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ARCOTHERES SP., A NEW REPORT ON PEA CRABS (CRUSTACEA: PINNOTHERIDAE) IN BIVALVES FROM THE SETIU WETLAND LAGOON, MALAYSIA

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Abstract: Pea crab infestations reduce the quality of bivalves, decreasing their market value and may result in consignment rejection during exportation in the bivalve aquaculture industry. This study investigates the prevalence of pea crabs in four different species of bivalves collected in habitats in the Setiu Wetland Lagoon, Terengganu. A total of 771 samples of bivalves including *Geloina expansa* (Mousson, 1849), *Meretrix meretrix* (Linnaeus, 1758), *Anadara cornea* (Reeve, 1844) and *Magallana bilineata* (Röding, 1798) were collected during low tide, with shell length measurements of 5.44 ± 1.3, 2.67 ± 0.6, 3.96 ± 0.6 and 0.00 ± 0.0, respectively. No length measurement was recorded for *M. bilineata* due to the unequal sizes of the shells. A total of 30 pea crabs were harboured with single colonisation and all of them were females. The pea crabs were identified to be from the genus *Arcotheres* sp. Manning, 1993 with carapace subcircular and invisible eyes in the dorsal view, chela slender, half of the palm length dactylus, palm slender, dactylus and pollex straight, propodus spatulate with apex rounded, dorsally and distally setose, slender exopod, dorsally and ventrally unarmed ambulatory legs, and relative length of meri P3>P2=P4>P5, P2 and P3 dactyl less than half of the propodal length. The prevalence of pea crabs was higher in *G. expansa* (P: 9.73%), followed by *M. bilineata* (P: 1.59%) and *M. meretrix* (P: 1.12%) which were highly influenced by the host size. No pea crab infestation was found in *A. cornea* probably due to muddy and strong waves area. Overall, the present study revealed that host size and habitat were the main factors affecting the colonisation of pea crabs in bivalves from the Setiu Wetland Lagoon, Terengganu.

Keywords: *Arcotheres* sp., bivalve, infestation, endosymbiont.

Introduction

Pea crabs are small marine invertebrates from the family Pinnotheridae and live within the mantle cavities of different bivalve hosts. Consumers may be turned off by the presence of pea crabs in the shell cavities of their hosts, which might lead to the rejection of exported consignments regarding biosecurity procedures. Longshaw *et al.* (2012) reported that pea crabs could be a pathogenic vector and they might cause serious production loss if the bivalve species is economically important. According to Asama and Yamaoka (2009), the females are larger compared with the males and rarely occur outside the host. However, the females are poor swimmers and are unable to enter a new host if the first host dies. Pinnotherids also induce a reaction in the host by tactile stimuli to facilitate intrusion (Stevens, 1990) and they choose appropriate conditions for their survival. This endosymbiosis is not host-specific but often involves certain groups of invertebrates as hosts, including bivalves, tunicates and sea cucumbers (Pati *et al.,* 2015).

The soft female pea crab has a sub-globular or wider carapace and a soft-shell uniform colour whereas the male possesses a hard shell and a flat top-to-bottom, dark-coloured and thin V-shaped abdomen (Palmer, 1995; Becker & Turkay, 2010) with the size varying with the host. The body of

a female pea crab is often translucent, showing its inner organs and gonads. The size of female pea crabs increases significantly with the size of the host while male pea crabs occupy bivalves at a random size (Afiati, 2013). The infestation of pea crabs in a host is species-dependent (De Bruyn *et al.,* 2011). Most pea crab species have been demonstrated to infect their hosts during the early stages and spend their adult lives with the same individuals (Wells & Wells, 1961) whereas other species can migrate from one host to another (De Bruyn *et al.,* 2009; 2011).

Pea crabs are kleptoparasites given that they steal food from their hosts to survive (Harun *et al.,* 2020). Bivalves feed themselves by filtering organic particles from the water and they produce mucus on the gills to increase their feed efficiency (Becker & Turkay, 2010). Pea crabs live within the mantle cavities of a variety of bivalve species and steal their food. They also tend to feed on the mucus secreted by their hosts (Becker & Turkey, 2017). This decreases the host's efficiency to filter fine particles and could damage its system. For example, pea crabs were reported to cause gill lesions in their hosts (Longshaw *et al.,* 2012). However, there is a lack of studies on pea crab's infestations in the bivalve populations in the Setiu Wetland Lagoon, Terengganu. Therefore, this study aims to determine the prevalence of pea crabs in four different species of bivalves.

Materials and Methods

Sampling of Bivalves

A total of 771 bivalve samples, *Geloina expansa* (Mousson, 1849) (n = 257), *Meretrix meretrix* (Linnaeus, 1758) (n = 269), *Anadara cornea* (Reeve, 1844) (n = 119) and *Magallana bilineata* (Röding, 1798) (n = 126) were collected from the Setiu Wetland Lagoon (5º40'38.6'' N, 102º 42' 36.30'') during the hot season from March 2018 to June 2018. *Geloina expansa* was found most in the marine coastal areas whereas *M. meretrix*, *A. cornea* and *M. bilineata* were found most in sandy areas, estuarine mudflats and mangrove roots, respectively. The temperature and water salinity ranged from 30°C to 31°C and 28 ppt to 32 ppt, respectively, measured using the YSI Multiparameter Pro Plus (Ribble Enviro Ltd., Wilton Centre, United Kingdom). All the collected bivalves were placed in an icebox and transported live to the laboratory of the Institute of Tropical Aquaculture and Fisheries for analysis and identification.

Laboratory Analysis and Pea Crabs' Observation

The length of the bivalves was measured using a manual vernier calliper as shown in Figure 2. Then, the bivalves were opened using a knife to observe the presence of pea crabs, and they were removed carefully using a scalpel if any was found. The isolated pea crabs were rinsed with a saline solution before being preserved in 70% ethanol for morphological description and identification. The morphological features of the pea crabs were illustrated using camera lucida and photographs of the body parts. The morphology of the pea crabs was described and referred to as the morphology description (Ahyong & Ng, 2007; Davie *et al.,* 2015; Ng *et al.,* 2018).

Statistical Analysis

The length and prevalence of pea crabs found in different species of bivalve hosts were recorded and calculated using the standard formula.

$$Prevalence\ (\%) = \frac{Number\ of\ sample\ infected}{Number\ of\ sample\ analysed} \times 100$$

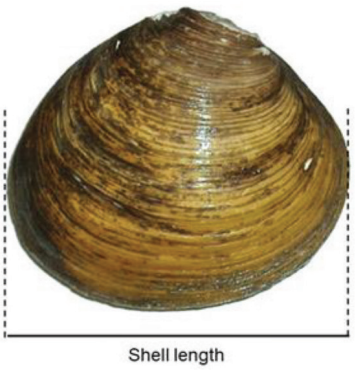

Figure 1: The standard procedure for measuring the length of bivalves

Results and Discussion

A total of 771 bivalves from four different species were analysed for the presence of pea crabs. The isolated pea crabs found in the bivalves were morphologically described as being of the genus *Arcotheres* Manning, 1993. All pea crabs were soft females with smooth dorsal and ventral surfaces, and their translucent dorsal carapace appeared pale red in fresh conditions. The genus was described as *Arcotheres* due to their subcircular carapace (Ahyong & Ng, 2007; Ahyong *et al.,* 2012; Pati *et al.,* 2015; Ng *et al.,* 2017; Harun *et al.,* 2020) which are distinctly wider than long, with a dorsal surface glabrous and a front projecting anterior beyond orbit (Figure 2 (A)). Their eyes were small and invisible in the dorsal view. Their third maxilliped with carpus was shorter than their propodus which was also a unique character for the identification of the genus *Arcotheres* (Ahyong & Ng, 2020; Harun *et al.,* 2020). The chela was slender, the dactylus was about half of the palm length and the palm was slender. The dactylus and pollex were straight; the dactylus occlusal margin with a large blunt triangular tooth was proximal to the mid length. The pollex occlusal margin with two and irregular teeth was proximal to the mid length (Figure 2 (B)). The propodus spatulate with apex was rounded, dorsally and distally setose. The dactylus was digitiformed and distally setose, inserted slightly proximal to the propodal midlength with the apex slightly beyond the propodal apex. The exopod was relatively slender, about one-third the length of the ischiomerus, with two-segmented flagella. The walking legs were dorsally and ventrally unarmed; the relative lengths of the meri were P3 > P2 = P4 > P5. The P2-P5 dactyl relative lengths were P5 > P4 > P3 = P2. Meanwhile, the P2 and P3 dactyl were less than half of the propodal length (Figure 2 (C-F)). A similar study on *Arcotheres* sp. was previously reported by Harun *et al.* (2020) which supported the fact that the pea crabs found in this Setiu wetland area are from the genus *Arcotheres*. However, no species identification has been described to date. Thus, we concluded that the *Arcotheres* sp. Manning, 1993 in this study are similar to *Arcotheres placunicola* P.K.L. Ng, 2018 from the Gulf of Siam which can be distinguished by the structures of the similar third maxilliped (Ng, 2018). There was a slight difference in the relative lengths of the meri where P4 > P3 > P5 > P2 in *A. placunicola*, thus, requiring further reassessment with detailed descriptions and illustrations in the future.

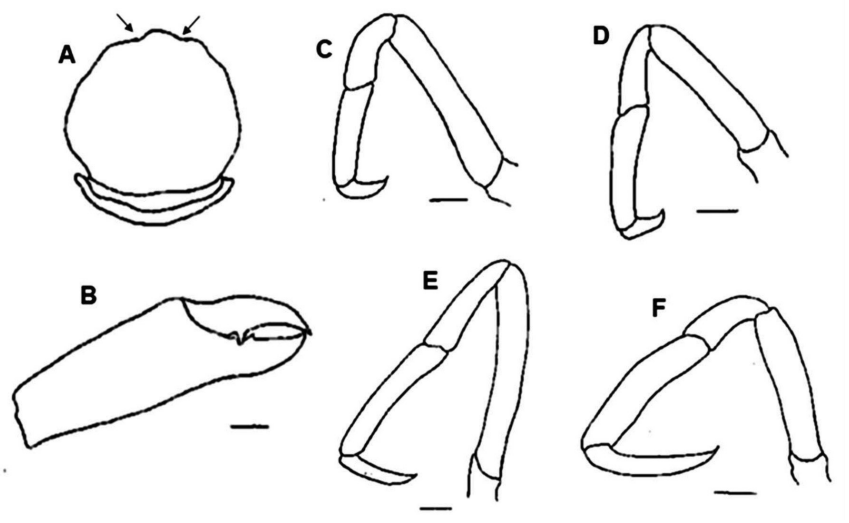

Figure 2: Soft female *Arcotheres* sp.: (A) Dorsal view of the carapace, arrow shows the eyes which are not visible in dorsal view, (B) Right cheliped, (C-F) P2 – P5: pereopods 2-5. scale bars = 0.5 mm

The lengths of the bivalves were recorded with *G. expansa, M. meretrix* and *A. cornea* being 5.44 ± 1.3 cm, 2.67 ± 0.6 cm and 3.96 ± 0.6 cm, respectively (Table 1). No length was measured in *M. bilineata* due to the unequal size. The highest pea crab infestation was found in *G. expansa* (P: 9.73%), followed by *M. bilineata* (P: 1.59%) and *M. meretrix* (P: 1.12%) whereas no pea crab infestation was found in *A. cornea*. The highest pea crab prevalence was found on the largest host species, *G. expansa* which confirmed the close association between host size and pea crab infestation. The finding was supported by previous researchers who also stated that the size of a host is a major factor in pea crab infestation (Becker & Türkay, 2010; Ocampo *et al.,* 2012). Table 1 shows the lengths of the bivalves and the infestation of pea crabs in each species of bivalves.

Besides the host size, the host habitat also influences the infestation of the pea crabs. *Geloina expansa* which was found mostly in the marine coastal area, recorded a higher pea crab infestation. Trottier *et al.* (2012) also discovered that pea crabs prefer seafloors with an abundance of hosts. The prevalence of pea crabs was higher in *M. meretrix* than *M. bilineata* which could be due to their varied habitats, *M. meretri*x favoured sandy areas whereas *M. bilineata* preferred mangrove areas. A similar reason for the absence of pea crabs in *A. cornea* could be related to the latter's habitat which included mud, deeper water, seagrass regions and strong waves. According to Perez-Miguel *et al.* (2018), aquaculture farms located offshore pose a minor risk since the water column is deeper than in wild populations or sheltered water. Water temperature and salinity may also affect pea crab infestation in the bivalve hosts. According to Harun *et al.* (2020), pea crab infestation was found lower during monsoon seasons than dry seasons due to the increase in water salinity caused by water discharge from nearby rivers to the coastal region. In terms of salinity, pea crabs can tolerate a wide range of salinity fluctuations (Hsueh, 2001). It was assumed that both pea crab moulting success and survival rate could be adapted to a salinity level of up to 36 ppt (Anger, 2003; Castejón *et al.,* 2015). In addition, there was a study also reported that no correlation between *Arcotheres tivelae* pea crab infestation in bivalve host *Amiantis umbonella* and water salinity (Saeedi & Ardalan, 2020). In this study, it was found that the pea crabs can survive in the Setiu Wetland Lagoon given that the condition was still in the range of the optimal temperature, salinity and host availability.

Conclusion

The pea crabs found in bivalves sampled from the Setiu Wetland Lagoon have been identified as *Arcotheres* sp. The morphology was most similar to *A. placunicola* Ng, P.K.L, 2018 from the window-pane shell sampled in Singapore. However, further reassessment and illustrations are needed. In terms of the prevalence of pea crabs, *Geloina expansa* had the highest compared with the other three species due to their larger size. Besides, they also preferred hosts in sandy, shallow water and slow-wave areas. In the case of the oyster aquaculture establishment at the Setiu Wetland Lagoon in the future, the infestation of pea crabs may be considered as a serious threat. Therefore, the findings of this study may contribute to our

Table 1: Infestation of pea crabs in different bivalve species

Parameters	Types of Bivalve Host			
	G. expansa **(n = 257)**	***M. meretrix*** **(n = 269)**	***A. cornea*** **(n = 119)**	***M. bilineata*** **(n = 126)**
Host total length (cm)	5.44 ± 1.3	2.67 ± 0.6	3.96 ± 0.6	-
Infested with pea crab	25	3	0	2
Prevalence (%)	9.73	1.12	0.00	1.59

Note: - = No record due to unequal size

understanding of the pea crab -bivalve mollusks relationship, particularly in terms of the health aspects for sustainable bivalve aquaculture management and development.

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