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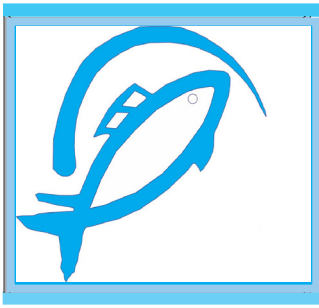

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Short Communication

Production, Diversity, and Distribution of Aquaculture Commodities in Tuban, Indonesia

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Abstract

The fishery sector is expected to overcome the food crisis. Indonesia is one of the leading countries in terms of high volumes of fishery production in most of its areas, including the Regency of Tuban in East Java Province. The area of Tuban Regency is 1,839.94 km2 with the coastline covering 65 km and a sea area of 22,608 km2. This study aims to provide information regarding aquaculture production, diversity, and distribution in Tuban. This study used a survey method to collect fishery commodity data directly from aquaculture areas. The results of this study showed that the highest production came from the brackish water with a value of 32.46% (13,561.79 tons), followed by rice field pond (27.79% or 11,612.45 tons), freshwater pond (25.76% or 10,764.62 tons), floating net cage (13.97% or 5,836.59 tons), and marine (0.1% or 5.67 tons). Aquaculture biodiversity in Tuban consisted of 11 families and 14 species of the main aquatic produces, such as Cyprinidae (*Cyprinus carpio, Barbonymus gonionotus, Parastromateus niger*), Clariidae (*Clarias bathracus*), Pangasiidae (*Pangasianodon hypophthalmus*), Penaeidae (*Penaeus monodon, Litopenaeus vannamei*), Channidae (*Channa striata*), Cichlidae (*Oreochromis niloticus, Oreochromis mosammbicus*), Osphronemidae (*Osphronemus gourami*), Serranidae (*Epinephelus* sp.), Lutjanidae (*Lutjanus* sp.), and Chanidae (*Chanos chanos*). *Cyprinus carpio,* or common carp, is a fish cultivated in four different aquacultures, namely rice field pond, floating net cages, freshwater ponds, and brackish aquaculture ponds. Unfortunately, the diversity and production of marine aquaculture have not been improved even though Tuban has large marine areas.

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1. Introduction

Food sovereignty and security are one of the crucial issues faced by the community in the world. Data from FAO stated that 60% of food must be produced in 2050, to meet global needs (FAO, 2015). Other studies also state that the food needs of 9.6 billion people must be met by 2050 and meat production could reach more than 470 million tons (Tripathi *et al*., 2019). Similar issues also arise in Indonesia, where a food crisis may occur due to the insufficient number of food supplies and nutrition availability. Data in 2019 stated that the supply of rice in Indonesia reached 31.31 million tons, which was only slightly above the state demand of 29.6 million tons (Simanjuntak and Erwinsyah, 2020). One sector that is expected to overcome the food crisis is aquaculture.

Aquaculture is the activity of raising and breeding various kinds of aquatic animals or plants that use water as their main growth component (Ahmad *et al*., 2022). Aquaculture has advantages over fishing. For example, it can help provide fish for consumption regardless of the season, and it can increase people's income (Brugere *et al*., 2021). A study found that the fishery sectors in the world will decline by up to 30% due to human activities and climate change (Henriksson *et al*., 2019). Many countries, including Indonesia, practice aquaculture for business purposes and to fulfill food needs. Indonesia has the third largest aquaculture production in the world after China and India (Humphries *et al*., 2021). One of the areas in Indonesia with great aquaculture potential is Tuban.

Tuban Regency has a total surface of 1,839.94 km^2, with the coastline covering 65 km and a sea area of 22,608 km^2 (Shofwan *et al*., 2022). Most of the residents are fishermen or farmers (Suprapti *et al*., 2021). Previous research stated that cultivation has been developing in Tuban began before 1985 with a pond system (Yusuf and Wisnu, 2019). Because Tuban is close to the sea, where milkfish (*Chanos chanos*) and tiger prawns (*Penaeus monodon*) were the main commodities for cultivation (Sudarno *et al*., 2018). Over time, the species have become more diverse and have been cultivated in marine and fresh waters (Mariskha and Abdulgani, 2012; Yanuhar and Wuragil, 2021). Only a few reports have addressed the diversity of commodities in Tuban. Therefore, this study aims to provide information regarding the distribution and diversity of aquaculture commodities in Tuban. Data related to aquaculture diversity is very important to increase fishery potential. Data obtained from the current survey make it possible to provide assistance and advice depending on the types of commodities cultivated by the targeted community.

2. Materials and Methods

2.1 Materials

Materials used in this study were pen (G2, pilot, Japan), camera (DSLR D7100, Nikon, Japan), identification book (Marine Fishes of South-East Asia from Allen (1999), Periplus, Singapore), paper of survey form (A4, Kiky, Indonesia), voice recorder (ICDUX560, Sony, Japan), and GPS by phone (POCO X3 NFC, Oppo, China).

2.1.1 Ethical approval

This study does not require ethical approval because it does not use experimental animals.

2.2 Study Site

This study was conducted in Tuban, East Java, Indonesia (6°40'–7°18'S; 111°30'–112°35'E) according to Figure 1 from January to April 2020. Twenty districts of Tuban were investigated and surveyed for their aquaculture commodities. The survey method was used to collect fishery commodities data directly from aquaculture areas (Andhikawati and Permana, 2023). Primary data was obtained by direct interviews with aquaculture practitioners and aquaculture survey officers in Tuban. Primary data was also obtained by direct observation in the field at several locations reviewed. Data consisted of the name of the district, type of aquaculture, fishery commodity, production, collector's name, and date. The form of the data is presented in Figure 2.

2.3 Fish Collection and Species Identification

During exploration, samples of fish were collected and recorded. The number of fish collected for identification is 10 types of fish species per sample per region (total of 200). The samples were identified directly using a fish identification book, as described in the previous study by Erfin *et al*. (2022). The camera (DSLR D7100, Nikon, Japan) was used to take fish photos. 14 species of aquaculture commodities were stored in labelled plastic bags and in a cooler box before being sent to the laboratory of the Faculty of Fisheries and Marine, Universitas Airlangga, Indonesia, for further analysis on the same day to ensure the fish species (Gufe *et al*., 2019). Fish were identified manuals using a fish identification book as described in the previous study by Erfin *et al*. (2022).

2.4 Analysis Data

In addition, secondary sources were used

to support the collected data (Shamsuzzaman *et al.*, 2020). All data were collected from various scientific research, peer-reviewed journals, periodicals, and government gazettes. From the available online databases were included some keywords i.e., 'Fisheries resources', 'Aquaculture resources', and 'Tuban'. More detailed information was obtained from the Central Bureau of Statistics, the East Java Fisheries Office, and the Department of Fisheries and Livestock of Tuban Regency. The collected data was then reviewed and synthesized using MS Excel. Only the relevant information was used and processed into graphs and tables for easier reading.

with a value of 32.46% (13,561.79 tons), followed by rice field pond (27.79% or 11,612.45 tons), freshwater pond (25.76% or 10,764.62 tons), floating net cage (13.97% or 5,836.59 tons), and marine (0.1% or 5.67 tons).

Table 1 shows aquaculture production from each regency. The results indicated that Bancar Regency had the highest fish production of 2,669.35 tons. It is also the only one that produces fishery products from marine aquaculture (5.67%). The highest amount of brackish water production was in Tuban Regency (6,160.88 tons), while the highest freshwater

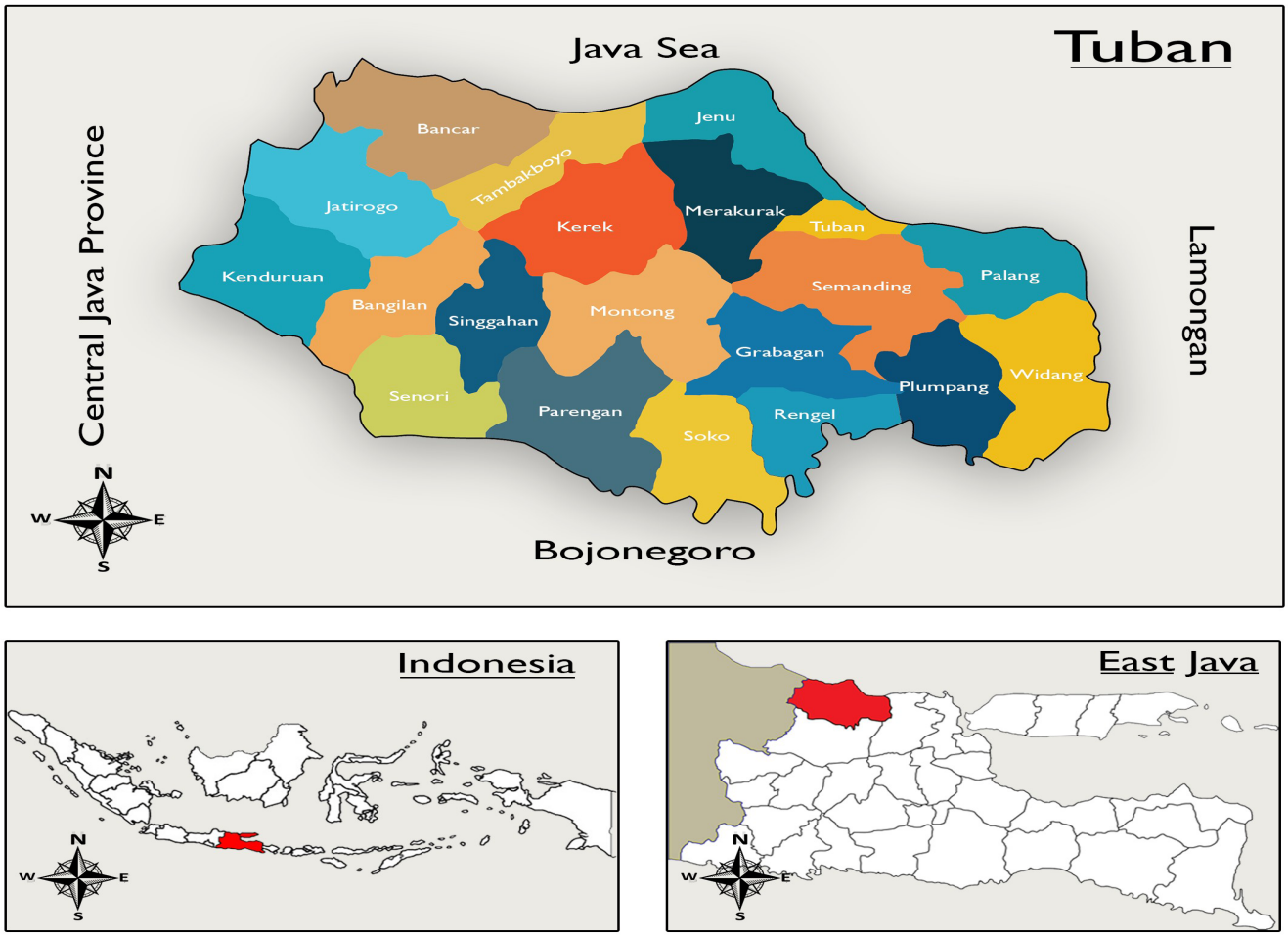

Figure 1. Map of research location in Tuban, East Java Province, Indonesia

3. Results and Discussion

3.1 Aquaculture Production

Aquaculture production in Tuban is divided into five categories, namely marine, brackish water pond, freshwater pond, floating net cage, and rice field pond. The number of aquaculture production in Tuban can be seen in Figure 2 by the categories. Aquaculture production in Tuban in 2020 reached 41,781.12 tons. The highest production came from the brackish water

production came from Merakurak (1,302.35 tons). The highest rice field pond production came from Widang, while Plumpang Regency had the highest cage-cultivation production (1,591.44 tons).

Based on this current study, brackish water has been mostly used for aquaculture since the 80s in Tuban. Around 1985, a Chinese investor named Peng Su came to Tuban Regency to rent 5 ha of land to be used as a tiger shrimp pond (Yusuf and Wisnu, 2019). The long-sustaining aquaculture back then has

developed the community's knowledge, government support, and the technology to advance the environment. According to previous studies, fish farmers in Tuban often received training and support from the government and agencies related to aquaculture training, increasing fishery production (Munir *et al*., 2020; Permata *et al*., 2021; Yanuhar and Wuragil, 2021).

From floating net-cage aquaculture, Tuban produced 2,240.75 tons or IDR 37,852,000 (Central Bureau of Statistics, 2020). Floating net-cage aquaculture in Tuban uses floating nets as fish rear in fresh media such as lakes or reservoirs (Joesidawati and Nurrudin, 2021). This method has several advantages such as high stocking density, adequate amount and quality

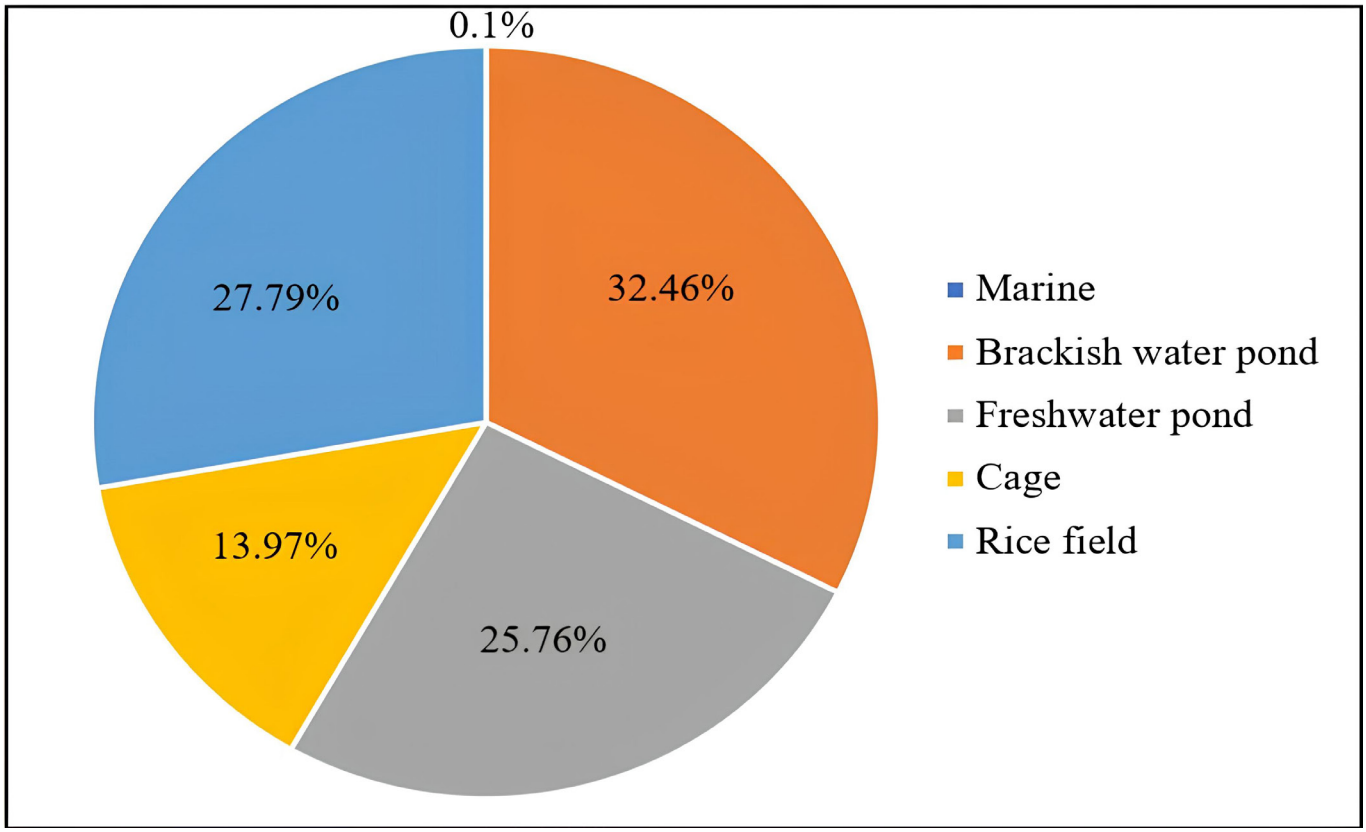

Figure 2. Aquaculture production in Tuban (ton)

Other research related to water quality shows that Tuban has an adequate water condition and is not turbid with a pH of around 7.0. Its salinity is never more than 40 ppt, and it is not located in a polluted area either from metal, organo-chlorine, or pesticide pollution (Suwarsih *et al*., 2016). A brackish water pond is one of the potential areas in Tuban. From this sector, Tuban produced 13,641.63 tons with a profit of IDR 482,686,357,000 (Central Bureau of Statistics, 2020). The rice field pond in Tuban successfully produced 12,424.73 tons with a total value of IDR 155,810,769,000.00 in 2020 (Central Bureau of Statistics, 2020). Rice field ponds are tilled and irrigated lands used for planting rice (Yi *et al*., 2020) and equipped with an irrigation system (Wang *et al*., 2019). Despite the traditional method, rice field ponds can also be used for aquaculture because such environments do not require high capital (Morshed *et al*., 2020) and complicated maintenance (Fatimah *et al*., 2020). of water, no need for tillage, easy control of predator disturbances, and easy harvesting (Farhaduzzaman *et al*., 2020). According to previous research, Tuban, one of the regencies in East Java besides Bojonegoro and Tuban, has good public water facilities (watersheds, reservoirs, and lakes). Thus, freshwater and floating net cage aquacultures are proper for establishment in Tuban (Yuniati and Rachman, 2017).

Meanwhile, for marine culture, Tuban managed to produce 2.72 tons or IDR 230,015,000 (Central Bureau of Statistics, 2020). Marine culture production in Tuban is the lowest. This needs to be improved because of Tuban's potential marine resources. The coastline of Tuban covers 65 km and a sea area of 22,608 km^2 (Huda *et al*., 2021) so marine culture commodity development needs to be conducted. Other Indonesian regions, such as Sangihe Island (North Sulawesi), can produce 576.09 tons of grouper per year with sea areas of 11,126.61 km^2 (Rizal *et al*., 2022).

Table 1. Species distribution according to aquatic environments for aquaculture in in Tuban

District	Marine	Brackish Water Pond	Freshwater Pond	Floating Net Cage	Rice Field Pond	Total
Kenduruan			193.9			193.9
Bangilan			338.27			338.27
Senori			241.34			241.34
Singgahan			584.67			584.67
Montong			675.55			675.55
Parengan			290.81			290.81
Soko			510.75	850.10		510.75
Rengel			920.88	1.401.25		920.88
Grabagan			96.94			96.94
Plumpang			825.62	1.591.44	4.351.82	825.62
Widang			883.71	1.453.70	7.260.63	883.71
Palang		4.160.86	872.42			872.42
Semanding			630.08			630.08
Tuban		6.160.88	545.4			545.4
Jenu			870.48			870.48
Merakurak			1.302.35			1.302.35
Kerek			19.39	540.10		19.39
Tambakboyo		1.002.59	484.37			484.37
Jatirogo			48.47			48.47
Bancar	5.67	2.237.46	462.22			2.669.35
Total	5.67	13.561.79	10.764.62	5.836.59	11.612.45	41.781.12

3.2 Aquaculture Biodiversity and Distribution

The biodiversity and distribution of aquaculture by aquatic environments is displayed in Table 2. The results indicated that 11 families and 14 species of main aquaculture commodities cultivated in Tuban include Cyprinidae (*Cyprinus carpio, Barbonymus gonionotus, Parastromateus niger*), Clariidae (*Clarias bathracus*), Pangasiidae (*Pangasianodon hypophthalmus*), Penaeidae *(Penaeus monodon*), Channidae *(Channa striata*), Penaeidae (*Litopenaeus vannamei*), Cichlidae (*Oreochromis niloticus*, *Oreochromis mosammbicus*), Osphronemidae (*Osphronemus gourami*), Serranidae (*Epinephelus* sp.), Lutjanidae (*Lutjanus* sp.), and Chanidae (*Chanos chanos*). *Cyprinus carpio* or common carp was cultivated in four aquatic environments, i.e., rice field ponds, floating net cages, freshwater ponds, and brackish water pond. At the same time, the catfish were cultivated in three aquatic environments, i.e., rice field ponds, floating net cages, and freshwater ponds.

Figure 3 shows the biodiversity percentage for each cultivation area. Six main commodities in the rice field pond were namely *L. vannamei* (40.67%), non-fish-shrimp commodity (18.99%), *P. hypophthalmus* (14,34%), *O. niloticus* (12.37%), *C. carpio* (10.81%), *C. striata* (2.39%), *C. bathracus* (0.42%), and other fish (0.1%). In floating net-cage aquaculture, five main commodities included *C. bathracus* (35.17%), *O. niloticus* (30.37%), *C. carpio* (23.53%), *P. hypophthalmus* (6.81%), and *P. niger* (4.12%). Nine main commodities comprised *C. bathracus* (58.77%), *O. niloticus* (30.37%), *C. carpio* (9.93%), *B. gonionotus* (8.52%), *P. hypophthalmus* (3.88%), *P. niger* (3.72%), other fish (1.82%), *C. striata* (0.13), and *O. gourami* (0.04%). The biodiversity of animals in brackish water aquaculture is composed of *L. vannamei* (54.29%), *Chanos chanos* (30.43%), *C. carpio* (8.19%), other shrimp (3.76%), other fish (1.87%), *Epinephelus* sp. (0.61%), *P. monodon* (0.38%), *O. mossambicus* (0.38%), and *Lutjanus* sp. (0.08%). For marine aquaculture, only one type of fish found was grouper or *Epinephelus*.

The most popular brackish water fishery commodity in Tuban is white leg shrimp (*L. vannamei*) mainly due to its high economic value. White leg

Table 2. Species distribution according to aquatic environments for aquaculture in in Tuban

Aquatic Diversity	Family	Rice Field Pond	Floating Net Cage	Freshwater Pond	Brackish Water Pond	Marine
 *Cyprinus carpio*	Cyprinidae	√	√	√	√	-
 *Pangasianodon hypophythalmus*	Pangasiidae	√	√	√	-	-
 *Channa striata*	Channidae	√	-	√	-	-
 *Litopenaeus vannamei*	Penaeidae	√	-	-	√	-
 *Oreochromis niloticus*	Cichlidae	√	√	-	-	-

	Clariidae	√	√	√	-	-
Clarias bathracus						
	Cyprinidae	-	√	-	-	-
Barbonymus gonionotus						
	Cyprinidae	-	√	-	-	-
Parastromateus niger						
	Osphronemi-dae	-	√	-	-	-
Osphronemus gourami						
	Serranidae	-	-	-	√	√
Epinephelus sp.						
	Penaeidae	-	-	-	√	-
Penaeus monodon						

	Lutjanidae	-	-	-	√	-
Lutjanus sp.						
	Cichlidae	-	-	-	√	-
Oreochromis mosammbicus						
	Chanidae	-	-	-	√	-
Chanos chanos						

Description: Notes: (√): found; (-): not found, photos are from this study's survey

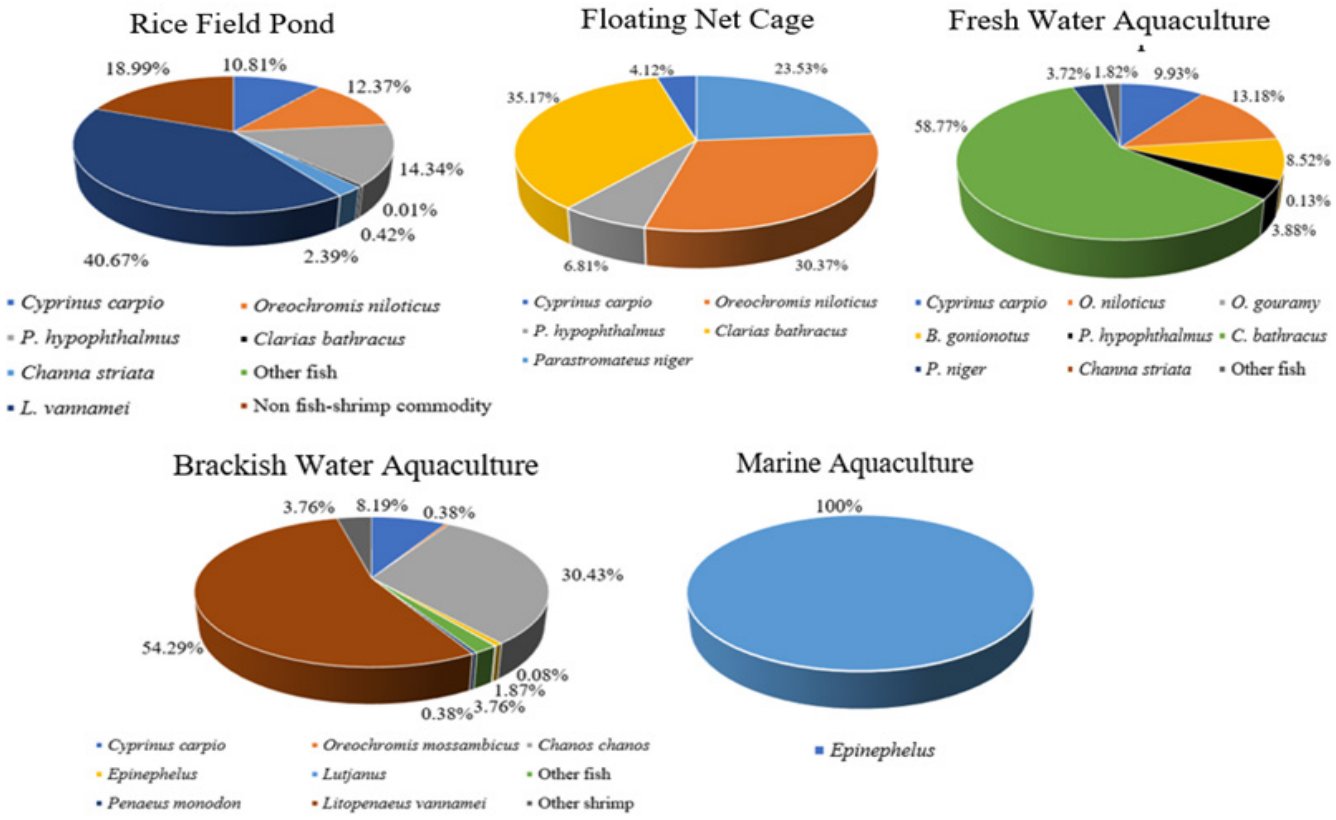

Figure 3. Aquaculture biodiversity percentage based on aquaculture place in Tuban.

shrimp is the highest commodity production in Tuban with 7,406.31 tons (54.29%). The price of white leg shrimp can reach 2.89 USD thousand-1 PL-1 in the global market (Peñalosa-Martinell *et al*., 2021). The demand for the white leg shrimp is also high. According to previous studies, the average volume of shrimp ex ports reached 91.7 thousand metric tons per year, with a growth rate of 6.75% per year to meet global demand (Amelia *et al*., 2021). White leg shrimp commodities are in high demand and selling prices (Nguyen *et al*., 2021). Indonesia is one of the five countries with high white leg shrimp production, besides India, Ecuador, Thailand, and Vietnam (Boyd *et al*., 2021). White leg shrimp has fast growth, high stocking density, as well a high tolerance to disease and bad environment (Trang *et al*., 2019).

Similar to brackish aquaculture, white leg shrimp (*L. vannamei*) is the most popular commodity in rice field ponds, amounting to 5,052.91 tons or 40.67% of the total production. Previous research stated that shrimp farming in rice field ponds is efficient because it needs low maintenance and an inexpensive environment (Dorber *et al*., 2020; Menon *et al*., 2023).

The catfish commodity was the main product of freshwater and floating net cage aquaculture with a total of 787.97 tons in 2020 (35.17%). Catfish (*C. bathracus*) was the main production commodity with a total of 6,512.27 tons (58.77%) of the total 11,080.3 tons in 2020. The fish is widely cultivated by the community because of its high demand, easy cultivation, and high disease resistance (Diatin *et al*., 2021). Like floating net-cage aquaculture, freshwater ponds are suitable for catfish. Catfish is a popular option for the community because it can be cultured on a backyard scale, grow fast, and require minimal maintenance in terms of water quality (Valenti *et al*., 2021). From freshwater ponds, Tuban obtained IDR 183,842,771,500 in 2020 (Central Bureau of Statistics, 2020).

The only commodity of marine culture in Tuban was grouper. Grouper is a popular commodity because it tastes good and is expensive (Chor *et al*., 2020). Indonesia itself is also among the top ten grouper producers and exports in the world (Amorim *et al*., 2019). All of these commodities need to be developed to expand the fishery potential in Tuban. Increasing grouper culture is a realistic thing to be conducted. This is because the technology for grouper culture is already known and applied in Indonesia (Khasanah *et al*., 2020; Astari *et al*., 2023). Neighbouring areas of Tuban, such as Gresik and Lamongan have intensively cultivated grouper (Syahlizawati *et al*., 2022; Lastianto *et al*., 2023). Apart from the known technology, there is still a lot of demand for groupers in the Tuban and surrounding areas (Rochmad and Mukti, 2020).

4. Conclusion

The highest production came from brackish water with a value of 32.46% (13,561.79 tons). Aquaculture biodiversity in Tuban consisted of 11 families and 14 species of the main aquatic produces, such as Cyprinidae (*Cyprinus carpio, Barbonymus gonionotus, Parastromateus niger*), Clariidae (*Clarias bathracus*), Pangasiidae (*Pangasianodon hypophthalmus*), Penaeidae *(Penaeus monodon*), Channidae *(Channa striata*), Penaeidae (*Litopenaeus vannamei*), Cichlidae (*Oreochromis niloticus*, *Oreochromis mosammbicus*), Osphronemidae (*Osphronemus gourami*), Serranidae (*Epinephelus* sp.), Lutjanidae (*Lutjanus* sp.), and Chanidae (*Chanos chanos*). *Cyprinus carpio,* or common carp, is a fish cultivated in four different aquaculture areas. Tuban must improve its production and biodiversity of marine aquaculture production.

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Authors' Contributions

All authors have contributed to the final manuscript. SHS; writing the article and concepting the idea. MA, WI, and VH; collected the data. MBS and MRNA; analyzed the data. MHA drafted the manuscript. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

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