

Evaluating the diversity of native ornamental fishes in Dong Nai biosphere reserve, Dong Nai province, Vietnam

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ABSTRACT

This study was conducted from May 2019 to December 2020 to investigate the diversity of native ornamental fishes in Dong Nai Biosphere Reserve (DNBR). The study identified 116 fish species belonging to 11 orders and 28 families in the water bodies of the DNBR. The analysis of compilation of the samples in the study further revealed that Cyprinidae was the most abundant family contributing 50 species followed by Perciformes and Siluriformes providing 24 species and 21 species, respectively. Out of 116 recorded species, 53 species were considered as ornamental fish, 77 species as food fish and 31 species as both ornamental and food fish. Among the ornamental fish group, many species have recorded good abundance at studied sites. Most of these fish species are high demand and sold at high prices in the domestic and international markets. The domesticated results showed that 21 ornamental fish species belong to 11 families were adapted and developed well in captivity conditions. The results also specified that eight species reach level 4 of domestication indicating truly domesticated, while the remaining 13 species belong to the first three levels of domestication, implying need to be further domesticated before being marketed. In addition, the study concluded that if managed sustainably, the collection of wild fish for the ornamental fish purpose could provide a stable income and livelihood for communities in the DNBR.

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1. Introduction

Aquarium keeping is one of the most popular hobbies with millions of enthusiasts worldwide today. It is also a good way to relax and reduce stress from work. The growing interest in aquarium species has resulted in steady increase in global aquarium trade. The international aquarium trade has grown dramatically over the past century, especially since the early 1980s, becoming one of the most popular amusements in global (Livengood & Chapman, 2011; Strecker et al., 2011). Today, millions of families around the world have owned at least one aquarium, especially in developed countries such as France, Italia, Germany, the

United State of America, Japan (Rhyne et al., 2012; Papavlasopoulou et al., 2014)... Surveys of the world aquarium market showed that about 6,000 species of ornamental fish are traded annually, of which freshwater aquarium fish contribute approximately 4,000 species, accounting for about 75% of the total number of marketed species (Rhyne et al., 2012, 2012; Raghavan et al., 2013). It is estimated that close to 30-35 species of freshwater aquarium fish have dominated the global trade such as *Poecilia reticulata*, *Paracheirodon innesi*, *Xiphophorus maculatus*, *Xiphophorus helleri*, *Poecilia velifera*, *Pterophyllum scalare*, *Carassius auratus*, *Brachydanio rerio*, *Symphysodon* spp (Monticini, 2010)...

Historically, all ornamental fish sold on the

aquarium market were caught from the wild. Wild fish keeping as aquarium fish is becoming popular in many places in the world. With the high demand and prices of many beautiful species, native aquarium fish are being harvested from the wild in larger volumes and at higher rates by manual fishing methods using small seines, dip nets, and a variety of small trap nets (Vagelli & Erdmann, 2002; Cato & Brown, 2003; Lunn & Moreau, 2004). In addition, many reports indicated that catching fish for ornamental purposes is usually in small quantities but often has a higher value than large catches of the same species but for local uses such as human food, bait for fishing, or food for fish and animals (Davenport, 2016; King, 2019).

Dong Nai Biosphere Reserve (DNBR) is well known for its high level of biodiversity and of global meaningful ecosystem. The flora of DNBR includes 2,812 species of vascular plants belonging to 192 families, 99 orders. While the fauna includes 110 species of mammals belonging to 31 families, 12 orders; 348 bird species; 134 reptile and amphibian species; 175 fish species and 1,243 insect species (DNDNRE, 2017). The fish fauna of DNBR maintains many rare and endangered fish species recorded in the Vietnam Red Book and IUCN's Red List such as *Scleropages formosus*; and high economic fish species included *Anguilla marmorata*, *Hemibarbus wyckioides*, *Oxyeleotris marmoratus*; and many other rare fish species such as: *Morulius chrysopehadion*, *Chitala ornata*, *Probarbus jullieni*, *Cyclocheilichthys enoplos* (Nguyen et al., 2009). In addition, many of native fish species have great potential as aquarium fish due to its peculiar body shape, colorations, swimming behavior, catching easily (and are free), and readily adapting to aquarium life and accepting standard fish food. However, at present, these fish species in the DNBR have not been used to their true value but are considered as trash fish with low economic value. Therefore, an up-to-date study to assess the diversity of native fish species, especially ornamental fish species at the DNBR is necessary to introduce proposed measures to conserve endangered species, protect and develop economic fish species and efficiently use of native ornamental fish species. The outcomes of the study will help local people to develop economy, to improve their livelihoods as well as to raise awareness in the sustainable use of aquatic resources and conservation of these species.

2. Materials and Methods

The study on the diversity of native ornamental fishes in the DNBR was implemented from May 2019 to December 2020.

The samples were collected from different types of water bodies of the typical aquatic ecosystems of the DNBR included Suoi Rang, Suoi Sa Mach, Suoi Da Dung, Suoi Cop, Ba Hau, Tri An Reservoir and Ramsar Bau Sau (Nam Cat Tien National Park). Dip nets, seine nets and fishing trap were used to catch fish because they are the most efficient and productive collection methods with the least negative impacts on the collected samples.

Fish samples were weighed and measured (according to the instructions of Pravdin, 1973). Fish samples were then photographed in the field, labeled with a local name, time, location, inserted labels into the mouth or gill, and stored in 10% formalin solution. Alive fish samples were kept in continuously aerated plastic containers and in the dark and at low temperatures during collecting and transportation. Fish specimens were transferred to the laboratory of Faculty of Fisheries, Nong Lam University (FoF, NLU) for identification. A total of 374 alive individuals of 21 collected species continue to be kept at Freshwater hatcheries of FoF, NLU to monitor the survival, growth, adaptation and reproduction in captivity conditions. The fish were typically separated by species and domesticated in separate tanks (600-L fiberglass tank). *Ceratophyllum* and black pebble stone were equipped into the domesticated tank to simulate the habitat of the fish in the wild. In addition, most of the native species are somewhat timid and have a hiding habit, so PVC pipes were also fitted. The tanks were kept in a quiet place with medium light and lightly aerated. Fish were fed satisfactorily once a day. Fish species liked *Rasbora* sp., *Esomus metallicus*, *Chela laubuca*, *Danio pulcher*, *Betta prima*, *Nemacheilus platiceps*,... were fed *Moina* and red worms (*Tubifex* sp.), while *Channa* cf. *gachua*, *Pseudomystus siamensis* and *Ompok siluroides*... were fed white spot fish (*Aplocheilichthys panchax*), small tilapia and freshwater Atyidae shrimp (*Caridina* sp.).

The morphometric and meristic characteristics of fish samples such as total length, standard length, and numbers of dorsal fin, pelvic fin, pectoral fin, lateral line scale, etc. were iden-

tified based on the taxonomic keys published by Vidthayanon (2008), Vasil'eva et al. (2013) and Nelson et al. (2016).

The economic importance and the threat and conservation status were determined according to the Vietnam Red Book (MOST, 2007) and IUCN Red list of Threatened Species (IUCN, 2015).

Ornamental fish were selected based on criteria such as having various and beautiful sizes, shapes and colors, and suitable for keeping as pets in an aquarium, a tank, pond or a container for decorative or display purposes.

3. Results and Discussion

Analytical results recorded a total of 116 fish species belonging to 11 orders and 28 families (Table 1). Of these, the most dominant order was Cypriniformes (50 species, accounting for 43.9%), followed by Perciformes (24 species, 20%) and Siluriformes (21 species, 18.4%) (Figure 1). Out of 116 recorded species, four species of fish

List), 77 species were considered as food fish. The study revealed the abundant occurrence of 53 native fish species belonging to 7 orders and 15 families in the DNBR (Table 1) that have ornamental value, such as *Nemacheilus platiceps*, *Lepidocephalichthys hasselti*, *Rasbora borapetensis*, *Rasbora trilineata*, *Gyrinocheilus pennocki*, *Gyrinocheilus aymonieri*, *Channa cf. gachua*, *Brachyogobius cf. nunus*, *Danio pulcher*, *Chela laubuca*... These species of fish are generally small in size, but this is what makes them beautiful. The small size also makes them suitable for keeping in aquariums. Among these native ornamental fish species, there are 31 species of food fish at the juvenile stage having special colors and morphology that are valuable as ornamental fish such as *Cyclocheilichthys cf. lagleri*, *Osteochilus lini*, *Cyclocheilichthys repasson*, *Myxus nemurus*, *Myxus singaringan*, *Xenentodon cancila*... Some of these native fish have been acclimated to artificial environmental conditions of aquariums such as *Chitala ornata*, *Pseudomystus siamensis*, *Mastacembelus armatus*, *Mastacembelus faves*, *Carinotetraodon lorteri*... Native fish are an excellent alternative to exotic fish species because of their availability, low cost and no devastating impact on the natural aquatic environment. In addition, keeping native fish in an aquarium allows aquarists to recreate a microcosm of their habitat in the wild and observe them at home or workplace. Through observing fish behavior and their interaction with different environmental conditions will help promote the awareness and understanding of aquarists about the beauty, function, and ecological services of the fish as well as how our activities affect the ecology of our environment. From there, it helps to raise awareness about protecting the natural environment, especially the aquatic ecosystem in their living areas (Figure 2).

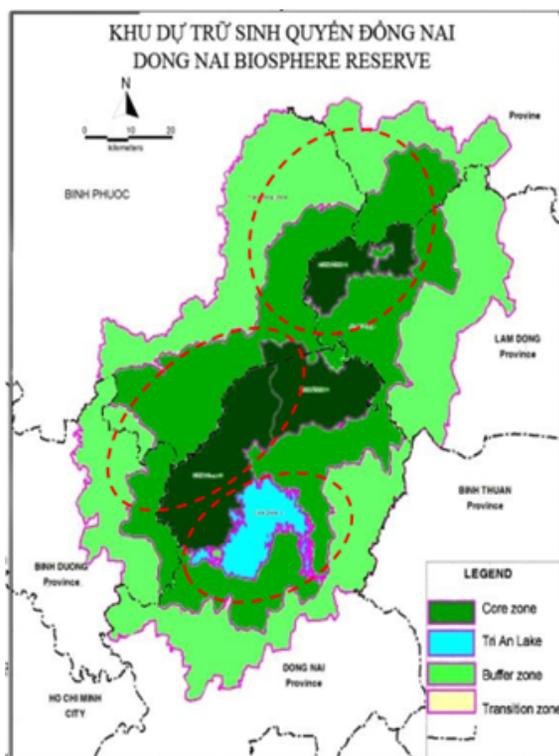


Figure 1. Studied sites at the Dong Nai biosphere reserve.

have been listed under the list of rare and endangered fish species (three species on the Vietnam Red List; one species on the IUCN's Red

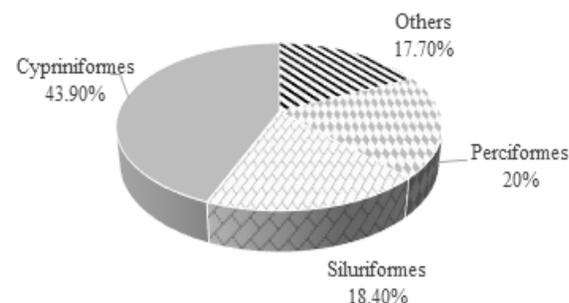


Figure 2. Fish species composition recorded at Dong Nai biosphere reserve.

Table 1. The fish species composition in DNBR, Dong Nai (2020)

	Scientific name	REF			FF	OF
		1	2	3		
	Osteoglossiformes					
	Notopteridae					
1	<i>Chitala ornata</i> Gray, 1831	EN	VU	LC	X	X
2	<i>Notopterus notopterus</i> Pallas, 1780				X	X
	Clupeiformes					
	Clupeidae					
3	<i>Corica laciniata</i> Fowler, 1935				X	
4	<i>Clupeichthys aesarnensis</i> Wongratana, 1983				X	
5	<i>Clupeoides borneensis</i> Bleeker, 1852				X	
	Cypriniformes					
	Balitoridae					
6	<i>Nemacheilus platiceps</i> Kottelat, 1990					X
7	<i>Acantopsis dialuzoha</i> van Hasselt, 1823					
8	<i>Lepidocephalichthys hasselti</i> Valenciennes, 1846					X
	Cyprinidae					
9	<i>Barbonymus gonionotus</i> Bleeker, 1849				X	
10	<i>Barbonymus schwanefeldi</i> Bleeker, 1854				X	X
11	<i>Barbonymus altus</i> Gunther, 1868				X	
12	<i>Cosmochilus harmandi</i> Sauvage, 1878	VU	VU	LC	X	
13	<i>Chela laubuca</i> Hamilton, 1822					X
14	<i>Cirrhinus microlepis</i> Sauvage, 1878				X	
15	<i>Crossocheilus reticulatus</i> Fowler, 1934				X	X
16	<i>Danio pulcher</i> Blyth, 1860					X
17	<i>Ctenopharyngodon idella</i> Valenciennes, 1844				X	
18	<i>Cyclocheilichthys armatus</i> Valenciennes, 1842				X	
19	<i>Cyclocheilichthys enoplos</i> Bleeker, 1849				X	
20	<i>Cyclocheilichthys repasson</i> Bleeker, 1853				X	X
21	<i>Cyclocheilichthys apogon</i> Valenciennes, 1842				X	X
22	<i>Cyclocheilichthys</i> cf. <i>lagleri</i> Sontirat, 1989				X	X
23	<i>Cyprinus carpio</i> Linnaeus, 1758				X	
24	<i>Leptobarbus hoevenii</i> Smith, 1945				X	X
25	<i>Poropuntius deauratus</i> Valenciennes, 1842					
26	<i>Puntius</i> cf. <i>brevis</i> Bleeker, 1806					X
27	<i>Puntius rhombeus</i> Kottelat, 2000					
28	<i>Hampala macrolepidota</i> van Hasselt, 1823	VU		LC	X	X
29	<i>Henicorhynchus caudimaculatus</i> Fowler, 1934				X	
30	<i>Henicorhynchus lobatus</i> Smith, 1945				X	
31	<i>Henicorhynchus siamensis</i> Sauvage, 1881				X	
32	<i>Labiobarbus lineatus</i> Smith, 1945				X	
33	<i>Labiobarbus siamensis</i> Sauvage, 1881				X	
34	<i>Thynnichthys thynnoides</i> Bleeker, 1852				X	
35	<i>Hypophthalmichthys molitrix</i> Valenciennes, 1844				X	
36	<i>Hypophthalmichthys nobilis</i> Richardson, 1845				X	
37	<i>Labeo chrysopekadion</i> Bleeker, 1849	VU		LC	X	X
38	<i>Labeo rohita</i> Hamilton, 1822				X	X
39	<i>Osteochilus hasselti</i> Valenciennes, 1842				X	X
40	<i>Osteochilus lini</i> Fowler, 1935				X	X
41	<i>Osteochilus waandersi</i> Bleeker, 1852				X	X
42	<i>Osteochilus microcephalus</i> Valenciennes, 1842			LC	X	X

Table 1. The fish species composition in DNBR, Dong Nai (2020) (continue)

	Scientific name	REF			FF	OF
		1	2	3		
43	<i>Paralaubuca barroni</i> Fowler, 1934					
44	<i>Parachela maculicauda</i> Smith, 1934					
45	<i>Puntioplites falcifer</i> Smith, 1929				X	
46	<i>Puntioplites proctozyron</i> Bleeker, 1865				X	
47	<i>Puntius orphoides</i> Valenciennes, 1842				X	X
48	<i>Rasbora trilineata</i> Steindachner, 1870					X
49	<i>Esomus metallicus</i> Ahl, 1923					X
50	<i>Rasbora tornieri</i> Ahl, 1922					X
51	<i>Rasbora paviana</i> syn. <i>R. paviei</i> Tirant, 1885					X
52	<i>Rasbora borapetensis</i> Smith, 1934					X
53	<i>Scaphognathops stejnegeri</i> Smith, 1931					
54	<i>Mystacoleucus marginatus</i> Valenciennes, 1842					
55	<i>Systomus aurotaeniatus</i> Tirant, 1885					
	Gyrinocheilidae					
56	<i>Gyrinocheilus aymonieri</i> Tirant, 1883	VU		LC	X	
57	<i>Gyrinocheilus pennocki</i> Fowler, 1937					
	Siluriformes					
	Bagridae					
58	<i>Hemibagrus nemurus</i> Valenciennes, 1839				X	
59	<i>Hemibagrus wyckioides</i> Fang & Chaux, 1949		NT	LC	X	
60	<i>Hemibagrus filamentus</i> Fang & Chaux, 1949				X	
61	<i>Mystus albolineatus</i> Roberts, 1994				X	X
62	<i>Mystus rhegma</i> Fowler, 1935				X	X
63	<i>Mystus mysticetus</i> Roberts, 1992				X	X
64	<i>Mystus nemurus</i> Valenciennes, 1840	VU	VU	DD	X	X
65	<i>Mystus singaringan</i> Bleeker, 1846				X	X
66	<i>Pseudomystus siamensis</i> Regan, 1913				X	X
	Bagriichthidae					
67	<i>Bagrichthys obscurus</i> Ng, 1999				X	
	Clariidae					
68	<i>Clarias batrachus</i> Linnaeus, 1758	CR		LC	X	X
69	<i>Clarias gariepinus</i> Burchell, 1822				X	
70	<i>Clarias macrocephalus</i> Gunther, 1864				X	
	Loricariidae					
71	<i>Pterygoplichthys disjunctivus</i> Weber, 1991					
	Pangasiidae					
72	<i>Pangasius macronema</i> Bleeker, 1850				X	
	Akysidae					
73	<i>Akysis maculipinnis</i> Fowler, 1934					X
	Siluridae					
74	<i>Micronema bleekeri</i> Bocourt, 1866				X	
75	<i>Micronema apogon</i> Bleeker, 1851				X	
76	<i>Ompok siluroides</i> Lacepede, 1803	CR		NT	X	
77	<i>Kryptopterus</i> sp.				X	
78	<i>Wallago attu</i> Bloch & Schneider, 1801				X	X
	Beloniformes					
	Belonidae					
79	<i>Xenentodon cancila</i> Hamilton, 1822				X	X
80	<i>Xenentodon canciloides</i> Bleeker, 1854				X	

Table 1. The fish species composition in DNBR, Dong Nai (2020) (continued)

	Scientific name	REF			FF	OF
		1	2	3		
	Hemiramphidae					
81	<i>Dermogenys siamensis</i> Fowler, 1934					X
82	<i>Hyporhamphus limbatus</i> Valenciennes, 1847				X	
83	<i>Zenarchopterus ectuntio</i> Hamilton, 1822				X	
84	<i>Dermogenys pusilla</i> Kuhl & van Hasselt, 1823				X	
	Synbranchiformes					
	Mastacembelidae					
85	<i>Mastacembelus</i> cf. <i>circumcinctus</i> Hora, 1924				X	X
86	<i>Mastacembelus armatus</i> Lacepede, 1800				X	X
87	<i>Macrognathus siamensis</i> Gunther, 1861				X	X
88	<i>Mastacembelus favus</i> Hora, 1923				X	X
	Synbranchidae					
89	<i>Monopterus albus</i> Zuiew, 1793				X	
	Perciformes					
	Anabantidae					
90	<i>Anabas testudineus</i> Bloch, 1792				X	
	Ambassidae					
91	<i>Parambassis siamensis</i> Fowler, 1937					X
92	<i>Parambassis apogonoides</i> Bleeker, 1851					
93	<i>Parambassis wolffi</i> Bleeker, 1850					
	Channidae					
94	<i>Channa lucius</i> Cuvier, 1831					
95	<i>Channa striata</i> Bloch, 1793				X	
96	<i>Channa</i> cf. <i>gachua</i> Hamilton, 1822					X
	Cichlidae					
97	<i>Cichla ocellaris</i> Bloch & Schneider, 1801				X	
98	<i>Oreochromis mossambicus</i> Peters, 1852				X	
99	<i>Oreochromis niloticus</i> Linnaeus, 1758				X	
100	<i>Oreochromis red hybrid</i>				X	
	Eleotridae					
101	<i>Oxyeleotris marmorata</i> Bleeker, 1852				X	X
	Gobiidae					
102	<i>Brachygobius sabanus</i> Inger, 1958					
103	<i>Glossogobius aureus</i> Akihito & Meguro, 1975					
104	<i>Glossogobius giuris</i> Hamilton, 1822				X	X
105	<i>Papuligobius ocellatus</i> Fowler, 1937				X	
106	<i>Gobiopterus</i> cf. <i>chuno</i> Hamilton, 1822					
107	<i>Brachygobius</i> cf. <i>nunus</i> Hamilton, 1822					X
	Helostomatidae					
108	<i>Helostoma temminckii</i> Cuvier, 1829				X	
	Pristolepididae					
109	<i>Pristolepis fasciata</i> Bleeker, 1851				X	
	Belontiidae					
110	<i>Trichopodus microlepis</i> Gunther, 1861					
111	<i>Trichopsis vittata</i> Cuvier, 1831					X
112	<i>Trichopodus trichopterus</i> Pallas, 1770					X
113	<i>Betta prima</i> Kottelat, 1994					X

Table 1. The fish species composition in DNBR, Dong Nai (2020) (continued)

Scientific name	REF			FF	OF
	1	2	3		
Tetrodontiformes					
Tetraodontidae					
114 <i>Monotrete leiurus</i> Bleeker, 1850 syn. <i>Tetraodon leiurus</i> Bleeker, 1951					
115 <i>Carinotetraodon lorteri</i> Tirant, 1885					X
Atheriniformes					
Phallostethidae					
116 <i>Phallostethus</i> cf. <i>smithi</i> Myers, 1928					

REF: Rare and Endangered Fish.

1: MARD (QĐ-82/2008); 2: Vietnam Red list-2007; 3: IUCN-2015.

FF: Food Fish.

OF: Ornamental Fish.

The results of domestication experiment showed that 21 selected native ornamental fish species, belong to 11 families, adapted, and grew well under captive conditions at the Freshwater hatcheries of FoF, NLU (Table 2). The study also recorded complete adaptations of eight fish species, including *Rasbora borapetensis smith*, *Rasbora trilineata steindachner*, *Esomus metallicus*, *Rasbora paviana* syn. *R. paviei*, *Betta prima*, *Mastacembelus armatus*, *Pseudomystus siamensis* and *Channa* cf. *gachua* with evidence that they grew well and reproduced naturally in captivity. Currently, the number of individuals of these species is greatly increased compared to the number of domestications at the beginning. Especially, the 2nd generation of these species have also reached sexual maturity and have spawned the 3rd generation. The importance is that the 3rd generation fish onwards fully met the criteria to be marketed in the aquarium market. The remaining fish species are well adapted and developed well but have not spawned in captivity, which may be due to the small number of individuals, sexual immaturity, inadequate male-female ratio as well as the unsuitable conditions necessary for reproduction. Therefore, it is necessary to have further studies on the reproductive characteristics of these species, then collecting more individuals from the wild for reproduction testing.

According to Teletchea & Fontaine (2014) there is 5 levels of domestication of wild species, with 1 being the least to 5 being the most domesticated. The classification of the domestication levels includes: level 1 (first trials of acclimatization to the culture environment); level 2 (part of the live cycle closed in captivity, also known as capture-based aquaculture); level 3 (en-

tire life cycle closed in captivity with wild inputs); level 4 (entire life cycle closed in captivity without wild inputs); and level 5 (selective breeding programmes are used focusing on specific goals). Based on this classification, it is clear that eight species recorded in this study, *Rasbora borapetensis smith*, *Rasbora trilineata steindachner*, *Esomus metallicus*, *Rasbora paviana* syn. *R. paviei*, *Betta prima*, *Mastacembelus armatus*, *Pseudomystus siamensis* and *Channa* cf. *gachua*, are at level 4 of domestication meaning truly domesticated. While the 13 species actually belong to the first three levels of domestication, implying that the current trade of these species is based on entirely or partly on wild catch. Therefore, these species need to be further domesticated before being marketed.

The survey results showed that freshwater ornamental fish accounted for about 99% of Vietnam's total ornamental fish exports in 2019, of which marine species contributed less than 1%. Out of the total of approximately 60 freshwater ornamental fish species being exported from Vietnam, there are approximately 50 artificial reproduction species and about 10 wild fish species (PSN, 2020). As of October 2019, Ho Chi Minh City's ornamental fish production reached 176 million fish, of which the export volume was 17.9 million fish. Export value reached 19,66 million USD. Ho Chi Minh City's ornamental fish has been exported to 50 countries of which Europe accounted for 54.1%, Asia accounted for 28.6% and America accounted for 14.5% (Chi, 2020). It indicated that ornamental fishes have a significantly important market of high demand and prices both in domestic market and in international markets. The results showed that many of the founded species in this study are

Table 2. The fish species are being domesticated at the Freshwater hatcheries of Faculty of Fisheries, Nong Lam University

	Scientific name	Adapted to captivity	Natural reproduction in captivity
	Cyprinidae		
1	<i>Chela laubuca</i> Hamilton, 1822	X	
2	<i>Danio pulcher</i> Blyth, 1860	X	
3	<i>Puntius rhombeus</i> Kottelat, 2000	X	
4	<i>Paralaubuca barroni</i> Fowler, 1934	X	
5	<i>Puntius orphoides</i> Valenciennes, 1842	X	
6	<i>Rasbora trilineata</i> Steindachner, 1870	X	X
7	<i>Esomus metallicus</i> Ahl, 1923	X	X
8	<i>Rasbora paviana</i> syn. <i>R. paviei</i> Tirant, 1885	X	X
9	<i>Rasbora borapetensis</i> Smith, 1934	X	X
	Bagridae		
10	<i>Pseudomystus siamensis</i> Regan, 1913	X	
	Akysidae		
11	<i>Akysis maculipinnis</i> Fowler, 1934	X	
	Siluridae		
12	<i>Ompok siluroides</i> Lacepede, 1803	X	
	Belontiidae		
13	<i>Xenentodon cancila</i> Hamilton, 1822	X	
	Channidae		
14	<i>Channa</i> cf. <i>gachua</i> Hamilton, 1822	X	X
	Belontiidae		
15	<i>Betta prima</i> Kottelat, 1994		
	Mastacembelidae		
16	<i>Mastacembelus</i> cf. <i>circumcinctus</i> Hora, 1924	X	
17	<i>Mastacembelus armatus</i> Lacepede, 1800	X	X
18	<i>Macrognathus siamensis</i> Gunther, 1861	X	
19	<i>Mastacembelus favus</i> Hora, 1923	X	X
	Tetraodontidae		
20	<i>Carinotetraodon lorteri</i> Tirant, 1885	X	
	Gobiidae		
21	<i>Brachygobius</i> cf. <i>nunus</i> Hamilton, 1822	X	
	Balitoridae		
22	<i>Nemacheilus platiceps</i> Kottelat, 1990	X	

on the list of the main export freshwater ornamental species of Vietnam, or have similar shapes and colors with these species. Information from aquarium trade websites shows that fish species found in this study such as *Brachygobius doriae*, *Rasbora borapetensis*, *Rasbora trilineata*, *Leiocassis siamensis*, *Pseudomystus siamensis*, *Carinotetraodon lorteri*, *Mastacembelus armatus*, *Mastacembelus favus*... are being exported to many countries around the world. However, the main supply of these species is still dependent on the wild-caught. As a result, native ornamental fish species are being harvested from the wild in greater numbers and at higher

rates, although many of these species have been domesticated and successfully artificial reproduction. Many studies revealed that fishing natives for the ornamental fish market is threatening the sustainability of aquatic ecosystems and fisheries (Chao et al., 2001; Vagelli & Erdmann, 2002; Lunn & Moreau, 2004). Fortunately, most of the sampling areas in this study are located in the protected area of the DNBR, so the native ornamental fish species are still abundant and has not been harvested for economic purposes. There are many beautiful endemic species and are not yet available on the ornamental market such as *Betta prima*, *Xenentodon cancila*, *Channa* cf.

gachua, *Akysis maculipinnis*, *Gyrinocheilus pen-
nocki*. Conversely, in other water bodies of the
DNBR such as Tri An Lake and Ba Hao Lake,
these native species are collected as by-catch of
fisheries and sold for much less than their true
value, called trash fish. There are three terms for
trash fish in Vietnamese: trash fish, trawler fish
and pig fish. Trash fish and trawler fish can be
used as human food but are rarely used, while
pig fish is the least quality and often used as
aquaculture feed, livestock feed. Survey results
showed that at aquarium shops in Ho Chi Minh
city, *Rasbora borapetensis* and *Rasbora trilineata*
were sold with average price of 0,3 USD/fish (av-
erage weight 3 g/fish), equivalent to 90 USD/kg).
However, at local market, it was sold as human
food with the price of 3 USD/kg and even lower,
less than 1 USD/kg, when used as feed for aqua-
culture and livestock husbandry.

The survey results also showed that the ma-
jority of people living in the DNBR have a re-
latively low standard of living. Fisheries are an
important source of livelihood for many local peo-
ple. However, the income from fisheries is of-
ten low and unstable due to low catches and
low value of harvested fish. Therefore, collecting
wild fish for ornamental purposes besides fishing
food fish can be an alternative for local people.
Many researchers agreed that if managed sus-
tainably, the collection of wild fish for the orna-
mental fish market could provide stable income
jobs in predominantly rural, low-income commu-
nities (Kiron & Dhanasiri, 2011; Rhyne et al.
2012; Murray & Watson, 2014). To obtain this
purpose, the local government must have com-
plete data/information about native ornamental
fish species, their status and distribution areas.
On that basis, local authorities could provide lo-
cal people with necessary information about these
species including images, market demand, com-
mercial size, and value... Moreover, the local au-
thority needs to issue regulations on fishing such
as fishing grounds, seasons, sizes, and catches. In
addition, training programs/instructions on the
methods of fishing, transportation, and acclima-
tization that ensuring the captured fish for orna-
mental purpose are alive and in good health, are
essential for local communities. However, in the
near future, there is a need to have a plan to do-
mesticate, artificial reproduce and farm of these
native ornamental fish species. This means that
these fish should reach level 4 of domestication.
If these goals are achieved, it will not only help

to increase income and livelihood of local peo-
ple, but also helps prevent over-fishing, helps to
conserve rare and critically endangered species as
well as help to protect and sustainably use these
aquatic resources.

4. Conclusions

Out of 116 fish species recorded in the Dong
Nai Biosphere Reserve, there are were four species
of rare and endangered fish; 21 species of orna-
mental fish. Eight species of ornamental species
reach level 4 of domestication meaning truly do-
mesticated, while the remaining 13 species belong
to the first three levels of domestication, imply-
ing that these species need to be further domes-
ticated before being marketed.

If managed sustainably, the collection of wild
fish for the ornamental fish market could provide
a stable income and livelihood for communities
in the Dong Nai biosphere reserve.

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