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Morphological and Morphometric Variations of Lantern Shell *Lingula anatina* from Madura Strait, East Java, Indonesia

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Abstract
Lingula anatina is an ancient invertebrate that still exists and has not experienced shell morphological evolution since the Silurian period. *Lingula anatina* lives burrowing in sand to mud substrates in mangrove ecosystems. This study aims to describe the morphological and morphometric variations of *L. anatina* that found in Madura Strait, East Java. Sampling was carried out using the purposive sampling method by digging the substrate in the plot area to a depth of 5-10 cm. Morphological characters were analyzed based on shell shape, while five morphometric profiles were analyzed using the Principal Component Analysis (PCA) method using PAST software version 4.12. The results showed that three morphological variations of *L. anatina* were found. Meanwhile, *L. anatina* is known to have morphometric profiles in varying data ranges. This study also found anomalies occurences or records in three individuals of *L. anatina*.

Keywords: Brachiopods; Probolinggo; Bangkalan; PCA Analysis
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INTRODUCTION

In addition to being known as lantern shells and leaf shells, *Lingula anatina* is also known as Tebalan (Ambarwati et al. 2019). In some areas in East Java, *L. anatina* are also often called sea sprouts. *Lingula anatina* is a species of ancient invertebrate that belongs to the Phylum Brachiopoda. Roda et al. (2022) also stated that Brachiopods are also known as two-petalled lophophorates. On the other hand, Wernström et al. (2022) stated that Brachiopoda is known as “living fossils” because there has not been much change in the morphology of their shells since the Silurian period. That statement is also in line with research conducted by Koneva and Ushatinskaya (2008), which states that Brachiopods is a member of ancient animals with the most complete fossil record, starting from the early Cambrian skeleton.

Lingula anatina can be found in mangrove ecosystems with sand to mud substrates (Samanta et al. 2015, Mitra and Pattanayak 2013, Rakmawati and Hariyanto 2020, Bitner 2019). In line with this, Bitner and Romanin (2018) and Samanta et al. (2014) found *L. anatina* in the intertidal area. *Lingula anatina* lives burrowing under the sediment or substrate of a body of water and associates with several other invertebrates, such as anemones, barnacles, and several members of the Bivalvia class (Bitner and Romanin 2018, Goto et al. 2022, 2014, Harahap et al. 2023, Rakmawati and Ambarwati 2019, Samanta et al 2015).

In the environment, *L. anatina* has the potential to be used as an indicator of marine environmental health. In its life profile, *L. anatina* can be categorized as a detritivore due to its life profile, which burrows under the substrate. This is an important factor in determining and establishing L. *anatina* as a keystone species for the health of the aquatic environment. Heavy metals that pollute the marine environment will accumulate in the body of *L. anatina* (usually flesh) through the process of analyzing heavy metal content in adult individuals. In addition to functioning as a biological indicator, *L. anatina* also has the potential to have high ecological and economic value, as well as great potential in the fields of biotechnology and pharmacy.

So far, the existence of *L. anatina* has been reported in several regions of the world, including India, Nepal, and Indonesia. The presence of *Lingula* sp. in Indonesia is reported in several areas, namely in Probolinggo, Situbondo, Bangkalan, Pamekasan, Banten, Muara Angke (North Jakarta), and Aceh

(Agustina et al. 2019, Ambarwati et al. 2019, Darmarini et al. 2017, Mudjiono and Suparman 1992, Octavina et al. 2023, Rakmawati and Ambarwati 2019, Rakmawati and Hariyanto 2020, Sahidin et al. 2018). Based on the reports of *L. anatina presence*, it is known that the reporting of *L. anatina* presence is dominated in East Java Province.

Previous research on the existence of *L. anatina* in Indonesia (especially in East Java) still covers its existence and ecological profile. Meanwhile, there has been no research on the morphometric analysis of *L. anatina*. The morphometric profile of a species can reflect the biopopulation of that species in a particular region (Octavina et al. 2021b). This study aims to describe the morphological and morphometric variations of *L. anatina* in Madura Strait, East Java.

MATERIALS AND METHODS

Lingula anatina samples were taken from two different locations, namely in the Kwanyar Beach Bangkalan (7º18'60.53“S 112º92'11.05”E) and Mayangan Beach Probolinggo (7º43'42.15“S 113º13'24.93”E) (Figure 1) on November 23th and 30th, 2020. Sampling was conducted during the lowest tide. The sampling was carried out by purposive sampling, namely by plotting technique. *Lingula anatina* samples were obtained by digging the substrate using a shovel 5-10 cm deep.

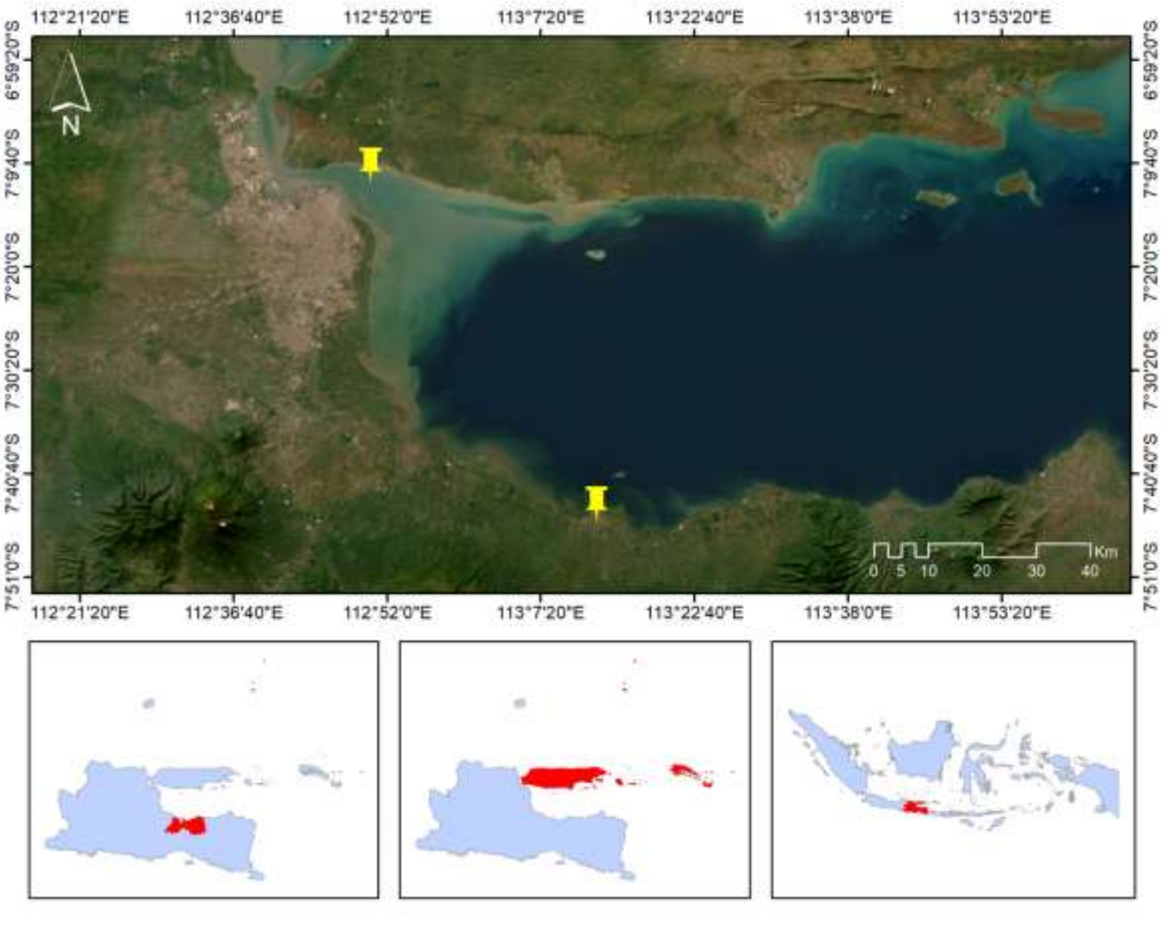

Figure 1. Sampling site of *L. anatina* in Madura Strait

The obtained *L. anatina* samples were placed in labeled plastic clips. The samples were then washed thoroughly with seawater and then preserved with 70% alcohol. Meanwhile, morphometric measurements of the samples were carried out with a caliper. The morphological character analyzed in this study was the shell shape of *L. anatina*. Shell shape analysis was carried out to determine the similarity of types and morphological variations of *L. anatina*. Meanwhile, the morphometric parameters measured included shell length, shell width, shell height, pedicle length, and mud length (Figure 2). The results of the morphometric measurements that have been carried out are then analyzed using the Principal Component Analysis (PCA) method using PAST software version 4.12 to determine the ordination similarities in research locations.

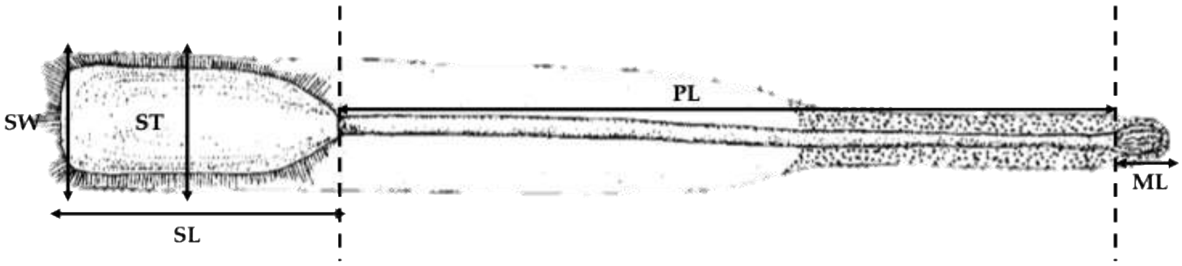

Figure 2. Morphometric measurements of *L. anatina;* SL: Shell Length; SW Shell Width; ST: Shell Thickness; PL: Pedicle Length; and ML: Mud Length (James et al, 1992)

RESULTS

In this study, data were collected on the *L. anatina* substrate, which further revealed that the type of substrate that was the habitat for the lamp shells in this study was silt substrate (Table 1). A total of 68 individuals were collected from the two research sites, with details of 31 individuals collected from Kwanyar Beach - Bangkalan Regency and 37 individuals obtained from Mayangan Beach - Probolinggo Regency (Table 1). In addition, in this study, three (3) variations in the morphology of *L. anatina* shells were found in Madura strait, namely *L. anatina* type (a) with an oval shell profile, type (b) with an oval shell profile with a slight sharp curve in the middle, and type (c) with a slightly oval shell profile with square tendention (Figure 3). The morphometric profile of *L. anatina* based on shell shape variations is presented in Table 2. Also from the two research locations, after analyzing the morphometric profile, it was found that *L. anatina* individuals found in Mayangan Beach – Probolinggo Regency had a higher mean shell length compared to the mean shell length of *L. anatina* found in Kwanyar Beach, Bangkalan (Table 1).

Table 1. Substrate profile of *L. anatina* encountered at the study site.

No.	Morphometric and Substrate Profile of *L. anatina*	Locations	
		Bangkalan (B)	Probolinggo (P)
1	Σ individuals (n)	31	37
2	SL (mm)	33.32 ± 8.94	44.41 ± 3.38
3	SW (mm)	15.91 ± 3.81	19.88 ± 1.53
4	SH (mm)	7.07 ± 3.12	9.04 ± 1.35
5	PL (mm)	27.48 ± 12.10	61.51 ± 17.70
6	ML (mm)	8.52 ± 4.35	12.38 ± 5.02
7	Type of Substrate	Silt	Silt
8	Color of Substrate	++++	+++++
9	Temperature (°C)	32	32
10	Salinity (%o)	45	34
11	pH	6.8	6.4

Note: + = indicates a darker color spectrum

Furthermore, the morphometric profile of *L. anatina* in the two research sites was analyzed using the Principal Component Analysis (PCA) method to determine the similarity of ordination between morphological characters in the two research sites. Based on the PCA diagram, it is known that morphological characters have various data ranges. The measurement results show that shell length (SL) has a higher size range than other morphological characters. The variation of all morphological characters is known to be acceptable, where all standard deviation values are lower than the mean value. The eigenvalue obtained reaches 97.039% (Figure 4). The PCA diagram shows that the *L. anatina* populations found in Bangkalan Regency and Probolinggo Regency each form their own groups, although some individuals overlap (Figure 4). This indicates that the two *L. anatina* populations are distinct populations. In addition, this study also found anomalies or inconsistencies in the size of the *L. anatina* pedicle. There were three (3) individuals of *L. anatina* with pedicle profiles that were much shorter than their normal size (Figure 5).

Figure 3. Morphological variations of *L. anatina* found in Madura strait: a: oval shell; b: oval shell with a slight sharp curve in the middle; c: slightly oval shell with square tendention.

Table 2. Characteristics of *L. anatina* in various morphological variations

No.	Characteristics	*L. anatina*		
		Type a	**Type b**	**Type c**
1.	Shell shape	Oval	Oval with a slight sharp curve in the middle	Slightly oval (with square tendention)
2.	SL (mm)	30.31 ± 6.27	34.14 ± 2.83	40.11 ± 4.31
3.	SW (mm)	14.29 ± 3.11	16.02 ± 5.51	19.78 ± 1.74
4.	SH (mm)	6.81 ± 2.66	7.07 ± 3.72	9.01 ± 1.24
5.	PL (mm)	21.74 ± 6.91	21.84 ± 7.91	21.21 ± 10.01
6.	ML (mm)	6.11 ± 2.41	7.67 ± 1.04	5.96 ±2.07

DISCUSSION

The existence of morphological variations in the shell shape of *L. anatina* is a form of interpretation of the genetic plasticity of the lamp shell itself. Genetic plasticity in a species can be caused by internal and external factors (environment). Internal factors that can support the genetic plasticity of a species are phenotypic plasticity events, while external factors (environment) that can cause genetic plasticity are habitat conditions, including the type of substrate and heavy metal content in the waters themselves. The condition of *L. anatina,* which is a key species in marine bioindicators, is that environmental conditions are the biggest contributing factor to the occurrence of genetic plasticity.

Furthermore, the difference in the number of *L. anatina* in the two research locations may be influenced by geographical differences, water conditions, and fishing and trading activities of the surrounding community. Mitra and Pattanayak (2013) in their research stated that water conditions can affect the composition of aquatic communities. In addition, differences in morphometric profiles can also be influenced by various environmental factors, including the type and content of aquatic substrates. The type of substrate of a water body will affect the foraging and survival mobility of *L. anatina* (Rakmawati and Hariyanto 2020). Based on the results of the analysis of substrate type and composition, it is known that all research sites have the same substrate type, but with different substrate colors. The silt substrate in Probolinggo Regency is known to have a darker color spectrum and a higher number of *L. anatina* sightings than *L. anatina* sightings in Bangkalan Regency. The dark color of a substrate indicates the high content of organic matter in a water body. The darker the substrate color, the higher the organic matter content.

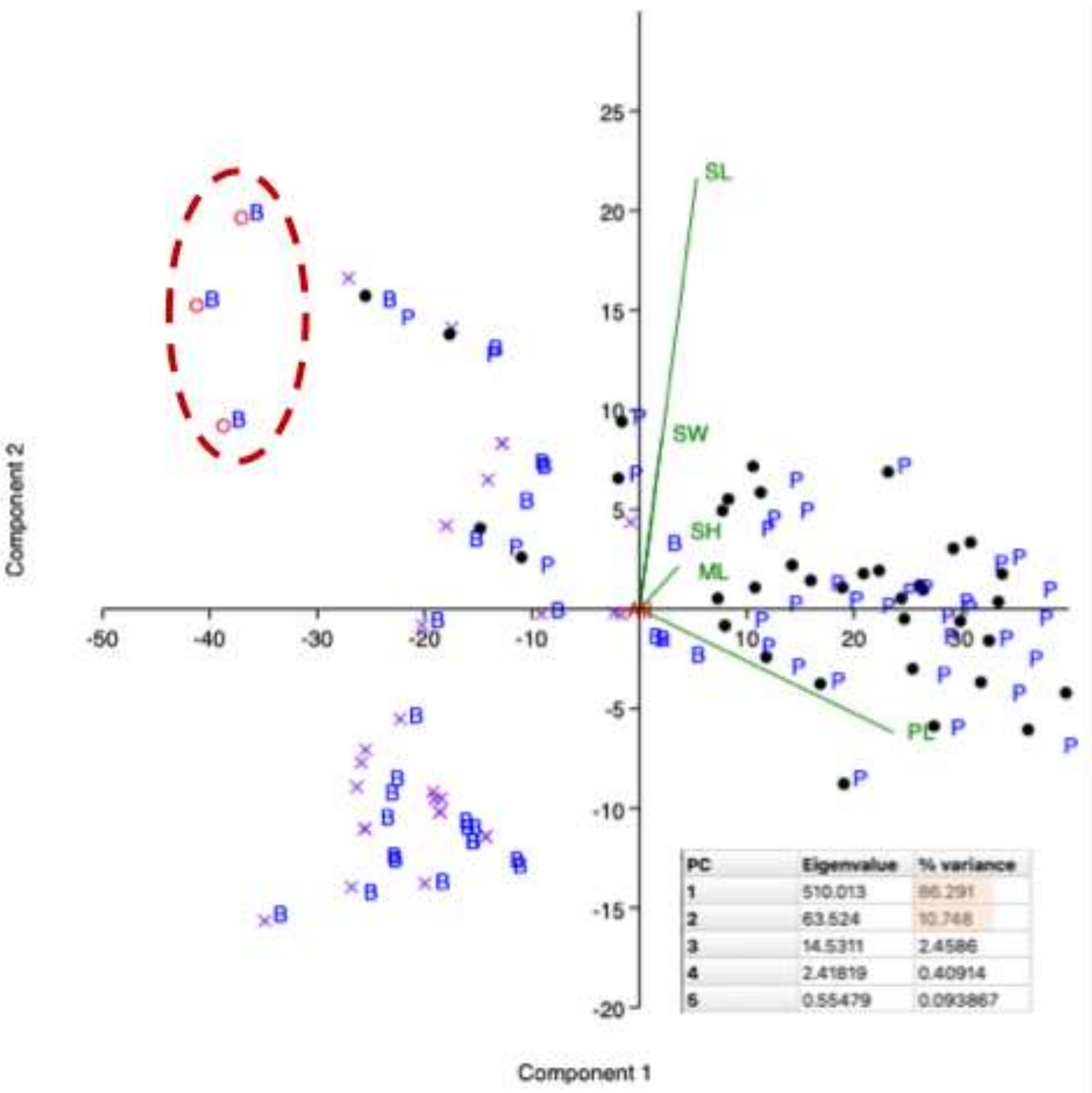

Figure 4. Diagram of the results of PCA analysis of *L. anatina* morphometry

Figure 5. *L. anatina* with anomalies in its pedicle structure: (a) and (c) found in Bangkalan; and (b) found in Probolinggo

In their research, Riniatsih and Kushartono (2009) explained that the substrate can determine the lifestyle of the invertebrate species that inhabit it. The substrate consists of two important components, namely the size of the substrate and the organic matter contained therein (Subiyanto *et al,* 2013). The size of the substrate will greatly influence the ability of the substrate to withstand water circulation. Meanwhile, the texture/fraction of the substrate and the organic matter content of the substrate will determine the presence of species, because the size of the substrate can determine a place to live. The darker the color of the substrate, the higher the organic matter content. Thus, the condition of the size of the substrate and the organic matter content of the substrate (which is reflected through the color of the substrate) of a body of water will be closely related to the existence of lamp shells, including influencing the number of individuals (density) in a population and the distribution pattern of individuals living in it.

In general, the size of the *L. anatina* shell found in this study is still within reasonable limits (similar) when compared to previous studies, for example studies conducted by Hutchins (2003); Printrakoon et al. (2014); and Sundaram and Deshmukh (2009) who respectively found *L. anatina* with sizes of 27.5 mm; 45-58 mm; and 24.84 ± 2.98 mm. However, based on PCA analysis, it is known that there are three *L. anatina* individuals found in Bangkalan District in the diagram plot that are far from the population plot. After further analysis (based on morphology), the three individuals have pedicle sizes that differ from the norm (inconsistency), which is much shorter than the normal size. In their research, Monteiro et al. (2022); Octavina et al. (2021); and Emig (2008) stated that Brachiopods have a cylindrical root-like tail structure (hereinafter referred to as pedicle) whose length reaches one and a half to twice the length of the shell. The existence of inconsistencies in size is certainly closely related to its habitat. It is known that Bangkalan waters have a high environmental pollution index. The high content of Cadmium and Lead in the waters of Bangkalan Regency can affect the growth patterns, development, and survival of fauna in these waters, including *Lingula* sp. (Sudaria et al. 2019; and Trisyani, 2020). Based on this, further studies on the habitat of *Lingula* sp. are deemed necessary.

Based on this, it can be known that the high occurrence of *L. anatina* in the Mayangan Beach of Probolinggo Regency, compared to *L. anatina* found in Kwanyar Beach, Bangkalan Regency is because the organic matter content in the Mayangan Beach of Probolinggo Regency is more supportive of the ability to survive and reproduce for *L. anatina* compared to the Kwanyar Beach of Bangkalan Regency. In other words, the silt substrate in Probolinggo District provides a high environmental carrying capacity for *L. anatina*.

CONCLUSION

Three morphological variations of *L. anatina* were found in Madura Strait. Meanwhile, the morphometric variations of *L. anatina* had various data ranges. This study also found anomalies or records in three individuals of *L. anatina*.

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CONFLICT OF INTEREST

There is no conflict of interest

REFERENCES

Agustina S, Octavina C, Sarong A, Nurhaliza A, Dewiyanti I and Iqbal TH, 2019. The Density and Distribution of *Lingula* sp. in Aceh Northern Shore. *IOP Conference Series: Earth and Environmental Science,* 348.

Ambarwati R, Rahayu DA and Faizah U, 2019. The Potency and Food Safety of Lamp Shells (Brachiopoda: *Lingula* sp.) as Food Resources *Journal of Physics: Conference Series,* Vol. 1417: 012039.

Bitner MA, 2019. Recent Brachiopods from the Tonga Islands, Sw Pacific: Taxonomy And Biogeography. *Rivista Italiana di Paleontologia e Stratigrafia (Research in Paleontology and Stratigraphy)*, 125(3): 587-608.

Bitner MA and Romanin M, 2018. Recent Brachiopods Collected During the ZhongSha. 2015. Expedition to the South China Sea, West Pacific. *Marine Biology Research,* 14: 551–64.

Darmarini AS, Wardiatno Y, Soewardi K and Prartono T, 2017. Short communication: New Record of Primitive Brachiopod, *Lingula* sp. in Mangrove Ecosystem of Lubuk Damar, Aceh Tamiang, Indonesia. *Biodiversitas,* 18: 1438–44.

Emig CC, 2008. On the History of the Names *Lingula anatina*, and on the Confusion of the Forms Assigned them Among the Brachiopoda. *Carnets de géologie (Notebooks on geology):* 1–13.

Goto R, Ishikawa H, Hamamura Y, Sato S and Kato M, 2014. Evolution of Symbiosis with *Lingula* (Brachiopoda) in the Bivalve Superfamily Galeommatoidea (Heterodonta), with Description of a New Species of *Koreamya*. *Journal of Molluscan Studies*, 80: 148–60.

Goto R, Takano T, Seike K, Yamashita M, Paulay G, Rodgers KS, Hunter CL, Tongkerd P, Sato S, Hong JS and Endo K, 2022. Stasis and Diversity in Living Fossils: Species Delimitation and Evolution of Lingulid Brachiopods. *Molecular Phylogenetics and Evolution*, 175.

Harahap RA, Barus TA and Wahyuningsih H, 2023. Bivalvia Assemblage in the Estuary and Mangrove of Belawan Waters, North Sumatra. *IOP Conference Series: Earth and Environmental Science* Vol. 1241 (Institute of Physics)

Hutchins M, 2003. *Grzimek's Animal Life Encyclopedia, 2nd Ed, Thomson-Gale.* ed Dennis A. Thoney, Paul V. Loiselle and Nell Schlager. Canada: Thomson Gale Group.

James MA, Ansell AD, Collins MJ, Curry GB, Peck LS, Rhodes MC, 1992. Biology of Living Brachiopods. *Advances in Marine Biologyl*, 28: 175–387.

Koneva SP and Ushatinskaya GT, 2008. New Upper Cambrian Lingulata (Brachiopoda) from the Agyrek Mountains (Northeastern Central Kazakhstan). *Paleontological Journal*, 2: 139–48.

Mitra S and Pattanayak J, 2013. Studies on *Lingula anatina* (Brachiopoda: Inarticulata) in Subarnarekha Estuary, Odisha with Special Reference to Habitat and Population *Rec. Zool. Surv. India*, 3: 49–53.

Monteiro FAC, Barroso CX, Junior WF, Emig CC and Matthews-Cascon H, 2022. Recent Brachiopods from South Atlantic Ocean: First Occurrence of the Lingulidae and its Biogeographic Implications. *Arquivos de Ciências do Maret*, 55: 147–53.

Mudjiono and Suparman M, 1992. Sekilas Tentang Kerang Lentera Filum Brakhiopoda. *Oseana*, XVII: 159–66.

Octavina C, Agustina S, Sarong MA, Sari PHP, Sahidin A, Razi NM, Agustiar M, Sakinah R and Fazillah MR, 2021. A Length-Weight Relationship of *Lingula* sp. In Aceh Southern Shore. *IOP Conference Series: Earth and Environmental Science*, Vol 674.

Octavina C, Ramadhaniaty M, Daulay RE, Dewiyanti I and Ulfah M, 2023. Genetic variation and Population Structure of Brachiopods, *Lingula anatina* Lamarck, 1801 in the Northern Aceh Shore, Indonesia. *Biodiversitas*, 24: 3951–3959.

Octavina C, Ulfah M, Agustina S, Haridhi H A and Yudistira A, 2021b. Population Structure of *Lingula* (Bruguière, 1791) in Alue Naga Waters, Banda Aceh City, Indonesia. *Depik*, 10: 201–206.

Printrakoon C, Kamlung-ek A and Fan H, 2014. Possible Use of *Lingula* sp. (Phylum Brachiopoda) as a Dissemination Strategy to Promote Sustainable Development in Fangchenggang Mangrove, China. *Chinese Journal of Population Resources and Environment*, 12: 269–277.

Rakmawati R and Ambarwati R, 2019. Komunitas Bivalvia yang Berasosiasi dengan Kerang Lentera (Brachiopoda: Lingulata) di Zona Intertidal Selat Madura. *Jurnal Riset Biologi dan Aplikasinya*, 2: 36–42.

Rakmawati R and Hariyanto S, 2020 Ecological Study of Primitive Brachiopods *Lingula* sp . in Probolinggo , East Java, Indonesia. *Ecology, Environment and Conservation*, 26: 54–59.

Riniatsih I and Kushartono EW, 2009. Substrat Dasar dan Parameter Oseanografi sebagai Penentu Keberadaan Gastropoda dan Bivalvia di Pantai Sluke Kabupaten Rembang. *Ilmu Kelautan*, 14: 50–59.

Roda MS, Griesshaber E, Angiolini L, Rollion-Bard C, Harper EM, Bitner MA, Milner Garcia S, Ye F, Henkel D, Häussermann V, Eisenhauer A, Gnägi H, Brand U, Logan A and Schmahl WW. 2022 The Architecture of Recent Brachiopod Shells: Diversity of Biocrystal and Biopolymer Assemblages in Rhynchonellide, Terebratulide, Thecideide and Craniide Shells. *Marine Biology*, 169(4).

Sahidin A, Zahidah Z, Herawati H, Wardiatno Y, Setyobudiandi I and Partasasmita R, 2018. Macrozoobenthos as Bioindicator of Ecological Status in Tanjung Pasir Coastal, Tangerang District, Banten Province, Indonesia. *Biodiversitas*, 19: 1123–1129.

Samanta S, Choudhury A and Chakraborty SK, 2015. Eco-biology of a Precambrian Intertidal Benthic Brachiopod, *Lingula anatina* from the Confluence of Subarnarekha Estuary with Bay of Bengal, India. *Journal of the Marine Biological Association of India*, 57: 41–46.

Samanta S, Choudhury A and Chakraborty SK. 2014. Morpho-Anatomical Study of *Lingula anatina* Lamarck, 1801 from West Bengal-Odisha Coast, India. *Journal of the Marine Biological Association of India*, 56: 26–33.

Subiyanto, Hartoko A and Umah K, 2013. Stuktur Sedimen dan Sebaran Kerang Pisau (*Solen lamarckii*) Di Pantai Kejawanan Cirebon Jawa Barat. *Journal of Management of Aquatic Resources*, 2: 65–73.

Sundaram S and Deshmukh VD, 2009. Record of Inarticulate Brachiopods, *Lingula* sp . from Mangrove Areas in Ratnagiri, Maharashtra and its Unusual Commercial Exploitation. *Marine Fisheries Information Service*, 207: 34–35.

Trisyani N, 2020. Heavy Metal Lead (Pb) in Sea Water, Sediment, and Bamboo Scallops Meat (*Solen* sp.) on Madura Beach. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 13: 163–167.

Ulfah ES, Rahardja BS and Pursetyo KT, 2019. Study of Heavy Metal Cadmium Content (Cd) in Various Sizes of Blood Shells (*Anadara granosa*) in Bancaran Coastal Bangkalan, Madura. *Journal of Marine and Coastal Science*, 8: 107–118.

Wernström JV, Gąsiorowski L and Hejnol A, 2022. Brachiopod and Mollusc Biomineralisation is a Conserved Process that was Lost in the Phoronid–Bryozoan Stem Lineage. *Evodevo*, 13: 1-11.