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# Benthic Foraminifera as a proxy for Paleo-productivity linked to monsoon changes: Result from Puthenthodu beach sediment, West coast of India

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## ABSTRACT

In this study, 75 sediment samples have been analyzed for benthic foraminifera at Puthenthodu beach core-sediment, West coast of India. In total 18 species of benthic foraminifera are reported in this study. For benthic foraminiferal faunal study, dry samples were sieved over 125 µm-size sieve and split into suitable aliquots to obtain ~250 specimens of benthic foraminifera. The most dominant benthic foraminiferal species are *Ammonia beccarii* followed by *Ammonia gaimardii, Cancris oblongus, Discopulvinulina bertheloti*, *Gyroidinoides nitidula*, *Gyroidinoides cibaoensis*, *Quinqueloculina seminulum* and *Textularia* sp. were recorded.Our goal is to reconstruct the paleoceanography, paleoclimatology and paleoproductivity changes from the study area region. The south-eastern Arabian Sea benthic foraminifera are good proxies to understand paleoproductivity linked to monsoon changes. The present study, benthic foraminifera like *Ammonia beccarii* and *Ammonia gaimardii* suggest a high productivity species a major change occurs at ~75 to 60cm and 10 to 5cm depth, an increasing trend indicative of a shallow-marine environment, suggested that strengthening of the summer monsoon. From ~60 to 20 cm depth, decreasing trend suggested that low productivity at the time of summer monsoon was weak (Figure 2). The intermediate productivity species are *Cancris oblongus, Gyroidinoides nitidula* and *Gyroidinoides cibaoensis* from ~60 to 20cm depth, an increasing trend indicate by low organic carbon flux or pulsed food supply and high oxygen environment (Figures 2 and 3).

**KEYWORDS:** Benthic foraminifera, Paleo-productivity, Indian monsoon, Puthenthodu Beach, West coast of India.

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# 1. INTRODUCTION

The Arabian Sea is highly productive regions of the world's oceans, it covering about 1% of the world's ocean surface but accounts for ~5% of global marine primary production owing to intense coastal and open-ocean upwelling caused by strong summer monsoon winds and deep convective mixing driven by winter monsoon winds[1]. The biological movement is thus elevated during the summer and winter monsoons, resulting in bimodal increase in surface productivity. The organic production in the Arabian Sea, however, is significantly higher during the summer monsoon compared to the winter monsoon season.

Foraminifera have long been recognized for their potential in paleoenvironmental reconstructions. Benthic foraminifera have extraordinary potential of adaptation and are able to endure in a wide range of marine environments. Benthic foraminifera are applied as proxies to understand deep-sea oxygenation (including reconstruction of biogeochemical cycling, ocean circulation, assessment of organic pollution or estimating preservation-potential of organic matter), paleo bathymetry (geohistory analysis of sedimentary basins) and organic flux (reconstruction of bioproduction i.e. quality and quantity of organic matter). The recent benthic foraminifera within the sediment are controlled mainly by a combination of oxygen content and organic carbon levels.[2 3] Oxygen decreases close to the sediment surface and becomes a limiting factor, favours low-oxygen species from the eutrophic regions.

The distribution of benthic foraminiferal species abundance and occurrence are immediately affected by organic flux[4 5 6] and seasonality whereas resource and competition have long term effects on microhabitat position. The seasonal changes in the oceanographic parameters are reflected in benthic foraminiferal productivity and assemblages. Benthic foraminifera are muscularly controlled by biological parameters like temperature, salinity, dissolved oxygen content of the bottom water masses, surface productivity and availability of nutrients, and carbonate saturation.[7 8 9 10]

The study on benthic foraminiferal faunal record to understand the reconstruction of paleoceanography, paleoclimatology and paleoproductivity changes from Puthenthodu beach sediment, West coast of India.

## 2. LOCATION MAP AND OCEANOGRAPHIC SETTING

The study on seventy five core-sediment samples were collected from Puthenthodu beach sediment, located in west coast of India. (Latitude 9°52.8'N, Longitude 76°15.48'E), Core depth 75cm). The study region is located around 30kms from Fort Cochin in the north to Puthenthodu beach in the south for a length of approximately 15 km. The study area region eastern side is the largest backwater system in the west coast of India and is the largest water body in Kerala.

Approximately 41 rivers brings vast quantity of sediments, deltas are not produced owing to the high wave energy condition of the coast. The coastal and near-shore sediments were studied over the past few decades by numerous researchers on different aspects, such as sea level changes, sedimentation and paleoenvironment in off-shore and on-shore region (Figure 1).

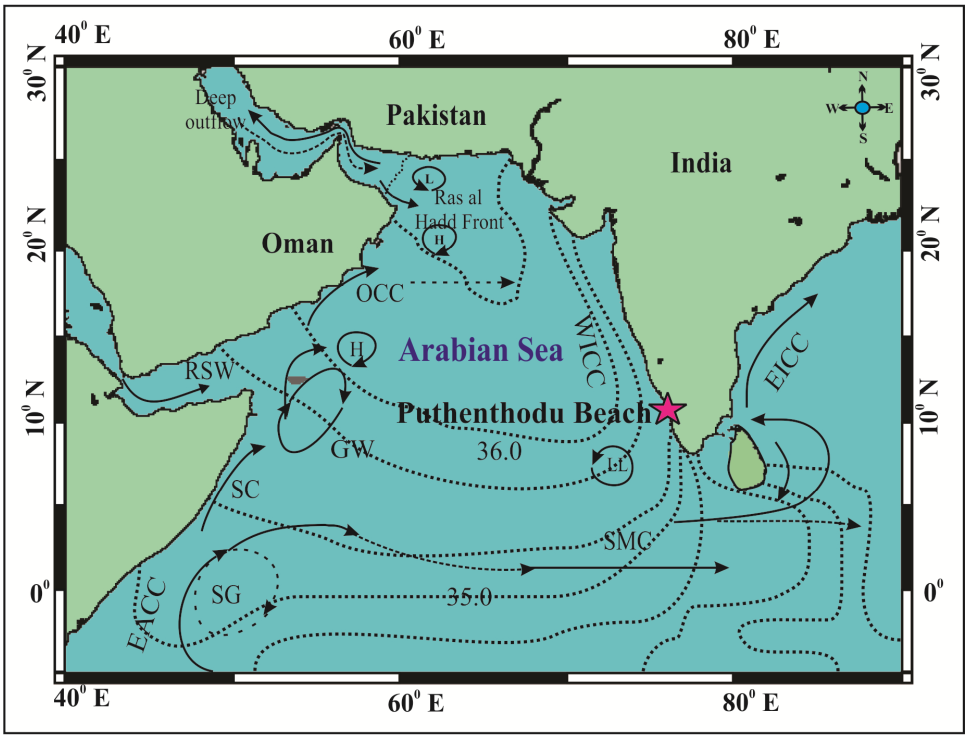


**Figure 1: Location map showing core-sediment from Puthenthodu beach, West coast of India. Ocean currents prevalent during summer monsoon (Jul/Aug) indicated by solid/broken lines with arrows and annual sea surface salinity indicated by dotted lines, values in psu in the Arabian Sea.**

## 3. MATERIALS AND METHODS

Seventy five core-sediment samples have been analyzed for benthic foraminifera from the region of Puthenthodu beach sediment, West coast of India. The sample collection was carried out in the month of October 2018. Core length 75cm, sub-sampled in the top 75cm length at every 1cm intervals. The beach core-sediment samples characterize a dominantly composed of fine sand and the sediment color varies from dark grey, light grey, brown, blackish and brownish grey. Seventy five samples were soaking in water with half a spoon of baking soda for 8-10 hours. Soaked samples were washed with clean water over 63µm-size sieve and oven-dried at ~50$^{o}$C temperature. After dried sample was transferred to the labeled borosil glass vials. For benthic foraminifera study, each dry sample was sieved over 125 µm size sieve and split into suitable aliquots. Benthic foraminiferal census counts were calculated from an aliquot of ~250 specimens from >125 µm size fraction. The samples are spread uniformly on a tray having gridlines that help us to keep track of the examined and non-examined specimens and then viewed under the stereo zoom microscope. Benthic foraminifera were picked by a water moistened thin brush and mounted on assemblage slides. Identical species were kept in a single square that were then identified to species level.

## 4. RESULT

The study on recent benthic foraminiferal faunal record to understand the reconstruction of paleoceanography, paleoclimatology and paleoproductivity changes at Puthenthodu beach core-sediment, West coast of India. A total of 18 species of benthic foraminifera was recorded from the study region. The most dominant benthic foraminiferal species are *Ammonia beccarii* followed by *Ammonia gaimardii, Cancris oblongus, Discopulvinulina bertheloti, Elphidium crisphum, Globobulimina pacifica, Gyroidinoides nitidula, Gyroidinoides cibaoensis, Planularia cassis, Quinqueloculina seminulum, Robulus* sp., *Spiroloculina* sp., *Spiroloculina cummunis, Textularia* sp., *Textularia gaudryina, Textularia goesii ,Trifarina angulosa* and *Trifarina bradyi* were recorded in this region.The distribution pattern of benthic foraminifera in beech sediment indicates that some taxa are dominant in a particular zone whereas others are present throughout the sequence (Figures 2 to 4). Benthic foraminifera showing pronounced changes at core (Puthenthodu beach sediment). For instance, high productivity species *Ammonia beccarii* and *Ammonia gaimardii* an abrupt increase ~75 to 60cm and 10 to 5cm depth, an increasing trend indicative of a shallow-marine environment, suggested that strengthening of the summer monsoon. The interval of ~60 to 20 cm depth, decreasing trend indicate by low productivity at the time of summer monsoon was weak (Figure 2). The intermediate productivity species are *Cancris oblongus, Gyroidinoides nitidula* and *Gyroidinoides cibaoensis* from ~60 to 20cm depth, indicates of low organic carbon flux or pulsed food supply and high oxygen environment (Figures 2 and 3). Species diversity variation of benthic foraminifera at core Puthenthodu beach sediment, scatter plot of *Ammonia beccarii* and *Ammonia gaimardii* against with core depth cm, shows the positive correlation with $R^2$=0.1 and 0.021, respectively. Species are *Cancris oblongus* and *Discopulvinulina bertheloti* against with core depth cm, have recorded positive correlation with $R^2$= 0.015 and 0.003, respectively, *Gyroidinoides nitidula* and *Gyroidinoides cibaoensis* shows $R^2$= 0.017 and 0.047. Species are *Quinqueloculina seminulum* and *Textularia* sp. showing $R^2$= 0.569 and 0.045 respectively (Figure 4).

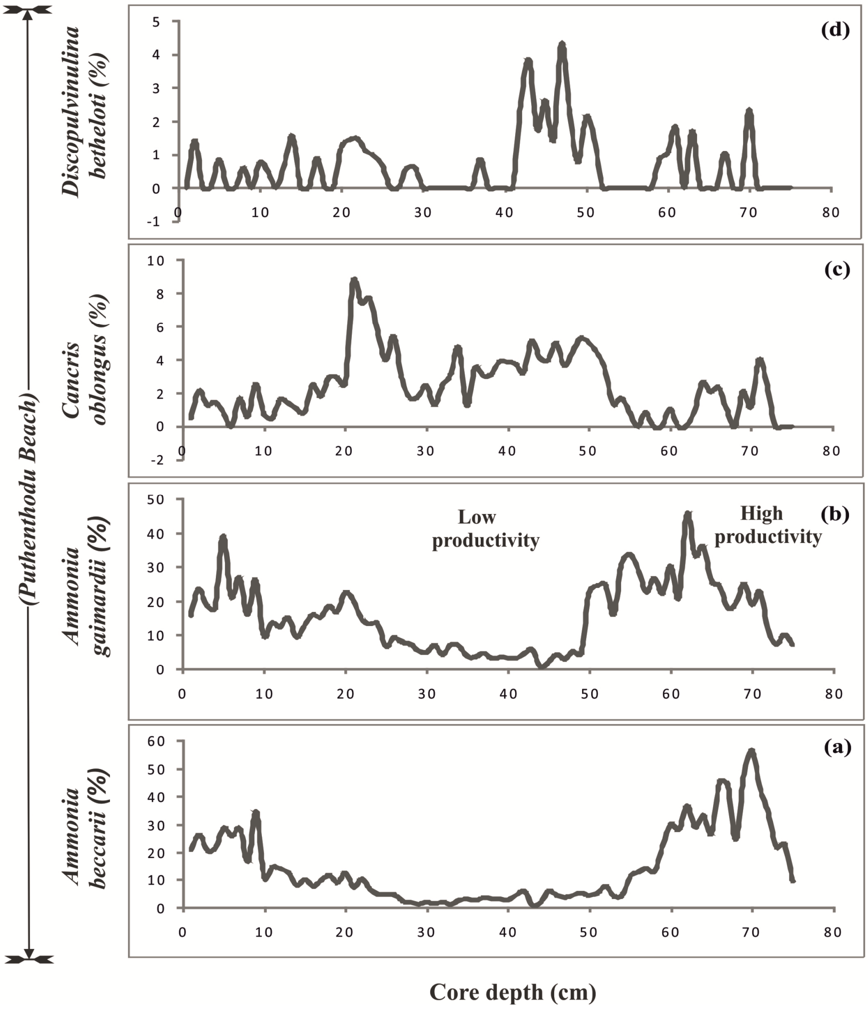


**Figure 2: Percent distribution of benthic foraminiferal species *Ammonia beccarii* (panel a), *Ammonia gaimardii* (panel b), *Cancris oblongus* (panel c) and *Discopulvinulina bertheloti* (panel d) at Puthenthodu beach sediment, West coast of India.**

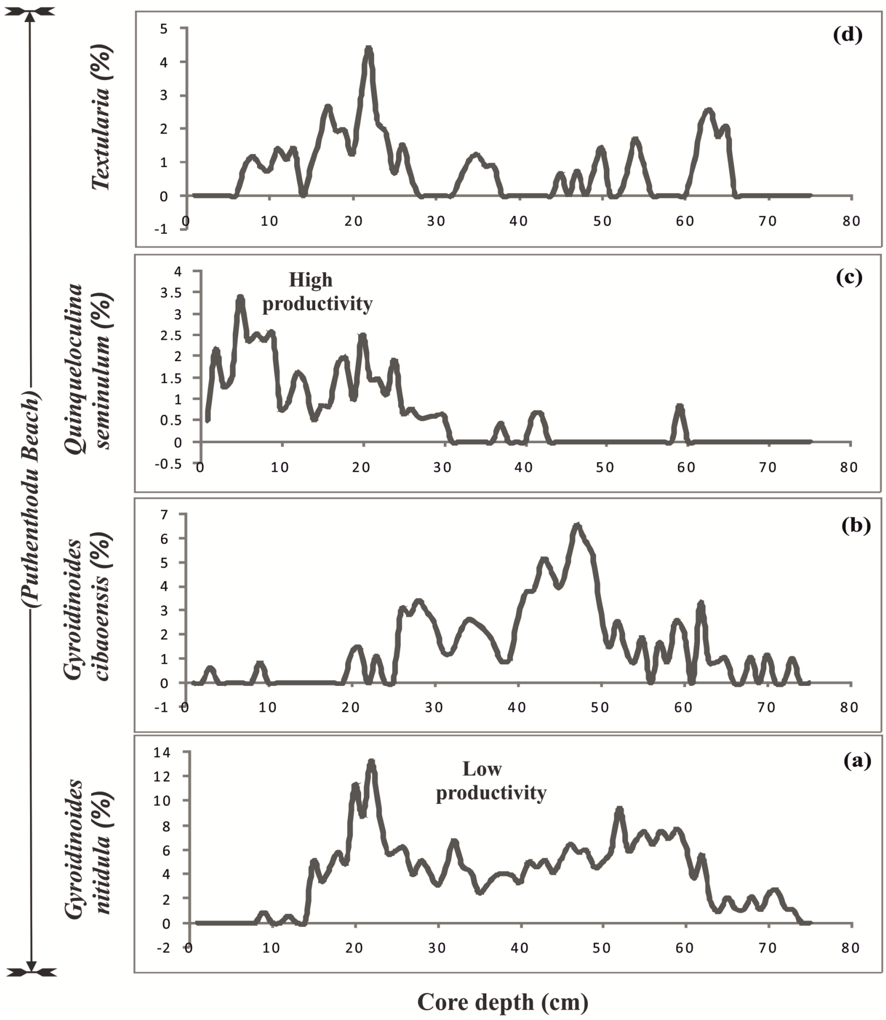


**Figure 3: Percent distribution of dominant benthic foraminiferal species *Gyroidinoides nitidula* (panel a), *Gyroidinoides cibaoensis* (panel b), *Quinqueloculina seminulum* (panel c) and *Textularia* sp. (panel d) at Puthenthodu Beach sediment, West coast of India.**

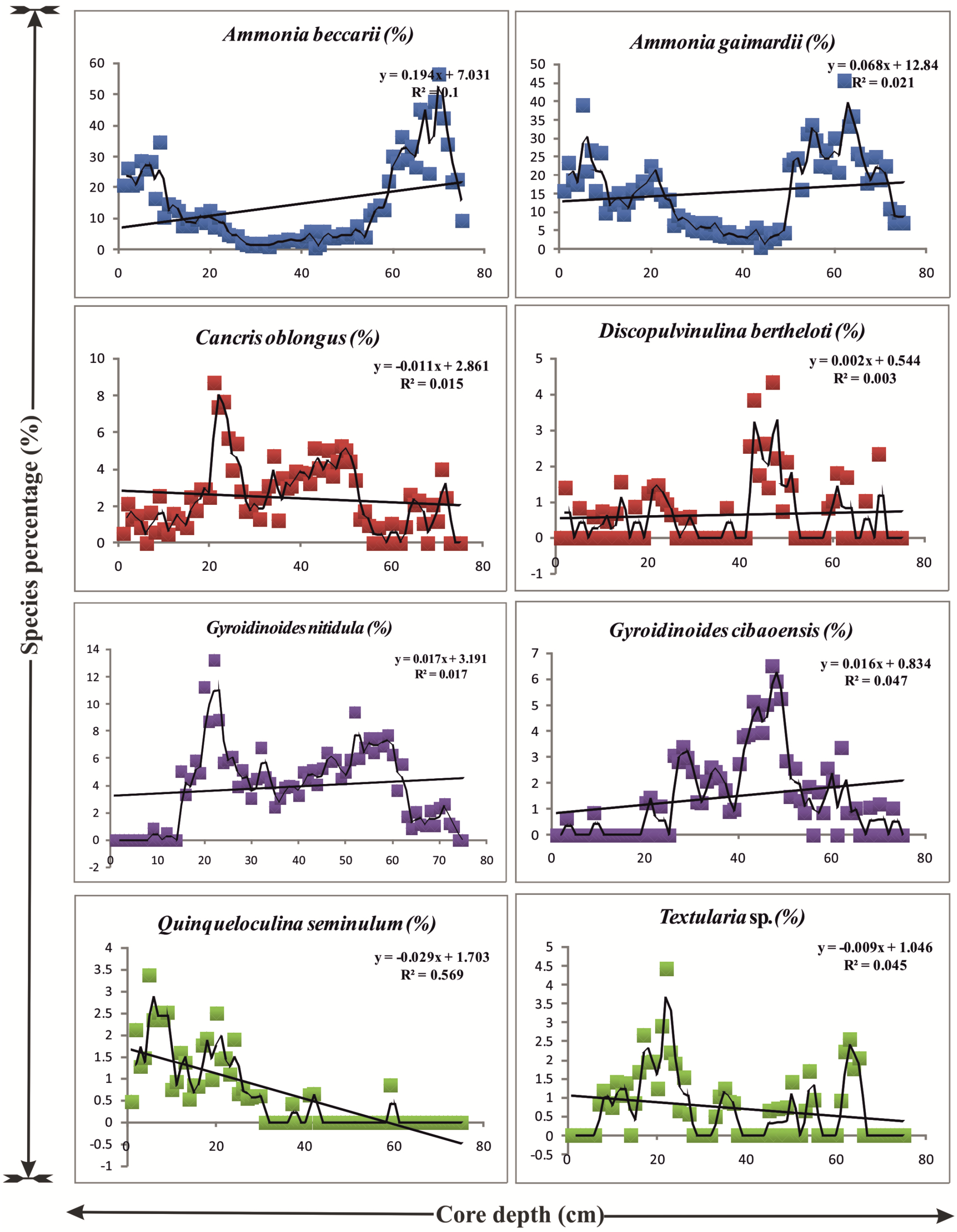


**Figure 4: Scatter plot of percent distribution of benthic foraminiferal species against with core depth (cm) from Puthenthodu beach sediment, West coast of India.**

## 5. DISCUSSIONS

Benthic foraminiferal taxa favor to live in different microhabitats in the upper sediment layers[3, 11, 12].Therefore, some of them are able to precisely record bottom water characteristics, while others reveal pore water properties. This group has been found in both oxygen-depleted and oxygen-rich environments, oligotrophic and eutrophic settings, cold and warm spheres and high and low energy environments, having both epibenthic and endobenthic microhabitats. the recent studies indicate that the benthic faunal composition is strongly correlated to the oxygen content of the ambient water, productivity of the overlying surface waters and the delivery of organic matter to the seafloor.[13 14 15] Thus benthic foraminifera can be used as indicators of paleoproductivity especially in areas where carbon flux is high[8].

### *5.1. Ecological preferences of benthic foraminifera:*

High productivity species of benthic foraminifera *Ammonia beccarii* indicate by a euryhaline and shallow sea environment.[16] *Ammonia beccarii* are indicative of a shallow-marine environment with sandy bottom.[17] Environmental preference of *Cancris oblongus* indicates of tolerance to mesotrophic-eutrophic conditions. This species maintained a high abundance along with opportunistic species and well oxygenated bottom waters in low oxygen environments. *Cancris oblongus* has been considered as a characteristic of well-oxygenated bottom waters and pulsed food supply, low to intermediate organic flux and high seasonality.[18] Environmental preference of *Discopulvinulina bertheloti* is typically an intermediate organic flux to the sea floor.[19] This species has commonly been reported as a surface dweller associated with well-aerated bottom waters and low organic flux in the Atlantic. [20 21 22 23].Its recent distribution appears to be associated with cooler water-masses off West Africa.[20] *Gyroidinoides nitidula* a dominant species from the study region found occupying shallow infaunal microhabit[24]. This species indicate by limited food environment in the Mediterranean Sea[25] and pulsed food supply in the South Atlantic.[26] *Gyroidinoides nitidula* also indicates an environment with intermediate organic flux and intermediate to high seasonality during the Plio-Pleistocene [27 26] suggest that this species indicate by low organic carbon flux or pulsed food supply and high oxygen content of deep-sea environment. *Gyroidinoides cibaoensis* has been described from low oxygenated deep waters of the north-western Indian Ocean with moderate flux of organic matter.[28] The genus *Quinqueloculina* has been observed in cold and well-oxygenated deep waters with strongly pulsed food supply.[27] Species *Quinqueloculina seminulum* prefers near-shore shallow marine environment and is also found in outer and inner shelf in high-energy environments.[29] The genus *Textularia* prefer to living in coarse sediments and high energy environments.[30 31] Ecological preference of *Textularia* spp. has been suggested in coarse sediments and high speed of bottom currents.[30 31]

## 6. CONCLUSION

The study on paleoceanography, paleoclimatology and paleoproductivity changes based on proxy records of benthic foraminifera from Puthenthodu beach sediment in the west coast of India. A total of 18 benthic foraminiferal species were recorded at this region. Benthic foraminiferal species are controlled by amount of organic matter reaching the seafloor and in turn by the surface ocean productivity. The study, proposed that Puthenthodu beach sediment are much favorable for blooming of benthic foraminiferal species. A high productivity species are *Ammonia beccarii* and *Ammonia gaimardii* shows an abrupt increase at ~75 to 60cm and 10 to 5cm depth, indicative of a shallow-marine environment, suggested that strong summer monsoon. The intermediate productivity species are *Cancris oblongus, Gyroidinoides nitidula* and *Gyroidinoides cibaoensis* from ~60 to 20cm depth, indicate by low organic carbon flux or pulsed food supply and high oxygen environment. The high organic productivity, low salinity condition and fine beach sediment texture are the most vital factors scheming foraminiferal faunal distribution from Puthenthodu beech sediment region.

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