

Crab diversity as support for ecotourism activities in Pejarakan Mangrove Forest, Buleleng, Bali, Indonesia

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Abstract. *Ginantra IK, Muksin IK, Joni M. 2021. Crab diversity as support for ecotourism activities in Pejarakan Mangrove Forest, Buleleng, Bali, Indonesia. Biodiversitas 22: 4139-4145.* This research aims to determine the diversity of crabs to support ecotourism activities in the coastal mangrove forest of Pejarakan Buleleng. Sampling of crabs was carried out using the square method, as many as 23 squares were spread over three mangrove zones, namely the front zone, the middle zone, and the rear zone. The number of individual crustacean species in each square plot was counted. Crab identification is based on morphological characters (shell color, claw shape, body-color, body size). Habitat use activities are observed directly. The diversity of crabs was calculated using the Shannon-Wiener diversity index. The results showed that in the coastal mangrove area of Pejarakan Buleleng, there were 11 species of crabs (9 species of crabs and 2 species of hermit crabs). Species diversity is in the medium category (index 2.25) and evenness index is high ($E = 0.93$, mangrove conditions are stable). The seaward mangrove zone shows a higher diversity of crab species than the middle zone and the rear zone. The species of crabs that are quite abundant in the three zonings are *Uca vocans*, *Chiromanthes* sp., and *Coenobita* sp. Characteristics of crabs, activities, habitat use in mangrove zoning are attractions for ecotourism activities.

Keywords: Crabs, ecotourism attractions, mangroves, species diversity

INTRODUCTION

The mangrove forest in the coastal area of Pejarakan Village which covers an area of 160 hectares is managed by the Putri Menjangan Conservation Forum (NCF Putri Menjangan). Area management includes mangrove conservation efforts and the development of educational tourism/ecotourism (Riyastini 2015; NCF Putri Menjangan 2016). Ecotourism activities are principally the use of mangrove areas while maintaining the biological/ecological functions of mangrove forests and having economic value for local communities (Duangjai et al. 2014; Sudarto 1999).

Data on the diversity of mangroves, birds, and mollusks species in the Putri Menjangan NCF mangrove ecosystem are available. There were 13 species of true mangroves and 14 species of associated mangroves, the dominant species were *Sonneratia alba*, *Lumnitzera racemosa*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Ceriops decandra*, and *Avicennia marina* (Ginantra et al. 2018). There were 39 species of birds, including 24 families, the dominant species being from the waterbird groups of the Ardeidae and Alcedinidae families (Ginantra et al. 2020). Mollusks are dominated by the gastropod class including *Terebralia palustris*, *Planaxis sulcatus*, and *Telescopium telescopium* (Ginantra et al. 2020). However, there are no data available on the diversity of Crustacea in this area. Furthermore, the diversity of crabs also characterizes the quality of mangroves and is an attraction for ecotourism activities.

Malacostraca is an important macro-fauna group in the mangrove ecosystem, consisting of crabs, shrimp, and hermit crabs. Crabs are omnivorous animals that live in

association with mangroves, eating carrion, algae, microbes, and detritus (Ravichandran et al. 2011). Crustaceans in mangrove areas have an important role in maintaining the balance of the food chain as prey and predators of other biota and as a source of community protein. Crab is a benthic animal that eats suspended material (filter feeders) and is generally very dominant on sandy and muddy substrates. The species found are shrimp and crab species that usually live in tidal areas and are included in the category of eating mangrove litter and fresh mangrove leaves (Widyastuti 2016).

Identification of crab species diversity is important because the diversity of crabs that interacts with mangrove ecosystems and patterns of diversity in habitat zoning is an attraction for ecotourism activities. This data could also be a reference for mangrove area managers (NCF Putri Menjangan) in developing ecotourism and mangrove forest conservation efforts.

MATERIALS AND METHODS

Study area and period

The research was conducted in April-June 2019, in the mangrove ecosystem area of the Putri Menjangan Conservation Forum, Pejisir, Pejarakan Village, Buleleng District, Bali, Indonesia (Figure 1). Field observations were carried out in the morning at 08.00-11.00 and at 16.00-18.00 Central Indonesian time in the afternoon. ZL1 to ZL8 is the square of the front zone sample (zone near the sea), ZT1 to ZT8 is the middle zone and ZD1-ZD7 is the

back/land zone sample.

Sampling technique

A sampling of crabs was carried out in 23 square plots. Each square measured 1 m x 1 m. Placement of squares was based on mangrove zoning (from near the sea to the mainland) (Figure 1). Sampling was carried out at low tide, at each predetermined square, the substrate was excavated to a depth of 20 cm. In each square plot, the number of individual crabs species was counted. Crabs were put in bottles and preserved with alcohol (70%), then identified in the laboratory.

Identifying the species of Crustaceae

All specimens were photographed and identified. Identification of crustaceans based on morphological characters (shell color, claw shape, body-color, body size), identification refers to Motoh and Kuronuma 2015; Harshith et al. 2016; Lapolo et al. 2018). The identification of crustaceans was carried out in the Animal Taxonomy Laboratory of the Biology Study Program, Faculty of Mathematics and Natural Sciences, Udayana University, Bali, Indonesia.

Determination of crustacean activity

The activity of crabs in the habitat was observed directly, namely recording all activities found in each location of the mangrove ecosystem. Activity observations were carried out in 3 zones (front, middle, and rear). The data recorded is the activity of each species of crustacean

(eating, walking, sticking to rocks/mangrove vegetation, entering the hole, getting out of the hole, entering the mud, entering the water). Observation of each crab activity was carried out for 10 minutes.

Data analysis

Crustacean diversity was calculated by the Shannon-Wiener diversity index ($H' = -\sum [ni/N \times \ln ni/N]$), where ni = the significance value of the i th species and N = the total significance value of all species. The importance value is determined from 2 parameters, namely: relative density and relative frequency. The criteria for the diversity index are; $H' < 1.5$ then the species diversity is low, $1.5 < H' < 3.5$ means that the species diversity is moderate, and $H' > 3.5$ then the species diversity is high (Krebs 1989). The evenness index (E) is calculated by the formula, $E = H'/\ln S$, where H' is the diversity index and S is the number of species. The uniformity index criteria are; if $0 < E \leq 0.5$ then the mangrove condition is depressed and uniformity is low, if $0.5 < E \leq 0.75$ then the condition is less stable and the uniformity is moderate, and if $0.75 < E \leq 1.0$ stable condition and high uniformity (Stiling 1996; Krebs 1989; Natania et al. 2017).

Habitat of crustaceans is presented descriptively in the form of tables. Analysis of the existence of crustaceans as an attraction for ecotourism refers to the results of the feasibility analysis of mangrove ecosystems as ecotourism objects according to Sari (2015) and Rahmila and Halim (2018).



Figure 1. Research location map mangrove ecosystem area in the Putri Menjangan Conservation Forum, Pejisir, Pejarakan Village, Buleleng District, Bali, Indonesia

RESULTS AND DISCUSSION

Crustacean diversity

The study results found 11 species of crustaceans, consisting of 8 species of crabs and 2 species of hermit crabs. The dominant species in the three mangrove zones is *Coenobita* sp. With a density of 59 ind./m², *Uca vocans* has a density of 41 ind./m² and *Chiromanthes* sp. with a density of 38 ind./m², but in general, the species of crustaceans found were fairly evenly distributed in density with one another. There are several species found only in one zone, namely *Scylla* sp., *Sesarma* sp. *Uca anulipes* and *Uca tetragonon* (sea zone), *Uca* sp. (middle zone) (Table 1, Figure 2).

The diversity of crabs in the Putri Menjangan mangrove area is moderate with a diversity index of 2.25 and a species evenness index of 0.93 (Figure 3), which means that the species composition is fairly even. Based on the diversity index, it can be said that the condition of mangroves in this area is still quite good.

The highest diversity of crustacean species is in the front (sea) zone, followed by the middle zone (Figure 3). In the front and middle zones, the density of plant mangrove species is quite high so that it produces a lot of mangrove litter which is the most important intake for mangrove crabs. This is in accordance with Ravichandran et al. (2011) stated that one of the factors that influence the diversity of mangrove crabs is the availability of natural food originating from mangroves and the presence of mangrove leaves. The results study by Ginantra et al. (2020) on mangrove vegetation and substrates show that the sea mangrove zone of Pejarakan coastal mangrove, has more complex vegetation, and consists of *Sonneratia alba*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Avicennia marina*, *Lumnitzera apiculata*, *Ceriops decandra*, *Ceriops tagal*, and *Aegiceras floridum*. There are more diverse types of mangrove roots, namely pneumatophore, knee root, and stilt root. A more diverse type of substrate, namely Sandy, gravel, rock, shallow mud depth up to 10 cm. Water level is high enough when the tide is high or low. Seagrass meadows are also found in some parts of the marine zone of the mangrove ecosystem of Pejarakan Buleleng.

Crabs diversity is higher in the sea zone and lowest in the landward zone Crab *Uca* spp. found more in the sea zone. The complexity of mangrove vegetation, substrate type, and the presence of seagrass in the sea zone support the high diversity of crustaceans. Pratiwi et al. (2018), also found that crustacean diversity (especially *Uca* spp.) at a mangrove in Kema North Sulawesi was higher in the marine and middle zones than in the landward zone.

Crabs diversity plays a vital role in the mangrove ecosystem. They decompose mangrove litter and increase the availability of nutrients for other flora and fauna. Crabs act as a bioturbator that includes nutrient cycling from mudflats and mangroves. Mangroves provide shelter for crabs from threats from other benthic fauna. The existence of crabs directly depends on mangrove resources for survival and adaptation to various conditions of sediments. The distribution and diversity of crabs are related to several parameters including substrate pH, nitrogen, potassium, phosphorus, and soil organic carbon (Saher and Qureshi 2011; Murugan and Anandhi 2016; Prasanna et al. 2017; Kamaruddin et al. 2019; Karniati et al. 2021).

The low diversity of crustacean species in the terrestrial zone is also caused by environmental pressures due to human activities, waste from salt pools in the form of mud, and solid waste that enters the mangroves. During our research, we found that a lot of waste from salt ponds enters the mangrove area of the land/back zone. Waste (including plastic, broken bottles, broken glass) can interfere with crustacean breeding grounds. Waste can also cover the surface of the substrate/mangrove roots containing food ingredients to prevent crustaceans from eating.

High and low tides in mangrove areas contribute to the existence of crabs, which can take food during low tide. Mangrove crabs are quite adaptive to environmental changes in their habitat, they will move if their habitat is disturbed (Lapolo et al. 2018). The results showed that crab species including *Uca* sp., *Chiromanthes* sp., and *Sesarma roberti* were often found in holes with relatively stable temperatures to adapt to extreme environments. Lapolo et al. (2018) stated that *Uca* spp. are commonly found in open areas and important in the mangrove ecosystem. These species have a habit of eating litter and leaves from mangrove seedlings or newly growing mangrove seedlings.

Table 1. Diversity and abundance of crabs crustaceans (ind./m²) in three coastal mangrove zones

Class/Family	Species	Mangrove zone			Total
		ZL	ZT	ZD	
Malacostraca / Sesarmidae	<i>Chiromanthes</i> sp.	11	11	16	38
Malacostraca / Sesarmidae	<i>Sesarma roberti</i>	-	11	17	28
Malacostraca / Sesarmidae	<i>Sesarma</i> sp.	11	-	-	11
Malacostraca / Ellobiidae	<i>Scylla</i> sp.	12	-	-	12
Malacostraca / Corbiculidae	<i>Uca anulipes</i>	10	-	-	10
Malacostraca / Corbiculidae	<i>Uca</i> sp.	-	16	-	16
Malacostraca / Corbiculidae	<i>Uca tetragonon</i>	11	-	-	11
Malacostraca / Corbiculidae	<i>Uca vocans</i>	13	15	13	41
Malacostraca / Xanthidae	<i>Etisus</i> sp.	4	2	-	6
Malacostraca / Coenobitidae	<i>Coenobita</i> sp.	32	18	9	59
Malacostraca / Diogenidae	<i>Diogenes</i> sp.	13	-	9	22
	Total individual	117	80	64	262
	Total species	9	7	5	-

Note: ZL: sea zone; ZT: middle zone; ZD: rear zone

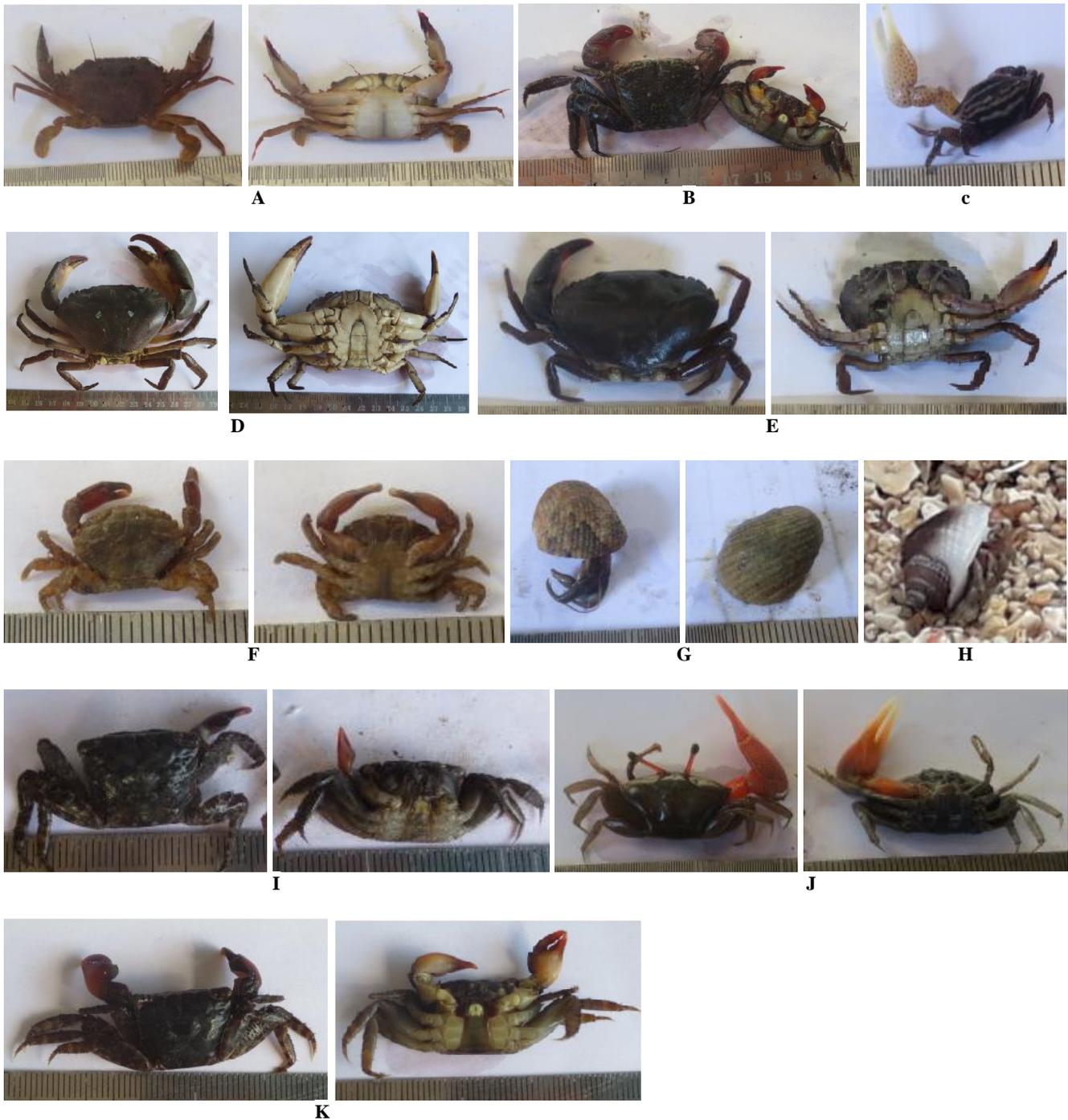


Figure 2. Species of Crustaceans in the coastal mangrove forest of Pejarakan Buleleng. A. *Scylla* sp.; B. *Chiromanthes* sp.; C. *Uca anulipes*; D. *Uca tetragonon*; E. *Uca* sp.; F. *Etisus* sp.; G. *Caenobita* sp.; H. *Diogenes* sp.; I. *Sesarma roberti*; J. *Uca vocans*; K. *Sesarma* sp.

Some species of crabs are quite low in number and are only distributed in the marine zone, namely *Scylla* sp. *Uca anulipes*, *Sesarma* sp. and *Etisus* sp. Several factors could cause the low population of this crab, including the substrate, mangrove plants, seagrass, and human disturbance. *Scylla* sp. is the edible type, so it is vulnerable to hunting. Lapolo et al. (2018) also reported that the crab *Scylla* spp. are hunted and caught using traditional traps in the mangrove habitat of Tanjung Panjang, Gorontalo. We

have found that *Scylla* sp. is quite specific to the sandy substrate in mangroves. Kamaruddin et al. (2019) also found that the crab *Scylla* sp. are more commonly found on sandy substrates in mangrove habitats at Sungai Pinang village, Lingga. Anggraeni et al. (2015) also stated that *Uca* sp. lives in a mangrove ecosystem with a sand bottom substrate in the coastal mangrove ecosystem of Tikus island. Anggorowati (2014) stated that the genus *Etisus* is common in seagrass beds.

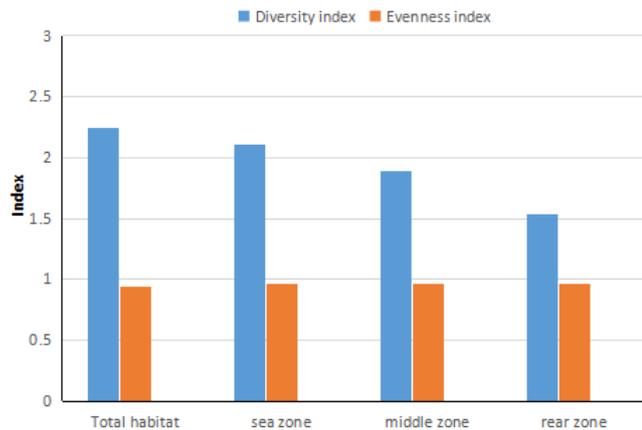


Figure 3. Diversity of crabs species in three mangrove zones

Crab diversity in the mangrove ecosystem as an ecotourism attraction

Information on the species found, their status of existence whether protected or not, rare or common, is important information in ecotourism activities. Activities and habitat use by crustaceans that were observed to stick to mangrove roots, cling to rocks, walk on sand/gravel, walk, enter holes, enter in the mud looking for food and walk on mudflats are interesting attractions for observing mangrove crustaceans. The observed activity data are presented in Figure 4 and Table 2.

Observation of crustaceans begins with field activities, namely by directly observing the fauna in the mangrove area. Ecotourism guides for observing mangrove fauna should have excellent competence (knowledge, expertise, and behavior) to interpret and explain the overall fauna of the mangrove forest habitat well. To assist ecotourism guides in observing fauna to interpret them well, it is necessary to prepare a handbook for crabs identification.



Figure 4. Crabs activity in Pejarakan coastal mangrove (A. hermit crabs are walking on gravel; B. crabs are eating around mangrove roots; C. crab walks in the mud; D. crab in the mud)

Table 2. Observable crabs activity in Pejarakan Coastal mangrove

Species	Mangrove zone		
	ZL	ZT	ZD
<i>Chiromanthes</i> sp.	Eat around the mangrove roots	Walk in the mud, enter the hole	Eat around the mangrove roots
<i>Sesarma roberti</i>	Eat in the litter in the mud	Walk in the mud, enter the hole	Walk in the mud, enter the hole
<i>Sesarma</i> sp.	Get out of the hole	-	-
<i>Scylla</i> sp.	Walking on the rock	-	-
<i>Uca anulipes</i>	Eating in the litter on the mudflat, out of the hole, into the water, making a sound	-	-
<i>Uca dussumieri</i>	-	Enter the hole	-
<i>Uca tetragonon</i>	Get in the hole, get into the mud	-	-
<i>Uca vocans</i>	Eating around the mangrove roots, making sounds	Eat around the mangrove roots	Eating around the mangrove roots, making a sound
<i>Etisus</i> sp.	Enter the hole	Enter the hole	-
<i>Coenobita</i> sp.	Clinging to the mangrove roots, walking on gravel	Sticking to the rock	Walking on mangrove roots
<i>Diogenes</i> sp.	Walking on gravel	-	Walking in the mud

Note: ZL: sea zone; ZT: middle zone; ZD: rear zone; - : species not found in the zone

In the handbook, it is necessary to display photos of the species of crabs, their morphological, ecological, and status characteristics. This information is important for both novice and experienced observers. The information in this handbook is also important to increase the insight and knowledge of ecotourists about the existence of crabs. Here are some species of mollusks and crustacean groups in the mangrove ecosystem that show interesting attractions. Some species are clinging to the coral, on the rocks, there are species of crabs walking in the mud.

Ecotourism attractions in the coastal mangrove area of Pejarakan and recreation are also important as educational tours. So the tourists do not just go around enjoying the expanse of mangroves. The introduction of species diversity, uniqueness of fauna, especially crabs, as a habitat for various aquatic and terrestrial fauna, is an important part of educational tourism.

The utilization of mangroves for ecotourism activities plays an important role in preserving fauna and mangrove ecosystems and provides economic value for local communities. Duangjai et al. (2014) showed that ecotourism activities in mangrove areas can provide a sustainable source of income for local communities and increase awareness of environmental services and the benefits of mangrove ecosystems to the Mangrove Forest Community in Satun Province, Thailand. Rahmila and Halim (2018); Sari et al. (2015) state that the feasibility of mangrove areas for ecotourism, in addition to the diversity of mangroves, is a characteristic of mangrove habitats (tidal, mud). Accessibility and diversity of fauna (mollusks, crustaceans, insects, reptiles, birds, fish and mammals). The diversity and activity of crustaceans are one of the supporting factors for the preservation of mangrove forests for ecotourism activities.

The sustainability of mangrove areas and the ecotourism business is highly dependent on a diversity of living things (including diversity of crustaceans, mollusks, birds, and mangrove plants), so it is important to reduce the loss of biodiversity. Stakeholders and policymakers need to integrate consideration of biodiversity and area management for tourism purposes. The contribution of local communities near mangroves in developing mangroves for tourism is very important (Hakim et al. 2017; Malik et al. 2019). In the coastal mangroves of Pejarakan, a local community forum is interested in managing mangroves for tourism is the Nature Conservation Forum (NCF) Putri Menjangan. This forum combines the concepts of mangrove biodiversity conservation and tourism.

In conclusion, the diversity of crabs species in the Putri Menjangan mangrove area is in the medium category (diversity index 2.25). Found 9 species of crabs and 2 species of hermit crabs. The marine mangrove zone shows a higher diversity of crabs species than the middle and land zones. Crab characteristics, activities, habitat use activities in mangrove zoning is an attractive attraction for ecotourism activities.

In recommendation, it is necessary to replant mangrove areas that are still open to increase the diversity of mangrove species, increasing the diversity of interacting

crabs. In the development of mangroves for ecotourism attractions, the trail should be built to a minimum of changing the landscape of the mangrove area because it will affect the availability of habitat for crabs.

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