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Morphological Characteristics and Spatial Distribution of Fiddler Crabs (*Uca* spp.) in the Mangrove Ecosystem of Poka Village, Inner Ambon Bay

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ABSTRACT

Fiddler crabs play a significant role in the mangrove ecosystem in Poka Village, Ambon Bay. The fiddler crabs are crustaceans that are very important for the mangrove ecosystem in Poka Village, Ambon Bay. Anthropogenic activities are now causing damage to the mangrove environment of Poka Village. It is suspected that the oil spill from damage to the Poka PLTD pipe caused most of the mangrove vegetation to experience drought, which affected the survival of fiddler crabs (*Uca* spp.) living in the mangrove ecosystem habitat. The research was conducted between June and September 2023 in the mangrove environment of Poka Village, Ambon Bay. The purpose of this study was to analyze the morphological characteristics and distribution patterns of fiddler crabs (*Uca* spp.). Sampling was carried out at five observation stations using the purposive sampling method. Crab fiddle samples were identified based on morphological characteristics. The shape, color, and angle of the orbital shell and the morphology of the large claws of each type of fiddler crab (*Uca* spp.) are important characters in identification. The results of sample identification from five stations showed four species of fiddler crabs in the Poka Village mangrove ecosystem, namely *Uca mjoebergi*, *Uca perplexa*, *Uca vocans*, and *Uca vomeris*. In addition, this research found that each species of fiddler crab has a different spatial distribution; of the four species of fiddler crab found, *Uca perplexa* has a wide distribution on all substrates, while the distribution of *Uca mjoebergi* is limited to certain substrates.

INTRODUCTION

Fiddler crabs (*Uca* spp.) are widely distributed across tropical and subtropical coastal regions worldwide. They are commonly found along muddy shorelines, estuaries, and mangrove forests in areas such as North and South America, West Africa, and Southeast Asia. These habitats provide optimal conditions for their feeding, burrowing, and reproduction. As semi-terrestrial organisms, fiddler crabs play a crucial role in coastal ecosystems by aerating the sediment and facilitating nutrient cycling, contributing to the overall health of intertidal environments **(Crane, 1975)**. Various species of fiddler crabs thrive in mangrove habitats, often in significant numbers **(Rahman *et al.*, 2024a)**. Their presence and activities contribute to controlling detritus levels and managing food sources such as bacteria, protozoa, algae, and diatoms. Additionally, their burrowing activities help break down sediment, which prevents mineral accumulation in the sediment's lower layers, thereby stabilizing nutrient levels and supporting plant growth **(Hogarth, 2007)**.

Fiddler crabs are integral to the mangrove food chain as detritivores, feeding on detritus and aiding in decomposition. They utilize mangrove habitats for spawning and nursing, supporting their lifecycle **(Crane, 1975)**. The soft, smooth substrate of mangrove forests is ideal for these crabs to create bioturbation burrows, which serve as shelters, reproductive sites, and feeding grounds, as detritus is plentiful in these ecosystems and has economic value **(Crane, 1975)**.

Furthermore, fiddler crabs are a popular addition to marine aquariums due to their unique appearance and contribution to substrate aeration. Through their burrowing activity, they create aerobic conditions and recycle nutrients, enhancing sediment fertility and water quality **(Hamidah *et al.*, 2014)**. The high density of fiddler crabs has a noticeable impact on sediment structure due to the air circulation from their burrows, which prevents mineral accumulation on the sediment floor and maintains stable nutrient content, ultimately fostering vegetation growth **(Krisnawati *et al.*, 2018)**.

In terms of physical characteristics, fiddler crabs are small and exhibit striking color patterns on their carapace **(Mojekwu & Anumudu, 2015)**. One distinguishing feature is the difference in claw size between males and females; male crabs possess one enlarged claw, often double the size of their carapace, which they use for attracting females and deterring predators **(Murniati & Pratiwi, 2015)**. Female crabs, however, have claws of equal size. Each species within a population may show variations in size, morphology, and morphometric traits **(Murniati, 2008)**. Studying these morphological and morphometric characteristics in *Uca* crabs is essential for understanding growth patterns, assessing gonad maturity, validating taxonomic identification, evaluating population distinctions, and analyzing shape differences in aquatic species **(Murniati, 2016)**.

Previous studies have explored morphometric variations among various crab species, including fiddler crabs (*Gelasimus vocans*), mangrove crabs, and coconut crabs (*Birgus latro*) **(Rahayu *et al.*, 2018)**. In addition to morphometric analysis, research on *Gelasimus vocans* has also focused on their behavioral ecology, including communication through claw waving, territoriality, and mating strategies **(Dyson, 2008)**. The distribution parameters significantly affect the density and abundance of fiddler crabs in mangrove ecosystems. In the Inner Ambon Bay, particularly in the mangrove area, fiddler crabs are found naturally. Preliminary observations indicate that certain fiddler crab species are dominant in this region. However, the aquatic environment in Inner Ambon Bay, particularly near Poka Village, is under threat from anthropogenic activities **(Sairmorsa & Tetelepta, 2024)**. A notable concern is the impact of an oil spill due to a pipeline leak from Poka PLTD, which has led to drought in portions of the mangrove vegetation in this area **(Rahman *et al.*, 2024b)**.

There is limited information on the morphological characteristics and distribution patterns of fiddler crabs in the Poka Village mangrove area. Therefore, this study aimed to examine the morphological characteristics and spatial distribution of *Uca* spp. fiddler crabs in the mangrove ecosystem of Poka Village, Inner Ambon Bay.

MATERIALS AND METHODS

Time and locations

Sampling was conducted in the mangrove environment of Poka Village, Ambon Bay (Fig. 1) from June to August 2023, at locations between 128.19311° to 128.19358° East Longitude and -3.64515° to -3.64606° South Latitude, with sampling carried out once per month during this period. Sample analysis was carried out in the Laboratory of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Pattimura University.

Sampling methods

Crab data were collected from five stations within the mangrove ecosystem using a purposive sampling method, with random 1x1m plots to assess the number of bioturbation burrows. Crab samples were separated by sex, distinguishing male and female crabs based on claw shape. Following this, each sample underwent identification, carapace measurement, and documentation. The carapace length of fiddler crab was measured from the anterior to the posterior edge using a vernier caliper or digital caliper for high accuracy. Measurements were performed carefully to prevent injury to the specimen **(Rosenberg, 2001; Shih *et al.*, 2015)**. Identification of fiddler crabs was conducted by observing key characteristics such as carapace shape, color, and orbital angle. Additionally, abdominal shape was noted, with males displaying a triangular and elongated abdomen, while females exhibited a round and broad abdomen. The distinct morphology of large and small claws—especially the large claw shape, which varies significantly between *Uca* species—served as an important identification feature, following the guidelines provided by **Rosenberg (2000)** and **Rianjuanda *et al.* (2020)**. Finally, each type of fiddler crab was documented using a digital camera.

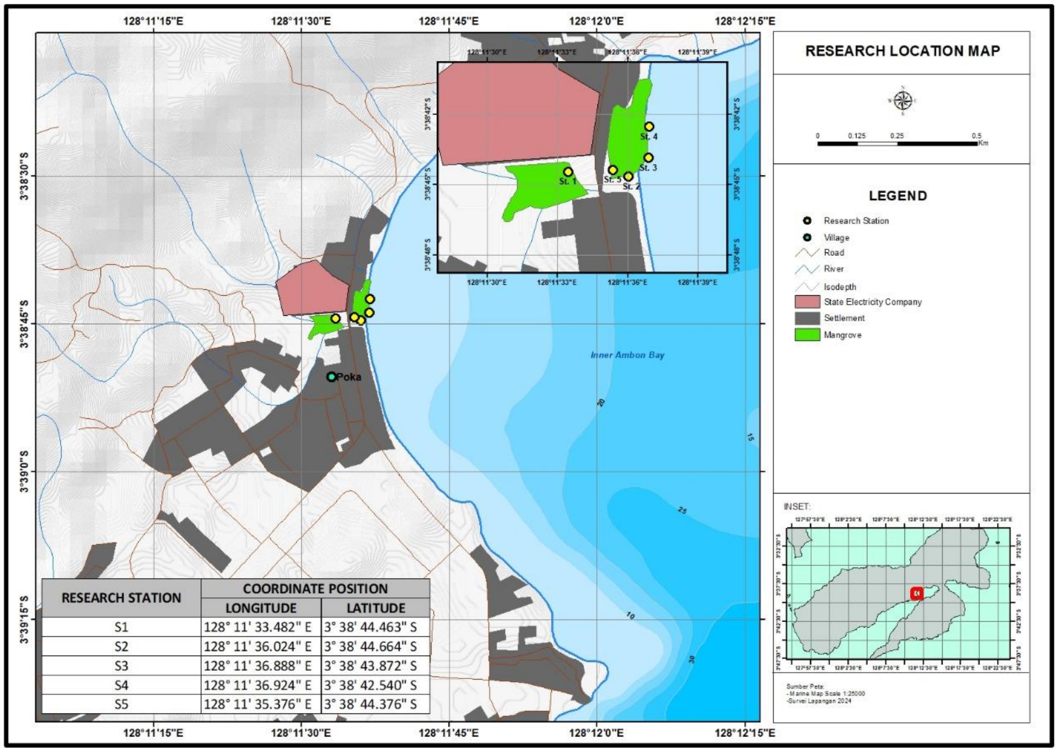

Fig. 1. Map of study sites

Substrate or sediment sample analysis was conducted in the laboratory using an electric oven, scales, and an automatic sieving shaker, arranged with sieve sizes from largest to smallest (4, 2, 1, 0.425, 0.25, 0.125, 0.063, and 0.038mm) to separate gravel, sand, silt, and clay particles. Each sample was filtered for 5 minutes to ensure thorough separation. Fiddler crabs exhibit sexual dimorphism, making morphological differences between males and females readily apparent. Based on the findings, male fiddler crabs outnumbered females overall. Previous research conducted in non-degraded mangrove conditions (September 2019–February 2020) found similar numbers of male *Uca mjoebergi* as in this study, but fewer female *Uca mjoebergi*. This discrepancy may be attributed to variations in mangrove ecosystem conditions and seasonal differences **(Rosenberg, 2001b)**.

Data analysis

To determine the sex ratio of *Uca* spp. crabs, a comparison was made between the number of male and female individuals using the following formula:

$$NK = NJB/N$$

Where, NK represents the sex ratio, NJB is the number of male or female individuals, and N is the total number of observed individuals.

The collected data on fiddler crab species were categorized taxonomically, plotted according to research stations, and described based on their morphological structure and habitat characteristics at the research site. Substrate fraction data were classified by grain size, and the weight percentage of each fraction was calculated. The substrate fractions were then analyzed using the Wentworth scale, with the following formula:

$$\text{Substrate fraction} = \frac{\text{Weight of each size segment of sediment particles}}{\text{Total weight of sediment}} \times 100$$

The spatial distribution of fiddler crabs within the mangrove ecosystem of Poka Village was mapped using ArcGIS 10.5 software.

RESULTS AND DISCUSSION

1. Size structure of fiddler crabs

In this study, four distinct fiddler crab species were identified in the mangrove ecosystem of Poka Village: *Uca mjoebergi*, *Uca perplexa*, *Uca vocans*, and *Uca vomeris*. Specimens were collected across five sampling stations, providing a solid basis for assessing both their morphological characteristics and spatial distribution. The results indicated that male fiddler crabs with the largest carapace lengths were observed at Station 5 for each species: *Uca vomeris* (20 ± 2.39mm), *Uca vocans* (11.38 ± 2.19mm), *Uca perplexa* (10.81 ± 1.30mm), and *Uca mjoebergi* (10.61 ± 1.24mm) (Table 1).

Previous research reported that the carapace length of male *Uca mjoebergi* ranged from 2.10 to 10.23mm, with an average of 6.26mm. In non-degraded mangrove conditions, smaller sizes of *Uca mjoebergi* were still present. The observation of small-sized male fiddler crabs without females may be related to the fiddler crab spawning season. Fiddler crabs typically engage in synchronized mating activities, with their breeding season usually occurring from June to August. The mating cycle of fiddler crabs is influenced by environmental conditions; those living in favorable environments may survive up to 3–4 years. Fiddler crabs reach reproductive maturity between 12 and 14 months of age **(Sahureka, 2020)**.

Table (1) also shows that the female fiddler crabs with the largest carapace length were found at Station 5: *Uca vomeris* (11 ± 1.27mm), followed by *Uca vocans* (10.60 ± 0.97mm). The smallest carapace lengths were observed in *Uca mjoebergi* (9.67 ± 0.71mm) and *Uca perplexa* (10.11 ± 1.49mm). These findings are consistent with previous studies that suggest differences in carapace size are closely linked to local environmental conditions—such as food availability and predation pressure—that influence growth rates and reproductive success. For instance, research by **Stoddart (1983)** and **Boyko (2002)** demonstrated that species with larger carapaces often enjoy advantages in territorial defense and mate attraction, which can enhance reproductive outcomes. Moreover, comparative studies conducted along the Atlantic coast **(Morris & Clerkin, 2001)** and within Indo-Pacific mangrove ecosystems **(Butcher, 2009)** further support the notion that these morphological variations represent adaptive responses to differing ecological pressures.

Table 1. The size of the carapace of a fiddler crab (*Uca* spp.)

St.	Species	Carapace Length (cm)[A]				Carapace Length (cm)[B]			
		Min	Max	Mean	Stdv	Min	Max	Mean	Stdv
1	*Uca mjoebergi*	-	-	-	-	-	-	-	-
	Uca vocans	-	-	-	-	-	-	-	-
	Uca vomeris	-	-	-	-	-	-	-	-
	Uca perplexa	10.00	11.00	10.50	0.71	9.00	9.00	9.00	-
2	*Uca mjoebergi*	-	-	-	-	-	-	-	-
	Uca vocans	-	-	-	-	-	-	-	-
	Uca vomeris	-	-	-	-	12.00	12.00	12.00	-
	Uca perplexa	-	-	-	-	11.00	11.00	11.00	-
3	*Uca mjoebergi*	-	-	-	-	-	-	-	-
	Uca vocans	-	-	-	-	10.00	12.00	11.50	2.12
	Uca vomeris	-	-	-	-	-	-	-	-
	Uca perplexa	-	-	-	-	11.00	12.00	11.50	0.71
4	*Uca mjoebergi*	-	-	-	-	-	-	-	-
	Uca vocans	10.00	10.00	10.00	-	10.00	10.00	10.00	-
	Uca vomeris	13.00	13.00	13.00	-	12.00	13.00	12.50	0.71
	Uca perplexa	-	-	-	-	9.00	11.00	10.00	1.41
5	*Uca mjoebergi*	9.00	13.00	10.61	1.24	9.00	11.00	9.67	0.71
	Uca vocans	8.00	15.00	11.38	2.19	9.00	12.00	10.60	0.97
	Uca vomeris	14.00	22.00	20.00	2.39	9.00	13.00	11.00	1.27
	Uca perplexa	8.00	13.00	10.81	1.30	7.00	13.00	10.11	1.49

Notes: A = male, B = female

The results also indicate that *Uca vomeris* exhibits the largest carapace length for both male and female fiddler crabs. Among the four species of male fiddler crabs, all have a larger carapace length than their female counterparts. All species were found at Station 5, with varying carapace sizes between males and females. At Stations 1–4, only one species was found at Station 1, two species at Stations 2 and 3, and three species at Station 4. In each species, fiddler crabs can reach different maximum adult carapace sizes, such as 40mm for *Uca mjoebergi* and *Uca perplexa*, and 50mm for *Uca vocans* and *Uca vomeris*. Thus, the findings from this study suggest that the observed sizes are still smaller than the maximum potential size for each fiddler crab species.

The absence of *Uca mjoebergi* at Stations 1–4 and its exclusive occurrence at Station 5 may be attributed to its specific habitat requirements and environmental tolerances. Like other fiddler crab species, *U. mjoebergi* is highly sensitive to variations in substrate type, salinity, and tidal influences, which can differ significantly between stations. Station 5 may offer a unique combination of these factors—such as a softer, muddier substrate ideal for burrowing, optimal salinity levels, and a high organic content in the sediment—that creates an environment conducive to the life cycle and feeding habits of *U. mjoebergi*. In addition to abiotic factors, biotic interactions, including interspecific competition and predation pressure, might also play a role; at Stations 1–4, *U. mjoebergi* may experience more intense competition or be more vulnerable to predators, thus limiting its distribution compared to Station 5, which may serve as a refugium for this species. These findings are consistent with previous studies linking fiddler crab distribution to microhabitat conditions, wherein variations in local environmental factors critically determine the success and adaptation of each species **(Stoddart, 1983; Boyko, 2002)**.

2. Morphological features of fiddler crabs

The following are the results of identification and morphological description of each fiddler crab species found in the mangrove ecosystem of Poka Village:

a. *Uca mjoebergi* (Paraleptuca)

Fig. (2) shows that the carapace is brown with a few white lines and a wide carapace face. The width of the carapace is greater than the length. The large male claws are yellow, and there are no large nodules on the surface of the manus. The dactylus is whitish-yellow and wider than the polex, and there are no large teeth on the dactylus and polex. The tip of the polex is keel-shaped, the tip of the dactylus is curved in the shape of a hook. There are no teeth on the small claws. Legs are light whitish brown.

This species is primarily characterized by its brown carapace adorned with subtle white lines and a relatively wide carapace face. The male's large claw is distinctly yellow and lacks prominent nodules on the manus, which along with the keel-shaped tip of the polex and the hook-shaped dactylus tip, sets it apart from the other species. The absence of teeth on the small claws further differentiates *Uca mjoebergi* **(Rathbun, 1924)**.

Fig. 2. *Uca mjoebergi*: overall view of the specimen (left); detailed morphological features (right)

b) *Uca perplexa* (Paraleptuca)

Uca perplexa is readily distinguished by its striking morphology. The crab's carapace is predominantly black with white markings, and its width is nearly twice its length, with a particularly broad anterior region. In males, the large claw is white and features a smooth manus surface. Notably, the dactylus is broader than the polex, and there is no shallow triangular depression at the base of the polex. The cutting edge of the polex is marked by large subdistal teeth, including one prominent tooth in the middle that is also present on the dactylus. Furthermore, the outer end of the polex is keeled, with an additional single tooth on the inner end, while the tip of the dactylus curves into a hook-like shape. In contrast, the small claw lacks any teeth, and the legs are a light whitish brown (Fig. 3). These characteristics collectively make *Uca perplexa* easily recognizable and distinct from other fiddler crab species **(Edwards, 1837)**.

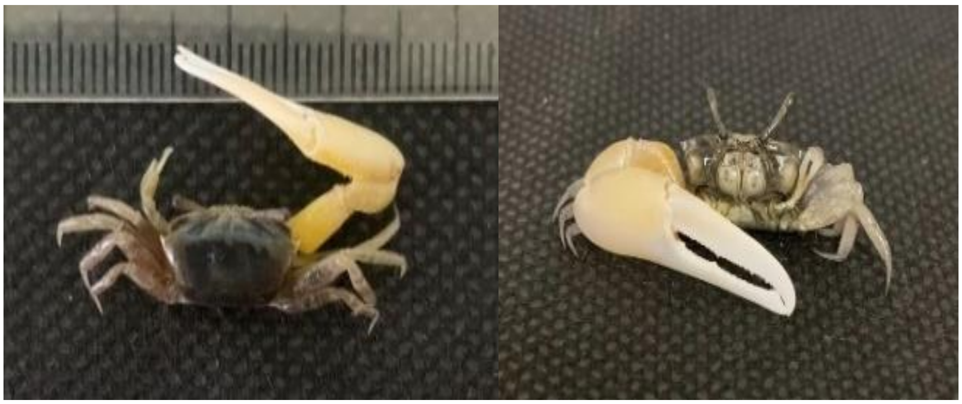

Fig. 3. *Uca perplexa*: overall view of the specimen (left); detailed morphological features (right)

c) *Uca vocans* (Gelasimus)

The carapace is black, with a narrow carapace face. The male's large claws are white and slightly orange, and the manus is orange with a large nodule on the surface. On the male's large claws, there is a triangular depression at the base of the polex, the tip reaching 2/3 of the length of the polex. Polexes and dactyls are wide flat. The large claw polex has two notches with triangular teeth. The tip of the dactylus is curved. The cutting edge of the small claw is longer than the manus. Legs are light brown (Fig. 4).

With a narrow carapace face and a black overall coloration, *Uca vocans* is identified by its large claw, which is unique due to its mixed white and slight orange hue. The manus of the claw is orange with a prominent large nodule and a triangular depression at the base of the polex, where the depression’s tip extends to about two-thirds of the polex length. Additionally, the wide and flat design of both the polex and dactylus, featuring two notches with triangular teeth, distinguishes this species. The extended cutting edge of the small claw also serves as an important identifying characteristic **(Linnaeus, 1758)**.

Fig. 4. *Uca vocans*: overall view of the specimen (left); detailed morphological features (right)

d) *Uca vomeris* (Gelasimus)

The carapace is greyish-black with grooves that form a pattern, and the front of the carapace is narrow. The male's large claw dactylus is white, and the polex and manus are orange. The surface of the manus of the large claw has large nodules. The polex and dactylus are flat and wide, with no large teeth. The ends of the polex and dactylus are curved; the polex is longer than the dactylus. The small claw has a longer claw gap than the manus. Legs are blackish brown (Fig. 5).

Fig. 5. *Uca vomeris*: overall view of the specimen (left); detailed morphological features (right)

Uca vomeris is characterized by its greyish-black carapace with a distinct grooved pattern and a narrow front. The large claw shows a notable color contrast: A white dactylus with an orange polex and manus, the latter adorned with large nodules. The structure of the claw—where both the polex and dactylus are flat, wide, and curve at the ends, with the polex being longer than the dactylus—is a key distinguishing feature. Furthermore, the small claw's longer gap compared to the manus is another diagnostic detail that helps differentiate *Uca vomeris* from the others. These morphological differences, when compiled into a table, provide a clear visual guide and aid in the accurate identification and differentiation of each fiddler crab species in the study **(McNeill, 1920)**.

In this study, the morphological features of four fiddler crab species were analyzed to assist in accurate species identification and to understand their ecological adaptations. While all species share common fiddler crab traits, such as a distinct carapace and sexually dimorphic claws, each one exhibits unique diagnostic characters (Table 2).

Table 2. Key morphological characteristics differentiating fiddler crab species

Species	**Carapace**	**Large Claw (Male)**	**Additional Features**
Uca mjoebergi	Brown with a few white lines; wide carapace face (width > length).	Yellow; lacks large nodules on the manus; dactylus is whitish-yellow and wider than the polex; tip of the polex is keel-shaped, and the dactylus tip is curved like a hook; no teeth on the small claws.	Legs are light whitish brown.
Uca perplexa	Black with white markings; carapace width is approximately twice the length with a broad front.	White with a plain manus surface; dactylus is wider than the polex; features large subdistal teeth on the cutting edge of both the polex and dactylus (including one large tooth in the middle); the outer end of the polex is keeled with an additional inner tooth.	Small claws lack teeth; legs are light whitish brown.
Uca vocans	Black with a narrow carapace face.	White with a slight orange tint; manus is orange and exhibits a prominent large nodule; possesses a triangular depression at the base of the polex (tip reaching about 2/3 of the polex length); both the polex and dactylus are wide and flat, with the polex having two notches with triangular teeth and a curved dactylus tip.	The cutting edge of the small claw is longer than the manus; legs are light brown.
Uca vomeris	Greyish-black with a grooved pattern; narrow front.	Dactylus is white, while the polex and manus are orange; the manus has large nodules on its surface; both the polex and dactylus are flat, wide, and have curved ends, with the polex being longer than the dactylus.	The small claw exhibits a longer gap than the manus; legs are blackish brown.

3. Spatial distribution pattern of fiddler crabs

The study results shows that each species of fiddler crab has a different spatial distribution, where some can spread across all substrates, such as *Uca perplexa*, but there are also species whose distribution is limited to certain substrates, such as *Uca mjoebergi* (Fig. 6).

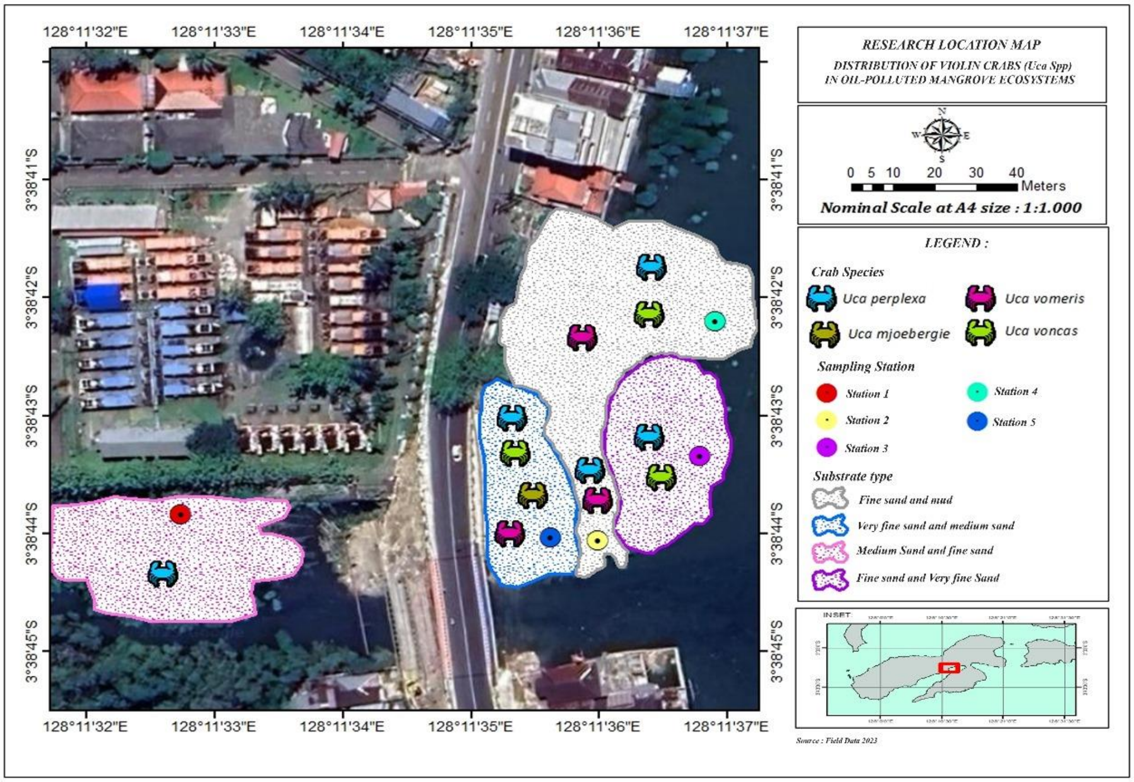

Fig. 6. The spatial distribution map of fiddler crabs at mangrove ecosystems of Poka Village

Fig. (6) illustrates the distribution of fiddler crab species across different stations with varying substrate types. At Station 1, with medium sand and fine sand substrates, only one species, *Uca perplexa*, was found. Station 2, with fine sand and mud substrates, hosted two species: *Uca perplexa* and *Uca vomeris*. At Station 3, with fine sand and sand substrates, two species were present: *Uca perplexa* and *Uca vocans*. Station 4, with the same fine sand and mud substrates as Station 2, contained three species: *Uca vocans*, *Uca vomeris*, and *Uca perplexa*. Finally, at Station 5, with fine sand and medium sand substrates, four species were identified: *Uca majorbergi*, *Uca perplexa*, *Uca vocans*, and *Uca vomeris*.

Uca perplexa has a wide distribution and can occupy all types of substrates (medium fine sand combination, fine mud sand combination, very fine sand combination and medium sand fine sand combination). It is because *Uca perplexa* lives in the middle of protected or open intertidal areas, river estuaries, and areas near mangrove communities with sand or muddy sand substrates, and *Uca perplexa* is cosmopolitan. After all, it is one of the seven species found throughout the Indonesian coast **(Krisnawati *et al*., 2018)**. *Uca vocans* were only found at three stations (Station 3,4,5) with substrates (a combination of sands with different textures, including fine sand, very fine sand, a mixture of fine mud sand and fine sand, as well as medium sand).

The *Uca vocans* species lives along the front intertidal zone, around mangrove communities with muddy to sandy substrates **(Krisnawati *et al*., 2018)**. *Uca vomeris* was only found at three stations (Station 2,4,5) with substrates (a combination of fine sand, very fine-grained sand, a mixture of fine sand, and medium sand). The *Uca vomeris* species lives in areas with mud substrates **(Krisnawati *et al*., 2018)** and tidal areas with sand substrates **(Saidah *et al*., 2021)**.

The species with a very narrow distribution is *Uca mjorbergi*, which was only found at station 5 with a fine sand medium sand substrate. *Uca mjobergi* lives along the intertidal zone and riverbanks/estuaries with muddy mud and sand substrates. This study showed a slight difference because this species was not found on muddy mud and sand substrates **(Krisnawati *et al*., 2018)**.

In general, station 1 has a very low number of fiddler crab species, although the sediment is generally similar to station 5 with a different dominant percentage. It may also be caused by the habitat being polluted by oil and the mangroves being degraded, which impact the diversity or composition of low species **(Sairmorsa & Tetelepta, 2024)**. The habitat characteristics of station 5 have a dense, open substrate and are closer to land, hence they have the highest species composition. This is because the population of fiddler crabs (*Uca* spp.) tends to be larger on dense substrates than on soft substrates. A dense substrate provides a stronger construction, making it safer to anchor the burrow **(Serosero *et al.*, 2018)**.

Apart from that, many crabs from the genus *Uca* are also found in the soft mud at the bottom of the mangrove forest, which is not too dense. These crabs can be found in areas closer to land, so they are more adapted to dry environments **(Suprayogi *et al*., 2014)**. The type of substrate is related to the sediment's oxygen content and nutrient availability. The oxygen content on sandy substrates is relatively greater than on smooth substrates because sandy substrates contain air pores, allowing more intensive mixing with the water above them **(Tuahatu & Rahalus 2009; Natan *et al*., 2023)**.

CONCLUSION

The are four species of fiddler crabs in the mangrove ecosystem of Poka Village, namely *Uca mjorbergi, Uca perplexa, Uca vocans,* and *Uca vomeris* have different morphological characters related to carapace shape and color, male and female claws, dactycus, polex, manus, as well as teeth and leg color. Morphological characteristics of male claws are a key to identification. Each species of fiddler crab has a different spatial distribution; of the four species of fiddler crab found, *Uca perplexa* has a wide distribution on all substrates, while the distribution of *Uca mjoebergi* is limited to certain substrates.

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