

First record of exotic alligator gar, *Atractosteus spatula* (Actinopterygii: Lepisosteiformes: Lepisosteidae), from Ganga River system, India: A possible threat to indigenous riverine fish diversity

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<http://zoobank.org/DD6EE48F-C7BF-4F98-B9ED-B060375CFED6>

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Academic editor: Predrag Simonović ♦ **Received** 6 August 2021 ♦ **Accepted** 8 October 2021 ♦ **Published** 29 November 2021

Citation: Manna RK, Ray A, Bayen S, Bera T, Palui D, Das BK (2021) First record of exotic alligator gar, *Atractosteus spatula* (Actinopterygii: Lepisosteiformes: Lepisosteidae), from Ganga River system, India: A possible threat to indigenous riverine fish diversity. *Acta Ichthyologica et Piscatoria* 51(4): 385–391. <https://doi.org/10.3897/aiep.51.72676>

Abstract

A new record of an exotic alligator gar, *Atractosteus spatula* (Lacepède, 1803), from an open wetland of the Ganga River was presented in this paper and discussed along with the environmental parameters. Entry of the exotic fish into the natural system was probably a result of uncontrolled ornamental fish trading. Considering threats of this predatory fish to become invasive and disturb riverine fish diversity, possible ways to avoid such risk have been discussed.

Keywords

alligator gar, exotic fish, Ganga River, wetland

Introduction

Large rivers basins harbor a significant share of the world's aquatic biodiversity, providing important goods and services to the society, including fisheries. Ganga basin is the largest and most important river basin in India. The wetlands of the Ganga basin are mostly formed as a result of the meandering of the river or sloughs or tectonic depressions receiving huge surface runoff or freshwater from the river. The connection of the wetland to the river promotes aquatic biodiversity, especially a higher abundance of small indigenous fishes (Manna et al. 2018). However, the intrusion of exotic fishes into associated wetland exerts invariable threats upon native riverine fish biodiversity (Singh and Lakra 2006). The

Ganga basin, which supports a wealthy fish diversity of more than 266 fish species (Talwar and Jhingran 1991), has already been invaded by more than 10 species of exotic fishes in almost its entire freshwater stretch (Sarkar et al. 2012) resulting in considerable damage to riverine fish diversity. The entry of exotics into the riverine system has been presumed mainly to have come about due to illegal or unwanted introduction from aquaculture practices or by other anthropogenic activities, including extreme climatic events like floods, etc. (Raj et al. 2021). Besides exotic carps, which have been legally brought for aquaculture enhancement in India, the Ganga River has experienced in recent years the appearance of a few exotic aquarium species like *Gambusia affinis* (Baird et Girard, 1853), *Pterygoplichthys pardalis* (Castelnau, 1855), and

Pterygoplichthys disjunctivus (Weber, 1991) (see Singh et al. 2013; Das et al. 2020). However, the occurrence of exotic alligator gar, *Atractosteus spatula* (Lacepède, 1803) has not been documented from the main channel or any of the water bodies associated with the largest river of the country. *Atractosteus spatula*, representing the family: Lepisosteidae, is a native to North America primarily from the Mississippi River basin (Raz-Guzmán et al. 2018). Alligator gar has been established worldwide as an outcome of the ornamental fish trade (Salnikov 2010). This highly predatory species has been reported recently from several water bodies of different Indian states like Assam (Anonymous 2020), West Bengal (Thakur 2016), Odisha (Anonymous 2017a), Andhra Pradesh (Vadlamudi 2021), Kerala (Kumar et al. 2019), and Maharashtra (Ghai 2018, Patil et al. 2019) displaying its probable congenial interaction with the varied environmental habitats (Fig. 1). The present paper documents the first record of the alligator gar from an open wetland connected to the Ganga River in West Bengal, India, along with a description of the aquatic environment.

Material and methods

A single specimen of *Atractosteus spatula* was captured from Chharaganga Beel (wetland) (23°27'48.87"N, 88°20'46.7592"E), Nabadwip, West Bengal using a gill-net (mesh 10–15 cm) on 23 July 2020 during the early morning hours of fishing activity. The fish was identified in line with the methodology of Bigelow et al. (1963).



Figure 1. Water bodies of India from where alligator gar, *Atractosteus spatula*, has recently been reported. The newly reported site is Chharaganga Beel.

The associated hydrological parameters were determined as a part of the assessment of the associated wetland of the Ganga River following standard methods (Baird and Bridgewater 2017).

Ethical statement. During the study, no harm was made to alligator gar which has been described in this paper. After the study, the fish was released in live condition into secured captivity so that it could not reach natural open water.

Results

The fish collected from Chharaganga wetland was identified as *Atractosteus spatula*, it weighed 2.25 kg, and was characterized by a long and cylindrical body (Figs 2–3). It had an elongated snout and rounded caudal fin. Both the dorsal and anal fins consisted of 7 rays respectively and were positioned close to the tail with the former slightly posterior to the latter. Body scales were hard, non-overlapping, and diamond in shape. Head and snout were devoid of scales. It could be easily distinguished by two rows of sharp series of teeth on the upper jaw. However, the second row of teeth was positioned within the mouth, which was different from the externally visible teeth. The pectoral fin ray count was 14 and the fin was situated in close proximity to the gill opening. The dorsal surface of the body was dark olivaceous while the lower abdominal portion of the body was characterized by whitish shades.

Discussion

Although the information on its habitat usage is scanty, *Atractosteus spatula* was reported to dwell in both freshwater and marine water habitats (Goodyear 1967). Reports from Indonesia (Hasan et al. 2020) and Texas (Buckmeier 2008) have provided evidence towards its wide tolerance of salinity gradients which has created an additional advantage for its survival, growth, and possible establishment. The presently described site of fish capture is freshwater in nature; however, since it is located at the head of Hooghly estuary, the lowermost stretch of the main channel of the river experiences minor tidal variations. The mean annual temperature [°C] of the wetland is 27.87 ± 3.16 (Table 1) which is slightly higher than the temperature (24–26°C) recorded from Vincente Guerrero Reservoir, Mexico (Garcia de Leon et al. 2001). Additional water quality parameters of the wetland, specifically its salinity (0.0167‰–0.079‰), and depth (mean 4.32 m) are at par with the values obtained from the water body of the USA (Boschung and Mayden 2004) indicating a somewhat agreeable environmental condition required for its survival, spawning, and maturation. Having a connection to the wetland, there remains a high chance of its entry into the river. However, the river water possesses a slightly different water quality status (Table 1). Significant differences in parameters like wa-



Figure 2. Alligator gar, *Atractosteus spatula*, recorded from Chharaganga Beel, Nabadwip, West Bengal (dorsal view).



Figure 3. Alligator gar, *Atractosteus spatula*, recorded from Chharaganga Beel, Nabadwip, West Bengal (anteroventral view showing the teeth).

ter turbidity and sediment soil organic carbon might be attributed to the dense growth of aquatic macrophytes, especially floating water hyacinth and different varieties of submerged macrophytes in the wetland (Table 2). Still, there is a high chance of the species establishing in the river as it is basically a riverine species of the Mississippi River system.

The alligator gar has been presumed to have been released by some aquarium hobbyists deliberately into the wetland which is a routine method to get rid of the pet when it attained a size large exceeding the capacity of an indoor aquarium. Other than willful release by the hobbyist, extreme climatic events have often been identified for entry of the exotic fishes into Indian inland open waters (Raj et al. 2021) as a route of entry of alien fishes into the natural ecosystem. In the absence of any such climatic event in the studied area in the recent past, its entry through the aquarium trade may be considered.

Aquarium trading has now created a miserable approach towards the non-native introduction of fishes (Krishnakumar et al. 2009) with more than 5000 species traded globally, which in turn has linked more than 200 countries of rapidly growing ornamental industry, associated with the second most popular hobby with about 100 million hobbyists in the world (Chan et al. 2020). Alligator gar has been illegally introduced into the Indian fishery system as it is not highlighted in the list of 92 different aquarium fish species considered for import (Kumar et al. 2019). The encroachment and establishment of several other exotic species, which thereby impact the local fishes, are reported from almost the entire riverine system in India (Knight 2010; Sandilyan 2016). As a consequence of ornamental fish trading, vermiculated sailfin catfish, *Pterygoplichthys disjunctivus*, has been recorded from various river systems of the country like the Ganga or Cauvery (Panikkar et al. 2015; Das et al. 2020). Suresh

Table 1. Water parameters of Chharaganga Beel adjacent to the Ganga River (at Nabadwip).

Parameter	Chharaganga Beel		Ganga River (Nabadwip)	
	Range	Mean \pm SD	Range	Mean \pm SD
Temperature [$^{\circ}$ C]	22.7–32.6	27.87 \pm 3.16	18.2–33.7	27.69 \pm 6.32
pH	6.8–9.2	7.97 \pm 0.55	7.4–8.7	8.18 \pm 0.44
Dissolved O ₂ [ppm]	1.0–10.5	5.27 \pm 2.15	5.4–9.5	7.01 \pm 1.43
Turbidity (NTU)	0.03–56.20	4.19 \pm 8.15	15.48–237.00	94.52 \pm 76.16
Conductivity [μ S \cdot cm ⁻¹]	172–570	276.42 \pm 64.56	177–338	249 \pm 62.41
Alkalinity [ppm]	78–188	129.43 \pm 22.09	67–134	99.91 \pm 25.83
Hardness [ppm]	80–150	113.62 \pm 19.15	60–140	91.5 \pm 28.81
Ca ²⁺ [ppm]	12.65–44.08	26.30 \pm 6.79	14.43–36.87	27.33 \pm 7.32
Mg ²⁺ [ppm]	4.70–28.56	13.42 \pm 6.35	1.88–16.44	6.55 \pm 4.79
Nitrate-N [ppm]	0.012–0.200	0.072 \pm 0.05	0.120–0.512	0.304 \pm 0.120
Total N [ppm]	0.074–2.297	0.616 \pm 0.44	0.376–0.700	0.495 \pm 0.110
Phosphate-P [ppm]	0.004–0.827	0.087 \pm 0.17	0.026–0.070	0.043 \pm 0.020
Silicate-Si [ppm]	1.6–24.2	6.028 \pm 4.280	0.4–10.2	7.10 \pm 3.47

SD = standard deviation.

Table 2. Soil parameters of Chharaganga Beel adjacent to the Ganga River (at Nabadwip).

Parameter	Chharaganga Beel		Ganga River (Nabadwip)	
	Range	Mean \pm SD	Range	Mean \pm SD
pH	7.01–8.24	7.68 \pm 0.30	7.60–8.70	8.27 \pm 0.39
Specific conductivity [mS \cdot cm ⁻¹]	0.218–2.08	0.924 \pm 0.470	0.058–0.274	0.192 \pm 94.770
Organic C [%]	0.10–2.00	0.74 \pm 0.51	0.09–0.54	0.34 \pm 0.15
Total N [%]	0.01–0.30	0.10 \pm 0.07	0.02–0.07	0.04 \pm 0.02
Available N [mg \cdot 100 g ⁻¹ soil]	8.40–26.30	15.26 \pm 3.53	2.80–7.84	5.79 \pm 2.65
Available P [mg \cdot 100 g ⁻¹ soil]	0.13–0.54	0.31 \pm 0.09	0.92–3.48	2.22 \pm 1.35

SD = standard deviation.

et al. (2019) have even documented the species from an ecologically important East Kolkata Wetland (a Ramsar site) with an estimated annual production of 300 t. Kumar et al. (2020) has recently reported increasing availability of another ornamental three-spot cichlid, *Cichlasoma trimaculatum* (Günther, 1867), in the Cauvery River. The *C. trimaculatum* was ranked as posing a “high” risk of being invasive in the river as determined using the Aquatic Species Invasiveness Screening Kit. The alligator gar, *Atractosteus spatula*, though being recorded regularly beyond its native area, has not yet been recognized as a potential threat as it was not included in the list of 259 non-native freshwater fish species for which risk assessment has been conducted so far using Aquatic Species Invasiveness Screening Kit (Vilizzi et al. 2021). However, considering its possible potential biodiversity risks, an assessment of the species within the United States beyond its native range was attempted (Anonymous 2017b).

West Bengal occupies a major position in the ornamental fish trade with 55% of total production in India. Gupta (2012) has recorded the availability of 139 species of exotic fishes in the ornamental fish market (widely known as Galiff Street) of Kolkata. However, the presence of alligator gar in the market remained unmentioned. The presently reported survey noted that the trading of live alligator gar is performed extensively year-round in the ornamental fish market of the city. Each specimen is marketed at 700.00 Indian Rupee (=8 Euro) at a size range of 15–17 cm. Due to the aggressive nature of their behavior, alligator gar are marketed and maintained indi-

vidually. Besides, as a part of the supply chain marketing system, this exotic fish is also transported to various local aquarium traders within the state. Exotic fishes with recreational and commercial purposes have now become potential threats to natural aquatic bodies. Many such fishes have already invaded rivers, reservoirs, wetlands, etc. and established themselves alongside the declined catch of other indigenous fish species. The invasion of *Clarias gariepinus* (Burchell, 1822), a highly carnivorous catfish in the Ganga River is one such example (Singh et al. 2013). Large-scale anthropogenic modification of the riverine habitat through water obstruction, pollution, etc. has provided a favorable habitat, allowing a competitive advantage for exotic varieties over native ones (Daga et al. 2016). The Ganga River has also observed an increasing number of barricades over the years, especially in the upper reaches of the river. The availability of the adult alligator gar in an open wetland certainly creates chances for ecological imbalance in the wetland as well as in the connected river by displacing the native fish species spectrum. As little is known about its population dynamics and breeding phenology, data regarding its juvenile availability in the local markets requires more attention. A strategy for developing legal ornamental fish trading is urgently needed. A detailed database on habitat preference, breeding habits, and other biological aspects must be developed before each individual fish being targeted is introduced into the ornamental sector.

Studying fish invasions in more than 1000 river basins on a global scale, Leprieur et al. (2008) opined that

more exotic invasions may occur in river basins of developing countries, including India. India is eighth in the world and third in Asia with 788 freshwater fish species where more than one-fourth is either vulnerable or in the endangered category (Kottelat and Whitten 1996, Gopi and Mishra 2015). With an increasing number of dams and barrages, exotic invasion can certainly aggravate the situation by causing a decline of precious fish diversity. The best approach to prevent non-native species is to identify the possible entry points rather than eradication methods. The list of fish species presently being imported into India should be critically revised based on their possibility of establishment and invasiveness, or if they reached natural water by chance. Alligator gar is yet to be included in the list of 14 freshwater invasive fish species compiled by Centre for Biodiversity Policy and Law (CEBPOL), National Biodiversity Authority (NBA) as updated in 2018. A priority list should be prepared including those exotic fishes which have the possibility to become invasive in the future. Existing laws like ‘The Biological Diversity Act, 2002’ also clearly mentioned

about not importing any such fish species into India. The National Biodiversity Strategy and Action Plan has many important suggestions for the control and management of such detrimental invasive species (MOEFCC 2014). Strict monitoring and implementation/enforcement of the law are required but this necessitates national/institutional level monitoring. Awareness among local communities about the detrimental effect of identified invasive species can help to reduce their inclusion for species enhancement in aquaculture or as an ornamental fish to be reared as a pet.

Acknowledgments

We wish to thank the National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti, Government of India for their funding support under Project No. T-17/2014 15/526/NMCG- Fish and Fisheries. Thanks to Ms. Manisha Bhor for the preparation of the fish distribution map given in the paper.

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