carpio* and *Oreochromis niloticus* from the Ganga river, India. *Inter. J. Poult. Fish. Sci.,* **2(2):** 1- 7.

Dwivedi, A.C., D. N. Jha & P. Mayank 2014. Food security, livelihood and non-native fish species: status, trends and future perspectives. *Journal of the Kalash Science*, **2(3) (Special Volume):** 41-46.

Dwivedi, A.C., P. Mayank & A. Tiwari 2016b. The river as transformed by human activities: the rise of the invader potential of *Cyprinus carpio* and *Oreochromis niloticus* from the Yamuna River, India. *Journal of Earth Science & Climatic Change*, **7(7):** 361. doi: 10.4172/2157- 7617.1000361.

Dwivedi, A.C., P. Mayank & S. Imran 2016d. Reproductive structure of invading fish, *Oreochromis niloticus* (Linnaeus, 1757) in respect of climate from the Yamuna river, India. *Journal of Climatology and Weather Forecasting*, **4(2):** 164. doi:10.4172/2332-2594.1000164.

Dwivedi, A.C., P. Mayank, S. Masud & S. Khan 2009. An investigation of the population status and age pyramid of *Cyprinus carpio* var. *communis* from the Yamuna river at Allahabad. *The Asian Journal of Animal Science*, **4(1):** 98-101.

Dwivedi, A.C., P. Mayank, S. Tripathi & A. Tiwari 2017. Biodiversity: the non-natives species versus the natives species and ecosystem functioning. *Journal of Biodiversity, Bioprospecting and Development*, 4(1), DOI: 10.4172/2376-0214.1000164.

France, K. E. & J. E. Duffy 2006. Diversity and dispersal interactively affect predictability of ecosystem function. *Nature*, **441:** 1139- 1143.

Froese, R. & D. Pauly 2002. Fishbase: Species summary for Cyprinus carpio (On-line). Accessed 2 April 2002 at http:// www.fishbase.org.

Gopesh, A., S. Tripathi, K. D. Joshi & A. C. Dwivedi 2021. Size composition, exploitation structure and sex ratio of *Clupisoma garua* (Hamilton) from middle stretch of the Ganga River at Allahabad, India. *National Academy Science Letter*, **44(4):** 309-311, **DOI**: 10.1007/s40009-020-01011-0.

Gozlan, R. E. 2008. Introduction of non-native freshwater fish: is it all bad? *Fish and Fisheries*, **9:** 106-115.

Gozlan, R. E., J. R. Britton, I. Cowx & G. H. Copp 2010. Current knowledge on non-native freshwater fish introductions. *J. Fish Biol.*, **76:** 751-786.

Gupta, B. K., H.S. Mogalekar, S.K. Nayak, R. Kumari & S. B. Gore 2022. Fish catch composition in the middle stretch of River Ganga, Uttar Pradesh. *Journal of Indian Fisheries Association*, **49(2):** 66-70.

Gupta, R. A. & R. K. Tyagi 1992. Analytical approach to analysis of fish stock of Ganga river system. *J. Inland. Fish. Soc. India,* **24:** 20-27.

Ishikawa, T., T. Shimose & K. Tachihara 2013. Life history of an invasive and unexploited population of Nile tilapia (*Oreochromis niloticus*) and geographical variation across its native and non-native ranges. *Environ. Biol. Fish*., **96(5):** 603-616.

Jackson, Z.J.M.C. Quist, J.A. Downing & J.G. Larscheid 2010. Common carp (*Cyprinus carpio*), sport fishes, and water quality: ecological thresholds in agriculturally eutrophic lakes. *Lake and Reservoir Management*, **26(1):** 12-22.

Jha, D. N., K. D. Joshi, M. A. Alam, S. C. S. Das & V. Kumar 2016. Dominance of exotic fishes in the river Ganga at Allahabad stretch. *J. Kalash Sci.,* **4:** 1-6.

Johnson, C., U.K. Sarkar, S.K. Koushlesh, A.K. Das, B.K., B.K. Das & Naskar 2020. Population structure of Nile Tilapia and its impact on fisheries of a tropical impacted Reservoir, Central India. *Environ. Sci. Pollut. Res.,* **27:** 29091–29099.

Kottelat, M. & J. Freyhof 2007. Handbook of European freshwater fishes. Cornol, Switzerland.

Kumar, A. 1996. Impact of industrial pollution on the population status of endangered gangetic dolphin (*Platanista gangetica*) in the river Ganga in Bihar, India. *Pol. Arch. Hydrobiol*., **43(4):** 469-476.

Kumar, A., A. C. Dwivedi & V. R. Thakur 2023. The record of the largest Fresh water Shark, *Wallago attu* (Bloch & Schneider, 1801) from the Sarayu river, Uttar Pradesh, India. *Journal of the Kalash Science,* **11(2):** 21-23.

Kumar, D., A. C. Dwivedi & J. Kumar 2023. Maximum size of Helicopter catfish, Wallago attu (Bloch & Schneider, 1801) from the Rapti river, Uttar Pradesh, India. *Journal of Nehru Gram Bharati University*, **12(2):** 48-51.

Mayank, P. & A. C. Dwivedi 2015a. Biology of Cirrhinus mrigala and Oreochromis niloticus. LAP LAMBERT Academic Publishing GmbH & Co. KG, Dudweiler Landstr. 99, 66123 Saarbrucken, Germany, Pp. 188.

Mayank, P. & A. C. Dwivedi 2015b. Role of exotic carp, *Cyprinus carpio* and *Oreochromis niloticus* from the lower stretch of the Yamuna river. In:Advances in biosciences and Technology (eds. K.B. Pandeya, A.S. Mishra R.P. Ojha and A.K. Singh), NGBU, Allahabad, pp 93-97, DOI: 10.13140/RG.2.1.3674.0241.

Mayank, P. & A. C. Dwivedi 2015c. Population structure of alien fish species, *Oreochromis niloticus* (Linnaeus 1758) from lower stretch of the Yamuna river, India. *Journal of the Kalash Science,* **3(1):** 35-40.

Mayank, P. & A. C. Dwivedi 2016. Stock assessment and population structure of alien fish species, *Oreochromis niloticus* (Linnaeus) from the lower stretch of the Yamuna river, India. *J. Exp. Zool. India*, **19:** 163-167.

Mayank, P. & A. C. Dwivedi 2017. Resource use efficiency and invasive potential of non-native fish species, *Oreochromis niloticus* from the Paisuni River, India. *Poultry Fisheries & Wildlife Sciences,* **5(1):** DOI: 10.4172/2375-446X.1000177.

Mayank, P., A. C. Dwivedi & N. Mishra 2021. Age pyramid of Common carp, *Cyprinus carpio* (Linnaeus, 1758) from the Tons River, India. *Journal of the Kalash Science*, **9(1):** 19-24.

Mehak, A, Y. Mu, M. Mohsin, M. Noman, & K. Nazir 2017. Population dynamics of Nile Tilapia (*Oreochromis niloticus*) at Chashma Barrage, Pakistan. *Indian J. Geo-Mari Sci*., **46(01):** 206-210.

Mishra, D. N. & U. Moza 2001 Evaluation of fish and fishery resources in river Yamuna part-1. *J. Inland Fish Soc. India,* **33:** 93-99.

Mishra, N. & A.C. Dwivedi 2020. Environmental derivers support to distribution, composition and biology of *Cyprinus carpio* (Linnaeus, 1758) in respect of time scale: A review. *Journal of the Kalash Science,* **8(2):** 91- 102.

Mishra, N., A.C. Dwivedi & P. Mayank 2021. Study on stock health of non-native fish species, *Cyprinus carpio* (Linnaeus, 1758) through age pyramid from the tributary of the Ganga River, India. *Journal of Aquaculture and Technical Development*, **4(1):** 011.

Nautiyal, P. & A.C. Dwivedi 2019. Fishery in the tributaries of Yamuna river (Ken river, Paisuni river) and Ganga river (Tons river). *Journal of Mountain Research*, **14(2):** 19-36.

Pathak, R. K., A. Gopesh & A. C. Dwivedi 2011a Alien fish species, Cyprinus carpio var. communis (common carp) as a powerful invader in the Yamuna river at Allahabad, India. *Natl. Acad. Sci. Lett.,* **34:** 367-373.

Pathak, R. K., A. Gopesh & A.C. Dwivedi 2011b. Age composition, growth rate and age pyramid of an exotic fish species, *Cyprinus carpio* var. *communis* from the Ganga river at Allahabad, India. *Natl Acad. Sci. Lett*., **34:** 223-228.

Pathak, R. K., A. Gopesh & A.C. Dwivedi 2015. Invasion potential and biology of *Cyprinus carpio* (Common carp) LAP LAMBERT Academic Publishing GmbH & Co. KG, Dudweiler Landstr. 99, 66123 Saarbrucken, Germany.

Pathak, R. K., A. Gopesh, A.C. Dwivedi & K. D. Joshi 2014b. Sex structure of commercially exploited fish species, *Cyprinus carpio* var. *communis* from the Ganga and Yamuna rivers at Allahabad, Uttar Pradesh. *Journal of the Kalash Science,* **2(1):** 43-46.

Pathak, R. K., A. Gopesh, A. C. Dwivedi & K. D. Joshi 2014a. Age and growth of alien fish species, *Cyprinus carpio* var. *communis* (Common carp) in the lower stretch of the Yamuna river at Allahabad. *Natl Acad. Sci. Lett.,* **37:** 419-422. DOI: 10.1007/ s40009-014-0262-3.

Pathak, R. K., A. Gopesh, K. D. Joshi & A. C. Dwivedi 2013. *Cyprinus carpio* var. *communis*, in middle stretch of river Ganga at Allahabad. *J. Inland Fish. Soc. India,* **45:** 60-62.

Ray, A., B. K. Das, D. Bhakta, C. Johnson, S. Roy, S. D. Gupta, S. P. Panda & R. Baitha 2023. Stock Status of a Few Small Indigenous Fish Species Exploited in the River Ganga, India. ***Fishes,* 8(12):** 572; https://doi.org/10.3390/fishes8120572

Ribeiro, F. & P. M. Leunda 2012. Non-native fish impacts on Mediterranean freshwater ecosystems: current knowledge and research needs. *Fish. Manag. Ecol.*, **19:** 142-156.

Rizvi, A. F., A. C. Dwivedi & K. P. Singh 2010. Study on population dynamics of *Labeo calbasu* (Ham.), suggesting conservational methods for optimum yield. *Natl. Acad. Sci. Lett.*, **33(7 & 8):** 247-253.

Savini, D, A. Occhipinti-Ambrogi, A. Marchini, E. Tricarico, F. Gherardi, S. Olenin & S. Gollasch 2010. The top 27 animal alien species introduced into Europe for aquaculture and related activities. *Applied Ichthyology*, **26:** 1-7.

Singh, H. R., A. I. Payne, S. K. Pandey & P. R. Singh 1998. Time scale changes in the catch structure of fishery in Allahabad. *Proc. Nat. Acad. Sci. India*, **68B:** 15-21.

Smith, L., K. Lorenzen & S. Nguyen Khoa 2005. Livelihood functions of inland fisheries: Policy implications in developing countries. *Water Policy*, **7:** 359–383.

Swain, H. S., S. Bayen, A. Ray, C. Johnson, R. Baitha, M. Bohr, S. Verma & B. K. Das 2021. Present status, distribution and relative abundance of IUCN red-listed fish species of river Ganga. *Current Science,* **121(5):** 709. https://doi.org/10.18520/cs/v121/i5/709-714

Teferi, Y., D. Admassu & S. Mengistou 2001. Breeding season, maturation and fecundity of *Oreochromis niloticus* L. (Pisces: Cichlidae) in Lake Chamo, Ethiopia. *SINET: Ethiop J. Sci.,* **24(2):** 255-264.

Tessema, A., A. Getahun, S. Mengistou, T. Fetahi & E. Dejen 2020. Reproductive biology of common carp (*Cyprinus carpio* Linnaeus, 1758) in Lake Hayq, Ethiopia. *Fisheries and Aquatic Sciences,* **23:** 16. 13.

Tiwari A. & A. C. Dwivedi 2014. Assessment of heavy metals bioaccumulation in alien fish species *Cyprinus carpio* from the Gomti river, India. *European Journal of Experimental Biology,* **4(6):** 112-117.

Tiwari A. & A. C. Dwivedi 2015. Distribution of heavy metals in tissues of the Common carp, *Cyprinus carpio* Linnaeus, 1758 from the Ganga river, India. *International Journal of Environmental Science*, **6(1):** 881-891, **DOI:** 10.6088/ijes.xxxxxxxxx.

Tiwari A., A. C. Dwivedi & D. N. Shukla 2013a. Accumulation of heavy metals in Liver, Muscle and Gill of *Cyprinus carpio* from the Gomti river at Jaunpur, Uttar Pradesh. *Journal of the Kalash Science*, **1(2):** 127-132.

Tiwari A., A. C. Dwivedi & D. N. Shukla 2013b. Level of heavy metals Cu, Cr, Pb and Zn in alien fish species, *Cyprinus carpio* from the Gomti river at Sultanpur, India. *Asian Journal of Bio Science,* **8(2):** 255-258.

Tiwari A., A. C. Dwivedi & M. A. Rahman 2020. Assessment of heavy metal accumulation in vital tissues of commercially exploited fish, *Cyprinus carpio* (common carp) from the river Ganga, India. *Journal of Emerging Technologies and Innovative Research*, **7(6):** 959-972.

Toussaint, A., O. Beauchard, T. Oberdorff, S. Brosse & S. Villeger 2016. Worldwide freshwater fish homogenization is driven by a few widespread non-native species. *Biological Invasions*, doi: 10.1007/s10530-016-1067-8.

Tripathi, S., A, Gopesh & A. C. Dwivedi 2017a. Framework and sustainable audit for the assessing of the Ganga river ecosystem health at Allahabad, India. *Asian J Environ Sci*., **12(1):** 37-42.

Tripathi, S., A, Gopesh & A. C. Dwivedi 2017b. Fish and fisheries in the Ganga river: current assessment of the fish community, threats and restoration. *Journal of Experimental Zoology, India,* **20(2):** 907-912.

Tripathi, S., A. Gopesh & A. C. Dwivedi 2023. Food and feeding habit of commercially important catfish, *Clupisoma garua* (Hamilton, 1822) from the middle stretch of subtropical the Ganga river, India. *Journal of Nehru Gram Bharati University*, **12(2):** 13-23.

Tripathi, S., A. Gopesh, K.D. Joshi & A.C. Dwivedi 2015. Size composition, exploitation pattern, sex ratio and sex structure of *Eutropiichthys vacha* (Hamilton, 1822) from the middle stretch of the river Ganga at Allahabad, India. In: Advances in biosciences and Technology (eds. K.B. Pandeya, A.S. Mishra R.P. Ojha and A.K. Singh), NGBU, Allahabad, pp 116-120.

Tsungai, A.Z., M.P. Robertson, A.J. Booth & C.T. Chimimba 2013. A qualitative ecological risk assessment of the invasive Nile tilapia, *Oreochromis niloticus* in a sub-tropical African river system (Limpopo River, South Africa). *Aqua. Conser. Mari. Freshwa. Ecosys*., **23 (1):** 51–64.

Tyagi, R. K. & S. K. Mandal 2008. Sampling methodologies for estimation of inland fish catch in India. CIFRI, Barrackpore, W.B. Pp. 71.

Ujjania, N.C. & N. Soni 2020. Age structure, growth rate and exploitation pattern of *Cirrhinus mrigala* (Ham. 1822) in Vallabhsagar reservoir, Gujarat, India. *Indian Journal of Experimental Biology*, **58:** 498-501.

Vass, K. K., R. K. Tyagi, H. P. Singh & V. Pathak 2010. Ecology, changes in fisheries, and estimates in the middle stretch of the river Ganges. *Aquatic Ecosyst. Health Manag.*, **13:** 374-384.

Yakubu, A., N. Li, J. Conrad & M. L. Zeeman 2011. Fish population dynamics and constant or periodic proportion harvesting policies. *Mathematical Biosciences*, **232:** 66-77.

Zambrano, I., M. Scheffer & M Martinez-ramos 2001. Catastrophic response of lakes to benthivorous fish introduction. *Oikos*, **94:** 344-350.