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RECENT BENTHIC OSTRACODA FROM THE INNER-SHELF OFF THE MALABAR COAST, KERALA, SOUTHWEST COAST OF INDIA

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ABSTRACT

A systematic study of Recent benthic Ostracoda of southwest coast of India was made, based on 28 beach samples and 48 grab samples collected from the inner-shelf off the Malabar coast, Kerala. Samples were collected from Kumbla in the north and Mahe in the south of the coast and these were subjected to standard micropalaeontological techniques. A total of 61 species belonging to 48 genera, 20 families, 3 superfamilies and 2 suborders of the order Podocopida were identified and reported with SEM photomicrography. Among these, *Cytherella semitalis, Cytherelloidea leroyi* and *Keijcyoidea praecipua* belong to Platycopa and remaining species belong to Podocopa. *Leptocythere pulchra* is recorded for the first time from the Indian waters. *Hemitrachyleberis siddiquii* and *Neocytheromorpha reticulata* are recorded for the first time from the west coast of India. The ostracod fauna of the study area shows close similarity with the ostracod assemblage of the Indo-Pacific region. A relatively slow rate of sedimentation is observed in the inner shelf, based on the carapace-valve ratio.

Keywords: Recent Ostracoda, faunal affinity, siltation, Malabar coast, Kerala

INTRODUCTION

Even though some contribution has been made pertaining to the systematics of Recent marine ostracodes of west coast of India (Jain, 1978, 1981; Bhatia and Kumar, 1979; Khosla *et al*, 1982; Vaidya and Mannikeri, 1994 and Rajesh Raghunath *et al*., 1999), the studies of these tiny crustaceans from Kerala coast have received scant attention in general and Malabar coast in particular. Hence, the present study has been taken up in order to record the ostracod assemblage, to know their faunal affinity from the zoogeographic distribution and to infer rate of siltation, based on carapace-valve ratio, in the Malabar coast, Kerala.

The study area includes on-shore and offshore areas of the Kerala coast (Latitude 11°42' to 12°35' N and longitude 74° 49' to75° 33' E). The area covers about 160 km along the Malabar Coast, northwestern part of Kerala, west coast of India. It is narrower in northern and southern parts and wider in the middle section. Physiographically, the region is a distinct strip of low lands on the coastal area, being made up of river deltas, backwater, sandy beaches, coastal sand dunes, mud flat and laterite platforms.

In the study area, a fairly equable climate with high temperature prevails almost throughout the year. Monthly temperature ranges between 23°C and 35°C, while the maximum temperature rarely exceeds 38°C and minimum rarely falls below 20° C. March, April and May are the hottest months of the year. High humidity and refreshing onshore breezes, particularly in the afternoons and evenings, are typical of this region. The area experiences two monsoons, viz., Southwest (June to September) and Northeast (October to December) seasons. Locally, these are known as "Edavappathi" and "Thulavarusham", respectively. The cool season extends from December to February. It is the period of low humidity, bright sunshine and little precipitation. The annual rainfall is uniformly high averaging 3465.98mm.

The area under study has large number of westward flowing rivers, originating from high mountains of Western Ghats. The important rivers are the Shiria, Chandragiri, Neeleshwaram, Karingote, Kavvayi, Peruvamba, Kuppam, Valapattanam and Mahe which are perennial and tidal fluctuations will be up to 10-20 km inland. They serve as important entries of inland communication and provide vast potential for irrigation.

Back waters – Estuaries and Lagoons (Kayals)

A chain of water bodies, locally known as 'Kayals' (backwaters) running parallel to the coast line is the characteristic feature of the study area. These are mostly interconnected by natural or man made canals, facilitating internal navigation almost for the entire length of the Kerala coast. A Kayal can be generally described as a body of brackish, marine or hypersaline water, impounded by a sandy barrier and having an inlet connecting it with the open sea. Numerous perennial rivers discharge into these Kayals. The Kayals of the Kerala coast are mostly separated from the sea by elongated sandbars and based on this, they can be treated as coastal lagoons since perennial rivers debouch into the sea through these water bodies making the system compound. These can be considered as lagoonal estuarine systems or partially mixed estuarine systems. During monsoon, the Kayals overflow into the sea, discharging sizable quantities of sediments, whereas in summer, seawater flows into the Kayal over considerable distances.

In the study area, 12 estuaries and one lagoon are present. The estuaries are located at Kumbla, Mogral, Chandragiri, Kalnad, Bekal, Chittari, Karingote, Ezhimala, Vallapattanam, Dharmadam, Tellicherry and Mahe. The lagoon is situated in Kavvayi.

MATERIALS AND METHODS

Seventy-six sediment samples were collected from various localities around the Malabar coast, northwestern part of Kerala

Table 1a: Locations of shore samples along Malabar coast, Kerala.

Sl. No	Sample No.	Latitude	Longitude
1.	S_1	12°34'05"	74°57'07
2.	S_2	12°31'23"	74°58'34"
3.	S_3	12°29'06"	75°00'07"
4.	S_4	12°27'35"	75°00'57"
5.	S_5	12°26'34"	75°01'35"
6.	S_6	12°24'22"	75°02'40"
7.	S_7	12°21'35	75°03'38"
8.	S_8	12°19'58"	75°04'40"
9.	S_9	12°17'30"	75°05'58"
10.	S_{10}	12°16'05"	75°05'02"
11.	S_{11}	12°13'42"	75°06'12"
12.	S_{12}	12°12'02"	75°07'00"
13.	S_{13}	12°10'00"	75°08'10"
14.	S_{14}	12°08'12"	75°09'07"
15.	S_{15}	12°05'48"	75°10'00"
16.	S_{16}	12°03'12"	75°11'07"
17.	S_{17}	12°01'52"	75°12'24"
18.	S_{18}	12°01'16"	75°15'34"
19.	S_{19}	11°59'02	75°16'07"
20.	S_{20}	11°57'48	75°17'50"
21.	S_{21}	11°55'02"	75°19'32"
22.	S_{22}	11°53'24"	75°21'11"
23.	S_{23}	11°52'02"	75°23'21"
24.	S_{24}	11°50'45"	75°25'00"
25.	S_{25}	11°49'12"	75°26'42"
26.	S_{26}	111°47'32"	75°28'57"
27.	S_{27}	11°45'58"	75°31'07"
28.	S_{28}	11°43'21"	75°32'30"

(Fig.1) for Ostracod studies. Of these, 28 shore samples and 48 grab samples were collected. The sample locations along with geographical co-ordinates for shore samples and offshore samples are given in Table 1a and Table 1b, respectively. The shore samples were collected from the beach surface of Kumbla, Kasaragod, Payyannur, Cannanore, Telicherry, Mahe and adjacent areas, northwestern part of Kerala coast. The grab samples (offshore) were obtained from the collections of Geological Survey of India, Marine wing, Mangalore, South Canara.

RESULTS

All the shore and offshore sediment samples were subjected to standard micropalaeontological techniques to retrieve the ostracod fauna and to present a monographic account supplementing with Scanning Electron Microscope (SEM) microphotography. A total of 61 species belonging to 48 genera, 12 families, three superfamilies and two suborders of the order Podocopida was identified. Among these, three species belong to the suborder Platycopa and the rest to the suborder Podocopa. Out of 61 taxa, 3 belong to superfamily Cytherellidae, 4 to Bairdiacea, 52 to Cytheracea, and the remaining 2 species belong to Cypridacea following the classification proposed by Hartmann and Puri (1974). Of these, 34 species are recorded for the first time from the Malabar coast, northwestern part of Kerala. SEM micrographs of all the species recorded were taken depicting different views from the facility available at CFTRI, Mysore (Plates 1 – 4). Numerical counts for carapace and open valves for the species of shore and offshore samples including adults and juveniles have been done. For the sake of brevity, only the check-list of the species is given (Table 2) along with their zoogeographic distribution. Specimens (hypotypes) of all the taxa identified and illustrated

Table 1b: Locations of off-shore samples along Malabar coast, Kerala.

Sl. No	Sample No.	Latitude	Longitude
1.	G_{10}	12°35'08"	74°53'54
2.	G_{13}	12°34'02	74°56'10"
3.	G_{15}	12°32'32	74°56'22"
4.	G_{16}	12°31'56	74°55'10"
5.	G_{32}	12°27'52"	74°51'50"
6.	G_{36}	12°29'16"	74°56'14"
7.	G_{37}	12°29'40"	74°57'00"
8.	G_{39}	12°29'11"	74°58'24"
9.	G_{41}	12°27'24"	74°58'34"
10.	G_{54}	12°20'56"	74°49'52"
11.	G_{62}	12°24'18"	74°58'30"
12.	G_{63}	12°24'48"	74°58'35"
13.	G_{64}	12°23'36"	75°00'54"
14.	G_{65}	12°22'35"	75°01'40"
15.	G_{84}	12°18'24"	74°59'36"
16.	G_{85}	12°19'05"	75°00'34"
17.	G_{86}	12°19'34"	75°01'48"
18.	G_{87}	12°19'54"	75°02'50"
19.	G_{91}	12°17'24"	75°03'42"
20.	G_{101}	12°13'22"	74°53'10"
21.	G_{105}	12°11'30"	74°56'20"
22.	G_{111}	12°14'00"	75°02'26"
23.	G_{112}	12°14'30"	75°03'32"
24.	G_{115}	12°13'32"	75°05'35"
25.	G_{117}	12°11'56"	75°05'55"
26.	G_{121}	12°10'26"	75°01'18"
27.	G_{123}	12°09'46"	74°59'17"
28.	G_{129}	12°05'28"	75°56"27
29.	G_{133}	12°07'00"	75°00'34"
30.	G_{136}	12°08'17"	75°03'40"
31.	G_{137}	12°09'24"	75°06'35"
32.	G_{139}	12°09'24"	75°06'35"
33.	G_{143}	12°07'00"	75°08'17"
34.	G_{144}	12°06'34"	75°07'18"
35.	G_{146}	12°06'04"	75°04'58"
36.	G_{148}	12°05'03"	75°02'50"
37.	G_{153}	12°02'39"	74°57'58"
38.	G_{157}	12°01'04"	75°01"00"
39.	G_{159}	12°01'56"	75°02'51"
40.	G_{162}	12°04'01"	75°06'02"
41.	G_{163}	12°03'41"	75°07'14"
42.	G_{165}	12°04'23"	75°09'03"
43.	G_{169}	12°01'44"	75°10'17"
44.	G_{171}	12°01'17"	75°09'16"
45.	G_{183}	11°57'46"	75°05'25"
46.	G_{186}	11°58'46"	75°08'42"
47.	G_{187}	11°58'27"	75°09'48"
48.	G_{188}	11°58'48"	75°10'57"

from the study area are reposited in the museum of Department of Applied Geology, M.E.S.College, Ponani, Kerala.

Carapace-valve ratio

The application of statistical data on Ostracoda such as juveniles and adults, closed and open valves; males and females; right and left valves; smooth and ornamented forms, etc. besides colour variation, pyritisation and perdition, is made to interpret the environment of deposition and to assess the potentiality of sediments as source rocks for hydrocarbon exploration. It has become important in the last two decades.

In an environment where deposition of the sediment is low, the carapaces in ostracodes are likely to open up by bacterial action, whereas in an environment of rapid deposition,

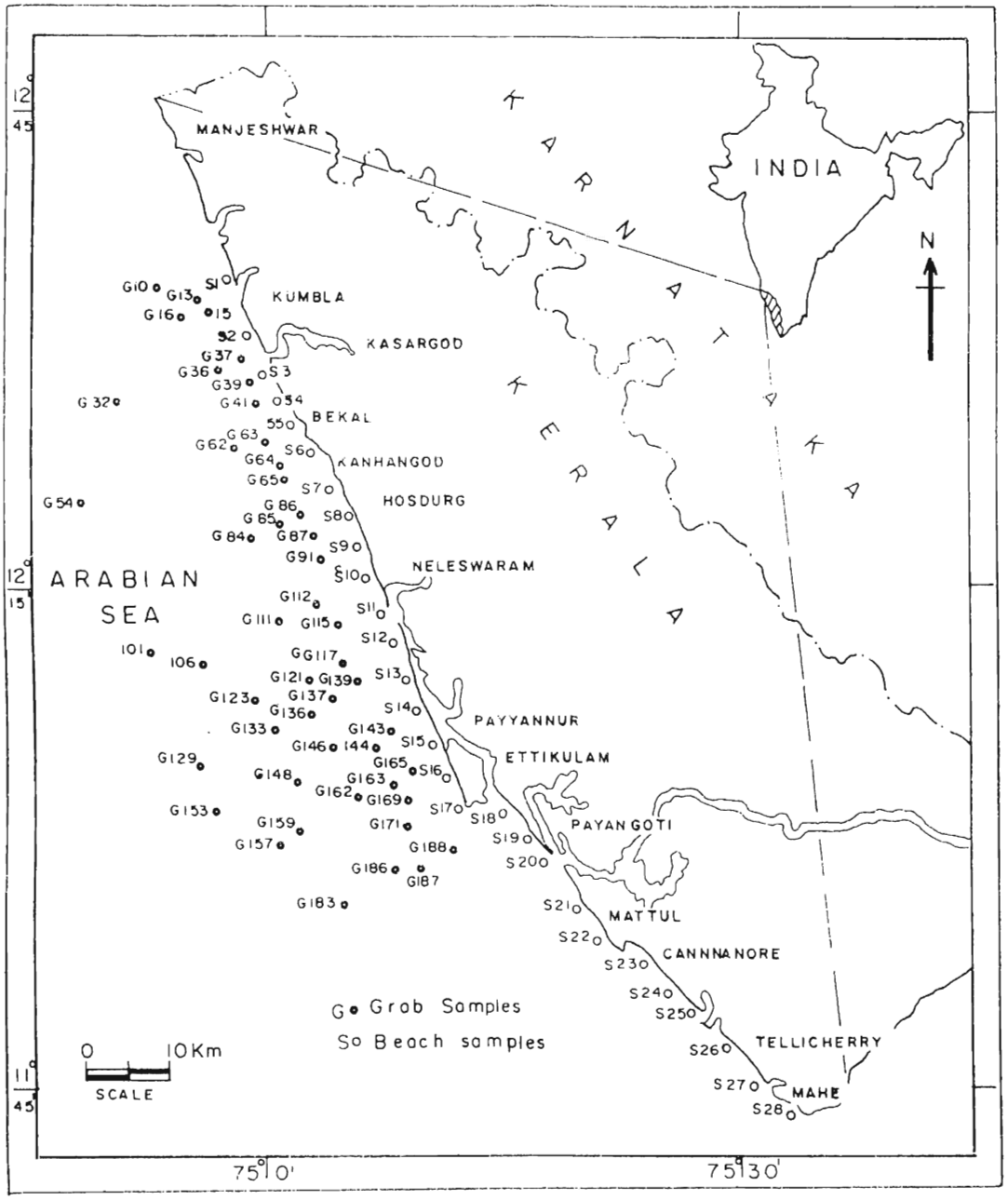

Fig. 1: Location of the samples collection in the Malabar coast, Kerala.

the carapace will sink into the sea bottom and will be quickly covered by sediment. Thus, the carapace will have less chance of being opened up after the destruction of muscles and ligaments.

The use of carapace–valve ratio for palaeoecological information was pioneered by Pokorny as early as 1965. Oertli (1971) reviewed the Pokorny's work and related the carapace-valve ratio to interpreting hydrocarbon potential of sediments. He summarized that when the carapace-valve ratio is high, the sedimentation is rapid, which minimise disarticulation of carapace into separate valves. With sufficiently rapid burial, organic matter is not absorbed by mineral particles and so retains potential for conversion into hydrocarbons. Honnappa and Venkatachalapathy (1978) studied the carapace-valve ratio to interpret the rate of deposition of sediments in the Mangalore Harbour area. They found that the open valves are more in number than the closed ones (ratio being 24:1). According to them, this is indicative of a slow rate of sedimentation in more agitating waters.

Ahmed, Neale and Siddiqui (1991), while studying the Tertiary Ostracoda from the Lindi area Tanzania, observed a high rate of sedimentation in the upper Eocene and lower Miocene than in the Oligocene on the basis of carapace-valve ratio. From a study of the ostracode assemblages in the Pulicat Lake estuarine sediment, Sreenivas *et al.* (1991) have found the higher percentage of complete shells as compared to the separate ones. According to them, it is an indication of comparatively rapid rate of sedimentation. While presenting the check-list of Recent Ostracoda from the marine and marginal marine water bodies of India, Hussain and Rajeshwara Rao (1996) observed a faster rate of sedimentation in the inner shelf of east coast and a slow rate of sedimentation in the west

Table 2: Check-list and zoogeographic distribution of ostracod taxa recorded along the Malabar coast, Kerala.

S. No	Name of the species	Occurrence in other localities of India													Indo-Pacific
		West Coast							East Coast						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	*Cytherella sp.* aff. C. *semitalis*	x	-	-	-	x	-	-	-	-	-	-	-	-	x
2	*Cytherelloidea leroyi*	-	-	-	-	x	-	-	x	x	x	x	x	x	x
3	*Keijcyoidea praecipua*	-	-	-	-	-	-	-	-	-	x	x	-	-	x
4	*Bairdoppilata (B) alcyonicola*	-	x	-	-	x	-	-	-	-	x	x	x	x	x
5	*Bairdoppilata (B) paraalcyonicola*	-	-	-	-	x	-	-	-	-	-	-	-	-	x
6	*Neonesidea woodwardiana*	-	-	-	-	x	-	-	-	-	-	-	-	-	x
7	*Triebelina* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	*Bythocypris* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	*Hemicytheridea paiki*	x	-	-	x	x	-	-	-	x	-	-	x	-	-
10	*Neomonoceratina iniqua*	x	x	-	x	x	-	-	x	x	x	x	x	x	x
11	*Neomonoceratina* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	*Paijenborchella* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	*Leptocythere pulchra*	-	-	-	-	-	-	-	-	-	-	-	-	-	x
14	*Callistocythere* sp. cf. *C .flavidofusca intricatoides*	x	-	-	x	x	-	-	x	x	-	x	x	x	x
15	*Tanella gracilis*	x	-	-	-	x	x	x	x	x	x	x	x	x	x
16	*Paracytheroma ventrosinuosa*	-	-	-	-	x	-	-	-	-	x	x	-	x	x
17	*Cypredeis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	*Cushmanidea guhai*	x	-	-	-	x	-	x	-	-	x	-	-	x	-
19	*Hemikrithe peterseni*	x	-	-	x	x	-	-	-	-	-	x	-	x	x
20	*Krithe kroemmelbeini*	x	x	-	-	-	-	-	-	-	-	-	-	-	x
21	*Copytus* sp.cf. *rara*	x	-	-	-	-	-	-	-	-	-	-	-	-	-
22	*Actinocythereis scutigera*	x	-	-	-	x	-	-	-	-	-	x	-	x	x
23	*Henryhowella (Neohenryhowella) hartmanni*	x	-	-	x	x	-	-	-	-	-	-	-	-	x
24	*Alocopocythere reticulata indoaustralica*	x	x	-	x	x	-	-	-	-	x	-	-	-	x
25	*Alocopocythere* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	*Chrysocythere keiji*	x	x	-	x	x	-	-	x	-	x	x	x	x	-
27	*Stigmatocythere indica*	x	-	-	-	x	-	-	x	x	x	x	x	x	x
28	*S. kingmai*	x	-	-	-	x	-	-	-	-	x	x	-	x	x
29	*Mosella cochinensis*	-	-	-	x	x	-	-	-	-	-	-	-	-	-
30	*Hemitrachyleberis siddiquii*	-	-	-	-	-	-	-	-	-	-	-	-	x	-
31	*Archicythereis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	*Puricythereis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	*Indet genus* ct sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	*Keijella karwarensis*	x	-	-	-	x	-	-	-	-	x	x	x	x	x
35	*K neali*	x	x	-	x	x	-	-	-	-	-	-	-	-	-
36	*K. whatleyi*	-	-	-	x	x	-	-	-	-	-	-	-	-	x
37	*K. reticulata*	-	-	-	x	x	-	-	-	-	x	x	x	x	x
38	*Ruggieria darwini*	x	-	-	-	x	-	-	-	-	-	-	-	-	x
39	*R. indoiranica*	x	-	-	x	x	-	-	-	-	-	-	-	-	x
40	*Lankacythere coralloides*	x	x	-	x	x	-	-	-	-	x	x	-	x	x
41	*Lankacythere* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	*Neocytheromorpha reticulata*	-	-	-	-	-	-	-	-	-	-	-	-	x	-
43	*Basslerites leibaui*	x	x	-	x	x	-	-	x	x	-	-	x	x	-
44	*Aurila* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	*Mutilus pentokensis*	x	-	-	-	x	-	-	-	-	x	x	x	x	x
46	*Caudites javana*	x	-	-	-	x	-	-	-	-	x	x	x	x	x
47	*C. sublevis*	-	-	-	-	x	-	-	-	-	-	x	-	-	x
48	*Falsocythere maccagnoi*	-	-	-	-	x	-	-	-	-	-	-	-	x	x
49	*Cytheretta trifurcata*	-	-	-	-	-	-	-	-	-	-	x	-	x	-
50	*Neocytheretta murilineata*	-	-	-	-	x	-	-	-	-	x	x	x	x	x
51	*Loxoconcha lilljeborgii*	-	x	-	x	x	-	-	-	-	x	x	-	-	x
52	*L. gruendeli*	x	x	-	x	x	-	-	-	-	-	-	-	x	-
53	*L. megapora indica*	x	-	-	-	-	-	x	-	-	-	-	-	-	-
54	*L. tekkaliensis*	-	-	-	-	-	-	-	x	x	-	-	-	-	-
55	*Neosinocythere indica*	-	-	-	-	x	-	-	-	-	-	-	-	-	-
56	*Paracytheridea pseudoremanei*	-	-	-	-	x	-	-	-	-	-	-	-	x	x
57	*Paijenborchellina indoarabica*	-	x	-	x	x	-	-	-	-	-	x	-	-	x
58	*Ornatoleberis morkhoveni*	-	-	-	-	-	-	-	-	-	x	x	-	-	x
59	*Xestoleberis variegata*	x	-	-	-	-	-	-	-	-	x	x	-	x	x
60	*Propontocypris (Schedopontocypris) bengalensis*	-	-	-	-	x	-	x	-	x	x	x	-	-	x
61	*Phlyctenophora orientalis*	-	-	-	-	x	-	-	x	x	x	x	x	x	x

Index: (Localities of India other than the study area)

West Coast: 1. Mandvi beach (Jain, 1978); 2. Off Karwar (Bhatia and Kumar, 1979); 3. Off Bombay and Ratnagiri (Guha, 1980); 4. Southwest Kerala coast (Jain, 1981); 5. Karwar – Kasargod (Vaidya and Mannikeri, 1994).

East Coast: 6. Chilka lake (Jain, 1976); 7. Pulicat lake estuary (Sreenivas *et al.*, 1991); 8. Tekkali creek (Varma *et al.*, 1993); 9. Gogulcru creek (Shyam Sunder *et al.*, 1995); 10. off Rameswaram (Sridhar *et al.*, 2002); 11. Off Tuticorin (Hussain, 1998); 12. Adyar river estuary (Hussain and Mohan, 2000); 13. Off Karikkattukuppam (Mohan *et al.*, 2001).

Outside India: 14. Indo-Pacific region (Red sea - Bonaduce *et al.*, 1976,1980); (Persian Gulf – Paik, 1977); (Australia – Hartmann, 1978); (South China sea – Zhao *et al.*, 1985); (Malacca Straits –Whatley and Zhao, 1987 a, b); (Malay Peninsula - Zhao and Whatley, 1989); (Western Australia – Howe and McKenzie, 1989).

Table 3: Occurrence of carapaces and open valves in the shore and offshore samples of Malabar coast, Kerala.

Location	No. of closed carapaces	No. of open valves	Total
Shore	467	1814	2281
Offshore	567	1325	1892
Total	1024	3139	4173

coast. This inference has been attributed by them to the larger number of eastward flowing rivers, which bring large quantities of sediments with them. While studying various aspects of ostracode assemblages in the Gulf of Mannar, Hussain *et al.* (2002) observed a high ratio (4:1) between the carapaces and open valves indicating rapid rate of sedimentation.

Hence, in the present work, the ratio between the carapaces and open valves is taken into consideration for finding out the rate of sedimentation in the Malabar coast of Kerala. A total of 4,173 ostracod shells was recovered from 76 sediment samples collected from shore and offshore areas of the Malabar coast. Among these, 3,139 specimens are the open valves, while the remaining 1,024 specimens are the complete carapaces (Table 3). Comparatively dimorphic forms and juveniles are very poor in number in all the samples. Besides, the pyritised and predated shells are also very rare in the samples. From the above observation, it may be concluded that the rate of sedimentation in the study area was slow under a strongly agitated sea-wave environmental condition.

SUMMARY

From the collection of seventy-six sediment samples from the various localities of the Malabar coast of Kerala, sixty one species belonging to 48 genera were identified and these were supplemented with SEM phtomicrography. Of these, the following 34 species are recorded for the first time from the Malabar coast, northwestern part of Kerala: *Cytherella* sp. aff. *C. semitalis, Cytherelloidea leroyi, Keijcyoidea praecipua, Bairdoppilata (B) alcyonicola, Bairdoppilata (B) paraalcyonicola, Neonesidea woodwardiana, Leptocythere pulchra, Callistocythere* sp. cf. *C .flavidofusca intricatoides, Paracytheroma ventrosinuosa, Cushmanidea guhai, Hemitrachyleberis siddiquii, Krithe kroemmelbeini, Copytus* sp.cf. *rara, Actinocythereis scutigera, Stigmatocythere indica, S. kingmai, Keijella karwarensis, K. neali, K. reticulata, Neocytheromorpha reticulata, Ruggieria darwini, Mutilus pentokensis, Caudites javana, C. sublevis, Falsocythere maccagnoi, Neocytheretta murilineata, L. megapora indica, L. tekkaliensis, Neosinocythere indica, Paracytheridea pseudoremanei, Ornatoleberis morkhoveni, Xestoleberis variegata, Propontocypris (Schedopontocypris) bengalensis, Phlyctenophora orientalis*. Among these, *Leptocythere pulchra* is recorded for the first time from the Indian waters, while *Hemitrachyleberis siddiquii* and *Neocytheromorpha reticulata* are recorded for the first time from the west coast of India.

From the zoogeographical distribution of the present fauna, it is observed that the ostracoda fauna of the study area exhibits close affinity with the ostracode assemblage of the Indo-Pacific region, e.g. other parts of east and west coast of India, Persian Gulf, Red Sea, east African coast, Malacca Straits, South China Sea, Indo-Malayan region and west coast of Australia. However, the presence of *Cushmanidea guhai, Keijella neali, Loxoconcha gruendeli, L. megapora indica* and *L. tekkaliensis* appear confined to the Indian coast. Based on carapace–valve ratio, a relatively slow rate of sedimentation is inferred in the study area, under a strongly agitated sea-wave environmental conditions.

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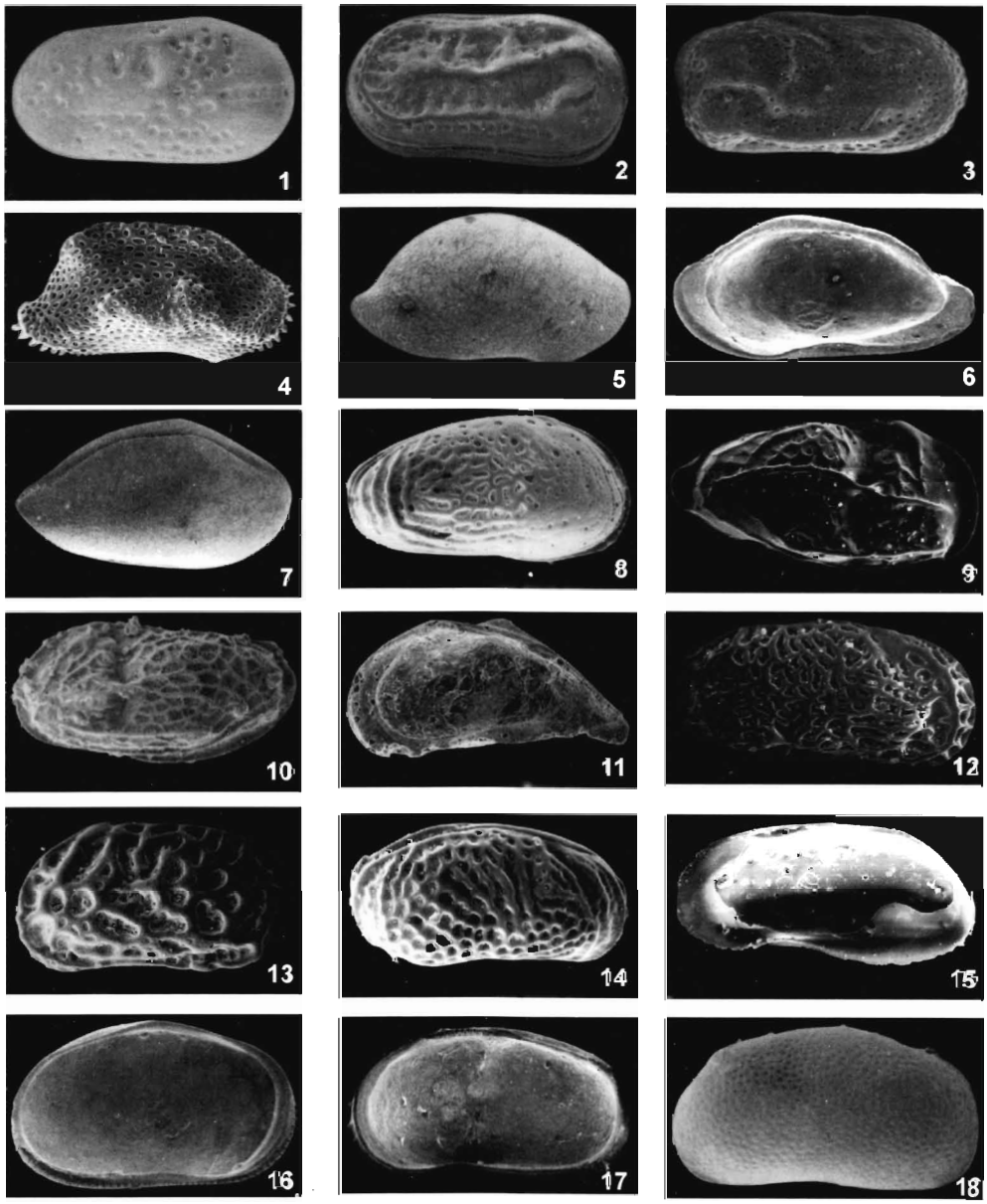
Plate I

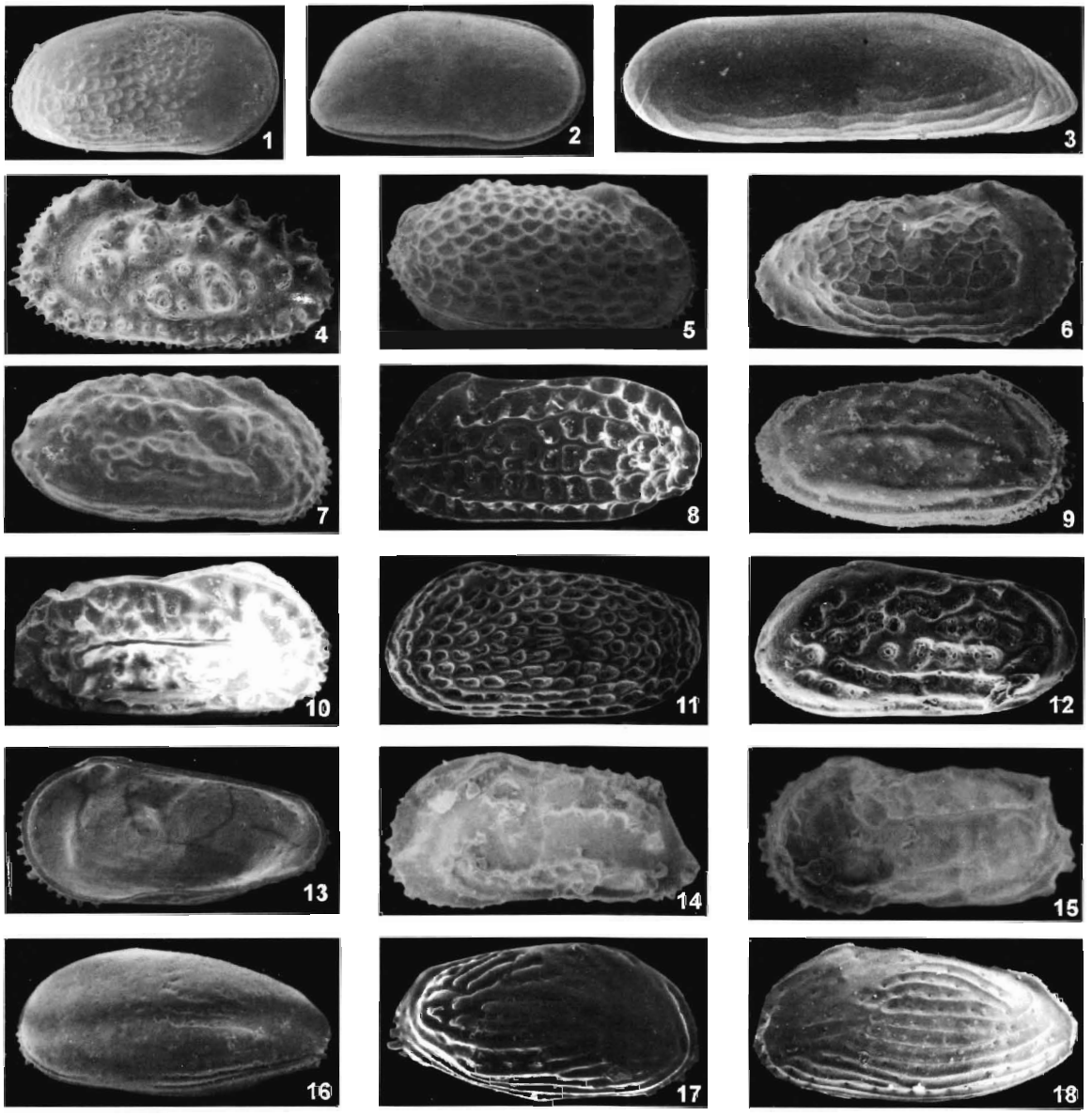


GOPALAKRISHNA, HUSSAIN, MAHESH BILWA AND AYISHA

EXPLANATION OF PLATE I

1. ***Cytherella*** sp. aff .***C. semitalis*** Brady, 1968 hypotype, carapace, left valve view (X150).
2. ***Cytherelloidea leroyi*** Keij, 1964 Hypotype 1, carapace, left valve view (X150).
3. ***Keijcyoidea praecipua*** Malz, 1981 Hypotype 1, carapace, left valve view (X125).
4. ***Tribelina*** sp. hypotype , right valve, external view (X150).
5. ***Bairdoppilata (B) alcyonicola*** Maddocks 1969 hypotype, right valve, external view (X80).
6. ***Bairdoppilata (B) paraalcyonicola***, Titterton and Whatley, 1988 hypotype, right valve, internal view (X80).
7. ***Neonesidea woodwardiana*** (Brady) hypotype, carapace, right valve view (X80).
8. ***Hemicytheridea paiki*** Jain, 1978 hypotype, female carapace, right valve view (X100).
9. ***Noemonoceratina*** sp. hypotype, carapace, left valve view (X150)
10. ***Neomonoceratina iniqua*** (Brady) hypotype, right valve, external view (X150).
11. ***Paijenborchella*** sp. hypotype, right valve, internal view (X150)
12. ***Leptocythere pulchra*** Zhao and Whatley, 1988 hypotype, carapace, right valve view (X150).
13. ***Callistocythere*** sp.cf.***C.flavidofusca intricatoides*** (Ruggieri) hypotype, carapace, left valve view (X150).
14. ***Tanella gracilis*** Kingma, 1948 hypotype, carapace, right valve view (X150).
15. ***Paracytheroma ventrosinuosa*** Zhao and Whatley, 1989 hypotype, right valve internal view.
16. ***Cypredeis*** sp. hypotype, left valve internal view (X100).
17. ***Cushmanidea guhai*** Jain, 1978 hypotype, right valve internal view (X100).
18. ***Bythyocypris*** sp. hypotype, right valve, external view (X100).

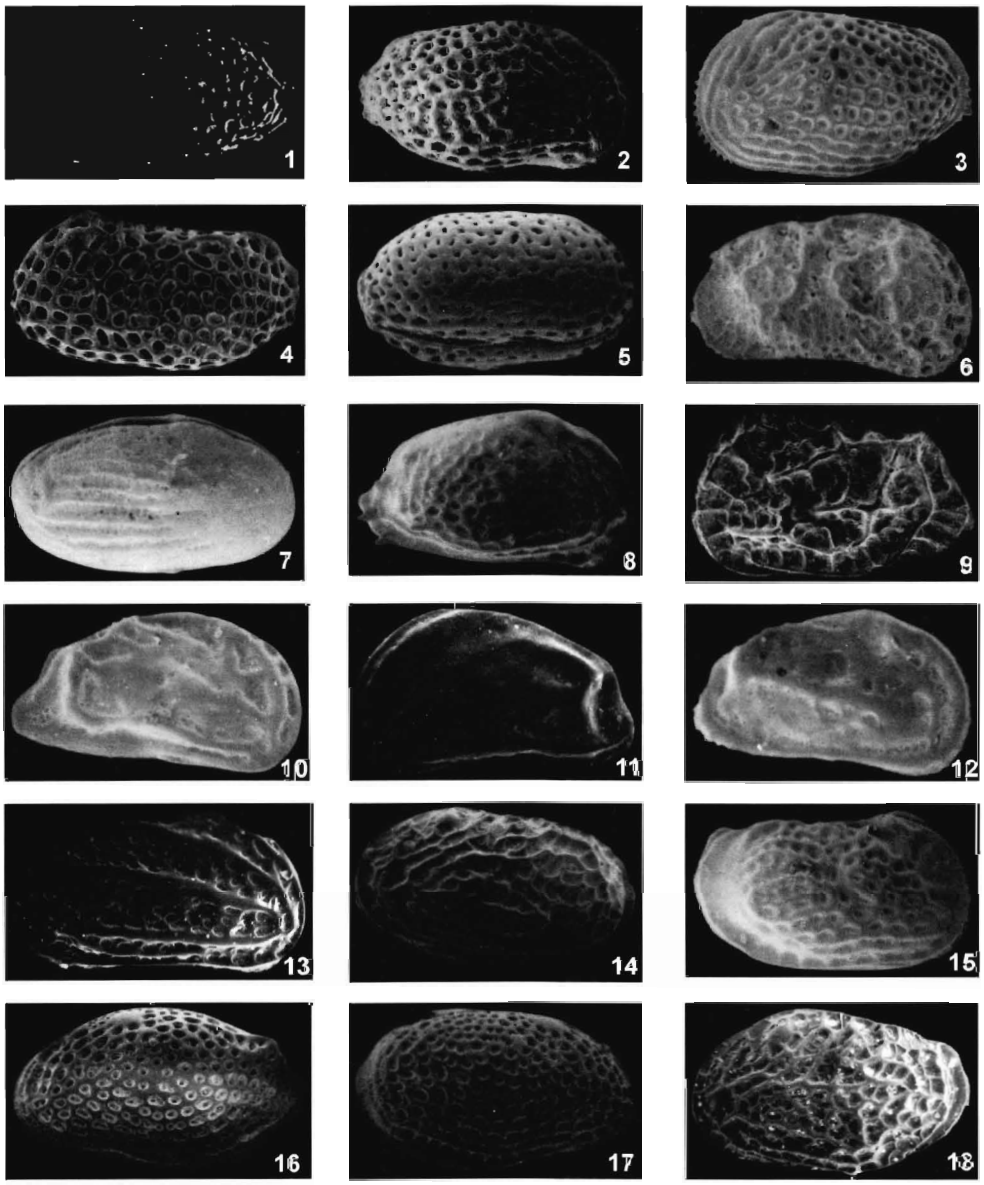
Plate II



GOPALAKRISHNA, HUSSAIN, MAHESH BILWA AND AYISHA

EXPLANATION OF PLATE II

1. ***Hemikrithe peterseni*** Jain, 1978 hypotype, carapace, right valve view (X150).
2. ***Krithe kroemmelbeini*** Jain, 1978 hypotype, carapace, right valve view (X100).
3. ***Copytus*** sp. cf. ***C. rara*** McKenzie, 1967 hypotype, left valve, external view (X100).
4. ***Actinocythereis scutigera*** (Brady) hypotype, left valve, external view (X100).
5. ***Alocopocythere reticulata indoaustralica*** Hartmann, 1964 hypotype, carapace, right valve view (X100).
6. ***Alcopocythere*** sp. hypotype, right valve, external view (X100).
7. ***Henryhowella (Neohenryhowella) hartmanni*** (Jain) hypotype, right valve, external view (X100).
8. ***Chrysocythere keiji*** Jain, 1978 hypotype, carapace, left valve view (X150).
9. ***Stigmatocythere indica*** (Jain) hypotype, carapace, right valve view (X100).
10. ***Stigmatocythere kingmai*** Whatley and Zhao, 1988 hypotype, carapace, right valve view (X100).
11. ***Moosella cochinensis*** Jain, 1981 hypotype, carapace, right valve view (X100).
12. ***Hemitrachyleberis siddiqui*** Mohan *et al.*, 2002 carapace, left valve view (X100).
13. ***Archicythereis*** sp. Hypotype, right valve, internal view (X100).
14. ***Puricythereis*** sp. hypotype, left valve, external view (X100).
15. ***Indet. Genus*** sp. A hypotype, Carapace, left valve, external view (X100).
16. ***Keijella karwarensis***, (Bhatia and Kumar) hypotype, Carapace, left valve view (X125).
17. ***Keijella neali*** Jain, 1978 hypotype, Carapace, right valve view (X100).
18. ***Keijella whatleyi*** Jain, 1981 hypotype, left valve, external view (X100).



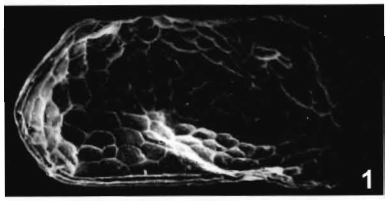
GOPALAKRISHNA, HUSSAIN, MAHESH BILWA AND AYISHA

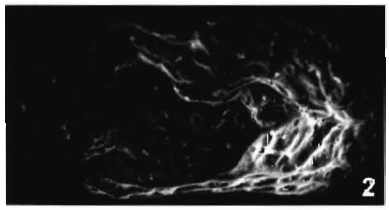
EXPLANATION OF PLATE III

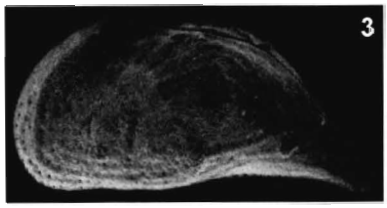
1. ***Keijella reticulata***, Whatley and Zhao, 1988 hypotype, Carapace, left valve view (X100).
2. ***Ruggieria darwini*** (Brady) hypotype, right valve, external view (X80).
3. ***Ruggieria indoiranica*** Jain,1981 hypotype, left valve, external view (X100).
4. ***Lankacythere coralloides*** (Brady) hypotype, Carapace, left valve view (X100).
5. ***Lankacythere*** sp. Hypotype, Carapace, right valve view (X100).
6. ***Neocytheromorpha reticulata*?** Mohan *et al.*, 2002 Hypotype, Carapace, right valve view (X120).
7. ***Basslerites liebaui*** Jain, 1978 hypotype, Carapace, right valve view (X100).
8. ***Aurila*** sp. hypotype right valve, external view (X150)
9. ***Mutilus pentokensis*** Kingma, 1948 hypotype, Carapace, left valve view (X120).
10. ***Caudities javana*** Kingma, 1948 hypotype, Carapace, right valve view (X120).
11. ***Caudites sublevis*** Bonaduce *et al.* 1980. hypotype, Carapace, left valve view (X150).
12. ***Falsocythere maccagnoi*** (Ciampo) hypotype, Carapace, right valve view (X120).
13. ***Cytheretta trifurcata*** Lubimova and Guha hypotype, Carapace, right valve view (X100).
14. ***Loxoconcha tekkaliensis*** (Verma) hypotype, Carapace, left valve (X120).
15. ***Neocytheretta murilineata*** Zhao and Whatley hypotype, Carapace, right valve view (X120).
16. ***Loxoconcha lilljeborgii*** Brady 1978 hypotype, Carapace, left valve view (X120).
17. ***Loxoconcha gruendeli*** Jain, 1978 hypotype, Carapace, right valve view (X120).
18. ***Loxoconcha megapora indica*** Jain, 1978 hypotype, Carapace, left valve (X120).

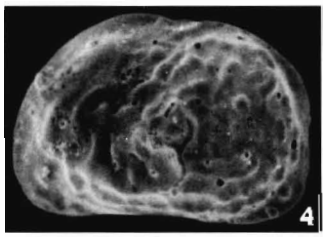
Journal of the Palaeontological Society of India
Volume 52(1), June 2007

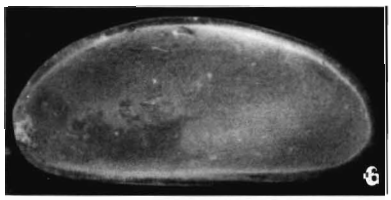
Plate IV

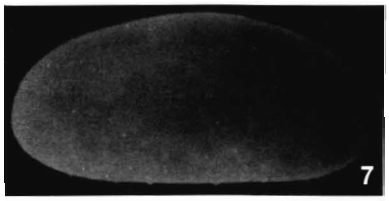












GOPALAKRISHNA, HUSSAIN, MAHESH BILWA AND AYISHA

EXPLANATION OF PLATE IV

1. ***Neosinocythere indica*** (Zhao and Whatley) hypotype, Carapace, male right valve view (X100).
2. ***Paracytheridea pseudoremanei*** (Banaduce *et. al.*) hypotype, Carapace, right valve external view (X120).
3. ***Paijenborchellina indoarabica*** Jain, 1981 hypotype, left valve, external view (X100).
4. ***Ornatoleberis morkhoveni*** Keij, 1975 hypotype, Carapace, left valve view (X100).
5. ***Xestoleberis variegata*** Brady hypotype, Carapace, right valve view (X100).
6. ***Propontocypris (Schedopontocypris) bengalensis*** Maddocks, 1969 hypotype, Carapace, left valve view (X130).
7. ***Phlyctenophora orientalis*** (Brady) hypotype, right valve, external view (X80).

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