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Dharamtar estuary: Unexplored ichthyofaunal diversity, a thrust area for diversity conservation

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The Dharamtar estuary has been receiving ecologists' attention, as the ecosystem is highly-stressed due to anthropogenic activities. This mangrove-associated critical ecosystem plays a vital role in the ichthyofaunal assemblages. Thus, the objective of the present study was to describe the ichthyofaunal diversity and their assemblages. The samples of the fishes were collected from DoI net landings from the Dharamtar estuary, part of the Arabian Sea. During the investigation, a total of 91 fish species belonging to 37 families and 12 orders were recorded. The exotic species *Clarias gariepinus* was recorded for the first time from the estuary. The fishes of the Dharamtar estuary were categorized as Not Evaluated (32 %), Data Deficient (5 %), Least Concerned (56 %), Near Threatened (3 %), Vulnerable (3 %) and Endangered (1 %) as per the IUCN criteria; where, 7 % of the species were traumatogenic, 5 % poisonous, 2 % venomous, and 1 % were with potential pest characteristics. The rich diversity of the estuary is associated with the sheltered area provided by mangroves that facilitates the assemblages, growth and survival of larval and juvenile fish. The results of the present investigation will be helpful in stock differentiation, biological study, conservation, etc.

[**Keywords**: Anthropogenic, Arabian Sea, Dharamtar estuary, Fish diversity, Mangrove]

Introduction

Estuaries and continental shelf areas of the sea contribute to 5.2 % of the earth's surface area and 2 % of the ocean volume[1]. The worldwide estuaries and coastal areas are facing the risk of destruction due to the disproportionate growth of the human population, riverine inputs and excessive utilisation of aquatic resources[2,3]. As a result, fisheries management and conservation of aquatic fauna have gained importance in recent years[4-6]. For the management and sustainable exploitation of marine resources, it is essential to have deep insight into the diversity and its availability with respect to time and space[7,8]. This becomes very much important when fishery resources are declining[9]. In India, Lakra *et al.*[10] reported 120 freshwater fish species under threatened categories (71 EN and 49 VU), 12 under schedule I, para 2 (A) of the Indian Wildlife Protection Act 1972, 6 species of freshwater and 36 species of marine water reported in Indian IUCN red list. It is due to the over usage of resources and deterioration of natural habitats[11]. In addition, high fishing pressure, juvenile catches and higher discard rate have led to collapse of the estuarine ecosystems[12].

The major threats to the ichthyofaunal diversity of India are natural and anthropogenic stressors[13-15], as has been observed for fishes in the Dharamtar estuary. The threats recorded for the estuary are overfishing, juvenile fishing, use of non-selective gears, near shore construction, siltation, sudden decline in salinity, and encroachment in spawning grounds in the estuary. The Dharamtar estuary is a transition zone between the Amba and Patalganga rivers and the Arabian Sea. Many industries and associated infrastructures, including dockyards, textile industries, port and oil refineries, are situated near the estuary. It is also used as transport routes by cargo ships. The estuary is surrounded by fishing communities and thus provides livelihood and nutritional security to them. Dharamtar estuary harbours a dense mangrove area and thereby acts as a nursery ground for various fish species, apart from its vital role in ecosystem services. The fish diversity of the Dharamtar estuary was underestimated in the previous study[16]. Hence, for conservation purposes, studies on the ichthyofaunal diversity of the Dharamtar ecosystem become inevitable.

Material and Methods

Samples were collected from the Dol net landings of Dharamtar estuary, located in Navi Mumbai, Maharashtra (Fig. 1). For biometric characteristics, the specimens were collected at the landing centre and transported to the laboratory in ice, washed and photographed with Canon EOS 1300D (DSLR camera). Morphometric characters were measured by digital Vernier callipers (accuracy: 0.01 mm) and meristic characters were counted using a magnifying glass in a well-illuminated background. Samples were identified up to the species level by applying an integrated approach using meristic, morphometric, otolith and molecular features[17,18]. Morphometric measurements were taken using truss networks[17-21]. The saccular otolith (sagitta) were extracted from both sides and cleaned with distilled water and diluted bleach[22], air-dried, and stored in plastic vials for photography.

Otoliths were photographed by a well-calibrated Leica stereo-zoom microscope placing the rostrum to the right and the convex side upwards. The analysis of general otolith morphology was performed[23] and analysed by Sigma Scan Pro. DNA barcoding using the COI gene was carried out by following the phenol-chloroform method[4] and information on IUCN status, feeding habits, migration and habitat of species is collected based on the secondary data[9,10,15].

The diversity of fish species was determined based on their presence/absence in the Dol net catches from September 2018 to February 2020. Data analysis was performed using software such as MS Excel, Digimizer and Statistica.

Results

In the present study, 91 fish species belonging to 37 families under 12 orders were recorded from the Dharamtar estuary, Maharashtra (Table 1). OrderPerciformes contributed dominantly with 54 % of the total fish species of the Dharamtar estuary, followed by Clupeiformes (13 %), Pleuronectiformes (5 %), Scorpaeniformes, Siluriformes, Anguilliformes, Batrachoidiformes, Beloniformes, Carcharhiniformes, Gadiformes and Orectolobiformes each contributing 3 %, and Tetraodontiformes and Aulopiformes contributed 2 % each (Fig. 2).

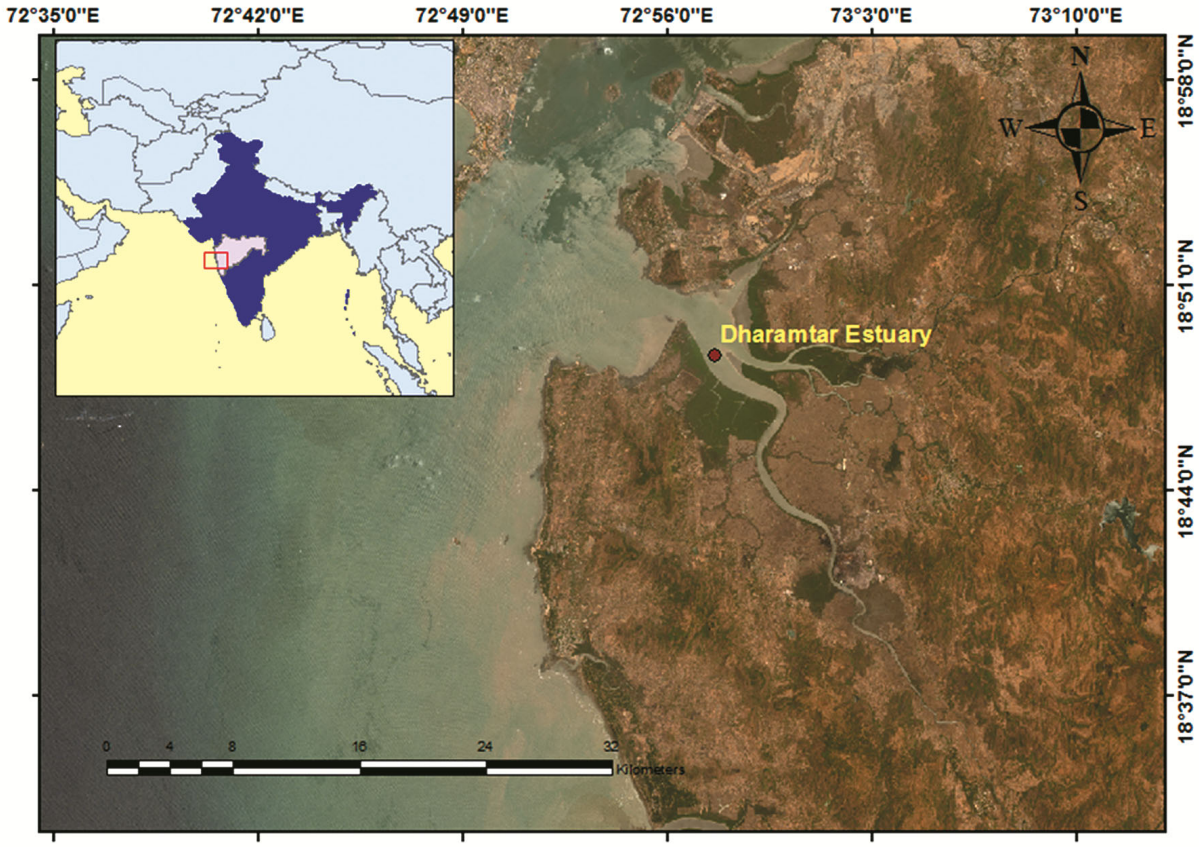

Fig. 1 — Geographical location of Dharamtar estuary (Generated using QGIS ESSEN (2.14.3) and Arc GIS 10.2)

Table 1 — Ichthyofaunal diversity of the Dharamtar estuary and their characteristics

Species	Habitat	Threat to humans	Feeding habit	Migration	Fisheries	Habitat
Order: Anguilliformes						
Family: Ophichthidae						
Pisodonophis boro (Hamilton, 1822)	F B M	H	Ca	AN	MC	DE
Order: Aulopiformes						
Family: Synodontidae						
Harpadon nehereus (Hamilton, 1822)	B M	H	Ca	OC	CO	PE
Saurida tumbil (Bloch, 1795)	M	H	Vf	OC	CO	PE
Saurida undosquamis (Richardson, 1848)	B M	H	Ca	OC	CO	PE
Order: Batrachoidiformes						
Family: Batrachoididae						
Colletteichthys dussumieri (Valenciennes, 1837)	M	H	Ca	OC	MC	DE
Order: Beloniformes						
Family: Hemiramphidae						
Hyporhamphus limbatus (Valenciennes, 1847)	F B M	H	Ca	PO	MC	PE
Order: Carcharhiniformes						
Family: Carcharhinidae						
Scoliodon laticaudus Müller & Henle, 1838	B M	H	Ca	AM	CO	BP
Order: Clupeiformes						
Family: Clupeidae						
Anodontostoma chacunda (Hamilton, 1822)	B M	H	Ca	AN	CO	PE
Escualosa thoracata (Valenciennes, 1847)	B M	H	Om	AM	CO	CW
Sardinella fimbriata (Valenciennes, 1847)	M	H	Plv	OC	CO	PE
Sardinella melanura (Cuvier, 1829)	B M	H	Plv	OC	CO	PE
Tenualosa toli (Valenciennes, 1847)	F B M	H	Ca	AN	CO	PE
Family: Engraulidae						
Coilia dussumieri Valenciennes, 1848	F B M	H	Ca	AM	CO	PE
Stolephorus indicus (van Hasselt, 1823)	B M	H	Ca	OC	CO	PE
Thryssa dayi Wongratana, 1983	M	H	Ca	OC	CO	PE
Thryssa hamiltonii Gray, 1835	B M	H	Ca	AM	CO	PE
Thryssa mystax (Bloch & Schneider, 1801)	B M	H	Ca	OC	CO	PE
Thryssa vitrirostris (Gilchrist & Thompson, 1908)	B M	H	Ca	OC	CO	PE
Family: Pristigasteridae						
Ilisha melastoma (Bloch & Schneider, 1801)	B M	H	Ca	AM	MC	PE
Ilisha filigera (Valenciennes, 1847)	B M	H	Ca	AN	MC	PE
Opisthopterus tardoore (Cuvier, 1829)	B M	H	Ca	AM	MC	PE
Pellona ditchela Valenciennes, 1847	B M	H	Ca	AN	CO	PE
Order: Gadiformes						
Family: Bregmacerotidae						
Bregmaceros mcclellandi Thompson, 1840	B M	H	Ca	OC	CO	CW
Order: Orectolobiformes						
Family: Hemiscylliidae						
Chiloscyllium griseum Müller & Henle, 1838	F B M	H	Ca	OC	BAN	PE
Order: Perciformes						
Family: Ambassidae						
Ambassis miops Günther, 1872	B M	H	Ca	AM	MC	CW
Family: Carangidae						
Alepes kleinii (Bloch, 1793)	M	H	Ca	OC	MC	CW
Atropus atropos (Bloch & Schneider, 1801)	M	H	Ca	AM	MC	PE
Family: Carangoides						
Carannmgoides coeruleopinnatus (Rüppell, 1830)	B M	H	Ca	AM	MC	CW
Caranx ignobilis (Forsskål, 1775)	B M	Po	Ca	OC	CO	CW
Megalaspis cordyla (Linnaeus, 1758)	B M	H	Ca	AM	CO	PE
Parastromateus niger (Bloch, 1795)	B M	H	Ca	AM	CO	PE
Family: Eleotridae						
Butis butis (Hamilton, 1822)	B M	H	Ca	AM	MC	PE

(*Contd*.)

Table 1 — Ichthyofaunal diversity of the Dharamtar estuary and their characteristics — (*Contd.*)

Species	Habitat	Threat to humans	Feeding habit	Migration	Fisheries	Habitat
Gerres filamentosus Cuvier, 1829	B M	H	Ca	AM	CO	PE
Family: Gobiidae						
Bathygobius niger (Smith, 1960)	M	H	Ha	NM	NIF	DE
Boleophthalmus boddarti (Pallas, 1770)	F B M	H	Ha	NM	MC	DE
Boleophthalmus pectinirostris (Linnaeus, 1758)	F B M	H	Ha	NM	MC	DE
Boleophthalmus dussumieri Valenciennes, 1837	F B M	H	Ha	NM	NIF	DE
Drombus globiceps (Hora, 1923)	B M	Po	Ca	AM	MC	DE
Glossogobius giuris (Hamilton, 1822)	F B M	H	Ca	AM	MC	DE
Glossogobius minutus Geevarghese & John, 1983	B M	H	Ca	AM	MC	DE
Odontamblyopus roseus (Valenciennes, 1837)	M	H	Ca	AM	MC	DE
Parachaeturichthys polynema (Bleeker, 1853)	B M	Po	Ca	OC	NIF	DE
Trypauchen vagina (Bloch & Schneider, 1801)	B M	H	Ca	AM	MC	DE
Family: Lactariidae						
Lactarius lactarius (Bloch & Schneider, 1801)	B M	H	Ca	OC	CO	PE
Family: Leiognathidae						
Gazza minuta (Bloch, 1795)	B M	H	Ca	OC	CO	PE
Family: Lutjanidae						
Lutjanus johnii (Bloch, 1792)	B M	H	Ca	OC	CO	PE
Family: Mugilidae						
Chelon parsia (Hamilton, 1822)	F B M	H	Ha	CAT	CO	PE
Valamugil cunnesius (Valenciennes, 1836)	F B M	H	Ha	CAT	CO	PE
Ellochelon vaigiensis (Quoy & Gaimard, 1825)	B M	H	Ha	CAT	CO	PE
Family: Menidae						
Mene maculata (Bloch & Schneider, 1801)	B M	H	Ca	OC	CO	BP
Family: Polynemidae						
Polydactylus mullani (Hora, 1926)	M	H	Ca	AM	CO	PE
Eleutheronema tetradactylum (Shaw, 1804)	F B M	H	Ca	AM	CO	PE
Family: Scatophagidae						
Scatophagus argus (Linnaeus, 1766)	F B M	VE	Ca	AM	MC	PE
Family: Sciaenidae						
Dendrophyssa russelli (Cuvier, 1829)	F B M	H	Ca	AM	CO	DE
Johnius dussumieri (Cuvier, 1830)	B M	H	Ca	OC	MC	DE
Johnius belangerii (Cuvier, 1830)	B M	H	Ca	AM	MC	DE
Johnius elongatus Lal Mohan, 1976	F B M	H	Ca	AM	CO	DE
Johnius macrorhynus (Lal Mohan, 1976)	M	H	Ca	AM	CO	DE
Joniops boreneesis (Bleeker, 1851)	B M	H	Ca	AM	CO	DE
Otolithes cuvieri Trewavas, 1974	M	H	Ca	AM	CO	DE
Otolithes ruber (Bloch & Schneider, 1801)	B M	H	Ca	AM	CO	DE
Otolithoides biauritus (Cantor, 1849)	B M	H	Ca	AM	MC	DE
Protonibea diacanthus (Lacepède, 1802)	B M	H	Ca	OC	CO	DE
Family: Scombridae						
Scomberomorus guttatus (Bloch & Schneider, 1801)	B M	H	Ca	OC	CO	PE
Family: Siganidae						
Siganus canaliculatus (Park, 1797)	B M	VE	Ca	OC	CO	PE
Family: Sillaginidae						
Sillago sihama (Forsskål, 1775)	B M	H	Ca	AM	CO	PE
Family: Sphyraenidae						
Sphyraena jello Cuvier, 1829	B M	Po	Ca	OC	CO	PE
Family: Stromateidae						
Pampus argenteus (Euphrasen, 1788)	B M	H	Ca	OC	CO	PE
Pampus chinensis (Euphrasen, 1788)	B M	H	Ca	OC	CO	PE
Family: Terapontidae						
Terapon jarbua (Forsskål, 1775)	F B M	H	Om	CAT	MC	CW
Terapon theraps Cuvier, 1829	B M	H	Om	CAT	MC	CW
Family: Trichiuridae						

(*Contd.*)

Table 1 — Ichthyofaunal diversity of the Dharamtar estuary and their characteristics — (*Contd.*)

Species	Habitat	Threat to humans	Feeding habit	Migration	Fisheries	Habitat
Eupleurogrammus muticus (Gray, 1831)	B M	H	Ca	AM	CO	BP
Eupleurogrammus glossodon (Bleeker, 1860)	M	H	Ca	AM	CO	BP
Lepturacanthus savala (Cuvier, 1829)	B M	H	Ca	AM	CO	BP
Order: Pleuronectiformes						
Family: Cynoglossidae						
Cynoglossus lingua Hamilton, 1822	F B M	H	Ca	AM	CO	BP
Cynoglossus macrostomus Hamilton, 1822	F B M	H	Ca	AM	CO	BP
Cynoglossus arel (Bloch & Schneider, 1801)	B M	H	Ca	AM	CO	DE
Cynoglossus lachneri Menon, 1977	M	H	Ca	OC	CO	DE
Lepturacanthus savala (Cuvier, 1829)	B M	H	Ca	AM	CO	BP
Family: Soleidae						
Solea elongata Day, 1877	M	H	Ca	OC	CO	DE
Order: Scorpaeniformes						
Family: Platycephalidae						
Grammoplites scaber (Linnaeus, 1758)	B M	H	Ca	AM	MC	DE
Grammoplites suppositus (Troschel, 1840)	M	H	Ca	AM	MC	DE
Order: Siluriformes						
Family: Ariidae						
Arius arius (Hamilton, 1822)	B M	Tr	Ca	AM	CO	DE
Arius maculatus (Thunberg, 1792)	F B M	Tr	Ca	PO	CO	DE
Nemapteryx caelata (Valenciennes, 1840)	B M	Tr	Ca	AM	CO	DE
Nemapteryx nenga (Hamilton, 1822)	B M	Tr	Ca	AM	CO	DE
Osteogeneiosus militaris (Linnaeus, 1758)	F B M	Tr	Ca	PO	CO	DE
Plicofollis layardi (Day, 1877)	B M	Tr	Ca	AM	MC	DE
Family: Clariidae						
Clarias gariepinus (Burchell, 1822)	F	Pp	Om	PO	BAN	BP
Order: Tetraodontiformes						
Family: Tetraodontidae						
Lagocephalus lunaris (Bloch & Schneider, 1801)	B M	Po	Ca	OC	NIF	DE
Takifugu oblongus (Bloch, 1786)	B M	H	Ca	OC	NIF	DE

F - Freshwater, B - Brackishwater, M - Marinewater, H - Harmless, Tr - Traumatogenic, Pp - Potential pest, Po - Poisonous, VE - Venomous, Ca - Carnivorous, OM - Omnivorous, Plv - Plantivorous, Ha - Herbivore, Vf - Voracious feeder, AM - Amphidromous, PO - Potamodromous, OC - Oceanodromous, NM - No Migration, CAT - Catadromous, AN - Anadromous, MC - Minor Commercial, CO - Commercial, BAN - Banned, NIF - Not Interested Fishery, DE - Demersal, PE - Pelagic, BP - Bentho-Pelagic, CW - Coastal water, NE - Near Threatened, LC - Least Concerned, DD - Data Deficient, VU - Vulnerable, NT - Near Threatened, and EN - Endangered

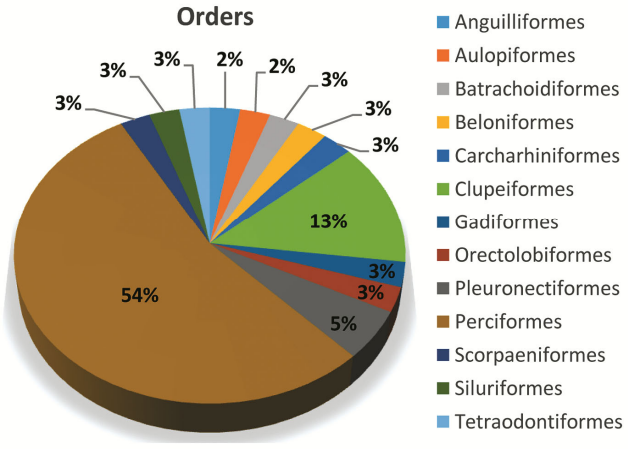

Fig. 2 — Characterization of ichthyofauna of Dharamtar estuary based on their classification (Order level)

In the current work, the maximum number of species belonged to Family Sciaenidae and Gobiidae (10 species each), followed by Ariidae (8), Carangidae (6), Engraulidae (6), Clupeidae (5) and Cynoglossidae (5 species; Fig. 3). The species recorded were categorized as Not Evaluated (NE; 32 %,) Data Deficient (DD; 5 %), Least Concern (LC; 56 %), Near Threatened (NT; 3 %), Vulnerable (VU; 3 %) and Endangered (EN; 1 %) (Fig. 4).

The species were also categorized based on the threat to humans where harmless species were 85 % followed by traumatogenic (7 %), poisonous (5 %), venomous (2 %) and species as potential pest contributed to 1 % (Fishbase, 2020; Fig. 5). The ichthyofaunal diversity of the Dharamtar estuary is composed of 43 % pelagic, 38 % demersal, 10 % benthopelagic and reef-associated

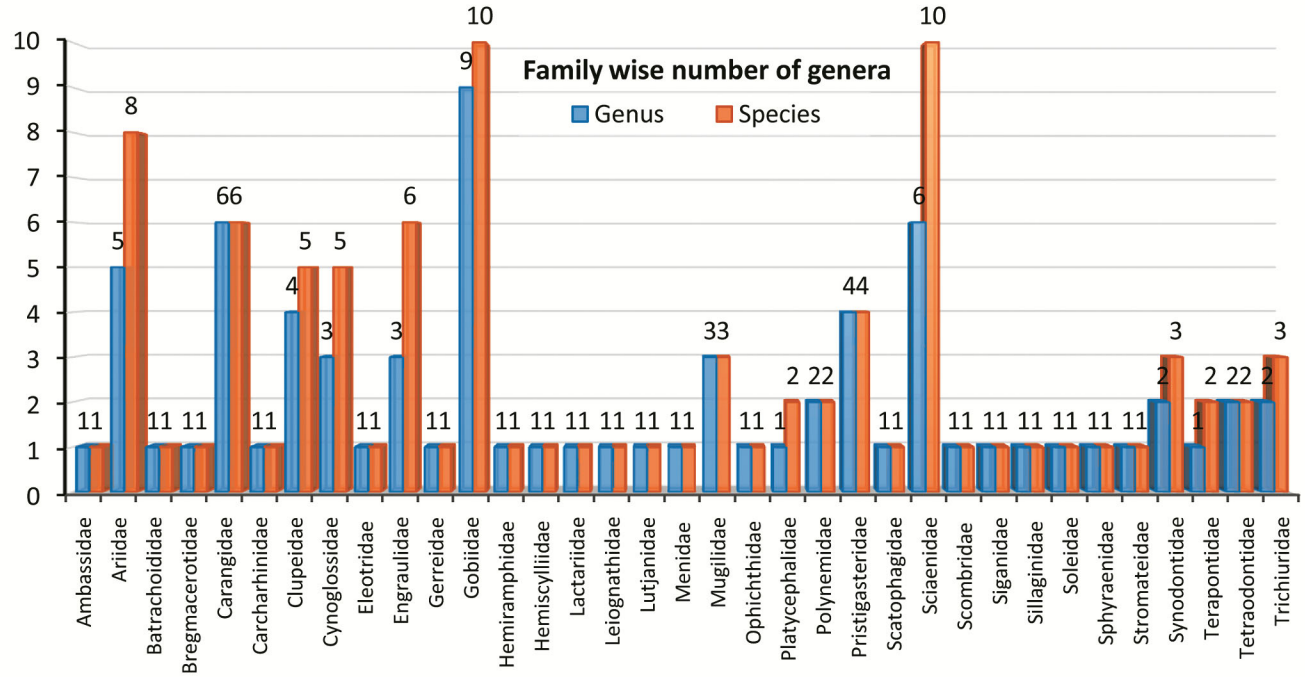

Fig. 3 — Family-wise distribution of genera of Dharamtar estuary ichthyofauna

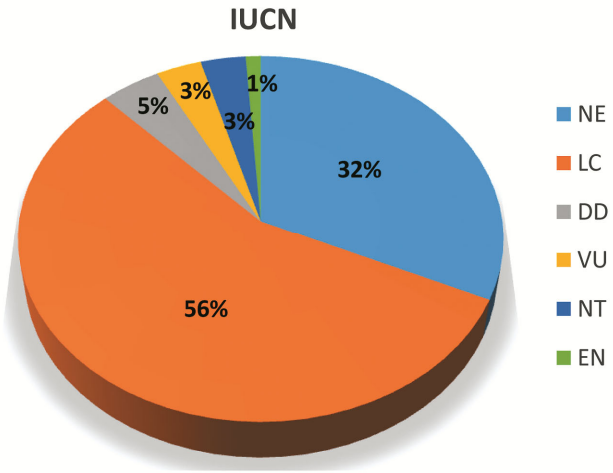

Fig. 4 — Characterization of Dharamtar estuary ichthyofauna based on IUCN categories (NE - Near Threatened, LC - Least Concerned, DD - Data Deficient, VU - Vulnerable, NT - Near Threatened, and EN - Endangered)

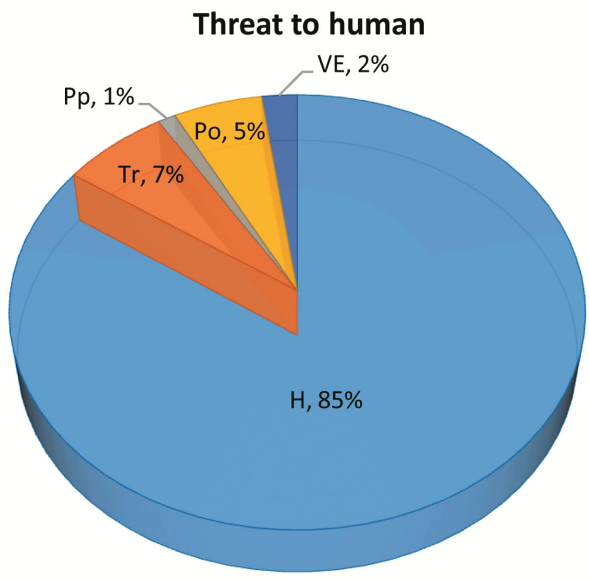

Fig. 5 — Characterization of Dharamtar estuary ichthyofauna based on the threat to humans (Tr - Traumatogenic, Pp - Potential pest, Po - Poisonous, and VE - Venomous)

and 9 % coastal water species (Fig. 6). Also, the diversity is comprised of 47 % amphidromous fish species followed by 33 % oceanodromous, 6 % catadromous, 4 % potamodromous, 6 % anadromous and 4 % resident species (Fig. 7). Of the species recorded, 63 % are commercially important, 30 % minor commercial, 5 % are non-sought-for species, and 2 % are banned fish species (Fig. 8). Based on the feeding ecology of the reported species, 84 % were carnivores, 9 % herbivores, 4 % omnivores, 2 % planktivores, and 1 % was voracious feeder (Fig. 9).

Discussion

The icthyofaunal diversity, recorded during the present study, is the first comprehensive documentation of fish species from the Dharamtar

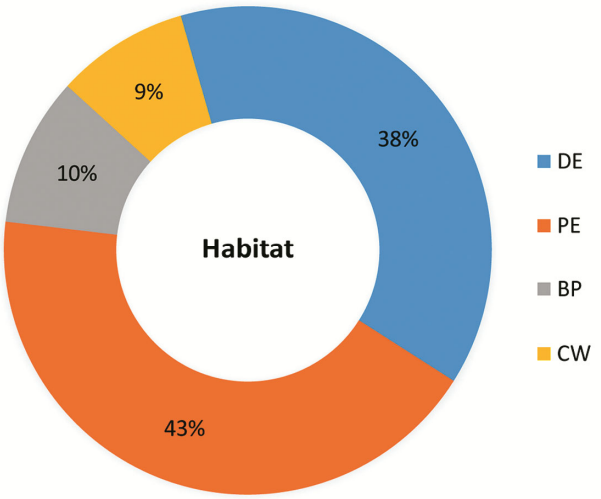

Fig. 6 — Classification of ichthyofauna of Dharamtar estuary based on their habitat (DE - Demarsal, PE - Pelagic, BP - Bentho-Pelagic, and CW - Coastal Water)

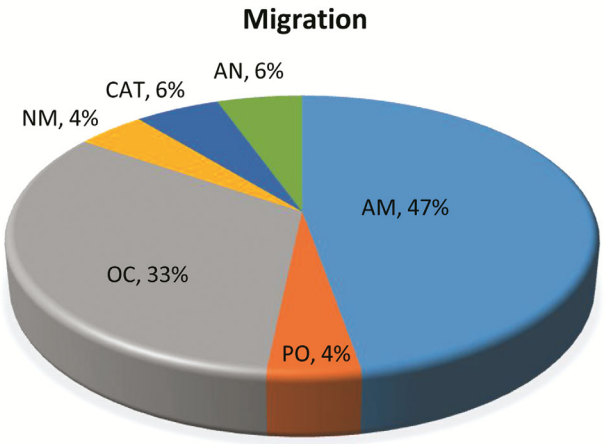

Fig. 7 — Classification of ichthyofauna of Dharamtar estuary based on their migration patterns (AM - Amphidromous, PO - Potamodromous, OC - Oceanodromous, CAT - Catadromous, AN - Anadromous, and NM - No Migration)

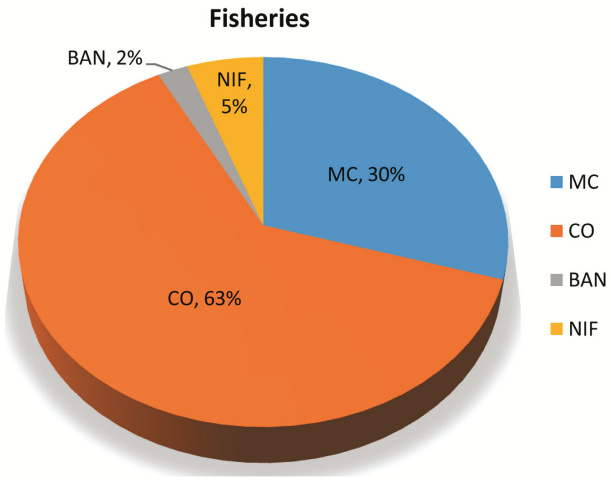

Fig. 8 — Classification of ichthyofauna of Dharamtar estuary based on their commercial importance (MC - Minor Commercial, CO-Commercial, BAN - Banned, and NIF- Not Interested Fishery)

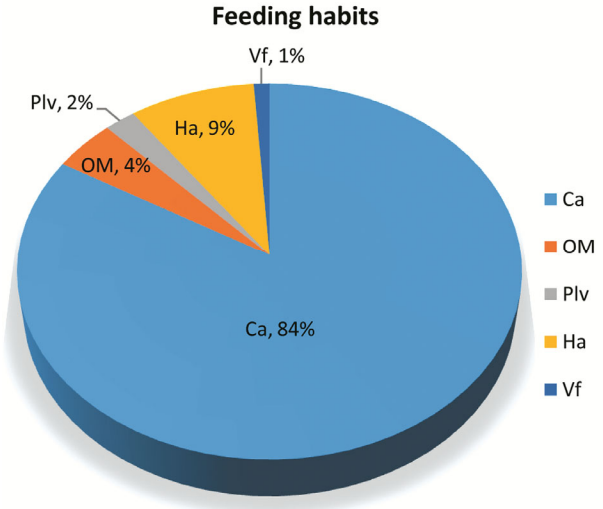

Fig. 9 — Classification of ichthyofauna of Dharamtar estuary based on their feeding habit (Ca - Carnivorous, OM - Omnivorous, Plv - Plantivorous, Ha - Herbivore, and Vf - Voracious feeder)

estuary. The previous investigation from the area reported only 31 fin fishes[16]. Documentation of the diversity under different categories will help formulate the desired conservation measures for sustainable utilisation. The species recorded under the order Perciformes were the most dominant, followed by Clupeiformes and Siluriformes. The results are obvious, as order Perciformes is the most diverse taxa of marine fishes[24]. In the present investigation, 2 % of species were categorized as NT, 3 % as VU and 1 % as EN, indicating the need for management and conservation measures. The looming threats to fishery resources in the Dharamtar estuary include indiscriminate fishing, destructive fishing methods, habitat modification, siltation, industrial pollution, mangrove deforestation and port construction, which may damage the Dharamtar estuarine ecosystem[25].

Though complete information on the diversity of fishes, their distribution, reproductive biology and growth is a pre-requisite for effective resource management strategy and conservation[26], banning of indiscriminate fishing practices, especially during breeding and spawning season, protection of breeding grounds, control over pollutants, construction of fish bypasses for fish migration, introduction of aquaculture, restocking of commercially important fishes and ban on plastics, raising awareness among

the fisherman about fishery resources and aquatic ecosystem conservation[9] may improve the ecological conditions and thus, production.

The family Mugilidae, revised by Eschmeyer & Fong[27], was considered in Perciformes and placed between Cichlidae and Cepolidae, while Nelson[28] placed the family Mugilidae in the order Mugiliformes (Froese & Pauly)[29] and the same classification (Eschmeyer & Fong[27]) is followed in the present study. The number of fin fish species recorded in the current work may not be final and may change in future.

Conclusion

This investigation provides the current status of ichthyofaunal diversity in the Dharamtar estuarine ecosystem, describing different types of fishes, such as poisonous, non-poisonous, traumatogenic, and venomous, and their migration pattern along with IUCN status. The findings will be beneficial for future biological studies, stock differentiation, conservation planning and management of fishery resources from the estuary.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Statement

We have not harmed any animal during the research and the authors declare that they have no competing financial interests

Author Contributions

The first author (VP) collected data and processed it, while other authors (RNB, SC, RK, SB, GD & AKJ) contributed to data processing, analysis and preparation of the manuscript.

References

1 Wolanski E, *Estuarine Ecohydrology*, (Elsevier, Amsterdam, Netherlands), 2007, pp. 157.

2 Jennerjahn T C & Mitchell S B, Pressures, stresses, shocks and trends in estuarine ecosystems–An introduction and synthesis, *Estuar Coast Shelf Sci*, 130 (2013) 1-8.

3 Eggleton, Jacqueline & Thomas K V, A review of factors affecting the release and bioavailability of contaminants during sediment disturbance events, *Environ Int*, 30 (7) (2004) 973-980.

4 Arthington A H, Nicholas K D, William G & Ian J W, Fish conservation in freshwater and marine realms: Status, threats and management, *Aquat Conserv*, 26 (5) (2016) 838-857. doi.org/10.1002/aqc.2712

5 Dawson D R & Koster W M, Habitat use and movements of Australian grayling (*Prototroctes maraena*) in a Victorian coastal stream, *Mar Freshw Res*, 69 (8) (2018) 1259-1267. doi.org/10.1071/MF17198

6 Pinto M F, Oliveira T P R, Rocha L A & Alves R R N, People and fishery resources: A multidimensional approach, In: *Ethnozoology*, edited by Alves R R N & Albuquerque U P, (Academic Press), 2018, pp. 119-149. doi.org/10.1016/B978-0-12-809913-1.00008-9

7 Yusoff F M, Shariff M & Gopinath N, Diversity of Malaysian aquatic ecosystems and resources, *Aquat Ecosyst Health Manag*, 9 (2) (2006) 119-135. https://doi.org/10.1080/14634980600713315

8 Bijukumar A & Deepthi G R, Mean trophic index of fish fauna associated with trawl bycatch of Kerala, southwest coast of India, *J Mar Biol Assoc India*, 51 (2) (2009) 145-154.

9 Hossain M, Rahman M M, Ali M M, Hossen M A, Nawer F, *et al*., Check list of fish species availability in Rupsha River, Bangladesh: Threat identification and recommendation for sustainable management, *Indian J Geo-Mar Sci*, 45 (10) (2016) 1292-1298.

10 Lakra W S, Sarkar U K, Gopalakrishnan A & Kathirvel P, *Threatened freshwater fishes of India*, (National Bureau of Fish Genetic Resources), 2010.

11 Adeyemo & Olanike K, Consequences of pollution & degradation of Nigerian aquatic environment on fisheries resources, *Environmentalist*, 23 (4) (2003) 297-306. doi.org/10.1023/B:ENVR.0000031357.89548.fb

12 Tsagarakis K, PalialexisA & Vassilopoulou V, Mediterranean fishery discards: Review of the existing knowledge, *ICES J Mar Sci*, 71 (5) (2014) 1219-1234. https://doi.org/10.1093/icesjms/fst074

13 Das P, De S P, Bhowmick R M, Nandy A C, Pandit, *et al.*, Diminishing trend of fish species diversity in West Bengal: field study, *Fish Chimes*, 24 (1) (2004) 73-78.

14 Kurup B M & Radhakrishnan K V, Freshwater fish biodiversity of Kerala; Status and utilization for commercial fishing, food security and livelihood, *Fish Chimes*, 25 (10) (2006) 111-122.

15 Rout S K, Malla S, Das B K, Trivedi R K & Sundaray J K, Conservation of Indian threatened ichthyofauna - Immediate implications, *Fish Chimes*, 27 (5) (2007) 40-44.

16 Prabhakar & Pawar R, Assessment of bycatch and discards in marine capture fisheries from Uran (Raigad), Navi Mumbai, Maharashtra, *Ecoscan*, 5 (2011) 105-109.

17 Murty V S & Manikyam Y, *Taxonomic revision of the flatheads (Platycephalidae: Pisces) of India*. No. 259, Zoological Survey of India, Kolkata, 2007, pp. 104.

18 Fischer W & Bianchi G (Eds.), *FAO species identification sheets for fishery purposes: Western Indian Ocean, Fishing Area 51*, Vol 5, (FAO, Rome), 1984, pp. 513.

19 Hensley D & Amaoka K, Bothidae, lefteye flounders, In: *The living marine resources of the Western Central Pacific 6*, edited by Carpenter K E & Niem V H, (FAO, Rome), 2001, 3799–3841.

20 Munroe T A, Soleidae, In: *FAO species identification guide for fishery purposes. The living marine resources of the western central Pacific*, Vol 6, (FAO, Rome), 2001, pp. 3848-3889.

21 Munroe T A, Paralichthyidae: sand flounders, In: *The living marine resources of the Western Central Atlantic*, Vol 3, (FAO, Rome), 2002, pp. 1898-1919.
22 Secor & David H, Application of otolith microchemistry analysis to investigate anadromy in Chesapeake Bay striped bass *Morone saxatilis*, *Fish Bull (Seattle)*, 90 (1992) 798-806.
23 Tuset V M, Antoni L & Carlos A A, Otolith atlas for the western Mediterranean, north and central eastern Atlantic, *Sci Mar*, 72 (S1) (2008) 7-198. doi.org/10.3989/scimar.2008.72s17
24 Kar D, Nagarathna A V, Ramachandra T V & Dey S C, Fish diversity and conservation aspects in an aquatic ecosystem in Northeastern India, *Zoos Print J*, 21 (7) (2006) 2308-2315. doi.10.11609/JoTT.ZPJ.1437a.2308-15
25 Pawar P R, Monitoring of impact of anthropogenic inputs on water quality of mangrove ecosystem of Uran, Navi Mumbai, west coast of India, *Mar Pollut*, 75 (2) (2013) 291-300. http://dx.doi.org/10.1016/j.marpolbul.2013.06.045
26 Olden J D, Kennard M J, Leprieur, F, Tedesco P A, Winemiller K O, *et al*., Conservation biogeography of freshwater fishes: Recent progress and future challenges, *Divers Distrib*, 16 (3) (2010) 496-513. doi.org/10.1111/j.1472-4642.2010.00655.x
27 Fricke R, Eschmeyer W & Fong J D, Species of fishes by family/subfamily, 2020. Accessed at http://research.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp, 15 August 2020.
28 Nelson J S, *Fishes of the world*, 4th edn, (Hoboken USA: John Wiley, Sons), 2006, pp. 601.
29 Froese R & Pauly D (eds.), *Fish Base*, World Wide Web electronic publication, 2020, version 08/2015. Accessed at http://www.fishbase.org, 15 July 2020.