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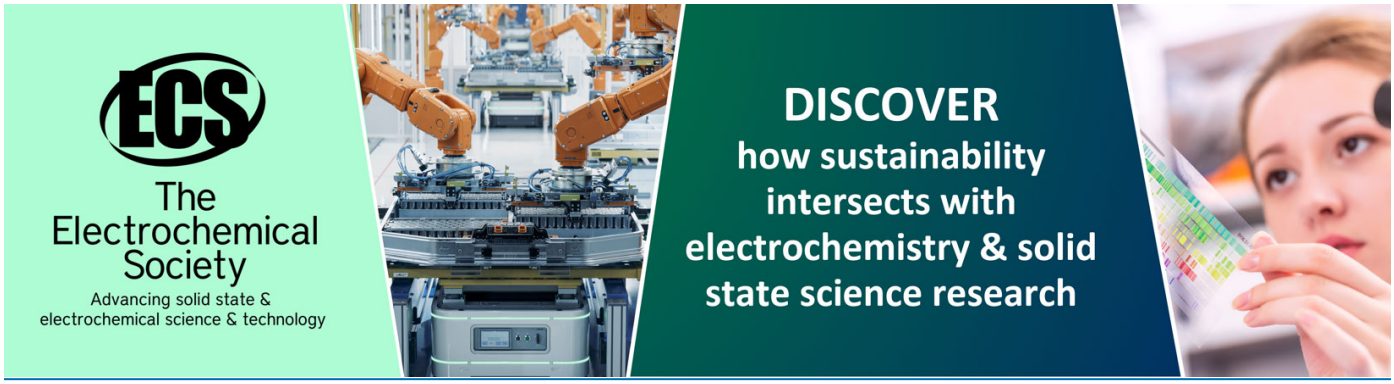

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The habitat of *Varuna litterata* in the bengawan solo river

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Abstract. *Varuna litterata* is a crab that belongs to the Varunidae and has been caught to fulfill the need for the availability of an animal protein source. The purpose of this study was to determine the existing habitat of V. litterata in the Bengawan Solo River Estuary. Sampling of *V. litterata* was carried out every month for five months in three stations by using fixed nets. Water and substrate quality parameters were measured and examined. The samples of *V. litterata* that had been obtained were then counted and differentiated based on sex and size. The morphological characteristics were then recorded. The sample was then weighed, the width and length of the carapace were measured. The results showed that the abundance of *V. litterata* was even at each station. The carapace width distribution was dominated by 3.5-3.99 cm in size. The ratio of male and female individuals is still in balance. The results of this study indicated that *V. litterata* can be found in waters that are directly opposite the sea and spread as far as 32 km from the estuary. *V. litterata* can be found in waters that are still affected by tidal currents with salinity ranging from 20-25 ppt, temperature ranging from 31-33.2, river surface water current ranging from 0, 39-0,52 m/s with a textured bottom consisting of silty, clayey, sandy, and muddy.

1. Introduction

V. litterata is a type of crustacean that belongs to the family varunidae, and because it has paddle-like legs that allow *V. litterata* to swim, it is also called a swimming crab or rowing crab. *V. litterata* usually inhabits mangroves, estuaries, freshwater, and shallow tidal areas. *V litterata* is also commonly found under rocks, logs and dead leaves and lives in burrows along pond embankments, creeks, and shallow banks [1].

V. litterata has been caught for consumption by local people because it contains animal protein. Ngan Kee [2] stated that varunid crabs have commercial value, scientific value, and medical value, including *Eriocheir sinensis, E. japonica, Platyeriocheir formosa*, *Varuna litterata*, *V. yui* and *Metaplax gocogensis*. Although *V. litterata* and *V. yui* are not as popular as Eriocheirs, but *V. litterata* and *V. yui* still have high selling value in East Asian and Southeast Asian countries.

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Many studies have been conducted on varunid crabs such as *Eriocheir sinensis*, *E. japonica*, *Platyeriocheir formosa*, but information on *V. litterata* is still limited. Information about the habitat of *V. litterata* is one of the information that is still being studied because this information is very useful as a basis for adaptations that lead to future cultivation activities, considering that *V. litterata* has medical value because it contains unsaturated fatty acids such as PUFAs [3].

The presence of *V. litterata* in Indonesia, precisely in Halmahera, Maluku, has been reported by Kali [1]**,** while in Gorontalo in the northern part of Sulawesi and the Special Region of Yogyakarta in the central part of Java [4-6] have reported their presence on the east coast of East Java, precisely in the Meru Betiri National Park, East Java. The existence of *V. litterata* in the mouth of the Bengawan Solo River has been reported by Fariedah et al., [7] but more detailed habitat information has not been studied at this location.

2. Materials and method

2.1 Study Area

It was carried out in the industrial area of the north coast of Gresik including the estuary in Kebomas District, Manyar District and Sembayat District. The first and second stations (Kebomas and Manyar District) are one of the estuaries of the Bengawan Solo rivers which is flanked by two large industrial complexes, while the third station (Sembayat) is located relatively further from the industrial area. The selection of the three stations was based on the results of a survey that had been conducted previously and based on the results of preliminary research (Figure 1).

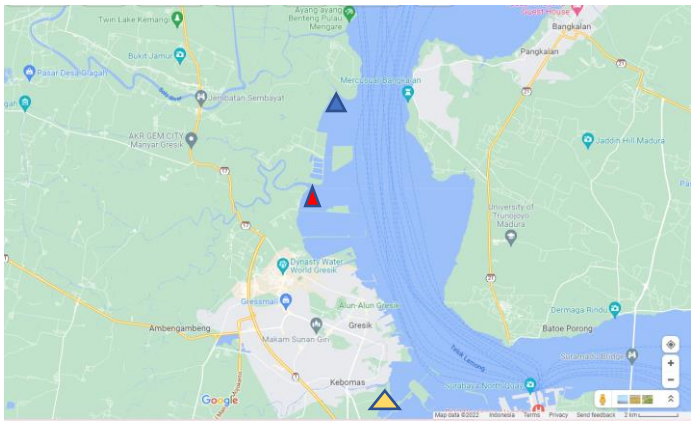

Figure 1. Sampling location (Station 1 with blue triangle, Station 2 with red triangle, Station 3 with yellow triangle)

2.2 Physiochemical parameters

Measurement of water and substrate quality parameters was carried out according to the placement of the plugged nets. Observations of the substrate parameters were carried out vertically. The observed soil parameter is the texture of the sediment. The water quality parameters measured were temperature, salinity, DO, and pH.

2.3 Sample collection

Crab samples were obtained by using a plug-in net installed at each station. Sampling was carried out once a month at high tide. The samples that have been obtained are then separated by sex, then weighed with an analytical balance, then the width and length of the carapace are measured.

3. Result and Discussion

V. litterata is included in the phylum Arthropoda (animals that have segments on their body**)** [8], belongs to the subphylum crustaceans (animals with a hard shell), belongs to the order decapoda (has five pairs

of legs) [9], and belongs to the family Varunidae, which has a square carapace, the exopod on the third maxilip is very strong, has legs that have distal segments that are laterally flattened, filled with seta [10]. The walking legs are long and slender. The last walking leg is very flat and shaped like a paddle, it allows the crab to be able to swim [11] (Figure 2). At the time of sampling, *V. litterata* was found swimming, or sitting on water hyacinth leaves or on tidal pond embankments.

Figure 2. *Varuna litterata*

3.1 Abundance of V. litterata

The abundance of *V. litterata* in each station was almost the same except for the first station. The abundance of *V. litterata* is shown in table 1.

Table 1. Abundance of *V. literatta*

Period	Station I	Station II	Station III
I	23	49	43
II	13	38	39
III	18	45	37
IV	32	67	57
V	41	66	68
Total	127	265	244

Table 1 shows that the highest abundance was obtained at the second station (Manyar) and followed by the third station (Sembayat), while the lowest abundance was obtained at the first station (Kebomas). The second station in the district Manyar located in the Kalimireng River has the highest abundance during the sampling period because it is directly adjacent to the sea and is downstream of the Bengawan Solo River tributary, so that a lot of nutrients are carried away from the river flow from upstream. In addition, the Kalimireng River also has a growing mangrove area. The existence of flow from the upstream direction and the presence of mangrove areas makes the Kalimireng River rich in nutrients and provides a lot of natural food for *V. litterata*.

The abundance of *V. litterata* at the third station was not much different from the abundance at the second station. This was possible because the river at the third station was not directly connected to the Bengawan Solo River, so that the nutrient cycle was not similar to the second station. Even though the river at the third station also borders the sea and has a mangrove area that is also developing.

The first station has the lowest abundance of *V. litterata*. Although it is connected to the Bengawan Solo River and directly adjacent to the sea, it can be described that the stretch of sea connected to the river is limited by the presence of ports and water transportation. Variations in abundance of *V. litterata* between sampling stations are in accordance with what was stated by Kali [1] that *V. litterata* inhabits fresh and brackish waters or in general is estuarine and prefers areas directly facing the ocean.

At the sampling process, *V. litterata* was not found in the middle of the mangrove area. *V. litterata* is often found swimming or on the leaves of aquatic plants such as water hyacinth, *V. litterata* also likes

to hide behind broken stems of aquatic plants that sink in water bodies. Slightly different from what was stated by Devi et al., [12]; Devi & Joseph [13] which stated that *V. litterata* likes mangrove areas because it is rich in organic carbon. The absence of *V. litterata* in mangrove areas means that this species does not like to stay in the mangroves ecosystem but prefers to be in water bodies. This is possible because *V. litterata* is also called a swimming crab because it has paddle-like legs, this causes *V. litterata* to be better known as a paddler crab than a mangrove crab. The importance of the existence of mangroves for *V. litterata* is as a natural food provider in the area.

The distribution of the carapace width of *V. litterata* can be seen in Figure 3.

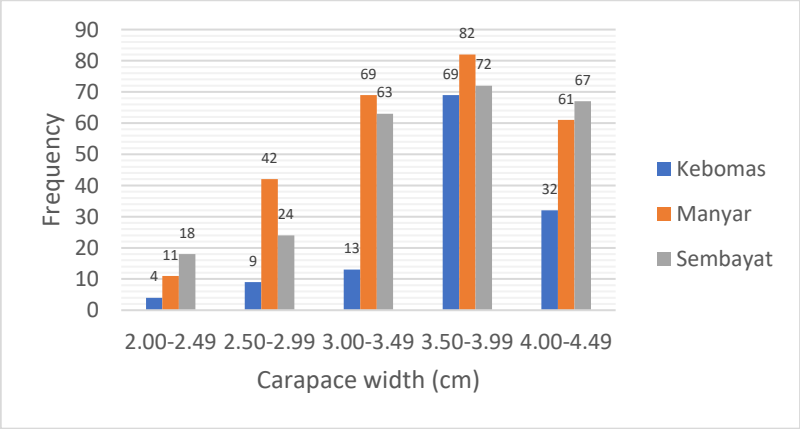

Figure 3. Distribution of Carapace Width of *V. literatta* in each station

Figure 3 illustrates that the carapace width distribution of *V. litterata* is in the range of 2.00-4.49 cm. Figure 3 also shows that each station has a wide distribution of carapace widths, although no megalopa stadia was found during the sampling period. At the first station it was dominated by a carapace width of 3.50-3.99 cm (69 individuals), as well as the width of the carapace at the second station as many as 82 individuals, while at the third station it was dominated by a carapace width of 4.00-4.99 cm, which was 67 individuals. This proves that *V. litterata* resides in estuary or river areas that are still influenced by tides until the adult stage, as explained by Ng [14] that *V. literatta* which is included in Varunidae spends their juvenile period in fresh water.

Sex differences in *V. litterata* can be seen from the dimorphism of sexual characters as in crabs in general, namely by looking at the shape of the abdomen. The abdomen of male individuals has a pointed shape like the letter T, while the abdomen of female individuals has a rounded shape (Figure 4).

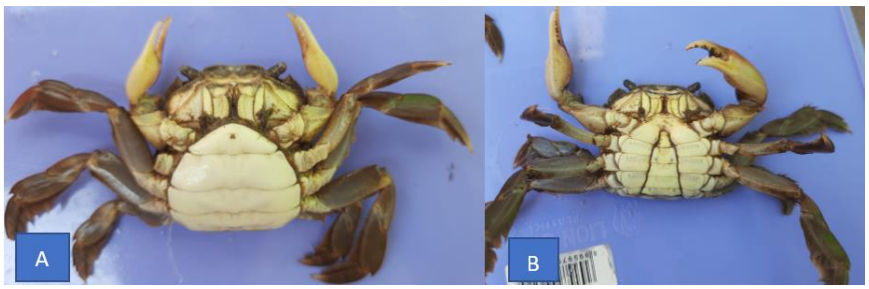

Figure 4. The abdomen of female individuals has a rounded shape (A), while the abdomen male individuals have a pointed shape like the letter T (B).

The results of the calculation of the comparison of males and females at the time of sampling are shown in Figure 5. Figure 5 describes that the ratio between male and female *V. litterata* species at each station is still in a balanced state. This situation is expected to be one of the factors in maintaining the availability of *V. litterata* in the future.

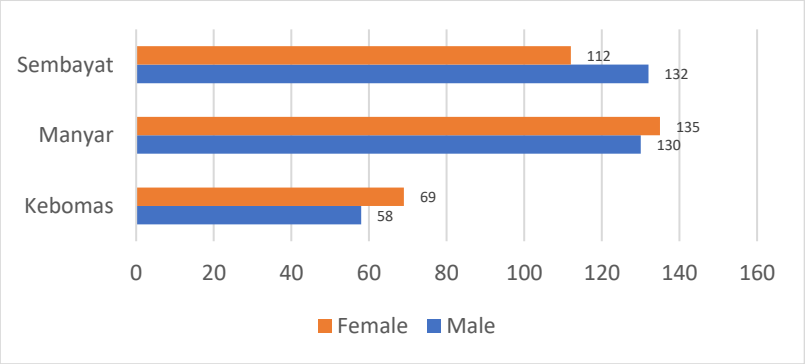

Figure 5. Sex distribution of *V. litterata*

3.2 Physiochemical parameters

The quality of water and sediment at each station is analyzed every month. The description of each station is shown in Figure 6. The results of the water quality analysis are shown in Table 2.

Figure 6. Location of sampling study

Tabel 2. Range of salinity, temperature, DO and pH during the study period.

Station	Salinity (ppt)	Temperature (°C)	DO (mg/l)	pH	Current river (m/s)
Kebomas	21-24	32-33,2	3,6-4,1	6-6,5	0,39
Manyar	22-25	32-32,4	3,7-4,2	6-6,7	0,48
Sembayat	22-24	31-31,6	4,4-5,7	6-6,8	0,52

In general, the water quality parameters at each station are not too different. The lowest salinity was found at the first station (21 ppt), while the highest salinity was found at the second station, namely 25 ppt. The salinity range during the sampling period was not too far away, this was because the sampling was carried out when the sea water was high tide, so the salinity of the river water was higher than when the sea water was not at high tide. The high salinity of river water at each station is also influenced by the absence of the rainy season, so that river water receives more influence from sea water. The salinity range in Table 2 illustrates that *V. litterata* can inhabit waters with higher salinity than fresh waters. This is in accordance with research reported by Eprilurahman & Baskoro [4] which states that *V. litterata* is an individual that has a wide tolerance range from seawater to fresh water.

The temperature of the river water during the sampling period did not vary, ranging from 31-33.2°C. This is because the sampling station has an elevation of <8% and is located at an altitude of ±3 meters

above sea level. In addition, the sampling period has not yet entered the rainy season so that the river water temperature is still high. DO and pH at each station are also not too varied and sufficient for the life of organisms in the water. The lowest DO was found at the first station, namely 3.6 mg/l and the highest DO was at the third station, namely 5.7 mg/l. Likewise, the pH value is not much different, namely between 6 to 6.8. Table 2 shows that *V. litterata* requires sufficient dissolved oxygen and waters that have a pH that is not too acidic to support its life.

The surface water currents in the three rivers at each station are not too different, although the third station has the fastest surface water current of 0.52 m/s, while at the other two stations (first and second stations) it has surface water currents the medium ones are 0.39 m/s and 0.48 m/s [15]. Moderate current speed allows *V. litterata* to enter brackish waters when entering the megalopa phase. Stadia megalopa will enter brackish waters in groups [12], where previously the egg hatching and larval stadia to post larvae were still in the sea because they still needed higher salinity. This is in accordance with what was written in [11, 13, 6]**.** The current of the river's surface water is still causing the discovery of *V. litterata* in the river with about 16-32 km from the mouth of the river. This is because when there is a tidal current, *V. litterata* will come out of its hiding place and will be carried away by the tidal current. This is in accordance with what has been reported by Susilo et al., [6] that *V. litterata* can be found at 32 km from the sea in the Meru Betiri national park area, East Java.

Analysis of sediment texture at each station shows that river sediments at each station consist of silt, clay, sand, and mud (Figure 7).

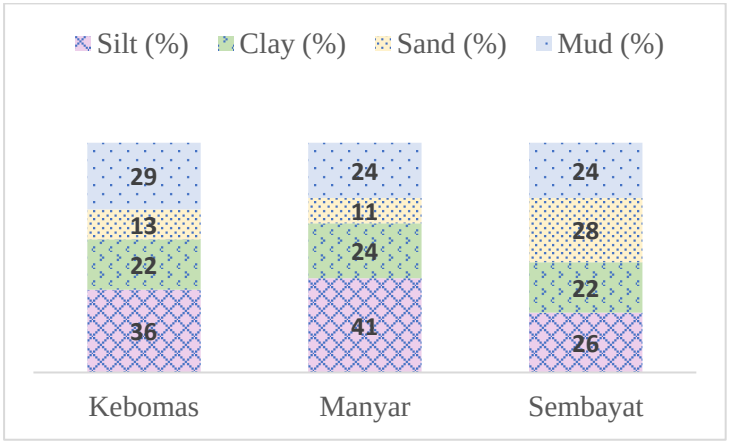

Figure 7. Percentage composition of silt, clay, sand, and mud in the sediments of the sampling stations.

Figure 7 depicted that sediment texture of each station due to the upstream of the three rivers comes from the Bengawan Solo River originating from Mount Lawu. The Bengawan Solo River sediment was formed by an alluvial fan pattern so that the sediment will consist of clay, silt, and sand. While the texture of the mud is much influenced by the results of human activities along the river at each station, besides that the texture of the mud is also obtained from the influence of the mangrove area in each station which comes from the fall of organic materials in the mangrove area [16].

Conclusion

The results of this study can be concluded that *V. litterata* is spread in the waters which are the upstream tributaries of the Bengawan Solo River. *V. litterata* can be found in rivers 32 km from the sea, which is still affected by tidal currents, with river water salinity around 21-25 ppt, with river surface water currents between 0.39 m/s-0.52 m/ s. At the sampling station, *V. litterata* was not found in the mangrove area, but *V. litterata* preferred to spend its time swimming and dwelling on the leaf surface of aquatic plants or in the trunks of drowned trees in river bodies. During the sampling period, no megalopa stadia were found, the carapace width of *V. litterata* ranged from 2.00-4.49 cm with a dominant size of 3.50-

3.99 cm which indicated that the estuary area was the habitat for *V. litterata* to grow up. The comparison between male and female individuals is still in a balanced ratio.

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