

# Species diversity and conservation status of ornamental fish traded in Kupang, East Nusa Tenggara, Indonesia

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**Abstract.** Usman Z, Hariyadi DR, Serihollo LGG. 2024. Species diversity and conservation status of ornamental fish traded in Kupang, East Nusa Tenggara, Indonesia. *Biodiversitas* 25: 1116-1126. The high demand for ornamental fish native to Indonesia has the potential to be used as a source of foreign exchange income. In addition to increasing the national income, the ornamental fish trade must also be considered to preserve the population of the fish species being sold. The study aimed to determine ornamental fish diversity and conservation status in Kupang City, East Nusa Tenggara. This research was conducted in Kupang City, East Nusa Tenggara, Indonesia, from August to September 2023. The research was conducted using survey (non-experiment) and observation methods. The survey method was carried out using a form to conduct interviews with sellers in 11 ornamental fish shops. At the same time, the observation method was used to identify the types of fish being traded. The study's results recorded 18 families, 39 genera, and 46 fish species (Include 1 species is hybrid fish). The highest species diversity came from the Cichlidae family with 9 species (1 species (*Amphilophus citrinellus* x *Cichlasoma trimaculatum*) is hybrid fish), followed by Cyprinidae with 7 species, whereas each species of the Characidae and Poeciliidae families were 5 species. Conservation status shows 4 status groupings, namely Least Concern (LC), Vulnerable (VU), Endangered (EN), and Not Evaluated (NE). Based on these groupings, there were 32 species in the Least Concern (LC) category, 3 species in the Endangered (EN) category, 2 species in the Vulnerable (VU) category, and 8 species in the Not Evaluated (NE) and 1 unclassified category. There is only 1 species that is included in the Appendix I category, namely *Scleropages formosus*, and other species are Not evaluated. This is the first study conducted in Kupang City to reveal the types of ornamental fish species sold and their conservation status. The study will be useful information to the government, researchers, and other stakeholders on the potential extinction risk of each type of fish being traded.

**Keywords:** Conservation status, Kupang City, ornamental fish, species diversity

## INTRODUCTION

Trading ornamental fish is one of the businesses that are widely practiced by the community (Rochadiani et al. 2022). In addition to the beauty of color and body shape (Restianti et al. 2023), economic value and many enthusiasts that have spread to all levels of society (Prasetya et al. 2013) are why ornamental fish are widely kept. Unique colors and body shapes make ornamental fish widely traded as living commodities both domestically (nationally) and abroad (internationally) (Shahputeri and Nurmalina 2023). Based on Direktorat Jenderal Perikanan Budidaya (2022), Indonesia's ornamental fish production reached 1.47 billion fish in 2021 and increased to 1.66 billion in 2022. Aquaculture of ornamental fishes is rapidly expanding because of the higher demand and value of ornamental than seawater fishes (value on each kg of fish produced) (Kültz 2022) and also because of the growing demand for native Indonesian ornamental fishes such as *Scleropages formosus* and several wild types siamese fighting fish (beta fish) (Direktorat Jenderal Perikanan Budidaya 2022).

The high demand for ornamental fish native to Indonesia has the potential to be used as a source of foreign exchange revenue. Therefore, the ornamental fish trade in urban areas also increases their economic value (Restianti

et al. 2023), increasing the country's foreign exchange. Kupang is one of the provincial capitals trading ornamental fish, including freshwater and marine fish. Kupang City is one of the entrances for shipping ornamental fish from outside the island, which will then be traded in Kupang City and its surroundings. Several ornamental fish shops operate in Kupang City and trade various freshwater and seawater ornamental fish, including some types from Kupang and some from outside Kupang. On the other hand, more fish shops were opened, leading to higher demand for ornamental fish. This phenomenon will also affect the sustainability of the ornamental fish populations.

The sustainability of natural fish populations depends on several factors, and the main factor is overexploitation. Overexploitation is one of the threats to freshwater biodiversity that can lead to collapsing fisheries and species extinction (Chevalier et al. 2023). In addition, the higher demand and higher prices are other factors that cause massive fishing activity. For instance, those cases already happened to *Pomacanthus xanthometopon* (Kasmi 2020). Furthermore, intensive capture can cause a considerable decline in the abundance and density of targeted ornamental fish species, and trade data are crucial to evaluating those related risks (Akmal et al. 2020). Species diversity and conservation status of the traded fish are very

important information indicating the fish's sustainability (Restianti et al. 2023).

Some research on species diversity and the conservation status of ornamental fish has been previously conducted in Indonesia. For instance, research and investigation have been conducted, including the Diversity and Conservation Status of Ornamental Fish in Bandung City by Cahyanto et al. (2019); the evaluation of the conservation and trade status of marine ornamental fish harvested from Pangandaran Coastal Waters, West Java (Nuryanto et al. 2020); study of ornamental fish biodiversity and conservation status in Surakarta City, Central Java, Indonesia (Restianti et al. 2023). However, such research has never been conducted in Kupang city. This is the first study conducted in Kupang City to reveal the types of ornamental fish species traded and their conservation status. The study will be useful information to the government, researchers, and other stakeholders to evaluate the extinction risk of each type of fish being traded.

## MATERIALS AND METHODS

### Study area

This research was conducted in Kupang City, East Nusa Tenggara, Indonesia, from August to September 2023, from all ornamental fish shops in Kupang City. Based on data collected independently, eleven (11) ornamental fish shops actively sell freshwater and marine ornamental fish in Kupang City. The 11 ornamental fish shop locations are located in several sub-districts, namely Kelapa lima sub-district (3 fish shops), Oebobo sub-district (3 fish shops), Kota lama sub-district (3 fish shops), Kota raja sub-district (1 fish shop) and Maulafa sub-district (1 fish shop). The location of these stores can be seen in Figure 1.

### Collecting data

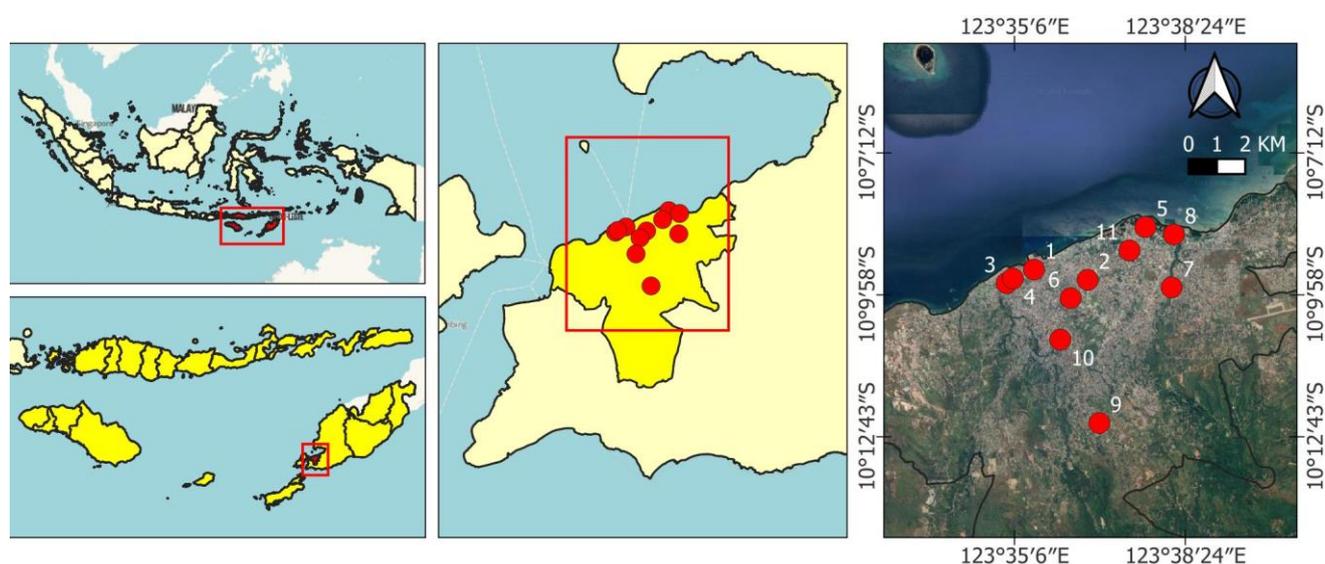
This research was conducted using survey and observation methods. The survey method used a form to

conduct interviews with sellers in 11 predetermined ornamental fish shops. Meanwhile, the observation method was used to identify the types of fish being traded. Observations were made to observe several aspects of the type of fish being traded, and fish samples were then photographed using an 8-megapixel camera. Photos of the fish can display the fish's color pattern and original color to identify the fish easily.

### Data analysis

Fish identity data obtained previously were then tabulated into Microsoft Excel and then re-analyzed using the Catalogue of Life, 2023 (<https://www.catalogueoflife.org/>), Encyclopedia of Life (EOL), 2023 (<https://eol.org/>) and Global Biodiversity Information Facility (GBIF), 2023 website available online at [www.gbif.org](http://www.gbif.org), to obtain the overall identity of each fish including family, genera, species (scientific name) and common name. In addition, analysis was also carried out by adjusting fish characteristics such as body color and body shape by comparing fish photos obtained during field data collection with existing data in Froese and Pauly, 2023 ([www.fishbase.org](http://www.fishbase.org)).

After obtaining the complete identity of each fish, the data was classified based on conservation status (Cahyanto et al. 2019; Restianti et al. 2023; Nurjirana et al. 2023) and trading status (Nuryanto et al. 2020; Valen et al. 2023). The conservation status classifications were Not Evaluated (NE), Extinct (EX), Extinct In The Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), and Data Deficient (DD). The conservation status of each fish species was determined using the International Union for Conservation of Nature (IUCN), 2023; website available online at <https://www.iucnredlist.org/>. Trade status was analyzed using the Convention on International Trade in Endangered Species (CITES), online website at <https://cites.org/eng/app/appendices.php>.



**Figure 1.** Fish shop locations that have been pin-pointing for collecting data, Kupang City, East Nusa Tenggara, Indonesia

All data obtained will be presented in tables, bar charts, or pie charts. Fish identity, conservation, and trading status data are tabular. Bar charts present data on the number of families in each order, the number of species in each family, and the number of species in their conservation status. At the same time, data on trade status per species is presented as pie charts.

## RESULTS AND DISCUSSION

### Results

Based on the data obtained, 18 families, 39 genera, and 46 species (and 9 variant species and 1 species it is hybrid fish) were collected during the study period (Figure 3a and 3b). The 9 variant species were divided into several families, namely, 4 species in the Cyprinidae family, 2 species in the Poeciliidae family, Danionidae, Pangasiidae, and Polypteridae, each had 1 species. The one species was hybrid fish is *Amphilophus citrinellus x Cichlasoma trimaculatum*. Eighteen (18) families were recorded during the study, namely, Acanthuridae, Apterontoridae, Catostomidae, Channidae, Characidae, Cichlidae, Cyprinidae, Danionidae, Datnionidae, Gyrinocheilidae, Mochokidae, Osphronemidae, Osteoglossidae, Pangasiidae, Policiliidae, Polypteridae, Pomacentridae, and Serrasalminidae. of the entire family, Cichlidae is the family with the most dominant genera, with 8 genera from a total of 39 genera found. Cyprinidae follows the next position with 7 genera, Characidae with 4 genera, Danionidae, and Poeciliidae with 3 genera. The Osphronemidae and Osteoglossidae with 2 genera, while the other families only have 1 genera. The total number of genera in each family can be seen in Figure 2.

Moreover, similar finding is also found for families with the number of dominant species, where Cichlidae is in

the first position with 9 species, followed by Cyprinidae with 7 species, and the third position is the family Characidae and Poeciliidae with 5 species. The next families are Danionidae, with 3 species; Osphronemidae, Osteoglossidae, and Pomacentridae, with 2 species. As for the remaining families, each has only 1 species. The detailed data on the number of species for each family can be seen in Figure 4.

Species of the family Cichlidae found during the study consisted of golden mbuna (*Melanochromis auratus*), Freshwater angelfish (*Pterophyllum scalare*), Oscar (*Astronotus ocellatus*), zebra tilapia (*Heterotilapia buettikoferi*), blue streak hap (*Labidochromis caeruleus*), humphead cichlid (*Cyphotilapia frontosa*), pindani (*Pseudotropheus socolofi*), demasoni (*Chindongo demasoni*), and discus (*Symphysodon discus*). Next, seven (7) species from Cyprinidae were classified, including tinfoil barb (*Barbonymus schwanefeldii*), redbfin and albino redbfin (*Epalzeorhynchus frenatus*), koi fish (*Cyprinus rubrofuscus*), komet goldfish, panda goldfish, oranda black goldfish, rancu goldfish (*Carassius auratus*), sumatran fish/tiger barb (*Puntigrus tetrazona*), barbirds (*Pethia conchonius*) and puntius denisoni (*Sahyadria denisonii*). The next most diverse families are Characidae and Poeciliidae, with 5 species each. Neon tetra (*Paracheirodon innesi*), cardinal tetra (*Paracheirodon axelrodi*), black tetra (*Gymnocorymbus ternetzi*), red eyes tetra (*Moenkhausia sanctaefilomenae*), and jewel tetra (*Hyphessobrycon eques*) are five species that belong to the Characidae family. Meanwhile, bloodred lyre tail and Kohaku lyre tail platy (*Xiphophorus hellerii*), variable platyfish (*Xiphophorus variatus*), molly and sailfin molly (*Poecilia latipinna*), silver molly (*Poecilia sphenops*), guppy (*Poecilia reticulata*) are five species in the Poeciliidae family.

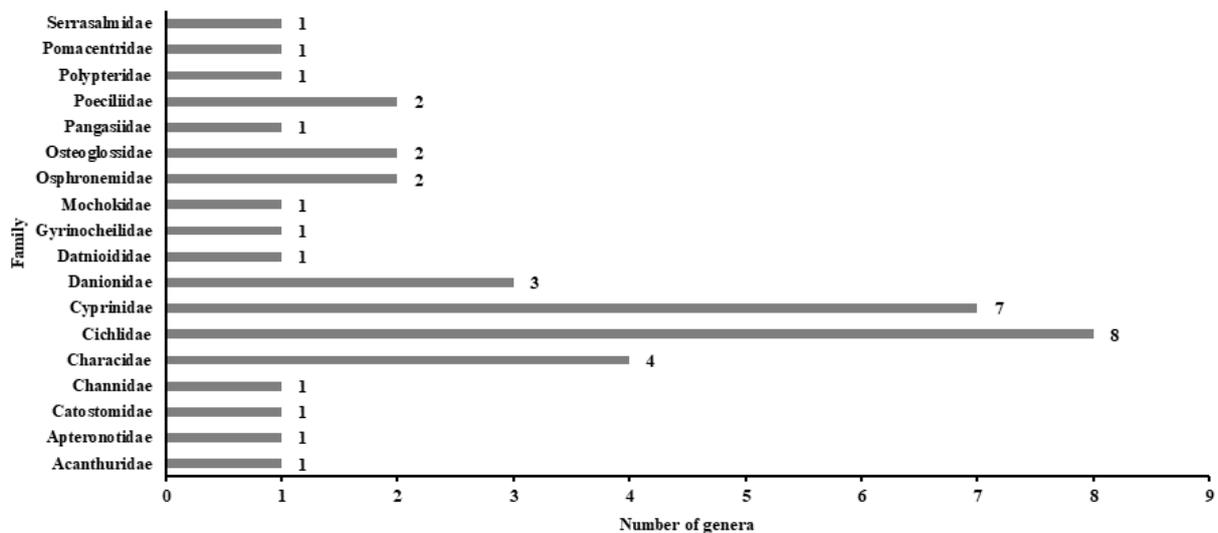
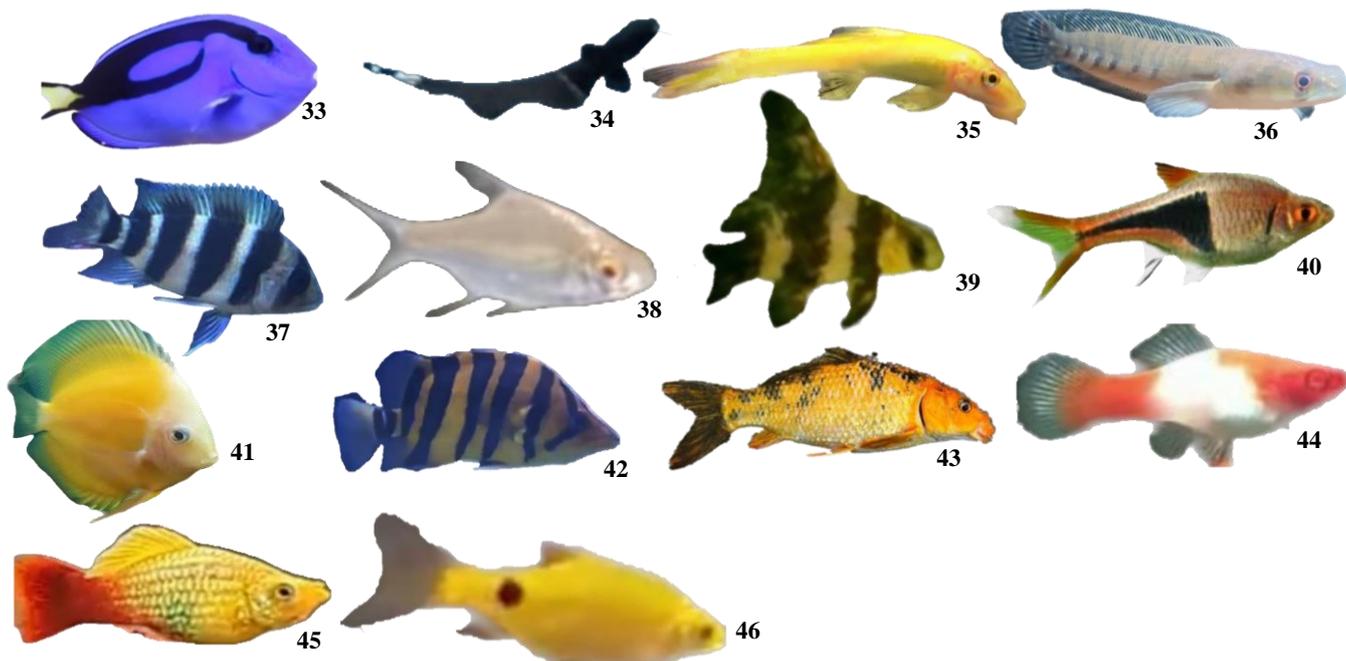


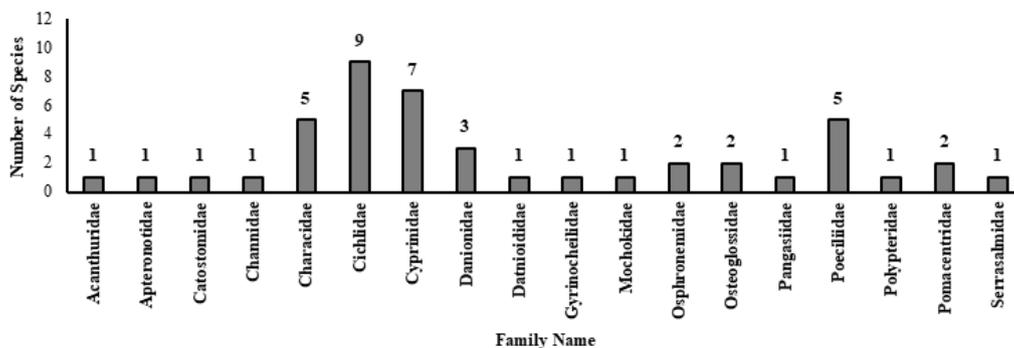
Figure 2. Total number of genera in each family



**Figure 3.A.** Ornamental fish traded in Kupang City. 1. *Scleropages formosus*, 2. *Osteoglossum bicirrhosum*, 3. *Amphilophus citrinellus* x *Cichlasoma trimaculatum*, 4. *Astronotus ocellatus*, 5. *Pterophyllum scalare*, 6. *Betta splendens*, 7. *Sahyadria denisonii*, 8. *Polypterus Endlicheri*, 9. *Epalzeorhynchus frenatus*, 10. *Boraras maculatus*, 11. *Pangasianodon hypophthalmus* (Albino), 12. *Moenkhausia sanctaefilomenae*, 13. *Pseudotropheus Socolofi*, 14. *Carassius auratus* (Komet), 15. *Chindongo demasoni*, 16. *Danio rerio* (Glofish), 17. *Trichogaster lalius*, 18. *Labidochromis caeruleus*, 19. *Melanochromis auratus*, 20. *Heterotilapia buettikoferi*, 21. *Paracheirodon innesi*, 22. *Paracheirodon axelrodi*, 23. *Hyphessobrycon eques*, 24. *Gymnocorymbus ternetzi*, 25. *Myloplus schomburgkii*, 26. *Poecilia latipinna*, 27. *Poecilia sphenops* (silver moly), 28. *Poecilia reticulata*, 29. *Synodontis eupterus*, 30. *Puntigrus tetrazona*, 31. *Amphiprion ocellaris*, 32. *Amphiprion percula*



**Figure 3.B.** 33. *Paracanthurus hepatus*, 34. *Apteronotus albifrons*, 35. *Gyrinocheilus aymonieri*, 36. *Channa marulioides*, 37. *Cyphotilapia frontosa*, 38. *Barbonymus schwanefeldii*, 39. *Myxocyprinus asiaticus*, 40. *Trigonostigma heteromorpha*, 41. *Symphysodon discus*, 42. *Danioides microlepi*, 43. *Cyprinus rubrofuscus*, 44. *Xiphophorus helleri* female (Kohaku Lyre tail), 45. *Xiphophorus variatus* 46. *Pethia conchonius*



**Figure 4.** Number of species according to family

The conservation status of animals around the world can be evaluated by referring to the 9 levels of extinction of a species (EX, EW, CR, EN, VU, NT, LC, DD, NE) listed on the IUCN *red-list* which has been developed since 1964 (Utami and Budiantoro 2022). The study revealed 4 levels, namely, EN (Endangered), VU (Vulnerable), LC (Least Concern), and NE (Not evaluated) (Table 1, Figure 5).

There are 3 species categorized as Endangered (EN), 2 species categorized as Vulnerable (VU), 32 species categorized as Least concern (LC), and 8 species categorized as Not evaluated (NE). One species (*Amphilophus citrinellus* x *Cichlasoma trimaculatum*) could not be evaluated for conservation status because it is a hybrid fish. There are 32 species in the Least Concern (LC) category, belonging to 14 families and 28 genera.

Based on the data, species included in Least Concern (LC) category are tinfoil barb (*Barbonymus schwanefeldii*), bloodred/lyre platy and kohaku platy/lyre tail (*Xiphophorus helleri*), variable platyfish (*Xiphophorus variatus*), zebra and glofish (*Danio rerio*), redfin and albino redfin (*Epalzeorhynchus frenatus*), golden mbuna (*Melanochromis auratus*), koi (*Cyprinus rubrofuscus*), komet, panda goldfish, oranda black goldfish, rancu goldfish (*Carassius auratus*), siamase algae eater (*Gyrinocheilus aymonieri*), sumatran fish/tiger barb (*Puntigrus tetrazona*), sailfin molly (*Poecilia latipinna*), molly fish (*Poecilia sphenops*), cardinal tetra (*Paracheirodon axelrodi*), black ghost (*Apteronotus albifrons*), guppy (*Poecilia reticulata*), zebra tilapia (*Heterotilapia buettikoferi*), dwarf carp (*Trichogaster*

*lalius*), barbir (*Pethia conchonius*), Blue streak hap (*Labidochromis caeruleus*), humphead cichlid (*Cyphotilapia frontosa*), harlequin rasbora (*Trigonostigma heteromorpha*), palette surgeonfish (*Paracanthurus hepatus*), orange clownfish (*Amphiprion percula*), clown anemonefish (*Amphiprion ocellaris*), tetra red eyes (*Moenkhausia sanctaefilomenae*), dwarf rasbora (*Boraras maculatus*), pindani (*Pseudotropheus socolofi*), palmas and palmas albino (*Polypterus endlicheri*), orange snakehead (*Channa maruloides*), finescale tigerfish (*Danioides microlepis*), featherfin squeaker (*Synodontis eupterus*) and discus (*Symphysodon discus*).

The next category status is Vulnerable (VU) and Endangered (EN). *Betta splendens* and *Chindongo demasoni* are fish species in the Vulnerable (VU) category. There are 3 species included in the Endangered (EN) category, namely siamese catfish and siamese catfish albino (*Pangasianodon hypophthalmus*), asian bonytongue (*Scleropages formosus*) and puntius denisoni fish (*Sahyadria denisonii*). The last category status is Not Evaluated (NE). Based on the results of the study, it was found that there were 8 species included in the Not Evaluated (NE) category. These species are chinese sucker (*Myxocyprinus asiaticus*), neon tetra (*Paracheirodon innesi*), freshwater angelfish (*Pterophyllum scalare*), black tetra (*Gymnocorymbus ternetzi*), oscar (*Astronotus ocellatus*), arawana (*Osteoglossum bicirrhosum*), black berry (*Myloplus schomburgkii*), jewel tetra (*Hyphessobrycon eques*). The overall data on fish identity and conservation status can be seen in Table 1.

During the study, the most common fish species found in all ornamental fish shops in Kupang City was the glofish (*Danio rerio*), a species from the Danionidae family. This fish was found in 8 of the 11 ornamental fish shops sampled. Other than glofish, the other dominant species were koi (*Cyprinus rubrofuscus*), siamese fighting fish (*Betta splendens*), and guppy (*Poecilia reticulata*), which were available in 7 fish shops (Table 2).

Each species was evaluated for Trade status based on the CITES website (<https://cites.org/eng/app/appendices.php>). Trade status data for all species can be seen in Figure 6. Based on the identification results, there is only 1 species that is included in the Appendix I category, namely *Scleropages formosus*, and other species are Not evaluated.

**Discussion**

Cichlidae was the family with the highest number of species during the study. The fish family Cichlidae presents a variety of fish species with high diversity (Ayisi 2014). Cichlidae is a family with 1,755 species (Fricke et al. 2023), and 5 of them have been introduced in Indonesia (Froese and Pauly 2023). Fish from the Cichlidae family found during the study are mostly fish from outside Indonesia. The unique patterns and colors and different body shapes in each family species are why this family has a special attraction for ornamental fish lovers (Restianti et al. 2023). The family with the next dominant number of species is the Cyprinidae family, with 7 species. Based on fish characters, species from the Cichlidae family are more

attractive than species from the Cyprinidae family (Saba et al. 2020), but Cyprinidae has more species than the Cichlidae family.

Cyprinidae is a freshwater fish family with the highest species diversity, morphological and behavioral properties, and habitat requirements (Bain 2011); this family is crucial in the fishery industry in Asian countries (Jeong et al. 2023), including Indonesia are 1,790 species recorded in this family (Fricke et al. 2023), and 135 of these are found in Indonesia (Froese and Pauly 2023). The large number of Cyprinidae species makes this species potentially important as a food source for the community and ornamental fish trade (Samitra et al. 2019).

Based on data from Froese and Pauly (2023), of the 7 species found, 2 species are native to Indonesia, namely tinfoil barb (*Barbonymus schwanefeldii*) and sumatran fish/tiger barb (*Puntigrus tetrazona*). In Indonesia, *Barbonymus schwanefeldii* is distributed on the islands of Kalimantan and Sumatra, while *Puntigrus tetrazona* is only distributed on the island of Sumatra. Apart from these 2 native species, 2 other fish species have been introduced in Indonesia, namely *Cyprinus rubrofuscus* (Mulya et al. 2021; Iskandar et al. 2021) and *Carassius auratus* (Andriyono and Fitriani 2021). Both species have their markets. However, *Cyprinus rubrofuscus* is a freshwater ornamental fish growing rapidly in Indonesia due to its high prices and relatively stable price fluctuation in the international market (Iskandar et al. 2021). This indicates that koi is one of the most popular ornamental fish species from the Cyprinidae family; hence, it can be found in most ornamental fish shops in Kupang City.

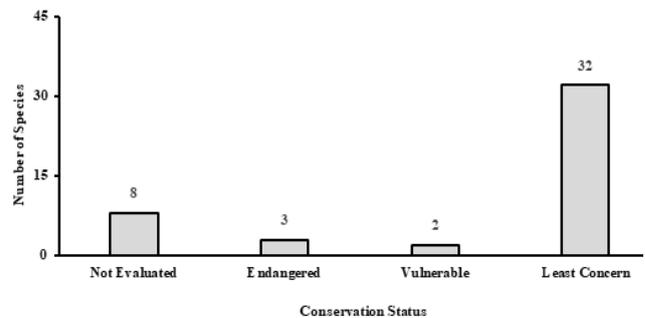


Figure 5. Conservation status according to the number of species

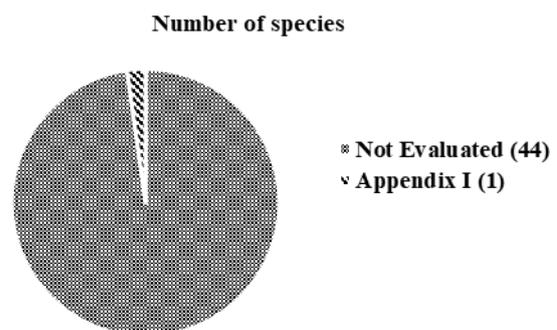


Figure 6. Trade status according to species numbers

The next dominant family are Characidae and Poeciliidae, with 5 species each. Table 2 shows that neon tetra is the type of fish from the Characidae family most widely available in the ornamental fish shop in Kupang City. Avianti et al. (2017) revealed this fish is a freshwater ornamental fish that is a favorite of Indonesians and foreigners. During the research, all fish from this family

were originally from outside Indonesia. Furthermore, guppy fish is the most widely available fish from the Poeciliidae family in Kupang City ornamental fish shops. Poeciliidae is one of the fish families that perform internal fertilization and is included in a family whose distribution is almost worldwide (Rahayu et al. 2013), and guppies (*Poecilia reticulata*) are one of them.

**Table 1.** Species diversity, conservation, and trade status of ornamental fish species that traded in Kupang City, East Nusa Tenggara

Family	Scientific name	Common name	IUCN status	Natural Environ.	
Characidae	<i>Gymnocorymbus ternetzi</i> (Boulenger, 1895)	Black tetra	NE	F	
	<i>Hyphessobrycon eques</i> (Steindachner, 1882)	Jewel tetra	NE	F	
	<i>Moenkhausia sanctaefilomenae</i> (Steindachner, 1907)	Red eye tetra	LC	F	
	<i>Paracheirodon axelrodi</i> (Schultz, 1956)	Cardinal tetra	LC	F	
Serrasalimidae	<i>Paracheirodon imnesi</i> (Myers, 1936)	Neon tetra	NE	F	
	<i>Myloplus schomburgkii</i> (Jardine, 1841)	Disk tetra	NE	F	
Catostomidae	<i>Myxocyprinus asiaticus</i> (Bleeker, 1864)	Chinese sucker	NE	F	
Cyprinidae	<i>Barbonymus schwanefeldii</i> (Bleeker, 1854)	Tinfoil barb	LC	F	
	<i>Carassius auratus</i> (Linnaeus, 1758)	Comet, Panda goldfish, Oranda black goldfish, Rancu goldfish	LC	F	
Danionidae	<i>Cyprinus rubrofuscus</i> (Lacepède, 1803)	Koi	LC	F	
	<i>Epalzeorhynchus frenatus</i> (Fowler, 1934)	Redfin sharkminnow and Redfin sharkminnow albino	LC	F	
	<i>Pethia conchoni</i> (Hamilton, 1822)	Rosy barb	LC	F	
	<i>Puntigrus tetrazona</i> (Bleeker, 1855)	Sumatra barb	LC	F	
	<i>Sahyadria denisonii</i> (Day, 1865)	Denison barb	EN	F	
	<i>Boraras maculatus</i> (Duncker, 1904)	Dwarf rasbora	LC	F	
	<i>Danio rerio</i> (Hamilton, 1822)	Zebra & Glofish	LC	F	
	<i>Trigonostigma heteromorpha</i> (Duncker, 1904)	Harlequin rasbora	LC	F	
	Gyrinocheilidae	<i>Gyrinocheilus ayonieri</i> (Tirant, 1883)	Siamese algae eater	LC	F
		<i>Poecilia latipinna</i> (Lesueur, 1821)	Sailfin molly	LC	F
Poeciliidae	<i>Poecilia reticulata</i> (Peters, 1859)	Guppy	LC	F	
	<i>Poecilia sphenops</i> (Valenciennes, 1846)	Molly & Silver molly	LC	F	
	<i>Xiphophorus hellerii</i> (Heckel, 1848)	Bloodred platy (Lyre tail) & Kohaku platy (Lyre tail)	LC	F	
Apterontidae	<i>Xiphophorus variatus</i> (Meek, 1904)	Variable platyfish	LC	F	
	<i>Apterontus albifrons</i> (Linnaeus, 1766)	Black ghost	LC	F	
Osteoglossidae	<i>Osteoglossum bicirrhosum</i> (Cuvier, 1829)	Arawana	NE	F	
	<i>Scleropages formosus</i> (Müller & Schlegel, 1840)	Asian bonytongue	EN	F	
Acanthuridae	<i>Paracanthurus hepatus</i> (Linnaeus, 1766)	Palette surgeonfish	LC	M	
Channidae	<i>Channa maruloides</i> (Bleeker, 1851)	Orange snakehead	LC	F	
Cichlidae	<i>Amphilophus citrinellus x Cichlasoma trimaculatum</i> (Hybrid)	Louhan	-	F	
	<i>Astronotus ocellatus</i> (Agassiz, 1831)	Oscar	NE	F	
	<i>Chindongo demasoni</i> (Konings, 1994)	Demasoni	VU	F	
	<i>Cyphotilapia frontosa</i> (Boulenger, 1906)	Humphead cichlid	LC	F	
	<i>Heterotilapia buettikoferi</i> (Hubrecht, 1881)	Zebra tilapia	LC	F	
	<i>Labidochromis caeruleus</i> (Fryer, 1956)	Blue streak hap	LC	F	
	<i>Melanochromis auratus</i> (Boulenger, 1897)	Golden mbuna	LC	F	
	<i>Pseudotropheus Socolofi</i> (Johnson, 1974)	Pindani	LC	F	
	<i>Pterophyllum scalare</i> (Schultze, 1823)	Freshwater angelfish	NE	F	
	<i>Symphysodon discus</i> (Heckel, 1840)	Red discus	LC	F	
	Datnioididae	<i>Datnioides microlepis</i> (Bleeker, 1854)	Finescale tigerfish	LC	F
	Mochokidae	<i>Synodontis eupterus</i> (Boulenger, 1901)	Featherfin squeaker	LC	F
	Osphronemidae	<i>Betta splendens</i> (Regan, 1910)	Siamese fighting fish	VU	F
		<i>Trichogaster lalius</i> (Hamilton, 1822)	Dwarf gourami	LC	F
	Pomacentridae	<i>Amphiprion ocellaris</i> (Cuvier, 1830)	Clown anemonefish	LC	M
<i>Amphiprion percula</i> (Lacepède, 1802)		Orange clownfish	LC	M	
Polypteridae	<i>Polypterus Endlicheri</i> (Heckel, 1847)	Palmas & Palmas albino	LC	F	
Pangasiidae	<i>Pangasianodon hypophthalmus</i> (Sauvage, 1878)	Striped catfish & Striped catfish albino	EN	F	

Note : LC: Least Concern, VU: Vulnerable, EN: Endangered, NE: Not Evaluated, -: Unclassified, F: Freshwater, M: Marine

**Table 2.** Species diversity and the number of shops where each species was recorded

Family	Scientific name	The count of shops	
Acanthuridae	<i>Paracanthurus hepatus</i> (Linnaeus, 1766)	1	
Apteronotidae	<i>Apteronotus albifrons</i> (Linnaeus, 1766)	3	
Catostomidae	<i>Myxocyprinus asiaticus</i> (Bleeker, 1864)	1	
Channidae	<i>Channa maruloides</i> (Bleeker, 1851)	2	
Characidae	<i>Paracheirodon innesi</i> (Myers, 1936)	3	
	<i>Paracheirodon axelrodi</i> (Schultz, 1956)	1	
	<i>Gymnocorymbus ternetzi</i> (Boulenger, 1895)	2	
	<i>Moenkhausia sanctaefilomenae</i> (Steindachner, 1907)	1	
Cichlidae	<i>Hyphessobrycon eques</i> (Steindachner, 1882)	2	
	<i>Amphilophus citrinellus x Cichlasoma trimaculatum</i> (Hybrid)	3	
	<i>Astronotus ocellatus</i> (Agassiz, 1831)	4	
	<i>Chindongo demasoni</i> (Konings, 1994)	2	
	<i>Cyphotilapia frontosa</i> (Boulenger, 1906)	1	
	<i>Heterotilapia buettikoferi</i> (Hubrecht, 1881)	1	
	<i>Labidochromis caeruleus</i> (Fryer, 1956)	4	
	<i>Melanochromis auratus</i> (Boulenger, 1897)	2	
	<i>Pseudotropheus Socolofi</i> (Johnson, 1974)	1	
	<i>Pterophyllum scalare</i> (Schultze, 1823)	4	
	<i>Symphysodon discus</i> (Heckel, 1840)	1	
	Cyprinidae	<i>Barbonymus schwanefeldii</i> (Bleeker, 1854)	3
		<i>Epalzeorhynchus frenatus</i> (Redfin sharkminnow) (Fowler, 1934)	5
<i>Epalzeorhynchus frenatus</i> (Redfin sharkminnow albino) (Fowler, 1934)		3	
<i>Cyprinus rubrofuscus</i> (Lacepède, 1803)		7	
<i>Carassius auratus</i> (Komet goldfish) (Linnaeus, 1758)		5	
<i>Carassius auratus</i> var <i>auratus</i> (Panda goldfish) (Linnaeus, 1758)		5	
<i>Carassius auratus</i> var <i>auratus</i> (Oranda black goldfish) (Linnaeus, 1758)		4	
<i>Carassius auratus</i> var <i>auratus</i> (Rancu goldfish) (Linnaeus, 1758)		1	
<i>Puntigrus tetrazona</i> (Boulenger, 1897)		6	
<i>Pethia conchonius</i> (Bleeker, 1855)		3	
<i>Sahyadria denisonii</i> (Day, 1865)		2	
Danionidae	<i>Danio rerio</i> (Zebra fish) (Hamilton, 1822)	4	
	<i>Danio rerio</i> (Glofish) (Hamilton, 1822)	8	
	<i>Trigonostigma heteromorpha</i> (Duncker, 1904)	1	
	<i>Boraras maculatus</i> (Duncker, 1904)	2	
Danioideidae	<i>Danioides microlepis</i> (Bleeker, 1854)	1	
Gyrinocheilidae	<i>Gyrinocheilus aymonieri</i> (Tirant, 1883)	4	
Mochokidae	<i>Synodontis eupterus</i> (Boulenger, 1901)	2	
Osphronemidae	<i>Trichogaster lalius</i> (Cuvier, 1829)	1	
	<i>Betta splendens</i> (Regan, 1910)	7	
Osteoglossidae	<i>Osteoglossum bicirrhosum</i> (Cuvier, 1829)	3	
	<i>Scleropages formosus</i> (Müller & Schlegel, 1840)	2	
Pangasiidae	<i>Pangasianodon hypophthalmus</i> (Striped catfish) (Sauvage, 1878)	1	
	<i>Pangasianodon hypophthalmus</i> (Striped catfish albino) (Sauvage, 1878)	3	
Poeciliidae	<i>Xiphophorus helleri</i> (Bloodred lyre tail) (Heckel, 1848)	1	
	<i>Xiphophorus helleri</i> (Kohaku lyre tail) (Heckel, 1848)	2	
	<i>Xiphophorus variatus</i> (Meek, 1904)	3	
	<i>Poecilia latipinna</i> (Lesueur, 1821)	3	
	<i>Poecilia reticulata</i> (Peters, 1859)	7	
	<i>Poecilia sphenops</i> (molly) (Valenciennes, 1846)	5	
Polypteridae	<i>Poecilia sphenops</i> (silver molly) (Valenciennes, 1846)	3	
	<i>Polypterus Endlicheri</i> (Heckel, 1847)	2	
Pomacentridae	<i>Amphiprion ocellaris</i> (Cuvier, 1830)	1	
	<i>Amphiprion percula</i> (Lacepède, 1802)	1	
Serrasalimidae	<i>Myloplus schomburgkii</i> (Jardine, 1841)	1	

Furthermore, the availability of this fish in several ornamental fish shops in Kupang City is due to its affordable price and ease of maintenance. Serihollo et al. (2023), states that this fish is one type of freshwater ornamental fish that has a high selling value in Indonesia.

In addition, according to Deacon et al. (2019), guppies easily adapt to other fish; they can be kept with other fish that are not aggressive (Alderton 2019), and in terms of aesthetics, guppies have bright colors and varied tail patterns, especially male fish (García and Giraldo 2023).

Currently, the number of fish species belonging to the Family Characidae totals 1,270 species, while that of the family Poeciliidae totals 274 (Fricke et al. 2023). All fishes found in the study belonged to this family and were fish species originating from outside Indonesia.

Table 2 also shows that of all the ornamental fish species sold, glofish are available in almost all ornamental fish shops in Kupang City. This fish has been a trendy fish species in recent years (Zahra et al. 2022); many bright and vibrant colors make this fish a concern, and it is usually owned in aquascape aquariums (Mustofa and Djutalov 2023). According to Restianti et al. (2023), this genetically modified fish has become popular or a trend because of its luminous color like neon lights (Vick et al. 2012).

Almost all species traded in ornamental fish shops in Kupang City are from outside Indonesia. Only 7 species are native to Indonesia; the remaining 38 are introduced species for the ornamental fish trade. Two (2) out of seven (7) species mentioned before are native to Indonesia and the other five (5) species are *Scleropages formosus* which from Osteoglossidae Family, *Channa maruloides* from Channidae family, *Trigonostigma heteromorpha* and *Boraras maculatus* from Danionidae family and the last is *Datnioides microlepis* from Datnioididae family. All species found during the study have their conservation status; it is pinned on living things as a response to environmental threats to plant and wildlife populations in nature (Utami and Budiantoro 2022).

Furthermore, 46 traded ornamental fish species belonged to 4 conservation status categories, namely, Least Concern (LC), Vulnerable (VU), Endangered (EN), and Not Evaluated (NE). Not Evaluated (NE) and Least Concern (LC) are the categories with the highest species. Not Evaluated (NE) is a status that describes the condition of a taxon that has not been evaluated based on criteria and is not published in the IUCN Redlist, and Least Concern (LC) category is a status that describes the condition of a taxon that is abundant so that the taxon when evaluated is not included in the threatened status; these species status are ideal for free trade (Restianti et al. 2023).

On the IUCN Redlist site (Version 2023-1), the population trend of three species categorized as Endangered (EN) is declining. The causes of these three species being categorized as Endangered (EN) vary. For instance *Pangasianodon hypophthalmus* is overfished for consumption and ornamental trade (Harmain and Dali 2017). In addition, habitat degradation and water quality changes are other causes that make this species rare. The international pet trade is the main factor causing *Scleropages formosus* and *Sahyadria denisonii* to be categorized as Endangered (EN). Also, *Sahyadria denisonii* is caught in a juvenile or immature condition (mature) because no regulations govern this fish capture classification, and this fish species is also affected by destructive fishing methods. *Scleropages formosus* species are particularly vulnerable to overharvesting due to their long lifespan, late maturity, and low fecundity (Yue et al. 2004). Harvesting methods can also be highly destructive, as adult males are often killed using explosives or electro-fishing to make them release chicks, which are then

collected and sold (Rowley et al. 2008). Another major threat to the species is habitat degradation and loss caused by various human activities.

*Betta splendens* and *Chindongo demasoni* are fish species in the Vulnerable (VU) category. *Betta splendens* is from the Osphronemidae family and is a globally popular ornamental bubble-nesting fish with brilliant and striking color variations (Prakhongcheep et al. 2018). *Betta splendens* are very popular among freshwater ornamental fish lovers because they are easy to maintain and have many color variations. However, based on data on the IUCN Redlist page (Version 2023-1), the population status in nature for this fish from Thailand is declining. This is due to the degradation of the fish's native habitat and genetic erosion by releasing fish from captive breeding into the wild. Other factors that can contribute to this species vulnerability are massive utilization and exploitation (Cahyanto et al. 2019).

Meanwhile, *Chindongo demasoni* is one of the most attractive fish species in aquariums from the Cichlidae family (Veeruraj et al. 2023). *Chindongo demasoni* inhabits the upper three to four meters of rocky habitat, and the species is endemic to a small reef at Pombo Rocks in Lake Malawi; this reef is probably an exposed part of a much larger rocky offshore area that is now mostly covered by sand and sediment (Konings 1994). The IUCN Redlist website does not mention the population trend status of this fish. Still, it does mention that the species is threatened by sedimentation and harvesting for the ornamental fish trade. Based on information collected in the field, the traded species originate outside the Kupang area. More precisely, the traders obtain the fish from suppliers and breeders from Java island, including koi (*Cyprinus rubrofasciatus*), guppy (*Poecilia reticulata*), molly (*Poecilia sphenops*), comet (*Carassius auratus*), siamese fighting fish (*Betta splendens*), neon tetra (*Paracheirodon innesi*), and Asian bonytongue (*Scleropages formosus*), a freshwater fish species in Southeast Asia (Yue et al. 2020). It is one of the world's most expensive cultivated ornamental fishes, and it is an endangered species (Bian et al. 2016). Appendix I species are endangered among the animals and plants listed under CITES and prohibited from international trade if the purpose is commercial. Apart from being the mascot of Indonesian ornamental fish (Decree of the Minister of Marine Affairs and Fisheries number 2 of 2021), the Indonesian government, through relevant Ministries has issued regulations on the protection of this fish including the regulation of the Minister of Environment and Forestry, Number P.106/MENLHK/SETJEN/ KUM.1/12/2018 and the regulation of the Minister of Marine Affairs and Fisheries, Number 18/PERMEN-KP/2020.

The Regulation of the Minister of Environment and Forestry lists *Scleropages formosus* as one of the protected species, while the Regulation of the Minister of Marine Affairs and Fisheries further regulates the prohibition of the release of this fish (<12 cm in size and including eggs) to outside Indonesian territory. Based on the applicable regulations, *Scleropages formosus* fish traded in several ornamental fish shops in Kupang city still follow the applicable regulations, such as the size of the fish sold

being more than 12 cm. However, monitoring the trade is still necessary to ensure the sustainability of the catch in the future. This consideration is based on population trend data showing a decline in the natural population (IUCN 2023) even though this fish has been successfully bred in Indonesia. Moreover, in 2014, 134 farms were breeding *Scleropages formosus* recorded in Indonesia (Kartamihardja et al. 2014) and became one of the contributors to non-tax state revenue (PNBP) with a nominal value of more than US\$2 million in 2010 (Yue et al. 2020).

This study concludes ornamental fish in Kupang City are 46 species divided into 18 families and 39 genera. Cichlidae is the family with the highest number of species, with a total of 9 fish species, followed by the Cyprinidae with 7 species and the Characidae and Poeciliidae with 5 fish species each. The species were represented by four IUCN conservation status categories, including Least Concern (LC), Vulnerable (VU), Endangered (EN), and Not Evaluated (NE). There are 32 species in the Least Concern (LC) category, 3 species in the Endangered (EN) category, 2 species in the Vulnerable (VU) category, and 8 species in the Not Evaluated (NE) category. One species (*Amphilophus citrinellus* x *Cichlasoma trimaculatum*) could not be evaluated for conservation status because it is a hybrid fish. Lastly, *Scleropages formosus* is the only species included in Appendix I. The information on the conservation status of ornamental fish species is helpful for sustainable fisheries management. The ornamental fish trade is considered to threaten ecosystems and the existence of species in nature. Apart from overexploitation due to high demand, another risk is introducing non-native fish and invasive fish into a water body.

Priority should be given to species whose conservation status is endangered but still being traded. In addition to enforcing the existing regulations, increasing the number of farmers for this species is possible. This can be done by organizing training on cultivating this fish and socializing on applicable regulations to be carried out so that business people and hobbyists understand the applicable rules. On the other hand, the involvement of ornamental fish businesses and hobbyists is also an important part of sustainable fisheries management efforts, especially for ornamental fish (Gani et al. 2021; Ndobe et al. 2022; Nurjirana et al. 2022). Educating buyers, seller and public, certifying stock and also preventing species from being released is essential in collaborating with the ornamental fish industry (Knight 2010).

In practice, the involvement of ornamental fish businesses and hobbyists is important in monitoring and managing introduced and invasive ornamental fish. There are several freshwater fish in Indonesia that are included in the list of invasive freshwater fish currently existing in Indonesia (Jatayu et al. 2023). The involvement of ornamental fish businesses and hobbyists can be achieved by the affordability of public information services that can be used as recording, monitoring, and reporting services. This public information service can be the key to tracing the type of fish entering and being sold, the number of fish, the seller's identity, and the buyer's identity.

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