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Ecological study of primitive brachiopods *Lingula* sp. in Probolinggo, East Java, Indonesia

Rakmawati[1] and Sucipto Hariyanto[2]*

[1]Magister Program in Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia
[2]Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia

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ABSTRACT

The purpose of this study was to describe the morphology and ecology of the primitive Brachiopods *Lingula* sp. in Probolinggo, Indonesia. The *Lingula* sp. collected from the intertidal zone of Mayangan Beach, Probolinggo Regency, East Java Province, Indonesia by digging substrate using a shovel in certain holes as deep as 5-20 cm in March 2019 when the beach was at its farthest recede (06.30 - 09.30 am). Sampling was carried out using the perpendicular transect method, by placing three transect lines towards the sea. The specimens obtained were then preserved using 70% alcohol. Identification, analysis, and description of *Lingula* sp. conducted at the Ecology Laboratory of the Faculty of Science and Technology, Universitas Airlangga. Analysis of substrate types (substrate components) and substrate content (Nitrogen, Phosphor, and Potassium) was carried out at Institut Teknologi Sepuluh Nopember Surabaya. The result showed that *Lingula* sp. having a slightly oval eggshell that is shiny green, the pedicle is found in the posterior region. In the interior of the body, *Lingula* sp. has a distinctive structure called lophophore. The total length of *the Lingula* sp. range between 40 - 120 mm. The substrate which is the habitat of *Lingula* sp. is silt smooth silky sand with a composition of 0.13% gravel, 88.44% sand, 11.43% fine grains (silt + clay). Meanwhile, the habitat of *Lingula* sp. containing 0.644% nitrogen (N), 0.087% phosphor (P), 0.362% potassium (K), with a pH of 8.30 and salinity 5.94‰.

Key words: *Lingula sp., Brachiopods, Ecology, Probolinggo, Indonesia.*

Introduction

The aquatic ecosystem is the largest contributor to germplasm biodiversity compared to terrestrial ecosystems. Heino (2005) explained that most of the biodiversity in aquatic ecosystems are dominated by invertebrates. In Indonesia, research on the ecology of invertebrates has been widely studied. However, the majority of invertebrate ecology studies in Indonesia are still dominated by studies of modern invertebrates, for example, studies on the ecology of crabs, lobsters, and shrimp (Ardika *et al.,* 2016; Wahyudin *et al.,* 2016; Wardiatno *et al.,* 2016). Meanwhile, information on the ecology of ancient marine invertebrates such as Brachiopods has not been much studied.

Brachiopods are members of marine invertebrates belonging to a minor community. The presence of Brachiopods in the environment is no more than one hundred genera and their existence can be found in the intertidal zone of water (William *et al.,* 1996). In addition, Brachiopods is also one of the few marine invertebrates that has the most complete fossil record, namely from the appearance of the

early skeletons during the Cambrian period to sporadic distribution in the modern ocean (Koneva and Ushatinskaya, 2008; Skovsted *et al.,* 2015; Topper *et al.,* 2017). Initially, Brachiopods was classified as a member of the phylum of Mollusca, but at the end of the 19th century, Brachiopods was excluded from the phylum of Mollusca and became a separate phylum (Carlson, 2016; Emig, 2008).

Phylogically, Brachiopods is a member of the Lophophorates group (Pechenik, 2010). Lophophore is a term for the structure of essential organs owned by Brachiopods which represents the way Brachiopods eat using the help of lophophore organs (Carlson, 2016; Samanta *et al.,* 2014; Zhang *et al.,* 2003). Hutchins (2003) named Brachiopods as a species of "inarticulate" lamp shell. Meanwhile, when viewed from its morphology, Brachiopods is similar to members of the Mollusc phylum which has two shells, namely Bivalves (Samanta *et al.,* 2014; Sundaram and Deshmukh, 2009). However, the morphological structure of Brachiopods is different from Bivalves.

The Brachiopods' member that can still be found in the environment is *Lingula* sp. Because of its existence in the environment to date, *Lingula* sp. also known as a living fossil (Darmarini *et al.,* 2017; Emig, 2008). Until now, the existence of *Lingula* sp. in the environment it is only used as raw material for food by the surrounding community (for consumption). One of the existence of *Lingula* sp. in Indonesia can be found in Probolinggo, precisely in the area of Mayangan Beach. The purpose of this study was to describe the morphology and ecology of the primitive Brachiopods *Lingula* sp. in Probolinggo, Indonesia.

Materials and Methods

Lingula sp. collected from the intertidal zone of Mayangan Beach, Probolinggo Regency, East Java, Indonesia (Figure 1) in March 2019 when the beach was at its farthest recede. Sampling was carried out using the perpendicular transect method, by placing three transect lines towards the sea. *Lingula* sp. taken and collected by digging substrate using shovel in certain holes as deep as 5-20 cm. Retrieval of the coastal substrate was also carried out with the aim as additional data or supporting ecological data for the habitat, namely the substrate which is the habitat and substrates which are not a habitat of *Lingula* sp.

The specimens obtained were then preserved using 70% alcohol. Identification, analysis, and description of *Lingula* sp. conducted at the Ecology Laboratory of the Faculty of Science and Technology, Universitas Airlangga. Meanwhile, analysis of substrate types (substrate components) was carried out at the Soil and Rock Mechanics Laboratory of the Faculty of Civil, Environmental, and Earth Engineering, Institut Teknologi Sepuluh Nopember Surabaya, and analysis of substrate content (Nitrogen, Phosphor, and Potassium) Laboratories conducted at the Quality Laboratory Environment Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember Surabaya.

Results and Discussion

Lingula sp. has bilateral body symmetry and is divided into the dorso-ventral section. Body shape follows the shape of the shell. The shape of the ovate shell is slightly oval, the length of the shell is ± 1-55

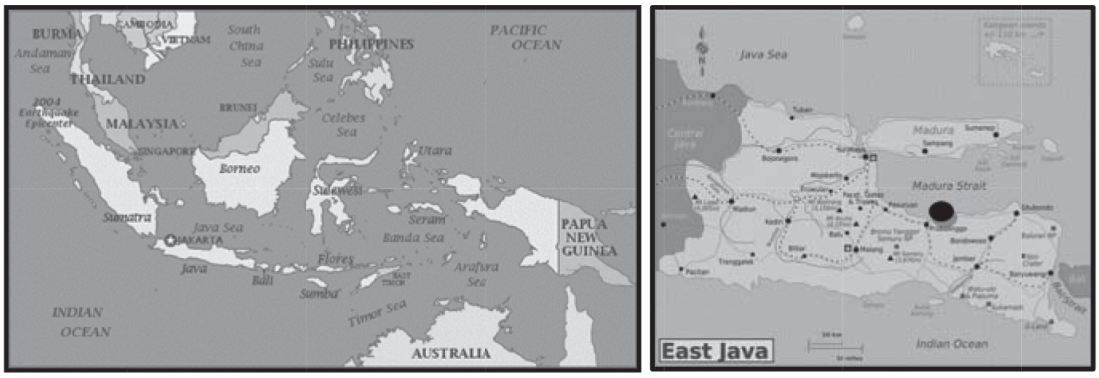

Fig. 1. Maps of research location; (a) Map of Indonesia; (b) Map of East Java ; ( ) Mayangan Beach, Probolinggo.

mm, the width of the shell is ± 0.4-20 mm, the shell is shiny green, the shell is not as small (the ventral shell (pedicle) is longer than the dorsal (brachial)), and there are chaeta throughout the shell, but on the anterior side, the chaeta structure is longer than the other parts. When the shell is opened, the visible structure of the lophophore in the body of *Lingula* sp. There is a long cylindrical tail (pedicle), tail length (pedicle) ± 10-80 mm, tail width (pedicle) ± 0.02-12 mm, consistency of a little hard, thick, transparent to white, inside the tail there is a liquid secret, and at the end of the tail (pedicle) there is an attachment structure on a black substrate that is typically the color of mud or sediment with a length of ± 5-10 mm. Meanwhile, total body length measures ± 40-120 mm with weights reaching ± 1-6.8 g. The shell of *Lingula* sp. is different from Bivalves' shells. The shell of *Lingula* sp. is oval-shaped, slightly flattened, and asymmetric (the ventral (pedicle) is longer than the dorsal (brachial)), whereas the shells owned by members of the Bivalves, are shells of the same dorsal and ventral size or shell that is cupped (symmetric) (Figure 2). In all parts of the shell, there is a chaeta structure, and specifically, in the anterior part of the shell, the chaeta is longer in size which functions as a pseudosiphon to aid breathing (Emig, 2008). In addition, the shells also have ornaments in the form of lines that can show the age evolution of *Lingula* sp.

Overall *Lingula* sp. found on Mayangan Beach, its shell is shiny green like *Lingula* sp. which was found by Mitra and Pattanayak, (2013) in the estuarine of Subarnarekha-India and *Lingula* sp. which was met by (Darmarini *et al.,* 2017) in Lubuk Damar, Aceh, Indonesia. However, in several studies that have been carried out, also found *Lingula* sp. with a light greenish-brown shell, for example, a study conducted by (Bitner, 2010) in Caledonia. The difference in the color of the shell can indicate differences in habitat types, so the availability of food *Lingula* sp. also different, so the color spectrum of the *Lingula* sp. also different, in other words, habitat type and food type will affect the color of the shell of *Lingula* sp. The size of *Lingula* sp. which is found in the beach ecosystem in Mayangan Beach is very diverse and the size depends on the mating season. However, the size of *Lingula* sp. found in this study is quite large (40-120 mm) when compared with previous studies, for example, research conducted by Darmarini *et al.,* (2017); Hutchins (2003); Printrakoon *et al.,* (2014); and Sundaram and Deshmukh (2009), who successively encountered *Lingula* sp. with a size of 27.5 mm; 45-58 mm; 24.84 ± 2.98 mm; and 3-122 mm.

The *Lingula* sp.' had a pedicle that was almost twice the length of its shell, which was 10-80 mm in size. This is in accordance with Emig *et al.,* (2013) which states that the length of the pedicle is found to be one and a half to two times the length of the shell. The pedicle is a solid cylindrical structure with varying lengths, diameters, and flexibility, which has a core in the form of connective tissue enveloped by the pedicular epithelium and the outer cuticle composed of chitin. At the proximal end of the pedicle is covered by epithelial capsules and cuticles, while at the distal end varies, with the existence of an extension, so that the structure is like a root which then forms a hold-fast structure (James *et al.,* 1992).

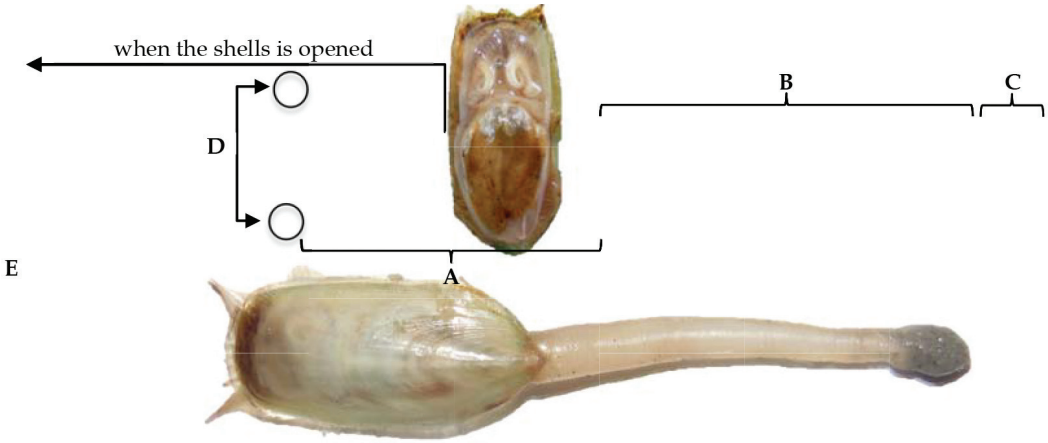

Fig. 2. Morphological structure of *Lingula* sp.; (A) shell; (B) pedicle; (C) mud; and (D) chaeta; and (E) lophophore

Based on its structure, the pedicle is divided into several parts, namely the pedicle itself which is colorless (transparent) to white, cylindrical in shape, consistency of a little hard, thick, and in it there is a white liquid which is a secret; and the small, black posterior part of the pedicle (typical color of the substrate) which functions to attach the substrate. This is consistent with what was explained by Yugan *et al.,* (1993), that *Lingula* sp.'s pedicle consists of deltoidal parts that are bound to the pedicle valve, cylindrical primary rods, and have a tip that has a bulblike structure that is tethered by mucosal secretions to the lower part of the burrow. Ball-like structures isolated from the pedicle are firmly attached to the substrate at the bottom of the burrow and are bound with a mass of sand and organic particles by sticky mucus. Carlson (2016) states that a pedicle structure that appears between the two shells of most Brachiopods will facilitate individual attachment to the substrate.

At the time of sampling, *Lingula* sp. is in a position inside the substrate when the specimen is taken, i.e. the pedicle is at the bottom and the shell is above the habitat. This is in line with research conducted by Emig *et al.,* (2013) and Hutchins (2003) which state that the species *Lingula* sp. has to dig vertically in soft sediments with shell positions at the top of the habitat burrow. So, in general, it can be seen that the pedicle serves as a means of attachment to the substrate and also as a tool for movement or mobility. James *et al.,* (1992) explained that the pedicle of *Lingula* sp. acts as a shaft, where the shell moves as a result of contraction and relaxation of the attached muscles, which acts as a means of movement.

In addition to the pedicle, another distinctive characteristic that is owned by *Lingula* sp. is lophophore. Lopophore is generally suspended from the anterior body wall, supported by the brachidium structure, and extends into the mantle cavity (brachial). Lophophore is located in the anterior shell. Shaped like a twisted snail shell, white, and has tentacles on the edges. Carlson (2016) describes lophophore as a two-arm organ that holds ciliated tentacles used to filter food and respiration. Carlson (2016) and Samanta *et al.,* (2015) add that lophophore is characterized by the presence of helical muscle folds with ciliated tentacles that produce water flow through the mantle cavity, extract oxygen and food particles, then transport them to the mouth. *Lingula* sp. has two lophophore. Emig *et al.,* (2013) states that the function of lophophore is related to food (feeding), breathing (respiratory), and protection.

On Mayangan Beach, the distribution or presence of *Lingula* sp. uneven, ie there are zones which are the habitat of *Lingula* sp., and there are zones that are not habitats of *Lingula* sp. Based on the results of substrate tests conducted, it is known that the type of substrate which is the habitat of *Lingula* sp. and the type of substrate that is not a habitat of *Lingula* sp. is the same, namely silt smooth substrate in gray. However, there are differences in the composition and physic-chemical structure of the substrate. In the habitat substrate, the composition is 0.13% gravel; 88.44% sand; 11.43% fine grains (silt + clay), moisture content 25.46%; pH 8.30; salinity 5.94‰; nitrogen (N) 0.644%; phosphor (P) 0.087%; and potassium (K) of 0.362%, while the composition of the substrate which is not a habitat of *Lingula* sp. is 1.09% gravel; 80.19% sand; 28.72% fine grains (silt + clay), moisture content 26.09%; pH 8.30; salinity 7.32‰; nitrogen (N) 0.721%; phosphor (P) 0.153%; and potassium (K) of 0.446%. The difference in composition and physic-chemical structure of this substrate allows the existence of *Lingula* sp. uneven. In addition, excessive gravel content, inappropriate chemical parameters, and the large number of sand dollars (members of the Echinodermata phylum) are also factors in the absence of *Lingula* sp. in that habitat. Bitner *et al.,* (2012) and Samanta *et al.,* (2015) reported the habitat of *Lingula* sp. with even density in the intertidal zone. Samanta *et al.,* (2015) also stated that *Lingula* sp. usually found in sandy loamy areas. Meanwhile, based on research conducted by Mitra and Pattanayak (2013), it is known that *Lingula* sp. prefers habitats in the form of decomposed black silt and sandy mud. At the study site, the substrate which is the habitat of *Lingula* sp. also found various kinds of macrozoobenthos, including members of Polychaeta, Bivalves, Gastropods, Arthropods, and many others. In addition, in some *Lingula* sp. caught also found a naked snail (sea slug) attached to the dorsal shell. This indicates that there may be an indirect relationship (association) between benthic animals and Brachiopods. Goto *et al.,* (2014) revealed that there is a symbiotic relationship between *Lingula* and *Korea setouchiensis*. Mollusc members are embedded in the anterior part of the shell, perhaps to utilize the water flow created by the host for food filtering, so it can be estimated that this type of Bivalves may prefer to use *Lingula*

sp. to help breathing.

Conclusion

Based on research, it can be concluded that *Lingula* sp. having a slightly oval eggshell that is shiny green, the pedicle is found in the posterior region. In the interior of the body, *Lingula* sp. has a distinctive structure called lophophore. The total length of *the Lingula* sp. range between 40 - 120 mm. The substrate which is the habitat of *Lingula* sp. is silt smooth silky sand with a composition of 0.13% gravel, 88.44% sand, 11.43% fine grains (silt + clay). Meanwhile, the habitat of *Lingula* sp. containing 0.644% nitrogen (N), 0.087% phosphor (P), 0.362% potassium (K), with a pH of 8.30 and salinity 5.94‰.

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