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BURROWING FAUNA OF BENGKALIS INTERTIDAL FLATS IMPACTED BY PEATLAND EROSION WITH PARTICULAR REFERENCE TO CRABS AND MUDSKIPPERS

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ABSTRACT

Burrowing fauna inhabiting the intertidal flats, such as certain crabs and mudskippers, are biotic component of intertidal ecosystem with a crucial ecological role. Their burrowing activity increases the porosity of intertidal substrates that promotes oxygenation, sediment dynamics, nutrient transport, and carbon storage. These positive contributions could however be disrupted by the degradation of their habitats as may be induced by coastal erosion. In the case of Bengkalis Island in Riau Province, Indonesia, coastal peatland erosion has generated a huge amount of peat debris that is eventually deposited on intertidal flats. The present study has been conducted to explore burrowing crabs and mudskippers inhabiting the island's intertidal flats most likely impacted by the deposition of peat debris. Two transect line, between the highest and the lowest tide, were made in two locations (Perepat Tunggal and Selat Baru). Observation were conducted along the transect line at interval of 5 m. Our inventory in two study locations, Perepat Tunggal and Selat Baru, has confirmed the presence of at least seven species of fiddler crabs (*Austruca annulipes, Gelasimus vocans, Tubuca Bellator, T. coarctata, T. forcipata, T. paradussmieri,* and *T. rosea*), one species of soldier crab (*Dotilla myctiroides*), and five species of mudskippers (*Periopthalmodon schlosseri, Periophthalmus argentilineatus, P. chrysospilos, P. gracilis, P. variabilis*. Our presentation shares the results in details and discusses how the disturbances induced by coastal peatland erosion might affect such fauna.

Keywords: Fiddler Crabs, Soldier Crabs, Mudskippers, Peat Debris Deposition

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INTRODUCTION

Riau Province has owned a peatlands of approximately 4 million hectares, it comprises of 55% peatlands in Sumatra Island. Those peatlands were distributed along the eastern coast of Riau Province, including the islands close to Sumatra Island, ie. Bengkalis Island. However, the damage or loss of mangrove vegetation along the coast of the island had caused abrasion within the peatland. Yamamoto *et al.* (2019a & 2019b) revealed that the abrasion was compounded by "*bog burst*" which usually happen after heavy rain. This phenomena caused the peat mass being scattered and some of them was swept away by the water as a debris which is then stranded and deposited at a certain points along the coastal area.

Preliminary observation revealed that the thicknes of peat debris varied between 0 to more than 10 cm. It presumed that peat debris which covered the coastal area have impact on animals that lived in intertidal zone along the coast of Bengkalis Island. However, it is still not clear which animal and how is the mechanism. Therefore, the research to reveal this problem is necessary to be done.

In this study we focused our attention on two groups of intertidal fauna, crabs (subfilum Crustacea, ordo Decapoda, especially on family Ocypodidae) and the mudskipper (class Actinopterygii, ordo Gobiiformes, family Exudercidae), which were known as "*ecosystem engineers*" in intertidal zone. These animals were known as burrowers in intertidal zone so that it can affect the dynamics of sedimentation process, gas exchange, and the mineralization process of organic matters (Kristensen. 2009; Araujo *et al*. 2012; Andreetta *et al*. 2014; Mokhtari *et al*.2015; Chen *et al*. 2017).

The Ocypodidae crabs and the mudskipper were active for searching the food on the mudflat during the ebb. When the tide is coming they recede to their burrows under the mudflat (Clayton and Snowden 2000; Bhatt *et al*. 2009; Machado *et al*. 2013). Both groups of animals have special adaptation that make them could stay under the water during the inundation. They also could stand under the mudflat by creating an air bubble inside their burrows. (Ishimatsu *et al.*1998).

MATERIAL AND METHODS

Study Area

This study has been conducted in two sites (site 1 and site 2) which are located within Desa Perepat Tunggal, Kec. Bengkalis. The coastal area of this village headed to Bengkalis Strait and also Malacca Strait. (Figure 1) Data collection has been done in July 2020 and August 2020.

Figure 1 Area of study in the Northwestern of Bengkalis Island, which is in Perepat Tunggal village, Bengkalis District

Data Collection

Transect lines have been used to observed environmental characteristics and fauna intertidal. At each site (site 1 and site 2) two transect lines, which length were adjusted to the width of the lowest and the highest tide line of intertidal zone, were made.

Habitat Characterization

Initially, we conducted an aerial photo shoot using a drone to have an image of existing macro-condition in study area. Based on the aerial photo shoot we decided the place to made the transect lines, which are 2 transect lines within site 1 and 2 transect lines within site 2. The observation was conducted within interval 5 m along each transect lines. Parameters which were observed including: (i) estimated-range between the ebb and tide lines; (ii) characteristics of mangrove vegetation (if exist); (iii) characteristics of subtrates; (iv) characteristics of peat-debris cover; and (vi) the existence of *tidal creeks*.

Direct-Faunal Observation

The crabs and the mudskipper on mudflat were observed when the sea water completely recedes. Along the transect lines, at a certain points with interval 5 m, an obsever will stand quietly and took a photograph of spots around him.

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Non-direct Faunal Observation

The crab's burrows densities on mudflat were observed in order to cover difficulties in direct crabs-observation. The mudflat was photographed at a range of 100 cm above the ground. The results were then analyzed using Adobe Photoshop for more accuracy in counting the number of crab's burrows.

Faunal-Sample Collection and identification

Sample faunas were collected for identification. The faunas which were captured were preserved and kept in a box for identification in the laboratory. References for identification were (i) Textbook : Crane J. (1975) *Fiddler Crabs of the World*; Michael S. Rosenberg MS. (2001) The Systematics and Taxonomy of Fiddler Crabs: A Phylogeny of The Genus Uca; A Taxonomic Revision and Cladistic Analysis of the Oxudercine Gobies (Gobiidae: Oxudercinae); Murdy E.O. (1989) *A Taxonomic Revision and Cladistic Analysis of the Oxudercine Gobies (Gobiidae: Oxudercinae* (ii) websites: http://species-identification.org; https://www.fiddlercrab.info/uca_systematics.htmland; https://www.fishbase.in/identification/SpeciesList.php?genus=Periophthalmus (iii) consultation with specialists.

RESULT AND DISCUSSION

Characteristics of Intertidal Zone

Characteristics of intertidal zone in Perepat Tunggal village could be seen in a photograph which was taken using a drone (Figure 2). The width of intertidal zone in this coast is varies widely, between 250 m to 650 m. The substrate at forefront of intertidal zone, the closer one to lower intertidal, was dominated with sand, and the closer to upper intertidal was mud or dominated with clay. Peat debris was deposited at the upper side of intertidal zone. The closer to the tide line the peat debris is thicker and the debris is bigger. However, at the accretion site (a), peat debris is thicker at the mid of intertidal zone.

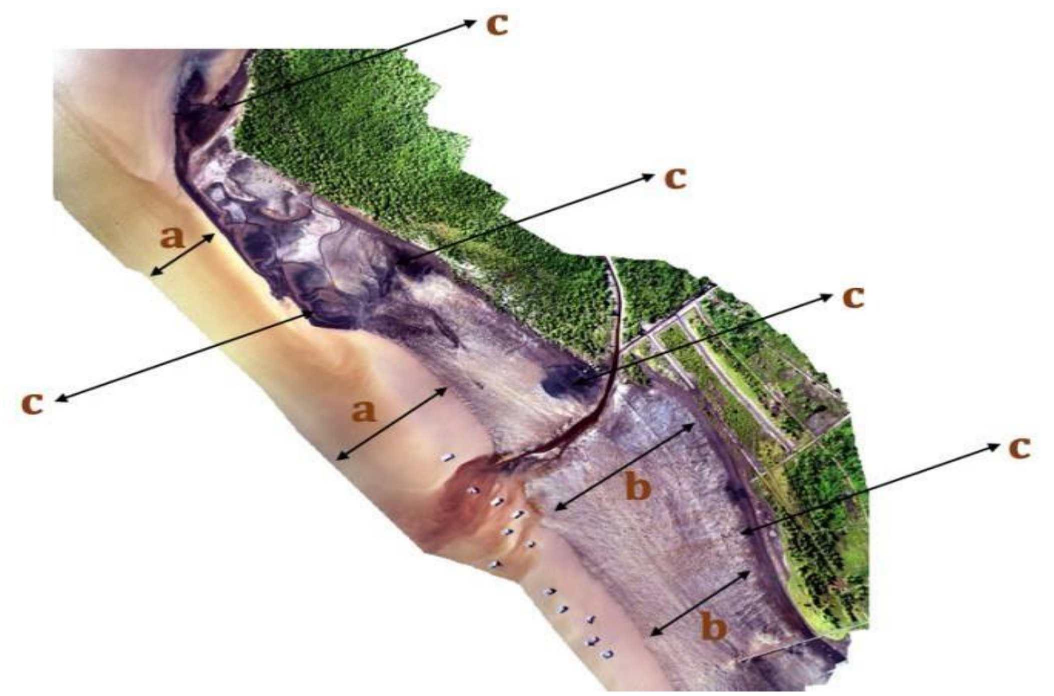

Figure 2 Characteristics of intertidal zone at study area as seen from the air: (a) subzone which dominated with sand; (b) subzona with mud or a mixture between sand and clay; (c) parts of intertidal zone covered with thick peat debris.(Photograph © Sigit Sutikno)

Based on those spatial characteristics, we have chosen two sites for observation, that is site 1, an area between the small river and the boat bridge; and the site 2, is an area formed by accretion process.

Table 1 Characteristics of intertidal zone which is found in four transect lines

Parameters	Transect			
	T1	T2	T3	T4
Range TL-EL*	500-600 m	500-600 m	250 m	250 m
Range transect	0-250 m	0-100 m	0-250 m	0-250 m
Mangrove Vegetation	remaining vegetation <5 m	Mature vegetation behind TL, succesion found between 0 and 100 m	Mature vegetation behind TL, succesion found between 0 and 100 m	Mature vegetation behind TL, succesion found between 0 and 100 m
Microtophography	0-60 m: Ground surface little bit lower 60-250 m: Ground surface with low slope level (<10%)	0-40 m: Ground surface little bit lower 40-90 m: Ground surface little bit higher, creating a mound 90-100 m: Ground surface lowering to EL.	0-100 m: Ground surface little bit lower 100-130 m: Ground surface rise, 130 -160 m: Ground surface is lower. 160-200 m: Ground surface rise,	0-100 m: Ground surface little bit lower 100-130 m: Ground surface rise, 130 -160 m: Ground surface is lower. 160-200 m: Ground surface rise

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Substrates	0-100 m: Mud (substrates dominated by clay) 100-250 m: Substrates is a mixture of clay and sand.	0-40 m: Mud (substrates dominated by clay) 40-100 m: Substrates was dominated by clay with quite high consistency 100-250 m: Substrates is a mixture of clay and sand	0-40 m: Substrates predominantly clay, generally with low consistency and therefore forming mud 100-200 m: Substrates is a mixture of clay and sand. 200-250 m: Substrates in the form of sand	0-100 m: Substrates predominantly clay, generally with low consistency and therefore forming mud. 100-200 m: Substrates is a mixture of clay and sand. 200-250 m: Substrates in the form of sand
Peat debris cover	0-60 m: Peat debris is rough, some in the form of charcoal flakes, thickness of peat debris commonly > 50 cm, or >100 cm 60-100 m: thickness of peat debris 0-5 cm 100-250 m: thickness of peat debris 0-30 cm, but, generally is difficult to determine because they are mixed with mineral sediment.	0-40 m: Peat debris is rough, some in the form of charcoal flakes, thickness of peat debris commonly > 50 cm, or >100 cm 40-100 m: thickness of peat debris 0- 30 cm, but, generally is difficult to determine because they are mixed with mineral sediment 100-250 m: peat debris is finer and difficult to separate from mineral sediment.	0-40 m: Thickness of peat debris 0-30 cm, but generally is difficult to determine because mixed with mineral sediment 40-100 m: Thickness of peat debris 0 m to >100 cm 100-130 m: Peat debris is rough, some in the form of charcoal flakes, thickness of peat debris generally > 50 cm, or >100 cm 130-150 m: Thickness of peat debris 0-30 cm, 150-220 m: Peat debris is rough, some in the form of charcoal flakes, thickness of peat debris generally > 50 cm, or >100 cm 220-250 m: No peat debris	0-40 m: Thickness of peat debris 0- 30 cm, but generally is difficult to determine because mixed with mineral sediment. 40-100 m: Thickness of peat debris 0 m to >100 cm 100-130 m: Peat debris is rough, some in the form of charcoal flakes, thickness of peat debris generally > 50 cm, or >100 cm 130-150 m: Thickness of peat debris 0- 30 cm, 150-220 m: Peat debris is rough, some in the form of charcoal flakes, thickness of peat debris generally > 50 cm, or >100 cm 220-250 m: No peat debris

The observation result on intertidal zone along each transect lines have been summarized in Table 1. As already mentioned before, characteristics between two sites is quite different. The difference could be seen on the width of intertidal zone and also from the pattern of peat debris cover.

Distribution pattern and abundance of fiddler crab and soldier crab

Species Diversity

There were 31 crabs specimen's collected from seven morphotype of male fiddler crab and one morphotype soldier crab. The result was presented in Table 2. We still do not know the distribution of each species. It is possible that each of them have different distribution.

Table 2 Species fiddler crab and soldier crabs which was found at two sites of study area

Spesies	Site 1	Site 2
Fiddler crab		
Uca annulipes	Found	Found
Uca coarcata	Found	Found
Uca forcipata	Found	Found
Uca rosea	Found	Found
Uca vocans	Found	Found
Uca sp 1	Found	Found
Uca sp 2	Found	Found
Soldier crab		
Dotilla myctiroides	Found	Found

Distribution and abundance

The abundance of crabs could be observed directly by counting them while they were on the mudflat. Unfortunately, this method was not easy to be implemented, because is not easy to walk on the mudflat. Furthermore, the crabs were so sensitive to disturbance caused by the observer and make them get in to their burrows.

This has led many researchers to pursue an indirect assessment of crab abundance using burrow density as indicator for individual abundance. This method is quite practical despite the possible relative degree of accuracy, because not all crabs make “I” or “J” shaped burrows which only have one hole on the ground surface. Some of them make “U” or “Y’ shaped burrows which has two holes in the ground surface (Bhatt *et al*. 2009). Burrows shape is not specific that can be associated with certain species, they tend to be associated with the diversity of crab’s individual and also with substrate characteristics faced by individual crabs.

Observation on crab’s burrows density along 4 transects line reveals three things. First, burrow densities were not well distributed on intertidal zone between tide line to ebb line, that is 0/m^2 to 129 burrow/m^2. Second, fiddler crabs and soldier crab have different distribution. Fiddler crabs more commonly found on muddy banks (which is closer to tide line) while soldier crab more commonly found on sandy banks (closer to ebb line). Third, the crab’s burrow density on the surface of beach front covered with peat debris. (Figure 3).

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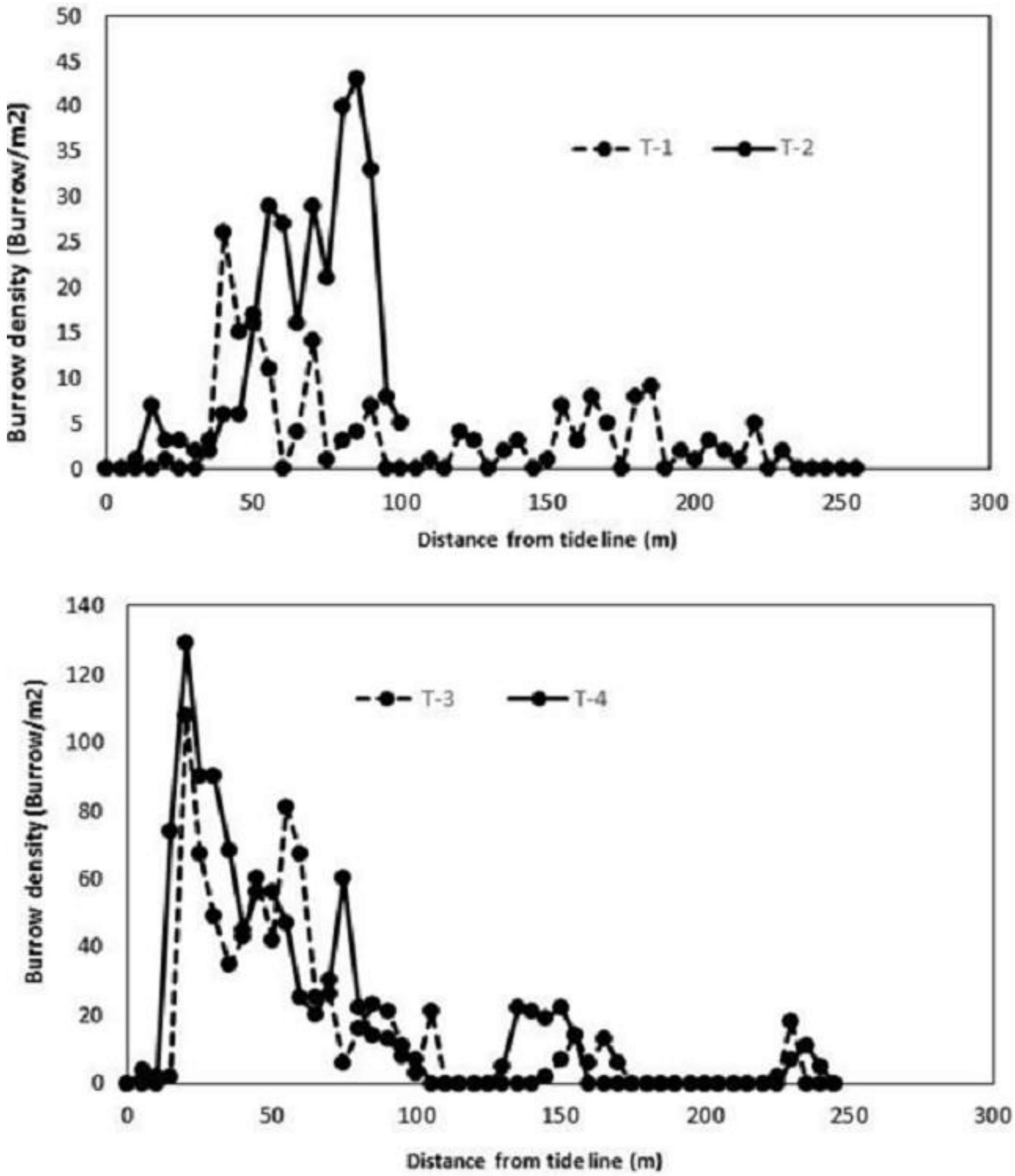

Figure 3 Distribution pattern of fiddler crabs and soldier crab as shown from their burrow density on the surface of beach front at site 1 (above) and site 2 (below).

The highest of crab's burrow density within site 1 were found on segment transect T-1 between 40-60 m and segment transect T- 2 between 40-90 m, each with density level between 14-26 burrow/m^2 and 16-43 burrow/m^2, respectively. The highest burrow density within site 2 were found on segment transect T-3 between 25-55 m and segment transect T-4 between 15-75 m, each with 35-90 burrow/m^2 and 60-129 burrow/m^2, respectively. These findings are suited with De (2015) which reported that the crabs is more likely to build the burrow in the sediment which soft mudd and closer to the tide line.

Distribution pattern and abundance of mudskipper

Diversity

In this study we found 5 species of mudskipper, 3 from site 1 and 3 from site 2 (**Table 3**). However, based on this finding we do not really sure that there is difference on number and species composition of mudskipper between two site observation. Further observation is needed to confirm this finding. Due to Species Area Relationship concept (Polgar 2009), given that site 1 and 2 are relatively close together and actually are on the same shoreline, therefore there is possibility that the number and species composition of mudskipper between both sites are not different.

Table 3 Species mudskipper which were found within study area

Spesies	Site 1	Site 2
Periopthalmodon schlosseri	Not Found	Found
Periophthalmus argentilineatus	Found	Found
Periophthalmus chrysospilos	Found	Not Found
Periophthalmus gracilis	Not Found	Found
Periophthalmus variabilis	Found	Not Found

Distribution and abundances

Temporary result about distribution of mudskipper is that they tend to be found only on muddy substrate surface and mixture of clay and sand. At the area of intertidal zone which covered by peat debris the mudskipper only found in tidal creeks. At the mudflat which is mixed with peat debris, this fishes can still actively move as long as the water still wet the surfaces.

CONCLUSIONS

Peat debris tends to cover the upper side of intertidal zone. The crabs which were founded including fiddler crab and soldier crab. Fiddler crabs which were found consisted of 7 species, while soldier crab only 1 species. Fiddler crabs were distributed on the upper side of intertidal zone which substrate was dominated with mud and clay and soldier crab was distributed on the lower side of intertidal zone which sediment dominated with sand. Distribution of crab's burrow is wider and more common within site 2, which was formed from accretion process.

The mudskipper which was found from study area consisted of 5 species, only 1 species found in both sites (site 1 and site 2). The other 4

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species only found in one site. The mudskipper only found in a site with water. They were not found in the sediment surface which is covered by peat debris, where the water was not existed.

Considering the impact of peat debris coverage on intertidal fauna (crabs and mudskipper), it is very important to relevant stakeholder to pay more attention on the condition of the remaining peat ecosystem. Restoration efforts on peat ecosystem are very important because it's not only save peat ecosystem but also save another ecosystem, intertidal ecosystem.

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