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ECHINOIDS FROM THE GAJ FORMATION (EARLY AND MIDDLE MIOCENE) OF KATHIAWAR, GUJARAT, INDIA

RATAN LAL JAIN

III/106, GSI COLONY, MALAVIYA NAGAR, JAIPUR, RAJASTHAN, INDIA

ABSTRACT

A new collection from the early and middle Miocene of the Gaj Formation in Kathiawar has yielded 27 echinoid species. Of these, 10 species were already known previously from the study area, 11 species were known from outside the study area of Kathiawar and remaining six have been named here as new species. Already recorded species are figured, described their additional characters and registered better types. Duncan and Sladen (1883, p. 86-87) had wrongly assigned the material of the genus *Maretia* from the present study area under *Eupatagus patellaris* d'Archiac, 1850. Since *Eupatagus patellaris* d'Archiac, 1850 is a valid species for Kachchh and Sind, the present collection of *Maretia* from Kathiawar is described as a new species. The new species are *Fibularia depressa*, *Mortonia lowraliensis*, *Brissus daviesi*, *Maretia ranjitpurensis* *Metalia harshadi* and *Clypeaster kurangaensis*.

Temnechinus costatus (d'Archiac & Haime), *T. rousseaui* (d'Archiac), *T. tuberculosus* (d'Archiac & Haime) *and T. affinis* Duncan & Sladen have been described under the genus *Opechinus* Desor. *Cidaris granulata* Duncan & Sladen and *Cidaris excelsa* Duncan & Sladen have been put under the genus *Prionocidaris*. Cidaroid spines mostly belong to the genus *Prionocidaris* and *Eucidaris*.

Key words: Echinoids, Systematic Palaeontology, Miocene, Gaj Formation, Kathiawar, Gujarat, India.

INTRODUCTION

In the Kathiawar Peninsular region of Gujarat, Deccan Trap activity ended in the Palaeocene. After the lateritisation of traps, marine transgression in the coastal region deposited Neogene rocks of the Gaj (early Miocene to middle Miocene) and Dwarka formation (middle Miocene to Pliocene). After a brief break in deposition, the Pleistocene rocks of the Miliolite Limestone Formation were deposited in nearshore and beach environment. Fedden (1884) first mapped the Kathiawar region on a 1: 2,50,000 scale. Later, Jain (1990), Jain and Agrawal (1992), and Jain (1997) mapped the study area on a 1: 50,000 scale.

Among the Neogene sediments, a few beds of the Gaj Formation contain a prolific fauna (i.e. bivalves, gastropods, cephalopods, corals, echinoids, barnacles, bryozoans, etc). The Dwarka Formation is scantily fossiliferous and yields very few identifiable mega-fossils. Jain (1997) studied molluscs of the above formations in detail. On the basis of mollusc zonation, the author delineated horizons of early and middle Miocene. The present work deals with a collection of echinoids from the Gaj Formation from the westernmost Kathiawar region.

In India, Tertiary echinoids are known from Andaman Island, Kerala, Kathiawar and Kachchh (Gujarat), Rajasthan, Kashmir and Assam. During the last century, Carter (1857) and J. de C. Sowerby (1840), d'Archiac (1850), d'Archiac and Haime (1853) first initiated the studies on these echinoids, and later Duncan and Sladen (1883, 1885) produced their classic work. Sahni and Sastry (1958), Srivastava (1978, 1980, 1981), Tandon and Srivastava (1980). Srivastava (1988) and Mathur (1988) published reviews on Indian echinoids. However, no detailed work has so far been carried out on the Kathiawar echinoids since the work of Duncan and Sladen (1883).

The present study deals with the systematics of early and middle Miocene echinoids of the Gaj Formation from Okha Mandal and Kalyanpur talukas of Jamnagar district, Kathiawar region of Gujarat. The classification by Durham (1966) has been followed in the present work. The present collection is an addition to the number of species, reporting eight species known previously from the other regions and six new species.

Type specimens are deposited in the repository of the Geological Survey of India, Curatorial Division, 27 Jawaharlal Nehru Road, Kolkata –700

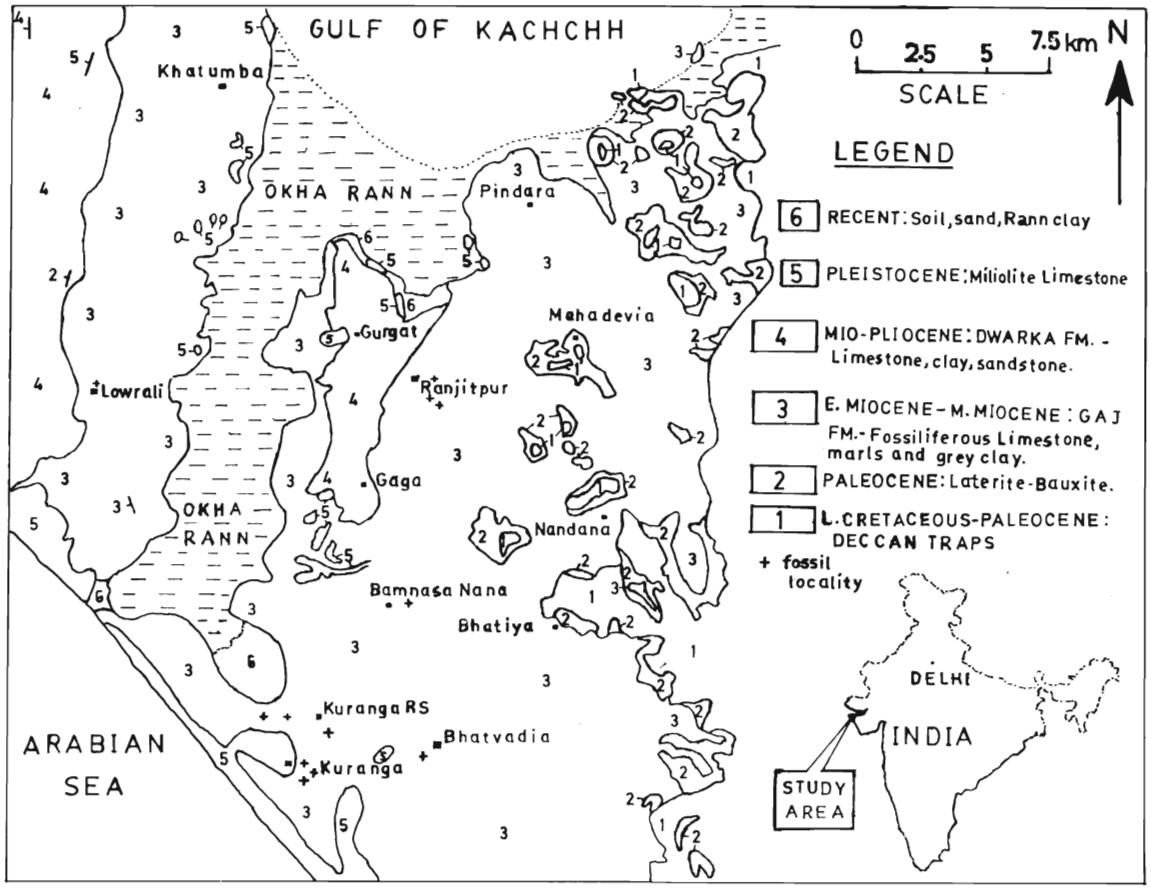


Fig. 1. Geological map of a part of Jamnagar District, Kathiawar, Gujarat (after Jain, 1997).

016 (India) under the registration numbers (GSI Type Nos. 20724 to 20794).

GEOLOGY OF THE AREA

The rocks exposed in the study area belong to the Gaj Formation (early Miocene to middle Miocene), Dwarka Formation (Mio-Pliocene), Miliolite Limestone Formation (Pleistocene) and Recent deposits (fig. 1).

The Gaj Formation is well developed on both sides of Okha Rann. Some good sections are exposed along the western coast of Okha Rann at Ashapuramata Temple, Charan Ganga, Charakla and Lowrali. The Gaj Formation comprises mainly the ash grey clays (gypsiferous at places), shell limestone, light yellow calcareous claystone; yellow, orange and red marls; variegated clays and foraminiferal limestone. Rocks of this formation dip at very low angles towards the northwest. The overall thickness of the Gaj Formation is about 65 metres (Table 1). The Dwarka Formation conformably overlies the Gaj Formation.

The Dwarka Formation (Middle Miocene to Pliocene) comprises yellow marly limestone, marl and variegated limestone in the lower part; laminated clay and sand, sandstone and marl in the middle part and greyish yellow limestone, generally current bedded and calcareous sandstone in the upper part. In general, the beds of this formation dip at about 2 - 4° towards the northwest.

The Miliolite Limestone Formation comprises oolitic, pelletoid and shell limestones, pink hard and

Table 1: Generalised lithological section from Bhatiya to Gurgat showing the order of superposition of the fossil localities.

Age/Formation	Thickness	Lithology	Fossil Locality
Dwarka Fm. (Mio-Pliocene)	7.50 m	Greyish yellow, sandy-gritty limestone full of shells of *Pecten pascoei* and *Crassostrea* sp.	
Gaj Formation (Middle Miocene)	3.50 m	Shell limestone at the top and yellow, orange, fossiliferous clayey limestone below.	
	7.00 m	Yellow silty calcareous claystone and ash-grey coloured clay with a band of yellow limestone (limestone band thickens laterally).	
	3.00 m	Yellow silty marl with sandy laminations.	
	3.50 m	Greyish yellow calcareous clay.	
	3.50 m	White calcareous fossiliferous claystone.	
	1.00 m	Greyish yellow, silty calcareous claystone laterally grading into yellowish-red limestone.	
	2.00 m	Grey calcareous silty clay.	
	2.00 m	Grey-yellow calcareous silty clay.	
	1.50 m	Orange sandy calcareous marl with grey sandy patches.	
	4.00 m	Orange-yellow, silty, profusely fossiliferous marl.	**Lowrali**
	3.00 m	Light grey friable calcareous siltstone with interbeds of grey silt and yellow marl.	
	3.00 m	Grey semi-plastic clay.	
Gaj Formation (Early Miocene)	2.00 m	Hard limestone.	
	2.50 m	Light pink to chocolate coloured calcareous silty clay.	
	0.80 m	Yellow calcareous siltstone.	
	1.00 m	Pink micaceous silty marl.	
	2.00 m	Yellow fossiliferous limestone.	
	2.00 m	Grey and yellow clay.	
	1.00 m	Light yellow shell limestone.	**Ranjitpur**
	3.00 m	Repetitive sequence of yellow and orange limestone, marl, limestone with thin bands of clay.	
	3.50 m	Yellow-orange weathered fossiliferous limestone.	**Bamnasa Nana**
	2.20 m	Greyish yellow/grey calcareous clay.	
	2.50 m	Yellow marl.	
	1.50 m	Reddish yellow to orange foraminiferal limestone	
	2.50 m	Yellow fossiliferous limestone	**Kuranga**
	3.50 m	Repetitive sequence of light grey-yellow fossiliferous limestone, marl and silty clay.	
	1.50 m	Yellow grey, calcareous clay with fossils	**Kuranga Rly. Station**
	2.00 m	Ash-grey clay with fossils.	
	1.50 m	Yellow and greyish yellow marl and calcareous clay.	
	2.00 m	Yellow marl and fossiliferous marly limestone.	**Bhatvadia**
Laterite (Palaeocene)	5.00 m	Laterite and Bauxite.	

compact, fine pelletoid limestone, and calcareous conglomerate/pebbly limestone. Soil, alluvium, shore sand, Rann clay and mud form the Recent cover.

FOSSIL LOCALITIES

Fossil locations are marked on the geological map (fig.1) with reference to 6 villages. They are Ranjitpur (22° 11' 00" N: 69° 12' 50" E), Bamnasa Nana (22° 05' 35" N: 69° 12' 10" E), Kuranga (22° 02' 30" N: 69° 10' 00" E), Kuranga Railway Station (22° 03' 39" N: 69° 10' 32" E), Lowrali (22° 10' 35" N: 69° 05' 15" E) and Bhatvadia (22° 03' 00" N: 69° 14' 00" E). Location of all the specimens is shown under the headings 'Horizon and Locality' with a precision of 50 metres. Five localities, i.e. Bhatvadia, Ranjitpur, Bamnasa Nana, Kuranga Railway Station and Kuranga expose strata of early Miocene age in ascending chronological order. Lowrali is the sole locality with rock of middle Miocene age. The relative position of other outcrops in the stratigraphic succession is difficult on account of very low dipping strata and litho-facies variations along the strike and dip. However, a generalised

section from Bhatiya to Gurgat (table 1) is included, indicating the order of superposition of the fossil localities.

SYSTEMATIC PALAEONTOLOGY

Class **Echinoidea** Leske, 1778

Subclass **Perischoechinoidea** M'Coy, 1849

Order **Cidaroida** Claus, 1880

Family **Cidaridae** Gray, 1825

Subfamily **Rhabdocidarinae** Lambert, 1900

Genus ***Prionocidaris*** A. Agassiz, 1863

(Type species: *Cidarites pustillaris* Lamarck, 1816; OD)

Prionocidaris

(Pl. I, fig. 1, a-h, j,k,n)

Many echinoid spines mostly of the Order Cidaroida have been collected from the beds of the Gaj Formation from a number of places. They have remained partially identified. Out of these, few representatives are shown in Pl. I, fig. 1, a-h,j,k,n. They belong to the genus *Prionocidaris*.

Prionocidaris granulata (Duncan & Sladen)

(Pl. I, figs. 2-5)

Cidaris granulata Duncan & Sladen, 1883, p. 80-81, pl. XII, figs. 4-6.

Material: Nine specimens, out of these, three specimens are well preserved.

Horizon and Localities: Gaj Formation, early Miocene.

3.00 km southeast of Ranjitpur. Sp. Nos. 43/1037 to 43/1038.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1039 to 49/1045.

Dimensions (mm):

Specimen	Height	Diameter	D/H
43/1037	14.4	27.4	1.90
49/1042 (Topotype)	9.0	32.5	1.71
49/1043 (Topotype)	25.4	47.2	1.86
49/1044	18.3	34.5	1.88
49/1045 (Topotype)	23.0+	46.0	2.00-

Description: The test is broad and depressed. Ambulacra are moderately wavy and interambulacra much wider than ambulacra. In the pore pairs, pores are connected by a groove and there is a raised, narrow linear ridge between the two pore pairs. Coronal interradial plate bears radial granulation marking on the boss and partial crenulations in very few primary tubercles. A small tubercle is found close to the inner pore, and towards the median line there are two tubercles, innermost is smallest. Thus, there are six vertical rows of tubercles in an interambulacral area. Interambulacrum is well defined by simple sutures. Interradial tract is having more space than the adradial tract of an interambulacrum plate. In the interambulacrum, towards the median line there is a row of smaller tubercles alternating with the larger, and still further there are two other rows of smaller and distinct tubercles, the last being almost miliary in size.

Distribution: Gaj Formation, Kathiawar, Gujarat, India.

Remarks: Both the species of Duncan and Sladen *Cidaris granulata* and *Cidaris excelsa* bear conjugate pores, sutures without grooves and mostly non-crenulate primary tubercles. Primary spines are large, long and robust and hence belong to the genus *Prionocidaris* of Subfamily Rhabdocidarinae.

Prionocidaris excelsa (Duncan & Sladen)

(Pl. I, figs. 6,7)

EXPLANATION OF PLATE I

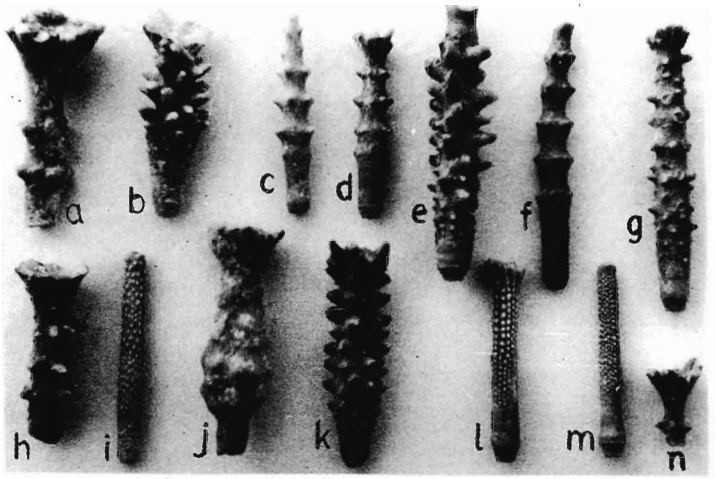
In the explanation of plates different views of tests are given for individual species. Magnifications are given, if not so, it should be taken as X 1.

1. Echinoid spines, Gaj Formation (early and middle Miocene), Okha Mandal and Kalyanpur tehsils of Jamnagar district; a-h,j,k,n - ***Prionocidaris*** spines and i,l,m - small, cylindrical and beaded spines possibly belong to *Eucidaris* .

2-5. ***Prionocidaris granulata*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, 2- Sp. No. 49/1043, X 1.25; 3,5- Sp. No. 49/1042, X 2.45 and 1.25 respectively; 4- Sp. No. 49/1045, X 1.25.

6-7. ***Prionocidaris excelsa*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, Sp. No. 49/1036, X 1.20 and 1.50 respectively.

8. ***Coelopleurus forbesi*** d'Archiac & Haime, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, Sp. No 49/1058, X 1.40.



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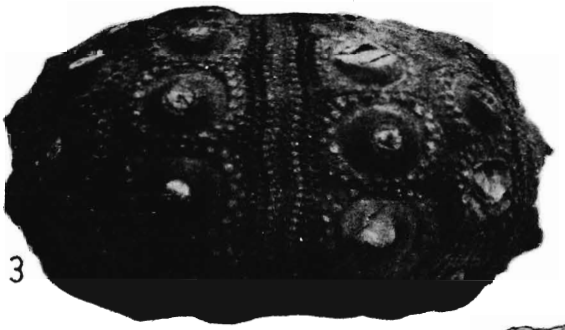

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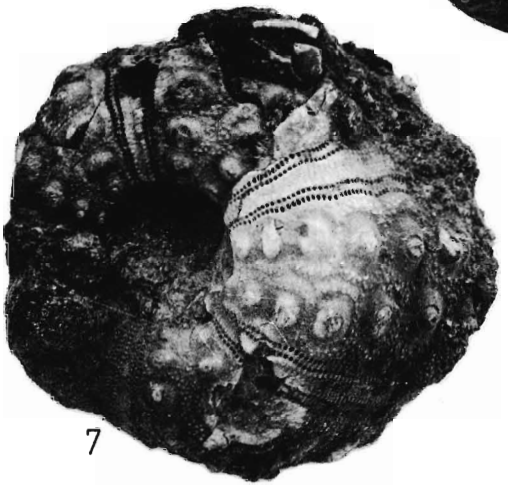

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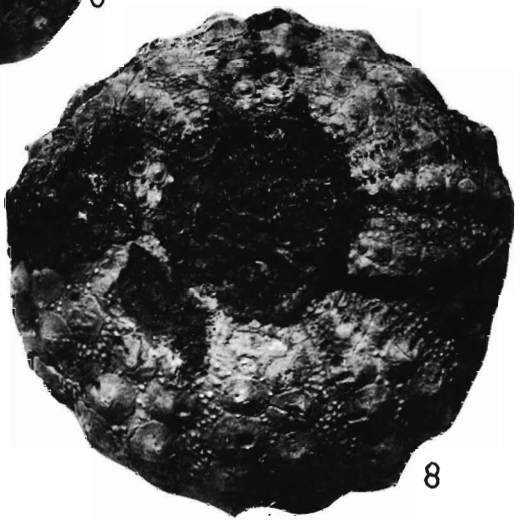

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Cidaris excelsa Duncan & Sladen, 1885, p. 282-283, pl. XLIV, figs. 9-11.

Material: Three tests partly broken and four fragments of test.

Horizon and Localities: Gaj Formation, early Miocene.

3.00 km southeast of Ranjitpur. Sp. Nos. 43/1032, 43/1033.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1034 to 49/1036.

Kuranga Railway Station Road. Sp. No. 62/1031.

2.50 km WSW of Bhatvadia. Sp. No. 66/1030.

Dimensions (mm):

Specimen	Height	Diameter	D/H
49/1034	26.2	32.7	1.25
49/1035	28.0	38.5	1.37
49/1036 (Topotype)	33.2	44.8	1.35

Distribution: Gaj Formation, Sind, Pakistan.

Remarks: Duncan and Sladen (1885) described this species based on two fragments of test. The present material (Sp. No. 49/1036) is almost complete (Pl. I, figs. 6,7). This species is easily distinguished from *Prionocidaris granulata* (Duncan & Sladen) by its comparatively quite high test, ornamentation of the interambulacral plates and by its scorbicular ring composed of 22-24 small miliary tubercles. Interambulacral plate is wider and extra-scrobicular surface in the present species is larger than the type and covered with granules.

Subfamily **Cidarinae** Gray, 1825

Genus ***Eucidaris*** Pomel, 1833

(Type species: *Cidarites metularia* Lamarck, 1816)

Spines of *Eucidaris* sp.

(Pl. I, fig.1, i,l,m)

Many echinoid spines mostly of the Order Cidaroida have been collected from the beds of the Gaj Formation from a number of places have remained partially identified. Out of these, few representatives (Pl. I, fig.1, i, l, m) are small, cylindrical and beaded and possibly belong to *Eucidaris*.

Subclass **Euechinoidea** Bronn, 1860

Superorder **Echinacea** Claus, 1876

Order **Arabacioida** Gregory, 1900

Family **Arabaciidae** Gray, 1855

Genus ***Coelopleurus*** L. Agassiz, 1840

(Type species: *Cidaris cornalis* Leske, 1778 ; OD, Eocene (Lutetian), France)

Coelopleurus forbesi d' Archiac & Haime

(Pl. I, fig. 8)

Coelopleurus forbesi d'Archiac & Haime, 1853, p. 200-201, pl. XII, fig. 6. —Duncan & Sladen, 1883, p. 53-54, Pl. XIII, fig. 1. — Duncan & Sladen, 1885, p. 287-297.

Material: Single partly broken but well-preserved specimen.

Horizon and Locality: Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Sp. No. 49/1058.

Dimensions (mm):

Specimen	Height	Diameter	D/H
49/1058 (Topotype)	27.8 +	53.0	1.91-

Distribution: Gaj Formation of Sind (Pakistan), Kachchh and Kathiawar (India).

Remarks: The present specimen is in conformity with the figures given by d'Archiac and Haime (1853) and Duncan and Sladen (1883).

Coelopleurus sindensis Duncan & Sladen

(Pl. II, figs. 4-6)

Coelopleurus sindensis Duncan & Sladen, 1885, p. 298-302, pl. XLVII, figs. 1-2 and pl. XLVI, figs. 3,5,6,8,10.

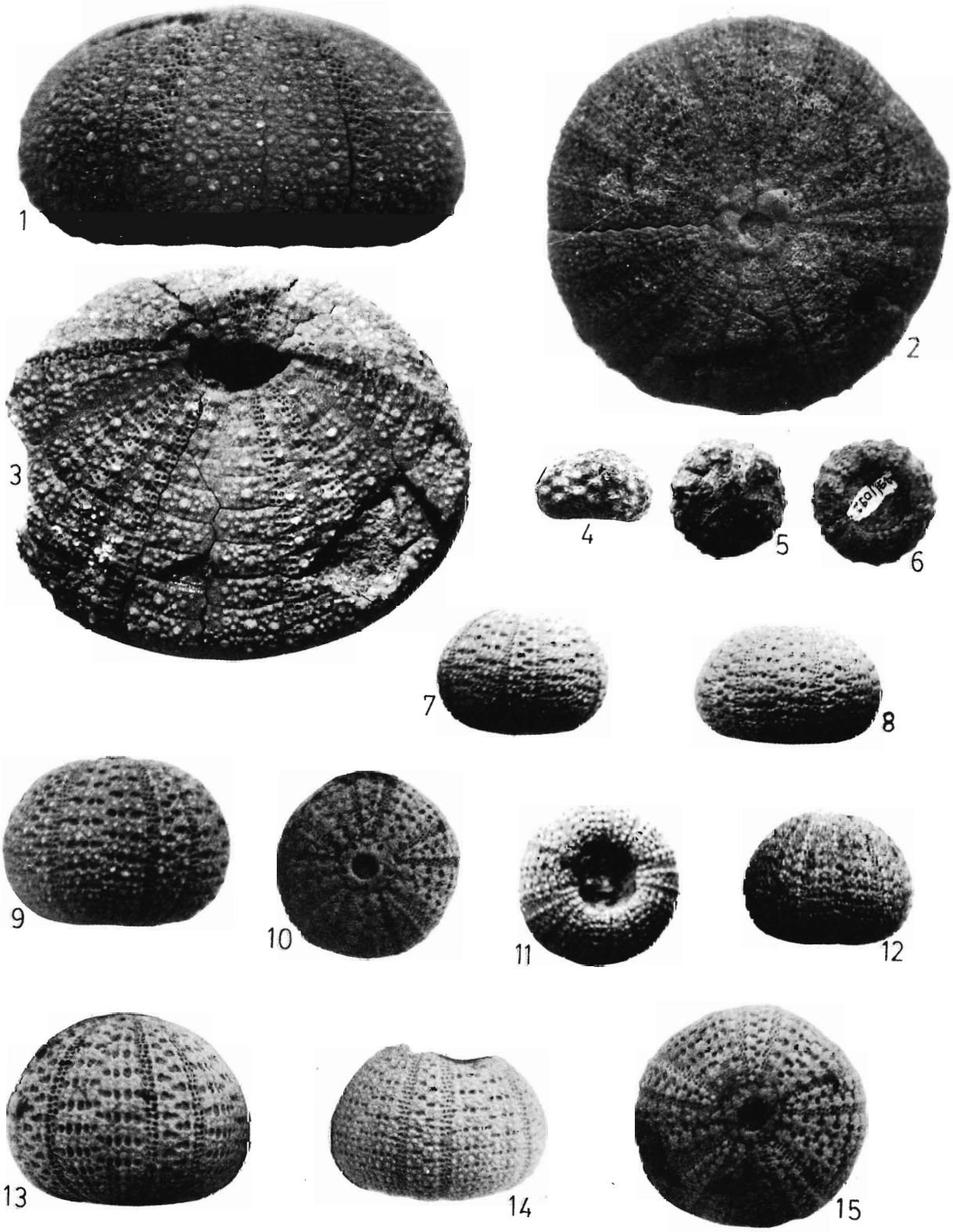
EXPLANATION OF PLATE II

1-3. ***Grammechinus regularis*** Duncan & Sladen, Gaj Formation, middle Miocene, 0.5 km east of Lowrali, Sp. Nos. 24/1066, 24/1067, 24/1068 and X 3.00, 2.50, 3.50 respectively.

4-6. ***Coelopleurus sindensis*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, Sp. No. 49/1092. X 1.20, 1.25 and 1.30 respectively.

7-11. ***Opechinus affinis*** (Duncan & Sladen), Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. 7,9- Sp. No. 49/1149; 8,11- Sp. No. 49/1146; 10- Sp. No. 49/1150. X 2.2, 2.2, 2.90, 2.70 and 1.95 respectively.

12-15. ***Opechinus costatus*** (d'Archiac & Haime), Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Sp. Nos. 49/1161, 49/1156, 49/1207, 49/1163 and X 1.95, 2.55, 2.40, 2.65 respectively.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Material: One poorly preserved specimen.

Horizon and Locality: Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Sp. No. 49/1092.

Dimensions (mm):

Specimen	Height	Diameter	D/H
49/1092 (Topotype)	10.0	18.0	1.80

Distribution: Gaj Formation, Sind, Pakistan.

Remarks: Specific characters are well described by Duncan and Sladen (1885). The present specimen represents a young individual. Ornamentation is also very distinct and characteristics of *Coelopleurus sindensis* Duncan & Sladen.

Order **Temnopleuroida** Mortensen, 1942

Family **Temnopleuridae** A. Agassiz, 1872

Genus ***Grammechinus*** Duncan & Sladen, 1883

(Type species : *Grammechinus regularis* Duncan & Sladen; OD, middle Miocene of India and Pakistan)

Grammechinus regularis Duncan & Sladen

(Pl. II, figs. 1-3)

Grammechinus regularis Duncan & Sladen, 1883, p. 82-83, pl. XII, figs. 7,8.

Material: 11 specimens, three are well preserved.

Horizon and Locality: Gaj Formation, middle Miocene; 0.5 km east of Lowrali. Sp. Nos. 24/1059 to 24/1069.

Dimensions (mm):

Specimen	Height	Diameter	D/H
24/1059	25.3	47.3	1.87
24/1060	25.7	46.2	1.80
24/1062	23.1	36.5	1.58
24/1063	14.9	34.1	2.29
24/1065	12.0	19.4	1.61
24/1066 (Topotype)	14.5	27.7	1.91
24/1067 (Topotype)	17.3	30.1	1.74
24/1068 (Topotype)	21.0	24.9	1.19

Distribution: Gaj Formation, Kathiawar from 0.8 km east of Lowrali.

Remarks: This species is characterised by the enormous width of its interambulacral plates and tubercles without crenulations, primary tubercles in the middle, and secondary tubercles which are slightly smaller than primaries and positioned on each side of primaries. Small tubercles near horizontal sutures are elongate and join with their counterparts on the other side of the suture to form bridges.

The present form is in full agreement with the original figured specimen by Duncan and Sladen (1883).

Genus ***Opechinus*** Desor, 1856

(Type species: *Temnopleurus costatus* d'Archiac & Haime, Tertiary of India)

Opechinus affinis (Duncan & Sladen)

(Pl. II, figs. 7-11)

Temnechinus affinis Duncan & Sladen, 1883, p. 86-87, pl. XII. figs. 11, 12.

Material: Many well-preserved specimens.

Horizon and Localities: Gaj Formation, early Miocene.

3.00 km southeast of Ranjitpur.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1144 to 49/1152.

2.75 km east of Bamnasa Nana. Sp. Nos. 57/1152 to 57/1154.

3.10 km S 65° east of Kuranga. Sp. No. 63/1155.

Description: The test is turban shaped, broader than high, symmetrical rather flat actinally, tumid at the ambitus and depressed abactinally. Peristome is very small. Apical system is small. At the ambitus the width of an ambulacrum is nearly equal to that of an interambulacrum. Poriferous zones are broad, slightly sunken and pairs of pores in triplets but in simple succession. There is a vertical row of small primary tubercles on each side of the interporiferous area near the poriferous zone. Each of these small primaries is connected with the smaller tubercle above the primary in the lower plate by a narrow process. The raised ribbing produces broad and rather low fossettes and their shape is that of a broad straight comma. There is a vertical row of these fossettes on either side of the median line of the

ambulacrum. In the interambulacra there are two vertical rows of small primaries, which are slightly larger than those of the ambulacra. Long and rather narrow zigzag ribs pass from near the primaries across the median line to those of the adjoining plates, and smaller costa join on to those of the poriferous zone on the other side of the primary tubercle. The tubercles are imperforate and non-crenulate.

Dimensions (mm):

Specimen	Height	Diameter	D/H
49/1144	10.6	16.3	1.54
49/1145	10.6	15.5	1.46
49/1146 (Topotype)	10.0	15.9	1.59
49/1147	10.0	15.3	1.53
49/1148	9.6	15.0	1.56
49/1149 (Topotype)	10.2	14.6	1.38
49/1150 (Topotype)	8.6	12.7	1.48
49/1151	6.9	10.6	1.54
49/1152	6.8	9.3	1.35
57/1153	9.4	15.0	1.60
57/1154	10.0	15.5	1.55
63/1155	7.8	12.3	1.57

Distribution: Gaj Formation, Kathiawar, India.

Remarks: Duncan and Sladen (1883) have originally described this species from the Gaj Formation, Kathiawar in detail. A part of the present collection comes from the same area, and the rest from the two new localities of Okha Mandal tehsil.

The present species is distinguished from other species by its turban-shaped, broader than high test and nearly equal width of ambulacrum and interambulacrum at the ambitus. Other characters are broad poriferous zone, pore pairs in triplets, slightly sunken, arranged in simple succession, vertical rows of fossettes on either side of the median line of the ambulacrum and imperforate, non-crenulated tubercles.

Opechinus costatus (d'Archiac & Haime)

(Pl. II, figs. 12-15)

Temnopleurus costatus, d'Archiac & Haime, 1853, p. 204-205, pl. XII, figs. 9, a, b.

Temnechinus costatus (d'Archiac & Haime), Duncan & Sladen, 1883, p. 84, pl. XIII, figs. 9, 10.

Material: Many, few excellently preserved specimens.

Horizon and Localities: Gaj Formation, early Miocene.

3.00 km southeast of Ranjitpur. Sp. Nos. 43/1156 to 43/1158.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1159 to 49/1162.

2.75 km east of Bamnasa Nana. Sp. No. 57/1163.

3.10 km S 65° east of Kuranga Village. Sp. No. 63/1164.

Dimensions (mm):

Specimen	Height	Diameter	D/H
43/1156 (Topotype)	14.7	17.9	1.21
43/1157	14.6	19.4	1.33
43/1158	13.8	18.9	1.37
49/1159	12.9	18.4	1.42
49/1160	14.0	17.6	1.26
49/1161 (Topotype)	13.0	16.9	1.30
49/1162	11.2	14.2	1.42
49/1207 (Topotype)	11.4+	17.2	1.51-
57/1163 (Topotype)	13.0	16.8	1.29
63/1164	11.7	15.0	1.28

Distribution: Gaj Formation, Kathiawar, India.

Remarks: It is distinguished from other described species of *Opechinus* by its tall and tumid shape, taller ornamented interambulacral plates, partitioned along the median line by short processes, which join the other plate obliquely. Interambulacral plates have broad, deep angular pits above and below the short processes. The specimens of the present collection are in full conformity with the type of Duncan and Sladen (1883).

Opechinus rousseaui (d'Archiac)

(Pl. III, figs.1- 2)

Temnopleurus rousseaui d'Archiac, 1850, p. 257. — d'Archiac & Haime, 1853, p. 205, pl. XIII, figs. 10, a, b, c.— *Temnechinus rousseaui* (d'Archiac), Duncan & Sladen, 1883, p. 84, pl. XIII, figs. 13, 14,15.

Material: Many well-preserved specimens.

Horizon and Localities: Gaj Formation, early Miocene.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1165, 49/1166, 49/1168, 49/1169.

2.75 km east of Bamnasa Nana. Sp. Nos. 57/

1170 to 57/1174, 57/1208.

3.10 km S 65° east of Kuranga Village. Sp. No. 63/1175.

Dimensions (mm):

Specimen	Height	Diameter	D/H
49/1165	16.3	24.2	1.48
49/1166	12.3	18.0	1.46
49/1168	10.6	14.4	1.36
49/1169	10.0	13.6	1.36
57/1170	10.6 +	22.6	2.13 -
57/1171 (Topotype)	11.2	17.8	1.59
57/1172	11.7	17.7	1.51
57/1173	10.0	16.0	1.60
57/1174	9.0	15.0	1.67
57/1208 (Topotype)	11.2	17.9	1.60
63/1175	0.8	12.1	1.51

Distribution: Gaj Formation, Kathiawar, India.

Remarks: This species is distinguished from others by its test having circular outline with flat base, bulges near ambitus; breadth of ambulacra is about 2/3 of interambulacra and the fossettes (broad, deep angular pits) are very large and deep. But the interambulacral plates are sunken abapically; and the angular pits of ambulacral ornamentation are like those figured in this species by Duncan and Sladen (1883, pl. XIII, fig. 15) but with larger size. There are minor variations in the shape and thickness of test among the individuals of this species.

Opechinus tuberculosus (d'Archiac & Haime)

(Pl. III, figs. 3-7)

Temnopleurus tuberculosus d'Archiac & Haime, 1853, p. 206, pl. XIII, figs. 11, a,b. — *Temnoechinus tuberculosus* (d'Archiac & Haime): Duncan & Sladen, 1883, p. 85, pl. XIII, figs. 16,17.

Material: Many well-preserved tests.

Horizon and Localities: Gaj Formation, early Miocene.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1167, 49/1175 to 49/1177, 49/1209 to 49/1211.

2.75 km east of Bamnasa Nana. Sp. Nos. 57/1178 to 57/1181.

3.10 km S 65°east of Kuranga Village.

Dimensions (mm):

Specimen	Height	Diameter	D/H
49/1209 (Topotype)	11.6+	19.0	1.64-
49/1210 (Topotype)	11.1	16.9	1.52
49/1211 (Topotype)	10.0	14.5	1.45
49/1167 (Topotype)	12.6	17.6	1.40
49/1175	11.1	17.6	1.58
49/1176	9.0	15.3	1.70
49/1177	9.2	15.0	1.65
57/1178	12.0	18.9	1.57
57/1179	11.2	17.7	1.58
57/1180	9.3	14.9	1.60
57/1181	8.2 +	14.7	1.79 -

Distribution: Gaj Formation, Kathiawar, India.

Remarks: Test is turban shaped, swollen at the margin and above, and then tapering off to a rather flat top. The specific distinction is the presence of vertical processes that divide the ambulacral fossettes (broad, deep angular pits) into two. Another character is the tumid body of the genital plates and their angular extremity, which is perforated by a large pore. Some, but not all, of the tubercles are excessively finely crenulate. In comparison to *Opechinus costatus* (d'Archiac & Haime), ambulacral ridges in the present species are stouter. Fossettes are small and crossed by vertical processes. Interambulacral plates resemble the larger plates of full-grown individuals of *Opechinus rousseaui* (d'Archiac).

EXPLANATION OF PLATE III

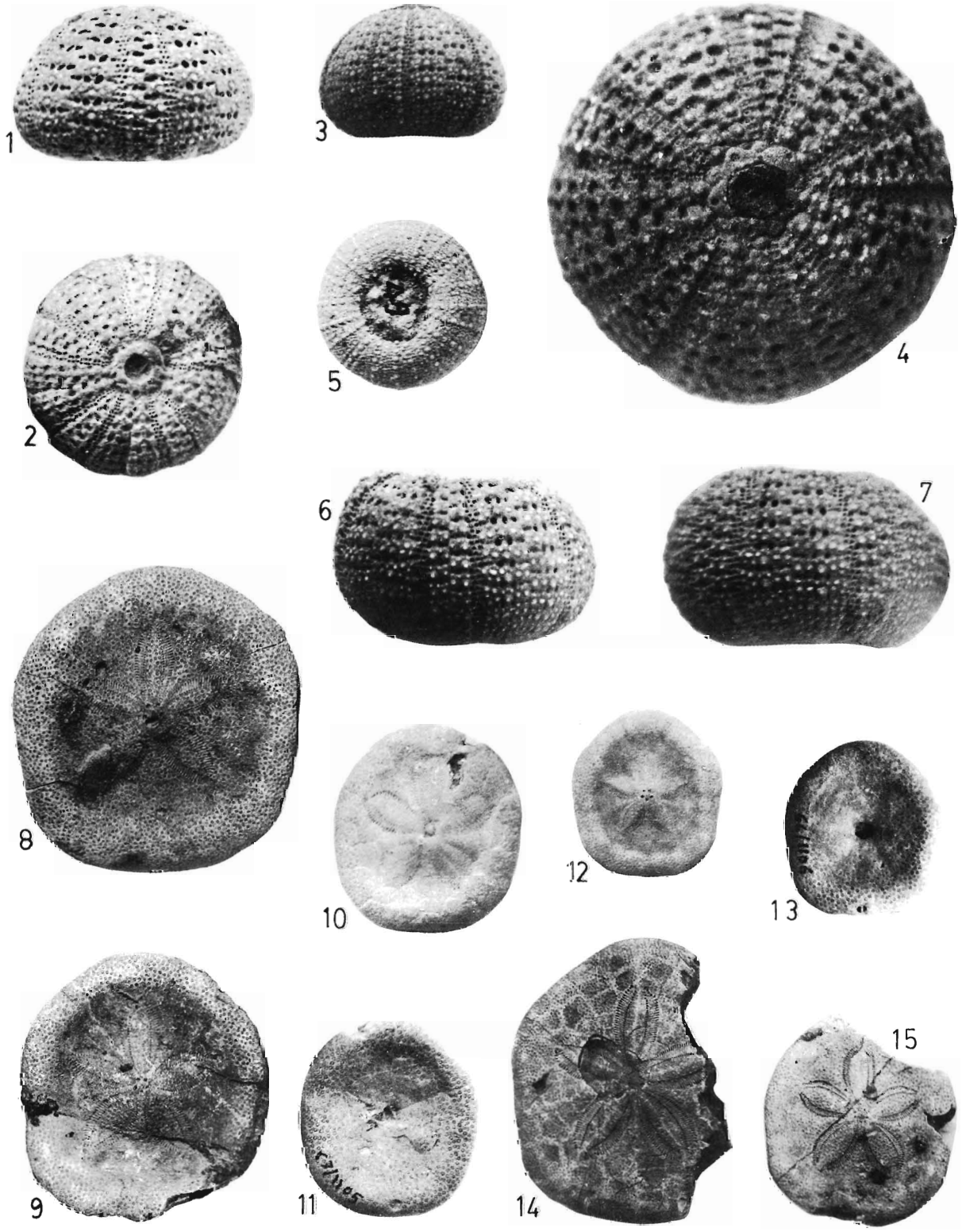
1-2. ***Opechinus rousseaui*** (d'Archiac), Gaj Formation, early Miocene, 2.75 km east of Bamnasa Nana. Sp. Nos. 57/1171, 57/1193 and X 2.50, 1.80 respectively.

3-7. ***Opechinus tuberculosus*** (d'Archiac & Haime), Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, 3-5, Sp. Nos. 49/1211, 49/1167, 49/1210; 6,7- Sp. No. 49/1209. X 2.35, 4.20, 1.85, 2.60 and 2.80 respectively.

8-9. ***Clypeaster depressus*** Sowerby, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Sp. Nos. 49/1115, 49/1116 and X 1.35 and 1.30 respectively.

10-13. ***Clypeaster carteri*** Duncan & Sladen, Gaj Formation, early Miocene. 10,11- Sp. No. 67/1105, X 1.35 and 1.25 respectively, 2.0 km east of Kuranga Village. 12,13- Sp. No. 66/1106, X 1.25 and 1.60 respectively.

14-15. ***Clypeaster complanatus*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Sp. Nos. 49/1095, 49/1094 and X 1.00, 1.50 respectively.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Superorder **Gnathostomata** Zittel, 1879

Order **Clypeasteroida** A. Agassiz, 1872

Suborder **Clypeasterina** A. Agassiz, 1872

Family **Clypeasteridae** L. Agassiz

Genus ***Clypeaster*** Lamarck, 1801

(Type species: *Echinus rosaceus* Linné, 1758, p. 665; SD Desmoulins, 1835, p. 183, Recent, Caribbean)

Clypeaster carteri Duncan & Sladen

(Pl. III, figs. 10-13)

Clypeaster carteri Duncan & Sladen, 1883, p. 49-50, pl. XII, fig. 12.

Material: Four very well preserved specimens.

Horizon and Localities: Gaj Formation, early Miocene.

2.50 km WSW of Bhatvadia. Sp. No. 66/1106.

2.00 km east of Kuranga Village. Sp. No. 67/1105.

4.00 km southeast of Kuranga Village. Sp. No. 79/1103.

Kuranga Railway Station. Sp. No. 81/1104.

Description: Test shape varies from pentagonal with rounded corners to pentagonal-oval, margins tumid, longer than broad, H/L ratio varies considerably among the individuals, peripetalous area depressed. Petals are distinctly petaloid with about 28 pore pairs in a single row, terminal pore not observed. Peristome is central and periproct marginal, just 1 mm inside the margin on the oral surface.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
66/1106 (Topotype)	25.6	22.7	4.8	0.89	0.19
67/1105 (Topotype)	29.2	25.2	5.0	0.86	0.17
79/1103	29.4	27.4	6.0	0.93	0.20
81/1104	29.5	25.3	5.0	0.86	0.17

Distribution: Neogene rocks of Kachchh from 5.5 km NNE of Pipur.

Remarks: This species is distinguished by its longer than broad, pentagonal to pentagonal-oval test with rounded corners, tumid margin, depressed peripetalous area. Petals are distinctly petaloid with about 28 pore pairs in a single row. Peristome is central and periproct marginal, just one mm inside the margin on oral surface.

The present material is similar in shape and outline of the test with the type described by Duncan and Sladen (1883) except that the former is comparatively more rounded. In the type, the sides are almost vertical and slightly higher than in the present material.

This species resembles *Clypeaster henjamensis* Clegg, 1933 in their external shape, tumid margin and depressed test, but the latter differs in bearing broad margins, comparatively slender petals and shorter pore pairs.

Clypeaster complanatus Duncan & Sladen

(Plate III, figs. 14, 15)

Clypeaster complanatus Duncan & Sladen, 1885, p. 325-326, Pl. L, figs. 10,11.

Material: Three excellently preserved partly broken specimens.

Horizon and Locality: Gaj Formation, early Miocene and 4.75 km southeast of Ranjitpur.

Description: Test greatly depressed, sub pentagonal in shape, flat actinal surface. Petal edges are not sharp and open at the extremity. Apical disc is central. The ambulacral petals are moderately long and wide and petaloid. The paired petals are subequal in length, and the odd anterior petal is a little longer. The distance of the anterior pair of petals from the margin is rather less than 2/3rd of their length and the distance of the posterior pair from the margin is rather greater. The poriferous zones are very wide and the breadth increases up to within 7 or 8 pairs of pore from the extremity. Peristome is small, circular and subcentral. The periproct is small and circular, and its distance from the margin is less than its own diameter.

Dimensions (mm):

Specimen	Length	Breadth	Height
49/1094 (Topotype)	37.1 +	23.5	7.1
49/1095 (Topotype)	52.1	40.4 +	8.5
49/1096	30.1 +	37.2	7.8

Distribution: Gaj Formation, Sind, Pakistan.

Remarks: This species is distinguished by its

depression, flat actinal surface, subpentagonal shape and petal edges which are not sharp and open at the extremity.

On comparison with the type described by Duncan and Sladen (1885), the present forms are found to be slightly less rounded and have comparatively higher apical area than the type. Other characters (petals, five gonopores, poriferous zone and the position of peristome and periproct) are exactly same as in the type.

Clypeaster depressus Sowerby

(Pl. III, figs. 8, 9)

Clypeaster depressus Sowerby, 1840, pl. 24, fig. 26. —Duncan & Sladen, 1883, p. 58, pl. X, figs. 5-9. —Duncan & Sladen, 1885, p. 327.

Material: Five specimens, two are well preserved.

Horizon and Localities: Gaj Formation, early Miocene.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1115, 49/1116.

2.75 km east of Bamnasa Nana. Sp. No. 57/1117.

2.50 km. west-southwest of Bhatvadia. Sp. Nos. 66/1118, 66/1119.

Description: The usual shape of large forms is depressed, hollow actinally, pentagonal at the margin that is slightly tumid. Test is suddenly raised at the inner third of the petals to the apex and depressed around the distal ends of the petals. Petals are unequal, slightly tumid and antero-laterals narrowest. The costae carry small miliaries, and sometimes one or more larger tubercles resembling those of the inter-miliaries, and sometimes one or more larger tubercles resembling those of the inter-poriferous area. It bears five gonopores. The anus is far back and sub-marginal. Great variation in shape and size of the petals is noticed and also in the outline of the test.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1115 (Topotype)	42.2	39.2	7.3	0.93	0.17
49/1116 (Topotype)	38.3	33.3	5.7	0.87	0.15
57/1157	24.0 +	30.2	6.5	1.33	0.27 -
66/1118	27.1	26.0	5.7	0.96	0.21
66/1119	32.0	29.1	5.5	0.91	0.17

Distribution: Gaj Formation of Sind, Pakistan and Kachchh, India.

Remarks: This species is distinguished by its depressed, actinally hollow, pentagonal test which is slightly tumid, raised at the inner third of the petals near the apex and depressed around the distal ends of the petals. Petals are unequal, slightly tumid and antero-lateral petals are narrowest. The anus is situated very near to the margin.

Clypeaster goirensis Duncan & Sladen

(Pl. IV, figs.1-3)

Clypeaster goirensis Duncan & Sladen, 1883, p. 59, Pl. XII, figs. 14.16.

Material: Two well preserved specimens.

Horizon and Localities: Gaj Formation, early Miocene.

2.5 km west-southwest of Bhatvadia. Sp. No. 66/1108.

1.5 km east of Kuranga Village. Sp. No. 67/1109.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
66/1108 (Topotype)	46.0	42.7	7.9	0.93	0.17
67/1109 (Topotype)	34.0	32.2	5.1	0.95	0.15

Distribution: Gaj Formation, Kachchh, India.

Remarks: This species is distinguished by the depressed nature of its test, which is very slightly elevated at the rosette (apical portion), and its irregularly pentagonal outline. Petals are tumid, long, broad, and widely open. Poriferous zones are broad but become narrow suddenly distally and terminal pairs are directed outwards. Inter-poriferous zone is more than twice as broad as the corresponding poriferous zone. It bears five gonopores.

Clypeaster pelviformis Duncan & Sladen

(Pl. IV, figs. 4-7)

Clypeaster pelviformis Duncan & Sladen, 1885, p. 324-325, pl. L, figs. 7-9.

Material: 13 specimens, mostly very well preserved.

Horizon and Localities: Gaj Formation, early Miocene.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1134 to 49/1141.

2.75 km east of Bamnasa Nana. Sp. No. 57/1129.

1.50 km east of Kuranga Village. Sp. Nos. 67/1131 to 67/1133.

Kuranga Railway Station. Sp. No. 81/1130.

Description: Test semicircular with uniformly rounded tumid margin. The actinal surface is deeply concave and widely basins formed, and the concavity occupying nearly the whole of the actinal surface. Abactinal surface slightly convex. Apical disc is central. The ambulacral petals are moderately long and wide, petaloid, suboval in contour, and rather widely open at the outer extremity. The odd anterior petal and the postero-lateral pair are subequal in length, and the antero-lateral pair is slightly shorter. Poriferous zone is very wide. A distinct conjugating furrow unites the pores of a pair. The distance of the petals from the margin is subequal. Scrobiculate tubercles widely spaced. The present material bears five gonopores and periproct is submarginal.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/H	H/L
49/1136	40.0	34.2	7.2	0.85	0.18
49/1138	33.8	30.1	7.5	0.89	0.22
49/1139	31.1	27.4	6.5	0.88	0.21
49/1140	32.1	27.2	6.5	0.85	0.20
49/1141 (Topotype)	27.2	25.0	5.2	0.92	0.19
67/1131	42.1	37.4	8.3	0.89	0.20
67/1132	25.1	23.6	5.2	0.94	0.21
67/1133 (Topotype)	22.7	9.7	5.3	0.87	0.23
81/1130	31.6	28.7	7.4	0.91	0.23

Distribution: Gaj Formation, Sind, Pakistan.

Remarks: This species is readily distinguished from other species by semicircular test having uniformly rounded margin, broad petaloid ambulacra, slightly convex abactinal surface, thick and tumid margins, deep and widely concave actinal surface, and widely spaced scrobiculate tubercles. The present material bears five gonopores. It is slightly more rounded than the type described by Duncan and Sladen (1885) but is otherwise similar leaving no doubt about its specific identification.

Clypeaster profundus d'Archiac

(Pl. IV, figs.8-11)

Clypeaster profundus d'Archiac, 1850. — Duncan and Sladen, 1885, p. 319-322, pl. L, figs. 1-4.

Material: Seven specimens, out of these four are very well preserved.

Horizon and Locality: Gaj Formation, early Miocene.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1120 to 49/1124.

2.75 km east of Bamnasa Nana. Sp. No. 57/1126.

1.50 km east of Kuranga Village. Sp. No. 67/1128.

4.00 km southeast of Kuranga. Sp. No. 79/1127.

Description: Marginal contour subpentagonal with the angles rounded, longer than broad. The apical disc is slightly subcentral, or very slightly eccentric in front. The distance of the paired petals from the margin is about equal or very slightly less than to their own length. The interradial areas are extremely narrow and band like near the apex. The ornamentation of the interradia and inter-poriferous zone consists of very small primary scrobiculated tubercles. The ambulacral petals are short, wide,

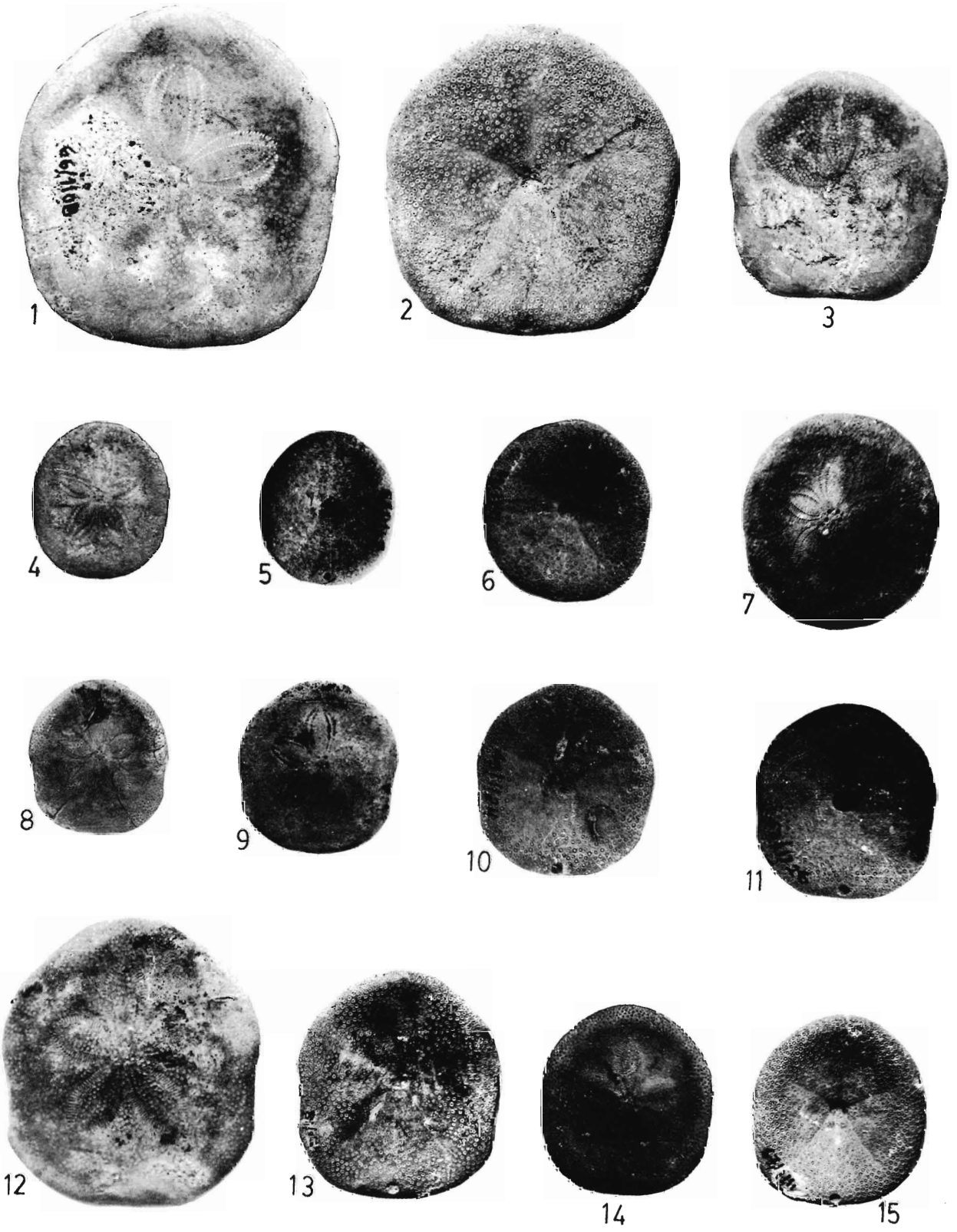
EXPLANATION OF PLATE IV

1-3. ***Clypeaster goirensis*** Duncan & Sladen, Gaj Formation, early Miocene. 1,2- Sp. No. 66/1108, 2.5 km WSW of Bhatvadia; 3- Sp. No. 67/1109, 1.5 km east of Kuranga village. X 1.40, 1.25 and 1.26 respectively.

4-7. ***Clypeaster pelviformis*** Duncan & Sladen, Gaj Formation, early Miocene. 4,5- Sp. No. 67/1133, 1.5 km east of Kuranga village. 6- Sp. No.49/1141, 4.75 km southeast of Ranjitpur; 7- Sp. No. 81/1130, Kuranga Railway Station. X 1.29, 1.28, 1.26 and 1.27 respectively.

8-11. ***Clypeaster profundus*** d'Archiac, Gaj Formation, early Miocene. 8.10- 49/1122 and 49/1124, 4.75 km southeast of Ranjitpur; 9- Sp. No.57/1126, 2.75 km East of Bamnasa Nana; 11- Sp. No. 67/1128, 1.5 km east of Kuranga village. X 1.10, 1.25, 1.45 and 1.45 respectively.

12-15. ***Clypeaster pulvinatus*** Duncan & Sladen, Gaj Formation, early Miocene. 12,13- Sp. No. 81/1114, Kuranga Railway Station, X 1.45 and 1.15 respectively. 14,15- Sp. No.67/1111, 1.5 km east of Kuranga village, X 1.15.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petaloid, very full and widely rounded, almost closed at the outer extremity, and prominently tumid. The poriferous zones are very wide on the outer part of the petal, their breadth increasing gradually from the apical extremity until within a few pairs of pores of the outer extremity. The actinal surface is concave with the deeply impressed peristome. The periproct is small and circular, situated at 1/3rd of its own diameter away from the margin.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1121	30.8	27.7	6.2	0.90	0.20
49/1122 (Topotype)	26.7	23.3	4.4	0.87	0.19
49/1123	29.0	25.4	6.2	0.88	0.21
49/1124 (Topotype)	24.8	22.7	5.7	0.92	0.23
57/1126 (Topotype)	25.7	23.1	5.7	0.90	0.22
67/1128 (Topotype)	25.0	23.0	5.7	0.92	0.23
79/1127	31.6	28.2	7.3	0.89	0.23

Distribution: Gaj Formation, Sind, Pakistan.

Remarks: This species is readily distinguished from other species of Indian *Clypeaster* by the abruptly elevated dome shaped region of the ambulacral petals. The present material is identical with the type in all the characters except that the H/L ratio is slightly more than the type. It bears five gonopores.

Clypeaster pulvinatus Duncan & Sladen

(Pl. IV, figs. 12-15)

Clypeaster pulvinatus Duncan & Sladen, 1885, p. 322-323, pl. L, figs. 5,6.

Material: Five very well preserved specimens.

Horizon and Localities: Gaj Formation, early Miocene.

1.50 km east of Kuranga Village. Sp. Nos. 67/1111, 67/1112.

2.75 km east of Bamnasa Nana. Sp. No. 57/1110.

Kuranga Railway Station. Sp. Nos. 81/1113, 81/1114.

Description: Marginal contour elongately subpentagonal, with the angles tumid and rounded, and the intervening areas more or less incurved. The length is much more than breadth. The lateral sides are distinctly incurved, and also the posterior margin, but to a less degree. The margins are very thick and tumid, especially in the radial regions. Seen in longitudinal profile the anterior slope is much less rapid than the posterior, and the anterior margin is also much thicker. The apical disc is subcentral. The ambulacral petals are long and broad, rather widely open at the outer extremity. The odd anterior petal and the posterior pair are nearly equal in length, and the anterior pair is slightly shorter. The greatest width of the petals is about midway between the extremities. The poriferous zones are very wide outwardly. An indistinct and shallow conjugating furrow unites pores. The widest part of the interporiferous area is nearer the apex. The distance of the paired petals from the margin is greater than the half of their length. Interradial area is very narrow and insignificant on the inner half of the abactinal area. The actinal surface is concave and the depression commencing at a little distance from the tumidity. The peristome is small and subcentral. Periproct is small, circular, and not more than its own diameter away from the margin.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
57/1110	28.9	26.2	5.9	0.94	0.20
67/1111 (Topotype)	30.9	28.0	6.4	0.91	0.21
67/1112	26.0	23.0	6.0	0.88	0.23
81/1114 (Topotype)	36.7	33.0	7.0	0.90	0.19
81/1113	30.8	28.2	7.5	0.92	0.24

Distribution: Gaj Formation of Sind, Pakistan.

Remarks: This species is distinguished from the other Kathiawarian species by its concave vertical sides, and comparatively small and rounded petals. It is also distinguished from others by its more pentagonal marginal contour, different form of the petals and its size. This species is well described in detail by Duncan and Sladen (1885). The present specimens are smaller than the type and have a slightly greater B/L ratio than the type of Duncan and Sladen. Specimen No. 81/1114 (Pl. IV, figs. 12,13) bears five gonopores.

Clypeaster waageni Duncan & Sladen

(Pl. V, figs.1- 2)

Clypeaster waageni Duncan & Sladen, 1883, p. 58, pl. XII, fig. 13.

Material: Four well preserved specimens.

Horizon and Locality: Gaj Formation, early Miocene.

4.75 km. southeast of Ranjitpur. Sp. Nos. 49/1098 to 49/1100.

2.75 km east of Bamnasa Nana. Sp. No. 57/1101.

Description: Test thin, very depressed, longer than broad, maximum breadth posteriorly, a long pentagon in shape. Petals are broad, long and widely open; the interporiferous zones are much wider than the poriferous ones. The odd ambulacrum is the narrowest, and is longer than the antero-lateral, and equal to the posterior pair in length. Poriferous zones become narrow distally and show no tendency to close. Interporiferous area is nearly three times as broad as poriferous zone. Last three pore pairs of lateral ambulacra turn slightly away from the medium line towards the interporiferous area. The very broad and long posterior ambulacra are also open. It bears five gonopores.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1098	26.7	21.0+	6.0	-	0.22
49/1099 (Topotype)	27.2+	24.8	5.8	-	-
49/1100 (Topotype)	26.2	23.6	5.4	0.90	0.21
57/1101	27.1	23.2	6.2	0.86	0.23

Distribution: Gaj/Khari Nadi Formation of Kachchh, India.

Remarks: This species is distinguished by its long pentagonal test, rounded anterior and incurved side margins; long and widely open petals; tongue-shaped and much wider interporiferous zone. The present specimens are in full conformity with the type in shape, dimensional ratios and the ornamentation of petals.

Clypeaster kurangaensis n. sp.

(Pl. V, figs. 3-4)

Material: Two specimens, out of these one is very well preserved.

Horizon and Locality: Gaj Formation, early Miocene. Kuranga Railway Station. Sp. Nos. 81/1091, 81/1092.

Etymology: This species is named after the village of Kuranga, Jamnagar district, Gujarat.

Diagnosis: It is characterised by its flattened test, which is moderately adorally concave, semicircular in outline, rounded and inflated margin. closed petals with sharp ends. Length of the petals is equal to the 3/5th distance from the centre of the test to the margin. Twenty-two pore pairs form a single row of poriferous zone. Periproct is inframarginal very near to the posterior margin at the position of interambulacrum number 5 on the oral surface.

Description: Test of medium size, flattened profile, semicircular in outline, margin rounded and not much inflated. Petaloid ambulacra adapically comparatively less wide than interambulacra, petals with pseudocompound plates, petals length is equal to the 3/5th distance from the centre of the test to the margin. Interambulacrum terminating adapically in a pair of plates. Primordial interambulacral plates greatly reduced. Petals are variable, closed and narrow. Anterior petal III is largest, petals of anterior pair II and IV are medium while posterior petals V and I are smallest. Petals have about 22 conjugate pore pairs in a single row. Outer pore of a pair is elongate while inner one rounded. Apical system is pentagonal with five gonopores and fused genital plates. Peristome is small funnel deep, without any gill slits and food grooves simple. Periproct is very near to the posterior margin at the position of interambulacrum number 5 on the oral surface.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
81/1091 (Holotype)	39.9	37.0	6.1	0.93	0.153
81/1092 (Paratype)	33.0	30.6	5.8	0.93	0.176

Remarks: In comparison with *Clypeaster pelviformis* Duncan & Sladen, the present species has almost equal length and breadth, comparatively slender petals and shorter pore pairs while *Clypeaster pelviformis* has length greater than the breadth. *Clypeaster* (*Stolonoclypus*) *virescens* Doderlein in Nisiyama (1966, 1968, Pl. 12, fig.1) from the Ryukyu Limestone of Okinawa Island, Ryukyu Islands differs from the present species in having a pentagonal-suboval outline, wide peripetalous area, broad and partly open petals, about

30 pore pairs in a single row. The present species, however, bears semicircular to semioval outline, rounded, not much inflated margin. Petaloid ambulacra are less wide adapically than interambulacra. Petals are variable, closed and narrow, and have about 22 pore pairs in a single row.

Suborder **Laganina** Mortensen, 1948

Family **Fibulariidae** Gray, 1855

Genus ***Fibularia*** Lamarck, 1816

(Type species: *Fibularia ovulum*, SD ICZN 1950, Recent, East Indies, Kei Island)

Fibularia ovulum Lamarck

(Pl. V, figs. 5, 6; Pl. VII, fig. 2)

Fibularia ovulum Lamarck in Moore, 1966, p. 469. — Brighton, 1931, p. 326, text fig. 1 in Nishiyama, 1968, p. 458.

Material: Three excellently preserved specimens and one partly distorted specimen.

Horizon and Localities: Gaj Formation, early Miocene and middle Miocene.

1.5 km east of Kuranga Village, Sp. Nos. 67/1142, 67/1143. early Miocene.

0.5 km east of Lowrali. Sp. Nos. 24/1090, 24/1212. middle Miocene.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
24/1090	10.1	8.7	6.2	0.86	0.61
24/1212	10.7	7.3+	7.0	0.68+	0.66
67/1142	12.4	10.8	8.3	0.87	0.67
67/1143 (Topotype)	8.1	7.2	5.3	0.89	0.65

Distribution: Recent, East Indies (Kei Island). *Fibularia ovulum* is also known to occur from the Pleistocene of Farsan Islands, Red Sea (Brighton, 1931, p. 326, text fig. 1 in Nishiyama, 1968, p. 458).

Remarks: Transverse section of the test of *Fibularia ovulum* does not show any internal partitions (Pl. VII, fig. 2). The present form is in full conformity with the figures of *Fibularia ovulum* Lamarck (in Moore, 1966, p. 469, fig. 360, 1a,b) from Recent, East Indies (Kei Island) in its oval shape, ambulacra and position of peristome and periproct. It bears 4 gonopores and 8 pairs of pores in each row.

Fibularia ovulum is known to occur in the Pleistocene of Farsan Islands, Red Sea (Brighton, 1931, p. 326, text fig. 1 in Nishiyama, 1968, p. 458). Hence, the present report of from the rocks of Miocene age is interesting. Both the localities are connected with Arabian Sea, and possibly the species might have migrated from Arabian Sea to Red Sea.

Fibularia depressa n. sp.

(Pl. V, figs. 7-12)

Material: Three excellently preserved specimens.

Horizon and Locality: Gaj Formation, middle Miocene, and 0.5 km east of Lowrali, Sp. Nos. 24/1087 to 24/1089.

Diagnosis: Test semi-oval and depressed, moderately tumid at margins, and button shaped. Petals variable, simple and partly open, anterior odd one is largest; petals of the anterior pair are medium, while petals of posterior pairs are smallest, with 9 pairs of pores in each row and pore pairs non-conjugate

EXPLANATION OF PLATE V

1-2. ***Clypeaster waageni*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Specimen Nos. 49/1099, 49/1100 and X 1.30, 1.35 respectively.

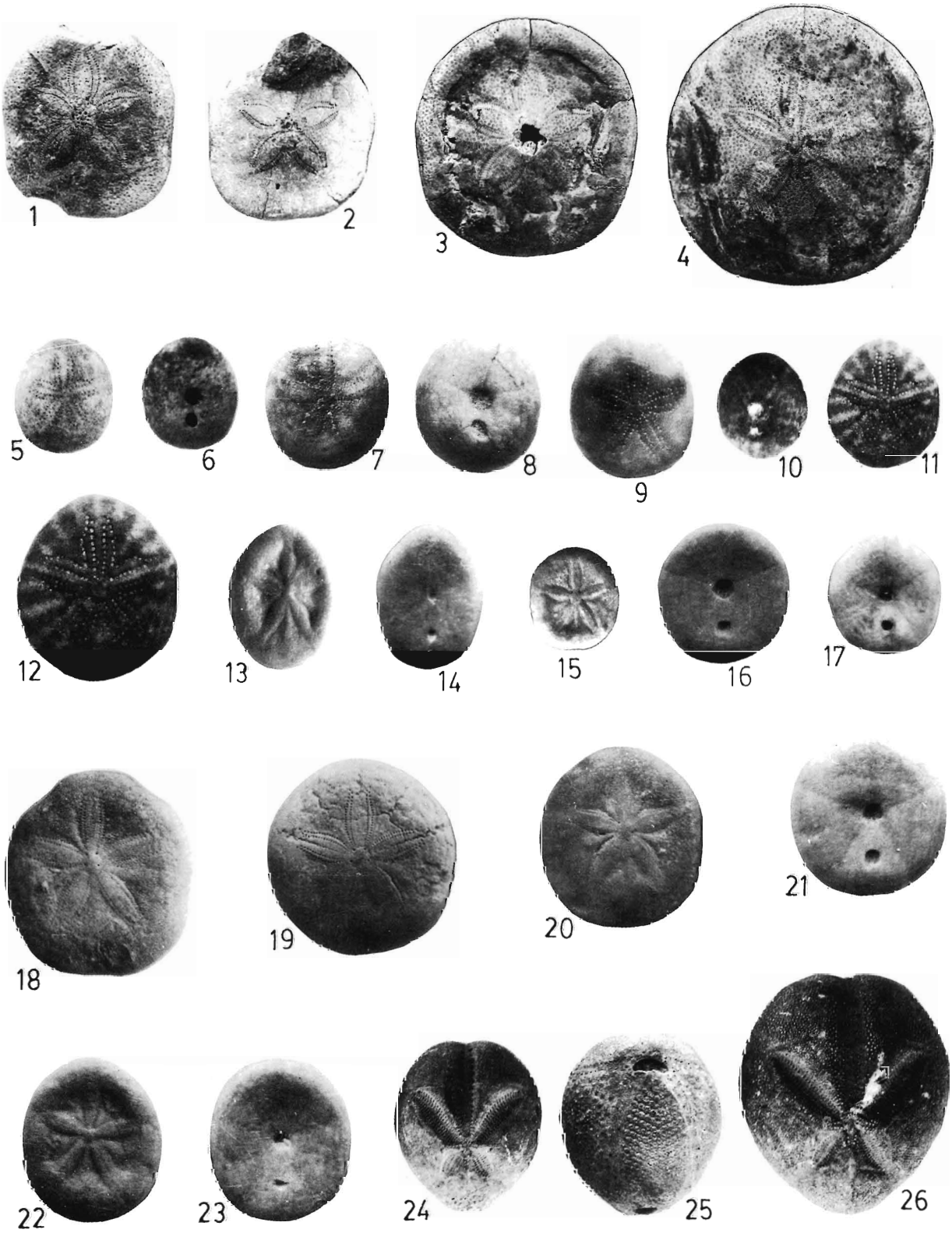
3-4. ***Clypeaster kurangaensis*** n. sp., Gaj Formation, early Miocene, Kuranga Railway Station. Sp. Nos. 81/1192, 81/1091 and X 1.45, 1.15 respectively.

5-6. ***Fibularia ovulum*** Lamarck, Gaj Formation, early Miocene, 1.5 km east of Kuranga village, Sp. No. 67/1143. X 2.70 and 2.60 respectively.

7-12. ***Fibularia depressa*** n. sp., Gaj Formation, middle Miocene, 0.5 km east of Lowrali. 7,8- Sp. No. 24/1088; 9- Sp. No. 24/1087; 10,11,12- Sp. No. 24/1089. X 2.30, 2.40, 2.30,1.85, 2.30 and 3.20 respectively.

13-23. ***Mortonia lowraliensis*** n. sp., Gaj Formation, middle Miocene, 0.5 km east of Lowrali. 13,14- Sp. No. 24/1197, X 1.90; 15- Sp. No. 24/2000, X 1.70; 16- Sp. No. 24/1201, X 1.85; 17- Sp. No. 24/1187, X 1.90; 18- Sp. No. 24/1198, X 3.00; 19- Sp. No. 24/1205, X 3.30; 20- Sp. No.24/1196, X 2.30; 21- Sp. No.24/1206, X 2.45; 22,23- Sp. No.24/1193, X 1.95.

24-26. ***Schizaster granti*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. Sp. Nos. 49/1085, 49/1082, 49/1081 and X 1.25, 1.10, 1.20 respectively.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Etymology: This species is named after the depressed character of its test.

Description: Test semi-oval, outline semi-circular to semi-elliptical, partially flattened and without internal partitions. Petals variable simple and partly open, anterior odd one III is largest, petals of the anterior pair II and IV are medium while petals of posterior pair I and V are smallest. Pores in the pairs are non-conjugate and petals bear nine pairs of pores in each row with one terminal pore. Periproct is semicircular and close to peristome. There are five large periproctal plates. Test margin is rounded. Apical disc is preserved but it is difficult to describe the characters.

Dimensions (mm):

Sp. No.	Length	Breadth	Height	B/L	H/L
24/1087 (Paratype)	2.2	10.2	5.5	0.84	0.45
24/1088 (Paratype)	11.5	10.2	5.0	0.89	0.43
24/1089 (Holotype)	10.9	9.3	5.0	0.85	0.46

Remarks: On comparison, the present species seems to differ from *Fibularia ovulum* in having a depressed, button-shaped test, comparatively larger ambulacral area on the test and of nine pairs of pores in each row instead of eight in *Fibularia ovulum* Lamarck.

Fibularia guvarensis Srivastava (1978, p. 426-427, pl. 1, figs. 10-14) is characterised by its elongate oval shape and much smaller test than the much larger and semi-oval present species.

Fibularia (*Fibulariella*) *acuta* Yoshiwawa, 1898 in Nishiyama (1966, 1968, pl. 13, figs. 3,4,11) differs from the present species in having a highly elongate and less thick test and by the comparatively smaller size of its periproct with respect to the size of the peristome.

Genus ***Mortonia*** Gray, 1852

(Type species: *Fibularia australis* Desmoulins, 1837, p. 86; OD, Recent, Hawaii)

Mortonia lowraliensis n. sp.

(Pl. V, figs. 13-23; Pl. VII, figs. 3-5)

Material: Many well-preserved specimens.

Horizon and Locality: Gaj Formation, middle Miocene, and 0.5 km east of Lowrali.

Diagnosis: Test flattened with variable thickness, outline from oval to pentagonal and concave oral surface. Ambulacral petals are simple and open. There are radial ridges between members of pore pairs with 18-22 non-conjugated pore pairs in a single row. It bears a single hydropore. Internal structure shows just two short partitions on either side of periproct opening.

Etymology: This species is named after its locality village Lowrali, Okha Mandal, district Jamnagar, Gujarat.

Description: Test flattened, outline highly variable from oval to pentagonal. It bears a single hydropore, not in groove. Periproct is between first and second pair of coronal plates with just two short partitions (Pl. VII, figs. 3, 4) on either side of periproct opening. Oral surface is concave. Petals are simple, open with radial ridge between members of pore pairs. Anterior odd petal III is smallest, anterior petals II and IV medium and posterior ones I and V longest and widest in size. There are 18-22 pore pairs in a single row with pores rounded and non-conjugated. Apical system bears four gonopores. Interambulacra terminated adapically by a single plate. Apices of apical system are opposite.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
24/1182	15.0	12.5	2.9	0.83	0.19
24/1183	14.2	12.1	2.6	0.85	0.18
24/1184	14.0	12.5	1.9	0.89	0.14
24/1185	14.2	12.5	3.2	0.88	0.22
24/1186	13.2	12.0	2.8	0.91	0.21
24/1187 (Syntype)	11.7	10.9	2.8	0.93	0.26
24/1188	11.9	10.0	2.7	0.84	0.27
24/1189	11.7	8.8	2.8	0.75	0.24
24/1190	13.0	10.3	1.7	0.79	0.13
24/1191	11.7	10.3	1.5	0.88	0.13
24/1192	17.8	16.2	4.0	0.91	0.22
24 /1193 (Syntype)	15.8	13.8	2.4	0.87	0.15
24/1194	15.8	13.3	2.0	0.84	0.13
24/1195	14.8	13.7	2.6	0.92	0.18
24/1196 (Syntype)	14.7	13.1	1.9	0.89	0.13
24/1197 (Syntype)	14.2	10.3	2.3	0.72	0.16
24/1198 (Syntype)	13.0	11.9	1.7	0.92	0.13
24/1199	12.9	11.2	2.2	0.87	0.17
24/1200 (Syntype)	11.4	10.2	2.0	0.89	0.18
24/1201 (Syntype)	11.3	10.7	2.2	0.95	0.19

24/1202	11.2	10.2	1.8	0.91	0.16
24/1203	10.7	10.1	2.0	0.94	0.19
24/1204	10.4	9.6	1.7	0.92	0.16
24/1205 (Syntype)	11.2	12.0	2.6	1.07	0.23
24/1206 (Syntype)	12.8	11.7	2.0	0.91	0.16
24/1213	13.4	12.3	3.2	0.92	0.16
24/1214	9.1	8.0	1.6	0.88	0.18

Remarks: Transverse section of the posterior part of the test around periproct exposes just two short partitions on either side of periproct opening (Pl. VII, figs. 3,4). This species is variable in shape. Oval forms (sp. no. 24/1189) resemble *Mortonia australis* (Desmoulins) in shape. But there is considerable variation in shape from pentagonal to oval, in height/length ratio and in the number of pore pairs from 18 to 22 which allows me to assign this form to a new species. Reporting of *Mortonia* from middle Miocene of Kathiawar is interesting as this genus is Recent, Indo-Pacific (Moore, 1966, p. 471).

Superorder **Atelostomata** Zittel, 1879

Order **Spatangoida** Claus, 1876

Suborder **Hemiasterina** A. G. Fischer, 1966

Family **Schizasteridae** Lambert, 1905

Genus ***Schizaster*** L. Agassiz, 1836

(Type species: *Schizaster studeri*; SD ICZN Op. 209, 1948, Eocene, France)

Schizaster granti Duncan & Sladen

(Pl. V, figs. 24-26)

Schizaster granti Duncan & Sladen, 1883, p. 88-89, pl. VI, figs. 8-12.

Material: Many specimens, preservation excellent.

Horizon and Locality: Gaj Formation, early Miocene and 4.75 km southeast of Ranjitpur. Sp. Nos. 49/1081 to 49/1085.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1081 (Topotype)	38.0	33.0	24.9	0.87	0.65
49/1082 (Topotype)	31.2	26.6	21.0	0.85	0.67
49/1083	27.2	23.2	16.6	0.85	0.61
49/1084	31.0	27.0	21.7	0.87	0.70
49/1085 (Topotype)	26.9	22.8	17.7	0.85	0.66

Distribution: Gaj Formation, Kathiawar and Kachchh, Gujarat; and Sind, Pakistan.

Remarks: The present species is well known from the Tertiary of the Indian Subcontinent. The present material agrees in all respects with the type of Duncan and Sladen (1883).

Genus ***Moira*** A. Agassiz, 1872

(Type species: *Spatangus atropos* Lamarck, 1816, p. 32, Recent, North America)

Moira antiqua Duncan & Sladen

(Pl. VI, figs. 1-3)

Moira antiqua Duncan & Sladen, 1883, p. 64-65, pl. VII, figs. 1-6.

Material: Two well-preserved specimens from Ranjitpur; and also a few distorted specimens from a locality 0.5 km east of Lowrali.

Horizon and Locality: Gaj Formation, early Miocene and 4.75 km southeast of Ranjitpur. Sp. Nos. 49/1024, 49/1025. A few distorted specimens were also collected from the middle Miocene horizons from Lowrali.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1024 (Topotype)	26.9	24.9	21.5	0.93	0.80
49/1025 (Topotype)	30.1	25.3	22.7	0.84	0.75

Distribution: Gaj Formation, Kachchh, Kathiawar and Sind.

Remarks: The present specimens are in full agreement with the type species.

Suborder **Micrasterina** A. G. Fischer, 1966

Family **Brissidae** Gray, 1855

Genus ***Brissus*** Gray, 1825

(Type species: *Spatangus brissus unicolor* Leske, 1778, p. 248, Recent, Cuba)

Brissus daviesi n. sp.

(Pl. VI, figs. 4-9)

Material: Four specimens, out of these two are excellently preserved.

Horizon and Locality: Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur.

Diagnosis: A species with the characters of the genus *Brissus* with triangular-oval shape, anterior end uniformly rounded and test gradually tapering

towards the posterior end, and ambulacra sunken with sharp margin.

Etymology: This species is named in honour of the renowned palaeontologist, the late Dr. A. M. Davies, author of the book *Tertiary Faunas*.

Description: Test is ovoid, lacking frontal sinus and apex anterior. Apical system is distinctly anterior to the middle, ethmolytic with 4 gonopores. Anterior ambulacrum is barely sunken and paired petals sunken. Anterior pair transversely oriented and petals of anterior pair bear 12 pore pairs in a single row. Petals of the posterior pair have 18 pore pairs in a single row. Subanal fasciole is broad with lateral lobes and anal branch. Peristome is far forward. Peripetalous fasciole is distinct.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1026 (Paratype)	41.1	34.7	25.6	0.84	0.62
49/1027 (Paratype)	28.5	23.2	18.0	0.81	0.63
49/1028 (Paratype)	24.2	19.9	15.7	0.82	0.65
49/1029 (Holotype)	25.1	20.8	17.1	0.83	0.68

Remarks: Whereas *Brissus unicolor* is uniformly rounded with a flat posterior end, the present specimens have a triangular-oval shape with the test gradually tapering towards the posterior. *Brissus latecarinatus* (Leske, 1778 in Nisiyama, 1966, 1968, pl. 29, figs. 1-3) from the Ryukyu Limestone of North Borodino Island (Kita-Daito-jima) is comparable with the present species. But *B. latecarinatus* differs from the present species in an oval shape, larger test (tapering towards interambulacrum number 5), longer shallow petals and near horizontal ambulacra II & IV. The present species has a smaller, ovate, rounded test, deeper petals in smaller peripetalous area, and ambulacra II and IV situated in the horizontal position.

Genus ***Metalia*** Gray, 1855

(Type species: *Spatangus sternalis* Lamarck, 1816; OD, Recent, Indo-Pacific)

Metalia harshadae n sp.

(Pl. VI, fig. 10; Pl. VII, fig. 1)

Material: Two specimens.

Horizon and Locality: Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, Sp. Nos. 49/1022, 49/1023.

Diagnosis: A species with ovate test and frontal sinus, typical crescent shaped posterior petals. Apical system is slightly anterior to the centre and ethmolytic with three gonopores. Large tubercles are absent within the peripetalous area. Ambulacra are depressed and their anterior pair forms an angle of about 94°.

Etymology: The species is named after a famous temple of the Goddess Harshad Mata in the vicinity of the study area.

Description: Test ovate, somewhat depressed with slight frontal sinus. Apical system is slightly anterior to the central and ethmolytic with 3 gonopores. Ambulacra depressed, paired petals are petaloid, anterior pair forming an angle of about 94°. Anterior odd petal is longest and bears 26-28 pore pairs in a single row followed by 24 pore pairs in a single row in the petals of the posterior pairs, and anterior pairs with 20 pore pairs in a single row. Large tubercles within the peripetalous area absent, proximal plates of petals have rudimentary pores. Petals are confluent in proximal plates. Subanal fasciole is not observed. Distinct peripetalous fasciole is not preserved but there are indications of its presence in the adapical region.

EXPLANATION OF PLATE VI

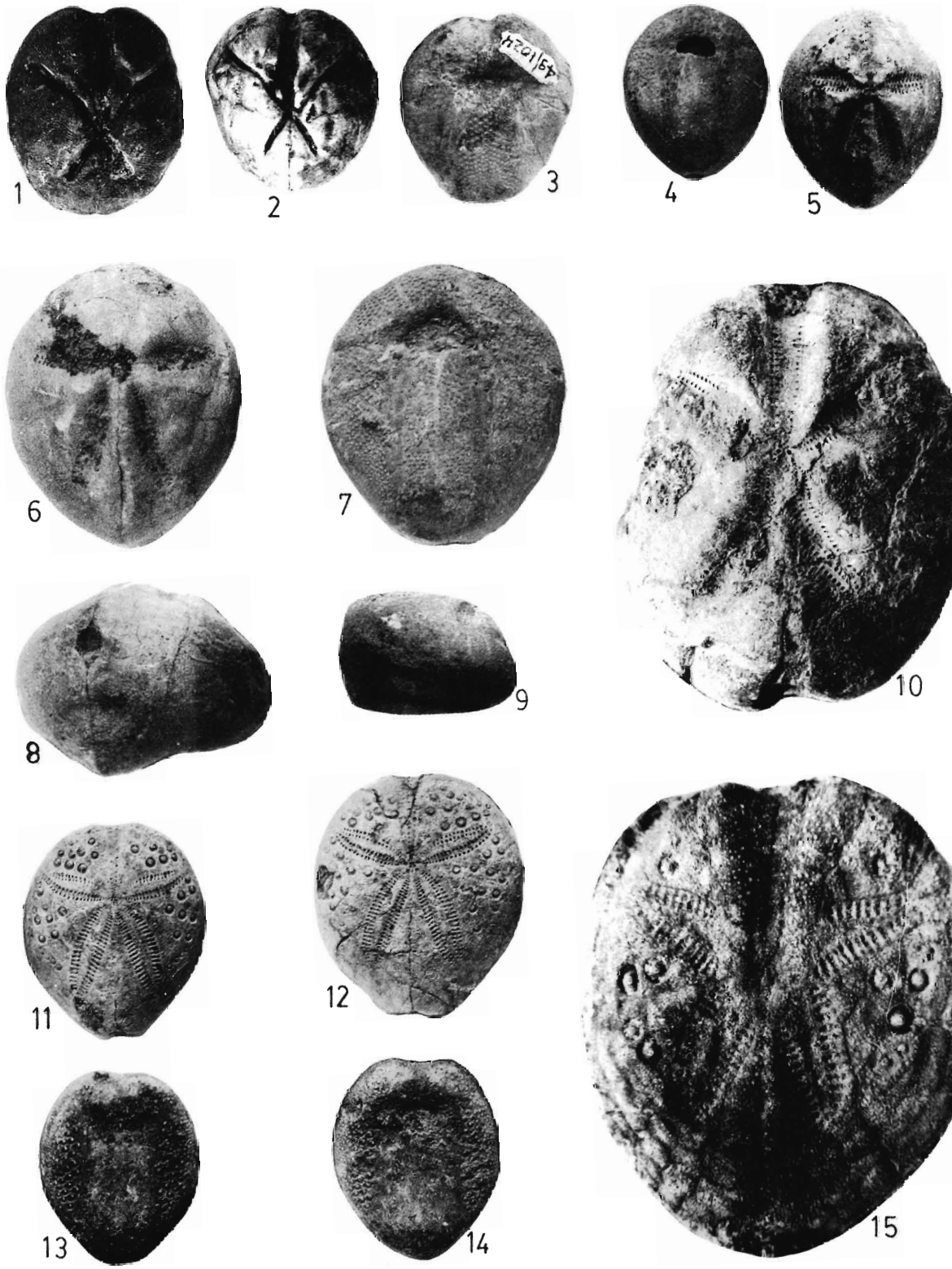
1-3. ***Moira antiqua*** Duncan & Sladen, Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, X 1.25. 1- Sp. No. 49/1025; 2, 3 - Sp. No. 49/1024.

4-9. ***Brissus daviesi*** n. sp., Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur. 4,5- Sp. No. 49/1089, X-1.25 and 1.45 respectively; 6,7- Sp. No. 49/1026, X-1.25; 8- Sp. No. 49/1026, X 1.33; 9- Sp. No. 49/1029, X 1.25.

10. ***Metalia harshadae*** n. sp., Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, X 1.00. Sp. No. 49/1023.

11-14. ***Maretia ranjitpurensis*** n. sp., Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur; Sp. Nos. 49/1051, 49/1049, 49/1053, 49/1052 and X 1.05, 1.00, 1.05,1.05 respectively.

15. ***Breynia carinata*** d'Archiac, Gaj Formation, middle Miocene, 0.5 km east of Lowrali, Sp. No. 24/1078, X 2.05.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Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1022 (Syntype)	69.4	58.0	24.8	0.84	0.36
49/1023 (Syntype)	28.3	23.3	9.8	0.82	0.35

Remarks: The present species differs from the *Metalia sternalis* in its anterior pair forming an angle of about 94°, while the *Metalia sternalis* bears an angle of 132° between anterior pair of crescent-shaped petals. Frontal and posterior sinuses are present with a slight broad curve in the present species. The present occurrence of *Metalia* from the early Miocene is interesting.

Metalia pelagica Nisiyama, Pl. 27, figs. 1-5, from the Donney Formation of Saipan Island, Mariana Islands) differs from the present species in its almost straight and less sunken petals and almost horizontal anterior pair of petals.

Family **Spatangidae** Gray, 1825

Genus ***Maretia*** Gray, 1855

(Type species: *Spatangus planulatus* Lamarck, 1816, p. 326; OD, Recent, Indo-Pacific)

Maretia ranjitpurensis n. sp.

(Pl. VI, figs. 11-14)

Material: Many well - preserved tests.

Horizon and Localities: Gaj Formation, early Miocene.

4.75 km southeast of Ranjitpur. Sp. Nos. 49/1047 to 49/1054.

Kuranga Railway Station Road. Sp. Nos. 62/1055 to 62/1057.

2.50 km west-southwest of Bhatvadia. Sp. No. 66/1046.

Etymology: This species is named after its locality Ranjitpur.

Diagnosis: A heart urchin with its betel-like outline and large sunken primary tubercles about 54 in the interambulacrua 1, 2, 3 and 4. Disposition of petals forming right angle between ambulacra I and II, and IV and V while it is slightly less than 90° between ambulacra II and III, and III and IV.

Description: This heart-urchin has an outline of betel nut. It has subanal fasciole only, ethmolytic apical system, with four gonopores, paired petaloid ambulacra, with petals nearly flush and all with well developed pore pairs and anterior ambulacrum with only small pores arranged in single series. Primary spines are differentiated, in some forms recessed into camellae. Large tubercles are on the apical side except in posterior interambulacrum. Ambulacrum III only slightly sunk. Test bears large sunken primary tubercles about 54 in number in interambulacra 1, 2, 3 and 4. Petals form a right angle between ambulacra I and II, IV and V, and an angle slightly less than 90° between interambulacra number II and III, and III and IV. Plastron is holamphisternous.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
49/1049 (Paratype)	43.3	37.0	13.0-	0.85	0.30+
49/1050	40.8	32.6	14.8	0.80	0.36
49/1051 (Holotype)	37.0	32.1	14.3	0.87	0.39
49/1052 (Paratype)	34.3	29.3	12.6	0.85	0.37
49/1053 (Paratype)	33.7	28.1	12.5	0.83	0.37
49/1054	32.3	26.9	11.2	0.83	0.35
62/1055	44.0	35.2	16.9	0.80	0.38
62/1057	43.4	32.9	14.6	0.76	0.34
66/1046	57.9	46.2	21.8	0.80	0.38

Remarks: *Maretia planulata* Lamarck (in Moore, 1966, p. 609, fig. 494,1) differs from the present species in bearing a greater number of

EXPLANATION OF PLATE VII

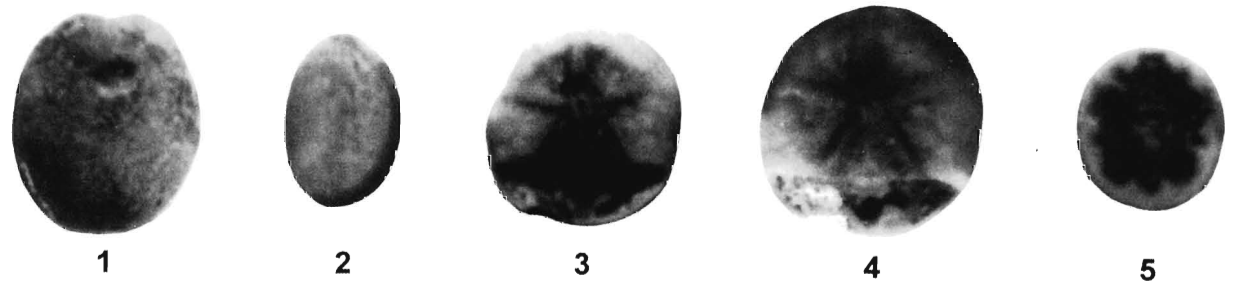
Photographs (1-5) are supplemented with sketches (1-5) based on the photographed specimens to show features not clearly visible in the documented photographs.

1. ***Metalia harshadae*** n. sp., Gaj Formation, early Miocene, 4.75 km southeast of Ranjitpur, X 1.07, Sp. No. 49/1023, oral view of the test.

2. ***Fibularia ovulum*** Lamarck, Gaj Formation, middle Miocene, 0.5 km east of Lowrali. Sp. No. 24/1212, X 2.18, transverse section of the test showing no internal partitons.

3-4. ***Mortonia lowraliensis*** n. sp., Gaj Formation, middle Miocene, 0.5 km east of Lowrali, Sp. No. 24/1213. X 2.03 and 2.39 respectively. Transverse section of a portion of posterior portion of the test showing just two short partitions on either side of the periproct opening.

5. ***Mortonia lowraliensis*** n. sp., Gaj Formation, middle Miocene, 0.5 km east of Lowrali, Sp. No. 24/1214. X 2.21. Transverse section of oral surface of the test showing position of the ambulacra and interambulacra.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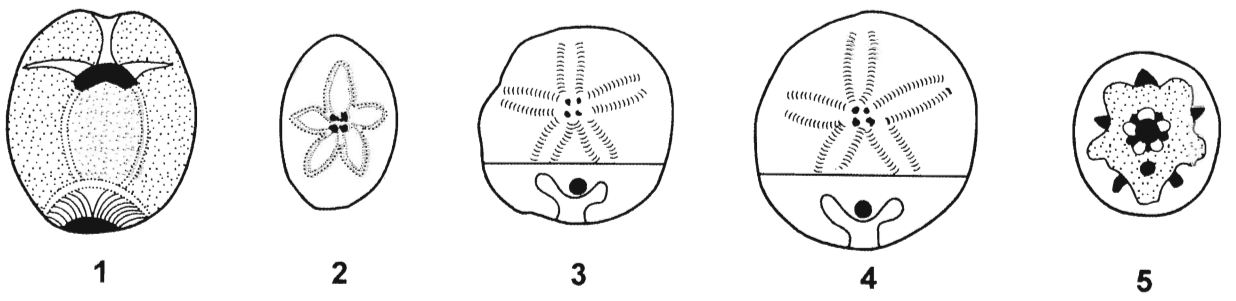
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primary tubercles, and its anterior paired petals form an angle about 30° with the horizon. In contrast, the present species bears an almost sub-horizontal anterior pair of petals and primary tubercles on aboral surface almost three times less than in *M. planulata*.

Family **Loveniidae** Lambert, 1905

Genus ***Breynia*** Desor, 1847

(Type species: *Spatangus australasiae* Leach, 1815, Recent, Australia).

Breynia carinata (d'Archiac)

(Pl. VI, fig. 15)

Eupatagus carinatus d'Archiac, 1850, p. 251.

Breynia carinata (d'Archiac), d'Archiac & Haime, 1853, p. 216-217. -Duncan & Sladen, 1883, p. 66, pl. X, figs. 1-4. -Duncan & Sladen, 1885, p. 343-354, pl. LIV, figs. 1-9 and pl. LV, figs. 1-8.

Material: 11 specimens (one well preserved and partly broken while other ten compressed / distorted specimens).

Horizon and Locality: Gaj Formation, middle Miocene, 0.5 km east of Lowrali.

Dimensions (mm):

Specimen	Length	Breadth	Height	B/L	H/L
24/1071	39.0	29.8	17.0	0.76	0.44
24/1072	38.7	31.3	9.0+	0.81	0.23+
24/1074	35.6	31.0	9.0+	0.87	0.25+
24/1077	48.5	38.2	4.5+	0.79	0.10+
24/1078 (Topotype)	41.2	35.1	4.7+	0.85	0.11+
24/1079	36.4	30.0	5.0+	0.82	0.14+
24/1080	36.0	30.8	7.3+	0.85	0.20+

Distribution: Gaj Formation, Sind, Kachchh and Kathiawar.

Remarks: The present specimens agree with the type species and the previously described material.

FAUNAL ANALYSIS

The echinoid species recorded by earlier workers from Kathiawar have been listed by Pascoe (1973) as follows: 1. *Cidaris depressa* Duncan & Sladen, 2. *Cidaris granulata* Duncan & Sladen, 3. *Cidaris halaensis* d'Archiac & Haime, 4. *Goniocidaris affinis* Duncan & Sladen, 5. *Coelopleurus forbesi* d'Archiac & Haime, 6. *Temnechinus rousseaui* (d'Archiac & Haime), 7. *Temnechinus costatus* (d'Archiac), 8. *Temnechinus tuberculosus* (d'Archiac & Haime), 9. *Temnechinus affinis* Duncan & Sladen, 10. *Grammechinus regularis* Duncan & Sladen, 11. *Clypeaster depressus* J. de C. Sowerby, 12. *Clypeaster goirensis* Duncan & Sladen, 13. *Clypeaster waageni* Duncan & Sladen, 14. *Echinodiscus desori* Duncan & Sladen, 15. *Echinolampas indica* Duncan & Sladen, 16. *Echinolampas jacquemonti* d'Archiac & Haime, 17. *Echinolampas spheroidalis* d'Archiac, 18. *Echinolampas wynnei* Duncan & Sladen, 19. *Schizaster* sp., 20. *Brissopsis sp.*, 21. *Schizaster granti* Duncan & Sladen, 22. *Moira antiqua* Duncan & Sladen, 23. *Breynia carinata* d'Archiac & Haime, 24. *Troschelia tuberculata* Duncan & Sladen, 25. *Eupatagus patellaris* d'Archiac & Haime.

Out of the above Pascoe's list of twenty-five species, 14 species are common with the present collection, while 11 species numbers (1, 3, 4, 14 to 20 and 24) are not found in the present collection. *Clypeaster* species with serial numbers from 11 to 13 were in fact collected from Kachchh but by mistake included in the list for Kathiawar by Pascoe (1973).

The four earlier described species of *Temnechinus* (serial numbers 6 to 9 of above) have been described under the genus *Opechinus* Desor, 1856. *Cidaris granulata* Duncan & Sladen and *Cidaris excelsa* Duncan & Sladen have been transferred to the genus *Prionocidaris*.

The present collection from the early and middle Miocene Gaj Formation in Kathiawar has yielded 27 echinoids. Of these, 10 species were already known previously from the study area, 11 species were known from outside the study area (Kathiawar), and rest six forms described as new species. Previously recorded species are figured, described with additional characters and registered with better types. New species are *Clypeaster kurangaensis, Fibularia depressa, Mortonia lowraliensis, Brissus daviesi, Metalia harshadi* and *Maretia ranjitpurensis*. Cidaroid spines mostly belong to the genus *Prionocidaris* and *Eucidaris*.

Those previously known from the study area (Kathiawar) are *Prionocidaris granulata* (Duncan & Sladen), *Coelopleurus forbesi* d'Archiac & Haime, *Grammechinus regularis* Duncan & Sladen,

Opechinus affinis (Duncan & Sladen), *O. costatus* (d'Archiac & Haime), *O. rousseaui* (d'Archiac), *O. tuberculata* (d'Archiac & Haime), *Schizaster granti* Duncan & Sladen, *Moira antiqua* Duncan & Sladen & *Bryenia carinata* (d'Archiac).

The remaining eleven species previously known from outside the study area are reported here for the first time. They include *Prionocidaris excelsa* (Duncan & Sladen), *Coelopleurus sindensis* Duncan & Sladen, *Clypeaster carteri* Duncan & Sladen, *C. complanatus* Duncan & Sladen, *C. depressus* Sowerby, *C. goirensis* Duncan & Sladen, *C. waageni* Duncan & Sladen, *C. pelviformis* Duncan & Sladen, *C. profundus* d'Archiac, *C. pulvinatus* Duncan & Sladen & *Fibularia ovulum* Lamarck.

REPOSITORY

Type specimens are permanently housed in the Repository of Geological Survey of India, Central Headquarters of Geological Survey of India, Curatorial Division, 27, Jawaharlal Nehru Road, Kolkata–700 016 (India) under the type registration numbers (GSI Type Nos. 20724 to 20794, total 71 types) serially as described in the text. Species wise detail of the repository is given below.

1. *Prionocidaris granulata* (Duncan and Sladen), Sp. Nos. 49/1042 (GSI Type No. 20724, Topotype), 49/1043 (GSI Type No. 20725, Topotype) and 49/1045 (GSI Type No. 20726, Topotype).
2. *Prionocidaris excelsa* (Duncan and Sladen), Sp. No. 49/1036 (GSI Type No. 20727, Topotype).x
3. *Coelopleurus forbesi* d' Archiac and Haime, Sp. No. 49/1058 (GSI Type No. 20728, Topotype).
4. *Coelopleurus sindensis* Duncan and Sladen, Sp. No. 49/1092 (GSI Type No. 20729 Topotype)
5. *Gran mechinus regularis* Duncan and Sladen, Sp. Nos. 24/1066 (GSI Type No. 20730, Topotype), 24/1067 (GSI Type No. 20731, Topotype) and 24/1068 (GSI Type No. 20732, Topotype).
6. *Opechinus affinis* (Duncan and Sladen), Sp. Nos. 49/1146 (GSI Type No. 20733, Topotype), 49/1149 (GSI Type No. 20734, Topotype) and 49/1150 (GSI Type No. 20735, Topotype).
7. *Opechinus costatus* (d'Archiac and Haime), Sp. Nos. 43/1156 (GSI Type No. 20736, Topotype), 49/1161 (GSI Type No. 20737, Topotype), 49/1207 (GSI Type No. 20738, Topotype) and 57/1163 (GSI Type No. 20739, Topotype).
8. *Opechinus rousseaui* (d'Archiac), Sp. Nos. 57/1171 (GSI Type No. 20740, Topotype) and 57/1208 (GSI Type No. 20741, Topotype).
9. *Opechinus tuberculosus* (d'Archiac and Haime), Sp. Nos. 49/1209 (GSI Type No. 20742, Topotype), 49/1210 (GSI Type No. 20743, Topotype), 49/1211 (GSI Type No. 20744, Topotype), and 49/1167 (GSI Type No. 20745, Topotype).
10. *Clypeaster carteri* Duncan and Sladen, Sp. Nos. 66/1106 (GSI Type No. 20746, Topotype) and 67/1105 (GSI Type No. 20747, Topotype).
11. *Clypeaster complanatus* Duncan and Sladen, Sp. Nos. 49/1094 (GSI Type No. 20748, Topotype) and 49/1095 (GSI Type No. 20749, Topotype).
12. *Clypeaster depressus* Sowerby, Sp. Nos. 49/1115 (GSI Type No. 20750, Topotype) and 49/1116 (GSI Type No. 20751, Topotype).
13. *Clypeaster goirensis* Duncan and Sladen, Sp. Nos. 66/1108 (GSI Type No. 20752, Topotype) and 66/1109 (GSI Type No. 20753, Topotype).
14. *Clypeaster pelviformis* Duncan and Sladen, Sp. Nos. 49/1141 (GSI Type No. 20754, Topotype) and 67/1133 (GSI Type No. 20755, Topotype).
15. *Clypeaster profundus* d'Archiac, Sp. Nos. 49/1122 (GSI Type No. 20756, Topotype), 49/1124 (GSI Type No. 20757, Topotype), 57/1126 (GSI Type No. 20758, Topotype) and 67/1128 (GSI Type No. 20759, Topotype).
16. *Clypeaster pulvinatus* Duncan and Sladen, Sp. Nos. 67/1111 (GSI Type No. 20760, Topotype) and 81/1114 (GSI Type No. 20761, Topotype).
17. *Clypeaster waageni* Duncan and Sladen, Sp. Nos. 49/1099 (GSI Type No. 20762, Topotype) and 49/1100 (GSI Type No. 20763, Topotype).

18. *Clypeaster kurangaensis* n. sp., Sp. Nos. 81/1091 (GSI Type No. 20764, Holotype) and 81/1092 (GSI Type No. 20765, Paratype).

19. *Fibularia ovulum* Lamarck, Sp. Nos. 67/1143 (GSI Type No. 20766, Topotype).

20. *Fibularia depressa* n. sp., Sp. Nos. 24/1087 (GSI Type No. 20767, Paratype), 24/1088 (GSI Type No. 20768, Paratype) and 24/1089 (GSI Type No. 20769, Holotype).

21. *Mortonia lowraliensis* n. sp., Sp. Nos. 24/1187 (GSI Type No. 20770, Syntype), 24/1193 (GSI Type No. 20771, Syntype), 24/1196 (GSI Type No. 20772, Syntype), 24/1197 (GSI Type No. 20773, Syntype), 24/1198 (GSI Type No. 20774, Syntype), 24/1200 (GSI Type No. 20775, Syntype), 24/1201 (GSI Type No. 20776, Syntype), 24/1205 (GSI Type No. 20777, Syntype), 24/1206 (GSI Type No. 20778, Syntype).

22. *Schizaster granti* Duncan and Sladen, Sp. Nos. 49/1081 (GSI Type No. 20779, Topotype), 49/1082 (GSI Type No. 20780, Topotype) and 49/1083 (GSI Type No. 20781, Topotype).

23. *Moira antiqua* Duncan and Sladen, Sp. Nos. 49/1024 (GSI Type No. 20782, Topotype) and 49/1025 (GSI Type No. 20783, Topotype).

24. *Brissus daviesi* n. sp., Sp. Nos. 49/1026 (GSI Type No. 20784, Paratype), 49/1027 (GSI Type No. 20785, Paratype), 49/1029 (GSI Type No. 20786, Paratype) and 49/1029 (GSI Type No. 20787, Holotype).

25. *Metalia harshadi* n. sp., Sp. Nos. 49/1022 (GSI Type No. 20788, Syntype) and 49/1023 (GSI Type No. 20789, Syntype).

26. *Maretia ranjitpurensis* n. sp., 49/1049 (GSI Type No. 20790, Paratype), 49/1051 (GSI Type No. 20791, Holotype), 49/1052 (GSI Type No. 20792, Paratype) and 49/1053 (GSI Type No. 20793, Paratype). *Breynia carinata* (d'Archiac), Sp. No. 24/1078 (GSI Type No. 20794, Topotype).

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