

ASSESSMENT OF COASTAL FISH DIVERSITY IN THE RIVER GANGA: IMPLICATIONS FOR BIODIVERSITY CONSERVATION AND SUSTAINABLE FISHERIES

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*The present study aims to understand fish diversity and assemblage patterns using the trophic guild approach in the coastal region of the river Ganga. Fish samples were collected from three estuarine sampling sites, viz., Godakhali, Diamond Harbour, and Fraserganj, from September 2022 to September 2024. The study period recorded a total of 97 fin fish species, representing 21 orders and 51 families. Among them, the greatest species diversity was recorded in Diamond Harbour (77 species), followed by Godakhali (56 species) and Fraserganj (49 species). Five fish species were recorded under the 'Near Threatened' category (*Ailia coila*, *Arius gogora*, *Brevitrygon walga*, *Harpadon nehereus*, and *Scoliodon laticaudus*), while *Gymnura poecilura* was classified as Vulnerable as per IUCN Red List status. The estuarine guilds show that the marine estuarine dependent (MMD) formed the major group, followed by marine estuarine opportunists (MMO), while the feeding guild shows that carnivores (CR) dominated the fish assemblages, followed by invertebrate feeders (IF). The present study gives the baseline information required to comprehend species-specific habitat use and can aid in future management strategies.*

Introduction

The river Ganga provides a rich diversity of aquatic life and sustains millions of livelihoods through fisheries and related ecosystem services, making it one of the most iconic and ecologically significant river systems in the Indian subcontinent. The Ganga River rises in the Indian Himalayas from the Gangotri Glacier and flows for 2,525 km before meeting the Bay of Bengal. It covers diverse ecological zones, including a dynamic coastal interface in its lower reaches¹. This transition zone, where freshwater meets a saline tidal influx, forms a biologically productive and ecologically sensitive estuarine environment that harbours a unique assemblage of fish fauna. Estuaries are renowned for their high productivity and biodiversity, serving as dynamic interfaces between riverine and marine

environments. The lower estuary section of the river Ganga is generally characterised by the mixing of freshwater and saline tidal influxes, which form a complex and ecologically significant habitat that supports a diverse assemblage of ichthyofauna. In this transitional region, physicochemical parameters exhibit significant spatiotemporal variability, offering a suitable ecological niche for various freshwater, brackishwater, and marine fish species.

Coastal fish diversity is influenced by complex hydrological regimes, seasonal variations, anthropogenic pressures, and climatic changes. However, this biodiversity is increasingly under threat from anthropogenic stressors such as overfishing, habitat fragmentation, pollution, and climate change. Moreover, due to the dam construction, sedimentation, industrial effluents, and accelerated urbanisation, estuarine habitats within the lower Ganga basin face extreme anthropogenic stresses.

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The delta zone, the Ganga River's coastal area, is home to a rich, diversified ecology that supports a broad range of living organisms. Despite the ecological importance of this transitional zone, comprehensive scientific assessments focusing on its ichthyofaunal diversity remain limited. A robust understanding of species diversity, assemblage patterns, and habitat specificity is crucial for effective conservation strategies and ensuring the sustainability of inland fisheries. The current study emphasizes the variety of fish species and assemblage patterns with a trophic guild approach found in the lower coastal region of the river Ganga for their conservation and management.

opportunists (MMO), anadromous (AN), marine estuarine dependent (MMD), oceanodromous (OD), amphidromous (AD), estuarine resident species (ES), catadromous (CA), and marine stragglers (MS). Fish species numbers were used to analyse the guilds. The taxonomic positions and IUCN status of fishes were taken from FishBase⁶. The IUCN status was classified under 5 categories: Near Threatened (NT), Vulnerable (VU), Not Evaluated (NE), Least Concerned (LC), and Data Deficient (DD). The migration patterns of fish were obtained from the India Biodiversity Portal⁷ and FishBase⁶.

Results and Discussion

The estuarine stretch of the Ganga River contributes a wide variety of fish species. The study period recorded a total of 97 fish species, representing 21 orders and 51 families. Among them, the highest species diversity was found in Diamond Harbour (77 species), followed by Godakhali (56 species) and Fraserganj (49 species) (Table 1). Similarly, the maximum abundance of fish species (by number) was recorded from Diamond Harbour, followed by Godakhali and Fraserganj. Figure 1 represents the order-wise species abundance at three sampling sites. The highest

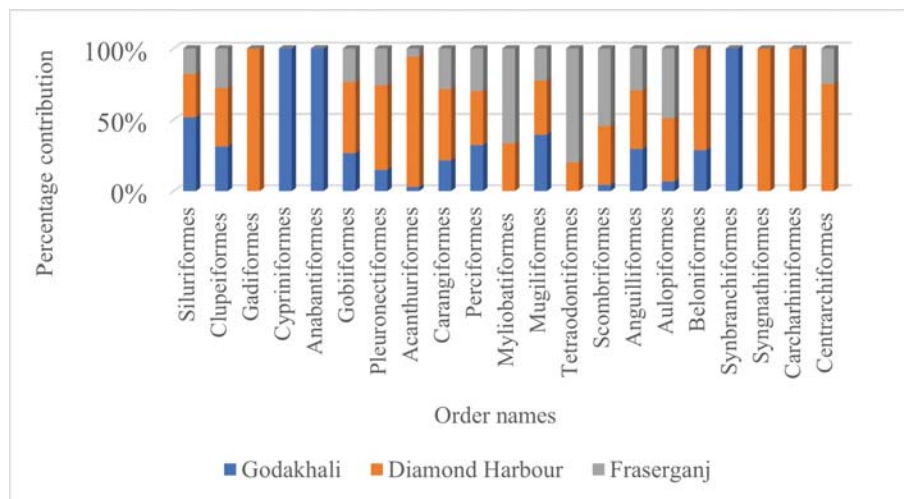


Fig. 1. Order-wise and site-wise species percentage contribution recorded from the coastal region of the Ganga River

Materials and Methods

Fish samples were collected from three estuarine sampling sites, viz., Godakhali, Diamond Harbour, and Fraserganj, in the coastal zone of the Ganga River from September 2022 to September 2024, monthly. Fish specimens were obtained from a gill net with a mesh size of 22-45 mm, a bag net of 5-22 mm, and a set barrier net with a mesh size of 20-40 mm.

Fish specimens were identified at the species level using standard literature^{2,3}. The trophic guilds of fishes were classified depending on their feeding habits^{4,5}. A total of nine feeding behaviours [omnivores (OV), invertebrate feeders (IF), carnivores (CR), planktivores (PV), zooplanktivores (ZP), detritus feeders (DV), zoobenthivores (ZB), herbivores (HV), and piscivores (PS)] were categorised based on the feeding habits of fishes. The species were categorized into ten types based on their habits in estuaries, as defined by Elliott et al.⁵: freshwater stragglers (FS), freshwater migrants (FM), marine estuarine

number of species of Cypriniformes, Anabantiformes, and Synbranchiiformes are found at Godakhali. In contrast, Diamond Harbour is home to Gadiformes, Syngnathiformes, and Carcharhiniformes, while Fraserganj is home to Tetraodontiformes. According to the IUCN status, five fish

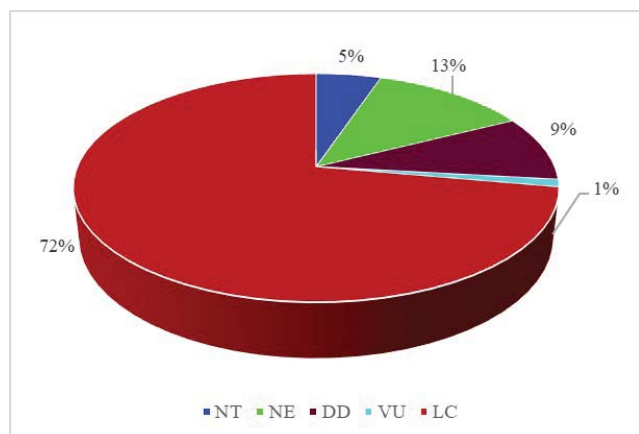


Fig. 2. IUCN Red List status of fish species obtained from the coastal region of the Ganga River

Table 1. List of finfish species recorded from the coastal zone of the Ganga River, IUCN Red List status and their corresponding guild classes (Estuarine and feeding guild)

Order	Family	Sl. No.	Species name	Common name	Estuarine guild	Trophic guild	IUCN status
Siluriformes	Ailiidae	1	<i>Ailia coila</i> (Hamilton 1822)	Gangetic alia	FS	OV	NT
		2	<i>Clupisoma garua</i> (Hamilton 1822)	Garua bachcha	FS	OV	LC
	Schilbeidae	3	<i>Eutropiichthys vacha</i> (Hamilton 1822)	Batchwa vacha	FM	OV	LC
		4	<i>Arius arius</i> (Hamilton,1822)	Threadfin sea catfish	MMO	IF	LC
	Ariidae	5	<i>Arius gagora</i> (Hamilton,1822)	Gagora catfish	MMO	IF	NT
		6	<i>Arius jella</i> (Day, 1877)	Blackfin sea catfish	MMO	IF	NE
Clupeiformes		7	<i>Nemapteryx caelata</i> (Hamilton,1822)	Engraved catfish	MMO	CR	NE
		8	<i>Osteogeneiosus militaris</i> (Linnaeus 1758)	Soldier catfish	MMO	CR	LC
		9	<i>Gagata cenia</i> (Hamilton, 1822)	Indian gagata	FM	OV	LC
		10	<i>Heteropneustes fossilis</i> (Bloch 1794)	Stinging catfish	FS	OV	LC
		11	<i>Mystus gulio</i> (Hamilton 1822)	Long whiskers catfish	FM	CR	LC
		12	<i>Pangasius pangasius</i> (Hamilton 1822)	Pangas catfish	FM	OV	LC
	Ehiravidae	13	<i>Corica soborna</i> (Hamilton 1822)	Ganges river sprat	FM	CR	LC
		14	<i>Anodontostoma chacunda</i> (Hamilton 1822)	Chacunda gizzard shad	AN	OV	LC
		15	<i>Escualosa thoracata</i> (Valenciennes 1847)	White sardine	MMO	PV	LC
		16	<i>Tenualosa ilisha</i> (Hamilton 1822)	Hilsa shad	AN	PV	LC
		17	<i>Hilsa keele</i> (Cuvier, 1829)	Keele shad	AN	OV	LC
	Chirocentridae	18	<i>Chirocentrus dorab</i> (Fabricius 1775)	Dorab wolf-herring	MMO	CR	LC
		19	<i>Coilia dussumieri</i> Valenciennes 1848	Goldspotted grenadier anchovy	MMD	ZP	LC
	Engraulidae	20	<i>Coilia reynaldi</i> Valenciennes 1848	Reynald's grenadier anchovy	MMD	ZP	LC
		21	<i>Setipinna phasa</i> (Hamilton 1822)	Gangetic hairfin anchovy	MMO	CR	LC
	Pristigasteridae	22	<i>Setipinna taty</i> (Valenciennes 1848)	Scaly hairfin anchovy	OD	ZP	LC
		23	<i>Setipinna tenuifilis</i> (Valenciennes, 1848)	Common hairfin anchovy	AD	ZP	DD
		24	<i>Stolephorus baganensis</i> Hardenberg, 1933	Bagan anchovy	AD	PV	LC
		25	<i>Stolephorus indicus</i> (van Hasselt, 1823)	Indian anchovy	OD	PV	LC
		26	<i>Ilisha elongata</i> (Anonymous [Bennett] 1830)	Elongate ilisha	MMD	PV	LC
		27	<i>Ilisha megaloptera</i> (Swainson 1838)	Bigeye ilisha	MMD	ZP	LC

Table 1. contd....

Order	Family	Sl. No.	Species name	Common name	Estuarine guild	Trophic guild	IUCN status
Gadiformes	Bregmaceroideae	28	<i>Pellona ditchella</i> Valenciennes 1847	Indian pellona	AN	PV	LC
		29	<i>Raonda russelfiana</i> Gray 1831	Raonda	MMD	PV	LC
		30	<i>Bregmaceros mcllellandi</i> Thompson 1840	Unicorn cod	MMO	PV	NE
Cypriniformes	Cyprinidae	31	<i>Osteobrama cotio</i> (Hamilton 1822)	FS	PV	LC	
		32	<i>Pethia conchonus</i> (Hamilton 1822)	Rosy barb	FM	OV	LC
		33	<i>Salmostoma bacaila</i> (Hamilton 1822)	Large razorbelly minnow	FM	OV	LC
Anabantiformes	Channidae	34	<i>Channa punctata</i> (Bloch 1793)	Spotted snakehead	FS	OV	LC
		35	<i>Trichogaster fasciata</i> Bloch & Schneider, 1801	Banded gourami	FS	OV	LC
		36	<i>Apocryptes bato</i> (Hamilton 1822)		FM	DV	LC
Gobiiformes	Oxudercidae	37	<i>Boleophthalmus boddarti</i> (Pallas 1770)	Boddart's goggle-eyed goby	AD	DV	LC
		38	<i>Oxuderces dentatus</i> Eydoux & Souleyet 1850	AD	DV	DD	
		39	<i>Pseudapocryptes elongatus</i> (Cuvier 1816)	AD	DV	LC	
	Gobiidae	40	<i>Brachygobius nusus</i> (Hamilton 1822)	AD	DV	NE	
		41	<i>Glossogobius giuris</i> (Hamilton 1822)	Tank goby	AD	CR	LC
		42	<i>Odontamblyopus rubicundus</i> (Hamilton 1822)	MMD	CR	LC	
Pleuronectiformes	Eleotridae	43	<i>Eleotris fusca</i> (Bloch & Schneider 1801)	Dusky sleeper	ES	CR	LC
		44	<i>Cynoglossus arel</i> (Bloch & Schneider, 1801)	Largescale tonguesole	MMO	ZB	DD
		45	<i>Cynoglossus cynoglossus</i> (Hamilton, 1822)	Bengal tongue sole	MMO	ZB	LC
		46	<i>Cynoglossus lingua</i> (Hamilton, 1822)	Long tongue sole	MMO	ZB	LC
		47	<i>Paraplagusia bilineata</i> (Bloch, 1787)	Doublelined tonguesole	MMO	ZB	LC
		48	<i>Brachirus pan</i> (Hamilton, 1822)	Pan sole	MMO	IF	LC
Acanthuriformes	Leognathidae	49	<i>Deveximentum insidiator</i> (Bloch 1787)	Pugnose ponyfish	MMO	IF	DD
		50	<i>Nuclaequula blochii</i> (Valenciennes 1835)	Twoblotch ponyfish	MMO	ZB	NE
		51	<i>Drepane punctata</i> (Linnaeus 1758)	Spotted sicklefish	MS	IF	LC
	Lobotidae	52	<i>Lobotes surinamensis</i> (Bloch 1790)	Tripletail	MS	IF	LC
		53	<i>Scatophagus argus</i> (Linnaeus 1766)	Spotted scat	ES	OV	LC
		54	<i>Siganus javus</i> (Linnaeus 1766)	Streaked spinefoot	MMO	HV	LC

Table 1. contd....

Order	Family	Sl. No.	Species name	Common name	Estuarine guild	Trophic guild	IUCN status
Carangiformes	Carangidae	55	<i>Alepes djedaba</i> (Fabricius, 1775)	Shrimp scad	MMO	IF	LC
		56	<i>Atropus atropos</i> (Bloch & Schneider, 1801)	Cleftbelly trevally	MMO	IF	LC
		57	<i>Megalaspis cordyla</i> (Linnaeus 1758)	Torpedo scad	MMO	PS	LC
		58	<i>Parastromateus niger</i> (Bloch 1795)	Black pomfret	MMO	IF	LC
		59	<i>Lates calcarifer</i> (Bloch 1790)	Barramundi	CA	IF	LC
Perciformes	Latidae	60	<i>Leptomelanosoma indicum</i> (Shaw, 1804)	Indian threadfin	MMD	ZB	NE
		61	<i>Polynemus paradiseus</i> Linnaeus 1758	Paradise threadfin	MMD	CR	LC
		62	<i>Eleutheronema tetradactylum</i> (Shaw 1804)	Fourfinger threadfin	MMD	IF	NE
		63	<i>Epinephelus coioides</i> (Hamilton, 1822)	Orange-spotted grouper	MMO	IF	LC
		64	<i>Johnius coitor</i> (Hamilton, 1822)	Coitor croaker	AD	CR	LC
	Epinephelidae	65	<i>Johnius gangeticus</i> (Talwar, 1991)		AD	CR	DD
		66	<i>Macropsinosa cuja</i> (Hamilton, 1822)	Cuja croaker	AN	CR	DD
		67	<i>Otolithoides pama</i> (Hamilton, 1822)	Pama croaker	MMD	CR	DD
		68	<i>Panna microdon</i> (Bleeker 1849)	Panna croaker	MMD	CR	LC
		69	<i>Gerres filamentosus</i> Cuvier 1829	Whipfin silver-biddy	MMD	IF	LC
	Gerreidae	70	<i>Gerres oyena</i> (Forsskål 1775)	Common silver-biddy	MMD	CR	LC
		71	<i>Parambassis ranga</i> (Hamilton, 1822)	Indian glassy fish	FM	IF	LC
		72	<i>Pseudambassis baculis</i> (Hamilton, 1822)	Himalayan glassy perchlet	FM	IF	LC
		73	<i>Platycephalus indicus</i> (Hamilton 1822)	Bartail flathead	MS	CR	DD
		74	<i>Sillaginopsis domina</i> (Cuvier 1816)	MS	CR	NE	
	Sillaginidae	75	<i>Sillaginopsis panijus</i> (Hamilton, 1822)	Flathead sillago	AD	CR	NE
		76	<i>Sillago sihama</i> (Fabricius 1775)	Silver sillago	AD	CR	LC
		77	<i>Brevitrygon walga</i> (Müller & Henle 1841)	Bengal whipray	MMD	IF	NT
		78	<i>Gymnura poecilura</i> (Shaw, 1804)	Long-tailed butterfly ray	MMD	IF	VU
		79	<i>Chelon parsia</i> (Hamilton 1822)	Goldspot mullet	MMD	OV	NE
Mugiliformes	Mugilidae	80	<i>Rhinomugil corsula</i> (Hamilton, 1822)	Corsula	MMD	OV	LC
		81	<i>Moolgarda tade</i> (Fabricius 1775)		MMD	OV	DD
		82	<i>Minimugil cascasi</i> (Hamilton, 1822)	Yellowtail mullet	MMD	OV	LC

Table 1. contd....

Order	Family	Sl. No.	Species name	Common name	Estuarine guild	Trophic guild	IUCN status
Tetraodontiformes	Tetraodontidae	83	<i>Chelonodontops patoca</i> (Hamilton, 1822)	Milkspotted puffer	MMO	ZB	LC
		84	<i>Lagocephalus lunaris</i> (Bloch & Schneider 1801)	Lunartail puffer	MMO	IF	LC
Scombriformes	Trichiuridae	85	<i>Eupleurogrammus muticus</i> (Gray 1831)	Smallhead hairtail	MMO	CR	NE
		86	<i>Trichiurus lepturus</i> Linnaeus, 1758	Largehead hairtail	MMO	CR	LC
Anguilliformes	Stromateidae	87	<i>Pampus argenteus</i> (Bloch, 1795)	Silver pomfret	MS	PS	NE
		88	<i>Gymnothorax tile</i> (Hamilton, 1822)	Indian mud moray	AN	CR	LC
	Muraenesocidae	89	<i>Muraenesox bagio</i> (Hamilton, 1822)	Common pike conger	MMO	CR	LC
		90	<i>Pisodonophis boro</i> (Hamilton 1822)	Rice-paddy eel	AN	CR	LC
	Ophichthidae	91	<i>Pisodonophis cancrivorus</i> (Richardson, 1848)	Longfin snake-eel	AN	CR	LC
		92	<i>Harpadon nehereus</i> (Hamilton 1822)	Bombay-duck	MMD	PS	NT
	Synodontidae	93	<i>Hyporhamphus limbatus</i> (Valenciennes 1847)	Congaturi halfbeak	MMO	IF	LC
Synbranchiformes	Mastacembelidae	94	<i>Macragnathus pancalus</i> (Hamilton, 1822)	Barred spiny eel	FM	CR	LC
		95	<i>Microphis cuncalus</i> (Hamilton 1822)	Crocodile-tooth pipefish	FM	CR	LC
Carchariniformes	Carcharhinidae	96	<i>Scoliodon laticaudus</i> Müller & Henle 1838	Spadenose shark	AD	CR	NT
		97	<i>Terapon jarbua</i> (Fabricius, 1775)	Jarbua terapon	MMO	IF	LC

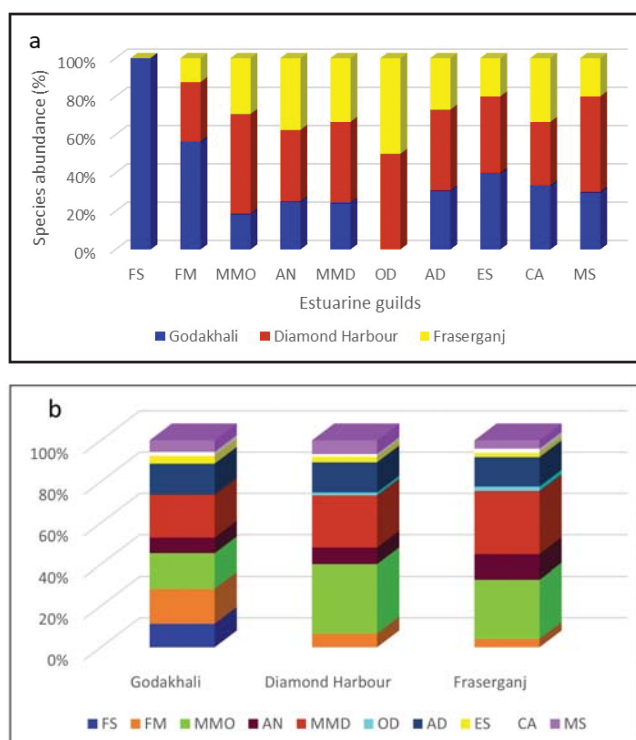


Fig 3. (a) Percentage of estuarine guilds for each sampling site by species abundance, (b) site-wise estuarine guilds percentage recorded from the coastal region of the Ganga River. Estuarine guilds-freshwater stragglers (FS), freshwater migrants (FM), marine estuarine opportunists (MMO), anadromous (AN), marine estuarine dependent (MMD), oceanodromous (OD), amphidromous (AD), estuarine resident species (ES), catadromous (CA), marine stragglers (MS)

species were recorded under the 'Near Threatened category (*Ailia coila*, *Arius gogora*, *Brevitrygon walga*, *Harpodon nehereus*, and *Scoliodon laticaudus*), while *Gymnura poecilura* was classified as Vulnerable (Fig. 2). The ecological significance of the estuarine region of the River Ganga is reflected in its high diversity, as fish serve as bioindicators of the health of the ecosystem⁸.

The estuarine guilds show that marine estuarine dependent (MMD), with 48 species, formed the largest group, next to MMO, with 45 species; AD, with 26 species; FM, with 16 species; AN, with 16 species; MS, with 10 species; FS, with 6 species; ES, with 5 species; CA, with 3 species; and OD, with 2 species. It was also observed that FM (9 species) is highest in Godakhali, while MMO and MMD are in Diamond Harbour [Figs. 3(a, b)]. However, Diamond Harbour and Fraserganj do not contain FS, as they fall under the estuarine to marine category.

The fish guild method has been used all around the world to comprehend the composition and dynamics of estuarine fish assemblages^{10, 11}. The species composition of estuaries, as well as their seasonal and spatial distribution across various trophic stages, might help

assess the ecosystem^{5, 12}. Fraserganj is located very close to the open sea connection in the Bay of Bengal. Due to this open connection between rising sea levels, tidal surges, and reduced river flow rates, the salinity increased before and after the monsoon, allowing marine species to enter the estuary without hindrance¹³. The reason saltwater species are more common in the Diamond Harbour and Fraserganj area could be because there is less freshwater flowing in and more saltwater coming in from the Bay of Bengal during high tides, which raises the salt levels. Freshwater primarily influences Godakhali, leading to the prevalence of freshwater stragglers (FS) in this region. Likewise, the physiological processes of most species are impacted by the comparatively harsh environment of estuarine habitats, which favours the majority of transient estuarine species (such as marine migrants and stragglers) over long-term inhabitants in these habitat¹⁰.

The feeding guilds reveal that 55 species of carnivores (CR) dominate the fish assemblages, followed by IF with 36 species, OV with 28 species, PV with 16 species, ZB and DV with 13 species, ZP with 12 species, PS with 7 species, and HV with a single species [Fig. 4(a, b)]. Carnivore-dominated feeding guilds define the presence of a huge abundance of top predators. Compared to marine

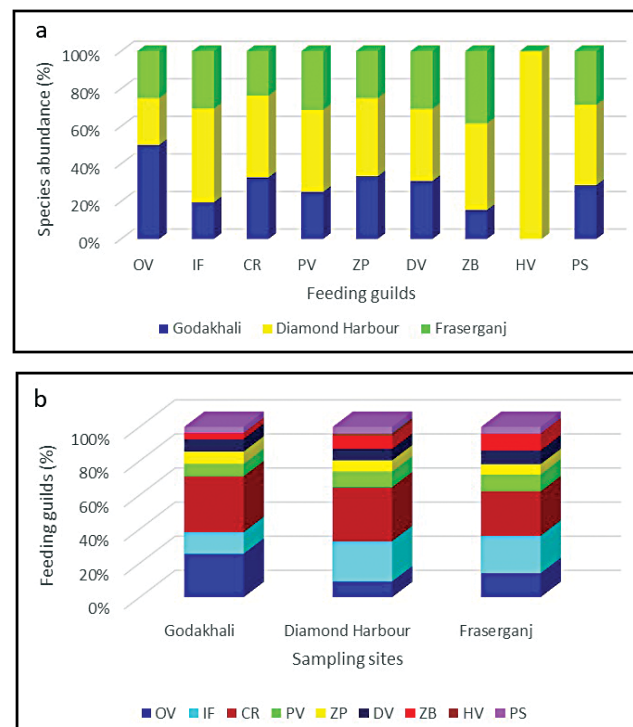


Fig 4. (a) Percentage of feeding guilds for each sampling site by species abundance, (b) site-wise feeding guilds percentage recorded from the coastal region of the Ganga River. Feeding guilds-omnivore (OV), invertebrate feeders (IF), carnivores (CR), planktivore (PV), zooplanktivore (ZP), detritus feeders (DV), zoobenthivore (ZB), herbivores (HV) and piscivores (PS)

waters, the murky shallow waters of estuarine ecosystems provide greater quantities of prey items, which foster the growth of juveniles of resistant species, many of which may be used as food by carnivorous fishes¹⁴. The increase in omnivorous fish may result from organic enrichment brought on by the significant freshwater influx, especially in the Godakhali region. Invertebrate feeders typically dominate estuarine fish assemblages due to the presence of benthic fauna such as polychaetes, amphipods, isopods, small bivalves, and oligochaetes¹⁵. Therefore, the substantial contribution of IF suggests the abundance of tiny benthic, epi-benthic, and hyper-benthic food sources that facilitate the foraging of invertebrate feeders. PV and ZP are the next dominant groups due to zooplankton availability, freshwater influx, and nutrient input from rivers. Harrison and Whitfield¹⁶ state that zooplanktivores (ZP) are known to be more prevalent in sub-tropical estuaries. Similar studies have been documented by other researchers on fish assemblages with low HV diversity and high CR diversity^{14,17}.

Conclusion

Fish diversity, their assemblages, and abundance using the guild approach provide useful information about the life history of fishes in the coastal zone of the lower Ganga River. In the estuarine area of the river, fish species that depend on both the sea and estuaries, especially carnivores, were the most common, with the highest variety and number of species found in Diamond Harbour. The study gives basic information about the types of fish found in different areas, looking at their diversity, which will help with future fishing management plans in the lower coastal area of the River Ganga.

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