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Research Article

# Biodiversity of benthic molluscs in Kaakkaithivu coastal waters, Jaffna estuary, Sri Lanka

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**Abstract**: Benthic mollusc diversity in the northern Jaffna estuary, particularly the coastal waters of Kaakkaithivu, was investigated from July 2018 to January 2019. A total of 266 individuals representing six families and eight species were collected from three sampling sites. The assemblage comprised five gastropods and three bivalves: *Terebralia palustris*, *Cerithidea cingulata*, *Murex virgineus*, *Volegalea* sp., *Morula margariticola*, *Cardita bicolor*, *Donax* sp., and *Dosinia lincta*. Shannon–Wiener diversity was highest at Site 1 (1.2303), followed by Site 3 (0.8709) and Site 2 (0.5632). *T. palustris* (41.00%) and *C. cingulata* (36.47%) were the most abundant species. The distribution of *C. cingulata* differed significantly among selected sites ($p < 0.05$), reflecting differences in site condition and environmental stress. The low diversity and evenness values indicate that the Kaakkaithivu coastal ecosystem is under considerable environmental pressure, particularly at Sites 2 and 3. These baseline data are relevant to ecological assessment, estuarine management, habitat restoration, and control of anthropogenic activities in the Jaffna estuary.

**Keywords**: abundance; benthic molluscs; coastal waters; diversity; environmental stress; Jaffna estuary.

## 1. Introduction

Estuaries occur at the interface between land and sea and are characterized by environmental conditions that fluctuate with tides and waves (Schröder-Adams et al., 2014). They provide important ecosystem services, including nutrient cycling, climate-change mitigation, habitat provision, shoreline protection, and support for fisheries (Carpenter et al., 2009). The distribution and dynamics of benthic communities are closely related to ecosystem condition and differ between relatively pristine and disturbed habitats.

Coastal regions are increasingly affected by urbanization, industrial development, waste disposal, transport, and other human activities (Törnroos et al., 2015). Understanding the structure and functioning of coastal communities is therefore important when evaluating environmental status and the impacts of development (Van Lavieren et al., 2011).

Benthic molluscs are soft-bodied invertebrates that live on or within bottom sediments and hard substrates. Coastal structures, mangrove trunks, jetties, groynes, guide walls, and natural substrate provide attachment and shelter for many species. Molluscan communities respond to water quality, sediment condition, pollution, and habitat alteration. Species with restricted environmental tolerances or limited dispersal capacity can therefore act as useful indicators of local ecological condition.

Although estuarine biodiversity has received considerable attention, limited information is available on macrobenthic mollusc diversity across the Kaakkaithivu coastal waters of the Jaffna estuary. This study documented mollusc species at three sampling sites, quantified abundance, richness, diversity, and evenness, compared species distributions among sites, and evaluated environmental stress within the study area.

## 2. Materials and Methods

### 2.1. Study Area and Sampling

The study was conducted from July 2018 to January 2019 at three sites in the coastal waters of Kaakkaithivu, Jaffna estuary (Figures 1 and 2). Site characteristics and geographic coordinates are summarized in Table 1.

Mollusc populations were estimated using $1\,\mathrm{m} \times 1\,\mathrm{m}$ quadrats. Specimens were collected by hand, transported to the laboratory, cleaned, photographed, and preserved in 70% ethanol. Identification was based on standard taxonomic keys (Carpenter and Niem, 1998; Fernando, 2009).

### 2.2. Statistical Analysis

Community structure was evaluated using the Shannon–Wiener diversity index. For $S$ species,

$$H' = -\sum_{i=1}^{S} p_i \ln p_i = -\sum_{i=1}^{S} \left(\frac{n_i}{N}\right) \ln\left(\frac{n_i}{N}\right), \quad (1)$$

where $n_i$ is the number of individuals of species $i$, $N$ is the total number of individuals, and $p_i = n_i/N$.

Shannon evenness was calculated as

$$E_H = \frac{H'}{\ln S}, \quad (2)$$

where $S$ is the total number of species recorded. One-way analysis of variance was used to compare species abundance among sampling sites. Statistical significance was evaluated at $p < 0.05$.

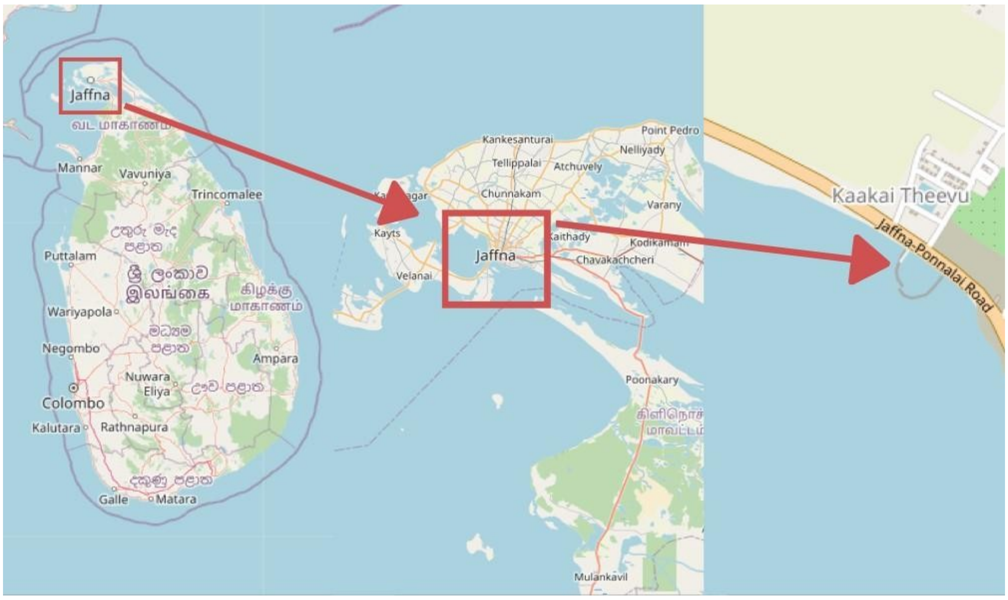


**Figure 1:** Geographic location of Kaakkaithivu in the Jaffna estuary, Sri Lanka.

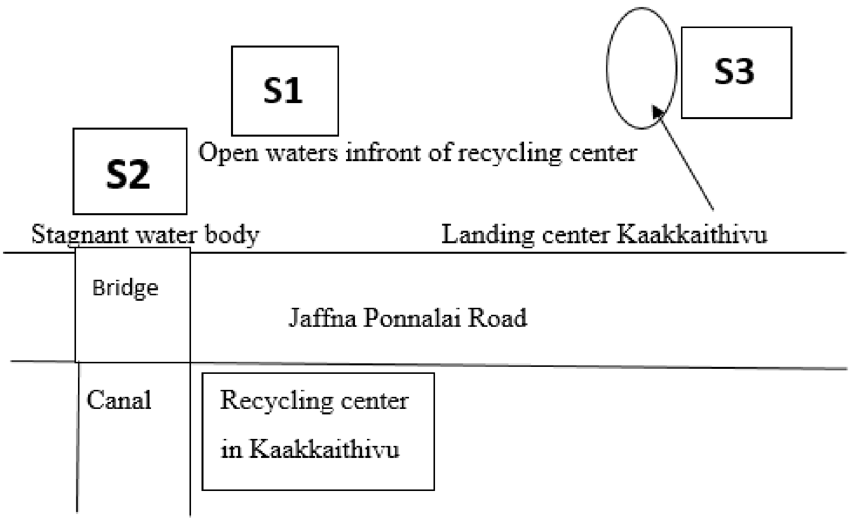


**Figure 2:** Relative locations of sampling Sites 1, 2, and 3 at Kaakkaithivu.

**Table 1:** Description of sampling sites in Kaakkaithivu coastal waters, Jaffna estuary.

| Site | GPS coordinates | Description |
|---|---|---|
| Site 1 | $9°41'12''$ N, $79°59'54''$ E | Open water in front of the recycling centre, freely connected to the Jaffna estuary. |
| Site 2 | $9°41'15''$ N, $79°59'51''$ E | Stagnant water body directly connected to the canal near the Kaakkaithivu recycling centre. |
| Site 3 | $9°40'57''$ N, $80°00'18''$ E | Waters near the jetty, directly connected to the Jaffna estuary. |

## 3. Results and Discussion

Eight dominant mollusc species were recorded: five gastropods and three bivalves (Figure 3). The gastropods were *Terebralia palustris* (Gmelin, 1791), *Cerithidea cingulata* (Swainson, 1840), *Murex virgineus* (Linnaeus, 1758), *Volegalea* sp. (Iredale, 1938), and *Morula margariticola* (Schumacher, 1817). The bivalves were *Cardita bicolor* (Lamarck, 1819), *Donax* sp. (Linnaeus, 1758), and *Dosinia lincta* (Pulteney, 1799).


**Figure 3:** Benthic molluscs recorded from Kaakkaithivu coastal waters.

**Table 1:** Taxonomic composition and abundance of benthic molluscs.

| Taxonomic order | Family | Number of individuals |
|---|---|---|
| Sorbeoconcha | Potamididae | 206 |
| Neogastropoda | Muricidae | 11 |
| | Melongenidae | 4 |
| Carditida | Carditidae | 15 |
| Cardiida | Donacidae | 24 |
| Venerida | Veneridae | 6 |
| **Total** | | **266** |

**Table 2:** Diversity indices of benthic molluscs at the three sampling sites.

| Index | Measure | Site 1 | Site 2 | Site 3 |
|---|---|---|---|---|
| Shannon–Wiener index | Diversity ($H'$) | 1.2303 | 0.5632 | 0.8709 |
| | Evenness ($E_H$) | 0.6321 | 0.3500 | 0.4861 |
| Species richness | $S$ | 7 | 5 | 6 |

The monthly abundance of individual species varied during the study period (Figure 4). *T. palustris* and *C. cingulata* dominated the assemblage, accounting for 41.00% and 36.47% of all individuals, respectively (Figure 5). The remaining species occurred at considerably lower percentages.

The Shannon–Wiener index was highest at Site 1, followed by Site 3 and Site 2 (Table 2). Site 2 had the lowest diversity and evenness, indicating an uneven as-

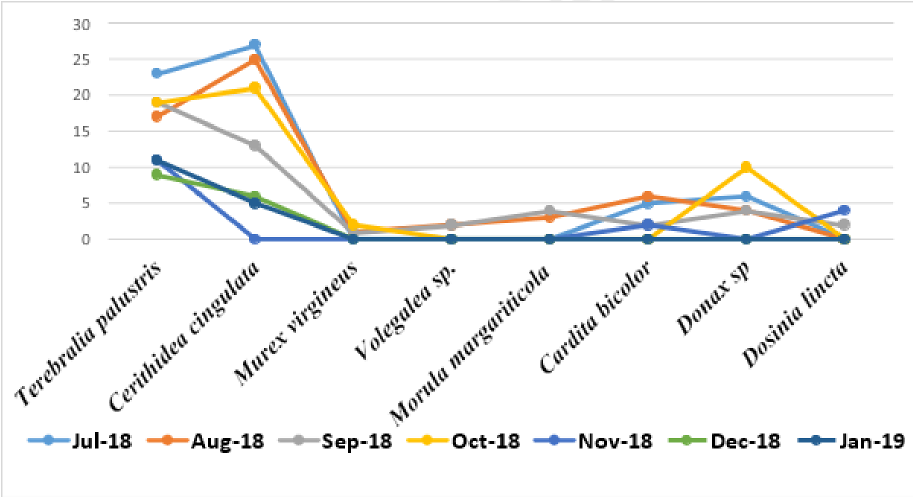


**Figure 4:** Monthly variation in benthic mollusc abundance from July 2018 to January 2019.

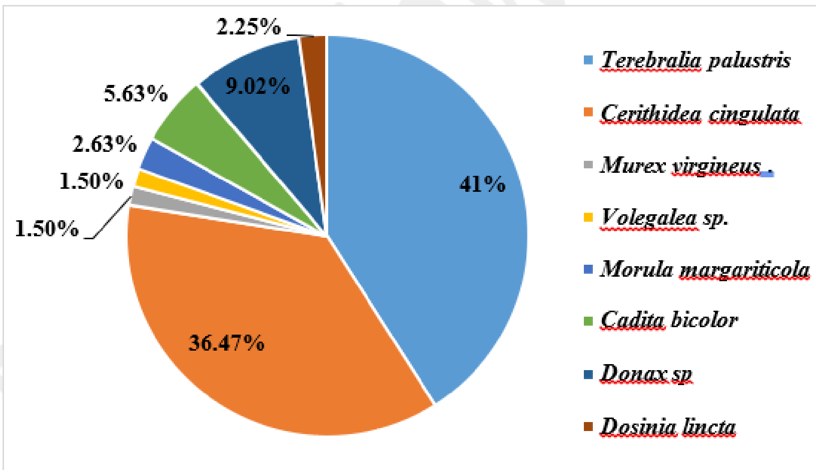


**Figure 5:** Percentage occurrence of benthic mollusc species collected from Kaakkaithivu coastal waters.

**Table 3:** Mean abundance of mollusc species at each sampling site.

| Species code | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| A (*T. palustris*) | $2.67 \pm 1.16^a$ | $3.00 \pm 1.48^a$ | $2.50 \pm 1.38^a$ |
| B (*C. cingulata*) | $3.67 \pm 3.58^a$ | $3.42 \pm 2.84^a$ | $0.58 \pm 1.38^b$ |
| C (*M. virgineus*) | $0.17 \pm 0.58^a$ | $0.00 \pm 0.00^a$ | $0.17 \pm 0.39^a$ |
| D (*Volegalea* sp.) | $0.08 \pm 0.29^a$ | $0.08 \pm 0.29^a$ | $0.17 \pm 0.58^a$ |
| E (*M. margariticola*) | $0.33 \pm 0.49^a$ | $0.25 \pm 0.87^a$ | $0.00 \pm 0.00^a$ |
| F (*C. bicolor*) | $0.83 \pm 1.41^a$ | $0.00 \pm 0.00^a$ | $0.33 \pm 1.16^a$ |
| G (*Donax* sp.) | $1.08 \pm 1.08^a$ | $0.58 \pm 0.90^a$ | $0.33 \pm 0.78^a$ |
| H (*D. lincta*) | $0.42 \pm 0.97^a$ | $0.33 \pm 1.16^a$ | $0.00 \pm 0.00^a$ |

Values are mean±SD. Within a row, means with different superscript letters differ significantly at $p < 0.05$.

semblage dominated by one or a few taxa. Such low diversity and evenness are commonly associated with environmental stress (Magurran, 2004).

Site 1 was an open coastal area with relatively limited direct anthropogenic activity and had the highest diversity. Site 3, near the jetty, had intermediate diversity. Site 2 had the lowest index and was associated with stagnant water and activities near the recycling centre and canal. The low value may reflect pollution, restricted water exchange, and other local disturbances.

Species diversity provides information on ecological stability and environmental pressure. Higher diversity is associated with more complex food webs, greater potential for symbiotic interactions, and stronger feedback control (Margalef, 1968). Staub et al. (1970) described diversity values of 3.0–4.5 as slightly polluted, 2.0–3.0 as lightly polluted, 1.0–2.0 as moderately polluted, and 0.0–1.0 as heavily polluted. Under that classification, Site 1 was moderately polluted, whereas Sites 2 and 3 were heavily polluted.

The Shannon–Wiener range of 0.5632–1.2303 indicates marked environmental stress. Based on species richness and distribution, the apparent stress gradient was Site 2 $>$ Site 3 $>$ Site 1.

Most species did not differ significantly in abundance among sites. *C. cingulata*, however, showed a significantly lower abundance at Site 3 than at Sites 1 and 2 ($p < 0.05$; Table 3), demonstrating that site condition influenced its distribution.

## 4. Conclusion

Eight macrobenthic mollusc species belonging to six families were recorded from Kaakkaithivu coastal waters: *Terebralia palustris*, *Cerithidea cingulata*, *Murex virgineus*, *Volegalea* sp., *Morula margariticola*, *Cardita bicolor*, *Donax* sp., and *Dosinia lincta*. *T. palustris* and *C. cingulata* were the dominant species.

The low diversity indices indicate that the ecosystem is under considerable environmental stress and emphasize the need for strict monitoring and control of anthropogenic activity along the Kaakkaithivu coast. Mangrove restoration could improve habitat quality through bioremediation, shoreline stabilization, and provision of attachment surfaces and refuges for molluscs. Continued monitoring is recommended to support management and restoration of the Jaffna estuary.

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