

MELONIS POMPILIOIDES (FICHTEL AND MOLL) IN THE LATE NEOGENE OF ANDAMAN-NICOBAR ISLANDS, NORTHERN INDIAN OCEAN: PALAEOCEANOGRAPHIC SIGNIFICANCE

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ABSTRACT

Varying depth distribution of *Melonis pompilioides* (Fichtel and Moll) in the modern oceans indicates that it is not an isobathyal species and its distribution is controlled by the water mass properties. This study examines the distribution of *Melonis pompilioides* in the Late Neogene sequence of Andaman-Nicobar Islands in relation to oceanographically significant species. It is suggested that *Melonis pompilioides* has a preference for a cool, oxygenated, bottom water mass and its appearance and proliferation in the latest Miocene-earliest Pliocene sequence of the study area indicate presence of a similar water mass during that period.

INTRODUCTION

In recent years, a large number of studies have been aimed to understand palaeoenvironmental and palaeoceanographic changes based on benthic foraminifera. Though our knowledge on the inter-relationship of benthic foraminiferal distribution and water mass characteristics is limited, some meaningful interpretations have been made by a number of workers.

In modern oceans, *Melonis pompilioides* (Fichtel and Moll) (fig. 1) is found in deep waters (Frerichs, 1970; Ingle, Keller and Kolpack, 1980; Corliss, 1979a, 1983a; Burke, Berger, Coulbourn and Vincent, 1993; Gupta, 1994). Though earlier considered an isobathyal species, its recent distribution shows that it is not true as it is found at varying depths in different oceans (Boltovskoy,

1983; Blake and Douglas, 1980; Hasegawa, 1984; Woodruff, 1985; Kurihara and Kennett, 1988). Studies indicate that its distribution is controlled by the bottom water masses (Douglas, 1973; Blake and Douglas, 1980; Woodruff and Douglas, 1981; Corliss, 1983a; Kurihara and Kennett, 1988).

In the Indian Ocean, studies concerning modern distribution of *Melonis pompilioides* are few. Data on the distribution of benthic foraminiferal species by Frerichs (1970) in the Andaman Sea (up to a depth of 3,800 meters) of the Northern Indian Ocean show its extremely rare occurrence (found in one sample only). It is of interest to note that the sea water at depths greater than 1800 meters in the Andaman Sea is characterised by a temperature of 4.9° C and dissolved oxygen content of

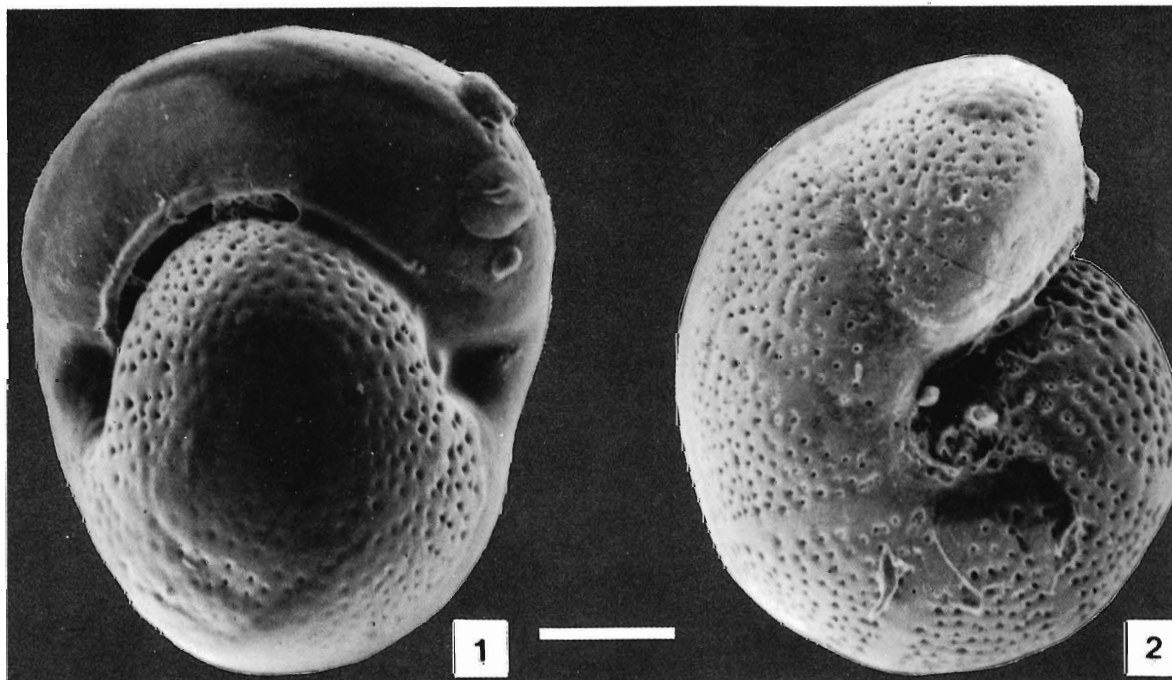


Fig. 1. *Melonis pompilioides* (Fichtel and Moll). Both specimens from sample number Mf 559. Scale Bar represents 100 microns

1.8 ml/L (Frerichs, 1970). Corliss (1979b) considered *Melonis pompilioides* an important deep sea form in the Southeast Indian Ocean between 2,500 m and 4,600 m. Quaternary piston core samples from the Southeast Indian Ocean contain an assemblage dominated by *Melonis pompilioides* along with *Uvigerina* spp. and *Melonis barleeanum* (Williamson) during cool intervals (Corliss, 1983b). Corliss (1983b) also found that high relative abundances of *Uvigerina* are associated in general with high abundances of *Melonis* species.

In our study of benthic foraminiferal fauna in the Late Miocene - Early Pliocene sequences of Neill and Car Nicobar Islands located at about 12°N and 9°N latitudes respectively in the Northern Indian Ocean (fig. 2), we found an interesting trend in the distribution of *Melonis pompilioides*. We have tried to explain this in relation to water mass with the help of associated fauna.

OCEANOGRAPHIC SETTING OF THE NORTHERN INDIAN OCEAN

The following lines briefly describe the oceanography of the Northern Indian Ocean. The Surface currents during the northeast monsoon include North Equatorial Current (NEC) flowing east-west between equator and about 8° N; Equatorial Counter Current (ECC) flowing eastward from equator to about 8° S, and South Equatorial Current (SEC) flowing east-west between about 8° S and 15° S (Pickard and Emery, 1982). During southeast monsoon, the flow of NEC is eastward which combines with ECC to form Monsoon Current (MC).

In the northern Indian Ocean, Arabian Sea has high surface salinity, while the Bay of Bengal has much reduced salinity, particularly in the northern part and especially during southwest monsoon (Pickard and Emery, 1982).

The deep waters in the northern Indian Ocean include the northward flowing Antarctic Bottom Water below about 3,800 meters, which is cold, oxygenated water mass having its origin in the surface waters of the Antarctic region. Because of shallow nature of the Bay of Bengal and Andaman Sea, AABW has no access in these regions (Kolla, Sullivan, Streeter and Langseth, 1976). Its northern limit, according to oxygen value map of Wyrski (1971), is not beyond 3° S latitudes. Occurring between about 1200 m and 3800 m is a highly saline, oxygen-poor and nutrient-rich water mass called the North Indian Deep Water which has its origin in the western part of the Arabian Sea region (also known as Red Sea Water). The T-S curves indicate very little effect of Red Sea Water to the south of the equator. Above 1200 m is the Antarctic Intermediate Water (AAIW) flowing northward. North of 10° S, AAIW does not exist because of blockade by a hydrological front (Wyrski, 1973; Tchernia, 1980). North of this front, the deep water is a mixture of Red Sea Water

of high salinity down to depths exceeding 3000 m and no large scale southward transport of deep water across the equator is found (Sverdrup, Johnson and Fleming, 1972).

MATERIAL AND METHODS

Samples from four sections, two each from Neill Island (East Coast Section and Nipple Hill Section) and Car Nicobar Island (Passa Bridge Section and Sawai Bay Section) have been examined for benthic foraminiferal fauna (fig. 2).

At Neill Island, the East Coast Section comprises soft, light to bluish grey, highly calcareous massive mudstone with occasional hard, calcareous concretions. The mudstones are unconformably overlain by Sub-Recent to Recent shell limestone and coral rags. Nipple Hill Section consists of massive mudstone with occasional silty mudstone laminations.

At Car Nicobar Island, the sequence at Passa Bridge Section consists of light grey, calcareous mudstone with occasional hard, calcareous bands. The Sawai Bay Section comprises moderately hard, highly calcareous, light grey to bluish grey mudstone with occasional thin sandstone bands. Calcareous concretions occur occasionally, particularly in the middle part of the section.

Benthic foraminiferal data on Neill Island is based on the re-examination of quantitative slides earlier used by Kumar (1986) and presently lodged in the Marine Micropaleontology Laboratory of the Department of Geology, University of Delhi. The quantitative slides were prepared by picking all benthic foraminifera (about 300 individuals) from an aliquot of washed residue (87 micron). Same procedure was adopted for the preparation of quantitative slides of benthic foraminifera from samples of Car Nicobar Island.

The bathymetric division used by Ingle *et al.* (1980) is applied in the text. Accordingly, outer shelf = <150 m, upper bathyal = 150 - 500 m, middle bathyal = 500 - 2,000 m, lower bathyal = 2,000 - 4,000 m and abyssal = > 4,000 m.

OBSERVATIONS

The assemblage consists of a large number of benthic foraminiferal species. Among these, thirteen are dominant species (10 % in any one sample) and nineteen are subdominant (5 % to 10 %) (figs. 3 and 4). Dominant species are well represented in the latest Miocene-earliest Pliocene sequence of Neill Island but are reduced in their abundance or are absent in the Early Pliocene Car Nicobar sequence.

Occurrence of *Melonis Pompilioides* is seen in the sequences of both Neill and Car Nicobar Islands (figs. 3 and 5). At Neill Island, it is absent in the lower part of the sequence and its first occurrence is found in sample Mf 523. In the upper part of the sequence, its abundance increases and reaches a maximum of 19.1 per cent. In the

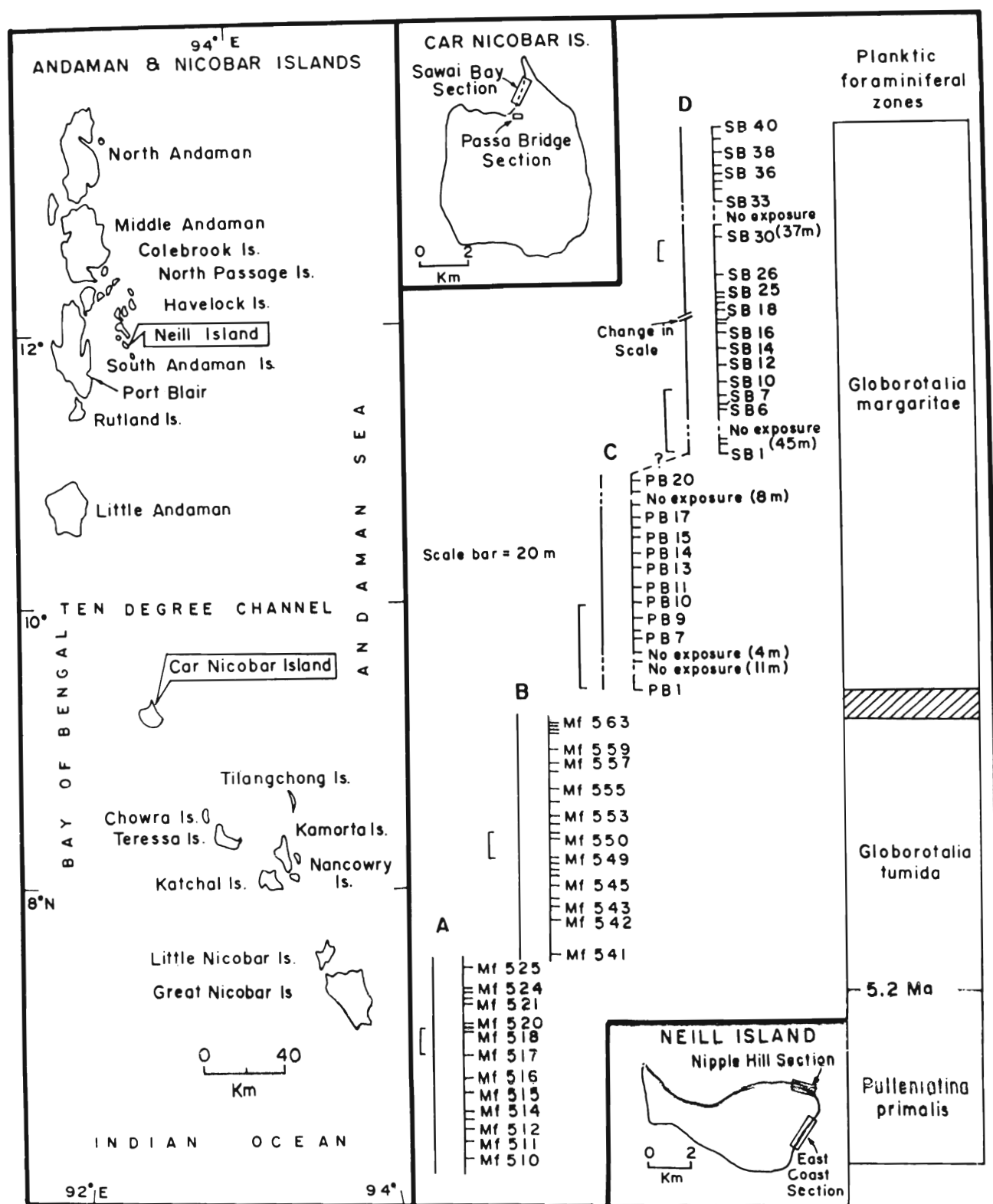


Fig. 2. Location map and stratigraphic position of samples in the studied sections. The planktic foraminiferal zones are after Srinivasan and Azmi (1976b) and Srinivasan (1984). Upper limit of *Globorotalia tumida* Zone is modified after Srinivasan (personal communication). A = East Coast Section, Neill Island; B = Nipple Hill Section, Neill Island; C = Passa Bridge Section, Car Nicobar Island; and D = Sawai Bay Section, Car Nicobar Island.

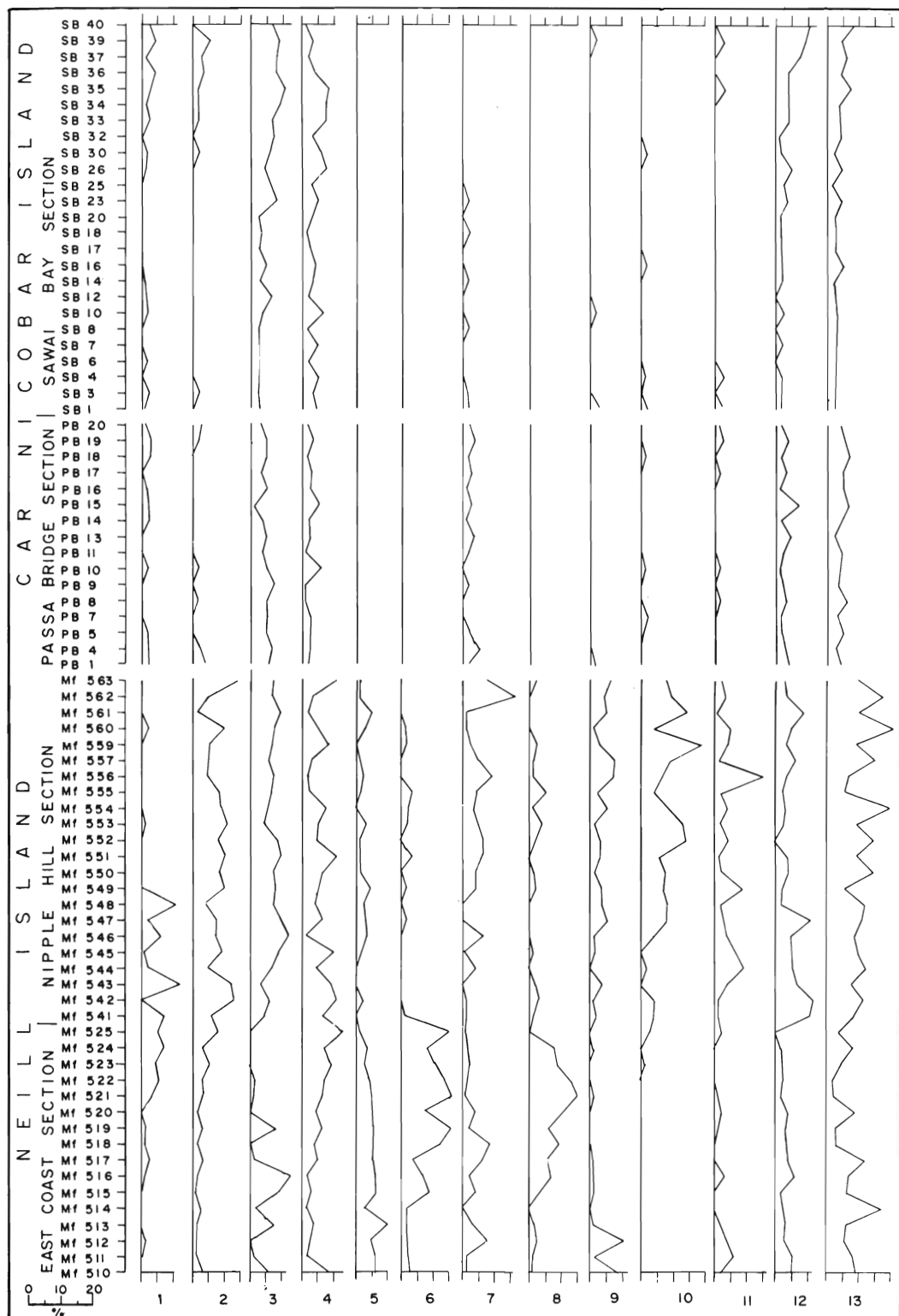


Figure 3: Percentage occurrence of dominant species (10%) in the samples of the studied sections 1 = *Angulogerina angulosa*; 2 = *Bolivina subreticulata*; 3 = *Cibicides bengalensis*; 4 = *Cibicides foxi*; 5 = *Cibicidoides bradyi*; 6 = *Elphidium advenum*; 7 = *Gyroidinoides nitidula*; 8 = *Hanzawaia* sp.; 9 = *Melonis nicobarensis*; 10 = *Melonis pompilioides*; 11 = *Pullenia bulloides*; 12 = *Stilostomella lepidula*; 13 = *Uvigerina proboscidea*.

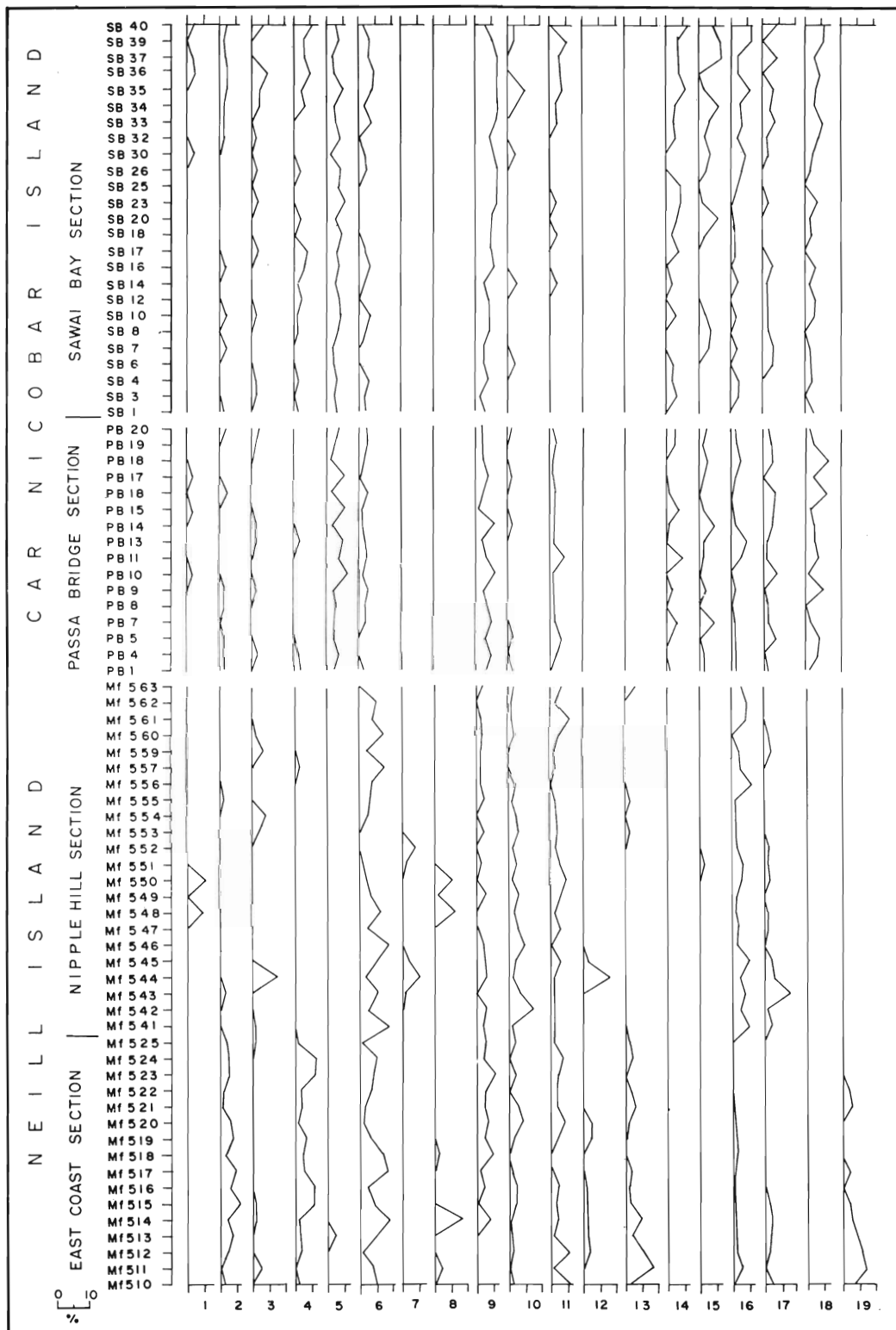


Figure 4: Percentage occurrence of subdominant species (5 - 10 %) in the samples of the studied sections 1 = *Amphistegina lessoni*; 2 = *Angulogerina bradyi*; 3 = *Bolivina pusilla*; 4 = *Bolivina robusta*; 5 = *Bolivinita quadrilatera*; 6 = *Boliviniopsis praelonga*; 7 = *Bulimina alazanensis*; 8 = *Calcarina calcar*; 9 = *Cibicides wuellerstorfi*; 10 = *Globocassidulina oblonga*; 11 = *Globocassidulina subglobosa*; 12 = *Gyroidinoides broeckhianus*; 13 = *Hoeglundina elegans*; 14 = *Lagena gracillima*; 15 = *Lagenonodosaria scalaris*; 16 = *Pleurostomella alternans*; 17 = *Rectuvigerina striata*; 18 = *Uvigerina nitidula*; 19 = *Valvulineria javana*.

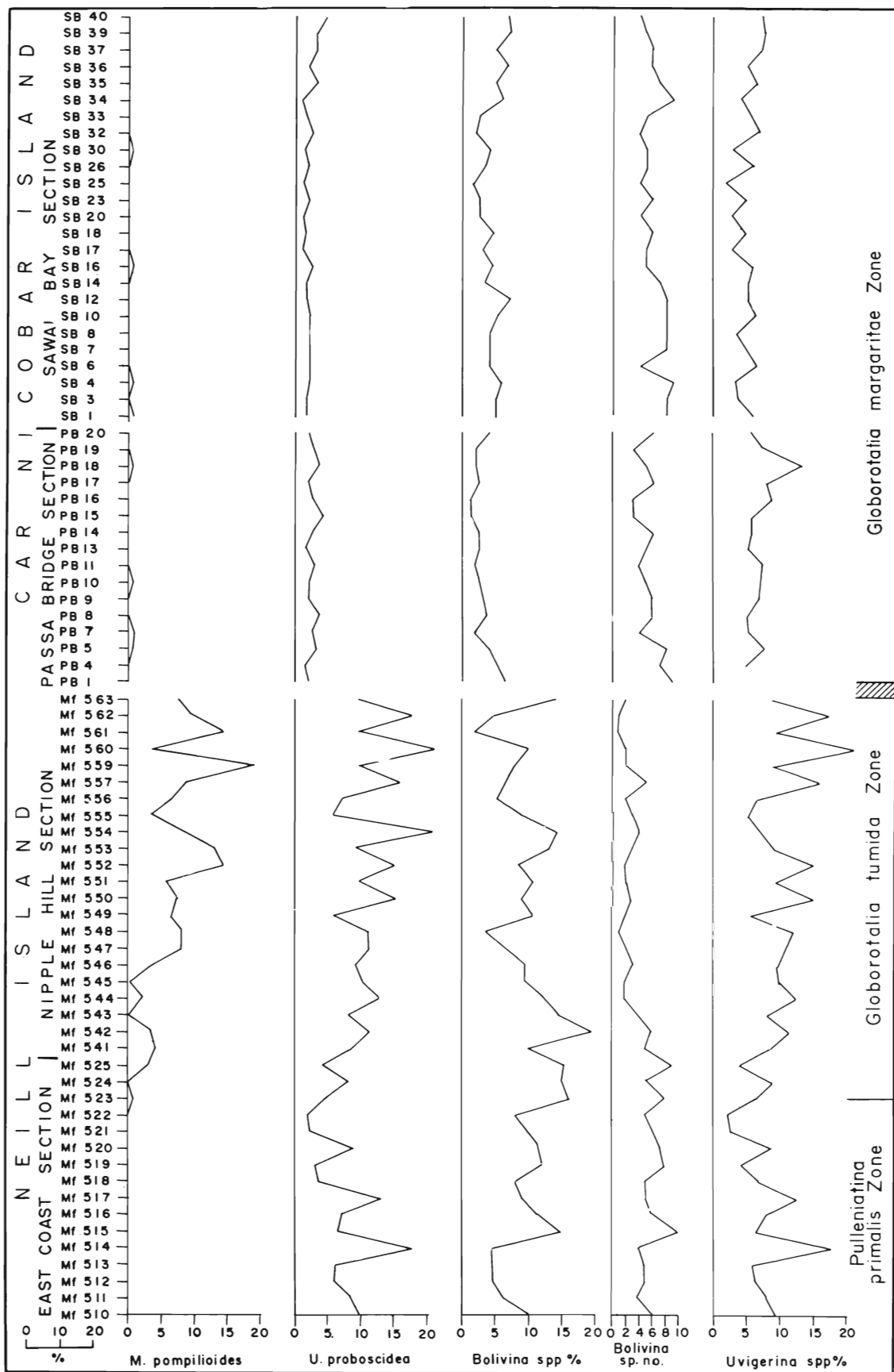


Figure 5: Percentage frequency of selected taxa in the examined sections.

Early Pliocene Car Nicobar sequence, this taxon is sporadic, present in only 8 samples, with a maximum of 0.9 per cent.

DISCUSSION

Taxa like *Cibicides wuellerstorfi* (Schwager), *Uvigerina proboscidea* Schwager, *Pullenia bulloides* (d'Orbigny), *Globocassidulina subglobosa* (Brady), *Melonis pompilioides* (Fichtel and Moll), *Oridorsalis umbonatus* (Reuss), *Astrononion schwageri* (Schwager) and *Laticarinina pauperata* (Parker and Jones) are reported from deep waters of middle to lower bathyal depths of the present-day oceans by a large number of workers. Among these, *Cibicides wuellerstorfi*, *Uvigerina proboscidea*, *Globocassidulina subglobosa* occur consistently in the studied sequences (figs. 3 and 4). Our distribution chart of benthic foraminifera (not included here) shows *Astrononion schwageri* to occur consistently, but in low abundance (5%), in the sequences of both Neill and Car Nicobar Islands, while *Oridorsalis umbonatus* is consistent (but 5%) in the Neill Island sequence. *Laticarinina pauperata* shows sporadic occurrence in the examined sections. The fauna, thus, is indicative of a middle to lower bathyal depth. Srinivasan and Azmi (1976a) suggested the deposition of the sequences to have taken place at lower bathyal depths (3,000 meters).

Higher percentage of *Uvigerina* is considered a measure of high surface productivity and organic carbon-rich sediments (Lohmann, 1978; Schnitker, 1979; Corliss, 1979a; Streeter and Shackleton, 1979; Douglas and Woodruff, 1981; Boersma, 1985; Woodruff, 1985; Corliss, Martinson and Keffer, 1986; Burke et al., 1993). Though its high occurrence is also linked by many with oxygen-poor water, this may not always be true and its percentage may vary independently of dissolved oxygen in the bottom waters (Miller and Lohmann, 1982; Corliss, 1983a; Corliss et al., 1986; Pederson, Pickering, Voges, Southon and Nelson, 1988). Streeter (1973) observed that its high occurrence is associated with cool bottom waters during glacial periods. Palaeoceanographic significance of *Uvigerina proboscidea* has been dealt by Gupta and Srinivasan (1992) who found its maximum abundance during the Late Miocene climatic cooling and considered its high abundance to reflect increased upwelling leading to high surface productivity and possibly also to high rates of biogenic sediment accumulation. Higher percentage of *Uvigerina* thus appears to indicate high surface water productivity and increased input of organic matter. In a study, *Uvigerina* should not be used alone to conclusively establish its relation with dissolved oxygen content.

Bolivina assemblage is found to coincide with the oxygen minimum layer in the Gulf of California (Streeter, 1972). Sen Gupta, Lee and May (1981) observed a direct relation between presence of high *Bolivina* and high organic carbon with the oxygen minima zone in the

sea. Data by Boersma and Mikkelsen (1990) in the Central equatorial Indian Ocean show that high abundance and diversity of *Bolivina* reflect lower oxygen level and higher percentage of organic carbon.

Melonis pompilioides, as already pointed out in previous lines, is a species of deep water habitat. Burke (1981) found that this species is associated with Deep Water Mass (2,500 m) on the Ontong Java Plateau which lies below the deep oxygen minimum layer and is characterised by low potential temperature (1.4°C to 1.9°C) and high oxygen content (3.4 ml/L to 4.6 ml/l).

In the latest Miocene-earliest Pliocene sequence of Neill Island a moderate inverse linear relationship ($r = -0.50$) is observed between percentage occurrences of *Bolivina* spp. and *Melonis pompilioides*. While this interval is marked by a reduction in *Bolivina* abundances and diversity, *Melonis pompilioides* shows its appearance and proliferation suggesting a transition from an oxygen-poor to a more oxygenated water mass. High abundances of *Uvigerina* and *Uvigerina proboscidea* during this interval indicate a period of higher productivity, a phenomenon seen during cooling episodes.

The Late Miocene climatic cooling, which has been linked with expansion of the Antarctic ice sheet gave rise to intense cooling of bottom waters (Shackleton and Kennett, 1975). Such a cooling resulted in more intense thermohaline circulation and expansion of deep water masses. In the study area, the cool, oxygenated deep water mass seems to have developed under the influence of northward flowing deep water having its origin in the Antarctic region. In the Early Pliocene (*Globorotalia margaritae* Zone), extremely poor occurrence of *Melonis pompilioides* suggests existence of a different water mass.

To conclude, *Melonis pompilioides* is a water mass dependent species and its appearance and abundance in the latest Miocene-earliest Pliocene suggest presence of an oxygenated cool bottom water in the area of deposition which resulted due to global cooling during that time. Very rare *Melonis pompilioides* in the Recent sediments of the Northeast Indian Ocean and in the Early Pliocene sequence of Car Nicobar Island indicates presence of a bottom water mass different from that present in the latest Miocene-earliest Pliocene.

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