

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

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...

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 (Emig, 2008; Pechenik 2010; Carlson, 2016).

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) (Carlson et al., 2016). All known species are solitary and benthic marine animals with a two-part shell Rowell, 1982; Popov, et al., 1993; Carlson, 1995; Holmer, et al., 1995; Williams, et al., 1996; Brusca and Brusca, 2003; Sperling, et al., 2011).

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.

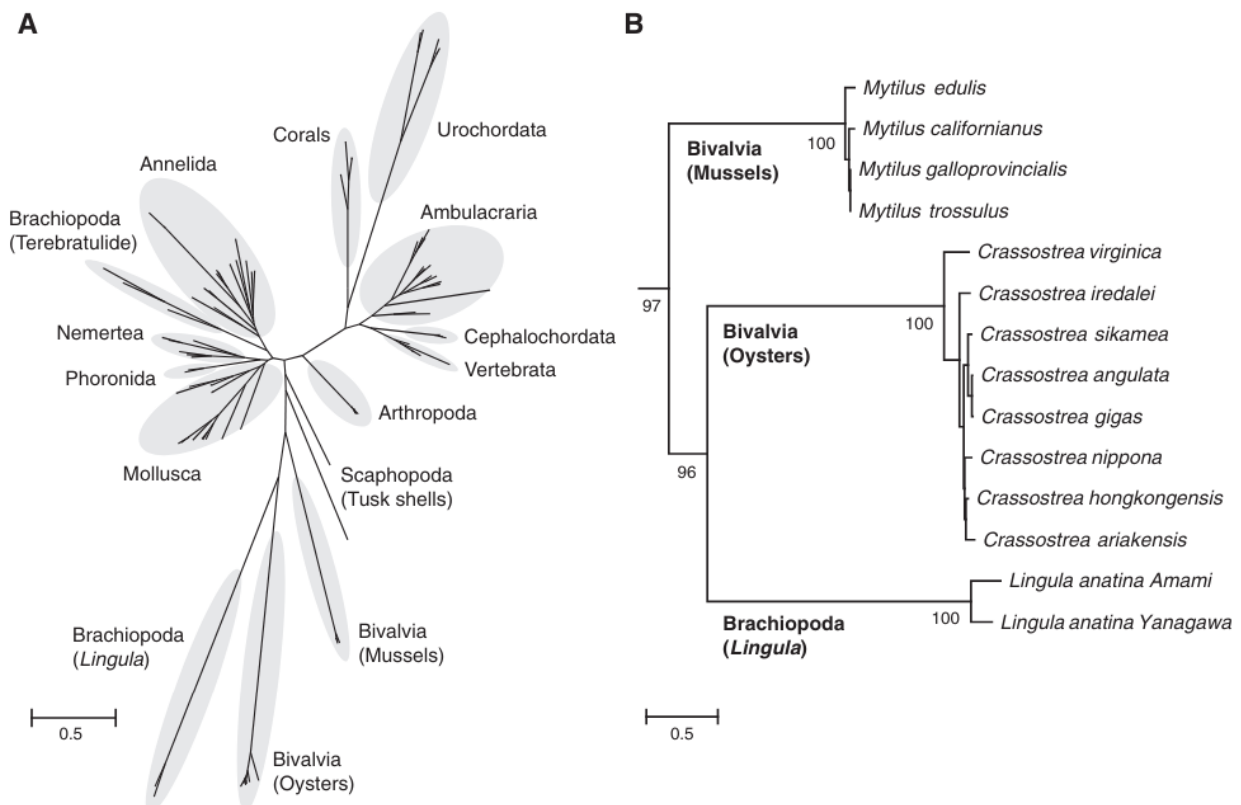


Fig 1. A. Phylogenetic tree B. relationship of lingual with mussels and oysters. Source: Y.-J. et al.,2015

Habitat, and distribution.

Brachiopods mostly found in oceans (Emig 1997; Emig et al. 2013). They are distributed considerably in the Indo-West Pacific area (Emig1997). *Lingula* is a wide distribution in Asia, Australia, Europe, and Africa (Williams et al. 2000; Mitra and Pattanayak 2013), such as in Singapore Island (Chuang 1961), Japan (Hayasaka and Hatai 1956;Emig 1984), Korea (Park et al. 2000; Hong et al. 2007), Thailand (Printrakoon and Kamlung-ek 2013), north-east coast of India (Samanta et al. 2014), China seas (Ricardson et al. 1989), Fangchenggang mangrove, China (Printrakoon et al. 2014), Nhatrang Bay, Vietnam(Temereva and Tsitrin 2015), Kaneohe Bay, Oahu, Hawaii, USA (Hunter et al. 2008), Atlantic (Williams et al 2000), Spain (Marques Aliaga et al. 1999), France (Emig et al. 2007), South Germany (Bitner et al. 2009), New Zealand (Allan. 1936), Australia (Kenchington and Hammod 1977), New Caledonia, New Zealand (Bitner 2010), Madagascar (Emig 1977),Western Indian Ocean (Bitner and Logan 2016). *Lingula* sp. is also found in the mangrove area of Ratnagiri Maharashtra, India, and its estuary Subarnarekha (Sundaram and Deshmuk, 2011; Mitra and Pattanayak, 2013). *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 (Taylor and Wilson 2003; Sprinkle and Rogers, 2010; Rodland et al., 2014).

By modifying habitat availability, an animal can have strong ecological importance as a physical ecosystem engineer, unrelated to its trophic importance (Jones et al., 1996, 1997; Hastings et al., 2007).

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; Goto et. al., 2022;).

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 (Harper et al., 2017).



Fig 3. *Lingula* sp. Source: Kim et al., 2017

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 coelom 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 (Harper et al., 2017).

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 (Branchipoda, 2015). 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. 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. (Pennington and Stricker, 2002; Brusca and Brusca, 2003). 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 *Argthrothea* genus members, and hermaphrodites) (Jain et al., 2017).

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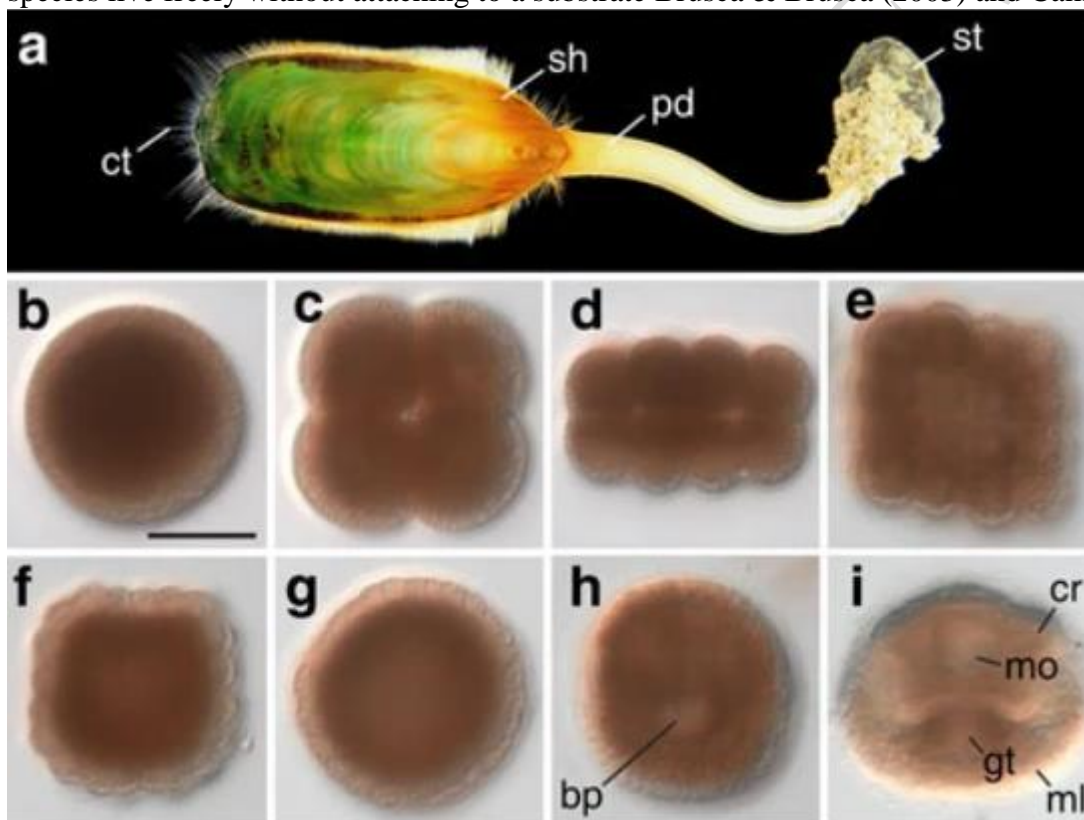


Figure 4: embryonic development of *Lingula Sp.* (a) mature stage size 5 cm; egg (b), embryos - 4-cell (c), 16-cell (d), 32-cell (e) 128-cell stages (f), blastula (g), late gastrula (h) and 2-pair cirri larva; blastopore (i) cr, cirri; ct, chaeta; gt, gut; ml, mantle lobe; mo, mouth; pd, pedicle; sh, shell; st, stone. Source: Luo et al., 2015

Ecological Importance of *Lingula sp.*:

Brachiopods were more diverse in the Paleozoic, although the difference was relatively small in the Carboniferous (Hsieh et al., 2015).

Estuarine food webs are often difficult due to the high diversity of both producers and consumers inhabiting such ecosystems (Chakraborty, 2010). 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 (Hoffmeister, et al., 2003; Rodrigues, et al., 2005; Rodrigues, 2007)

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 (Amarbati et al., 2019). 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, (2013). 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. 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. 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 (Printakroon et al., 2013). 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 (Wahyudin 2013) (Ekasari et al. 2019). The harvesting and processing of Branchiopoda). jobs, supporting the economic stability of coastal communities (Fitria et al. 2024) (Cahyadinata et al. 2020). The economic conditions of these communities are sensitive to market fluctuations in fishery products, including Branchiopoda, impacting their overall welfare (Wahyudin 2013).

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.

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Reference:

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