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Abundance and growth pattern of gastropods (*Telescopium telescopium* and *Cerithidea obtusa*) and association with mangrove ecosystem at bee jay Bakau resort, Probolinggo East Java

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Abstract
Bee Jay Bakau Resort (BJBR) is a mangrove ecotourism that has been rehabilitated from damaged mangrove areas. This rehabilitation have an impact on typical mangrove fauna such as *Telescopium telescopium* and *Cerithidea obtusa*. The present study was performed in December 2020. This study aims to analyze about abundance and growth pattern of gastropods *T. telescopium* and *C. obtusa* and the association with BJBR mangrove ecosystems. The sampling was determined using the purposive sampling technique and carried out at three stations based on the distinct locations using a 1mx1m transect. The association of gastropods and mangrove ecosystems was analyzed using Correspondence Analysis (C.A.). The results show that gastropods abundance ranged from 9 ind/m^2 to 84 individuals/m^2. Overall, the growth pattern is allometric negative, which means the length growth is faster than the weight growth. The result of C.A. showed that there are three association groups of between gastropods and mangroves.

Keywords: Gastropods, mangrove rehabilitation, association mangrove, Bee Jay Bakau Resort Probolinggo

Introduction
Gastropods are a vital biological resource in mangrove ecosystems. Gastropods are the largest class of the mollusk phylum, with about 100.000 species of mollusks scattered almost all over the world (Strong *et al.* 2008) [22]. According to Nontji (2002) [13], there are about 1.500 species of gastropods in Indonesia. Its existence plays a role in the food chain in the mangrove ecosystem. This organism takes an essential link for organic matter from mangroves to the third trophic level, such as fish or birds, through the leaf (Kabir *et al.*, 2014) [9]. Generally, gastropods live on roots, stems, and the substrate. These organisms have relatively limited movement, so their abundance and distribution are strongly influenced by habitat, food availability, and predation (Silaen *et al.*, 2013) [21].

BJBR is a rehabilitated mangrove eco-tourism area in Mangunharjo village, Mayangan district, Probolinggo East Java, Indonesia. This area is a formerly damaged mangrove ecosystem and full of trash. The mangrove ecosystem of the Mayangan district experienced a change in area from 13 hectares in 1998 to 47 hectares in 2018 after decreasing to 0 hectare in 2008 (Widyantara and Solihuddin, 2020) [24]. This change in mangrove areas may also affect the condition of the ecosystem. Changes in the content of organic matter, sediment, and the structure of mangrove species affect the diversity and abundance of gastropods (Kottè-mapoko *et al.*, 2017; Supratman and Syamsudin, 2018) [12, 23].

Telescopium and *Cerithidea obtusa* are gastropods belonging to the family Potamididae, typical fauna of the mangrove ecosystem and dependent on the mangrove. Its existence will be affected if there is a change in the mangrove ecosystems. Based on these conditions, gastropods are potentially used as mangrove bioindicators (Reid *et al.* 2008) [17]. Therefore, this research is expected to produce information about the abundance and growth pattern of gastropods *Telescopium* and *Cerithidea obtusa*, which can be used to monitor the condition of the mangrove ecosystems in this location.

Materials and Methods
Description site
The research was conducted in December 2020, at Bee Jay Bakau (BJBR) Resort Probolinggo, East Java, Indonesia. The sediment samples were analyzed in Proling Laboratorium, IPB University, Bogor, and West Java, Indonesia. The research site was determined based on the Salma *et al.* (2021) [20] research on "Vegetation Analysis of Mangrove Rehabilitation in the BeeJay Bakau Resort, Probolinggo, which took three stations with three iterations (figure 1).

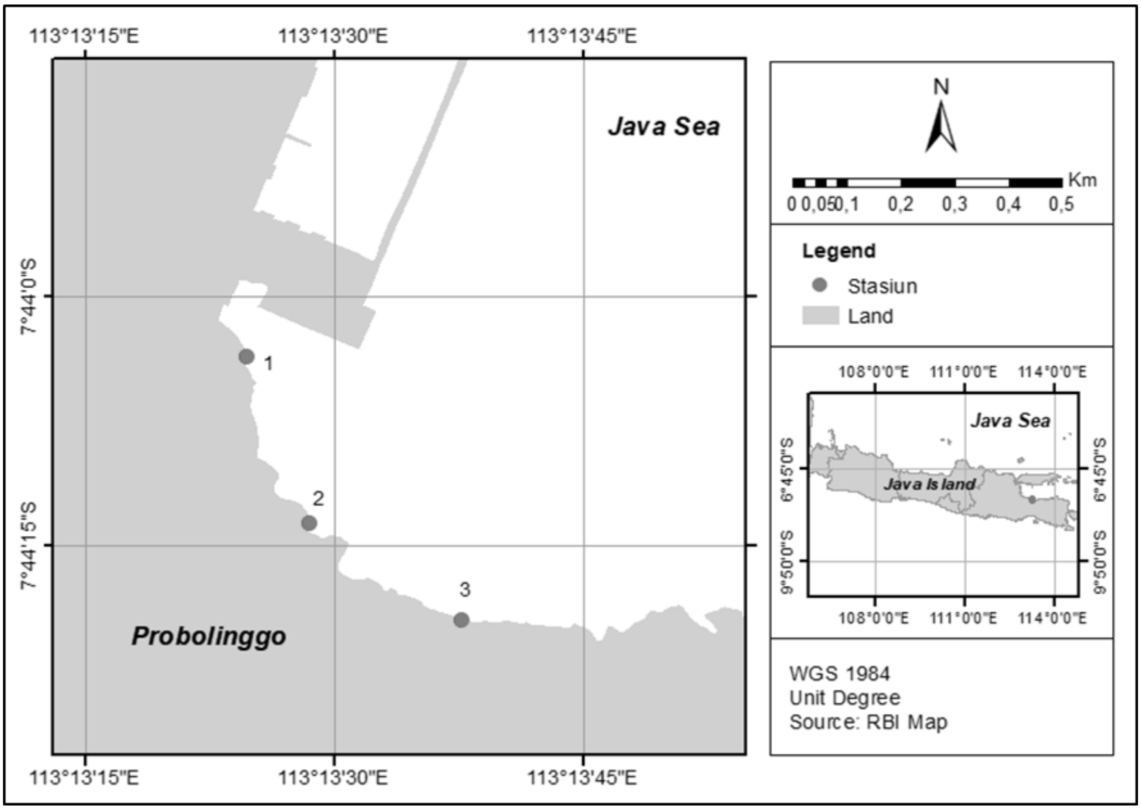

Fig 1: Map of Site Research

The iterations depending on the characteristics of the mangrove ecosystem found in the BJBR. Site one is rehabilitated mangroves nearest the tourist area entrance (substations 1.1, 1.2, 1.3). Site two is a combination of rehabilitated and natural mangroves at the center of the tourist area with many tourist buildings (substations 2.1, 2.2, 2.3). Site three is a natural mangroves area (substations 3.1, 3.2, 3.3). BJBR mangrove vegetation has a density displayed in figure 2:

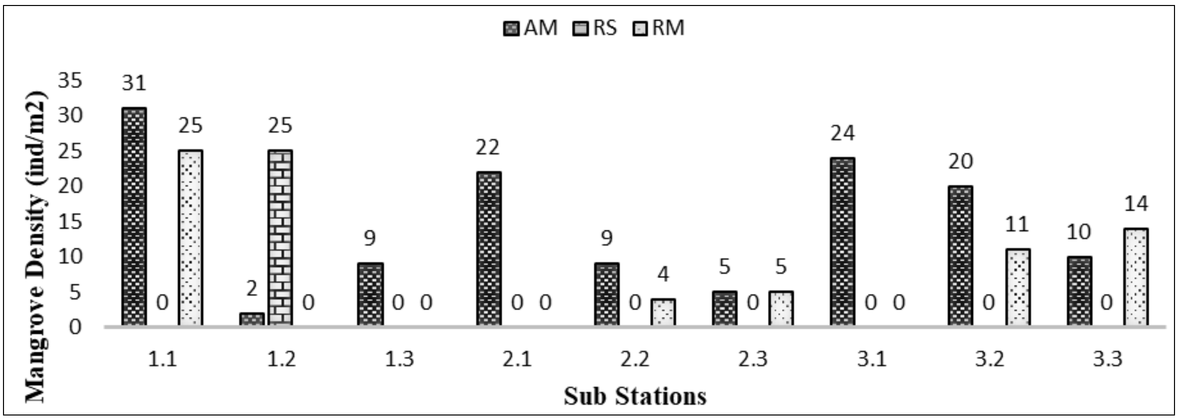

Fig 2: Mangrove Density

Data Collection
Mangrove collection was using a 100m^2 transect divided into three categories, trees (10mx10m), sapling (5mx5m), and seedlings (1mx1m). The diameter was measured by tree: d>4cm, sapling:4>d>1, seedling: <1 (Kitamura *et al.* 1997) [11]. Gastropods sampling was hand-picked from the substrate on a 1mx1m transect placed in a 10mx10m mangrove transect. Gastropods samples were preserved using 4% formalin and 70% ethanol. The sediment data collection was carried out using a sediment core diameter of 5 cm and length of 1 m into a depth of 10 cm because that depth is where the gastropods most occur. Parameters of temperature using a thermometer, salinity using refractometer, and pH using a pH meter were measured in situ. Parameter of sediment fraction and Total Organic Matter (TOM) was carried out ex-situ using gravimetric methods

Data analysis

The population abundance was measured by using the formula (Ariyanto, 2018) [2]:

Di = ni/A

Where:

Di = abundance of gastropods (individual/m^2)
Ni = number of individuals of the "i" species
A = size of the plot that "i" species found (m^2).

The length-weight relationship was determined by regression analysis (Ariyanto, 2018) [2]:

$W = aL^b$

Where
W = weight (g)
A-b = constanta
L = length (cm)

The logarithmic transformation of the formula is
Log W= Log a + b Log L

The association between gastropods and mangrove ecosystems was analyzed using Correspondence Analysis (C.A.) (Bengen, 2000) [4].

Results

Abundance of Gastropods

Based on the observations (figure 3), the highest *T. telescopium* abundance was at station 2 (84 ind/m^2), followed by station 1 (37 ind/m^2) and station 3 (23 ind/m^2). The highest abundance of *C. obtusa* was found at station 1 (11 ind/m^2), while stations 2 and 3 have the same abundance (9 ind/m^2).

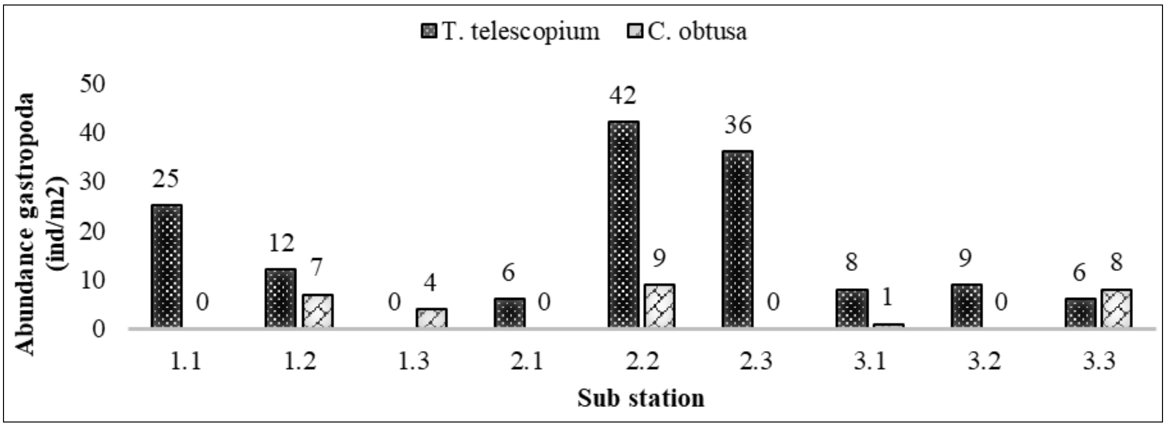

Fig 3: Abundance of Gastropods

Length-Weight Relationship

The relationship between length and weight analysis showed that *T. telescopium* and *C. obtusa* are allometric negative (Table 1). However, it was different at station 2 *C. obtusa* had an isometric pattern. The determination value (R^2) at each station has a different value. The R^2 of *T. telescopium* at station 1(0,786) and 2 (0,946) tends to approach the value 1, while at station 3, the R^2 is o, 324. *C. obtusa* has the same pattern, at station 1 (0,739) and station 2 (0,745) has a value close to 1. While station 3 has a value of 0,347.

Table 1: Growth pattern *T. telescopium* and *C. obtuse*

Station	*Telescopium telescopium*		*Cerithidea obtusa*	
	b	R^2	b	R^2
1	2,996	0,786	2,649	0,739
2	2,666	0,946	3,068	0,745
3	2,827	0,324	1,779	0,347

Environmental Characteristics

The environmental characteristic of substations is shown in table 2. Based on table 2, showed that dominating substrate was clay (71,01%-80,34%) followed by silt (9,68%-12,48%), then sand (9,98%-12,48%). We use the TOM value to determine the level of ecosystem fertility in an area and classified as a low category with a score between 1, 71-2,74. Salinity values ranged from 0-4 ppt. The pH value range from 7, 3 – 8,8. The redox potential is normal range from -11, 4 – (-46,8) mV. In the wetlands area, the redox potential range from -300 – (-700) mV. The negative value showed that the substrat was in a reduced condition. The difference of redox potential conditions are influenced by several factor, including size of sediment fraction, the input of organic matter, and frequency of water inundation (Mustafa *et al*. 2011; Deborde *et al*. 2015) [4, 12].

Table 2: Environmental Characteristic

Parameter	Station 1			Station 2			Station 3		
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
Sand (%)	11,9	11,58	9,98	16,57	16,3	17,84	15,28	15,27	16,12
Silt (%)	12,29	11,55	9,68	9,98	10,05	11,15	11,2	12,48	11,32
Clay (%)	75,81	76,87	80,34	73,45	73,65	71,01	73,52	72,25	72,56
TOM (%)	2,74	2,1	2,08	1,91	2,33	2,04	1,89	1,71	1,49
Salinity (ppt)	3,0	3,1	1,9	4	3,5	2,1	3	3,2	0
pH	8,1	8,4	8,5	8,8	8,3	7,9	7,3	7,7	7,9
Redox Potential (eH)	-40,7	-12,2	-11,4	-46,8	-31,5	-30,7	-52,1	-23,3	-45,6

Association of Gastropods Size Class with Mangrove Environmental Characteristics

The size class of gastropods divided into three categories (Figure 4), small (*T. telescopium*: 2.00 cm-6.66 cm & *C. obtusa*: 3.88 cm-4.26 cm), medium (*T. telescopium*: 6.74 cm-7.51 cm& C. obtusa: 4.29 cm-4.5 cm), large (*T. telescopium*: 7.53 cm-8.98 cm & C. obtusa: 4.52 cm-4.86 cm).

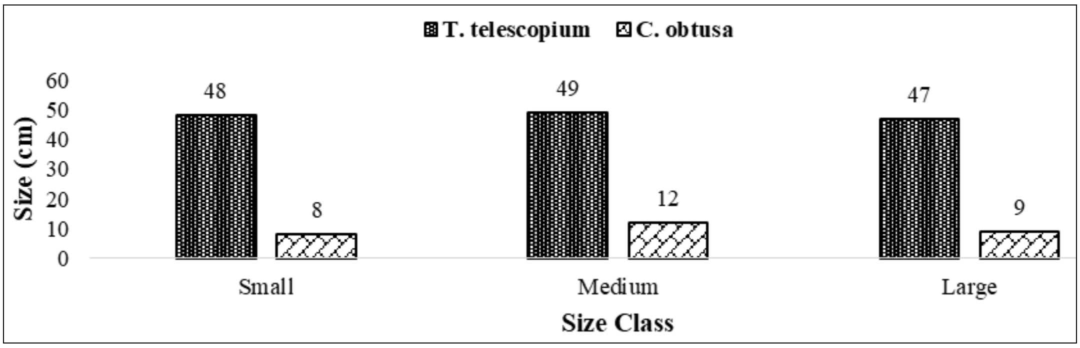

Fig 4: Size Class of Gastropods

According to C.A., there are three groups of relationships between gastropods size classes and environmental characteristics of mangroves centered on the F1 axis with variance values 59, 55% and F2 axis with 27, 94% variance value (Figure 5). The first group showed that *C. obtusa* in all sizes clustered in areas with rare mangrove density (<10 ind/100m^2) with salinity ranged between 0 ppt – 1,5 ppt. pH ranged from 8,4-8,9, and TOM ranged from 1,4-1,8. The second group was dominated by small *T. telescopium* with dense mangrove density (≥15 ind/10m^2) and moderate (≥10 - <15 ind/100m^2). Salinity ranged from 1, 6‰ - 3, 0‰, pH between 7, 8-8, 3 and TOM ranged from 1, 9-2, 3. The third group was dominated by large and medium-size *T. telescopium* with salinity ranged from 3, 1‰ – 4, 5‰. PH between 7, 2-7, 7 and TOM ranged from 2, 4-2, 8.

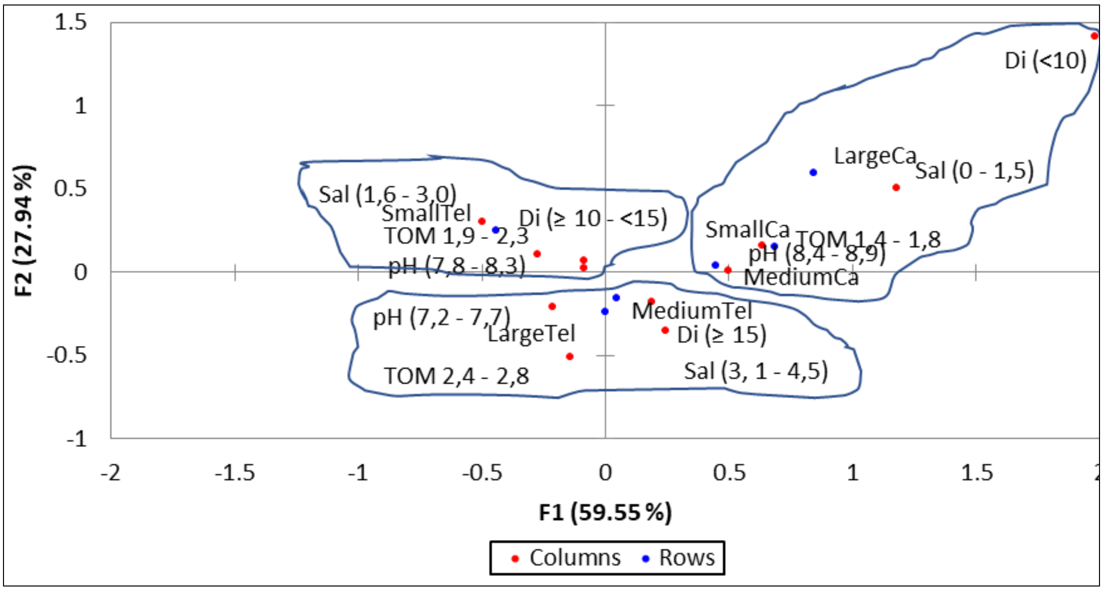

Fig 5: Symmetric plot (axes F1 and F2:87.48%)

Discussion

According to the Decree of the State Minister for the Environment No 201 (2004), the density of mangroves in all stations is included in the dense category (>15 ind/100m^2). The dominant species is *A. marina*. This mangrove species habitat on the muddy substrate. This species can be found in freshwater swamp areas, muddy shores, the area of high salinity (Halidah and Kama, 2013) [6]. Mangrove density can affect the abundance of gastropods (Putra *et al.* 2019) [16]. The abundance of gastropods at stations 2 and 3 are not directly proportional to the density of mangroves. Food availability, habitat, and competition can affect the density and distribution of gastropods (Silaen *et al.* 2013) [21]. *T. telescopium* is commonly found near the roots of *A. marina*. Dense roots can trap TOM, which is a food resource for *T. telescopium*. According to figure 3 and table 2, locations with high TOM concentrations will find many *T. telescopium*. *A. marina* is often found in the area with high TOM concentrations (Bengen 2004) [4].

The increase in size and weight are influenced by food (Haumahu *et al.* 2014) [8]. The "b" value indicates the growth pattern. According to Effendie (2002) [5], if the value of b>3, then the growth pattern of gastropods is an allometric positive, namely the weight gain is faster than the length increase. Otherwise, if the value of b<3, then the growth pattern of gastropods is allometric negative, namely, the weight gain is slower than the length increase. The growth pattern of *T. telescopium* in all stations had an allometric negative. While *C. obtusa* at station 2 had an isometric growth pattern, the weight gain was proportional to the length increase. The determination value (R^2) at stations 1 and 2 has a value close to 1, which indicates that the “length” variable is increasingly contributing to the weight variable. Different conditions are shown at station 3, which has a determination value of 0,324 (*T. telescopium*) and 0,347 (*C. obtusa*), which means that the "weight" variable has a small contribution to the "length" variable, so there are other factors that affect the variable "length." Food availability will affect the growth of gastropods (Ariyanto *et al.* 2018) [2]. In addition, internal (genes and sex) and external factors (parasites, disease, and food) can also have an effect (Nybakken, 1998) [14].

Correspondence analysis showed that large and medium *T. telescopium* clustered in an area with TOM values ranged from 2,4-2,8 found at substation 1.1. This location is dominated by mangrove *A. marina* with 75, 81% clay substrate. The finer sediment fraction will increase the potential for trapping organic matter (Riniatsih and Kushartono, 2010) [18]. *T. telescopium* likes waterlogged, muddy areas and is abundant in mangrove pneumatophores (Haque and Choudhury, 2015) [7]. Small *T. telescopium* was abundant in station 2 with TOM values ranged from 1, 9-2, 3 with moderate (≥10 - <15 ind/100m^2). This location is suspected to be a breeding area because there are many small *T. Telescopium. C. obtusa* of all sizes clustered in one area with low mangrove density (<10 ind/100m^2) and dense mangrove density (≥15 ind/10m^2) with TOM values ranged from 1, 4-1,8. The clustering of all size classes *C. obtusa* on certain characteristics is caused by specific microhabitat factors that affect the distribution. The distribution depends on shelter and food (Zakaria and Rajpar, 2015; Ariyanto *et al.* 2020) [25, 1]. Also, predation, habitat change, and individual competition affect (Belgrad and Smith, 2014; Peng *et al.* 2017) [3, 15].

Conclusion

There was a difference between the abundance of *T. telescopium* and *C. obtusa*. Generally, the growth pattern of both species is allometric negative. Mangrove environmental characteristics such a pH, salinity, and TOM affect gastropods. The discovery of gastropods in various class groups with reasonably even distribution indicates that the BJBR mangrove ecosystem is in good condition and supports gastropods life.

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