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Hasan Sitorus
Department of Fisheries, Nommensen HKBP University, Jl. Sutomo No. 4 A Medan, North Sumatera, Indonesia

Indra Lesmana
Department of Aquatic Resource Management, University of North Sumatera, Medan, Indonesia, Jl. Prof. A. Sofyan No. 3 Campus USU, Medan, North Sumatera, Indonesia

Ria Tarigan
Department of Aquatic Resource Management, University of North Sumatera, Medan, Indonesia, Jl. Prof. A. Sofyan No. 3 Campus USU, Medan, North Sumatera, Indonesia

Correspondence
Hasan Sitorus
Department of Fisheries, Nommensen HKBP University, Jl. Sutomo No. 4 A Medan, North Sumatera, Indonesia

Relationship of mangrove density with fish diversity in the waters of mangrove area at Lubuk Kertang Village, Langkat District of North Sumatera

Hasan Sitorus, Indra Lesmana and Ria Tarigan

Abstract
Mangrove ecosystem is one among of the several ecosystems that is found in coastal areas. Mangrove in Lubuk Kertang Village managed together by local peoples to fufill the needs of their community. The present study was aimed to know the mangrove density, fish diversity, and the correlation of mangrove density to fish diversity. Research was conducted by using survey method with three times sampling for two months. Mangrove species that were reported at the research site consists of 10 species of the *Rhizophora apiculata*, *Rhizophora stylosa*, *Avicennia alba*, *Avicennia lanata*, *Avicennia marina*, *Soneratia alba*, *Bruguiera sexangula*, *Acanthus ilicifolius*, *Excoecaria agallocha*, dan *Scyphiphora hydrophyllaceae*. The kind of fish species that were found in the research site consists of 16 species that belonged to the 5 orders, 15 families, 15 genera that was *Gymnothorax tile*, *Epinephelus fuscoguttatus*, *Plotosus canius*, *Johnius trachycephalus*, *Valamugil engeli*, *Scatophagus argus*, *Carangoides praeustus*, *Gerres filomentosus*, *Lutjanus fulviflamma*, *Leiognathus equulus*, *Lutjanus johnii*, *Hemaloptera ocellata*, *Butis amboinensis*, *Batrachomoeus trispinosus*, *Bodianus izuensis*, and *Pomadasys argenteus*. The fish species diversity index was 1.972 (moderatly), and correlation coefficient of mangrove density to fish diversity was 0.876 (very strong).

Keywords: Mangrove vegetation, fishes diversity, Lubuk Kertang Village

1. Introduction
1.1 Background
One of the ecosystem in coastal area that has important role for sustainale fisheries is Mangrove ecosystem. At coastal zone of Indonesia, mangrove ecosystem is generally found that relation to the tidel cycles. Mangrove forest is very important to support the ecomical of costal zone communities [28].

The area mangrove in Indonesia is almost 23% of world mangrove area [8]. At present, mangrove forest are degradated by several factors. The main causes of the mangrove degradation in Indonesia is the changes of mangrove function because the mangrove area has been converted to brackishwater culture area. Beside that, the cutting of mangrove trees for making charcoal and firewood accelerate the degradation of mangrove forest and causes the instability of mangrove ecosystem [7, 8].

Physical structure of mangrove gives protection for small nectons from predators by reducing visuliazation of predator. As a part of coastal ecosystem, mangrove has highly productivity near to 5,000 g C/m2/year, and about 95% of its production enter to the coastal waters as detritus and become potensial source of nutrient for organisms in waters [13, 9].

Characteristics of steady state mangrove ecosystem is the stability of structure, composition and diversity of communities in mangrove ecosystem. Species diversity is generally used as key parameter to describe the richness of species and its balance in community. Ecosystem which has low diversity tend to low stability and more sensitive to external perturbations compared to high diversity [14].

Relation to marine fisheries aspects, the mangrove is very important to the life cycle of fishes, shrimp, oyster, crab and others sea organism. Mangrove ecosystem became as spawning ground, nursery ground and feeding ground for them both as resident species or migration species [17, 1].

In several years later, the local community at Lubuk Kertang Village witness the decrease of

fish catch linked to the mangrove degradation. Local peoples believe that the decreasing of fish catcth both kind of fish species and total fish catch related to the mangrove deforestation.

Mangrove forest at Lubuk Kertang Vilage, West Brandan, Langkat District has been degradated since 2005, and now the area of mangrove forest only 1,200 hectares [24]. Lubuk Kertang Village is one village that located in coastal area of West Brandan Subdistrict, Langkat District of North Sumatera. The use of mangrove for ecotourism, mangrove deforestation for firewood and brackishwater culture development, and other utilizations has made negative impact on the natural function of mangrove ecosystem, and become vulnerable environment in coastal areas was such a study conducted in the given area.

1.2 Objectives of the Research

The objectives of the research are to analize the mangrove vegetation, fish diversity, correlation of mangrove forest density to the fishes diversity at Lubuk Kertang Village, Langkat District.

1.3 Useful of the Research

The importance of the research is a base information about mangrove condition, species diversity of fishes and water qualities in mangrove area that could be used in mangrove management by local peoples or local government of Lubuk Kertang Village, Langkat District.

2. Materials and Methods

2.1 Time and Location of Research

The research had been conducted on March to April, 2017 at mangrove ecosystem area of Lubuk Kertang Village, Langkat District of North Sumatera, Indonesia. Sampling was done three times with two weeks interval for two months. Setting of research site was based of purposive method by considering of community activitites at mangrove areas. Station I was the natural mangrove area (no activity), Station II was the fishing area of local peoples, and Station III was the resettlement area of local peoples. Identification of mangrove vegetations carried out insitu, while the fish identification was carried out at the Laboratory of Faculty of Agricultural, University of North Sumatera.

2.2 Procedures of Research

Data Colletion of Mangrove Vegetation

Collection of primary data of researh involve the kind of mangrove species and mangrove density. The data used to analize the Important Value Index (IVI), and Diversity Index of mangrove species. Data collected by using transect method of 10 x 10 m square in each station. Analysis of mangrove vegetation based on Survey Method of Vegetation by Kusmana (1997) [12], and identification of mangrove species based on Guidance for Mangrove Study in Indonesia by Noor *et al*. (2012) [16].

Data Collection of Fishes

Sampling of fishes was carried out by using gill net with three times in each station in order to collect the data of fish species, and amount of fish. Fix gill nets was installed on waters at 4.00 pm and hauling at 8.00 am tomorrow morning. The data used to analize the fish diversity index in each station. Identification of fish based on Saanin (1984) and Kottelat *et al.* (1993) [22, 11]

Data Colletion of Water Parameters

Measurement of physic and chemical parameters was carried out three times at each station with two weeks interval period. Water sampling at mangrove area was carried out between 16.00 pm to 18.00 pm in low tide level. All parameters were compared to Sea water Quality Standard from Ministry of Enviroment No. 51 of 2004 by using Storet Method.

2.3 Data Analysis

Data of mangrove vegetation and fishes in each station analized by using formula from Odum (1983) and Bengen (2000) [17, 1] to determine the important value index, mangrove diversity index, fish diversity index. While the correlation of mangrove density (X) to fish diversity (Y) analized by using linier regression from Steel and Torrie (2003) with model $Y = a + bX$.

3. Results and Discussion

3.1 Mangrove Vegetation

Mangrove vegetation analysis at Lubuk Kertang Village by using transect method has found 10 species which are presented in Table 1.

Table 1: Mangrove Species at Lubuk Kertang Village, Langkat District

No.	Mangrove Species	Local Name	St. I	St. II	St. III
1.	*Rhizophora apiculata*	Bakau	✓	✓	✓
2.	*Rhizophora stylosa*	Bakau	✓	✓	✓
3.	*Avicennia alba*	Api-api	✓	✓	✓
4.	*Avicennia marina*	Api-api	✓	-	-
5.	*Avicennia lanata*	Api-api	✓	-	-
6.	*Sonneratia alba*	Pidada	✓	✓	✓
7.	*Bruguiera sexangula*	Mata Buaya	✓	✓	✓
8.	*Excoecaria agallocha*	Buta-buta	✓	✓	✓
9.	*Acanthus ilicifolius*	Jeruju	✓	✓	-
10.	*Scyphiphora hydrophyllaceae*	Cingam	✓	✓	-
	Total of Species		10	8	6

Note : ✓ = present; - = no present

Trees Density

At Station I, 10 spesies of mangrove were recorded which include *Rhizophora apiculata, Rhizophora stylosa, Avicennia alba, Avicennia lanata, Avicennia marina, Sonneratia alba, Bruguiera sexangula, Acanthus ilicifolius, Excoecaria agallocha*, and *Scyphiphora hydrophyllaceae*. The highest density was for *Avicennia alba* of 967 trees/hectare and the lowest density was for *Sonneratia alba* of 333 trees/hectare. The difference of density might be related to high salinity of the water because of the area facing to the sea waters. The species of *Avicennia alba* prefers to high salinity for growing [6]. Beside that, the type of substrate in the station is influence on the suitable of habitat for its species to grow. According to Noor *et al*. (2012) [16], *Avicennia alba* goodly grow in sandy-loam substrate habitat at coastal zone that facing to open sea with high salinity.

While at Station II, 8 species of mangrove were found viz. *Rhizophora apiculata, Rhizophora stylosa, Avicennia alba, Acanthus illicifolius, Sonneratia alba, Bruguiera sexangula, Excoecaria agallocha* and *Scyphiphora hydrophyllaceae*. The highest density was for *Rhizophora apiculata* of 867 trees/hectare and the lowest density was for *Sonneratia alba* and *Scyphiphora hydrophyllaceae* of 233 trees/hectare. The highest density of *Rhizophora apiculata* supposed relation to the type substrate that suitable for its species for growing.

Rhizophora apiculata was very suitable growing at sandy-loam substrate type at mangrove area [10].

At the Station III, 6 species of mangrove were found which include *Rhizophora apiculata, Rhizophora stylosa, Avicennia alba, Sonneratia alba, Bruguiera sexangula,* and *Excoecaria agallocha*. The highest density was for *Sonneratia alba* of 767 trees/hectare and the lowest density plant was *Avicennia alba* of 167 trees/hectare. The highest density of its species was supposed related to kinds of substrate in this Station. Analysis of substrate showed that the substrate type was terestrial sandy-clay. The species of *Sonneratia alba* prefer to grow at sandy-clay substrate [27, 2].

The highest average density of mangrove trees was found at Station I of 548 trees/hectare, and the lowest density goes to Station III of 416 trees/hectare (See Table 2).

Table 2: Average Density of Mangrove at Each Station of Observation

No	Mangrove Species	Density (Trees/hectare)		
		1	2	3
1	*Rhizophora apiculata*	533	867	463
2	*Avicennia alba*	967	333	167
3	*Avicennia lanata*	567	-	-
4	*Rhizophora stylosa*	400	633	333
5	*Avicennia marina*	633	-	-
6	*Sonneratia alba*	333	233	1,033
7	*Scyphiphora hydrophyllaceae*	400	233	-
8	*Bruguiera sexangula*	-	367	433
9	*Excoecaria agallocha*	-	-	333
Total		3,833	2,666	2,496
Average per Species		548	445	416

The difference of average density at each station was caused by internal and external factors. Internal factors include type of substrate, nutrient availability in substrate, water quality in each station, development stage of mangrove ecosystem, and adaptation ability of mangrove to the habitat changes. While the external factors include cutting of mangrove tree, land corvertion to aquaculture area, resettlement area, and ecotourism area, and pollutant which was disposed by local peoples. The density level and diversity of mangrove indicated the condition of mangrove regeneration [13].

At Station I, the total density of mangrove trees was 3,833 trees/hectare, at Station II was 2,666 trees/hectare, and Station III was 2,496 trees/hectare. This mangrove trees density indicated that mangrove forest at Lubuk Kertang Village was still good condition compared to mangrove standar density from Regulation of Ministry of Environment No. 51 of 2004 that arrange density more than 1,500 trees/hectare was categorized high density and mangrove in good condition.

Important Value Index of Mangrove

The intensity of vegetation impact on the coastal area was determined by Important Value Index (IVI) of vegetation species. IVI was influenced by frequency and diameter of trees species.

Table 3: Important Value Index of Mangrove Species

No.	Name of Species	Station I	Station II	Station III
1.	*Rhizophora apiculata*	44.69	69.64	56.60
2.	*Avicennia alba*	57.22	49.65	29.81
3.	*Avicennia lanata*	45.80	-	-
4.	*Rhizophora stylosa*	35.56	61.36	43.18
5.	*Avicennia marina*	47.74	-	-
6.	*Sonneratia alba*	33.09	31.55	78.28
7.	*Scyphiphora hydrophyllaceae*	14.63	37.90	-
8.	*Bruguiera sexangula*	-	49.98	48.96
9.	*Excoecaria agallocha*	-	-	-
	Total	300	300	300

The highest Important Value Index (IVI) at Station I own by *Avicenia alba*, Station II of *Rhizophora apiculata*, and Station III of *Sonneratia alba*. It was supposed related to substrate type in each station that influenced the environment carrying capacity. Smilar type of results were reported by Parmadi *et al*. (2016)

3.2 Fish Diversity

Based on the fish sampling by using gill net at waters of mangrove area at Lubuk Kertang Village had reported 16 species of fish that belonged to the 5 orders, 15 families, and 15 genera (Table 4).

Table 4: Fish Species in Waters of Mangrove Area at Lubuk Kertang Village

Order and Family	Genera	Species	St. I	St. II	St. III
Order Anguiliformes					
Family Muraenidae	Gymnothorax	*G. tile*	✓	✓	✓
Order Batrachoidiformes					
Family Batrachomoidae	Batrachomoeus	*B. trispinosus*	✓	✓	-
Order Cypriniform					
Family Balitoridae	Hemaloptera	*H. ocellata*	✓	✓	✓
Order Perciformes					
Family Cangidae	Carangoides	*C. praeustus*	✓	-	-
Eleotrididae	Butis	*B. amboinensis*	✓	✓	✓
Gerreidae	Gerres	*G. filamentosus*	-	-	✓
Haemulidae	Pomadasys	*P. argenteus*	-	✓	✓
Labridae	Bodianus	*B. izuensis*	✓	-	-
Leiognathidae	Leiognathus	*L. equulus*	✓	✓	✓
Lutjanidae	Lutjanus	*L. fulfiflamma*	-	✓	-
		L. johnii	✓	-	✓
Mugilidae	Valamugil	*V. engeli*	✓	✓	-
Scatophagidae	Scatophagus	*S. argus*	✓	-	-
Sciaenidae	Johnius	*J. trachycephalus*	✓	✓	-
Serranidae	Ephinephelus	*E. fuscoguttatus*	✓	✓	✓
Order Siluriformes					
Family Plotosidae	Plotosus	*P. canius*	✓	✓	✓
Total Species			12	11	9

At Station I, 12 species of fish were recorded, at Station II, 11 species of fish were reported, while at Station III were 9 species of fish. All of the fish species was dominated by Order Perciformes. The difference in number of species was caused by the different of environmental condition in each station. According to Latupapua (2011) and Eddy (2013) [14,4], environmental factor highly influence on the diversity and abundance of fishes in the ecosystem.

The fish catch had varied size from young stage to adult fish. It was related to the ecological function of mangrove as nursery ground for fish larvae and fries [15]. Mangrove has alot of detritus as source of nutrient to waters that utilized by phytoplankton as natural feeds for fishes. There was strong relationship between of detritus available in waters with fish abundances and biomass of producers in mangrove ecosystem [23].

The highest fish diversity was found at Station I because of location facing to the open sea water and had good mangrove condition based on trees density. While the lowest fish diversity found at Station III due to location that had been used as ecotourism area. The development of ecotourism at Station III such as building of bridge and other facilities had made the degradation of mangrove vegetation. The total species of fish at Station II was less than Station I due to mangrove utilized as source of wood for building and firewood caused the decrease of trees density that influenced on fish diversity.

Diversity Index and Evenness Index of Fish Species

The highest Diversity Index of fish species was found at Station I, and the lowest Diversity Index was found at Station III (See Table 5). While the Evenness Index show the highest value own by Station III, and the lowest Evenness Index own by Station I. The difference of Diversity Index and Evenness Index is related to different density of mangrove in each station. The density of mangrove vegetation give influence on the richness of fish species at waters around of mangrove area [17, 29].

Table 5: Diversity Index (H') and Evenness Index (E') of Fish Species

Keterangan	Station I	Station II	Station III	Mean
Diversity Index (H')	1.991	1.977	1.929	1.972
Evenness Index (E')	0.801	0.832	0.877	0.837

The mean value of Diversity Index of fish species of 1.972 means moderatly condition which indicate the mangrove condition goes to moderate stability level [17, 13]. This is due to the external perturbations by human activities at mangrove ecosystem.

3.3 Correlation of Mangrove Density to Fish Diversity

Table 6 showed that the mangrove trees density had relation to fish diversity. The increase in plant density result in increase in fish diversity. This is related to the availability of organic matter and detritus in the mangrove ecosystem that enter to the waters and ulitized by aquatic organisms. This condition accordanced to Odum (1983) and Indriani *et al*. (2012) [17, 9] that mangrove density influence the abundance and fish diversity in waters around of mangrove area.

Based on the linier regression analysis found the regression equation of variable mangrove density (X) with variable fish diversity (Y) was Y = 1.606 + 0.019 X. The increased one unit of mangrove density would increase the fish diversity of 1.606 unit. Correlation coefficient (R) was 0.876 and determination coefficient (R^2) was 0.767. It means that mangrove density had strong correlation to fish diversity at Lubuk Kertang Village, Langkat District. Beside that, as much 76.7% of variable fish diversity was affected by mangrove density variable. This correlation had proved the theory of Odum (1983) which stated the mangrove density influenced on the community structure at mangrove ecosystem.

Table 6: Mangrove Density and Fish Diversity at Lubuk Kertang Village

Items	Station I	Station 2	Station 3
Mangrove Density (trees/hectare)	3,833	2,666	2,496
Sum of Fish Species	12	11	9

3.4 Water Quality Parameters

Chemical parameters of water quality that measured at mangrove area included salinity, pH, and Dissolved Oxygen (DO) of waters, while physical parameter was substrate type. The result related to physic-chemical parameters are given in Table 7.

Table 7: Parameters Value of Water Quality at Each Station Observed

Parameters	Standard	Station I	Station II	Station III
Temperature	28-32 °C	29.7	30.0	29.7
Salinity	max 30 ppt	25.6	24.2	25.1
pH	6.5-8,5	6.6	6.7	6.7
DO	> 5ppm	6.3	6.3	6.4
Substrate Type	-	(Sandy-Clay-Loam)	(Sandy-Loam)	(Sandy-Clay)

Standard from Ministry of Environment No. 51 of 2004

The water temperatures at mangrove area ranges between 29.7 – 30.0 ^oC. This temperature is suitable for mangrove life and aquatic organism because the temperature near to the standard value from Ministry of Environment No. 51 of 2004. Its means that temperature support the life of all organism in mangrove ecosystem. According to Humaidy (2010) and Wantasen (2013) [8, 30] the mangrove vegetation has limit minimum temperature of 20 ^oC and maximum temperature of 40 ^oC for growing in nature.

Parameter of salinity has value between 24.2 to 25.6 ppt which below of salinity standard. Its means that salinity is appropriate to support the mangrove life and aquatic organism in waters of mangrove ecosystem. The optimum of salinity for mangrove gowth ranges between 10 – 30 ppt [5, 6]. Therefore, the salinity of waters is suitable for mangrove life.

Dissolved oxygen (DO) in the waters at mangrove area ranges between 6.3 to 6.4 ppm that suitable for fish life. DO standard for aquatic life more than 5 ppm, so the DO value in waters is very support to all aquatic organism in mangrove ecosystem. The difference of DO in each station was due to the different of temperature, and salinity of waters.

Parameter of acidity level (pH) of waters had range 6.6 – 6.7, that means acid to netral condition. This pH was still suitable for aquatic life in mangrove ecosystem, because the standard of pH was 6.5 to 8.5 for brackishwater and sea water. The ranges of pH between 6.0 to 9.0 was still toleranced by sea water organism for growth [30].

3.5 Recommendation for Mangrove Management

Several recommendations could be proposed to manage the mangrove ecosystem at Lubuk Kertang Village, Langkat District, i.e : a) stop the cutting of mangrove trees for fire wood and building materials by impelemtation the government regulation, b) develop silvofishery system at mangrove ecosystem to gain the sustainable of mangrove utilization, c) to develop community based management.

Implementation of government regulation which was published by Ministry of Environmental and Forestry (P.16/Menhut-II/2014) was very important to avoid the mangrove degradation caused by all human activities at around mangrove area. One alternative to develop the sustainable mangrove utilization was the development of silvofishery culture by local peoples without convertion the mangrove land to brackishwater culture area. To gain the high effectiveness of mangrove management at Lubuk Kertang Vilage, it was suggested to build the community based management included controling and conservation of mangrove resouces.

4. Conclusions

1. Mangrove vegetation at Lubuk Kertang Village, Langkat District still good condition, consist of 16 species that belonged to 5 orders, 15 families and 15 genera. The mangrove density at Station I was 3,833 trees/hectare, Station II was 2,666 trees/hectare, and Station III was 2,496 trees/hectare.
2. Fish diversity at mangrove ecosystem consist of 16 species that belonged to the 5 orders, 15 families, and 15 genera.. The fish species at Station I was 12 species, Station II was 11 species, and Station III was 9 species, and Fish Diversity Index was 1.972 (moderatly condition).
3. The mangrove density had strong correlation to fish diversity (R : 0.876) at Lubuk Kertang Village, Langkat District.

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