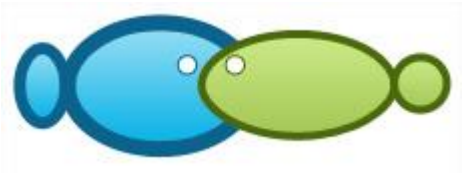

Proximate content of *Teredo navalis* (Linnaeus 1758) mollusk from mangrove habitats in East Halmahera, Indonesia

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Abstract. *Teredo navalis* Linnaeus 1758 are usually consumed and used by the local people of East Halmahera as food, a substitute for side dishes, and as a source of medicine. Proximate analysis is useful for assessing the quality of feed or food ingredients. The purpose of the proximate analysis in this study is to quantitatively analyze the content of water, ash, fat, protein, and carbohydrates contained in *Teredo navalis*. This study aims to analyze the proximate content of *Teredo navalis* from the mangrove ecosystem of East Halmahera by using the Kjeldahl method through the stages of destruction, distillation, and titration. The results showed that *Teredo navalis* which lives in the mangroves of *Rhizophora* sp. and *Avicennia* sp. has a smooth body morphology, a clear yellowish shell, brownish-red gills, two tentacles, soft and clear texture, elastic body texture, it is dense and slippery, and a body size of 10 - 60 cm. The proximate content of carbohydrates was 44.73%, protein 13.30%, fat 1.057%, and crude fiber 0.056%. Based on this result, *Teredo navalis* can be used as a source of carbohydrates, protein, and fats that can be consumed by humans, and has crude fibers, which provides proportion to the metabolic process.
Key Words: bivalve, community, nutritional content.

Introduction. Fishery resources are an important economic source for some countries in the world, including Indonesia. Most of the fish processing industries prioritize products containing protein, carbohydrates, and fats to fulfill human nutrition (Dekker et al 2011). The prevalence of scarcity and progress towards a World Food Summit (WFS) in developing countries are key issues for FAO. Food insecurity and malnutrition are complex issues that cannot be solved by a single sector or stakeholder alone, but need to be addressed in a coordinated way, with integrated commitment and leadership (FAO 2011). The government's efforts to combine support for production with social protection have been backed by a much broader commitment made at the June 2014 African Union Summit to end hunger by 2025 (FAO 2014). Food is a basic need that is always required by humans for daily survival.

Nutritious food contains nutritional elements, namely protein, carbohydrates, fat content, crude fiber content, and other components such as vitamins and enzymes (Diniz et al 2013; Rosaini et al 2015). These elements and compounds are needed by body cells such as nerves, blood, and muscle cells. Proximate analysis is useful for assessing the quality of feed or food ingredients (Koir et al 2017). The purpose of the proximate analysis in this study is to quantitatively analyze the content of water, ash, fat, protein, and carbohydrates contained by *Teredo navalis*. Proximate classification is based on the chemical composition of water, ash, crude protein, crude fat, and extracts without

nitrogen. Each composition has its own components, namely, the water component is a volatile organic compound, ash is a mineral element. Crude protein components consist of protein, amino acids, and non-protein nitrogen (NPN). Crude fat components are fats, oils, organic acids, waxes, pigments, and vitamins. The components of crude fiber are hemicellulose, cellulose, and lignin. BETN is a carbohydrate that is soluble in acid and alkaline solutions and has high digestibility, its components being monosaccharides, disaccharides, and polysaccharide. BETN is composed of sugar, organic acids, pectin, hemicellulose, and lignin which are soluble in alkaline solutions (Kurnijasanti 2016).

Water content plays an important role in feed quality, so it can determine acceptance, freshness, and durability of feed (Mirsani et al 2020). Ash is an inorganic substance leftover from the combustion of an organic material. The higher the ash content, the worse the quality of the feed. Ash consists of mineral components (Koir et al 2017). Protein is the main component in various natural foods and determines overall texture, for example, meat tenderness (Ibrahim 2015) and is a macronutrient that plays a role in the formation of biomolecules (Shaviklo et al 2012) and is an organic substance containing carbon, hydrogen, nitrogen, oxygen, and phosphorus (Bello 2013). The function of protein is to repair tissues, growth of new tissues, metabolism for energy, metabolism into vital body substances, essential enzymes, and certain hormones (Lestari et al 2017).

The mollusk *Teredo navalis* (Linnaeus 1758) is a species of the bivalve's class Teredinidae which is found in habitats of weathered mangroves (Swaim et al 2017). In East Halmahera, *T. navalis* was found living and active in the roots and stem of *Rhizophora* sp. and *Avicennia* sp. mangroves (Sinyo et al 2019). *T. navalis* is consumed by the local community, used as food, a substitute for side dishes, and a source of medicine (Sinyo et al 2020). *T. navalis* presence in East Halmahera is quite abundant in the mangrove ecosystem. The local people consume *T. navalis* in the form of fresh or preserved meat (dried). The way to consume *T. navalis* after being taken from its habitat is to clean it with freshwater and to remove the shell on the head. After cleaning, *T. navalis* can be eaten directly as raw meat. In Thailand, people consume *T. navalis* meat by cooking the fresh meat first by mixing it with spices and then serving it and when eaten it tastes salty, and the dish is often found in restaurants (Lippert et al 2017).

T. navalis living in the roots and trunks of mangroves has an ecological character that can use the shell on the head to damage mangrove wood by making holes/burrows (Swaim et al 2017). *T. navalis* is also called shipworm or marine wood-boring organism (Didžiulis 2011); Pati et al 2014), and is distributed throughout the world from the poles to the tropics (Treneman et al 2018; Eriksen et al 2014). *T. navalis* is important to study because it can be consumed and has an appropriate proximate composition. It was reported that the types of mollusks that have been studied and have appropriate proximate content and antioxidants are *Pleuroploca trapezium* (Merdekawati et al 2017), *Lymnaea stagnalis* (Vorontsova et al 2010), sea leeches (*Discodoris* sp.) (Hafiluddin et al 2011), ipong-ipong snails (*Fasciolaria salmo*) (Nurjana et al 2011), pokea shells *(Batissa violacea)* (Yenni 2012), mussel clams (*Corbicula moltkiana*) (Rosaini et al 2015), kowoe conch (*Pomacea canaliculata*) (Haslianti et al 2017) and mangrove gastropods like *Telescopium* sp. (Haerullah 2017).

T. navalis itself has been widely studied including the genetic population structure of larvae (Lippert et al 2017; Macintosh et al 2014), distribution, and diversity of *T. navalis* in mangroves (Swaim et al 2017), biological aspects, morphology, geographic distribution, wood destruction (Voight 2015), wood damage rate and environmental parameters (Pati et al 2014), the abundance of *T. navalis* (Macintosh et al 2014), attack activity of *T. navalis* on wood (Eriksen et al 2014), food source for *T. navalis* (Paalvast & Velde 2013; Appelqvist et al 2015) and the effect of temperature on the mating season of *T. navalis* (Appelqvist & Havenhand 2016). Until now, research on proximate levels in *Teredo navalis* has never been carried out either in Indonesia or in other countries. Therefore, it is very important to study the chemical composition of *T. navalis*, to provide

information about the nutritional content, efficacy, and benefits of *T. navalis* to the body. The study of *T. navalis* is useful for the development and optimal use of *T. navalis* in the future. This study aims to analyze the proximate content (protein, carbohydrate, fat, and crude fiber content) of *T. navalis* from the mangrove ecosystem of East Halmahera.

Material and Method

Research sites. This research was conducted in the mangrove waters of Wailukum, East Halmahera Regency, Indonesia (Figure 1) for 4 months, from March to June 2020. Sampling was carried out for two months at two sampling locations, namely Site 1 in the northern part of Wailukum and Site 2 in the southern part of Wailukum. Determination of the location is based on mangrove areas that are still natural, and the area of each sampling location is of 5000 m^2 (100 x 50 m). Sampling is carried out every month focused on the mangrove species *Rhizophora* sp. and *Avicennia* sp. which are used as habitat by *T. navalis*.

Figure 1. Research site (source: Sinyo et al 2019).

Sample collection. The activities of collecting samples of *T. navalis* at site 1 and 2 were carried out at low tide using sensor machines, machetes, tongs, gloves, buckets and coolboxes. The sensor machine is used to cut the mangrove roots and stems measuring 70 cm, then the mangrove roots and stems are split using a machete. The samples of *T. navalis* that were found were taken using gloves and tongs as many as 50 samples at each location, then stored in a bucket to be cleaned using distilled water. Before the sample is packed into the coolbox, the morphological characterization of the body and the measurement of total body length are carried out, the results of observations and measurements are recorded in the observation table, then the sample is put into the coolbox to be taken to the Center of Industrial Pollution Prevention Technology (BBTPPI Semarang) testing and calibration laboratory for proximate testing purposes. Proximate analysis was carried out to determine the levels of protein, carbohydrates, fat and crude fiber using the Kjeldahl method according to Association of Official Analytical Chemist (AOAC 2005) which was carried out through the stages of destruction, distillation and titration.

Data analysis. Characteristics of body morphology and body length of *T. navalis* are presented in Table 1, and the proximate content measurement data was calculated using the formula suggested by (AOAC 2005).

Results and Discussion

Bioecology of T. navalis. The results obtained based on observations are that it has morphological characteristics of a elongated body like a worm, its body is naked, has two tentacles, and has a shell on its head, and has gills. The body color of young *T. navalis* is clear while that of adult *T. navalis* is brownish red (Sinyo et al 2019). Body length ranges from 15 cm to 60 cm (Table 1).

Table 1

Morphological characteristics of *T. navalis*

Characteristic	*Description*
Body surface	Clear and smooth
Shell on head	Clear yellowish
Gills	Red brown
Tentacles	Two, soft and clear
Body texture	Elastic, solid and slippery
Body size interval	10-60 cm

T. navalis which inhabits the roots and stems of *Rhizophora* sp. and *Avicennia* sp. mangroves has different body size (Figure 2), from *T. navalis* found in 2019 (Sinyo et al 2019) there, with three types of body size, namely 45 cm, 35 cm, and 15 cm. Samples from this study have the same morphological characteristics with those from the 2019 study, namely having a shell on the head and a smooth body surface (Sinyo et al 2019). This is in line with the statement (Pati et al 2014) that the color, shell size, and body length of *T. navalis* are largely determined by the texture of the roots and stems of the mangroves used as habitat. The high and low activity of *T. navalis* in this habitat indicates its wide distribution in that habitat (Sinyo et al 2019), as shown in (Figure 2).

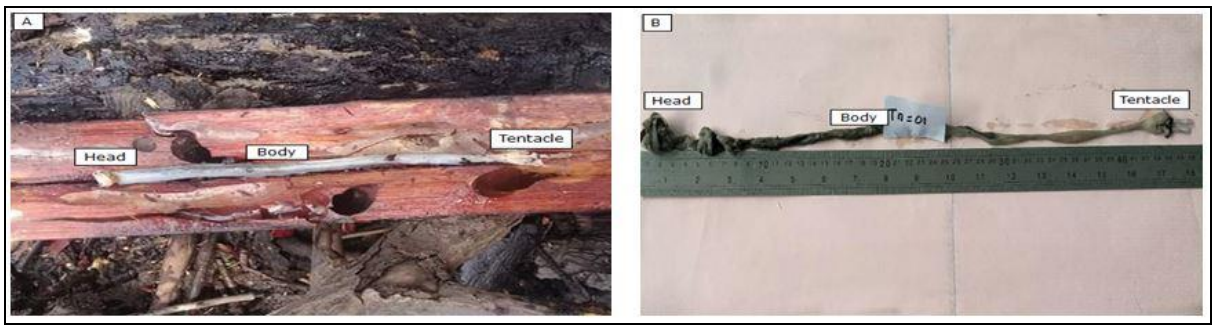

Figure 2. (A) Description of characters in 2019 (Sinyo et al 2019) and (B) description of characters in 2020.

Results of the proximate analysis. *Teredo navalis* proximate content consists of carbohydrates 44.73%, protein 13.30%, fat 1.057%, and crude fiber 0.056% (Figure 3). The carbohydrate content was higher than the protein, fat, and crude content. Rosaini et al (2015) found that the highest protein content was found in fried mussels (7.1491%±0.0249), curry mussels (6.5771%±0.1095), and fresh mussels (6.3927%±0.0206) respectively. Mussels are one type of shellfish that are quite popular with most Indonesian people because they have a nutritional content like shellfish. Mussels can be processed into a variety of dishes. In his research, Bello (2013) said that the average value of the proximate composition in percentage for fresh samples was 24.31% protein, 35.10% water, 7.25% fat, 10.50% crude fiber, 13.32% ash and 9.52% carbohydrates. Meanwhile, the boiled sample recorded a water content of 38.33%, 18.83% protein, 15.21% ash and crude fiber and fat content ranged between 5 and 7%.

The carbohydrate content of smoked samples was very high compared to other processed samples, 44.56%. This is compared to the research conducted by Diniz et al (2013) on the conversion factor of nitrogen into protein, amino acids by fish in a tropical environment. The results showed that the amino acid composition and nitrogen, phosphorus, lipid, carbohydrate, and protein content in the muscles of showed low carbohydrate content (<3.5% dry weight in all species) and rich in protein (>66% dry weight in all species). Total lipid percentage varied widely between species, and *Mullus argentinae* showed the highest concentration (16%). The proximate content obtained in *T. navalis* is presented in Figure 3.

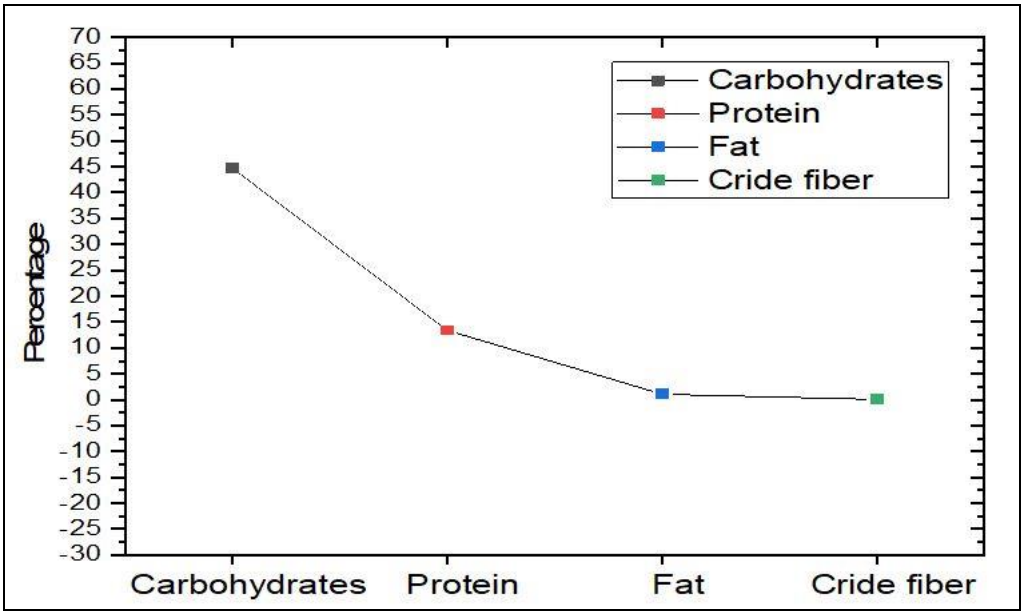

Figure 3. Proximate composition of *T. navalis*.

The percentage of protein, fat, and crude fiber is lower than the percentage of carbohydrates. Fresh T. navalis meat consumed by the public has a salty taste. This is in line with the results of interviews with the people of East Halmahera who consume *T. navalis* meat fresh (raw), that *T. navalis* meat tastes salty when consumed directly (Sinyo et al 2019). Meanwhile, meat that has been dried when consumed tastes very sweet. When compared with the results of research conducted by Ehigiator and Oterai (2012), the protein content of *Macrobrachium vollenhovenii* and *Tympanotonus fuscatus* is relatively high compared to other nutritional compositions. The high protein content of *M. vollenhovenii* could be attributed to its omnivorous eating habits and to stress conditions caused by heavy metal toxicity in protein metabolism or due to increased proteolytic activity because of increased metabolic demands after exposure to toxic pollutants in the environment. Chelladurai and Uma (2020) reported that the nutritional composition of a good protein profile in the species *Babylonia spirata* (Linnaeus 1758) added economic importance. The fat content of *M. vollenhovenii* and *T. fuscatus* in the mentioned study was low and could be included in the low-fat class. An indication that the species will not go rancid. The protein content of *T. navalis* obtained in this study when compared with the results of the research on the protein content of *Babylonia spirata*, the nutritional composition of protein in *Babylonia spirata* was higher so it had the opportunity to add economic value.

Achi et al (2007) reported an increase in the proximate protein content of fermented crabs. The high protein content is needed by the body because it helps in replacing worn-out tissue and regulating body metabolism. Bello and Akinyele (2007) reported an increase in the protein content of processed *Termitomyces robustus* and Huda et al (2010) reported a decrease in the protein content of comparing and

distinguishing the physicochemical properties of crackers from different producers in Malaysia. The results were significantly different ($p<0.05$) in their chemical composition, linear color, and expansion. The water content ranged from 9.37 to 13.83%, while fat and ash levels ranged from 0.85 to 3.38% and 3.39 to 5.94%. However, the protein content, which is 5.53 to 15.80%, distinguish products with high fish content and those who have low fish content. Carbohydrate content varies between 53.62 and 80.43%, reflecting the use of starch in high formulations. These results show that Malaysian fish crackers produced by various producers are significantly different in chemical composition, the nature of color expansion, and linear. On the other hand, Ehigiator and Oterai (2012) reported that protein values ranged from 67.68 to 69.71%, fat values ranged from 6.87 to 7.68%, ash values ranged from 10.16 to 10.55%, fiber values ranged from 0.40 to 0.54%, water content values ranged from 10.25 to 10.71%, carbohydrate values ranged from 0.58 to 3.65%. These values are needed to compare with the research results the authors get.

Conclusions. Based on the results of the study, it can be concluded that *Teredo navalis*, which lives in the mangroves of *Rhizophora* sp. and *Avicennia* sp., has a smooth body morphology, a clear yellowish shell, brownish-red gills, two tentacles, soft and clear texture, elastic body texture, it is dense and slippery, and a body size of 10 cm - 60 cm. *T. navalis* is consumed by the people of East Halmahera, used as a substitute for side dishes, and a source of medicine. *T. navalis* is a nutritious food and contains nutritional elements, namely protein, carbohydrates, fat, and crude fiber content. Proximate analysis was carried out to assess the quality as a food. The proximate content obtained from the analysis was the highest in carbohydrates followed by protein, fat and the lowest in crude fiber. Based on these results, it can be said that Teredo navalis contains carbohydrates, proteins, and fats that can be consumed by humans.

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Conflict of Interest. The authors declare no conflict of interest.

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