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Occurrence of parasitic barnacles Sacculinidae (Rhizocephala) infection on mud crab *Scylla olivacea* in Sabah, Malaysia

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Abstract
The present study was conducted to investigate the occurrence of parasitic barnacle sacculinid infection on mud crabs *Scylla* spp. in Marudu Bay from October 2012 to September 2013. Three species of mud crabs were found; *Scylla tranquebarica*, *S. paramamosain* and *S. olivacea*. However sacculinid infection was only found in *S. olivacea*. Approximately 51.5% (85 out of 165 individuals) of the *S. olivacea* caught were infected. On average, the infection in male and female of *S. olivacea* was almost similar, 48.4% male and 59.6% female ($p > 0.05$). The infected male can be found every month while infected female was found high towards the end of Northeast monsoon (wet season) from February onwards until end of the Southwest monsoon in September (dry season). The present study showed the sacculinid infection exhibited no clear specificity on neither sex nor seasonal as infection can be found throughout the year.

Keywords: Sacculinidae; Parasitic barnacles; Mud crab; *Scylla olivacea*; Sabah

1. Introduction
Mud crabs genus *Scylla* are widely distributed in the tropical and subtropical Indo-West Pacific region [1]. There are four species of mud crabs; *Scylla serrata*, *S. tranquebarica*, *S. olivacea* and *S. paramamosain* [1]. *Scylla serrata* tend to be found throughout the Indo-Pacific region [1], while *S. tranquebarica* is frequently found in the South China Sea and generally associated with *S. olivacea* [1]. *Scylla paramamosain* was often found at the continental coast of the South China Sea towards the South of the Java Sea [2, 3]. These mud crab species are closely associated with each other within the same geographical area [4].
Sacculinidae family from the subclasss of Cirripidia, are parasitic barnacles that mostly infected different species of crustacean including mud crabs [5-9]. Sacculinid parasitisation has been reported to induce severe modification changes in morphology, behavior and reproductive of their host [5, 10-12]. The infection can cause sterility and alter the taste of the infected crabs [13] although the infections seldom lead to instant mortality [14]. Mud crabs are highly demanded in Asia, America, Europe and Australia due to their attractive size, delicate flavour with high meat yield [15]. However, this parasitic barnacle had caused significant economic losses as it reduce the marketable value of the crabs [5-18].
There are several studies reported on the species diversity and biology of Sacculinidae. Sacculinidae can be divided into four genus; *Heterosaccus*, *Loxothylacus*, *Ptychascus* and *Sacculina*. The genus *Sacculina* was widely found to infect the crabs while *Sacculina beauforti* and *Loxothylacus ihlei* were found infecting mud crab, *S. serrata* [9, 19]. Besides, ealier studies also reported that *Sacculina* spp. was found infecting the intertidal crab (*Hemigrapsus sanquineus*) and swimming crabs (*Charybdis variegata*, *C. orientalis*, *C. truncate*, *Portunus longispinosus*, *P. sanguinolentus* and *Thalamita sima*) in many countries [5, 20-22].
Relatively high level of sacculinid have been found infecting the *Paralomis spinosisima* crab in South Georgia and this parasitism had reduce the effective spawning stock biomass [16]. In order to prevent this parasitic infection problem from continuing, previous study had suggested either to harvest or to remove the infected individual from the population [16].
Malaysia has a long coastline with 4675 kilometres (km). Part of this coastline is mangrove forests which are home to the mud crabs. Some of the local fishery communities are still

depend on the catch of mud crabs and other seafood from these mangrove forests as their income and food. These communities are aware of the occurrence of sacculinid in the mud crabs and face the problem of low marketable value of the infected crabs. However, no scientific record is found on sacculinid infection in mud crabs *Scylla* spp. in Malaysia. Thus, the present study was conducted to investigate the occurrence of sacculinid infection on mud crabs, *Scylla* spp. in Sabah coastal waters. To the best knowledge of the authors, this is the first report on sacculinid infection on mud crabs in Malaysia.

Materials and methods

The present study was conducted at Marudu Bay, Sabah (06°42'N, 116°54'E). This area constitute of extensive mangroves covering approximately 9550 ha of mangrove forest (Figure 1). The sampling areas are the regular fishing ground for the local fishermen. Twelve consecutive months of samplings were done from October 2012 until September 2013 with the assistance of local fisherman to examine the occurrence of sacculinid on mud crabs genus *Scylla*.

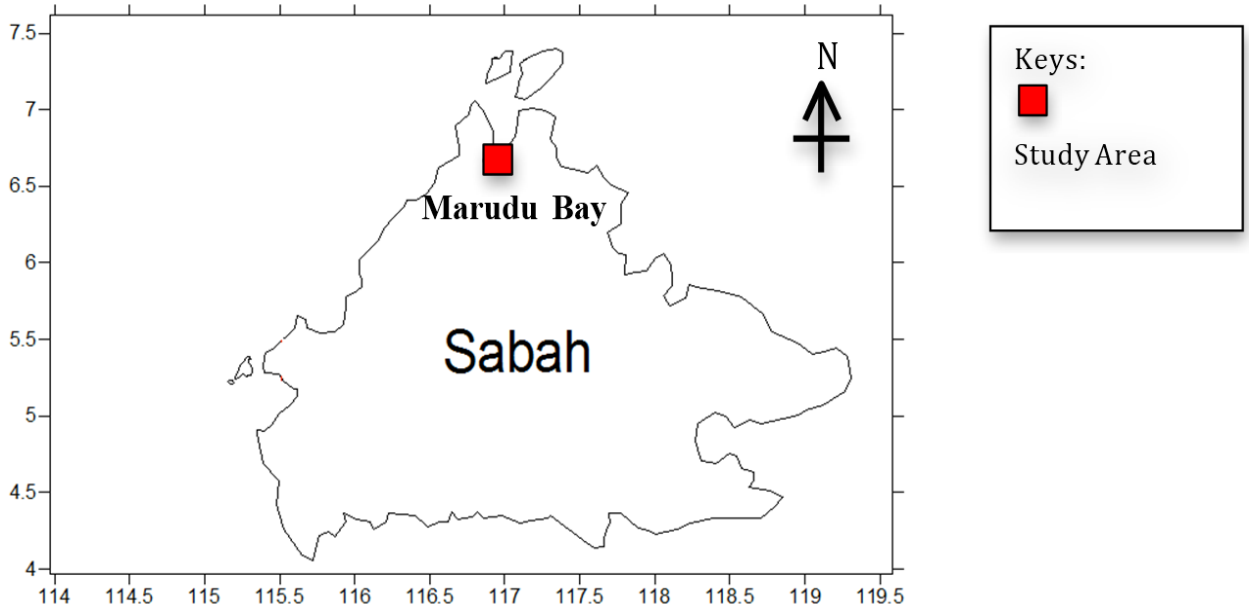


Fig 1: The location of Marudu Bay Sabah at which samplings were conducted.

Mud crabs were fished by using collapsible baited crab traps (dimension of 50cm X 25cm, with the entrance hole of 15cm) commonly used by the local fishermen. A total of 50 baited crab traps were used for each sampling. This process was repeated two to three times daily depending on the tides condition. The crabs caught were then species identified and examined for the infection of sacculinid inside their abdominal flaps. The presence and the morphological characteristics of sacculinid were recorded. The carapace width (CW), body weight (BW) of the healthy and infected crabs were also recorded. The data on infection for the different species of mud crab and sexes were compared using Chi-square analysis that was performed by using SPSS v 18.0.

Results

Observation of sacculinid

The infection of sacculinid in mud crabs can be easily detected with a sac like structure or known as the externae located inside the abdominal flaps of the mud crabs (Figure 2). The color of the externae found on the mud crabs was whitish or yellowish to light brown color (Table 1). A single externae was recorded attached on the abdominal flaps of all crabs caught infected by sacculinid. The position of the externae on the host is ventrally located on the first four abdominal segments. The diameter of the externae recorded was from 1.0 to 4.3 cm. Parasitic barnacles were found on crabs with CW ranging from 76.9 mm to 128.20 mm which fall within the range of the healthy Scylla spp. crabs ranging from 75.7 mm to 133.7 mm CW.

Table 1: Morphological characteristics of the externae of the infected crabs.

Sacculinid	
Color of the externae	Whitish, yellowish to light brown
Number of externae	Single
Position on the host	Ventrally on the first four abdominal segments
Diameter of the externae	0.7 to 4.3 cm
Carapace width (CW) of the infected mud crabs	76.9 mm to 128.20 mm CW
Carapace width (CW) of mud crabs caught	75.7 mm to 133.7 mm CW

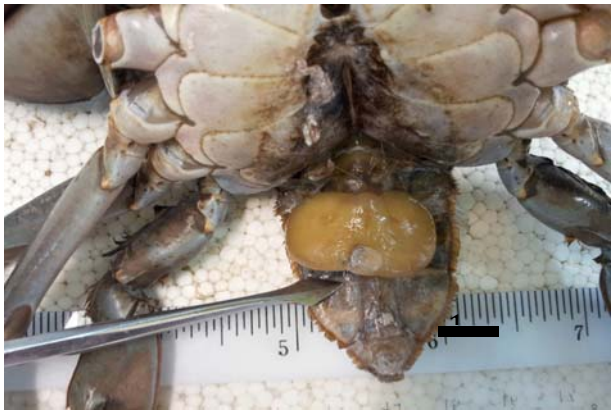
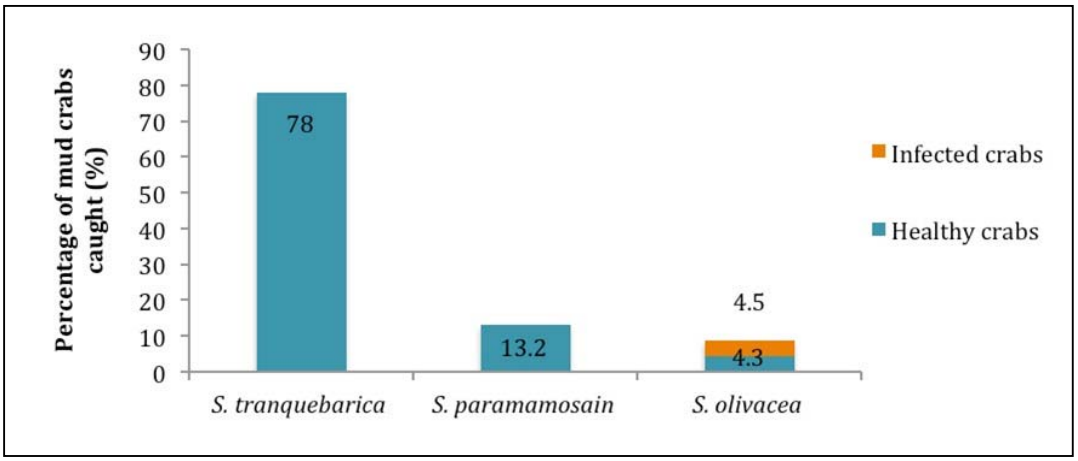


Fig 2: Male *Scylla olivacea* with the presence of *Sacculina* externae in the abdominal flaps.

Infection of sacculinid in *Scylla* spp.

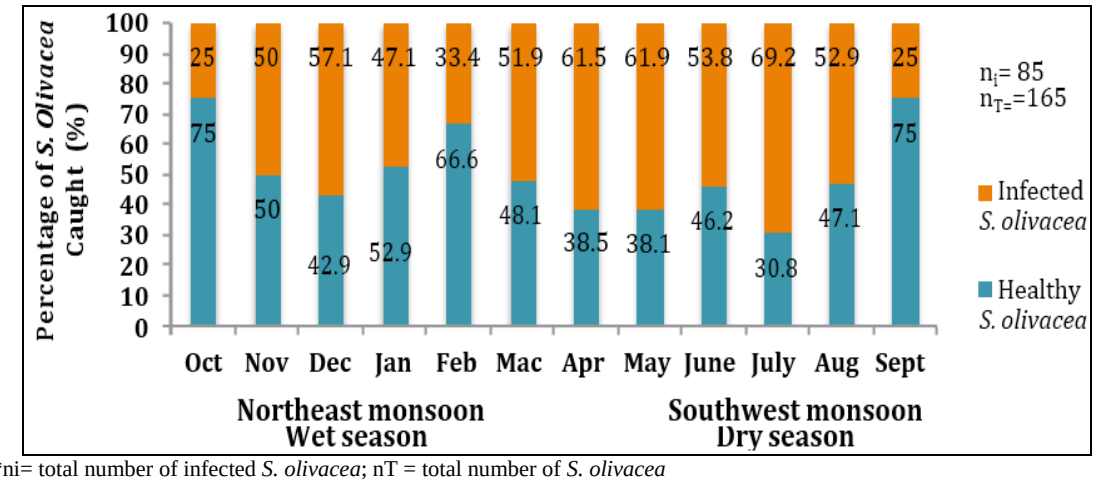
Total of 1870 of mud crabs were caught throughout the sampling period. In Marudu Bay, three species of mud crabs were found. About 78.0% of the total catch was identified as *S. tranquebarica*, 13.2% was *S. paramamosain* and remaining 8.8% was *S. olivacea*. From the total catch, 95.5% of the crabs were in healthy condition without sacculinid infection while 4.5% were found infected by sacculinid (Figure 3). Interestingly, this infection was only found in *S. olivacea*. Not a single infection was recorded in *S. tranquebarica* and *S. paramamosain.*



Percentage of mud crabs caught in Marudu Bay from October 2012 until September 2013.

The occurrence of sacculinid infection in *S. olivacea*

Scylla olivacea was found throughout the 12 consecutive months of sampling (Figure 4) at lower salinity areas (0.59 to 16.71 ppt) that dominated by *Nypa fruticans* vegetation in the Marudu Bay. From the total number of *S. olivacea* caught, 85 crabs out of 165 or 51.5% of the crabs were found infected. On average the infection of sacculinid in male and female *S. olivacea* was almost similar (p>0.05) with 48.4% in male crabs and 59.6% female crabs (Figure 5) without significant different (p> 0.05).



*ni= total number of infected *S. olivacea*; nT = total number of *S. olivacea*

Fig 4: The percentage of healthy and infected *Scylla olivacea* caught in the Marudu Bay, Sabah on monthly basis from October 2012 to September 2013.

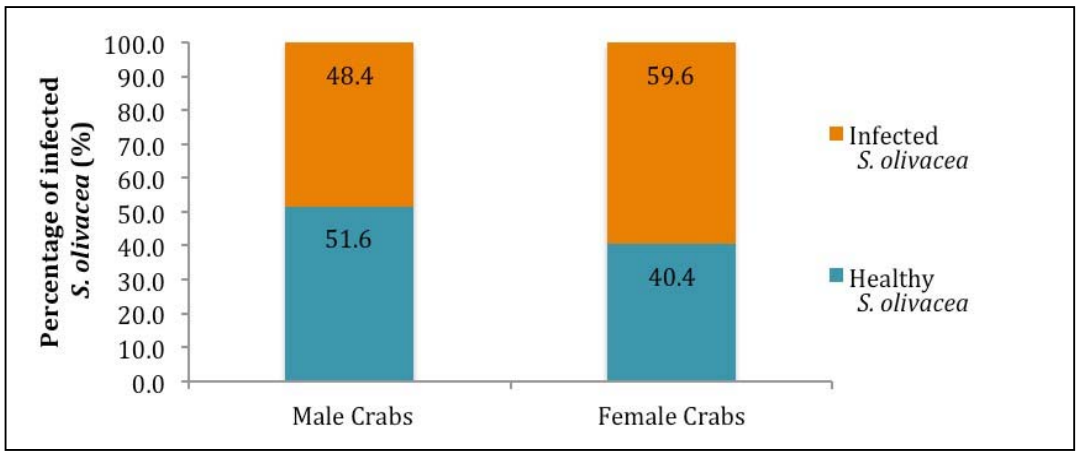
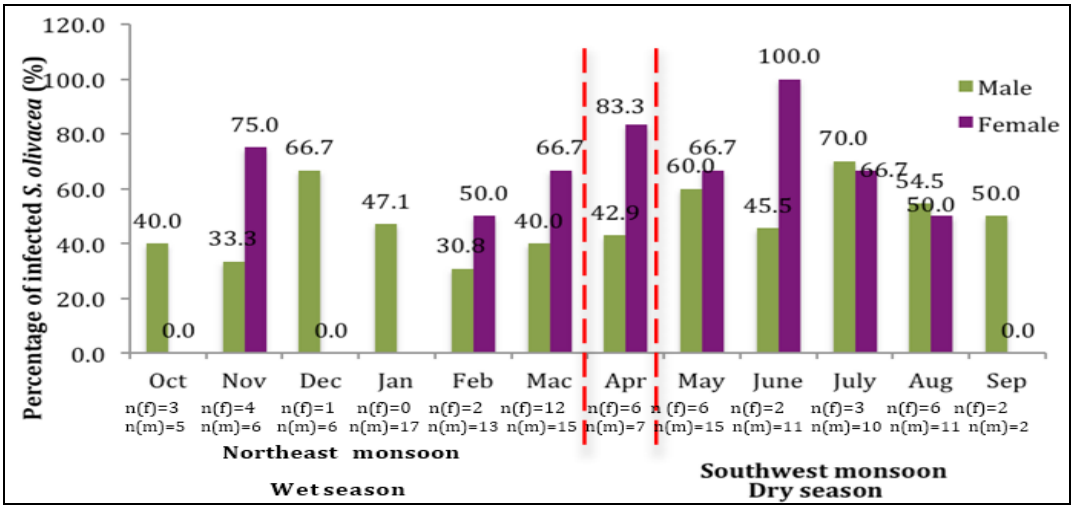


Fig 5: The percentage of infected and healthy male and female mud crabs, *Scylla olivacea* caught in Marudu Bay

The occurrence of sacculinid in male crabs can be found in every month throughout the year (Figure 6). While for the female crabs, infection of sacculinid was found high towards the end of Northeast monsoon (wet season), from February onwards until the end of the Southwest monsoon (dry season) in August. Generally, the infection of sacculinid is relatively higher in the dry season where temperature was relatively higher and lower during the wet season in the Northeast monsoon (Figure 6).



*n(m): total number of male *S. olivacea* caught in each month
*n(f): total number of female *S. olivacea* caught in each month

Fig 6: The percentage number of male and female *Scylla olivacea* infected by sacculinid in Marudu Bay, Sabah.

Discussion

Sacculinidae are parasitic barnacles that commonly found infecting crabs [8, 7, 22]. The present study demonstrated that out of the three species of mud crabs that were caught in Marudu Bay; *S. tranquebarica*, *S. paramamosain* and *S. olivacea*, only *S. olivacea* were found infected by the parasitic barnacles, Sacculinidae. The occurrence of this sacculinidae infection on *S. olivacea* may due to many factors. Previous study reported that environmental factor was one of the factors that need to be considered as abiotic and biotic habitat characteristics can influence the distribution and growth of these parasitic barnacles [23]. In addition, previous study also reported that abiotic parameters such as salinity, pH, water hardness, UV radiation and pollutants emersion into their habitat [5, 24-26] may also influencing the parasite transmission. The three species of mud crabs that were caught in Marudu Bay, *S. olivacea*, *S. paramamosain* and *S. tranquebarica* were found in the same habitat and geographical condition. Throughout the study period, *S. olivacea* was found associated with *S. paramamosain* and *S. tranquebarica* in low salinity area (0.59 to 16.71 ppt) mostly in the landward area surrounded by *Nypa fruticans* and *Rhizophora sp*. vegetation. However, only *S. olivacea* was found infected by this parasitic barnacles. Thus, habitat, geographical condition or salinity may not be the factor that may cause sacculinid infection on *S. olivacea* in Marudu Bay mangrove area. This suggests that this sacculinid infection is limited to *S. olivacea* due to unknown factors that was not examined in this study. On the contrary, previous study on parasitic barnacles *Sacculina carcini* reported that this barnacles was found to be host specific on European green crab, *Carcinus maenas* [27]. Earlier studies reported that the occurrence of sacculinidae infection on Japanese shore crab, *Hemigrapsus sanguineus* was low if the infected crab was caught in areas that facing the open sea and the occurrence was high when the infected crabs were caught in sheltered area locations [28]. However due to limited information, further studies and investigation on sacculinid infection on *S. olivacea* should be done in order to clarify the reason or factor that contributes to the infection of this mud crab.

The infected *S. olivacea* can be found throughout the year at any sizes and sexes. On average 51.5% of the *S. olivacea* was found infected by Sacculinid. The infected crabs were found within the same range of sizes of the healthy crabs and infection in male (48.4%) was not significant different with female (59.6%) ($p > 0.05$). This study is in agreement with previous study that showed 50% of the population of blue king crab, *Paralithodes platypus* was infected by sacculinid regardless of the sexes [29]. On the contrary, study on the infection of parasitic barnacles on *P. pelagicus* showed female host specificity in Gulf of Mannar, Southeast Coast of India [30]. This indicates the occurrence of sacculinid infection may be species specific.

The present study also showed that sacculinid was observed to infected *S. olivacea* more frequently at the end of the wet season (Northeast monsoon) onwards until the end of the dry season with relative higher temperature (Southwest monsoon). This is in agreement with previous studies that documented a higher occurrence of *Sacculina granifera* during the warmer months in Western Australia [31] and higher number of female *Portunus pelagicus* was found carried externae during the summer months in Moreton Bay, Australia [32]. Earlier study suggested that small increase in air and water temperature forecast will influence the geographical distribution of parasite and may promote the proliferation of their infective stages and also raise their local abundance in the ecosystem [33].

The infection of sacculinid commence when the female cyprid infects the crabs by settling on the external cuticle or the gill filaments [22]. A root system is then developed inside the host's tissue with function to absorb nutrients from the host [34, 22] and later develops into a reproductive body that constitutes of the virgin externae growing from the abdominal flap of the crab. Then the male cyprid entered through the mantle opening of the virgin externa and the male receptacles where spermatogenesis took place [35]. Once the externae is fertilized, the infected crabs starts to mimic a female crab including broadening their abdominal flaps, they also do not moult and cause changes to the taste of the crabs [13]. Apart from that, the infected crabs become sterile and therefore no longer part of the spawning stock [36, 37, 16]. Previous study also reported that growth of the infected crabs was affected and mortality was higher compared to healthy individuals [16]. The life span of the parasite could extend until its host dies [16]. However, another finding suggested that the parasite may also die before the host does as observed on lithodid crabs with scars of *B. callosus* infection where the externae have been lost [18].

Conclusion

The present study reported the occurrence of parasitic barnacles, Sacculinidae in *Scylla olivacea* in Sabah, Malaysia. The infection was only found in *S. olivacea* with approximately half of the total *S. olivacea* caught were found to be infected. This infection exhibits no clear specificity on sex, sizes and seasonal, however, only with slight increase of infection during the dry season with warmer temperature. Although, *S. olivacea* only comprises of 8.8% of the total catch of

mud crabs in Marudu Bay, however, this infection not only affects the reproductive capacity and future recruitment of *S. olivacea* in wild habitat, and also reduced the marketable value of the crabs. Therefore, precautionary measures should be taken to ensure sustainable management of mud crabs in the future.

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