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Diversity of Molluscs at selected sites of district Devbhumi Dwarka, Gujarat, India

Gadhvi, M.K.*[1], Dudhagara, D.M. [1], Shiyani J.V. [1], Makda Zahra[1], Shabanam Saiyad[1] and Kardani H.K.[2]

[1]Department of Zoology, H. & H.B. Kotak Institute of Science, Rajkot, Gujarat, India
[2]Fisheries Research Station, Kamadhenu University, Sikka, Gujarat, India

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ABSTRACT

The intertidal zone is home to various invertebrate animals and the most dynamic marine environment. Among the entire invertebrate phylum, the mollusc is the second largest phylum in the coastal tropical climate. Molluscs are under pressure due to pollution & habitat change. Molluscs are also under pressure as exploitation is high due to their high demand for souvenirs and ornaments. This paper documents the diversity of phylum molluscs at the selected study sites of Devbhumi Dwarka. Two sites were selected in the mouth of the Gulf of Kachchh while the other two sites were selected in the coastal region of the Arabian Sea. The study was carried out during the monsoon and winter season from October 2021 to January 2022 for the collection of molluscs. Molluscs were identified using standard identification keys. Individual checklists for each site as well as a combined checklist of individual sites were prepared. The available literature on molluscs of Devbhumi Dwarka was reviewed and a comprehensive checklist of molluscs in Devbhumi Dwarka district was prepared. Total 56 molluscs of molluscs were recorded from four sites in the Devbhumi Dwarka district. A total of 150 species of molluscs were recorded from the available literature while 22 species were first time recorded in the current study. A total of 172 molluscs were listed in the paper.

Key words: *Checklist, Invertebrate, Intertidal area, Gulf of Kachchh,Arabian Sea*

Introduction

The tropical coastal environment is the most biologically diverse of all marine ecosystems. The intertidal zone is an important habitat for biota between the area of the high tide line and low tide (Kardani and Mankodi, 2014). It is the most dynamic zone between marine and terrestrial environments. The intertidal zone is also home to several species from different Phyla such as Porifera, Annelida, Coelenterata, Aarthropoda, Molluscs, etc. The Mollusca is the second largest phylum of invertebrates in the coastal tropical environment. These animals were found throughout the world in a wide range of habitats including marine, freshwater, and terrestrial. The Mollusca is an extraordinarily varied phylum with an estimated 80,000 to 1, 00,000 described species (Bhatt *et al.,* 2020). In India, 5,073 species of Molluscs have been recorded of which, 3370 marine Mollusc species (Nijman *et al.,* 2015). The Molluscs are a great source of human food in various parts of the world and Molluscan shells have been used for currency, jewelry, ornaments, tools, horns, medicine, and as magical or religious symbols. Molluscs are also used as a Bioindicator of their ecosystem's pollution; hence play a pivotal role in ecological studies

of an aquatic ecosystem. As part of their aesthetic and commercial value, Molluscs are under pressure due to anthropogenic activity around the coastal habitat.

Gujarat has a 1650 km long coastline, which is the longest of any state in India (Solanki, *et al*., 2016). In the coastline of Gujarat, the Gulf of Kachchh (GoK) is the most significant area in terms of marine biodiversity. The ever-growing industrialization in this coastal region is a major threat to the marine ecosystem. Devbhumi Dwarka is situated at the Mouth of GoK and is an important pilgrimage place. The annual tourist population reached 5 to 6 Lakhs (Kapdiya, 2018). Due to this tourist population, there is high demand for unique ornaments and souvenirs of marine molluscs. These high demands of molluscs lead to exploitation pressure on molluscs. Diversity record is the first step to conserving diversity. The present paper investigates the diversity and distribution of molluscs on rocky coasts, rocky-sandy beaches, and reef from selected study sites of district Devbhumi Dwarka.

Materials and Methods

Study Area

The Gulf of Kutch is the richest coastal region of Gujarat having ecologically different ecosystems like; coral reefs, mangroves, and sea grass (Lakhmapurkar, 2022). Devbhumi Dwarka district has a subtropical desert/low-latitude, arid hot climate. The average annual rainfall is 404 millimeters and the average annual humidity 56% (Dave, *et al*., 2017). Atmospheric temperature varies from 390C to 280c (www.timeanddate.com). The selected study sites describe below. Two study sites are situated at the Mouth of the Gulf of Kachchh while two sites are situated in the coastal region of the Arabian Sea (Fig. 1).

Site-1: Dwarka (Bhadkeshwar Mahadev Temple) (Latitude: 22.244306N, Longitude: 68.954256E) is situated southern range of the Arabian Sea. It inhibits rocky substratum and also consists of patches of dunes and mudflats.

Site-2: Bet Dwarka (Invincible campsite) (Latitude: 22.465631N, Longitude: 69.106210E) is situated at the mouth of the Gulf of Kutch. The shore of Invincible is partially covered with sand bar and some parts have rocky substratum.

Site-3: Okha (Latitude: 22.470801N, Longitude: 69.069230E) is situated on the westernmost coast of India and the north side of the Saurashtra coast at the Arabian Sea. It inhibits rocky substratum.

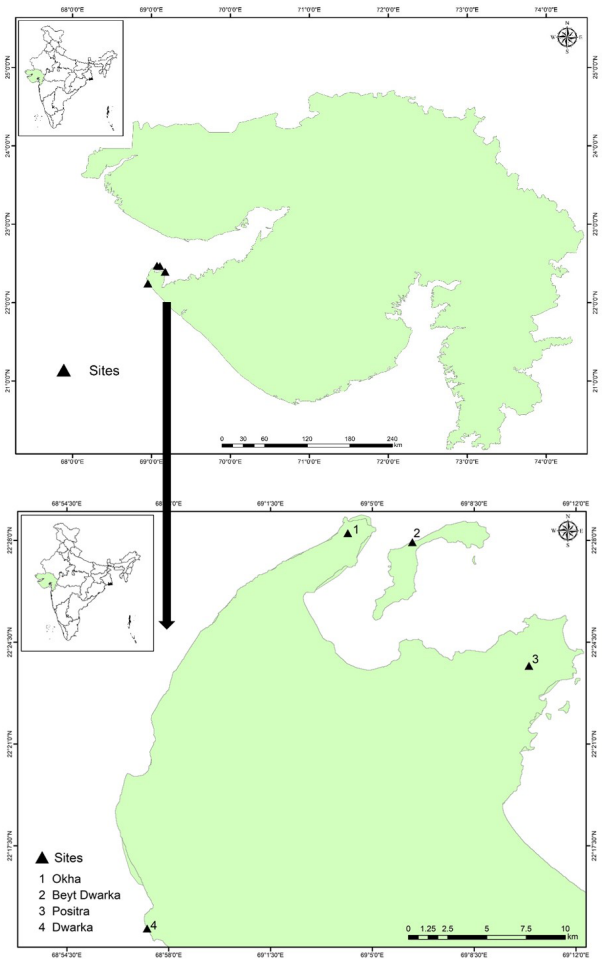

Fig. 1. Map of Study site

Site-4: Poshitra (Latitude: 22.394785N, Longitude: 69.173036E) is located in the mouth of the Gulf of Kutch on the east side of Okha. It is a reef consisting of live coral reef, dead corals with rocky, sandy, and muddy patches followed by mangrove forests.

Methodology

A study has been carried out during monsoon and winter from October 2021 to January 2022 for the collection of molluscs. Mollusc shells were collected and photographed by handpicking during low tide in the intertidal area. Live animals were photographed precisely so all the morphological characters shall be recorded for identification. Dead shells were brought to the laboratory and the shells were

Table 1. List of Identified molluscs species from selected sites of Devbhumi Dwarka district

Sr No.	Family	Genus species	Dwarka	Bet Dwarka	Okha	Positra
1	Turbinidae	*Turbo bruneus(green form)*	1		1	
2	Muricidae	*Purpura panama*	1			
3	Nassariidae	*Nassariusdistortus*	1			
4	Muricidae	*Chicoreuscapucinus*	1			
5	Tegulidae	*Tectus tentorium*	1	1	1	
6	Trochidae	*Monodontaaustralis*	1			
7	Pisaniidae	*Poliaundosa*	1			
8	Neritidae	*Narita albicilla*	1			
9	Columbellidae	*Pyrene flava*	1		1	
10	Conidae	*Conus quercinus*	1			
11	Cypraridae	*Austrocypraeareevei*	1	1	1	
12	Cypraridae	*Erroneaerrones*	1			
13	Cymatiidae	*Monoplexaquatilis*		1		
14	Turritellidae	*Turritella radula*		1	1	
15	Terebridae	*Duplicariaduplicata*		1		
16	Olividae	*Oliva carneola*		1		
17	Drilliidae	*Clavusaglaia*		1		
18	Strombidae	*Strombusepidromus*		1		
19	Muricidae	*Ergalataxcontracta*		1	1	
20	Turbinidae	*Turbo bruneus(Brown form)*		1	1	
21	Neritidae	*Neritaoryzarum*		1		
22	Trochidae	*Clanculusscabrosus*		1		
23	Neritidae	*Neritabalteata*		1		
24	Architectonicidae	*Architectonicalaevigata*		1	1	
25	Patellidae	*Patella spp.*		1		
26	Columbellidae	*Mitrellascripta*		1		
27	Angariidae	*Angariadelphinus*			1	
28	Neritidae	*Nerita sp.*			1	
29	Neritidae	*Neritaundata*			1	
30	Chilodontaidae	*Euchelus asper*				
31	Cerithiidae	*Clypeomorusbifasciata*			1	
32	Cerithiidae	*Cerithiumcaeruleum*			1	
33	Cerithiidae	*Cerithiumcoralium*			1	
34	Melongenidae	*Volegaleacochlidium*				1
35	Rostellariidae	*Tibia curta*				1
37	Neritidae	*Neritainsculpta*				1
36	Bursidae	*Bufonariaechinata*				1
38	Mitridae	*Strigatellascutulata*				1
39	Muricidae	*Chicoreusvirgineus*				1
40	Trochidae	*Trochuskotschyi*				1
41	Veneridae	*Dosiniacretacea*		1	1	
42	Carditidae	*Carditesbicolor*		1		
43	Arcidae	*Anadarainaequivalvis*		1		
44	Veneridae	*Venus reticulata*		1		
45	Veneridae	*Dosiniaprostrata*		1		
46	Cardiidae	*Vepricardiummultispinosum*		1		
47	Arcidae	*Anadara gubernaculum*		1		
48	Mactridae	*Mactraviolacea*	1		1	
49	Veneridae	*Dosiniaexoleta*	1	1		
50	Mactridae	*Lutrariarhynchena*				1
51	Veneridae	*Tapes literatus*				1
52	Veneridae	*Paphiavernicosa*				1
53	Arcidae	*Barbatiaobliquata*				1
54	Veneridae	*Pelecyora nana*		1		1
55	Dentaliidae	*Dentaliumoctangulatum*		1		
56	Muricidae	*Murex trapa*				1

brushed to clean the fouling biomass andmud. They were then stocked in filtered seawater pumped in the laboratory from the localities for observation then animals were preserved in 70% alcohol for taxonomical identification of animals (Kardani and Mankodi, 2014). Animals were identified using standard identification keys (Kamboj *et al.,* 2019; Apte, 2012). Individual checklists of all the sites and a combined checklist were prepared. Species richness indices and correlation of four sites were calculated in PAST software19 (Hammer et al., 2001). The available literature on Molluscs on the diversity of Devbhumi Dwarka was reviewed and a comprehensive checklist of Molluscs of Devbhumi Dwarka was prepared. All the listed species on the checklist were examined for their correct and accepted scientific names on WoRMS (World Register for Marine Species) and Molluscbase.org and Encyclopedia of Life (eol.org).

Results

During the present study total of 56 species belonging to 31 families of Phylum Molluscs were recorded from four sites in District Devbhumi Dwarka, Gujarat, India (Table 1, Plate 1, 2, 3, 4). The highest number of species belong to the class Gastropoda (41 species), followed by the class Bivalve (14 species) and Scaphopoda (1 species). The highest num-

Table 2. Species Diversity Indices of all selected sites

	Dwarka	Bet Dwarka	Okha	Poshitra
Taxa_S	12	26	15	15
Menhinick	3.464	5.099	3.873	3.873
Margalef	4.427	7.673	5.17	5.17

Plate 1. Pictures of Identified species from selected sites (numbers as per the name given name in Table 1)

Plate 2. Pictures of Identified species from selected sites (numbers as per the name given name in Table 1)

Plate 3. Pictures of Identified species from selected sites (numbers as per the name given name in Table 1)

Plate 4. Pictures of Identified species from selected sites (numbers as per the name given name in Table 1)

Table 3. Checklist of molluscs of Devbhumi Dwarka district recorded by literature review and current work

	Class	Order	Family	Species	Gopalkrishnan, 1970					Sarvaiya, 1977				Thakur & Soni, 2015	Current work, 2021-22			
					Dwarka	Okha	Adatra Reef	Beyt Dwarka	Balapur	Okha	Dwarka	Sikka	Poshitra	Beyt Dwarka	Dwarka	Bet Dwarka	Okha	Positra
1	Gastropoda	Trochida	Turbinidae	*Turbo intercostalis*	Yes	Yes	Yes	Yes		Yes								
2				*Astreasemicostata*		Yes		Yes		Yes				Yes				
3				*Turbo coronatus*		Yes				Yes				Yes				
4				*Turbo brunneus*										Yes	Yes	Yes	Yes	Yes
5			Trochidae	*Trochussp*		Yes												
6				*Monodontaaustralis*				Yes						Yes	Yes			
7				*Trochusradiatus*				Yes						Yes				
8				*Clanculusceylanicus*										Yes				
9				*Isandacrenulifera*										Yes				
10				*Clanculusscabrosus*												Yes		
11				*Angariadelphinus*												Yes		
12				*Trochuskotschyi*											Yes			
13		Balano-morpha	Tetraclitidae	*Tetraclitrasp*	Yes													
14		Cycloneritida		Neritidae	*Neritarumphii*	Yes	Yes											15
				Neritaalbicella		Yes		Yes							Yes			
16				*Neritadombeyi*						Yes								
17				*Neritaoryzarum*										Yes		Yes		
18				*Neritabalteata*												Yes		
19				*Neritainsculpta*														Yes
20				*Neritaundata*													Yes	
21		Littorinimorpha		Cypraeidae	*Cypreaocellata*	Yes		Yes										
22				*Cypreaarabica*	Yes													
23				*Cyprea lynx*		Yes	Yes											
24				*Cypreacarneola*		Yes												
25				*Cypreamoneta*		Yes												
26				*Cyprea onyx*			Yes											
27				*Cypreasp*						Yes								
28				*Cypreatigris*										Yes				
29				*Erosariaocellata*										Yes				
30				*Monetariamoneta*										Yes				
31				*Ornamentaria annulus*										Yes				
32				*Erosariaturdus*										Yes				
33				*Pustularia globules*										Yes				
34				*Ravitronacaputserpentis*										Yes				
35				*Talostolidateres*										Yes				
36				*Talpariatalpa*										Yes				
37				*austrocypraeareevei*											Yes	Yes	Yes	
38				*Erroneaerrones*											Yes			
39				*Arabica depressa*										Yes				
40				*Arabica histrio*										Yes				
41			vermetidae	*Vermetessp*		Yes	Yes	Yes										
42			Naticidae	*Sinumcuvierianum*		Yes												
43				*Naticalamarckii*				Yes										
44				*Naticarufa*										Yes				
45				*Naticatigrina*										Yes				
46				*Natica vitellus*										Yes				
47			Bursidae	*Bursa granularis*		Yes		Yes										

Table 3. *Continued ...*

	Class	Order	Family	Species	Gopalkrishnan, 1970					Sarvaiya, 1977				Thakur & Soni, 2015	Current work, 2021-22			
					Dwarka	Okha	Adatra Reef	Beyt Dwarka	Balapur	Okha	Dwarka	Sikka	Poshitra	Beyt Dwarka	Dwarka	Bet Dwarka	Okha	Positra
48				*Bursa tuberculata*										Yes				
49				*Bursa spinosa*										Yes				Yes
50			Ovulidae	*Calpurnuslacteus*										Yes				
51			Cymatiidae	*Monoplexaquatilis*												Yes		
52			Strombidae	*Strombusepidromus*												Yes		
53		Caenogas-tropoda	Potamididae	*Cerithidaefluviatilis*		Yes	Yes											
54				*Telescopium telescopium*				Yes	Yes									
55			Cerithiidae	*Cerithiumsp*		Yes												
56				*Cerithiumobeliscus*					Yes									
57				*Cerithiumscabridium*					Yes									
58				*Clypeomorusbifasciata*													Yes	
59				*Cerithiumcaeruleum*													Yes	
60			Turritelli	*Turritellaacutangula*		Yes		Yes										
61			dae	*Turritellacolumnaris*				Yes										
62				*Turitella radula*												Yes	Yes	
63			Epitonoidae	*Ianthinasp*		Yes												
64			Planaxidae	*Planaxissulcatus*										Yes				
65			Rostellariidae	*Tibia curta*										Yes				Yes
66		Neogas-tropoda	Muricidae	*Nassa hepatica*		Yes		Yes										
67				*Murex adustus*				Yes										
68				*Thais rudolphi*		Yes		Yes		Yes				Yes				
69				*Murex vergineus*									Yes					
70				*Murex trapa*									Yes					Yes
71				*Thais rugosa*									Yes					
72				*Chicoriusramosus*										Yes				
73				*Chicoriusvirgineus*										Yes				Yes
74				*Drupacontracta*										Yes		Yes	Yes	
75				*Hexaplexcichoreus*										Yes				
76				*Murex pecten*										Yes				
77				*Nassafrancolina*										Yes				
78				*Thais intermedia*										Yes				
79				*Purpura panama*														
80				*Chicoreuscapucinus*														
81				*Drupakonkanensis*										Yes				
82			Pisanidae	*Cantharusundosus*		Yes								Yes	Yes			
83			Olividae	*Oliva gibbosa*		Yes		Yes		Yes								
84				*Oliva lepida*				Yes										
85				*Oliva nebulosa*				Yes										
86				*Olivia caerulea*										Yes		Yes		
87			conidae	*Conus piperatus*		Yes												
88				*Conus planorbis*										Yes				
89			Nassariidae	*Nassathersites*				Yes										
90				*Nassariasuturalis*										Yes				
91				*Nassaornatus*										Yes				
92				*Nassariusnodifera*										Yes				
93				*Nassariusolivacea*										Yes				

Table 3. *Continued ...*

	Class	Order	Family	Species	Gopalkrishnan, 1970					Sarvaiya, 1977				Thakur & Soni, 2015	Current work, 2021-22			
					Dwarka	Okha	Adatra Reef	Beyt Dwarka	Balapur	Okha	Dwarka	Sikka	Poshitra	Beyt Dwarka	Dwarka	Bet Dwarka	Okha	Positra
94				*Nassariusdistortus*														
95			Terebridae	*Duplicariaduplicata*				Yes								Yes		
96			babylonidae	*Babylonia spirata*					Yes									
97			Turbinellidae	*Xancuspyrum*						Yes								
98			Mitridae	*Chrysameambigua*										Yes				
99				*Strigatellascutulata*														Yes
100			Columbellidae	*Pyrene splendidula*										Yes				
101				*Pyrene flava*										Yes	Yes		Yes	
102				*Mitrellascripta*												Yes		
103			Drilliidae	*Clavuscrassa*										Yes		Yes		
104			Clavatulidae	*Surculaamicta*										Yes				
105			Turridae	*Turrisindica*										Yes				
106			Melogenidae	*Hemifususcochlidium*										Yes				Yes
107			Pisaniidae	*Poliaundosa*														
108		Nudibranchia		Discodorididae *Kentrodorisfunebris*			Yes	Yes										
109			Tethydidae	*Meliberangii*		Yes			Yes									
110			Aeolidiidae	*Eolis sp*			Yes											
111			Polyceridae	*Placomopherusceylanicus*					Yes									
112		Systellommapophora		Onchidiidae *Oncidiumverruculatum*				Yes	Yes		Yes							Yes
113		Aplysiida	Aplysiidae	*Aplysiabenedicti*		Yes		Yes										
114		Lepetellida	Fissurellidae	*Diodara lima*										Yes				
115		Seguemziida		Chilodontaidae *Euchelus asper*					Yes									Yes
116				*Euchelustricarinata*										Yes				
117		__	Patellidae	*Patella radiata*		Yes		Yes										
118		__	__	*Patella spp.*														
119		__	Plakobranchoidae	*Elysiagrandifolia*					Yes									
120		__	Architectonicidae	*Atchitectonialaevigata*						Yes								Yes
Yes																		
121		__	Nacellidae	*Cellanaradiata*										Yes				
122		__	__	*Branchyodontskarachiensis*										Yes				
123		__	__	*Retina cotata*										Yes				
124	Cephalopoda	Octopoda	Octopodidae	*Octopus sp*		Yes	Yes	Yes				Yes						
125		Sepiida	Sepiidae	*Sepia sp*		Yes	Yes	Yes										
126				*Sepiellaintermis*							Yes							
127		Myopsida	Loliginidae	*Loligosp*							Yes							
128	Bivalvia	Mytilida	Mytilidae	*Lithophagussp*			Yes											
129		Ostreida	Ostreidae	*Ostreacuculata*			Yes		Yes									
130				*Astreastellata*										Yes				
131			pinnidae	*Pinna vexillum*					Yes									
132				*Pinna bicolor*					Yes			Yes						
133		Pectinida	Placunidae	*Placuna placenta*			Yes		Yes				Yes					
134			Pectinidae	*Chlamystranquebaricus*										Yes				
135		Cardiida	Cardiidae	*Cardiumsp*				Yes										
136				*Cardiumflavum*										Yes				
137				*Cardiumsetosum*										Yes				
138				*Vepricardiummultispinosum*												Yes		
139			psammobiidae	*Solenocurtissp*					Yes									

Table 3. *Continued ...*

	Class	Order	Family	Species	Gopalkrishnan, 1970					Sarvaiya, 1977			Thakur & Soni, 2015	Current work, 2021-22			
					Dwarka	Okha	Adatra Reef	Beyt Dwarka	Balapur	Okha	Dwarka	Sikka	Poshitra	Beyt Dwarka	Dwarka	Bet Dwarka	Okha	Positra
140				*Pasmmobiaradiata*										Yes				
141		venerida	veneridae	*Gaffrarlumaltwaricata*				Yes										
142				*Dosiniacretacea*										Yes		Yes	Yes	
143				*Dosiniaprostrata*										Yes		Yes		
144				*Gafrariumdivaricata*										Yes				
145				*Paphia ala-papilionis*										Yes				
146				*paphiamalabarica*										Yes				
147				*Sunettadonacina*										Yes				
148				*Venus reticulate*										yes		Yes		
149				*Dosiniaexoleta*													Yes	Yes
150				*Tapes literatus*														yes
151				*Paphiavernicosa*														Yes
152				*Pelecyora nana*												Yes		Yes
153				*Pitarerycina*								Yes						
154				*Dosiniarustica*										Yes				
155				*Periglyptafischeri*										Yes				
156				*Pita rerycina*										Yes				
157				*Catelysiaoptima*										Yes				
158			Mactridae	*Mactraviolacea*												Yes		Yes
159				*Lutrariarhynchena*														Yes
160		Arcida	Arcidae	*Arca gubernaculum*				Yes								Yes		
161				*Arcagranosa*										Yes				
162				*Arcatortuosa*										Yes				
163				*Anadarinaequivalvis*												Yes		
164				*Barbatiaobliquata*														Yes
165		Carditida	Carditidae	*Caraditabicolor*				Yes								Yes		
166				*Caraditaantiquata*										Yes				
167				*Benguina variegate*										Yes				
168		Adape-donta	solenidae	*Solensp*					Yes									
169	Polyplaco-phora	Chitonida	ischnochitoi dae	*Ischnochitonsp*						Yes								
170			Chitonidae	*Chiton sp*		Yes												
171	Scaphopoda	Dentellida	Dentaliidae	*Dentaliumoctangulatum*										Yes		Yes		
172				*Dentaliumeiph*										Yes				

ber of species recorded from the family Veneridae (7 species) followed by Neritidae and Muricidae (5 species) followed by Trochidae, Cerithiideae, and Arcidae (3 species). A total of 12 species were recorded from site 1, 26 from site 2, and 15 species from site 3 & site 4. Species richness indices of the four sites showed in Table 2.

An updated checklist compiled with a corrected scientific name of marine Mollusc of Devbhumi Dwarka by reviewing available literature on a diversity of Molluscs (Gopalkrishnan, 1970, Sarvaiya, 1977, Thakur & Soni, 2015). A total of 150 species of Molluscs were recorded from the available literature while 22 species were first time recorded by the current study in Devbhumi Dwarka district. A total, of 172 Molluscs were listed belonging to, 61families, and 24 orders under 5 classes (Table 3). The highest number of species belong to the class Gastropoda (126 species), followed by the class Bivalve (41 species), Cephalopoda (4 species), Polyplacophora (2 species), and

Table 4. Linear r (Pearson) Correlation between selected sites of Devbhumi Dwarka

	Dwarka	Bet Dwarka	Okha	Poshitra
Dwarka		0.019381	0.57164	0.017713
Bet Dwarka	0.019381		0.98315	0.00217
Okha	0.57164	0.98315		0.040398
Poshitra	0.017713	0.0021695	0.040398	

Scaphopoda (2 species) (Figure 2).

Discussion

In the present study highest species were recorded from the Bet Dwarka site as there are sandy and rocky substratum are presently providing two microhabitats. At Dwarka and Okha sites only rocky substratum whereas at Poshitra consist of reef substratum. Linear r (Pearson) Correlation suggests Dwarka site has a high correlation with Okha site is highly expected as both consist of a rocky substrate and both are directly facing the Arabian Sea (Table 4). Bet Dwarka site shows a high correlation with Okha site is slightly surprising but understandable with the fact that Bet Dwarka site also consists of a rocky substrate like Okha site and linear distance is very less between two sites (Table 4). Poshitra site is very less correlated with the other three sites as it consists of different substratum than other three sites.

Conclusion

Devbhumi Dwarka district. A checklist of 172 mollusc species was compiled from available literature including 22 species recorded for the first time in this study from Devbhumi Dwarka district. As the tourist rush is very high in Devbhumi Dwarka district demands for molluscs as souvenirs and ornaments are also high and there is no study available on the exploitation of molluscs in the district. We conclude that the diversity of mollusc is very high in the Devbhumi Dwarka district there are need to study the exploitation of molluscs and also a quantitative analyst of an exploited mollusc is necessary.

Conflict of interest

There is no conflict of interest between authors.

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