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RESEARCH ARTICLE

Shell Chemistry of Cytherellidae, Bythocyprididae and Bairdiidae Family, Recent Benthic Ostracoda, Off Rameswaram, Tamil Nadu, Palk Bay, Southeast Coast of India

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Abstract

The area under investigation is off Rameswaram in eastern transect of the shallow inner shelf region. From the bottom sediment samples that were collected from October 2010 to September 2011, during four different seasons that exist in the study area, benthic Ostracoda from its different three family Cytherellidae, Bythocyprididae and Bairdiidae namely, *Cytherella dictyon, Cytherella semitalis, Cytherella* sp., *Cytherelloidea leroyi, Anchistrocheles* sp., *Bairdoppilata (B) alcyonicola* and *Paranesidea fracticorallicola* were identified and their shell chemistry were determined using SEM-EDAX. The following elements were found to be present in the above mentioned seven species in different percent: C, O, Na, Mg, Al, Si, Cl and Ca. The percentages of these elements in each species are discussed and their sources were arrived at.

Keywords: Shell chemistry, Benthic Ostracoda, Cytherellidae, Bythocyprididae, Bairdiidae, Rameswaram.

Introduction

Trace element geochemistry of Ostracod shells is a recently developed method, increasingly used to infer past environmental conditions in diverse water bodies (Holmes, 1996; Correge and De Deckker, 1997; Xia *et al*., 1997; Hu *et al*., 1998). Trace-element contents recorded in Ostracoda shells may be related to environmental changes that occur at a very short time scale seasonally. Thus, knowledge of the life history of the studied species is required to enhance the palaeoenvironmental interpretation of trace-element contents in Ostracoda shells (Xia *et al.,* 1997a). Past and current ecological conditions of aquatic habitats can be characterized by using Ostracoda as indicator (Delorme, 1969; Chivas *et al.,* 1983; Mezquita *et al.,* 2001). In the case of dead Ostracod valves deposited in areas of high sedimentation rate usually display fewer micro-boring holes and the degree of dissolution of the calcareous wall is less for Ostracod valves deposited in environments with low rate of sedimentation as reported by Danielopol *et al*. (2002). Yuhong (1990) discussed the result that reveals that the Ostracod shells contain 9 kinds of elements, Calcium (Ca), Aluminium (Al), Iron (Fe), Magnesium (Mg), Potassium (K), Chlorine (Cl), Sulphur (S), Sodium (Na) and Barium (Ba).

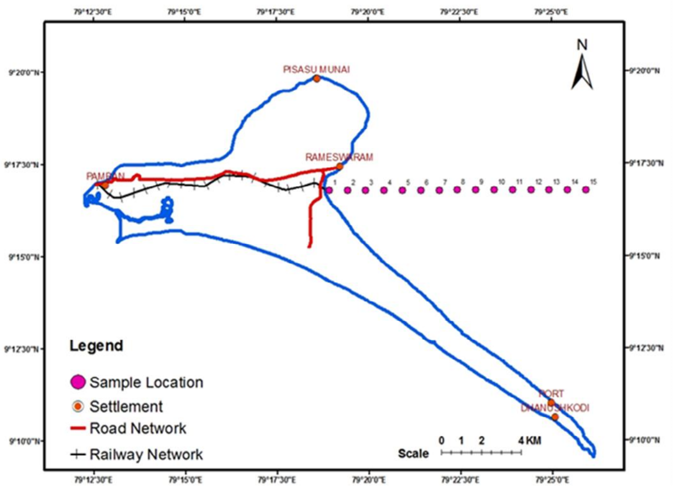
The Ostracod mineralized portion is carbonatic and mainly composed of low Mg calcite. In some cases, the presence of amorphous Calcium carbonate is reported (Xia *et al*., 1997). The calcitic Ostracod shell contains a number of elements of which Mg and Sr are generally the most abundant. The fact that the phase of mineralization is relatively quick and that Ostracods have a short life span, is of interest in that chemical elements entering the newly formed shell may record diagnostic features of the marine (or fresh-water) environment, such as pollution, at the time of secretion of the new shell. The trace-element chemistry of the shell provides a reliable indication of the composition of the host water at the time of shell secretion. The living Ostracods shell consists of about 80% to 90% or more of Calcium carbonate, various minor elements and from about 2% to about 15% of Chitin and Proteins (Sohn, 1958). Chivas *et al*. (1983, 1986a,b, 1993) conducted experiments with endemic Australian Ostracoda, (*Australocypris/Mytilocypris*) examining the relationship between Ostracod shell chemistry and water chemistry. Their results showed that Mg uptake by Ostracod is dependent on both water temperature and the Mg/Ca ratio of the host water; whereas, Sr uptake is only dependent on the Sr/Ca ratio of the water. Similarly, Engstrom and Nelson (1991) recognized a relationship between Ostracod's shell chemistry and the host water using a ubiquitous North American sp., *Candona rawsoni*. Their study indicates, however, that the Mg/Ca ratio in Ostracod has a direct function of salinity to Mg/Ca of the water. Rio *et al*. (1997) reported the anisotropic fixing of elements in the carapace before or during molting of *Leptocythere psammophila* and distribution of elements, namely, Si-Al-Fe-Ca-Mg-Na-Mn-Ba-Sr-P-S-Cl is controlled by metabolism and passive trapping in a marine environment of Baltic Sea, North Sea and English Sea.

The present study deals with Benthic Ostracoda, namely, *Cytherella dictyon, Cytherella semitalis, Cytherella* sp., *Cytherelloidea leroyi, Anchistrocheles* sp., *Bairdoppilata (B) alcyonicola* and *Paranesidea fracticorallicola* that were identified and their shell chemistry using SEM-EDAX.

Materials and methods

Study area: The area under present investigation is a tropical region situated off Rameswaram, in the Palk Bay, Southeast coast of India. The study area is represented in the Survey of India toposheet Nos. 57 O/7 and 57 O/8. It lies between coordinates: latitude 9°20' N and 9°24'40" N; longitude 79°20' E and 79°24'40" E, which is the eastern, transect off Rameswaram island. The region is a shallow inner shelf, with a topography having a gentle slope towards the sea. Plenty of coral reefs are seen. The location map of the study area is shown in Fig. 1. The climate has been divided into four different seasons, namely, Northeast monsoon (October-December), Winter (January-March), Summer (April-June) and Southwest monsoon (July-September).

Fig. 1. The location map of the study area.



Sample collection: The sample collections were done by adopting standard scientific methods established by Murray (2006). Bottom sediments and bottom water samples were collected at 15 locations as shown in Fig. 1. About 25 mL (dry weight) of samples were slowly passed through a 63 µm sieve, and the samples were stained rose Bengal in order to recognize the living individuals. Ostracods were hand-picked using a .00 soft-bristled brush under a stereo zoom binocular microscope (NOVEX-Holland) from a representative (25 mL) preserved sample. The use of total assemblage (live and dead specimens) was preferred as an indicator of average environmental conditions for documenting of the Ostracoda response to anthropogenic inputs (Armynot and Debenay, 2004).

Shell analysis by EDAX: The species selected for EDAX were dead species. As the species for the present study are from recent benthic Ostracoda, there is no coating over the shells. They rarely contain the external organic layer, which may alter the results of EDAX; therefore, most of the potential contamination comes from adhering particles. The adhering foreign particles can be composed of organic material and/or clay particles. However, in practice, for fossil populations without a chitin sheath, most authors (Barker *et al*., 2003; Jin *et al*., 2006; Keatings *et al*., 2006) found that the use of a chemical reagent to remove the organic fraction (sodium hypochlorite, hydrogen peroxide) alters either the isotopic or the elemental composition of carbonates and is therefore, not recommended. Consequently, foreign organic matter is removed only physically from the valve. Water parameters were analyzed in the Tamil Nadu Water Supply and Drainage (TWAD) Board's Hydrological Laboratory. Sediment samples have been digested for the present study following the procedure elaborated by Tessier *et al*. (1979). Trace element concentration were determined using Atomic Absorption Spectrophotometry (AAS–Perkin Elmer AA700 AAS equipped with a deuterium background corrector) involving direct aspiration of the aqueous solution into an air-acetylene flame.

Results and discussion

After the cleaning procedures, the hypo-types that were picked and identified species-wise were made use of their shell chemistry in EDAX and the results are shown in Table 1 and from Figs. 2 to 8. The instrument model number is S3000n whose brand name is Hitachi, attached with a Scanning Electron Microscope (SEM) instrument. Shell-chemistry offers a mean of testing Ostracod environmental interpretation and in many cases a means of refining those interpretations (Pugliese *et al*., 2006) since Ostracod shells commonly consist of ~90% $CaCO_3$ (Chivas *et al*., 1986a). Benthic Ostracoda from its family Cytherellidae, Bythocyprididae and Bairdiidae, namely, *Cytherella dictyon, Cytherella semitalis, Cytherella* sp., *Cytherelloidea leroyi, Anchistrocheles* sp., *Bairdoppilata (B) alcyonicola* and *Paranesidea fracticorallicola* that were identified in the study area and these seven species were taken into consideration for the present study. The following elements were determined: C, O, Na, Mg, Al, Si, Cl and Ca and the average concentration of elements/compounds that are found in water and sediments for four different seasons are shown in Table 2.

Shell chemistry

Carbon (C): The element C ranges from 12.28 to 31.97%, its lowest and highest were found in *Cytherella* sp. and *Bairdoppilata (B) alcyonicola*, respectively. The carbon content in Ostracoda valves, except some rare species are in equilibrium with the DIC (Dissolved Inorganic Carbon) of water (Decrouy *et al.,* 2011). Organic carbon or organic matter enters the marine environment from allochthonous (external) and autochthonous (internal) sources (Pearce, 1988). Hyland *et al*. (2005) attempted to provide a general framework for evaluating the risks of reduced benthic species richness from organic loading and associated stressors in sediments within different ranges of total organic carbon.

Table 1. Elemental composition of Cytherellidae, Bythocyprididae and Bairdiidae family.

Sl. No.	Species/Elements	C	O	Na	Mg	Al	Si	Cl	Ca
1	*Cytherella dictyon*	25.39	59.50	-	-	-	-	-	15.11
2	*Cytherella semitalis*	21.58	63.10	0.79	1.13	-	1.31	-	12.09
3	*Cytherella* sp.	12.28	57.29	-	1.86	-	-	-	28.57
4	*Cytherelloidea leroyi*	21.91	55.25	-	-	1.20	1.35	1.17	19.12
5	*Anchistrocheles* sp.	23.59	64.82	-	2.97	-	-	-	08.61
6	*Bairdoppilata (B) alcyonicola*	31.97	56.96	0.93	1.85	-	-	-	08.29
7	*Paranesidea fracticorallicola*	25.46	66.56	-	1.93	-	1.08	-	04.97
	Minimum	12.28	55.25	0.79	1.13	-	1.08	-	04.97
	Maximum	31.97	66.56	0.93	2.97	-	1.35	-	28.57
	Average	22.94	60.59	0.86	1.98	-	1.23	-	14.48

Fig. 2. *Cytherella dictyon.*

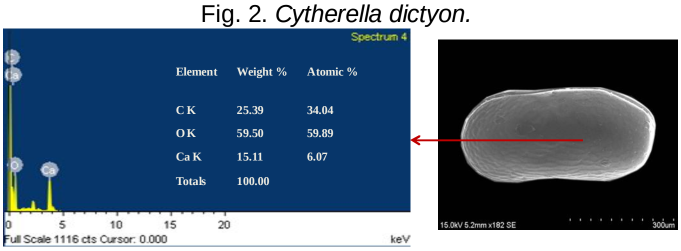


Fig. 3. *Cytherella semitalis.*

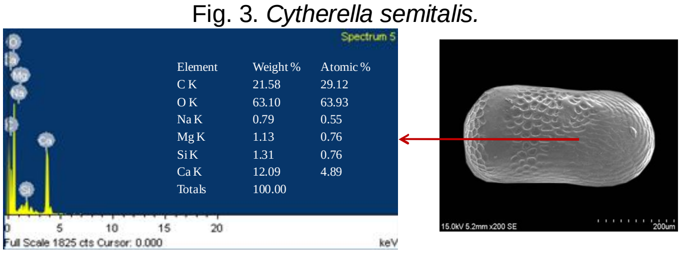


Fig. 4. *Cytherella* sp.

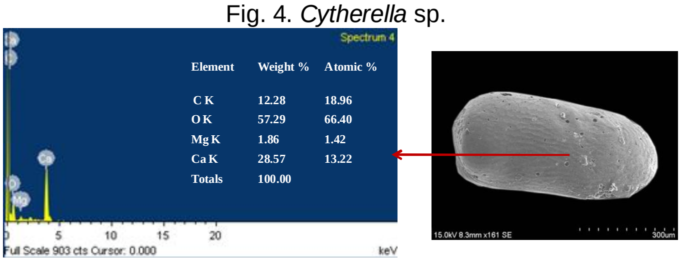


Fig. 5. *Cytherelloidea leroyi.*

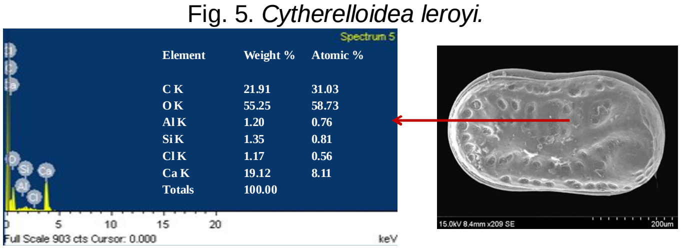


Fig. 6. *Anchistrocheles* sp.

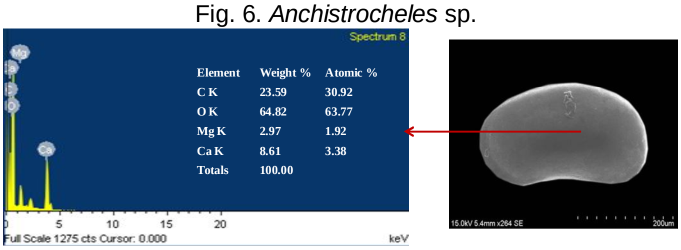


Fig. 7. *Bairdoppilata (B) alcyonicola.*

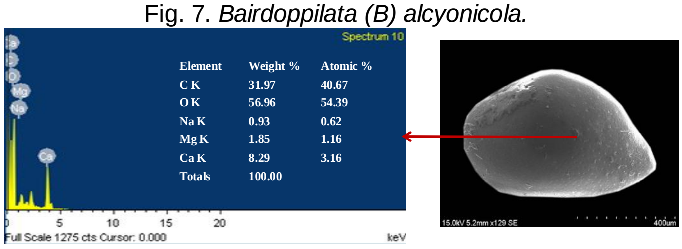
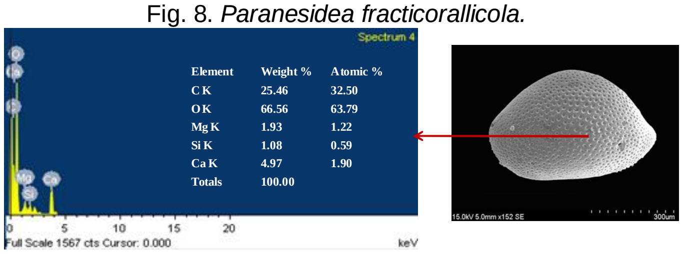


Fig. 8. *Paranesidea fracticorallicola.*



In the present investigation, the element C is being recorded in all the seven species and it might have come from both water and sediments.

Oxygen (O): O ranges from 55.25 to 66.56% and it is found in *Cytherelloidea leroyi* and *Paranesidea fracticorallicola* respectively. The present study shows that the element O is being recorded in all the seven species and it is inferred that the element might have come from both water and sediment. Oxygen being available readily as Dissolved Oxygen (DO) in water, it is attributed that the DO might have played a conspicuous role in the composition of shells.

Sodium (Na): Na ranges from 0.79 to 0.93% and it is found as lowest and highest in *Cytherella semitalis* and *Bairdoppilata (B) alcyonicola* respectively. Veizer *et al.* (1977) determined that in lower Paleozoic carbonate sequence of Arctic Canada a hyper-saline facies is recognizable by high soluble sodium concentrations in comparison with the open-marine facies which has lower values. Similarly, Land and Hoops (1973) attempted to establish an index for the salinity of diagnostic solution by studying bulk sodium in carbonates. The element Na is being recorded in two species and being inferred that it might have come from water.

Table 2. Average concentrations of elements/compounds during different seasons.

Elements in mg/L/Season	NE-Monsoon	Winter	Summer	SW-Monsoon	Average
			From water		
Ca	1720.00	1460.00	1400.00	1620.00	1550.00
Mg	860.00	578.00	564.00	816.00	704.50
Na	5950.00	5650.00	6750.00	7250.00	6400.00
K	1150.00	1000.00	950.00	750.00	962.50
Fe	0.59	0.19	0.06	0.06	0.22
NH_3	0.03	0.04	0.03	0.04	0.03
NO_2	0.01	0.01	0.01	0.01	0.01
NO_3	2.50	2.00	2.50	3.00	2.50
Cl_2	14704.00	13115.00	13613.00	15717.00	14287.30
F	0.54	0.62	0.47	0.12	0.43
SO_4	8261.50	1350.00	2300.00	1630.00	3385.50
PO_4	0.11	0.01	0.02	0.02	0.04
O	0.25	0.85	0.80	0.70	0.65
SiO_2	2.19	1.14	1.08	3.50	1.98
			From sediment		
Al	76380.20	75109.60	73102.70	74206.40	74699.70
$CaCO_3$ (%)	26.64	24.80	23.80	23.60	24.71
Org. mat. (%)	0.70	1.84	0.61	0.68	0.96

Magnesium (Mg): Mg ranges from 1.13 to 2.97%, its lowest and highest were found in *Cytherella semitalis* and *Anchistrocheles* sp. The Magnesium concentration has low for all the species, and some species Mg content is absent. Deckker *et al.* (1999) suggested that for *Cyprideis*, temperature dependency of magnesium uptake increases with increasing Mg/Ca. Mg/Ca ratios of other calcifying organism have also been shown to be sensitive to changes in temperature, these include Ostracoda also (Chivas *et al*., 1986a,b; Dwyer *et al*., 1996; Wansard, 1996). Ca is being reported by Yuhong (1990) as main constituent and makes up about 32% of the shell composition. The present study shows that the element presents five species, even though very less in content, except *Cytherella dictyon* and *Cytherelloidea leroyi.* The element Mg is being inferred that it might have come from water.

Aluminum (Al): Al is found as 1.20% in *Cytherelloidea leroyi* only. Yuhong (1990) reported the element Al in the shell that varies between 1.10 and 1.30% of the composition. Only a few specimens showed higher values and there is a little difference in the average content of marine and non-marine shells, which is 1.317% and 1.29%, respectively. He (op. cit.) also reported from various areas, like, South China Sea, Bohai Sea, East Lake in Wuhan of Hubei, Caohai Lake in Guizhou and a pond near Daqing of Heilongjiang. In the present study, *Cytherelloidea leroyi* have recorded this element and is being inferred that it might have come from the sediment alone because the water parameters does not have this element.

Silicon (Si): Si ranges from 1.08 to 1.35% and were found in *Paranesidea fracticorallicola* and *Cytherelloidea leroyi*, respectively as lowest and highest.

The most important factor controlling the dissolution rate is the specific surface area of the constituent parts (silicon spheres and nanometer-scale structures) and also the morphology of the whole diatom, which can lead to differential preservation of certain species as reported (Hurd *et al.,* 1981; Barker, 1992; Ryves *et al.,* 2001, 2003; Battarbee *et al.,* 2005). The present study shows that the element Si is present only in three species namely, *Cytherella semitalis, Cytherelloidea leroyi* and *Paranesidea fracticorallicola*. It is being inferred that it might have come from both water and sediment.

Chloride (Cl): Cl is found as 1.17% in *Cytherelloidea leroyi* only. The element Cl to be present in less than half of the specimens examined and only in a smaller amount reported Yuhong (1990). Cl is being determined in only one species in the present study, namely, *Cytherelloidea leroyi* and it might have come from water. As salinity plays an important role for the element Cl, the concentration of Cl in the shell depends on salinity.

Calcium (Ca): Ca ranges from 04.97 to 28.57% and found in *Paranesidea fracticorallicola* and *Cytherella* sp. The percentage of Ca seems not to be related to the thickness of calcitic shell but, the Ca content seems inversely proportional to the amount of all the trace elements in the Ostracoda shell. Ca is being reported by Yuhong (1990) as main constituent and makes up about 32% of the shell composition. All the seven species taken into consideration recorded the element Ca and it is being the chief element that occurs in the coral areas, it is being inferred that the element is from coral apart from the sediment.

Conclusion

Eight elements, namely, C, O, Na, Mg, Al, Si, Cl and Ca have been determined from the shell chemistry of species belonging to Cytherellidae, Bythocyprididae and Bairdiidae famies. The highest percentage is being recorded by Oxygen (66.56%) following Carbon (31.97%) and Calcium (28.57). Other elements are either minor or trace. The element Na is being recorded in two species namely, *Cytherella semitalis* and *Bairdoppilata (B) alcyonicola*. The element Mg was found in five species, even though very less in content, except *Cytherella dictyon* and *Cytherelloidea leroyi*. Al and Cl were in *Cytherelloidea leroyi* species only and Si was present in the three species namely, *Cytherella semitalis, Cytherelloidea leroyi* and *Paranesidea fracticorallicola.* Elements that constitute the shell might have come either from water or sediment or from both. But, most of the elements are from water. "Al" might have come from sediment, as it is not found in water.

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