Macro and meiofaunal abundance in six sandy beaches of Lakshadweep islands

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The macro and meiofauna were investigated quantitatively. Of the 8 macrofaunal taxa recorded, the polychaetes and crustaceans made up the bulk of the population and biomass on all beaches. Total macrofaunal density varied from 71 to 3157 m$^{-2}$ and biomass from 5.22 to 325.1 g m$^{-2}$. High meiofaunal density (2620-6555.10 cm$^{-2}$) was recorded at most of the beaches and these were made up mainly of nematodes (46.7%) and benthic copepodes (23.7%). On all beaches the meiofauna tended to be concentrated at those tide levels where no high degree of desiccation of the sand occurred. Macrofauna and meiofauna biomass were extrapolated to 1 m transect of beach giving macrofaunal values of 26.12 to 975 g (1 m transect)$^{-1}$ and meiofaunal values of 295.7 to 794.5 g (1 m transect)$^{-1}$. Based on biomass, meiofauna contributed more than 50% to the total production on all the beaches. The macrofauna/meiofauna ratio gave low values indicating the dominance of meiofauna on all beaches.

Sandy shores provide an environment of high physical stress to marine fauna, as a result of which relatively few species inhabit this zone. Different authors studying the intertidal macro and meiofauna, have reported impoverished macrofauna but abundant and diverse meiofauna\(^1-4\). Quantitative studies on the intertidal coralline sandy sediment of Indo-Pacific coral atolls in general and Lakshadweep in particular, are very few. Some studies have been carried out on macro and meiofauna of Polynesian atolls\(^5\). From Lakshadweep archipelago reports\(^6-8\) on molluscan and benthic faunal distribution in the intertidal sand of Kavaratti atoll and other beaches are available. In the present study an attempt was made to give comparative account of intertidal macro and meiofaunthos, on quantitative basis, of the 6 beaches, namely Agatti, Kalpeni, Bingaram, Kavaratti, Minicoy and Kadmat atoll of Lakshadweep.

Lakshadweep archipelago consists of 12 atolls and 5 submerged banks. Except Minicoy, the Agatti, Kalpeni, Bingaram, Kavaratti and Kadmat are located within the geographical limits of 10°-12°N and 71°40'-74°E. The Minicoy atoll (8°18'N and 73°E) is the southernmost atoll and the largest in the Lakshadweep archipelago. The shore of the lagoon side of the atolls are characterized with sandy beach having medium to coarse coralline sand and beach rocks exposed during low tide. The beaches are of semiclosed type with varying exposure and with minimum wave action.

The Lakshadweep Archipelago has a tropical climate where the year may be divided into three seasons e.g, the southwest monsoon (June-September), post-monsoon (October-January) and premonsoon (February-May). During monsoon period heavy rainfall is reported in this region which terminates in late September or early October after which the weather is less varying. The air temperature fluctuates around 30°C except during monsoon time when it is below 25°C. The tides are of mixed type with a strong semidiurnal influence. The beaches are fairly stable except during the monsoon season when changes in beach profile take place due to erosion. The width of intertidal areas ranges from 7 to 15 m with gentle slope and little wave action.

Materials and Methods

Data presented here are based on 108 samples collected during different seasons and different years (1985-1987) during 3 cruises of R. V. Gaveshani. The results therefore do not necessarily pertain to the seasonal cycle. The comparisons depict a broad based picture of changes in macro and meiofauna of the 6 beaches of 6 atolls studied. The sampling stations were located along a transect from high water mark (HW) to the low water mark (LW) and three transects were selected on each island. For macrofauna a quadrant (0.25 m$^2$ area) was forced into the sediment and the sand of the enclosed area was dug out to a depth of 15 cm and sieved (0.5 mm screen). The material remaining on the screen was fixed in 5% buffered formalin Rose Bengal solution. Duplicate samples were taken at each level. Meiofauna was collected at each tide level in 3 replicate series of 10 cm$^2$ area to a depth of 10 cm. Each core sample was sliced into 2 sub samples of 5 cm layer and preserved in 5% formalin Rose Bengal solution. 

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solution. All macrofauna were grouped, counted and wet weight mass was determined. Similarly all meiofauna were counted and average wet weight of the major taxa recorded. The biomass of macrofauna and meiofauna were extrapolated to get biomass values for 1 m wide transect. The total biomass was then converted to production estimates by multiplying factor 8 for meiofauna and 2.5 for macrofauna. Mechanical properties of the sediment were analysed by the method of Folk. Organic content of the sediment was determined by the titration method.

Results and Discussion

Sediment characteristics—The median particle diameter of all the beaches (Table 1) ranged from 0.27 to 0.55 mm indicating the dominance of median coralline sand particles. Narayanan and Sivadas reported median particle size of 0.38 to 0.43 mm at Kavaratti. The low phi quartile deviation (Qdφ) and very low values of skewness (SKφ) indicate that at all the beaches a high proportion of sand particles fall in narrow range around the median and the particles of both larger and smaller sizes were equally sorted. Harkantara working in a high energy beach reported strongly fine skewed to strongly coarse skewed sediment. The differences in the sediment characteristics may be due to the differences in exposures between these beaches. However it may be mentioned here that all the beaches are protected by reef which are several hundred meters away from the shore and therefore the wave action on these beaches is minimum. This was further confirmed by the fact that no significant relationship exists between the degree of exposure and beach slope.

The sediment organic carbon, as expected, was moderate. The values were highest (0.47%) at Kalpeni and lowest (0.24%) at Kavaratti. On these oceanic beaches the sources of organic input are limited. The main contribution of organic carbon are the dead and decaying seagrasses and seaweeds. Thomassin and Vitte also reported low value of organic carbon in the coralline sediment of Tulear reef Madagascar.

Macrofauna—Total macrofaunal density (no. m⁻²) was highest at Agatti (3157) and lowest at Kadmat (71) (Table 2). Of the 8 groups, polychaetes were the most dominant group at all the beaches, contributing from 55 to 92% of the total population. Next in abundance were crustaceans and bivalves. Miscellaneous groups consisted of hydrozoans, echinoid worms, sea anemones, etc. formed a substanti-
ial portion of the population in the present study. Narayanan and Sivadas\(^7\) also reported polychaetes and crustaceans as the major macrobenthic components in the intertidal sand of Kavaratti. Ansell\(^1\) et al.\(^8\) found polychaetes and bivalves as the major group on the south Indian beaches. However, Mclachlan\(^9\) has reported the dominance of bivalves in the intertidal macrofauna of South African beaches. Among other studies Thomassin et al.\(^5\) reported the dominance of molluscs in the coral sediments of Polynesian atolls. Thus the intertidal macrofauna population at Lakshadweep atolls show wide variation from extremely poor at Kadmat to extremely high density at Agatti. These extreme range of macrofaunal density could be the result of differing food supply and the sediment characteristics. Beach exposure also plays important role in the distribution of intertidal fauna\(^15\).

There was a distinct zone of faunal distribution along the tidal gradients and several faunistic assemblages could be identified. While the polychaetes occurred consistently at all tidal levels, the upper zone was characterized by the presence of crustaceans such as *Eurydice* sp. and *Talorchestia* sp. The mid water level was characterized by the presence of pelecypods, ghost crab and mole crab (*Hippa* sp.). Among two species of pelecypods *Mesodesma glabratum* was recorded at all the beaches excepting Kadmat while *Donax* sp. was found only at Minicoy. The neap tide was unproductive in terms of macrofaunal density except at places of seagrass beds. The distribution of major taxa also varied along the exposure gradient. Similar observations have been made at Kavaratti\(^7\).

Studies on intertidal fauna of South African beaches also revealed the pattern in the distribution of fauna along tidal gradient\(^11\).

Macrobenthic biomass was highest at Agatti and lowest at Kadmat (Table 2). Biomass values followed the trend of population density in the distribution from high water to low water. High to very high biomass values have been reported from Indian beaches\(^9\) which are attributed to high density of bivalves.

**Meiofauna**—Nematodes are generally the dominant taxon in marine meiofauna\(^17\), although the proportion of harpacticoid copepods increases in coarser sand on exposed beaches. The meiofaunal density (Table 3) was highest at Agatti and lowest at Kavaratti. Total density (no. 10 cm\(^{-2}\)) varied between 2620 and 6555. In an other study from Andaman islands, Ansari and Ingole\(^18\) reported meiofaunal density ranging from 2270 to 6116.10 cm\(^{-2}\) in the fine intertidal sand which coincidently is similar to the values observed in the present study. The meiofauna was mainly represented by nematodes, harpacticoids, turbellarians and polychaetes. Among other groups the gastro-

<table>
<thead>
<tr>
<th>Group</th>
<th>Minicoy</th>
<th>Kavaratti</th>
<th>Agatti</th>
<th>Kalpeni</th>
<th>Bingham</th>
<th>Kadmat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polychaeta</td>
<td></td>
<td></td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Amphipoda</td>
<td>43</td>
<td>23</td>
<td>23</td>
<td>23</td>
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<td>23</td>
</tr>
<tr>
<td>Pelecypoda</td>
<td>43</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Isopoda</td>
<td>43</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Hippa sp.</td>
<td>43</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Decapoda</td>
<td>43</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Others</td>
<td>43</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Total density (no. m(^{-2}))</td>
<td>660</td>
<td>1197</td>
<td>1900</td>
<td>3157</td>
<td>503</td>
<td>475</td>
</tr>
<tr>
<td>Total biomass (g m(^{-2}))</td>
<td>238.1</td>
<td>238.1</td>
<td>238.1</td>
<td>238.1</td>
<td>238.1</td>
<td>238.1</td>
</tr>
</tbody>
</table>
Trich, kinorhynchs, tardigrada, archiannelida and nauplii were present. On all the beaches except Agatti nematodes form numerically the most dominant group followed by harpacticoids and turbellarians. At Agatti harpacticoids were dominant, followed by nematodes and turbellarians. Averaging the proportion (percentage wise) for the six beaches, it is observed that nematodes contribute 46.7%, harpacticoids 23.7%, turbellarians 12.3% and polychaetes 5.17%. Other groups also made significant contributions, averaging 12.2%.

Total meiofaunal biomass (wet weight, mg 10 cm⁻²) for each beach and tidal level was calculated and presented in Table 3. These beaches have highly variable meiofaunal biomass like their larger counterparts and do not show consistency with tidal exposure.

**Table 3—Average meiofaunal density (no. 10 cm⁻²) and biomass (mg. 10 cm⁻²) of six coralline beaches at Lakshadweep**

<table>
<thead>
<tr>
<th>Group</th>
<th>Agatti</th>
<th>Kalpeni</th>
<th>Bingaram</th>
<th>Kavaratti</th>
<th>Minicoy</th>
<th>Kadmat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tides</td>
<td>LW</td>
<td>MW</td>
<td>HW</td>
<td>TOT</td>
<td>LW</td>
<td>MW</td>
</tr>
<tr>
<td>Nematoda</td>
<td>144</td>
<td>208</td>
<td>1142</td>
<td>1494</td>
<td>1587</td>
<td>827</td>
</tr>
<tr>
<td>Harpacticoida</td>
<td>631</td>
<td>1633</td>
<td>308</td>
<td>2572</td>
<td>14</td>
<td>620</td>
</tr>
<tr>
<td>Polychaeta</td>
<td>393</td>
<td>11</td>
<td>265</td>
<td>669</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>Turbellaria</td>
<td>165</td>
<td>820</td>
<td>352</td>
<td>1337</td>
<td>76</td>
<td>186</td>
</tr>
<tr>
<td>Others</td>
<td>175</td>
<td>186</td>
<td>122</td>
<td>483</td>
<td>30</td>
<td>47</td>
</tr>
<tr>
<td>Total density (no. 10 cm⁻²)</td>
<td>1508</td>
<td>2858</td>
<td>2189</td>
<td>6555</td>
<td>1707</td>
<td>1730</td>
</tr>
<tr>
<td>Total biomass (mg. 10 cm⁻²)</td>
<td>25.91</td>
<td>23.59</td>
<td>82.52</td>
<td>132.02</td>
<td>100.17</td>
<td>58.46</td>
</tr>
</tbody>
</table>
From Table 4 it appears that the fauna at all tide levels was aggregated mainly in the top 0-5 cm layer except at Kavaratti which may be due to changes in sampling time. Because of a better drainage (coarse sand) and high atmospheric temperature and exposure, the fauna seems to migrate downward in the sand column. This emphasizes the importance of drainage on oceanic sandy beaches. The meiofauna of the present study appears to be concentrated more at those levels where desiccation is not too severe and oxygen is available. Others have also reported concentration of meiofauna in the upper layer of sandy beaches. Due to varying degrees of exposure and flooding different tidal level will experience different temperature and oxygen regime, depending on the width of the beach. This accounts for the differences in faunal density at various tidal levels.

Comparison of meiofauna—An attempt has been made in the present study to compare the density of meiofauna with other areas (Table 5). Total density recorded in the present study area is comparable with other areas except that of Malaya, Porto Novo and Stockholm where densities were comparatively low. One of the reasons for differences in meiofauna densities recorded by other is the methodology used by different workers. It may be noted that in the coral sand at Malaya the dominant group was copepoda. In the coarse sand of 0.55 mm median diameter Jansson also observed dominance of benthic copepoda and so did McLachlan in the median grain size of 0.27 mm diameter. In the present study only Agatti showed dominance of copepoda in the sediment of 0.55 mm diameter. It reemphasizes that benthic copepod increases in coarser sand on exposed sandy beaches. In the medium and fine sand the copepods were second most important group.

Comparison of macrofauna and meiofauna—The macrobenthos and meiobenthos of the six beaches under investigation are compared on the basis of their density, biomass values and production estimates for 1 m transect of beach (Table 6). For macrofauna, total density per 1 m transect was highest at Agatti and lowest at Kadmat. Similarly the biomass was highest at Agatti and lowest at Kadmat. Total macrofaunal biomass (g per 1 m transect) of all the beaches varied from 26.12 to 975. Narayanan and Sivadas reported an average value of 90.47 g (1 m transect) from Kavaratti beach, while Ansell et al. found maximum wet weight biomass value of 500 g (1 m transect) from the south Indian beaches. Wide range of biomass values between 7.04 and 6600 are reported from South African beaches which was attributed to the presence or absence of bivalves and gastropods. A noticeable feature of the beaches under investigation is the very low number of bivalves and the absence of gastropods. This is probably due to the textural properties of the sediment and beach exposure. Namboodiri and Sivadas reported only one species of bivalve in the sandy beach and 19 species in the lagoonal floor of Kavaratti. They reported that poor representation of mollusca was due to increased exposure of the beach. Ganapati and Lakshaman Rao found paucity of the faun...
The organic matter coming from the sea is mainly in the form of washed up algae and seagrasses. The meiofaunal component showed less variation in density of organic matter lying on and in the sediment in the form of washed up algae and seagrasses. Thomassin et al. have estimated ratio between 1/190 and 1/12 in the coral sediment of Tiahura reef of Polynesia.

The production estimates indicate that the meiofauna are quantitatively more important than the macrofauna on these oceanic sandy beaches and contribute > 50% to the secondary production on these beaches. McLachlan has estimated macro and meiofauna production from ELWS to a height of 2 m at sandy beaches of South Africa. He reported a macrofaunal contribution of 53% and meiofauna contribution of 47% in the secondary production of these beaches. He, however, emphasized that, had estimates of production for transect been extended to a height of > 2 m above the ELWS, as in the present study, the meiofaunal contribution would have been greater than macrofauna. The high contribution of meiofauna in the secondary production of intertidal sandy areas of Lakshadweep atolls is therefore justified.

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References