



(RESEARCH ARTICLE)



Association of crustacean diversity with mangrove vegetation in perancak mangrove forest, Jembrana, Bali

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Abstract

The study aims to determine the diversity of crustaceans and their association with mangrove vegetation in the Perancak Mangrove Forest. Sampling was carried out using the square method. A total of 30 squares were carried out in three mangrove forest zones (land, middle and estuary zones). Species diversity was analyzed using the Shannon-Wiener index. The strength of the association of crustaceans with mangroves was analyzed using the Ochiai Index and DCA (Detrended Correspondence Analysis) correspondence. The results of the study found 15 species of crustaceans included in 3 families. the most dominant of which were Sesarmidae and Ocypodidae. The most dominant crab species include *Sesarma roberti*, *Sesarma pictum*, *Uca anulipes*, *Perisesarma eumolpe* and *Uca vocans*. The crustacean diversity index is 2.50, the evenness index is 0.92, including the moderate category. This indicates that the condition of the Perancak mangrove forest is in the stable category. Crustaceans are associated with mangroves in four strata, namely the substrate, roots, stems and leaves of mangrove vegetation. There are 11 species of mangrove plants associated with 15 species of crustaceans in the Perancak mangrove sampling area. This association can be based on the presence of crustaceans on the substrate, roots, stems and leaves of mangrove plants where both species are found together in a sampling plot. The strength of the association ranges from very low to very high. Several species show high associations including *Sesarma pictum-Avicennia marina*, *Sesarma pictum-Excoecaria agallocha*, *Sesarma quadrata-Ceriops decandra*, *Sesarma quadrata-Xylocarpus granatum*, *Uca crassipes-Avicennia lannata*, and *Uca dusumieri-Bruguiera gymnorrhiza*.

Keywords: Mangrove Forest; Crustacean Diversity; Species Association; Perancak Mangrove

1. Introduction

The mangrove forest area of Perancak Village, Jembrana covers an area of 177.09 hectares. This mangrove forest has quite a variety of flora and fauna. There are 16 species of true mangrove plants that make up the Perancak mangrove forest. including *Rhizophora* spp., *Sonneratia* spp., *Avicennia* spp., *Xylocarpus* spp., *Bruguiera* spp., *Ceriops* spp. and several associated mangrove plants. The fauna found consists of Mollusks, Crustaceans, Reptiles, fish, and birds. Bird wealth is recorded at 25 species, including the kingfisher (*Alcedo caerulescens*), red heron (*Ardea purpurea*), little egret (*Egretta garzeta*) and linchi swiftlet (*Collocalia linchi*). 15 species of crustaceans, namely crabs and hermit crabs. 15 species of mollusks from the gastropod and bivalve classes are recorded [5], [6], [7], [8], [9], [22].

Fauna that interact in the mangrove area show distinctive characteristics. including molluscs. crustaceans. fish. birds and several mammals. The main and distinctive fauna in the mangrove consists of the avifauna (birds). molluscs and crustaceans. Crustaceans are omnivorous animals that live in association with mangroves, eating carrion, algae, microbes and detritus. Crustaceans are a group of benthic animals that eat suspended material or filter feeders and are generally very dominant on sandy and muddy substrates. The species found were shrimp. hermit crabs and crabs that usually live in tidal areas and are included in the category of mangrove litter and fresh mangrove leaf eaters [24].

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The presence of crustaceans in the mangrove area has an important role in maintaining the balance of the food chain. Crustaceans play an important role in maintaining the balance of the food chain as prey and predators of other biota and as a source of protein for the community. Crabs also play a role in moving large amounts of sediment and changing sediment characteristics, changing the composition of sediment microflora, influencing the addition of water and organic matter content in sediment and playing a role in the nutrient cycle and energy flow. So, crustaceans play an important role in the balance of biotic factors (plants, animals, microbes) and abiotic factors (nutrients in the substrate, aeration and oxygen in the substrate) [1], [21], [24].

So far, there has been no report on the diversity of crustaceans, their association with mangrove vegetation and the use of vegetation stratification for eating activities, resting and sheltering in the Perancak mangrove forest. In fact, crustaceans are an ecologically important fauna group and are one of the indicators for the balance of the mangrove ecosystem. Therefore, this study aims to analyze the association of crustaceans with mangrove plants and the use of vegetation stratification by crustaceans.

2. Materials and methods

2.1. Study Sites and Periods

The study was conducted in April-August 2024, in the Perancak Jembrana mangrove ecosystem area. Sampling was carried out in three mangrove zones, namely in the land zone, middle zone and estuary zone (Figure 1).

2.2. Methods

2.2.1. Crustacean sample collection

Crustacean collection was carried out in 30 quadrats. The sample quadrats were placed in three mangrove zones, namely the land zone (PD), middle zone (PT) and estuary zone (PE). Each quadrat measures 1 m x 1 m (Figure 1). In each quadrat, crustacean specimens were taken. Fauna found in the plot were taken and put in sample bottles. Samples in the bottles were preserved with alcohol (70%), then identified at the Animal Taxonomy Laboratory of the Biology Study Program, Faculty of Mathematics and Natural Sciences, Udayana University.

2.2.2. Identification of Crustacean Species

Identification of crustaceans based on morphological characters (shell color, claw shape, body color, body size), identification refers to Montoh (2015) [14] and Lapolo *et al.* (2018) [10].

2.2.3. Abundance of Crustaceans

In each square plot the number of individuals of each crustacean species found was counted. The abundance of each species was calculated based on the number of individuals per unit area (M^2). In each square, the stratification of habitat/vegetation use by crustaceans was recorded. Habitat stratification is grouped into four strata, namely strata I (substrate), strata II (mangrove roots), strata III (mangrove stems) and strata IV (mangrove branches and leaves).



(Map source: google earth. image © 2023 Maxar Technologies)

Figure 1 Map of research location

3. Data analysis

Crustacean diversity was calculated by the Shanon-Wiener diversity index (H), which is $H = -\sum [ni/N \times \ln ni/N]$, where ni = the importance of the i -th species and N = the total importance of all species. The importance value (iv) is determined from the sum of the two parameters, namely: relative density (Kr) = $(Ni/\sum N) \times 100\%$ (Ni = density of the i -th species, $\sum N$ = total density of all species) and relative frequency (Fr) = $(Fi/\sum F) \times 100\%$ (Fi = frequency of presence of the i -th species, $\sum F$ = total frequency of all species). Evenness index (E) = $H/\ln S$, (H = diversity index, S = number of species). The criteria for the Shannon-Weiner diversity index (H) are as follows: if $H > 3$: high category, if $1 \leq H \leq 3$: medium category, and if $H < 1$: low category [4], [20].

The association of crustaceans and mangroves was analyzed using the 2 x 2 contingency table method (Table 1).

Table 1 The 2x 2 contingency table

Species A	Species B			
		Present	Absen	Amount
	Present	a	b	$m=a+b$
	Absent	c	d	$n=c+d$
Amount	$r=a+c$	$s=b+d$	$N=a+b+c+d$	

Which a = number of squares containing species A and species B, b = number of squares containing species A only, c = number of squares containing species B only, d = number of squares containing no species A and species B, N = Number of a, b, c and d. Furthermore, to determine the nature of the association the following formula is used: $E(a) = (a + b)(a + c) / N$. Based on this formula, the association is a positive association if the value of $a > E(a)$ means that the pair of species occurs together more often than expected. and a negative association if the value of $a < E(a)$ means that the pair of species occurs together less often than expected.

The value of the association between crustacean and plant mangrove species is calculated using the Ochiai Index (IO), with the following formula: $IO = \frac{a}{\sqrt{a+b} \cdot \sqrt{a+c}}$.

The range of association index categories between species is; if the IO value between 1-0.75 including very high association; the IO value of 0.74-0.49 is high; 0.48-0.23 is low and IO <0.23 is very low [12]. The association analysis of the use of habitat stratification by crustaceans was carried out using the DCA (Detrended Correspondence Analysis) test with SPSS version 24.

4. Results and discussion

A total of 15 species of crustaceans from the crab and hermit crab groups were found. which are included in 3 families. The families that are quite dominant are Sesarmidae and Ocypodidae (Table 2). Of the 15 species found, several species are quite dominant, namely *Sesarma roberti*, *Sesarma pictum*, *Uca anulipes*, *Perisesarma eumolpe*, *Uca vocans*. The diversity of crustacean species in the Perancak mangrove area is included in the moderate category with a diversity index of 2.50, and a species evenness index of 0.92, which means that the species composition is quite even. Based on the diversity index, it can be said that the condition of the mangroves in this area is still relatively good/stable

Table 2 Diversity of crustaceans in the Perancak mangrove forest

No	Species	Family	Density (Ind./m ²)	Distribution frequency (%)	Importance values (iv)
Crabs					
1	<i>Chiromantes eumolpe</i>	Sesarmidae	0.75	8.22	9.14
2	<i>Perisesarma eumolpe</i>	Sesarmidae	1.42	20.83	19.34
3	<i>Sesarma crassipes</i>	Sesarmidae	0.08	4.17	2.33
4	<i>Sesarma pictum</i>	Sesarmidae	1.79	33.33	27.30
5	<i>Sesarma quadrata</i>	Sesarmidae	1.50	8.33	14.89
6	<i>Sesarma roberti</i>	Sesarmidae	1.29	45.83	28.55
7	<i>Uca anulipes</i>	Ocypodidae	1.46	29.17	23.05
8	<i>Uca crassipes</i>	Ocypodidae	0.75	12.50	10.84
9	<i>Uca cryptica</i>	Ocypodidae	0.17	4.17	2.97
10	<i>Uca dusumieri</i>	Ocypodidae	0.88	12.50	11.79

11	<i>Uca rosea</i>	Ocypodidae	0.54	12.50	9.24
12	<i>Uca triangularis</i>	Ocypodidae	0.79	8.33	9.46
13	<i>Uca vocans</i>	Ocypodidae	1.38	29.17	22.41
	Hermit Crabs				
14	<i>Coenobita violescens</i>	Coinobitidae	0.13	8.33	4.35
15	<i>Coenobita purpureus</i>	Coinobitidae	0.13	8.33	4.35

Diversity index (H): 2.50; Evenness index (E): 0.92

4.1. Association of Crustacea with Mangrove Vegetation

There are 11 species of mangrove plants associated with 15 species of crustaceans in the Perancak mangrove sampling area. Thus, 154 species pairs (crustacea-mangrove) with the associative nature of negative-positive, with association strengths ranging from very low to very high (Table 3). The association of crustaceans with mangrove plants can be based on the presence of crustaceans on the substrate, roots, stems and leaves of mangrove plants where both species are found together in a sampling plot. The strength of the association ranges from very low to high. A species is positively or negatively associated with each other. A positive association means that indirectly several species are well-related or dependent on each other, while a negative association means that indirectly several species have a tendency to eliminate or exclude others or also means that two species have different influences or reactions in their environment [3], [23].

Several species showed high associations including *Sesarma pictum-Avicennia marina*; *Sesarma pictum-Excoecaria agallocha*; *Sesarma quadrata-Ceriops decandra*; *Sesarma quadrata-Xylocarpus granatum*; *Sesarma quadrata-Clerodendrum inerme*; *Uca crassipes-Avicennia lannata*; and *Uca dusumieri-Bruguiera gymnorhiza*. The high association of *Sesarma* spp. crab species with mangrove plants is closely related to the behavior of sesarma genus and some crabs of the genus *Uca* which are generally climbing crab types. Matillano *et al.* (2018) [13] stated that sesarmid crabs are a group of crabs that often climb mangrove roots and trunks to find food and rest. These crabs are often found climbing mangrove trees, namely *Avicennia marina*, *Ceriops decandra*, *Xylocarpus granatum*, *Clerodendrum inerme* and *Bruguiera gymnorhiza*. However, most crustacean associations with mangrove species are low and very low (Table 2), indicating that most crustacean species are more associated with the diversity of mangrove plant species than with associations with specific species. Riska *et al.* (2023) [16] and Syahrera *et al.* (2016) [19] also found that the abundance of crabs in mangrove forests is highly dependent on the condition of the diversity of mangrove plant species. The unique root system of mangrove species also provides advantages for crab species to find food and shelter in mangrove roots.

Hermit crabs found only two species, namely *Coenobita violacens* and *Coenobita purpureus*. These species are associated with mangrove plants *Avicennia lannata*, *Avicennia marina*, *Rhizophora mucronata* and *Bruguiera gymnorhiza*. These hermit crabs were observed foraging in the substrate, in the roots and around the stems of mangrove plants. Laidre and Greggor (2015) [11] stated that hermit crabs are opportunistic omnivores, meaning they eat quite a variety of foods, including plants and animals. They eat detritus, shoots of young mangrove leaves, bark of mangrove roots or stems, carcasses of mollusks or other animals, and can even eat living organisms. They are opportunistic scavengers, using various techniques like antennary beating, scraping, filtering particles and some species actively hunt for prey (for example molluscs).

Table 3 Association of crustaceans with plants in Perancak mangroves

No	Species pair (Crustacea-Mangrove plant)	Number of plots of species present together (a)	Properties of association E(a)	Association category (*)	Association i index of Ochiai (IO)	power of association
1	<i>Chiromantes eumolpe-Rhizophora mucronata</i>	2	1.33	positive	0.35	low
2	<i>Chiromantes eumolpe-Rhizophora apiculata</i>	1	0.25	positive	0.41	low
3	<i>Chiromantes eumolpe-Avicennia marina</i>	0	0.58	negative	0.00	very low
4	<i>Chiromantes eumolpe-Avicennia lannata</i>	0	0.42	negative	0.00	very low
5	<i>Chiromantes eumolpe-Bruguiera gymnorhiza</i>	0	0.42	negative	0.00	very low
6	<i>Chiromantes eumolpe-Excoecaria agallocha</i>	0	0.25	negative	0.00	very low
7	<i>Chiromantes eumolpe-Sonneratia alba</i>	1	0.33	positive	0.35	low
8	<i>Chiromantes eumolpe-Ceriops decandra</i>	0	0.08	negative	0.00	very low
9	<i>Chiromantes eumolpe-Xylocarpus granatum</i>	1	0.25	positive	0.41	low
10	<i>Chiromantes eumolpe-Sesuvium portulacastrum</i>	0	0.17	negative	0.00	very low
11	<i>Chiromantes eumolpe-Clerodendrum inerme</i>	0	0.08	negative	0.00	very low
12	<i>Caenobita violescens-Rhizophora mucronata</i>	2	1.33	positive	0.35	low
13	<i>Caenobita violescens-Rhizophora apiculata</i>	0	0.25	negative	0.00	very low
14	<i>Caenobita violescens-Avicennia marina</i>	1	0.58	positive	0.27	low
15	<i>Caenobita violescens-Avicennia lannata</i>	1	0.42	positive	0.32	low
16	<i>Caenobita violescens-Bruguiera gymnorhiza</i>	1	0.42	positive	0.32	low
17	<i>Caenobita violescens-Excoecaria agallocha</i>	0	0.25	negative	0.00	very low
18	<i>Caenobita violescens-Sonneratia alba</i>	0	0.33	negative	0.00	very low
19	<i>Caenobita violescens-Ceriops decandra</i>	0	0.08	negative	0.00	very low
20	<i>Caenobita violescens-Xylocarpus granatum</i>	0	0.25	negative	0.00	very low
21	<i>Caenobita violescens-Sesuvium portulacastrum</i>	0	0.17	negative	0.00	very low
22	<i>Caenobita violescens-Clerodendrum inerme</i>	0	0.08	negative	0.00	very low
23	<i>Coenobita purpureus-Rhizophora mucronata</i>	2	1.33	positive	0.35	low
24	<i>Coenobita purpureus-Rhizophora apiculata</i>	0	0.25	negative	0.00	very low

25	<i>Coenobita purpureus-Avicennia marina</i>	0	0.58	negative	0.00	very low
26	<i>Coenobita purpureus-Avicennia lannata</i>	1	0.42	positive	0.32	low
27	<i>Coenobita purpureus-Bruguiera gymnorhiza</i>	0	0.42	negative	0.00	very low
28	<i>Coenobita purpureus-Excoecaria agallocha</i>	0	0.25	negative	0.00	very low
29	<i>Coenobita purpureus-Sonneratia alba</i>	0	0.33	negative	0.00	very low
30	<i>Coenobita purpureus-Ceriops decandra</i>	0	0.08	negative	0.00	very low
31	<i>Coenobita purpureus-Xylocarpus granatum</i>	0	0.25	negative	0.00	very low
32	<i>Coenobita purpureus-Sesuvium portulacastrum</i>	0	0.17	negative	0.00	very low
33	<i>Coenobita purpureus-Clerodendrum inerme</i>	0	0.08	negative	0.00	very low
34	<i>Perisesarma eumolpe-Rhizophora mucronata</i>	3	3.33	negative	0.34	low
35	<i>Perisesarma eumolpe-Rhizophora apiculata</i>	0	0.63	negative	0.00	very low
36	<i>Perisesarma eumolpe-Avicennia marina</i>	1	1.25	negative	0.18	very low
37	<i>Perisesarma eumolpe-Avicennia lannata</i>	2	1.04	positive	0.40	low
38	<i>Perisesarma eumolpe-Bruguiera gymnorhiza</i>	1	1.04	negative	0.20	very low
39	<i>Perisesarma eumolpe-Excoecaria agallocha</i>	0	0.63	negative	0.00	very low
40	<i>Perisesarma eumolpe-Sonneratia alba</i>	0	0.83	negative	0.00	very low
41	<i>Perisesarma eumolpe-Ceriops decandra</i>	1	0.21	positive	0.45	low
42	<i>Perisesarma eumolpe-Xylocarpus granatum</i>	1	0.63	positive	0.26	low
43	<i>Perisesarma eumolpe-Sesuvium portulacastrum</i>	1	0.42	positive	0.32	low
44	<i>Perisesarma eumolpe-Clerodendrum inerme</i>	1	0.21	positive	0.45	low
45	<i>Sesarma crassipes-Rhizophora mucronata</i>	1	0.67	negative	0.25	very low
46	<i>Sesarma crassipes-Rhizophora apiculata</i>	0	0.13	negative	0.00	very low
47	<i>Sesarma crassipes-Avicennia marina</i>	0	0.24	negative	0.00	very low
48	<i>Sesarma crassipes-Avicennia lannata</i>	0	0.21	negative	0.00	very low
49	<i>Sesarma crassipes-Bruguiera gymnorhiza</i>	0	0.21	negative	0.00	very low
50	<i>Sesarma crasipes-Excoecaria agallocha</i>	0	0.13	negative	0.00	very low
51	<i>Sesarma crassipes-Sonneratia alba</i>	0	0.17	negative	0.00	very low

52	<i>Sesarma crassipes-Ceriops decandra</i>	0	0.04	negative	0.00	very low
53	<i>Sesarma crassipes-Xylocarpus granatum</i>	0	0.13	negative	0.00	very low
54	<i>Sesarma crassipes-Sesuvium portulacastrum</i>	0	0.08	negative	0.00	very low
55	<i>Sesarma crassipes-Clerodendrum inerme</i>	0	0.04	negative	0.00	very low
56	<i>Sesarma pictum-Rhizophora mucronata</i>	5	5.33	negative	0.44	low
57	<i>Sesarma pictum-Rhizophora apiculata</i>	1	1.00	negative	0.20	very low
58	<i>Sesarma pictum-Avicennia marina</i>	5	2.33	positive	0.67	high
59	<i>Sesarma pictum-Avicennia lannata</i>	1	1.67	negative	0.16	very low
60	<i>Sesarma pictum-Bruguiera gymnorhiza</i>	2	1.67	positive	0.32	low
61	<i>Sesarma pictum-Excoecaria agallocha</i>	2	1.00	positive	0.41	low
62	<i>Sesarma pictum-Sonneratia alba</i>	1	1.00	negative	0.20	very low
63	<i>Sesarma pictum-Ceriops decandra</i>	0	0.33	negative	0.00	very low
64	<i>Sesarma pictum-Xylocarpus granatum</i>	0	1.00	negative	0.00	very low
65	<i>Sesarma pictum-Sesuvium portulacastrum</i>	0	0.67	negative	0.00	very low
66	<i>Sesarma pictum-Clerodendrum inerme</i>	0	0.33	negative	0.00	very low
67	<i>Sesarma quadrata-Rhizophora mucronata</i>	0	1.33	negative	0.00	very low
68	<i>Sesarma quadrata-Rhizophora apiculata</i>	0	0.25	negative	0.00	very low
69	<i>Sesarma quadrata-Avicennia marina</i>	0	0.58	negative	0.00	very low
70	<i>Sesarma quadrata-Avicennia lannata</i>	1	0.42	positive	0.32	low
71	<i>Sesarma quadrata-Bruguiera gymnorhiza</i>	1	0.33	positive	0.35	low
72	<i>Sesarma quadrata-Excoecaria agallocha</i>	0	0.33	negative	0.00	very low
73	<i>Sesarma quadrata-Sonneratia alba</i>	0	0.33	negative	0.00	very low
74	<i>Sesarma quadrata-Ceriops decandra</i>	1	0.08	positive	0.71	high
75	<i>Sesarma quadrata-Xylocarpus granatum</i>	1	0.17	positive	0.50	high
76	<i>Sesarma quadrata-Sesuvium portulacastrum</i>	0	0.17	negative	0.00	very low
77	<i>Sesarma quadrata-Clerodendrum inerme</i>	1	0.08	positive	0.71	high
78	<i>Uca anulipes-Rhizophora mucronata</i>	4	4.67	positive	0.38	low

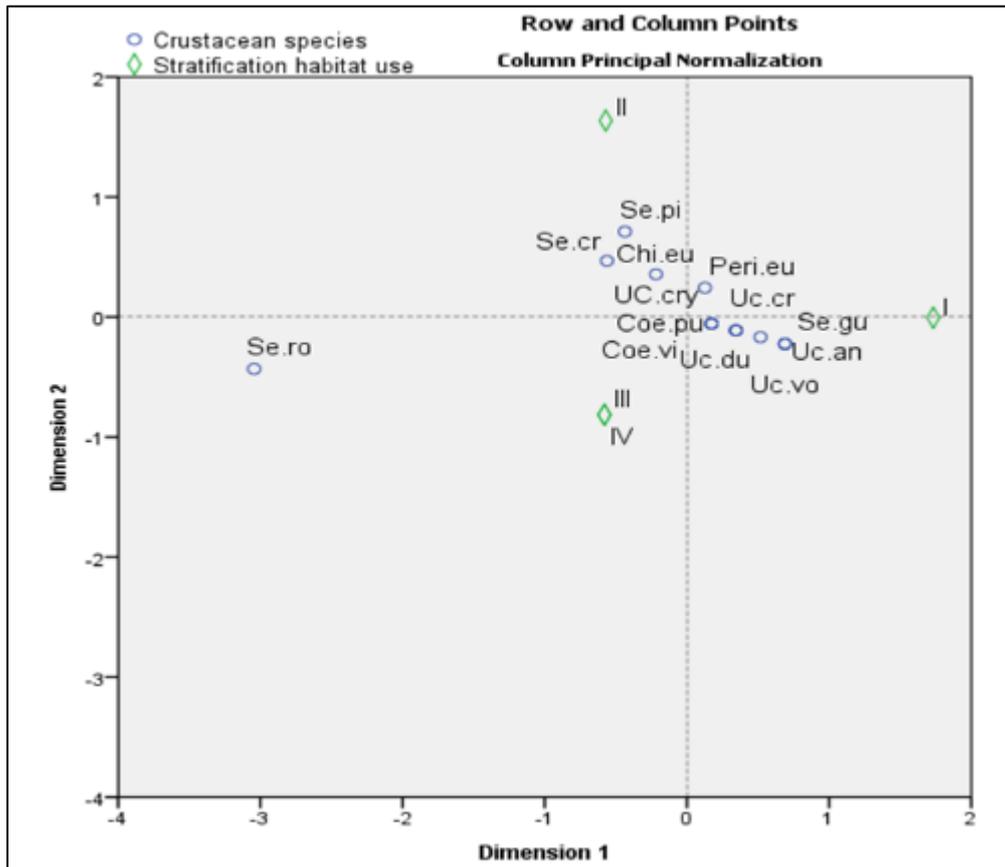
79	<i>Uca anulipes-Rhizophora apiculata</i>	1	0.88	positive	0.22	very low
80	<i>Uca anulipes-Avicennia marina</i>	1	2.04	negative	0.14	very low
81	<i>Uca anulipes-Avicennia lannata</i>	1	1.46	negative	0.17	very low
82	<i>Uca anulipes-Bruguiera gymnorhiza</i>	2	1.25	positive	0.37	low
83	<i>Uca anulipes-Excoecaria agallocha</i>	1	0.75	positive	0.24	low
84	<i>Uca anulipes-Sonneratia alba</i>	1	1.00	negative	0.20	very low
85	<i>Uca anulipes-Ceriops decandra</i>	0	0.25	negative	0.00	very low
86	<i>Uca anulipes-Xylocarpus granatum</i>	2	1.25	positive	0.37	low
87	<i>Uca anulipes-Sesuvium portulacastrum</i>	1	0.50	positive	0.29	low
88	<i>Uca anulipes-Clerodendrum inerme</i>	0	0.25	negative	0.00	very low
89	<i>Uca crassipes-Rhizophora mucronata</i>	3	2.00	negative	0.43	low
90	<i>Uca crassipes-Rhizophora apiculata</i>	0	0.38	negative	0.00	very low
91	<i>Uca crassipes-Avicennia marina</i>	0	0.88	negative	0.00	very low
92	<i>Uca crassipes-Avicennia lannata</i>	2	0.63	positive	0.52	high
93	<i>Uca crassipes-Bruguiera gymnorhiza</i>	0	0.63	negative	0.00	very low
94	<i>Uca crassipes-Excoecaria agallocha</i>	0	0.38	negative	0.00	very low
95	<i>Uca crassipes-Sonneratia alba</i>	0	0.50	negative	0.00	very low
96	<i>Uca crassipes-Ceriops decandra</i>	0	0.13	negative	0.00	very low
97	<i>Uca crassipes-Xylocarpus granatum</i>	1	0.38	positive	0.33	low
98	<i>Uca crassipes-Sesuvium portulacastrum</i>	0	0.25	negative	0.00	very low
99	<i>Uca crassipes-Clerodendrum inerme</i>	0	0.13	negative	0.00	very low
100	<i>Uca cryptica-Rhizophora mucronata</i>	1	0.67	positive	0.25	low
101	<i>Uca cryptica-Rhizophora apiculata</i>	0	0.13	negative	0.00	very low
102	<i>Uca cryptica-Avicennia marina</i>	0	0.29	negative	0.00	very low
103	<i>Uca cryptica-Avicennia lannata</i>	1	0.21	positive	0.45	low
104	<i>Uca cryptica-Bruguiera gymnorhiza</i>	0	0.21	negative	0.00	very low
105	<i>Uca cryptica-Excoecaria agallocha</i>	0	0.13	negative	0.00	very low

106	<i>Uca cryptica-Sonneratia alba</i>	0	0.17	negative	0.00	very low
107	<i>Uca cryptica-Ceriops decandra</i>	0	0.04	negative	0.00	very low
108	<i>Uca cryptica-Xylocarpus granatum</i>	0	0.13	negative	0.00	very low
109	<i>Uca cryptica-Sesuvium portulacastrum</i>	0	0.08	negative	0.00	very low
110	<i>Uca cryptica-Clerodendrum inerme</i>	0	0.04	negative	0.00	very low
111	<i>Uca dusumieri-Rhizophora mucronata</i>	2	2.13	negative	0.28	low
112	<i>Uca dusumieri-Rhizophora apiculata</i>	0	0.38	negative	0.00	very low
113	<i>Uca dusumieri-Avicennia marina</i>	1	0.88	positive	0.22	low
114	<i>Uca dusumieri-Avicennia lannata</i>	0	0.63	negative	0.00	very low
115	<i>Uca dusumieri-Bruguiera gymnorhiza</i>	2	0.63	positive	0.52	high
116	<i>Uca dusumieri-Excoecaria agallocha</i>	1	0.38	positive	0.33	low
117	<i>Uca dusumieri-Sonneratia alba</i>	0	0.50	negative	0.00	very low
118	<i>Uca dusumieri-Ceriops decandra</i>	0	0.12	negative	0.00	very low
119	<i>Uca dusumieri-Xylocarpus granatum</i>	1	0.38	positive	0.33	low
120	<i>Uca dusumieri-Sesuvium portulacastrum</i>	0	0.25	negative	0.00	very low
121	<i>Uca dusumieri-Clerodendrum inerme</i>	0	0.13	negative	0.00	very low
122	<i>Uca rosea-Rhizophora mucronata</i>	3	2.00	positive	0.43	low
123	<i>Uca rosea-Rhizophora apiculata</i>	0	0.38	negative	0.00	very low
124	<i>Uca rosea-Avicennia marina</i>	0	0.88	negative	0.00	very low
125	<i>Uca rosea-Avicennia lannata</i>	1	0.63	positive	0.26	low
126	<i>Uca rosea-Bruguiera gymnorhiza</i>	0	0.63	negative	0.00	very low
127	<i>Uca rosea-Excoecaria agallocha</i>	0	0.38	negative	0.00	very low
128	<i>Uca rosea-Sonneratia alba</i>	0	0.50	negative	0.00	very low
129	<i>Uca rosea-Ceriops decandra</i>	0	0.13	negative	0.00	very low
130	<i>Uca rosea-Xylocarpus granatum</i>	0	0.38	negative	0.00	very low
131	<i>Uca rosea-Sesuvium portulacastrum</i>	1	0.25	positive	0.41	low
132	<i>Uca rosea-Clerodendrum inerme</i>	0	0.13	negative	0.00	very low

133	<i>Uca triangularis-Rhizophora mucronata</i>	1	1.33	negative	0.18	very low
134	<i>Uca triangularis-Rhizophora apiculata</i>	0	0.25	negative	0.00	very low
135	<i>Uca triangularis-Avicennia marina</i>	1	0.58	positive	0.27	low
136	<i>Uca triangularis-Avicennia lannata</i>	1	0.42	positive	0.32	low
137	<i>Uca triangularis-Bruguiera gymnorhiza</i>	1	0.42	positive	0.32	low
138	<i>Uca triangularis-Excoecaria agallocha</i>	0	0.25	negative	0.00	very low
139	<i>Uca triangularis-Sonneratia alba</i>	0	0.33	negative	0.00	very low
140	<i>Uca triangularis-Ceriops decandra</i>	0	0.08	negative	0.00	very low
141	<i>Uca triangularis-Xylocarpus granatum</i>	0	0.25	negative	0.00	very low
142	<i>Uca triangularis-Sesuvium portulacastrum</i>	0	0.17	negative	0.00	very low
143	<i>Uca triangularis-Clerodendrum inerme</i>	0	0.08	negative	0.00	very low
144	<i>Uca vocans-Rhizophora mucronata</i>	3	4.67	negative	0.28	low
145	<i>Uca vocans-Rhizophora apiculata</i>	0	0.88	negative	0.00	very low
146	<i>Uca vocans-Avicennia marina</i>	2	2.04	negative	0.29	low
147	<i>Uca vocans-Avicennia lannata</i>	2	0.88	positive	0.44	low
148	<i>Uca vocans-Bruguiera gymnorhiza</i>	2	1.46	positive	0.34	low
149	<i>Uca vocans-Excoecaria agallocha</i>	2	0.88	positive	0.44	low
150	<i>Uca vocans-Sonneratia alba</i>	0	1.17	negative	0.00	very low
151	<i>Uca vocans-Ceriops decandra</i>	0	0.29	negative	0.00	very low
152	<i>Uca vocans-Xylocarpus granatum</i>	1	0.88	positive	0.22	very low
153	<i>Uca vocans-Sesuvium portulacastrum</i>	1	0.58	positive	0.27	very low
154	<i>Uca vocans-Clerodendrum inerme</i>	0	0.29	negative	0.00	very low

(*): positive association if the value of $a > E(a)$; negative association if the value of $a < E(a)$

Based on Figure 2, shows that crustaceans are more associated with strata I of the mangrove forest floor/substrate and a little in strata II, namely on the roots of the mangrove forest. Most members of the Sesarmidae and Ocypodidae families are associated with the mangrove forest floor, namely on the substrate and mangrove roots. Salleh-Mukri and Shuhaida (2021) [17] also found that crustacean diversity was high on the forest floor and roots of mangrove forests in Penang, Malaysia. It was further stated that the mangrove forest floor provides a more complex habitat in providing food sources or shelter. Only one species was found associated with strata III (stems) and Strata IV (leaves, twigs), namely *Sesarma roberti*. The use of strata IV by *Sesarma* sp. crabs is related to their eating habits, which generally consist of leaves or leaf shoots from mangrove plants. Ashton (2002) [2] stated that the Sesarmid group of mangrove crabs prefer to eat the leaves of the mangrove plants *Avicennia* sp., *Rhizophora* sp. and *Bruguiera* sp.



(Habitat stratification; I: Substrate. II: Roots. III: Stems. IV: twigs/leaves. Crustacean species: Chi.eu:*Chiromantes eumolpe*. Coe.pu: *Coenobita purpureus*. Coe.vi: *Coenobita violescens*. Peri.eu: *Perisesarma eumolpe*. Se.cr: *Sesarma crassipes*. Se.pi: *Sesarma pictum*. Se.qu: *Sesarma quadrata*. Se.ro: *Sesarma roberti*. Uc.an: *Uca anulipes*. Uc.cr: *Uca crassipes*. Uc.cry: *Uca cryptica*. Uc.du: *Uca dusumieri*. Uc.ro: *Uca rosea*. Uc.tri: *Uca triangularis*. Uc.vo: *Uca vocans*)

Figure 2 Space use by crustaceans in Perancak mangroves (DCA analysis)

Fiddler crabs (including the genus *Uca*) generally use stratum I for feeding activities, because their food is detritus, algae, and bacteria eroded from sand and mud particles in the mangrove substrate. They sift through the sediment to obtain these food sources, often feeding in puddles to help separate food from the sand. Nallos and Macusi (2023) [15] and Setiawan *et al.* (2025) [18] state that fiddler crabs mainly feed on sediment rather than leaves. Mangrove forest sediments contain a large number of active bacteria. These bacterial communities break down organic debris, including leaf litter, and incorporate remineralized nutrients into the mangrove sediment, making them available to plants and detritivores. Fiddler crabs' dietary habits are generally detritivorous, consuming between 20% and 80% of the carbon from mangrove leaf litter. They are the most active and visible detritivores in mangrove forests.

Observed crustacean habitat activities and use. whether attached to mangrove roots. attached to mangrove stems or roots, walking on the substrate/mud, moving towards holes, walking and making holes in the mud looking for food (Figure 3). The mangrove forest environment provides a good habitat for various fauna with the presence of a shaded base substrate, trees as a place to attach and most importantly the abundance of organic detritus as a food source.

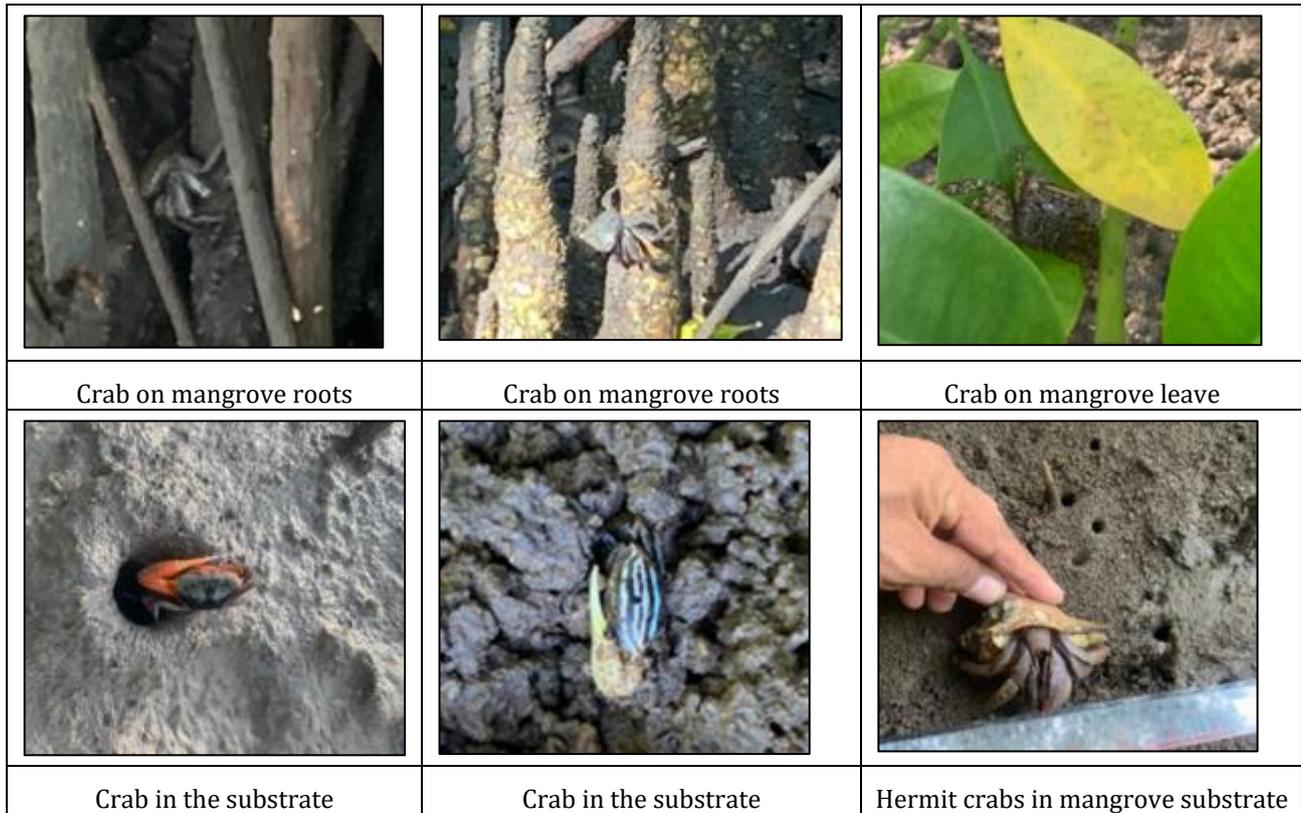


Figure 3 Habitat use by crustaceans in mangrove habitats

5. Conclusion

A total of 15 species of crustaceans included in 3 families found in Perancak mangrove forest. The most dominant species include *Sesarma roberti*, *Sesarma pictum*, *Uca anulipes*, *Perisesarma eumolpe* and *Uca vocans*. The crustacean diversity index including the moderate category. Crustaceans are associated with mangroves in four strata, namely the substrate, roots, stems and leaves of mangrove vegetation. There are 11 species of mangrove plants associated with 15 species of crustaceans in the Perancak mangrove sampling area. The strength of the association ranges from very low to high. Several species show high associations including *Sesarma pictum-Avicennia marina*, *Sesarma pictum-Excoecaria agallocha*, *Sesarma quadrata-Ceriops decandra*, *Sesarma quadrata-Xylocarpus granatum*, *Sesarma quadrata-Clerodendrum inerme*, *Uca crassipes-Avicennia lannata* and *Uca dusumieri-Bruguiera gymnorhiza*.

Compliance with ethical standards

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Disclosure of conflict of interest

We declare that there is no conflict of interest with any person or organization in the research and publication of this article.

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