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Ichthyofaunal diversity of Interu mangrove swamp of river Krishna estuarine region Andhra Pradesh, India

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Abstract
Interu Mangrove swamp located at 81°14′ E longitude and 16° 16′ N latitude is a shallow water body enclosed by the mangrove vegetation situated in the north-eastern part of the River Krishna estuarine region. The water levels in the swamp are subjected to variations depending on the tidal inflow and the incoming water from the irrigation canals from the river Krishna and during monsoon period the surface run off from the surrounding upland areas. Depending on the freshwater in flows in to the swamp, the depth of the swamp ranges from 2 to 3 meters and also varies during high tide and low tide periods. The biodiversity assessments were carried out during 2013–2018 and documented 76 species belonging to 54 genera, in 34 families and 9 orders, including two endemic (*Acentrogobius griseus*, *Bathygobius ostreicola*) and one exotic cichlid species (*Oreochromis mossambicus*). The Order Perciformes is the dominant whereas Gonorynchiformes, Siluriformes and Beloniformes are least representation. Of which 42 species are Not Evaluated (NE), 25 species are Least Concern (LC), 4 species are Vulnerable (VU); 3 species are Data Deficient (DD) and 2 species are while 39 species and 17 species from the Interu mangrove swamp. An account of faunal characteristics for 39 commercially important species is provided.

Keywords: Krishna estuary, mangrove swamp, fishes, IUCN status

Introduction
River Krishna is one of the largest perennial rivers in east coast of India, (next to River Godavari) originating in the Deccan plateau flowing eastwards and opening in the Bay of Bengal near Machilipatnam in Andhra Pradesh. Krishna estuarine system cover an area of 320 Km^2 of which mangrove extends over an area of 25,000 ha which representing 5.13% of India and 42.9% of Andhra Pradesh state mangrove area [1]. In the Krishna estuarine region, Interu mangrove swamp located in the North Eastern part and extends over an area of 1079 ha covering 560 ha mangrove vegetation [1]. It is a shallow water body with an average depth of 1-3 m and opens into Bay of Bengal with a channel of 200 m wide. During high tide period sea water enters into the swamp through this channel and leaves during low tides. The swamp receives freshwater mainly from distributaries of River Krishna irrigation drains during monsoon and surface runoff of surrounding areas [2]. Depending upon freshwater inflow into the swamp salinity varies. The unique and fragile ecosystem of Interu mangrove swamp gradually began to lose its ecological integrity due to coastal processes, significant decrease in salinity regime, and degraded drainage basin with associated anthropogenic impacts. The introduction of these pollutants into aquatic systems constitutes a major threat to hydro-chemical and fauna characteristics of the aquatic ecosystems. Fish is one of the most valuable sources of high grade protein available to man and knowledge of its composition and nutritional value is essential. Due to industrialization and urbanization many pollutants are being introduced directly and indirectly into aquatic ecosystem [3].
The rapid increase in human population and the intense activities to meet its economic needs and growing aspirations have placed an immense pressure on the natural resources, and have led to misuse or abuse of available resources. Human activities have dramatically increased the intensity, pace and kinds of environmental change, posing severe adaptive challenges to marine organisms. Anthropogenic destruction of resources, fragmentation and change of habitats, release of pollutants, introduction of species and climate change, are now more rapid, intensive and widespread than natural changes. Mangrove ecosystems are important wetlands along tropical and sub tropical coasts which providing environmental,

economical sustainability and also richest storehouses of biological diversity [4]. Even though, the estimated global total mangrove area occupies only 0.1% of (137,760 Km^2) of earth's continental surface [6]. Of which Mangrove of India occupies 3% of the world mangrove flora [7]. In the energy food web of coastal mangrove systems detritus appears to be as one of the chief sources of carbon and nitrogen which causes excellent biological productivity [8, 9, 10]. Hence mangrove forests act as good nursery grounds for near shore fish and fishery populations and 90% of all marine organisms are resident in the mangrove ecosystem during one or more parts of their life cycle [11]. Moreover, Indian mangroves harbor 919 floral species and 3066 faunal species. Surprisingly no other country in the world supports so many species in the mangrove ecosystem [5]. However, such important ecosystems are undergoing degradation due to a combination of physical, biological, anthropogenic and social factors. A variety of human induced stress and factors such as changes in water quality, soil salinity, sedimentation and diversification of freshwater in the upstream are causing mangrove degradation [1]. On the other hand mangrove plants have been eliminated from coast because of grazing cattle/goat, cutting mangrove trees for timber and fire wood and aquaculture activities and industrial development. Upcoming predictions suggest that 30%-40% of coastal wetlands and 100% of mangrove forests could be lost in the next 100 years if existing rate of decline continue [12, 13, 14]. The present study provides an intensive study of the ichthyofauna of Interu mangrove swamp to assess the presence of earlier recorded species and report new records. This data will serve as a baseline of the ichthyofaunal diversity of the Interu Mangrove swamp and will facilitate future ichthyofaunal surveys, monitoring and fish biodiversity studies in this area.

Materials and Methods

The fish collections were done fortnightly in the Interu mangrove swamp (Fig-1) from January 2013 to December 2018. Fish were preserved in 10% formalin for proper species identification and further investigations. All the necessary data of captured fish like morphmetric meristic characters were recorded in fresh condition. Based on the standard taxonomic keys [15, 16, 17, 18, 19]. Fish were identified and the current valid name of each species and IUCN status were given based on the Catalog of Fishes (CofF version 2018) and IUCN-2018 [20].

Results and Discussion

The systematic taxonomic position of the recorded species and their details from the present study site are given in Table 1. A total number of 76 species belonging to 54 genera, in 34 families and 9 orders, of fishes were reported during the present investigations. Of which, Perciformes dominates the total fauna with thirty nine (45) species followed by eight (9) species of each by Anguilliformes 9, Clupeiformes. (8) Scorpaniformes represented by two (2) species whereas mugilformis (5), Siluriformes 4 and Osteoglossiformes Beloniformes and Gonorhynchiformes, were represented by one species each.

The present study reports the following 27 species as new records to the River Krishna estuary; *Notopterus notopterus, Anguilla bengalensis, Acentrogobius griseus, Bathygobius ostreicola Moringua raitaborua* (Hamilton); *Gymnothorax meleagris* (Shaw); *Strophidon sathete* (Hamilton); *Pisodonophis boro* (Hamilton); *P. cancrivorus* (Richardson); *Muraenichthys schultzei* Bleeker*; Uroconger lepturus* (Richardson); *Muraenesox bagio* (Hamilton); *Sardinella gibbosa* (Bleeker); *Coilia reynaldi* Valenciennes; *Stolephorus baganensis* Hardenberg; *Ambasis kopsii* Bleeker; *Epinephalus maculates* (Bloch); *Promicrops lanceolatus* (Bloch); *Terapon puta* (Cuvier); *Leiognathus daura* Cuvier; *Lutjanus flaviflammus* (Forsskal); *L. russellii* (Bleeker); *Gerres limbatus* Cuvier; *Acentrogobius cyanomos* (Bleeker); *Psammogobius biocellatus* (Valenciennes); *Brachyamblyopus brachysoma* (Bleeker); *Taeniodes buchanani* (Day). Of these 2 species namely *Muraenichthys schultzei* Bleeker and *Brachyamblyopus brachysoma* (Bleeker) are reported first time from India estuaries. In the current study records presence of two species near threatened (*Oreochromis mossambicus and Anguilla bengalensis*); four species represented as vulnerable; three species deficient; 25 species are least concern and remaining 42 species are not evaluated. The IUCN status (Percentage) of fish fauna of Interu mangrove swamp is presented Fig.2.

With increasing population, industrialization and urbanization, water pollution by agricultural, aquaculture, municipal and industrial sources has become a major concern for the welfare of humanity. Water soluble toxicants from industrial and municipal wastes, leached soils and the atmosphere have rapidly transferred to natural bodies of water. While some of the pollutants decompose or volatilize, others form insoluble salts, which precipitate and get incorporated into the sediment. Uptake of such toxicants by aquatic organisms like fish may be followed by metabolism of the toxicants into more toxic derivatives [21]. The mercury from industrial effluents may be converted by microbial action into highly toxic methyl mercury which can then be taken up by fish. Many aquatic organisms have been known to concentrate toxic solutes from their habitat without any obvious damage to themselves. In spite of pressure from anthropogenic activities of mangrove swamps of Krishna estuary were overwhelming due to perennial flow of river Krishna and other climatic disturbances. However, current industrialization in the upstream and port activities along core mangroves might obstruct the faunal diversity in the near-future. Krishna and Madhusudhanarao [1]. Have reported that the degradation of mangroves due to aquaculture activities and other industrial activities. Further, they reported that changes in the species composition noticed can be attributed to the impacts of solid waste from shrimp and fish ponds effluents released from the surrounding areas and decreased inflow of freshwater from the surrounding areas from the river Krishna due to the construction of dams across the river for used of water for agriculture and other purpose. From the standpoint of conservation, faunal diversity of Krishna estuarine systems has so far received little attention. Their existence has now come under the threat of a host of anthropogenic activities, of which the habitat distinction is most alarming. The present study reveals that the fish composition of the Interu mangrove swamp is helpful to extend our knowledge of fish communities in the Krishna estuarine systems for conservation and management of east coast mangrove ecosystem. Hopefully, this checklist will be a good reference for current and future studies and also ensure the sustainability of wetland ecosystems and fisheries importance.

The most of the common threats to the biodiversity of fishes of Indian water bodies from various anthropogenic and

natural stressors [22, 23], and also fishes in Krishna estuary observed by (Krishna *et al*.,) [24]. There, the most relevant threats were degradation of aquatic environment, siltation and encroachment of spawning grounds in the estuary by different operations, other destructive fishing practices, unabated expansion of illegal large culture units, drastic decline in salinity dynamics, and siltation at the river mouth [25]. Mohanty *et al*. [26] (2007) reported that six economic species (*Tenualosa ilisha, Rhinomugil corsula, Acanthopagrus berda, Chanos chanos, Megalops cyprinoides and Elops machnata*) almost disappeared from commercial landings during the ecodegradation phase but gradually reappeared during the ecorestoration phase at Chilaka lake. However, very little work is known in the Krishna estuarine region and earlier studies on the fish fauna reported that 27 species of Clupeioids by Ankamma and Sharma [27] and 18 species of gobioids by Luther Das and Sharma [28]. The present study has been taken up to access and document the current status of fish fauna of Interu mangrove swamp which helps for further studies in the conservation and management of estuarine ecosystems in the east coast of India.

Conclusions: Due to rapid industrialization, urbanization and other related developmental activities, the natural aquatic ecosystems adversely affected. The fish resources are under severe threat from various natural as well as manmade activities in this area. The important anthropological stresses are industrial, domestic and pesticide pollution, habit destruction, aquaculture and agriculture developmental activities, soil erosion and over exploitation due to ever increasing demand for fish as food against inadequate supply. Hence the study concluded that declining the fish fauna and to suggest conservative measures for protecting the precious ichthyofauna of Interu swamp. The important causes for the depletion of fish fauna observed in Krishna estuary particularly Interu swmap was obstructions in breeding grounds and reduction in the available spawning area have together caused the decline in breeding, recruitment and availability of dangerous carnivores fishes. Regular monitoring of existing threatened populations must be done along with their stock assessment. The most apparent causes for decline in fish and fishery are over exploitation (over-fishing), destruction of brood stock and juveniles. In view of the paucity of information on endangered and other economically important fish on aspects related to population structure, distribution range, habitat, life history traits and factors responsible for their endangerment, research in these lines shall be initiated and strengthened. Urgent action is needed for the treatment domestic sewage and industrial effluents in this Krishna estuary.

Table 1: Taxonomic composition of fish fauna from Interu mangrove swamp.

S. No.	Order	Family	Species	IUCN Status
1	Osteoglossiformes	Notopteridae	*Notopterus notopterus* (Pallas, 1769)	LC
2	Anguilliformes	Anguillidae	*Anguilla bengalensis* (Gray, 1831	
3		Moringuidae	*Moringua raitaboura* (Hamilton, 1822)	NE
4		Muraenidae	*Gymnothorax meleagris* (Shaw, 1795)	NE
5			*Strophidon sathete* (Hamilton, 1822)	NE
6		Ophichthidae	*Muraenichthys schultzei* Bleeker, 1857	NE
7			*Pisodonophis boro* (Hamilton, 1822)	LC
8			*Pisodonophis cancrivorus* (Richardson, 1848)	NE
9		Congridae	*Uroconger lepturus* (Richardson, 1845)	NE
10		Muraenesocidae	*Muraenesox bagio* (Hamilton, 1822)	NE
11	Clupeiformes	Clupeidae	*Anodontostoma chacunda* (Hamilton, 1822)	NE
12			*Escualosa thoracata* (Valenciennes, 1847)	NE
13			*Sardinella gobbosa* (Bleeker,1849)	NE
14		Engraulidae	*Coilia reynaldi* Valenciennes,1848	NE
15			*Stolephorus baganensis* (Hardenberg,1931)	NE
16			*Thryssa hamiltonii* Gray, 1835	NE
17			*Thryssa purava* (Hamilton, 1822)	NE
18			*Thryssa setirostris* (Broussonet, 1782)	NE
19	Gonorynchiformes	Chanidae	*Chanos chanos* (Forsskål, 1775)	NE
20	Siluriformes	Bagridae	*Mystus gulio* (Hamilton, 1822)	LC
21			*Mystus cavasius* (Hamilton, 1822)	LC
22			*Mystus vittatus* (Bloch, 1794)	VU
23		Pangasiidae	*Pangasius pangasius* (Hamilton, 1822)	VU
24	Mugiliformes	Mugilidae	*Liza macrolepis* (Smith, 1846)	NE
25			*Liza parsia* (Hamilton, 1822)	LC
26			*Mugil cephalus* Linnaeus, 1758	LC
27			*Valamugil speigleri* (Bleeker, 1958)	NE
28			*Rhinomugil corsula* (Hamilton, 1822)	VU
29	Beloniformes	Hemiramphidae	*Hyporhamphus limbatus*	LC
30	Scorpaeniforms	Platycephalidae	*Grammoplites scaber* (Linnaeus, 1758)	NE
31			*Platycephalus indicus* (Linnaeus, 1758)	DD
32	Perciformes	Ambassidae	*Ambassis kopsii* Bleeker, 1856	NE
33			*Ambassis nalua* (Hamilton, 1822)	LC
34		Latidae	*Lates calcarifer* (Bloch, 1790)	NE
35		Serranidae	*Epinephelus maculatus* (Bloch, 1790)	LC
36			*Epinephelus lanceolatus* (Bloch, 1790)	VU
37		Terapontidae	*Terapon jarbua* (Forssåkl, 1775)	LC
38			*Terapon puta* Cuvier, 1829	NE

39		Sillaginidae	*Sillago sihama* (Forssåkl, 1775)	NE
40		Leiognathidae	*Leiognathus daura* (Cuvier, 1829)	NE
41			*Leiognathus equulus* (Forssåkl, 1775)	LC
42			*Eubleekeria splendens* (Cuvier, 1829)	LC
43		Lutjanidae	*Lutjanus fulviflamma* (Forssåkl, 1775)	NE
44			*Lutjanus johnii* (Bloch, 1792)	NE
45			*Lutjanus russellii* (Bleeker, 1849)	NE
46		Gerreidae	*Gerres filamentosus* Cuvier, 1829	LC
47			*Gerres limbatus* Cuvier, 1830	LC
48		Haemulidae	*Pomadasys maculates* (Bloch1793)	NE
49		Polynemidae	*Eleutheronema tetradactylum* (Shaw, 1804)	NE
50		Mullidae	*Upeneus sulphureus* Cuvier, 1829	NE
51.	Perciformes	Drepaneidae	*Drepane punctata* (Linnaeus, 1758)	NE
52		Nandidae	*Nandus nandus* (Hamilton, 1822)	LC
53		Terapontidae	*Terapon jarbua* (Forsskal, 1775)	LC
54		Cichlidae	*Oreochromis mossambicus* (Peters, 1852)	NT
55		Eleotridae	*Butis butis* (Hamilton, 1822)	LC
56			*Eleotris fusca* (Forster, 1801)	LC
57		Gobiidae	*Stigmatogobius sadanundio* (Hamilton, 1822)	NE
58			*Boleophthalmus boddarti* (Pallas, 1770)	LC
59			*Pseudapocryptes elongates* (Cuvier, 1816)	NE
60			*Brachyamblyopus brachysoma* (Bleeker, 1853)	NE
61			*Taenioides buchanani* (Day, 1873)	NE
62			*Taenioides cirratus* (Blyth, 1860)	DD
63			*Trypauchen vagina* (Bloch & Schneider, 1801)	NE
64			*Acentrogobius cyanomos* (Bleeker, 1849)	NE
65			*Acentrogobius griseus* (Day, 1876)	NE
66			*Acentrogobius viridipunctatus*(Valenciennes,1837)	NE
67			*Bathygobius ostreicola* (Chaudhuri, 1916)	NE
68			*Glossogobius giuris* (Hamilton, 1822)	LC
69			*Psammogobius biocellatus* (Valenciennes, 1837)	LC
70			*Yongeichthys criniger* (Valenciennes, 1837)	NE
71		Scatophagidae	*Scatophagus argus* (Linnaeus, 1766)	LC
72		Sphyraenidae	*Sphyraena jello* Cuvier, 1829	NE
73		Anabantidae	*Anabas testudineus* (Bloch, 1792)*	DD
74		Channidae	*Channa punctata* (Bloch, 1793)	LC
75			*Channa striata* (Bloch, 1793)	LC
76			*Channa marulius* (Hamilton, 1822)	LC

Abbreviations: NE = Not Evaluated; LC = Least Concern; DD = Data Deficient;
NT = Near Threatened; VU: Vulnerable

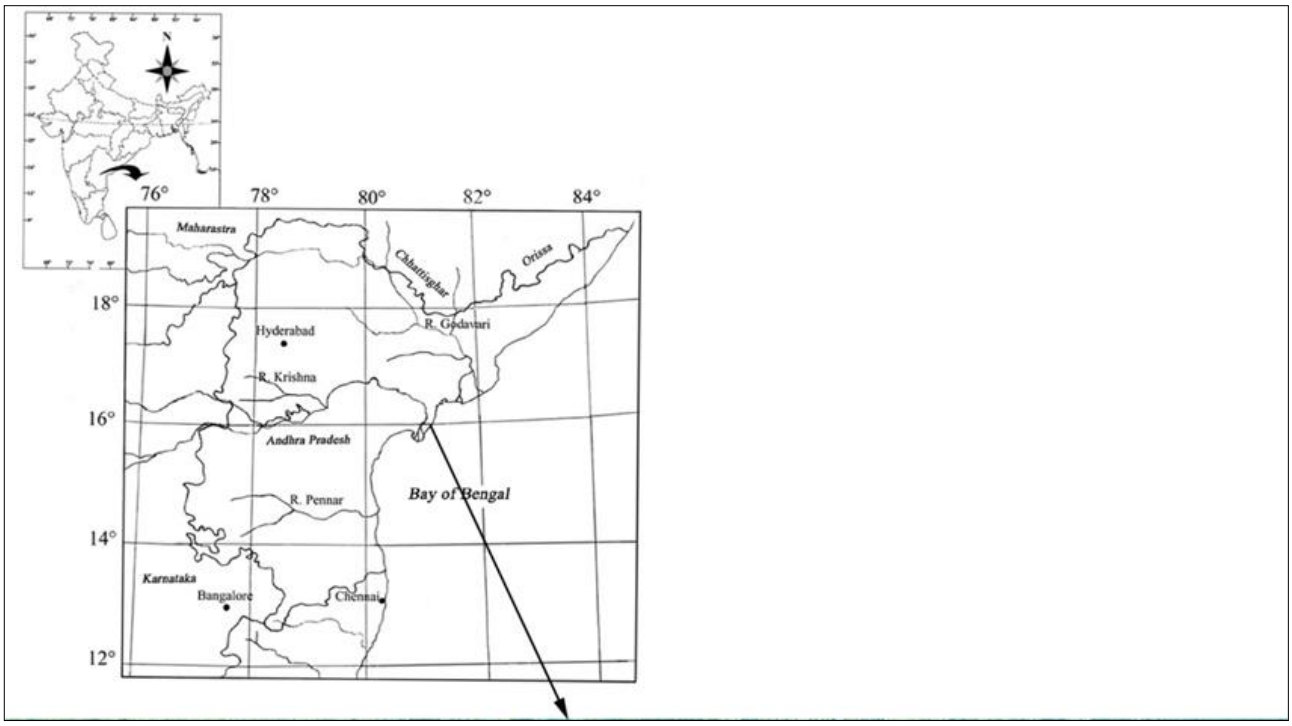

Fig 1: Aerial view of Interu mangrove swamp of River Krishna estuarine region.

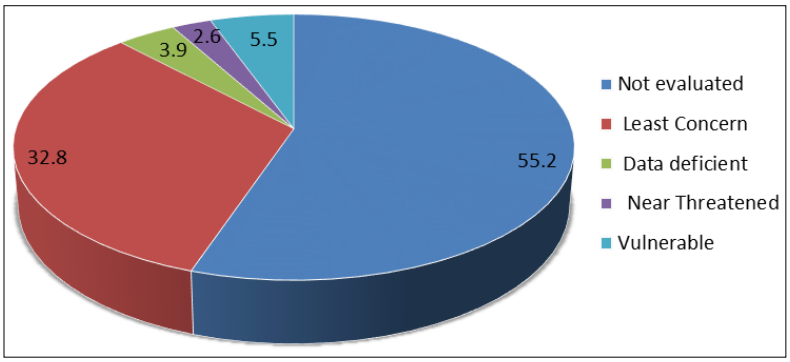

Fig 2: IUCN status (Percentage) of fish fauna of Interu mangrove swamp.

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