

ADDITIONAL DATA ON SPECIES COMPOSITION OF FISH IN TIEN HAI WETLAND NATURE RESERVE, THAI BINH PROVINCE

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Abstract. Mangrove forests are important for many fish species, but this information is still poorly understood in Vietnam. Tien Hai Wetland Nature Reserve is located in the core areas of the Red River Delta Biosphere Reserve, where mangrove forests are presented. To provide fundamental data for a better understanding of the role of mangroves for fishes, three surveys in March, July, and August 2019 at 5 stations within Tien Hai Wetland Nature Reserve were conducted. A total of 817 individuals were collected and 65 species belonging to 54 genera, 28 families of 11 orders were identified. Of the 11 orders, Perciformes was the most diverse in a number of families, and Gobiiformes was dominant in the number of species. Of the 65 species, three were listed in Vietnam Red Data Book (2007), i.e., *Bostrychus sinensis* as CR level, *Clupanodon thrissa* as EN level, *Konosirus punctatus* as VU level, and an invasive alien species (*Oreochromis mossambicus*). The present study added 15 species to the study site and 10 fish to the lowland of the Red River in comparison with previous works. In the additional list, there were some typical species, which are associated with mangrove forests, such as *Escualosa thoracata*, *Muraenichthys gymnopterus*, and 17 species of gobies. The ichthyofauna in Tien Hai Wetland Nature Reserve was different from Phu Long mangrove forests (in Hai Phong), and significantly different from Van Uc estuary (in Hai Phong) and Bung Binh Thien wetland (in An Giang). These findings will be valuable for fish conservation and fisheries resources development in the study area.

Keywords: estuaries, mangrove forests, Northern Vietnam, rare and invasive species, species diversity of fish.

1. Introduction

Mangroves forests provide a range of valuable functions that influence nearby coastal systems, and impact human activities such as fisheries [1]. One of the most important functions of the mangrove forests is the provision of a nursery for fish species

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that relates to local fisheries [1]. Mangrove forests are distributed throughout the coastal areas of Vietnam and are of importance for many fish species [2], but information about ichthyofauna in this ecosystem is still limited [3, 4]. Tien Hai Wetland Nature Reserve is one of the two core areas of the Red River Delta Biosphere Reserve, where many types of habitats are available, including estuarine mangroves. Previous works have reported fish from the Ba Lat estuary and Xuan Thuy National Park, which is located on the right side of the Ba Lat estuary (Figure 1) [4]. The mangrove forests in Tien Hai are a suitable habitat for a variety of associated aquatic organisms, such as benthos [5], mudskippers [6], and gobies [7].

In 2010, Nguyen Huu Duc determined a total of 186 species based on surveys in the mouth of the Red River and Tien Hai Wetland Nature Reserve [8]. Tran Duc Hau et al. (2020) reported a list of 25 species of gobies in the mangroves of Tien Hai [7]. Of which, 9 species were new records for the study area and 5 species for Northern Vietnam. These findings show the potential for fish species diversity in the Tien Hai Wetland Nature Reserve. Thus, the present study attempted to elucidate additionally the diversity of fishes associated with this estuarine mangrove, which will be valuable for fish conservation and fisheries resources development in the study area.

2. Content

2.1. Materials and methods

Three surveys were conducted in March, July, and August 2019 at 5 stations (TH1-TH5) from the Tien Hai Wetland Nature Reserve, Thai Binh province (Figure 1). Fishes were collected using hand fishing nets (2 mm mesh aperture) and eight-hole fishing nets (2 cm mesh aperture), with supports from local fishers. All collected specimens were fixed in 8 - 10% formalin, and then were transferred to 70% ethanol, and deposited at the Department of Zoology, Faculty of Biology, Hanoi National University of Education.

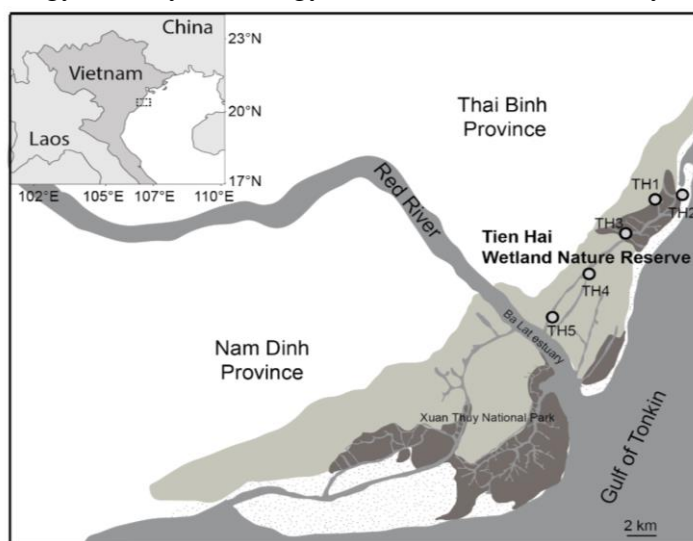


Figure 1. A diagram showing where fishes were collected from Tien Hai Wetland Nature Reserve, Thai Binh Province

Counting and measurement methods followed Nakabo (2002) [9] and Nguyen Van Hao (2005) [10]. Fishes were identified using available keys in the following references: Nguyen Van Hao (2005) [10], and Kimura et al. (2018) [11]. Taxonomy status confirmation followed Eschemeyer (2021) [12]. The list of fish was ordered in accordance with Nelson et al. (2016) [13].

Relationship index between faunas was determined according with Stugren – Radulescu (1961) formula:

$$R = (2R_s + R_{ss})/3$$

$$R_s = (X + Y - Z) / (X + Y + Z); R_{ss} = (X' + Y' - Z') / (X' + Y' + Z')$$

where, X (X') indicates the number of species (subspecies) present in fauna A and not in fauna B; Y (Y') denotes the number of species (subspecies) present in fauna B and not in fauna A; Z (Z') is the number of species (subspecies) found in both A and B.

- $1.0 \leq R < 0.7$: significant similar.
- $0.69 \leq R < 0.35$: similarity.
- $0.34 \leq R < 0$: little similarity.
- $0 \leq R < 0.35$: little difference.
- $0.35 \leq R < 0.69$: difference.
- $0.7 \leq R < 1.0$: significant difference.

2.2. Results and discussion

* *Species composition*

A total of 817 individuals were collected and using morphological characters, the present study identified 65 species belonging to 54 genera, 28 families of 11 orders (Table 1), including 25 species of gobies previously reported by Tran Duc Hau et al. (2020) [7]. Hence, the results have added 15 species to the study area [8] and 10 species to the lowland of the Red River [14]. In the additional list, there were some typical species associated with mangrove forests, such as *Escualosa thoracata*, *Muraenichthys gymnopterus*, and 17 species of gobies [7]. In addition, compared with the work by Nguyen Huu Duc (2010), a total of 54 species were not recorded again in the present study [8], and the majority of which are marine fish that may not be distributed in the mangrove forests. One possibility is that the previous survey was not conducted inside the mangrove forests in the study area.

Of the 65 species, there were 3 species listed in Vietnam Red Data Book (2007), which are necessary to be protected (Table 1) [15]. They were *Bostrychus sinensis* (Lacepède, 1801) as CR level, *Clupanodon thrissa* (Linnaeus, 1758) as EN level, and *Konosirus punctatus* (Temminck & Schlegel, 1846) as VU level. In addition, there was an invasive alien species, *Oreochromis mossambicus* [16] occurring abundantly in the study site. This is a common species for aquaculture, and recently it has been expanded to all aquatic ecosystems in Vietnam. Thus, further investigations into ecological impacts and biological characters of this species in order to assess the level of its danger to biodiversity in aquatic habitats in the study area.

When we compared the fish species composition with Xuan Thuy National Park and the Ba Lat estuary, it shows that amongst 114 species reported by Nguyen Xuan

Huan et al. (2013) [17], 85 were demersal fish (accounting for 74.56% of total species), which were also similar to the present study, with 53 species being in the bottom (accounting for 81.54%). Another work in Xuan Thuy National Park and the Ba Lat estuary by Nguyen Dinh Tao et al. (2013) [4] reported a list of 122 fish species belonging to 46 families, 13 orders. Of which 3 species were listed in Vietnam Red Data Book (2007), i.e., *Bostrychus sinensis*, *Clupanodon thrissa*, *Konosirus punctatus* and two invasive alien species, *Oreochromis mossambicus* and *Oreochromis niloticus* [16]. The fauna in mangrove forests between the two sides of the Ba Lat estuary seems to be similar in terms of rare and invasive alien species. Tran et al. (2021) stated that the mangrove forests in Xuan Thuy National Park are more favorable for fish, especially mudskippers and gobies (which are highly associated with mangroves) than those in Tien Hai Wetland Nature Reserve [6]. However, further studies of ichthyofauna between the two mangrove forests will provide detailed information about the function of this typical ecosystem for fish.

Table 1. List of fishes collected Tien Hai Wetland Nature Reserve, Thai Binh Province

No.	Scientific name	No.	Scientific name
	I. ANGUILLIFORMES	29	<i>Nibea albiflora</i> (Richardson, 1846) ▼
	1. Ophichthyidae		18. Scatophagidae
1	<i>Muraenichthuys gymnopterus</i> (Bleeker, 1853) *	30	<i>Scatophagus argus</i> (Linnaeus, 1776)
	II. CLUPEIFORMES		19. Callionymidae
	2. Clupeidae	31	<i>Callionymus</i> sp. ▼
2	<i>Clupanodon thrissa</i> (Linnaeus, 1758) ^{EN}		20. Scombridae
3	<i>Konosirus punctatus</i> (Temminck & Schlegel, 1846) ^{VU}	32	<i>Scomberomorus sinensis</i> (Lacépède, 1800) * ▼
4	<i>Sardinella albella</i> (Valenciennes, 1847)		21. Siganidae
5	<i>Sardinella gibossa</i> (Bleeker, 1849)	33	<i>Siganus fuscescens</i> (Houttuyn, 1782)
6	<i>Escualosa thoracata</i> (Valenciennes, 1847) *		VIII. CICHLIFORMES
	3. Engraulidae		22. Cichlidae
7	<i>Stolephorus tri</i> (Bleeker, 1852) *	34	<i>Oreochromis mossambicus</i> (Peters, 1852) * ▼
8	<i>Encrasicholina heteroloba</i> (Ruppell, 1837) *		IX. GOBIIFORMES

9	<i>Coilia lindmani</i> Bleeker, 1857 * ▼		23. Butidae
	III. SALMONIFORMES	35	<i>Bostrychus sinensis</i> (Lacepède, 1801) ^{CR}
	4. Salangidae	36	<i>Butis butis</i> (Hamilton, 1822)
10	<i>Salanx cuvieri</i> Valenciennes, 1850 ▼	37	<i>Butis koilomatodon</i> (Bleeker, 1849)
	IV. SILURIFORMES		24. Gobiidae
	5. Plotosidae	38	<i>Acentrogobius moloanus</i> (Herre, 1927)
11	<i>Plotosus lineatus</i> (Thunberg, 1787) *	39	<i>Acentrogobius viridipunctatus</i> (Valenciennes, 1837)
	V. BELONIFORMES	40	<i>Aulopareia unicolor</i> (Valenciennes, 1837)
	6. Hemirhamphidae	41	<i>Eugnathogobius illothus</i> (Larson, 1999)
12	<i>Hyporhamphus unifasciatus</i> (Ranzant, 1841) *	42	<i>Glossogobius aureus</i> (Akihito & Meguro, 1975)
	VI. SCORPAENIFORMES	43	<i>Glossogobius giuris</i> (Hamilton, 1822)
	7. Platycephalidae	44	<i>Glossogobius olivaceus</i> (Temminck & Schlegel, 1845)
13	<i>Platycephalus indicus</i> (Linnaeus, 1758)	45	<i>Gobiopsis macrostoma</i> (Steindachner, 1861)
	VII. PERCIFORMES	46	<i>Gobiopsis chuno</i> (Hamilton, 1822)
	8. Theraponidae	47	<i>Mugilogobius abei</i> (Jordan & Snyder, 1901)
14	<i>Terapon jarbua</i> (Forsskal, 1775)	48	<i>Psammogobius biocellatus</i> (Valenciennes, 1837)
15	<i>Terapon therap</i> Cuvier, 1829	49	<i>Pseudogobius masago</i> (Tomiya, 1936)
	9. Carangidae	50	<i>Pseudogobius poicilosoma</i> (Bleeker, 1849)
16	<i>Atule mate</i> (Cuvier, 1833) ▼	51	<i>Tridentiger barbatus</i> (Günther, 1861)
	10. Sillaginidae	52	<i>Tridentiger trigonocephalus</i> (Gill, 1859)

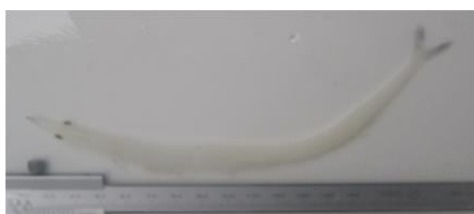
17	<i>Sillago sihama</i> (Forsskal, 1775)	53	<i>Wuhanlinigobius polylepis</i> (Wu & Ni, 1985)
	11. Serranidae		25. Oxudercidae
18	<i>Epinephelus coioides</i> (Hamilton, 1822) * ▼	54	<i>Acanthogobius flavimanus</i> (Temminck & Schlegel, 1845)
	12. Lutjanidae	55	<i>Apocryptodon madurensis</i> (Bleeker, 1849)
19	<i>Lutjanus russellii</i> (Bleeker, 1849)	56	<i>Boleophthalmus pectinirostris</i> (Linnaeus, 1758)
	13. Leiognathidae	57	<i>Odontamblyopus rubicundus</i> (Keith, Hadiaty, Busson & Hubert, 2014)
20	<i>Leiognathus bindus</i> (Valenciennes, 1835)	58	<i>Periophthalmus modestus</i> (Cantor, 1842)
21	<i>Secutor ruconius</i> (Hamilton, 1822) *	59	<i>Scartelaos histophorus</i> (Valencienne, 1837)
22	<i>Nuchequula nuchalis</i> (Temminck & Schlegel, 1845) *		X. MUGILIFORMES
	14. Gerridae		26. Mugilidae
23	<i>Gerres lucidus</i> Cuvier, 1830	60	<i>Liza carinata</i> (Valenciennes, 1836)
24	<i>Gerres filamentosus</i> Cuvier, 1829	61	<i>Chelon subviridis</i> (Valenciennes, 1836)
25	<i>Gerres limbatus</i> Cuvier, 1830		XI. PLEURONECTIFORMES
	15. Apogonidae		27. Soleidae
26	<i>Ambassis vachellii</i> Richardson, 1846 * ▼	62	<i>Brachirus orientalis</i> (Bloch & Schneider, 1801) *
	16. Sparidae	63	<i>Zebrias zebrinus</i> (Temminck & Schlegel, 1846)
27	<i>Acanthopagrus latus</i> (Houttuyn, 1782)		28. Cynoglossidae
	17. Sciaenidae	64	<i>Cynoglossus puncticep</i> (Richardson, 1846)
28	<i>Collichthys lucidus</i> (Richardson, 1844) ▼	65	<i>Cynoglossus cynoglossus</i> (Hamilton, 1822) *

Notes: Levels in Vietnam Red Data Book (2007): ^{CR}: Critically, ^{EN}: Endangered and ^{VU}: Vulnerable;

(*) Additional species to Nguyen Huu Duc (2010);
(▼) Additional species to Nguyen Huu Duc et al. (2019)



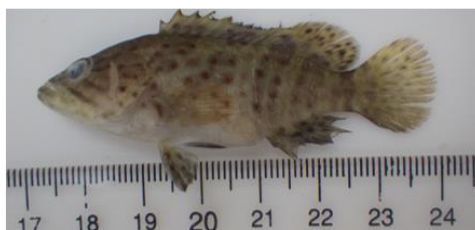
9. *Coilia lindmani*



10. *Salanx cuvieri*



16. *Atule mate*



18. *Epinephelus coioides*



26. *Ambassis vachellii*



28. *Collichthys lucidus*



29. *Nibea albiflora*



31. *Callionymus* sp.



32. *Scomberomorus sinensis*



34. *Oreochromis mossambicus*

Figure 2. Photos of additional fishes to [14] collected from Tien Hai Wetland Nature Reserve (Number indicates the order in Table 1)

*** Fish community structure**

Of the 11 orders, Perciformes was the most diverse in the present study (14 families, accounting for 50%) with Gobiiformes second (3 families, accounting for 10,71%),

followed by Clupeiformes and Pleuronectiformes (2 families, accounting for 7.14%), and Anguilliformes, Salmoniformes, Siluriformes, Beloniformes, Scorpaeniformes, Cichliformes and Mugiliformes (1 family, accounting for 3.57%). Gobiiformes was the most common order in terms of species number (25 species, accounting for 38.46%) (Table 1).

Of the 28 families found, Gobiidae was the most dominant, consisting of 11 genera (constituting 20.37%), followed by Oxudercidae (6 genera, constituting 11.11%), Clupeidae (4 genera, constituting 7.41%), Engraulidae, and Leiognathidae (3 genera, constituting 5.56%). There are 2 genera (constituting 3.70%) in the following families: Sciaenidae, Butidae, Mugilidae, and Soleidae. The rest of the families consisted of 1 genus for 1.85%.

Of the 54 genera, *Glossogobius* and *Gerres* were the most diverse with 3 species accounting for 4.62%, followed by *Sardinella*, *Terapon*, *Butis*, *Acentrogobius*, *Pseudogobius*, *Tridentiger* and *Cynoglossus* (2 species, accounting for 3.07%). The rest of the genera consisted of 1 species.

Of the 65 species, Perciformes was the most diverse with 47 species accounting for 72.31%, followed by Clupeiformes (8 species, accounting for 12.31%), Pleuronectiformes (4 species, accounting for 6.15%) and Mugiliformes (2 species, accounting for 3.07%). The rest of the orders consisted of 1 species accounting for 1.54%.

*** Diversity**

In order to understand the diversity of the present fauna, we compared the species composition between Tien Hai Wetland Nature Reserve with other relevant areas, such as Van Uc estuary, Hai Phong [18]; Phu Long mangrove forest, Hai Phong [19], and Bung Binh Thien Wetland, An Giang [20]. The results are shown in Table 2.

Table 2 shows that the number of families in the study area is higher than that of the Phu Long mangrove forest but lower than that of Van Uc estuary and Bung Binh Thien wetland. Some rare fish species have conservation value such as *Bostrychus sinensis*; *Clupanodon thrissa*; *Konosirus punctatus* occur in the study area and the Van Uc estuary, Hai Phong, but they are not in the Phu Long Mangrove Forests, Hai Phong (Table 3). These species are considered to be distributed in mangrove forests and estuarine habitats [10].

The species relationship index shows that the fauna in Tien Hai Wetland Nature Reserve is different from Phu Long mangrove forests, and significantly different from Van Uc estuary and Bung Binh Thien wetland (Table 3). The more southern ward community seems to reduce the relationship index with the present study. The fauna in Tien Hai is closer to that in the Van Uc estuary rather than the Phu Long mangrove forest. This phenomenon could be explained as follows. Both the Van Uc estuary and the study area are located coastal wetlands and influenced by estuarine environments. On the other hand, Phu Long mangrove forests are situated on the coast of Cat Ba island, far from the Bach Dang estuary. This finding implies that the importance of estuarine mangroves for biodiversity, especially for fishes.

Table 2. Data and relationship index between the present study and other areas

Area	F	G	S	Pair	R	Research scale	Habitat trait
Van Uc estuary - Hai Phong (VU) [18]	40	79	104	TH-VU	0.53 Difference	Surveys from 24-28 July 2007 and 20-23 April 2011	Van Uc estuary is one of the important wetland areas in Vietnam, located in the border of Tien Lang district and Kien Thuy district of Hai Phong province. With the topography of the Van Uc estuary extending to the sea, it has created a wetland with many diverse habitats with alluvial flats
Phu Long Mangrove Forest - Hai Phong (PL) [19]	25	42	63	TH-PL	0.81 Significant difference	Surveys in the dry season (March 2011) and the rainy season (July 2011)	Phu Long mangrove forest is located on the coast of Cat Hai town, Hai Phong, with the characteristic of the funnel-shaped estuary, it creates brackish and salty ecological conditions suitable for fish species
Bung Binh Thien Wetland - An Giang (BT) [20]	27	64	111	TH-BT	0.97 Significant difference	Eight surveys from 2008 to 2011	Bung Binh Thien Wetland is located in An Phu district, An Giang province. It has an area of more than 200 ha in the dry season and expands to 800 ha in the rainy season. It is located in the upstream area of the Mekong Delta region.

Tien Hai Wetland Nature Reserve (TH) [the present study]	65	54	28			Three surveys in 2019	With an area of 12,500 ha, the Tien Hai Wetland Nature Reserve is one of the two core areas of the Red River Delta Biosphere Reserve, where many types of habitats are available, including estuarine mangroves.
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Notes: F: Family, G: Genus, S: Species, R: Relationship index between faunas

Table 3. List of fish species distributed in Tien Hai Wetland Nature Reserve and other areas

No.	Species	Areas in Table 2				No.	Species	Areas in Table 2			
		TH	PL	VU	BT			TH	PL	VU	BT
1	<i>Muraenichthys gymnopterus</i>	+				34	<i>Oreochromis mossambicus</i>	+			
2	<i>Clupanodon thrissa</i>	+		+		35	<i>Bostrychus sinensis</i>	+		+	
3	<i>Konosirus punctatus</i>	+		+		36	<i>Butis butis</i>	+		+	
4	<i>Sardinella albella</i>	+				37	<i>Butis koilomatodon</i>	+		+	
5	<i>Sardinella gibossa</i>	+		+		38	<i>Acentrogobius moloanus</i>	+			
6	<i>Escualosa thoracata</i>	+		+		39	<i>Acentrogobius viridipunctatus</i>	+	+		
7	<i>Stolephorus tri</i>	+				40	<i>Apocryptodon madurensis</i>	+			
8	<i>Encrasicholina heteroloba</i>	+				41	<i>Aulopareia unicolor</i>	+			
9	<i>Coilia lindmani</i>	+				42	<i>Glossogobius aureus</i>	+			+
10	<i>Salanx cuvieri</i>	+				43	<i>Glossogobius giuris</i>	+		+	+
11	<i>Plotosus lineatus</i>	+		+		44	<i>Glossogobius olivaceus</i>	+		+	
12	<i>Hyporhamphus unifasciatus</i>	+			+	45	<i>Gobiopsis macrostoma</i>	+			
13	<i>Platycephalus indicus</i>	+	+	+		46	<i>Psammogobius biocellatus</i>	+	+		

14	<i>Therapon jarbua</i>	+	+	+		47	<i>Acanthogobius flavimanus</i>	+		+	
15	<i>Therapon therap</i>	+	+	+		48	<i>Boleophthalmus pectinirostris</i>	+		+	
16	<i>Atule mate</i>	+				49	<i>Eugnathogobius illotus</i>	+			
17	<i>Sillago sihama</i>	+	+	+		50	<i>Gobiopterus chuno</i>	+			
18	<i>Epinephelus coioides</i>	+				51	<i>Mugilogobius abei</i>	+			
19	<i>Lutjanus russellii</i>	+		+		52	<i>Odontamblyopus rubicundus</i>	+		+	
20	<i>Leioignathus bindus</i>	+	+	+		53	<i>Periophthalmus modestus</i>	+		+	
21	<i>Secutor ruconius</i>	+				54	<i>Pseudogobius policilosoma</i>	+			
22	<i>Nuchequula nuchalis</i>	+				55	<i>Pseudogobius masago</i>	+			
23	<i>Gerres lucidus</i>	+		+		56	<i>Scartelaos histophorus</i>	+		+	
24	<i>Gerres filamentosus</i>	+	+	+		57	<i>Tridentiger barbatus</i>	+		+	
25	<i>Gerres limbatus</i>	+				58	<i>Tridentiger trigonocephalus</i>	+			
26	<i>Ambassis vachellii</i>	+				59	<i>Wuhanlinigobius polylepis</i>	+			
27	<i>Acanthopagrus latus</i>	+		+		60	<i>Liza carinatus</i>	+			
28	<i>Collichthys lucidus</i>	+	+	+		61	<i>Chelon subviridis</i>	+			
29	<i>Nibea albiflora</i>	+		+		62	<i>Brachirus orientalis</i>	+		+	
30	<i>Scatophagus argus</i>	+		+		63	<i>Zebrias zebrinus</i>	+		+	
31	<i>Callionymus sp.</i>	+				64	<i>Cynoglossus puncticep</i>	+	+	+	
32	<i>Scomberomorus sinensis</i>	+				65	<i>Cynoglossus cynoglossus</i>	+			
33	<i>Siganus fuscescens</i>	+	+	+							

3. Conclusions

A total of 65 fish species belonging to 54 genera, 28 families of 11 orders were recorded in the Tien Hai Wetland Nature Reserve, Thai Binh Province. Of the 11 orders, Perciformes was the most diverse in a number of families and Gobiiformes was dominant in a number of species. Of the 65 species, 3 species were listed in Vietnam Red Data Book (2007) (i.e., *Bostrychus sinensis*, *Clupanodon thrissa*, *Konosirus punctatus*, and an invasive alien species (*Oreochromis mossambicus*). Compared with previous studies, 15 species were added to the study area and 10 species to the lowland of the Red River. The fauna in Tien Hai Wetland Nature Reserve is different from Phu Long mangrove forests and significantly different from the Van Uc estuary and Binh Thien wetland.

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