THE ICHTHYOFAUNA OF THE BA RIVER, CENTRAL VIET NAM

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Abstract

This study documents the ichthyofaunal composition of the Ba River basin in Central Vietnam, recording a total of 182 species across 55 families and 15 orders. Perciformes is the most diverse order (20 families, 36.36%), while Cyprinidae is the most diverse family (24 genera, Northern element accounts for 35.84% of species, the Southern element for 59.43%, and the Mekong element for 71.69%."21.62%). The genus Osteochilus is the most dominant, represented by 6 species (3.30%). In terms of zoogeographic elements, the Northern element accounts for 35.84% of species, the Southern element for 59.43%, and the Mekong element for 71.69%. Characterized by high taxonomic diversity, the basin functions as a biogeographical transition zone where the South China and Indochinese subregions converge. These findings position the Ba River as a pivotal ecological buffer, mediating the distribution of freshwater fish fauna between the Northern and Southern zoogeographic provinces of Vietnam.

Keywords: Ba River; freshwater fish; geozoology; South Central Vietnam.

1. Introduction

The Ba River is the largest river in the South Central coast of Vietnam, with a length of 388 km and a basin area of 13.800 km². Its coordinates are from 12°38' to 14°33' N latitude and 108°5' to 109°20' E longitude. Originating from the high slopes of Kong Ka Kinh (1.761 m) and Kong Plong (1.376 m) mountains in Kon Tum Province, it flows through Gia Lai and Dak Lak Provinces before emptying into the Da Giang estuary in Tuy Hoa ward, Dak Lak Province. According to the bio-geographical zonation for aquatic organisms by (Dang et al., 2002), the Ba River system is located within two bio-geographical regions: the Central highland (region 5) and the South Central coast (region 6). The Central highland is a mountainous and plateau region with unique topography, steep slopes, and volcanic soil. Its rivers and streams have high gradients, flowing eastward to the sea and also westward into the Mekong River system. This area also has a lake, originating from an ancient volcanic crater and a large lake (Lak lake), with a highland climate characterized by hot, dry and long rainy seasons. The South Central coast, considered a transitional zone for aquatic organism distribution, is a narrow coastal plain from Hai Van pass to Khanh Hoa Provinces. Its water bodies are mainly short coastal rivers and estuaries. The species composition is mixed, containing species from both the North and the South.

Thus, according to this classification, the entire upper and a part of the middle sections of the Ba River lie within the Central highland biogeographical region. However, the entire Ba River basin in the upper and middle sections is located on the eastern side of the Truong Son mountain range, within the territory of Kon Tum, Gia Lai and Dak Lak provinces. It has no connection to the river systems flowing into the Mekong and Dong Nai basins. Therefore, similar to the Thu Bon River (Quang Nam), Tra Khuc River, Ve River (Quang Ngai), and Con River (Binh Dinh) in the South Central coast, the middle and upper reaches of the Ba River are located in the high mountains to the east of the Truong Son range. The fish fauna of these rivers, including the Ba River, belongs to the South Central coast region. Nguyen Thi Thu He (1999) also ranked the fish species of the Ba River in the Central highlands as belonging to the South Central coast region. This study identified the boundaries between the Northern and Southern fish fauna, the species exhibiting Northern and Southern characteristics, and the species with wide distribution. The Ba River is considered a transitional zone between these two sub-regions.

This study identified the zoogeography of the fish fauna of the Ba River, including the boundaries between the Northern and Southern fish faunas, species with Northern and Southern affinities, and widely distributed species. It further concluded that the Ba River is a transitional zone between these two sub-regions. Furthermore, the geographical isolation of river systems in this area has given rise to endemic species of scientific significance.

2. Materials and methods

Field survey from downstream to upstream of Ba River (June 2022 to October 2024) at 6 sites (Tuy Hoa, Phu Hoa, Song Hinh, Crong Pa, Chu Se, Kong Plong).

Determining the coordinates of the Ba River basin using GPSMAP78. Collect fish samples and updating data information on the composition of fish species in the Ba River from previously researched data by (Nguyen, 2010) and other fish faunas in Vietnam and the Mekong River basin (Nguyen, 2005a, b; Rainboth, 1996), related documents on the geofauna of freshwater fish in Vietnam (Nguyen, 2005a, b). Analyzing the percentage of common species, the closeness coefficient between fish faunas.

Closeness coefficient: $R = \frac{2Rs+Rss}{2+1}$ (Stugren-Radulescu, 1961)

In which: Rs: Relationship between two faunas at the species level

Rss: Relationship between two faunas at the subspecies level

The fish species were described and identified based on external morphological characteristics, following the references of (Taki 1975, Mai, 1978, 1992, Rainboth, 1996, Kottelat, 2001, Nguyen and Ngo, 2001, Nguyen, 2005a, 2005b, and Eschmeyer, 1998, 2020).

3. Results and Discussion

3.1. Species composition structure

The investigation results, 182 species were identified in the Ba River, belonging to 111 genera, 55 families and 15 different orders. The biodiversity of fish in the Ba River is not only expressed at the species level but also at higher taxon levels (Table 1).

Table 1: Species composition structure

TT	Name of the fish order	Family		Genus		Species	
		Number of	Percentage (%)	Number of	Percentage (%)	Number of	Percentage (%)
1	Osteoglossiformes	1	1,82	1	0,90	1	0,55
2	Elopiformes	2	3,64	2	1,80	2	1,10
3	Anguilliformes	6	10,90	8	7,21	10	5,50
4	Clupeiformes	1	1,82	5	4,50	5	2,75
5	Gonorhynchiformes	1	1,82	1	0,90	1	0,55
6	Cypriniformes	3	5,45	30	27,03	66	36,26
7	Characiformes	1	1,82	1	0,90	1	0,55
8	Siluriformes	9	16,36	14	12,61	23	12,63
9	Beloniformes	2	3,64	2	1,80	2	1,10
10	Syngnathiformes	1	1,82	2	1,80	2	1,10
11	Synbranchiformes	2	3,64	3	2,70	5	2,75
12	Scorpaeniformes	1	1,82	1	0,90	2	1,10
13	Perciformes	20	36,36	34	30,63	54	29,67
14	Pleuronectiformes	3	5,45	4	3,60	5	2,75
15	Tetraodontiformes	2	3,64	3	2,70	3	1,64
	Total	55	100	111	100	182	100

Source: Results of the author's investigation and survey in 2024

Results of Table 1, the species composition structure of Ba River fish is as follows:

- Order level: Among 15 orders and 55 families, the most diverse is the order of (Perciformes) with 20 families (36.36%), followed by the order of catfish (Siluriformes) with 9 families (16.36%), the order of eel (Anguilliformes) with 6 families (10.90%), the order of carp (Cypriniformes) and the order of (Pleuronectiformes) each have 3 families (5.45%). The remaining orders have only 1 to 2 families with a low proportion.
- Family level: In 55 families and 111 genera, the most diverse is the Cyprinidae family with 24 genera (21.62%), followed by the Gobiidae family with 9 genera (8.11%), the Clupeidae family with 5 genera (4.50%), the Belonidae family with 4 genera (3.60%), the Cobitidae, Balitoridae, Bagridae, and Pangasiidae families with only 3 genera (2.70%). The remaining families have only 1 to 2 genera.
- Genus level: In total 111 genera, the most dominant is genus (*Osteochilus*) with 6 species (3.30%), genus (*Rasbora*) with 5 species (2.75%), 7 genera with 4 species (2.20%) are *Hypsibarbus*, *Tor*, *Garra*, *Channa*, *Hemibagrus*, *Clarias*, *Poropuntius*, 9 genera with 3 species (1.65%) are *Mugil*, *Anguiilla*, *Barbonymus*, *Acrossocheilus*, *Systomus*, *Cirrhinus*, *Caranx*, *Trichogaster*, *Mystus*, 23 genera with 2 species (1.10%), 70 genera with 1 species (0.55%).
- Species level: In 182 species, the Cypriniformes order has the largest number of species with 66 species (36.26%), followed by the Perciformes order with 54 species (29.67%), the Siluriformes order with 23 species (12.63%), the Angulliformes order with 10 species (5.50%), the remaining orders have from 1 to 5 species.

3.2. Geo-fauna of freshwater fish in the Ba River

Aquatic organisms of inland freshwater bodies in Vietnam (Dang et al., 2002) provided a relatively comprehensive description of the geo-biological characteristics of aquatic

organisms in Vietnam's inland freshwater bodies. Most authors currently agree that Vietnam cannot be considered a single homogeneous unit within the Indo-China region due to the clear differences between Northern and Southern Vietnam in terms of geo-biological relationships, hydrological systems, and climate. According to these authors, Northern Vietnam (North of the Ngang pass-Hai Van pass boundary at 16°-18°N latitude) is a separate geo-biological unit from the Indo-Malayan subregion (which includes Southern Vietnam), as well as from the China subregion to the North. Northern Vietnam-Southern China is a subregion within the Indo-China region, and the Indo-Malayan subregion includes Southern Vietnam. In the article "Geo-fauna of freshwater fish in Vietnam" (2005), Nguyen Thai Tu suggested that Vietnam belongs to two geo-zoological provinces: Northern Vietnam-Southern China and Mekong. The boundary between these two provinces is the eastern watershed of the Mekong River basin. This watershed extends from Yunnan down to Central Vietnam at 14° latitude, including the basins of the Tra Khuc and Ve Rivers (Quang Ngai). The Mekong Province, in addition to the Mekong River basin, also includes Dong Nai River basin and the rivers of the South Central coast up to Ba River (Dak Lak) and Con River (Binh Dinh). The author also separated the area from Ngan Pho River at 18°30' latitude (Ha Tinh) to Tra Khuc and Ve Rivers at 14°20' latitude (Quang Ngai) into a specific zone: the Mid-Truong Son zone, part of the Northern Vietnam-Southern China Province. This zone is characterized by many narrowly endemic species that have not yet dispersed due to the fragmented terrain and natural barriers. The Northern Vietnam-Southern China Province has its Southern boundary at the Tra Khuc and Ve Rivers at 14° latitude. Thus, there is no consensus on the boundary demarcation between the two geo-zoological subregions within Vietnamese territory. We observe that the watershed running along the Truong Son mountain range from North to the Southernmost part of the South Central coast serves as the East-West boundary (within Vietnamese territory) for the two subregions: Northern Vietnam-Southern China and the Indo-Malayan subregion. However, according to Nguyen Thai Tu's division, the Ba River is the Northern boundary of the Mekong geo-zoological Province, which belongs to the Indo-Malayan subregion. We believe there is no basis to separate the Mekong River basin and the Southernmost part of the South Central coast of Vietnam into one geo-zoological Province of the Indo-Malayan subregion. Because the Mekong River basin includes a Northern part within China territory at high latitudes (32°-34°), sharing a common source with the Yangtze River and Yellow River and the western boundary of this province has not been mentioned. The entire Ba River system is located in the South Central coast bio-geographical region, extending from 16°N latitude (Hai Van-Da Nang) to 11°S latitude (Khanh Hoa). Few studies have been conducted on the fish fauna of rivers in the South Central coast region. Nguyen Van Hao (2005a, b) summarized studies by various authors on the fish fauna of the South Central coast, reporting a total 251 species, including Phu Ninh lake with 114 species, Tam Ky River with 53 species (Quang Nam), Tra Khuc River with 50 species (Quang Ngai), Con River with 42 species (Binh Đinh), and Cai River (Khanh Hoa). Serov et al., 2006 reported 55 fish species, noting that 33% of the species belong to the Southern Vietnam fish fauna, characteristic of the lower Mekong River. Another 31% of the species are characteristic of rheophilic (current-loving) fish groups typically living in rivers in Central Vietnam and tributaries of the Mekong River. Some of these species (*Hemiculter krempfi*, *Schistura namboensis*, *Schismatogobius* sp.) are endemic to the Cai River basin and a few other small rivers in Khanh Hoa. The remaining 36% are widely distributed in Indochina and can be found in Vietnam. No species distributed in Northern Vietnam were found in the

Cai River basin. The fish fauna of the Cai River is more similar to the fish fauna of the middle and lower Mekong River in terms of origin characteristics and includes some endemic species from Central Vietnam. Based on the survey, research and data compilation, the species composition of the Ba River fish fauna has 38 species shared with the freshwater fish fauna of Northern Vietnam and 63 species shared with that of Southern Vietnam. There are 76 species shared with the middle and lower Mekong River. Among them, 18 species are widely distributed, found in water bodies of the North, Central, South, Central highlands, and the Mekong River basin in Cambodia (Table 2). The species composition of the Ba River's fish fauna shows significant differences in the proportion of species shared with Northern and Southern freshwater fish faunas. The percentage of Ba River fish species shared with the Southern freshwater fish fauna is 59.43%. Conversely, this percentage decreases to 35.84% for Northern freshwater fish species. The species composition of the Ba River fish fauna also includes many species distributed in the Northern Vietnam-Southern China subregion and the Indo-Malayan subregion. Thus, the Ba River fish fauna carries two geographical elements: Northern Vietnam-Southern China and Indo-Malayan.

The boundary between Northern and Southern Vietnam is from Ngang pass-Hai Van pass, and the boundary between the Northern Vietnam-Southern China and Mekong geo-zoological provinces is the eastern watershed of the Mekong River basin, extending from Yunnan (China) down to 14° latitude, including the Tra Khuc and Ve River basins. We believe this watershed extends further south to 13° latitude, including Con and Ba River basins, because the fish fauna here still contains a Yunnan element, accounting for 23.58%.

To find the relationship between the water bodies and to help determine the geo-faunal characteristics of the Ba River fish, we compared the species composition of the Ba River fish with some other water bodies in Vietnam. The research results and updated data provided by previous studies are presented in (Table 2) show that the number of shared species between the Ba River fish fauna and other fish faunas in Vietnam is not high. Of the total 379 freshwater fish species in northern Vietnam (Mai, 1978; Nguyen, 2005a,b), there are 38 species in common with the Ba River fish fauna, accounting for 35.84%, with a similarity coefficient of 0.16. Among the 306 freshwater fish species of Southern Vietnam (Mai et al., 1992; Nguyen, 2005a, b), there are 63 species common with the Ba River fish fauna, accounting for 59.43%, with a similarity coefficient of 0.31. The degree of species composition similarity is not yet high.

For the freshwater fish fauna of the North Central coast (Nguyen, 2005a, b), there are 57 in common species, with a similarity coefficient of 0.35. For the fish faunas of Phu Ninh Lake, Tam Ky River, Tra Khuc River, Con River, and Cai River, the number of common species is 54, 45, 41, 37, and 30, respectively, with corresponding similarity coefficients of 0.49, 0.57, 0.53, 0.50, and 0.37.

The freshwater fish fauna of the Central highlands shares 71 species in common with the Ba River, exhibiting a similarity coefficient of 0.51 (Nguyen, 1999; Nguyen, 2005a, b). Compared to the fish fauna of the Mekong River in Cambodia (Rainboth, 1996), 76 species are shared, resulting in a lower similarity coefficient of 0.32 (Table 2). The highest similarity coefficient observed between the Northern and Southern fish faunas is 0.31. The number of Northern faunal elements gradually decreases, while the number of Southern faunal elements increases from the outside in (referring to a transition, likely

geographically). This suggests that the species composition of the Ba River fish fauna is closer to that of Southern Vietnam and the middle-lower Mekong River, thus belonging to the Indo-Malayan subregion.

Thus, the fish fauna of Central Vietnam, from Hai Van pass at 16° N latitude (Da Nang) to Ca pass at 12°50' N latitude (Dak Lak), has a transitional character between two geo-zoological subregions: the Northern Vietnam - Southern China subregion and the Indo-Malayan subregion. The further south one goes in this transitional zone, the more the fish species composition will resemble that of southern Vietnam and the middle-lower Mekong River, and vice versa. The Ba River system is the Southwestern boundary of this transitional zone.

Table 2. Relationship between species composition of Ba River fish and some other freshwater fish faunas in Vietnam and Cambodia.

TT	Fish fauna	Total Number of species	Number of common species		S**	Author and year of publication
			Number of	Percentage %		
1	Northern Freshwater Fish Fauna	379	38	35,84	0,16	Mai Dinh Yen, 1978; Nguyen Van Hao, 2005a, b
2	Freshwater fish fauna of North Central	219	57	53,77	0,35	Nguyen Thai Tu et al., 2003; Vo Van Phu, 2003, 2004, Nguyen Van Hao, 2005a, b
3	Fish fauna of Phu Ninh Lake, Quang Nam Province	114	54	50,94	0,49	Vo Van Phu et al., 2009
4	Tam Ky River Fish Fauna, Quang Nam Province	53	45	42,45	0,57	Vo Van Phu and Vu Thi Phuong Anh, 2003
5	Tra Khuc River Fish Fauna Quang Ngai Province	50	41	38,67	0,53	Mai Dinh Yen and Nguyen Huu Duc, 1991
6	Fish fauna of the Con River, Binh Dinh Province	42	37	34,90	0,50	Mai Dinh Yen and Nguyen Huu Duc, 1991
7	Fish fauna of Cai River, Khanh Hoa Province	55	30	28,30	0,37	Seror.D. V, Nezdoliy.V. K, Pavlov.D. S, 2006
8	Freshwater fish fauna of the Central Highland	172	71	66,98	0,51	Nguyen Thi Thu He, 1999; Nguyen Van Hao, 2005a, b.
9	Southern Freshwater Fish Fauna	306	63	59,43	0,31	Mai Dinh Yen et al., 1992, Nguyen Van Hao, 2005a, b
10	Mekong River fish fauna of Cambodia	374	76	71,69	0,32	Rainboth, 1996

Source: The results of the field survey, and updated with data from previous studies, are the author's own findings in 2024

4. Conclusion

The results of the study on the fish fauna in Ba River have identified 182 fish species belonging to 111 genera, 55 families, 15 different orders, of which 11 species are exotic, 171 species are present in the Ba River system. The fish species composition of the Ba River is diverse in terms of order, family, genus, and species. Among them, the most diverse is the order of (Perciformes) with 20 families (36.36%). About family level the most diverse is the Cyprinidae family with 24 genera (21.62%) and genus level the most dominant is genus (*Osteochilus*) with 6 species (3.30%). A total of 182 species, number of species exhibiting the Northern element, accounts for 35.84%, Southern element, accounts for 59.43%, and Mekong, accounts for 71.69%.

The Ba River fish fauna is located in the Sino-Indian faunal region in the transition zone between two faunal subregions: the Northern Vietnam-Southern China region and the Indian-Malayan subregion. This transition zone is limited to the North by Hai Van pass (Da Nang), latitude 16º North, and to the South by Ca pass (Dak Lak), latitude 12º50' North. In this transition zone, the further South the fish species composition is closer to the fish of the Southern region and the middle - lower Mekong River, belonging to the Indian-Malayan subregion.

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