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Short Communication

Redescription of *Bactronophorus thoracites* Gould (1856) and *Bankia gracilis* Moll (1935) from Sabah Waters, Malaysia, with Short Ecological Notes and Measurements Metrics

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Abstract

Mollusc wood-borers are classified into two groups: pholads and teredinids. While pholads have a limited distribution to temperate and tropical marine waters, teredinids are found worldwide. However, limited info on the taxonomy was documented on the marine wood borer in Sabah, Malaysia. Present study focuses on determining the wood borer species from Sabah waters, Malaysia. Samples were collected from fallen tree debris in the mangrove at Kota Kinabalu, Kuala Penyu and W.P. Labuan during low tide and water quality parameters were taken in-situ from all three sampling sites. Specimen identification was carried out by observing the physical characteristics of the pallets which are unique between genuses. The species *Bactronophorus thoracites* was identified from the Kota Kinabalu sampling site and species *Bankia gracilis* were found in both the Kuala Penyu and W.P. Labuan sampling site. The pallet of *B. thoracite* are of "dagger-and-sheath" shape, it is 26mm in length, with blade measuring 10mm in length, basal cup 4mm in length and stalk 12mm in length. The pallet of *B.gracilis* is characterized by the dark periostacum covering the 3-lobbed upper margin of the calcareous portion of the inner face of the cone, the pallet is 20mm in length, with the blade and stalk both measuring 10mm in length. The present study described two species of marine wood borers namely *B. thoracites* and *B. gracilis* in Sabah and W.P. Labuan with some measurement metrics and ecological parameters that were missing from previous studies that aided the process of species identification in future.

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1. Introduction

Marine wood borers are wood boring organisms that belong to two phyla namely mollusca and crustacea, and both phyla can live in seawater and brackish water (Rajapakse, 2016; Borges *et al*., 2012). Among these two phyla, there are four kinds of wood-boring organisms, two of which belonging in crustacea and the other two in mollusca. Mollusc wood borers comprise of the species belonging to pholads and teredinids, although the distribution of pholads are limited to temperate and tropical marine waters, teredinids are widespread throughout the world (Sivrikaya, 2019).

Wooden materials had been used for centuries to build structures to meet human needs, due to their unique characteristics such as renewability, aesthetic appearance, flexibility, high strength and elasticity under load (Sivrikaya, 2019). When a teredinid larvae settle on untreated wood, it will begin boring into the wood, the entry hole is hardly visible on the surface but the interior of the wood will be riddled with tunnels, affecting the structural integrity of the wood (Turner, 1966; Borgers *et al*., 2014). The damage of teredinids is most severe at the mud-line but they are able to attack wood at mid-tide as well (Sivrikaya, 2019). In addition, climate change with inclining global temperature will increase the risk of damage to wooden structures by shipworm (Paalvast and Velde, 2011). However, because crucial precise measurement metrics on the pallets and ecological parameters were lacking from earlier investigations, the researchers found themselves in a difficult scenario when it came to identification.

Distribution and abundance of shipworm is insufficient all around the world with only few studies conducted. Study of Beasly *et al.* (2005); Filho *et al.* (2008) was conducted in Brazil, Appelqvist *et al.* (2015) was in Sweden, Paalvast and Velde (2011) was in Netherlands, and Velásquez and Shipway (2018) was in the Southwest Pacific. In Malaysia, there were several studies on shipworms that had been conducted in the past. These studies primarily focus on the distribution and ecological aspects of shipworms. Several of the most notable researches conducted in Malaysia were done by Singh and Sasekumar (1994); Demas (2004); Roszaini and Salmiah (2014); Lee *et al.* (2019) and most recently Loo *et al.* (2019). Both Singh and Sasekumar (1994) and Demas (2004) focused on the distribution of shipworms in Lumut, Perak and Blungei Bay mangrove area, Sarawak respectively. Roszaini and Salmiah (2014) targeted on determining the resistance of five different mangrove tree species to marine wood borer attacks. The study done by Lee *et al.* (2019) focused on the phylogenetic placement of the shipworm species *Bactronophorus thoracites*. The most recent study to describe a species was done by Loo *et al.* (2019) describing the first record of shipworm species *Dicyathifer mannii* in Sabah.

The existing pictorial key that had been used for identification are depending on the characteristics of the pallets and some notable internal anatomy present in each genus but with limited morphometric information. The present study describes the species *Bactronphorus thoracites* and *Bankia gracilis* under the family Teredinidae Rafinesque, 1815 in Sabah, Malaysia with detailed measurements on the pallets to provide some morphometric information to the species of wood borers that inhabits Sabah coastal areas for future references and studies

2. Materials and Methods

2.1 Sample collection

A total of five samples were collected from dead wood debris in the mangrove area of Kota Kinabalu, Kuala Penyu, and W. P. Labuan (Figure 1). During the samplings, the physiochemical water quality of the site water was taken in-situ using a multiparameter probe (YSI Pro Plus). Specimens were collected from dead wood debris during low tide when the woods debris that were submerged during high tide were exposed; sample collection was solely carried out by splitting the wood debris with an axe and then extracting the exposed specimens (Loo *et al*., 2019).

2.2 Sample identification

Specimens were then fixed in 10% formaldehyde. Specimen identification was carried out by observing the characteristics of the pallets and using the work of Turner (1966) as reference. The pallets were then digested in 10% Hydrogen Peroxide (H_2O_2) to dissolve any residual organic matter on the pallets, then the pallets were observed under a stereo microscope (Olympus SZ61) with a camera attachment (Xcam Alpha 61), pictures of the pallets were taken for the production of illustrations.

2.3 Data analysis

Measurements of the pallets were taken using computer software (analySIS, getIT, and MeasureIT). Descriptions of the pallets were made from drawings produced. The measurement metrics of the pallets on stalk length, stalk width, cone length, cone width, blade length and blade width were measured and recorded (Table 1).

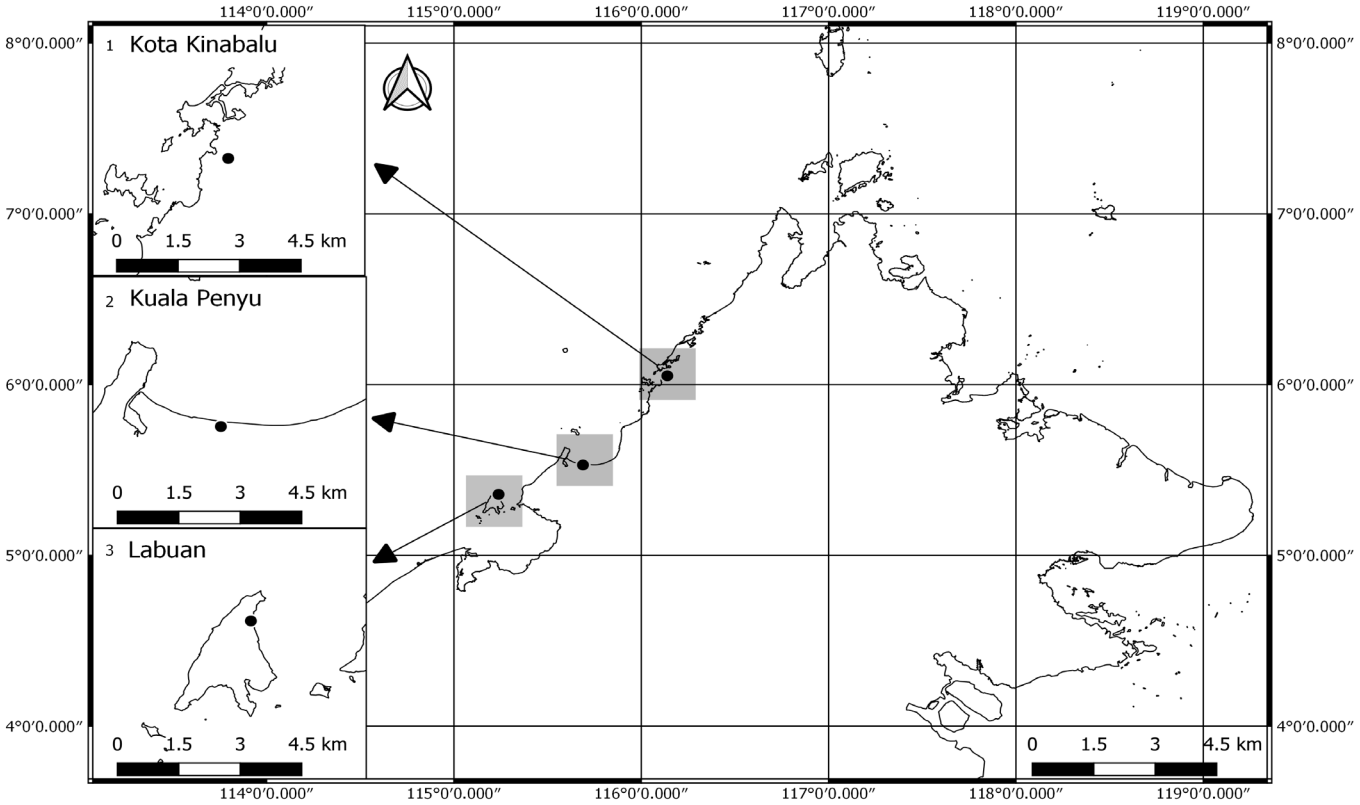

Figure 1. Map of Sabah-Borneo with sampling sites marked for *Bactronophorus thoracites*[1] and *Bankia gracilis*[2,3]. [1]Kota Kinabalu sampling site (6°3'07.10"N, 116°8'19.10"E), [2]Kuala Penyu sampling site (5°31'49.70"N, 115°41'20.11"E), [3]W.P. Labuan sampling site (6°58'03.0"N, 115°14'16.9"E).

Table 1. Measurements for pallet of Bactronophorus thoracites and Bankia gracilis (unit mm).

	Bactronophorus thoracites	***Bankia gracilis***
Stalk length	12	10
Stalk width	2	0.55
Cone length	4	11.38
Cone width	11	4
Blade length	10	10
Blade width	2	4

3. Result and Discussion

Taxonomy

Order Myida

Family Teredinidae Rafinesque, 1815

The family Teredinidae is known to have greatly reduced shell on the anterior end, a pair of specialized organs called pallets protruding from the base of the siphons and a long worm-like body. The pallets of shipworms are unique to each genus; identification of species is carried out primarily from the characteristics of the pallets.

Genus *Bactronophorus* Tapparone-Canefri, 1877

The pallets of *Bactronophorus* are of "dagger-and-sheath" shape. It is asymmetric, non-segmented with a long blade extending from a basal cup. The length of the blade is almost equivalent to that of the stalk.

***Locality*:** Kota Kinabalu, Sabah

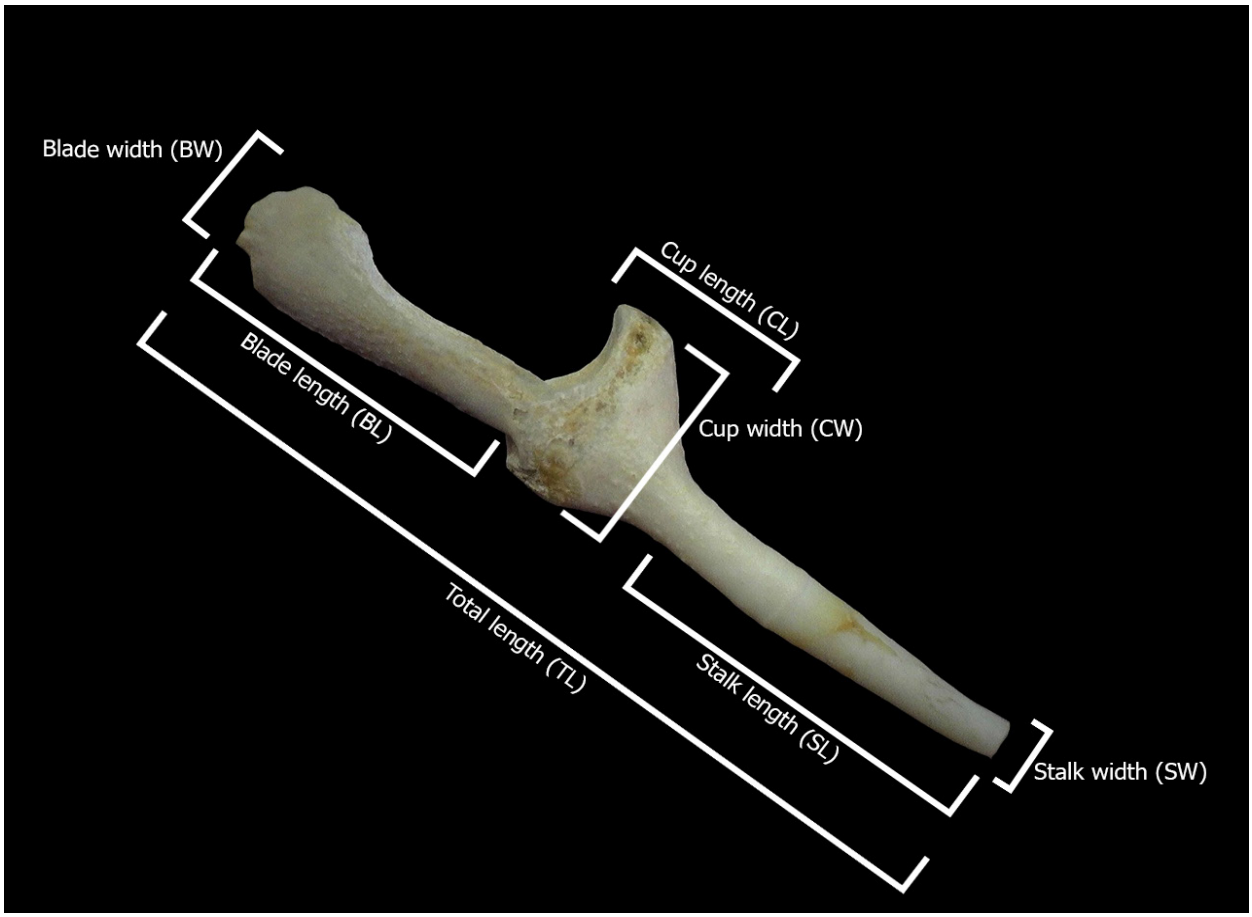

Figure 2. Right side pallet of the pair of *Bactronophorus thoracites*. Pallet with labels to the parts measured

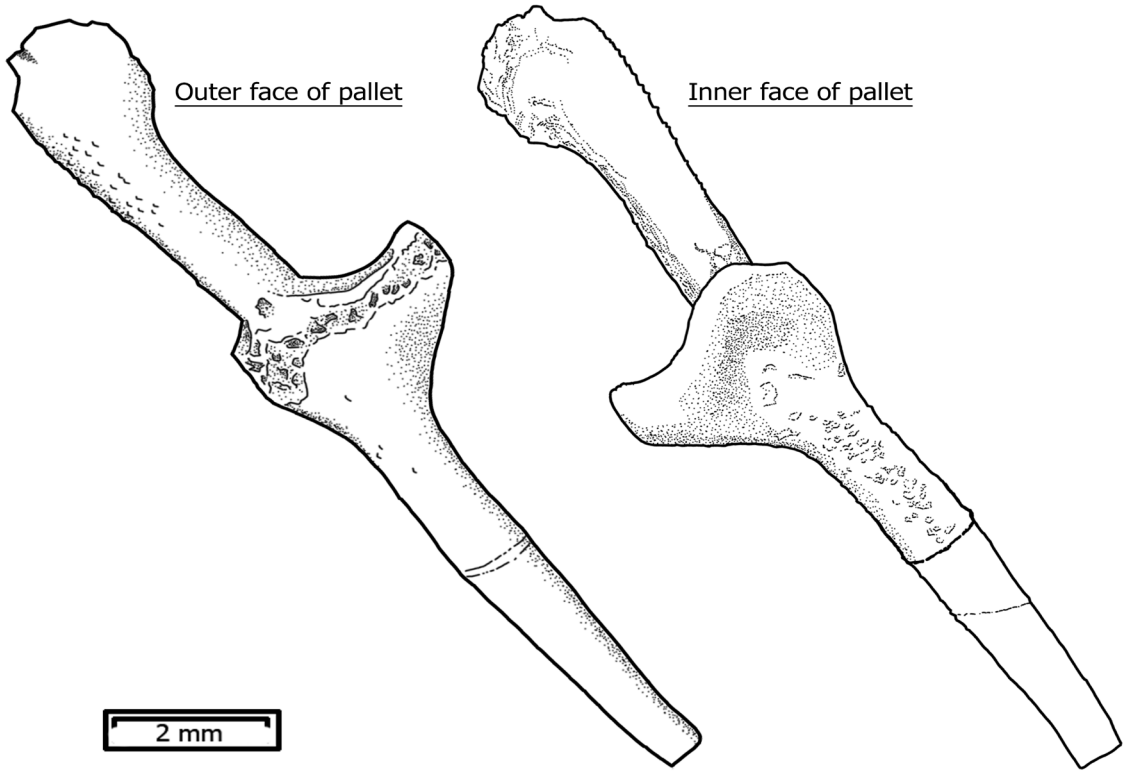

Figure 3. Illustration of the right-side pallet of *Bactronophotus thoracites*. Illustration of the inner and outer faces of the pallet

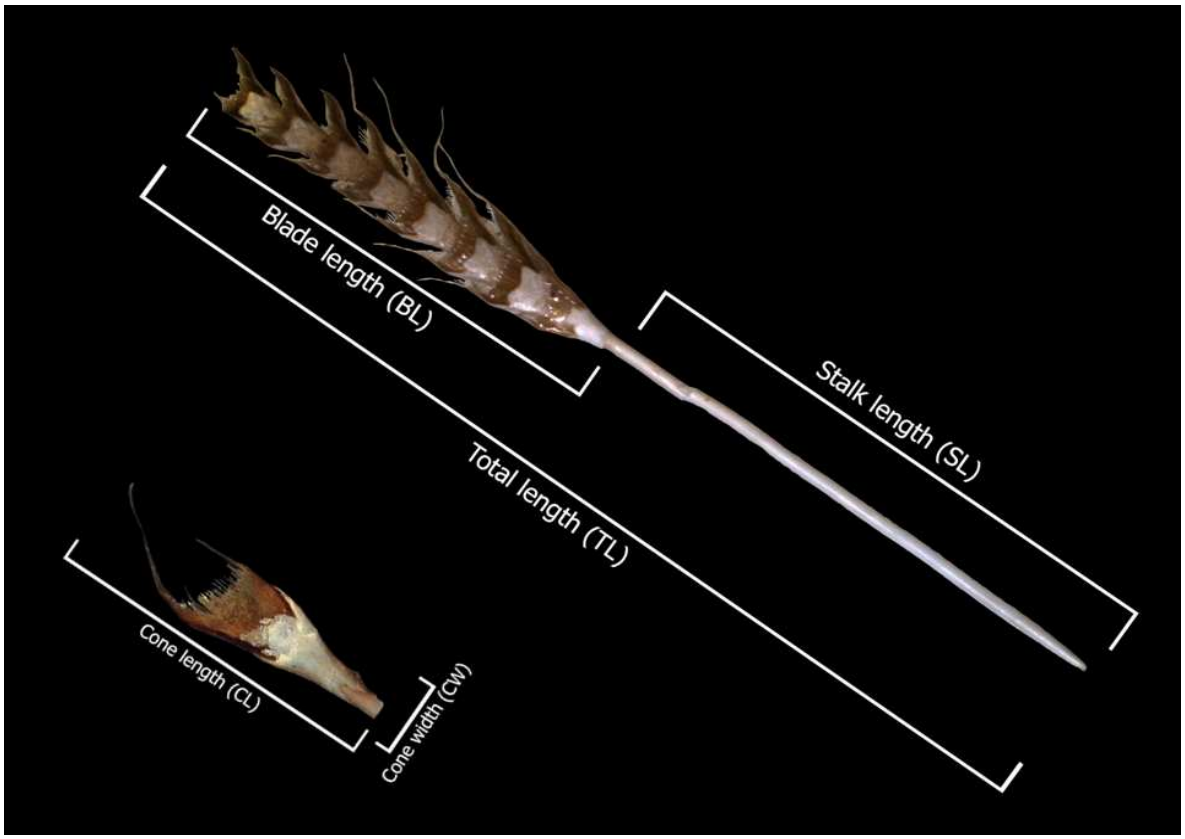

Figure 4. Right side pallet of the pair and a cone from the left side pallet of *Bankia gracilis.* Pallet and cone with labels to the parts measured

Figure 5. The right side pallet of the pair of *Bankia gracilis.* Comparison of features between the inner and outer face of the pallet

Figure 6. The base and tip cone of the pallet of *Bankia gracilis.* Differences in size of the base cone and tip cone of the pallet of Bankia gracilis

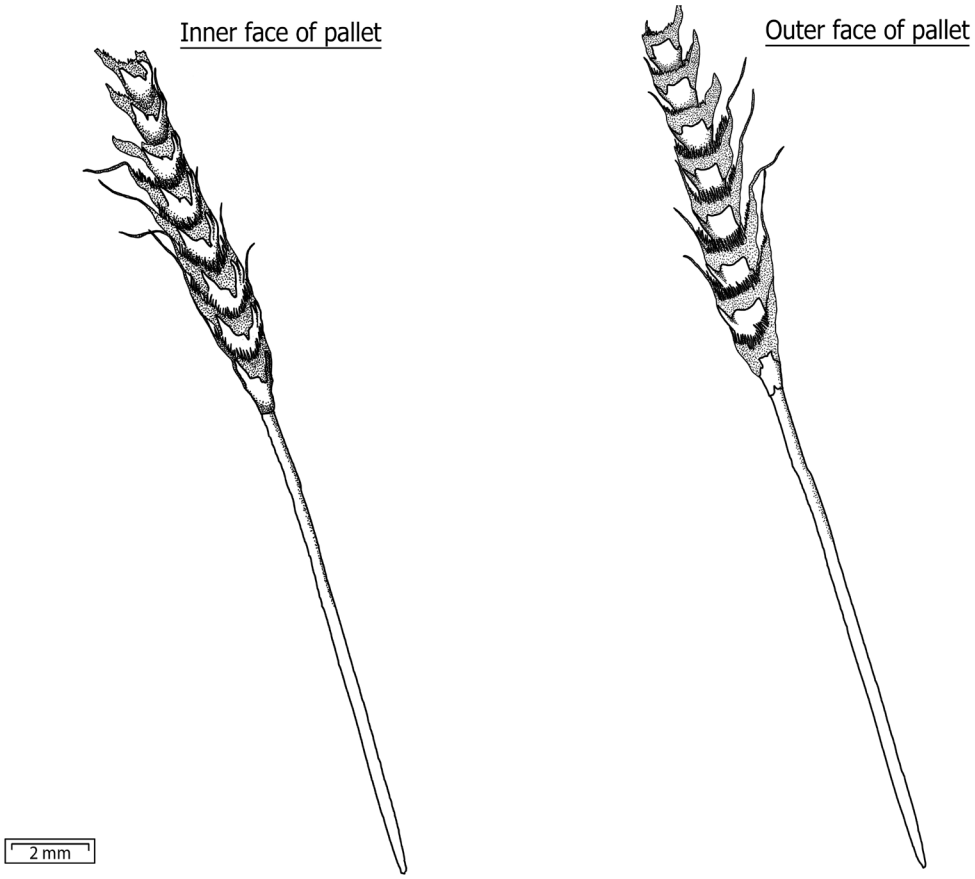

Figure 7. Illustration of the inner and outer face of the pallet of *Bankia gracilis.* The inner and outer faces of the pallet has different calcareous features

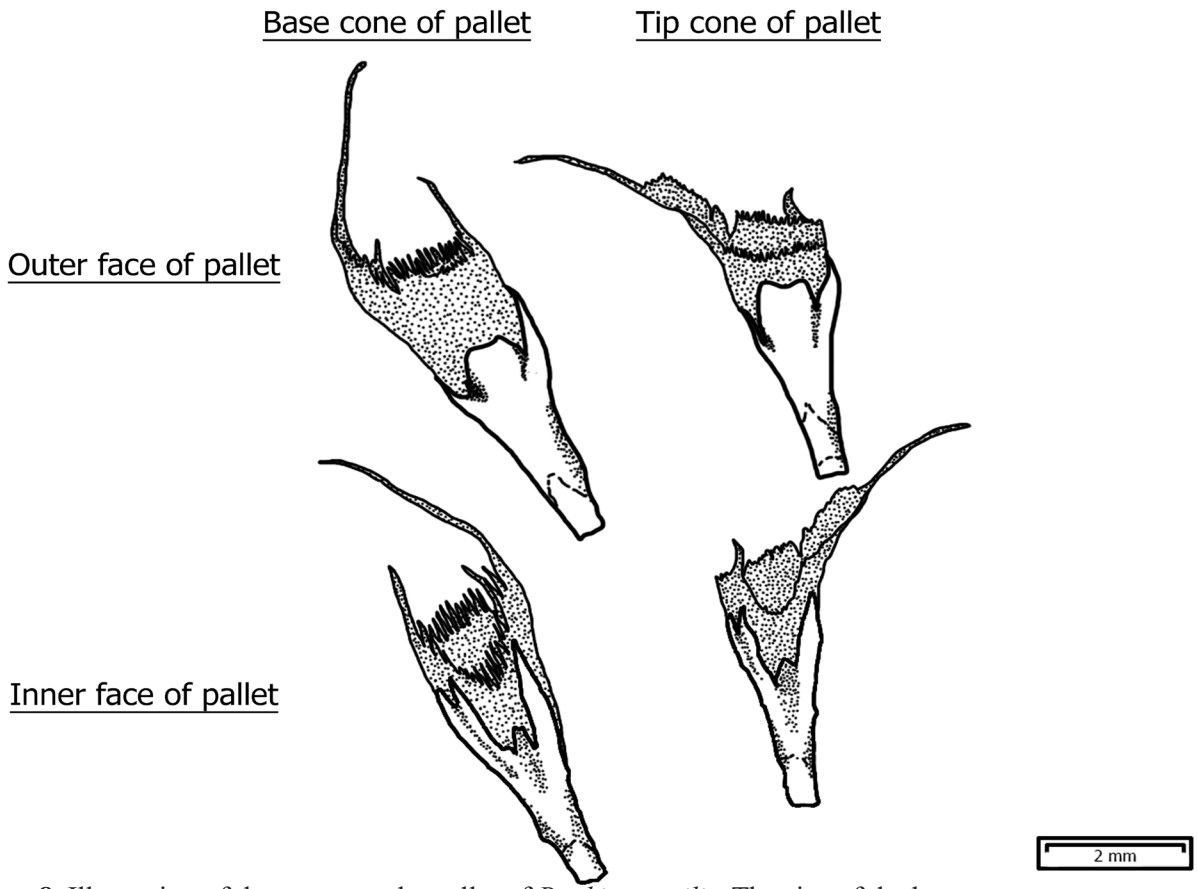

Figure 8. Illustration of the cones on the pallet of *Bankia gracilis.* The size of the base cone is larger than the tip cone

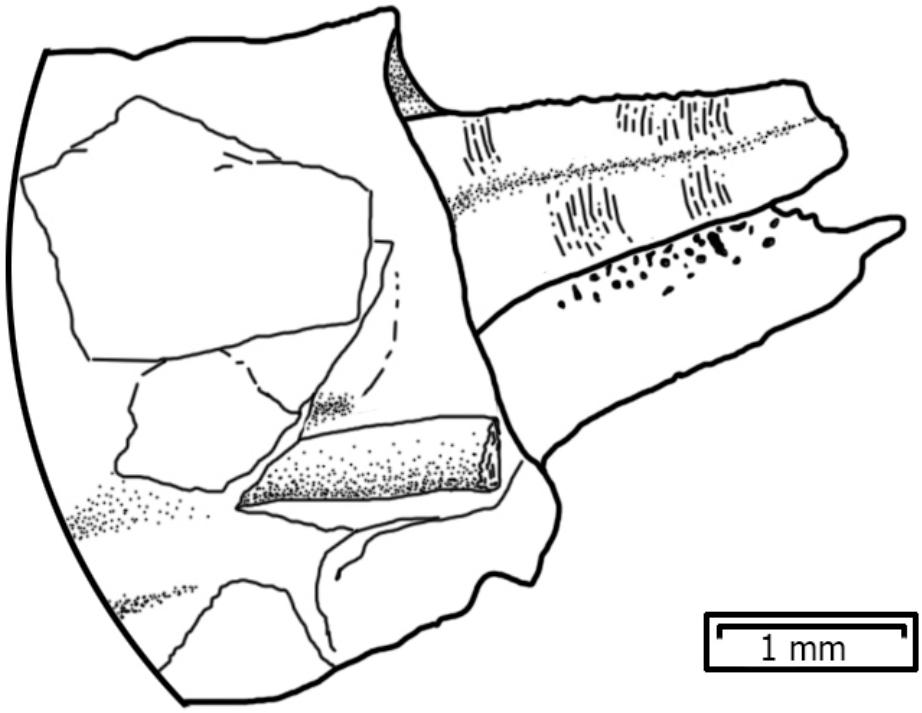

Figure 9. Magnified view of the siphons of *Bankia gracilis* under a microscope. Illustration of the magnified view of the siphons

Ecological notes: Temperature: 32.1°C; DO 8.9 mg/L; Salinity: 26.08 ppt; pH: 6.69.

Description of morphometric

The total body length of the specimen is 31cm, the siphons of the specimen are joined for most of its length and are 0.6cm in length (Table 1).

The pallets of genus *Bactronophorus* is of "dagger-and-sheath" shape, it is non-segmented and asymmetric with a long blade extending from a basal cup. The length of the pallet is measured 26mm and the stalk is 12mm in length and 2mm wide (Figure 2). The basal cup is 4mm in length and 11mm wide (Figure 3). The blade extension is 10mm in length and 2mm wide (Figure 3). Along the outer face of the blade, small bumps cover the surface of the blade; the coverage of the bumps may extend from the base of the blade to the tip. Some of these bumps are pointed while some are rounded (Figure 3).

Genus *Bankia* Gray, 1842

The genus *Bankia* was first described with the type species *Teredo bipalmulata* Lamarck, 1801 which was later accepted as *Bankia bipalmulata* (Turner, 1966). This genus contains 28 species and has occurrences throughout the world with exception to the polar region (Turner, 1966).

The pallets of *Bankia* are of "cone-in-cone" shape. It is segmented and composes of multiple individual cones stacking on each other forming the blade, the cones towards the tip gets progressively smaller. Each cone is composed of a calcareous portion which is covered by a layer of periostracum. The border of the periostracum is serrated and expands laterally forming awns.

Locality: Kuala Penyu, Sabah, and W.P. Labuan

Ecological notes: i) *Kuala Penyu* - Temperature: 26.9°C; DO 2.9 mg/L; Salinity: 30.35 ppt; pH: 7.7, ii) *W.P. Labuan* - Temperature: 32.0°C; DO 6.2 mg/L; Salinity: 22.35 ppt; pH: 7.69

Description of morphometric

The total body of the specimen was unidentified due to mismanagement of specimen, only the pallets with the siphons were remained. The siphons of the specimen are joined for most of its length and are 2mm in length. The total length of the pallet was 20mm. The physiochemical water parameters of the sampling sites where the specimen was collected as a record.

The body of the specimen was lost due to mismanagement of specimen during collection, only the pallet remained as they were removed from the specimen to be used for identification. The specimen is identified as *Bankia gracilis* by the characteristic dark periostracum covering and the 3-lobbed upper margin of the calcareous portion of the inner face of the cone (Figure 6). The pallet is 20mm in length with the blade and stalk both measuring 10mm in length (Figure 4 and Figure 5). The blade is composed of multiple individual cones stacking on each other, the individual cones can be removed easily from one another, and the cones towards the tip of the blade is smaller than the base cone (Figure 6). The base cone is measured 4mm in width. The distal surface of the cone is covered by a layer of periostracum which has a border with serrated characteristics (Figure 6). The results of the physio-chemical parameters from the two study stations indicated that *Bankia gracilis* potentially has a wider range of temperature (26-32°C), DO (2.9-6.2 mg/L) and salinity (22-30 ppt) tolerances.

The species *Bactronophorus thoracites* was first described by Gould in 1856 as *Teredo thoracites*. It is the only known species in the genus *Bactronophorus* but it was given several other names (*B. edulis, B. filoteoi, B. subaustralis, Calobates australis, Teredo furcelloides*, and *T. thoracites*) which were synonymised as *B. thoracites* (MolluscaBase, 2021). The presence of *B. thoracites* had been reported in Australia (Brearley *et al*., 2003), India (Santhakumaran and Srinivasan, 1988), Indonesia (Hendy, 2012), Malaysia (Singh and Sasekumar, 1994; Demas, 2004; Lee *et al*., 2019), Singapore (Tan and Woo, 2010), and Thailand (Yoosukh and Jitkaew, 1997).

The second species described in the present paper, *B. thoracites,* is the second largest species in terms of size after the mud boring *Kuphus polythalamia* (Sigwart, 2017). Gould (1856) emphasized on the great body length as well as the unique shape of the pallet of this species when compared to other described species of shipworms. Since the first discovery of *B. gracilis* in 1935 by Moll in Singapore, it had been recorded in several research studies in the region: Malaysia (Roszaini and Salmiah, 2014), India (Manavi, 2013; Santhakumaran and Srinivasan, 1988; Swain *et al*., 2017) and Thailand (Yoosukh and Jitkaew, 1997). The presence of this species was recorded in several habitat including polluted sites (Pati *et al*., 2012).

Little info on the measurements of the pallets were included in the past taxonomic studies. The general descriptions provided a vague description on the size of the pallet potentially causing some confusion in

determining the actual size of the subjects. Therefore, the measurements of described specimens intended to provide a more accurate and insight for future species identifications (Table 1).

4. Conclusion

The current study is the morphometric description of the marine wood borer species *Bactronophorus thoracites* and *Bankia gracilis* in Sabah, Malaysia, and includes some measurement parameters on the pallets that were previously lacking from prior morphological descriptions as well as some environmental parameters that were previously unknown. Further studies of *B. thoracites* and *B. gracilis* may help in visualizing the ecological distribution of these two species throughout Malaysia.

Descriptions of new species of shells

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Authors' Contributions

All authors have contributed to the final manuscript. The contribution of each author as follow, Loo; collected the data, drafted the manuscript and designed the figures. Chen, Khairul and Fara; devised the main conceptual ideas and critical revision of the article. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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