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by Agus Nuryanto

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Species diversity and conservation status of marine ornamental fish traded at three market spots in the southern coast of West Java

A Nuryanto*, D Bhagawati, Kusbiyanto

Biology Faculty, Universitas Jenderal Soedirman, Central Java, Indonesia

*Email: agus.nuryanto@unsoed.ac.id

Abstract. Several studies had reported marine ornamental fish are exported from Indonesia to the United States of America. However, there is no study about marine ornamental fish that has been done with particular reference to specific localities across Indonesia, mainly from the southern coast of West Java. This study aims to know species diversity and conservation status of marine ornamental fish traded in Pelabuhan Ratu, Ujung Genteng, and Taman Manalusu. Fish samples were bought from the first collector in each sampling locality. Fish species were identified morphologically according to the previous publication. A total of 93 nominal species, 22 families, and six marine ornamental fish orders were traded. The highest number of species belonged to Pomacentridae and followed by Achanturidae, Labridae, and Chaetodontidae. The remaining families consisted of one up to six species. Perciformes was the dominant order with 19 families. Most of the species are listed as Least Concern conservation status, and one species listed as vulnerable, namely *Hippocampus kuda* (sea horse). Our results proved that many marine ornamental fish were on the southern coast of West Java and mostly listed as Least Concern species.

1. Introduction

Ornamental fish is among the popular marine ornamental animal traded in the international aquarium trade. However, little interest has been paid to these marine resources. Therefore, not much data can be obtained about fish species traded in the marine ornamental fish trade [1]. The available data about marine ornamental fish was mostly extracted from import data to the United States of America (USA) [2-4].

Indonesia is positioned as the second biggest exporter to the USA [2-4] and exports a higher number of marine ornamental fish species than the Philippines [2][3]. Nevertheless, limited reports were available in terms of localities, where the specimens were collected across Indonesia. The most recent studies reported that most of the fish specimen for marine ornamental trade was collected from eastern Indonesia, pooled in Makassar or Bali and afterward was exported to the destination countries [1][2].

Lack of data has also occurred for the marine ornamental fish trade in the southern coast of West Java. A preliminary survey proved that there are at least three market spots for marine ornamental fish species, namely Pelabuhan Ratu and Ujung Genteng Sukabumi Regency and Taman Manalusu in Garut Regency. The available information was about the potential marine ornamental fish on West Java's southern coast [5][6]. Nevertheless, the study by [5] stated the total number of species



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potentially sold as ornamental fish. Still, the data on which fish species are referred to and traded as ornamental species cannot be traced electronically any longer. Meanwhile, a previous study by [6] reported the potential of marine ornamental fish on the family level from the Sukabumi Regency. Therefore, no recent scientific data was available about marine ornamental fish, which are traded on the southern coast of West Java with particular reference to Pelabuhan Ratu and Ujung Genteng Sukabumi Regency and Taman Manalusu Garut Regency. This study aims to know the species and conservation status of marine ornamental fish traded at three market spots on West Java's southern coast.

2. Material and methods

The fish collection was conducted four times during the field trips in February and March 2018. The samples consisted of adult and juvenile individuals. Fish samples were bought from the first collector in three market spots on West Java's southern coast. The selected locations were Pelabuhan Ratu and Ujung Genteng in Sukabumi Regency. The third location was Taman Manalusu, Garut Regency (Figure 1).

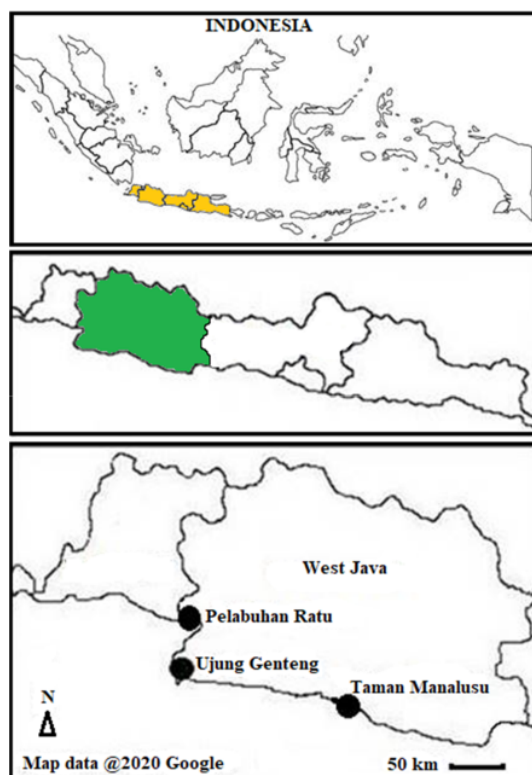


Figure 1. Three market spots as sampling site in the southern coast of West Java.

2.1. Sample handling

Fresh individuals were directly photographed using 8 megapixels camera to have figures with natural colour and colour patterns. Both morphological characters are among the vital taxonomic characters for species diagnosis in marine ornamental fish. [\[12\]](#)erward, the samples were preserved in labelled bottle jars containing 70% ethanol. Upon arrival [in the laboratory](#), the [samples were washed](#) under

running water, and the fresh 70% ethanol replaced the residual ethanol. Permanent preservation was also performed in bottle jars filled with new 70% ethanol.

2.2. Species determination and storage

The samples were identified by comparing their general body shapes to the picture available in the reference book [7]. The samples' taxonomic status was determined based on their color, color pattern, and meristic characters and checked with the characters of certain species available in determination book [7]. In the case of early juvenile stages were obtained, our samples' photographs were also verified and compared to the photographs of pictures available in FishBase [8]. The samples were stored at Animal Systematics Laboratory, Faculty of Biology, Jenderal Soedirman University, Purwokerto, Central Java, Indonesia, as the collection for an undergraduate student's laboratory activities in Animal Systematics.

2.3. Data presentation and analysis

Data about species, family, order, and conservation status were presented in a table and bar chart. Data were analyzed descriptively by comparing to the characteristic of particular species available in the determination book. According to the International Union for Conservation of Nature (IUCN), the conservation status of each species was determined through the IUCN's website. The IUCN categorizes conservation status of species as Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), and Extinct (E) (<https://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species>).

3. Results

3.1. Species diversity

Morphological identification and determination placed the marine ornamental fish samples into 93 species. The obtained species was divided into 27 families and six orders. The detailed data on species numbers and their taxonomic status are presented in Table 1.

Table 1. Taxonomic status of marine ornamental fish traded in Pelabuhan Ratu (PR), Ujung Genteng (UG), and Taman Manalusu (TM).

No	Ordo	Familia	Species	PR	UG	TM
1	Anguilliformes	Muraenidae	<i>Gymnothorax microstictus</i>			√
			<i>Gymnothorax reticularis</i>	√		
			<i>Echidna nebulosa</i>	√		√
			<i>Strophidon sathete</i>	√		
			<i>Gymnothorax pseudoherrei</i>	√		
2	Beryciformes	Ophichthidae	<i>Muraenichthys schultzei</i>	√		
		Holocentridae	<i>Myripristis hexagona</i>	√		
			<i>Sargocentron praslin</i>		√	
3	Perciformes	Acanthuridae	<i>Sargocentron punctatissimum</i>			√
			<i>Acanthurus triostegus</i>	√	√	√
			<i>Acanthurus lineatus</i>		√	√
			<i>Acanthurus nigrofusus</i>		√	√
			<i>Acanthurus maculiceps</i>		√	√
			<i>Acanthurus guttatus</i>			√
			<i>Acanthurus nigricauda</i>			√

No	Ordo	Familia	Species	PR	UG	TM
			<i>Acanthurus xanthopterus</i>			√
			<i>Acanthurus nigricans</i>		√	√
			<i>Acanthurus dussumieri</i>	√		
			<i>Naso brevirostris</i>			√
			<i>Naso lituratus</i>		√	√
		Apogonidae	<i>Ostorhincus chrysotaenia</i>	√		√
		Blenniidae	<i>Blenniella periophthalmus</i>			√
		Chaetodontidae	<i>Chaetodon collare</i>	√		
			<i>Chaetodon vagabundus</i>	√	√	√
			<i>Chelmon rostratus</i>	√		
			<i>Chaetodon auriga</i>		√	
			<i>Chaetodon kleinii</i>		√	
			<i>Chaetodon citrinellus</i>		√	√
			<i>Chaetodon lunula</i>			√
			<i>Chaetodon decussatus</i>			√
			<i>Chaetodon rafflesii</i>			√
		Carangidae	<i>Gnathanodon speciosus</i>	√		
			<i>Caranx sp1</i>	√		
			<i>Caranx sp2</i>	√		
		Gobiidae	<i>Cryptocentrus cyanospilotus</i>			√
			<i>Acentrogobius nebulosus</i>	√		
		Haemulidae	<i>Plectorhinchus picus</i>		√	
			<i>Plectorhinchus polytaenia</i>		√	
		Labridae	<i>Halichoeres miniatus</i>	√	√	√
			<i>Halichoeres marginatus</i>		√	√
			<i>Thalassoma nigrofasciatum</i>		√	
			<i>Stethojulis trilineata</i>		√	√
			<i>Cheilio inermis</i>			√
			<i>Halichoeres erdmanni</i>			√
			<i>Halichoeres hortulanus</i>		√	
			<i>Novaculichthys taeniourus</i>		√	
			<i>Cheilinus trilobatus</i>		√	
			<i>Thalassoma lunare</i>	√		
		Lethrinidae	<i>Lethrinus ornatus</i>			√
			<i>Gymnocranius elongatus</i>	√		
		Lutjanidae	<i>Lutjanus decussatus</i>			√
			<i>Lutjanus bohar</i>	√		
			<i>Lutjanus ehrenbergii</i>	√		
		Plesiopidae	<i>Plesiops coeruleolineatus</i>			√
		Pomacanthidae	<i>Pomacanthus semicirculatus</i>	√		√
			<i>Centropyge eibli</i>			√
		Pomacentridae	<i>Abudefduf sexfasciatus</i>	√		

No	Ordo	Familia	Species	PR	UG	TM
			<i>Dascyllus trimaculatus</i>	√		√
			<i>Abudefduf septemfasciatus</i>	√		
			<i>Abudefduf vaigiensis</i>		√	√
			<i>Abudefduf notatus</i>			√
			<i>Chrysiptera brownriggii</i>	√		√
			<i>Neoglyphidodon bonang</i>			√
			<i>Chrysiptera unimaculata</i>		√	
			<i>Plectroglyphidodon leucozonus</i>			√
			<i>Chromis opercularis</i>	√		
			<i>Amblyglyphidodon indicus</i>			√
			<i>Plectroglyphidodon lacrymatus</i>			√
		Scaridae	<i>Scarus flavipectoralis</i>	√	√	
		Scatophagidae	<i>Scatophagus argus</i>	√		
		Serranidae	<i>Epinephelus faveatus</i>		√	
			<i>Epinephelus ongus</i>			√
			<i>Cephalopholis cyanostigma</i>			√
			<i>Epinephelus polystigma</i>			√
			<i>Cephalopholis leopardus</i>	√		
			<i>Epinephelus merra</i>	√		
		Siganidae	<i>Siganus spinus</i>	√	√	
			<i>Siganus vermiculatus</i>	√		
			<i>Siganus guttatus</i>	√		
		Terapontidae	<i>Terapon jarbua</i>	√		
		Zanclidae	<i>Zanclus cornutus</i>		√	√
4	Scorpaeniformes	Scorpaenidae	<i>Dendrochirus zebra</i>		√	
			<i>Pterois miles</i>		√	√
			<i>Scorpaenodes guamensis</i>		√	
5	Syngnathiformes	Syngnathidae	<i>Hippocampus kuda</i>	√		
			<i>Syngnathoides biaculeatus</i>		√	
6	Tetraodontiformes	Balistidae	<i>Sufflamen chrysopterum</i>	√		
			<i>Sufflamen bursa</i>		√	
			<i>Balistapus undulatus</i>	√		√
		Ostraciidae	<i>Ostracion cubicus</i>		√	
		Tetraodontidae	<i>Arothron hispidus</i>		√	
			<i>Chelonodon patoca</i>		√	√
			<i>Canthigaster compressa</i>			√

Remarks: √ = present

A detailed examination of the obtained samples indicated that different numbers and species had been traded Pelabuhan Ratu, Ujung Genteng, and Taman Manalusu. In Pelabuhan Ratu, a total of 38 marine ornamental fish species were changed. In the same period, as much as 34 species were sold in Ujung Genteng, while in Taman Manalusu, 47 ornamental fish species were traded. The total number of species in each spot was presented as a bar chart in Figure 2.

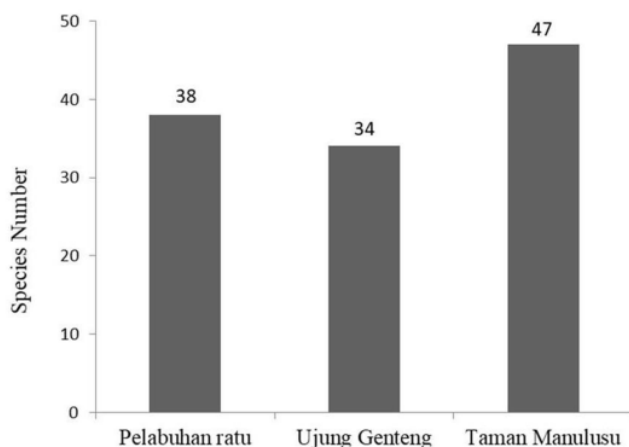


Figure 2. Number of species in each sampling locality.

Note: value above bars indicate the number of species

On the family level, Pomacentridae was the most abundant family with 12 species traded at three market spots in the southern coast of West Java and followed by Acanthuridae, Labridae, and Chaetodontidae with eleven, ten, and nine species, respectively. Serranidae has six species, while Muraenidae has five species. The remaining 21 families have one up to three species, respectively. Detail information about the number of species in each family traded during the survey is illustrated as a bar chart in Figure 3.

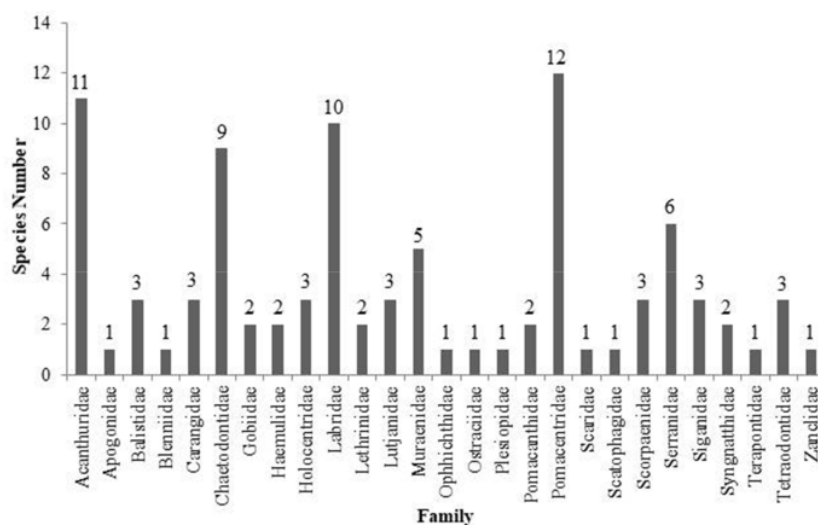


Figure 3. Number of species for each family.

Note: value above bars indicate the number of species

During the study, it was observed that Perciformes was the dominant order with 19 families was traded at three market spots in the southern coast of West Java. Tetraodontiformes had three families, while Anguilliformes had two families. The remaining orders had one species, respectively (Figure 4).

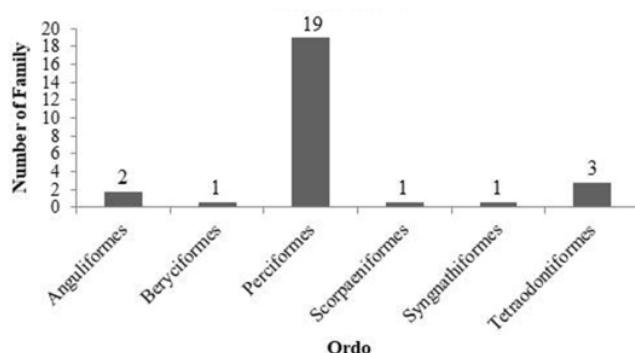


Figure 4. Total number of the fish family in each order.

Note: number above bars indicate the number of families

3.2. Conservation status

The conservation status of each fish sample is illustrated in Figure 5. It can be seen in Figure 5 that most of the species listed as Least Concern and Not Evaluated conservation status by the International Union for Conservation Nature (IUCN), except for *Hippocampus kuda*. *H. kuda* listed as Vulnerable species by IUCN with the traded must be monitored according to the Convention on International Trade in Endangered Species (CITES) Appendix II.

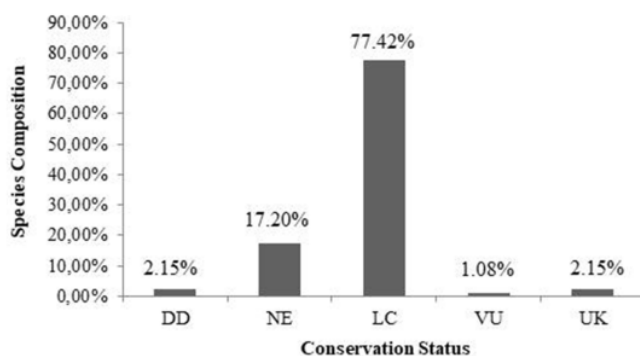


Figure 5. Species composition for each conservation status.

Note: value above bars indicate species composition, DD= data deficient, NE= not evaluated, LC= least concern, VU= vulnerable, UK= unknown

4. Discussion

4.1. Species diversity

During the field trips in three markets, the obtained species indicated that West Java's southern coast has high potential marine ornamental fish diversity. The data also suggest that the south coast of West Java provides significant support in Indonesia's ornamental fish trade. The statement comes from the comparison to the previous study [9]. From the above comparison, we proved that fishermen in West Java's southern coast collected higher species numbers than the number of species targeted by the fishermen in Bali [9]. From an economic perspective, our data provide information that the southern

coast of West Java offers the high potential of coastal ornamental fish resources to support the communities' livelihood in the region.

Our result also showed a higher number of species than the previous study by [10]. However, we performed the study in narrower areas and sampled ornamental fish only. At the same time, they collected samples directly on all fish assemblages in the fields, which did in more extensive areas. In part, the comparison to the study by [10] was not parallel since our study was performed in a tropical aquatic ecosystem at the centre of mega-biodiversity [11][12]. In contrast, the research from [10] was conducted in a subtropical aquatic ecosystem with lower taxonomic diversity than Indonesia's tropical ecosystems [13]. However, in other parts, our study provides additional scientific data to support the concept that Indonesia is a mega biodiversity nation.

The number of species observed during the study was far below what was reported by [3] marine ornamental fish species exported to the United States of America in 2005. Nevertheless, in our perspective, the data available within this report more valuable for local government in Garut and Sukabumi Regency for making policy in the sustainable use of marine ornamental in their territory rather than the export data [3]. The data from [3] was only valuable for legal protection at the national level. Moreover, comparing this study to a study by [3] was not congruent since our research and the study by [3] had different locality coverage and focuses. In this study, we only covered and focused on ornamental fish from the collectors in the coastal region of southern West Java, while [3] focused on recording the total number of species imported to the USA from numerous countries from all over the world.

Our result also reported a lower species richness than the earlier studies performed in a different region [7][14-17]. We also obtained fewer species numbers than other studies in several areas of Indonesia. For instances, we found lower species diversity than the study by [18] in Tuhaha Bay, Saparua Island, Maluku Province; by [19] in Ulee Lheue breakwater Banda Aceh; by [20] in Weh Island, Aceh; by [21] in Karimunjawa National Park, Java Sea; [22] in Thousand Islands, Java Sea; Jakarta, and [23] in Wakatobi Marine National Park, Southeast Sulawesi. The difference between our study and those previous studies could be that we only focused on marine ornamental fish. In contrast, those earlier studies covered all fish species in their natural habitats. However, our report contains valuable information that has important implications for managing marine resources on the southern coast of West Java since our study's focus was on ornamental fish. Marine ornamental fish trade has different characteristics compared to the consumable fish trade. Therefore, addressing management on marine ornamental fisheries needs specific data.

Comparison among three localities in West Java's southern coast indicated that those three localities showed similarities and differences in the number of species inhabitants. These phenomena could be due to different ecological characteristics among sampling sites. Pelabuhan Ratu beach is a bay ecosystem characterized by having a sandy bottom without stones and seagrass. Ujung Genteng is a peninsular area but having broad plat areas covered by seagrass, and on the fore tip of the plat areas, it has stony habitat surrounded by stone coral. Taman Manalusu is also a peninsular area with very wide plat stony areas covered by slight seagrass and complemented by many notches as fish shelter. This means that both Ujung Genteng and Taman Manalusu have a more similar heterogeneous habitat to support more variable taxa compared to Pelabuhan Ratu. Therefore, it is not surprising that Ujung Genteng and Taman Manalusu inhabited by a higher number of ornamental fish species. Similar phenomena were also reported by [22], who obtained a different number of species among sampling sites with different ecological conditions in the Thousands of Islands, Java Sea. These conditions agreed with the general acceptance that different habitats have different biodiversity values.

This finding is expressed to strengthen the present data about Perciformes as the main constituent of Indonesia's marine fish communities. So far, 82 fish families under Perciformes are described from Indonesia. At the species level, Perciformes contribute up to 62% to the total species of Indonesia's marine fish species [8]. Therefore, it was a common phenomenon that we obtained more Perciformes during the study. Our finding was similar to what was reported by [22][23]. Moreover, our result provides additional data to support the dominance of Perciformes over other fish orders.

4.2. Conservation status

If we refer to the conservation status of each fish sample as provided in Figure 5. Most of the species are listed as Least Concern and Not Evaluated conservation status by IUCN. None of them is listed as protected species under Indonesia's laws (Ministerial decree no 106/ 2018). Theoretically, the nature extraction of marine ornamental fish along the coastline of southern West Java did not violate any rules based on that information. However, the extraction of marine ornamental fish is running continuously and involved hundreds of fishermen. It has been described to occur across Indonesia [9]; Ornamental fish collection from the southern coast of West Java still needs to be monitored so that the ornamental fish sector's economic sustainability can be maintained.

During the field trips, no official data was available for marine ornamental fish on West Java's southern coast. This condition is also exaggerated by destructive fishing practices to collect the target species, such as used poisonous chemicals and destroying the coral habitat when the target specimens hide behind the corals, and no supervision has been made. These fishing methods have an adverse impact not only to target species but also to not target species or events to the ecosystem in general and might lead to overfishing [24]. Therefore, without continuous monitoring, the sustainable use of these resources is still in a big question because mortality due to fishing and natural mortality rates of marine ornamental fish species in the south coast of West Java might be higher than their capability to recruit.

Special attention must pay to the *Hippocampus kuda*. Although these species are not listed as protected species under Indonesia laws (Ministerial decree no 106/ 2018), this species is already listed as vulnerable species [25] and put in Appendix II of CITES red list databook. Moreover, fishers and collectors on West Java's south coast clearly understood that *H. kuda* is already hardly found and not allowed to trade from nature collections. However, fishing of this species is still running either for marine aquarium trade or illegally in dried commodities [4]. Therefore, trades of *H. kuda* must vigorously be monitored. Vigorous law enforcement and application of ministerial decree on flora and fauna protection are also urgently needed. It is due to that the aquarium trade of this species will have the worst impact on *H. kuda*. According to [26], the marine ornamental fish trade harms rare species. Finally, to prevent an adverse effect of marine ornamental fish extraction on the southern coast of West Java, government intervention and law enforcement are needed.

5. Conclusion

The southern coast of West Java hosted high species diversity of marine ornamental fish and positively contributed to Indonesia's marine ornamental trade. Most of the species listed as not evaluated and least concern conservation status, except *Hippocampus kuda*. According to CITES, law enforcement is needed to secure and protect *Hippocampus kuda*, and their trade should be monitored vigorously. An on-going survey is urgently required to seek the trend on marine ornamental fish collection in West Java's southern coast to ensure sustainable fisheries in the region.

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