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Species composition and size distribution of fishes in mangrove ecosystems in Kendari and Staring Bays, Southeast Sulawesi, Indonesia

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Abstract. *Fekri L, Analuddin K, Yusnaini, Adimu HE, Chadijah A. 2024. Species composition and size distribution of fishes in mangrove ecosystems in Kendari and Staring Bays, Southeast Sulawesi, Indonesia. Biodiversitas 25: 3683-3692.* Mangrove ecosystem plays very important role in supporting marine organisms including fishes, shells, etc. This study aimed to determine the species composition and size distribution of fishes living around the mangrove ecosystems in Kendari and Staring Bays, Southeast Sulawesi, Indonesia. Fish samplings were conducted using 6 gill nets fishing gear with mesh sizes of 1, 1.5 and 2 inches. Mangrove species composition was sampled using circular plots with diameter of 14 m. The fish conservation status and abundance were determined, while size distribution was analyzed in terms of frequency distribution of body weight, and correlation of body weight and body length. A total of 33 fish species were recorded across the two sampling sites with 30 species found in Kendari Bay and 19 species found in Staring Bay. The fish species are mostly classified as least concern based on the IUCN Red List. We found that species richness, presence and abundance of fishes varied according to the moonlightness periods during the fish catchments. The highest species richness was found in the dark moon both in Kendari and Staring Bays, while the lower fish richness was found in the transition from the dark to the full moon in Kendari Bay and the transition from the full moon to the dark moon in Staring Bay. Five fish species associated with mangroves of Kendari and Staring Bays were found more abundant and showed different size distribution patterns, i.e., normal shape of size distribution for *Zenarchopterus dispar* (Valenciennes, 1847), *Ambassis dussumieri* Cuvier, 1828 and *Upeneus moluccensis* Bleeker, 1855, while *Mugil cephalus* Linnaeus, 1758 and *Acentrogobius viridipunctatus* Valenciennes, 1837 showed L-shaped size distribution. These five dominant fishes showed well allometric relationships between body length and weight. Our findings suggested that mangrove ecosystems in Kendari and Staring Bays play an important role in maintaining fish diversity.

Keywords: Fish abundance, fish composition, fish size distribution, mangroves Bays, Southeast Sulawesi

INTRODUCTION

Mangroves are known to play very important role in providing habitat and food sources for various marine organisms, supporting coastal community life and sustaining fisheries. Mangrove ecosystems have been recognized to provide habitat and abundant food sources of numerous marine organisms as well as potential as nursery grounds for juvenile fishes (Blaber et al. 1989; Parrish 1989; Lugendo et al. 2005). The mangrove ecosystems are known as major feeding habitat for fish and macrozoobenthos (Rodelli et al. 1984; Sheaves and Molony 2000; Chong et al. 2001; Guest and Connolly 2004). According to Wahyudewantoro (2018) and Yuliana et al. (2022), mangrove ecosystem is essential habitat for various fishes and other animals, including birds, mammals and reptiles. Many species of animals and microorganisms connected to mangrove ecosystem demonstrate an intricate relationship with the physical and biological characteristics of mangrove ecosystem (Sari et al. 2022). Mangrove ecosystem plays an important role as feeding ground, nursery and spawning sites of marine organisms (El-Regal and Ibrahim 2014; Descasari et al. 2016; Sari et al. 2022; Yuliana et al. 2022), which is the key to sustaining fisheries sector beneficial for human consumption. Through its unique ecological mechanism, mangroves also regulate soil and hydrology by retaining nutrients or inorganic elements from land and water. It also serves as physical protector against tsunamis, storms, abrasion and sea intrusion (Das and Crépin 2013; Sari et al. 2022). Considering its importance, it is therefore imperative to protect mangrove ecosystem to continue offering services that benefit humanity (Hewindati et al. 2023).

Mangrove forests in Indonesia are the largest in the world, occurring in most of the coastal lines of the country. In Southeast Sulawesi Province, mangrove ecosystems are found in almost all coastal areas including in Rawa Aopa National Park, Tinanggea, Kendari Bay, Staring Bay and others. These mangrove ecosystems play an important role as a source of livelihood for coastal communities and habitat and nursery sites for various coastal as well as marine organisms. Several studies related to mangrove ecosystem in Southeast Sulawesi have explained the structure, biomass and carbon sequestration in mangroves (Analuddin et al. 2013, 2018, 2020), the nutritional and antioxidant potential of leaves and fruit of various types of mangroves (Septiana et al. 2016; Analuddin et al. 2019), and the ability of the mangrove ecosystem as a heavy metal biofilter (Analuddin et al. 2017, 2023). However, there was limited study regarding the fish associated with mangrove ecosystem in this region.

Staring Bay and Kendari Bay are essential mangrove areas in Southeast Sulawesi, yet population growth and rapid urban development are expected to disrupt the carrying capacity of the mangrove ecosystem in supporting fisheries sector in these areas. Staring Bay is one of the conservation areas in Southeast Sulawesi which is managed using a zoning system (Adimu et al. 2017, 2018). Staring Bay is widely used by the community for seaweed cultivation (Nalarati et al. 2016), capture fisheries and shrimp/fish farming (Rajab et al. 2016). Moreover, Kendari Bay and Staring Bay are managed for fishing and shellfish collection as well as aquaculture. Although several studies related to the mangrove ecosystem in both Staring Bay and Kendari Bay have been done by Herman et al. (2011), Chairunnas and Amelia (2022), and Tumoro and Christanto (2012), there was lack of information regarding fish-associated with mangroves in these sites.

It is known that Kendari Bay suffered from anthropogenic pressures due to waste pollutants, reclamation and other activities in Kendari City (Analuddin et al. 2023), while Staring Bay is impacted by various coastal developments including electricity power plant, shipyard port and mining. Such conditions might affect the sustainability of coastal and marine organisms, particularly for fish-associated mangroves in both sites. Therefore, the study aimed to determine the species composition and size distribution of fishes living around the mangrove ecosystems of Kendari and Staring Bays in Southeast Sulawesi. This study results give scientific information about the important roles of mangrove ecosystems in sustaining the life of various fishes, and would contribute to sustainable management of mangrove ecosystems to improve economy and welfare of communities in the coastal areas of Southeast Sulawesi.

MATERIALS AND METHODS

Study area

The research was carried out in Kendari Bay and Staring Bay, Southeast Sulawesi, Indonesia (Figure 1). The two sites have a distance of 45 km which represents mangrove ecosystems with different characteristics. Kendari Bay is a semi-closed estuary located in the middle of Kendari City. It is geographically located at 3°58’3”-4°3’11” S and 122°32”-122°36” E. Kendari Bay is an estuary with freshwater inputted from 13 rivers, while the coastal ecosystems are found including mangroves and seagrasses, and few part of coral. High sedimentation from terrestrial activities occurred in the Kendari Bay including reclamation, hotels and port developments, and conversion of mangrove forest into aquaculture, housing and new road construction. On the other hand, Staring Bay is located between 4°02’40”-4°08’53” S and 122°40’03”-122°48’02” E. The northern and western sides of Staring Bay are relatively open water with the presence of waves, and relatively strong currents influenced by the mass of water from the Banda Sea, while the southern and eastern sides are relatively protected from big waves, while water deep is relatively shallow with gentle slope. Various aquatic ecosystems, namely mangroves, seagrass and coral reefs are found in Staring Bay. Several activities for coastal development including electricity power plants, shipyard ports, minings, etc., are found in Staring Bay.

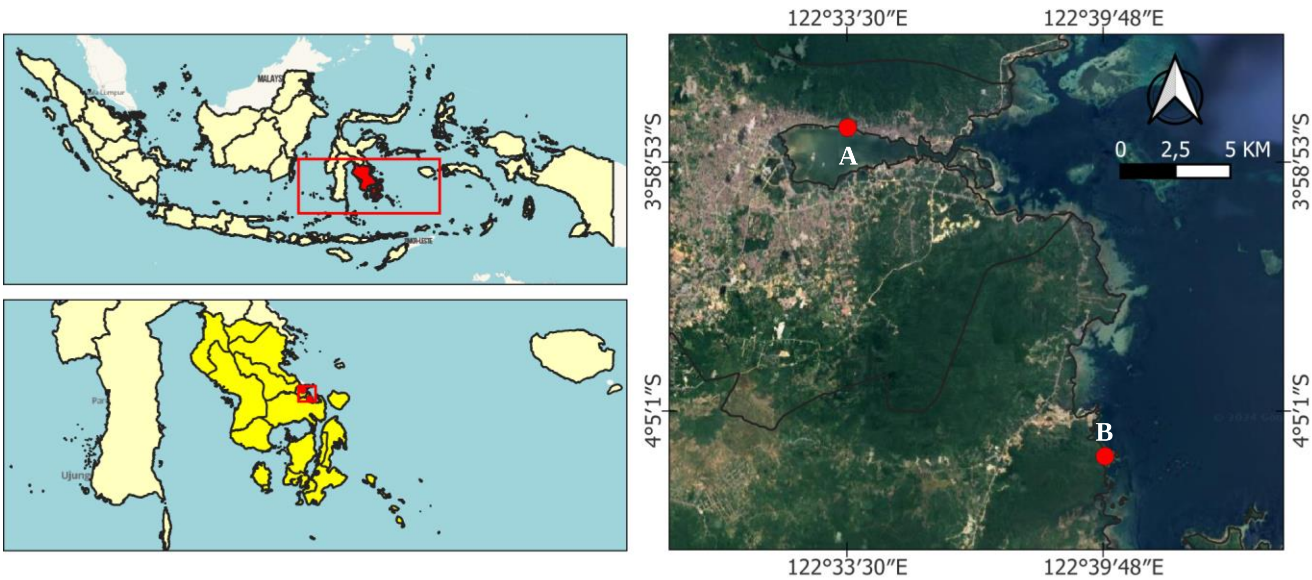

Figure 1. Map of research location and fish sampling sites in Kendari Bay (A) and Staring Bay (B), Southeast Sulawesi, Indonesia

Data collection

Information regarding fish species and mangrove vegetation in the surrounding area was gathered using transect line method with plots circle. Vegetation data was collected to obtain the diversity, frequency, and density of mangrove plants with diameter of more than 10 cm and a height of more than 1.5 m. At each site, three circular sampling plots were established with diameter of 14 m each. A total of 6 circle plots were established along transect in both sites, perpendicularly from land to the sea to record and measure mangrove vegetation data. The stem Diameter at Breast Height (DBH) of all mangrove trees found in each circle plot was measured, while mangrove species were identified and their individual number was counted.

Fish composition and size samples data were collected by putting 6-gill nets fishing gear in both sites or 3-gill nets in each study site with mesh diameters of 1, 1.5, and 2 inches. Sampling collections for fish data were carried out once a week from August to November 2023 in the four time periods of dark moon, transition from dark to the full moon, full moon and transition from the full to the dark moon. In total, there were 32 times fish sampling catchments in both sites, i.e., 16 times fish samplings in Kendari Bay and 16 times fish samplings in Staring Bay.

Data analysis

Mangrove vegetation data were analyzed to obtain the density, frequency and dominance using the following formulas:

$$\text{Density (individuals/ha)} = \frac{\text{number of plots where species are found}}{\text{number of all sampling plots}}$$

$$\text{Frequency (\%)} = \frac{\text{number of individuals of species}}{\text{size of sampling plot (ha)}}$$

The composition of the fish caught was calculated based on their weight. Furthermore, records were made per fish species. The composition based on the weight percentage of the fish caught compared to the total weight was then calculated.

The correlation between the length and weight was calculated using the following formulas (Jisr et al. 2018):

$$W = a.L^{b}$$

Where: W: fish's weight (gram); L: fish's total length (mm); 'a': constant; 'b': fish's growth pattern estimator

The values of ‘a’ and ‘b’ are obtained from a simple linear equation:

$$Y = b_0 + b_1X$$

Where: Y = Log W; X = Log L

Therefore, the constants b1 and b0 can be calculated using the following equation:

$$b_1 = \frac{\sum_{i=1}^{n} x_i y_i - \frac{1}{n}\sum_{i=1}^{n} x_i \ \sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\ (\sum_{i=1}^{n} x_i)^2}$$

and

$$b_0 = \bar{y} - b_1\bar{x}$$

RESULTS AND DISCUSSION

Mangrove composition

There were 4 species of mangroves found at each sampling site, namely *Bruguiera gymnorrhiza* (L.) Lam., *Rhizophora mucronata* Lam., *Rhizophora apiculata* Blume and *Sonneratia alba* Sm. (Table 1). Identification of mangrove species is important to determine the fish species associated to the mangrove species in an area. *B. gymnorrhiza* was the most frequent and dominant mangrove species around the study site in Kendari Bay, while *S. alba* was the most frequent and dominant mangrove around the study site in Staring Bay.

Because of their roots system, mangrove species including *Sonneratia* spp., *Bruguiera* spp., and *Rhizophora* spp. may thrive well in shallow water environments (Costa et al. 2015; Yapanto et al. 2021). Mangrove plants can transform nutrients from the mud flats into food sources of various marine species, including fish, crabs, and shellfish. The diversity and abundance of fishes species correlate with and the diversity and density of mangrove plants (Descasari et al. 2016). A high abundance of ichthyofauna is found in a high density and variety of mangrove species. This shows that mangrove ecosystem is used as a nursery ground, feeding ground, and shelter from predatory fish. Ermgassen et al. (2020) said that mangroves are critical nursery habitats for fishes and invertebrates, which are essential in the provision of livelihoods for many coastal communities.

Table 1. Mangrove species at the sampling sites in Kendari and Staring Bays, Southeast Sulawesi

Scientific name	Frequency (%)		Density (Individual/ha)	
	Kendari Bay	Staring Bay	Kendari Bay	Staring Bay
Bruguiera gymnorrhiza (L.) Lam.	68	11	120	20
Rhizophora mucronata	53	29	90	50
Rhizophora apiculata Blume	26	63	40	110
Sonneratia alba Sm.	18	85	30	140

Species composition and IUCN red list status of fish in Kendari and Staring Bays

A total of 33 species of fish were recorded across the two study sites, viz., Kendari Bay and Staring Bay (Table 2). Of these, 30 species were found in Kendari Bay, and 19 species were found in Staring Bay. Higher species richness in Kendari Bay might indicate a more suitable environmental condition for a variety of fishes as compared to that in Staring Bay. Five fish species with the highest abundance were *Z. dispar* (615 ind.), *Mugil cephalus* (132 ind.), *A. dussumieri* (102 ind.), *U. moluccensis* (55 ind.), and *A. viridipunctatus* (25 ind.) (Figure 2).

The present study of fish richness in Kendari Bay was higher than 16 species in Rasu Bay and 27 species in Sepi Bay, Lombok Island (Wahyudewantoro 2018). However, fish species richness in Staring Bay was lower than in Sepi Bay, Lombok Island. Various types of fish can be found in mangrove areas (Hewindati et al. 2023). The diversity of fish in the mangrove ecosystem is greater than at coastal water in Indramayu, West Java, Indonesia (Sihombing et al. 2017). Thus, high species richness of fishes found in the mangrove ecosystems of present study sites might be attributed to the high mangrove capacity as fish habitat and nursery sites in the Kendari and Staring Bays. Although there were some anthropogenic pressures in these bays, it might less affect the fishes that inhabit and use the mangrove ecosystems as habitat, nursery and spawning sites. Moreover, biotic and abiotic aspects are known as major factors affecting the diversity and distribution of fishes in a habitat (Chadijah et al. 2018). A healthy environment provides space for animals and plants as a food source to grow and reproduce (Fekri et al. 2018). Thus, physical, chemical and biological changes in land and marine ecosystems affect the mangrove ecosystem (Palit et al. 2022). The diversity of fish in a water body is related to food availability and ecosystem health. Fish will grow and reproduce well when food is abundant and the environmental conditions support their survival (Fekri et al. 2020). Food, both in terms of quantity and quality, is the main factor for fish to grow (Fekri et al. 2019; Fekri et al. 2021). A healthy aquatic ecosystem with the absence of industrial and domestic wastes can sustain the diversity of fish. However, many aquatic ecosystems, such as mangroves, seagrass and coral reef, are damaged due to wastes and pollution caused by human activities at local and global scales (Jambeck et al. 2015).

Table 2. Fish species composition in the mangrove ecosystems in Kendari Bay and Staring Bay, Southeast Sulawesi, Indonesia and the conservation status. Note: ●: present

Species	Location		IUCN red list status
	Kendari Bay	Staring Bay	
Strongylura notata (Poey, 1860)	●	●	Least Concern (LC)
Zenarchopterus dispar (Valenciennes, 1847)	●	●	Least Concern (LC)
Mugil cephalus (Linnaeus, 1758)	●	●	Least Concern (LC)
Sillago sihama (Forsskål, 1775)	●	●	Least Concern (LC)
Microgobius gulosus (Girard, 1858)	●	-	Least Concern (LC)
Acentrogobius viridipunctatus (Valenciennes, 1837)	●	-	Least Concern (LC)
Oxyeleotris marmorata (Bleeker, 1852)	●	-	Least Concern (LC)
Ambassis dussumieri (Cuvier, 1828)	●	●	Least Concern (LC)
Toxotes microlepis (Günther, 1860)	●	-	Least Concern (LC)
Pelates quadrilineatus (Bloch, 1790)	●	●	Not Evaluated (NE)
Portunus pelagicus (Linnaeus, 1758)	●	-	Not Evaluated (NE)
Lutjanus fulviflamma (Forsskål, 1775)	●	-	Least Concern (LC)
Stolephorus indicus (van Hasselt, 1823)	●	-	Least Concern (LC)
Chanos chanos (Forsskål, 1775)	●	●	Not Evaluated (NE)
Ambassis nalua (Hamilton, 1822)	●	●	Least Concern (LC)
Gazza minuta (Bloch, 1795)	●	-	Least Concern (LC)
Caranx ignobilis (Forsskål, 1775)	●	●	Least Concern (LC)
Selaroides leptolepis (Cuvier, 1833)	●	-	Least Concern (LC)
Gerres filamentosus (Cuvier, 1829)	●	●	Least Concern (LC)
Oreochromis niloticus (Linnaeus, 1758)	●	-	Least Concern (LC)
Scomberoides tala (Cuvier, 1832)	●	●	Least Concern (LC)
Upeneus moluccensis (Bleeker, 1855)	●	●	Not Evaluated (NE)
Epinephelus bleekeri (Vaillant, 1878)	●	●	Data Deficient (DD)
Triacanthus biaculeatus (Bloch, 1786)	●	-	Not Evaluated (NE)
Upeneus taeniopterus (Cuvier 1829)	●	●	Least Concern (LC)
Nuchequula gerreoides (Bleeker, 1851)	●	-	Not Evaluated (NE)
Siganus canaliculatus (Park, 1797)	●	-	Least Concern (LC)
Scatophagus argus (Linnaeus, 1766)	●	-	Least Concern (LC)
Litopenaeus vannamei (Boone, 1931)	●	●	Not Evaluated (NE)
Upeneus sulphureus (Cuvier, 1829)	-	●	Least Concern (LC)
Drepane longimana (Bloch & Schneider, 1801)	-	●	Not Evaluated (NE)
Strongylura strongylura (van Hasselt, 1823)	-	●	Not Evaluated (NE)
Fibramia lateralis (Valenciennes, 1832)	●	●	Not Evaluated (NE)
Species number	30	19	

Based on the IUCN red list, the fishes found in the study sites were mostly classified as Least Concern (LC), meaning they are not likely to become extinct soon. However, there were 10 fish species with Not Evaluated (NE) status yet, while there were one species with the status of Data Deficient (DD), namely *Epinephelus bleekeri* (Vaillant, 1878). The fishes recorded in this study are not the focus of conservation because many fishes are still abundant in the wild. Furthermore, the fish diversity in the studied sites was high. Government Regulation Number 60 of 2007 concerning the Conservation of Fish Resources has outlined that biodiversity conservation at the species level can be carried out with three main conservation efforts: protection, preservation, and sustainable use. Protection and preservation of fish species in the bays can be done by monitoring the fish caught by fishermen.

Periodical trends of species composition, presence and abundant of fishes in Kendari and Staring Bays

The compositions, presence and abundance of fishes caught in the mangrove ecosystems of Kendari Bay (Table 3) and Staring Bay (Table 4) varied according to moonlightness periods of catch. As shown in Table 3, the fish species richness caught in Kendari Bay were found 21 species in dark moon, 8 species in the transition from dark moon to the full moon, 12 species in the full moon and 16 species in the transition from full moon to the dark moon. Thus, higher fish species number was caught during the transition from full moon to dark moon around the mangrove ecosystem of Kendari Bay, while lower species numbers were caught during the full moon in Kendari Bay. However, only three fish species (*Z. dispar*, *M. cephalus* and *A. nalua* Hamilton, 1822) were caught in the whole moonlightness periods during the study in Kendari Bay, indicating as common fish species living in Kendari Bay. Furthermore, four fish species were caught in three moon lightness periods of observation, and seven fish species were caught in the two moonlightness periods of study. Nearly half of fish species (14 species) were only caught in the one moonlightness period, indicating rare fishes which use the mangrove ecosystem as their habitat and other purposes. In term of abundant, in the mangrove ecosystem of Kendari Bay there were 146 individuals caught in dark moon, 146 individuals in the period from the dark to the full moon, 84 individuals in the period of full moon and 225 individuals found in the period from the full to the dark moon. Thus, higher fish abundance was caught during the transition from full moon to the dark moon in the mangrove ecosystem of Kendari Bay, while lower fish abundance was caught during the full moon.

As shown in Table 4, fish composition, presence and abundant in Staring Bay varied according to moon lightness catch with respective 15 species in the dark moon, 8 species in the transition from dark to full moon, 6 species in the full moon and 3 species only in the transition from full to the dark moon in Staring Bay. There were only three fish species (*Z. dispar, M. cephalus* and *Strongylura notata* (Poey, 1860)) caught in the whole period of the study in Staring Bay, indicating they were as common fish species living around the mangrove ecosystem of Staring Bay. Furthermore, three fish species were caught in three periods of observation, and one species only (*Strongylura strongylura* (van Hasselt, 1823)) was caught in two periods of observation. However, more than half of fish species (12 species) were caught in one period of observation. As many as 167 individuals were caught in the dark moon, 113 individuals in the time period from the dark to the full moon, 140 individuals in the period of the full moon and 77 individuals found in the period from the full to the dark moon. Thus, higher fish species numbers were caught during the dark moon in the mangrove ecosystem of Staring Bay, while lower individual number was caught during the transition from the full moon to the dark moon.

The present study found that the species richness and abundance of fish were much higher in Kendari Bay than in Staring Bay. This might be caused Kendari Bay is relatively close to the open sea and has many food sources available for fish, while Staring Bay is a more open area and has fewer food sources for fish. Moreover, higher number of fish species was caught during the dark moon in both locations of Kendari Bay and Staring Bay. Meanwhile, lower species number was caught during the transition from the dark to the full moon in Kendari Bay. Although, higher abundance of fish was caught in the transition from the full moon to the dark moon in Kendari Bay, but it found more abundant during the dark moon in Staring Bay. During the full moon phase, the influence of moonlight on fish behavior is considered significant (Permana et al. 2017). The position of the moon relative to the earth causes the ebb and flow of the earth's water surface. In addition, the intensity of light and the duration of full moon also affect the life of the organisms in the waters. According to Karuwal and Bagafih (2016), the light of the full moon will spread evenly in the waters, so it is not effective for fishing activities. The results of acoustic detection also show that fish move deeper away from the surface towards the inside of the waters during the full moon period (Alwi et al. 2021). Nevertheless, the physical parameters of water, habitat quality, and the seasonal variability of the salinity (0-35‰) are factors affecting the fish structure and distribution in coastal ecosystems including in mangroves (Laegdsgaard and Johnson 1995). Furthermore, variability of water quality in mangroves depends on several factors such as seasons (wet, transitional, dry), flood intensity and tides, etc. (Tzeng and Wang 1992).

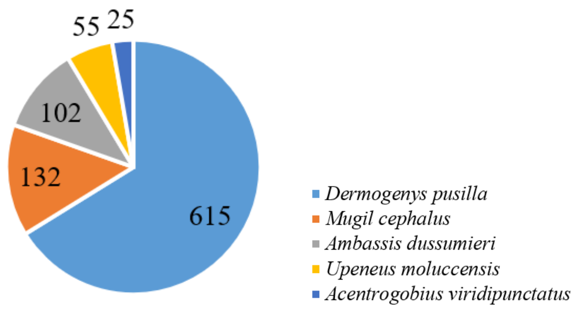

Figure 2. Fish species with the highest abundance in mangrove areas of Kendari Bay and Staring Bay, Southeast Sulawesi

Table 3. Periodical trends in species composition, presence and abundant of fishes in Kendari Bay, Southeast Sulawesi, Indonesia

Species	Periods of fish catch				
	Dark moon	Transition from dark to full moon	Full moon	Transition from full to dark moon	Frequency
Strongylura notata (Poey, 1860)	6	0	0	0	0.25
Zenarchopterus dispar (Valenciennes, 1847)	41	94	25	156	1
Mugil cephalus (Linnaeus, 1758)	11	21	7	25	1
Sillago sihama (Forsskål, 1775)	4	0	0	2	0.5
Microgobius gulosus (Girard, 1858)	16	0	0	0	0.25
Acentrogobius viridipunctatus (Valenciennes, 1837)	12	5	8	0	0.75
Oxyeleotris marmorata (Bleeker, 1852)	2	0	0	0	0.25
Ambassis dussumieri (Cuvier, 1828)	9	0	1	2	0.75
Toxotes microlepis (Günther, 1860)	1	6	1	0	0.75
Pelates quadrilineatus (Bloch, 1790)	1	0	0	0	0.25
Portunus pelagicus (Linnaeus, 1758)	10	7	2	0	0.75
Lutjanus fulviflamma (Forsskål, 1775)	0	0	1	0	0.25
Stolephorus indicus (van Hasselt, 1823)	0	0	1	0	0.25
Chanos chanos (Forsskål, 1775)	0	0	1	0	0.25
Ambassis nalua (Hamilton, 1822)	14	7	34	17	1
Gazza minuta (Bloch, 1795)	5	0	3	2	0.75
Caranx ignobilis (Forsskål, 1775)	1	0	0	8	0.5
Selaroides leptolepis (Cuvier, 1833)	0	0	0	1	0.25
Gerres filamentosus (Cuvier, 1829)	2	0	0	2	0.5
Oreochromis niloticus (Linnaeus, 1758)	0	0	0	2	0.25
Scomberoides tala (Cuvier, 1832)	0	0	0	3	0.5
Upeneus moluccensis (Bleeker, 1855)	0	1	0	2	0.5
Epinephelus bleekeri (Vaillant, 1878)	0	0	0	1	0.25
Triacanthus biaculeatus (Bloch, 1786)	0	0	0	1	0.5
Upeneus taeniopterus (Cuvier 1829)	1	1	0	1	0.75
Nuchequula gerreoides (Bleeker, 1851)	1	0	0	0	0.25
Siganus canaliculatus (Park, 1797)	2	0	0	0	0.25
Scatophagus argus (Linnaeus, 1766)	1	0	0	0	0.25
Litopenaeus vannamei (Boone, 1931)	3	4	0	0	0.5
Fibramia lateralis (Valenciennes, 1832)	3	0	0	0	0.25
Species number	21	8	12	16	
Total abundant	146	146	84	225	

Table 4. Periodical trends in species composition, presence and abundant of fishes in Staring Bay, Southeast Sulawesi, Indonesia

Species	Periods of fish catch				
	Dark moon	Transition from dark to full moon	Full moon	Transition from full to dark moon	Frequency
Strongylura notata (Poey, 1860)	3	4	1	4	1
Zenarchopterus dispar (Valenciennes, 1847)	52	77	113	57	1
Mugil cephalus (Linnaeus, 1758)	9	20	23	16	1
Sillago sihama (Forsskål, 1775)	1	0	0	0	0.25
Ambassis dussumieri (Cuvier, 1828)	12	0	0	0	0.25
Pelates quadrilineatus (Bloch, 1790)	9	3	0	0	0.5
Chanos chanos (Forsskål, 1775)	0	1	0	0	0.25
Ambassis nalua (Hamilton, 1822)	6	0	0	0	0.25
Caranx ignobilis (Forsskål, 1775)	6	0	0	0	0.25
Gerres filamentosus (Cuvier, 1829)	2	0	0	0	0.25
Scomberoides tala (Cuvier, 1832)	0	1	0	0	0.25
Upeneus moluccensis (Bleeker, 1855)	51	0	1	0	0.5
Epinephelus bleekeri (Vaillant, 1878)	1	0	0	0	0.25
Upeneus taeniopterus (Cuvier 1829)	0	0	1	0	0.25
Litopenaeus vannamei (Boone, 1931)	4	4	0	0	0.5
Upeneus sulphureus (Cuvier, 1829)	6	0	0	0	0.25
Drepane longimana (Bloch & Schneider, 1801)	3	0	0	0	0.25
Strongylura strongylura (van Hasselt, 1823)	1	3	1	0	0.75
Fibramia lateralis (Valenciennes, 1832)	1	0	0	0	0.25
Species number	15	8	6	3	
Total abundant	167	113	140	77	

One of the biological parameters usually used to see the health quality of water is by looking at the diversity of aquatic fauna, especially the diversity of fish species. The more diverse and abundant types of fish in a body of water indicate the water is in good category. The large number of fish species in mangrove areas in Kendari Bay and Staring Bay of the present study indicates the important roles of mangrove vegetation in supporting the life of various fish and preserving biodiversity. Numerous studies in various regions of the world have elucidated the importance of mangroves as habitats for fishes (Dorenbosch et al. 2004) and support the high diversity and abundance of coral reef fishes in the Caribbean (Weinstein and Heck 1979), in the Indian Ocean (Pinto and Punchihewa 1996), nursery ground for juvenile reef fishes in the southern Egyptian Red Sea, Egypt (El-Regal and Ibrahim 2014). The present study demonstrates the importance of mangroves as habitat for various fish species along the Kendari and Staring Bays, Southeast Sulawesi, Indonesia. Laegdsgaard and Johnson (1995) pointed that mangrove habitats are unique in their function as nurseries for many fish species enter in estuarine mangroves as post larvae and juveniles. Nevertheless, fringing mangroves in the Caribbean are found not an important feeding habitat for most fish species occurring in adjacent habitats (Nagelkerken and van der Velde 2004b).

Size distribution of dominant fishes

Figure 3 depicts the size distribution of five dominant species at mangrove areas in Kendari Bay and Staring Bay. The size distribution of dominant fish species showed normal shape for *Dermogenys pusilla* Kuhl & van Hasselt, 1823 (Figure 3.A), *U. moluccensis* (Figure 3.B) and *Ambassis nalua* Hamilton, 1822 (Figure 3.C). Meanwhile, L shape size distribution of the other two dominant fish is showed by *M. cephalus* (Figure 3.D) and *A. viridipunctatus* (Figure 3.E).

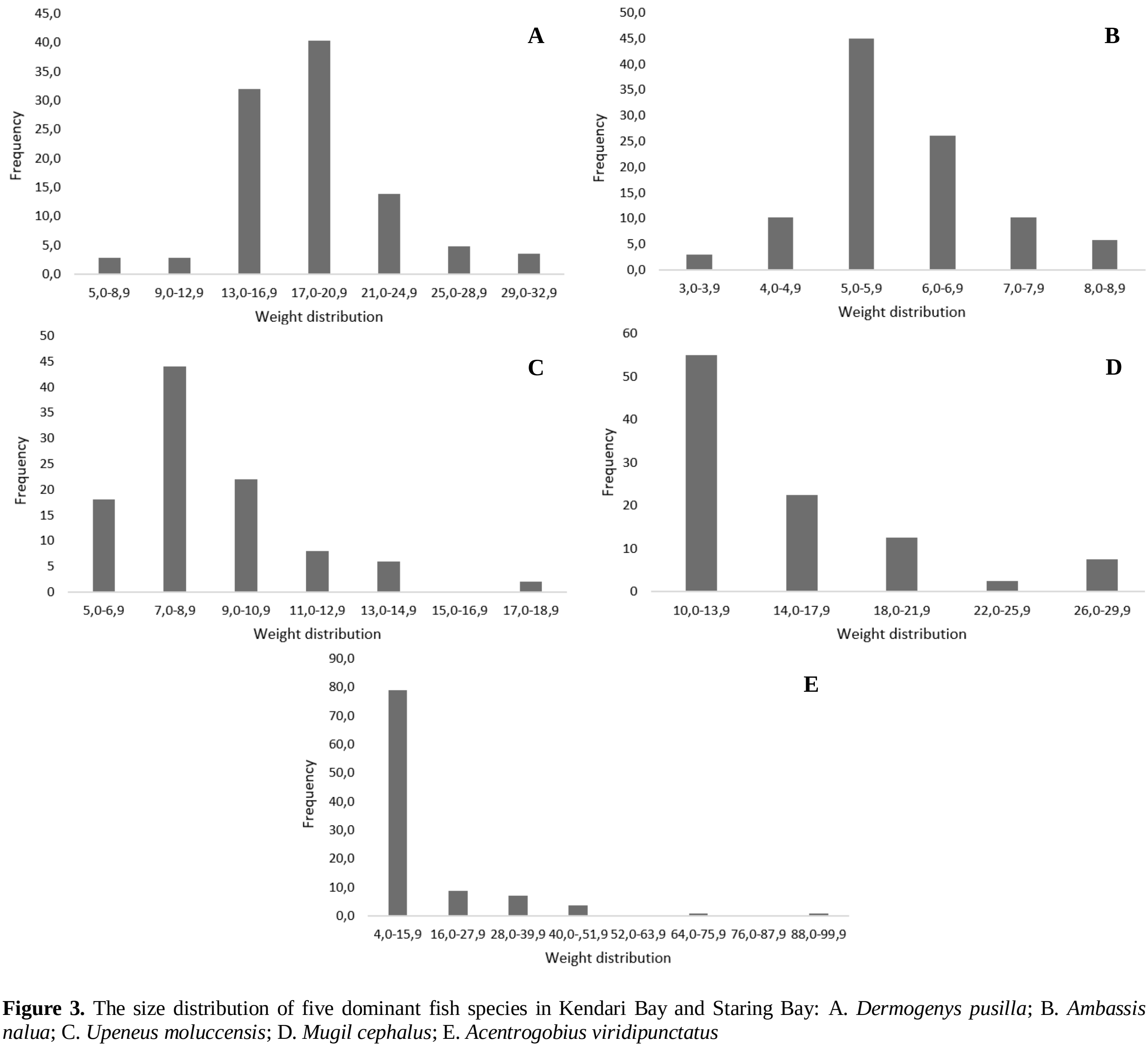

Figure 3. The size distribution of five dominant fish species in Kendari Bay and Staring Bay: A. *Dermogenys pusilla*; B. *Ambassis nalua*; C. *Upeneus moluccensis*; D. *Mugil cephalus*; E. *Acentrogobius viridipunctatus*

The allometric pattern of length and weight of dominant fishes

Figure 4 depicts the allometric patterns of length and weight of five dominant fishes of the present study, which presented as fish species Length-Weight Relationships (LWRs) following the method of Mehanna and Farouk (2021). The LWR relationships of five fish species were presented in Figure 4.A for *D. pusilla*, Figure 4.B for *M. cephalus*, Figure 4.C for *A. dussumieri*, Figure 4.D for *U. moluccensis*, and Figure 4.E for *A. viridipunctatus*. The weight of five dominant fishes showed strong correlations with their length (Figures 4.A-E, R^2>0.6). Jisr et al. (2018) pointed out that the R^2 values categorized as strong if R^2>0.67, moderate if R^2 values ranged 0.33-0.67), and weak if R^2 values ranged 0.19-0.33. The relationships between the body length and body weight of five dominant fish species found in the mangrove ecosystems showed similar growth patterns, although the allometric pattern indicated that the increase in length was more dominant than the increase in weight (i.e., fishes have a thin body size). Generally, various factors determine the fish's growth including the size, quality and amount of available food, intraspecific competitions, temperature, salinity, oxygen, etc. (Orio 2019) and water quality (Viadero 2019). Mehanna and Farouk (2021) mentioned that the LWRs are not constant over the year, and the LWR parameters may vary significantly due to food availability and biological, temporal, and sampling factors. Moreover, temperature and dissolved oxygen conditions in the seawater are known to affect the growth and distribution of fish in the waters (Chadijah et al. 2019). The LWR of fish differs among species according to the body shape within the same species and the condition of individual fish (Mehanna and Farouk 2021). Active swimming fish tend to have a lower b coefficient than passive swimming fish (Afdhila et al. 2019). This is related to the level of energy used for swimming (Jisr et al. 2018). Nazeef and Yerima (2023) stated that growth patterns of fish species are related to the exponential values (b) of allometric model of the Length - Weight Relationships (LWR) which can be changed due to the changes in environmental parameters (seasonal temperature regimes) and habitat availability (Olopade et al. 2019). Furthermore, Nazeef and Yerima (2023) argued that numerous environmental factors affect the fish growth pattern including optimal temperature, adequate food, seasonal changes; ontogenetic development, habitat, feeding rate, fish health, sexual dimorphism; gonadal development and spawning period; and reproduction stage.

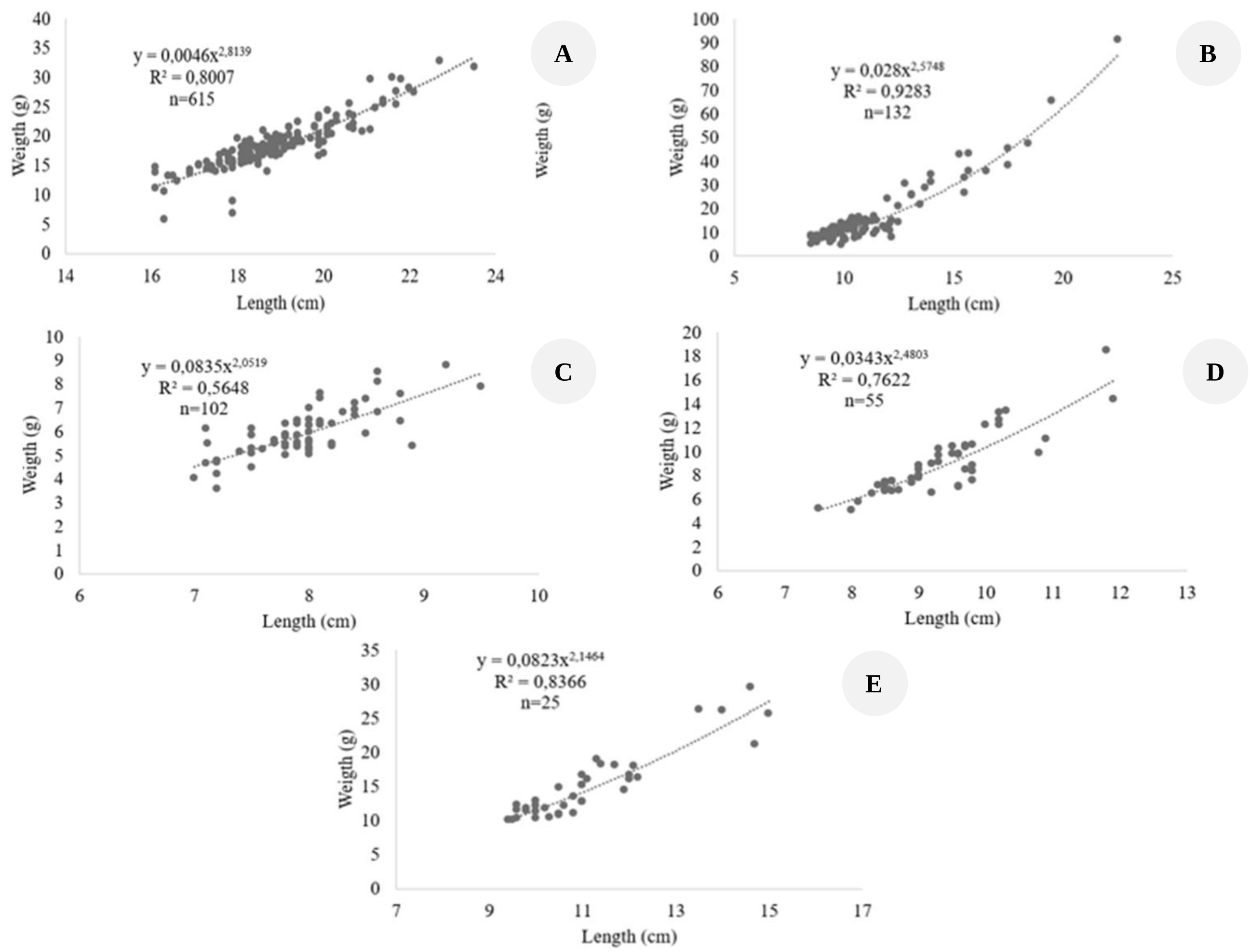

Figure 4. The allometric relationships between the body weight and body length of five dominant fishes living in the mangrove ecosystems of Kendari Bay and Staring Bay: A. *Dermogenys pusilla*; B. *Ambassis nalua*; C. *Upeneus moluccensis*; D. *Mugil cephalus*; E. *Acentrogobius viridipunctatus*

In conclusion, the present study well documented the species composition and size distribution of fishes occurring in mangrove ecosystems in Kendari Bay and Staring Bay, Southeast Sulawesi, Indonesia. Large fish species number and abundance were found in the mangrove ecosystems in both Kendari and Staring Bays with a total 33 fish species, which are mostly classified as Least Concern (LC) species. The species composition, presence and abundant of fishes varied according to the moon lightness periods of fish catch. The highest species richness was found in the dark moon period for both Kendari and Staring Bays, while the lowest of fish richness was found in the transition from dark to the full moon in Kendari Bay, and the transition from full to the dark moon in Staring Bay. Five most abundant fishes in the areas showed different size distribution where *Z. dispar*, *A. dussumieri* and *U. moluccensis* showed normal shape, while *M. cephalus* and *A. viridipunctatus* showed L-shaped size distribution. These five dominant fishes showed well allometric relationships of body length and weight. The mangroves in both Kendari Bay and Staring Bay play a very important role in maintaining fish diversity in Southeast Sulawesi. Therefore, mangrove conservation and management are needed to sustain and conserve fish diversity in Southeast Sulawesi.

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REFERENCES

Adimu HE, Boer M, Yulianda F, Damar A. 2017. The role of stakeholders in marine conservation areas in Wakatobi National Park, Indonesia. Aquacult Aquarium Conserv Legislation 10 (6): 1483-1491.

Adimu HE, Boer M, Yulianda F, Damar A. 2018. Review management policy marine conservation area of Wakatobi National Park. IOP Conf Ser: Earth Environ Sci 176: 012035. DOI: 10.1088/1755-1315/176/1/012035.

Afdhila R, Muhammadar AA, Chaliluddin MA. 2019. Length-weight relationship and condition factors of laying fish *(Decapterus macrosoma)* that landed at Lampulo Ocean Fishing Port, Banda Aceh. IOP Conf Ser: Earth Environ Sci 348: 012079. DOI: 10.1088/1755-1315/348/1/012079.

Alwi D, Nurafni, Sofiati T, Kodobo MJ. 2021. Application of acoustic underwater technology (fish finder) to the vertical disribution pattern of fish in boat charts in Pilowo Village Morotai Island District. Aurelia J 2 (2): 133-143. DOI: 10.15578/aj.v2i2.9893. [Indonesian]

Analuddin K, Armid A, Ruslin R, Sharma S, Kadidae LO, Haya LOMY, Septiana A, Rahim S, McKenzie RA, La Fua J. 2023. The carrying capacity of estuarine mangroves in maintaining the coastal urban environmental health of Southeast Sulawesi, Indonesia. Egypt J Aquat Res 49 (3): 327-338. DOI: 10.1016/j.ejar.2023.03.002.

Analuddin K, Jamili, Septiana A, Raya R, Rahim S. 2013. The spatial trends in the structural characteristics of mangrove forest at the Rawa Aopa Watumohai National Park, Southeast Sulawesi, Indonesia. Intl Res J Plant Sci 4 (8): 214-221.

Analuddin K, Sharma S, Jamili, Septiana A, Sahidin I, Rianse U, Nadaoka K. 2017. Heavy metals bioaccumulation in mangrove ecosystem at the Coral Triangle Ecoregion, Southeast Sulawesi, Indonesia. Mar Pollut Bull 125 (1-2): 472-480. DOI: 10.1016/j.marpolbul.2017.07.065.

Analuddin K, Kadidae LO, Haya LOMY, Septiana A, Sahidin I, Syahrir L, Rahim S, Fajar LOA, Nadaoka K. 2020. Aboveground biomass, productivity and carbon sequestration in *Rhizophora stylosa* mangrove forest of Southeast Sulawesi, Indonesia. Biodiversitas 21 (4): 1316-1325. DOI: 10.13057/biodiv/d210407.

Analuddin K, Septiana A, Nasaruddin, Sabilu Y, Sharma S. 2019. Mangrove fruit bioprospecting: Nutritional and antioxidant potential as a food source for coastal communities in the Rawa Aopa Watumohai National Park, Southeast Sulawesi, Indonesia. Intl J Fruit Sci 19 (4): 423-436. DOI: 10.1080/15538362.2018.1555507.

Analuddin K, Sharma S, Jamili, Septiana A, Raya R, Sahidin I, Usman R, Rahim S, Nadaoka K. 2018. Trends in allometric model and aboveground biomass of family Rhizophoraceae mangroves in Coral Triangle Ecoregion, Southeast Sulawesi, Indonesia. J Sustain For 37 (7): 691-711. DOI: 10.1080/10549811.2018.1453843.

Blaber SJM, Brewer DT, Salini JP. 1989. Species composition and biomasses of fishes in different habitats of a tropical northern Australian estuary: Their occurrence in the adjoining sea and estuarine dependence. Estuar Coast Shelf Sci 29 (6): 509-531. DOI: 10.1016/0272-7714(89)90008-5.

Chadijah A, Sulistiono, Haryani GS, Affandi R, Mashar A. 2018. Species composition of *Telmatherina* caught in the vegetated and rocky habitats in Matano Lake, South Celebes, Indonesia. AACL Bioflux 11 (3): 948-955.

Chadijah A, Sulistiono, Haryani GS, Affandi R, Mashar A. 2019. Size distribution, growth pattern, and condition factor of endemic opudi fish (*Telmatherina prognatha*) in Lake Matano, South Sulawesi. J Indones Agric Sci 24 (4): 295-303. DOI: 10.18343/jipi.24.4.295.

Chairunnas A, Amalia HAM. 2022. Structure and composition of brachyura based on tree density in mangrove communities in Kendari Bay. Biodidaktika: Jurnal Biologi dan Pembelajarannya 17 (1): 113-119. DOI: 10.30870/biodidaktika.v17i1.16110. [Indonesian]

Chong VC, Low CB, Ichikawa T. 2001. Contribution of mangrove detritus to juvenile prawn nutrition: A dual stable isotope study in a Malaysian mangrove forest. Mar Biol 138: 77-86. DOI: 10.1007/s002270000434.

Costa P, Dórea A, Mariano-Neto E, Barros F. 2015. Are there general spatial patterns of mangrove structure and composition along estuarine salinity gradients in Todos os Santos Bay? Estuar Coast Shelf Sci 166: 83-91. DOI: 10.1016/j. ecss.2015.08.014.

Das S, Crépin AS. 2013. Mangroves can provide protection against wind damage during storms. Estuar Coast Shelf Sci 134: 98-107. DOI: 10.1016/j.ecss.2013.09.021.

Descasari R, Setyobudiandi I, Affandi R. 2016. The relationship between mangrove ecosystem and fish diversity in Pabean Ilir and Pagirikan, Indramayu District, West Java. Bonorowo Wetlands 6 (1): 43-58. DOI: 10.13057/bonorowo/w060104.

Dorenbosch M, van Riel MC, Nagelkerken I, van der Velde G. 2004. The relationship of reef fish densities to the proximity of mangrove and seagrass nurseries. Estuar Coast Shelf Sci 60 (1): 37-48. DOI: 10.1016/j.ecss.2003.11.018.

El-Regal MA, Ibrahim NK. 2014. Role of mangroves as a nursery ground for juvenile reef fishes in the southern Egyptian Red Sea. Egypt J Aquat Res 40 (1): 71-78. DOI: 10.1016/j.ejar.2014.01.001.

Ermgassen PSEz, Mukherjee N, Worthington TA, Acosta A, Araujo ARdRA, Beitl CM, Castellanos-Galindo GA, Cunha-Lignon M, Dahdouh-Guebas F, Diele K, Parrett CL, Dwyer PG, Gair JR, Johnson AF, Kuguru B, Lobo AS, Loneragan NR, Longley-Wood K, Mendonça JT, Meynecke J-O, Spalding M. 2020. Fishers who rely on mangroves: Modelling and mapping the global intensity of mangrove-associated fisheries. Estuar Coast Shelf Sci 247: 106975. DOI: 10.1016/j.ecss.2020.106975.

Fekri L, Affandi R, Rahardjo MF, Budiardi T, Simanjuntak CPH, Fauzan T, Indrayani. 2018. The effect of temperature on the physiological condition and growth performance of freshwater eel elver *Anguilla bicolor bicolor* (McClelland, 1844). Jurnal Akuakultur Indonesia 17 (2): 181-190. DOI: 10.19027/jai.17.2.181-190.

Fekri L, Affandi R, Rahardjo MF, Budiardi T, Simanjuntak CPH. 2019. Growth of stunted elver of the Indonesian shortfin eel *Anguilla* *bicolor* McClelland, 1844 rearing in semi-natural media. Indones J Ichthyol 19 (2): 243-257. DOI: 10.32491/jii.v19i2.481.

Fekri L, Affandi R, Rahardjo MF, Budiardi T, Simanjuntak CPH. 2020. Stunting of elver *Anguilla bicolor bicolor* McClelland, 1844: Innovation in the framework restocking. [Dissertation]. Institut Pertanian Bogor, Bogor. [Indonesian]

Fekri L, Budiardi T, Affandi R. 2019. Technique for restocking eel seeds in fresh waters. IPB Press, Bogor. [Indonesian]

Fekri L, Pangerang UK, Halili. 2021. Favorite food of eels (*Anguilla marmorata*) in the Bombana River, Southeast Sulawesi. Warta Iktiologi 5 (1): 27-31. [Indonesian]

Guest MA, Connolly RM. 2004. Fine-scale movement and assimilation of carbon in saltmarsh and mangrove habitats by resident animals. Aquat Ecol 38: 599-609. DOI: 10.1007/s10452-005-0442-9.

Herman, Rolan, Ilimu, Hamid, Haeruddin. 2011. Analysis of mineral content in nipa fruit ash (*Nypa Fructicans*) Kaliwanggu Bay Kendari Southeast Sulawesi. J Trop Pharm Chem 1 (2): 104-110. DOI: 10.25026/jtpc.v1i2.17. [Indonesian]

Hewindati YT, Yuliana E, Winata E, Adimu HE, Djatmiko WA. 2023. Mangrove vegetation and fish diversity in Kaledupa Island, Wakatobi National Park, Southeast Sulawesi, Indonesia. Biodiversitas 24 (3): 1766-1772. DOI: 10.13057/biodiv/d240351.

Jambeck JR, Geyer R, Wilcox C, Siegler TR, Perryman M, Andrady A, Narayan R, Law KL. 2015. Plastic waste inputs from land into the ocean. Science 347 (6223): 768-771. DOI: 10.1126/science.1260352.

Jisr N, Younes G, Sukhn C, El-Dakdouki MH. 2018. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. Egypt J Aquat Res 44 (4): 299-305. DOI: 10.1016/j.ejar.2018.11.004.

Karuwal J, Bagafih A. 2016. The influence of the moon day period to the catch anchovies (*Stelophorus* spp.) and its relationship to the physical waters factor by boat lift net. J Inf Innov Agrofor Environ Small Isl Sci Technol 11 (3): 177-187.

Laegdsgaard P, Johnson CR. 1995. Mangrove habitats as nurseries: Unique assemblages of juvenile fish in subtropical mangroves in Eastern Australia. Mar Ecol Prog Ser 126 (1-3): 67-81. DOI: 10.3354/meps126067.

Lugendo BR, Pronker A, Cornelissen I, de Groene A, Nagelkerken I, Dorenbosch M, van der Velde G, Mgaya YD. 2005. Habitat utilization by juveniles of commercially important fish species in Chwaka Bay, Zanzibar, Tanzania. Aquat Living Resour 18 (2): 149-158. DOI: 10.1051/alr:2005016.

Mehanna SF, Farouk AE. 2021. Length-weight relationshipof 60 fish species from the Eastern Mediterranean Sea, Egypt (GFCM-GSA 26). Front Mar Sci 8: 625422. DOI: 10.3389/fmars.2021.625422.

Nagelkerken I, van der Velde G. 2004b. Relative importance of interlinked mangroves and seagrass beds as feeding habitats for juvenile reef fish on a Caribbean Island. Mar Ecol Prog Ser 274: 153-159. DOI: 10.3354/meps274153.

Nalarati LOL, Ola, Siang RD. 2016. Analysis of seaweed fishermen's exchange rate in Ranooha Raya Village, Moramo District, South Konawe Regency. J Fish Socioecon 1 (1): 1-9.

Nazeef S, Yerima R. 2023. Interpretation of allometric growth pattern of fish species from Dadin-Kowa Reservior. Bima J Sci Technol 7 (1): 62-71. DOI: 10.56892/bima.v7i01.389.

Olopade OA, Dienye HE, Nworgu UC. 2019. Estimation of growth, mortality, and exploitation status of nurse tetra (*Brycinus nurse*) and true big scale tetra (*Brycinus macrolepidotus*) (Family: Alestidae) from the New Calabar River, Nigeria. Indonesian. Indones Fish Res J 25 (2): 113-122. DOI: 10.15578/ifrj.25.2.2019.113-122.

Orio A. 2019. Understanding the spatiotemporal dynamics of demersal fish species in the Baltic Sea. [Thesis]. Swedish University of Agricultural Sciences, Lysekil.

Palit K, Rath S, Chatterjee S, Das S. 2022. Microbial diversity and ecological interactions of microorganisms in the mangrove ecosystem: Threats, vulnerability, and adaptations. Environ Sci Pollut Res Intl 29 (22): 32467-32512. DOI: 10.1007/s11356-022-19048-7.

Parrish JD. 1989. Fish communities of interacting shallow-water habitats in tropical oceanic regions. Mar Ecol Prog Ser 58: 143-160. DOI: 10.3354/meps058143.

Permana A, Wahju RI, Soeboer DA. 2017. Moon phase effect of lobster (*Panulirus homarus*) catches in Palabuhanratu Gulf, Sukabumi District. Jurnal Teknologi Perikanan dan Kelautan 7 (2): 137-144. DOI: 10.24319/jtpk.7.137-144. [Indonesian]

Pinto L, Punchihewa NN. 1996. Utilisation of mangroves and seagrasses by fishes in the Negombo Estuary, Sri Lanka. Mar Biol 126: 333-345. DOI: 10.1007/BF00347457.

Rajab A, Bahtiar, Salwiyah. 2016. Study on density and distribution of Lahubado (*Glauconome* sp) in Staring Bay of Ranooha Raya, South Konawe. Jurnal Manajemen Sumber Daya Perairan 1 (2): 103-114. [Indonesian]

Rodelli MR, Gearing JN, Gearing PJ, Marshall N, Sasekumar A. 1984. Stable isotope ratios as a tracer of mangrove carbon in Malaysian ecosystems. Oecologia 61 (3): 326-333. DOI: 10.1007/BF00379629.

Sari A, Tuwo A, Saru A, Rani C. 2022. Diversity of fauna species in the mangrove ecosystem of Youtefa Bay Tourism Park, Papua, Indonesia. Biodiversitas 23 (9): 4490-4500. DOI: 10.13057/biodiv/d230915.

Septiana A, Jamili, Harlis WO, Analuddin K. 2016. Bioprospecting mangroves: Antioxidant source and habitat for the endemic *Bubalus* sp. in Rawa Aopa Watumohai National park, Indonesia. Malays Appl Biol 45 (1): 23-34.

Sheaves M, Molony B. 2000. Short-circuit in the mangrove food chain. Mar Ecol Prog Ser 199: 97-109. DOI: 10.3354/meps199097.

Sihombing VS, Gunawan H, Sawitri R. 2017. Diversity and community structure of fish, plankton and benthos in Karangsong Mangrove Conservation Areas, Indramayu, West Java, Indonesia. Biodiversitas 18 (2): 601-608. DOI: 10.13057/biodiv/d180222.

Tumoro R. Christanto J. 2012. Potential of marine tourism in Tanjung Tiram Village, North Moramo District, South Konawe District, Southeast Sulawesi Province. Jurnal Bumi Indonesia 1 (2): 300-308. [Indonesian]

Tzeng W-N, Wang Y-T. 1992. Structure, composition and seasonal dynamics of the larval and juvenile fish community in the Mangrove Estuary of Tanshui River, Taiwan. Mar Biol 113: 481-490. DOI: 10.1007/BF00349175.

Viadero R. 2019. Water quality factors affecting fish growth and production. Water Encyclopedia 3: 129-133. DOI: 10.1002/9781119300762.wsts0119.

Wahyudewantoro G. 2018. The fish diversity of mangrove waters in Lombok Island, West Nusa Tenggara, Indonesia. Biodiversitas 19 (1): 71-76. DOI: 10.13057/biodiv/d190112.

Weinstein MP, Heck Jr. KL. 1979. Ichthyofauna of seagrass meadows along the Caribbean coast of Panamá and in the Gulf of Mexico: Composition, structure and community ecology. Mar Biol 50: 97-107. DOI: 10.1007/BF00397814.

Yapanto LM, Nurdiansah DP, Noho Y, Paramata AR, Musa DT. 2021. Mangroves and different health conditions of mangrove forests in North Lembeh Waters. Ann Rom Soc Cell Biol 25 (6): 3016-3025. DOI: 10.31219/osf.io/28hzu.

Yuliana E, Winata A, Adimu HE, Hewindati YT, Djatmiko WA. 2022. Reef fish in the mudflats of Kaledupa Island in Wakatobi National Park, Indonesia. Hayati J Biosci 29 (2): 245-254. DOI: 10.4308/hjb.29.2.245-254.