Morphologic characteristics and population density of Teredo Navalis L in mangrove forest area, Wailukum East Halmahera Regency

Y. Sinyo¹, S. Anggoro¹,² and T. R. Soeprobawati¹,³
¹Doctoral Program in Postgraduate School of Environmental Sciences, Diponegoro University, Semarang Indonesia
²Faculty of Fisheries and Marine Sciences, Diponegoro University Semarang Indonesia
³Department of Biology, Faculty of Science and Mathematics, Diponegoro University, Semarang Indonesia.
E-mail: sinyoyumima@gmail.com

Abstract. This study aimed to analyze the population density and distribution patterns of Teredo Navalis L in the mangrove forest area of Wailukum Maba, East Halmahera Regency. A survey method with descriiptive analysis used in this research, while the research location was determined using a purposive method. The research location is 100 meters long and 50 meters wide, making it 5,000 m². The research location was divided into 4 stations. Station I in the north, station II at the center, station III in the east and station IV in the west. At each station, five transect lines were made using a rope and 5 plots were placed alternately with a size of 10x10 meters. The results showed that there were three morphological characteristics of T. navalis L. These characteristics divided in mangrove logs based on body measurements of 60 cm long, 30 cm long and 15 cm long. The population density of T. navalis L at the four stations varied between 1-2 ind/m², the highest population density was measured at station II (2 ind/m²) and the lowest was measured at station III (1 ind/m²).

1. Introduction
Teredo navalis L is a type of mollusk from the Bivalva Teredinidae class which was first discovered in the 1930s and 1950s in the waters of Denmark, Sweden and Germany. Since 1969 until now T. navalis L has been found in Thailand, Australia and Indonesia as well. T. navalis L a unique and characteristic habitat by punching holes in wood and living in mangrove logs that are dry and submerged in the sea [1], as well as consuming the wood as food [2]. Among Thai and Australian people, T. navalis L is called shipworm or mangrove worms because they are found in mangrove forests. People in the precisely in the province of Krat consume T. navalis L meat as a substitute for side dishes because it has good nutritional value animal protein [2]. People from Krat konsume raw T. navalis L after the head been removed or after cooking (processed). T. navalis L meat that has been processed and is ready to be served is called the Gaeng liang priyang menu [3]. T. navalis L has a goods prospects to develop because of its rapid growth compared to other types of bivalves in Indonesia waters [4]. T. navalis L, found in the coastal mangrove forest area of Wailukum, East Halmahera Regency, resides in old mangrove wood. Mangrove forests are ecosystems located between land and sea ecosystems [5]. The mangrove ecosystem is an ecosystem that contributes greatly to the
availability of organic detritus, which plays an important role as a biota energy source that lives in the surrounding waters. One of the biota inhabiting mangrove forests are mollusks [6]. Based on survey results in the field, especially in the coastal mangrove forest area of Wailukum, East Halmahera Regency, 

\[ T. navalis \] L plays an active role as decomposer in destroying wood. Therefore this fauna is also called wood destroyer [7]. Morphologically the head of \[ T. navalis \] L contains a small drill-shaped shell that functions to pierce wood, the body's surface is not covered in shells, but rather is smooth and soft like the inside of oysters, \[ T. navalis \] L's body is long like that of a worm, and has gills [8]. Physiologically \[ T. navalis \] L can carry out its physiological adaptation by damaging wood assisted by cellulose and nitrogen binding bacteria and other morphological functions so that the wood can be used as a source of food [9]. The population of \[ T. navalis \] L which has grown breeding is quite difficult [1]. According to [10], \[ T. navalis \] L worms have very few predators or other types of worms to compete with in obtaining food sources [7]. The distribution of \[ T. Navalis \] L is very broad and adapted to its physiological tolerance to environmental parameters such as temperature, salinity, and dissolved oxygen. Therefore, a spec understanding is needed, especially in relation to population density and distribution patterns.

East Halmahera Regency is one of the regencies in North Maluku Province whose capital in Maba has a vast and unspoiled mangrove forest area. The East Halmahera community gave \[ T. navalis \] L the local name Omoy. Local people consume \[ T. navalis \] L as a substitute for side dishes because they contain very high protein. From the results of interviews with local communities, \[ T. navalis \] L can be easily harvested because they arcis only found in mangrove trees that have been damaged [5]. Besides being taken for consumption, \[ T. navalis \] L is also sold locally by the community. Until now, research on \[ T. navalis \] L in Indonesia, especially in North Maluku Province is still very lacking, in particular research related to population density and distribution patterns. Due to this, the researcher felt that it was necessary to do research on the morphological characteristics and population density of \[ T. navalis \] L in the mangrove forest of Wailukum Maba, East Halmahera Regency.

2. Methods

2.1. Procedure

This research was carried out in Januari until May 2018 and took place in the mangrove forest area of Wailukum Maba, East Halmahera District, as shown on the following location map (Figure 1).

Figure 1. Map of Research Location (Source: DKP, MALUT, August 25, 2018)

Tools and materials used in the research were sensor machines, axes, swords, knives, tongs, plastic buckets, jerry cans (water containers), cool boxes, cameras, plastic straps, plastic jars, keybooks for classification of mollusks, notebooks, label paper, and distilled water. The data collection
method in this study uses a case study method with descriptive analysis. The research objective was to find information, observation and direct practice in the field, while descriptive analysis aims to make systematic, factual and accurate descriptions of the facts and the nature of the population in a particular area [11].

Determination of the location of the study was carried out using a purposive method, namely location sampling techniques based on certain considerations. The reason for using purposive sampling technique is because not all location samples have criteria that are in accordance with the phenomenon under study. Therefore, the author chose purposive sampling technique that specifies certain considerations or criteria that must be met by the samples used in this study [12]. Technical implementation is started by selecting the mangrove forest area that has the furthest tides, then installing transects perpendicular to the coastline.

The research location was 100 meters long and 50 meters wide, making it 5,000 m². The area of each station is 1,250 m². The research location was divided into 4 stations, station I in the north, station II in the center, station III in the east and station IV in the west. At each station five transect lines were made using ropes and 5 plots were placed alternately with a size of 10 meters x 10 meters. The T. navalis L fauna sampling procedure is as follows: Sampling was done in the designated area. Samples of T. navalis L before being taken, were first cut into wood by using a sensor machine and ax to split the mangrove logs that had been dried and submerged in sea water. Subsequently, T. navalis L was taken from the logs (Results-results of the research). Taking sample documentation, samples that were successfully taken were put in a plastic, labeled bucket that had been cleaned using distilled water. Then, the sample was placed in the cool box and analyzed in the laboratory. Finally, the morphological characteristics and population density were analyzed. Environmental parameters measured are water temperature, salinity, and substrate pH. This environmental parameter data may be used as supporting data to determine the ecological conditions in T. navalis L habitat in the mangrove forest area of Wailukum Maba, East Halmahera Regency.

2.2 Data Analysis
The density calculation of T. navalis L can be made using the following formula [13].

\[ D = \frac{n_i}{A} \]

Information-information:
D: Density T. navalis L (individual / m²)
Ni: Number of individual species T. Navalis L
A: Area area observed (m²).

3. Results and Discussion
3.1. Description of the research location
The geographical location of East Halmahera Regency in the eastern part of Halmahera Island is located between 0° 40' - 1° 4 North Latitude and 126° 45' - 129° 30' East Longitude, with an area of 14,202.01 km² and land area of 6,506.19 km² and sea area of 7,695.82 km² consisting of a large group of islands and surrounded by a cluster of small islands. Special Kota Maba District has an area of 83.57 ha. While administratively Wailukum Beach is an area of city of Maba Subdistrict, which has the boundaries of the area that is to the north bordering the City of Maba, in the south bordering the Central Halmahera Regency, in the west bordering Wasile South and the East bordering South Maba [14]. The slope conditions on the coastline of City of Maba and South Maba sub-districts are as big as 15%, with an average height of 0-5 meters above sea level. This shows that most areas that have a height between 0-5 and which have an elevation of 0-2%, are areas that are affected by tides (rob). The area affected by tides (rob) in East Halmahera Regency is the city of Maba, south Maba, and the Wasile Districts. The city of Maba has an area of 6,529 hectares of mangrove forest that is productive and still natural. These productive mangrove forest areas always receive salt water from the sea body, as well as fresh water so that they have the potential to receive and accommodate nutrients derived from domestic waste and industrial waste. The mangrove forest area in the Wailukum Maba beach
area is used as a transportation route and also as a fishing area for fish, shrimp, crabs, shellfish, *T. navalis* L.

3.2. The results morphological characteristics of *T. navalis* L

Based on the identification and analysis of *T. navalis* L morphological characteristics scattered in mangrove logs, three types of body size were obtained, namely long, medium and short. These three body sizes can be found at the four research stations. *T. navalis* L is categorized as a long body size of 60 cm, medium body size 30 cm and a short body size of 15 cm. At *Teredo navalis* L station I, 400 long individuals, 222 medium individuals size and 200 short individuals. In *T. navalis* L station II, the length is 1,300 long individuals, 624 medium individuals and 400 short individuals. The number of *T. navalis* L in station III was 306 long individuals, 230 medium individuals and 200 short individuals. Whereas in the IV station, *T. navalis* L is 20 long individuals, 280 medium individuals and 652 short individuals. This makes the total number of individuals 4834 ind/m². It can be said that the number of *T. navalis* L in each station varies. Based on the morphological character, it was found that the highest number for long body size was found in station II while the highest number for short body size was at station IV. The morphological characters of *T. navalis* L can be observed directly when they are still in the mangrove tree trunks and after they are taken from their habitat. Based on identification characteristics (traits) *T morphology, navalis L* scattered the mangrove wood trunk then get the three types of body size that measures 60 cm long, medium and short measuring 30 cm by 15 cm, and a third body size can be found in two research stations. As shown in the following at table 1:

| Body size | Picture | Morphological characteristics |
|-----------|---------|-------------------------------|
| Long 60 cm| ![Picture](image1.png) | Long body size *Teredo navalis* L head has a small drill-shaped shell that serves to punch wood. Her naked body was not covered in a shell. The surface of the body is slippery and soft [15]. |
| Medium 30 cm| ![Picture](image2.png) | |
| Short 15 cm| ![Picture](image3.png) | |

3.3. Results Population density analysis of *T. Navalis* L

The results of *T. navalis* L population density analysis showed that the average range of population density of *T. navalis* L between the stations varied between 1–2 ind/m². The highest population of *T. navalis* L is at station II (2 ind/m²) and the lowest is at station III (1 ind/m²). As shown in table 2.

| Station | Area (m²) | Total Individual | Density Value |
|---------|-----------|-----------------|---------------|
| I       | 1250      | 822             | 1             |
| II      | 1250      | 2324            | 2             |

Table 1. The results of identification of morphological characteristics

Table 2. Value of *T. navalis* L population density
The high population density of *T. navalis* L is due to the higher level of mangrove density resulting in the availability of more habitat land. A high level of mangrove density creates a high absorption capacity [4]. Population density (abundance value) *T. navalis* L in mangrove wood in coastal waters Wailukum Maba East Halmahera District has different values. At station II the value of population density is 2 ind/m² while population values, at stations I, III and IV that is, each population density value is 1 ind/m². This can also be seen through the following diagram (Figure 2):

Based on the graph above, it can be said that the highest population density is found in Station II. This is because the location in station II has a lot of old mangrove trees and even most of the dead ones have rob stems to the surface of the soil and are always inundated by tidal water. Whereas at stations I, III and IV the value of low population density is due to the fact that there are still many types of mangrove trees that are still young compared to the older ones. This is also affected by climate change that occurs. When the summer occurs for a long time, evaporation occurs, thus reducing the water discharge. This causes increased salinity and accelerates the occurrence of leaf fall in mangrove trees. The occurrence of climate change like this can trigger the activity of *T. Navalis* L in playing its role as a destroyer or decomposer of wood [2]. Change in population density is influenced by four primary parameters of the population, namely natality, mortality, immigration and emigration [3].

4. Conclusion

Based on the results of the study, it can be concluded that the results of identification and morphological characteristics of *T. navalis* L which are spread in mangrove logs consist of three types of body size namely long, medium and short, and obtained from analysis of population density of *Teredo navalis* L at four varied stations.

**Recommendation**

Management of mangrove environment and fauna conservation needs to be carried out sustainable by the government in a stakeholders to maintain the existing populasi fauna.

**Acknowledgement**

Thank you to the 2018 FSM-ISNPINSA journal manager who received my article. Which is based on the address of research and technology no. 101-88/Un.704.3/PP/2018. Thank are adress to the above allocation.

**Reference**
[1] Borges, L. M. S., Merckelbach, L. M., Sampaio, Í., & Cragg, S. M. (2014). Diversity, environmental requirements, and biogeography of bivalve wood-borers (Teredinidae) in European coastal waters, 1–13.
[2] Paalvast, P., & Velde, G. Van Der. 2013. Journal of Sea Research. 80 58–60
[3] Lippert, H., Weigelt, R., Glaser, K., Krauss, R., & Bastrop, R. 2017. Teredo navalis in the Baltic Sea: Larval Dynamics of an Invasive Wood-Boring Bivalve at the Edge of Its Distribution, 4 October, 1–12.
[4] Eriksen, AM, Gregory, DJ, & Matthiesen, H. 2017. Journal of Cultural Heritage. 28 75–81.
[5] Voight, J. R. (2018). Molluscan Studies Xylotrophic bivalves: aspects of their biology and the impacts of humans, (March 2015), 175–186.
[6] Gonz, M. M., & Izquierdo, A. 2018. Estuarine, Coastal and Shelf Science Effects of substrata and environmental conditions on ecological succession on historic shipwrecks, 200, 2009–2018.
[7] Weigelt, R., Lippert, H., Karsten, U., & Bastrop, R. 2017. Genetic Population Structure and Demographic History of the Widespread Common Shipworm Teredo navalis Linnaeus 1758 (Mollusca : Bivalvia : Teredinidae) in European Waters Inferred from Mitochondrial COI Sequence Data, 4 (June), 1–12.
[8] Appelqvist, C., & Havenhand, J. N. 2016. A phenological shift in the time of recruitment of the shipworm, Teredo navalis L., mirrors marine climate change.
[9] Macintosh, H., Nys, R. De, & Whalan, S. 2014. Journal of Experimental Marine Biology and Ecology. 459 80–86.
[10] Mohrholz, V., Naumann, M., Nausch, G., Krüger, S., & Gräwe, U. 2015. Journal of Marine Systems. 148 152–166.
[11] Swaim D, Pacllu AV, and Rao.MV 2017. Biodiversity of Shipworms (Mollusca: Bivalvia: Teredinidae) in the Vicinity of a Tropical Mangrove Ecosystem along Bay of Bengal, Andhra Pradesh, India. 20 (November), 1-5.
[12] Sugiyono. 2016. Quantitative, Qualitative and R & D Research Methods. Bandung: PT Alphabet.
[13] Ehrich, D., Jorde, P. E., Krebs, C. J., Kenney, A. J., Stacy, J. E., & Stenseth, N. C. (2001). Spatial structure of lemming populations (Dicrostonyx groenlandicus) fluctuating in density, 481–495.
[14] DKP, 2012. Zoning Plan for Coastal Areas and Small Islands North Maluku Province. Department of Fisheries and Maritime Affairs of North Maluku Province.