湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

第 49 卷 第 12 期
2022 年 12 月

Available online at http://jonuns.com/index.php/journal/index

Vol. 49 No. 12
December 2022

Open Access Article https://doi.org/10.55463/issn.1674-2974.49.12.15

New Record of Marine Wood-Borer Species in Mangrove Forest of Nusa Lembongan, Bali, Indonesia

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Received: July 13, 2022 / Revised: September 15, 2022 / Accepted: November 11, 2022 / Published: December 30, 2022

Abstract: Research has been carried out on the presence of wood-borer species in the mangrove forest of Nusa Lembongan, in May-June 2022. The study was conducted at five representative sites of mangrove forests in Nusa Lembongan. The data collection of the mangrove wood-borer was carried out by purposive sampling, which directly searches for dead mangrove stems, twigs, or roots that were attacked by the marine wood-borer found at each site. A total of There were new record four species of mangrove wood-borer, namely, *Phaenops* sp. beetle group (Coleoptera) and *Cenoloba* sp. moth group (Lepidoptera), two species of Mollusks, namely, *Bankia minima* and *Bactronophorus* sp. were identified. The larval stages of *Phaenops* sp. were found within the dead mangrove stems of *Rhizophora apiculata* and *Sonneratia alba*. *Cenoloba* sp. which was found in the larvae phase, the host plant was the dead stems of the mangrove *Sonneratia alba*. *Bankia minima*, the host plants are dead stems of mangroves *Sonneratia alba, Rhizophora apiculata, Rhizophora stylosa* and *Avicennia* sp. *Bactronophorus* sp., the host plant is dead wood from the mangrove *Sonneratia alba, Rhizophora apiculata*. The most widely distributed wood-borer species in the mangroves of Nusa Lembongan is *Bankia minima*. The results showed that four species of marine wood-borer are new records in the mangrove forest of Nusa Lembongan.

Keywords: marine wood-borers, *Phaenops* sp., *Bankia minima*, mangrove.

印度尼西亚巴厘岛蓝梦岛红树林中海洋蛀木虫的新记录

摘要：2022 年 5 月至 6 月，对蓝梦岛红树林中蛀木虫物种的存在进行了研究。该研究是在蓝梦岛红树林的五个代表性地点进行的。红树林蛀木虫的数据收集是通过有目的的抽样进行的，即直接搜索在每个地点发现的被海洋蛀木虫袭击的死红树茎、树枝或根。共有 4 种新记录的红树蛀木虫，即褐藻。甲虫组(粉翅鸡)和芹菜。蛾类 (鳞翅目),两种软体动物，即最小的银行和杆菌属. 被确定。褐藻。的幼虫阶段。在根茎菌和白铃的死红树茎中发现。切诺洛巴服务提供商。在幼虫阶段被发现，寄主植物是红树林海桑的枯死茎。最小的银行，寄主植物是红树林海桑、细根根瘤菌、柱状根瘤菌和白骨. 的枯茎。杆菌属.，寄主植物是来自红树林白铃, 根茎菌的枯木。蓝梦岛红树林中分布最广的蛀木虫物种是最小的银行。结果表明，四种

海洋蛀木虫为蓝梦岛红树林新记录种.

关键词：海洋蛀木虫、酚类、最小的银行、红树林.

1. Introduction

The mangrove ecosystem is a system comprising of organisms (animals, plants, microbes) that interact with environmental factors in a mangrove habitat. The mangrove ecosystem is a unique ecotone (transitional area), which connects the life of land and sea biota [1]. The Nusa Lembongan mangrove forest with a forest area of 202 ha. some are planted and most of them are natural forests. The diversity of mangrove flora in Nusa Lembongan consists of three main components, namely, major, minor and associated mangroves. Approximately, around 13 true mangrove species and several associated plant species have been found in the Nusa Lembongan mangroves. True mangrove species include *Rhizophora* spp., *Avicennia* spp. *Sonneratia alba*, *Lumnitzera racemose*, *Xylocarpus granatum* and associated species include *Pandanus tectorius*, *Hibiscus tiliaceus*, *Caloptropics gigantea* and *Ipomoea pes-capre* [2, 3].

Mangroves are the habitat of several aquatic fauna (mollusks, fish, crustaceans, insects) and avifauna (birds). Mangrove wood-borer is one of the fauna groups that use mangrove plants for their life. The marine wood-borer consists of various species, the fauna groups identified are from the Mollusks, Crustacean and Insect groups. Mollusks group, the best known are *Teredo*, *Bankia* and *Martesia*, Crustacean group includes *Limnoria*, *Chelura* and *Sphaeroma*; and Insect group (moth and beetle larvae), common genera are *Bottegia*, *Cenoloba*, and *Phaenops*.

The distribution area of the sea wood-borer is very wide and is found in almost all saltwater and brackish waters, in tropical waters, these animals can thrive and can be found throughout the year [4, 5]. Shipway et al. [6] and Weigelt et al. [3] stated that the marine wood-borer worm is a group of drill and wood eating bivalves that cause structural damage to mangrove trunks or roots. The hosts of several types of wood-borers that have been found are dead logs of the mangrove species *Rhizophora* spp., *Sonneratia* spp., and *Avicennia* spp.

Several studies on the marine wood-borer in mangrove forests of Southeast Asia have been conducted, such in Kalimantan, Peninsular Malaysia, Taiwan, China. Diba et al. [7] found several species of wood-borers including *Neoteredo reynes*, *Teredo pocalifer*, *Teredo utriculus*, *Teredo siamens*, *Teredo navalis*, *Teredo batiliformis*, *Teredo dagmarae*, *Teredo dallii*, *Martesia setacea*, *Bankia setace*a, *Bankia minima* and *Petricola pholadiformis*; from the Teredinidae and Pholadidae families in the mangrove forests of West Kalimantan, Loo et al. [8] identified the species *Dicyathifer mannii* and *Bankia gracilis* (Mollusca:Teredinidae) in the mangrove area of the Kuala Penyu area of Malaysia; Loo et al. [8] identified the species *Bactronophorus thoracites* and *Bankia gracilis* from Sabah Waters, Malaysia. Davidson et al. [9], Thiri and Yang [10] and Trinh et al. [11] reviewed the wood boring Isopod pest, *Sphaeroma* spp., which causes a destructive impact on Mangrove Forest in China, Southwestern Taiwan and Binh Dinh province, Vietnam; and Treneman et al. [12] found Six shipworm species in the coastal waters of Japan, including *Bankia* spp., *Teredothyra smithi*, *Psiloteredo* sp., *Lyrodus takanoshimensis*, and *Teredo* spp. and *Uperotus clava*. Some research results show that the presence of woodborer pests can cause damage to mangroves. Marine woodborers can negatively impact mangroves and change the morphology of the tree.

Damage to mangrove roots (pneumatophores and lenticels), namely with more necrotic tissue and holes in tree trunks, which resulted in the collapse of *Avicennia marina* mangrove plants. The hollow roots of *Rhizophora stylosa* cause the collapse of the mangrove tree [9].

Research data on the diversity of wood-borer species in mangroves in Indonesia is still very minimal. Indonesia, *Phaenops* sp, *Cenoloba* sp, *Bankia minima* and *Bactronophoru*s sp. were reported previously this study, we provide the first report on the occurrence of marine wood-borer in Nusa Lembongan, Bali, Indonesia. In fact, the scientific data regarding wood-borer in the Nusa Lembongan mangroves, are not yet available. In the Mangrove Forest of Nusa Lembongan, twigs, stems and roots of dead mangroves places were found, as well as showing signs of the presence of wood-borers in them. Thus, this study aims to identify wood-borer species in several species of mangrove plants and the results of this study will be a new record for the existence of wood-borers in the mangroves of Nusa Lembongan.

2. Materials and Methods

2.1. Study Sites

The research was conducted for two months, from May-June 2022 in the mangrove ecosystem area of Nusa Lembongan. Table 1 shows the characteristics, GPS reading (coordinates) and the description of study sites in mangrove forest Nusa Lembongan and study sites are shown in Figure 2. Identification of mangrove wood-borer species was carried out in the Animal Taxonomy Laboratory, Biology, Faculty of

Mathematics and Natural Sciences, Udayana University.

Table 1 The coordinates and description of study sites in mangrove forest Nusa Lembongan [13]

Location	Coordinates	Dominance species
Site 1	8^0 41'17.20" S 115^0 27'19.31" E	*Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba*
Site 2	8^0 40'55.62" S 115^0 27'44.92" E	*Rhizophora stylosa, Bruguiera gymnorrhiza, Sonneratia alba*
Site 3	8^0 40'16.12" S 115^0 27'54.45" E	*Bruguiera gymnorrhiza, Ceriops tagal, Rhizophora stylosa, Xylocarpus granatum, Avicennia rumphiana, Rhizophora x lamarckii, Sonneratia alba*
Site 4	8^0 40'02.82" S 115^0 27'41.39" E	*Rhizophora stylosa, Ceriops tagal, Xylocarpus granatu*m, *Avicennia marina, Sonneratia alba.*
Site 5	8^0 40'11.99" S 115^0 28'16.28" E	*Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba*

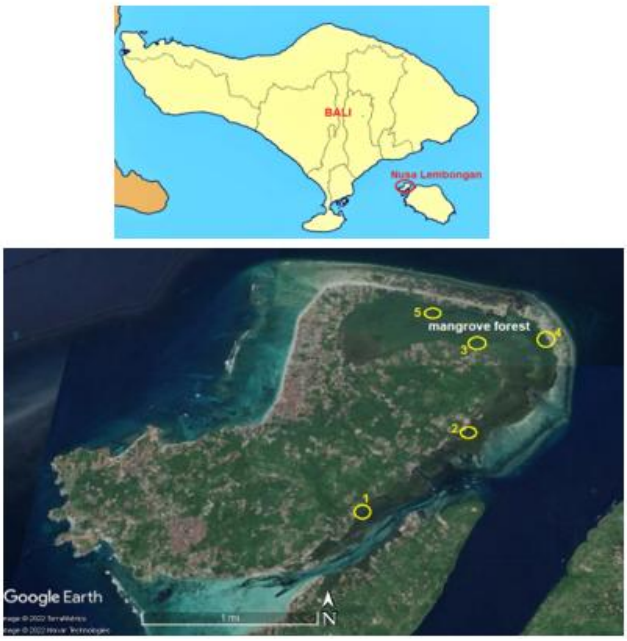

Fig. 1 Maps (Google Earth) showing sampling stations at five locations in the mangrove forest at Nusa Lembongan

2.2. Data Collection and Species Identification

The data collection of the mangrove wood-borer was carried out by purposive sampling [14]. The sample collection was limited to dead mangrove stems at five research sites. The inventory was carried out by directly searching for dead mangrove stems, twigs, or roots that were attacked by the marine wood-borer found in each site (5 sites) of the Nusa Lembongan mangrove forest.

All affected wood is taken and collected. Wood that is attacked by the wood-borer is cut with an ax to a size of about 1 meter, then split using an ax to remove the marine wood-borer. All marine wood-borer specimens found in the wood were taken with tweezers and collected in vials 70% alcohol. Identification of marine wood-borer species is based on morphological characteristics and shell shape (for mollusks) and characteristics of holes in dead mangrove wood [7, 11, 15-18].

2.3. Data Analysis

The data were analyzed descriptively, by describing the morphological structures, shell structure, holes in the dead mangrove wood. The specimens found were compared with the descriptions of the species or genus [7, 8, 10, 16-19].

3. Results and Discussion

3.1. Existence of Wood-Borer in Mangrove Forest

A total of four species of marine wood-borer in Nusa Lembongan were recorded. This includes two species from the insect class, *Phaenops* sp. (Coleoptera, beetle) and *Cenoloba* sp. (Lepidoptera, moths), respectively. Both species are found in the larval phase in *R. stylosa* and *S. alba*, which were spread out at sites1,3 and 4. The other two marine wood-borer species are of the Bivalvia, namely, *Bankia minima* and *Bactronophorus* sp. These two species were found mainly in *Sonneratia alba*, *Rhizophora apiculat*a and *Avicennia* sp and *Bankia minima* is the most widely distributed species in the Nusa Lembongan mangroves (Table 2).

Previous studies on species composition and distribution of fauna in mangrove forests in Indonesia mostly focused on crabs, shellfish (Bivalvia), snails (Gastropod), fish and birds [13-18, 21-23]. However, the information on the occurrences and species composition of marine wood-borer in mangrove areas is still lacking. Thus, the discovery of four species of marine wood-borer mangrove areas is the first record of these species on the island of Nusa Lembongan, Bali, Indonesia. The larval characteristics of *Phaenops* sp. are similar to those of the same genus described by Ciesla [17]. The larvae phase of this genus generally attacks dead wood cores from mangrove plants, including *Rhizophor*a sp., *Sonnerati*a sp. The adult phase of this beetle lays its eggs in the pith of the mangrove wood, then hatches into larvae that can make holes in the wood. The larval characteristics of *Cenoloba* sp. found in the mangroves of Nusa

Lembongan correspond/resemble with to the characteristics of the same genus described by Abu El-Ghiet [16]. It was further stated that the species *Cenoloba obliteralis* is a pest that attacks mangrove plants (references). This species, in the larval phase, mostly attacks the *Avicennia marina* mangroves, especially on the fruit and leaves. Abdel-Rahman et al. [24] also found other insect species in the larval stage, namely, *Trichogramma* sp., which is a common parasitoid in *Avicennia marina* mangroves.

Table 2 Marine wood-borer species were collected from five sites in Nusa Lembongan mangrove forest

No.	Species (common name)	Host plant	Class/Order/ Family	Occurrence on site				
				1	2	3	4	5
1	*Phaenops* sp. (Larvae phase of Flatheaded wood-borer)	*Rhizophora stylosa, Sonneratia alba*	Insecta/Coleoptera/Buprestidae			V	V	
2	*Cenoloba* sp. (Larvae phase of moth)	*Sonneratia alba*	Insecta/Lepidoptera/Tineodidae	V		V		
3	*Bankia* minima (Shipworm wood-borer)	*Sonneratia alba, Rhizophora stylosa, Rhizophora apiculata, Avicennia* sp.	Bivalvia/Myoida/Teredinidae	V	V		V	V
4	*Bactronophorus* sp. (woodworm wood-borer "Tembelo")	*Sonneratia alba, Rhizophora apiculata*	Bivalvia/Myoida/Teredinidae			V	V	

Wood-borer from the Lepidoptera and Coleoptera groups caused damage to the mangrove wood during the larval stage. This attack begins when the female insect lays its eggs into the bark. Eggs are laid or oviposition in several different parts of the stem (2–6 clusters), each cluster can contain 100–200 eggs. After the eggs hatch into larvae, they begin eating wood while forming a tunnel. Damage to the wood occurs after being drilled by the larvae, which is indicated by discoloration and the stem begins to weaken. The tunnels formed by these larvae cause the tree to weaken structurally, which can then become brittle [25].

Bankia minima is wood-borer worm from the mollusk group, which is common species found in the mangroves of Nusa Lembongan. The host of this mollusk is dead mangrove wood, namely from the species *Sonneratia alba, Rhizophora apiculata*, *Rhizophora stylosa* and *Avicennia marina*. Several previous researchers have also published the existence of *Bankia* sp. on mangrove wood in some mangrove forest areas. Diba et al. [7] noted the presence of *B. setacea and B. minima* in the mangrove forests of West Kalimantan. Treneman *et al.* [12] reported the presence of *Bankia* spp. in the coastal mangrove forests of Japan. Loo et al. [8] and Loo et al. [19] found *Bankia gracilis* in the mangrove forest Kuala Penyu Malaysia. *Bactronophorus* sp. is also a wood-borer from the mollusk group, which is less common in the mangroves of Nusa Lembongan.

Species of the same genus, *Bactronophorus thoracite*s, have been reported by Loo et al. [8] and Loo et al. [20] in the Kinabalu mangrove forest, Sabah, Malaysia. Hendy and Cragg [6] have also studied the impact of the mollusk group (Family Teredinidae) wood-borer on damage to mangrove wood in the *Rhizophora stylosa* species.

The ability of wood-borers to digest wood or drill wood, which generally contains cellulose, is greatly assisted by the symbiosis with microorganisms. Some species of wood-borer in the digestive tract there are bacteria and protozoa. Most wood-borers (groups of lepidoptera, coleoptera, molluscs, isopods) can digest wood because of their symbiosis with bacteria and protozoa in their digestive tract. Only a few species of wood-borers can actually produce their own cellulose enzymes. In several shipworm (Trinididae) species, dense communities of intracellular bacterial endosymbionts have been observed within specialized cells (microorganisms) of the gills. These bacteria are proposed to contribute to the digestion of wood by the host [26, 27]. Altamia et al. [28] have also isolated three bacterial species, namely, *Teredinibacter turnerae*, *Teredinibacter purpureus* and *Teredinibacter franksiae*, in the digestive tract of shipworm species *Bankia setacea* (Bivalvia: Teredinidae). It was further stated that these bacteria become endosymbiotic in digestion and play a role in producing cellulose enzymes to digest wood cellulose.

3.2. Description of Wood-Borer Species

3.2.1. Phaenops Sp. (Coleoptera, Buprestidae)

Larvae phase: The body of the larvae is white, legless, similar to the larvae of the bark beetle, but the shape of the body and the head are slightly different from the larvae of the bark beetle, namely the body shape is longer, the head (cephal) and the body segment of the thorax are much wider than the next segment, also usually has a hardened plate at the top and bottom (Figure 2).

The larvae immediately drill into the wood and slowly enter the core, making it difficult to see. The

larvae will continue to consume wood, which is the brand's only food source. Inside the wood, the larvae become safe, continue to dig for food for several years. Adult: the adult phase is a flat-headed wood-borer, a distinctive oval body shape, small antennae. Its body size is relatively small to relatively large, which is between 6–64 mm. Adult Buprestidae are called metallic wood-borers because they are iridescent or metallic looking underneath and sometimes on top. Adult beetles will lay their eggs in cracks in wooden objects, floorboards and timbers [29-31].

Fig. 2 *Phaeonops* sp. (larvae phase); image on the left: larval morphology; on the right: larvae in the wood core hole [15]

3.2.2. Cenoloba Sp. (Lepidoptera, Tineodidae)

Larvae: Larvae eruciform, peripneustic, frequently with 8 pairs of limbs. All larvae of moths and butterflies (Lepidoptera) have proles on their abdomen. These legs are tipped with hooks, the crochet (Figure 3). Pupae usually adecticous and more or less object, and generally enclosed in a cocoon or an earthen cell; a few primitive forms are decticous and exarate. Adult: Insects with 2 pairs of membranous wings; cross-veins few. The body, wings and appendages were clothed with broad scales. Mandibles are almost always vestigial or absent, and the principal mouth parts generally represented by a suctorial proboscis formed by the maxillae. Wing tracheation complete [16].

Fig. 3 *Cenoloba* sp. (larvae phase) [15]

3.2.3. Bankia Minima (Mollusca, Teredinidae)

The marine wood-borer found had a length of about 4–7 cm, its body color was brownish, somewhat similar to the color of its host plant wood, its tail color was yellowish white to brown and had a soft and transparent body. Sea wood-borer worms contain water, but the water is easily reduced when the wood-borer's body is removed from the wood. The shape will immediately change to small even though when first encountered it is countless. The head has a pair of small spheres called shells, white to brown in color, which are useful for making holes in wood. The tail shape (palette) is used for species identification. Inside the mollusk's wood it forms a circular tunnel in cross-section and is lined with a calcareous material extruded by the mollusk (Figure 4).

Fig. 4 *Bankia* sp. (left image: body morphology; right image: circular tunnel in dead wood) [15]

3.2.4. Bactronophorus Sp. (Mollusca, Teredinidae)

The body of *Bactronophorus* sp. tubular, its body length reaches 4 cm, pale white. The body can be elongated or shortened. The wider anterior end is closed, has a rounded end. From there, the tube tapers to the open posterior end, by the central septum. The siphon projects through this end to feed and breathe. They can be pulled into the tube and ends can be sealed with a set of pallets. The mollusk's two tiny valves are inside the tube along with the mantle, intestines, and other soft organs. Inside this mollusk wood also forms a circular tunnel in its cross-section and is coated with calcareous material produced by the mollusk (Figure 5). The larger species of sea woodwork, which also lives in dead mangrove trunks, is often called “Tembelo” by the people of Eastern Indonesia and can be consumed.

Fig. 5 *Bactronophorus* sp. (left image: body morphology; right image: Tunnel in log) [15]

4. Conclusion

Four species of mangrove wood-borer were found in the Nusa Lembongan Mangrove Forest. Two species were found in the larvae phase, namely *Phaenops* sp. from the beetle (Coleoptera) group, the host plant is dead mangrove stems from *Rhizophora apiculata*, *Sonneratia alba* and *Cenoloba* sp. is a group of moths (Lepidoptera), whose host plant is the dead stems of the mangrove *Sonneratia alba*. Two species from the mollusk group, namely *Bankia minima*, whose host plant is dead stem from the mangrove *Sonneratia alba*, *Rhizophora*, *apiculata*, *Rhizophora stylosa*, *Avicennia* sp. and *Bactronophorus* sp., the host plant is dead wood from the mangrove *Sonneratia alba*, *Rhizophora apiculata*. *Bankia minima* is the most widely distributed species among the mangroves of Nusa Lembongan. Research on the existence of marine wood-borers in mangrove ecosystems in Bali has never been reported before, so the discovery of wood-borers,

namely, two species from the mollusk group and two species from the insect group, is a recent finding.

Acknowledgments

We would like to thank the Research and Community Service Institute of Udayana University, for funding research through the Foreign Cooperation Research Grant scheme. Thanks to Abdi Janaguna, Sugiyama, Adianto Wibisana and Made Goura Premananda for their assistance in field sampling.

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