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Species Diversity of Seagrass-Associated Bivalves as an Ecological Parameter to Support Seagrass Conservation Along the Coastal Waters of South Lombok, Indonesia.

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Abstract. Seagrasses can be found in coastal environments, and they play a role in providing habitat to marine life such as bivalves. This study aims to assess the value of the primacy of the existence of seagrass as a habitat for bivalves species diversity. The research method utilizes observation and transect quadrant for mapping bivalve habitats in seagrasses. Data analysis is carried out through statistical analysis and Pearson correlation. The results found 44 species of bivalves, spanning 11 families, where the family with the highest number of species was Veneroidae. The highest number of species was found in Gili Kere, with a total of 22 species (55%), and the lowest number of species was found in Lungkak and Gerupuk, with a total of nine species (22.5%). The only species found in all locations was *Anadara antiquate*. Correlation results (Pearson r = 0.1–0.9). The average value of the pH variable lay between 7.6 ppt and 8.04 ppt, temperature 25.67°C and 26.21°C, salinity between 24.91 ppt and 33.5 ppt, phosphate between 0.8 mg/L and 1.93 mg/L, dissolved oxygen (DO) between 6.43 mg/L and 7.76 mgL, brightness between 5.84 m and 7.99 m and nitrates between 0.2 mg/L and 0.92 mg/Ll. Based on the measurement results, these parameters are still within normal limits. This means that these conditions are still good and can support marine life optimally. The diversity of bivalve species associated with seagrass in the study location is a piece of ecological evidence supporting the significance of seagrass for the preservation of marine life.

Keywords: Species Diversity, Seagrass, Ecological, Bivalvia and Conservation

I. Introduction

Pelecypoda bivalvia is a class in the Mollusca phylum, which includes all shellfish, and their main characteristic is that they have a body that is as tall as. Animals belonging to the bivalvian class inhabit muddy places such as in coastal areas and lakes, and they are often found at depths of 0.01 to 5000 meters (Matozzo et al., 2012). In water bodies, bivalves live as infauna and epifauna (Lazo, 2004). Bivalves as epifauna associated with seagrass live by immersing themselves in a water substrate, while bivalves as infauna live by crawling on the substrate (Vermeij, 2017). Bivalves have a high diversity of species and are widespread in various marine habitats, including the intertidal zone (tidal). The tidal site is a coastal area located between the highest and lowest tide (Esqueda et al, 2000; Short et al., 2007). Based on environmental/substrate conditions, the tidal zone is divided into rocky, sandy, and muddy substrates. The local distribution of bivalves spatially and their growth depends on the characteristics of the substrate, temperature, and water currents, which can determine the diversity of bivalves (Bódis et al., 2011; Crame, 2000). Habitat conditions (substrate quality), the number and species of available food, and interactions between ecosystems in coastal waters, supported by several oceanographic factors such as tides, also influence bivalve distribution (Champion et al., 2020; Hyrenbach et al., 2002). They are mostly found in sandy and muddy substrate types but are also often found on rigid substrates such as corals (Gingras et al., 2001; LukeNeDer, 2008).

Bivalves play an essential role both from economic and ecological perspectives. Some bivalves have a tremendous significance, constituting food sources with high economic value, raw materials for decorative crafts, and building materials (Deutsch et al., 2011; Santhanam, 2018). Meanwhile, in terms of ecology, bivalves have a role in the food chain and determine the waters (Sousa et al., 2009). One of the factors that influence the abundance of bivalves in the tidal zone is the substrate condition (Bateman & Bishop, 2017; Hosack et al., 2006). The substrate is a surface or medium to which living things attach themselves and grow. Each type of substrate has a content of materials – organic is different – such that the substrate affects the preferences of habitat, deployment, and composition of the species of animals benthic such as scallops sea (Best & Kidwell, 2016). The substrate has an essential role in the life of bivalves. In general, bivalves living in the substrate determine the pattern of life, absence, and type of organisms (Bromley & Heinberg 2006; Brumbaugh & Coen, 2009). Some kinds of substrates in the study's location, namely sandy and rocky, sandy, muddy, sand are muddy and muddy sandy. The diversity of habitats and substrates that exist at the study location is believed to be the place to live for some types of shells (Abele et al., 2009; Lowery et al., 2007). Substrate damage will decrease the amount and even eliminate some types of bivalves (Chadwick et al., 2006). This is supported by the statement (de Souza et al., 2018) that an ecosystem's physical, chemical, and biological environment will affect the biota contained in it.

The relation of seagrass and bivalves is mainly expressed through chemosymbiotic associations. Lucinid bivalves support foundation species (seagrass) in the face of increasing anthropogenic impacts and global change (Chin et al., 2020). In this case, one of the seagrass ecosystem services is providing a habitat for a variety of invertebrate organisms (Lebreton et al., 2012; Nordlund & Gullström, 2013). However, the provision of seagrass ecosystem services varies, both in seagrass species and in the location of seagrass at different scales and regions (Nordlund et al., 2016). As evidence, their presence contributes to the abundance and diversity of bivalve species (Gagnon et al., 2020). Besides, environmental factors contribute to increasing the diversity and richness of bivalve species (Lukwambe et al., 2020; Lu et al., 2018). As mentioned by Altamirano et al. (2017), the organic material content of the substrate varies at each station, with the type of substrate. Organic matter content and substrate type can also influence the high or low density of bivalves. Meanwhile, Lee et al. (2016) states that the material of dissolved organic matter in sediments has been affected by the density growth of organisms such as bivalves. The finer the substrate texture, the greater is its ability to trap organic matter (Duniway et al., 2010). Furthermore, Seagrasses provide a diversity of habitats for bivalves communities. However, the ecological evidence of the presence of bivalve communities in seagrass beds has not become the main parameter in the conservation of coastal ecosystems. Meanwhile, the bivalve community in seagrass is the prey of the diversity of seabirds (Unsworth & Butterworth, 2021).

The development of seagrass conservation parameters is urgently needed at the study site, especially for the protection of marine biodiversity, such as bivalves communities. Previous studies explained that the association of fish with seagrass and their use through ecotourism can be an indicator of seagrass conservation at local and regional scales (Syukur et al., 2021a). In addition, the value of seagrass cover is a parameter that has a significant correlation in determining the species richness of bivalves at the micro scale (Syukur et al., 2021b). Therefore, the study of the ecological aspects of bivalves by seagrass habitat diversity, particularly in the study area is very important as a parameter for conservation. This study aims to describe the diversity of bivalves species associated with seagrass in the coastal waters of South Lombok . The results of this research can be scientific information on seagrass contribution to the preservation of marine life, especially bivalves community. In addition, the results of this research can be a scientific basis in the conservation of seagrass local scale, such as in the study area and other relevant locations

II. Materials and Method

2.1. Research sites

The research was carried out from April 2019 to July 2021, and the research location was the southern coastal area of Lombok Island (Figure 1). The coastal waters of the study location have an area of 1,255 hectares and have a seagrass ecosystem of about 156.9 hectares. This research location is the catchment area of traditional fishermen and is currently starting to be used for natural coastal tourism and marine cultivation (Syachruddin et al., 2018; Syukur et al., 2020). In addition, the location of seagrass beds in Lungkak and Poton Bakau is adjacent to mangrove areas, and that of the seagrass beds in Gili Kere (small island) is adjacent to coral reef ecosystems. Meanwhile, mangrove revegetation at two seagrass beds (Lungkak and Poton Bakau) has increased the value of fauna diversity, such as bivalves (Idrus et al., 2019). The research location, especially Kuta and Gerupuk Beach, is a tourism development area. Meanwhile, Teluk Awang is a location for the development of capture fisheries and aquaculture.

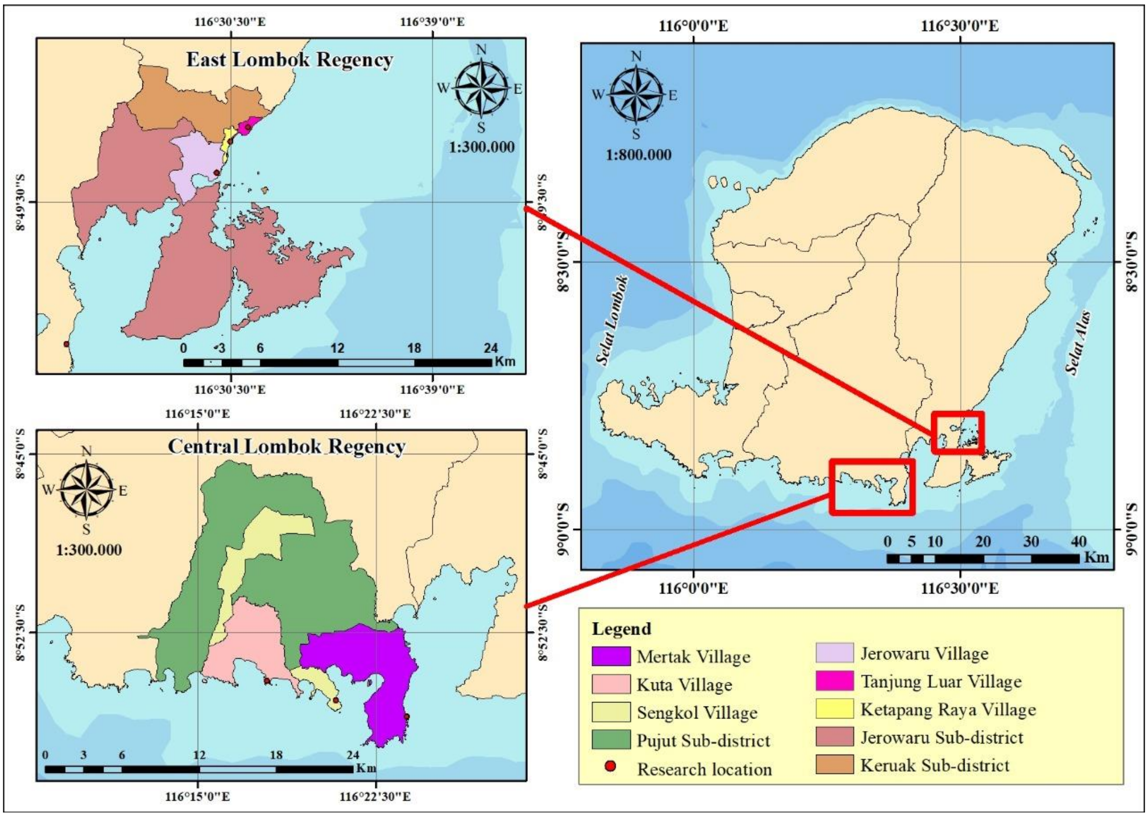


FIGURE 1. Map of research locations in coastal Lombok.

TABLE 1. Research locations and coordinates

No.	Location	X coordinate	Coordinate Y	Regency
1	Gili Kere	116 ° 31 '35,540 "E	8 ° 48 '14,544 "S	East Lombok Regency
2	Lungkak	116 ° 30 '27,092 "E	8 ° 47 '25,972 "S	East Lombok Regency
3	Poton Bako	116 ° 30 '16,614 "E	8 ° 48 '5,261 "S	East Lombok Regency
4	Pantai Kuta	116°16’59”E	8°53’45”S	Central Lombok Regency
5	Gerupuk	116°20’53”E	8°55’03”S	Central Lombok Regency
6	Awang	116°23’34”E	8°52’21”S	Central Lombok Regency

2.2. Data Collection and Analysis

The type of research in this study was descriptive and explorative, with the main focus on making a comprehensive description (research by observation), and the line-transect method and the quadratic method were used. The stages of bivalvia data collection were carried out at six locations of seagrass beds, namely in Gili Kere seagrass, Lungkak fields, Poton Bakau, Kuta, Awang and Gerupuk seagrass beds. Data were collected during the lowest low tide using a combined method of transect-line and quadratic. The transect line was used to follow the length of the intertidal area perpendicular to the coastline and the area of the square measuring 1 x 1 m^2. The transect line was drawn perpendicularly from the shoreline to the sea. Squares measuring 1 x 1 m^2 were drawn up in a systematic or straight line of transects. The distance between each square on the transect line was 10 meters. Sampling for each square was carried out using the free collection. Samples embedded in the substrate were taken by digging the substrate to a depth of 10 cm. Samples collected from the squares were immediately identified and counted. All samples were photographed for documentation. Assessment was carried out for the environmental parameters, which were the object of observation, constituting physical-chemical ecological parameters that are thought to have contributed to the presence of seagrass in the study location: a number of transects and their size at six study locations (Table 2).

TABLE 2. Number and size

Location	Substrate	Number of Transects	Size of Transects (m^2)
Gili Kere	Seagrass	9	315 m^2
Lungkak	Seagrass	9	135 m^2
Poton Bako	Seagrass	9	360 m^2
Kuta	Seagrass	9	190 m^2
Awang	Seagrass	9	150 m^2
Gerupuk	Seagrass	9	150 m^2

Analysis of research data was carried out using descriptive statistical analysis. Meanwhile, data analysis on the ecological index used several analyses, including abundance analysis, which utilizes the formula from Odum (1998), density analysis, and seagrass cover using the formula from Odum (1993). Furthermore, to see the relationship between environmental parameters and ecological indicators (safe diversity, uniformity, and dominance), the Pearson correlation formula was applied using SPSS 17 and the Microsoft Excel 2007 software.

III. Results and Discussion

3.1. Seagrass Composition in the Study Area

The results of this study, pertaining to the species composition of seagrass, consist of two families, which include nine types (Table 3). Furthermore, the seagrass species only existing in one location was *Halophila spinulosa.* According to Patty (2013), the mixed seagrass type is seagrass, which consists of more than one class and can reach eight or more categories. The results of this study are relevant to the research locations in the study (Poton Bakau and Gili Kere), which are indicated by the diversity of the seagrass species in these places (Table 3). A mixture of several seagrass species in a location is often found in the fields of seagrass in Indonesia (Liu et al., 2017). Furthermore, in addition to the eight species of seagrass associated with Aquatic Sea Flores, 11 species of seagrass are mutually associated with the Gulf of Kuta and the Gulf Gerupuk, South Lombok (Wainwright et al., 2018). The types of seagrass at three sampling locations in the study exemplify the potential diversity of seagrass species. It also describes the differences in the number of seagrass species at each field of seagrass in the area of the study. It can therefore be concluded that the diversity of seagrass species depends upon the conditions of the environment, such as the condition of the substrate, salinity and types of aquatic beach, and source of nutrients.

TABLE 3. Species of seagrass found studi location.

Lokasi	Name of Seagrass Species	Number of Species	% Cover of Seagrass ± SD
Gili Kere	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulate* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halophila ovalis* (Robert Brown) Hook f. 1858	7	75.33 ± 9.0

	Syringodium isoetifolium (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871		
Lungkak	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871 *Halophila spinulosa* (R. Brown) Ascherson, 1875	9	82.16 ± 2.3
Poton Bako	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871	8	79.5 ± 3.0
Kute	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium Isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871	8	71.18 ± 8.6
Awang	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium Isoetifolium* (Ascherson) Dandy, 1939	7	69.5 ± 0.7
Gerupuk	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871 *Halophila minor* (Zollinger) Den Hartog, 1957 *Thalassodendron ciliatum* (Forsskal) Den Hartog, 1970	10	77.5 ± 2.8

3.2. Composition of the Bivalve Species Found at Study Sites

Pelecypods (bivalves) are a class within the phylum mollusks that includes all shellfish. The results of the research at the study location found 44 species, including 11 families (Table 4), where the family with the highest number of species was Veneroidae. The highest number of species was found in Gili Kere, with a total of 22 species (55%), and the lowest number of species was found in Lungkak and Gerupuk, with a total of nine species (22.5%) (Table 5). The only species found in all locations was Anadara antiquate.

TABLE 4 Family and species of bivalves in the study location

Family	Name of species	Location					
		Gili Kere	Lungkak	Poton Bako	Kuta	Awang	Gerupuk
Veneroidae	*Lioconcha fastigiata*	+	-	+	+	+	-
	Gafrarium pectinatum	+	-	+	+	+	+
	Tapes literatus	+	+	-	-	+	-
	Paphia undulate	+	-	-	-	-	-
	Gafrarium dispar	+	-	-	-	-	-
	Paphia gallus	+	-	-	+	-	-
	Tapes sulcaris	-	+	-	+	+	+
	Marcia hiantina	-	-	-	+	-	-
	Meretrix meretrix	-	+	-	-	-	-
	Tapes belcheri	+	-	-	+	-	-
	Katelysia marmorata	+	-	-	-	-	-
	Protapes gallus	+	-	-	-	-	-
	Politita pesaureus	+	-	-	-	-	-
	Lioconcha castrensis	+	-	-	-	-	-
	Pitar simpsoni	+	-	-	-	-	-
	Circe tumefacta	+	-	-	-	-	-
	Pitar pellucidus	-	-	+	-	-	-
	Pitar citrinus	-	-	-	+	-	-
	Pitar subpellicidus	-	-	+	-	-	-
	Samela jecunda	-	-	+	-	-	-
	Pitar fulminatus	-	-	+	-	-	-
	Samele australis	-	-	+	-	-	-
	Gafrarium tumidum	-	-	+	-	-	-
	Calista impar	-	-	-	-		+
Arcidae	*Anadara antiquate*	+	+	+	+	+	+
	Anadara granosa	-	-	-	+	+	+
Mytilidae	*Perna viridis*	+	-	-	-	-	-
	Idas simpsoni	-	+	-	-	-	-
Cardidae	*Modiolus philipinarum*	-	+	-	-	-	-
	Trachhycardium flavum	+	-	-	+	+	+
	Fragum unedo	-	-	+	-	-	-
Pinnadae	*Pinna muricata*	+	-	-	+	+	-
	Atrina vexillum	+	-	-	-	-	-
Pteriidae	*Pinctada imbricate*	+	-	-	+	+	+
Mactridae	*Mactra grandis*	-	+	-	-	-	-
	Mactra nitida	-	-	+	-	-	-
	Mactrinula depressa	-	+	-	-	-	-
Lucinidae	*Lucinoma heroic*	-	-	+	-	-	-
	Codakia tigerina	-	-	+	-	-	+
Pectinidae	*Chlamys luculenta*	+	-	-	-	-	-
Tellinidae	*Marcia recens*	+	-	-	-	-	-

	Tellinella staurella	+	-	-	-	-	-
	Tellinella palatum	-	-	-	-	+	+
Donacidae	*Donax faba*	-	+	-	-	-	-
Total number of species		22	9	13	12	10	9

Information: (+) = Found (-) = Not found

The existence of a diversity of bivalve species in the study site evidences the association of bivalves with seagrass. Besides, it can be an ecological indicator of the function of seagrass as a habitat for bivalves. Another factor that influences species' existence, especially *Anadara antiquata*, is the condition of the aquatic environment. It is suspected that environmental factors have a strong influence. However, the range of tolerance required by *Anadara antiquata* is between 24 and 31ºC (Braby & Somero, 2006; McPherson & Chapman, 2000), containing CO_2, large currents, TSS, and salinity, which affect the distribution patterns and densities (Harley et al., 2015; Schneider & Helmuth, 2007). Thus, the spread is limited by the intertidal habitat (Nicholson & Lam, 2005). Furthermore, the distribution of bivalve fauna is influenced not only by human activities and management strategies but also by biological and other environmental factors such as the type of substrate (Feng & Papeş, 2017).

TABLE 5. The abundance of bivalve species found at the study site

No,	Species of Bivalves	Station						Total (ind/m^2)
		Gili Kere	Lungkak	Poton Bako	Kuta	Awang	Gerupuk	
1	*Donax faba*	0	0.03	0	0	0	0	0.03
2	*Mactra grandis*	0	0.08	0	0	0	0	0.08
3	*Tapes sulcaris*	0.01	0.21	0	0.03	0.05	0.04	0.33
4	*Meretrix meretrix*	0	0.01	0	0	0	0	0.01
5	*Modiolus philipinarum*	0	0.09	0	0	0	0	0.09
6	*Tapes literatus*	0.01	0.19	0	0	0.07	0	0.27
7	*Anadara granosa*	0	0.13	0.04	0.27	0.11	0.17	0.72
8	*Mactra nitide*	0	0	0.15	0	0	0	0.15
9	*Lioconcha fastigiata*	0.05	0.01	0.05	0.02	0.08		0.21
10	*Gafrarium pectinatum*	0.07	0.17	0.09	0.1	0.13	0.07	0.63
11	*Lucinoma heroic*	0	0	0.06	0	0	0	0.06
12	*Paphia gallus*	0.03	0	0	0.06	0	0	0.09
13	*Tapes belcheri*	0.06	0	0	0.05	0	0	0.11
14	*Anadara antiquate*	0.17	1.04	0.22	0.2	0.14	0.11	1.88
15	*Pinctada imbricate*	0.05	0	0	0.08	0.05	0.03	0.20
16	*Perna viridis*	0.59	0	0	0	0	0	0.59
17	*Pinna muricata*	0.04	0	0	0.03	0.02		0.09
18	*Paphia undulate*	0.04	0	0	0	0	0	0.04
19	*Gafrarium dispar*	0.05	0	0	0	0	0	0.05
20	*Trachhycardium flavum*	0.01	0	0	0.07	0	0.06	0.14
21	*Katelysia marmorata*	0.01	0	0	0	0	0	0.01
22	*Tellinella staurella*	0.01	0	0	0	0	0	0.01

23	*Protapes gallus*	0.01	0	0	0	0	0	0.01
24	*Politita Pesaureus*	0.003	0	0	0	0	0	0.003
25	*Marcia recens*	0.07	0	0	0	0	0	0.07
26	*Lioconcha castrensis*	0.01	0	0	0	0	0	0.01
27	*Pitar simpsoni*	0.01	0	0	0	0	0	0.01
28	*Circe tumefacta*	0.07	0	0	0	0	0	0.07
29	*Atrina vexillum*	0.003	0	0	0	0	0	0.003
30	*Chlamys luculenta*	0.003	0	0	0	0	0	0.003
31	*Mactrinula depressa*	0	0.03	0	0	0	0	0.03
32	*Idas simpsoni*	0	0.03	0	0	0	0	0.03
33	*Pitar pellucidus*	0	0	0.01	0	0	0	0.01
34	*Pitar subpellicidus*	0	0	0.02	0	0	0	0.02
35	*Semela jecunda*	0	0	0.24	0	0	0	0.24
36	*Pitar fulminates*	0	0	0.07	0	0	0	0.07
37	*Semele australis*	0	0	0.04	0	0	0	0.04
38	*Fragum unedo*	0	0	0.003	0	0	0	0.003
39	*Codakia tigerina*	0	0	0.13	0	0	0.03	0,16
40	*Gafrarium tumidum*	0	0	0.73	0	0	0	0.73
41	*Marcia hiantina*	0	0	0	0.04	0	0	0.04
42	*Pitar citrinus*	0	0	0	0.13	0	0	0.13
43	*Calista impar*	0	0	0	0	0	0.03	0.03
44	*Tellinella palatum*	0	0	0	0	0.03	0.02	0.047

3.3. Correlation of Environmental Factors with Bivalves

The results are based on the observations on the condition of the aquatic environment at each location during the research period (Figure 2**)**. The average value of the pH variable lay between 7.6 ppt and 8.04 ppt, temperature 25.67°C and 26.21°C, salinity between 24.91 ppt and 33.5 ppt, phosphate between 0.8 mg/L and 1.93 mg/L, dissolved oxygen (DO) between 6.43 mg/L and 7.76 mgL, brightness between 5.84 m and 7.99 m and nitrates between 0.2 mg/L and 0.92 mg/Ll. (Figure 2). The condition of the environment waters at the study location still was in the range of tolerance needed for the growth and development of the species of bivalves. For example, the salinity tolerance range was between 19 and 44 pp and temperature was between10°C and 42°C (McLachlan & Dorvlo, 2005). Furthermore, they contained CO_2, large currents, TSS, and salinity, which affect the distribution patterns and densities.

The results also show that the three study locations had almost the same substrate in sandy mud, muddy sand, muddy, sandy, and rocky sand. The majority of Mollusca organisms prefer to live in a sandy mud substrate. Bivalves tend to choose sandy mud substrate, as the sand is easy to move/mobilize in, while mud substrate tends to have less oxygen content; therefore, the organisms living in it must be able to adapt accordingly. The environmental conditions of each seagrass bed in the research location is related to the substrate as a medium of growth and development; Gili Kere seagrass beds, the main source of the substrate, constitutes sand from dead coral fragments with a little characteristic of Lungkak mud, and Poton Bako, the main source of the substrate, comes from river sand with more characteristics. Since it is a source of seagrass' major substrate, it can be an instrument in the assessment condition of seagrass, the pattern of distribution of seagrass, and bivalves in these habitats. Meanwhile, the diversity of species of bivalves are found in all research locations, as shown in (Figure 3). The presence of a diversity of bivalves in all locations of the seagrass beds proves that seagrass has contributed to the suitability of the habitat of each bivalve species.

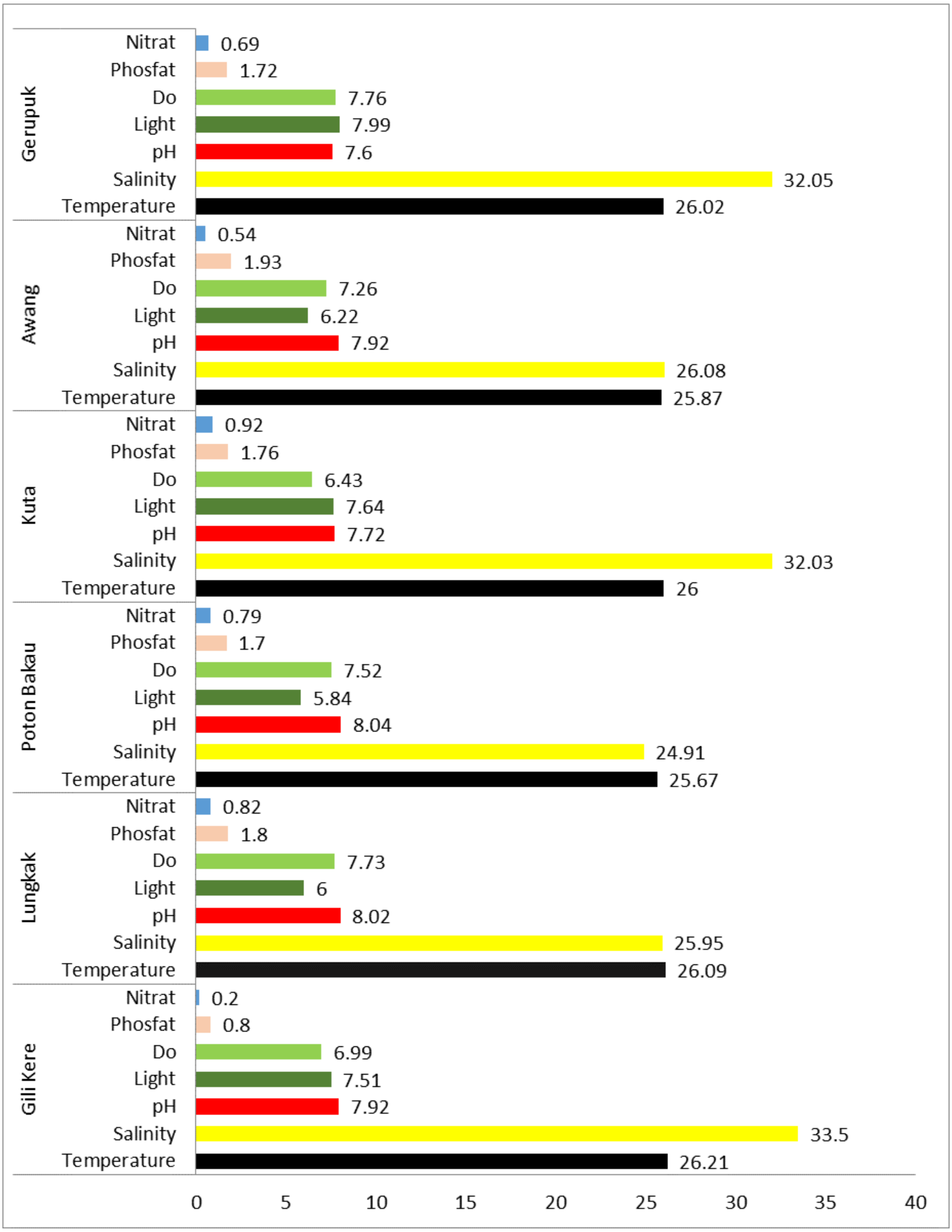


FIGURE 2. Aquatic environmental conditions in the study location

Anadara granosa

Skala 1:0.63 cm

Anadara antiquate

Skala 1: 0.77 cm

Donax faba

Skala 1: 0.60 cm

Mactra grandis

Skala 1: 0.59 cm

Modiolus philipinarum

Skala 1: 1.09 cm

Meretrix meretrix

Skala 1: 0.55 cm

Paphia gallus

Skala 1: 1.21 cm

Paphia undulata

Skala 1: 1.17 cm

Tapes sulcaris

Skala 1: 0.83 cm

Gafrarium pectinatum

Skala 1: 0.72 cm

Perna viridis

Skala 1: 1.2 cm

Lioconcha fastigiata

Skala 1: 1.15 cm

Tapes belcheri

Skala 1: 1.28 cm

Tapes literatus

Skala 1: 1.24 cm

Gafrarium dispar

Skala 1: 1.06 cm

Trachhycardium flavum

Skala 1: 0.73 cm

Pinna muricata

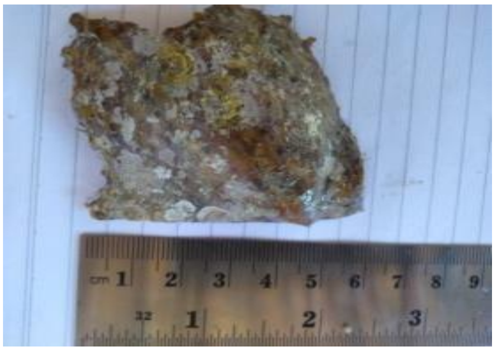
Skala 1: 2.71 cm

Mactra nitida

Skala 1: 0.63 cm

Lucinoma heroica

Skala 1: 0.55 cm



Pinctada imbricata

Skala 1: 0.93 cm

Katelysia marmorata

Skala 1: 1.27 cm

Tellinella staurella

Skala 1: 0.01 cm

Protapes gallus

Skala 1: 1.33 cm

Politita Pesaureus

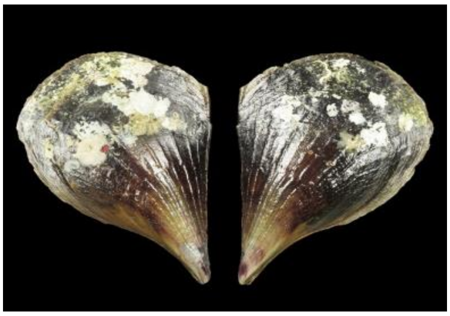
Skala 1: 1.39 cm

Marcia recens

Skala 1: 1.34 cm

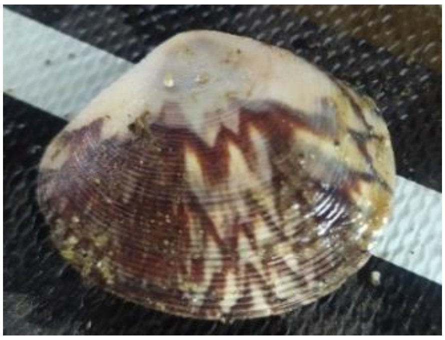
Pitar simpsoni

Skala 1: 0.01 cm



Atrina vexillum

Skala 1: 1.24 cm



Lioconcha castrensis

Skala 1: 1.35 cm

Circe tumefacta

Skala 1: 1.38 cm

Chlamys luculenta

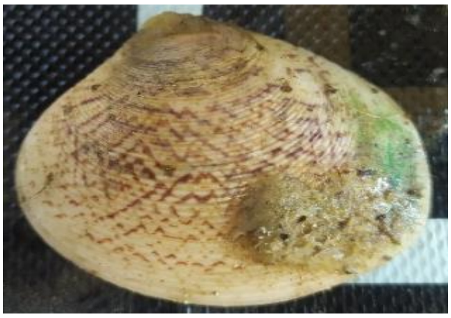
Skala 1: 1. 36 cm

Mactrinula depressa

Skala 1: 0.67 cm

Idas simpsoni

Skala 1: 0.69 cm



Pitar pellucidus

Skala 1: 1.19 cm

Pitar subpellicidus

Skala 1: 0.96 cm

Semela jecunda

Skala 1: 0.99 cm

Pitar fulminates

Skala 1: 0.92 cm

Semele australis

Skala 1: 0.80 cm

Codakia tigerina

Skala 1: 1.23 cm

Marcia hiantina

Skala 1: 1.24 cm

Calista impar

Skala 1: 1.26 cm

Fragum unedo

Skala 1: 0.68 cm

Gafrarium tumidum

Skala 1: 0.89 cm

Pitar citrinus

Skala 1: 0.67 cm

Tellinella palatum

Skala 1: 0.69 cm

FIGURE 3. Bivalves Species found at the Study Site

The correlation indices of abundance, species diversity, and uniformity with environmental parameters are presented in Table 6. Environmental factors that have the highest correlation with abundance value have the highest correlation with DO (r = 0.884) and the lowest with pH (r = 0.221). Furthermore, the value of diversity (H') has the highest correlation with DO (r = 0.783) and the lowest with temperature (r = 0.124), while the evenness has the highest correlation with environmental factors phosfat (r = 0. 931) and has a correlation lows with DO (r = 0.317). The roles of DO, light, pH, phosphate, temperature, salinity, and nitrate have a correlation (Pearson r = 0.1-0.9) with diversity, abundance, and species uniformity. The correlation value of environmental factors is an important factor in explaining bivalves' presence in the research location. Based on the results of the measurement of the physical parameters, the numbers obtained in each parameter are within normal limits. This means that this condition is still good and can support marine life optimally. Good conditions can be maintained if the ecosystem has not significantly influenced human intervention (Byers et al., 2006). The results of the measurement of environmental parameters at the study location are still below the seawater quality standard, so these environmental factors can support the life of bivalves.

TABLE 6. Correlation of environmental parameters with ecological indices

	Diversity	Evenness	Abundance	Temperature	Salinity	pH	Light	Do	Phosfat	Nitrat
Diversity	1									
Evenness	0.73	1								
Abundance	0.604	0.688	1							
Temperature	0.124	0.830	0.583	1						
Salinity	0.414	0.722	0.698	0.690	1					
pH	0.579	0.490	0.221	0.270	0.705	1				
Light	0.483	0.509	0.539	0.566	0.985	0.876	1			
Do	0.783	0.317	0.884	0.183	0.483	0.204	0.384	1		
Phosfat	0.267	0.931	0.562	0.577	0.606	0.920	0.384	0.250	1	
Nitrat	0.346	0.717	0.401	0.448	0.374	0.133	0.208	0.490	0.788	1

IV. Conclusion

The result of this research shows 44 species were found, spanning 11 families, in Lungkak, Poton Bako, and Gili Kere coastal waters. The only species found in all locations was *Anadara antiquate*. Meanwhile, the diversity of bivalve species associated with seagrass in the study location is supported by ecological evidence of the potential of seagrass in creating a habitat, especially for bivalve species. Therefore, protection of seagrass from the threat of damage is an adequate strategy to protect the habitat of the diversity of marine life that is in contact with seagrass, such as in the study location.

ACKNOWLEDGMENT

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AUTHOR'S CONTRIBUTIONS

Abdul Syukur, Agil Al Idrus, Lalu Zulkifli and Baiq Nunung Hidayati: Conducted all experiments, participated in data analysis and preparation of the manuscript

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[biodiv] Editor Decision

Smujo Editors <smujo.id@gmail.com>
To:Abdul Syukur,Lalu Zulkifli,Agil Al Idrus,Baiq Nunung Hidayati
Fri, 17 Sept 2021 at 9:57 pm

Abdul Syukur, Lalu Zulkifli, Agil Al Idrus, Baiq Nunung Hidayati:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Species Diversity of Seagrass-Associated Bivalves as an Ecological Parameter to Support Seagrass Conservation Along the Coastal Waters of South Lombok, Indonesia".

Our decision is: Revisions Required

Reviewer 1:

An interesting piece of work, but I have one major concern. You have found out the correlation between various environmental variables and various assemblage metrics but nowhere do you state the statistical significance of these correlations. Without knowing whether the correlations are significant or not they are effectively meaningless! You should do this and then where there is no significant correlation there is nothing to discuss (I suspect quite a number of them will not be significant), but where the correlation is a significant one then things become interesting and you should discuss why there might be a correlation.

Recommendation: Revisions Required

[biodiv] Editor Decision
Yahoo/Inbox
Smujo Editors <smujo.id@gmail.com>
To:Abdul Syukur,Lalu Zulkifli,Agil Al Idrus,Baiq Nunung Hidayati
Mon, 20 Sept 2021 at 5:12 pm

Abdul Syukur, Lalu Zulkifli, Agil Al Idrus, Baiq Nunung Hidayati:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Species Diversity of Seagrass-Associated Bivalves as an Ecological Parameter to

Support Seagrass Conservation Along the Coastal Waters of South Lombok, Indonesia".

Our decision is: Revisions Required
Note: Invite a more qualified proofreader to improve your paper, such as scribendi.com or elsevier.com.

Reviewer 2:

This paper is well reported about bivalve abundance at six sites in Indonesia. It seems to be important as local information about bivalve distribution, however scientific discussion is a little lacking. In addition, at least English proofreading is needed, as this paper includes so many typographical errors, and I cannot understand the meanings of some sentences. This paper also should follow the "Guidance for Authors", e.g. Abstract < 200 words, and Figure ~ 3 pages.

Abstract

- < 200 words
- L13: 22 species (55%) -> 50%
- L14: nine species (22.5%) -> 20.5%
- L15: *Anadara antiquate* -> *antiquata* [also check all the remaining pages]
- L15-16: no need to use unit (ppt) for pH and salinity [also check all the remaining pages]
- L17: What is "brightness"? Need methods.
- L17-L18: typographical errors of "mg/L"

Keywords

- Sort from A to Z

Introduction

- About 400–600 words
- L23-24: The meaning of the first sentence is not clear. In addition, I think "shellfish" includes Crustacean which belongs to Arthropoda.
- L25: References, see "Guidance for Authors" [also check all the remaining pages]
- L46-47: Check the sentence.

Materials and methods

- L76: Methods
- L84: Poton Bakau -> Bako
- L85: Teluk Awang -> (remove Teluk)
- Add the methods of water quality sampling/analysis including brightness.
- 1: Show the sampling sites in the map. Increase the resolution.
- Table 1: 4 Pantai Kuta -> Kuta

- I think it is better to show (1) the date and time of water/bivalves sampling, as lunar cycle can be checked, and DO shows diurnal cycle, and (2) the distance from the shoreline for water sampling sites, as salinity etc. depends on it.
- Table 2: Size of Transects -> Length?

Results and discussion

- Table 3: studi location -> study. For species, sort from A to Z. Gili Kere, "Syringodium isoetifoliumu 9" -> (remove "9"). Kute -> Kuta
- L126: shellfish
- L128, 129: 55%, 22:5%
- L129: Table 5 -> 4?
- Table 4: What is this sorting order of species? I think Table 4 and 5 can be combined. L132, add "," after "Found".
- Table 5: What is this sorting order of species?
- L147: mg/L l -> mg/L
- L152-: Clarify each substrate (e.g. sandy, muddy) at all sampling site.
- Figure 2: Nitrat -> Nitrate. Phosfat -> Phosphate. Do -> DO. (Maybe no need to use color.) Show the unit. Data should be shown as, e.g. Kuta Temperature 26 -> 26.00. It may be easier to understand this figure by showing per each water quality parameter, not by per each site. Sort sampling site from Gili Kere to Gerupuk.
- Figure 3: < 3 pages. Are these pictures needed in this paper? What does "Skala l" means, and which length? Increase the resolution. Why each picture size is different? If this Figure is needed, it may be better to add the information of sampling sites.
- L174-: It is better to check the significance of correlation, or at least r^2, not r.
- L182, L184: normal limits, seawater quality standard -> Add references.
- L178, Table 5: Do, Phosfat, Nitrat

I think it is better to add the following discussion:

- Relationship between substrate (e.g. sandy, muddy) and bivalve diversity/distribution.
- Compare this diversity (H') etc. with them shown in the previous papers, and then, emphasize the value of seagrass ecosystem services.
- Some bivalve species are known as filter-feeder, surface feeder, grazer etc., and this result includes Lucinid. Therefore, the relationship between each species' distribution and substrate/water quality.
- As the information, it might be useful to show the bivalve distribution along the transect line from shoreline to offshore.

References

- See "Guidance for Authors".

Revisions

Name	Date	Component
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Species Diversity of Seagrass-Associated Bivalves as an Ecological Parameter to Support Seagrass Conservation Along with the Coastal Waters of South Lombok, Indonesia.

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Abstract. Seagrass has a role in supporting the survival of marine life, such as bivalves. This study aimed to investigate the relationship between bivalve species diversity as a parameter for seagrass conservation. The research approach was through observation and data collection for seagrass and bivalves using quadrant and transect methods—Analysis of the data through descriptive statistical analysis, ANOVA, and Pearson correlation. The number of seagrass species in the six research sites was nine. Furthermore, the species composition of bivalves consisted of 11 families comprising 47 species. The ANOVA results showed a significant difference based on the F-count value, higher than the F-table value of the three ecological indices (H', E, and Ki). Two ecological indices, namely H' and Ki, have r values less than 0.5 for all environmental parameters (temperature, brightness, pH, salinity, DO, phosphate, and nitrate) and show no significant correlation. However, the E index value has an r value greater than 0.5 for nitrate, salinity DO, and phosphate. The highest significance value of the four environmental variables is for nitrate, with an r = 0.875. The conclusion is that the richness and abundance of seagrass-associated bivalves in the study area are predetermined by the characteristics of the seagrass environment, especially the substrate. Secondly, seagrasses could create a suitable substrate for bivalves to survive. Therefore, the indicator of the presence of associated Bivalvia species can be a parameter for local scale seagrass conservation at the study site.

Keywords: Bivalvia, Conservation, Ecology, and Seagrass.

Introduction

Bivalves are a group of marine organisms associated with seagrass and have a role in tropical systems in seagrass ecosystems, such as forming food chains (Sousa et al., 2009). In addition, several species of bivalves are a source of protein for public consumption, and their skins can be a source of raw material for handicraft products that have economic value (Deutsch et al., 2011; Santhanam, 2018). Bivalve animal communities generally live in marine waters, especially in intertidal conditions, such as seagrass meadows (Bateman & Bishop, 2017; Hosack et al., 2006). Seagrass substrate conditions are a habitat preference for distribution and species composition of benthic animals such as seashells (Best & Kidwell, 2016). The substrate can significantly affect the number of Bivalves population and even eliminate some bivalves species (Chadwick et al., 2006). Furthermore, the statement (de Souza et al., 2018) that the physical, chemical, and biological environment in the ecosystem, such as damage to seagrass ecosystems, can affect the survival rate of marine biota associated with seagrass.

The relationship between seagrass and bivalves is through chemosymbiotic associations. Several bivalves support primary species (seagrass) and play a role in dealing with increasing anthropogenic impact and global climate change (Chin et al., 2020). Seagrass has a significant meaning for bivalves' diversity, especially seagrass services in providing a habitat (Lebreton et al., 2012; Nordlund & Gullström, 2013). Although the service capacity provided by seagrass may vary by seagrass species and between seagrass ecosystems (Nordlund et al., 2016), seagrass-vegetated areas have contributed to the bivalve community, especially in increasing the abundance, richness, and diversity of bivalve species (Gagnon et al., 2020). In addition, environmental conditions in the seagrass area are a factor that plays a role in increasing the diversity and species richness of bivalves (Lukwambe et al., 2020; Lu et al., 2018). For example, seagrass substrates can determine whether the density of Bivalvia species is high or low (Altamirano et al., 2017).

Meanwhile, as Lee et al. (2016) state, dissolved organic matter in sediments is affected by the dense growth of organisms such as bivalves. The finer the substrate texture, the greater is its ability to trap organic matter (Duniway et al., 2010). Furthermore, Seagrasses provide a diversity of habitats for bivalve communities. However, the ecological evidence of the presence of bivalve communities in seagrass beds does not constitute the main parameter in the conservation of coastal ecosystems. Significantly, the bivalve community in seagrass is the prey of a diversity of seabirds (Unsworth & Butterworth, 2021).

The development of seagrass conservation parameters is essential at the study site, especially for protecting marine biodiversity such as bivalved communities. Previous studies have explained that the association of fish with seagrass and their use through ecotourism could indicate seagrass conservation at local and regional scales (Syukur et al., 2021a). In addition, seagrass cover is a parameter that has a significant correlation in determining the species richness of bivalves at the micro-scale (Syukur et al., 2021b). However, a broader study of the ecological aspects of the Bivalvia community on a spatial and temporal scale, especially in the study area, has not been carried out. In fact, the existing condition of the Bivalvia community at the study site can be the main parameter in the design of seagrass conservation. Therefore, the study of the ecological aspects of bivalves by seagrass habitat diversity, particularly in the study area, is critical as a parameter for seagrass environmental protection. This study aims to describe the variety of bivalve species associated with seagrass in the coastal waters of South Lombok. This research can provide scientific information on seagrass's contribution to preserving marine life, especially the bivalve community. In addition, the results of this research can be a scientific basis for the conservation of seagrass on a local scale, such as in the study area and other relevant locations.

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Materials and Method

Research sites

The research was carried out from 2019 to 2021, and the sampling was from March to July/year. The study sites were in six areas of seagrass beds along the southern coast of Lombok Island (Figure 1). The research location, especially the seagrass area and its environment, is designated as a traditional fishing and coastal nature tourism area (Syukur et al., 2020). The environmental characteristics between the research locations are in Lungkak, Poton Bakau, and Awang, directly adjacent to the mangrove ecosystem. Furthermore, Gerupuk and Kute are not directly adjacent to the mangrove ecosystem. However, Gili Kere is a small island in the southern coastal waters of East Lombok. Mangrove vegetation, especially on the south coast of East Lombok, was the result of revegetation in the early 1990s (Idrus et al., 2021). The two indicators of success are the first value of fauna diversity, such as Bivalvia species associated with mangroves (Idrus et al., 2019a); both local communities have their livelihoods from the mangrove area as a result of revegetation (Idrus et al., 2019b). Therefore, the success of mangrove revegetation and its protection by local communities can be the basis for the development of seagrass protection in the study location.

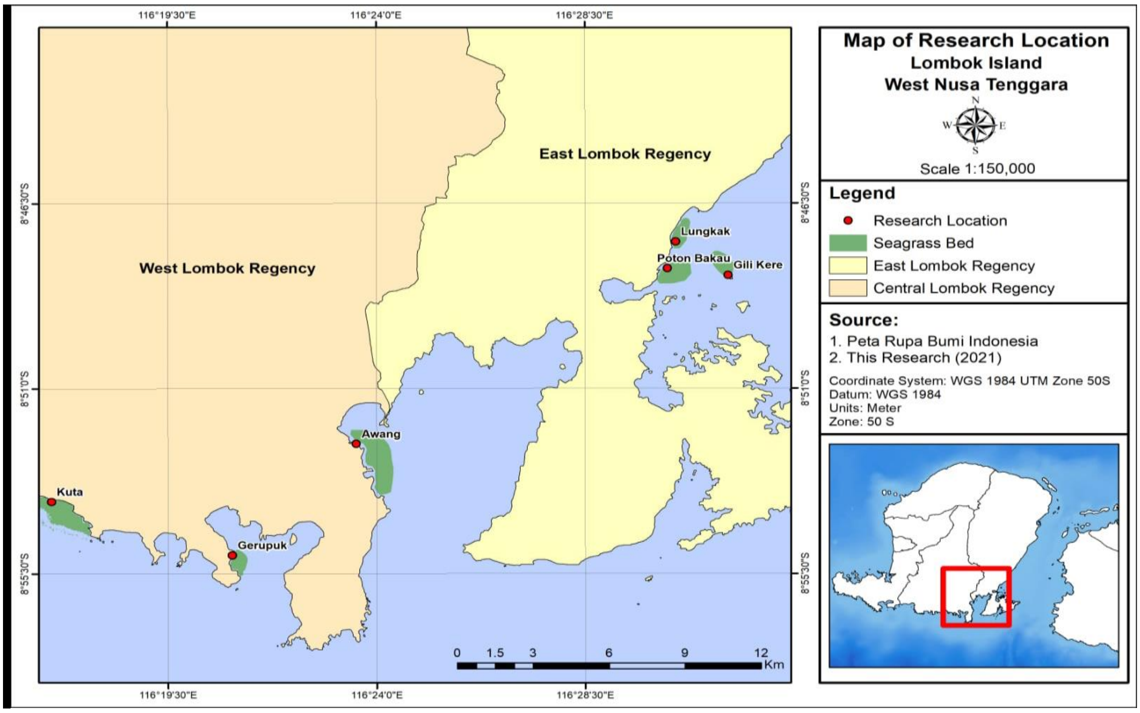

FIGURE 1. Map of research locations in coastal Lombok.

TABLE 1. Six research sites and their coordinates

No.	Location	X coordinate	Coordinate Y	Regency
1	Gili Kere	116 ° 31 '35,540 "E	8 ° 48 '14,544 "S	East Lombok Regency
2	Lungkak	116 ° 30 '27,092 "E	8 ° 47 '25,972 "S	East Lombok Regency
3	Poton Bakau	116 ° 30 '16,614 "E	8 ° 48 '5,261 "S	East Lombok Regency
4	Awang	116°23’34”E	8°52’21”S	Central Lombok Regency
5	Gerupuk	116°20’53”E	8°55’03”S	Central Lombok Regency
6	Pantai Kuta	116°16’59”E	8°53’45”S	Central Lombok Regency

Data Collection and Analysis

The data collection design of the study involved determination of intersecting points at each research station (i.e., Gili Kere, Lungkak, Poton Bakau, Awang, Gerupuk, and Kuta). The condition of seagrass beds at each study site became the basis for determining the transect length. The size and number of transects at each study site are detailed in Table 2; data collection was done using the quadrant method (Mueller-Dombois & Ellenberg, 1974). Furthermore, the placement of transects was perpendicular to the coastline to the sea, and observation and research data collection happened during every full moon for three days from March to July in 2020 and 2021. Observations on research variables (seagrass and bivalves) was carried out in quadrants measuring 1 x 1 m^2, and the distance between the squares on each transect was 25 m. The research variables pertained to the seagrass species, including the number of species, the number of individual seagrasses/species, and the percentage of seagrass cover based on (Pitcher et al., 2010).

The Bivalvia variables that became the object of the research were the species and the number of individuals/species, and samples embedded in the substrate were taken by digging the substrate to a depth of 10 cm. Samples were collected in prepared containers (plastic buckets) and documented through photographs for identification purposes, as guided by (Abbott, 1985). Meanwhile, the environmental parameters used as research variables were the characteristics of the substrate, temperature, pH, salinity, DO, brightness, nitrate, and phosphate. The next stage was assessing the nitrate and phosphate content of the samples in the chemistry laboratory of the Chemistry Study Program, Faculty of Mathematics and Natural Sciences, University of Mataram. Other parameters (i.e., substrate characteristics, salinity, DO, brightness, pH, and temperature) were assessed directly.

The data analysis approach employed was descriptive statistical analysis. Data analysis on the ecological index referenced several studies, including abundance analysis, which utilizes the formula from Odum (1998), density analysis, and seagrass cover using Odum's (1993) formula. Furthermore, the Pearson correlation formula was applied using SPSS 17 and the Microsoft Excel 2007 software to determine the relationship between environmental parameters and ecological indicators (Diversity, Evenness, and Abundance).

TABLE 2. The number and length of transects at the six research sites

Location	Ecosystem	Number of Transects	Transect length of sampling at six research sites
Gili Kere	Seagrass	9	1300 meters
Lungkak	Seagrass	9	750 meters
Poton Bakau	Seagrass	9	1300 meters
Awang	Seagrass	9	900 meters
Gerupuk	Seagrass	9	800 meters
Kuta	Seagrass	9	1200 meters

Results and Discussion

Seagrass Composition in the Six Study Site

The species richness in each research location showed a different number of species, and ranged from seven to nine species. The largest number of seagrass species were in Lungkak, Gerupuk, and Kuta, and the lowest number were in Gili Kere (Table 3). The average % value of seagrass cover at the six study sites ranged from 69.5 ± 0.7 to 82.16 ± 2.3 , with the highest average % of seagrass cover being at Lungak, and the lowest at Gili Kere and Awang. Meanwhile, the number of seagrass species, especially in Gerupuk and Kute, is lower than in Kiswara's study (1994). Still, in Poton Bakau it is higher than revealed by the research results of Rahman et al. (2018). The number of species is different from the data of previous studies, firstly due to differences in observation points. Secondly, there is no permanent station for monitoring the condition of seagrass and its environment regularly. However, the representation of the composition of seagrass species can explain the status of the seagrass community in the study location as a mixed type of seagrass community. Patty (2013) demonstrated that seagrass communities with more than one class and eight species are a mixed-type category. Liu et al. (2017) explained that diverse types dominated seagrass communities in Indonesian coastal waters. Furthermore, differences in seagrass species richness between seagrass meadow locations influence environmental conditions, such as substrate, salinity, and their geographic location in coastal waters (Wainwright et al., 2018).

TABLE 3. The number of species and % of seagrass cover at each location of seagrass beds at six research sites

Lokasi	Name of Seagrass Species	Number of Species	% Cover of Seagrass ± SD	Substrate
Gili Kere	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulate* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium isoetifolium* (Ascherson) Dandy,	7	75.33 ± 9.0	Dominant sand from coral fragments and a little mud

	1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871			
Lungkak	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Halophila spinulosa* (R. Brown) Ascherson, 1875 *Syringodium isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871	9	82.16 ± 2.3	Sandy mud
Poton Bakau	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871	8	79.5 ± 3.0	Sandy mud
Awang	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium Isoetifolium* (Ascherson) Dandy, 1939	7	69.5 ± 0.7	Sandy mud
Gerupuk	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halophila minor* (Zollinger) Den Hartog, 1957 *Halophila ovalis* (Robert Brown) Hook f. 1858 *Syringodium isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871	9	77.5 ± 2.8	Muddy sand
Kuta	*Cymodocea rotundata* Ascherson & Schweinfurth in Ascherson,1870 *Cymodocea serrulata* (R. Brown) Ascherson & Magnus in Ascherson, 1870 *Enhalus acoroides* (Linnaeus f.) Royle, 1839 *Halodule uninervis* (Forsskal) Ascherson in Boissier, 1882 *Halodule pinifolia* (Miki) Den Hartog, 1964 *Halophila ovalis* (Robert Brown) Hook f. 1858	9	71.18 8.6	Muddy sand

	Halophila minor (Zollinger) den Hartog, 1957 *Syringodium Isoetifolium* (Ascherson) Dandy, 1939 *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871			

Meanwhile, the growth, productivity, and distribution of seagrass species are more a result of the availability of light. The brightness values at all research sites are within the tolerance limits of the Seawater Quality Standard (KMNLH No. 51 of 2014). The complete results of the measurement of environmental variables at all locations of seagrass beds during the study period are in Table 4. The values of environmental parameters, such as temperature, salinity, and dissolved oxygen (DO), are at the acceptable levels for seagrass species to survive. However, the average values of phosphate and nitrate are above the standard values of the Seawater Quality Standard, with Phosphate (PO4-P) = 0.015 and Nitrate (NO3-N) = 0.008 (KMNLH No. 51 of 2014). The range of phosphate values is between 0.55 mg/l – 1.10 mg/l, with the highest being in Lungkak and the lowest in Gili Kere.

The range of nitrate values is between 0.30 mg/l – 0.72 mg/l, with the highest in Poton Bakau and the lowest in Gili Kere. The average weight of high phosphate content, such as in Poton Bakau, Lungkak, was sourced from rivers and run-off at the two seagrass meadows, and similarly in Awang, Gerupuk, and Kute. However, the average value of phosphate content in Gili Kere being the lowest is due to Pulau Kecil, which cannot supply from the river, and run-off from the mainland of Lombok Island. In addition, it can be due to anthropogenic activities, such as waste from tourism activities, households, and traditional markets such as Kute, Gerupuk, and Lungkak, which have become tourist destinations, and from Awang which has fishing ports and traditional markets. However, the value of the parameter ratio of nitrate and phosphate is lower than the Redfield ratio of N:P (16:1). Therefore, the overall average value of environmental parameters is still suitable for marine life. Moreover, seagrass is one species that can recover from disturbances originating from natural processes and anthropogenic activities (Boudouresque et al., 2009).

TABLE 4. Measurement results of environmental parameters at six locations of seagrass beds in the study site

Parameters	Locations														
	Gili Kere					Lungkak					Poton Bakau				
	I	II	III	Rata-rata	SD	I	II	III	Rata-rata	SD	I	II	III	Rata-rata	SD
Physics															
Temperature (ºC)	26.21	26	26	26.07	0.12	26.09	25	25	25.36	0.63	25.67	25	25	25.22	0.39
Light (m)	7.51	6.4	6.4	6.77	0.64	6	5.8	5.8	5.87	0.12	5.84	5.4	5.4	5.55	0.25
Chemical															
pH	7.92	7.6	8	7.84	0.21	8.02	8.3	7.4	7.91	0.46	8.04	8.2	7.2	7.81	0.54
Salinity (%o)	33.5	32	32	32.5	0.87	25.95	31.2	28	28.38	2.65	24.91	31.3	29	28.40	3.24
DO (mg/l)	6.76	6.9	6.45	6.70	0.23	7.23	7.42	7.5	7.38	0.14	7.52	7.34	7.4	7.42	0.09
Phosphate (mg/l)	0.8	0.4	0.45	0.55	0.22	1.8	0.4	0.48	0.89	0.79	1.7	0..3	0.5	1.10	0.85
Nitrate (mg/l)	0.2	0.32	0.37	0.30	0.09	0.82	0.65	0.65	0.71	0.10	0.79	0.7	0.68	0.72	0.06
Parameter	Lokasi														
	Awang					Gerupuk					Kuta				
	I	II	III	Rata-rata	SD	I	II	III	Rata-rata	SD	I	II	III	Rata-rata	SD

Physics														
Temperature (ºC)	25.87	25	25	25.29	0.50	26.02	26	26	26.01	0.01	26	26	26	26	0
Light (m)	6.22	5.8	5.8	5.94	0.24	7.99	8.22	8.22	8.14	0.13	7.64	6.98	6.98	7.2	0.38
Chemical															
pH	7.92	8.24	8	8.05	0.17	7.6	7.87	7	7.49	0.45	7.72	7.8	8	7.84	0.14
Salinity (%o)	26.08	30.2	30.2	28.86	2.41	32.05	31.2	31.3	31.54	0.45	32.03	31.4	31.2	31.56	0.42
DO (mg/l)	7.26	7.16	7.2	7.21	0.05	7.46	7.25	6.5	7.07	0.50	6.8	6.9	6.5	6.73	0.21
Phosphate (mg/l)	1.93	0.3	0.4	0.88	0.91	1.72	0.3	0.1	0.71	0.88	1.76	0.2	0.1	0.69	0.93
Nitrate (mg/l)	0.54	0.69	0.66	0.63	0.08	0.69	0.48	0.5	0.56	0.12	0.92	0.52	0.49	0.64	0.24

Description: I = 2019, II = 2020, III = 2021

Composition of the Bivalves Species Found at Study Sites

The six study sites' breeding species associated with seagrass totaled 44, comprising 11 families (Table 5). Species composition based on family showed that Family Veneroidae had the most species and reached 52.17% of the total bivalve species at six research sites. The next largest family is Mactridae at 8.70 %, and the species composition is in line with family size at all study sites (Figure 2). In addition, the species composition of bivalves based on the number of individuals is the first species with the number of individuals on the average of the total number of individuals. The average number of individuals for all 46 species was 73.67. The number of individuals was above the average for ten species, or 21.73% of the total number of bivalve species, at the six study sites. The composition of species with above average number of individuals was as follows: Anadara antiquate 19.95%, Perna viridis 16.73%, Gafrarium tumidum 9.21%, Anadara granosa 8.59%, Gafrarium pectinatum 7.17%, Lioconcha fastigiata 3.51%, Mactra nitida 3.1%, Samela jecunda 3.07 %, Tapes literatus 3.07%, and Tapes sulcaris 2.51% (Figure 3). Second, for 36 species or 78.26% of the total, the number of individuals was below the average value.

The composition of bivalve species associated with seagrass at the six research sites can explain: (1) bivalve species richness, (2) both species distribution based on family and individual abundance based on species, and (3) species abundance based on the largest family and species with the most numbers of individuals. In addition, the presence of all species of Bivalvia associated with seagrass at the six research sites is evidence of the ecological services of seagrass for the survival of Bivalvia species diversity. Concerning the presence of bivalve fauna in seagrass beds, the factor that supports their survival is the complexity of seagrass habitats, which can determine the distribution and habitat preferences of fauna, including bivalve species (van der Heide et al., 2012). Another explanation states that biodiversity in seagrass communities can facilitate the presence of bivalves, and that bivalves facilitate fouling and algae diversity (Zhang & Silliman, 2019). Bivalve species also show significant correlation with the biomass of *E. acoroides* (Satumanatpan et al., 2011). However, generally at high seagrass biomass, the number of Bivalvia species may be lower due to dense seagrass roots (van der Heide et al., 2004). Although this study has not described the presence of Bivalvia species, it is relevant in producing extreme biodiversity, with evidence that Bivalvia species richness can be a parameter to support conservation and restoration programs for seagrass along the southern coast of Lombok Island.

TABLE 5. The total number and species composition of the sampled Bivalvia are associated with the six locations.

Family	Species	Number of Species	Number of individuals/species	% of individuals/species
Arcidae	*Anadara granosa*	3	293	8.65
	Anadara antiquata		715	21.10
	Tegillarca addita		8	0.24
Cardidae	*Fragum unedo*	3	4	0.12
	Modiolus philipinarum		52	1.53
	Trachhycardium flavum		61	1.80
Donacidae	*Donax faba*	1	16	0.47
Lucinidae	*Codakia tigerina*	2	56	1.65
	Lucinoma heroica		65	1.92
Mactridae	*Mactrotoma ovalina*	4	8	0.24
	Mactrinula depressa		9	0.27
	Mactra grandis		31	0.91
	Mactra nitida		10	0.30
Mytilidae	*Idas simpsoni*	2	9	0.27
	Perna viridis		567	16.73
Pectinidae	*Chlamys luculenta*	2	4	0.12
	Marcia recens		27	0.80
Pinnadae	*Atrina vexillum*	2	3	0.09
	Pinna muricata		48	1.42
Pteridae	*Pinctada imbricata*	1	69	2.04
Tellinidae	*Tellinella palatum*	2	11	0.32
	Tellinella staurella		18	0.53
Veneroidae	*Calista impar*	25	6	0.18
	Circe tumefacta		30	0.89
	Gafrarium tumidum		292	8.62
	Gafrarium dispar		32	0.94
	Gafrarium pectinatum		259	7.64
	Katelysia marmorata		4	0.12
	Lioconcha castrensis		9	0.27
	Lioconcha fastigiata		133	3.92
	Marcia hiantina		8	0.24
	Meretrix meretrix		10	0.30
	Paphia gallus		52	1.53
	Paphia undulata		34	1.00
	Pitar citrinus		21	0.62
	Pitar fulminatus		31	0.91
	Pitar simpsoni		11	0.32
	Pitar pellucidus		6	0.18
	Pitar subpellicidus		9	0.27
	Politita pesaureus		4	0.12
	Protapes gallus		6	0.18
	Samela australis		21	0.62
	Samela jecunda		101	2.98
	Tapes sulcaris		78	2.30
	Tapes belcheri		63	1.86
	Tapes literatus		79	2.33
	Tivela stefaninii		6	0.18
Total		47	3389	100

The species richness or the number of species of bivalves from all study sites was much more than at other locations, such as Ela-Ela Sekotong Beach, West Lombok, with only six species (Zusron et al., 2015), or in the seagrass beds of Sungai Pulai, Peninsular Malaysia, with seven species as mentioned in (Daud, 2008), and 18 species in the seagrass ecosystem of Kung Krabaen Bay, Chantaburi Province, Thailand (Satumanatpan et al., 2011), and on the Algarve coast of southern Portugal, with 25 species (Gaspar et al., 2002). The distribution and species richness of bivalves are limited to the local scale and a broader scale at the regional and global levels. The existence of bivalve species is critical to understanding their relationship with the presence of seagrass in tropical and subtropical coastal waters. However, between locations there can be different species richness, even though the sites are close together. For example, the species richness of bivalves in the study area shows that Gili Kere has a higher number of species than in Lungak and Poton Bakau (Table 6). In addition, it can serve as information in the study of dominant factors that significantly determine the species richness of bivalves in a seagrass area, such as substrates and other environmental factors. The spatial distribution of bivalve species and their growth depend on the characteristics of the substrate, temperature, and water currents. These have a significant influence in determining the diversity of bivalve species (Bódis et al., 2011). Moreover, habitat conditions (substrate quality), the amount and species of available food, interactions between ecosystems in coastal waters, and oceanographic factors such as tides influence the distribution of bivalve species (Champion et al., 2020). Bivalve species are generally found on sandy and muddy substrate types, but are often mainly sourced from coral rubble (Lukeneder, 2008). Therefore, the species richness of bivalves at the six research sites can be a parameter for seagrass conservation.

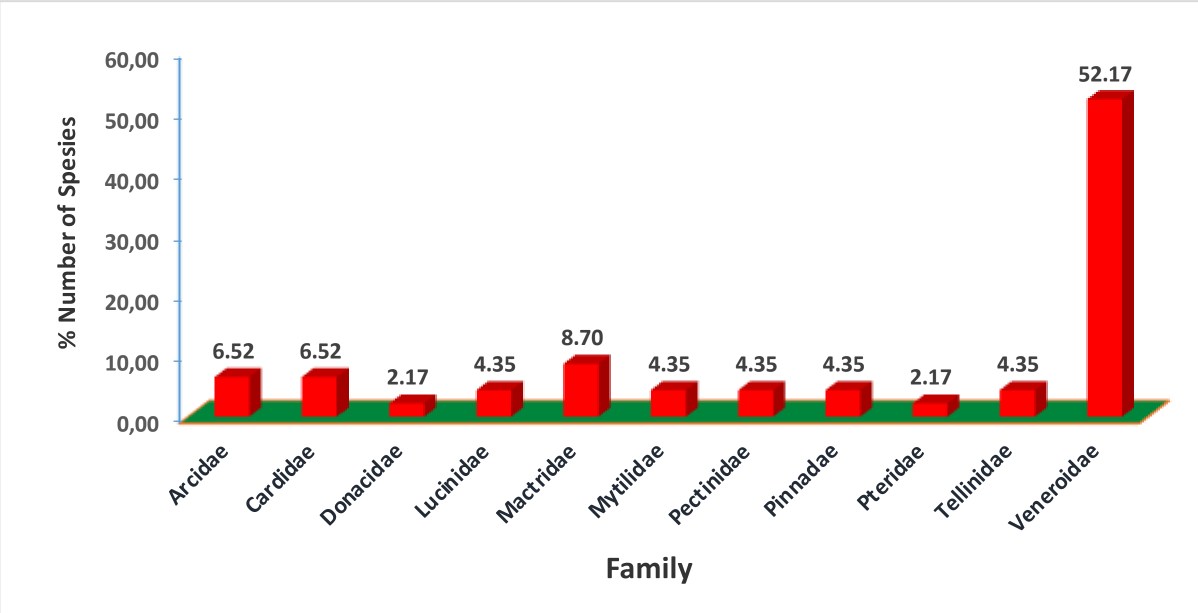

Figure 2. Species Bivalvia community composition by family based on the number of species present in the six study site

Meanwhile, the species richness of Bivalves at the six research sites showed that Gili Kere had the highest number of species, and the lowest was in Lungkak (Table 6). Species with the highest distribution and distribution in all study sites were *Anadara antiquata*, *Anadara granosa*, and *Gafrarium pectinatum*, followed by the species *Lioconcha fastigiata*, *Pinctada imbricata*, and *Tapes literatus*, distributed in five study sites. *Trachhycardium flavum* was the only species distributed at four research sites. However, the highest number of Bivalvia species were distributed in two locations and reached 34.04%, followed by the number of species at one place, which reached 29.78%, and 19.14% at three sites (Table 5). Of the 14 species of bivalves found in one location, 12 species were in Gili Kere. The one species in Gerupuk was *Calista impar*, and one species in Kuta was *Pitar citrinus* (Table 5). However, the highest individual species abundance value was of *Perna viridis*, only lying in Gili Kere. On the other hand, the species *Anadara antiquata* had the highest abundance in Lungkak, but was evenly distributed in the six study sites. Furthermore, the lowest abundance among Gili Kere species was for *Atrina vexillum*, *Katelysia marmorata*, *Mactrotoma ovalina*, and *Tegillarca addita*, while in Lungkak the lowest abundance was for *Lioconcha fastigiata* and *Tegillarca addita*. In Poton Mangrove the species with the highest abundance was *Gafrarium tumidum*, and the least abundant were *Fragum unedo*, *Mactrotoma ovalina*, *Pinctada imbricata*, and *Pitar pellucidus*, whereas in Awang the species with the highest abundance value was *Anadara antiquata*. The least abundant were *Fragum unedo*, *Idas simpsoni*, *Mactra grandis*, *Tegillarca addita*, and *Pitar pellucidus*. In Gerupuk the species with the highest abundance was *Anadara antiquata*, and the lowest abundance was of *Pitar subpellicidus*, *Samela australis*, and *Samela jecunda*. In Kuta, the species with the highest abundance was *Anadara granosa*, and those with the lowest abundance were *Mactrinula depressa, Mactrotoma ovalina,* and *Tivela Stefaninii*.

. **TABLE 6**. The abundance of bivalve species found at the study site

Family	Species of Bivalvia	Abundance (Species/m^2)						Jumlah lokasi ditemukan spesies Bivalvia
		Gili Kere	Lungak	Poton Bakau	Awang	Gerupuk	Kuta	
Arcidae	*Anadara granosa*	0,03	0,32	0,09	0,31	0,37	0,60	6
	Anadara antiquata	0,33	1,62	0,40	0,36	0,43	0,51	6
	Tegillarca addita	0,01	0,03		0,01			3
Cardidae	*Fragum unedo*			0,01	0,01	0,02		3
	Modiolus philipinarum		0,26		0,04		0,05	3
	Trachhycardium flavum	0,04			0,08	0,11	0,11	4
Donacidae	*Donax faba*		0,12		0,03			2
Lucinidae	*Codakia tigerina*			0,15		0,03		2
	Lucinoma heroica			0,15	0,03		0,03	3
Mactridae	*Mactrotoma ovalina*	0,01		0,01			0,01	3
	Mactrinula depressa		0,05				0,01	2
	Mactra grandis		0,23		0,01			2
	Mactra nitida			0,28		0,03		2
Mytilidae	*Idas simpsoni*		0,04		0,01			2
	Perna viridis	1,80						1
Pectinidae	*Chlamys luculenta*	0,02						1
	Marcia recens	0,06						1
Pinnadae	*Atrina vexillum*	0,01						1
	Pinna muricata	0,09			0,03		0,04	3
Pteridae	*Pinctada imbricata*	0,03		0,01	0,05	0,03	0,11	5
Tellinidae	*Tellinella palatum*				0,03	0,04		2
	Tellinella staurella	0,03						1
Veneroidae	*Calista impar*					0,04		1
	Circe tumefacta	0,04						1
	Gafrarium tumidum		0,15	0,81				2
	Gafrarium dispar	0,05						1
	Gafrarium pectinatum	0,12	0,26	0,20	0,16	0,29	0,15	6
	Katelysia marmorata	0,01						1
	Lioconcha castrensis	0,03						1
	Lioconcha fastigiata	0,09	0,03	0,12	0,11		0,17	5
	Marcia hiantina			0,02			0,05	2
	Meretrix meretrix		0,05		0,02			2
	Paphia gallus	0,08			0,05		0,11	3
	Paphia undulata	0,07				0,02		2
	Pitar citrinus						0,14	1
	Pitar fulminatus			0,09				1
	Pitar simpsoni	0,02				0,02	0,04	3
	Pitar pellucidus	0,02		0,01	0,01			3
	Pitar subpellicidus			0,02		0,01		2
	Politita pesaureus	0,02						1
	Protapes gallus	0,02						1
	Samela australis			0,05		0,01		2

	Samela jecunda	0,01		0,28		0,01		2
	Tapes sulcaris	0,03	0,30	0,01	0,05	0,11	0,03	6
	Tapes belcheri	0,11				0,03	0,08	2
	Tapes literatus	0,11	0,32	0,01	0,08	0,05		5
	Tivela stefaninii	0,01					0,01	2
Number of Spesies		27	14	19	20	18	18	
Average abundance of bivalve /m^2		0,07	0,08	0,06	0,03	0,04	0,05	

The species composition of bivalves at each study site (Figure 3) shows the differences in the number of species between the seagrass bed locations. Gili Kere has the highest number of species (57.45%), whereas Lungkak has the lowest number (29.79%). The spatial species richness of bivalves is related to the seagrass environment, especially the substrate conditions at the six research sites (Table 3). The seagrass substrate on Gili Kere is mainly derived from coral rubble and a small amount of mud. Furthermore, three areas (Lungkak, Poton Bakau, and Awang) have a sandy silt substrate, and two locations (Gerupuk and Kuta) a silty, sandy seagrass substrate. Thus, the species richness of bivalves in seagrass areas could be limited by intertidal habitat (Nicholson & Lam, 2005; Feng & Papeş, 2017).

Furthermore, other environmental conditions were the limiting factors for the survival of the Bivalvia species at the study site (Table 4). Environmental viability values at all research sites are shown in Table 6. However, all environmental parameter values (i.e., temperature, brightness, pH, salinity, DO, phosphate, and nitrate) were at the standard levels for marine life (KMNLH No 51 of 2014). Meanwhile, although the phosphate and nitrate values were higher at all study sites, they were still lower than the Redfield ratio, which is N:P (16:1). Environmental variables are a limiting factor, such as for *Anadara antiquata* which requires a temperature range between 24 ^oC to 31^oC (Braby & Somero, 2006; McPherson & Chapman, 2000). Currents and salinity can also affect the distribution pattern and density of bivalve species (Harley et al., 2015; Schneider & Helmuth, 2007). Another factor is the community's pattern of use, which contributes significantly to the preservation of bivalve species, such as at the study site. Further, the distribution of bivalve fauna is influenced by human activities and management strategies and other biological and environmental factors such as the type of substrate. Therefore, the spatial parameters of the distribution of Bivalvia species can be one of the considerations in seagrass conservation at the study site.

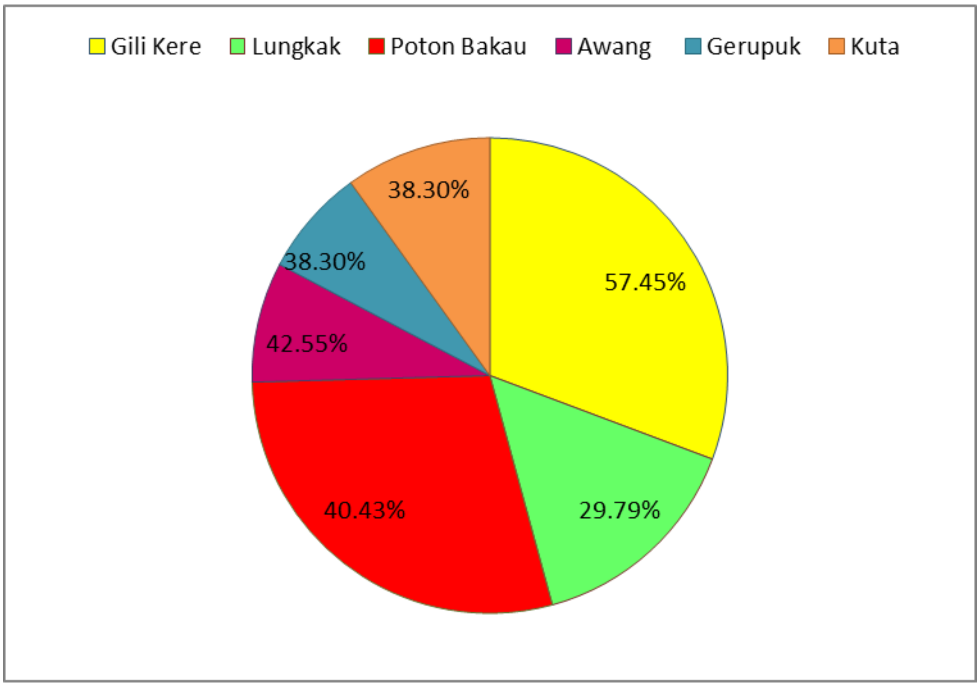

Figure 3. the percentage of all seagrass-associated bivalves species identified in this study found at each of six locations.**Ecological index of fish species associated with seagrass in the six study sites**

The values of the ecological index, which includes the diversity index (H'), evenness index (E) (E), and abundance (Ki) of the bivalve species/year, and the average at the six research sites, are shown in Table 7. The mean values for the H' index and the standard deviation (SD) values at all study sites ranged from 1.94±0.20 to 2.15 ±0.30, with the highest H' index value in Awang and the lowest in Lungkak. Furthermore, the average value of the index (E) and SD ranged from 0.62 ± 0.07 – 0.73 ± 0.07, where the highest was in Lungkakand the lowest in Gili Kere. The average value of Ki and SD indices was 0.49 ± 0.12– 1.15 ± 0.76, the highest being in Lungkak and the lowest in Awang. The average value of the ecological index (Table 7) can explain the differences in the structure of the Bivalvia community at each study site. The diversity index value describes the condition of the community structure, which is determined by the number of species and individual species of bivalves associated with seagrass.

Meanwhile, the species richness index value describes the number of different species related to seagrass in the six seagrass beds in the study location. The number of individuals/species does not determine the value of species richness. However, the abundance index value describes the individual abundance value of each Bivalvia species associated with seagrass at the six research sites (Table 6). In addition, spatially integrated Bivalvia species' ecological index values can be scientific information for developing sustainable landscape metrics, improving understanding of the area's ecological functions, and enabling management and monitoring of seagrass ecosystems' health (Barrell & Grant, 2015). Therefore, the three parameters of the environmental index of Bivalvia species at the study site (H', E, and Ki) can enable the health assessment of seagrass ecosystems. Moreover, the ecological function of seagrass in the survival of Bivalvia species diversity at specific environmental index values (H', E, and Ki) is scientific evidence as a parameter of seagrass protection and conservation, such as at the study site.

TABLE 7. Ecological index values for seagrass-associated Bivalvia species by year at the six study locations.

Lokasi	Index	Tahun			Mean	± SD
		1	2	3		
Gili Kere	Species Diversity Index (H)	1,93	2,3	1,91	2,05	± 0,22
	Evenness Index (E)	0,59	0,7	0,58	0,62	± 0,07
	Abundance (Ki)	1,28	1,65	0,85	1,26	± 0,40
Lungkak	Species Diversity Index (H)	2,04	1,71	2,06	1,94	± 0,20
	Evenness Index (E)	0,77	0,65	0,78	0,73	± 0,07
	Abundance (Ki)	0,86	2,26	0,73	1,28	± 0,85
Poton Bakau	Species Diversity Index (H)	1,79	2,01	2,42	2,07	± 0,32
	Evenness Index (E)	0,61	0,68	0,82	0,70	± 0,11
	Abundance (Ki)	0,55	2,03	0,2	0,93	± 0,97
Awang	Species Diversity Index (H)	2,36	1,81	2,27	2,15	± 0,30
	Evenness Index (E)	0,79	0,6	0,76	0,72	± 0,10
	Abundance (Ki)	0,62	0,42	0,42	0,49	± 0,12
Gerupuk	Species Diversity Index (H)	2,17	1,79	2,28	2,08	± 0,26
	Evenness Index (E)	0,75	0,62	0,79	0,72	± 0,09
	Abundance (Ki)	0,59	0,6	0,46	0,55	± 0,08
Kuta	Species Diversity Index (H)	2,3	1,71	2,22	2,08	± 0,32
	Evenness Index (E)	0,8	0,59	0,77	0,72	± 0,11
	Abundance (Ki)	1,12	0,63	0,49	0,75	± 0,33

The one-way ANOVA results show the ecological index values (H', E, and Ki) as presented in Table 8. The distribution of the results of the analysis is: F-count 5.12, F-table 2.14, and P-value 0.18, on the ecological index H'; F-count 5.12, F-table 3.08, and P-value 0.11, on the environmental index E; and F. -count 5.12, F-table 2.96, and P-value 0.12, on the ecological index Ki. The analysis results using the F test show from the comparison between the F-count and F-table values for each ecological index value (H', E and Ki) that the F-count value is higher than the F-table value. Therefore, it can be concluded that there are significant differences between the three parameters (H', E, and Ki) at each research location. Furthermore, based on the results of the dendrogram analysis (Fig. 4), Lungak and Awang are in one group and are characterized by having the highest similarity of the three ecological index values, although geographically Lunkgak is closer to Poton Bakau and Gili Kere. Likewise, Gerupuk and Kuta, although geographically close together, are not in the same group.

On the other hand, Kuta has similarities with Gili Kere, although geographically the location does not differ. The level of similarity or grouping can explain that location proximity can lead to significant differences in species richness, number of individuals/species, and species abundance of populations and communities of bivalves. Another explanation is that the distribution of bivalve species is not limited by geographic position. Still, the distribution of bivalve species is determined by the presence of seagrass in providing a habitat to survive. Therefore, the variable of the ecological index values of Bivalvia species can be an essential aspect to be considered as a parameter of seagrass conservation, such as at the study site (Table 8).

TABLE 8. The one-way ANOVA analysis of the ecological indices for seagrass-associated Bivalvia at the six study locations.

One-way Anova	Source of Variation	Diversity index (H')	Evenness index (E)	Abundance (Ki)
SS	Between Groups	127.61	183.29	176.29
	Within Groups	536.26	536.24	536.55
Df	Between Groups	1	1	1
	Within Groups	9	9	9
MS	Between Groups	127.62	183.29	176.29
	Within Groups	59.58	59.58	59.62
F-crit		5.12	5.12	5.12
F-table		2.14	3.08	2.96
P-value		0.18	0.11	0.12

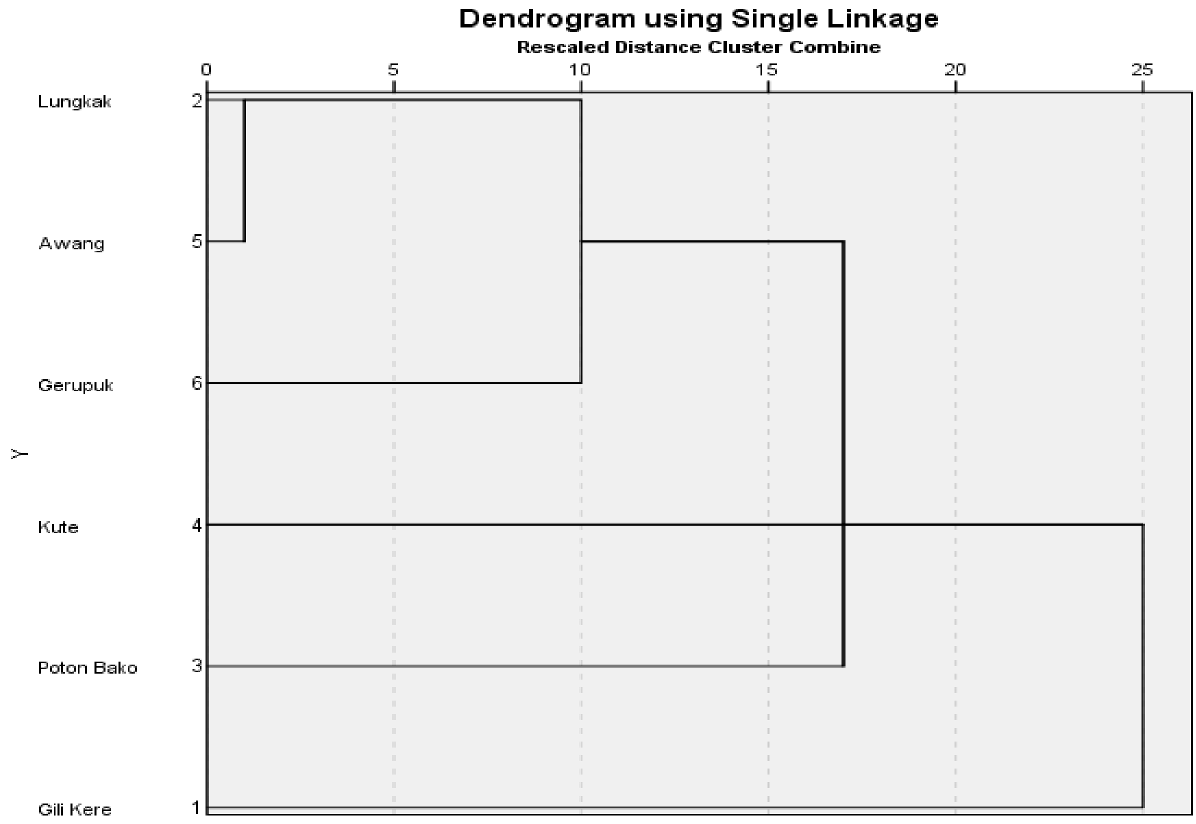

Figure 4. Cluster analysis of the Euclidean distance between seagrass-associated Bivalvia at the six study locations.

Correlation of Environmental Factors with Bivalves

The results also show that three study locations had the same substrate of sandy mud, muddy sand, sand, and rocky sand. The majority of mollusks prefer to live on a sandy mud substrate. Bivalves tend to choose sandy mud substrate, as the sand is easy to move/mobilize in, whereas mud substrate tends to have less oxygen content; therefore, the organisms living in it must be able to adapt accordingly. At Gili Kere, the dominant type of substrate is sand from dead coral debris. In the seagrass beds of Lungkak, Poton Bakau, and Awang mud is more prevalent, with the mud originating from the river.

In the seagrass beds of Gerupuk and Kuta sand is more prevalent, with fine sand being deposited from run-offs. Since this is a source of seagrass's primary substrate, it can be an instrument in the assessment of the condition of seagrass, the pattern of seagrass distribution, and bivalves in these habitats. Furthermore, the species richness of bivalves associated with seagrass can provide information about the ecological warfare of seagrasses in providing habitat for the growth and development of bivalve communities

TABLE 9. Correlation of environmental parameters with ecological indices

	Diversity	Evenness	Abundance	Temperature	Salinity	pH	Light	Do	Phosfat	Nitrat
Diversity	1									
Evenness	0.015	1								
Abundance	0.743	0.524	1							
Temperature	0.058	0.423	0.143	1						
Salinity	0.174	0.552	0.127	0.981	1					
pH	0.053	0.014	0.287	0.554	0.479	1				
Light	0.175	0.028	0.465	0.870	0.807	0.770	1			
Do	0.227	0.539	0.112	0.890	0.927	0.146	0.619	1		
Phosfat	0.032	0.509	0.038	0.915	0.921	0.257	0.716	.904	1	
Nitrat	0.117	0.875	0.298	0.699	0.794	0.166	0.414	0.735	0.817	1

The Pearson correlation value has a range (r= 0 -1), and the results of the correlation analysis of environmental variables with ecological index variables are between 0.028 – 0.875**.** The correlation values between environmental variables (Table 9) can help explain that environmental factors have a relationship with the diversity of bivalved species associated with seagrass, such as at the study site. However, in fact, the environmental conditions of all parameters are still at the standard allowed for marine life, including bivalve (KMNLH No. 51 of 2014), although the parameters from the investigators' results show differences in significance values of the ecological parameters of Bivalvia species (i.e., diversity, evenness, and abundance), as in Table 9. The index of evenness has a significant correlation of four parameters: nitrate ($r = 0.875$), salinity (0.552), DO ($r = 0.539$), and phosphate ($r = 0.509$). However, the two ecological indices, namely the diversity index and the abundance index, show that the value obtained is $r < 0.5$, revealing no significant correlation.

It can be explained that the values of diversity and abundance of species are determined by other factors, such as the substrate. Nevertheless, Seo et al. (2013) explained that environmental parameters such as phosphate, salinity, nitrate, temperature, and organic matter are essential factors supporting the bivalve species' diversity to survive. In addition, a factor that has a significant contribution to the survival of the variety of bivalve species is the presence of seagrass, which can help create a suitable habitat for the growth and development of bivalve species (Syukur et al., 2021). Therefore, the presence of bivalve species diversity in seagrass, such as in the study site, can be scientific information and can be considered as a parameter of local scale seagrass conservation, such as **at the study site.**

Conclusion

The species composition of Bivalves at the six research sites consisted of 11 families and 47 species. The location with the highest number of species was Gili Kere, and the lowest was Lungkak. Meanwhile, the family with the highest number of species was the Veneroidae family, including 25 species. In addition, the two families with the lowest number of species were the Donacidae and Pieridae families. Both families consist of only one species. Another parameter is the value of the ecological index (H', E, and Ki), which can describe the richness of the Bivalvia community at each seagrass bed in the study location. Meanwhile, it was found that there was a significant difference in species richness of Bivalves from the six study sites. One of the limiting factors that caused differences in species richness from the six research sites was the suitability of substrate conditions. Therefore, ecological variables and environmental conditions are the main parameters for seagrass conservation, such as at the study site.

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AUTHOR'S CONTRIBUTIONS

Abdul Syukur, Agil Al Idrus, Lalu Zulkifli, and Baiq Nunung Hidayati: Conducted all experiments, participated in data analysis and preparation of the manuscript.

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