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Diversity and distribution of crustaceans in the mangrove forest of Nusa Lembongan, Bali, Indonesia

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Abstract. *Ginantra IK, Muksin IK, Joni M, Wijaya IMS. 2023. Diversity and distribution of crustaceans in the mangrove forest of Nusa Lembongan, Bali, Indonesia. Biodiversitas 24: 4533-4541.* Research on the diversity and distribution of crustaceans in the mangrove forest of Nusa Lembongan, Bali, Indonesia was conducted from March to June 2022. Sampling was carried out using the quadratic method at seven mangrove forest sites. The identification of crustacean species is based on morphological characteristics, namely carapace color, claw shape, legs, and body size. Crustacean density was determined based on the number of individuals per unit area of mangrove forest, diversity was determined by the Shanon-Wiener Index, and crustacean distribution was determined based on the frequency of species presence in each square at the seven study sites. Environmental factors were also measured: Mangrove vegetation, substrate type, temperature, pH, and salinity. The results showed that 12 species of crustaceans were found, consisting of 10 species of crabs and two species of hermit crabs. Several species of crabs are quite dominant in the mangroves of Nusa Lembongan namely *Sesarma pictum* (De Haan, 1835), with a density of 7 individuals/5 m^2, *Uca tetragonon* (Herbst, 1790) of 3.7 individuals/5 m^2, *Uca rosea* (Tweedie, 1837) with a density of 2.5 individuals/ 5 m^2, and *Uca triangularis* (A. Milne-Edwards, 1873) with a density of 2 individuals/5 m^2. Environmental factors support the life of Nusa Lembongan crustaceans, namely the type of substrate, mostly muddy and sandy, diverse species of mangrove plants, both true and associated mangroves, water temperature 27.70-29.00°C, pH 6.88-7.15 and water salinity ranging from 27.83-31.53‰. Crustacean diversity is included in the moderate category with their diversity index. There are three crab species with moderate to frequent (absolute) frequency of presence, namely *U. rosea* (Fi: 57.15%), *S. pictum* (Fi: 71.43%), and *U. tetragonon* (Fi: 85.71%). These species are present in four to six mangrove forest sites.

Keywords: Crabs, crustaceans, distribution, diversity, Lembongan, mangroves

INTRODUCTION

The mangrove ecosystem is a unique ecotone connecting land and sea biota life. The mangrove ecosystem is more productive than other ecosystems for decomposing organic matter, becoming an important ecological chain for living things. Mangrove ecosystems are important for mangrove fauna because they have various ecological and socio-economic functions (Ngo-Massou et al. 2014; Katili et al. 2017); mangrove forests in the coastal area of Lembongan Island, Bali, Indonesia cover an area of 202 ha. Mangrove forests are located on the island's eastern to the northern side. The mangrove forests of Lembongan have quite a variety of flora and fauna; 13 true mangrove species make up the Nusa Lembongan mangrove forest, including *Rhizophora* spp., *Sonneratia* spp., *Avicennia* spp., *Xylocarpus* sp., *Bruguiera* sp., *Xylocarpus* sp., *Lumnitzera* sp. and some associated plants. The fauna comprised molluscs, crustaceans, reptiles, fish, and birds. Bird richness has recorded 32 species, and wood-borers recorded 4 species in the mangroves of Nusa Lembongan (Setiawan et al. 2012; Pricillia et al. 2021; Ginantra et al. 2022a; Ginantra et al. 2022b).

The crustacean group is a macrozoobenthic animal that lives in association with mangroves. This animal becomes a keystone or plays an important role in the mangrove ecosystem, and each activity has an effect. The crustaceans in the mangrove ecosystem play a role, among others, as detritus eaters or included as decomposers. It is important in recycling carbon, and crabs that have died as part of their carapace are also important in nutrient cycles, a source of minerals. In mangrove habitats (Mokhtari et al. 2015). Crab activity in making holes in the mangrove substrate can improve oxygen aeration in the mangrove habitat. Crustaceans are also natural food providers for other biota because the thousands of larvae produced can be food for other mangrove biota (Setyadi et al. 2022).

The diversity, abundance, and distribution of crustaceans in mangrove forests are related to abiotic and biotic factors. Some abiotic factors that play a role are salinity, sediment characteristics, substrate, temperature, water availability/water discharge, inundation frequency, pH, and topography of the mangrove forest land (Salleh-Mukri and Shuhaida 2021). Liquid and solid waste pollution is also an abiotic factor that greatly influences the abundance of crustaceans in mangrove forests. Biotic factors are related to flora diversity, mangrove vegetation structure, mangrove plant species richness, mangrove plant litter, forest complexity, and parasites (Ngo-Massou et al. 2014; Sharifian et al. 2021; Bojko et al. 2022). Human harvesting also contributes to the abundance of certain species of crustaceans, especially edible crabs or of high economic value, for example, from the genus *Scylla* (Indarjo et al. 2020).

At least 300 species of brachyuran crabs are reported to be associated with mangrove forests worldwide. Crab species that live in mangrove areas are usually from the families Ocypodidae, Sesarmidae, Grapsidae, Macropthalmidae, Porcellanidae, Portunidae, and Varunidae. Besides that, species of hermit crabs were also found in mangrove habitats, namely from the family Coenobitidae and Diogenidae (Doi et al. 2020; Mukhopadhyay et al. 2022).

Several studies have been carried out on the diversity of crustaceans in mangrove forests in Bali (Indonesia) and its surroundings. Ginantra et al. (2021) found 11 species of crabs and hermit crabs in the coastal mangroves of Pejarakan Buleleng, Indraswari et al. (2018) found 20 species of crabs in the Mertasasri mangroves, Wahyudi et al. (2014) found 10 species of *Uca* crab in the mangrove forest area of Benoa, Bali and Krisnawati et al. (2018) recorded 10 species of *Uca* crab in the mangrove area of Kampoeng Kepiting, Tuban Badung Bali. Data on crustacean diversity in the mangroves of Nusa Lembongan have not been widely reported. Ceningandivers.com (2021) wrote down only a few aspects of the existence of fiddler crabs in the mangroves of Nusa Lembongan and Ceningan, namely the habitat where fiddler crabs are found, the characteristics of their claws, mating behavior, feeding behavior and holes where fiddler crabs hide. However, the diversity and distribution of crustaceans in mangrove habitats has not been reported in detail.Given the important role of crabs in the nutrient cycle, carbon cycle, mineral cycle, and as a biotic component in mangrove forests, it is important to study crab diversity in the Nusa Lembongan Mangrove. Thus, the purpose of this study was to determine the diversity and distribution of crabs along the mangroves of Nusa Lembongan.

MATERIALS AND METHODS

Methods

Sampling was conducted at seven mangrove forest sites in Nusa Lembongan Island, Klungkung District, Bali Province, Indonesia (Figure 1). The geographical location of the research is 80 40' 02.79" S; 1150 28'09.52" E. The study was conducted from March to June 2022.

Sampling was done on 35 squared plots, each square measuring 1 m x 1 m. The squares laid vertically follow the mangrove zonation (from near the sea onto the land), with 5 plots for each site (Figure 1). Individual representatives of each type of crustacean were taken and put in a sample bottle. Samples in bottles were preserved with alcohol (70%) and then identified in the laboratory. All crustacean specimens were photographed and identified. Identification of crustaceans based on morphological characteristics (shell color, claw shape, body size), identification refers to Katili et al. (2017), Lapolo et al. (2018), and Abraham and Prakasan (2020). Environmental factors were also measured at each site: Vegetation (true mangrove species and associated mangroves), substrate type, and water chemistry. The physics-chemical parameters of the water measured were temperature, pH, and salinity.

Determining the distribution and abundance of crustaceans

In each squared plot of each species of crustacean found, the number of individuals was counted. The distribution of crustaceans was determined based on the presence and number of individuals of each species in each study site. The abundance of each species was calculated based on the number of individuals per unit area (m^2). The presence of crustaceans in mangrove habitat was recorded (in mud, sand, on rocks, attached to roots, or on mangrove trunks).

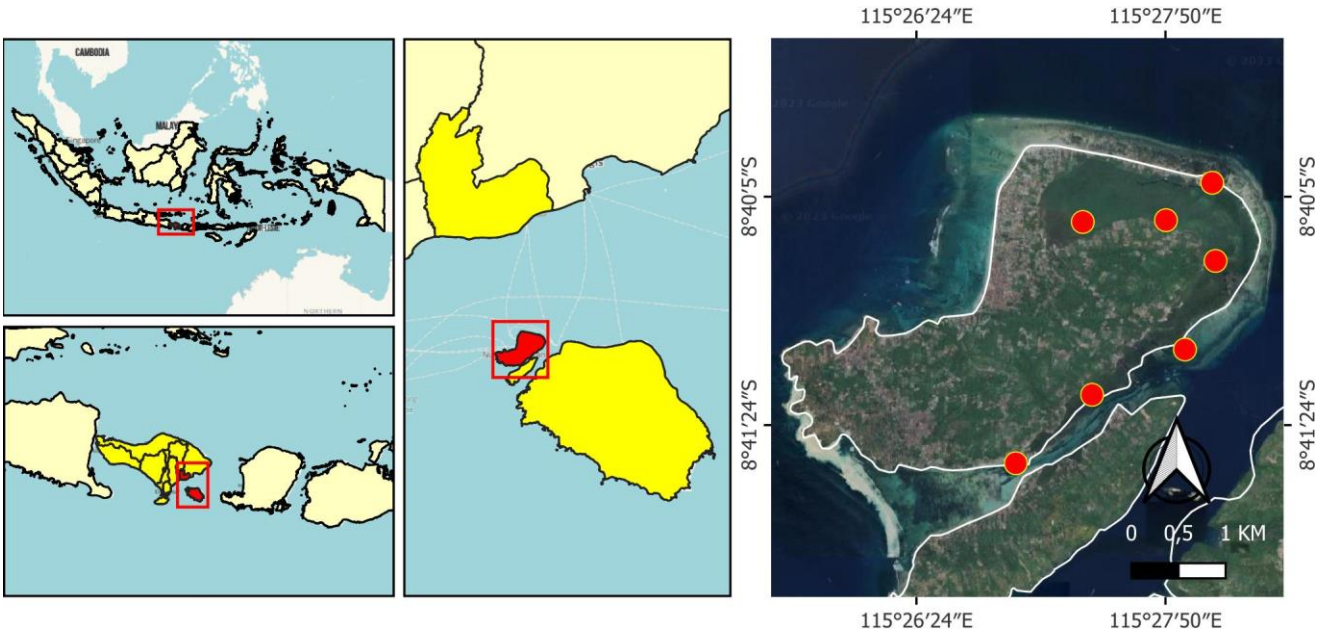

Figure 1. Map of the study site in Nusa Lembongan Island, Klungkung District, Bali Province, Indonesia

Data analysis

Crustacean diversity was calculated by the Shanon-Wiener Diversity Index (H), which is:

$$H = -\sum\left(\frac{ni}{N} \times ln\frac{ni}{N}\right)$$

Where:
ni : Importance of the i-th species
N : Total importance of all species

The significant value is determined from the sum of the two parameters, namely relative density (Kr) and relative frequency (Fr):

$$\text{Relative density (Kr)} = \frac{Ni}{\sum N} \times 100\%$$

Where:
Ni : Density of the 1st species
∑N : Total density of all species

$$\text{Relative frequency (Fr)} = \frac{Fi}{\sum F} \times 100\%$$

Where:
Fi : Frequency of presence of the i-th species
∑F : Total frequency of all species

$$\text{Evenness index (E)} = \frac{H}{ln\ (S)}$$

Where:
H : Diversity index
S : Number of species (Stiling 1996).

The frequency of the presence of crustacean species is determined by the formula

$$\text{Fi (\%)} = \left(\frac{fi.p}{P}\right) \times 100$$

Where:
fi.p : Number of plots a species is present
P : Total number of sampling plots

The categories of attendance frequency values are as follows: Fi<25% is in the very rare category, 25%≤Fi <50% is in the rare category, 50%≤Fi≤75% is in the moderate category, and Fi>75% is in the frequent/ absolute category (Romimohtarto and Juwana 2001).

RESULTS AND DISCUSSION

Crustacean diversity

A total of 12 species of crustaceans were found in the mangrove forests of Nusa Lembongan, Bali, Indonesia, consisting of 10 species of crabs and two species of hermit crabs. Crab *Uca* spp. (Fiddler crab) the most commonly found, recorded six species. Two species of crabs from the *Sesarma* (sesarmid crabs) genus were found: *Sesarma roberti* (H. Milne Edwards, 1853) and *Sesarma pictum* (De Haan, 1835). While from the genus *Scylla*, there is only one species, namely *Scylla serrata* (Forskål, 1775) (Table 1). Several researchers also reported that groups of crabs from the genus *Uca* quite dominate the mangrove ecosystem in Bali, including on the Pejarakan Buleleng coast (Ginantra et al. 2021), in the mangrove forest of Merta Sari Sanur (Indraswari et al. 2018), the mangrove forest of Kampoeng Kepiting Tuban Badung Bali (Krisnawati et al. 2018) and in the Benoa Badung mangrove forest (Wahyudi et al. 2014). Crabs from the genus *Uca* are also a common genus in mangrove ecosystems in several mangrove forests in Indonesia, including in the Monta Bima mangroves, mangrove forest of Kahyapu, Enggano Island (Duya et al. 2021), in the Probolinggo mangrove forests, East Java (Riswandi et al. 2019), in Tanjung Panjang Mangrove Forest, Gorontalo Sulawesi (Katili et al. 2017; Lapolo et al. 2018).

The crab species found showed morphological variations, including the shape and color of the carapace, the shape and color of the claws, and the shape and color of the legs. The edges of the carapace are jagged; some are flat, and some are slightly indented. Likewise, with the legs and claws, some are jagged, and some have thorns that appear on the edges of the legs. This morphological variation is important in species identification. Short descriptions and morphology of the 12 crustacean species are presented in Table 2 and Figure 2.

Several crabs species dominate the mangroves of Nusa Lembongan, namely *S. pictum* (sesarmid crabs) with a density of 7 individuals/5 m^2, *Uca tetragonon* (Herbst, 1790) (Tetragonal fiddler crab) with a density of 3.7 individuals/5 m^2, Rosea fiddler crab (*Uca rosea* Tweedie, 1837) with a density of 2.5 individual/5 m^2, triangularis fiddler crab (*Uca triangularis* A. Milne-Edwards, 1873) with a density of 2 individuals/5 m^2. Only 2 species of the hermit crab group were found: *Coenobita rugosus* (H. Milne Edwards, 1837) (wrinkled hermit crabs) and *Coenobita violescens* (Heller, 1862) (orange hermit crab). Teoh et al. 2014 state that hermit crabs from the genus *Coenobita* are commonly associated with mangrove forests, besides the genera *Diagones* and *Clibanarius*.

The diversity of crustaceans in the mangrove forest of Nusa Lembongan is in the medium category with a diversity index (Shannon-Wiener Index) of 2.31. The crustacean species evenness index is high at 0.93, which means that the distribution of species is even or no species dominates absolutely. This shows that the condition of the mangrove ecosystem in Nusa Lembongan is in the stable/good category; the ecological functions, namely food webs, nutrient cycles, and energy flows, work well in mangrove forests. Sharifian et al. (2021), Nozarpour et al. (2023), and Sathish et al. (2023) stated that crustacean and mangrove vegetation diversities are equally important in ecological balance, which means that crustacean diversity is important in maintaining the balance of ecosystems in mangroves. Crustaceans are important species in mangrove ecosystems, where crustaceans consume detritus and filter microbes in mangroves; in this case, crustaceans promote decomposition and are crucial in nutrient cycles.

Table 1. Diversity of crabs in the mangrove forest of Nusa Lembongan, Klungkung, Bali, Indonesia

Specific Name	Family	Common Name	Density (Ind./5m^2)	Important Value
Uca annulipes	Ocypodidae	Small fiddler crab	1	13.5
Uca dussumieri	Ocypodidae	Purple fiddler crab	0.5	5.6
Uca rosea	Ocypodidae	Rosea fiddler crab	2.5	21.7
Uca tetragonon	Ocypodidae	Tetragonal fiddler crab	3.7	32.9
Uca triangularis	Ocypodidae	Fiddler crab	2.0	17.4
Uca vocans	Ocypodidae	Fiddler crab	1.5	11.2
Sesarma roberti	Sesarmidae	Sesarmid crab	1.0	9.9
Sesarma pictum	Sesarmidae	Sesarmid crab	7.0	43.2
Scylla serrata	Portunidae	Mangrove crabs	1.0	9.2
Platypodia granulosa	Xanthidae	Crested reef crab	1.0	9.2
Coenobita rugosus	Coenobitidae	wrinkled hermit crabs	1.5	15.2
Coenobita violescens	Coenobitidae	Orange hermit crabs	1	11.2
Shanon-Wiener indeks (H) = 2.31				
Evenness index (E) = 0.93				

Table 2. Short description of crab and hermit crab species in the Nusa Lembongan Mangrove, Klungkung, Bali, Indonesia

Species	Figure Number	Short Description
Uca annulipes (H.Milne Edwards, 1837)	2.A	The carapace is 1.4 cm wide; there are light and dark stripes on the carapace; square body shape in males; the left claw is larger (almost 1.5 times the body length), orange to white, with light brown spots; the claws are harder and jagged. Shorter walking legs, dark color with light or whitish stripes. Two dark eyes with yellowish stalks.
Uca dussumieri (H.Milne Edwards, 1852)	2.B	The carapace width reaches about 2 cm. The trapezoidal carapace surface color of the carapace is blue-black. Paws and claws for females are dominantly purple. Right claws for males are large (almost 1.5 times body length), orange in color, and claws are whitish with serrated teeth inside.
Uca rosea (Tweedie, 1837)	2.C	The size of the carapace is about 1.5 cm, the color of the carapace is reddish-black, the carapace is rectangular, and the tip of the carapace is blunt, the dorsal part is elongated at the top, and the bottom is slightly narrowed. Thorax is black, and the abdomen is curved, black, and slightly segmented; pincers are red, and at the tips of the claws are white; the pincers surfaces are serrated and grooved; rough black spots are red.
Uca tetragonon (Herbst, 1790)	2.D	The body length reaches 11 cm (including the largest crab found in the mangroves of Nusa Lembongan), the carapace is trapezoidal, colored with dark blue spots, and the piston abdomen is milky white. The claws are large, light brown, and black with serrations on the inside, and the four pairs of walking legs are light brown with hair around the edges.
Uca triangularis (A.Milne-Edwards, 1873)	2.E	The carapace size is about 2.5 cm, black and dark blue, and the thorax and abdomen are purplish. The male claws are larger, about 1.5 times the body length, and orange; the claws are pointed, and the tips of the claws are whitish; four pairs of walking legs are purplish.
Uca vocans (Linnaeus, 1758)	2.F	Carapace size 1.5 cm, square shape, carapace color dark brown. In males, the right claw is large (almost 2 times the body length), orange in color, the claws on the claws are hard and serrated, orange-white in color, and the small pincers are darker; shorter walking legs, grayish to brown. The eyes are grayish-gray with darker tops with gray stalks.
Sesarma roberti (H.Milne Edwards, 1853)	2.G	The carapace length is about 2 cm, rectangular, with the front part wider than the back; the carapace is black with bright spots, and the abdomen is milky white. One pair of pincers in front are larger, with claws serrated on the inside; walking legs are flatter, there are hairs along the walking legs, and at the end of the walking legs are hooks adapted for climbing.
Sesarma pictum (De Haan, 1835)	2.H	The carapace is up to 2 cm long and rectangular, with the front part wider than the back; the carapace is black-green moss, and the abdomen is moss green. One pair of pincers at the front with claws serrated on the inside, the claws are orange, and the claws are dark brown; four pairs of walking legs with hair along the walking legs, at the ends of the walking legs, there are hooks adapted for climbing.
Scylla serrata (Forskål, 1775)	2.I	The carapace is oval; in adults, its width reaches 9.5 cm. It has four triangular frontal teeth between the eyes and nine anterolateral teeth on each side; the color is a mixture of light brown and green. Pincers larger, with sharp claws, walking legs smaller than pincers, one pair of hind legs flatter than the other walking leg.
Platypodia granulosa (Rüppell, 1830)	2.J	The carapace is oval, up to 3.5 cm long, and milky yellow; the back is slightly wavy, and the surface of the abdomen is smoother. One pair of pincers on the front is larger than the walking legs; the claws are black and serrated, the walking legs are flatter, and there is sparse hair on the edges of the walking legs.
Coenobita rugosus H.Milne (Edwards, 1837)	2.K	Hermit crabs found in the mangroves of Nusa Lembongan use shells from the gastropod species *Nerita plicata*. The abdomen and thorax are brown. Legs are segmented and striped in black and white, eye stalks are flat, and there is black on the underside of the eye stalks.
Coenobita violescens (Heller, 1862)	2.L	The hermit crabs found in the mangroves of Nusa Lembongan use shells from the gastropod species *Cerithidea obtusa.* Body color (abdomen-thoracic) orange, legs segmented, orange, on each knuckle whitish, two pairs of antennae on the inside are bright red; the outside is brown, eye stalks flat and dark.

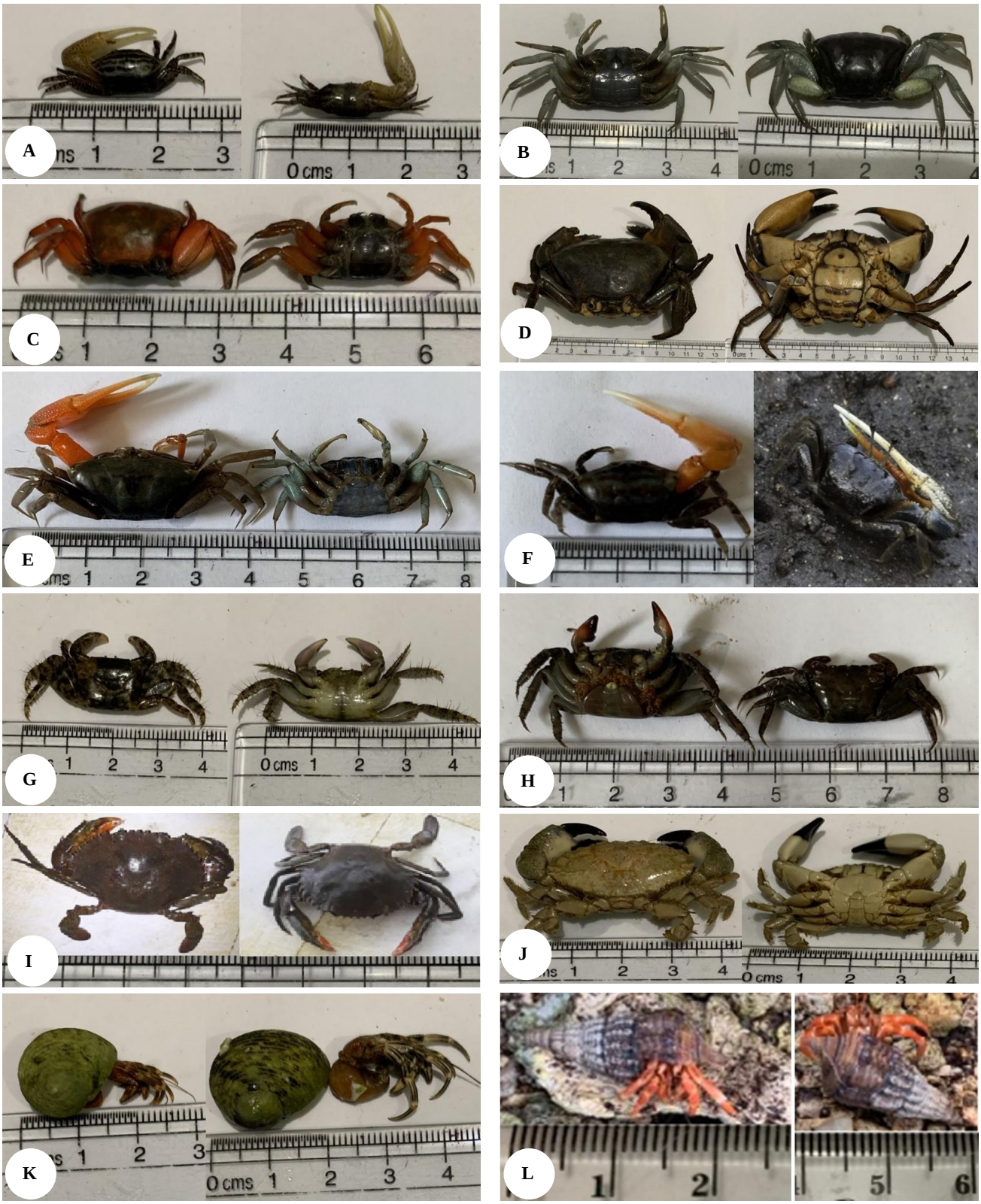

Figure 2. Crabs and hermit crabs in Nusa Lembongan mangrove, Klungkung, Bali, Indonesia: A. Small fiddler crab (*Uca annulipes*), B. Purple fiddler crab (*Uca dussumieri*), C. Rosea fiddler crab (*Uca rosea*), D. Tetragonal fiddler crab (*Uca tetragonon*), E. Fiddler crab (*Uca triangularis*), F. Fiddler crab (*Uca vocans*), G. Sesarmid crab (*Sesarma roberti*), H. Sesarmid crab (*Sesarma pictum*), I. Mangrove crabs (*Scylla serrata*), J. Crested reef crab (*Platypodia granulosa*), K. wrinkled hermit crabs (*Coenobita rugosus*), and L. Orange hermit crabs (*Coenobita violescens*)

Distribution of crustaceans in the mangroves of Nusa Lembongan

Crustaceans were found distributed from site 1 to site 7 of the Nusa Lembongan mangrove forest. The number of crustaceans found ranged from 3 to 7 species (Table 3). This shows that each Nusa Lembongan mangrove forest site's environmental factors support crustacean life; these are the type of substrate which is mostly muddy and sandy; various species of mangrove plants, both true mangroves and associated mangroves; water temperature 27.70-29.00°C; pH 6.88-7.15 and water salinity ranging from 27.83-31.53 ‰ (Table 4). Mokhtari et al. (2015) state that environmental factors that influence the crabs' life cycle from larvae to adults are the state of the substrate, vegetation, salinity, temperature, and water flow patterns. A good salinity range is 20-30 ppt, and a good temperature range is 27-32°C; the current pattern is related to the movement of crab larvae onto suitable parent habitat, an important substrate for crabs to make holes to protect from enemies; the unsuitable temperatures and vegetation are closely related to food sources for crabs. Setyadi et al. (2021) also found that environmental factors, namely the density of mangrove vegetation, substrate, water pH, temperature, salinity, and organic content in the Nagari Gasan Gadang mangrove forest in Sumatra, all support the life of crustaceans.

Another factor that cannot be ignored regarding the distribution of crab presence in mangroves is disease caused by parasites. Several researchers have reported the presence of parasites in crabs, both parasites from groups of viruses, fungi, bacteria, protozoa, and metazoa. The presence of parasites in the host (crabs) can have ecological consequences for the existence of crabs in mangrove forests. Bojko et al. (2022) reported the presence of parasites from a group of viruses in the intestinal epithelium, ciliated protozoa in the gill lamellae, fungi in the gonads, and metazoan ectoparasites in the gills of the *Aratus pisonii* mangrove crab. Nur et al. (2021) reported parasites from the phytoplankton arthropods *Octolasmis* spp. on mangrove *Scylla* spp. Rumondang et al. (2022) reported that 4 species of ectoparasites attacked *S. serrata* crabs, namely *Octolasmis* sp. (Arthropoda), *Ichtyopthyrius multifilis* (ciliates), *Trichodina* sp. (ciliates) and *Zoothamnium* sp. (ciliates). This is a challenge for future research on crustacean diversity in the mangrove forests of Nusa Lembongan to reveal the distribution of existing crustacean species.

Li et al. (2015) and Setyadi et al. (2021) state that the density of mangrove vegetation is positively correlated with the presence of crabs. This is related to the crabs' food supply: leaf litter, mangrove leaves, and mangrove saplings or mangrove propagules as food sources. Gust (2017) stated that most mangrove crabs eat leaf litter; some climb trees and eat live leaves or other crustaceans associated with mangrove forests. It was further stated that crabs play a major role in leaf litter recycling in the soil into organic matter. Crabs play a major role in influencing the zoning of mangrove flora because they are soil aeration engineers, spreading mangrove propagules, and eating mangrove leaves.

Muddy and sandy substrate types support the life of crabs to build holes/tunnels for shelter, although some crabs and hermit crabs use rock mounds as hiding places. Most crab species found nested in holes/tunnels in muddy and sandy substrates, namely *Uca* spp. (6 species), *Sesarma* spp. (2 species) and *S. serrata*. Only three species, namely *Platipodia granulosa* (Rüppell, 1830) (Crested reef crab) and *Caenobita* spp. (two species of hermit crabs) were found using mounds of rocks, coral, gravel, and sand as shelter or hiding. Seyfabadi et al. (2013) also stated that good habitat for hermit crabs is sand, gravel, and rocky habitat.

This study found two species of hermit crabs: *C. rugosus* and *C. violescens*. These hermit crabs are commonly found in Site 1 and Site 2 on rocky sand and gravel substrate types, with more frequent water-logging. This is related to the living habits of hermit crabs that walk and hide in sand and rocks. Doi et al. (2020) stated that hermit crabs are generally in a constant flow of oxygenated water, snacking on leftovers, and hermit crabs will hide in sand or rock crevices that are safe and wet to avoid drying out. Furthermore, Teoh et al. (2014) and Mukhopadhyay et al. (2022) state that hermit crab populations are limited by their shells' availability, size, and quality. Because they rely on empty shells and rarely prey on gastropods or discard meat from dead gastropods, hermit crabs compete intra- or inter-specifically for shell resources. Although the availability of empty shells may experience adjective forces such as tides and waves and the hermit crabs themselves, the concurrent assemblage of live gastropods usually reflects the availability of shells in intertidal habitats. Hermit crab species in the Nusa Lembongan Mangrove, namely *C. rugosus*, was found using shells from the gastropod species *Nerita plicata* and *C. violescens* using shells from *Cerithidea obtusa*. Teoh et al. (2014) and Mukhopadhyay et al. (2022) stated that the species of gastropod shells used by hermit crabs are quite varied, including *Nassarius livescens*, *Cerithidea cingulata*, *Cerithium zonatum*, *Clypeomorus batillariaeformis*, *Clypeomorus bifasciata*, *Rhinoclavis sinensis* and *Tenguella musiva*. That means hermit crabs depend highly on the diversity of gastropods in the mangrove habitat.

The three crab species are distributed in four to six research sites (Table 3). The *U. tetragonon* is the largest crab species (carapace length up to 11 cm) found in the mangrove forest of Nusa Lembongan. These crabs are almost always found in the back zone of mangrove forests, with a slightly sandy mud substrate; the vegetation is a mixture of true mangroves and associated mangroves and the lowest frequency of puddles. Sesarmid crabs (*S. pictum*) are often found in the middle zone to the marine zone of mangrove forests, where puddles are more frequent. These crabs are commonly found climbing mangrove trees, namely *Rhizopora mucronata*, *Rhizophora apiculata*, *Rhizophora stylosa*, *Sonneratia alba*, and *Bruguiera gymnorhiza* at site 2, site 3, site 5, site 6, and site 7. Matillano et al. (2018) stated that sesarmid crabs often climb the roots and trunks of mangrove trees to find food and rest. Rosea fiddler crab (*U. rosea*) is also a crab with a fairly high distribution. This species is found in four sites (site 1, site 3, site 5, and site 6) in the back zone of the mangrove forest with a sandy mud substrate.

Table 3. Distribution of crustaceans in the mangrove forest of Nusa Lembongan, Klungkung, Bali, Indonesia

Species	Common Name	Attendance in site						
		1	2	3	4	5	6	7
Uca annulipes	Small fiddler crab	●			●			●
Uca dussumieri	Purple fiddler crab			●				
Uca rosea	Rosea fiddler crab	●		●		●	●	
Uca tetragonon	Tetragonal Fiddler Crab		●	●	●	●	●	●
Uca triangularis	Fiddler Crab			●	●	●		
Uca vocans	Fiddler Crab			●	●			
Sesarma roberti	Sesarmid crab	●						●
Sesarma pictum	Sesarmid crab		●	●		●	●	●
Scylla serrata	Mangrove crabs		●	●				
Platypodia granulosa	Crested reef crab	●	●					
Caenobita rogusus	wrinkled hermit crabs	●	●					
Caenobita violescens	Orange hermit crabs	●	●					
Number of species		**6**	**6**	**7**	**4**	**4**	**3**	**4**

● Note: Indicates that the species is found at the study site

Table 4. Data on environmental factors at the seven mangrove forest sites in Nusa Lembongan, Klungkung, Bali, Indonesia

Site and Coordinate	Vegetation	Substrat Type	Water Temp. (°C)	pH	Water Salinity (‰)
Site 1 8° 41’ 36.97” S 115° 27’00.22” E	True mangrove: *Rhizophora mucronata, Rhizophora stylosa, Sonneratia alba* Mangrove associate: *Terminalia cattapa, Hibiscus tiliaceus, Leucaena leucocephala*	The sand is a bit muddy, with rocky sand and gravel	29,00	7.15	31.53
Site 2 8° 41’ 12.82” S 115° 27’25.50” E	True mangrove: *Rhizophora mucronata, Rhizophora apiculata, Sonneratia alba, Lumnitzera racemosa, Excoecaria agallocha, Aegyceras* sp., *Sonneratia alba* Mangrove associate: *Acacia auriculiformis, Acacia leucophloea, Gliricedia sepium, Leucaena leucocephala, Opuntia* sp., *Pandanus tectoriu, Terminalia cattapa, Borrasus flabelifer, Portulacca* sp.	Mud, sandy silt, and grave	28.76	7.11	27.83
Site 3 8° 40’ 54.27” S 115° 27’45.11” E	True mangrove: *Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba* Mangrove associate: *Leucaena leucocephala, Hibiscus sinensis, Lannea grandis, Ficus glabella, Cocos nucifera, Euphorbia malli*	Mud, rocky sand	27.70	6.99	28.83
Site 4 8° 40’ 32.06” S 115° 28’06.11” E	True mangrove: *Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba, Rhizophora mucronata* Mangrove associate: *Hibiscus sinensis, Ipomoea pes-capre, Lannea grandis, Cocos nucifera, Azadirachta indica*	Mud, rocky sand	27.90	7.05	28.57
Site 5 8° 40' 16.14" S 115° 27'53.92" E	True mangrove: *Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba, Rhizophora mucronata, Bruguiera gymnorhiza, Excoecaria agalloca, Lumnitzera racemosa* Mangrove associate: *Tespesia populnea, Morinda citrifolia*	Mud, rocky sand, and gravel	28.43	6.96	28.77
Site 6 8° 40’ 12.85” S 115° 27’21.38” E	True mangrove: *Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba, Lumnitzera racemosa , Avicennia alba* Mangrove associate: *Salicornia* sp. (glasswort), *Cyperus* sp., *Opuntia* sp., *Hibiscus sinensis*	Mud, slightly sandy	29.30	6,88	28.50
Site 7 8° 40’ 02.79” S 115° 28’09.52” E	True mangrove: *Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba, Lumnitzera racemosa , Avicennia alba* Mangrove associate: *Pandanus tectorius, Hibiscus tiliaceus, Thespesia populnea, Terminalia cattapa, Guettarda speciosa*	Sand	28.30	6.93	29.97

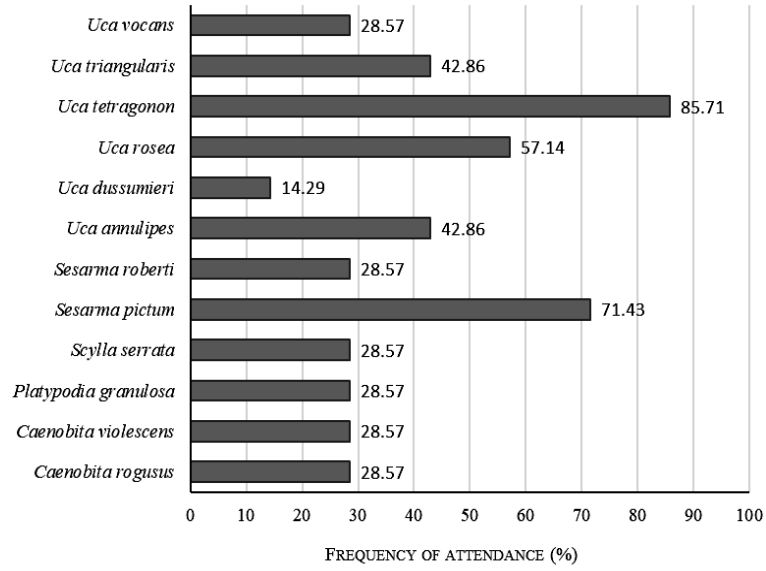

Figure 3. Frequency of presence of crustaceans at the Nusa Lembongan mangrove forest site (Bali, Indonesia)

In Figure 3, it can be seen that there are three crab species with moderate to frequent categories, namely *U. rosea* (Fi: 57.15%), *S. pictum* (Fi: 71.43%), and *U. tetragonon* (Fi: 85.71%). At the same time, the frequency of their presence for the other nine species is very rare to rare. Mokhtari et al. (2015) also found that the crab *Uca* sp. presence frequency is high in the tropical mangrove ecosystem. The type of substrate, the frequency of standing water, and the presence of mangrove plants strongly support the life of crab species in the mangroves of Nusa Lembongan. The muddy, slightly sandy substrate type is the main characteristic of the mangroves of Nusa Lembongan, so it is very good for the survival of *Uca* spp. crabs, for living holes, hiding places or looking for food. Riswandi et al. (2019) stated that the different soil textures of mangrove ecosystems greatly affect the life of mangrove crabs because the substrate is a habitat for foraging, foster habitat, and spawning grounds. Besides that, crabs have limitations in terms of environmental factors to support crab life, such as pH, temperature, and type of substrate.

The genus *Uca* crab is most commonly found in the mangroves of Nusa Lembongan, namely six out of ten crab species found; even these species are distributed in 3-6 mangrove forest sites, and their population is quite abundant. Uca crabs can be found in mangrove forests' front, middle, and back zones on various substrate types (mud, sand, gravel, and rock). Several other studies have also found that crab species from the genus Uca are the most common in mangrove forest habitats, including Katili et al. (2017) found 4 species in the Tabongo mangrove forest, Gorontalo Province; Ginantra et al. (2021) found 4 species in the coastal mangrove forest of Pejarakan Village; Riswandi et al. (2019) in the Mangrove Ecosystems in the Curahsawo Probolinggo Mangrove Area, found 6 species; Aprilyanto and Annawaty (2017) found 6 species in the mangrove forest of Kabonga Kecil, Donggala, Central Sulawesi. That shows the *Uca* crabs genus has a broad adaptability in various mangrove forest habitats.

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