



A Brief Overview on *Lingula* Species (Brachiopoda: Lingulidae)

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Authors' contributions

This work was carried out in collaboration among all authors. Author SG conceptualized the study and prepared the manuscript, Authors DTB and NP prepared the manuscript, Authors SBC and SD did language correction and Author NK collected the data. All authors read and approved the final manuscript.

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ABSTRACT

Lingula Bruguière, 1791, a living fossil within the brachiopod phylum, represents a critical link to early marine life, with origins tracing back to the Cambrian Period. Despite its superficial resemblance to bivalve mollusks, *Lingula* is characterized by distinctive anatomical features such as a lophophore and inarticulate shells, which have enabled its survival across various marine environments, particularly in the Indo-West Pacific region. This study explores *Lingula*'s ecological role, its significance in marine biodiversity, and its economic importance in coastal communities. By examining its unique evolutionary adaptations and long-standing presence in marine ecosystems, the research highlights the necessity of conserving *Lingula* as a vital component of marine heritage. This preservation is crucial for maintaining ecological balance and furthering our understanding of one of Earth's oldest living organisms.

Keywords: *Linguliformea*; *Lingulata*; *Lingulida*; *Linguloidea*.

1. INTRODUCTION

Brachiopods comprise the phylum *Brachiopoda*, of which there are around 15,000 species (living and extinct), of which only 300–500 species are known to survive now. A group of five worldwide mass extinctions known as the "Big Five" have punctuated the evolution of life on Earth since the advent of complex life forms before the Cambrian. The most significant of them occurred approximately 252 million years ago after the Permian Period when 95 percent of the species were extinct—proof of an extinction in the Capitanian era. Members of the Phylum *Brachiopoda* (also known as lamp shells) represent a group of bilaterally symmetrical,

coelomate metazoan that superficially resemble bivalve molluscs. Brachiopods and bivalves share a twin-valved exoskeleton but differ in feeding methods, internal anatomy, and evolution (Fourestier et al., 2017) *Brachiopoda* are classified as "inarticulated" due to their shells lacking articulation. Non-articulated lingulata are identified as inarticulated *brachiopoda* [1,2,3].

Approximately 450 species of living brachiopods are currently known, divided into two classes: Inarticulata (orders *Lingulida* and *Acrotretida*) and Articulata (orders *Rhynchonellida*, *Terebratulida*, and *Thecideidina*) [3]. All known species are solitary and benthic marine animals with a two-part shell [4,5,6,7,8,9,10].

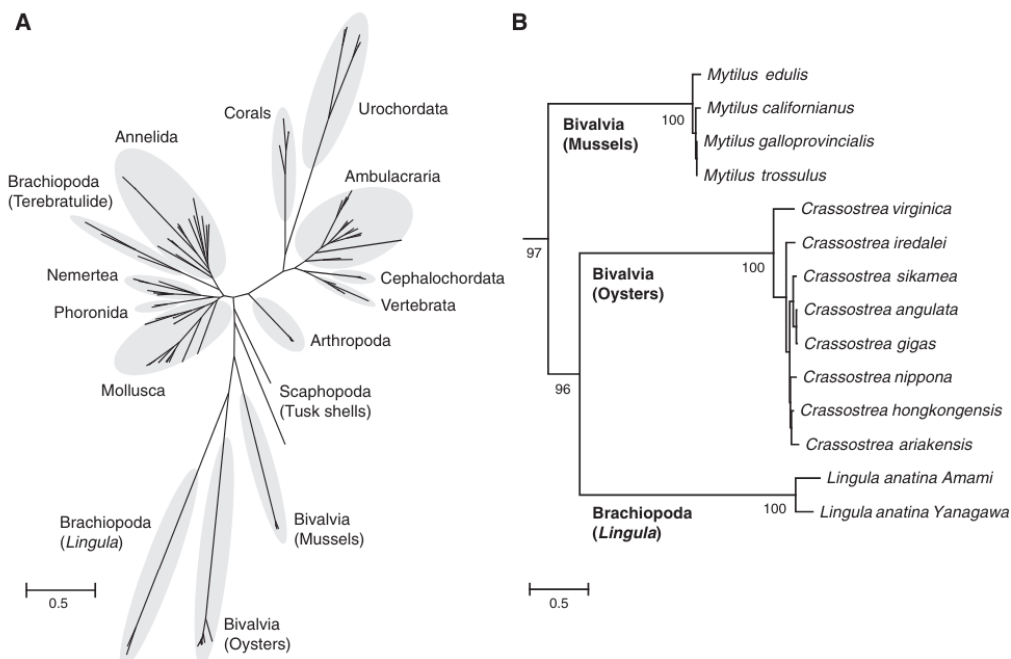


Fig. 1. A. Phylogenetic tree B. relationship of lingual with mussels and oysters.

Source: Y.-J. et al. [11]

Brachiopods have one of the most prolific fossil records of any organism group exists from the early Cambrian Period between 245 million to 545 million years ago (British zoological survey). This review captures a glimpse into the captivating world of brachiopods, highlighting their evolutionary significance and ecological role in marine ecosystems throughout geological time.

2. HABITAT, AND DISTRIBUTION

Brachiopods mostly found in oceans [12,13]. They are distributed considerably in the Indo-West Pacific area [12]. *Lingula* is a wide distribution in Asia, Australia, Europe, and Africa [14,15], such as in Singapore Island [16], Japan [17,18,19], Thailand [20], north-east coast of India [21], China seas (Ricardson et al. 1946), Fangchenggang mangrove, China [20], Nhatrang Bay, Vietnam [22], Kaneohe Bay, Oahu, Hawaii, Atlantic [14], Spain (Marques Aliaga et al. 1999), South Germany [23], New Zealand [24,25], Australia (Kenchington and Hammod 1977), New Caledonia, New Zealand (Bitner 2010), Madagascar [26], Western Indian Ocean (Bitner and Logan 2016). *Lingula* sp. is also found in the mangrove area of Ratnagiri Maharashtra, India, and its estuary Subarnarekha [15,9,27]. *Lingula* present in soft muddy area. Brachiopods are crucial in the biotic and trophic interactions of benthic marine fauna, acting as substrates, refuge, and food. They were more diverse at the global level in the Paleozoic but declined in the Permian-Triassic extinction. Brachiopods had higher shell volume but were more important than suspension feeders. They were even more important ecologically at times when they were much more diverse than others, such as the Early Devonian and Permian [28,29,30].

By modifying habitat availability, an animal can have strong ecological importance as a physical ecosystem engineer, unrelated to its trophic importance [31] (Jones et al., 1996, 1997).

Lingula present in the tropical and subtropical waters of the Indo-west Pacific area living in vertical burrows in sandy bottoms. Habitat of *Lingula* with even density present on intertidal areas, which is found partially exposed in the middle intertidal muddy area during low tide. The difference in composition and chemical structure of this substrate allows the coexistence of *Lingula* sp. in the habitat usually found in sandy loamy areas in cold deep-sea environment in polar region (Zoological survey of india; Sammanta et al.,2014), [32].

3. ANATOMY AND PHYSIOLOGY OF *Lingula*

A. Feeding and circulation

Brachiopods need to split their valves to eat. Two deductor muscles are used by articulate species to open the valves, while both striated and smooth adductor muscles are used to close them. Inarticulate animals use their adductor muscles to seal their valves after retracting their bodies to generate coelomic pressure and force the valves open. Brachiopod tentacles feature lateral and frontal ciliary tracts, and ciliary action generates a feeding current. Food travels along a brachial food groove to the mouth via the brachial axis, also known as the lipophoral ridge. These organisms have an open circulatory system; it has been proposed that the coelomic fluid serves as the medium for oxygen transport and that the primary purpose of this system is to distribute nutrients [33].



Fig. 2. *Lingula* sp. Source: Kim et al. [34]

B. Circulation

The only surfaces that can remove carbon dioxide and absorb oxygen are the mantle and lophophore. The fluid of the coelom appears to distribute oxygen; it circulates through the mantle and is powered by either cilium beating or the lining of the coelomor contracting. In certain species, the respiratory pigment erythrin plays a role in carrying oxygen to the lymphocyte cells. Brachiopods have a low maximal oxygen consumption and an unquantifiable minimum demand. In addition to having colorless blood, brachiopods also have a muscular heart located in the dorsal region of the body, above the stomach. The blood travels via arteries that branch to the lophophrenic nerve at the front of

the body, as well as the stomach, muscles, gonads, and nephridia at the back. Blood and coelomic fluid must mix to some extent because the blood circulation does not appear to be entirely closed. Perhaps the blood's primary purpose is to convey nutrients [33].

C. Nervous system

The dorsal and ventral ganglia, a nerve ring, the lophophore, the mantle, and the related muscles are all home to nerves. Tactile receptors are present on the setae and mantle margins. Certain species may also have mantle edges or tentacles that are chemoreceptive. One species in the genus *Lingula* has two statocysts; this is a burrowing species, therefore these structures might help with body orientation in the substrate [35]. Adult articulates' "brain" is made up of two ganglia: one above and one below the oesophagus. Adults only have the lower ganglion. Nerves travel to the lophophore, the antelopes, and the muscles that control the valves from the commissures where the ganglia meet. There are most likely the most sensors concentrated at the edge of the mantle. The chaetae of the mantle likely

transmit touch impulses to receptors in the epidermis of the mantle, while not being directly attached to sensory neurons. The cells that cause many brachiopods to seal their valves when shadows appear above them are unknown.

D. Reproduction and life-cycle

Brachiopod species typically have a life span of 3 to 30 years, which is a rather large range. Brachiopods are characterized by temporary gonads that originate from the metacoel's peritoneum [36,37]. Through the nephridia, gametes are discharged. Most of the time, fertilization is external; however, in a few species of brachiopods, internal fertilization occurs when females collect sperm from the water. [38,9]. Brachiopods have a breeding season (often spring or summer for Inarticulata species, or fall and winter for Articulata species) or they can breed all year long, depending on their species and environment. Brachiopods reproduce sexually and are mostly dioecious (although a small number of species, including some *Argrotheca* genus members, and hermaphrodites) [39].

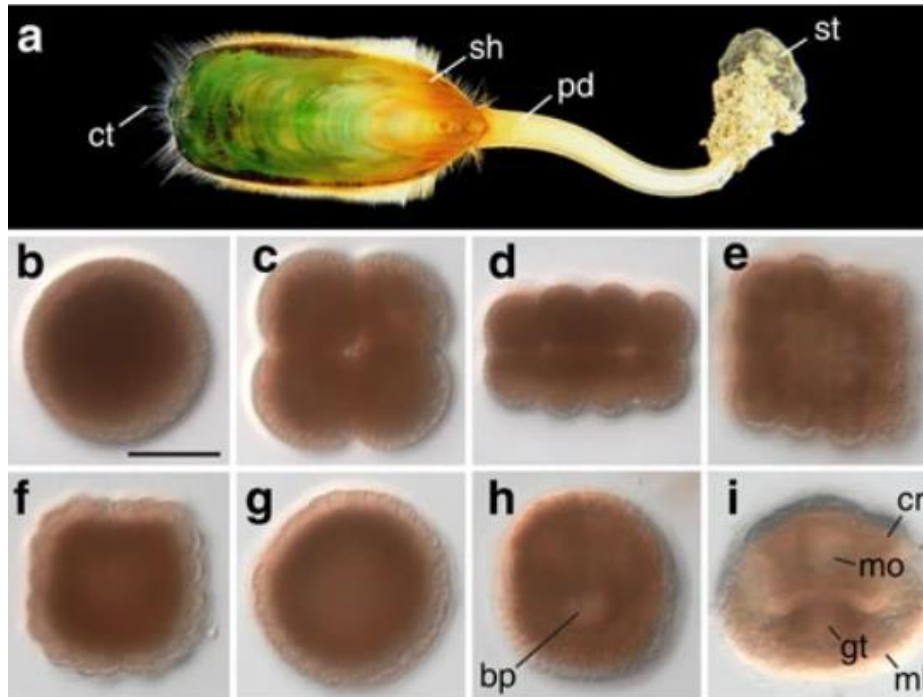


Fig. 3. embryonic development of *Lingula Sp.* (a) mature stage size 5 cm; egg (b), embryos - 4-cell (c), 16-cell (d), 32-cell (e) 128-cell stages (f), blastula (g), late gastrula (h) and 2-pair cirri larva; blastopore (i) cr, cirri; ct, chaeta; gt, gut; ml, mantle lobe; mo, mouth; pd, pedicle; sh, shell; st, stone

Source: Luo et al. [11]

Brachiopods reproduce sexually and are mostly dioecious (although a small number of species, including some *Argthrothea* genus members, and hermaphrodites) [38,9,40]. While their larvae are planktonic, at least for a few days, the adults are sessile and usually use their pedicles to cling to the substrate. Certain solitary species live freely without attaching to a substrate Brusca & Brusca [9] and Campbell [41].

4. ECOLOGICAL IMPORTANCE OF *Lingula sp.*

Brachiopods were more diverse in the Paleozoic, although the difference was relatively small in the Carboniferous [42].

Estuarine food webs are often difficult due to the high diversity of both producers and consumers inhabiting such ecosystems [43]. The fossil record shows that brachiopods have been hosts to various parasites, including polychaetes and gastropods. Present-day brachiopods have been found infested with polychaetes, and evidence suggests that they create calciferous blisters to prevent parasites from entering the space between the valves [44,45,46]

5. ECONOMIC SIGNIFICANCE OF *Lingula*

Numerous brachiopod species have been documented to exist in the tropical coastal regions of China, India, Indonesia, and so forth. *Lingula* meat and pedicle had high protein contents of $14.02 \pm 0.62\%$ and $12.06 \pm 0.44\%$, respectively. Additionally, $1.12 \pm 0.13\%$ of the fat was found in the flesh, while $0.84 \pm 0.07\%$ was found in the pedicle. When comparing the meat and visceral mass of lamp shells to the pedicle, the flesh had higher fat and protein content [47]. This content was similar to the number of nutrients found in seashells. The fat and protein composition of seashells was reported by Salman and Nasar [48]. Furthermore, cholesterol and fatty acids are also present in seashells. The amount of heavy metals in the meal was one indicator of food safety. Lamp shells (*Lingula*) have relatively low levels of lead and cadmium, two hazardous metals. In comparison, this number was below the upper limit of heavy metal contamination in food [49,50]. Furthermore, the levels of heavy metal lead and cadmium in lamp shells were found to be lower than in consumer bivalves that were caught in the Madura Strait. Therefore, it may be said that lampshells have potential as food sources [51-55,56]. The use of *lingula* in mangrove dependency. *Lingula* is a

true economic cost of consuming natural resources in the mangrove ecosystem, which become value added to fisheries [20]. The economic importance of Branchiopoda for coastal communities is multifaceted, primarily revolving around their role in local fisheries and aquaculture, which are vital for sustaining livelihoods. Coastal communities heavily rely on marine resources, including Branchiopoda, for food security and income generation. Branchiopoda serve as a crucial food source in aquaculture, enhancing fish growth and health, which directly benefits local fisheries [57,58,59-61]. The harvesting and processing of Branchiopoda). jobs, supporting the economic stability of coastal communities [62,63]. The economic conditions of these communities are sensitive to market fluctuations in fishery products, including Branchiopoda, impacting their overall welfare [57].

6. CONCLUSION

The genus **Lingula**, a living fossil, is a unique and significant phylum of brachiopods, dating back to the early Cambrian Period. These marine invertebrates have adapted to various environments, particularly in the Indo-West Pacific region. Their unique anatomical and physiological features, such as their lophophore for feeding and inarticulate shells, demonstrate their evolutionary resilience. They play a crucial role in marine ecosystems, contributing to biotic and trophic interactions within their habitat. Additionally, their economic importance in coastal communities, particularly as a food source, underscores their multifaceted value. The conservation of **Lingula** is essential for maintaining ecological balance and preserving the heritage of one of the oldest living organisms on Earth. As we continue to explore and understand these ancient organisms, their significance in both ecological and evolutionary contexts becomes increasingly apparent, reinforcing the need for ongoing research and conservation efforts. Furthermore, this review highlights the economic value of *Lingula* as a food source. Ultimately, this review emphasizes the need for the conservation and management of *Lingula* as a living fossil, ensuring the continued well-being of both ecosystems and local communities reliant on these resources.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models,

etc have been used during writing or editing of this manuscript. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. CHATGPT

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Emig C. On the history of the names *Lingula anatina*, and on the confusion of the forms assigned them among the *Brachiopoda*. *Carnets de Geologie*. 2008;A08:1-13.
2. Pechenik, Jan A. *Biology of the Invertebrates*. Boston, MA: McGraw-Hill Education; 2010.
3. Carlson SJ. The evolution of *Brachiopoda*. *Annual Review of Earth and Planetary Sciences*. 2016;44, 409-438. DOI:10.1146/annurev-earth-060115-012348
4. Rowell AJ. The monophyletic origin of the *Brachiopoda*. *Lethaia*. 1982;15(4):299-307
5. Popov LE, Bassett MG, Holmer LE, Laurie J. Phylogenetic analysis of higher taxa of *Brachiopoda*. *Lethaia*. 1993;26(1):1-5.
6. Carlson SJ. Phylogenetic relationships among extant brachiopods. *Cladistics*. 1995;11(2):131-197. Available:https://doi.org/10.1111/j.1096-0031.1995.tb00084.x
7. Holmer LE, Popov LE, Bassett MG, Laurie J. Phylogenetic analysis and ordinal classification of the *Brachiopoda*. *Palaeontology*. 1995;38:713-741.
8. Williams A, Carlson SJ, Brunton CHC, Holmer LE, Popov L. A supra-ordinal classification of the *Brachiopoda*. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*. 1996;351(1344):1171-1193. Available:https://doi.org/10.1098/rstb.1996.0101
9. Brusca Richard C, Brusca Gary J. *Invertebrates**. Sunderland, MA: Sinauer; 2003 Available:https://doi.org/10.1080/10635150490472968
10. Sperling EA, Pisani D, Peterson KJ. Molecular paleobiological insights into the origin of the *Brachiopoda*. *Evolution and Development*. 2011;13(3):290-303. DOI: 10.1111/j.1525-142X.2011.00480.x
11. Luo YJ, Satoh N, Endo K. Mitochondrial gene order variation in the brachiopod *Lingula anatina* and its implications for mitochondrial evolution in lophotrochozoans. *Mar Genomics*. 2015; 24:31-40. DOI:10.1016/j.margen.2015.08.005.
12. Emig CC. Ecology of inarticulated brachiopods. *Treatise on Invertebrate Paleontology, Part H. Brachiopoda Revised*. 1997;473-495.
13. Emig C, Bitner A, Alvarez F. *brachiopoda* database; 2016.
14. Williams A, Cohen BL, Cusack M, Long SL. Provenance of Atlantic lingulid brachiopods. *Palaeontology*. 2000;43(6): 999-1018 DOI: 10.1111/1475-4983.00159
15. Mitra S, Pattanayak JG. Studies on *Lingula anatina* (*Brachiopoda: Inarticulata*) in Subarnarekha Estuary, Odisha with special reference to habitat and population. *Records of the Zoological Survey of India*. 2013;49-53. DOI:10.26515/rzsi/v113/i3/2013/121795
16. Chuang SH. Growth of the postlarval shell in *Lingula unguis* (L.) (*Brachiopoda*). In *Proceedings of the Zoological Society of London*. Oxford, UK: Blackwell Publishing Ltd. 1961, September; 137(2):299-310.
17. Hayasaka I, Hatai K. 292. A New species of *Lingula* from Hokkaido, JAPAN. In *Transactions and proceedings of the Paleontological Society of Japan*. New series. *Palaeontological Society of Japan*. August 1956;23:219-220.
18. Emig CC. Ecology of inarticulated brachiopods. *Treatise on Invertebrate Paleontology, Part H. Brachiopoda revised*. 1997;473-495.
19. Emig CC. Part H, *Brachiopoda (Revised)*. *Treatise on Invertebrate Paleontology*. 1997;1(6):473-502.

20. Printragoon C, Kamlung-ek A. Socioeconomic study and economic value of living fossil, *Lingula* sp. in mangrove ecosystem in Trat Province, Thailand. Chinese J Popul Resour Environ. 2013; 11(3):187-199.
DOI:10.1080/10042857.2013.800376.
21. Samanta S, Choudhury A, Chakraborty SK. Morpho-micro anatomical study of *Lingula anatina* Lamarck, 1801 from West Bengal-Odisha coast, India. J Mar Biol Assoc India. 2014;56(1):2.
DOI:10.6024/jmbai.2014.56.2.01775-04
22. Temereva EN, Tsitrin EB. Modern data on the innervation of the lophophore in *Lingula anatina* (Brachiopoda) support the monophyly of the lophophorates. Plos One. 2015;10(4):e0123040.
23. Bitner MA, Schneider S. The Upper Burdigalian (Ottangian) brachiopod fauna from the northern coast of the Upper Marine Molasse Sea in Bavaria, southern Germany. Neues Jahrbuch fur Geologie und Palaontologie-Abhandlungen. 2009;254(1):117.
24. Allan HH. Indigene versus alien in the New Zealand plant world. Ecology. 1936;17(2):187-193.
25. Allan RS. New records of the genus *Lingula* (Brachiopoda) from Tertiary strata in New Zealand. Trans R Soc B Biol Sci. 1936;65:383-385.
26. Emig CC. A redescription of the inarticulate brachiopod *Lingula reevii* Davidson; 1978.
27. Sundaram S, Deshmukh VD. Record of inarticulate Brachiopoda, *Lingula* sp. from mangrove areas in Ratnagiri, Maharashtra and its unusual commercial exploitation. Marine Fisheries Information Service. 2011;207:34-35.
28. Taylor PD, Wilson MA. Palaeoecology and evolution of marine hard substrate communities. Earth Sci Rev. 2003;62(1-2):1-103.
DOI:10.1016/S0012-8252(02)00131-9.
29. Sprinkle J, Rodgers JC. Competition between a Pennsylvanian (Late Carboniferous) edrioasteroid and a bryozoan for living space on a brachiopod. J Paleontol. 2010;84(2):356-359.
DOI:10.1666/09-089r.1.
30. Rodland DL, Simoes MG, Krause RA Jr, Kowalewski M. Stowing away on ships that pass in the night: sclerobiont assemblages on individually dated bivalve and brachiopod shells from a subtropical shelf. Palaios. 2014;29(4):170-183.
31. Hastings A, Byers JE, Crooks JA, Cuddington K, Jones CG, Lambrinos JG, Wilson WG. Ecosystem engineering in space and time. Ecology Letters. 2007;10(2):153-164.
32. Goto R, Takano T, Seike K, Yamashita M, Paulay G, Ku'u'lei SR, et al. Stasis and diversity in living fossils: species delimitation and evolution of lingulid brachiopods. Mol Phylogenet Evol. 2022; 175:107460.
DOI:10.1016/j.ympev.2022.107460.
33. Harper DA, Popov LE, Holmer LE. Brachiopods: origin and early history. Palaeontology. 2017;60(5):609-631.
34. Kim SG, Karagozlu MZ, Kim CB. Phylogenetic investigations of *Lingula anatina* among some northwestern Pacific populations, based on mitochondrial DNA cytochrome c oxidase subunit I gene. J Asia-Pac Biodivers. 2017;10(2): 162-166.
DOI:10.1016/j.japb.2017.04.007
35. *Brachiopoda*; 2015.
Available:https://doi.org/10.1093/acprof:oso/9780199682201.003.0027.
36. Darmarini AS, Wardiatno Y, Prartono T, Soewardi K. New record of a primitive brachiopod, *Lingula* sp. in Lubuk Damar, Indonesia. Biodiversitas Journal of Biological Diversity. 2017;18(4):1438-1444.
37. Hammond LS, Kenchington RA. A biometric case for revision of the genus *Lingula* (Brachiopoda: Inarticulata) from Queensland, Australia. Journal of Zoology. 1978;184(1):53-62.
38. Pennington JT, Stricker SA. Phylum *Brachiopoda*. In: Young CM, Sewell MA, Rice MA, editors. Atlas of Marine Invertebrate Larvae. 2002;461.
39. Jain S, Jain S. Brachiopods. In: Fundamentals of Invertebrate Palaeontology: Macrofossils. 2017;229-277.
40. Kaulfuss A, Seidel R, Lüter C. Linking micromorphism, brooding, and hermaphroditism in Brachiopods: insights from Caribbean *Argyrotheca* (*Brachiopoda*). J Morphol. 2013;274(4): 361-376.
DOI:10.1002/jmor.20093.

41. Campbell NA. Biology. Boston, MA: Pearson Education; 2012.
42. Hsieh S. The Ecological Importance of Brachiopods versus Bivalves in the Paleozoic: Taphonomy, Biomass, and Energy use.
Available:<https://www.bgs.ac.uk/discovering-geology/fossils-and-geological-time/brachiopods/>.
43. Chakraborty SK. Coastal environment of Midnapore, West Bengal: Potential threats and management. *J Coast Environ.* 2010;1(1):27-40.
44. Hoffmeister AP, Kowalewski M, Bambach RK, Baumiller TK. Intense drilling in the Carboniferous brachiopod *Cardiarina cordata* Cooper, 1956. *Lethaia.* 2003; 36(2):107-117.
45. Rodrigues SC, Simoes MG, Kowalewski M. Fragmentation and bioerosion as taphonomic records of biotic interactions: a case study of extant brachiopods (Bouchardiidae) from Brazil. In: *Proceedings of the International Meeting Taphos*; 2005.
46. Rodrigues SC, Simões MG, Kowalewski M, Petti MA, Nonato EF, Martinez S, et al. Biotic interaction between spionid polychaetes and bouchardiid brachiopods: Paleocological, taphonomic and evolutionary implications. *Acta Palaeontol Pol.* 2008;53(4):657-668.
DOI:10.4202/app.2008.0410.
47. Ambarwati R, Rahayu DA, Faizah U. The potency and food safety of lamp shells (*Brachiopoda*: *Lingula* sp.) as food resources. In: *Journal of Physics: Conference Series.* 2019;1417(1): 012039.
DOI:10.1088/1742-6596/1417/1/012039.
48. Salman JM, Nasar AJ. Total lipids and total protein in two mollusc species as environmental biomarkers of pollution in Euphrates River, Iraq. *Int J Curr Microb App Sci.* 2013;2:207-214.
49. Kowalewski M. Taphonomy of a living fossil: The lingulide brachiopod *Glottidia palmeri* Dall from Baja California, Mexico. *Palaios.* 1996;244-265.
50. Samanta S, Choudhury A, Chakraborty SK. Eco-biology of Precambrian intertidal benthic brachiopod, *Lingula* anatina from the confluence of Subarnarekha estuary with Bay of Bengal, India, Marina Biology Association. 2015;57(1)
51. Balthasar U, Butterfield NJ. Permian-Triassic Mass Extinction and Brachiopods. *Geology.* 2008.
52. Gaston KJ, Fuller RA. Biodiversity and extinction: losing the common and the widespread. *Prog Phys Geogr.* 2007; 31(2):213-225.
DOI:10.1177/0309133307076488.
53. Gould SJ, Calloway CB. Clams and brachiopods—ships that pass in the night. *Paleobiology.* 1980;6(4):383-396.
DOI:10.1017/S0094837300003572.
54. Japan. *Transactions and Proceedings Palaeontological Society Japan.* 1985;23:219-220.
55. Skovsted CB, Holmer LE. Early Cambrian brachiopods from north-east Greenland. *Palaeontology.* 2005;48(2):325-345.
DOI:10.1111/j.1475-4983.2005.00450.x.
56. Richardson J. Report on the ichthyology of the seas of China and Japan R, Taylor JE; 1846.
57. Wahyudin Y. General socio-economic profile of coastal community. Available from: SSRN 2211334.
58. Ekasari R, Arif D, Purnamasari W, Yucha N. Analysis of Economic Empowerment of Coastal Communities Towards Prosperous Communities. In: *Proceedings of 1st Workshop on Environmental Science, Society, and Technology*; 2019.
59. Machalski M, Bitner MA. The brachiopod assemblage from the Maastrichtian white chalk at Chelm, eastern Poland: Stratigraphical and palaeoecological implications. *Netherlands Journal of Geosciences.* 2024;103:e3.
60. Márquez-Aliaga A, Emig CC, Brito JM. Triassic lingulide brachiopods from the Iberian Range (Spain). *Geobios.* 1999;32(6):815-821.
61. Mitra S, Pattanayak JG. Studies on *Lingula* anatina (Brachiopoda: Inarticulata) in Subarnarekha Estuary, Odisha with special reference to habitat and population. *Records of the Zoological Survey of India.* 2013;49-53.
62. Fitria AD, Sianturi ACK, Salwa F, Haridani H, Manik HF, Khairini K, et al. Perilaku dan Sikap Karakteristik serta Ekonomi Masyarakat Pesisir di Dusun XIV Desa

- Percut. El-Mujtama: J Pengabdian Masyarakat. 2024;4(2):1068-1078.
63. Cahyadinata I, Nusril G. Descriptive, correlation analysis and analytical hierarchy process of coastal community empowerment of Bengkulu City, Indonesia. Int J Adv Sci Eng Inf Technol. 2020;10:1304-1310.

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