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Textural characteristics and distribution of ostracoda in core sediments from the Gadilam river estuary, Cuddalore, Tamil Nadu, southeast coast of India

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ABSTRACT

To know the distribution of brackish water Ostracoda and to investigate the sediment characteristics, a core (105 cm) has been collected from the Gadilam river estuary and it was sub-sampled into 21 samples at 5 cm width regular interval. All the sediment samples were analyzed as per standard micropaleontological techniques in order to investigate the distribution and occurrence of ostracod fauna. A total of 27 ostracod taxa belonging to 16 genera, 12 families, 3 superfamilies and 2 sub-order of the order Podocopida, have been identified based on published articles Throughout the core (from top to bottom) the calcareous forms were noticed. The ostracod species *Kalingella mckenziei* and *Jankeijcythere mckenziei* are widely distributed in the core and they outnumbered the rest of the species. The faunal assemblages recorded are tropical, brackish to neritic (shallow marine) and benthic in nature (*Hemicytheridea paiki, Hemicytheridea bhatiai, Jankeijcythere mckenziei, Kalingella mckenziei, Neosinocythere dekrooni, Paijenborchellina* sp., *Stigmatocythere indica and Tanella gracilis)*. In the analyzed core, there is no faunal assemblage at the depth between 80-85 and 95-105 cm. The sediment characteristics such as calcium carbonate, organic matter and sand-silt-clay ratio also determined and correlated with the observed ostracod populations. Based on the detailed study, it is noticed that high calcium carbonate and low organic matter of the sediment are congenial for population abundance. From the overall distribution of Ostracoda in all the subsamples, siltysand is found to an accommodative substrate for the prosperity of Ostracoda. The statistical aspect of ostracod carapace-valve ratio has been studied to identify the rate of sedimentation which infers a faster rate of deposition of sediments in the Gadilam River estuary.

KEYWORDS: Ostracoda; Gadilam river estuary; Tamil Nadu; Environmental implications; Micropalaeontology

INTRODUCTION

Ostracoda (microscopic, aquatic Crustacea) from brackish waters provides a great potential for ecological monitoring and palaeoenvironmental analyses in different environments. This has been studied and stated in many articles during recent decades but their potential has yet to be fully developed or utilized in various studies. The analysis of ostracod species distributions, eco-phenotypic variability and stable isotopes and trace elements in ostracod shells provide valuable information about water salinity, temperature and chemistry, hydrodynamic conditions, substrate characteristics, climate, sea level variations, oxygen and nutrients availability (García-Madrigal et al., 2022). Ostracods are typically around 1 mm in size, but varying between 0.2 and 30 mm, laterally compressed and protected by a bivalve-like, chitinous or calcareous shell carapace (Barik et al., 2022). Ostracods are living in various aquatic environments, including fresh, brackish and marine waters. In the oceans, they inhabit both the sea floor and the planktonic zones. Ecologically ostracods can be part of the zooplankton, or (most commonly) they are part of the benthos, living on or inside the upper layer of the sea floor (Matzke-Karasz and Smith, 2022). Ostracods can live in an environment in with the controlling factors are temperature, bottom topography, depth, salinity, dissolved oxygen, substrate, food supply and sediment organic matter (Puri, 1966). However, the main controlling factors governing ostracod distribution in estuarine environments and continental shelf zones are salinity, water temperature and substrate (Yassini and Jones, 1995). While some ostracod species are sensitive to small changes in their environment, others are capable of withstanding a wide range of conditions, even to the extent of inhabiting heavily polluted areas. The effects of sewage pollution and oil spill on coastal ostracod fauna has been investigated by Eagar (1999, 2000) and Mostafawi (2001) from New Zealand and Pacific Atoll, Persian Gulf (Pacific atoll), respectively. These studies show that although increasing level of pollution result in reduced ostracod abundance and diversity, some species are capable of withstanding quiet high levels of contaminations. Ostracods are particularly useful for the biozonation of marine strata on local or regional scales, and they are invaluable indicators of ancient shorelines, salinities and relative sea-floor morphology. Marginal marine environments like marshy rivers, coastal lagoons, deltas, estuaries, mangrove islands, salt marshes and fluvial marine assemblages are characterized by several species, which are peculiar to these environments. Marginal – marine environmental conditions challenging physiological problems for most organisms, including ostracods, since they may have to survive in marked environmental changes over very short periods. In general, the Ostracods diversity is often low in these habitats, although abundance may be remarkably high, usually two or three species dominating. Ostracods is one of the microfaunal groups with increasing usage as biomonitors of stressed conditions in recent and Quaternary environments (Malard et al., 1996; Mosslacher, 2000; Anadon et al., 2002; Boomer and Eisenhauer, 2002). Coastal zones are very sensitive to environmental changes (Ayala-Pérez et al., 2021). Though India has a longest coastline of about 7,500 km and various marginal marine water bodies, the study on recent brackish water ostracoda and their environmental implications have received notable attention. Hence, the present study has been initiated with great concern to describe the distribution of ostracods in the Gadilam River Estuary.

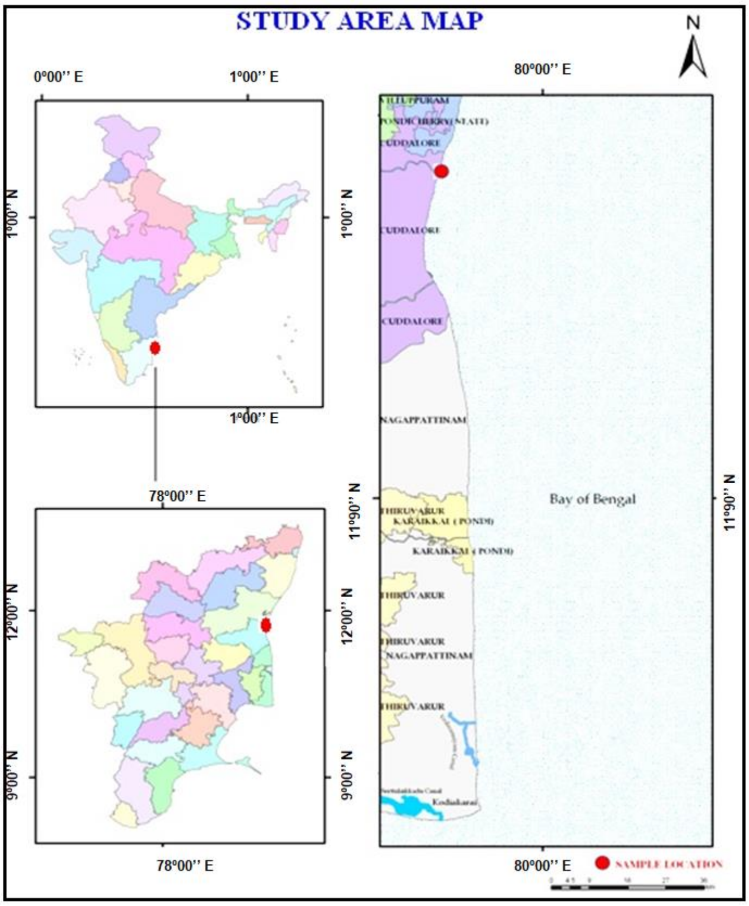

Figure 1. Location map of the study area Gadilam River Estuary

STUDY AREA

The study area is characterized by gently undulating topography with low relief sandstone and laterite hills. A mangrove forest is present near the mouth of the Gadilam river at Devanampattinam, Cuddalore. Gadilam river enters the sedimentary part of the basin from the Archaean- sedimentary contact at Thirunavallur in Ulundurpet Taluk and traverses via Thiruvamur, where Malattar confluence's the main Gadilam before confluence with Bay of Bengal. Uppanar, a backwater stream joining Gadilam, east of Devanampattinam, near Cuddalore. The southern part of the study area is drained by Manimutharu and Main Vellar river. The study area is also covered by Quaternary rocks. Central part of the study area was found to have river alluvium derived from Tertiary rocks, which comprises of lignite deposit and coastal alluvium adjacent to the coast. As it is the sedimentary basin, hydraulic boundary was extended up to the two river boundaries in the south. The study area comprises of two major hydrogeologic environments: (a) Recent alluvium and (b) sandstones in the lateritic terrain.

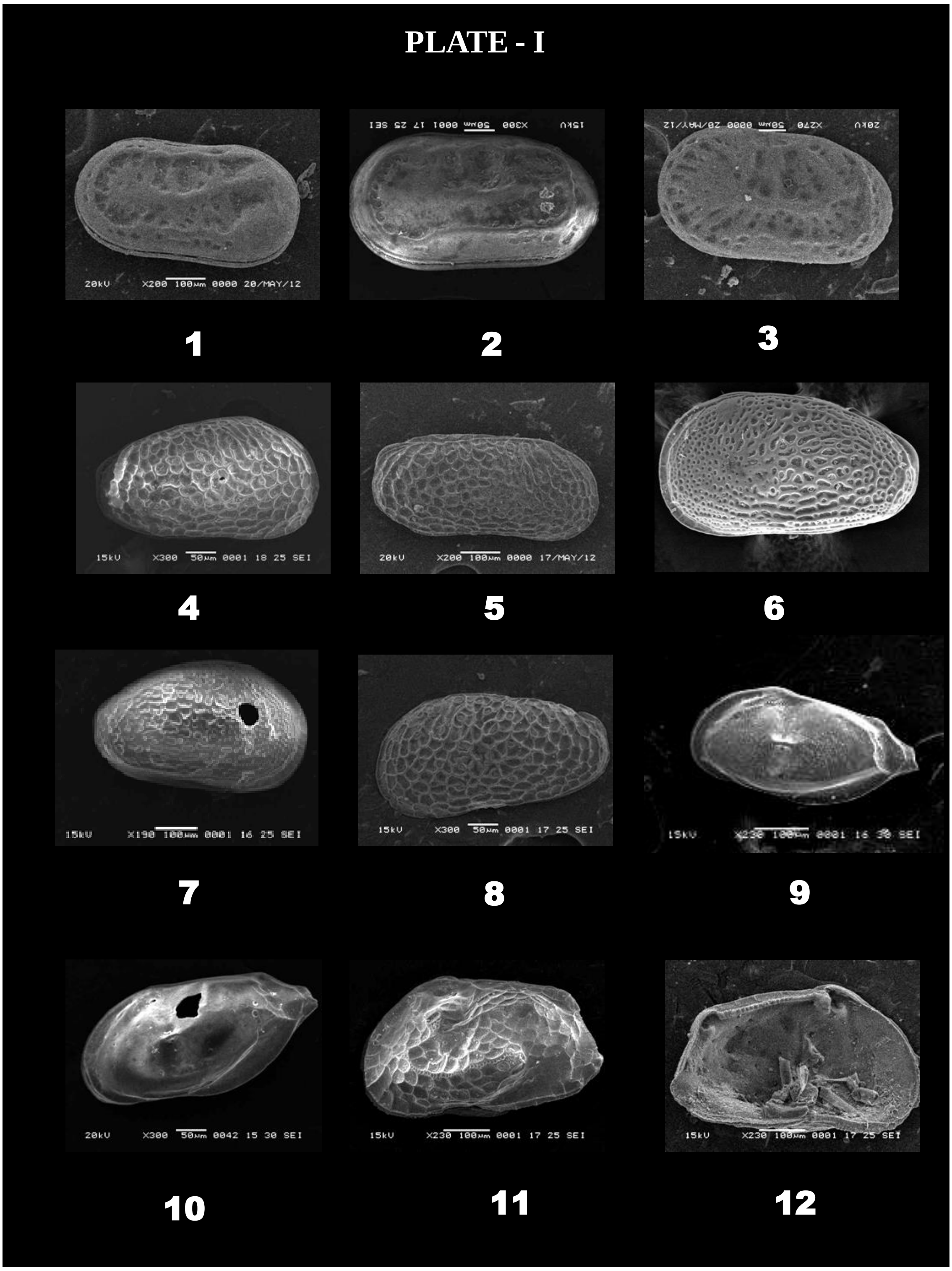

PLATE - I

(Bar scale equals 100 µm unless specified)

Fig. 1. *Cytherelloidea leroyi* Carapace, left valve external view, **Fig. 2.** *Cytherelloidea* sp1 Carapace, right valve external view, **Fig. 3**. *Cytherelloidea* sp2 Carapace, right valve external view, **Fig. 4.** *Hemicytheridea bhatiai* x 150 Carapace, right valve external view, **Fig. 5.** *Hemicytheridea khoslai* Carapace, right valve external view, Figs. 6-7 *Hemicytheridea paiki* **Fig.6**- Carapace, left valve external view, **Fig.7**- Carapace, right valve external view (single predation), **Fig. 8**. *Hemicytheridea reticulate* Carapace, left valve external view, Figs. 9-10. *Neomonoceratina jaini* **Fig. 9**- Carapace, left valve external view, **Fig.10**- Carapace, left valve external view (predated), Figs. 11-12. *Jankeijcythere mckenziei* **Fig.11** - Carapace, left valve external view, Fig.12 - Left valve internal view

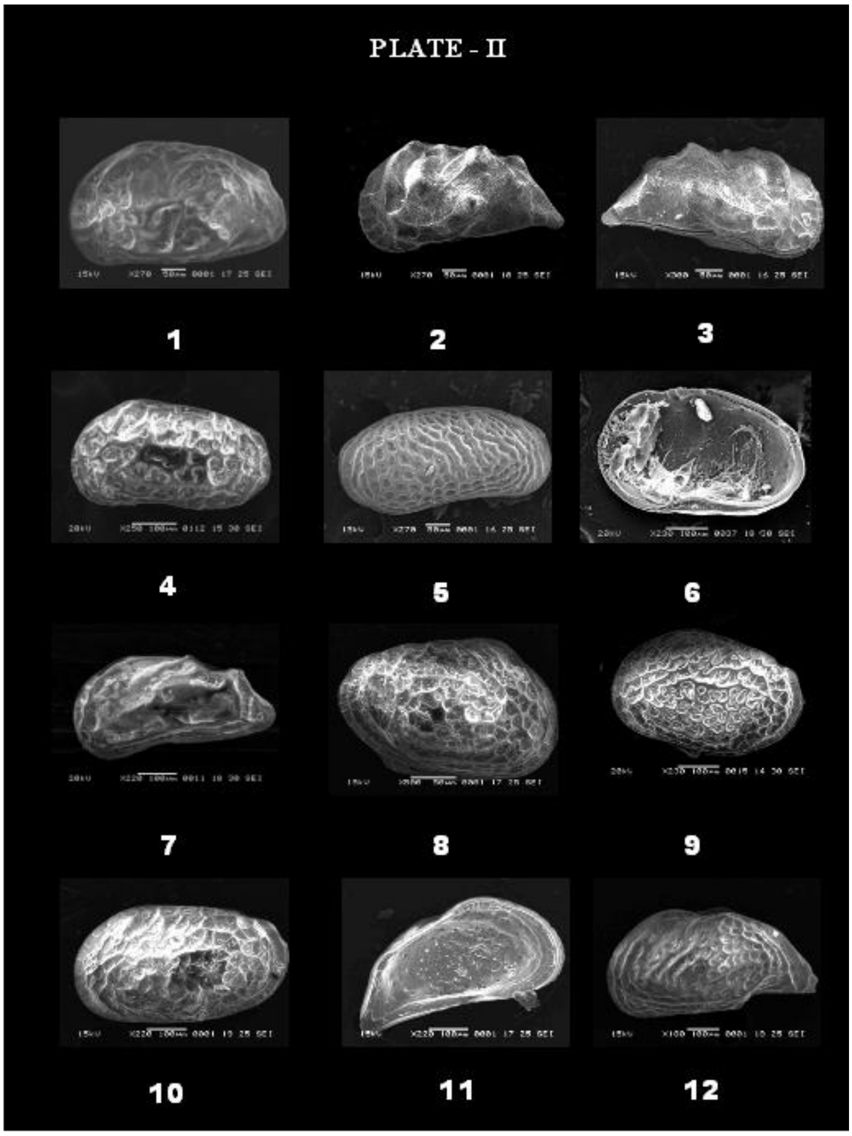

PLATE - II

(Bar scale equals 100 µm unless specified)

Fig. 1. *Jankeijcythere* sp. Carapace, left valve external view, Figs. 2-3. *Neosinocythere dekrooni* **Fig.2**- Carapace, left valve external view **Fig.3**- Carapace, right valve external view, **Fig. 4.** *Callistocythere flavidofusca intricatoides* Carapace, left valve external view, **Fig. 5**.*Tanella gracilis* Carapace, right valve external view **Fig. 6**. *Hemikrithe peterseni* Right valve internal view, **Fig. 7**.*Caudites javana* Carapace, left valve external view, **Fig. 8**. *Loxoconcha cercinata* Carapace, right valve external view, **Fig. 9**. *Loxoconcha megapora indica* Carapace, left valve external view, **Fig. 10**. *Loxoconcha tekkaliensis* Carapace, left valve external view, **Fig. 11**. *Paijenborchellina prona* Left valve internal view, **Fig. 12** *Paijenborchellina* sp. Carapace, left valve external view

MATERIALS AND METHODS

In order to fulfill the objective of this paper and to study the different microenvironmental implications of benthic brackish water ostracoda, a fieldwork was carried out and a sediment core sample was collected from the Gadilam river estuary, Cuddalore (Fig. 1). The length of the core was 105 cm. The core sample is sub-sampled at each 5 cm interval, for regular standard analysis. Thus, a total of 21 samples were obtained. The geographical co-ordinates of latitude 11° 24' 18" N and longitude 79° 46' 46" E were recorded using GPS. A mangrove species *Avicennia marina* is dominated in the estuary area. The other notable mangrove species noticed in the study area are *Acanthus ilicifolius, Egiceras corniculatum, Excoecaria agallocha* and *Rhizopora mucronata*. The sedimentological parameters such as $CaCO_3$, organic matter and sand-silt-clay ratio have been established by the standard procedures. The $CaCO_3$ content in sediments has been determined using rapid titration method (Piper, 1947). Organic matter content is determined by the procedure suggested by Gaudette et al. (1974). Fine fractions (sand, silt and clay) in the samples were analysed by the pipette method in accordance with the standard procedure adopted by Krumbein and Pettijohn (1938). The sediment type was classified by Trefethen’s (1950) classification.

SYSTEMATIC PALEONTOLOGY

The classification of ostracods proposed by Hartmann and Puri (1974) has been followed in the present study. In total, 27 ostracod taxa belonging to 16 genera, 12 families, 3 superfamilies and 2 suborders of the order Podocopida have been identified from the Gadilam river estuary sediments, Tamil Nadu, southeast coast of India. A checklist of the ostracod fauna identified in the Gadilam river

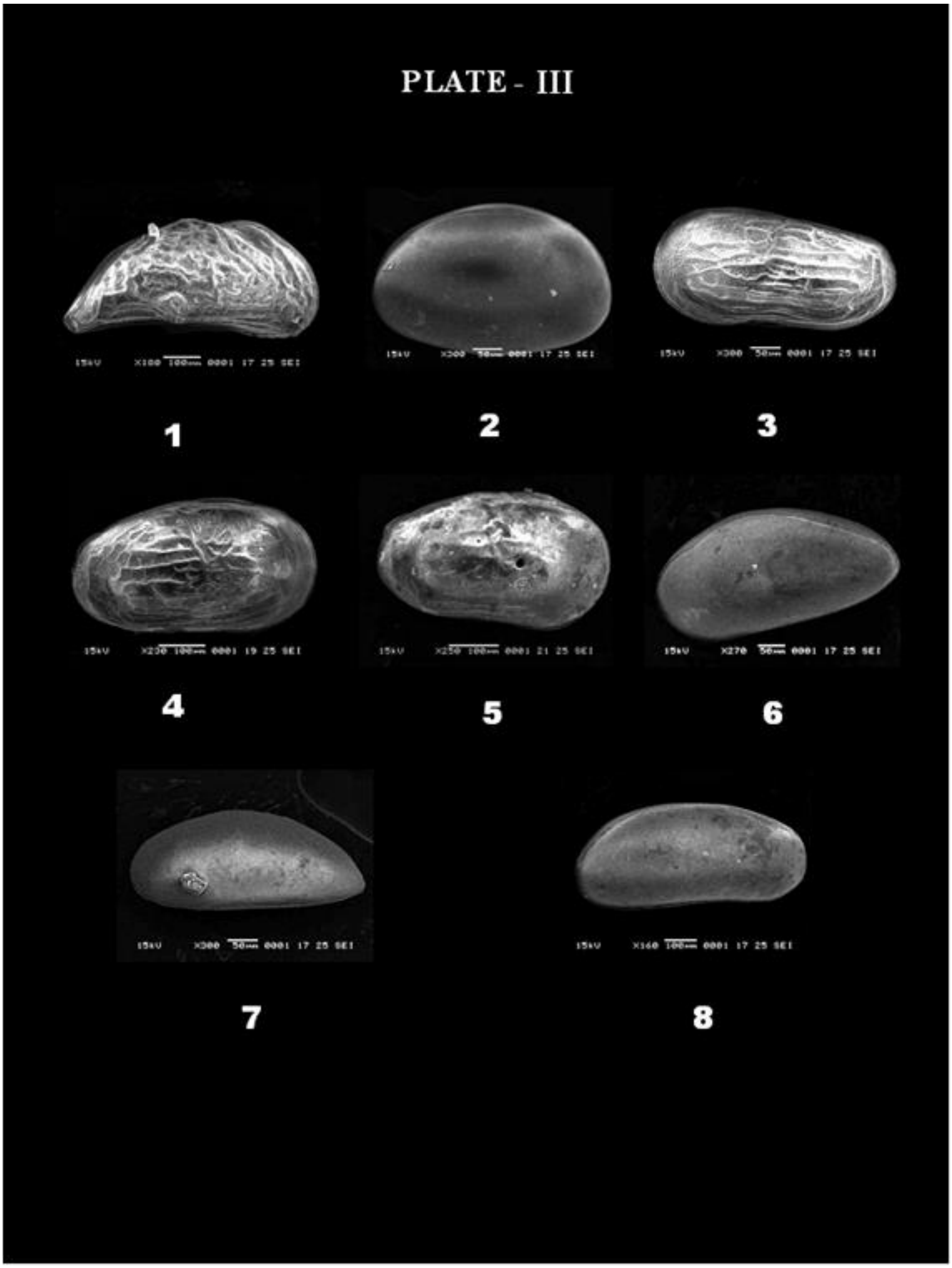

PLATE - III

(Bar scale equals 100 µm unless specified)

Fig. 1. *Paijenborchellina* sp. cf. *P. indoarabica* Carapace, right valve external view, **Fig. 2**. *Xestoleberis variegate* Carapace, left valve external viewFig. 3-4. *Kalingella mckenziei*, **Fig. 3**- Carapace, male left valve external view, **Fig. 4**- Carapace, female right valve external view, **Fig. 5.** *Kalingella* sp. Carapace, right valve external view (Predated), **Fig. 6.** *Propontocypris* (*Schedopontocypris*) *bengalensis* Carapace, left valve external view, **Fig. 7**. *Paracypris* sp. Carapace, left valve external view, **Fig. 8**. *Phlyctenophora orientalis* Carapace, Right valve external view

Table 1. Distribution of $CaCO_3$ OM, sand, silt, and clay with type of sediments and ostracod populations in Gadilam River Estuary, Cuddalore, Tamil Nadu

Samp. No	Depth in cm	$CaCO_3$ %	OM %	Sand %	Silt %	Clay %	Sediment type	Ostracod Population
1	0-5	5.0	2.30	56.04	29.46	14.50	Siltysand	80
2	5-10	5.5	1.32	62.03	25.47	12.50	Siltysand	77
3	10-15	4.5	2.09	61.59	23.91	14.50	Siltysand	66
4	15-20	5.5	1.73	52.19	45.31	2.50	Siltysand	72
5	20 -25	4.5	1.40	57.43	34.57	8.00	Siltysand	66
6	25-30	1.0	1.03	72.72	21.78	5.50	Siltysand	49
7	30-35	1.0	1.80	61.19	37.81	1.00	Siltysand	39
8	35-40	2.0	1.41	56.12	43.38	0.50	Siltysand	36
9	40-45	0.5	1.31	67.79	26.71	5.50	Siltysand	15
10	45-50	1.5	1.65	68.69	30.31	1.00	Siltysand	66
11	50-55	1.0	1.76	59.25	39.75	1.00	Siltysand	45
12	55-60	2.0	1.17	61.88	28.12	10.00	Siltysand	47
13	60-65	1.0	2.10	55.91	32.59	11.50	Siltysand	41
14	65-70	2.0	2.28	72.10	15.90	12.00	Siltysand	25
15	70-75	3.0	1.43	56.33	33.17	10.50	Siltysand	40
16	75-80	2.5	1.80	69.85	19.65	10.50	Siltysand	22
17	80-85	3.5	1.01	65.40	21.60	13.00	Siltysand	73
18	85-90	1.5	1.22	63.15	26.85	10.00	Siltysand	0
19	90-95	3.0	2.10	68.77	19.73	11.50	Siltysand	38
20	95-100	1.5	1.50	63.15	35.35	1.50	Siltysand	0
21	100-105	2.0	1.98	76.02	22.98	1.00	Siltysand	0
Average		2.6	1.64	63.22	29.26	7.52		897
Maximum		5.5	2.30	76.02	45.31	14.50		
Minimum		0.5	1.01	52.19	15.90	0.50		

estuary is given below and the SEM microphotographs depicting different views are presented in Plates I – III. Among these, 3 species belong to the suborder Platycopa and the remaining to suborder Podocopa. The following species, namely *Basslerites liebaui*, *Jankeijcythere mckenziei, Kalingella mckenziei*, *Neomonoceratina jaini* and *Propontocypris (Schedopontocypris) bengalensis* are endemic to Indian waters only.

Checklist of the ostracod fauna encountered in the Gadilam river estuary.

1. *Cytherelloidea leroyi*
2. *Cytherelloidea sp.1*
3. *Cytherelloidea sp.2*
4. *Hemicytheridea bhatiai*
5. *H. paiki*
6. *Hemicytheridea khoslai*
7. *H. reticulata*
8. *Neomonoceratina jaini*
9. *Jankeijcythere mckenziei*
10. *Jankeijcythere sp.*
11. *Neosinocythere dekrooni*
12. *Callistocythere flavidofusca intricatoides*
13. *Tanella gracilis*
14. *Hemikrithe peterseni*
15. *Caudites javana*
16. *Loxoconcha cercinata*
17. *L. megapora indica*
18. *L. tekkaliensis*
19. *Paijanborchellina prona*
20. *P. indoarabica*
21. *Paijanborchellina sp.*
22. *Xestoleberis variegata*
23. *Kalingella mckenziei*
24. *Kalingella sp.*
25. *Paracypris sp.*
26. *P.Schedopontocypris) bengalensis*
27. *Phyctenophora orientalis*

OSTRACOD DISTRIBUTION AND POPULATION

In the Gadilam river estuary sediment core, 27 taxa have been recognized from 897 specimens of ostracods, picked from 21 subsamples and are studied in detail. Among them, species belongs to Cytheracea are represented by 95% of the population. The minimum ostracods population size is 15 nos. in the interval of 40-45 cm and maximum population size of 80 specimens are noted at the surface, 0-5 cm interval. In the sediment core, ostracod population is abundant in the middle and top portions, while it is less abundant in the bottom section. No ostracod species are recorded between 85 - 90 cm and 95 - 105 cm intervals.

SEDIMENT CHARACTERISTICS

CALCIUM CARBONATE ($CaCO_3$)

The source of carbonate content in sediments is due to the abundance broken shell fragments of molluscs and also due to the dilution of biogenic calcite (Ramos-Vázquez and Armstrong-Altrin, 2021). Similar observation was documented by Sebastian et al. (1990) in the Mahe estuary sediments, West Coast of India. The association of $CaCO_3$ with sand fractions is indicating its association with sand fraction. Similarly, Hussain et al. (1997) also observed a relationship between $CaCO_3$ and sand fractions in the Gulf of Mannar sediments, off Tuticorin.

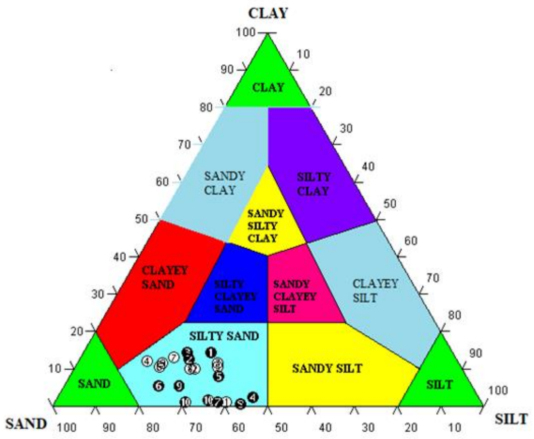

Figure 2. Sand, silt and clay ratio plot for the Gadilam River estuary sediments (after Trefethen, 1950)

The calcium carbonate percentage in the sediment cores ranges from 0.5 to 5.5 % (Table 1), which is higher particularly in the top portion of the core between 0 and 25 cm. The $CaCO_3$ content in the remaining subsamples is showing less percentage compared to top portion of the core. Hence, it is inferred that the calcium carbonate content of the sediment is one of the important parameters, which governs the population of Ostracoda, especially its vertical distribution. Similarly, the calcium carbonate content is directly proportional to the population size of the Ostracoda.

ORGANIC MATTER

Subba Rao (1960) observed that the silty clay materials of the Pennar, Krishna and Godavari rivers, are poor in organic matter. In the Suddagedda river estuary, sandy sediments have been found to be poor in organic matter content, while fine-grained materials are rich in organic matter (Venkata Rao and Subba Rao, 1974; Armstrong-Altrin et al., 2015). These authors further documented that the sandy types are poor in organic matter, while materials containing higher amount of clay are rich in organic matter. According to Joy and Clark (1977), organic carbon being directly related to food supply, is one of the major environmental parameters, which influence the distribution of benthic ostracods. Whatley and Quanhong (1987, 1988) considered the nature of substrate to be the main controlling factor for the abundance of ostracod; highest values occur in association with medium to coarse-grained sand rich in organic debris, and lower values with gravels and sands poor in carbonate. From off Tuticorin, Gulf of Mannar, Hussain et al. (1997) observed that a relative decrease in the organic matter content of the sediments favours a maximum population of Ostracoda.

In the present study, organic matter content was determined for all the 21 sub-samples of core sediments. The analytical concentration of organic matter varies from 1.01 to 2.30 %, in which the lower value is noticed at 80-85 cm interval and moderately high value (2.30 %) is noticed from 0 to 5 cm interval (Table 1). The concentration of organic matter is relatively high in the bottom and top portions of the core. Overall, the organic matter content in all the subsamples exhibits lower values. The impact of this parameter on the distribution of ostracod fauna in all the intervals appears insignificant level.

SUBSTRATE AND OSTRACODES

Annapurna and Rama Sarma (1982) documented that ostracods prefer areas high in sand and clay rather than areas rich in silt, in the Bimili back waters and the Balacheruvu tidal stream. Such a relationship has also been observed in the marine marginal water bodies of many other localities (Alvarez Zarikian et al., 2022).

The substrate sediment texture has a control on the ostracod fauna that can colonize a particular sediment type (Brasier, 1980). The texture stability of the sediment composing the substrate exerts a strong influence on marine ostracods, just as it does on brackish water and fresh water forms. Smooth shelled forms are predominant in fine-grained muds whereas, more ornamented forms are being found in coarse-grained, or in more calcareous sediments (Brasier, 1980).

In the Bimili backwaters and Balacheruvu tidal stream, Annapurna and Rama Sarma (1982) have noted that the genus *Phlyctenophora* occurs in forms such as *Tanella, Loxoconcha*, *Pajenborchellina* and *Kalingella* occur in considerable numbers in the sandy areas. Al-Abdul Razzaq *et al.* (1983) stated that ostracoda occur more in fine-grained sediments due to the greater quantities of organic material in those fractions which provide nutritive material. Hussain (1992), noticed in the Gulf of Mannar, off Tuticorin, that silty sand has been found to be the favourable substrate for the ostracod population abundance.

All the subsamples collected in the study area were analyzed for sand, silt and clay ratio. The sand content in the core sample varies from 52.19 to 76.02 % with an average of 63.22 %; silt percentage is recorded in ranging from 15.90 to 45.31 % at an average of 29.26 %. Clay content has an average of 7.52 % and ranges from 0.50 to 14.50 % (Table 1). The relative abundance of sand-silt-clay ratio of core sample were plotted on a trilinear diagram (Trefethen, 1950) and its sediment type in the core is composed by only silty sand (Fig. 2).

SURFACE ORNAMENTATION AND SEDIMENT TEXTURE

The carapace of few ostracods has smooth surface, and devoid of any sculpture. However, in many species, the carapaces are with simple to complex surface ornamentation. Hence, surface ornamentation serves as direct evidence for ecological interpretations.

Although there are research papers on taxonomy, systematic studies on internal character such as the normal pore system, muscle scar pattern and ocular sinuses of these micro crustaceans, papers pertaining to surface ornamentation of Ostracoda are relatively rare (Jones, 1956; Benson, 1961; Hulings and Puri, 1964; Puri, 1966; Krutak, 1972; Brasier, 1980; Annapurna and Rama Sarma, 1982; Vaidya et al., 1995; Sridhar et al., 1998 and Hussain et al., 2002). Hence, an attempt has been made to study briefly on the relationship between the sculpture in Ostracoda and grain size of the substrate based on direct observations by a Scanning Electron Microscope (SEM).

The substrate sediment texture has a control on the kind of ostracod fauna that can colonise a particular sediment type (Brasier, 1980). The texture stability of sediment comprising the substrate exerts a strong influence on marine ostracods. Smooth forms are predominant in fine-grained muds, whereas more ornamented forms are being found in coarser or in more calcareous sediment (Brasier, 1980).

In the present study, 4 types of ornate forms of Ostracoda (including smooth ones) have been noticed (Plates I – III). They are categorized as follows: **Smooth and fragile forms:** *Paracypris* sp., *Phlyctenophora orientalis*, *P*. (*Schedopontocypris*) *bengalensis* and *Xestoleberis variegata;* **Moderately calcified and pitted forms:** *Hemicytheridea bhatiai*, *H. khoslai*, *H. paiki*, *Neomonoceratina jaini*, *Neosinicythere dekrooni*, *Kalingella mckenziei*, *Kalingella* sp., *Paijenborchellina indoarabica*, and *Paijenborchellina* sp., **Fine to moderately reticulate and ridged forms:** *Cytherelloidea leroyi*, *Cytherelloidea* sp1., *Cytherelloidea* sp2., *Caudites javana*, *Hemicytheridea reticulata*, *Hemikrithe peterseni*, *Jankeijcythere mckenziei*, *Jankeijcythere* sp., *Loxoconcha cercinata*, *L. megapora indica*, *L. tekkaliensis* and *Tanella gracilis* and **Conspicuously ornate forms (typical box type, spinose and nodose etc.):** *Callistocythere flavidofusca intricatoides* and *Paijenborchellina prona*.

The surface sculptures of ostracod carapaces have direct relationship with the substrate type. Puri (1966) and Malz and Lord (1976) are of the opinion that more ornate and rather heavily calcified forms are present commonly in shallow water high-energy environments and inhabit sandy substrates in modern seas. In the Bimili backwaters and Balacheruvu tidal stream, Annapurna and Rama Sarma (1982) noticed that the genus *Phlyctenophora* occurs in sand dominated areas and not in muddy areas. They further noticed that the moderately ornamented forms like *Tanella*, *Loxoconcha*, *Paijenborchellina* and *Kalingella* occur in considerable numbers in sandy areas. Vaidya et al. (1995) observed good faunal content in the substrates consisting of medium to fine-grained sand, whereas poor occurrence was noticed in the clean, coarse-grained sand. Sridhar et al. (1998) found a greater number of species in siltysand and sandy substrates and less in fine-grained materials.

OSTRACOD CARAPACE –VALVE RATIO

The application of statistical data on Ostracoda, such as juveniles and adults, closed and isolated valves, males and females, right and left valves, and smooth and ornamented forms, etc. Besides colour variation, pyritization and predation to interpret the environment of deposition, rate of deposition and to assess the potentiality of sediments as source rocks for hydrocarbons has attained importance, during the last five decades.

Honnappa and Venkatachalapathy (1978) studied the carapace-valve ratio to interpret the rate of deposition of sediments in the Mangalore Harbour area, southwest coast of India. They found that the occurrence of open valves is much more in number than the closed one (ratio being 24:1). According to them, this is an indicative of a slow rate of sedimentation in more agitating waters. While comparing Eocene/Oligocene ostracods from southeastern Australia and India for petroleum potential indicators, McKenzie and Guha (1987) inferred a rapid rate of sedimentation through the presence of high percentage of carapaces. Sreenivas et al. (1991) found rapid rate of sedimentation in

Table 2. Distribution of Ostracod Carapaces and open valves in core sediments recovered from the Gadilam river estuary

S.No	Species Name	Carapace	Valve	Total
1	*Cytherlloidea leroyi*	8	1	9
2	*Cytherlloidea sp.1*	3	0	3
3	*Cytherlloidea sp.2*	1	0	1
4	*Hemicytheridea bhatiai*	98	2	100
5	*Hemicytheridea paiki*	35	3	38
6	*Hemicytheridea khoslai*	15	0	15
7	*Hemicytheridea reticulata*	106	4	110
8	*Neomonoceratina jaini*	3	0	3
9	*Jankeijcythere mckenziei*	144	5	149
10	*Jankeijcythere sp.*	9	1	10
11	*Neosinocythere dekrooni*	45	4	49
12	*Callistocythere flavidofusca intricatoides*	3	0	3
13	*Tanella gracilis*	85	7	92
14	*Hemikrithe peterseni*	6	1	7
15	*Caudites javana*	3	0	3
16	*Loxoconcha cercinata*	4	0	4
17	*L.megapora indica*	41	4	45
18	*L.tekkaliensis*	7	0	7
19	*Paijanborchellina prona*	10	1	11
20	*P.indoarabica*	4	0	4
21	*Paijanborchellina sp.*	2	0	2
22	*Xestoleberis variegata*	2	0	2
23	*Kalingella mckenziei*	190	8	198
24	*Kalingella sp.*	8	0	8
25	*Macrocyprina decora*	7	0	7
26	*Propontocypris (Schedopontocypris) bengalensis*	6	0	6
27	*Phyctenophora orientalis*	10	1	11
Total		**855**	**42**	**897**

Pulicat lake estuary on the basis of occurrence of a greater number of closed carapaces. Sridhar (1996) from the Palk Bay, off Rameswaram identified the carapace to valve ratio to 5:1 indicative of the fairly faster rate of sedimentation.

Hussain and Rajehswara Rao (1996) observed a greater number of carapaces than open valves along inner shelf sediments, the east coast of India. While the number is much less from the sediments from off the west coast of India. From this observation, they inferred that the rate of sedimentation is rapid on the east coast, whereas it is slow on the west coast of India, which is attributed to a greater number of streams/rivers flowing and debouching the sediments into the Bay of Bengal. Hussain et al. (2002) studied carapace and valve ratio and observed faster rate of sedimentation in the inner shelf of Gulf of Mannar, off Tuticorin, southeast coast of India. They counted four – fold occurrence of carapaces to open valves, which was attributed to the inflow of sediments through Tamirabarani River. Faster rate of deposition of the sediments favours conversion of organic matter into hydrocarbons, in reduced aquatic conditions, under optimum temperature and pressure. Ganesan and Hussain (2010) observed a faster rate of sedimentation in Tamiraparni Estuary, Punnaikayal, near Tuticorin, Tamil Nadu. Scott (2009) has inferred comparatively a faster rate of deposition of sediments in the Ennore creek, near Chennai. Kalaiyarasi (2010) has also noticed a very high rate of sedimentation in the Mullipallam creek, near Muthupet through the carapace and valve ratio of Ostracoda.

In the present work, the ratio between the carapaces and open valves has been taken into consideration for the determination of the rate of sedimentation in the study areas. The distribution of the carapaces and open valves found down core in the study area is given in Table 2. From a total of 21 sub-samples of this core, as many as 897 ostracod shells were recovered including 855 specimens are carapaces and remaining 42 specimens are open valves.

DISCUSSIONS

Of the 27 species encountered in the study area, only 4 are smooth forms while the remaining are either moderately calcified, moderately reticulate and ridged, pitted or highly ornate forms. The Gadilam river estuary is considered to be shallow and the substrate is mainly silty-sand in nature. Certain forms are slightly calcified, whereas most of the other forms are ornamented with strong reticulations, sinuosity and tubercles. These forms are *Callistocythere flavidofusca intricatoides*, *Paijenborchellina prona*, *Cytherelloidea leroyi*, *Cytherelloidea* sp1., *Cytherelloidea* sp2., *Caudites javana*, *Hemicytheridea reticulata*, *Hemikrithe peterseni*, *Jankeijcythere mckenziei*, *Jankeijcythere sp.*, *Loxoconcha cercinata*, *L. megapora indica*, *L. tekkaliensis* and *Tanella gracilis*. The silty-sand substrate carrying some organic debris yielded a good number of Ostracoda. These sediments also contain numerous other micro-organisms such as foraminifera and micro gastropods. The present material incorporates numerous carapaces and few open valves, but there are fewer dimorphic forms and juveniles. The number of carapaces, valves and sex ratio reflect ambient energy conditions.

Most of these species are indicative of typical marginal marine brackish water taxa. They frequently occur in the mangrove habitats. Their distributions in the core samples deduce a medium to low energy environmental conditions of deposition of sediments. It also reflects in the type of sediments deposited. The occurrence of taxa such as *Cytherelloidea leroyi*, *Paijenborchellina prona*, *Phlyctenophora orientalis*, *P. (Schedopontocypris) bengalensis* and *Xestoleberis variegata* represents shallow marine to neritic habitat forms (Zhao and Whatley, 1988; 1989a). Their distribution in the core may be attributed to the tidal fluctuations and deposition of the sediments due to the shallow water currents. However, the persistent occurrence of *T. gracilis* in the core indicates that this species is considered as cosmopolitan in nature (White, 1993; Ganesan and Hussain, 2010). The spatial distribution of ostracods is largely in influenced by the nature of substrate besides other environmental factors. Hence it is inferred from the microfaunal assessment of the shelf region off Chennai–Cuddalore that this area experiences well-oxygenated, alkaline, high-moderate energy conditions within a tropical environmental setting (Tabita Symphonia and Senthil Nathan, 2021). The statistical analysis is the easiest method available to understand the ostracod species diversity in an area (Hammer et al., 2001; Rajkumar et al., 2020).

CONCLUSIONS

Among 27 ostracod species identified in mangrove areas of Gadilam river estuary, the sediment ecological discussion for the following nine species namely, *H. paiki, H. reticulata, Jankeijcythere mckenziei, Kalingella mckenziei, Loxoconcha megapora indica, L. tekkaliensis, Neosinocythere dekrooni* and *Tanella gracilis* is found that they are typical brackish water ostracod fauna occur in fine to medium-grained sediments (silty-sand substrate) and they are considered as a widespread and abundant persistent taxa in the mangrove environments. The interpretation on ornamentation of ostracod carapace reflects that the forms, which are smooth and finely pitted, prefer finer substrate, while the highly calcified and ornamented forms prefer coarse-grained sediments.

In the Gadilam river estuary, it is observed that the calcium carbonate content of the sediment is one of the important parameters, which governs the population of Ostracoda, especially its vertical distribution. The calcium carbonate content is generally found to be directly proportional to the population size. The organic matter content shows lower values in the entire core collected in the Gadilam river estuary. The impact of this parameter on the distribution of ostracod fauna down the core is insignificant level.

The high numbers of ostracod diversity values are noticed in middle portion of the core samples, it is also inferred that silty-sand is the favorable substrate for the thriving and abundance of the fauna. The relatively higher diversity index encountered in the samples is attributed to the nature of substrate, silty-sand. The domination of siltysand sediments in the entire core without any textural variations may be due to the presence of uniformly more or less medium energy environmental conditions of deposition of sediments in the mangrove area of core collection.

The distribution of carapaces and open valves, in Gadilam River estuary core sediments (considering all adults and juveniles together), reveals that the carapaces outnumbered open valves, which may be concluded that relatively a very faster rate of sedimentation prevails in the core sample as the carapace to valve ratio is 20:1. In the core sediments, almost all the carapaces are light yellow and white in colour, supporting the fact that the sediments were deposited under normal oxygenated environment.

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