



Malacofaunal Diversity and Abundance along the Coastline of Gaddani, Balochistan

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ABSTRACT

This paper deals the diversity and abundance of molluscs along the coast of Gaddani, Balochistan. A total of 2997 specimens of 4 different classes (Gastropoda, Bivalvia, Polyplacophora and Cephalopoda) of phylum Mollusca were collected. 1930 specimens of 216 species of 38 families of class Gastropoda were recorded while 1059 specimens of 134 species of 24 families of class Bivalvia, 7 specimens of one species of one family of Cephalopodes and one specimen of class polyplacophora were collected. Family Trochidae Rafinesque, 1815 with 28 species while family Veneridae Rafinesque, 1815 with 25 species, which were found in highest species richness of class Gastropoda and Bivalvia, respectively from this coast. Family Littorinidae Children, 1834 was found in highly abundance of 19% (370 specimens of total collection of Gastropoda), while family Ostreidae Rafinesque, 1815 of Bivalvia, with 28% of abundance (296 specimens). Simpson's diversity index was very high about 0.893 and 0.869 of Gastropoda and Bivalvia, respectively.

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Authors' Contribution

SR: Conceived the Idea of research and supervised the study; NA and ZA: Performed the experimental work, and analyzed the data; SR and RM: writing of original draft of the manuscript; SR: Revised the manuscript.

Key words

Malacofauna, Gaddani, Diversity, Simpson's Diversity of Index (SDI), Balochistan.

INTRODUCTION

Malacofauna means molluscs of an area. Molluscs are benthic macro invertebrates which play an important part in intertidal ecosystem (Rajendra and Sivaperuman, 2020). They are found in many parts of the biosphere such as ocean, brackish, freshwater and terrestrial areas. Molluscs are one of the leading groups of ocean communities contributing mainly to the local biodiversity (Rueda *et al.*, 2009; Rubal *et al.*, 2018). Molluscs are one of the most diverse phylum in terms of species diversity, showing a diverse variety of form, size, colour and shape. They provide a vital source of protein for human after fish (Khan and Liu, 2019). Besides food they are also valuable in different industries such as jewelry, medicine, dyes and cement.

Woodwards (1856) was probably the first to report marine molluscs from Pakistan. In the recent past several reports have appeared on the molluscs from the coastline of Pakistan (Tirmizi and Zehra, 1982; Moazzam and Ahmed, 1994; Kazmi and Naushaba, 2004; Kazmi *et al.*, 2019; Barkati and Rehman, 2005; Khanum *et al.*, 2020), through the information on molluscs from Balochistan coast is limited (Khan and Dastagir, 1971; Tirmizi and Zehra, 1982; Afsar *et al.*, 2012; Ghani and Afsar, 2017; Gondal *et al.*, 2020).

The aim of this study to initiate study the diversity of Mollusca from Balochistan coast. This study will help to develop a plan to conserve marine molluscan diversity from Balochistan. The information should be useful for fisheries biologists as well as shell fisheries managers to determine the fishing efforts for this shellfishery from Pakistani waters.

MATERIALS AND METHODS

Samples were collected from coast of Gaddani (25° 07' N, 66° 43' E) Balochistan frequently visiting at low tide on monthly basis from June 2022 to November 2022. The sites were thoroughly investigated for molluscan diversity and their distribution pattern. Samples of molluscs were

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collected as epifauna, and as infauna by using hand picking method. The tools like hammer, forceps, sieves, chisels were used to detach species from their substratum. Samples were sorted and preserved in 70% alcohol. The samples were properly labeled and then frozen until further investigation.

Identification of molluscs

Molluscan samples were identified on the basis of conchological characteristics such as shell characters, color and shape (Baharuddin *et al.*, 2018) also spire length and shape, mouth opening, opercula shape, umbilicus shape and size colour, and ornamentation of the shell were primarily used to identify the gastropoda. For bivalves shell, characters such as adductor muscle scars, pallial line and no of lateral tooth were noticed to identify the species using references of Roberts *et al.* (1982), FAO (1998) and Kazmi *et al.* (2019). The index of world register of marine species (WoRMS) and Marine Molluscan fauna of the Pakistani coastal waters, was checked for the authenticity of species taxonomy and identification.

Data analysis

Quantitative analysis were conducted for the study of occurrence and diversity. For this purpose, randomly three replicates quadrates of 1x1m² from each site was set, to detect the distribution and occurrence pattern of malacofauna in different coastal areas of Balochistan. Simpson's Diversity Index was calculated by Simpson diversity index equation as:

$$D = 1 - \sum n_i (n_i - 1) / N (N - 1)$$

where, D is diversity Index, n_i is number of organisms of a particular species, N is total number of organisms of all species.

RESULTS AND DISCUSSION

Diversity of Malacofauna in Gaddani

During study period 1930 specimens of 216 species of 38 families of gastropods were collected while 1059 specimens of 134 species of 24 families of Bivalvia, were reported. Seven specimens of one species of one family of Cephalopodes were collected while only one specimen of class polyplacophora was collected from Gaddani site (Fig. 1).

Simpson's Diversity Index (SDI) of families of Gastropoda from Gaddani was about 0.893 which shows the high diversity of families of Gastropoda of this area. While Simpson's Diversity Index (SDI) of Bivalvia from Gaddani was about 0.869 which shows less high diversity of Bivalvia of this site as compared to Gastropoda. Species richness of Gastropoda and Bivalvia were about 216 and

134, respectively, which was very high in this area. Month wise highest SDI of gastropods was observed in June 2022 which was about 0.9103 and least high SDI in July about 0.8552. SDI in September with 0.8638, in August was about 0.8658; 0.8740 in October and 0.8794 in November 2022. SDI of families of class Bivalvia was observed in June about 0.894, 0.882 in July, 0.880 in August, 0.828 in September, 0.843 in October and 0.826 in November. Which was shown the highest SDI in June while least high SDI in November 2022 (Fig. 2).

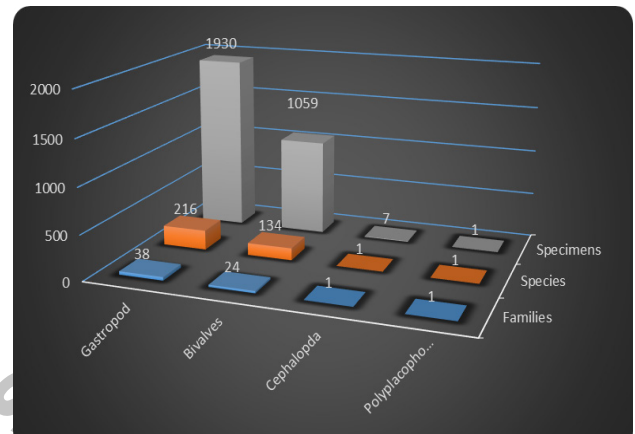


Fig. 1. Comparison of occurrence of 4 different classes of Mollusca and their families, species and specimens from Gaddani coast.

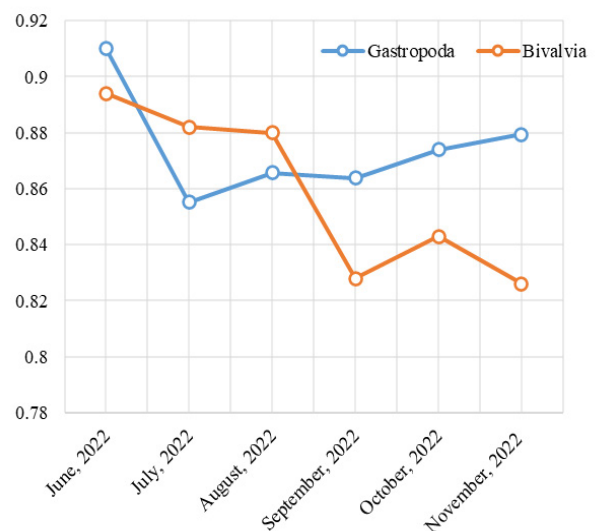


Fig. 2. Monthly Simpson Diversity Index (SDI) of families of Class Gastropoda and Bivalvia from Gaddani coast.

Class Gastropoda

Gastropods were reported in highest percentage of occurrence about 64% of total collection of malacofauna from Gaddani. Table I shows the name of species and families of Gastropoda which were collected which Table II shows % abundance of individuals and species of different families of Gastropoda in different months from June, 2022 to November 2022. Figure 3 shows the % of occurrence of 38 families of class Gastropoda. Species richness showed that much diversified class which were about 216 species. SDI of families of Gastropoda from Gaddani was about 0.893 which shown the high diversity of families of Gastropoda of this area. Family Littorinidae was found in highest % of abundance which about of (19%) out of 370 specimens of total collection of Gastropoda. Only one species *Nodilittorina sp.* of this family was collected in every month in high quantity. Out of 1815 highest number of species of any family 42 specimens of 28 species of family Trochidae Rafinesque, out of 1815 collected only during three months (June–August 2022) (Table I).

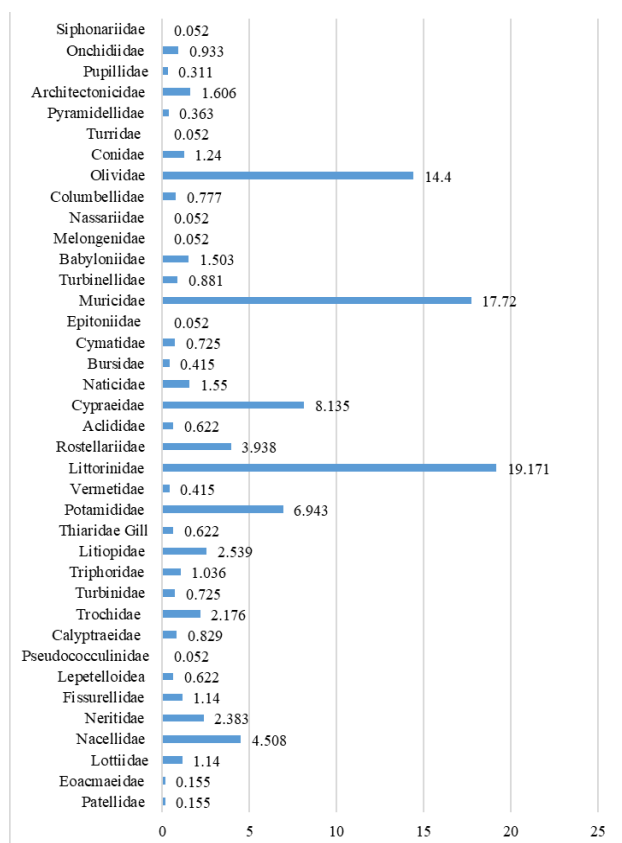


Fig. 3. Occurrence (%) of 38 families of class Gastropoda from Gaddani coast.

Table I. Gastropoda, 38 Families and 216 species collected from Gaddani coast.

Families/ Species
Patellidae Rafinesque, 1815
<i>Patella Swakopmundensis</i> W. Massier, 2009
<i>P. candei</i> d'Orbigny, 1758
<i>P. vulgata</i> Linnaeus, 1758
Eoacmaeidae Nakano and Ozawa, 2007
<i>Eoacmaea omanensis</i> (Christaens, 1975)
Lottiidae Gray, 1840
<i>Niveotectura pallida</i> A.A. Gould, 1859
<i>Erginus rubellus</i> (Fabricius, 1780)
<i>E. sybariticus</i> (W.H. Dall, 1839)
<i>Scurria parasitica</i> d'Orbigny, 1841
<i>S. variabilis</i> Sowerby, 1839
Nacellidae Thiele, 1891
<i>Cellana denticulate</i> (Martyn, 1784)
<i>C. flava</i> (Hutton, 1873)
<i>C. radians</i> (Gmelin, 1791)
<i>C. tramoserica</i> (Holtén, 1802)
<i>C. pricei</i> A.W. B. Powell, 1973
<i>C. synonymus</i> (L.A. Reeve, 1854)
<i>C. radiata</i> (Born, 1778)
Neritidae Rafinesque, 1815
<i>Nerita albicilla</i> Linnaeus, 1758
<i>N. versicolor</i> Gmelin, 1791
<i>N. chamaeleon</i> Linnaeus, 1758
<i>N. peloronta</i> Linnaeus, 1758
<i>N. funiculata</i> Menke, 1850
<i>N. olivaria</i> Le Guillou, 1841
<i>Neripteron (Dostia) bensoni</i> (Récluz, 1850)
<i>Nerita debilis</i> Dufo, 1840
Fissurellidae Fleming, 1822
<i>Diodora arcuata</i> Sowerby, 1862
<i>D. bombayana</i> Sowerby, 1862
<i>D. calyculata</i> (Sowerby, 1835)
<i>D. cayenensis</i> (Lamarck, 1822)
<i>D. demartinorum</i> Buzzurro and Russo, 2005
<i>D. dorsata</i> (Monterosato, 1878)
<i>D. galeata</i> (Helbing, 1779)
<i>D. inaequalis</i> Sowerby, 1835

Table continues on next page.....

Families/ Species
<i>D. italica</i> (Defrance, 1820)
<i>D. occidua</i> (Cotton, 1930)
<i>D. occitanica</i> (C.A.Receluz, 1843)
<i>D. aspera</i> (Rathke, 1833)
<i>D. occultata</i> Poppe and Tagaaro 2020
<i>D. philippiana</i> (Dunker, 1846)
<i>D. product</i> (Monterosato, 1880)
<i>D. singaporensis</i> (Reeve, 1850)
<i>D. multifida</i> (Deshayes, 1830)
<i>Montfortia submarginata</i> (Blainville, 1819)
<i>M. emarginata</i> (Blainville, 1825)
<i>Cemoria flemingiana</i> Leach, 1852
Lepetelloidea Dall, 1882
<i>Lepetella espinosae</i> Dantar and Luque, 1994
<i>L. barrajonii</i> Dantar and ALuque, 1994
<i>L. sierra</i> Dantar and Luque, 1994
<i>L. tubicola</i> Verrill and Smith, 1880
<i>L. wisshaki</i> Hoffman, 2018
<i>L. ionica</i> F.Nordsieck, 1997
Pseudococculinidae Hickman, 1983
<i>Kaiparapelta askewi</i> J.H.McLean and Harasewych, 1995
Calyptraeidae Lamarck, 1809
<i>Crepidula moulinsii</i> Michaud, 1829
<i>Crucibulum umbrella</i> Deshayes, 1830
<i>C. guiriguinae</i> Lesson, 1830
<i>C. auricular</i> Gmelin, 1790
<i>Crepidula walchi</i> (Reeve, 1859)
Trochidae Rafinesque, 1815
<i>Austrocochlea constricta</i> (Lamarck, 1822)
<i>Bankivia fasciata</i> (Menke, 1830)
<i>Cantharidus dilatatus</i> (G.B.Sowerby II, 1870)
<i>C. opalus</i> (Martyn, 1784)
<i>Clanculus flagellatus</i> (Philippi, 1849)
<i>C. undatus</i> (Lamarck, 1816)
<i>C. floridus</i> (Philippi, 1850)
<i>C. plebejus</i> (Philippi, 1851)
<i>C. limbatus</i> (Quoy and Gaimard, 1834)
<i>C. consobrinus</i> Tate, 1893
<i>C. maugeri</i> (W.Wood, 1828)
<i>Coelotrochus tiaratus</i> (Quoy and Gaimard, 1834)
<i>C. oppressus</i> (F.W.Hutton, 1878)
<i>Table continues on next column.....</i>

Families/ Species
<i>C. viridis</i> (Gmelin, 1791)
<i>Calliostoma zizyphinum</i> (Linnaeus, 1758)
<i>Diloma subrostratum</i> (Gray, 1835)
<i>Elaphriella eukhonikhe</i> Vilvens and Williams, 2016
<i>Gibbula magus</i> (Linnaeus, 1758)
<i>Jujubinus exasperatus</i> (Pennant, 1777)
<i>Oxystele impervia</i> (Menke, 1843)
<i>Prothalotia pulcherrima</i> (W.Wood, 1828)
<i>P. ramburi</i> (Crosse, 1864)
<i>Pomaulax gibberosus</i> (Dillwyn, 1817)
<i>Steromphala rarilineata</i> (Michaud, 1829)
<i>S. umbilicalis</i> (da Costa, 1778)
<i>Spectamen bellulum</i> (Angas, 1869)
<i>Trochus rota</i> Dunker, 1860
<i>Zethalia zelandica</i> (Hombron and Jacquinot, 1848)
Turbinidae Rafinesque, 1815
<i>Megastraea undosa</i> (Wood, 1828)
<i>Lunella (Subnina) undulata</i> (Lightfoot) 1786
<i>L. smaragda</i> (Gmelin, 1791)
<i>Turbo canaliculatus</i> Hermann, 1781
<i>Bolma rugosa</i> (Linnaeus, 1767)
<i>Pomaulax gibberosus</i> (Dillwyn, 1817)
<i>Turbo intercostalis</i> Menke, 1846
Triphoridae Gray, 1847
<i>Marshallora nigrocincta</i> (Adams, 1839)
<i>Magnosinister hedleyi</i> Laseron, 1954
<i>Nototriphora regina</i> (Hedley, 1903)
<i>Bouchettriphora pallida</i> (Pease, 1871)
<i>Monophorus angasi</i> (Crosse and Fischer, 1865)
<i>Inella rossiteri</i> Jousseaume, 1884
<i>Coriophora fusca</i> (Dunker, 1860)
<i>Monophorus monachus</i> (Hervier, 1898)
<i>Viriola morychus</i> Jousseaume, 1898
<i>Nototriphora regina</i> (Hedley, 1903)
<i>Talophora subulata</i> (Laseron, 1958)
Litiopidae Gray, 1847
<i>Diffalaba opiniosa</i> Iredale, 1936
<i>Alaba monile</i> A.Adams, 1862
<i>Dalliella brusinae</i> Cossmann, 1895
<i>Alaba culliereti</i> (Dautzenberg, 1890)
<i>Styliferina goniochila</i> A.Adams, 1860
<i>Table continues on next page.....</i>

Families/ Species	Families/ Species
<i>Alaba guayaquilensis</i> Bartsch, 1928	<i>Notocypraea declivis</i> (Sowerby II, 1870)
<i>Alaba incerta</i> (d'Orbigny, 1841)	<i>Melicerona felina subsp. fabula</i> (Kiener, 1844)
<i>Styliferina translucida</i> (Hedley, 1905)	<i>Naria lamarckii</i> (Gray, 1825)
<i>Litiopa bombix</i> Kiener, 1833	<i>Lyncina vitellus</i> (Linnaeus, 1758)
<i>Gibborissoia virgata</i> (Philippi, 1849)	<i>Erronea erronea</i> (Linnaeus, 1758)
Thiaridae Gill, 1871 (1823)	<i>Erronea (Erronea) ovum</i> (Gmelin, 1791)
<i>Melanoides (Melanoides) tuberculata</i> (O.F.Müller, 1774)	<i>Palmadusta androyensis</i> subspecies <i>Consanguinea</i> Blöcher and Lorenz, 2000
<i>Melania furfurosa</i> A.Gould, 1847	Naticidae Guilding, 1834
Potamididae Adams and Adams, 1854	<i>Polinices mammilla</i> (Linnaeus, 1758)
<i>Telescopium telescopium</i> (Linnaeus, 1758)	<i>Polinices peselephanti</i> (Link, 1807)
<i>Pirenella cingulata</i> (Gmelin, 1791)	<i>P. panamaensis</i> (Récluz, 1844)
Vermetidae Rafinesque, 1815	<i>P. candidissimus</i> (Le Guillou, 1842)
<i>Vermetus triquetrus</i> Bivona-Bernardi, 1832	<i>P. jukesii</i> (Reeve, 1855)
<i>Thylacodes sipho</i> (Lamarck, 1818)	<i>Neverita josephina</i> Risso, 1826
<i>T. adamsii</i> (Mörch, 1859)	<i>Natica vitellus</i> (Linnaeus, 1758)
<i>Eualetes tulipa</i> (Rousseau, 1843)	Bursidae Thiele, 1925
<i>Thylacodes squamigerus</i> (Carpenter, 1857)	<i>Tutufa rubeta</i> (Linnaeus, 1758)
Littorinidae Children, 1834	<i>Tutufa tenuigranosa</i> (E.A.Smith, 1914)
<i>Nodilittorina pyramidalis</i> (Quoy and Gaimard, 1833)	<i>Bufonaria echinata</i> (Link, 1807)
Rostellariidae Gabb, 1868	<i>Bufonaria rana</i> (Linnaeus, 1758)
<i>Tibia insulaechorab</i> Röding, 1798	<i>B. crumena</i> (Lamarck, 1816)
<i>T. curta</i> (G.B.Sowerby II, 1842)	<i>B. elegans</i> (Sowerby II, 1836)
<i>T. fusus</i> (Linnaeus, 1758)	Cymatidae Iredale, 1913
<i>T. delicatula</i> (G.Nevill, 1881)	<i>Cabestana tabulata</i> (Menke, 1843)
<i>Rostellaria palliata</i> Forbes, 1846	<i>C. spengleri</i> (Perry, 1811)
Calyptraeidae Lamarck, 1809	<i>Monoplex pilearis</i> (Linnaeus, 1758)
<i>Crepidula walchi</i> (Reeve, 1859)	Epitoniidae Berry, 1910
Aclididae G. O. Sars, 1878	<i>Epitonium clathrus</i> (Linnaeus, 1758)
<i>Austrorissopsis consobrina</i> (Tate and May, 1900)	Muricidae Rafinesque, 1815
Cypraeidae Rafinesque, 1815	<i>Purpura persica</i> (Linnaeus, 1758)
<i>Naria ocellata</i> (Linnaeus, 1758)	<i>P. bufo</i> Lamarck, 1822
<i>N. turdus</i> (Lamarck, 1810)	<i>Purpura Bruguière</i> , 1789
<i>Purpuradusta gracilis</i> (Gaskoin, 1849)	<i>Rapana venosa</i> (Valenciennes, 1846)
<i>Naria boivinii</i> (Kiener, 1844)	<i>Indothais lacera</i> (Born, 1778)
<i>Mauritia arabica</i> (Linnaeus, 1758)	<i>Hexaplex (Trunculariopsis) trunculus</i> (Linnaeus, 1758)
<i>Palmadusta clandestina</i> (Linnaeus, 1767)	<i>Dicathais orbita</i> (Gmelin, 1791)
<i>Erronea xanthodon</i> (Gray, 1832)	<i>Ocenebra erinaceus</i> (Linnaeus, 1758)
<i>Naria nebrites</i> (Melvill, 1888)	<i>Indothais malayensis</i> (Tan and Sigurdsson, 1996)
<i>Palmadusta humphreyii</i> (Gray, 1825)	<i>Thais tricolorata</i> Bozzetti, 2010
<i>Naria spurca</i> (Linnaeus, 1758)	<i>Thais bufo</i> (Lamarck, 1822)
<i>Cypraeovula algoensis</i> (Gray, 1825)	
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Families/ Species
<i>T. ambustulata</i> Hedley, 1912
<i>Murex (Murex) spinastreptos</i> Houart, 2010
<i>T. tricolorata</i> Bozzetti, 2010
<i>Murex (Murex) aduncospinosus</i> Sowerby, 1841
<i>Murex carbonnieri</i> (Jousseau, 1881)
<i>M. falsitribulus</i> Ponder and Vokes, 1988
<i>Murex (Tribulus) acanthostephes</i> Watson, 1883
<i>Murex (Murex) queenslandicus</i> Ponder and Vokes, 1988
<i>Murex trapa</i> Röding, 1798
<i>Murex (Murex) indicus</i> Houart, 2011
Turbinellidae Swainson, 1840
<i>Vasum muricatum</i> (Born, 1778)
<i>Turbinella pyrum</i> (Linnaeus, 1767)
<i>Vasum caestus</i> (Broderip, 1833)
Babyloniidae Habe and Oyama, 1971
<i>Babylonia valentiana</i> (Swainson, 1822)
<i>B. spirata</i> (Linnaeus, 1758)
Melongenidae Gill, 1871
<i>Pugilina cochlidium</i> (Linnaeus, 1758)
Nassariidae Iredale, 1916(1835)
<i>Nassarius persicus</i> (Martens, 1874)
Columbellidae Swainson, 1840
<i>Pyrene filmerae</i> (Sowerby Iii, 1900)
Olividae Latreille, 1825
<i>Oliva reticularis</i> Lamarck, 1811
<i>O. mustelina</i> Lamarck, 1811
<i>O. sayana</i> Ravenel, 1834
<i>O. julieta</i> Duclos, 1840
<i>O. incrassata</i> (Lightfoot) 1786
<i>O. bulbosa</i> (Röding, 1798)
<i>O. polypasta</i> Duclos, 1833
<i>O. australis</i> Duclos, 1835
<i>O. truncata</i> Marrat, 1867
<i>O. carneola</i> (Gmelin, 1791)
<i>O. concavospira</i> Sowerby, 1914
Conidae Fleming, 1828
<i>Conus mus</i> Hwass, 1792
<i>C. daucus</i> Hwass, 1792
<i>C. anemone</i> Lamarck, 1810
<i>C. angasi</i> Tryon, 1884
Turridae Adams and Adams, 1853
<i>Turricula javana</i> (Linnaeus, 1767)
Pyramidellidae Gray, 1840
<i>Turbonilla (Turbonilla)</i> Risso, 1826

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Families/ Species
Architectonicidae Gray, 1850
<i>Architectonica nobilis</i> Röding, 1798
<i>A. perdix</i> (Hinds, 1844)
Pupillidae Turton, 1831
<i>Pupoides albilabris</i> (Adams, 1841)
Onchidiidae Rafinesque, 1815
<i>Onchidella steindachneri</i> (Semper, 1882)
<i>Onchidium typhae</i> Buchannan, 1800
<i>Peronia peronii</i> (Cuvier, 1804)
Siphonariidae Gray, 1840
<i>Siphonaria denticulata</i> Quoy and Gaimard, 1833

Second abundant family was Muricidae with 342 (17.72%) specimens of 20 species. Highly abundant species was *Hexaplex (Trunculariopsis) trunculus* with 170 specimens were collected all months except Sep. and Oct., 2022.

Twenty two specimens of 20 species of family Fissurellidae Fleming, 1822 were collected. One specimen of *Cemoria flemingiana* Leach, 1852, *Diodora* 17 species (Reeve, 1850), *Montfortia submarginata* (Blainville, 1819) and *Montfortia emarginata* (Blainville, 1825) was found while 2 specimens of *Diodora occultata* Poppe and Tagaro, 2020 and *Diodora bombayana* Sowerby, 1862 were collected.

Family Cypraeidae Rafinesque, 1815 was found with 157 (8.13%) specimens of 18 species. 85 specimens of *Naria nebrites* were found every month, which was highly abundant species.

Eleven species of *Oliva* from family Olividae was found in 14% (278 specimens) of abundance of total collection of gastropoda from Gaddani. 65 and 57 specimens of *O. sayana* and *O. julieta* were collected from all months of collection.

Family Potamididae was found in relatively less abundance about (6.94%) 134 specimens of 2 species of gastropoda. 124 specimens of *Telescopium telescopium* (Linnaeus, 1758) were collected every month of collection while 10 specimens of *Pirenella cingulata* (Gmelin, 1791) were found only June 2022. 87 specimens of 7 species of *Cellana* of family Nacellidae was found in 4.51% of abundance. Highly abundant species *C. tramoserica* was found in every month of collection. Twenty specimens of 11 species of family Triphoridae Gray, 1847 was found in 1.02% of abundance.

Family Litiopidae Gray, 1847 were collected with 49 specimens of 10 species, only in two-month June and July 2022.

Table II. SDI (Simpson's Diversity Index), Number and % of abundance of individuals (Indi.) and species (spp.) of different families of class Gastropoda in different months from June 2022 to November 2022.

Families	Jun. 22	Jul. 22	Aug. 22	Sep. 22	Oct. 22	Nov. 22	Total No. of Indi.	%	No. of Spp.	%
Patellidae Rafinesque, 1815	0	0	1	1	1	0	3	0.15	3	1.389
Eoacmaeidae Nakano and Ozawa, 2007	0	0	3	0	0	0	3	0.15	1	0.463
Lottiidae J. E. Gray, 1840	1	0	2	11	2	6	22	1.14	5	2.315
Nacellidae Thiele, 1891	16	13	17	21	7	13	87	4.54	7	3.241
Neritidae Rafinesque, 1815	17	1	0	0	21	7	46	2.38	8	3.704
Fissurellidae Fleming, 1822	5	2	0	0	5	10	22	1.14	20	9.259
Lepetelloidea Dall, 1882	1	0	0	1	1	9	12	0.62	6	2.778
Pseudococculinidae Hickman, 1983	0	0	0	0	0	1	1	0.05	1	0.463
Calyptraeidae Lamarck, 1809	2	2	2	1	1	8	16	0.83	5	2.315
Trochidae Rafinesque, 1815	37	3	2	0	0	0	42	2.23	28	12.96
Turbinidae Rafinesque, 1815	10	3	1	0	0	0	14	0.72	7	3.241
Triphoridae Gray, 1847	10	5	2	1	1	1	20	1.03	11	5.093
Litiopidae Gray, 1847	47	2	0	0	0	0	49	2.53	10	4.630
Thiaridae Gill, 1871 (1823)	2	3	3	2	1	1	12	0.62	2	0.926
Potamididae Adams and Adams, 1854	23	20	35	7	41	8	134	6.94	2	0.926
Vermetidae Rafinesque, 1815	5	3	0	0	0	0	8	0.41	5	2.315
Littorinidae Children, 1834	80	75	65	45	70	35	370	19.17	1	0.463
Rostellariidae Gabb, 1868	17	12	19	13	8	7	76	3.94	5	2.315
Aclididae G. O. Sars, 1878	2	2	2	2	2	2	12	0.63	1	0.463
Cypraeidae Rafinesque, 1815	26	29	24	18	18	42	157	8.13	18	8.333
Naticidae Guilding, 1834	3	1	4	5	12	5	30	1.51	7	3.241
Bursidae Thiele, 1925	5	0	0	1	1	1	8	0.41	6	2.778
Cymatidae Iredale, 1913	4	3	2	2	1	2	14	0.72	3	1.389
Epitoniidae Berry, 1910	1	0	0	0	0	0	1	0.05	1	0.463
Muricidae Rafinesque, 1815	52	71	70	62	49	38	342	17.72	20	9.722
Turbinellidae Swainson, 1840	5	4	2	2	1	3	17	0.88	3	1.389
Babyloniidae Kuroda, 1971	3	6	11	5	2	2	29	1.51	2	0.926
Melongenidae Gill, 1871	1	0	0	0	0	0	1	0.05	1	0.463
Nassariidae Iredale, 1916	1	0	0	0	0	0	1	0.05	1	0.463
Columbellidae Swainson, 1840	6	1	2	3	2	1	15	0.77	1	0.463
Olividae Latreille, 1825	56	48	47	41	41	69	278	14.4	11	5.093
Conidae Fleming, 1828	4	4	3	3	2	8	24	1.24	4	1.852
Turridae H. Adams and Adams, 1853	1	0	0	0	0	0	1	0.05	1	0.463
Pyramidellidae Gray, 1840	1	1	1	1	1	2	7	0.36	1	0.463
Architectonicidae Gray, 1850	7	5	2	3	7	7	31	1.63	2	0.926
Pupillidae Turton, 1831	1	1	1	1	1	1	6	0.32	1	0.463
Onchidiidae Rafinesque, 1815	3	3	3	3	3	3	18	0.93	3	1.389
Siphonariidae Gray, 1840	1	0	0	0	0	0	1	0.05	1	0.463
Total	452	319	323	252	300	284	1930	100	216	100
SDI	0.910	0.855	0.866	0.864	0.874	0.879	0.893		0.995	

Family Turbinidae Rafinesque, 1815 and Naticidae Guilding, 1834 both were found with 7 species each and 14 and 30 specimens, respectively.

Family Rostellariidae was found in 3.94 % of abundance. 74 specimens of 5 species were found, among them 4 species of *Tibia* were collected.

Twelve families of Gastropoda from Gaddani had only one species with different number of specimens i.e., 374 individuals of *Nodilittorina pyramidalis* of family Littorinidae, 15 individual of *Pyrene filmerae* of family Columbidae, 12 individuals of *Austrorissopsis consobrina* of family Aclididae, 7 individuals of *Turbonilla* sp. of family Pyramidellidae, 6 specimens of *Pupoides albilabris* of Pupillidae and 3 individuals of *Eoacmaea omanensis* of family Eoacmaeidae were recorded. Remaining 6 families namely: Pseudococculinidae, Epitoniidae, Melongenidae, Nassariidae, Turridae, and Siphonariidae had only one specimen of species *Kaiparapelta askewi*, *Epitonium clathrus*, *Pugilina cochlidium*, *Nassarius persicus*, *Turricula javana* and *Siphonaria denticulate* respectively. The lowest % of occurrence was found in Pseudococculinidae, Epitoniidae, Melongenidae, Nassariidae, Turridae and Siphonariidae which was about 0.05% (only one specimen).

Class Bivalvia

Second highest abundant class was Bivalvia which were about 34 % of total collection of mollusca from Gaddani. 1059 specimens of 134 species of 24 families of bivalvia were collected during study from Gaddani (Table III). SDI of bivalvia from Gaddani was about 0.8693 which shows the less high diversity of Bivalvia at this site compared to gastropodas.

Figure 4 revealed the % of occurrence of 24 families of class Bivalvia. Out of 24 families, 15 families were found throughout study period. Out of 134 species, 93 (69%) species belonged to 6 families and remaining 41 (31%) of species were other 18 families (Table IV). Family Ostreidae was highly abundant family with 28% of abundance (296 specimens of 11 species). These 11 species belonging to 4 genera. Family Carditidae was second abundant family about 13 % of total bivalve's collection from Gaddani. Only one species *Cardites floridanus* of the family Carditidae was collected every month in high quantity.

Family Veneridae was highly diversified family which had 25 species (19%) with 81 specimens (7.56%) of total collection of Bivalvia. 19 species of Genus *Dosinia* and one species of 6 genus namely *Leukoma*, *Sunetta*, *Venerupis*, *Petricola*, *Callista* and *Paphia* of family Veneridae were collected. 12 specimens of *Dosinia exoleta* was collected during study in this site. Second diversified family

Table III. Bivalvia, 24 Families and 134 species collected from Gaddani coast.

Families/ Species
Yoldiidae Dall, 1908
<i>Yoldia lanceolata</i> (Soweby, 1820)
<i>Y. nitida</i> (Brocchi, 1814)
Mytilidae Rafinesque, 1815
<i>Mytilus edulis</i> Linnaeus, 1758
<i>M. californianus</i> Conrad, 1837
<i>Perna canaliculus</i> (Gmelin, 1791)
<i>Solamen glandula</i> (Totten, 1834)
Noetiidae Stewart, 1930
<i>Noetia ponderosa</i> (Say, 1822)
<i>Striarca lactea</i> (Linnaeus, 1758)
Arcidae Lamarck, 1809
<i>Barbatia barbata</i> (Linnaeus, 1758)
<i>B. novaezealandiae</i> (E.A.Smith, 1915)
<i>B. foliata</i> (Forsskål, 1775)
<i>B. obliquata</i> (W. Wood, 1828)
<i>B. mytiloides</i> (Brocchi, 1814)
<i>B. domingensis</i> (Lamarck, 1819)
<i>B. lacerata</i> (Bruguière, 1789)
<i>B. reeveana</i> (d'Orbigny, 1846)
<i>B. pistachia</i> (Lamarck, 1819)
<i>Arca natalensis</i> Krauss, 1848
<i>Anadara corbuloides</i> (Monterosato, 1881)
<i>A. kagoshimensis</i> (Tokunaga, 1906)
<i>A. auriculata</i> (Lamarck, 1819)
<i>A. brasiliensis</i> (Lamarck, 1819)
<i>A. (Scapharca) natalensis</i> (Krauss, 1848)
<i>A. pilula</i> (Reeve, 1843)
Glycymerididae Dall, 1908
<i>Tucetona laticostata</i> (Quoy and Gaimard, 1835)
Pteriidae Gray, 1847
<i>Pteria colymbus</i> (Röding, 1798)
<i>Isognomon alatus</i> (Gmelin, 1791)
<i>I. legumen</i> (Gmelin, 1791)
<i>I. radiatus</i> (Anton, 1838)
<i>I. perna</i> (Linnaeus, 1767)
<i>I. nucleus</i> (Lamarck, 1819)
Ostreidae Rafinesque, 1815
<i>Magallana gigas</i> (Thunberg, 1793)

Table continues on next page.....

Families/ Species

Dendostrea cristata (Born, 1778)
D. folium (Linnaeus, 1758)
D. frons (Linnaeus, 1758)
D. vespertina (Conrad, 1855)
D. frons (Linnaeus, 1758)
Saccostrea scyphophilla (Peron and Lesueur, 1807)
S. glomerata (Gould, 1850)
S. cucullata (Born, 1778)
Ostrea edulis Linnaeus, 1758
O. chilensis Küster, 1844

Gryphaeidae

Parahyotissa inermis (Sowerby, 1871)
Pododesmus macrochisma (Deshayes, 1839)

Limidae Rafinesque, 1815

Lima vulgaris (Link, 1807)

Pectinidae Rafinesque, 1815

Mimachlamys varia (Linnaeus, 1758)

Anomiidae Rafinesque, 1815

Anomia simplex d'Orbigny, 1853
A. ehippium Linnaeus, 1758
A. peruviana d'Orbigny, 1846
A. trigonopsis F.W.Hutton, 1877

Spondyliidae Gray, 1826

Spondylus sp.

Plicatulidae Gray, 1854

Plicatula complanata Deshayes, 1863
Euanodontia ovum (Reeve, 1850)

Lucinidae Fleming, 1828

Arcinella cornuta Conrad, 1866
Loripes clausus (R.A. Philippi, 1849)

Carditidae Férussac, 1822

Cardites floridanus (Conrad, 1838)

Chamidae Lamarck, 1809

Chama buddiana C.B.Adams, 1852
C. arcana F.R.Bernard, 1976
C. congregata Conrad, 1833
C. gryphoides Linnaeus, 1758
C. asperella Lamarck, 1819
C. buddiana C.B.Adams, 1852
C. coralloides Reeve, 1846
C. florida Lamarck, 1819

Table continues on next column.....

Families/ Species

C. macerophylla Gmelin, 1791
C. crassa Chenu, 1846
C. pacifica Broderip, 1835
C. limbula Lamarck, 1819
C. dunkeri Lischke, 1870
C. brassica Reeve, 1847
Pseudochama gryphina (Lamarck, 1819)
P. exogyra (Conrad, 1837)
Arcinella cornuta Conrad, 1866

Cardiidae Lamarck, 1809

Vasticardium flavum (Linnaeus, 1758)
V. berschaueri Thach, 2014
V. vertebratum (Jonas, 1844)
V. assimile (Reeve, 1844)
Acrosterigma fidele Vidal, 1992
Papyridea soleniformis (Bruguière, 1789)
Dinocardium robustum (Lightfoot) 1786
Microfragum festivum (Deshayes, 1855)
Serripes groenlandicus (Mohr, 1786)
Fulvia (Fulvia) fragilis (Forsskal, 1775)

Mactridae Lamarck, 1809

Mactra stultorum (Linnaeus, 1758)
M. chinensis Philippi, 1846
M. isabelleana d'Orbigny, 1846
M. olorina Philippi, 1846
Mactra eximia Reeve, 1854
Spisula trigonella (Lamarck, 1818)

Pharidae Adams and Adams, 1856

Ensiculus cultellus (Linnaeus, 1758)

Tellinidae Blainville, 1814

Macoma inexpectata Cosel, 1995
Macomangulus tenuis (da Costa, 1778)
Hanleyanus vestalioides (Yokoyama, 1920)
Angulus tenuis (da Costa, 1778)
Pseudomacalia antillarum (d'Orbigny, 1853)
Tellina parvula Bertin, 1878
T. cruciata (Spengler, 1798)
Semelangulus boucheti Huber, 2015
Gari depressa (Pennant, 1777)
Limecola balthica (Linnaeus, 1758)
Quidnypagus palatam Iredale, 1929

Table continues on next page.....

Families/ Species*Serratina aequistriata* (Say, 1824)*Paphia crassiuscula* (Lamarck, 1818)**Donacidae Fleming, 1828***Donax scortum* (Linnaeus, 1758)*Hecuba scortum* (Linnaeus, 1758)**Veneridae Rafinesque, 1815***Dosinia subrosea* (Gray, 1835)*D. lupinus* (Linnaeus, 1758)*D. sculpta* (Hanley, 1845)*D. discus* (Reeve, 1850)*D. exoleta* (Linnaeus, 1758)*D. erythraea* Römer, 1860*D. concentrica* (Born, 1778)*D. tumida* (Gray, 1838)*D. afra* (Gmelin, 1791)*D. (Pectunculus) maoriana* Oliver, 1923*D. labiosa* Römer, 1862*D. (Austrodosinia) anus* (Philippi, 1847)*D. hepatica* (Lamarck, 1818)*D. japonica* (Reeve, 1850)*D. mactracea* (Broderip, 1835)*D. orbignyi* (Dunker, 1845)*D. alta* (Dunker, 1849)*D. (Austrodosinia) anus* (Philippi, 1847)*D. fibula* (Reeve, 1850)*Leukoma staminea* (Conrad, 1837)*Sunetta bruggeni* Fischer-Piette, 1974*Venerupis corrugata* (Gmelin, 1791)*Petricola (Rupellaria) bicolor* G.B.Sowerby II, 1854*Callista chione* (Linnaeus, 1758)*Paphia semirugata* (Philippi, 1847)**Myidae Lamarck, 1809***Mya truncata* Linnaeus, 1758**Periplomatidae Dall, 1895***Periploma (Periploma) planiusculum* Sowerby, 1834

was Chamidae which had 17 species (12.68%) with 106 (10.01%) specimens. 3 Genus namely *Chama*, *Pseudochama* and *Arcinella* were collected of this family. 14 species of genus *Chama* were reported during study. Family Arcidae with 16 species (11.94 %) with 81 specimens (7.65%) were reported. One species of *Arca*, 6 species of *Anadara* and 9 species of *Barbatia* were collected of this family.

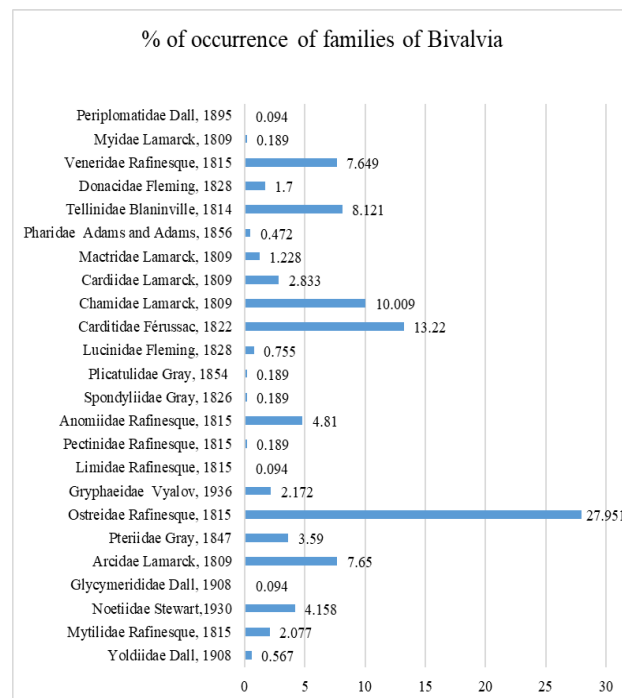


Fig. 4. Occurrence (%) 24 families of class Bivalvia from Gaddani coast.

Family Tellinidae with 86 specimens of 12 genus and 13 species were collected during this study. Family Ostreidae with 11 species of 4 genus and 296 specimens while family Cardiidae with 11 species of 6 genus and 30 specimens were reported.

Eight families of Bivalvia from Gaddani were reported only one genus and one species with different number of specimens *i.e.*, 140 individuals of *Cardites floridanus* of family Carditidae, 5 specimens of *Ensisculus cultellus* of family Pharidae, 2 individuals of *Mya truncata* of Myidae, *Mimachlamys varia* of Pectinidae and *Loripes clausus* of Spondyliidae were collected. Only one specimen *Tucetona laticostata*, *Lima vulgaris* and *Periploma (Periploma) planiusculum* of family Glycymerididae, Limidae and Periplomatidae was collected in June 2022, respectively.

Class Cephalopoda

Seven specimens of one species (*Sepia officinalis*) of family Sepiidae Keferstein, 1866 was collected whole study period except July 2022. 3 specimens of *S. officinalis* were found in Oct. 2022 from the coast of Gaddani (Table V).

Class Polyplacophora

Only one specimen of *Chiton lamyi* of family Chitonidae Rafinesque, 1815 of class Polyplacophora, was collected in June 2022 (Table V).

Table IV. SDI (Simpson's Diversity Index), Number and % of abundance of individuals (Indi.) and species (spp.) of different families of class Gastropoda in different months from June 2022 to November 2022.

Families	Jun. 22	Jul. 22	Aug. 22	Sep. 22	Oct. 22	Nov. 22	Total No. of Indi.	%	No. of Spp.	%
Yoldiidae Dall, 1908	2	1	1	1	1	0	6	0.58	2	1.49
Mytilidae Rafinesque, 1815	9	3	1	4	3	2	22	2.08	4	2.99
Noetiidae Stewart, 1930	8	6	7	6	5	12	44	4.15	2	1.49
Arcidae Lamarck, 1809	35	15	9	6	12	4	81	7.65	16	11.94
Glycymerididae Dall, 1908	1	0	0	0	0	0	1	0.09	1	0.75
Pteriidae Gray, 1847	13	3	4	2	7	9	38	3.59	6	4.48
Ostreidae Rafinesque, 1815	59	34	27	51	64	61	296	27.95	11	8.21
Gryphaeidae Vyalov, 1936	4	3	1	3	5	7	23	2.17	2	1.49
Limidae Rafinesque, 1815	1	0	0	0	0	0	1	0.09	1	0.75
Pectinidae Rafinesque, 1815	0	0	0	1	0	1	2	0.19	1	0.75
Anomiidae Rafinesque, 1815	29	6	4	4	4	4	51	4.82	5	3.73
Spondyliidae Gray, 1826	0	0	0	0	2	0	2	0.19	1	0.75
Plicatulidae Gray, 1854	2	0	0	0	0	0	2	0.19	2	1.49
Lucinidae Fleming, 1828	1	1	1	1	3	1	8	0.75	2	1.49
Carditidae Férussac, 1822	15	30	15	30	20	30	140	13.22	1	0.75
Chamidae Lamarck, 1809	22	18	14	23	20	9	106	10.01	17	12.69
Cardiidae Lamarck, 1809	12	2	2	1	10	3	30	2.83	11	8.21
Mactridae Lamarck, 1809	5	2	1	1	4	0	13	1.23	6	4.48
Pharidae Adams, 1856	1	4	0	0	0	0	5	0.47	1	0.75
Tellinidae Blainville, 1814	11	15	9	14	22	15	86	8.12	13	9.7
Donacidae Fleming, 1828	4	4	5	1	2	2	18	1.7	2	1.49
Veneridae Rafinesque, 1815	34	11	6	9	6	15	81	7.65	25	18.66
Myidae Lamarck, 1809	2	0	0	0	0	0	2	0.19	1	0.75
Periplomatidae Dall, 1895	1	0	0	0	0	0	1	0.09	1	0.75
Total	271	158	107	158	190	175	1059	100	134	100
SDI	0.894	0.882	0.88	0.828	0.843	0.826	0.869		0.905	

Table V. Abundance of family Sepiidae of Class Cephalopoda family Chitonidae of Class Polyplacophora from months of June 2022 to November 2022 from Gaddani coast.

Class	Family	Jun. 22	Jul. 22	Aug. 22	Sep. 22	Oct. 22	Nov. 22	Total
Cephalopoda	Sepiidae	1	0	1	1	3	1	7
%		14.28%	0.00%	14.28%	14.28%	42.86%	14.28%	100
Polyplacophora	Chitonidae	1	0	0	0	0	0	1

DISCUSSION

This study was carried out to evaluate the occurrence and abundance molluscan fauna specially gastropoda and bivalvia in intertidal region of Gaddani Coast, Balochistan. The surveys were conducted at three sampling sites, which

were revealed 216 species of Gastropoda and 134 species of Bivalvia, that are commonly inhabit in coast. It is very difficult to assess the total number of molluscan species from the previously-published literature because many studies did not describe any taxonomic detail, nor provided illustrations or images. The usage of different and older

synonyms is also a problem. A previous study on the total number of species recorded from Pakistan by [Kazmi *et al.* \(2019\)](#) reported 713 species of Gastropoda, 349 species of Bivalvia from the Pakistan coast and concluded that the Balochistan coast was highly diverse with respect to molluscan community but not studied in detailed.

Present study, gastropods were reported in highest percentage of occurrence about 64% of total collection of malacofauna from Gaddani. Out of 216 species of gastropoda, 50% of species were belonged to 6 families and remaining 50% species were other 211 families. One species *Nodilittorina* sp. of family Littorinidae was collected in every month in highest % of abundance, of total collection of gastropoda. During the present study it was observed that 42 specimens of 28 species of family Trochidae Rafinesque, 1815, were collected which was the highest number of species of any family of gastropoda.

Simpson's Diversity Index (SDI) of families of gastropoda was about 0.893 which shown the high diversity of families of gastropoda of this area. While 134 species of 24 families of Bivalvia, were reported from this site. Out of 134 species, 93 (69%) species were belonging to 6 families and remaining 41 (31%) of species were other 18 families. Family Carditidae was second abundant family about 13 % of total bivalve's collection from Gaddani. Only one species *Cardites floridanus* of the family Carditidae was collected every month in high quantity. 8 families of bivalvia from Gaddani were reported only one genus and one species with different number of specimens. SDI of bivalvia from Gaddani was about 0.869 which shown the less high diversity of bivalvia of this site as compared to gastropoda. 7 specimens of one species of one family of Cephalopodes were collected while only one specimen of class polyplacophora was collected from Gaddani site.

The current findings of *Cerithium* spp. and *Thais* spp. were like the findings of [Ghani and Afsar \(2017\)](#), who found these species in Jiwani, Balochistan. These were also reported by [Gondal *et al.* \(2012\)](#) from Sonmiani Bay in Balochistan. [Khan and Dastagir \(1971\)](#) reported *Telescopium telescopium* (Potamididae) from Pakistan. Molluscan species like *Tibia* spp., *Andara* spp., *Marcia* spp., and *Gari* spp. have been discovered in Balochistan's Sonmiani Bay, Ormara, Kalmar Hor, and Pasni Bay ([Gondal *et al.*, 2012](#); [Moazzam and Ahmed, 1994](#)). *Marcia* species have been found in the mangroves of Karachi, according to [Barkati and Tirmizi \(1986\)](#). Those of *Gari* spp. were identified by [Kazmi and Khan \(2014\)](#). [Gondal *et al.* \(2012\)](#) identified *Veneridae* spp. from Sonmiani, Balochistan. In present study family Veneridae was highly diversified family which had 25 species (19%) with 81 specimens (7.56%) of total collection of Bivalvia.

Conservation of biological diversity is one of the major

goals for sustainable management of marine renewable resources. The species diversity has a good relationship with species richness and evenness and diversity index is maximum with high number of species and minimum with low number of species ([Srinivasan, 1999](#)). Data obtained from this study represents an important step to gain a better understanding of molluscan habitats and their essential role as habitat provider to other species.

DECLARATION

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IRB approval

This article is part of the M.Phil. Research work of Nazeer Ahmed. Their M.Phil. Dissertation was approved by the Departmental Appraisal Committee, external and Internal examiner.

Ethical statement

We ensured that all research was conducted in accordance with ethical principles. Neither human was the subject in research nor such kind of animal, which required any administrative approval.

Statement of conflict of interest

The authors have declared no conflict of interest.

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