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Ecology, species composition and potential application of the enzyme extraction of marine wood borer from mangrove forest of Borneo

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PREFACE

Final report with title **Ecology, species composition and potential application of the enzyme extraction of marine wood borer from mangrove forest of Borneo** was from the result of the research. This research was founding by DIPA SEAMEO BIOTROP. The duration of research was from March 21, 2018 until December 1, 2018. Inventory of marine wood borer from mangrove forest in three location, in West Kalimantan, Indonesia; Sarawak and Sabah Malaysia. Location in mangrove forest in West Kalimantan were Mempawah Mangrove Park, Pasir village in Mempawah Regency, Polaria Mangrove Park, Mendalok village in Mempawah Regency, and Setapok Mangrove Park, Setapuk village in Singkawang City. Location on Sarawak was mangrove forest of Asajaya Sarawak, Malaysia and mangrove forest of Murudu Bay, Kota Kinabalu, Sabah, Malaysia. Research team was grateful for SEAMEO BIOTROP and all the people who help the research.

Pontianak, 1 December 2018

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CONTENT

List of Figure

LIST OF TABLE

ABSTRACT

Marine wood borer has important role in mangrove forest as decomposer. The diversity, ecology and distribution of marine wood borer in Kalimantan Island which has many mangrove forest areas has comprehensive study was ever carried out. This research aimed to investigate the ecology, biodiversity and distribution of marine wood borer. The locations were at West Kalimantan Indonesia, Sarawak Malaysia and Sabah Malaysia. The locations in West Kalimantan consist of Polaria mangrove forest (PMF) in Mendalok village, Mempawah Regency and Mempawah mangrove forest (MMF) in Pasir village, Mempawah Regency, Setapok Mangrove Park in Setapok village, Kota Singkawang. Meanwhile in Sarawak the location was at Asajaya Mangrove Forest and in Sabah was located in Teluk Murudu Kota Kinabalu. All the Infested log in each mangrove forest area were collected and dismantled. All specimen was collected and identification. The ecology data consist of vegetation, soil characteristics (pH, C-organic and soil texture) and water characteristics (salinity, pH, Biological oxygen demand, and dissolved oxygen and chemical oxygen demand).. The results showed that biodiversity of marine wood borer consist of *Teredo navalis, Teredo pocalifer, Teredo tritubulata, Teredo calmani, Teredo medilobata, Teredo siamens, Teredo utriculus, Teredi batiliformais, Teredo dagmarae, Teredo brevis, Teredo dallii, Neoteredo reynei, Bankia caribbea, Bankia fimbriulata, Bankia minima, Bankia setacea, Martesia striata,*and *Petricola pholadiformis.* The marine wood borer consist of three family, Teredinidae, Pholadidae and Lymnoridae. The soil characteristics on C-organic content was 1.75% - 2.39%; pH was 7.59 - 8.50; sand 0.60% - 16.39%; silt 55.65% - 57.41% and clay 43.33% - 43.13%. Water characteristics on salinity was 6.55- 10.5; Dissolved Oxygen was 4.74 - 5.59; pH was 7.31- 8.33; Biological Oxygen Demand was 4.74 mg/l - 8.47 mg/l and Chemical Oxygen Demand was 512.3 mg/l - 600 mg/l . Marine wood borer was degradation the wood by enzymes. The wood which attack by marine wood borer was mostly high on holocellulose and alpha cellulose values. The conclusion of research the marine wood borer diversity in Kalimantan Island was high and distribution was achieved along the West Kalimantan, Sarawak and Sabah. The potential development of use marine wood borer as edible food and other uses was high.

1. Introduction

1.1. Background

Marine wood borer commonly knowns as shipworms or teredinids occurs in almost aquatic ecosystems such as in marine and brackish water ecosystem in temperate and tropical zones. Although many studies on the species composition of marine wood borer have been conducted at various location in Peninsular Malaysia, however, there has been no detailed study undertaken to examine the species composition of marine wood borer such as in Borneo particularly in Sabah and Sarawak in Malaysia and in Kalimantan, Indonesia. Information on the distribution of marine wood borer species in Borneo Island coastal waters is scarce. Recent study has shown that new species of marine wood borer were found in Philippines and Australian waters. Thus, there was an urgent need to examine the fauna diversity inhabiting mangrove habitats. The scientific baseline data obtained from the study would provide in depth understanding of the current fauna diversity status for better future conservation and management initiatives particularly in Borneo.

The ecology and distribution of marine wood borer species in the coastal area of Borneo and the factors controlling their species composition and distribution is also poorly known. Studies by Pearson and Dawson (2003) and Borges et al. (2014a,b,c) shown that certain environmental factors are known to control the species composition and distribution of marine wood borer. Temperature and salinity have been recognized to be the most important environmental factors that influenced the abundance and geographical distribution of marine poikiloterms (Gogina and Zettler, 2010). The environmental requirements for marine wood borer that potentially influence the geographic distribution and species composition in Borneo Island have not been investigated in details.

Shipworms or Teredinidae is comprised largely of wood-boring species with wide-ranging economic and ecological impacts in coastal marine systems (Turner, 1966; Weigelt et al., 2016). The teredinid's ability to bore into and digest wood is estimated to cause billions of dollars in damage per year to coastal development. Although often considered pest species, teredinids play fundamental roles in carbon cycling in marine and brackish environments by degrading lignocellulose in floating or deposited wood and in the wood of living mangroves (Voight,

2015). Furthermore, marine wood borer such as *Teredo* sp has developed secret enzymes (cellulases and nitrogenases), which breaking down the cellulose and fixing nitrogen to build amino acids digest cellulose and hemicellulose. Some studies have shown that the enzymes have been applied as a major ingredient in most laundry detergents for cleaning efficiency. In addition, the *Teredo* sp. represent a rich source of lingo cellulolytic enzymes that can be harnessed for conversion of biomass into simple sugars for a variety of uses including bioethanol/biofuels. Examining the *Teredo*-derived cellulases component that possibly have a potential for new cosmetic and beauty product should also be evaluated. We hope that some of the enzymes we are working on can be applied in pharmaceutical industrial especially for new cosmetic and beauty product.

Although, there is no known commercial value for the marine wood borer, the shipworm however, is often used for food by the Australian aborigines. The Teredo worms from families Teredinidae make a special Philippine delicacy called “tamilok”, appreciated by the natives of Palawan Island and Aklan Province of Panay Island. In Sarawak, Malaysia this can be eaten fresh and now can be found sold in the market RM 12 per packet. This indicated that although this marine wood borer mainly known as pest, but it has a potential for edible seafood for local communities. With the increasing population, the demand for fish as a food source is growing. Thus, the shipworm has a great potential as exotic and edible food for local communities.

1.2. Objectives

The aims of this study were to:

i- Investigate the diversity, distribution and species composition of marine wood borer in mangrove are of Borneo

ii- Determine the environmental factors that influence the species composition, abundance and distribution of marine wood borer.

iii- Examine the cellulose and hemicellulose component in the wood borer that possibly have a potential to applied in pharmaceutical industrial such as for new cosmetic product.

iv- Promote the potential of marine wood borer as edible and exotic seafood for local communities

1.3. Expected Output

i-Novel theories/New findings/Knowledge

This study will be the first to examine the ecology, distribution and species composition of marine wood borer from different location in Borneo island and will be among the pioneer research to examine and to extract enzyme from marine wood borer for the application in pharmaceuticals and cosmetic industry.

ii- Research Publications

Three (3) scientific papers will be published in local and international indexed journals.

iii-Specific or Potential Applications

The study of the ecology, distribution and species composition of marine wood borer population from different location in mangrove can be used to determine the new record or species and also to identify the invasion of alien species of marine wood borer in the coastal area of Borneo Island.

The data on physicochemical parameter analysis can be used to identify the main environmental factors that generally influence the geographic distribution and species composition of marine wood borer in Borneo. Enzyme extraction developed through this project can be utilized for subsequent studies of the potential application as the new natural resources in pharmaceuticals and cosmetic industry.

iv-Number of PhD and Masters (by research) Students

One MSc student by research will be involved and trained in this project.

v-Impact on Society, Economy and Nation

Survey of marine wood borer organism in a mangrove area helps in documentation of the spread and activity of the biodeterioration, besides furthering knowledge on the ecology of borers which is a prerequisite to evolve timber damage control strategies. This information may assist researchers and governments authorities concerned with service life and protection of wood in the marine. With the increasing population, the demand for fish as a food source is growing. The marine wood boring/shipworm have a great potential as cheap sources of protein and edible food for local communities. Further application in enzyme extraction of the new potential resources in pharmaceuticals and cosmetic industry and also as edible food may generate better income for economic development.

2. State of the art of the research

Mangroves habitats are consistently undervalued degraded and are being lost at an alarming rate due to human activities. Huge area of mangrove forest has been lost from Southeast Asia due to population expansion and human activities such as wood extraction, conversation to agriculture and aquaculture pond, salt production, mining and through pollution from coastal industrialization and urbanization (Zakaria and Rajpar, 2015). For instance, the mangrove forest in Malaysia decreased 12% between 1980 and 1990 (Splading, 1997) and 75% in Sulawesi, Indonesia (Nurkin, 1994). However, the mangrove ecosystems play a significant role in providing suitable habitats for flora and fauna, breeding and nurseries grounds for a diversity of fishes and shellfishes and also ideal foraging grounds for animals such as fishes, birds and aquatic invertebrates and refuge from predators (Hamdan et al., 2012; Goessens et al., 2014; Zakaria and Rajpar, 2015).

Marine wood borer or shipworm are responsible for wood deterioration in marine and mangrove ecosystem (Singh, 2012). These species are grouped into two classes; Bivalvia from family Teredinidae and Pholiadidae and Crustacea from Family Limnoriidae and Cheluridae (Singh, 2012; Turner, 1971). According to Turner (1971) fourteen genera of Teredinidae occur worldwide and only four are common in Malaysian water (*Teredo,Lyrodus, Nausitora and Bankia*) (Eaton 1982, Singh, 1991;2012).

Teredinidae is comprised largely of wood-boring species with wide-ranging economic and ecological impacts in coastal marine systems (Turner,1966; Weigelt et al.,2016). There are currently 72 known species of the Teredinidae family, and these are distributed throughout the seas and oceans around the world (Bouchet, 2013). Numerous researchers have conducted field surveys and observations on the species composition habitat and distribution marine wood borer populations around the globe. This includes those in European Coastal Water (Borges et al., 2012; 2014a,b,c; Lopes et al., 2014; Toth et al., 2016), Baltic Sea (Appelqvist and Toth, 2014), eastern Mediterranean Sea (Shipway et al., 2014), Venezuelan coastal water (Lopez, 2016); Brazalian coast (Rocha et al., 2013), eastern Australia (Macintosh, 2012), Caribbean mangroves (Davidson et al., 2016) and in Peninsular Malaysia (Singh, 2012; Roszaini and Salmiah, 2015). For instance, Borges et al. (2012) found six species of marine wood borer established in European Coastal waters. Velásque and López (2015, 2016) have record the occurrence of two species of Teredinidae in Venezuelan coastal water. In addition Borges et al (2014b) have recorded the warm water shipworm *Teredo bartschi* Clapp in southern Turkey.

A total of 30 species of bivalves in 18 families and 19 species of gastropods in 15 families were recorded in Peninsular Malaysia (Singh, 2012). Roszaini and Salmiah (2015) identified nineteen species of marine wood borers of which 11 species were from the family Teredinidae. However, information on the same marine organisms from Borneo such in Sabah, Sarawak and Kalimantan and surrounding areas is still lacking. Only a few studies have been carried out in Sarawak and Brunei in last 10 years (Yahya, 2004; Pangiran 2007; Hossain and Bamber (2013). A total of 13 families of marine wood borer were found by Pangiran (2007) in Lundu coastal water of Sarawak. Hossain and Bamber (2013) found a new record of wood boring isopod, *Sphaeroma terebans* from Brunei estuary. Recently, Distell et al. (2017) found the giant shipworm, or *Kuphus polythalamia*, live inside large shells on the seafloor and grow to a length of more than five feet in Philippines waters. Inventory of marine wood boring animals in mangrove and coastal area will support in documentation of the spread and activity of the deteriogens, besides furthering knowledge on the ecology of borers which is a prerequisite to evolve timber damage control strategies (Voight, 2015).

The activity of marine wood-borers causes great destruction in maritime wooden structures. The capability of teredinid to bore into and digest wood is estimated to cause billions of dollars in damage per year to coastal constructions, such as piers, jetties, wharfs, fishing and aquaculture equipment (Borges et al., 2014a,b; Weigelt et al., 2016). Many studies on wood resistance and wooden material deterioration to marine borer have been conducted (Sivrikaya et al., 2012; Borges 2014a; Kluppel et al., 2014; Lopes et al., 2014b; Slevin et al., 2015; Roszaini and Salmiah, 2015; Davidson et al., 2016; Rao et al., 2016;). Davidson et al. (2016) found that boring isopods (*Sphaeroma terebrans*) frequently bore into root tips of mangroves causing atrophy, which can alter the structure and extent of mangrove habitat. Roszaini and Salmiah, (2015) revealed that the threat to five timber species in Peninsular Malaysia are caused by molluscans (Teredinidae and Pholadidae) with slight attack by crustaceans (Sphaeromatidae and Limnoriidae).

Several methods have been developed to protect the wood exposed in the sea against marine borers (Borges, 2014). For instance, the chemical modification of wood for use in the marine environment has been developed to control the vulnerable attack by groups marine wood-borers, which are voracious consumers of wood (Betcher et al., 2012; Lopes et al., 2014). It is vital to evaluate the threat posed by marine wood-borers in mangrove area. A better understanding of wood degradation mechanisms used by marine wood borer may lead to the development of more specific treatments to control

biodeterioration. Thus, a clear understanding of digestion in wood boring animals is required.

Several environmental factors have been identified influence on marine wood-borers. A few researchers such as Singh (2012), Tyberghein et al. (2012), Borges (2014), Borges et al. 2014a; Roszaini and Salmiah (2015) have shown that water salinity and temperature, pH and dissolved oxygen played a major role in terms of marine borer intensity and distribution in the coastal and mangrove areas. The service life of wood in the sea is dependent on marine borer species, water temperature, pollution and depth of immersion of specimens (Cragg et al., 2001; Brown et al., 2003). Leonel et al. (2006) suggested that teredinids prefer the same salinity range as the mangrove species into which they bore most often. According to Borges (2014), salinity and temperature emerged as the environmental conditions that best explain the occurrence and abundance of wood boring species in the sites surveyed.

Borges et al. (2012) and Weiglt et al. (2016) investigated the molecular taxonomic and identification of common shipworm from different location in Europe. Weiglt et al. (2016) found that the samples of *Teredo navalis* from six areas in Europe and North America represent a single species. However Yahaya (2004) and Pengiran (2007) found 11 and six species of Teredinidae from Blungei Bay and Sematan mangrove area in Sarawak respectively.

Marine wood borer or shipworms are wood-feeding bivalves that harbor cellulolytic bacteria in their digestive system (Inoue, 2014). These boring organism which have a close association with tropical mangrove plants represent a rich source of potential lingo cellulolytic enzymes that can be harnessed for conversion of biomass into simple sugars and other monomers for a variety of uses (Bosireet et al., 2013). Several studies on the enzyme isolation and extraction found that ligninolytic enzymes can be applied in bio bleaching of pulp and decolouration of textile dyes, whereas cellulolytic and hemicellulolytic enzymes can be used such as in animal feed, manufacture of bread and bioethanol production (Alias et al., 2010; Betcher et al., 2012;, Bosire et al., 2013; Eborall, 2013; Inoue et al., 2014).

The information of the digestive strategies used by wood borer such as *L. quadripunctata* could also be applied to the degradation of lignocellulose, and provide a novel source of enzymes which could be used to degrade this recalcitrant substrate (Malyon, 2011). Honeina et al. (2012) studied new endogenous genes encoding cellulose-degrading enzymes from the shipworm and found five newly identified genes

showed a significant alignment to endoglucanases, enzymes that arbitrarily break-up -1,4-glycosidic linkages within the amorphous regions of cellulose, weakening the structure of cellulose. Inoue et al. (2014) had isolated 197 bacterial strains associated with the shipworm *Teredo navali*s and 47 bacterial strains from wood particles around shipworms suggesting that shipworms are rich reservoirs of novel cellulolytic bacteria in extreme environments. There is still lack of data and analysis relating to enzyme production by marine wood borer species that can be applied for human such as in pharmaceutical and the cosmetic industry. However, recent finding by local researcher from Universitas Bangka Belitung has shown that extracted glicogen from Temilok Clams (*Bactronophorus thoracites*) can be used to detect DNA material in human bone (Bangkatribune, 2016).

There are no specific studies on the importance of marine wood borer or locally known as kerang temilok for economically valuable. The shipworm is often used for food by the Australian aborigines (Gardner, 2013). The teredo worms from families Teredinidae make a special Philippine delicacy called tamilok, appreciated by natives of Palawan Island and Aklan Province of Panay Island (Paynesville Maritime Museum 2016). In Sarawak, Malaysia, local communities from various ethnic this can be eaten fresh and now can be found sold in the market RM 12 per tin. (Borneopost, 2015). Recently, local researcher in Bangka, Indonesia found that marine wood borer such as *Bactronophorus thoracites* contains high economic value (Bangkapost, 2016). The glycogen that is extracted from the Temilok Clams is useful for the police forensic investigation.

3. Methods

3.1. Description of study area

The study will be carried out for a period of 24 months (January 2018 to December 2019) in mangrove forest at three locations namely Asajaya Mangrove Forest in Sarawak and Marudu Bay in Sabah, Malaysia and Mempawah Mangrove in Pontianak, Kalimantan. All sampling locations will be determined and relocated with a differentially corrected Global Positioning System (GPS) receiver (Model Garmin, GPS 76, SN 80308437, Olathe USA).

3.2. Wood Borer sampling

The survey of marine wood borer species will be conducted in an area measuring 100 m by 50 m delimited at the mangrove in three locations in Sabah, Sarawak and Kalimantan. Each area will be divided into 10 adjacent; parallel transects measuring 10 by 50 m. On each sampling occasion, a three transect within each area was chosen randomly and searched for logs. The criteria for transect was at least consist of two species of mangrove trees and suitable habitat for marine wood borer. All logs measuring between 18 and 23 cm in circumference were marked and numbered in situ and of these 10 were randomly selected for examination. The selected logs were cut so as to measure 30 cm in length. The logs will be opened carefully and boring organisms will be removed with a forceps.

The morphological and ecological characteristics of the boring organisms will be recorded and photographed in their natural habitats. After removal of the specimens from wood, the samples will be washed through a sieve with 0.5 and 1 mm mesh size and will be transferred into containers with alcohol of 70%. Samples collected in the local area will be carried to the laboratory for further investigation. Fresh samples for enzyme analysis will be keep it in dry ice before storing in freezer for further analysis Morphological description and taxonomic identification of the marine wood borer specimens will be based on the diagnostic characters of the pallets, using the keys of Turner (1966); Turner (1971), Hayward and Ryland (1990), Ozturk and Cevik (2000), Didziulis (2007), Clemam (2009) and Castello (2011).

All specimens belonging to bivalves and gastropods will be deposited based on the location of samples collected at Fakultas Kehutanan, Universitas Tanjungpura, Pontianak, Faculty of Resources Science & Technology, Universiti Malaysia Sarawak, Sarawak and Borneo Marine Research Institute Universiti Malaysia Sabah.

3.3. Physicochemical water parameters

A set of basic physicochemical water parameter variable including temperature, pH, dissolved oxygen and salinity will be measured at all sites during each sampling period. Measurement of physical water quality parameters such as pH, temperature (°C), dissolved oxygen (D.O) (mg L–1), and salinity (ppt) will be determined *in situ* using Water Quality Multiprobe. Soil in the each transect sampling will collect and analyze the texture at Laboratory of Soil Nutrition at Tanjungpura University.

3.4. Standard Protein/enzyme Extraction Protocol

The standard protocol for protein extraction as described by Heinis et al. (2002); Bisswanger 2012, Chen et al. (2015) and Patel et al. (2015) are followed:

a. Preparation of crude extracts:

Efficient extraction of the total protein from the starting material is vital for success of any purification procedure. Complete disruption of cells and release of contents from cellular debris is the most important step in the process. For purification of proteins in the native state, the first step involves the extraction of bulk protein fraction. All steps in the procedure will be carried out at 4ºC to minimize protein degradation. Protein extraction will be carried out by lyophilizing the liquid culture at -70 ^{o}C for overnight or snap frozen the liquid in liquid nitrogen and ground to powder form using mortar & pestle. The lyophilized liquid powder is then resuspended in 10 volumes of an extraction buffer (50 mM Tris-HCl, pH 7.5, 0.1 mM EDTA, 1 mM β-mercaptoethanol or dithiothreitol) and the mixture is stirred for 45 min in the cold room. The presence of EDTA serves to inhibit protease action and β-

mercaptoethanol (or DTT) is necessary for maintenance of a reducing environment.

This slurry is homogenized using a glass homogenizer and the homogenate is centrifuged at 12 000 x g for 20 min (to remove cellular debris) in a refrigerated Centrifuge. The pellet will be discarded and the supernatant is used in subsequent steps. At this stage it may prove helpful to add a mixture of protease inhibitors (Complete cocktail: Roche or Sigma) if the target protein is suspected to be unstable. [Note: Nucleic acids can be removed from the extract by addition of protamine sulfate to a final concentration of 0.2%, while stirring. The precipitated nucleic acids are removed by centrifugation. For most purposes, nucleic acid removal is not necessary; the precipitate may also bind the protein of interest.

b. Precipitation of proteins:

Several methods are available for precipitation of proteins utilizing changes in pH and temperature, or addition of salts and organic solvents. Ammonium sulfate is the most commonly used precipitant for salting out of proteins.

At saturation (3.9 M at 0 ^{o}C and 4.04 M at 20 ^{o}C) it precipitates most proteins and protects proteins in solution from denaturation and bacterial growth. To the supernatant from step 31, sufficient solid $(NH_4)_2SO_4$ (Ultrapure reagent or Enzyme grade) will be added to achieve 40% saturation. To avoid surface denaturation, the solution should not be stirred vigorously and $(NH_4)_2SO_4$ should be added gradually, in small amounts, allowing each successive batch to dissolve completely before addition of the next. The precipitated protein will be removed by centrifugation at 12 000 x g for 10 min and to the supernatant more $(NH_4)_2SO_4$ will be added to yield 80% saturation. The fraction of precipitated proteins between 40 and 80% saturation will be recovered by centrifugation, resuspended gently in 5 to 10 ml of a suitable buffer (e.g. 20 mM Tris-HCl, pH 7.5, 20mM NaCl, 10 mM $MgCl_2$) and dialyzed in the cold room against several, 4-L changes of the same buffer over a 16-h period to remove residual $(NH_4)_2SO_4$. The dialyzed suspension is then will be centrifuged at 12 000 x g for 10 min to remove insoluble particulate matter and the supernatant is tested for the presence of the target protein.

c. Hydrolytic enzyme qualitative plate assays:

Amylase assay:

"Starch agar" Composition of starch agar medium in g/l (prepared): KNO_3 0.5, K_2HPO_4 1, $MgSO_4$. $7H_2O$ 0.2, $CaCl_2$ 0.1, $FeCl_3$ traces, potato starch 10, Agar 15, dH_2O 1000 ml. Mix, check the pH (should be 7.2) and autoclave.

Lugol iodine solution: 1 g crystalline iodine, 2 g KI, 300 ml dH_2O (prepared) as follow:

a) Pour 14 ml of sterile starch agar medium into a Petri dish
b) Let the agar solidify
c) Label the starch agar plate with the name of the amylase enzyme to be tested
d) Streak a drop of the enzyme supernatant onto the starch agar plate
e) Leave it for 10 to 15 mins
f) Flood the plate with Lugol solution
g) Let the iodine react for at least 1 min
h) Pour off the iodine from the plate
i) Wash the plate with dH_2O.

Results:

If starch is present in the agar, a blue-black color will appear: the test result is negative (i.e. hydrolysis of the starch did not take place).

If the starch has been hydrolyzed by the excreted amylase, a clear zone around the enzyme drop will appear. The test result is positive.

Protease assay:

"Skim milk agar" Mix 1 g of agar will be suspended in 50 ml dH_2O with 5 g skim milk powder will be suspended in 50 ml dH_2O to make 100 ml "skim milk agar"; pH = 7.2. Autoclave and pour plates

a) Pour 14 ml of sterile skim milk agar medium into a Petri dish
b) Let the agar solidify
c) Label the agar plate with the name of the protease/caseinase enzyme to be tested
d) Inoculate the plates with one drop of the enzyme supernatant

e) Incubate the plates for 10 to 15 mins

f) Visible inspect the plates for clear zones around for protease/caseinase-positive.

Cellulase assay:

Congo-Red agar media with the following composition: KH_2PO4 0.5 g, $MgSO_4$ 0.25 g, carboxymethylcellulose 2 g, agar 15 g, Congo-Red 0.2 g; distilled water 1 L and at pH 6.8–7.2. The use of Congo-Red as an indicator for cellulose degradation in an agar medium provides the basis for a rapid and sensitive screening test for cellulolytic enzyme activity. Enzyme drop showing discolouration of Congo-Red is taken as positive cellulose-degrading supernatant.

Results:

If CMC is present in the agar, an orange red color will appear: the test result is negative (i.e. hydrolysis of the starch did not take place).

If the CMC has been hydrolyzed by the excreted cellulase, a clear zone around the enzyme drop will appear. The test result is positive.

3.5. Data analyses

Descriptive statistics including minimum and maximum values, means and standard deviation of pH, Dissolved Oxygen (D.O), water temperature (ºC), and salinity from each survey station will be calculated. Analyses of Variance (ANOVA) will be used to compare the differences in the physicochemical water parameters of all stations surveyed (Zar, 1996). Post-hoc Tukey Honestly Significant Difference tests were carried out to compare pairs of sample means from the three locations.

The relationship between physicochemical parameters and marine wood borer composition and distribution will be explained by correlation analysis. All statistical analyses will be done using SYSTAT Version 14.0. All significant differences are at $P < 0.05$, unless otherwise stated. The total bivalve sample for each sampling station will be analyzed in terms of total number of individual bivalve (N), the total number of individual species (SR), Species diversity (H') and Simpson's Index of Diversity (1 – D).

The presence–absence (1, 0) of marine wood borer species will be summarized by calculating pairwise Jaccard's coefficient of percentage faunal similarity: $J = [a/(a + b + c)] \times 100\%$; a is the number of species shared between any two regions being compared, b is the number of species found only in the first area, and c is the number of species found only in the second area (Rahel, 2000; Real and Vargas, 1996). Marine wood borer taxonomic similarity, among locations was summarized by clustering estimates of Jaccard's similarity coefficient (subtracted from 1.0 to generate a "distance" measure). Calculation of these statistics was produced by the method of average association (UPGMA, "arithmetic average clustering"), using Multivariate Statistical Packages (MVSP, Version 3.13), (Kovach, 2007).

4. Results and Discussion

4.1. Survey research location in West Kalimantan, Sarawak and Sabah

After signing the contract at BIOTROP SEAMEO, Bogor, on March 21, 2018, the research team held a meeting to prepare for the activities of the research. The research locations are in three provinces, namely West Kalimantan Province, Indonesia; The State of Sarawak, Malaysia and Sabah, Malaysia. The results of the meeting of the research team decided:

1. Preparation of documents and tools for research activities carried out in March 2018.
2. The initial survey for the location of the study was carried out in April 2018 and the activity of marine wood borer sampling was carried out in May, June and July 2018.
3. Initial survey at the research site in the Mempawah Mangrove Park mangrove forest in Pasir Village Mempawah Regency; Polaria Mangrove Park mangrove forest in Mendalok Village of Mempawah Regency; Setapok Mangrove Park mangrove forest in Singkawang City, West Kalimantan Province was conducted in April 2018 with the implementer was Dr. Farah Diba.
4. The initial survey at the study site in the Asajaya mangrove forest, Sarawak, Malaysia was carried out in April 2018 with the implementer was Dr. Khairul Adha A Rahim.
5. The initial survey at the study site in the mangrove forests of Teluk Murudu, Sabah, Malaysia was carried out in April 2018 with the implementer was Dr. Chen Cheng Ann.
6. The activity of marine wood borer sampling at the location of the Mempawah Mangrove Park mangrove forest in Pasir Village Mempawah Regency; Polaria Mangrove Park mangrove forest in Mendalok Village of Mempawah Regency; Setapok Mangrove Park mangrove forest in Singkawang City, West Kalimantan Province was held in May 2018. The research team consisting of Dr. Farah Diba and Dr. Khairul Adha A Rahim and assisted by field staff.
7. The activity of marine wood borer sampling at the Asajaya mangrove forest in Sarawak, Malaysia was carried out in May 2018. The research team consisted of Dr. Farah Diba, Dr. Khairul Adha A Rahim and Dr. Chen Cheng Ann and assisted by field staff.

8. The activity of marine wood borer sampling at the location of the Teluk Murudu mangrove forest, Sabah, Malaysia was conducted in July 2018. The research team consisted of Dr. Farah Diba, Dr. Khairul Adha A Rahim and Dr. Chen Cheng Ann and assisted by field staff.
9. Analysis of ecological data, physical chemical properties of water and soil conditions and identification of marine wood borer carried out from May to August 2018.
10. Writing progress reports in July 2018. Writing the final report in November 2018.
11. Writing papers for publication in international journals is carried out in August 2018 to November 2018

Survey location studies in West Kalimantan, Indonesia, Sarawak, Malaysia and Sabah Malaysia were carried out for the process of permit research and selection of sampling plot locations. Survey activities to the research locations as follows:

1. Survey the location of the study in the Mempawah Mangrove Park mangrove forest in Pasir Village Mempawah District, West Kalimantan Province

   Site surveys were carried out to process research permits and to determine the location of research plots for sampling marine wood borer. Licenses were made to Mempawah Mangrove Park staff, Mr. Gorianto. He allowed research activities and assisted in showing potential areas as research sites for sampling marine wood borer. Mempawah Mangrove Park is a mangrove forest area managed by the community in Pasir Village in Mempawah Regency. Villagers get assistance from Bank Indonesia for the management of facilities and infrastructure and that the forest area becomes an ecotourism area that is widely known by the people of West Kalimantan. Every day there is always a community visit to the Mempawah Mangrove Park forest area, both from elementary, junior high, senior high school students as well as students from universities and the general public. The manager of Mempawah forest area Mangrove Park is currently developing a business of cultivating kelulut honey and trying to produce honey kelulut as a superior product from Mempawah Mangrove Park.

Figure 1. Entrance gate to Mempawah Mangrove Park in Pasir Village, Mempawah District, West Kalimantan Province, Indonesia

2. Survey location of the study in the Polaria Mangrove Park mangrove forest in Mendalok Village, Mempawah Regency, West Kalimantan Province

   Site surveys were carried out to process research permits and to determine the location of research plots for sampling marine wood borer. Licensing was carried out to Polaria Mangrove Park staff, namely Mr Mahrani. Polaria mangrove forests are managed by communities in Mendalok Village and are ecotourism attractions that are a source of income for villagers. Lots of places to do selfie photos at the location of the Polaria Mangrove Park mangrove forest and game locations for children have been built. Mr. Mahrani allowed research activities and several of his staff assisted in showing potential areas as research sites for sampling marine wood borrow worms. The Polaria area of Mangrove Park is always visited by students, as well as the general public. The condition of the Polaria Mangrove Park area on Saturday and Sunday is very crowded with the general public. Zonation of mangrove forest was already established and there are three main constituents, namely *Avicennia* sp (Api-api), *Rhizophora* sp (Bakau) and *Bruiguir*a sp.

Figure 2. Entrance gate of Polaria Mangrove Park in Mendalok Village, Mempawah District, West Kalimantan Province, Indonesia

3. Survey the location of the study in the Setapok Mangrove Park mangrove forest in Singkawang City, West Kalimantan Province

   Site surveys were carried out to process research permits and to determine the location of research plots for sampling marine wood borer worms. Licenses were made to Mr Jumadi, chairman of the non-governmental organization Surya Perdana Mandiri, which manages Setapok Mangrove Park, in the Singkawang Utara Village, Singkawang City. The Setapok mangrove forest has 9 hectares of land and is managed independently by a fishing community group in Setapok. Currently the community focuses on rehabilitation and planting of *Rhizophora mucronata* seeds. Mr. Jumadi allowed research activities and he assisted in showing potential areas as research sites for sampling marine wood borer. Access to the Setapok Mangrove Park forest area can only be reached by two-wheeled vehicles. Four-wheeled vehicles have not been able to get to the location because the condition of the bridge is not strong for the load of four-wheeled vehicles. However, every Saturday and Sunday the Setapok Mangrove Park area is always crowded with people, not only from the people of Singkawang City but also from other cities and regencies in West Kalimantan Province.

Figure 3. Entrance gate of Setapok Mangrove Park in Setapok Village, Singkawang City, West Kalimantan Province, Indonesia

4. Survey the study site in the Asajaya mangrove forest, Sarawak, Malaysia

   Site surveys were carried out to process research permits and to determine the location of research plots for sampling marine wood borer. Licensing is carried out to the management of the Asajaya forest, Sarawak, Malaysia. The Asajaya mangrove forest has two areas, higher intertidal zone and lower intertidal zone. The location of marine wood borer sampling will be carried out in the highland mangrove forest area and the lowland mangrove forest area. When conducted research for sampling marine wood borers, its must adjust to the river water level because the Asajaya River often has high tide. The dominant vegetation in Asajaya mangrove forest is *Avicennia* sp (Api-Api).

Figure 4. Asajaya Mangrove Forest, Sarawak, Malaysia

5. Survey site research in the mangrove forests of Teluk Murudu, Sabah, Malaysia

   Site surveys were carried out in the mangrove forests of Teluk Murudu, Sabah, Malaysia to process research permits and locate the research plots for sampling marine wood borer. Licensing is done to the management of the Teluk Murudu forest, Sabah, Malaysia. The sampling location at the mangrove forest area is located in the Menggatal River area, Murudu Bay, Kota Kinabalu, Sabah.

Figure 5. Mangrove Forest of Teluk Murudu, Sabah, Malaysia

4.2. Sampling of Marine Wood Borer at Asajaya Mangrove Forest, Sarawak Malaysia

Sampling of species marine wood borer in Asajaya mangrove forest, Sarawak, Malaysia was carried out on 3 - 6 May 2018. Sampling locations were carried out in two mangrove forest areas, including higher intertidal zone and lowland mangrove forest areas (lower intertidal zone). All the research teams were conducted the inventory sampling, i.e. Dr. Farah Diba, Dr. Khairul Adha and Dr. Cheng Chen Ann. The activities were assisted by field research staff as well as students from Tanjungpura University and Malaysia University Sarawak.

A trip sampling from the Malaysia University Sarawak campus in Sarawak to Asajaya mangrove forest was carried out by traveling by car for two (2) hours and then continued by traveling through the river using 2 speed boats for 45 minutes. The mangrove forest that became the first sampling location was a higher intertidal zone and then continues to the lower intertidal zone.

Figure 6. Activities of sampling wood borer worms in the Asajaya mangrove forest, Sarawak, Malaysia

The sampling results found different species of marine wood borer between the high intertidal zones and low intertidal zones. The number of log sampled was 5 of wood logs in low intertidal zones areas and 7 of wood logs in the high intertidal zones area. The physical and chemical properties of water are measured in the field which includes salinity, pH, water temperature and dissolved oxygen. Soils in high intertidal zones and low intertidal zones mangrove forests were taken and analyzed for the texture of the soil in laboratories at University Malaysia Sarawak. The number of soil samples was three samples from low intertidal zones mangrove forests and three samples from high intertidal zones mangrove forests. The marine wood borer samples obtained were then stored in sample bottles and taken to a laboratory at University Malaysia Sarawak for identification. The marine wood borer found were stored in sample bottles with 70% ethanol.

Figure 7. Collection of marine wood borer from the Asajaya mangrove forest, Sarawak, Malaysia

Figure 8. The research team sampled marine wood borers from the Asajaya mangrove forest, Sarawak, Malaysia

4.3. Sampling of Marine Wood Borer in the mangrove forest of Pasir village (Mempawah Mangrove Park) in Mempawah District, West Kalimantan Indonesia

Sampling of species marine wood borer in the Mempawah Mangrove Park mangrove forest in Pasir Village, Mempawah Regency was carried out on 9-11 May 2018. The location of sampling was carried out on the mangrove beach. The tree vegetation in the mangrove forest includes *Rhizophora mucronata, Candelia candel, Avicennia marina,* and *Bruguiera xylindrica*. The research team consisted of Dr. Farah Diba and Dr. Khairul Adha and assisted by field staff.

Figure 9. Sampling of marine wood borer from Mempawah Mangrove Park in Pasir Village Mempawah District, West Kalimantan, Indonesia

Marine wood borer in Mempawah Mangrove Park mangrove forest in Pasir Village, Mempawah Regency were found in two logs of *Rhizophora mucronata*. The first wood has a length of 220 cm with a diameter of 50 cm and the second wood has a length of 180 cm with a diameter of 35 cm. Wood is split by using an axe to collect marine wood borer. The results of the sampling were obtained by marine wood borer genus Teredo sp and Bankia sp.

4.4. Sampling of Marine Wood Borer at Polaria Mangrove Park, Mendalok village, Mempawah Regency, West Kalimantan, Indonesia

Sampling of species marine wood borer in the Polaria Mangrove Park mangrove forest in Mendalok Village, Mempawah District was conducted on 9-11 May 2018. The main vegetation was the *Rhizophora mucronata* tree, *Bruguiera xylindrica, Avicennia marina, Sonneratia ovata, Nypa fruticans. Avicennia officinalis,* and *Sonneratia alba*. The research team consisted of Dr. Farah Diba and Dr. Khairul Adha and assisted by field staff.

Figure 10. Sampling of marine wood borer from Polaria Mangrove Park in Mendalok Village Mempawah District, West Kalimantan, Indonesia

Marine wood borer are found in wood logs in the vegetation area of *Avicennia marina*. The logs are 285 cm long with a diameter of 65 cm from the type of Api-api wood. Several species of marine wood borer were found in the log. The second wood of the mangrove species is 245 cm long and 50 cm in diameter. After the wood was cleaved, it was found more than one species of marine wood borer. The results of the sampling were obtained by marine wood borer of the genus *Teredo* sp, *Martesia* sp and *Bankia* sp.

4.5. Sampling of Marine Wood Borer in Setapok village (Setapok Mangrove Park), Singkawang City, West Kalimantan, Indonesia

Sampling of marine wood borer species in the mangrove forest of Setapuk Village, Singkawang City was carried out on 11-13 May 2018. The journey from Pontianak City to Setapok mangrove forest in Singkawang City was taken by road trip for 4 hours. The Setapok mangrove forest has been managed by the Setapok Village community group for nine years. The research team consisted of Dr. Farah Diba and Dr. Khairul Adha and assisted by field staff.

Figure 11. Sampling of marine wood borer from Setapok Mangrove Park in Setapok Village, Singkawang City, West Kalimantan, Indonesia

The sampling locations were carried out on the edge of the mangrove beach. The dominant vegetation in the Setapok mangrove forest was *Rhizophora mucronata* Lamk and *Avicennia marina*. Logs are 120 cm long and 18 cm in diameter. There are not many types of marine wood borer, and are included in the genus of *Teredo* sp.

4.6. Sampling of Marine Wood Borer at mangrove forest of Teluk Murudu, Kota Kinabalu, Sabah, Malaysia

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Sampling of marine wood borer in the mangrove forests of Teluk Murudu, Kota Kinabalu, Sabah, Malaysia is carried out on July 24-28, 2018. The journey to Teluk Murudu mangrove forest is carried out by speed boat from University Malaysia Sabah campus for 60 minutes. The sampling location of the mangrove forest is located along the Menggatal River. The dominant vegetation is *Rhizophora mucronata, Avicennia marina, Bruguiera xylindrica, Sonneratia ovata, Sonneratia alba, Nypa fruticans.* and *Avicennia officinalis.*

Figure 12. Sampling of marine wood borer at mangrove forest at Teluk Murudu, Kota Kinabalu, Sabah, Malaysia

All the research teams sampled, Dr. Farah Diba, Dr. Khairul Adha and Dr. Cheng Chen Ann were assisted by field research staff and students from Tanjungpura University and the University Malaysia Sabah. Marine wood borer was found at three logs. The first log was 140 cm long and 18 cm in diameter. The second log was 190 cm long and 62 cm in diameter and the third log was 90 cm long and 20 cm in diameter. The type of marine wood borer found includes several species.

4.7. Identification of Marine Wood Borer found in Asajaya mangrove forest, Sarawak Malaysia

The ecological conditions of Asajaya mangrove forests, Sarawak, Malaysia were analyzed on soil and water. The dominant vegetation is *Avicennia marina, Sonneratia alba* and *Rhizophora mucronata*. The ecological characteristics of the Asajaya mangrove forest were assessed on water and soil in higher intertidal zones and lower intertidal zones. Vegetation in higher intertidal zones is dominated by *Avicennia marina* and vegetation in lower intertidal zones areas is dominated by *Nypa fruticans*.

Fgure 13. Vegetation of mangrove forest at Asajaya, Kota Sarawak, Malaysia

The composition of marine wood borer species in Asajaya mangrove forests in Sarawak Malaysia on higher intertidal zones and lower intertidal zone includes three families, namely Teredinidae, Pholadidae and Limnoridae. The Teredinidae family consists of *Teredo Navalis, Bankia fimbriatula, Dicyathifer manni,* and *Teredothyra matoconata*. The Pholadidae family consists of *Martesia* sp and the Limnoridae family consisting of *Limnoria* sp. The composition of marine wood borer species is presented in Table 1.

Table 1. Composition of marine wood borer at Asajaya mangrove forest, Sarawak, Malaysia

Family	Genus / species	Place and number	
		higher intertidal zone	*lower intertidal zone*
Teredinidae	*Teredo navalis*	53	105
	Bankia fimbriatula	26	19
	Dicyathifer manni	5	11
	Teredothyra matoconata	4	10
Pholadidae	*Martesia sp*	0	1
Limnoridae	*Limnoria sp*	0	1

4.8. Identification of Marine Wood Borer from mangrove forest of Pasir Village (Mempawah Mangrove Park) Mempawah Regency, West Kalimantan Indonesia

The identification of marine wood borer species in the mangrove forest of Pasir Village, Mempawah Regency was carried out in June 2018. The type found was *Teredo pocalifer* which belongs to the Teredinidae family. Marine wood borer are found on mangrove log located in observation plots. Mangrove wood measures 15 cm in diameter and 2 meters 35 cm in length. The wood was in humid conditions. Marine wood borer will attack damp wood. The process of collecting marine wood borer is by splitting mangrove wood with axes and taking marine wood borer inside the wood by using pinset. *Teredo pocalifer* the marine wood borer found in Mempawah Mangrove Park is shown in Figure 14.

Figure 14. Marine wood borer *Teredo pocalifer* from mangrove forest of Mempawah Mangrove Park, Mempawah Regency, West Kalimantan

The marine wood borer *Teredo pocalifer* from the mangrove forest of Mempawah Mangrove Park, Mempawah Regency, West Kalimantan have a length of 10 cm and a diameter of 1 cm. The shape of the marine wood borer palette or tail is used as a feature of identification of marine wood borer. Identification was carried out by comparing the shape of the marine wood borer palette with Turner (1966) and Turner (1971).

4.9. Identification of marine wood borer from mangrove forest at Mendalok Village (Polaria Mangrove Park), Mempawah Regency, West Kalimantan Indonesia

Identification of marine wood borre species in mangrove forest of Mendalok Village Mempawah Regency has more marine wood borer species than from mangrove forest in Mempawah Mangrove Park in Pasir Village. The species found included *Neoteredo reynei, Teredo pocalifer, Teredo navalis, Teredo tritubulata, Teredo calmani* and *Teredo medilobata* which belonged to the Teredinidae family. The marine wood borers found are shown in Figure 15.

Figure 15. Marine wood borer from mangrove forest at Polaria Mangrove Park, Mendalok Village, Mempawah Regency, West Kalimantan

Marine wood borer in mangrove forest of Mendalok Village Mempawah Regency, West Kalimantan has more species than marine wood borer in the mangrove forest in Pasir Village, Mempawah Regency, West Kalimantan. This can be caused by the condition of the vegetation in the mangrove forest in Mendalok Village with more species diversity compared to the vegetation in the mangrove forest in Pasir Village. The zonation of mangrove vegetation in Mendalok Village has been established and is divided into three zones. Meanwhile in the mangrove forest at Pasir village the zonation has not been formed. The vegetation of mangrove trees in the forest area influences the diversity of marine wood borer species.

4.10. Identification the marine wood borer at mangrove forest of Setapuk village (Setapok Mangrove Park), Singkawang City, West Kalimantan, Indonesia

Research is looking for wood that is attacked by marine wood borer in the mangrove forest in Singkawang City. Two woods were found in the mangrove forests of Setapuk Village, Singkawang City, namely *Avicennia marina* wood (Api-api putih) and *Rhizophora mucronata* wood (Bakau). Api-api putih wood has a length of 1 meter 85 cm with a diameter of 11 cm. Bakau wood has a length of 1 meter 55 cm with a diameter of 10 cm. Then the wood is cut into a size of 40 cm then split with an axa to remove the marine wood borer inside the wood.

In addition to wood from the mangrove forest area, the wood also searches from sero or fish ponds. This area was located about 4 miles from the Setapuk mangrove forest area. This is done based on information from the community that the wood used for ponds in the middle of the sea is mostly attacked by marine wood borer. Marine wood borer cause damage to wood and cannot be used as patches after 6-8 months from the first of installation. The wood taken from fish ponds is *Drybalanops rappa* (kayatan wood) and *Hopea mangarawan* wood (red sangai wood). The wood obtained is 4 meters in length 25 cm in length and 12 cm in diameter for kayatan wood and 4 meters in length 35 cm with a diameter of 14 cm for red sangai wood.

Identification of marine wood borer species from mangrove forest in Setapok Village, Singkawang City includes *Bankia caribbea, Bankia fimbriulata, Bankia minima, Teredo navalis* and *Martesia striata*. Identification of marine wood borer species from fish ponds in the middle of the South China Sea which

are 4 miles from mangrove forest in Setapuk Village include *Neoteredo reynes, Bankia setacea, Bankia minima, Teredo pocalifer, Teredo utriculus, Petricola pholadiformis, Teredo siamens, Teredo navalis, Teredo navalis, Teredo batiliformis, Teredo dagmarae, Teredo brevis, Teredo dallii*, and *Martesia striata*. Marine wood borer species found in wood originating from fish ponds are more abundant than wood in mangrove forests. This can be caused by the wood in the pond area is in the South China Sea area which is suitable habitat for marine wood borer. Location of marine wood borer sampling in Setapuk Village, Singkawang City is presented in Figure 16. The type of wood borer worm found is presented in Figure 17.

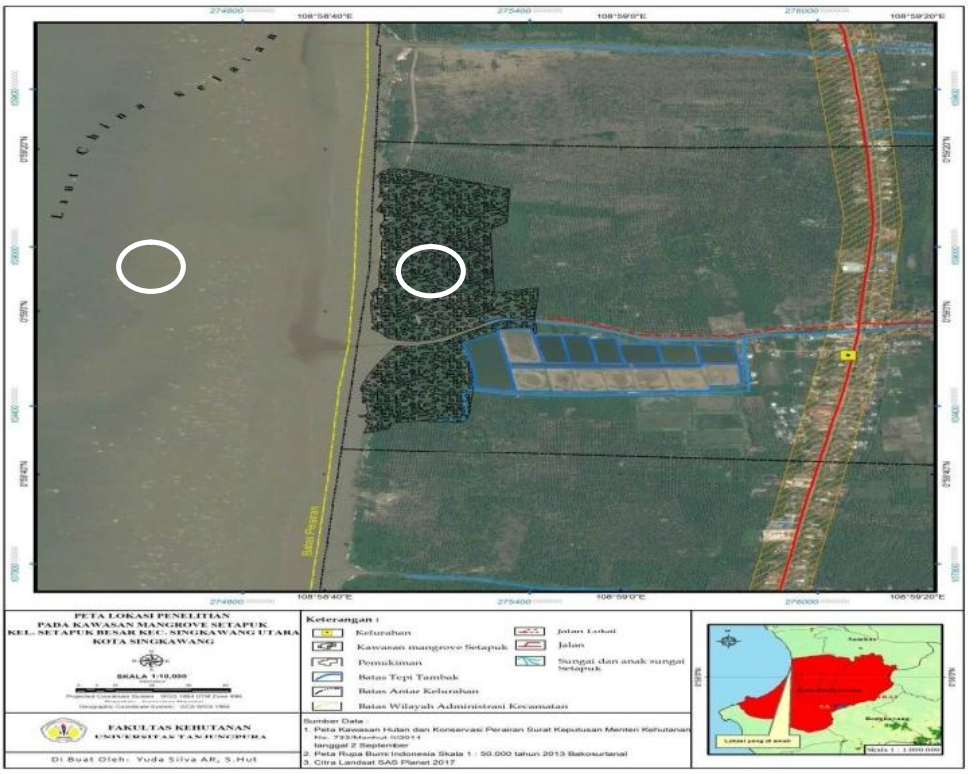

Figure 16. Location of sampling marine wood borer in Setapok Mangrove Park, Singkawang City, West Kalimantan

= Location of sampling in mangrove forest and In fish pond around 4 mil from mangrove forest

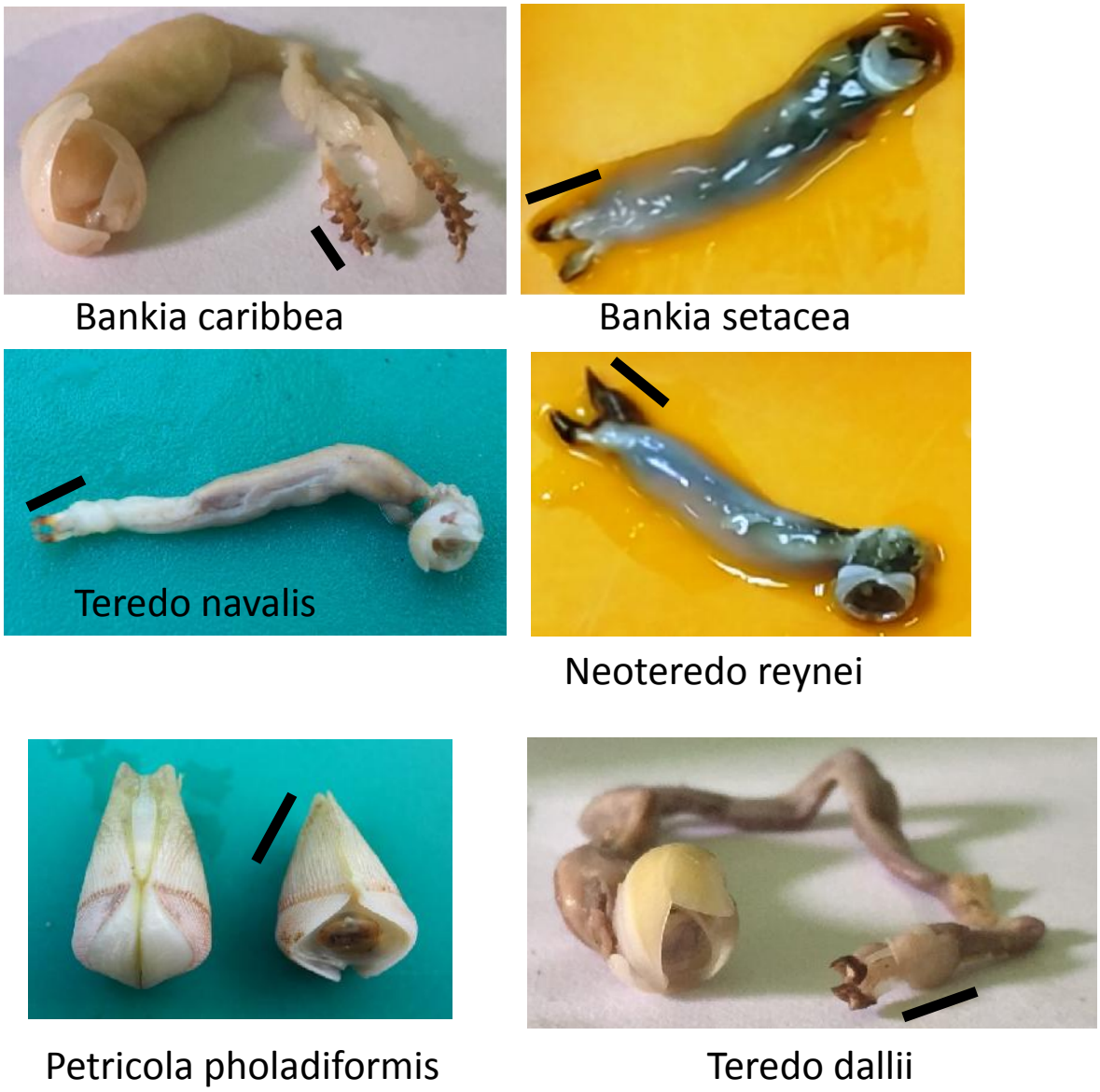

Figure 17. Marine wood borer found in mangrove forest at Setapok Mangrove Park, Singkawang City, West Kalimantan
= 10 mm

4.11. Identification marine wood borer from mangrove forest at Murudu Bay, Kota Kinabalu, Sabah, Malaysia

Identification of marine wood borer species from the mangrove forests of Murudu Bay, Kota Kinabalu, Sabah, found 12 species. Marine wood borer found in the Teredo and Pholadidae families. Marine wood borer species found in the mangrove forests of Murudu Bay, Kota Kinabalu, Sabah, Malaysia as follows: *Teredo lamyi, Bankia setacea, Neoteredo reynei, Bankia indica, Teredo diegensis,*

Teredo helleniusi, Bankia caribbea, Martesia striata, Lyrodus pedicellatus, Bankia minima, Teredo siamensis and *Teredo modosa*. The types of marine wood borer found are presented in Figure 18.

Teredo lamyi

Teredo diegensis

Bankia setacea

Teredo siamensis

Neoteredo reynei

Teredo helleniusi

Figure 18. Marine wood borer from mangrove forest at Murudu Bay, Kota Kinabalu, Sabah, Malaysia

4.12. Ecology and composition of marine wood borer in West Kalimantan, Indonesia, Sarawak dan Sabah, Malaysia

The aim of this study was to study the ecology and composition of species of marine wood borer in mangrove forests on the island of Borneo. The research location is located in three mangrove areas, namely in West Kalimantan, Indonesia, in the mangrove forests of Asajaya Sarawak and Murudu Bay, Kota Kinabalu, Sabah, Malaysia. The three mangrove forest locations are expected to be a source for identification of types of marine wood borer on the island of Borneo. The location of the research activities is presented in Figure 19.

Figure 19. Locations of sampling marine wood borer in mangrove forest in Kalimantan Island, A = West Kalimantan, Indonesia, B = Sarawak, Malaysia and C = Sabah, Malaysia

The ecology of mangrove forests influences the composition of species of marine wood borer found in mangrove forests on the island of Kalimantan. The ecology studied includes the physical and chemical properties of water in mangrove forests. Physical and chemical properties include temperature, pH, salinity, and dissolved oxygen. The physical and chemical of water quality in the Asajaya Sarawak Malaysia mangrove forest is presented in Table 2.

Table 2. Physical and Chemical Water Quality in Mangrove Forest from Asajaya, Sarawak, Malaysia and Murudu Bay, Sabah, Malaysia

Water physical and chemical properties	Place		
	Asajaya Sarawak higher intertidal zone	Asajaya Sarawak lower intertidal zone	Murudu Bay Kota Kinabalu Sabah
Temperature (^{o}C)	29.60 ± 0.32	30.92 ± 0.22	28.92 ± 0.25
pH	8.00 ± 0.09	8.43 ± 0.04	8.20 ± 0.06
Salinity (%)	18.00 ± 0.30	29.70 ± 0.17	25.70 ± 0.37
Dissolved oxygen (mg/L)	5.22 ± 0.18	5.64 ± 0.04	5.74 ± 0.05

The results of measurements of water quality in the Asajaya mangrove forest, Sarawak, Malaysia obtained a temperature value of 29.60 ± 0.32 ^{o}C to 30.92 ± 0.22 ^{o}C. Meanwhile from Murudu Bay, Kota Kinabalu, Sabah, the temperature was 28.92 ± 0.25^{o}C. This value is still included in the tolerance limit of the mangrove ecosystem to breed. A suitabel water temperature for the optimal proliferation of organisms in mangrove forests is at temperatures above 20 ^{o}C (Bengen, 2002) and not more than 40 ^{o}C (Kordi, 2012). The pH value obtained from water in the Asajaya mangrove forest was 8.00 ± 0.09 to 8.43 ± 0.04. Meanwhile from Murudu Bay, Kota Kinabalu, Sabah, the temperature was 8.20 ± 0.06 ^{o}C The pH value refers to the activity of hydrogen ions in water. The proliferation of wood borrow worms is influenced by the pH value of water. Effendi (2003) states that most aquatic organisms can be reproduce well at water pH 7 - 8.5. The pH value of water obtained in Asajaya mangrove forest and Murudu Bay showed the ecology of both place was very suitable for the growth of marine wood borer.

Water salinity values in Asajaya mangrove forest, Sarawak, Malaysia amounted to 18.00 ± 0.30% to 29.70 ± 0.17%. Meanwhile from Murudu Bay, Kota Kinabalu, Sabah, the salinity value was 25.70 ± 0.37. This salinity value still meets seawater quality standards for the life of organisms in mangrove forests according to the values set by the Minister of Environment Republic Indonesia Decree No. 201 of 2004. According to Bengen (2002) the life of biota in mangrove ecosystems including marine wood borers can develop in salinity value of 2-38%.

The physical and chemical properties of water in mangrove forests in West Kalimantan were studied in three locations, namely in Mempawah mangrove park in Pasir Village, Mempawah Regency, Polaria mangrove park in Mendalok Village, Mempawah Regency and in Setapuk mangrove park in Singkawang City. The results of measurements of water quality obtained a temperature value of 28.00^{o}C - 28.40^{o}C. This value is still included in the tolerance limit of the mangrove ecosystem to breed. A good water temperature for the optimal proliferation of organisms in mangrove forests is at temperatures above 20^{o}C (Bengen, 2002) and not more than 40^{o}C (Kordi, 2012). The pH value obtained from water in the mangrove forest was 7.31 - 8.34. The pH value indicates the activity of hydrogen ions in the water. The proliferation of wood borrow worms is influenced by the pH value of water. Effendi (2003) states that most aquatic organisms can reproduce well at water pH 7 - 8.5. The pH value of water obtained in mangrove forests shows that the ecology of mangrove forests in West Kalimantan is very supportive for the growth of marine wood borer. The physical and chemical properties of water in mangrove forests in West Kalimantan are presented in Table 3.

Table 3. Physical and Chemical Water Quality from Mangrove Forest at Polaria Mangrove Park in Mendalok Village, Mempawah Regency, Mempawah Mangrove Park in Pasir Village, Mempawah Regency and in Setapok Mangrove Park in Singkawang, West Kalimantan Province, Indonesia

Water physical and chemical properties	Place		
	Mempawah Mangrove Park, Pasir village, Mempawah Regency	Polaria Mangrove Park, Mendalok village, Mempawah Regency	Setapok Mangrove Park, Setapok village, Singkawang City
Temperature (^{o}C)	28.06 ± 0.23	28.00 ± 0.22	28.40 ± 0.25
pH	7.31 ± 0.03	8.34 ± 0.07	7.92 ± 0.05
Salinity (%)	10.50 ± 0.35	6.55 ± 0.15	7.86 ± 0.20
Dissolved oxygen (mg/L)	4.74 ± 0.10	5.59 ± 0.14	4.68 ± 0.07
Biological Oxygen Demand (BOD) (mg/L)	8.47 ± 0.15	4.74 ± 0.07	9.54 ± 0.18
Chemical Oxygen Demand (BOD) (mg/L)	600.00 ± 0.20	512.30 ± 0.14	528.86 ± 0.17

The salinity of water in mangrove forest was 6.55% - 10.50%. This salinity value still meets seawater quality standards for the life of organisms in mangrove forests according to the values set by the Minister of Environment Republic Indonesia Decree No. 201 of 2004. According to Bengen (2002) the life of biota in mangrove ecosystems including wood borers worms can multiply well in salinity value of 2-38%. The dissolved oxygen value of water in mangrove forests in the study area in West Kalimantan was 4.68 mg/L – 5.59 mg/L. These value still meets seawater quality standards for the life of organisms in mangrove forests. The biological oxygen demand (BOD) value was 4.74 mg/L – 9.54 mg/L. Meanwhile the chemical oxygen demand value was 512.30 mg/L – 600.00 mg/L.

In addition to the physical and chemical properties of water, the properties and characteristics of the soil found in mangrove forests were examined. The parameters studied included soil pH, soil organic matter content and soil texture. Soil pH values affect the activity of sea wood caciing brokers. The more alkaline earth causes wood worming to be more difficult to breed. High soil organic content causes mangrove forests to be very suitable for breeding wood borers. The characteristics of the physical and chemical properties of mangrove soils in the study locations are presented in Table 4.

Table 4. Physical and Chemical Soil Quality from Mangrove Forest at Polaria Mangrove Park in Mendalok Village, Mempawah Regency, Mempawah Mangrove Park in Pasir Village, Mempawah Regency and in Setapok Mangrove Park in Singkawang, West Kalimantan Province, Indonesia

Soil physical and chemical properties	Place		
	Mempawah Mangrove Park, Pasir village, Mempawah Regency	Polaria Mangrove Park, Mendalok village, Mempawah Regency	Setapok Mangrove Park, Setapok village, Singkawang City
pH	7.59	8.50	8.16
C-organic (%)	1.75	2.39	2.76
Sand (%)	0.60	16.39	12.30
Silt (%)	55.65	57.41	50.51
Clay	43.33	43.13	37.19

The composition of marine wood borer species in the mangrove forests found in West Kalimantan, which includes the Mempawah Mangrove Park mangrove forest, Pasir Village, Mempawah Regency; Polaria Mangrove Park in Mendalok Village, Mempawah District and Setapok Mangrove Forest, Singkawang City, belong to the Teredinidae and Pholadidae families. The composition of marine wood borer species in mangrove forests in West Kalimantan Province is presented in Table 5 and in Malaysia are presented in Table 6.

Table 5. Composition of marine wood borer from mangrove forest in West Kalimantan, Indonesia

Family	Genus / Species	Place and Number of MWB		
		Mempawah Mangrove Park, Desa Pasir, Kabupaten Mempawah	Polaria Mangrove Park, Desa Mendalok, Kabupaten Mempawah	Setapok Mangrove Park, Desa Setapok, Kota Singkawang
Teredinidae	*Teredo pocalifer*	15	3	10
	Teredo navalis	0	75	30
	Teredo tritubulata	0	50	0
	Teredo calmani	0	35	0
	Teredo medilobata	0	32	0
	Teredo siamens	0	0	25
	Teredo utriculus	0	0	20
	Teredo batiliformis	0	0	26
	Teredo dagmarae	0	0	30
	Teredo brevis	0	0	28
	Teredo dallii	0	0	16
	Neoteredo reynei	0	12	6
	Bankia caribbea	0	0	25
	Bankia fimbriulata	0	0	10
	Bankia minima	0	0	27
	Bankia setacea	0	0	15
Pholadidae	*Martesia striata*	0	0	40
	Petricola pholadiformis	0	0	30

Tabel 6. Composition of marine wood borer from mangrove forest in Sarawak and Sabah Malaysia

Family	Genus / species	Place and Number of MWB		
		Asajaya Sarawak *higher intertidal zone*	Asajaya Sarawak *(lower intertidal zone*	Murudu Bay Kota Kinabalu Sabah
Teredinidae	*Teredo navalis*	53	105	0
	Bankia fimbriatula	26	19	0
	Dicyathifer manni	5	11	0
	Teredothyra matoconata	4	10	0
	Teredo lamyi	0	0	12
	Teredo diegensis	0	0	20
	Teredo helleniusi	0	0	35
	Teredo modosa	0	0	24
	Teredo siamensis	0	0	20
	Bankia caribbea	0	0	30
	Bankia minima	0	0	27
	Bankia setacea	0	0	48
	Neoteredo reynei	0	0	32
	Bankia indica	0	0	26
Pholadidae	*Martesia sp*	0	1	0
	Martesia striata	0	0	14
	Lyrodus pedicellatus	0	0	28
Limnoridae	*Limnoria sp*	0	1	0

Marine wood borers are species of wood destroying organisms in mangrove forests that have economic and ecological impacts. This wood-destroying organism attaches to the surface of the wood then multiplies in wood. The ability of marine wood borers to drill and digest wood causes damage of high economic value to timber in coastal areas. The chemical components of the wood attacked by marine borer were analyzed to study the utilization aspects of marine wood borer. Marine wood borer have enzymes that can digest wood. Chemical analysis of wood includes extractive substances dissolved in hot water (TAPPI T 207 om-02) and soluble in cold water, holocellulose and alpha cellulose levels (TAPPI T 203 om-02), and lignin levels (TAPPI T 222 om-02). The wood analyzed includes Api-api putih wood (*Avicennia marina*), Bakau kurap wood *(Rhizophora mucronata*), kayatan wood (*Drybalanops rappa*) and red sangai wood (*Hopea merawan)*. Forms of attacked wood are presented in Figure 20. Results of analysis of extractive substances dissolve in hot water, extractive substances dissolve in cold water, holocellulose levels, alpha cellulose levels and lignin levels are presented in Figure 21, Figure 22, Figure 23, Figure 24 and Figure 25.

Figure 20. Wood attack by marine wood borer in mangrove forest of Kalimantan Island

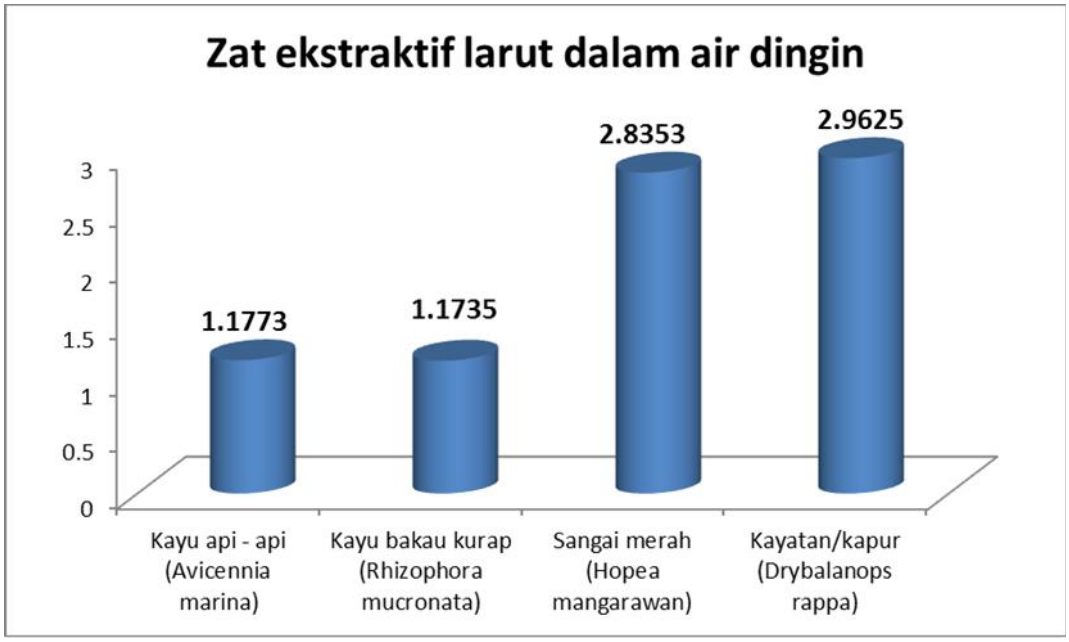

Figure 21. The value of Extractive dissolved in cold water from wood attack by marine wood borer from the mangrove forest at Setapok, Singkawang City, West Kalimantan

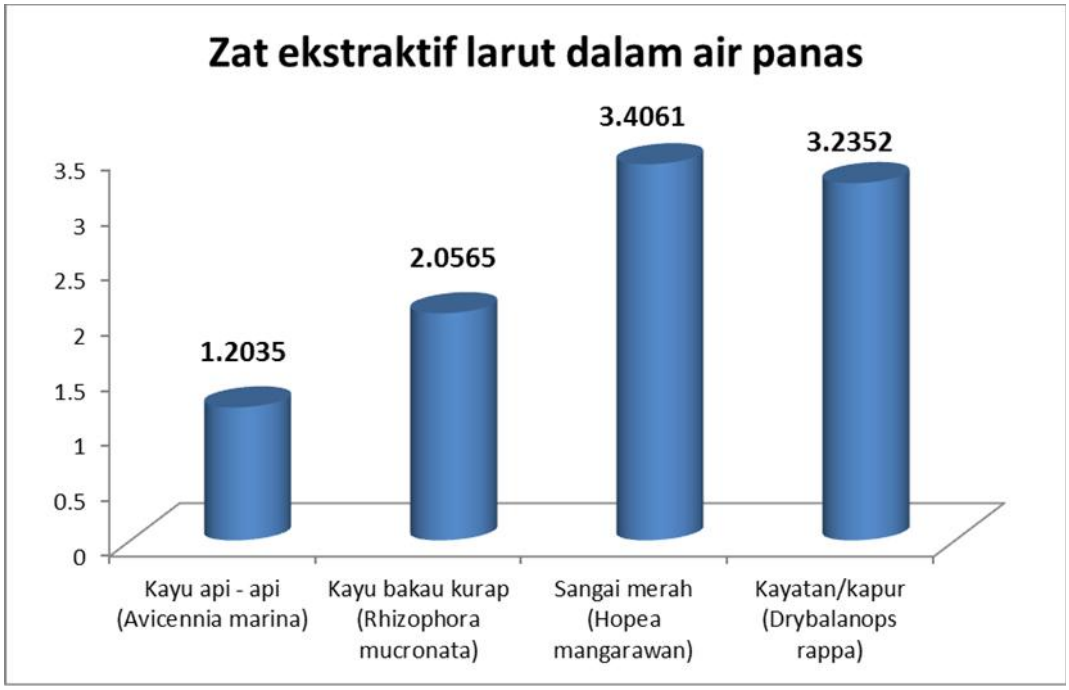

Figure 22. The value of Extractive dissolved in hot water from wood attack by marine wood borer from the mangrove forest at Setapok, Singkawang City, West Kalimantan

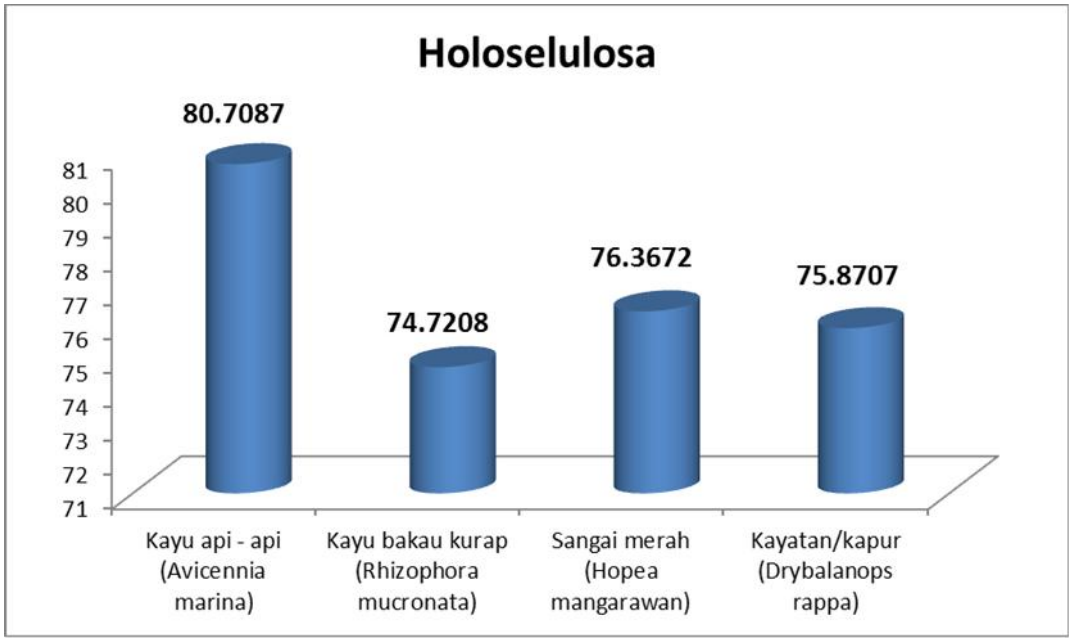

Figure 23. The value of holocellulose from wood attack by marine wood borer from the mangrove forest at Setapok, Singkawang City, West Kalimantan

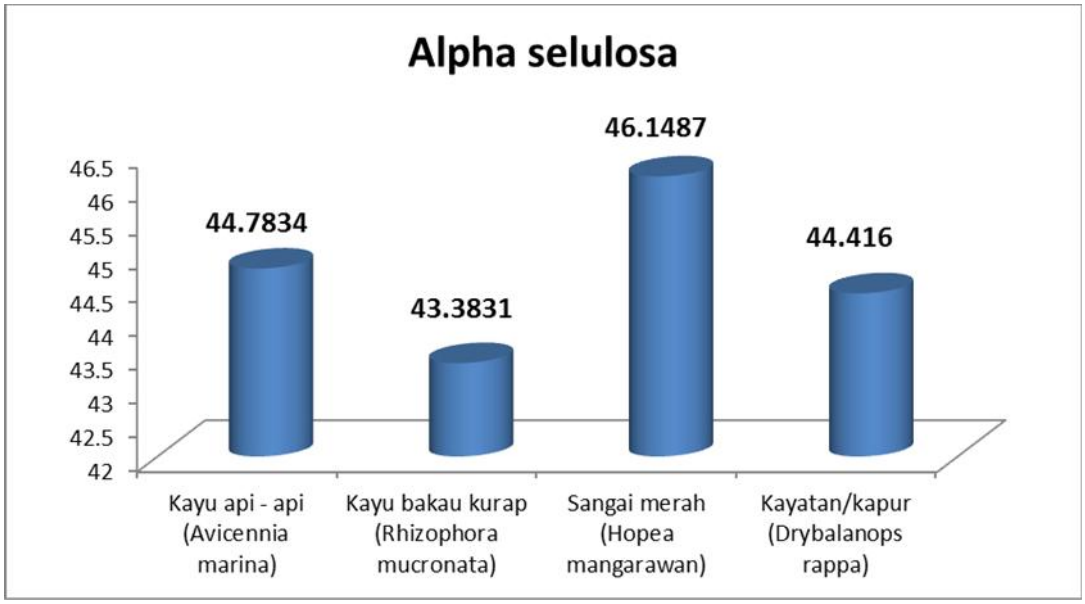

Figure 24. The value of Alpha Cellulose from wood attack by marine wood borer from the mangrove forest at Setapok, Singkawang City, West Kalimantan

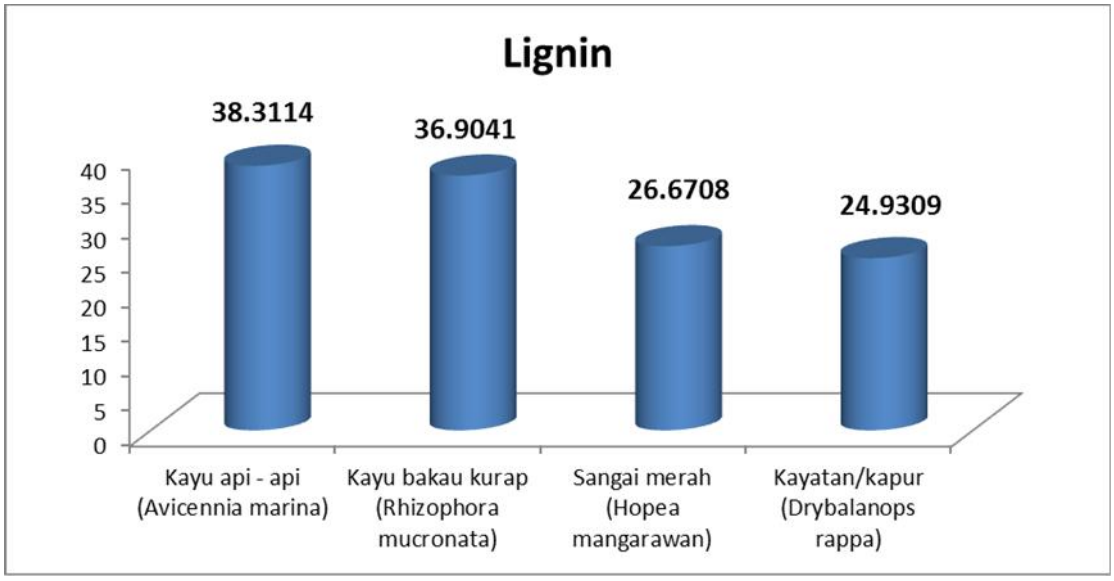

Figure 25. The value of lignin from wood attack by marine wood borer from the mangrove forest at Setapok, Singkawang City, West Kalimantan

The value of extractive substances dissolved in hot water were 1.2053%, 2.0565%, 3.2352% and 3.4061% respectively. Holocellulose values were 80.7087%, 74.7208%, 76.3672% and 75.8707%, respectively. Cellulose α values were 44.7843%, 43.3831%, 46.1487% and 44.416% respectively. The value of lignin content was 38.3114%, 36.9041%, 26.6708% and 24.9309% respectively. Wood attacked by marine borer has a high cellulose content. Marine borer digest cellulose and use wood as a nest and food source. Efforts to utilize enzymes produced by marine borer in digesting cellulose are the development of future marine borer utilization.

5. Conclusion

5.1. The diversity of marine wood borers on Kalimantan Island is very high, obtained by three families, namely Teredinidae, Pholadidae and Limnorida. Spesies found include *Teredo pocalifer, Teredo navalis, Teredo tritubulata, Teredo calmani, Teredo medilobata, Teredo siamensis, Teredo utriculus, Teredo batiliformis, Teredo dagmarae, Teredo brevis, Teredo dallii, Teredothyra matoconata, Teredo lamyi, Teredo diegensis, Teredo helleniusi, Teredo modosa, Bankia caribbea, Bankia fimbriulata, Bankia minima, Bankia setacea, Bankia indica, Neoteredo reynei, Martesia striata, Petricola pholadiformis, Dicyathifer manni, Martesia sp, Lyrodus pedicellatus,* and *Limnoria sp.*

5.2. Distribution of marine wood borer worms on the island of Borneo has an even distribution, there are several species of wood borrow worms found in West Kalimantan also found in Sarawak and in Sabah. The same types found include *Teredo navalis, Bankia minima* and *Martesia striata.*

5.3. The mangrove forest habitat in Kalimantan Island is very suitable for the growth and breeding of wood borers worms. The physical and chemical properties of water as well as the physical and chemical properties of the soil meet the standards for the propagation of wood borrow worms.

6. Research Team

Principle Investigator : Dr. Farah Diba, S.Hut, M.Si

Research staff : Dr. Khairul Adha A. Rahim

Dr. Chen Cheng Ann

Field assistance : Bayu Wanamukti

Dwi Yoga Budi Pranoto

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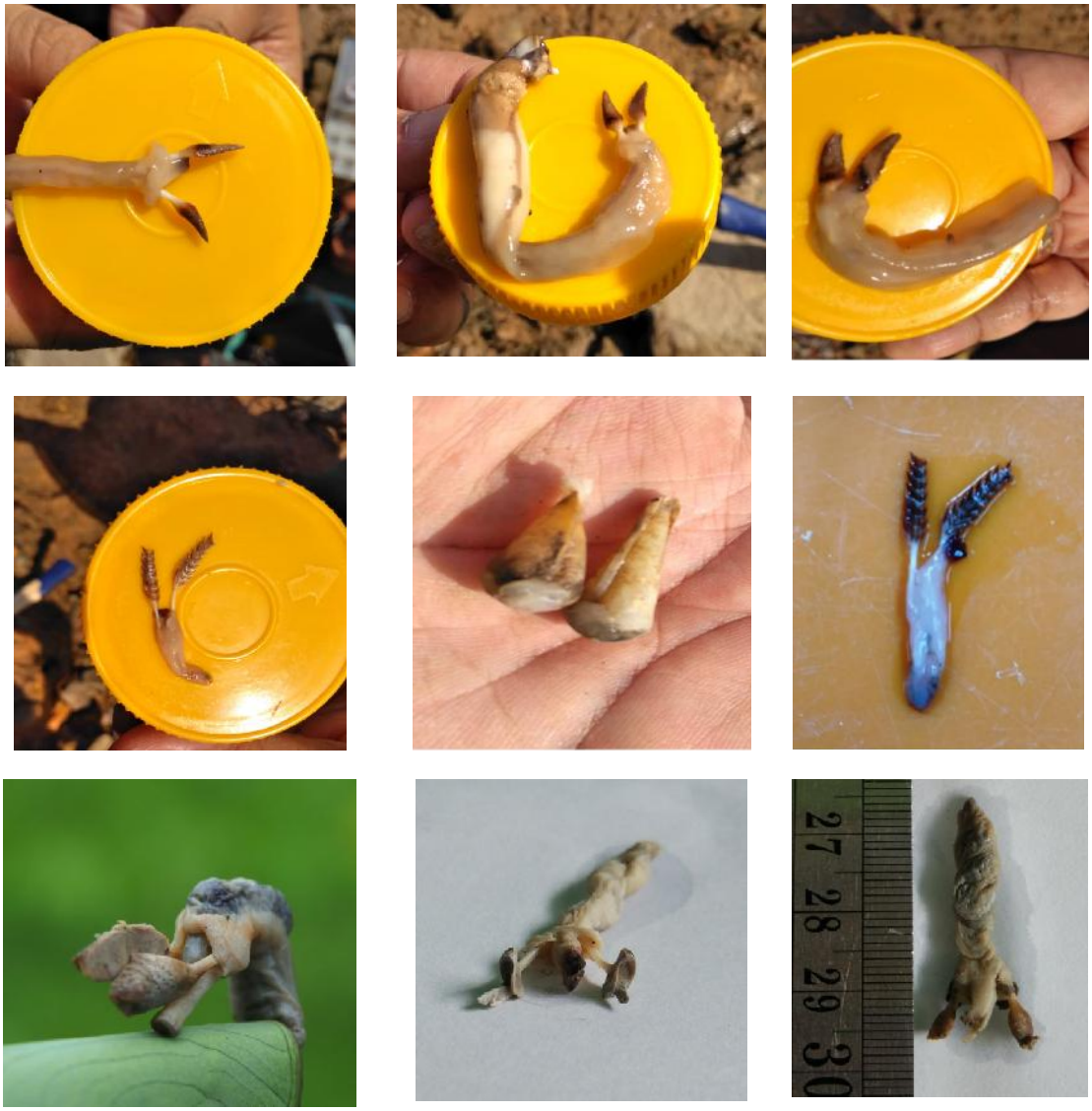
Appendix of marine wood borer from mangrove forest at Mempawah Mangrove Park, Pasir village and Polaria Mangrove Park, Mendalok village from Mempawah Regency, mangrove forest from Setapok Mangrove Park, Singkawang City, West Kalimantan, Indonesia; mangrove forest of Asajaya at Sarawak, Malaysia and mangrove forest at Marudu Bay, Kota Kinabalu, Sabah, Malaysia





EFFECT OF VEGETATION ON ECOLOGY AND BIODIVERSITY OF MARINE WOOD BORER IN MANGROVE FOREST ECOSYTEM OF WEST KALIMANTAN INDONESIA

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ABSTRACT

Marine wood borer has important role in mangrove forest as decomposer. West Kalimantan has many mangrove forest areas but no comprehensive study was ever carried out on occurrence and distribution of marine wood borer. This research aimed to investigate the effect of vegetation of mangrove forest on ecology and biodiversity of marine wood borer. The locations were Polaria mangrove forest (PMF) in Mendalok village, Mempawah Regency and Mempawah mangrove forest (MMF) in Pasir village, Mempawah Regency. Infested log in each mangrove forest area were collected and dismantled. All specimen was collected and identification at Laboratory of Forest Technology, Faculty of Forestry, Tanjungpura University. The ecology data consist of vegetation, soil characteristics (pH, C-organic and soil texture) and water characteristics (salinity, pH, Biological oxygen demand, and dissolved oxygen and chemical oxygen demand). Soil and water characteristics was analyze at Laboratory of Chemistry and Soil Fertility, Faculty of Agriculture, Tanjungpura University. The results showed that biodiversity of marine wood borer from Polaria mangrove forest was higher than Mempawah mangrove forest. The marine wood borer in PMF consist of *Neoteredo reynei, Teredo pocalifer, Teredo navalis, Teredo tritubulata, Teredo calmani and Teredo medilobata* and they all included of family Teredinidae. Meanwhile in MMF only consist of *Teredo pocalifer* which included of family Teredinidae. The vegetation in PMF consist of *Rhizophora mucronata, Bruguiera xylindrica, Avicennia marina, Sonneratia ovata, Nypa fruticans. Avicennia officinalis,* and *Sonneratia alba.* Meanwhile in MMF the vegetation consist of *Rhizophora mucronata, Candelia candel, Avicennia marina,* and *Bruguiera xylindrica.* The soil characteristics on C-organic content was 1.75% (MMF) and 2.39% (PMF); pH was 7.59 (MMF) and 8.50 (PMF); sand 0.60% (MMF) and 16.39% (PMF), silt 55.65% (MMF) and 57.41% (PMF), and clay 43.33% (MMF) and 43.13% (PMF). Water characteristics on salinity was 10.5 (MMF) and 6.55 (PMF); DO was 4.74 (MMF) and 5.59 (PMF); pH was 7.31 (MMF) and 8.33 (PMF); BOD was 8.47 mg/l (MMF) and 4.74 mg/l (PMF) and COD was 600 mg/l (MMF) and 512.3 mg/l (PMF). The conclusion of research the vegetation has an effect on biodiversity of marine wood borer. This result gave the important data for conservation and management of marine wood borer in mangrove forest of West Kalimantan.

Keywords: biodiversity, marine wood borer, mangrove forest, Teredinidae , Teredo, West Kalimantan

Surabaya, September 27th 2018

To **Farah Diba**
Faculty of Forestry
Tanjungpura University
Pontianak, Indonesia

Dear Author(s)

On behalf of the organizing committee of 4th IBOC (International Biology Conference) 2018, we are very pleased to inform you that your abstract of the paper entitled:

EFFECT OF VEGETATION ON ECOLOGY AND BIODIVERSITY OF MARINE WOOD BORER IN MANGROVE FOREST ECOSYTEM OF WEST KALIMANTAN INDONESIA

had **accepted** for oral presentation. Concerning to this status, we would like to invite you to be one of the oral presenters on the seminar that will be held on;

Date : Saturday – October 13th, 2018
Time : 08.00 – untill end
Venue : Harris Hotel, Surabaya

The information on detail of time schedule will be came afterward. Finally, we would like to take this opportunity to thank you for your interest in participating and presenting your research works at the 4th IBOC-2018. We look forward to meet you at the seminar day. Meantime, you may also visit our official website http://iboc.its.ac.id/ for any update information.

Cordially yours,

Aunurohim, DEA
Chairman of Committee of 4th IBOC2018

EFFECT OF VEGETATION ON ECOLOGY AND BIODIVERSITY OF MARINE WOOD BORER IN MANGROVE FOREST ECOSYSTEM OF WEST KALIMANTAN INDONESIA

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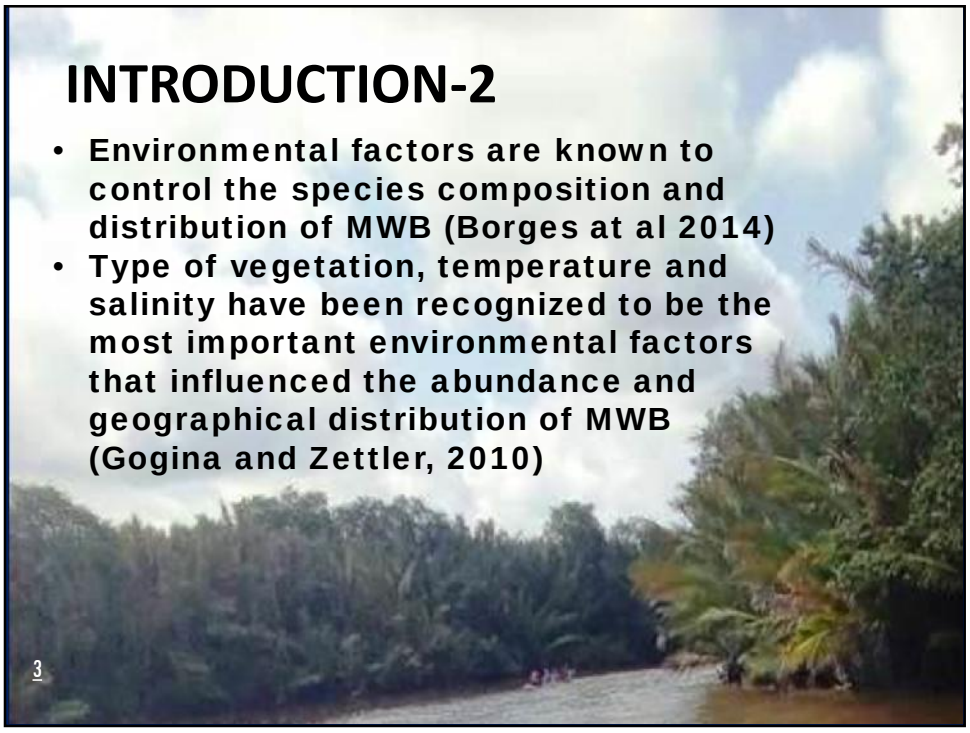
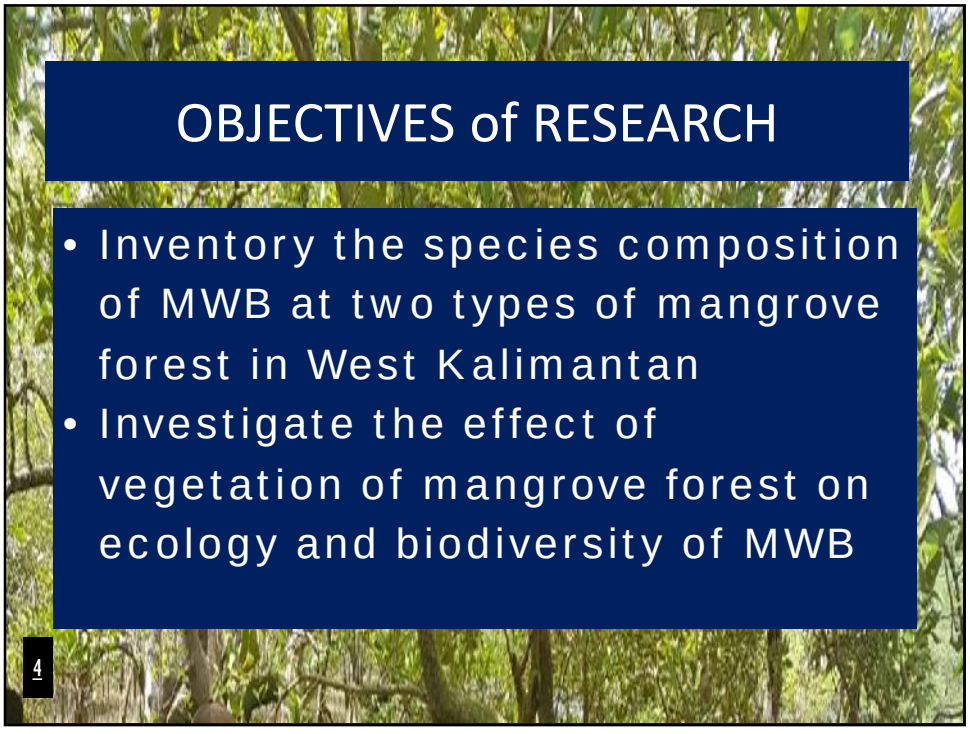
The 4th International Biology Conference, Surabaya, 13 October 2018

INTRODUCTION-1

- Mangrove forest highly specialized and unique ecosystems, having flora and fauna which well adapted to salinity (Alongi 2012)
- Marine wood borers (MWB) in mangrove ecosystem cause extensive damage to underwater timber structure (Swain et al 2017)
- Until now the biodiversity and ecology of MWB in West Kalimantan have not been investigated in details

2


INTRODUCTION-2
• Environmental factors are known to control the species composition and distribution of MWB (Borges at al 2014)
• Type of vegetation, temperature and salinity have been recognized to be the most important environmental factors that influenced the abundance and geographical distribution of MWB (Gogina and Zettler, 2010)
3


OBJECTIVES of RESEARCH
• Inventory the species composition of MWB at two types of mangrove forest in West Kalimantan
• Investigate the effect of vegetation of mangrove forest on ecology and biodiversity of MWB
4

MATERIALS AND METHODS-1

- Research location were at Polaria mangrove forest (PMF) in Mendalok village, Mempawah Regency and Mempawah mangrove forest (MMF) in Pasir village, Mempawah Regency
- **Around 2 hours travel by car from Pontianak City to the mangrove forest**


5

MATERIALS AND METHODS-2

- **MWB were collected from destroyed tress and trash-wood in the mangrove ecosystem.**
- **The morphological and ecological characteristics of the MWB recorded and photographed in their natural habitats.**
- **After removal the specimens from wood, the samples washed through a sieve with 0.5 and 1 mm mesh size and transferred into containers with alcohol of 70%.**
- **Morphological description and taxonomic identification of MWB specimens based on the diagnostic characters of the pallets, using the keys of Turner (1966); Turner (1971), Hayward and Ryland (1990), Ozturk and Cevik (2000), Didziulis (2007), Clemam (2009) and Castello (2011).**



6

MATERIALS AND METHODS-3

- Inventory of the vegetation on each mangrove forest were conducted, also on the zonation of the mangrove forest.
- Soil on each mangrove forest was collected to evaluate the physicochemical characteristics, consist of pH value, C-organic, sand, silt and clay content
- Water on each mangrove forest was collected to evaluate the physicochemical characteristics, consist of pH value, salinity, temperature, BOD, COD and DO

7

RESULTS AND DISCUSSION

- The marine wood borer in PMF consist of ***Neoteredo reynei***, ***Teredo pocalifer, Teredo navalis, Teredo tritubulata, Teredo calmani and Teredo medilobata.*** **All MWB included of family Teredinidae.**
- **Meanwhile in MMF only consist of *Teredo pocalifer* which included of family Teredinidae**

8

Neoteredo reynei

Teredo calmani

Teredo medilobata

Teredo pocalifer

T. tritubulata

Teredo navalis

9

10 mm

VEGETATION AND ZONATION

- PMF consist of three zonation, Avicennia sp; Rhizophora sp and Bruguiera sp.
- The species of mangrove at PMF consist of *Avicennia marina, A. alba, Rhizophora stylosa, R. mucronata, R. apiculata, Bruguiera parviflora, B. cylindrica, B. gymnorrhiza, Sonneratia alba, Ceriops decandra,* and *Xylocarpus granatum.*
- MMF consist of *Sonneratia ovata, S. caseolaris, Rhizophora stylosa, R. mucronata, Avicennia marina, Bruguiera cylindrical, B. gymnorrhiza, Xylocarpus granatum, Nypa fruticans, Excoecaria agallocha, Kandelia candel, Ceriops tagal.*

10

Soil characteristics

	PMF	MMF
pH	8.50	7.59
C-organic	2.39%	1.75%
sand	16.39%	0.60%
silt	57.41%	55.65%
clay	43.13%	43.33%

11

Water characteristics

	PMF	MMF
pH	8.33	7.31
Salinity	6.55	10.5
BOD	4.74 mg/l	8.47 mg/l
COD	512.30 mg/l	600.00 mg/l
DO	5.59 mg/l	4.74 mg/l

12

Discussion

- The mangrove ecosystems play a significant role in providing suitable habitats for MWB (Hamdan et al., 2012)
- Diversity of mangrove tree, especially the zonation has a significant effect on MWB species composition (Zakaria and Rajpar, 2015).
- Roszaini and Salmiah (2015) have shown that water salinity, temperature, pH and dissolved oxygen played a major role in terms of MWB distribution in the coastal and mangrove areas.
- The vegetation has an effect on biodiversity of MWB

13

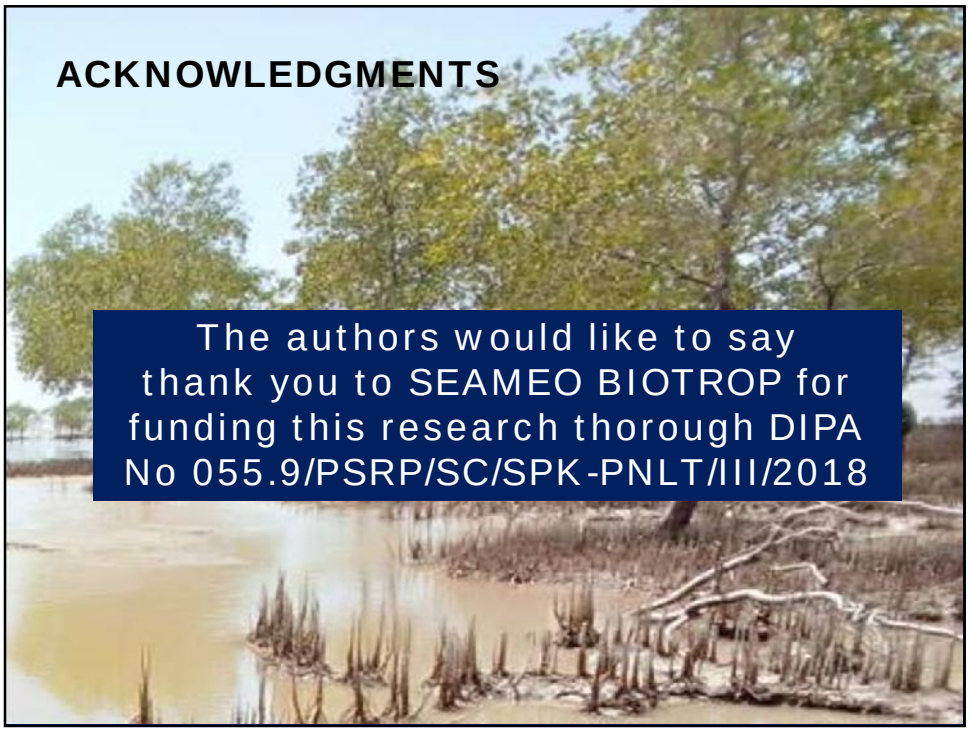
CONCLUSION

The MWB in Polaria Mangrove Forest has higher diversity than Mempawah Mangrove Forest. All the MWB are included of family Teredinidae.

The vegetation and zonation of mangrove forest has an effect on MWB species composition

These data was important for management of MWB in West Kalimantan

14


ACKNOWLEDGMENTS
The authors would like to say thank you to SEAMEO BIOTROP for funding this research thorough DIPA No 055.9/PSRP/SC/SPK-PNLT/III/2018


THANK YOU

CERTIFICATE

is hereby awarded to

Farah Diba

for valuable contribution as ORAL PRESENTER with the paper entitled

Effect of vegetation on ecology and biodiversity of marine wood borer in mangrove forest ecosystem of West Kalimantan Indonesia

at the 4th INTERNATIONAL BIOLOGY CONFERENCE - 2018

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Biology Department
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Dr. Dewi Hidayati, M.Si
Head
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Rector
Institut Teknologi Sepuluh Nopember (ITS)

Species Diversity and Distribution of Marine Wood Borer in Setapok Besar Mangrove Forest, Singkawang City, West Kalimantan, Indonesia

Bayu Wanamukti[1*], Farah Diba[1], Khairul Adha[2], and Chen Cheng Ann[3]

[1]*Faculty of Forestry, Tanjungpura University Pontianak Kalimantan Barat, Indonesia*
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ABSTRACT

Setapok Besar Mangrove Forest was located in Singkawang City, West Kalimantan Province. This area was directly as a border to South China Sea and as a source for fishing area to the community. The fisherman built a fish pond as a place for catches the fish which around 4 mile from the beach. The fish pond made from wood and it's always attack by marine wood borer after 6 month and damage. Despite the economic importance of marine wood borer the study of the species diversity and distribution on these organisms in Setapok Besar mangrove forest has never been conducted. This study aimed to inventory the species diversity and distribution of marine wood borer in Setapok Besar mangrove forest. The methods consist of collected the marine wood borer from wood in mangrove forest area and from wood in fish pond. The environment factor consists of soil and water quality was evaluated. The result of research found the species diversity of marine wood borer in wood from fish pond was higher than wood from mangrove forest. The species from wood of fish pond were Neoteredo reynes, Teredo pocalifer, Bankia setacea, Teredo utriculus, Petricola pholadiformis, Teredo siamens, Martesia striata, Teredo navalis, Teredo batiliformis, Teredo dagmarae, Teredo brevis, Teredo dallii, and Bankia minima. The species from wood in mangrove forest were Bankia caribbea, Teredo navalis, Bankia fimbriulata, Bankia minima and Martesia striata. The average of soil pH was 8.16, C-organic content was 2.76%, sand content was 12.30%, silt content was 50.51% and clay content was 37.19%. The average of water pH was 7.92, salinity was 7.86, BOD was 9.54 mg/l, COD was 528.86 mg/l, and DO was 4.68 mg/l. The distribution of marine wood borer was from fish pond until the mangrove forest area. These indicate the habitat was suitable for development of marine wood borer and gave the highest potential prospect of utilization the marine wood bores as a food source.

Keywords: Bankia sp, diversity, marine wood borer, Setapok Besar mangrove forest, Singkawang City, Teredo

Surabaya, September 27th 2018

To **Bayu Wanamukti**
Faculty of Forestry
Tanjungpura University
Pontianak, Indonesia

Dear Author(s)

On behalf of the organizing committee of 4th IBOC (International Biology Conference) 2018, we are very pleased to inform you that your abstract of the paper entitled:

SPECIES DIVERSITY AND DISTRIBUTION OF MARINE WOOD BORER IN SETAPOK BESAR MANGROVE FOREST, SINGKAWANG CITY, WEST KALIMANTAN INDONESIA

had **accepted** for oral presentation. Concerning to this status, we would like to invite you to be one of the oral presenters on the seminar that will be held on;

Date : Saturday – October 13th, 2018
Time : 08.00 – untill end
Venue : Harris Hotel, Surabaya

The information on detail of time schedule will be came afterward. Finally, we would like to take this opportunity to thank you for your interest in participating and presenting your research works at the 4th IBOC-2018. We look forward to meet you at the seminar day. Meantime, you may also visit our official website http://iboc.its.ac.id/ for any update information.

Cordially yours,

Aunurohim, DEA
Chairman of Committee of 4th IBOC2018

Species Diversity and Distribution of Marine Wood Borer in Setapok Besar Mangrove Forest, Singkawang City, West Kalimantan, Indonesia

BAYU WANAMUKTI[1], FARAH DIBA[1], KHAIRUL ADHA[2], CHEN CHENG ANN[3]

1. Forestry Faculty, Tanjungpura University, Pontianak, West Kalimantan, Indonesia
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3. Borneo Marine Research Institute, Universiti Malaysia Sabah

The 4th International Biology Conference, Surabaya, 13 October 2018

INTRODUCTION

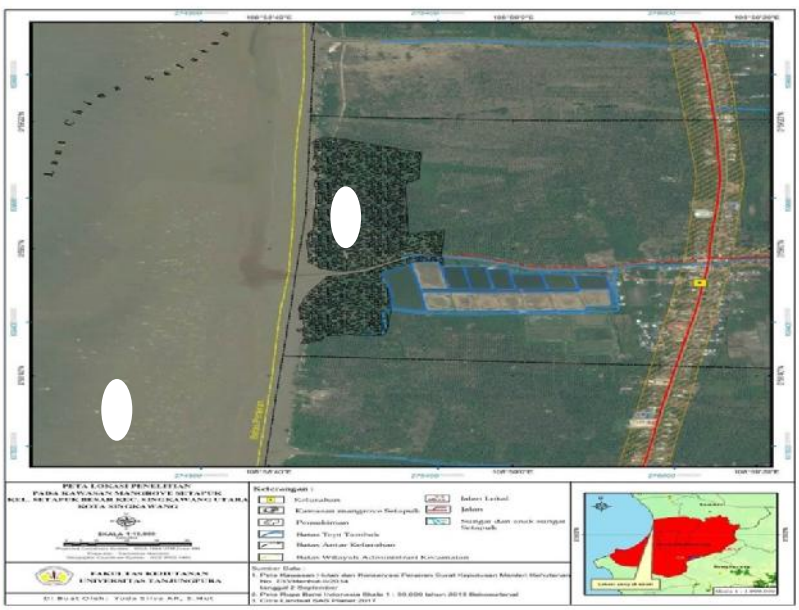
- Marine wood borer also called the termites of the sea, has responsible on wood destruction in mangrove forest, marine and estuarine water ecosystems (Singh, 2012)
- Are grouped into two classes; Bivalvia from family Teredinidae and Pholididae and Crustacea from Family Limnoriidae and Cheluridae (Turner, 1971)
- Wide-ranging economic and ecological impacts in coastal marine systems (Weigelt et al., 2016).
- Information on the species diversity and distribution of marine wood borer species in West Borneo coastal waters is scarce.

OBJECTIVES

1. Investigate the diversity, distribution and species composition of marine wood borer in Setapok Besar Mangrove Forest, Singkawang City, West Kalimantan.
2. Determine the environmental factors that influence the species composition, abundance and distribution of marine wood borer

3

STUDY SITE



Setapok Besar Mangrove Forest was located at Singkawang Utara subdistrict, Singkawang City, West Kalimantan. Total mangrove forest area was ± 102.67 Ha

Sample location

4

MATERIALS AND METHODS

5

RESULTS AND DISCUSSION

The species from wood of fish pond were *Neoteredo reynes, Bankia setacea, Bankia minima,Teredo pocalifer,Teredo utriculus, Petricola pholadiformis, Teredo siamens, Teredo navalis, Teredo batiliformis, Teredo dagmarae,Teredo brevis, Teredo dallii, and Martesia striata.*

6

RESULTS AND DISCUSSION

The species from wood in mangrove forest were *Bankia caribbea,Bankia fimbriulata, Bankia minima Teredo navalis and Martesia striata*



7

Marine Wood Borer Diversity


Bankia caribbea


Bankia setacea


Teredo dallii


Teredo navalis


Neoteredo reynei


Petricola pholadiformis

10 mm

4

Physico-chemical water and soil characteristics

Water characteristics	
pH	7.92
Temperature	28.4°C
Salinity	7.86
BOD	9.54 mg/l,
COD	528.86 mg/l
DO	4.68 mg/l

Soil characteristics	
pH	8.16
C-organic	2.76%
sand	12.30%
silt	50.51%
clay	37.19%

9

Discussion

- The species richness was 15 species, consist of two family: Teredinidae and Pholadidae.
- Often considered pest species BUT
- MWB play fundamental roles in carbon cycling in marine and brackish environments by degrading lignocellulose in floating or deposited wood and in the wood of living mangroves (Voight , 2015).
- Has developed enzymes (cellulases and nitrogenases), which breaking down the cellulose and fixing nitrogen to build amino acids digest cellulose and hemicellulose.
- Have a potential for edible seafood for local communities

10

CONCLUSION

1. The species of marine wood borer in Setapok Besar Mangrove Forest consist of 15 species and two family, Teredinidae and Pholadidae.
2. Marine wood borer has a potential to used as edible food and source of biofuel
3. The habitat at Setapok Besar Mangrove Forest was suitable for development of marine wood borer

11

ACKNOWLEDGMENTS

The authors would like to say thank you to SEAMEO BIOTROP for funding this research thorough DIPA No 055.9/PSRP/SC/SPK-PNLT/III/2018

12

Thank You



13

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FB	: Bayu Wanamukti
Motto	: Be grateful all the times

CERTIFICATE

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ANALISIS KIMIA KAYU YANG DISERANG MARINE BORER DI HUTAN MANGROVE SETAPOK BESAR KOTA SINGKAWANG, KALIMANTAN BARAT

Bayu Wanamukti[1*], Farah Diba[1], Khairul Adha[2], Chen Cheng Ann[3]

[1]*Fakultas Kehutanan, Universitas Tanjungpura Pontianak Kalimantan Barat, Indonesia*
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ABSTRAK

Marine borer adalah spesies cacing penggerek kayu di hutan mangrove yang memiliki dampak ekonomi dan ekologis. Organisme perusak kayu ini menempel di permukaan kayu kemudian berkembang biak di dalam kayu. Kemampuan marine borer untuk mengebor dan mencerna kayu menyebabkan kerusakan yang bernilai ekonomi tinggi untuk kayu kayu di daerah pesisir. Penelitian bertujuan untuk menganalisis komponen kimia kayu yang diserang oleh marine borer. Lokasi penelitian di hutan mangrove Setapok Besar Kota Singkawang, Provinsi Kalimantan Barat. Hutan mangrove ini berbatasan langsung dengan Laut China Selatan. Sampel diperoleh dari kayu yang diserang marine borer di kawasan hutan mangrove dan dari kayu yang digunakan untuk tambak ikan di laut. Lokasi tambak ikan sejauh 4 mil dari pantai mangrove Setapok Besar. Analisis kimia kayu meliputi zat esktraktif larut dalam air panas (TAPPI T 207 om-02) dan larut dalam air dingin, kadar holoselulosa dan alpha selulosa (TAPPI T 203 om-02), dan kadar lignin (TAPPI T 222 om-02). Hasil penelitian menunjukkan kayu yang terserang marine borer adalah kayu api-api putih (*Avicennia marina*), kayu bakau kurap (*Rhizophora mucronata),* kayu kayatan *(Drybalanops rappa)* dan kayu sangai merah *(Hopea mengarawan)*. Nilai zat ekstraktif larut dalam air panas berturut-turut 1,2053%, 2,0565%, 3,2352% dan 3,4061%. Nilai holoselulosa berturut-turut 80,7087%, 74,7208%, 76,3672% dan 75,8707%. Nilai α selulosa berturut-turut sebesar 44,7843%, 43,3831%, 46,1487% dan 44,416%. Nilai kandungan lignin berturut-turut sebesar 38,3114%, 36,9041%, 26,6708% dan 24,9309%. Kayu yang diserang marine borer memiliki kandungan selulosa yang tinggi. Marine borer mencerna selulosa dan menggunakan kayu sebagai sarang dan sumber makanan. Upaya pemanfaatan enzim yang dihasilkan oleh marine borer dalam mencerna selulosa merupakan pengembangan pemanfaatan marine borer di masa depan.

Kata Kunci: *hemiselulosa, hutan mangrove Setapok Besar Singkawang, kimia kayu, lignin, marine borer*

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Yogyakarta, 1 Oktober 2018

Nomor : 1203/UN1/2018
Hal : Undangan sebagai presenter Seminar Nasional *Research Update* FKT 2018
Lamp. : -

Kepada

Yth. Dr. Farah Diba, S.Hut, M.Si

Dengan hormat,

Sehubungan dengan diterimanya abstrak penelitian Saudara yang akan dipresentasikan pada Seminar Nasional *Research Update* Fakultas Kehutanan UGM 2018 yang merupakan Dies Natalis ke-55 FKT UGM dengan tema **"Menuju Kejayaan Kehutanan Indonesia"** maka kami mengundang Bapak/Ibu/Saudara untuk hadir dalam acara tersebut sebagai presenter yang akan diselenggarakan pada :

Hari/Tanggal	: Kamis, 25 Oktober 2018
Waktu	: 07.30 - 17.00 WIB
Tempat	: Fakultas Kehutanan UGM

Demikian surat undangan ini kami sampaikan. Atas perhatian serta kehadiran Bapak/Ibu/Saudara diucapkan terima kasih.

a.n. Dekan
Wakil Dekan Bidang Penelitian,
Pengabdian Masyarakat, dan Kerjasama

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a.n. Dekan
Wakil Dekan Bidang Penelitian,
Pengabdian Masyarakat, dan Kerjasama

Dr. Muhammad Ali Imron, S.Hut., M.Sc.

Analisis Kimia Kayu yang Diserang Marine Borer di Hutan Mangrove Setapok Besar Kota Singkawang Kalimantan Barat

BAYU WANAMUKTI[1], FARAH DIBA[1], KHAIRUL ADHA[2], CHEN CHENG ANN[3]

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2. Faculty of Resources Science and Technology, Universiti Malaysia Sarawak
3. Borneo Marine Research Institute, Universiti Malaysia Sabah

PENDAHULUAN

- Marine borer adalah spesies cacing penggerek kayu di hutan mangrove yang memiliki dampak ekonomi dan ekologis. Organisme perusak kayu ini menempel di permukaan kayu kemudian berkembang biak di dalam kayu.
- Penggerek kayu laut juga disebut rayap laut, bertanggung jawab atas kerusakan kayu di hutan mangrove, ekosistem laut dan perairan pesisir (Singh, 2012)
- Kemampuan marine borer untuk mengebor dan mencerna kayu menyebabkan kerusakan yang bernilai ekonomi tinggi untuk kayu di daerah pesisir

1

TUJUAN

Penelitian bertujuan untuk menganalisis komponen kimia kayu yang diserang oleh marine borer.

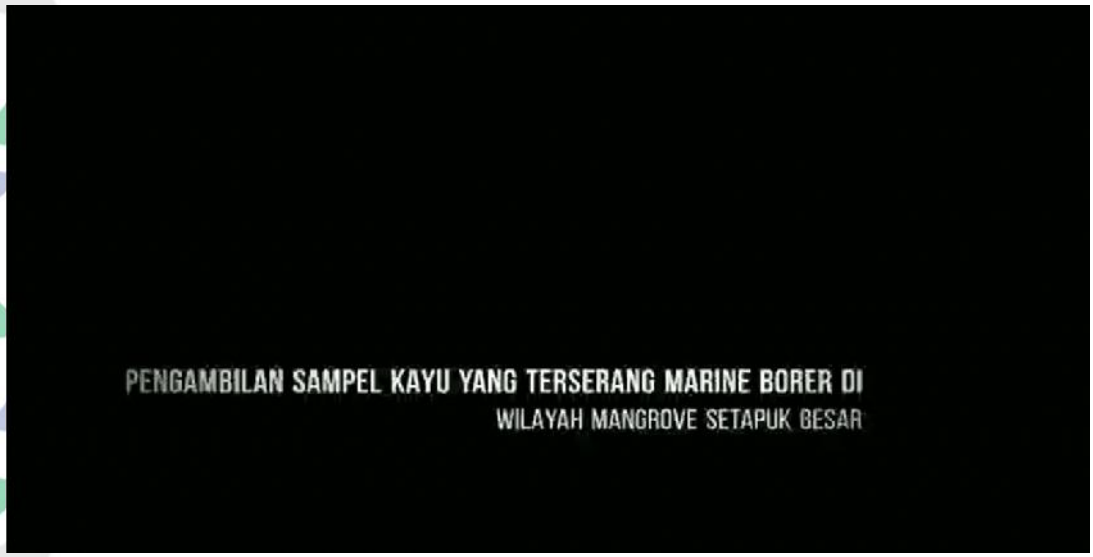
2

LOKASI PENELITIAN

Hutan Mangrove Setapok Besar mempunyai total wilayah ± 102.67 Ha

3

Metode Penelitian



4

Metode Analisis kimia kayu

- Analisis kimia kayu dilakukan di Laboratorium Teknologi Kayu Fakultas Kehutanan Universitas Tanjungpura dengan 4 jenis kayu yang didapatkan dari 2 lokasi (Hutan mangrove dan Sero). Kayu yang di dapatkan adalah : Api – api putih (*Avicennia marina*), bakau kurap (*Rhizophora mucronata*), kayu kayatan (*Drybalanops rappa*) dan sangai merah (*Hopea mangarawan*)
- Analisis kimia dilakukan dengan 5 pengujian :
  1. Zat ekstraktif larut dalam air panas (TAPPI T 207 om-02)
  2. Zat ekstraktif larut dalam air dingin
  3. Holoselulosa (TAPPI T 203 om-02)
  4. Alpha selolosa ((TAPPI T 203 om-02)
  5. Lignin (TAPPI T 222 om-02)

5

Metode Analisis kimia kayu

Kayu dari hutan mangrove dan sero

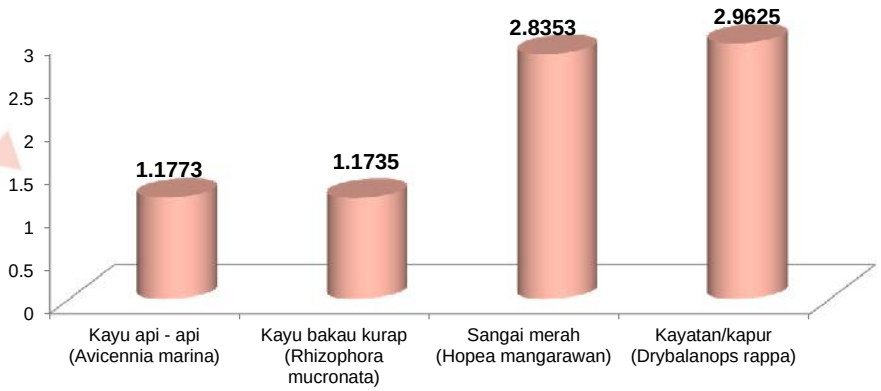
Pengeringan, penghancuran menjadi serbuk lolos 40 mesh tertahan 60 mesh

Analisis komponen kimia kayu

6

HASIL DAN PEMBAHASAN

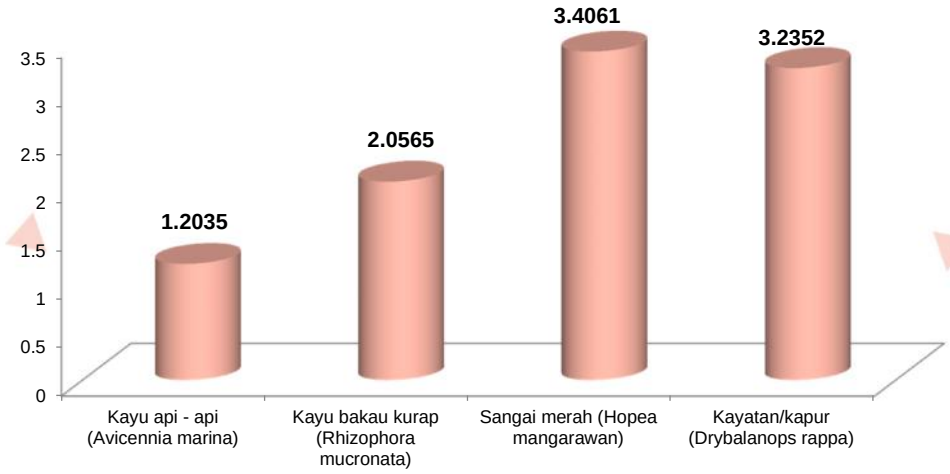
Zat ekstraktif larut dalam air dingin



Nilai tertinggi diperoleh pada kayu Kayatan

7

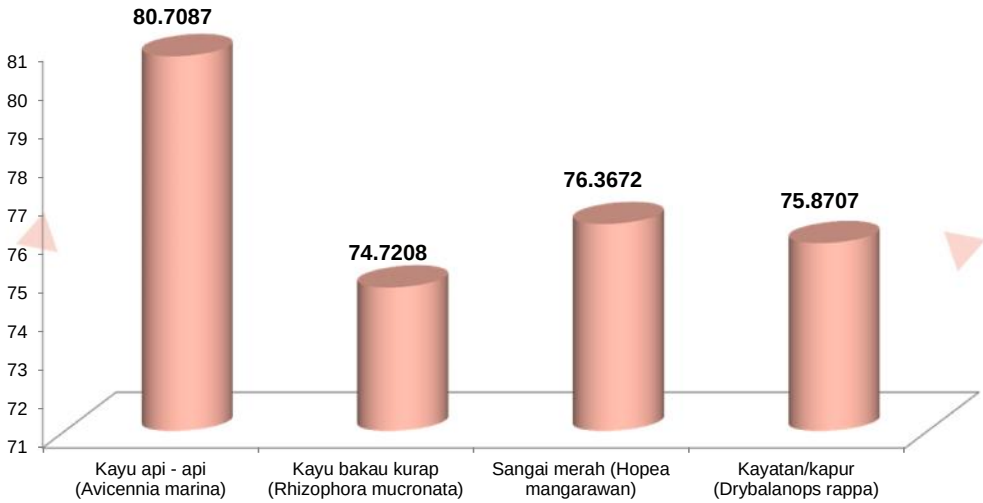
Zat ekstraktif larut dalam air panas



Nilai tertinggi diperoleh pada kayu Sangai merah

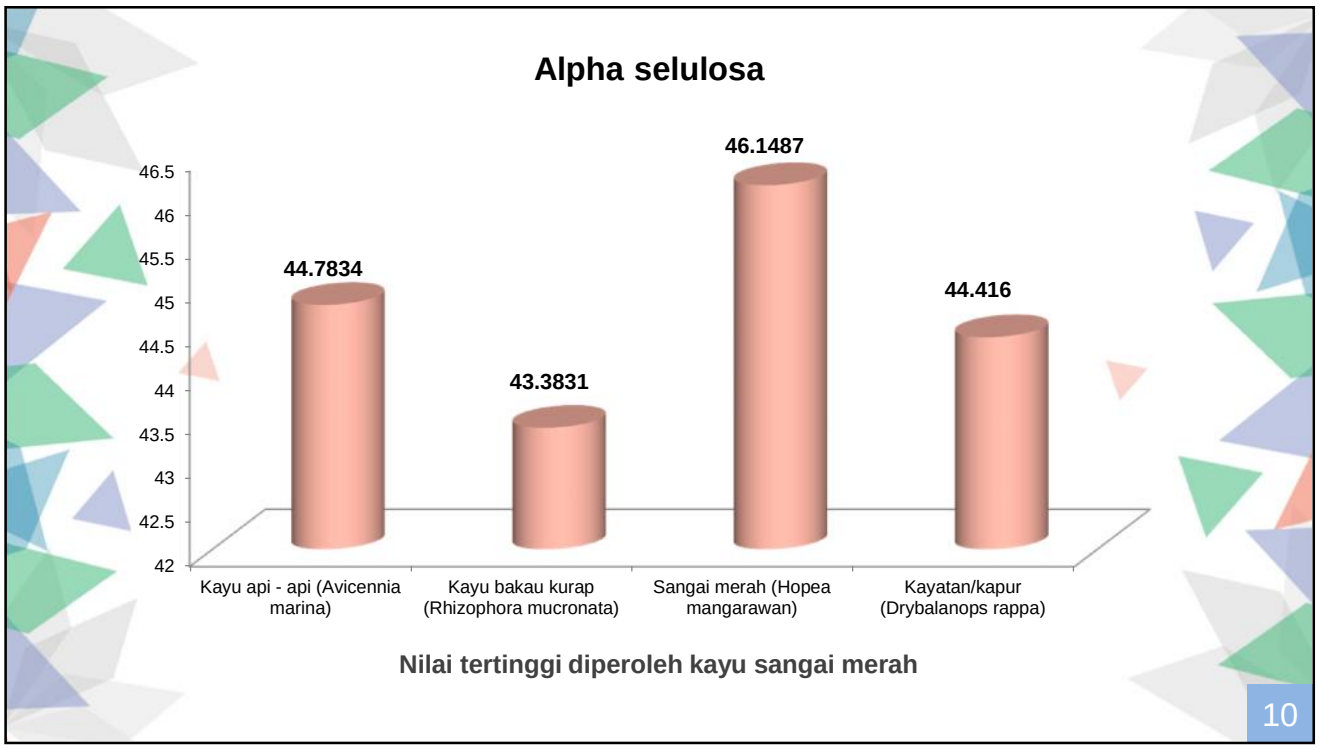
8

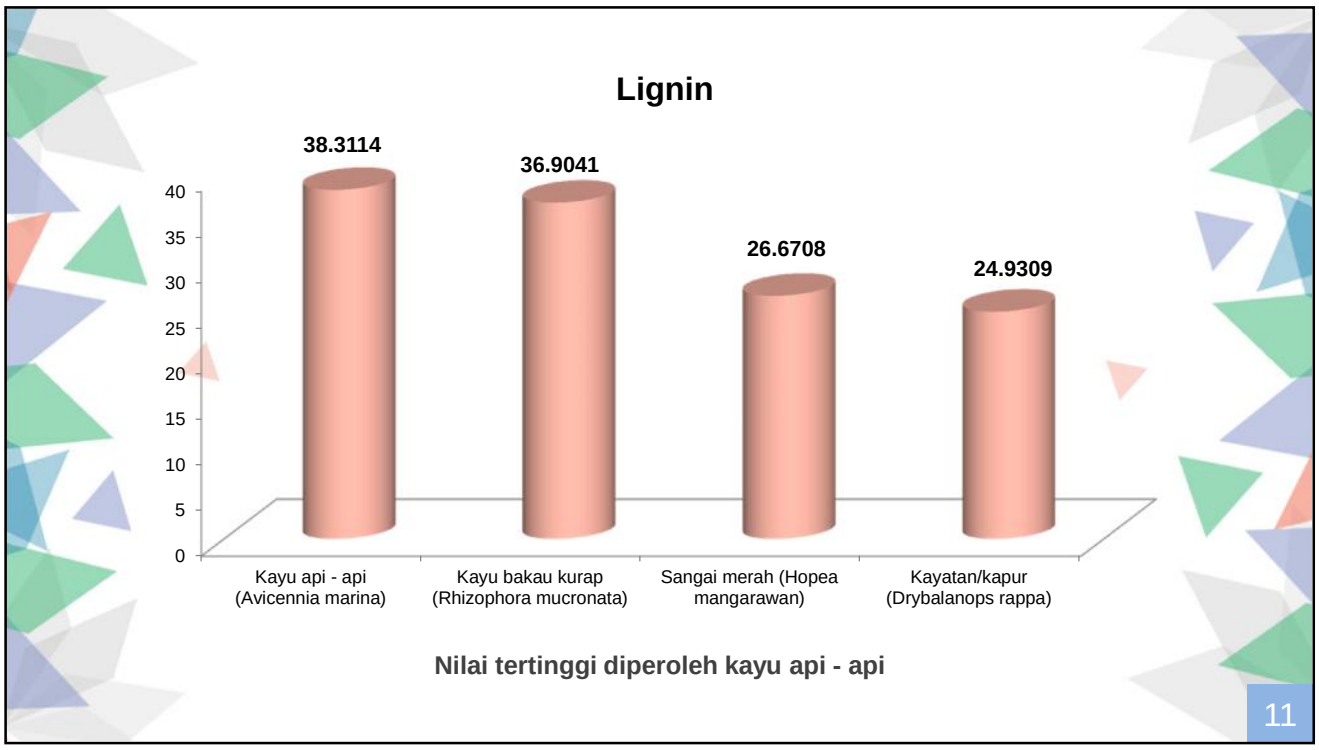
Holoselulosa



Nilai tertinggi diperoleh Kayu api - api

9


Alpha selulosa
46.5
46
45.5
45
44.5
44
43.5
43
42.5
42
44.7834
43.3831
46.1487
44.416
Kayu api - api (Avicennia marina)
Kayu bakau kurap (Rhizophora mucronata)
Sangai merah (Hopea mangarawan)
Kayatan/kapur (Drybalanops rappa)
Nilai tertinggi diperoleh kayu sangai merah
10


Lignin
40
35
30
25
20
15
10
5
0
38.3114
36.9041
26.6708
24.9309
Kayu api - api (Avicennia marina)
Kayu bakau kurap (Rhizophora mucronata)
Sangai merah (Hopea mangarawan)
Kayatan/kapur (Drybalanops rappa)
Nilai tertinggi diperoleh kayu api - api
11

PEMBAHASAN

- **Nilai holoselulosa dan α selulosa dari kayu yang berasal dari hutan mangrove (*Avicennia marina* dan *Rhizophora mucronata*) mencapai 74-80% dan 43-44%, merupakan potensi dalam pemanfaatan kayu tersebut untuk papan komposit dan pembuatan kertas.**
- **Mun *et al* (2011) menyatakan kayu *Avicennia alba, Bruguiera gymnorhiza* dan *Sonneratia apetala* yang berasal dari hutan mangrove di Sunderban, Khulna, Bangladesh memiliki nilai holoselulosa sebesar 76 – 83% dan berpotensi untuk dimanfaatakan sebagai bahan baku kertas.**
- **Kandungan kimia kayu yang terserang marine borer rata-rata memiliki nilai holoselulosa yang tinggi, sehingga masih dapat dimanfaatkan untuk industri perkayuan**

12

KESIMPULAN

- **Kayu yang diserang marine borer memiliki kandungan selulosa yang tinggi.**
- **Marine borer mencerna selulosa dengan bantuan enzim dan enzim ini berpotensi untuk dimanfaatkan dalam industri perkayuan.**

13

UCAPAN TERIMA KASIH

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14

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13

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SEMINAR NASIONAL *RESEARCH UPDATE*

"Menuju Kejayaan Kehutanan Indonesia"

Fakultas Kehutanan Universitas Gadjah Mada
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