

Research article

# The Biparjoy Cyclone Impact on Molluscan Fauna Inhabiting Clifton Beach, Karachi

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**Abstract**

Intertidal zones are dynamic marine ecosystems subjected to constant tidal fluctuations, exposing organisms to physicochemical stress and environmental variability. Cyclones, such as the Biporjoy Cyclone that impacted the Arabian Sea in June 2023, pose significant threats by inducing mortality, displacement, and altering species communities. Sandy beaches, lacking a solid substratum, exacerbate these effects, making them susceptible to sediment displacement and suspension. This study investigates the impact of Cyclone Biporjoy on molluscan communities at Clifton Beach, Karachi. Sampling conducted in June 2023 revealed notable shifts in species composition post-cyclone. *Nevirita didyma* emerged as the most abundant mollusc, indicating disturbances caused by the cyclone. *Marcia opima* also showed increased numbers. The findings underscore the cyclone's profound impact on intertidal dynamics, highlighting implications for biodiversity and community structure. Moreover, ongoing plastic pollution exacerbates beach degradation, compounding environmental challenges. This research contributes valuable insights into the resilience and vulnerability of molluscan populations in coastal ecosystems, particularly in response to natural disturbances like tropical cyclones.

**Keywords:** Biparjoy Cyclone, Gastropoda, Bivalvia, Clifton beach, Intertidal zone

## 1. Introduction

Natural variation in the environment has been renowned as an organizing force in many communities, e.g. rocky intertidal invertebrates, algae and coral reefs [1]. Cyclones are natural phenomena that induce mortality, dislodgment, and alterations in the community structure of species. Tropical cyclones have varying effects on the marine environment including water column disturbance, increased sedimentation, and sudden short-term changes in the physico-chemical parameters [2]. Coastal regions, particularly sandy beaches are at higher risk for such events, as the consequences can be severe because of sediment movement and suspension [3]. Sessile marine organisms are more exposed to cyclonic effects than moveable species [4] Nevertheless, sedentary marine species (such as clams) have been impacted by a lack of energy to

migrate to another place [5]. Various studies have been published on the macrobenthic animals of Clifton Beach, particularly those belonging to phylum Mollusca. Ahmed and Hameed (1999), reported 11 gastropods and 4 bivalve species among other animal groups such as polychaetes, crustaceans etc. According to them, *Ergaea walshi* was the most abundant gastropod followed by *Bullia tranquebarica* (as *B. lineolate*) and *Babylonia spirata*. In the case of bivalve molluscs *Anadara inaequalvis* (as *Arca inaequalvis*) outnumbered the other three bivalve species [6]. The abundance and diversity of crustacean assemblages in the intertidal zone of Clifton Beach have been reported [7]. Another study reported the abundance, breeding, and growth of *Dotilla blanfordi*, a brachyuran crab in the family Ocypodidae [8]. Some observations on the benthic organisms has been reported at Clifton Beach which was badly

affected by the Taman Spirit oil spill in summer 2003 [9]. The only study that deals with the distribution, abundance, and diversity of intertidal macrobenthos, including molluscs, from Clifton Beach. They reported 49 species, of which 25 were molluscs (16 gastropods and 9 bivalves). Their study shows that the most abundant gastropods were *Umbonium vestiarium* and *Rhinoclavis fasciata*, whereas *Latona cuneata* (as *Donax cuneatus*) and *Cerastoderma edule* were the most abundant bivalves [10]. However, there is no publication on the impacts of cyclones on molluscan communities on the Clifton coast.

Intertidal zones represent one of the most dynamic divisions within marine ecosystems, characterized by continuous coverage and exposure due to tidal fluctuations. Organisms in these zones are subject to significant physicochemical stress during tidal changes, particularly between upper and lower intermediate zones. This stress includes exposure to air (desiccation) during low tide and variations in environmental parameters such as temperature and salinity. Unlike rocky shores, sandy beaches lack a hard substratum for benthic animals to settle on, making the shifting sand due to wave action a challenging living environment for these organisms. The sandy beach ecosystem is highly dynamic, with constant interactions between air, seawater, and sand. Benthos and epibenthos in this environment are highly vulnerable to both natural and human-induced disturbances. Over the past decade, there has been a continuous increase in terrestrial input, hydrodynamic processes, offshore dredging/mining, and beach nourishment due to growing populations and economies. These activities have reshaped the nearshore seafloor and disturbed habitat substrates to varying degrees. As a result, alterations in benthic communities have led to significant changes in abundance, density, productivity, and biodiversity [11]. Additionally, recovery from these disturbances may take longer than anticipated. Typically, the regular physical effects of waves and tides can enhance suspension and organic enrichment, which benefits filter feeders by helping them adapt and thrive [12].

In June 2023, the Biporjoy Cyclone entered the Arabian Sea, approaching the Pakistan coast between Mandvi in Gujarat

and Karachi near Jakhau Port (Figure 1). Classified as a severe cyclonic storm, it exhibited wind speeds ranging from 125 to 135 km/h. The Pakistan Meteorological Department issued detailed warnings, indicating that sea conditions would be extremely turbulent over the northeast and adjacent east-central Arabian Sea until June 15th, with a storm surge of approximately 2-3 meters above the astronomical tide. This cyclone was the longest-duration cyclone in Pakistan's recorded history lasting from June 6th to June 15th. Although the coastal belt of Sindh was not directly hit by the cyclone the coastal area experienced rough sea with very high tides and strong winds resulting in changes in the benthic assemblages on the shore.

This study is conducted to collect information regarding molluscs occurring at Clifton Beach in the month of June 2023, when the beach was under the influence of tropical cyclone Biparjoy.

## 2. Material and methods

Clifton Beach (24°47'09.22"N 67°02'17.76"E) is a natural shoreline located along the southern coast of Karachi, Pakistan, facing the Arabian Sea (Figure 2). There is an abundance of very fine-grained sand <200µm [7] often enriched with diverse quantities of coarser mica flakes [10]. It experiences a semi-diurnal tidal pattern, which means it typically undergoes two high tides and two low tides within a 24-hours .

The Lyari River flows into the eastern side of this beach, while the Malir River meets its western side. Although these rivers are temporary, they carry the majority of the city's wastewater particularly during the rainy season (July and August) [13]. The beach is also important as a tourist point and people visit it frequently. Camel and horse riding, and beach buggy riding are some of the common activities people are involved in. Several eateries can be seen on the beach (Figure 3). All these activities disturb and pollute Clifton Beach

The present study was conducted to assess the impact of the Biparjoy cyclone on marine molluscs at Clifton beach Karachi, Pakistan. A 1m<sup>2</sup> quadrat was randomly placed 3 times to collect Marine gastropods and bivalves from the affected site to evaluate the total count of species that were washed ashore by the cyclone.

The literature used for identifying the molluscan species includes [14,15,16,17] and other relevant papers. The collection of abiotic data encompassed physical parameters such as seawater temperature and salinity. The temperature was taken by a mercury thermometer and the salinity was recorded by a hand-held refractometer (PAL-3 Atago).



**Figure 1.** Map showing the location of Clifton Beach along the Arabian Sea in Karachi.

### 3. Results

The molluscan fauna observed during the present study belonged to 20 families and 24 species. The total number of molluscs collected was 567, as shown in Table 1. Two classes of the phylum Mollusca were represented Gastropoda and Bivalvia. Gastropods comprised 11 families and 12 species

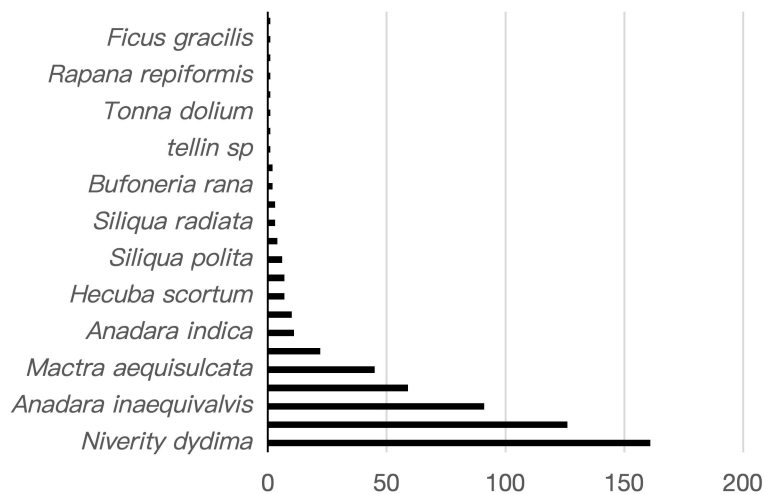
while bivalves comprised 9 families and 12 species. The abundance of class Bivalvia is 54% whereas the abundance of class Gastropoda is 46%. The three most abundant species of mollusc were *Anadara inaequalis*, *Marcia opima* and *Neverita dydima*.

Out of 567 specimens collected, 259 (46 %) were gastropods and 308 (54 %) were bivalves. Among gastropods the most abundant species was *Neverita didyma* represented by 161 individuals out of 259 (62.16 %) followed by *Babylonia spirata* 59 (22.78 %) and *Indothias lacera* 22 (8.49 %). These three species of gastropod constituted 93.43 % of all the gastropods encountered. Among the bivalve species *Mercia opima* was the most abundant with 126 individuals out of 308 (40.91 %). The next abundant species of bivalve was *Anadara inaequalis* with 91 individuals (29.55 %) followed by *Mactra equisulcata* with 45 individuals (14.61 %).

These three bivalve species accounted for 85.08 % of the total bivalves present in the collection (Figure 2). The recorded physical parameters included a temperature of 32°C and a salinity of 35 ppt. Most organisms were found freshly dead, interspersed with plastic debris, and distributed extensively along the coast.



**Figure 2.** The intertidal area of the Clifton sandy beach shows the blanket of molluscs all over the beach.



**Figure 3.** Numerical abundance of molluscan species at Clifton Beach (combined data of high, mid, and low tide marks).

**Table 1.** Cumulative percentage of microbenthic molluscs collected from Clifton Beach

Species	No. of individuals	Percentage %	Cumulative percentage %
<i>Neverita didyma</i>	161	28.395	28.395
<i>Marcia opima</i>	126	22.222	50.617
<i>Anadara inaequalvis</i>	91	16.049	66.666
<i>Babylonia spirata</i>	59	10.406	77.072
<i>Mactra aequisulcata</i>	45	7.936	85.008
<i>Indothais lacera</i>	22	3.880	88.888
<i>Anadara indica</i>	11	1.940	90.828
<i>Atrina pectinata</i>	10	1.764	92.592
<i>Hecuba scortum</i>	7	1.235	93.827
<i>Olivia bulbosa</i>	7	1.235	95.061
<i>Siliqua polita</i>	6	1.058	96.119
<i>Solen ceylonensis</i>	4	0.705	96.825
<i>Siliqua radiata</i>	3	0.529	97.354
<i>Perna viridis</i>	3	0.529	97.883
<i>Bufonaria rana</i>	2	0.353	98.236
<i>Tibia curta</i>	2	0.353	98.589
<i>Tellinimactra edentula</i>	1	0.176	98.765
<i>Tellina sp.</i>	1	0.176	98.941
<i>Tonna dolium</i>	1	0.176	99.118
<i>Linatella caudata</i>	1	0.176	99.294
<i>Netica vitellus</i>	1	0.176	99.470
<i>Ficus gracilis</i>	1	0.176	99.647
<i>Rapana repiformis</i>	1	0.176	99.823
<i>Turricula nelliae spuria</i>	1	0.176	100
<b>Total no. of individuals</b>	<b>567</b>	<b>100</b>	

The presence of a strong odour of decaying organisms was notable in the air. This phenomenon, typically not observed on this beach, was documented during this study. The organisms appeared to have been dislodged by the severe

cyclonic waves and subsequently accumulated in the intertidal zone. However large clusters of specific kind of plastic debris, potentially originating from the shipping and fishing industries, were observed.



#### 4. Discussions

The results of the present study show that the most abundant species of molluscs in the intertidal zone of Clifton Beach, Karachi was a prosobranch gastropod *Nevirita didyma* which is commonly known as moon snail or moon shell. This species is common on sandy beaches of Karachi coast. It has been reported as *Natica didyma* in the old literature [18, 19, 20]. In 1999, Ahmed and Hameed studied animal communities of Clifton Beach reported that *N. didyma* was present in small number. They found only five specimens of this species during a period of 12 months. This does not replicate the findings of the present study in which 161 specimens were found in just one month (June, 2023) contributing 28.395 % of all the molluscs collected. Similarly, Ahmed and Hameed (1999) also found *Ergaea walshi* a gastropod as the most abundant molluscs on Clifton Beach, whereas it was not found in the present study. They did not mention the exact location of sampling stations on Clifton Beach and it may be possible that the location of sampling station of the present study was quite different.

Clifton beach Macro-benthos of *Donax cuneatus* (now *Latona cuneatus* according to World Register of Marine Species) as the most abundant species collected from station C2 which was near sewage outfall [21] whereas in the present study sampling was done away from the sewage discharge. However, this species was not found during the present study. This discrepancy in the results may be due to different sampling stations. *Latona cuneate* is known to occur in large number on the sandy beaches where organic load is high.

The second most abundant species of molluscs that was found in the present study was *Marcia opima* commonly known as Venus shell or fertile Venus (<https://www.conchology.be/>). This species of clam is edible hence commercially important [22]. It is usually found in protected coastal areas in sandy and muddy substrate, but it may also occur in backwaters and estuaries. It is suspension feeder filtering organic matter and planktonic algae from the water [23]. Although *Marcia opima* has been reported from Pakistani coast [10, 21, 24] who

studied Clifton Beach macrobenthic animals did not find this species. It may be possible that they had found *M. opima* in small number hence no mention. The occurrence of *M. opima* in large number (126 individuals out of 567) in the present study may be attributed to the Biparjoy cyclone in June, 2023. The rough sea and strong winds might have dislodged these clams from subtidal zone and deposited on the intertidal zone of the beach.

The significant deviations observed in our study compared to previous research are primarily attributed to the impact of Cyclone Biparjoy's wave action. The cyclonic turbulence led to a substantial detachment of mollusc shells from their habitats, resulting in their deposition in the intertidal zone. Severe storms generate near-bed currents and oscillatory flows that disrupt the substratum, exacerbating erosion and sediment transport processes. These disturbances are responsible for observed mass mortalities among gastropods and bivalves due to sediment deposition caused by Cyclone Biparjoy.

Species such as *Nevirita didyma*, *Marcia opima*, and *Anadara inaequalis* were notably affected, showing disrupted vertical distributions during the monsoon season, directly attributable to the cyclone's turbulence at Clifton Beach. Additionally, large accumulations of plastic debris, originating from fishing and shipping activities including discarded nets, lines, and packaging, exacerbated the environmental impact during and after the cyclone.

The deteriorating condition of Clifton Beach during Cyclone Biparjoy underscores the compounding effects of climate change, where warmer oceans contribute to cyclone intensification and potentially more severe coastal erosion. Despite not causing severe weather events of catastrophic scale, Cyclone Biparjoy significantly disrupted molluscan communities, highlighting the challenges faced by these ecosystems.

Understanding the ecological responses of benthic communities to storm disturbances remains challenging, hindered by limited real-time data availability during such events. Anticipated future adverse effects and increased mortality rates underscore the urgency for extensive research into the physiological

Understanding the ecological responses of benthic communities to storm disturbances remains challenging, hindered by limited real-time data availability during such events. Anticipated future adverse effects and increased mortality rates underscore the urgency for extensive research into the physiological

adaptations of organisms under escalating anthropogenic activities and global climate change pressures. This study thus emphasizes the critical need for comprehensive investigations into ecological and environmental stresses to enhance resilience and conservation efforts in coastal ecosystems.

## 5. Conclusion

The silver sandy beach of Clifton is a widespread picnic spot in Karachi. It is easily nearby by road and hence forth severely wedged by anthropological activity. Biparjoy is a Bengali term for disaster or bad luck. Cyclones are copious in the Indian Ocean, and they are frequently deadly, while cyclones are rare in the Arabian Sea. The Biparjoy incident at Clifton beach has significantly Impact on ecosystem. This event disrupted vertical distributions of species like *Nevirita didyma*, *Marcia opima*, *Anadara inaequalvis* and mainly depleted the Molluscan population dynamics and caused significant environmental damage throughout the beach. However, the plastic debris worsened situation during Cyclone. Present study highlighting the importance of empathetic to mitigate future antagonistic effects and recommend extensive research on the ecological adaptations of benthic ecosystem to prevent the future cyclonic events.

### Data Availability statement

Not applicable

### Conflicts of Interest

All authors declare that, they have no conflict of interest.

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### Author Contributions

Shahnaz Rashid: Conceptualization, Methodology, Supervision Review and Editing, Conceived and designed the analysis. Saedul Bibi: Collected the data, The first draft of the manuscript was written. Sumaiya Adil: Collected the data, The first draft of the manuscript was written. Rabia Bibi: Collected the data, The first draft of the manuscript was written. Ghulam Abbas : Contributed data or analysis tools, Review and Editing, provided critical feedback and helped

shape the research, analysis and manuscript. Shanila Khan: Collected the data, The first draft of the manuscript was written. Muhammad Wasim Khan: Collected the data, The first draft of the manuscript was written. Javed Mustaqim: Performed the analysis, Investigation, Writing -Original draft. Roquia Fatima: Collected the data, The first draft of the manuscript was written.

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