



Diversity of Invertebrate Fossils in Pakistan

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ABSTRACT

Occurrence of various invertebrate fossils groups is quite variable. Largest group was that of Gastropods (22%), Bivalves were (17%), Echinoderms were (15%), Corals (13%), Cephalopods (Nautiloids, Belminites, Ammonites) were (13%), Brachiopods (10%), Crustaceans and Foraminiferons were (5%) each. Fossils studied presently belong to 8 classes, 52 orders and 88 families. 136 genera are reported here from various provinces of Pakistan. 35% of these are from Sindh; 27% from KPK (Khyber Pakhtunkhwa); 21% from Balochistan and 17% from Punjab.

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Key words

Diversity, Fossils, Invertebrates, Pakistan

INTRODUCTION

Few isolated publications are available on invertebrate fossil fauna of Pakistan. Costello (1860) published the 1st report on rock types in the mountain ranges of Bannu Area in KPK. He recognized some Brachiobods and Molluscs. Some Tertiary crabs were reported from Sindh and Kutch, India (Stoliczka, 1871). Another early report on invertebrate fossil of Dera Bugti Area of Balochistan was published by Blandford (1883).

Siddiqui (1971) recorded some Ostracods from Pakistan. In a detailed study of Bannu and DI Khan Area (KPK), Grant (1968) discussed the occurrence of brachiobods, ammonites, bivalves, gastropods and crinoids of triassic, jurassic and cretaceous age. Sillurain nummulites were reported from Drazinda formation in KPK (Ozyan et al., 2019). Nizami (2019) described the faunal assemblage of Jurassic age from Chichali gorge, salt range in Punjab. Fossils included foraminiferans, gastropods, bivalves, bryozons, brachiobods, echinoids, sponges and corals. Paleozoic and cenozoic bivalves were recorded from Dhok Pathan formation (District Chakwal),

Punjab by Farooqui et al. (2018). Fiest et al. (2001), reported a new species of Trilobite *Newcolmonia chitralensis* from Chitral, KPK.

Siddiqui et al. (2009) recorded 4 species of Ammonites from Raskoh area of Balochistan. Similarly, 3 genera of Tertiary Nautiloids were reported from Katch area, Western India (Halder, 2012). Iqbal (1972) studied Gastropods fauna from Jhriak-Lakhra-Bara Nai (Sindh), Salt range, Punjab and Samana Suke range in KPK.

The area where collision of two tectonic plates (Indian and Eurasian) occurred, lies in Nagar state in Gilgit Baltistan. Pakistan geologically overlaps Indian and Eurasian tectonic plates. Sindh and Punjab provinces are located in north-western corner of Indian plate. Balochistan and KPK are within the Eurasian plate which is a part of Iranian plateau. The Northern Areas and Azad Kashmir lie mainly in central Asia along the edge of Indian plate. Pakistan belongs to eastern part of Gondwanaland while western part constitutes rest of the Indo-Pak plate (Wong et al., 2012). In Paleozoic age a type of platform developed which was known as Indian shield. In the north it forms the Hiamalayan foredeep and Penensular region. Early Eocene is exposed in Sakesar limestone of Nummal gorge in central salt range of Punjab. 9 genera of Foraminiferans were identified from this area (Ghazi et al., 2010).

Malkani (2011) discussed the general geology of Balochistan province. The rocks consists of Igneous, Sedimentary and Metamorphic deposits. Sulaiman and Kirthar Basins consist of Triassic to recent strata. Punjab province includes Tertiary and Mesozoic rocks. These are sedimentary in nature while Quarterny age rocks are also present. That saline series of salt range is located

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in northern Punjab and KPK. These deposits have been estimated to be of Pre-Cambrian age (Fig. 2). This area contains abundant micro-fossils in salt marle. Drazinda Formation located near Drazinda town (District D.I. Khan) in KPK province, which is in fact part of Sulaiman range, forms a lobe in this area (Powell, 1979; Kazmi and Rana, 1982). The lobe is widest at this point. The Sulaiman fold belt continues into Baluchistan and Sindh provinces up to Makran and Karachi coast.



Fig. 1. Map of Pakistan showing fossil collection sites.

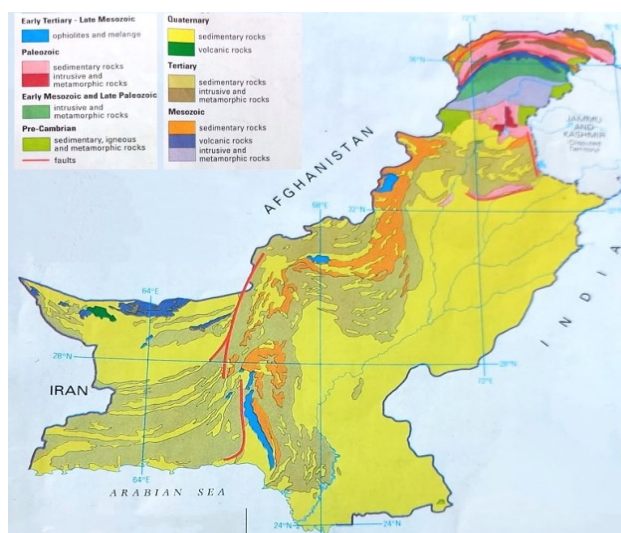


Fig. 2. Geological map of Pakistan showing various types of rocks.

Indian subcontinent collided with Eurasian plate about 55-60 million years ago during Paleocene age at closure of Tethys Sea. Since then, this subcontinent has witnessed three distinct cycles of flooding and receding of sea level (Gingerich *et al* 1979). Paleogeographic information on Cretaceous-Paleocene sequence of rocks in this area was reported earlier (Davies, 1939; Pinfold, 1937). Pleistocene sedimentary rocks are also found in the foot hills of Sulaiman range (Kazmi and Rana, 1982; Hamayun, 1990). Blanford (1879) coined the term 'Kirthar Formation' to describe the range in Balochistan and Sindh. Later, the stratigraphy of lower Indus basin. Drazinda shale of Kirthar range consists of gray clay stone and marle beds at lower level and are highly fossiliferous. The upper level consists of limestone deposit which contains abundant Foraminifera, Bivalves and Echinoids (Hemphill and Kidwai, 1973) reported some Shark teeth, Nummulites as well as some Mammalian remains of Oligocene age in the foot hills of Dera Bugti area of Balochistan.

A small group of low hills extend from Khairpur to Rohri in north-south direction in the province of Sindh. These hills are located on the right bank of river Indus and in fact are the eastern most limit of Kirthar range foot hills remnants. These hills mainly consist of stratified limestone which arises in fluvial plan of river Indus (Fig. 2). These are part of Brahui formation which extends up to Hyderabad, Thatta and Karachi districts (Blandford, 1879; Hunting Survey Corporation, 1960). In Indus basin area of Sindh, two flooding cycles in sea level have been recognized (Wakefield and Montil, 2002). These rocks are considered to be deposits of Eocene and Oligocene age and are highly fossiliferous. Soil profile studies at various points in these hills indicated presence of Calcite, gypsum, quartz granules and red clay deposits (Fig. 3). Limestone deposits have incursion of flint nodules on the surface as well (Biagi and Crumachi, 1988). Palynological (Fredrickson, 1994) and sedimentation studies indicate a shallow marine paleoenvironment in Indus plain area of Sindh (Mohan, 1982; Usmani, 1983; Usmani *et al.* 2008; Wakefield and Monteil, 2002) during tertiary period.

MATERIALS AND METHODS

The fossils specimens were collected from various places in Pakistan. Drazinda range in KPK yielded a considerable number consisting of many groups of invertebrates. Similarly, fossils are also collected from Khairpur Hills, Hyderabad and Jamshoro Area of Sindh Province. Some fossils are obtained from Dera Bugti and Khuzdar in Balochistan (Fig. 1). Due to paucity of published information on taxonomy of fossils groups, the

present specimen has been identified up to generic level.

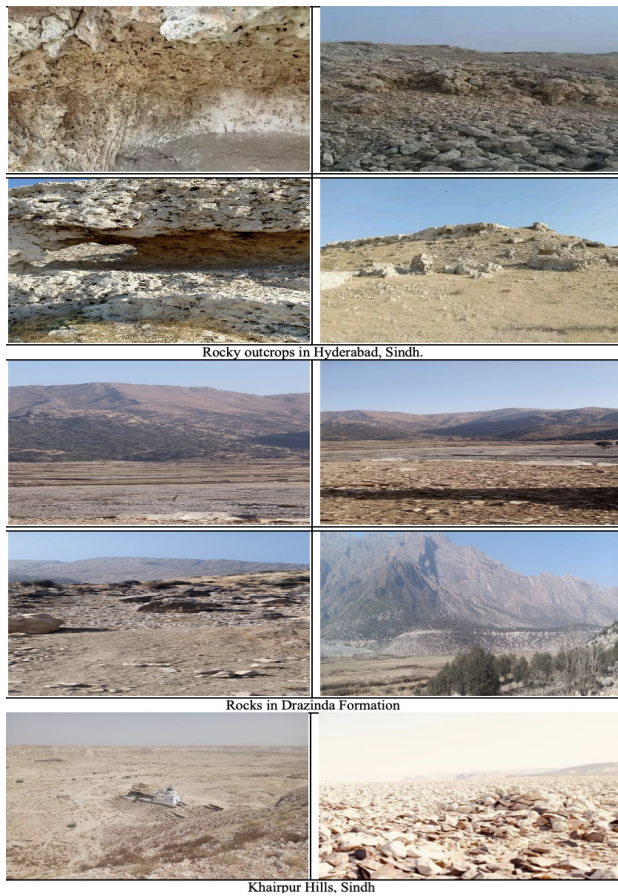


Fig. 3. Various collection sites of fossils.

SYSTEMATIC PALEONTOLOGY

Phylum Protozoa

Class Rhizaria

Order Foraminifera

Family Nummulitidae

1. Genus *Nummulites*
Age: Eocene, about 40 million years old.
Locality: Drazinda formation, KPK and Dera Bugti, Balochistan.
 2. Genus *Discocyclina*
Age: Miocene, about 20 million years old.
Locality: Sindh.
- #### Order Fusulinida
- #### Family Fusulinidae
3. Genus *Astrorhizona*
 4. Genus *Fusilia*
Age: Permian, about 240 million years old.
Locality: Karachi, Sindh and Khuzdar, Balochistan.

Family Heterohelicidae

5. Genus *Heterohelise*
6. Genus *Lepidocyclina*
7. Genus *Metapolymeria*
Age: Eocene, about 40 million years old
Locality: Khuzdar, Balochistan.

Order Sprinilida

Family Sprilininidae

8. Genus *Spirulina*
Age: Pliocene, 1.5 million years old.
Locality: Karachi, Sindh (Fig. 4).

Phylum Cnidaria

Class Anthozoa

Order Scleractinia

Family Merulinidae

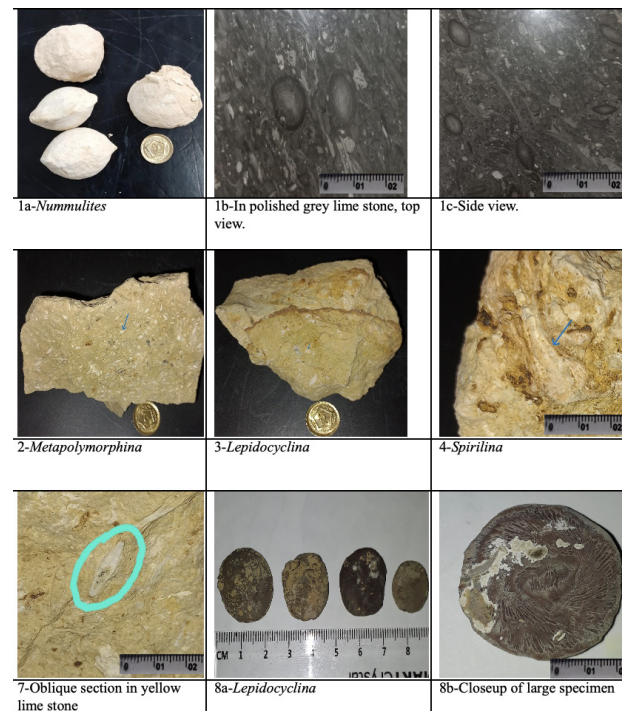


Fig. 4. Foraminiferan fossils.

9. Genus *Fevites*
 10. Genus *Echinopora*
- #### Family Fevidae
11. Genus *Fevia*
Age: Miocene, about 20 million years old.
Locality: Karachi, Sindh.
 12. Genus *Astrocerium*
Age: Silurian, about 425 million years old.
Locality: Chinji Formation, Balochistan.
 13. Genus *Paleofevosites*
Age: Silurian, about 425 million years old.
Locality: Wargal Formation, Balochistan.

14. Genus *Protaria*
Age: Silurian, 420 million years old.
Locality: Salt range, Punjab
15. Genus *Cladocora*
16. Genus *Cyphastria*
Age: Eocene, about 50 million years old.
Locality: Drazinda, KPK.
17. Genus *Leptastrea*
Age: Pleistocene, about 1.5 million years old.
Locality: Karachi, Sindh.

Class Hexacoralia**Order Rugosa****Family Lithostrotionidae**

18. Genus *Siphenodendron*
Age: Permian, about 280 million years old.
Locality: Khairpur, Sindh and Drazinda formation, KPK.

Family Disphyllidae

19. Genus *Hexagonaria*
Age: Silurian, 420 million years old.
Locality: Salt range, Punjab.
20. *Lithostrotion*
Age: Permian, 280 million years old.
Locality: Drazinda, KPK.

Order Tabulata**Family Syringophyllidae**

21. Genus *Calapoecia*
Age: Ordovician, about 460 million years old.
Locality: Kalat, Balochistan.
22. Genus *Acropora*
Age: Eocene, about 40 million years old.
Locality: Drazinda formation, KPK.

Family Lophophyllidae

23. Genus *Lophophyllidium*

Family Zephrentidae

24. Genus *Zaphrentis*
Age : Permian, about 250 million years old.
Locality: Drazinda formation, KPK and Sindh.
25. Genus *Heliophyllum*
Age: Permian, about 250 million years old.
Locality: Jamshoro Area, Sindh.

Family Paleocyclidae

26. Genus *Paleocyclus*
27. *Septasteria*
Age: Devonian, about 400 million years old.
Locality: Drazinda formation, KPK.

BRANCHED CORAL**Phylum Cnidaria****Class Tabulata****Order Feositida****Family Feositidae**

28. Genus *Coenites*
Age: Devonian, about 400 million years old.

Locality: Sindh.

29. Genus *Fevosites*
Age: Eocene, 40 million years old.
Locality: Kalat, Balochistan.

Family Heliolitidae

30. Genus *Proheleolites*
Age: Eocene, 40 million years old.
Locality: Kalat, Balochistan (Fig. 5).

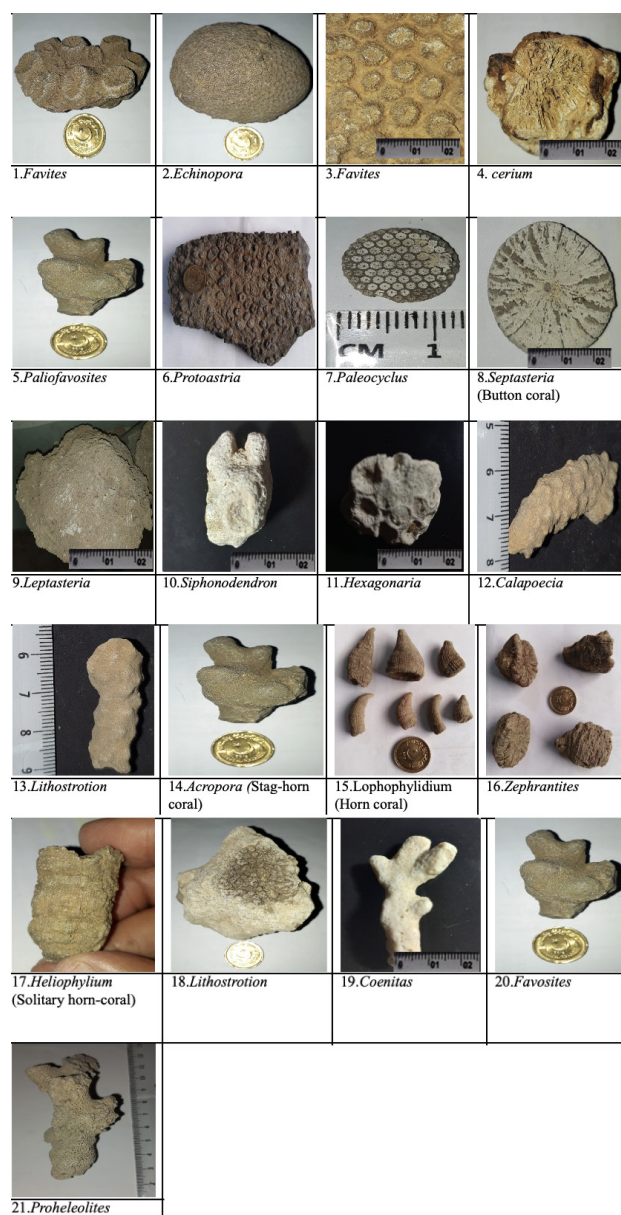
Phylum Echinodermata**Class Echinoida****Family Echinoidae**

Fig. 5. Fossil Corals.

31. Genus *Micraster*

Age: Eocene, about 40 million years old.

Locality: Drazinda formation, KPK.

Khuzdar, Balochistan.

32. Genus *Clypeas*

Age (a): Eocene, about 40 million years old.

Locality: Drazinda formation, KPK.

Age (b): Miocene, about 20 million years old.

Locality: Hyderabad, Sindh.

Age (c): Eocene, about 40 million years old.

Locality: Barkhan, Baluchistan.

Class Echinoidea**Order Clypeastroida****Family Clypridae**33. Genus *Heteraster*

Age: Cretaceous, about 70 million years old.

Locality: Gaj Formation, Sindh.

34. Genus *Clypeaster*

Age: Oligocene, about 30 million years old.

Locality: Khuzdar, Balochistan.

Class Echinoidea**Order Echinoida****Family Echinoidae**35. Genus *Psephechinus*36. Genus *Stomoechinus*37. Genus *Schizoaster*

Age: Eocene, about 40 million years old.

Locality: Barkhan, Balochistan.

Order Holasteroida**Family Holoasteridae**38. Genus *Echinocorys***Order Cidaroida****Family Cidaroidae**39. Genus *Cidaris*

Age: Pliocene, about 1.5 million years old.

Locality: Malir, Karachi, Sindh.

40. Genus *Tretocidaris*

Age: Cretaceous, about 70 million years old.

Locality: Gaj Formation, Sindh.

Order Echinoida**Family Echinolampidae**41. Genus *Echinolampus***Family Echinometritidae**42. Genus *Echinometra*

Age: Miocene, about 15 million years old.

Locality: Kirthar Formation, Sindh.

Order Spatangoida**Family Spatangidae**43. Genus *Spatangus* (Heart urchin cross section)

Age: Oligocene, about 30 Million years old.

Locality: Khuzdar, Balochistan.

CRINOIDS:**Class Crinoidia****Order Flexibilia**44. Genus *Onychocrinus*

Age: Eocene, about 50 million years old.

Locality: Drazinda formation, KPK.

Order Comatulida**Family Antedonidae**45. Genus *Anteodon* (Feather star, Theca)

Age: Eocene, about 20 million years old.

Locality: Hyderabad, Sindh.

CRINOID CALYX:**Class Crinoidia****Order Encrinida****Family Encrinidea**46. Genus *Encrinus*

Age: Triassic, about 240 million years old.

Locality: Salt Range, Punjab (Fig. 6).

CRUSTACEANS:**Crabs and Lobster:****Arthropoda****Class Crustacea****Order Decapoda****Family Carpiloidae**47. Genus *Proxicarpilius*

Age: Miocene, about 20 million years old.

Locality: Khairpur hills, Sindh.

Family Carpiloidae48. Genus *Paleocarpilius*

Age: Miocene, about 20 million years old.

Locality: Khairpur, Sindh.

Family Cancridae49. Genus *Lobocarcinus*

Age: Eocene, about 40 million years old.

Locality: Jamshoro, Sindh.

Order Decapoda**Family Thalassinidae**50. Genus *Thalassina* (Mud Lobster)

Age: Eocene, about 50 million years old.

Locality: Drazinda formation, KPK.

Order Balanomorphia**Family Balanidae**51. Genus *Notobalanus* (Acorn Barnacle)

Age: Eocene, about 40 million years old.

Locality: Sindh.

Order Crripedia**Family Archeobalinidae**52. Genus *Semibalanus*

Age: Cretaceous, about 70 million years old.

Locality: Malir, Karachi, Sindh.

SEED SHRIMP:**Order Ostracoda****Family Mydocopidae**

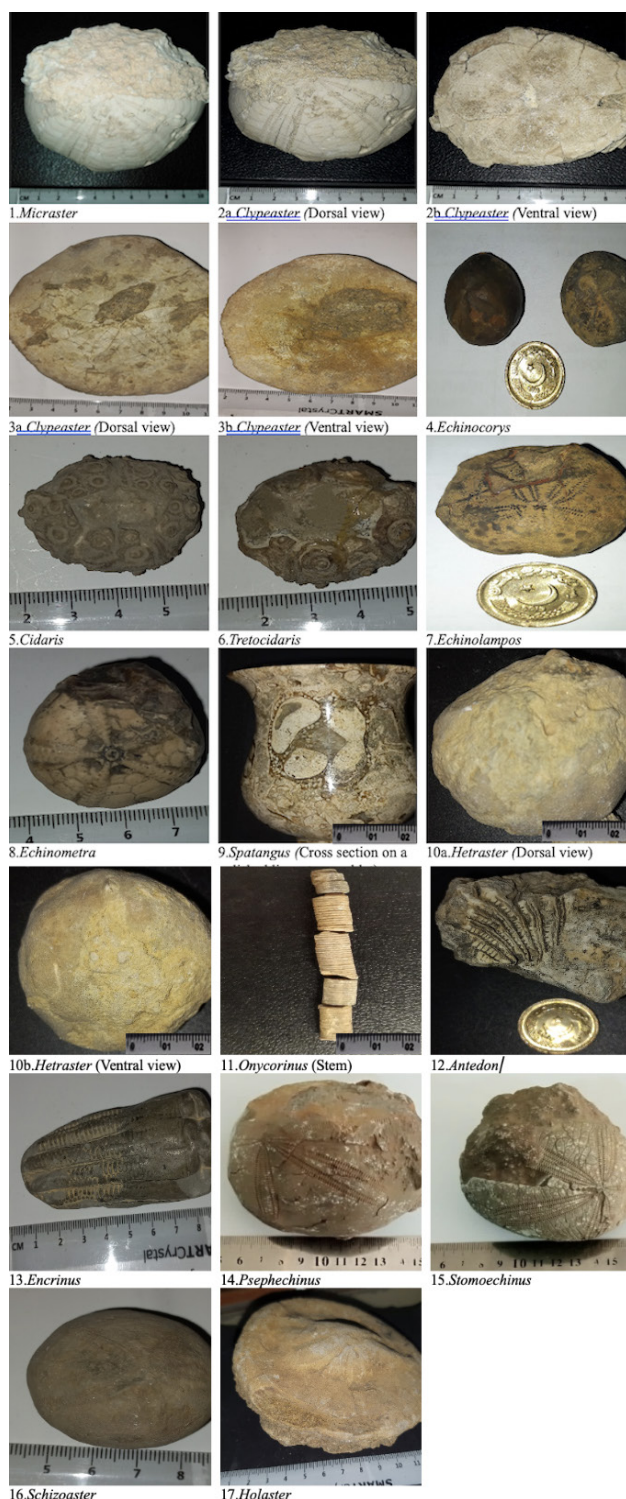


Fig. 6. Echinoderm fossils.

53. Genus *Cycloliberis*

Age: Oligocene, about 30 million years old.

Locality: Khuzdar, Balochistan (Fig. 7).

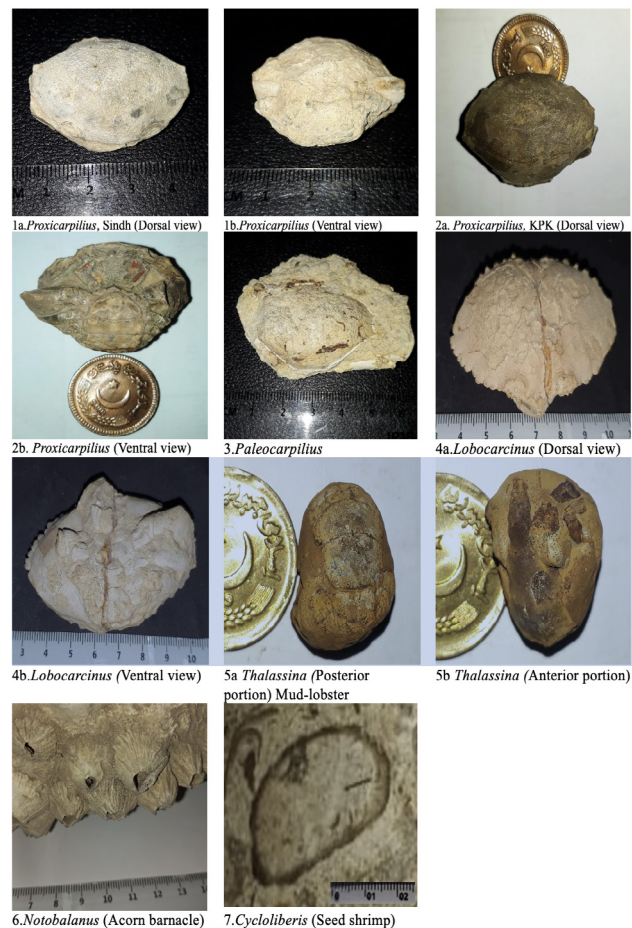
Phylum Brachiopoda**Class Rhynchonellata****Order Terebratulida****Family Terebratulidae**

Fig. 7. Crustaceans fossils.

54. Genus *Terebratulida*

Age: Triassic, about 280 million years old.

Locality: Drazinda formation, KPK.

Order Spiriferida**Family Spiriferidae**55. Genus *Spiriferina*

Age: Triassic, about 220 million years old.

Locality: Gadani, Balochistan.

Order Spiriferidina**Family Spinocrytidae**56. Genus *Spinocrytia*

Age: Devonian, about 390 million years old.

Locality: Salt Range, Punjab.

Order Orthida

Family Plarostomyidae

57. Genus *Plarostomys*

Age: Ordovician, about 400 million years old.

Locality: Salt Range, Punjab.

Order Spiriferida

Family Crytospiriferidae

58. Genus *Crytospirifer*

Age: Permian, about 250 million years old.

Locality: Salt Range, Punjab.

Class Strophomenata

Order Productida

Family Linoproductidae

59. Genus *Linoproductus*

Age: Permian, about 250 million years old.

Locality: Salt Range, Punjab.

Family Productidae

60. Genus *Antiquatinia*

Age: Carboniferous, about 300 million years old.

Locality: Salt Range, Punjab.

61. Genus *Penicularis*

Age: Carboniferous, about 300 million years old.

Locality: Salt Range, Punjab.

Order Trebratulida

Family Cancellothyridae

62. Genus *Ortholina*

Age: Cretaceous, about 100 million years old

Locality: Salt Range, Punjab.

Order Orthida

Family Platystrophiae

63. Genus *Vinlandostrophia*

Age: Ordovician, about 480 million years old.

Locality: Salt Range, Punjab.

Order Spiriferida

Family Neospiriferidae

64. Genus *Neospirifer*

Age: Cretaceous, about 100 million years old

Locality: Salt Range, Punjab (Fig. 8).

Phylum Mollusca

Class Cephalopoda

Order Nautiloidea

Family Nautiloidae

65. Genus *Dertoidovarrtius*

Age: Cretaceous, about 65 million years old.

Locality: Hub Range, Balochistan.

Order Nautilida

Family Solanochelidae

66. Genus *Acanthonautilus*

Age: Carboniferous, about 320 million years old.

Locality: Khuzdar, Balochistan.

Family Permoceratidae

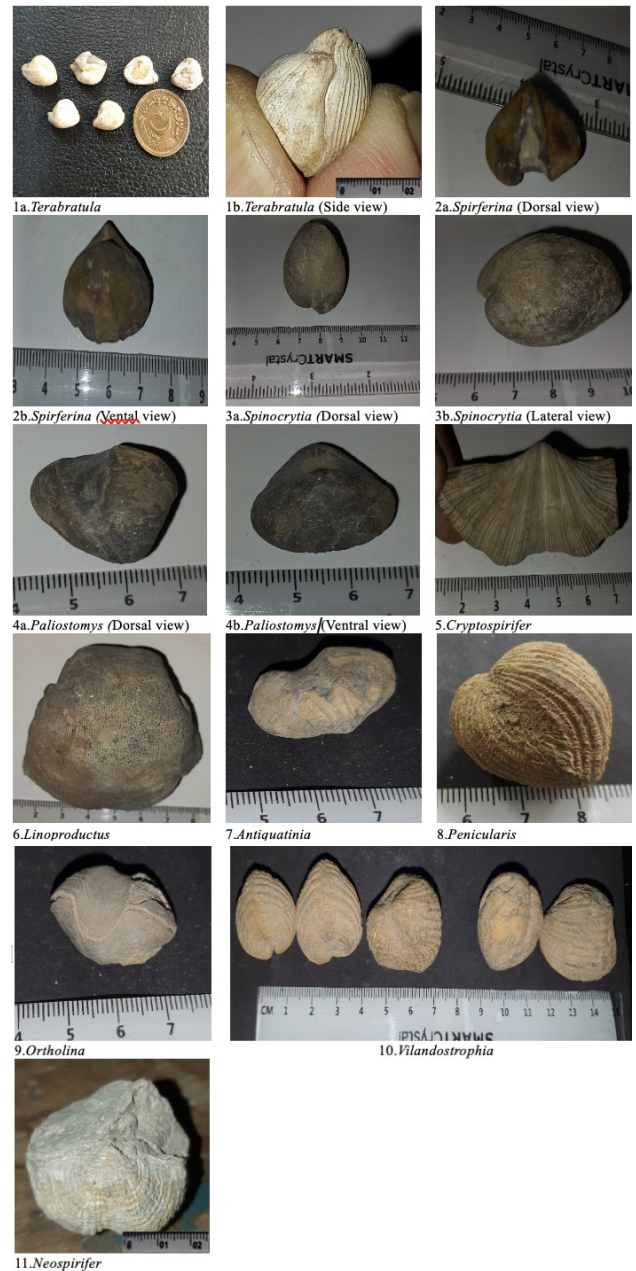


Fig. 8. Brachiopods fossils.

67. Genus *Permoceras*

Age: Permian, about 260 million years old.

Locality: Khuzdar, Balochistan.

Family Trigonoceratidae

68. Genus *Domatoceras*

Age: Triassic, about 230 million years old

Order Pseudorthocerida

Family Spiroceratidae

69. Genus *Spiroceras* (Cross section)

Age: Silurian, about 420 million years old.
 Locality: Khuzdar, Balochistan.

Order Tarphycerida

Family Uranocletoidea

70. Genus *Bionautilus*

Age: Silurian, about 420 million years old
 Locality: Salt range, Punjab

Order Nautiloidea

Family Nautiloidae

71. Genus *Eutrophoceras*

Age: Eocene, about 50 million years old.
 Locality (a): Drazinda formation, KPK.
 Age: Miocene, about 20 million years old.
 Locality (b): Jamshoro, Sindh.

BELEMENITES:

Order Coleoidea

Family Coleoidea

71 a. Genus *Phragmoteuthis* (Bellminite Guard)

Age: Cretaceous, about 70 million years old.
 Locality: Drazinda, KPK.

71b. Genus *Acroteuthis*

Age: Miocene, about 15 million years old.
 Locality: Sindh.

71c. Genus *Dimetobalus*

72. Genus *Belimentela*

Age: Cretaceous, about 60 million years old.
 Locality: Sindh.
 Ammonites:

Order Ammonoidea

Family Ammonoidae

73. Genus *Mammites*

74. Genus *Demotoceras*

Age: Cretaceous, about 65 million years old.
 Locality: Salt range, Punjab.

75. Genus *Collina*

Age: Jurassic, about 190 million years old.
 Locality: Sindh.

Order Ceratitida

Family Ceratitidae

76. Genus *Paradonticeras*

77. Genus *Ceretites*

78. Genus *Analcites*

79. Genus *Rohlites*

Age: Triassic, about 230 million years old.
 Locality: Chaghi, Balochistan.

Order Goniatitida

Family Agathiceratidae

80. Genus *Agathiceras*

Age: Permian, about 260 million years old.
 Locality: Balochistan.

Order Discorida

Family Phragmoceratidae

81. *Phylloceras*

Age: Silurian, about 420 million years old.
 Locality: Sindh.

Order Ammonitida

Family Phylloceratidae

82. Genus *Phragmoceras*

Age: Triassic, about 200 million years old.
 Locality: KPK.

Order Ceratitida

Family Ceratitidae

83. Genus *Egnoceras*

84. Genus *Protoegnoceras*

Age: Cretaceous, about 100 million years old.
 Locality: KPK.

Order Riocereda

Family Bactroceratidae

85. Genus *Bactroceras*

Age: Ordovician, about 450 million years old.

Order Ascocerida

Family Ascoceritidae

86. Genus *Ascoceras*

87. Genus *Plactoceras*

Age: Silurian, about 420 million years old.
 Locality: Khuzdar, Balochistan.

BIVALVES:

Class Bivalvia

Order Carditida

Family Carditidae

88. Genus *Venericardia*

Age: Pliocene, about 1 million years old.
 Locality: Karachi, Sindh.

Order Megalotontida

Family Megalontidae

89. Genus *Neomegalodon* (Heart clam)

Age: Jurassic, about 150 million years old.
 Locality: Drazinda formation, KPK.

Order Unionida

Family Unionidae

90. Genus *Parreysea*

Age: Eocene, about 50 million years old.
 Locality: Drazinda formation, KPK.

91. Genus *Lemillidens*

Age: Eocene, about 50 million years old.
 Locality: Drazinda formation, KPK.

Order Arcida

Family Arcidae

92. Genus *Anadara* (Ark clam)

Age: Eocene, about 50 million years old.
 Locality: Drazinda formation, KPK.

Order Myida

Family Anomiidae

93. Genus *Placonopsis*
Age: Eocene, about 50 million years old.
Locality: Drazinda formation, KPK.
Order Pholadoidea
Family Pholadidae
94. Genus *Pholas* (Rock borer)
Age: Eocene, about 50 million years old.
Locality: Drazinda formation, KPK.
Order Myidea
Family Corbulidae
95. Genus *Corbula* (Beaked clam)
Age: Eocene, about 50 million years old.
Locality: Drazinda formation, KPK.
Family Corbiculidae
96. Genus *Carbicula*
Age: Miocene, about 20 million years old.
Locality: Hyderabad, Sindh.
Order Limida
Family Limidae
97. Genus *Plagiostoma*
Age: Eocene, about 50 million years old.
Locality: Drazinda formation, KPK.
Order Veneroida
Family Veneridae
98. Genus *Circe*
Family Mactridae
99. Genus *Lutraria*
100. Genus *Lirophora*
Age: Eocene, about 50 million years old.
Locality: Drazinda formation, KPK.
Order Arcida
Family Cuculleidae
101. Genus *Cucullaea* (Deer Heart clam)
Age: Miocene, about 20 million years old.
Locality: Hyderabad, Sindh.
Order Ostereida
Family Ostereidae
102. Genus *Ostera*
Age (a): Miocene, about 20 million years old.
Locality: Khairpur, Sindh.
Age (b): Pleistocene, about 1.5 million years old.
Locality: Karachi, Sindh.
Order Ostereida
Family Ostereidae
103. Genus *Crossostrea*
Age: Pliocene, about 2 million years old.
Locality: Malir, Karachi, Sindh.
104. Genus *Astarte*
Age: Miocene, about 20 million years old.
Locality: Khairpur, Sindh.
105. Genus *Laevstarta*
Age: Eocene, about 40 million years old.
Locality: Drazinda, KPK.
Family Gryphaeidae
106. Genus *Gryphaea*
(Devil's toe-nail oyster)
Age (a): Eocene, about 50 million years old.
Locality: Drazinda formation, KPK.
Age (b): Miocene, about 20 million years old.
Locality: Sindh.
Order Arcida
Family Noeitedae
107. Genus *Noetia*
Age: Miocene, about 20 million years old.
Locality: Khairpur, Sindh.
Family Arcidae
108. Genus *Striarca*
Age: Eocene, about 40 million years old.
Locality: Drazinda, KPK.
Order Neotrigonida
Family Tregonidae
109. Genus *Neotrigonia*
Age: Eocene, about 40 million years old.
Locality: Punjab.
Order Myida
Family Myidae
110. Genus *Mya*
Age: Oligocene, about 20 million years old.
Locality: Sonmiani, Balochistan.
Order Pectinidea
Family Pectinidae
111. Genus *Argopecten*
Age: Miocene, about 20 million years old.
Locality: Hyderabad, Sindh.
112. Genus *Sinopecten*
Age: Eocene, about 50 million years old.
Locality: Rawalpindi, Punjab (Fig. 10).
Class Gastropoda
Order Neogastropoda
Family Busyconidae
113. Genus *Fulguropsis* (Crown Couch)
114. Genus *Spinifulgar* (Whelk)
Age: Pliocene, about 1 million years old.
Locality: Karachi Coast, Sindh.
Family Strombidae
115. Genus *Strombus*
Order Neogastropoda
Family Conidae
116. Genus *Conus*
117. Genus *Cylinder*
Age: Pliocene, about 1.5 million years old.
Locality: Malir, Sindh.
Order Littorinimorpha
Family Scaphisidae



Fig. 9. Molluscan fossils: Cephalopoda



Fig. 10. Bivalves

118. Genus *Terrabellum*
 Age(a): Miocene, about 20 million years old.
 Locality: Khairpur hills, Sindh.
 Age (b): Eocene, about 40 million years old.
 Locality: Drazinda Formation, KPK.
 Age (c): Eocene, about 50 million years old.
 Locality: Salt Range, Punjab.
Family Cypraeidae
119. Genus *Proadusta*
 Age: Pliocene, about 1 million years old.
 Locality: Karachi Coast, Sindh.
120. Genus *Trona*
 Age: Eocene, about 50 million years old.
 Locality: Rawalpindi, Punjab
Family Olividae
121. Genus *Olivauicularia*
 Age: (a) Eocene, about 50 million years old.
 Locality: Drazinda KPK.
 Age: Pliocene, about 1 million years old.
 Locality: Karachi Coast, Sindh.
Order Archeogastropoda
Family Macluritidae
122. Genus *Maclurites*
 Age: Cretaceous, about 66 million years old.
 Locality: Balochistan and Sindh.
Order Orthogastropoda
Family Hormotomidae
123. Genus *Hormotoma*
124. Genus *Orthonema*
125. Genus *Cyclonema*
Order Lepitellida
Family Fissurellidae
126. Genus *Medurafissurella*
 Age: Eocene, about 35 million years old.
 Locality: Khuzdar, Balochistan.
Order Neritimorpha
Family Paleotrochidae
127. Genus *Turbonopsis*
 Age: Devonian, about 370 million years old.
 Locality: Hyderabad, Sindh.
Order Trochida
Family Trochidae
128. Genus *Trochus*
 Age: Devonian, about 370 million years old.
 Locality: Khuzdar, Balochistan.
Order Cenogastropoda
Family Globocornidae
129. Genus *Angaria*
 Age: Miocene, about 10 million years old.
 Locality: Sindh.
130. Genus *Globocornus*
 Age: Eocene, about 55 million years old
 Locality: Salt Range, Punjab
 Family Megalomastidae
131. Genus *Tomocyclus*
 Age: Eocene, about 55 million years old
 Locality: Salt Range, Punjab
Family Nassariidae
132. Genus *Nassarius*
 Age: Eocene, about 55 million years old
 Locality: Salt Range, Punjab
Family Sibulitidae
133. Genus *Subulitus*
 Age: Triassic, about 200 million years old.
 Locality: Salt Range, Punjab.
Family Horiclanidae
134. Genus *Carinapex*
 Age: Pliocene, about 1.5 million years old.
 Locality: Malir, Karachi, Sindh.
Family Naticidae
135. Genus *Amacurellina* (Moon Snail)
 Age: Eocene, about 55 million years old.
 Locality: Drazinda Formation, KPK.
Family Turritellidae
136. Genus *Turritella*
Family Ampullinidae
137. Genus *Globularia*
Family Ovulidae
138. Genus *Morgula*
Family Volutidae
139. Genus *Scaphella*
Family Triviidae
140. Genus *Trivellona*
Family Hetrohelicidae
141. Genus *Hetrohelix* (in polished lime stone goblet)
 Age: Oligocene, about 30 million years old.
 Locality: Khuzdar Balochistan.
Family Cypridae
142. Genus *Umbilia*
 Age (a): Eocene, about 55 million years old.
 Locality: Drazinda, KPK.
 Age (b): Pliocene, about 1.5 million years old.
 Locality: Sindh.
Order Neogastropoda
Family Buccinidae
143. Genus *Neptuna*
 Age: Eocene, about 55 million years old.
 Locality: Drazinda, KPK.
Family Helicidae
144. Genus *Halicionella*
 Age: Carboniferous, about 300 million years old.
 Locality: Khuzdar, Balochistan.
Order Cenogastropoda
Family Strombidae

145. Genus *Volutispina*

Age: Pliocene, about 3 million years old.

Locality: Karachi Sindh.

Order Patellogastropoda

Family Patellidae

146. Genus *Prostcutum* (in lime stone slab)

Age: Cretaceous, about 100 million years old.

Locality: Punjab (Fig. 11).





Fig. 11. Gastropods.

DISCUSSION

Causes for rich invertebrate fossil fauna are probably due to impact of two global events, Cretaceous-Eocene -Paleogene crises and Paleocene–Eocene Thermal optimum in relation to the collision of Indian and Eurasian tectonic plates (Jablonski, 2008). Iqbal (1980) opines that faunal composition is significantly different from that of KPK and Balochistan. Observations of present study do not show this trend. Among Foraminiferans genus *Nummulites* was common in Eocene rocks of KPK and Balochistan, whereas genus *Disocyclus* was found in Miocene deposits of Sindh only. Genus *Astrorhiza* and *Fusulina* were found in deposits of Permian age in Sindh and Balochistan only. Genus *Spirulina* was found only from Sindh in Pleistocene rocks. Three genera of family Heterohalicidae are reported only from Khuzdar Balochistan in Eocene age rocks. Ozycan *et al.* (2019) has reported *Nummulites* of Silurian age from Drazinda formation, KPK and Salt range, Punjab. Siddiqui *et al.* (2022) studied the Jhimpir area, Lucky formation of Southern Indus basin. Three Eocene age genera of foraminiferans, *Globogerina*, *Morsovella* and *Acrinina* were recorded.

Ten species of fossil corals from Jiواني area of Balochistan are identified. In present study genus *Favites*, *Echinopora* and *Favia* have been recorded from Miocene rocks of Karachi, Sindh. Two Silurian age genera *Astrocerium* and *Paleofavites* have been identified from Balochistan. Among colonial Rugose corals, genus *Siphonodendrone* has been reported from Permian rocks of Dranzinda KPK and Khairpur Hills of Sindh. Similarly, Horn corals of genus *Lophophylidium*, *Zaphrentes* and *Heleophyllam* are recorded from Permian rocks of Sindh and KPK. Branched corals of genus *Favosites* and *Coenites* have been identified from Eocene rocks of Sindh only. Ghobadipour and Popove

(2022), recently studied the Ordovician corals from Iran, Afghanistan and Pakistan. *Cruzina rugosa* was recorded from KPK.

Among Echinoderms, Genus *Micraster* and *Clypeas* of Eocene age have been identified from KPK and Balochistan. Similarly, genus *Cidaris* (Pleistocene age) and *Tretocidaris* (Cretaceous age) have been recorded from Sindh. Three species of Ordovician echinoids were reported from Donghan Region of Alberz mountain range, Iran (Lefebvre *et al.*, 2005).

Crustaceans were recorded in very small number in present study. Crabs of genus *Proxycarpilius* and *Lobocarcinus* have been identified from Eocene age rocks of Sindh. Balanus of genus *Semibalanus* of Cretaceous age has also been recorded from Sindh. A small mud – lobster of genus *Thalassina* has also been identified from Eocene deposits of KPK. Hyzny *et al.* (2016) have described two new species of Ghost shrimp (f. Axiididea), *Newcallichernus khadroensis* and *N. lakharaensis* from Eocene deposits of Sindh (Fig. 12).

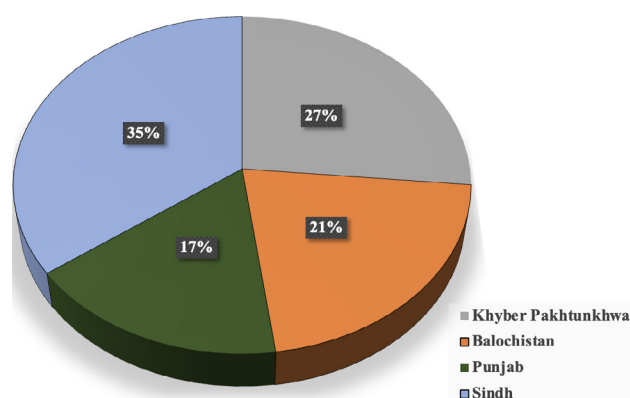


Fig. 12. Occurrence of fossils in various provinces of Pakistan.

Brachiopods flourished during Paleozoic era and became extinct by the end of Permian age. Only one genus is extant at present. In present study ten species of Brachiopods have been identified. Genus *Cryptospirifer*; *Antiquantia* and *Penicularis* belong to Carboniferous age. *Ortholina*; *Spiriferina* and *Trebratula* are from Triassic age, while *Plarostomys* and *Vinlandostrophia* belong to Ordovician age. According to Angiolini *et al.* (1999), late Carboniferous brachiopod fauna from Northern Karakoram area of Pakistan shows affinities with the fauna of contiguous pre-gondwanan rocks of Afghanistan and Lahasa block and are also related to those of Tethys-Himalayas.

Among Cephalopods, 8 genera of *Nautiloids* and *Belmenites* have been recorded while 14 genera of *Ammonites* have been identified in present study.

Cephalopods appeared during Cambrian age and became dominant during the Ordovician age. Ammonites and belemnites became extinct by the end of Cretaceous age. Few representatives of subclass Nautiloidea and Coleoidea are still found today in ocean of the world. Majority of Cephalopod fossils have earlier been found from salt range, Punjab (Spath, 1939) and Balochistan (Fatmi *et al.* 1999; Siddiqui *et al.*, 2009). In present study some Cephalopod fossils have been recorded from KPK and Sindh province as well. Earlier Fatmi *et al.* have recorded Jurassic age Cephalopod from Kishor- Marwat range of D.I. Khan KPK. Helder (2012) identified 3 new species of Cenozoic Nautiloids from Kutch area of W. India. Three Ordovician age Orthoconic cephalopods have been recorded from Albarz mountain range, Iran (Evans *et al.*, 2013).

In present study 23 genera of bivalves have been identified. Bivalves appeared in middle of Cambrian age. These flourished in Mesozoic and Cenozoic era. They are found in abundance in modern day seas (Tichart, 1966). Majority of fossils identified in present study belong to Eocene age. Only one genus, *Neomegelodon* (heart-clam) belongs to Jurassic age which has been recorded from Drazinda formation, KPK. Genus *Venecardia* belonging to Pliocene age has been recorded from Karachi, Sindh. Most of bivalves identified from Drazinda formation, KPK, belong to Eocene age. A scallop genus *Argopectin* belonging to the Miocene age has been recorded from Hyderabad, Sindh.

Gastropods from the largest group of fossils (30 genera) in present study (Fig. 13). Gastropods are a highly successful group of molluscs. Among 721 families of known gastropods, 245 are extinct today. Gastropods appeared in Paleozoic era (Cambrian age) and continue up to present age. Brohi *et al.* (2009) while discussing the economic significance of Tertiary rocks in Thana Bola Khan area of Sindh also recorded various invertebrate fossil groups from different formations. Lucky formation yielded large

Foraminiferans; Gastropods; bivalves and Echinoids. Tiyon formation contained the fossils of all the above groups. Similarly, Gaj formation; Nari formation and Manchar formation revealed the fossils of above-mentioned groups. In another study of fossil Gastropods (f. Volutidae) were studied from Lakhra formation of Sindh. Ten new species of Eocene age were identified. Harzausurs *et al.* (2017) recorded 19 species of Gastropods from Makran area of S.E. Iran. These included 3 new species.

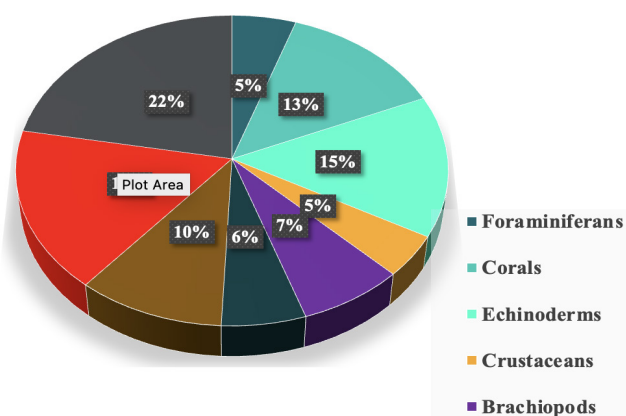


Fig. 13. Occurrence of various groups of fossil invertebrates.

DECLARATIONS

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Statement of conflict of interest

The authors have declared no conflict of interest.

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