STM JOURNALS

International Journal of
Marine Life

ISSN No.: 3048-8885
Volume 3, Issue 1, 2026
January–June
DOI (Journal): 10.37591/ IJML

https://journals.stmjournals.com/ijml

Research IJML

Spatial Distribution and Species Diversity of Marine Bivalves Along the Rocky Intertidal Zone of Veraval, Gujarat, India

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Abstract

The rocky intertidal shoreline of Veraval, located along the Saurashtra coast of Gujarat, serves as a vital habitat for various marine organisms due to its unique composition of rocky–sandy patches and tidal pools. This study was undertaken to evaluate the diversity and spatial distribution of marine bivalves at the Jaaleshwar coast (20° 54' 36.210'' N, 70° 21' 09.090'' E). Field observations were carried out over nine months from July 2020 to March 2021. To ensure a comprehensive assessment, a quadrat sampling technique (0.25 m^2) was employed in a zig-zag pattern across the vertical intertidal zones during low tide periods. Our findings recorded a total of 8 bivalve species representing 5 families and 5 orders. Among these, the family Veneridae emerged as the most dominant, showcasing the highest diversity index of 47.36 and a mean density of 1.0. On the other hand, families, such as Ostreidae and Lucanidae, showed minimal presence. The data clearly indicates a seasonal trend, where the maximum population density was observed during the Monsoon, likely due to optimal environmental conditions, while the lowest density was noted in Summer. Furthermore, the study noted that human-induced activities, like port operations, fisheries, and waste disposal, are increasingly putting pressure on this fragile ecosystem. These results underline the importance of consistent ecological monitoring to preserve the malacofauna of the Veraval coast.

Keywords: Bivalves, intertidal zone, spatial distribution, species diversity, Veraval coast

INTRODUCTION

The global oceans serve as a vast reservoir of biological diversity, supporting a wide array of marine life forms essential for maintaining ecological balance (Hornell, 1951). Among coastal ecosystems, the intertidal zone, the dynamic interface between high and low tide is recognized as one of the most productive environments for marine organisms (Vaghela et al., 2010) [1]. Within this habitat, the Phylum Mollusca represents the second-largest group of invertebrates globally, evolving over 600 million years since the Cambrian period (Anandaraj et al., 2012) [2]. Specifically, the class Bivalvia, including clams, oysters, and mussels, plays a crucial role as filter feeders and reliable bio-indicators of environmental health (Subba Rao, 2017) [3]. India possesses a rich malacofauna, with approximately 3,600 recorded species of molluscs, of which 632 belong to the class Bivalvia (Karthick et al., 2020) [4].

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Received Date: March 16, 2026
Accepted Date: March 27, 2026
Published Date: March 28, 2026

Citation: Rahul B. Solanki, Jatin V. Raval. Spatial Distribution and Species Diversity of Marine Bivalves Along the Rocky Intertidal Zone of Veraval, Gujarat, India. International Journal of Marine Life. 2026; 3(1): 25–30p.

Previous research has highlighted that rocky shores provide a complex architecture that supports higher species richness compared to sandy beaches, making them ideal for studying bivalve diversity (Apte, 1998). Several studies along the Saurashtra coastline have documented various molluscan species, with specific surveys in Veraval providing a baseline for intertidal health (Dave & Chudasama, 2018) [5, 6]. However, the rocky intertidal stretches

of the Saurashtra coast, particularly around Veraval, face significant ecological challenges due to increasing anthropogenic pressure [7]. Despite being a vital habitat characterized by unique rocky–sandy patches and tidal pools, this region is under stress from intensive fishing, large-scale port operations, and urban waste disposal (Agravat & Raval, 2019) [8]. There is a critical need for updated seasonal data to understand how these factors influence the spatial distribution and species diversity of bivalves in this fragile ecosystem (Gohil & Kundu, 2012) [9].

The primary goal of this research is to provide a comprehensive assessment of bivalve communities at the Jaaleshwar coast of Veraval (20º 54' 36.210'' N, 70º 21' 09.090'' E). This study aims to identify species composition and analyse seasonal population trends over nine months from July 2020 to March 2021. By employing a quadrat sampling technique across vertical intertidal zones (Thivakaran & Kasinathan, 1990), the research seeks to document shifts in population density, which typically show maximum growth during the Monsoon due to optimal environmental conditions (Dey, 2006) [4, 10, 11]. Ultimately, these results underline the importance of consistent ecological monitoring to preserve the malacofauna of the Veraval coast against human-induced pressures and ensure long-term conservation (Pandya, 2014) [12].

METHODOLOGY

Study Area and Site Description

The current investigation was carried out along the rocky intertidal shoreline of the Jaaleshwar coast in Veraval, Gujarat (20º 54' 36.210'' N, 70º 21' 09.090'' E). Veraval is a prominent hub for fisheries and port activities on the Saurashtra coast, offering a unique habitat composed of rocky–sandy patches and numerous tidal pools that support diverse marine life Figure 1. The selection of this site was based on its ecological significance and the increasing environmental pressure it faces from urban and industrial operations (Solanki et al., 2024) [13].

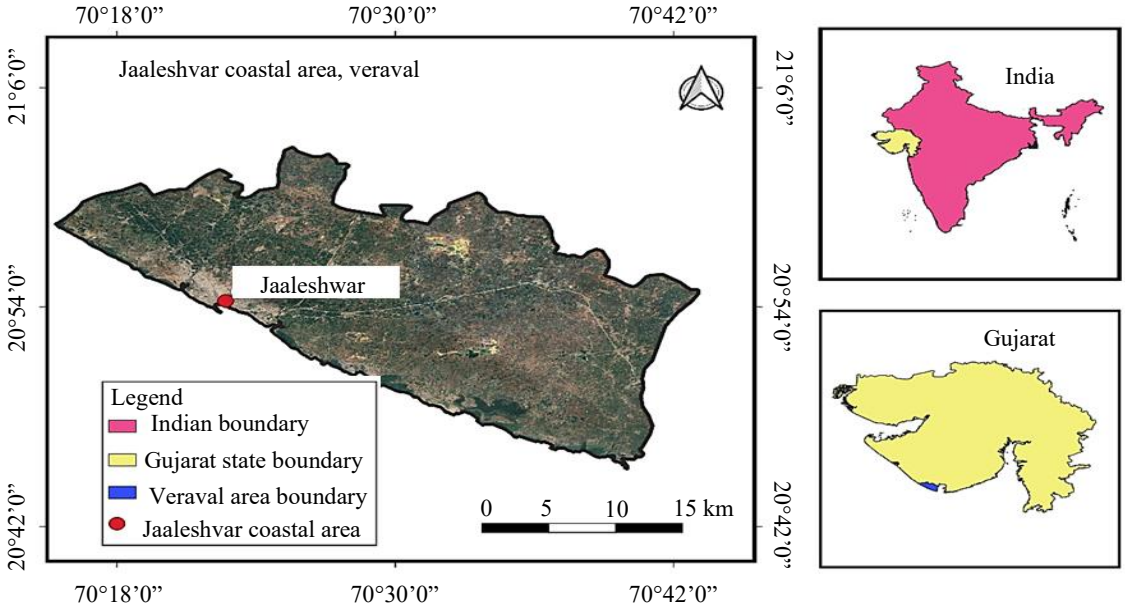

Figure 1. Location map of the Jaaleshvar coastal area at Veraval, Gujarat, India, showing study site in relation to Gujarat state and national boundaries (Solanki et al., 2024) [13].

Sampling Design and Field Observations

To capture the seasonal variations in bivalve populations, field observations were conducted over a continuous nine-month period from July 2020 to March 2021. Following the standard ecological protocols for intertidal surveys, a quadrat sampling technique was employed (Solanki et al., 2024) [13]. A quadrat frame of 0.25 m^2 was placed in a zig-zag pattern across the vertical intertidal zones moving from the high-tide line to the low-tide line to ensure a representative assessment of the entire exposed area. All sampling activities were strictly performed during low tide periods when the intertidal belt was maximally accessible.

Species Identification and Data Analysis

During the field surveys, bivalve specimens found within the quadrats were identified based on their distinct shell morphology and external characteristics [1]. In cases where immediate field identification was challenging, high-resolution photographs were taken for later verification using standard taxonomic keys (Karthick et al., 2020) [4]. Quantitative data, such as species richness, mean density, and spatial distribution patterns, were calculated to evaluate the community structure. Additionally, the diversity index was computed to determine the dominance of specific families, such as Veneridae, across different seasons.

RESULTS

The systematic survey of the Jaaleshwar coast at Veraval resulted in the identification of 8 distinct species of marine bivalves, belonging to 5 families and 5 orders Table 1. The environmental conditions of the rocky–sandy patches and tidal pools appear to provide a conducive habitat for these molluscs.

Table 1. Taxonomic classification of marine bivalves recorded at Veraval coast.

Class	Subclass	Order	Family	Species name
Bivalvia	Autobranchia	Venerida	Veneridae	*Sunetta scripta* (Linnaeus, 1758).
				Periglypta reticulata (Linnaeus, 1758).
				Gafrarium pectinatum (Linnaeus, 1758).
		Ostreida	Ostreidae	*Crassostrea virginica* (Gmelin, 1791).
				Saccostrea cucullata (Born, 1778).
		Lucinida	Lucinidae	*Ctena decussata* (O. G. Costa, 1829).
		Carditida	Carditidae	*Cardita variegata* (Bruguiere, 1792).
		Arcida	Arcidae	*Barbatia decussata* (G. B. Sowerby I, 1833).

Among the recorded taxa, the family Veneridae emerged as the most dominant group in the study area Figure 2. It showcased the highest diversity index of 47.36 and maintained a mean density of 1.0, indicating its strong adaptation to the local intertidal conditions. In contrast, families, such as Ostreidae and Lucinidae, showed minimal presence during the nine-month study period. This distribution pattern is consistent with previous findings on the Saurashtra coast, which suggest that substrate type significantly influences bivalve settlement (Solanki, R. B., *Frontiers in Public Health*).

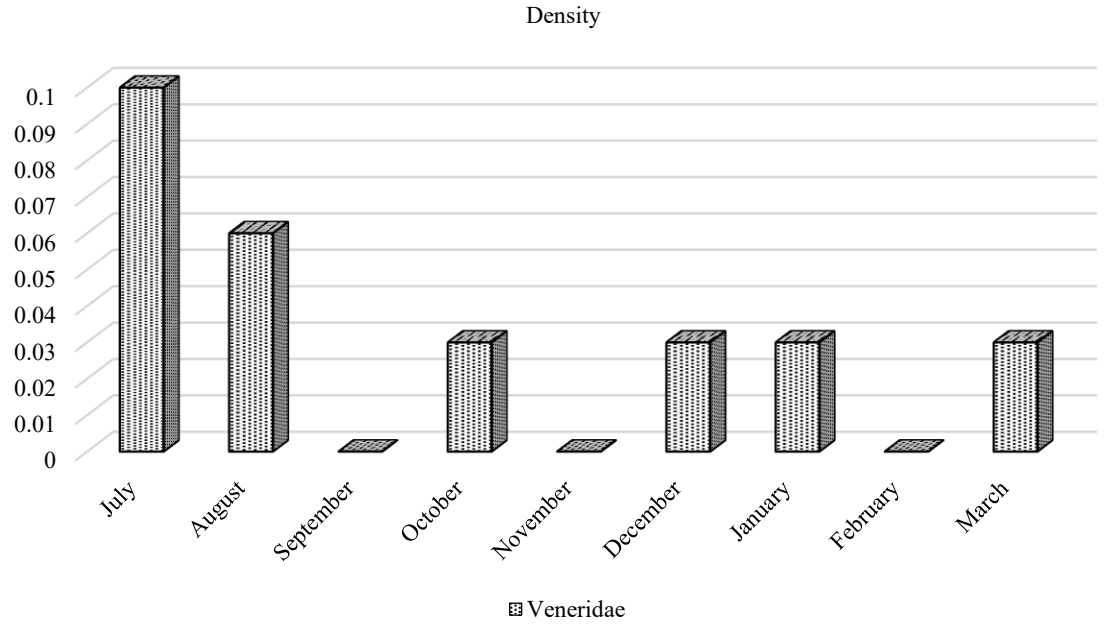

Figure 2. Seasonal variation in the density of *Veneridae* recorded at the Veraval coast (July–March).

Seasonal Variations in Population Density

The data clearly indicates a significant seasonal trend in the population dynamics of bivalves. The maximum population density was observed during the Monsoon season. This peak can be attributed to optimal environmental factors, such as nutrient availability and favourable salinity levels, during the rainy months. Conversely, the lowest density was recorded during the summer season, likely due to increased thermal stress and desiccation in the intertidal zone. The seasonal occurrence of recorded bivalve species was monitored from July 2020 to March 2021 Figures 3 & 4. While some species, like *Gafrarium pectinatum*, showed a broad presence across several months, others, like *Saccostrea cucullata*, were observed only during specific periods like February. The detailed monthly presence–absence checklist of bivalves is presented in Table 2 below.

Table 2. Checklist of the bivalve species recorded during the study period at Veraval coast (+ or – signs denote presence or absence of species).

No.	Species name	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	*Sunetta scripta* (Linnaeus, 1758)	–	+	–	–	–	+	–	–	–
2	*Periglypta reticulata* (Linnaeus, 1758)	+	–	–	–	–	–	–	–	–
3	*Gafrarium pectinatum* (Linnaeus, 1758)	+	+	–	+	–	–	+	–	+
4	*Crassostrea virginica* (Gmelin, 1791)	–	–	+	–	+	–	–	–	–
5	*Saccostrea cucullata* (Born, 1778)	–	–	–	–	–	–	–	+	–
6	*Ctena decussata* (O. G. Costa, 1829)	+	–	–	–	–	–	–	–	+
7	*Cardita variegata* (Bruguiere, 1792)	–	+	+	–	–	–	–	–	–
8	*Barbatia decussata* (G. B. Sowerby I, 1833)	–	–	–	+	+	–	+	–	+

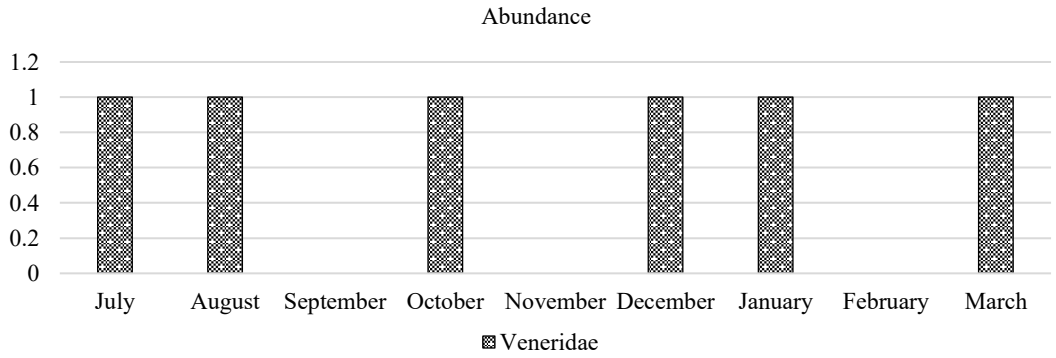

Figure 3. Monthly abundance patterns of *Veneridae* showing peaks in July, August, October, December, January, and March.

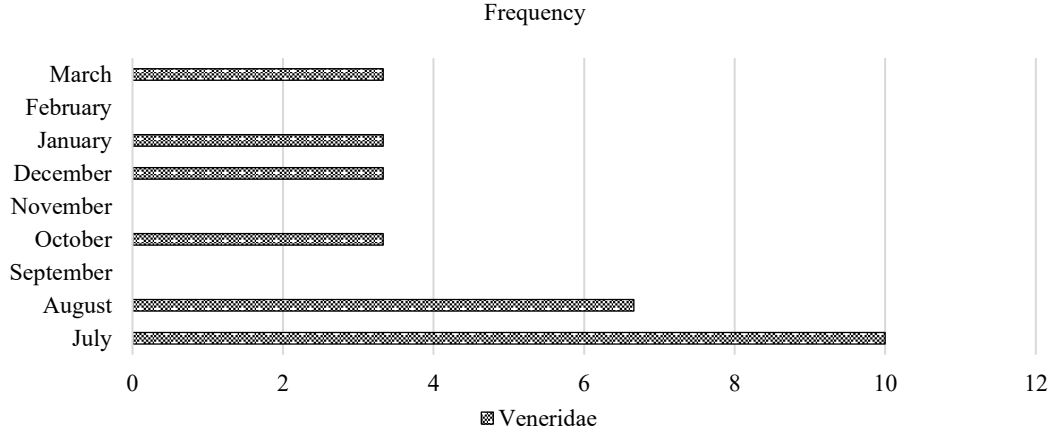

Figure 4. Monthly frequency distribution of *Veneridae* recorded at the Veraval coast (July–March).

Anthropogenic Impact and Conservation

The study further observed that the fragile ecosystem of Veraval is under constant threat from human-induced activities. Port operations, intensive fisheries, and improper waste disposal near the Jaaleshwar coast are putting immense pressure on the malacofauna. Similar concerns regarding urban pressure on marine habitats were highlighted in earlier regional studies (Pooja A. Agravat and Jatin V. Raval, 2019) [8]. These results underline the urgent need for consistent ecological monitoring to mitigate the impact of pollution and preserve the species diversity of the Veraval coast.

DISCUSSION

The intertidal bivalve community at Jaaleshwar coast, Veraval, exhibits a distinct pattern of diversity and distribution influenced by both environmental variables and habitat architecture. The identification of 8 species across 5 families confirms that this region remains a significant pocket of malacofauna diversity within the Saurashtra coastline, despite being subjected to high levels of anthropogenic stress (Agravat & Raval, 2019) [8].

Community Structure and Family Dominance

The taxonomic results highlight the dominance of the family Veneridae, which was represented by the highest number of species and the greatest diversity index. This dominance is consistent with the findings of Narasimham (2005), who noted that Venerid clams are among the most successful bivalve groups in Indian coastal waters due to their robust shell morphology and ability to thrive in mixed rocky–sandy substrates. Species, like *Gafrarium pectinatum* and *Sunetta scripta*, were particularly prevalent, likely benefiting from the complex architecture of the rocky–sandy patches that provide refuge from predators and wave action (Apte, 1998; Subba Rao, 2017) [3].

Seasonal Dynamics and Population Density

The most significant finding of this study is the peak in population density during the Monsoon season. This seasonal surge can be attributed to the nutrient enrichment of coastal waters through land run-off, which enhances primary productivity and provides ample food for filter-feeding bivalves (Dey, 2006). Similar patterns have been observed in other intertidal macro-invertebrate studies along the Gujarat coast, where the monsoon-induced drop in salinity and increase in nutrients create a favorable window for recruitment (Vaghela et al., 2010; Gohil & Kundu, 2012) [9].

Conversely, the sharp decline in density during the summer months suggests a high degree of environmental stress. The rocky intertidal zone at Veraval is characterized by tidal pools that experience extreme temperature fluctuations and high evaporation rates during the summer (Pandya, 2014) [12, 14, 15]. Such conditions lead to desiccation and thermal stress, which are detrimental to bivalve survival, particularly for species with thinner shells or those located in the upper intertidal zones (Dave & Chudasama, 2018) [6].

Spatial Distribution and Habitat Preference

The spatial distribution of bivalves across the vertical intertidal zones at Jaaleshwar reflects a clear zonation pattern. The presence of *Saccostrea cucullata* and *Crassostrea virginica* was largely restricted to the mid-to-high tide rocky surfaces, where they form dense clusters to minimize water loss (Poutiers, 1998). In contrast, the Venerids and Arcids were more common in the lower intertidal zones and sandy crevices, where they remain submerged for longer durations (Thivakaran & Kasinathan, 1990) [16].

Conservation Concerns

Despite the recorded diversity, the bivalve populations at Veraval are under significant pressure. The proximity of the study site to port operations and urban centers exposes these organisms to pollutants and habitat fragmentation. As filter feeders, bivalves are highly susceptible to the bioaccumulation of toxins, making them “sentinels” of the degrading health of the Veraval coast (Karthick et al., 2020) [4]. The findings of this study reinforce the need for a dedicated conservation framework that limits industrial discharge and regulates fishing activities to preserve the remaining malacofaunal diversity of the Saurashtra coast.

CONCLUSION

The present study confirms that the Jaaleshwar coast of Veraval is a significant habitat for marine bivalves, supporting 8 distinct species across 5 families. The research identifies the family Veneridae as the most dominant group, reflecting its strong adaptation to the rocky–sandy intertidal substrate of the Saurashtra coast. The data clearly indicates a seasonal population shift, with peak density during the Monsoon and a significant decline during the Summer due to environmental stress. While the current diversity is stable, increasing anthropogenic pressures from port activities and urban waste at Veraval remain a serious concern. This study underlines the necessity for regular ecological monitoring and sustainable management to preserve the malacofaunal heritage of the Gujarat coastline.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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