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FIRST COMPREHENSIVE ASSESSMENT OF FISH DIVERSITY IN THE TRANG AN SCENIC LANDSCAPE COMPLEX, NINH BINH PROVINCE, VIETNAM

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ABSTRACT

The Trang An Scenic Landscape Complex, a UNESCO World Heritage Site located in Ninh Binh province, Vietnam, harbors a rich diversity of terrestrial and aquatic ecosystems. To provide the first comprehensive list of fish species in the complex, this study conducted four field surveys in 2024 across 20 sites located within four areas: Trang An Core, Surroundings of Trang An, Tam Coc-Bich Dong, and Tam Coc Surroundings. A total of 41 fish species belong to 33 genera, 17 families, and 8 orders. Among these, the order Cypriniformes and the families Xenocyprididae and Gobiidae were the most species-rich. Additionally, twelve species were newly recorded for the fish fauna of the Red River. Biodiversity indices, including the Shannon-Wiener index (H') and species richness (d), indicated a Fair to Very Good level of fish diversity. The species evenness index (J') suggested a relatively uniform distribution of species across the sampling points. Notably, several marine and brackish water species, as well as exotic species with potential ecological impacts, were also recorded. These findings provide a critical baseline for biodiversity monitoring and offer scientific evidence to support conservation planning and sustainable ecotourism development in the Trang An Scenic Landscape Complex.

Keywords: Biodiversity indices, conservation, exotic species, freshwater, Trang An Scenic Landscape Complex.

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INTRODUCTION

Trang An Scenic Landscape Complex (TASLC), Ninh Binh province, is the first mixed heritage site of Vietnam and Southeast Asia recognized by UNESCO as a World Cultural and Natural Heritage site. This research area covers around 12,252 hectares, including the Trang An Complex, Tam Coc-Bich Dong, Hoa Lu Ancient Capital Cultural and Historical Relic Site, and Hoa Lu Special-Use Primeval Forest (UNESCO, 2014). The complex's landscape is characterized by tropical humid tower karst formations, representing the final stages of geomorphological evolution. These formations have been repeatedly invaded by the sea during the Pleistocene and Holocene epochs. Trang An features a variety of classic karst cones and towers interconnected by an extensive network of subterranean waterways and caves (Kahlert et al., 2021). Furthermore, the region contains a special-use forest ecosystem on limestone mountains, wetlands, and a network of rivers, lakes, and lagoons with high biodiversity in both flora and fauna. Trang An is a nationally significant protected area, designated for both conservation and ecotourism development (Government of Vietnam, 2016). Biodiversity conservation activities are strictly implemented, with little human impact. However, despite the ecological importance of fish communities in maintaining biodiversity within the complex, no specific studies has been conducted on this group to date.

This study aims to compile a comprehensive list of fish species and evaluate species diversity in TASLC. The results will provide essential data to inform biodiversity conservation strategies and support the sustainable development of local ecosystems and tourism.

MATERIALS AND METHODS

Ichthyofauna surveys in TASLC, Ninh Binh province were conducted in four periods (March, June, September-October, and December) in 2024. Specimens were collected in 10 stations in Trang An Core (TAC); 5 stations in the Surrounding of Trang An (TAS); 4 stations in Tam Coc-Bich Dong (TC) and 1 station in Tam Coc Surrounding (TCS) (Figs. 1, 2).

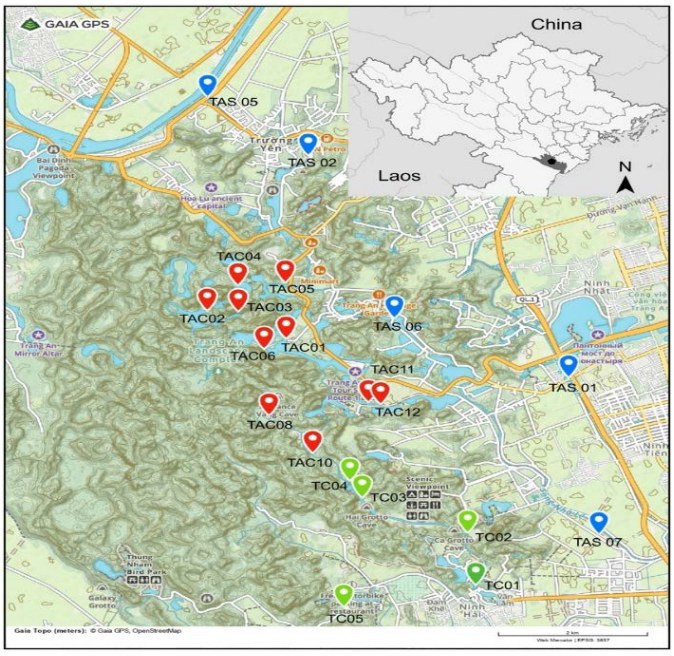

Figure 1. Sampling points for the ichthyofauna study in Trang An Scenic Landscape Complex, Ninh Binh province in 2024. TAC. Trang An Core, TAS. Trang An Surrounding, TC. Tam Coc and TCS. Tam Coc Surrounding

Figure 2. Photos of different habitats in Trang An Scenic Landscape Complex. TAC. Trang An Core, TAS. Trang An Surrounding, TC. Tam Coc and TCS. Tam Coc Surrounding

Fish collection and fixation

Fish specimens were collected using hand nets, casting nets, gill nets, single long trap nets, moclever fishing trap nets (Foldable 6-sided 6-sole bait trap) and electrofishing during the survey period. For electrofishing, only low-intensity electrical pulses were applied, sufficient to temporarily stun fish without causing mortality under permission from the management board of Trang An Scenic Landscape. In Tam Coc, electrofishing was conducted only in March and June. In addition, surveys in the Tam Coc Surrounding were carried out in September-October and December. To determine biodiversity indices of the fish community, quantitative data were collected by sampling all individuals of fish using different gears at each sampling point to compare the abundance of fish among the research areas. At each sampling point, fieldwork was carried out for approximately 30 minutes. Some larger specimens were released and these data were recorded in the field notes. Specimens were initially fixed in 10% formalin solution in the field. Fixed specimens were then placed in trays and photographed under a light system.

Identification methods

Samples were analyzed and classified based on external morphological characteristics and reference to the following documents: Kottelat (2001a, 2001b), Nguyen & Ngo (2001), Nguyen (2005a, 2005b). The arrangement of orders and families followed Fricke (2025), genus and species were ordered alphabetically.

Data analysis

The study used biodiversity indices to compare and evaluate the level of fish species diversity between areas and sampling points, including:

Shannon-Weiner index (H′) (Shannon, 1948):

$$H' = -\sum_{i=1}^{n} \frac{N_i}{N} \ln \frac{N_i}{N}$$

N_i is the number of individuals of the i-th species. N: is the total number of individuals of all species encountered in the survey point.

Margalef index (d) (Margalef, 1958):

$$d = (S-1)/\ln N$$

S is the number of fish species in the sampling point/area; N is the total number of individuals of all species encountered in the sampling point/area.

Evenness index (J′) (Pielou, 1966):

$$J' = \frac{H'}{\ln S}$$

H′: is the Shannon-Weiner diversity index; S: is the number of species in the sample.

The indices were calculated using Primer version 6.1.6 and the data are standardized and re-evaluated to avoid errors in statistical analysis.

The frequency of species occurrence was calculated according to the formula of Sharma (2003):

$$C_i = \frac{p_i}{P} \times 100$$

p_i: number of points where species i appears; P: total number of sampling points.

Based on the frequency of occurrence, the studied species were divided into 5 groups, including group A ($C_i \leq 20\%$): Rare occurrence, group B ($C_i = 21–40\%$): Moderate occurrence, group C ($C_i = 41–60\%$): Fairly frequent occurrence, group D ($C_i = 61–80\%$): Frequent occurrence and group E ($C_i \geq 81\%$): very high occurrence.

RESULTS AND DISCUSSION

Fish composition

Based on the examination of 3125 fish specimens collected in the study area in 2024, 41 species belonging to 33 genera, 17 families, and 8 orders were identified (Fig. 3 & Table 1). This study provides the first fish species list for TASLC. Compared to the fish fauna of the Red River as reported by Nguyen et al. (2019), the current list includes twelve new records, including *Esomus metallicus*, *Rasbora daniconius*, *Rasbora* cf. *atridorsalis*, *Hemiculter leucisculus*, *Pterygoplichthys* sp., *Pterygoplichthys disjunctivus x P. pardalis*, *Brachygobius aggregatus*, *Rhinogobius similis*, *Trichopodus trichopterus*, *Trichopsis vittata*, *Oryzias pectoralis* and *Oryzias curvinotus*. Furthermore, a comparison with the fish composition of the Boi River (Ngo et al., 2012) revealed 17 different species and 24 similar species. The different species are *Esomus metallicus*, *Rasbora daniconius*, *Rasbora* cf. *Atridorsalis*, *Pterygoplichthys* spp., *Pterygoplichthys disjunctivus x P. Pardalis*, *Neodontobutis tonkinensis*, *Periophthalmus modestus*, *Acanthogobius flavimanus*, *Brachygobius aggregatus*, *Parapocryptes serperaster*, *Rhinogobius leavelli*, *Rhinogobius similis*, *Trichopsis vittata*, *Oreochromis mossambicus*, *Gambusia affinis*, *Oryzias pectoralis* and *Oryzias curvinotus*. Compared with the fish composition of Van Long Wetland Nature Reserve, Ninh Binh province reported by Ta et al. (2022), who listed a list of 33 species, 26 genera, 18 families, and 8 orders, the present study shared many species, likely due to habitat similarities, as both were conducted in lentic (still-water) systems.

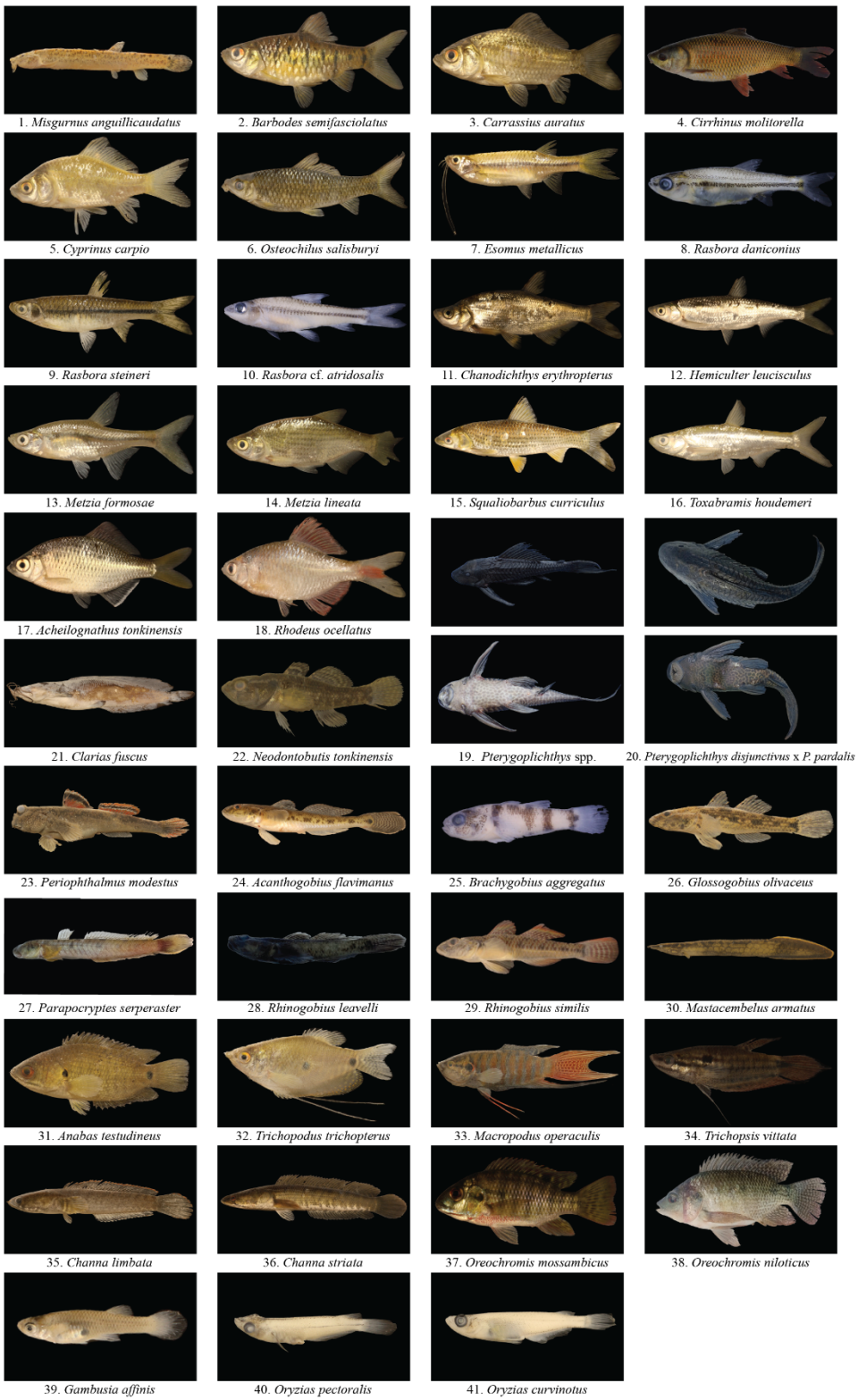

Figure 3. Photos of fixed specimens in Trang An Scenic Landscape Complex

Table 1. Species composition of fish in Trang An Scenic Landscape Complex

No.	Scientific name	Area				Time			
		TAC	TAS	TC	TCS	Mar	Jun	Sep–Oct	Dec
I	Cypriniformes								
	1. Cobitidae								
1	*Misgurnus anguillicaudatus* (Cantor, 1842)		+			+			
	2. Cyprinidae								
2	*Barbodes semifasciolatus* (Günther, 1868)	+	+	+	+	+	+	+	+
3	*Carassius auratus* (Linnaeus, 1758)	+	+	+		+	+	+	+
4	*Cirrhinus molitorella* (Valenciennes, 1844)	+				+			
5	*Cyprinus carpio* Linnaeus, 1758	+	+			+			
6	*Osteochilus salisburyi* Nichols & Pope, 1927	+	+	+	+	+	+	+	+
	3. Danionidae								
7	*Esomus metallicus* Ahl, 1924	+	+	+		+	+	+	+
8	*Rasbora daniconius* (Hamilton, 1822)	+	+					+	+
9	*Rasbora steineri* Nichols & Pope, 1927	+		+	+	+	+	+	+
10	*Rasbora* cf. *atridorsalis* Kottelat & Chu, 1988	+		+			+	+	
	4. Xenocyprididae								
11	*Chanodichthys erythropterus* (Basilewsky, 1855)	+	+	+		+			+
12	*Hemiculter leucisculus* (Basilewsky, 1855)	+	+			+	+		
13	*Metzia formosae* (Oshima, 1920)	+	+	+	+	+	+	+	+
14	*Metzia lineata* (Pellegrin, 1907)		+	+		+	+	+	+
15	*Squaliobarbus curriculus* (Richardson, 1846)	+	+	+		+		+	+
16	*Toxabramis houdemeri* Pellegrin, 1932	+	+	+	+	+	+	+	+
	5. Acheilognathidae								
17	*Acheilognathus tonkinensis* (Vaillant, 1892)	+	+	+		+	+	+	+
18	*Rhodeus ocellatus* (Kner, 1866)	+	+	+	+	+	+	+	+
II	Siluriformes								
	6. Loricariidae								
19	*Pterygoplichthys* spp.	+	+	+	+	+	+	+	+
20	*Pterygoplichthys disjunctivus x P. pardalis*		+				+		
	7. Clariidae								
21	*Clarias fuscus* (Lacepède, 1803)	+	+				+	+	
III	Gobiiformes								
	8. Odontobutidae								
22	*Neodontobutis tonkinensis* (Mai, 1978)	+	+			+	+	+	+
	9. Oxudercidae								
23	*Periophthalmus modestus* Cantor, 1842	+	+			+	+		
	10. Gobiidae								
24	*Acanthogobius flavimanus* (Temminck & Schlegel, 1845)	+				+			
25	*Brachygobius aggregatus* Herre, 1940			+		+			
26	*Glossogobius olivaceus* (Temminck & Schlegel, 1845)	+	+			+	+	+	+
27	*Parapocryptes serperaster* (Richardson, 1846)		+			+			
28	*Rhinogobius leavelli* (Herre, 1935)	+	+	+		+	+	+	+
29	*Rhinogobius similis* Gill, 1859	+	+	+		+	+	+	+
IV	Synbranchiformes								
	11. Mastacembelidae								
30	*Mastacembelus armatus* (Lacepède, 1800)	+	+	+		+	+		
V	Anabantiformes								
	12. Anabantidae								
31	*Anabas testudineus* (Bloch, 1792)		+	+		+	+	+	+

No.	Scientific name	Area				Time			
		TAC	TAS	TC	TCS	Mar	Jun	Sep–Oct	Dec
	13. Osphronemidae								
32	*Trichopodus trichopterus* (Pallas, 1770)	+	+			+			+
33	*Macropodus opercularis* (Linnaeus, 1758)		+	+		+			
34	*Trichopsis vittata* (Cuvier, 1831)	+	+	+		+	+	+	+
	14. Channidae								
35	*Channa limbata* (Cuvier, 1831)[VU]	+	+	+		+		+	+
36	*Channa striata* (Bloch, 1793)	+	+	+		+	+	+	+
VI	Cyprinodontiformes								
	15. Poeciliidae								
37	*Gambusia affinis* (Baird & Girard, 1853)	+	+	+	+	+	+	+	+
VII	Beloniformes								
	16. Adrianichthyidae								
38	*Oryzias pectoralis* Roberts, 1998	+	+	+		+	+	+	+
39	*Oryzias curvinotus* (Nichols & Pope, 1927)	+	+	+			+	+	+
VIII	Cichliformes								
	17. Cichlidae								
40	*Oreochromis mossambicus* (Peters, 1852)[VU]	+	+	+	+	+	+	+	+
41	*Oreochromis niloticus* (Linnaeus, 1758)	+	+	+	+	+	+	+	+
	Number of species	34	36	28	10	36	29	28	28

Notes: TAC - Trang An Core, TAS - Trang An Surrounding, TC - Tam Coc-Bich Dong, TCS - Tam Coc Surrounding.

The number of species recorded at the study site varied across space and time from March to December 2024. In the first two sampling periods (March and June), species richness was generally higher in TAC, TAS, and TC, with TAS reaching its peak in March (26 species) and TAC slightly increasing in June (22 species). In contrast, during the last two periods (September-October and December), species richness tended to decline, particularly in TC, which dropped from 22 species in March to only 12 species in December. Species richness was higher in the two early sampling periods, whereas the later periods showed a reduction in diversity, especially in TC. It may be attributed to the absence of electrofishing which was only applied during the first two sampling periods, thereby limiting the effectiveness of fish collection.

Table 2. Number of species in the study site from March to December, 2024

Time	Area			
	TAC	TAS	TC	TCS
March	20	26	22	No survey
June	22	16	17	No survey
September–October	21	19	19	7
December	21	20	12	6

There were no obvious differences in the number of orders, families, and species between the four research areas (Fig. 4). The number of fish species in all three locations were higher than 28 species; in contrast, there were only 10 species in the Tam Coc Surrounding. This lower species count is likely due to the limited sampling effort; there was one collected station and survey period (only in September-October and December). Among the four research areas, Trang An Surrounding possessed the highest number of species, genera, and families of fish, with 28 species, 26 genera, and 15 families.

A total of nine species, including *Barbodes semifasciolatus*, *Osteochilus salisburyi*, *Metzia formosae*, *Toxabramis houdemeri*, *Rhodeus ocellatus*, *Pterygoplichthys* spp., *Oreochromis mossambicus*, *Oreochromis niloticus* and *Gambusia affinis*, were recorded across all four research areas, indicating their wide distribution and adaptability within the study region. In contrast, certain species displayed a more restricted spatial distribution. For example, *Cirrhinus molitorella* and *Acanthogobius flavimanus* were recorded exclusively in the Trang An Core. Similarly, *Misgurnus anguillicaudatus*, *Pterygoplichthys disjunctivus* x *P. pardalis* and *Parapocryptes serperaster* were found only in the Trang An Surrounding area, while *Brachygobius aggregatus* was detected solely in Tam Coc-Bich Dong. Notably, *Rasbora* cf. *atridorsalis* was found exclusively in protected areas, specifically within the Trang An-Tam Coc-Bich Dong, suggesting potential sensitivity to environmental conditions and a preference for undisturbed habitats.

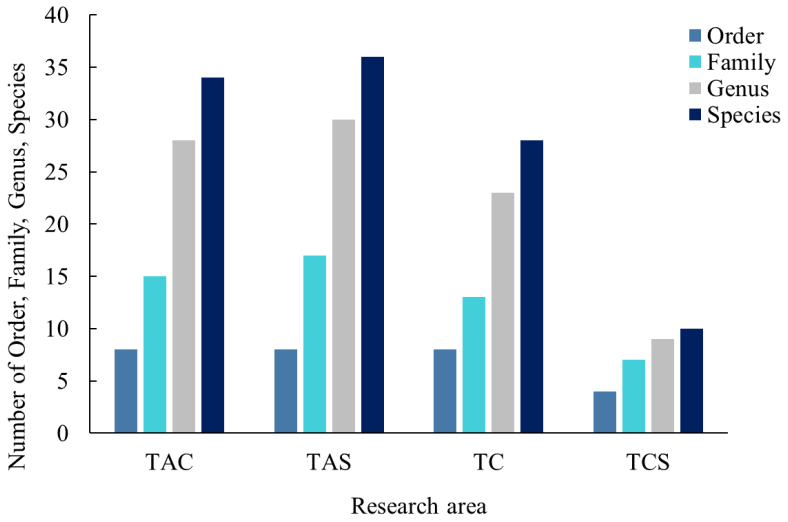

Figure 4. Number of order, family, genus, and species in Trang An Core (TAC), Trang An Surrounding (TAS), Tam Coc-Bich Dong (TC) and Tam Coc Surrounding (TCS)

According to the IUCN Red List (IUCN, 2025), two species classified as VU (Vulnerable) level occur at the study site, including *Channa limbata* and *Oreochromis mossambicus*. In addition, several marine or brackish fishwater species were recorded in this freshwater section, specifically in TAC and TAS, i.e., *Acanthogobius flavimanus*, *Periophthalmus modestus*, *Glossogobius olivaceus* and *Parapocryptes serperaster* (Table 1). The presence of these species may be attributed to the area's history of repeated marine incursions (Kahlert et al., 2021).

The distribution of Gobiidae species across the surveyed sites reveals significant ecological differences likely associated with different stages of recovery from historical saltwater intrusion. Specifically, TAC and TAS exhibit relatively high species richness, with 5 and 6 goby species, respectively, suggesting these areas may still retain brackish characteristics. In contrast, TC and TCS show markedly lower gobiid diversity, with only 2 species recorded in TC and none in TCS, indicating a trend of ecological recovery toward freshwater conditions. Besides, the appearance of alien fish species at all four research areas may have adverse impacts on the local fish community, including *Pterygoplichthys* spp., *Pterygoplichthys disjunctivus* x *P. Pardalis*, *Oreochromis mossambicus* and *Gambusia affinis*. Further field work is essential to examine the composition and distribution of exotic fish species, specifically the genus

Pterygoplichthys, to assess the risks that exotic fish species may pose to the research area.

Fish diversity

The most species-rich order was Cypriniformes, accounting for 29.41% of families, 45.45% of genera, and 43.90% of species. Gobiiformes is the second diverse order, with 17.65%, 21.21%, and 19.51%, respectively. The next two orders are Anabantiformes, accounting for 17.65%, 15.15%, and 14.63% respectively, and then Siluriformes, accounting for 11.76%, 6.06%, and 7.32% respectively. Cichliformes and Beloniformes have 1 family, 1 genus and 2 species. Synbranchiformes and Cyprinodontiformes have 1 family, 1 genus and 1 species (Fig. 5).

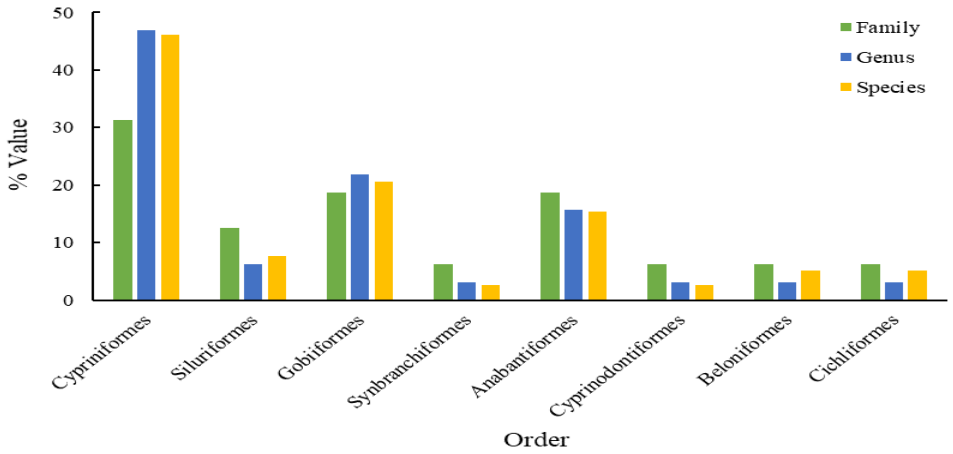

Figure 5. Ratio of species composition structure according to orders in Trang An Scenic Landscape Complex

Table 3. Ratio of species composition structure according to family in Trang An Scenic Landscape Complex

No.	Family	Genus	%	Species	%
1	Cobitidae	1	2.9	1	2.4
2	Cyprinidae	5	14.7	5	12.2
3	Danionidae	2	5.9	4	9.8
4	Xenocyprididae	5	14.7	6	14.6
5	Acheilognathidae	2	5.9	2	4.9
6	Loricariidae	2	5.9	2	4.9
7	Clariidae	1	2.9	1	2.4
8	Odontobutidae	1	2.9	1	2.4
9	Oxudercidae	1	2.9	1	2.4
10	Gobiidae	5	14.7	6	14.6
11	Mastacembelidae	1	2.9	1	2.4
12	Anabantidae	1	2.9	1	2.4
13	Osphronemidae	3	8.8	3	7.3
14	Channidae	1	2.9	2	4.9
15	Poeciliidae	1	2.9	1	2.4
16	Adrianichthyidae	1	2.9	2	4.9
17	Cichlidae	1	2.9	2	4.9
Total		34	100	41	100

Xenocyprididae and Gobiidae exhibited the largest number of genera and species, with 5 genera and 6 species. The next families are Cyprinidae (5 genera and 5 species), Osphronemidae (3 genera and 3 species), Danionidae (2 genera and 4 species), Loricariidae and Acheilognathidae (2 genera and 2 species). Other families have 1 genus and 1-3 species (Table 3).

In 34 genera, *Rasbora* has 3 species (7.32%), *Metzia*, *Rhinogobius*, *Channa*, *Oreochromis* and *Oryzias* have 2 species (4.88%), and the remaining have 1 species (2.44%) (Table 1).

The distribution frequency of species, based on Raunkiaer's classification (1934), shows that most species, 28 species, fall into group A, indicating rare occurrence (Table 4). This suggests high species diversity with many species occurring infrequently, a typical pattern in natural, less disturbed ecosystems. Only three species, such as *Barbodes semifasciolatus*, *Rhodeus ocellatus*, *Oreochromis mossambicus*, are classified as frequent occurrence, likely playing key ecological roles (Table 5). The high abundance of the exotic species *O. mossambicus* may affect native species and ecosystems, warranting further investigation. The dominance of rare species highlights the ecological stability and potential habitat specificity of the study area. This pattern reflects a balanced community structure with limited anthropogenic disturbance of TASLC.

Table 4. The frequency of species occurrence in Trang An Scenic Landscape Complex

Number of species	Group division (Raunkiaer, 1934)	Occurrence Level
28	A	Rare occurrence
6	B	Moderate occurrence
4	C	Fairly frequent
3	D	Frequent

Table 5. The distribution frequency of some species in Trang An Scenic Landscape Complex

No.	Species	Mar	Jun	Sep–Oct	Dec	Frequency of occurrence	Group division (Raunkiaer, 1934)
1	*Barbodes semifasciolatus* (Günther, 1868)	17	15	12	15	79	D
2	*Carassius auratus* (Linnaeus, 1758)	7	8	1	4	27	B
3	*Osteochilus salisburyi* Nichols & Pope, 1927	4	5	1	6	21	B
4	*Rasbora steineri* Nichols & Pope, 1927	12	6	8	7	44	C
5	*Metzia formosae* (Oshima, 1920)	9	8	6	7	40	C
6	*Acheilognathus tonkinensis* (Vaillant, 1892)	14	11	7	8	53	C
7	*Rhodeus ocellatus* (Kner, 1866)	15	11	16	12	72	D
8	*Rhinogobius leavelli* (Herre, 1935)	5	2	9	9	33	B
9	*Rhinogobius similis* Gill, 1859	8	8	3	2	28	B
10	*Trichopsis vittata* (Cuvier, 1831)	5	6	7	13	41	C
11	*Channa striata* (Bloch, 1793)	6	5	1	5	23	B
12	*Gambusia affinis* (Baird & Girard, 1853)	5	9	6	4	32	B
13	*Oreochromis mossambicus* (Peters, 1852)	14	14	9	12	65	D

Figure 6 shows that species composition similarity among the four study areas is generally low, all below 45%. Among them, Tam Coc and Trang An surrounding exhibit the highest similarity, specifically 43%. In contrast, Tam Coc surrounding has a significantly lower recorded species richness due to differences in sampling frequency and the number of sampling points. As a result, its similarity index compared to the other three regions is markedly lower, at less than 10%. The substantial differences in species composition among the areas may be related to variation in aquatic environmental

conditions. Therefore, further in-depth studies on the water environment across these regions are necessary to provide a more accurate assessment.

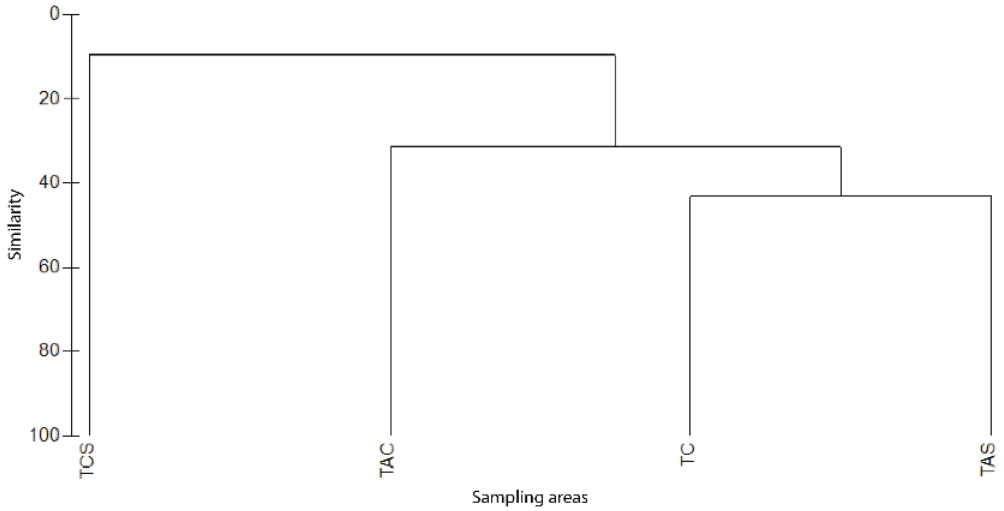

Figure 6. Diagram of similarity in species composition between four areas of TASLC

The results indicated that the overall similarity among the 20 sampling points was relatively low (Fig. 7). The highest similarity was observed between sites TC.01 and TAC.05, with a similarity index of 77.02%, which can be attributed to their comparable habitat characteristics. A total of 11 species were recorded as shared between these two sites. Several other site pairs also exhibited moderate levels of similarity, such as TAC.01 with TAC.04 (58.93%) and TAS.01 with TAS.07 (58.27%). In contrast, the similarity in species composition between TAS sites and other regions was generally low, below 30%. Compared to those in others, this lower similarity reflects the different habitats and the effect of human activities at the five sampling points of TAS. The graph also clearly shows that the similarity between the 20 sampling points was low, with the final clusters combining at a similarity of only 22.59%. These results support the conclusion that species composition among samples varied widely, reflecting significant environmental heterogeneity among the study sites.

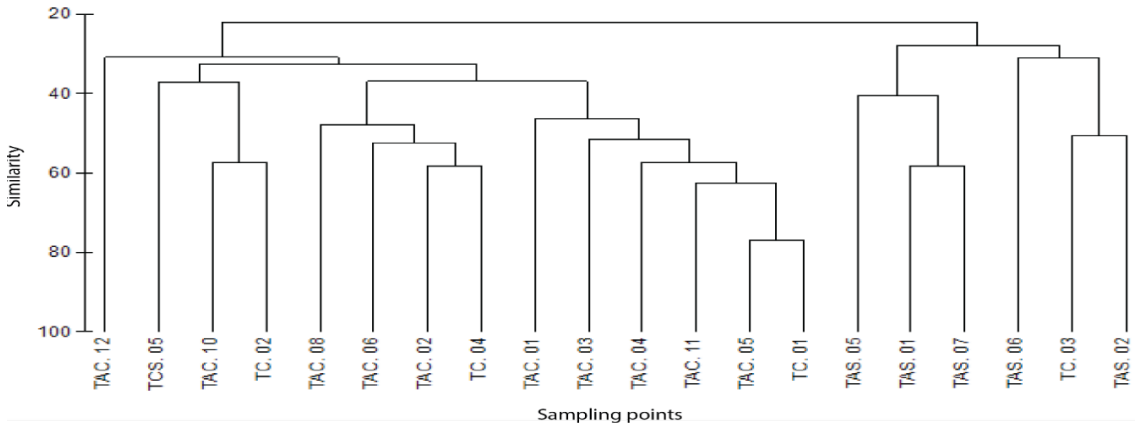

Figure 7. Diagram of similarity in species composition between sampling points

Biodiversity indices

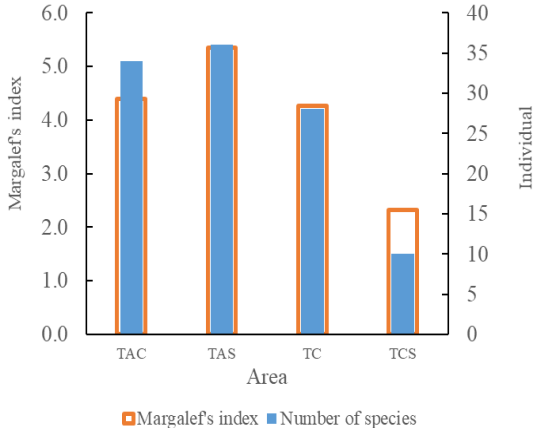

Figure 8. Margalef's index of fish species diversity in four areas of TASLC

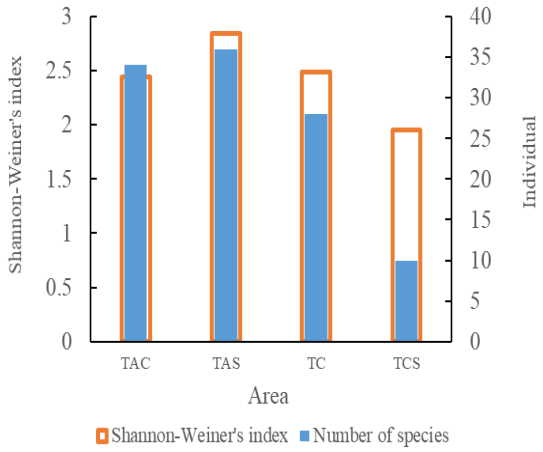

Figure 9. Shannon-Weiner index of fish species diversity in four areas of TASLC

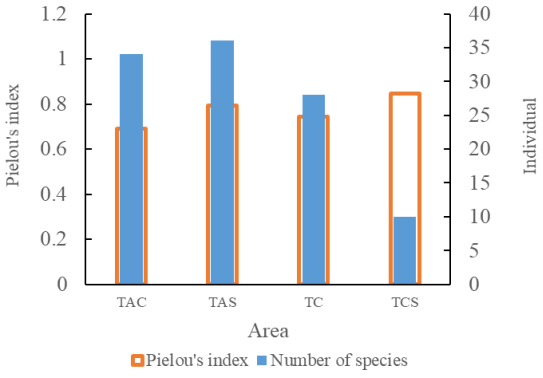

Figure 10. Pielou's index of fish species distribution evenness in four areas of TASLC

To evaluate the diversity of fish species in the study area, Margalef's index, Shannon-Weiner index and Pielou's index were applied. Margalef's and Shannon-Weiner indices indicated that the fish diversity in TASLC ranged from Fair to Very Good (Figs. 8–10). Among the four survey areas, the Trang An Surrounding area exhibited the highest overall diversity. The Trang An Surrounding area exhibits greater habitat diversity, including both standing and flowing water bodies. As a result, the species composition in TAS is significantly more diverse than in the others. Pielou's evenness index values are all above 0.69, indicating a relatively even distribution of species across the sites. The highest Pielou's evenness value, 0.8467, was recorded in the Tam Coc Surrounding area, suggesting it has the most evenly distributed species composition among the studied areas. However, the limited number of sampling points and collection times reduces the reliability of these findings. Additional sampling is necessary to improve the accuracy and comprehensiveness of the results.

CONCLUSION

This study presents the first comprehensive assessment of fish species in TASLC, identifying 41 species across 33 genera, 17 families, and 8 orders. The order Cypriniformes and the families Xenocyprididae and Gobiidae were the most diverse at the order and family levels, respectively. Two species *Channa limbata*, and *Oreochromis mossambicus* are classified as Vulnerable (VU) on the IUCN Red List. In the study area, three exotic species/types were recorded, i.e., *Pterygoplichthys* spp., *Oreochromis mossambicus*, and *Gambusia affinis*, which may influence the fish community and warrant further investigation. Based on the frequency of fish species occurrence, the fish community structure in TASLC appears to be minimally affected by anthropogenic disturbances. *Barbodes semifasciolatus*, *Rhodeus ocellatus*, and *Oreochromis mossambicus* are categorized as frequent species, suggesting they may play important ecological roles in maintaining the stability and

function of the aquatic ecosystem. Biodiversity indices show that the fish diversity in TASLC ranged from Fair to Very Good. Trang An Surrounding exhibited the highest species richness and diversity indices. These findings provide a valuable baseline for biodiversity monitoring and support future efforts in aquatic ecosystem conservation and management within this UNESCO World Heritage site.

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