

# Molluscan fauna from the Miocene sediments of Kachchh, Gujarat, India – Part 3. Gastropods

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Systematic description of 25 gastropod species from the Khari Nadi Formation (Aquitanean) and Chhasra Formation (Burdigalian) from the Kachchh District, Gujarat, India is given. A checklist of 116 forms including those reported by earlier researchers, emending taxonomic identifications wherever necessary, is also provided. Vredenburg had referred these two formations together as 'the Gaj Beds of Kachchh'. He noticed the affinity of molluscs among the Miocene deposits of Kachchh and Kathiawar regions of Gujarat, and Sind province of Pakistan. He also observed that molluscs from his 'Lower Gaj' and 'Upper Gaj' Formations showed relationship respectively with the Rembang (Aquitanean) and Njalindung (Burdigalian) series of the East Indies. Aquitanean and Burdigalian ages assigned by him were later substantiated by Raju on the basis of foraminifera. Present studies corroborated that the molluscan assemblage from the Miocene rocks of Kachchh is closely related to that from the Gaj Beds of Sind and the Ashapura Clay Member of Kathiawar; besides revealing that the fauna from these three formations taken together is essentially endemic. Discovery of certain species from the Quilon Beds in the Miocene of Kachchh evinces a close affinity between these two formations. The present fauna includes five extant forms, while 29 forms have related species in the Recent fauna.

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## 1. Introduction

Tertiary rock formations occur in different parts of Peninsular India, but their development is nowhere as extensive as in Kachchh region of the Gujarat State. An account of fossil molluscs occurring in the Tertiary sediments of Kachchh was provided in olden days by Sowerby (1839). However, after establishing the Geological Survey of India, geological mapping of Kachchh was assigned to Fedden and Wynne in the late 1860s. Their findings were published by the Survey as a memoir (Wynne 1872). The Miocene sediments had formally been designated by Wynne as the 'Argillaceous Series'. However, this term was barely used by subsequent researchers.

Fossil molluscs collected by Fedden, Wynne and other researchers were subsequently put at the

disposal of Vredenburg (1925, 1928). Vredenburg's work included molluscs from the Tertiary formations of Kachchh and Kathiawar regions of western India along with those occurring in Sind and Baluchistan Provinces of Pakistan. For designating Tertiary sediments of Kachchh, he preferred to employ stratigraphical nomenclature for the formations in Sind and Baluchistan Provinces, now in Pakistan. Thus we find that the Miocene rocks of Kachchh and Kathiawar have been referred by him as the 'Gaj Beds of Kachchh' and 'Gaj Beds of Kathiawar'. He found that molluscan assemblages had an unmistakable affinity respectively with the molluscan assemblages from the Rembang (Aquitanean) and Njalindung (Burdigalian) series of Java and other islands of the Malaya Archipelago, described by Martin (1879).

**Keywords.** Gastropods; Miocene; Kachchh (India).

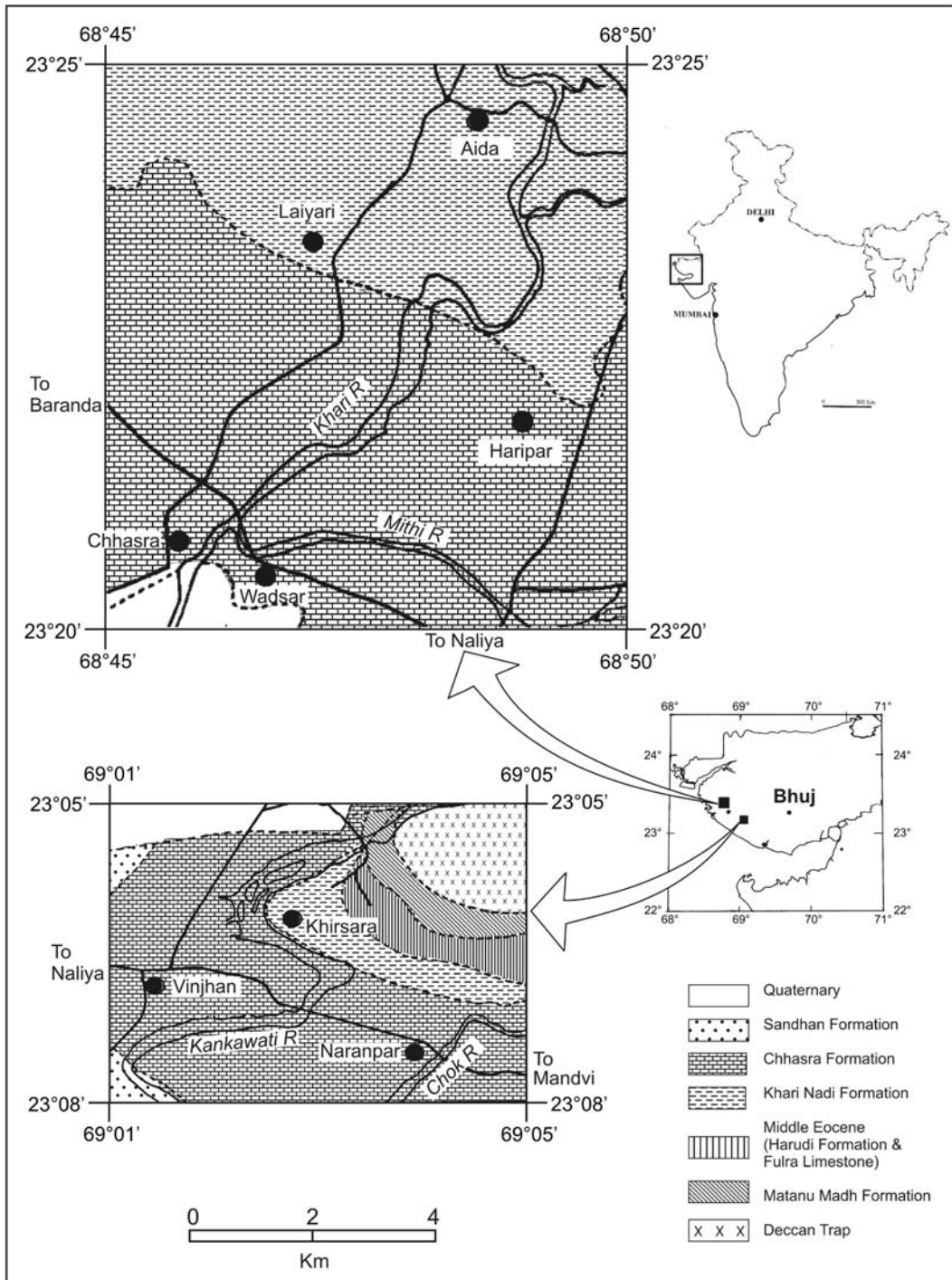


Figure 1. Geological map of parts of Kachchh Region, Gujarat State, India; slightly modified after Biswas and Deshpande. Formational boundaries approximate.

This promising molluscan fauna, however, did not receive the attention it deserved for nearly 80 years. The present authors have undertaken a revision of molluscan remains from the Miocene rocks of Kachchh. Two communications in the present series of research communications – pertaining to oysters and the bivalve subgenus *Indoplacuna* – have already been published (Borkar

et al 2004; Kulkarni et al 2009). The present communication deals with gastropods from the Miocene rocks of Kachchh.

Stratigraphy of Kachchh was revised by Biswas (1992). Lithostratigraphic classification suggested by him is adopted in the present work (table 1). Type sections of the Miocene rock formations are located in the Abdassa subdivision of Kachchh

Table 1. Lithostratigraphic classification of Miocene rocks of Kachchh (after Biswas 1992).

Sandhan Formation (Pliocene)	
—————Unconformity—————	
Chhasra Formation (Burdigalian)	{ Siltstone member
	{ Claystone member
—————Unconformity—————	
Khari Nadi Formation (Aquitainian)	
—————Unconformity—————	
Maniyara Fort Formation (Oligocene)	

District, where Miocene sediments overlies the Ber Moti Member (Chattian) of the Maniyara Fort Formation (Oligocene) with a minor erosional

unconformity. The Miocene rocks are classified into two formations: The Khari Nadi Formation and the Chhasra Formation. Chhasra Formation is further subdivided into two members: the Claystone member and the Siltstone member. The Khari Nadi Formation corresponds more or less to the Lower Gaj Beds of Vredenburg, while Chhasra Formation to the Upper Gaj Beds. The Aquitainian and Burdigalian ages respectively of the Khari Nadi and Chhasra Formations were subsequently corroborated by Raju (1974) on the basis of foraminifera, especially the Miogypsinids. This succession is unconformably overlain by the Sandhan Formation of Pliocene age.

The Miocene sediments of the Kathiawar region, previously called 'the Gaj Beds of Kathiawar' (Fedden 1884; Pascoe 1964) are now formally termed as the Ashapura Clay Member by Bhatt (2000).

## 2. Systematic palaeontology

Subclass: Prosobranchia  
 Order: Archaeogastropoda  
 Suborder: Trochina  
 Superfamily: Trochacea  
 Family: Trochidae  
 Subfamily: Trochinae  
 Genus: *Tectus*

*Tectus cognatus* (J de C Sowerby 1839) Eames, 1950

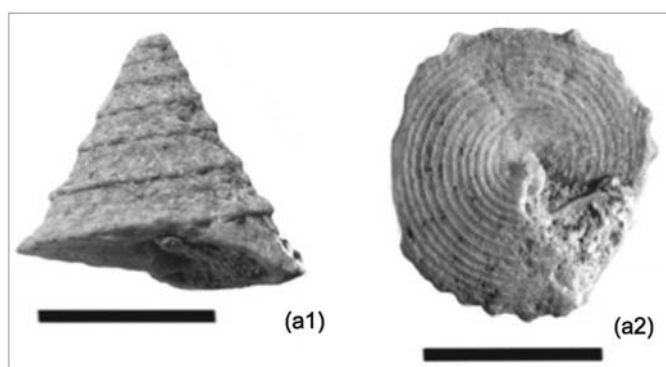


Figure 2(a). *Tectus cognatus* (J de C Sowerby) Eames; Topotype no. MACS G 4957. a1: adapertural view. a2: basal view, showing fine, concentric, equidistant lirae. Bar scale = 10 mm.

1839 *Trochus cognatus*: J de C Sowerby, plate 26, figure 6.

*Non-Trochus cognatus* J de C Sowerby: d'Archiac and Haime (1854), p. 290, plate 27, figure 18.

1928 *Trochus (Tectus) cognatus* J de C Sowerby: Vredenburg, p. 407.

1962 *Trochus (Tectus) cognatus* J de C Sowerby: Dey, p. 51, plate V, figure 27.

**Material:** Solitary specimen, fairly well preserved.

**Topotype:** MACS G 4957.

**Dimensions:**

Specimen no.	Height of shell (calculated)	Height of preserved spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4957	15.2 mm	10.8 mm	4.0 mm	15.8 mm	40°

**Description:** Initial part of spire lost, only eight whorls preserved. Last whorl about one-fourth of the total height. Tubercles on earlier whorls in the form of four axial rows of slightly oblique axial costae, whose spiral alignment defines spiral ribs. Except last whorl, tubercles of anteriormost spiral rib slightly more prominent. On last whorl, tubercles on two anteriormost spiral ribs unite forming prominent costae. Base of specimen flat; ornamented by fine, concentric, equidistant lirae (figure 2-a2).

**Remarks:** The plesiotype no. 13,471 of this form in the Central Fossil Repository, G.S.I., Kolkata (Vredenburg 1928, p. 407), also from the Miocene of Kachchh, is somewhat larger than the present specimen. It has also been observed that the fusion of two anteriormost tubercles on each axial rib of the last whorl is not as complete in the present specimen as that in the Vredenburg's. This difference could probably be due to its smaller size, indicating that growth was not as full as that of the plesiotype. However, tall nature, more acute disposition of younger part of the spire than the later and details of ornamentation leave no doubt in identifying this specimen with *Trochus cognatus* Sowerby.

According to Vredenburg (1928, p. 407), *T. cognatus* from the Gaj of Sind, described by d'Archiac

and Haime (1854, p. 290; plate 27, figure 18), is in reality *T. loryi*. Hence, occurrence of this species in the Miocene of Sind is yet to be established.

*Tectus tjilonganensis* Martin from the Miocene of Java (Martin 1905, p. 279; plate 41, figure 669) was also considered as a junior synonym of this form by Vredenburg. Dey (1962), however, observed that the Javan specimens have four or five rows of primary and secondary tubercles and the spiral lirae on the base are closely spaced towards the periphery. In contrast, spiral lirae on the base of *T. cognatus* are equidistant. Lately, while revising the Martin collection from the East Indies, Hoek Ostende *et al* (2006) considered *T. tjilonganensis* as a subspecies of the Recent form *T.(T.) pyramis*. In this regard, it may be mentioned here that Dey earlier had alluded to the semblance between *T.(T.) cognatus* and *T.(T.) pyramis*.

This form is described here under *Tectus*, and not under *Trochus*, following Eames (1950); who rectified the identification on the basis of acute spire and anomphalous nature of the shell.

**Distribution:** Ashapura Clay member of Kathi-awar, Quilon Beds of Kerala.

**Occurrence:** A shell limestone intercalation within the Claystone member, Chhasra Formation on the right bank of Khari River, 1.5 km NE of Chhasra.

Genus: *Clanculus*

*Clanculus pascoei* Dey, 1962

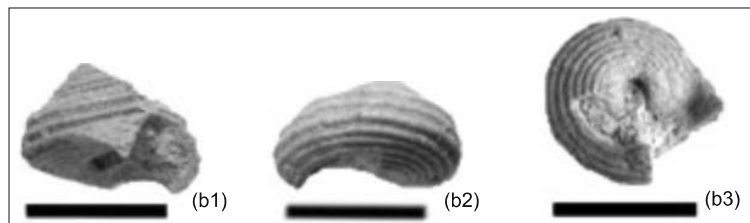


Figure 2(b). *Clanculus pascoei* Dey (1962); Plesiotype MACS G 4958. b1: adapertural view. b2: abapertural view. b3: basal view, showing umbilicus. Bar scale = 10 mm.

1962 *Clanculus pascoei*: Dey, p. 51, plate V, figures 14 and 16.

**Material:** Solitary, fairly well preserved specimen.

**Plesiotype:** MACS G 4958.

**Dimensions:**

Specimen no.	Height of shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4958	5.2 mm	2.0 mm	3.2 mm	6.1 mm	75°

**Description:** Specimen fairly well preserved. Aperture slightly damaged. Shell globose, umbilicate, with distinct conical spire. Whorls convex; suture subcanaliculate. Spiral ribs with granules; posterior-most rib on each whorl tuberculated. Interspaces broader, bearing very delicate spiral intercalary threads.

**Remarks:** The specimen is compared with the type specimen of *Clanculus pascoei* described by Dey from the Quilon Beds of Kerala (No. 15,426;

Central Fossil Repository, G.S.I., Kolkata; Dey 1962, p. 51, plate V, figures 14, 16). The Kachchh specimen is slightly smaller. However, by its globose form, convex whorls and exactly identical ornamentation, it is specifically identified with the Quilon form.

**Distribution:** Quilon Beds, Kerala.

**Occurrence:** A shell limestone intercalation within Claystone member, Chhasra Formation, near Chhasra.

Family: Angariidae  
Genus: *Angaria*  
Subgenus: *Angaria*

*Angaria (Angaria) delphinus* (Linné 1758) Röding, 1798



Figure 2(c). *Angaria (Angaria) delphinus* (Linné 1758) Röding; Plesiotype MACS G 4959. Adapertural view, exposed slightly oblique to show whorls. Bar scale = 10 mm.

1798 *Angaria delphinus*: Röding, p. 71.

1962 *Angaria delphinus* (Linné): Dey, p. 50.

2002 *Angaria (Angaria) delphinus* (Linné): Hoek Ostende *et al*, p. 6.

**Material:** Solitary, fairly well preserved specimen.

**Plesiotype:** MACS G 4959.

**Dimensions:** Specimen being fragmentary, it is not possible to ascertain dimensions.

**Description:** Silicified shell comprising mostly the last whorl, spire eroded to a large extent. Traces of at least four earlier whorls distinctly visible. Shoulder of last whorl angulate with spiny nodules. Lamellate spines of spiral ridges on last whorl not satisfactorily preserved, discerned by their eroded bases.

**Remarks:** The specimen has been identified by comparing it with the illustration of *A. delphinus* by Dance (1977, p. 48) in his 'Encyclopedia of the

Shells'. The specimen agrees with it in having a low turbate form and presence of spiral nodes.

**Distribution:** Quilon Beds of Kerala, Miocene of Java and Pliocene of Timor. It is an extant form known to occur in the Indian Archipelago, Torre's Straits (N. Australia), Japan, China, Singapore, Mergui Archipelago, Sri Lanka, East Africa and Malagasy.

**Occurrence:** *Turritella* bed at the top of Khari Nadi Formation, 2 km west of Buta.

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Order: Mesogastropoda  
 Superfamily: Cerithiacea  
 Family: Turritellidae  
 Subfamily: Turritellinae  
 Genus: *Turritella*

*Turritella narica* Vredenburg, 1928

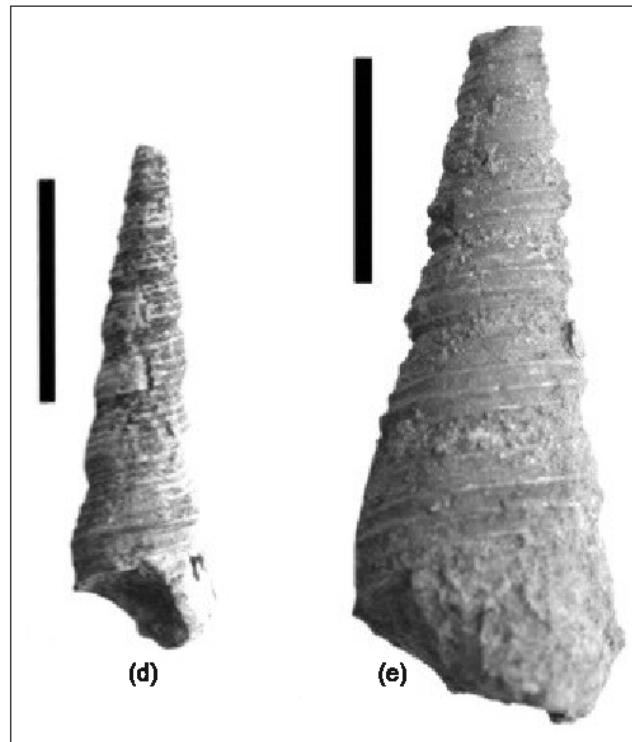


Figure 2(d–e). *Turritella narica* Vredenburg. (d): abapertural view, Plesiotype no. MACS G 4960. (e): abapertural view, Paratype no. MACS G 4961. Bar scale = 10 mm.

1928 *Turritella narica*: Vredenburg, p. 375, plate 18, figures 13–17, 21; plate 19, figures 2 and 6.

**Material:** Four satisfactorily preserved specimens.

**Plesiotype:** MACS G 4960.

**Paratype:** MACS G 4961.

**Dimensions:**

Specimen no.	Height of preserved shell	Height of preserved spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4960	32.0 mm	23.5 mm	8.5 mm	12.1 mm	20°
MACS G 4961	22.7 mm	18.3 mm	4.4 mm	12.1 mm	–
44/75	37.4 mm	29.0 mm	8.5 mm	11.5 mm	19°
44/6	30.8 mm	23.6 mm	7.2 mm	11.6 mm	18°

**Description:** Shells turreted with more or less flat slopes. Anterior and posterior declivities of whorls very narrow, close to sutures; anterior declivity slightly pronounced. Spiral threads six, the most prominent coinciding with brink of anterior declivity; slightly less prominent thread one anterior to, and four posterior to it.

**Remarks:** When compared with *Turritella narica* described by Vredenburg (1928, p. 375, plate 18, figures 13–17; plate 19, figures 2, 6) from the Nari Beds of Pakistan, the Kachchh specimens

agree in all essential respects. Variation seen in the Nari specimens (Oligocene) of Sind is not observed in Kachchh specimens, especially pertaining to the number of spiral threads. The number of spiral threads posterior to the most prominent thread in Nari specimens may rarely range upto 10 or 12, while that in specimens procured from Kachchh is four.

**Distribution:** Nari Beds of Sind and Baluchistan, Pakistan.

**Occurrence:** *Turritella* Bed at the top of Khari Nadi Formation, 2 km west of Buta.

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*Turritella narica* Vredenburg, 1928 *baluchistanensis* Vredenburg, 1928

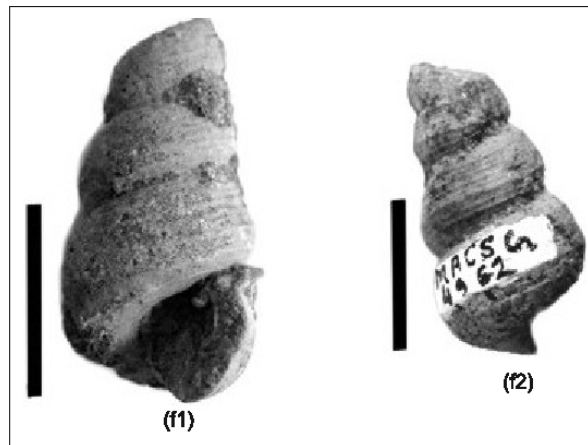


Figure 2(f). *Turritella narica* var. *baluchistanensis* Vredenburg; Plesiotype no. MACS G 4962. f1: adapertural view; f2: abapertural view. Bar scale = 10 mm.

1928 *Turritella narica* Vredenburg *baluchistanensis*: Vredenburg, p. 375, plate 18, figures 10, 20–25; plate 21, figure 5.

**Material:** Two incomplete specimens.

**Plesiotype:** MACS G 4962.

**Dimensions:**

Specimen no.	Height of preserved shell	Height of preserved spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4962	20.8 mm	13.3 mm	7.5 mm	11.9 mm	16°
26/39	27.0 mm	20.8 mm	6.2 mm	15.0 mm	–

**Description:** Last three whorls seen in both specimens. Individual whorls low, height being half of width. Whorls somewhat convex with fairly pronounced anterior and posterior declivities and sunken sutures. Spiral threads vary in prominence. Most prominent spiral thread coinciding with beginning of anterior declivity. Two major spiral threads on anterior declivity with two minor in intervening sulci. Six spiral threads, posterior to most prominent, subequal in their importance; of which the second almost as prominent as the most prominent thread.

**Remarks:** As has been observed in specimens from Nari Beds by Vredenburg (1928, p. 375, plate 18, figures 10, 20, 22–25; plate 21, figure 5), the Kachchh specimens of this variety differ from *T. narica* by having slightly more convex whorls and subequal spiral threads.

**Distribution:** Nari Beds of Sind and Baluchistan, Pakistan.

**Occurrence:** *Turritella* Bed at the top of Khari Nadi Formation, 2 km west of Buta.

Subfamily: Pareorinae

Genus: *Zaria*

*Zaria angulata* (J de C Sowerby 1839) comb. nov.

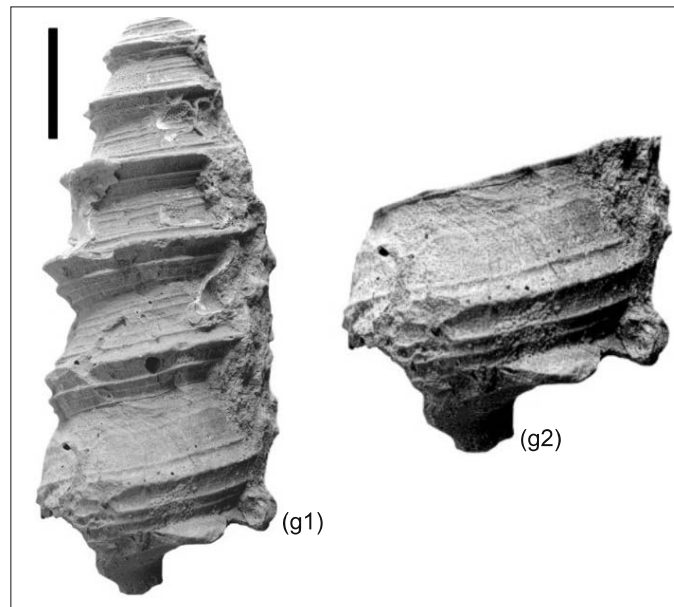


Figure 2(g). *Zaria angulata* (J de C Sowerby 1839) comb. nov.; Topotype no. MACS G 4963. g1: abapertural view. g2: same, close-up of the last whorl, showing opisthocline growth lines. Bar scale = 10 mm.

1839 *Turritella angulata*: J de C Sowerby, plate 26, figure 7.

1854 *Turritella angulata* J de C Sowerby: d'Archiac and Haime, p. 294; plate 27, figures 6–9.



1928 *Turritella angulata* J de C Sowerby: Vredenburg, p. 378.

**Material:** Three specimens, satisfactorily preserved.

**Topotype:** MACS G 4963.

**Dimensions:**

Specimen no.	Height of preserved shell	Height of preserved spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4963	54.5 mm	47.0 mm	7.5 mm	23.7 mm	34°
42/69	51.0 mm	38.4 mm	12.6 mm	22.0 mm	34°
11/6	24.8 mm	19.2 mm	5.6 mm	11.6 mm	35°

**Description:** Shell turreted; axial angle acute. Anterior and posterior declivities highly dissimilar; width of anterior declivity roughly one-third height of the whorl, while that of posterior declivity almost negligible. Carina on whorls at one-third from anterior (figure 2-g1), coinciding with brink of anterior declivity. Exterior of whorls defined by two straight lines joining base of the carina with anterior and posterior sutures. Owing to unequal distances from carina to the two sutures, slope posterior to the carina appears gentle, while anterior to carina steep. Three fine spiral threads between carina and anterior suture and six between carina and posterior. Spiral threads of unequal strength. Opisthocline growth lines seen on well preserved areas of certain shells (figure 2-g2).

**Remarks:** When compared with the type specimen (No. 13,450, Central Fossil Repository of the G.S.I., Kolkata) of this species (Vredenburg 1928, pp. 378–380), our specimens agree in all essential respects. It is being identified here as belonging to the genus *Zaria* on the basis of the presence of spiral keel, following Davies (1971, p. 312).

**Distribution:** Gaj Beds of Sind, Ashapura Clay member of Kathiawar, Miocene of Myanmar, Miocene of Java (represented by variety *djadjariensis*), Mekran Series of Pakistan and Karikal Beds of east coast of India.

**Occurrence:** Limestone intercalations within the Claystone member, Chhasra Formation, 0.5 km south of Khirsara.

Subfamily: Protominae

Genus: *Protoma*

*Protoma kayalensis* (Dey 1962) comb. nov.

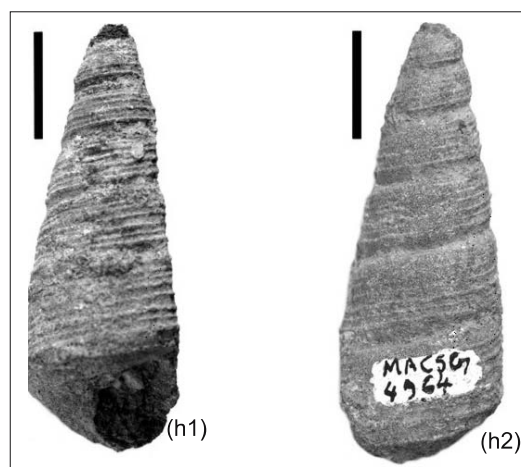


Figure 2(h). *Protoma kayalensis* (Dey 1962) comb. nov.; Plesiotype MACS G 4964. h1: adapertural view. h2: abapertural view. Bar scale = 10 mm.

1962 *Turritella kayalensis*: Dey, p. 59, plate 7, figure 18.

**Material:** One specimen.

**Plesiotype:** MACS G 4964.

**Dimensions:**

Specimen no.	Height of preserved shell	Height of preserved spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4964	41.4 mm	32.3 mm	9.1 mm	15.5 mm	20°

**Description:** Turreted, conical shell with almost flat-sided whorls. Neanic whorls broken, last six whorls preserved. Seven thin spiral cords on whorls; separated by sulci, much broader than cords. Cords bear minute nodes. Sutures impressed.

**Remarks:** When compared with the holotype of *Turritella kayalensis* (No. 16,431, Central Fossil Repository of the G.S.I., Kolkata; Dey 1962, p. 59, plate 7, figure 18) from the Quilon Beds of Kerala, the present specimen shows remarkable similarity regarding flat nature of whorls, seven spiral cords

with minute nodes and comparable spiral angle, establishing its specific identity with *Protoma kayalensis*. The Kachchh specimen is, however, bigger than the Quilon specimen.

The turritellids with flat sided whorls are accommodated under the generic epithet *Protoma* (Davies 1971) and, therefore, the present specimen described here under *Protoma*.

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** Limestone intercalation within the Khari Nadi Formation, exposed in the escarpment of the Khari River, 0.5 km NE of village Aida.

Family: Architectonicidae

Genus: *Architectonica*

*Architectonica affinis* (Sowerby 1839) Dey, 1962

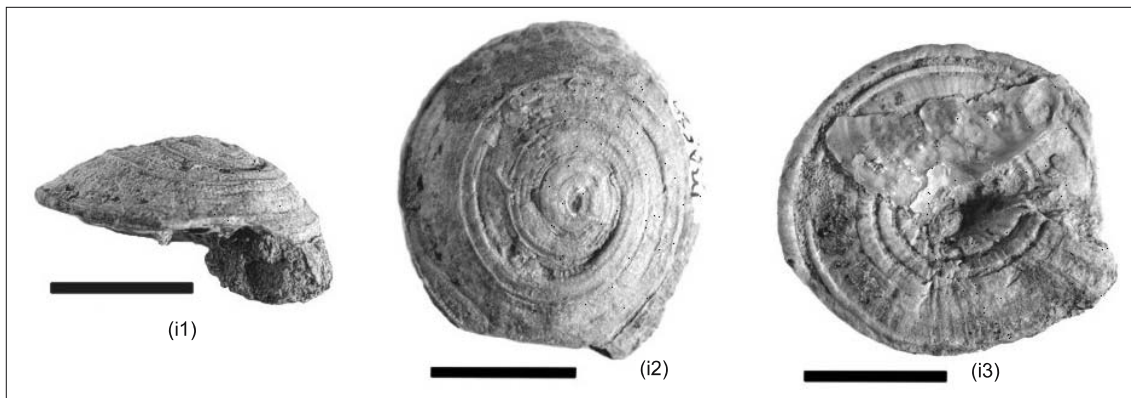


Figure 2(i). *Architectonica affinis* (Sowerby) Dey; Topotype no. MACS G. i1: apertural view. Note the elliptical aperture. i2: apical view. i3: basal view, showing the umbilicus surrounded by two keel-like, granulated spiral ribs. Bar scale = 10 mm.

1839 *Solarium affine*: J de C Sowerby, plate 26, figure 5.

1854 *Solarium affine* J de C Sowerby: d'Archiac and Haime, p. 288, plate 26, figure 13, (*non* figure 14).

1928 *Solarium affine* J de C Sowerby: Vredenburg, p. 393.

1962 *Architectonica affinis* (J de C Sowerby): Dey, p. 53, plate 1, figure 1.

**Material:** Four specimens.

**Syntotypes:** MACS G 4965 and MACS G 4966.

**Dimensions:**

Specimen no.	Height of the shell	Height of spire	Height of last whorl	Maximum width
MACS G 4965	11.4 mm	6.4 mm	5.0 mm	22.1 mm
MACS G 4966	13.4 mm	6.7 mm	6.7 mm	25.6 mm

**Description:** Low-conical shell. Five spire-whorls. Sutures sunken. Base flat, umbilicus rather wide. Four pronounced spiral sulci on whorls, increasing in width and depth when traced from posterior to anterior; intervening bands with granules. Narrow rim intervenes between anterior suture and anterior-most sulcus. At base, umbilicus surrounded by two keel-like, well granulated, spiral ribs (figure 2-i3) and two without granulation towards periphery. Aperture elliptical (figure 2-i1).

**Remarks:** After comparing with the topotype of this form (Vredenburg 1928, p. 393; No. 13,463, Central Fossil Repository of G.S.I., Kolkata) the present specimens were found to be identical with it in all essential respects including ornamentation. They also agree with the description and

illustration of *Architectonica affinis* from the Quilon Beds, Kerala (Dey 1962, p. 53; plate 1, figure 1). Since *Solarium* is *nomen invalidum*, Dey (1962) corrected the generic identification and put the present form under *Architectonica*.

According to Vredenburg (1928) and Dey (1962), this species is closely related to the Recent form *A. maxima* occurring in the Indo-Pacific Province, and also to the Recent form *A. quadriceps* from the Indian and Pacific Oceans.

**Distribution:** Gaj Beds of Sind and Quilon Beds of Kerala.

**Occurrence:** (1) A shell limestone intercalation in the Claystone member, Chhasra Formation, west of Haripar. (2) A shell limestone intercalation in the Claystone member, Chhasra Formation, SSE of Chhasra.

Family: Cerithiidae  
Subfamily: Cerithiinae  
Genus: *Ptychocerithium*

*Ptychocerithium rude* (J de C Sowerby 1839) Eames, 1950



Figure 2(j). *Ptychocerithium rude* (J de C Sowerby) Eames; Plesiotype no. MACS G 4967. j1: adapertural view. j2: abapertural view. Bar scale = 10 mm.

1839 *Cerithium rude*: J de C Sowerby, plate 16, figure 10.

1854 *Cerithium rude* J de C Sowerby: d'Archiac and Haime, p. 299, plate 28, figures 9–12.

1928 *Cerithium* (*Ptychocerithium*) *rude* J de C Sowerby: Vredenburg, plate 2, p. 358.

1962 *Cerithium* (*Ptychocerithium*) *rude* J de C Sowerby: Dey, plate 5, figures 11, 19.

**Material:** Solitary specimen.

**Plesiotype:** MACS G 4967.

**Dimensions:** The dimensions could not be ascertained as the specimen is fragmentary.

**Description:** Compressed shell. Only three whorls, including the last, preserved. Ornamentation satisfactorily preserved. Fifteen slightly oblique axial costae, separated by wide interspaces. Twelve spiral lirae on each whorl, two posterior-most prominent, followed by alternating weak and strong lirae. Aperture small, damaged. Presence of both canals indicated by notches. Columellar lip shows slight thickening.

**Remarks:** The specimen is comparable with the illustrations of Quilon specimens provided by Dey (1962, figures 11 and 19 of plate 5). Morphology of this species is very variable as discussed at length by Vredenburg (1928, p. 358). Spiral lirae of alternating prominence, slight thickening of the inner lip, flat whorls and subulate shape as can be

gathered from this solitary fragmentary specimen help in placing it under *P. rude*. *Cerithium* (*s.s*) ranges from Pleistocene to Recent only (Davies 1971). Forms with crenulated colabral lips, a small aperture with a narrow posterior canal and short, truncated, weakly bent-back anterior canal are best identified as *Ptychocerithium* (Davies 1971), hence the present form is described here under *Ptychocerithium*.

**Distribution:** Gaj Beds of Sind, Ashapura Clay member of Kathiawar and Quilon Beds of Kerala.

**Occurrence:** Shell limestone bed within the Claystone member, Chhasra Formation, on the right bank of the Khari River, 0.5 km SSE of Chhasra.

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Superfamily: Scalacea  
 Family: Scalidae  
 Subfamily: Scalinae  
 Genus: *Clathrus*

*Clathrus gajensis* (Vredenburg 1928) comb. nov.

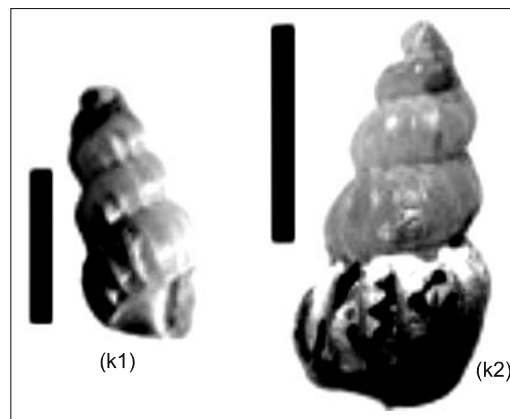


Figure 2(k). *Clathrus gajensis* (Vredenburg) comb. nov. Topotype no. MACS G 4968. k1: adapertural view. k2: abapertural view. Bar scale = 10 mm.

1928 *Scala* (*Clathrus*) *gajensis*: Vredenburg, p. 401, plate 20, figure 14; plate 21, figure 9.

**Material:** Solitary specimen.

**Topotype:** MACS G 4968.

**Dimensions:**

Specimen no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4968	9.6 mm	6.4 mm	2.2 mm	4.0 mm	40°

**Description:** Only specimen in collection a small, silicified shell. Protoconch lost. Five whorls including last preserved. Whorls convex, separated by deep sutures; carry 19 thin, sharp, axial, costae, showing perfect continuation. Posterior ends of costae deflected towards aperture, while anterior ends in exactly opposite direction with rather sharp bends. Round nature of aperture adjudged from broken periphery.

**Remarks:** The specimen described above is compared with the synholotypes of *Scala* (*Clathrus*) *gajensis* from Kachchh, described by Vredenburg (Nos. 13,332 and 13,333, Central Fossil Repository, G.S.I., Kolkata; Vredenburg 1928, p. 401, plate 20, figure 14; plate 21, figure 9). Present specimen agrees in all essential respects with the type specimen, barring the size of the specimen.

According to Morley Davies (1971), subgenus *Clathrus* is given the status of an independent genus. Therefore, the present form is identified here as *Clathrus gajensis*.

According to Vredenburg (1928) the fossil form is nearest to the recent form *Scala indianorum* Cpr. of the eastern Pacific, which is more broadly conical. It also resembles two more recent forms, viz., *Scala gradate* Hinds from Amboyna, and *S. georgentina* Kien. from the Atlantic. But these two forms have fewer lamellae and are also more broadly conical.

**Distribution:** This form is not known to occur outside Miocene of Kachchh.

**Occurrence:** Yellowish, fine grained sandstone at the base of the Claystone member, Chhasra Formation, 2 km west of Buta.

Genus: *Cirsotrema*

*Cirsotrema subtenuilamella* (d'Archiac and Haime 1854) comb. nov.

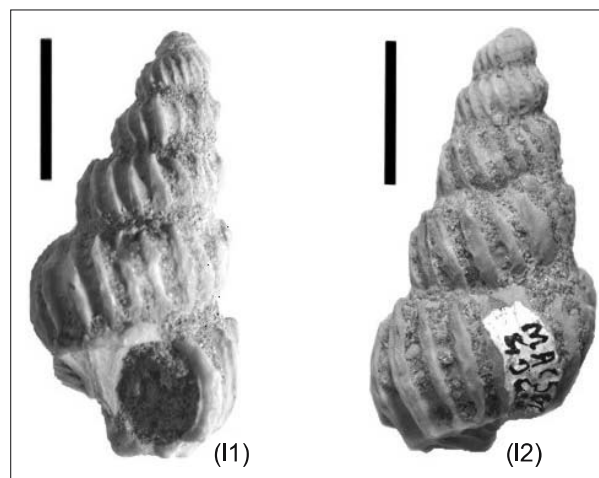


Figure 2(1). *Cirsotrema subtenuilamella* (d'Archiac and Haime) comb. nov.; Plesiotype no. MACS G 4969. 11: adapertural view. 12: abapertural view. Bar scale = 10 mm.

1854 *Scaloria subtenuilamella*: d'Archiac and Haime, p. 286, plate 27, figure 9.

1854 *Scaloria sedgwicki*: d'Archiac and Haime, p. 286, plate 27, figure 10.

1928 *Scala (Clathrus) subtenuilamella* d'Archiac and Haime: Vredenburg, p. 402.

**Material:** Eight specimens, fairly well preserved.

**Plesiotype:** MACS G 4969.

**Paratype:** MACS G 4970–MACS G 4971.

**Dimensions:**

Specimen no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4969	30 mm	21.8 mm	8.2 mm	14.1 mm	10°
MACS G 4970	27.8 mm	19.6 mm	8.2 mm	15.1 mm	30°
MACS G 4971	41.4 mm	30 mm	11.4 mm	20.4 mm	22°
6/9	21 mm	14.9 mm	6.1 mm	10.4 mm	38°
21/12	29.9 mm	23.6 mm	6.3 mm	12.6 mm	38°
10/60	21.6 mm	15.1 mm	6.5 mm	11.4 mm	32°

**Description:** Specimens well preserved, tall, slender, medium sized. Protoconchs broken. Five to six whorls preserved in individual shells; convex, separated by deep sutures. Twenty axial costae thin, lamella-like, narrow, sharp. In some specimens crest of lamella-like costae form carina with small spine like posterior end. Intervals between successive lamellae traversed by six to eight fine lirae, separated by broader grooves, which feebly continue on other side of costae. A few varices discernible in some specimens. Ear-like expansion of inner lip at termination of columella; labrum raised to form circular lip. Basal disc delineated by conspicuous spiral thread.

**Remarks:** Ornamentation of these specimens goes very well with those described by Vredenburg (1928, p. 402) as *Scala (Cirsotrema)*

*subtenuilamella* from the Gaj Beds of Sind, Pakistan; especially the lamella-like axial costae, aid in identifying them as *C. subtenuilamella*.

These specimens are described here under *Cirsotrema* in view of spiral lirae continuing on posterior side of axial costae, following Morley Davies (1971, p. 324), who has assigned *Cirsotrema* the status of a genus.

**Distribution:** Gaj Beds of Sind.

**Occurrence:** (1) The limestone intercalation within the Khari Nadi Formation, at the top of lower one-third variegated siltstones, on the right bank of Khari River, 0.5 km NE of Aida. (2) *Turritella* Bed at the top of Khari Nadi Formation, 2 km west of Buta. (3) Yellowish, fine grained sandstone at the base of Claystone member, Chhasra Formation, 2 km west of Buta.

Superfamily: Strombacea  
 Family: Strombidae  
 Genus: *Rimella*

*Rimella subrimosa* (d'Orb. 1847) Vredenburg, 1925

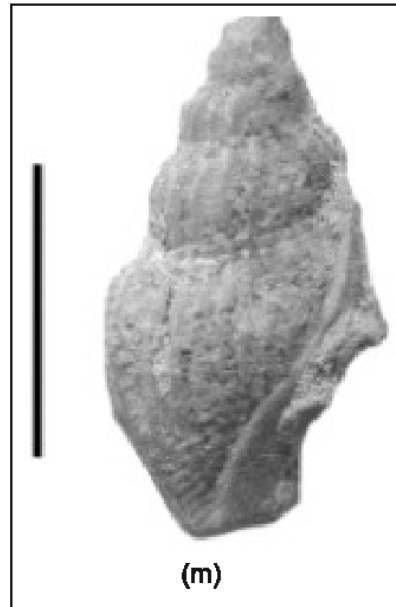


Figure 2(m). *Rimella subrimosa* (d'Orb.) Vredenburg; Topotype no. MACS G 4972, in apertural view. Bar scale = 10 mm.

1839 *Rostellaria rimosa*: J de C Sowerby, plate 27, figure 17 [*non Rostellaria rimosa* Sol. in Sowerby 1923, Mineral Conchology of Great Britain, vol. 1, plate 91, figures 4–6].

1925 *Rostellaria subrimosa* d'Orbigny: Vredenburg, p. 320, plate 6, figures 7–10.

1962 *Dientomochilus (varicospira) subrimosus* (d'Orb.): Dey, p. 67.

**Material:** Solitary specimen.

**Topotype:** MACS G 4972.

**Dimensions:**

Field no.	Height	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4972	18.1 mm	8.9 mm	9.2 mm	9.8 mm	38°

**Description:** Moderately well preserved, small, fusiform shell. Protoconch not preserved. Four whorls, including last, present; slightly convex. From general form and outline, height of spire appears equal to that of last whorl. Last whorl elongate, tapers to anterior, producing sizeable rostrum. Height of each whorl slightly less than half its width. About 25 sharp axial costae, separated by sulci having thrice the width of costae. Eleven distinct spiral lirae in the axial sulci. Spiral lirae

faintly cross the axial costae; they are more conspicuous in axial sulci than on costae. Aperture partially preserved. Distinct prolonged posterior canal reaches two spires preceding last whorl. Callosus thickening on columellar lip preserved to some extent.

**Remarks:** The specimen is compared with the description and illustrations of *R. subrimosa* from the Gaj Beds of Kachchh (Vredenburg 1925, p. 320, plate 6, figures 7–10). Present specimen could be

identified with it on the basis of exactly similar ornamentation and style of prolongation of the posterior canal.

According to Vredenburg the fossil form resembles the extant *Rimella cancellata* in shape, but is distinguished by the absence of crenulations on the outermost margin of the aperture. Besides, the hook-like prolongation of the aperture reaches closer to the apex in the living form than the fossil.

Dey (1962) has identified this form under sub-genus *Varicospira* of the genus *Dientomochilus*. However, spiral ribs cross the axial costae in the present specimen. Therefore, following the generic definition given by Davies (1971) this form is described here under *Rimella*.

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** Yellowish, fine grained sandstone bed of the base of the Claystone member, Chhasra Formation, 1 km south of village Buta.

*Rimella subrimosa* (d'Orbigny 1847) Vredenburg *narica* Vredenburg, 1925

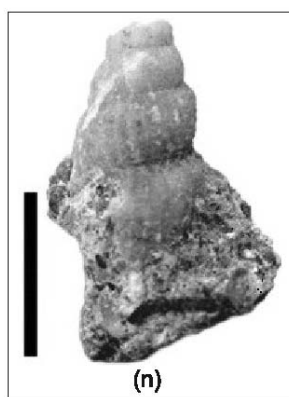


Figure 2(n). *Rimella subrimosa* (d'Orbigny) Vredenburg var. *narica* Vredenburg 1925; Plesiotype no. MACS G 4973, in adapertural view. Bar scale = 10 mm.

1925 *Rimella subrimosa* d'Orbigny *narica* Vredenburg: p. 321, plate 3, figures 15 and 16.

**Material:** Solitary specimen.

**Plesiotype:** MACS G 4973.

**Dimensions:** The specimen is attached to rock matrix. It is not possible to ascertain the dimensions.

**Description:** Fusiform shell, with somewhat convex whorls, neanic whorls lost, only last four whorls present. Thin axial costae, intervened by wider sulci. Thin spiral lirae, more distinct on axial sulci. Aperture incomplete, but prolonged posterior canal distinct.

**Remarks:** This form differs from *Rimella subrimosa* (*vide supra*), in having taller spire whorls.

Comparison of the specimen under consideration with the description and illustrations of

*R. subrimosa* var. *narica* from the Nari Beds near Quetta, Pakistan (Vredenburg 1925, p. 321, plate 3, figures 11–16) reveals that the present specimen agrees well in all essential respects.

**Distribution:** Nari Beds of Pakistan.

**Occurrence:** A shell limestone intercalation within the Claystone member, Chhasra Formation, 0.5 km SSE of Chhasra.



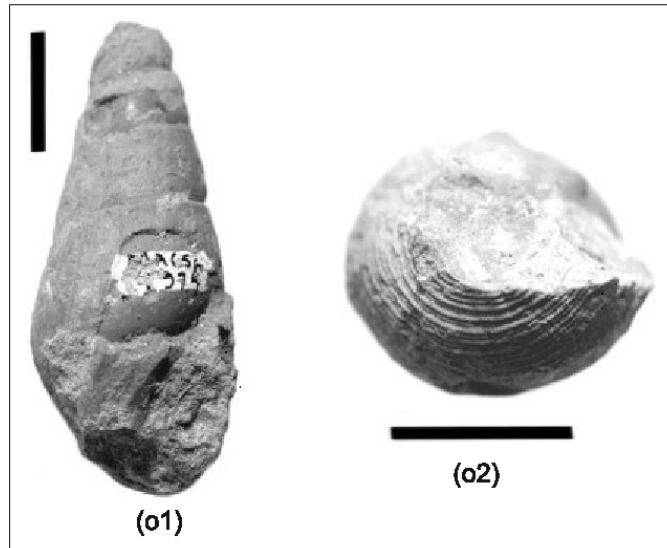
Genus: *Tibia**Tibia curta* (J de C Sowerby 1842) comb. nov.

Figure 2(o). *Tibia curta* (J de C Sowerby) comb. nov; Plesiotype no. MACS G 4974. o1: adapertural view. o2: basal view, showing details of spiral ornamentation. Bar scale = 10 mm.

1925 *Rostellaria curta* Sowerby: Vredenburg, p. 319, plate 4, figure 2(a, b).

**Material:** Solitary specimen.

**Plesiotype:** MACS G 4974.

**Dimensions:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4974	41.8 mm	23.7 mm	18.2 mm	15.7 mm	23°

**Description:** Only last five whorls preserved. Whorls short, almost half their length, feebly convex, separated by linear sutures. Step-like disposition of suture in last two whorls. Ornamentation not satisfactorily preserved. Curvilinear costae preserved on some whorls. Two delicate spiral threads seen on whorls, very close to the anterior suture. On the base, intercalaries developed in the intervening sulci (figure 2-o2). Neck and labrum lost, but part of columella preserved.

**Remarks:** When compared with the description and illustrations of *Rostellaria curta* (Vredenburg 1925, p. 319; plate 4, figures 2a-b), from

the Mekran Beds of Pakistan, the present specimen could be identified with it on the basis of flat to slightly convex whorls, linear sutures tending to get a step-like disposition in the later whorls and flat spiral ribs of two orders on the base. According to Morley Davies (1971), *Rostellaria* is an invalid name. Therefore, this species is identified here under the genus *Tibia*.

**Distribution:** Mekran Beds of Pakistan.

**Occurrence:** A limestone intercalation in the Claystone member, Chhasra Formation, on the bank of Kankawati River, 0.5 km south of Khirsara.

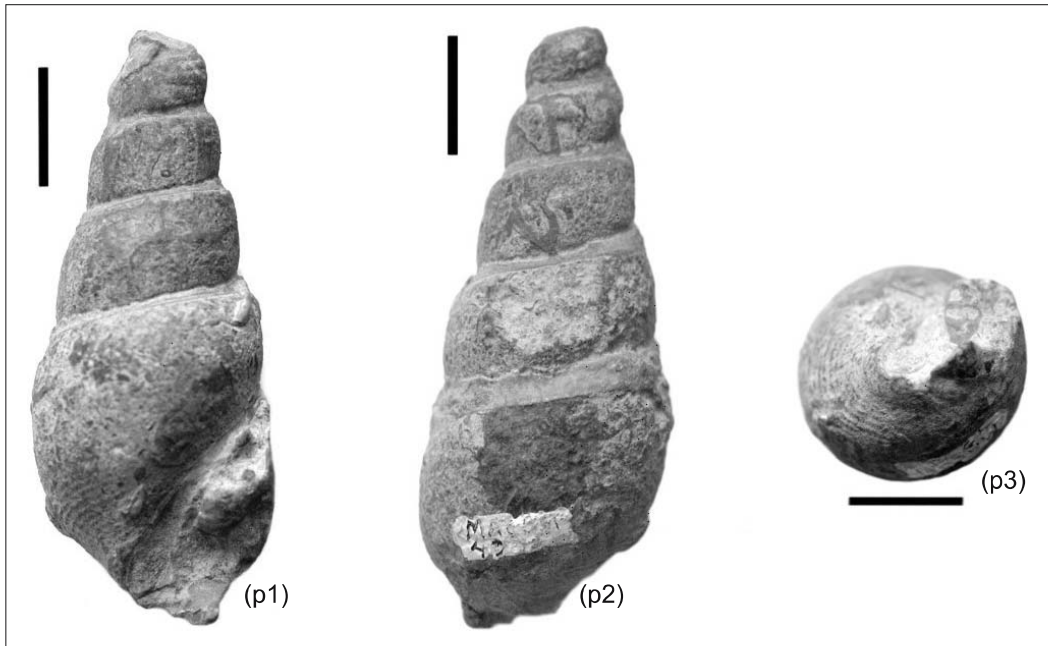
*Tibia indica* Dey, 1962

Figure 2(p). *Tibia indica* Dey; Plesiotype no. MACS G 4974. p1: adapertural view. p2: abapertural view. p3: basal view, showing spiral ribs of two orders. Bar scale = 10 mm.

1962 *Tibia indica*: Dey, p. 66, plate 7, figures 1, 7.

**Material:** Solitary specimen.

**Plesiotype:** MACS G 4975.

**Dimensions:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4975	51.7 mm	23.1 mm	28.6 mm	23 mm	20°

**Description:** Elongate fusiform shell with acute spire. Only last five whorls preserved, feebly convex, separated by linear suture. At places very weak spiral threads can be detected. The base shows spiral ribs of two orders (figure 2-p3). Ros-trum lost, aperture partially preserved. Anterior canal lost; hook-like projection of posterior canal crosses posterior suture of the last whorl.

**Remarks:** This species differs from *T. curta* (Sow.) (*vide supra*) since the whorls in the present form are slightly taller and spiral ribs on the base are not flat.

The specimen is compared with the type specimen of *Tibia indica* from the Quilon Beds of Kerala (holotype no. 16,442, Central Fossil Repository, G.S.I., Kolkata; Dey 1962, p. 66, plate 7, figures 1, 7). It is specifically identified on the basis of comparable general outline of the whorls and spiral ornamentation on the base.

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** Shell limestone intercalation at the variegated siltstones constituting the lower one-third of the Khari Nadi Formation, on the right bank of the Khari River, 0.5 km NE of Aida.

Genus: *Terebellum*  
 Subgenus: *Terebellum*

*Terebellum (Terebellum) terebellum* (Linné 1758)



Figure 2(q). *Terebellum (Terebellum) terebellum* (Linné 1758); Plesiotype no. MACS G 4076, in apertural view. Bar scale = 10 mm.

1839 *Terebellum obtusum*: Sowerby, plate 26, figure 31.

1854 *Terebellum obtusum* Sowerby: d'Archiac and Haime, p. 333, plate 32, figure 21, *non* figure 20.

1925 *Terebellum subulatum* Lamarck var. *obtusum* Sow: Vredenburg, p. 322, plate I.

1962 *Terebellum terebellum* (Linné): Dey, p. 67.

1994 *Terebellum terebellum* (Linné): McNamara and Kendrick, p. 34, figures 12(E, F).

**Material:** Four specimens.

**Plesiotype:** MACS G 4976.

**Paratype:** MACS G 4977.

**Dimensions:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4976	39.1 mm	–	–	12.1 mm	15°
MACS G 4977	41.4 mm	–	–	–	–
6/9	21 mm	–	–	12.6 mm	18°

**Description:** Medium-sized, slenderly elongate, paucispiral shells; without a true shell-tube. Spire very small. Exterior smooth. Slit-like narrow aperture widening anteriorly. Labrum truncated, turns towards base at right angle.

**Remarks:** When compared with *T. (T.) terebellum* described and illustrated in the Encyclopedia of shells (Dance 1977, p. 75) the specimens from Kachchh agree in all essential respects, especially the way of coiling, slit-like pseudo aperture and absence of true shell-tube. The specimens from Miocene variously have been called *T. obtuse*, *T. subulatum* and *T. subulatum* var., etc. Dey (1962) as well as McNamara and Kendrick (1994) have rightly regarded these

specimens synonymous with *T. (T.) terebellum*, as there appears no reason for considering them a separate form.

**Distribution:** Gaj Beds of Sind, Quilon Beds of Kerala, Miocene and Pliocene of Java, Miocene of Saipan Island, Miocene of Saonek of Besar, Miocene of Eucla Basin, Pliocene of Billiton and Farsan Islands, Miocene and Pleistocene of the Barrow Island, Australia.

**Occurrence:** (1) A shell limestone intercalation within the Claystone member, Chhasra Formation, west of Haripar. (2) Shell limestone intercalation within Claystone member, Chhasra Formation, on the right bank of the Birwati River, 1 km SSE of Chhasra.

Family: Xenophoridae

Genus: *Xenophora*

*Xenophora terpstrai* Dey, 1962

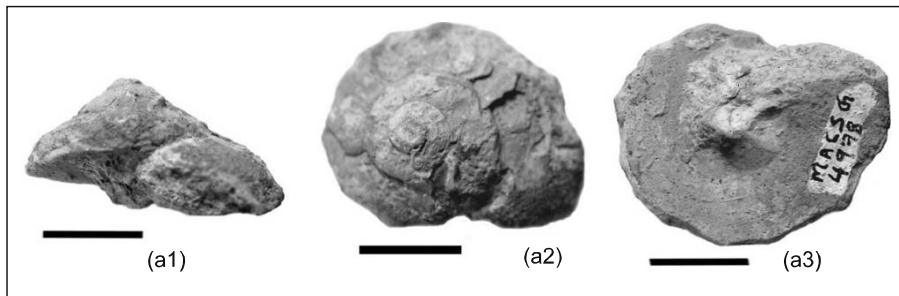


Figure 3(a). *Xenophora terpstrai* Dey; Plesiotype no. 4978. a1: adapertural view, a2: apical view, a3: basal view. Bar scale = 10 mm.

1962 *Xenophora terpstrai*: Dey, p. 58, plate V, figures 9–10.

**Material:** Five specimens.

**Synplesiotypes:** MACS G 4978 and MACS G 4979.

**Dimensions:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4978	15.1 mm	6.7 mm	8.4 mm	–	90°
MACS G 4979	15.1 mm	12.1 mm	4.4 mm	–	80°
11/22	17.8 mm	–	–	–	79°
11/35	21.2 mm	16.2 mm	–	–	74°
97/14	16.6 mm	–	–	–	73°

**Description:** Small, trochiform shell. Dorsal surface incorporating foreign objects like foreign shell fragments. Flanged base, basal profile of aperture sigmoidal. Ornamentation on base feebly visible, spiral threads discerned with difficulty.

**Remarks:** The specimens agree with the holotype of *X. terpstrai* described by Dey, from the Quilon Beds of Kerala (No. 16,430, Central Fossil Repository of the G.S.I., Kolkata; Dey 1962,

p. 58; plate 5, figures 9 and 10) in all essential respects.

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** (1) Shell limestone intercalation at the top of variegated siltstones constituting the lower one-third of the Khari Nadi Formation, on the right bank of Khari River, 0.5 km NE of Aida. (2) Shell limestone intercalation within the Claystone member, Chhasra Formation, 0.5 km SSE of Chhasra.

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Superfamily: Naticacea  
 Family: Naticidae  
 Subfamily: Ampullospirinae  
 Genus: *Globularia*  
 Subgenus: *Globularia*

*Globularia (Globularia) carlei* (Finlay 1927) Dey, 1962

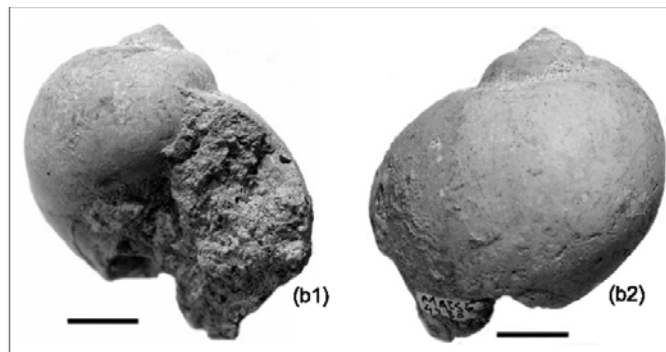


Figure 3(b). *Globularia (Globularia) carlei* (Finlay) Dey; Plesiotype no. MACS G 4080. b1: adapertural view, b2: abapertural view. Bar scale = 10 mm.

1839 *Natica callosa*: J de C Sowerby, plate 26, figure 3, *non N. callosa* Cristofori and Jan (1832).

1927 *Natica carlei*: Finlay, plate 57, p. 498.

1928 *Ampullina (Cernina) callosa* Sowerby: Vredenburg, p. 400.

1962 *Globularia (Cernina) carlei* (Finlay): Dey, p. 54, plate 5, figures 3 and 6.

**Material:** Two specimens.

**Topotype:** MACS G 4980.

**Dimensions:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4980	45.3 mm	5.5 mm	39.8 mm	46.7 mm	110°
97/15	32.3 mm	–	–	39.8 mm	–

**Description:** Specimens fairly well preserved; one small, while the other medium in size. Protoconch noticeably obtuse. Spire very small, of only three whorls. Shell distinctly globose. Semicircular labrum of aperture partially but clearly seen in the topotype.

**Remarks:** The specimens from Kachchh agree well with the description and illustrations of *Globularia (Cernina) carlei* (Finlay) from the Quilon Beds of Kerala (Dey 1962, p. 54; plate 5, figures 3 and 5). Sowerby had identified this form under the genus *Natica*, while Vredenburg had identified it under the subgenus *Cernina* of the genus *Ampullina*. It is rectified here as *Globularia (Globularia)*. According to Davies (1971) generic term *Ampullina* is a junior synonym of *Ampulella* and therefore invalid, whereas subgeneric term *Cernina* is a junior synonym of *Globularia (ss)*. As this form does not possess stepped spire, it is not *Ampulella*.

Also, Sowerby (1839) and Vredenburg (1928) had identified this form under the specific epithet '*callosa*'. Being a preoccupied epithet, Finlay proposed the new name *carlei* for this species.

According to Dey (*op. cit.*), *G. (G.) carlei* could be an ancestral form of the extant form *Natica fluctuata* since the fossil form very closely resembles it. However, these two genera belong to two different subfamilies, Ampullospirinae and Naticinae. Hence the remark by Dey is unwarranted.

**Distribution:** Ashapura Clay member of Kathiawar, Quilon Beds of Kerala and Miocene of Kenya.

**Occurrence:** (1) A shell limestone intercalation at the top of variegated siltstones constituting lower one-third of the Khari Nadi Formation, 0.5 km northeast of Aida. (2) A shell limestone intercalation within the Claystone member, Chhasra Formation, 2 km west of Haripar.

Family: Cassidae  
Genus: *Semicassis*  
Subgenus: *Semicassis*

*Semicassis (Semicassis) pila* Reeve, 1858

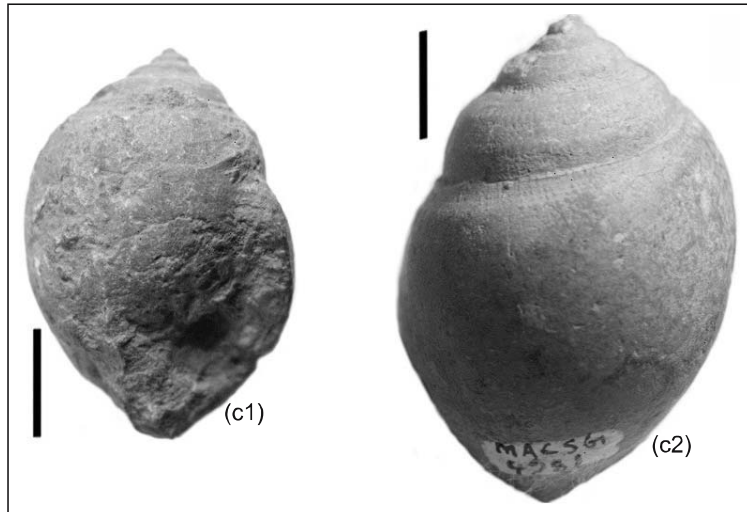


Figure 3(c). *Semicassis (Semicassis) pila* Reeve. Plesiotype no. MACS G 4982. c1: adapertural view, c2: abapertural view two spiral ribs. Bar scale = 10 mm.

1962 *Cassis (Semicassis) pila* Reeve: Dey, p. 68, plate 5, figure 13.

**Material:** Solitary specimen.

**Plesiotype:** MACS G 4981.

**Dimension:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4981	36.4 mm	11.4 mm	24.6 mm	26.3 mm	110°

**Description:** Protoconch distinctly conical and depressed. Spire very short, less than a third of entire height. Whorls moderately convex, separated by fine, shallow sutures. Ornamentation not clearly discernible; however, four spiral ribs bearing beads seen on each whorl immediately anterior to the posterior suture. Aperture with moderate width.

**Remarks:** The specimen is compared with the illustration of *Cassis* (*Semicassis*) *pila* var. Martin from the Quilon Beds of Kerala (Dey 1962, p. 68; plate 5, figure 13). Identity of this specimen with

that from Quilon can be established relying on the same proportion of spire to the body whorl and four beaded spiral ribs.

**Distribution:** Quilon Beds of Kerala, Upper Miocene of South Sumatra and East Borneo, Upper Miocene (Sonde Beds) and Pliocene of Java, Pliocene of north Sumatra, Southwest New Guinea, Timor and Ceram. Occurs in the Recent waters of China, Philippines, Madura strait and Ceram.

**Occurrence:** The *Turritella* Bed marking the top of the Khari Nadi Formation, 2 km west of Buta.

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*Semicassis* (*Semicassis*) *quilonensis* Dey, 1962

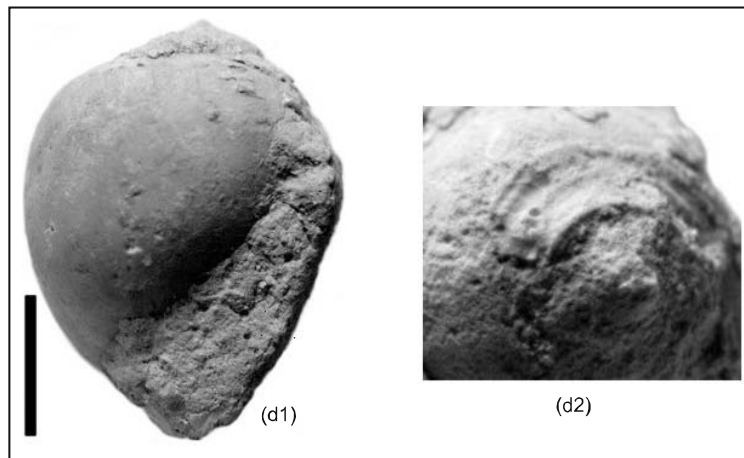


Figure 3(d). *Semicassis* (*Semicassis*) *quilonensis* Dey 1962; Plesiotype no. MACS G 4083. d1: apertural view, d2: close up of an apical portion. Bar scale = 10 mm.

1962 *Cassis* (*Semicassis*) *quilonensis*: Dey, p. 68, plate 5, figures 20 and 26.

**Material:** Solitary specimen.

**Plesiotype:** MACS G 4982.

**Dimension:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4982	30.9 mm	7.2 mm	23.7 mm	23.3 mm	112°

**Description:** Ovately elongate form, five whorls present. Spire very short, less than one-fourth of entire height. Last whorl big, inflated. Though original shell eroded, tiny preserved portion shows two spiral ribs, bearing delicate beads to the anterior of, and close to sutures (figure 3-d2). On the last whorl, a couple of axial ribs are also seen. Aperture partially preserved, yet its long and wide nature discernible. Two spiral wrinkles seen at the base.

**Remarks:** This form can be distinguished from *Semicassis* (*Semicassis*) *pila* (*vide supra*), on the basis of a shorter spire. Also, in *S.(S.) pila*, number of spiral ribs is four, while it is two in the present form. Spiral ribs in former are evenly distributed, while in the present form they are very close to the posterior suture of the whorl.

This specimen is compared with holotype and paratype of *Cassis* (*Semicassis*) *quilonensis*

(holotype no. 16,443 and paratype no. 16,444; Central Fossil Repository, G.S.I., Kolkata; Dey 1962, p. 69; plate 5, figures 20 and 26). It helps in identifying the present specimen with them, especially on the basis of a very short spire and two delicately beaded spiral ribs. Like holotype, the present specimen too, shows wrinkles at the base.

The species under consideration [*S. (S.) quilonensis*] and the previous one [*S. (S.) pila*] are identified as *Semicassis* (*s.s.*) following the work of Davies (1971, p. 346), wherein the epithet *Semicassis* has been given generic status. Both these specimens have wider apertures, and hence cannot be accommodated in *Cassis* (*s.s.*).

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** A shell limestone intercalation within the Claystone member, Chhasra Formation, 0.5 km SSE of Chhasra.

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Family: Fusunidae  
Subfamily: Fasciolariinae

*Fasciolaria nodulosa* (J de C Sowerby 1839) Dey, 1962

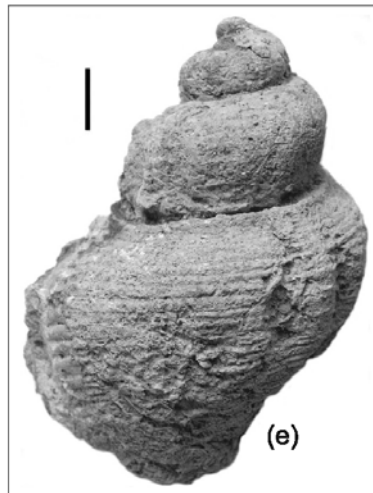


Figure 3(e). *Fasciolaria nodulosa* (J de C Sowerby) Dey; Plesiotype no. MACS G 4084, abapertural view. Bar scale = 10 mm.

1839 *Fusus nodulosus*: J de C Sowerby, plate 24, figure 14.

1854 *Fusus nodulosus* Sowerby: d'Archiac and Haime, p. 307.

1925 *Siphonalia* (*Kelletia*) *nodulosa* (Sowerby): Vredenburg, p. 186.

1962 *Fasciolaria nodulosa* (Sowerby): Dey, p. 83, plate 8, figures 2 and 15.

**Material:** Solitary specimen.

**Topotype:** MACS G 4983.



**Dimension:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width
MACS G 4983	76.6 mm	33.0 mm	43.5 mm	45.2 mm

**Description:** Specimen partially preserved, protoconch and adapertural portion lost. Ramp of the whorls flat, tending to be slightly concave. Anterior slope of whorls very steep and slightly convex. Sutures deep with distinct circumsutural rim. Axial ridges ten, prominent, closely spaced, rounded; very prominent at shoulder. Their prominence decreases gradually towards anterior and rapidly towards posterior. Spiral ribs on slope anterior to the shoulder separated by spiral furrows as broad as ribs. Lira-like intercalaries seen between primary ribs. Number of spiral ribs increases on last whorl, where width of spiral furrows is less than that of ribs. With the growth of shell, additional spiral intercalaries inserted, gradually becoming as prominent as primary ribs.

**Remarks:** Comparison of the present specimen with description and illustrations of *Fasciolaria*

*nodulosa* (Sow.) from the Quilon Beds of Kerala (Dey 1962, p. 83; plate 8, figures 2 and 15) shows its identity with the Quilon specimen. Despite identification of this form from Kachchh under the genus *Siphonalia* by Vredenburg (1925, p. 186), it is identified as *Fasciolaria* by Dey (1962) since a few oblique plications at the end of the aperture were clearly observed in the Quilon specimen. Hence, it is described here as *Fasciolaria*.

According to Vredenburg (1925), this form closely resembles *Siphonalia tjibaliungensis* Martin, from the Tertiary of Java.

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** Yellowish, fine grained sandstone at the base of the Claystone member, Chhasra Formation, 2 km west of Buta.

Superfamily: Volutacea  
 Family: Volutidae  
 Subfamily: Lyriinae  
 Genus: *Lyria*

*Lyria jugosa* (J de C Sowerby 1839) Vredenburg, 1925

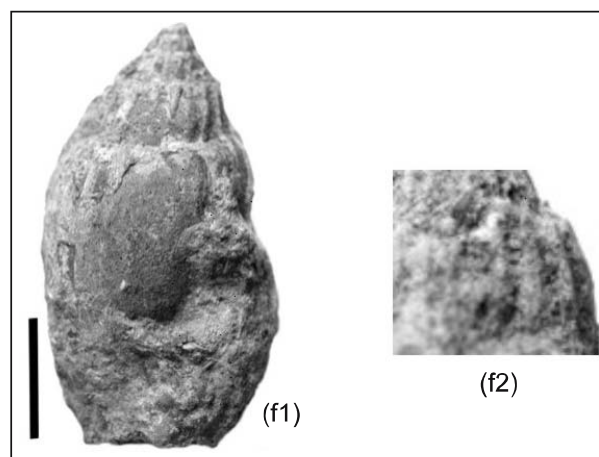


Figure 3(f). *Lyria jugosa* (J de C Sowerby) Vredenburg; Topotype no. MACS G 4984. f1: adapertural view, f2: close up of a portion, showing fine spiral threads restricted to bottom of axial furrows, between the axial ribs. Bar scale = 10 mm.

1839 *Voluta jugosa*: J de C Sowerby, plate 26, figure 25.

1850 *Voluta jugosa* J de C Sowerby: d'Archiac, p. 298.

1854 *Voluta jugosa* J de C Sowerby: d'Archiac and Haime, p. 323, plate 31, figures 19–21.

1854 *Voluta edwardsi* d'Archiac: d'Archiac and Haime, p. 323, plate 31, figures 22–24.

1925 *Lyria jugosa* J de C Sowerby: Vredenburg, p. 138.

1962 *Lyria jugosa* J de C Sowerby: Dey, p. 84, plate 5, figure 6.

**Material:** Two specimens.

**Syntopotype:** MACS G 4984 and MACS G 4985.

**Dimensions:**

Field no.	Height spire	Height of last whorl	Height of width	Maximum angle	Spiral
MACS G 4984	–	–	–	18.6 mm	61°
MACS G 4985	28.8 mm	–	–	–	–

**Description:** Moderately preserved fusiform shells of moderate size. Spire constitutes about two fifths of the entire height. Sutures broad and deeply grooved. Whorls have rather straight, fairly steep slope between sutures, imparting conoidal shape to spire. Sharp, nineteen narrow axial ribs in each whorl, giving rise to spinose projections near posterior margin, imparting step-like appearance. Spiral lirae delicate, discernible at places, present only within the axial furrows. Intervening furrows, having thrice the width as lirae. In one specimen (MACS G 4985), transverse ribs distinctly seen on columellar fold.

**Remarks:** These specimens agree with the description of *Lyria jugosa* (Sowerby) from the Gaj Beds of Kachchh (Vredenburg 1925, p. 139) and illustrations of this form from the Quilon Beds of Kerala (Dey 1962, p. 85; plate 6, figures 2 and 6).

This form can be distinguished from *L. anceps*, described from the Nari Beds of Sind (type specimens nos. 12,544 and 12,545, Vredenburg 1925, v. 50, p. 142, plate II, figures 7 and 8) by its relatively larger size and by the sharp terminations of the axial ribs imparting a step-like appearance to the spire. Besides, suture in *L. anceps* is narrower and the antero-dorsal bulge is more prominent.

**Distribution:** Gaj Beds of Sind, Ashapura Clay member of Kathiawar, Quilon Beds of Kerala, Lower Miocene of Java.

**Occurrence:** (1) The *Turritella* Bed at the top of the Khari Nadi Formation, 2 km west of Buta. (2) The *Turritella* Bed at the top of the Khari Nadi Formation, on the bed of Khari River, 2.5 km west of Haripar.

*Lyria eodelessertiana* Dey, 1962

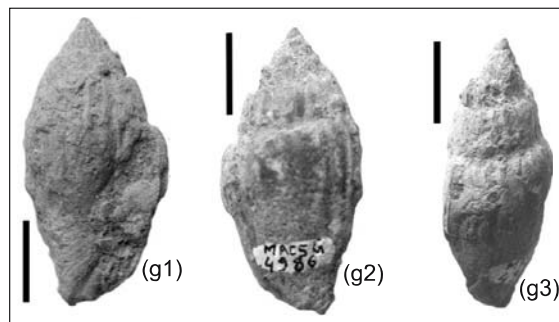


Figure 3(g). *Lyria eodelessertiana* Dey; Plesiotype no. MACS G 4986. g1: adapertural view, g2: abapertural view. g3: Note spiral threads on last whorl of spire. Bar scale = 10 mm.

1962 *Lyria eodelessertiana*: Dey, p. 85, plate 6, figures 2 and 6.

**Material:** Four specimens.

**Plesiotype:** MACS G 4986.

**Paratype:** MACS G 4987.

**Dimension:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width	Spiral angle
MACS G 4986	35.1 mm	11.8 mm	23.3 mm	17.4 mm	63°
MACS G 4987	35.9 mm	25.2 mm	10.7 mm	—	65°

**Description:** Medium sized, fusiform specimens. Anterior end of neck slightly curved at base to the left side. Twenty four sharp axial ribs, whose posterior ends project above the shoulder into sharp points. Intervening furrows slightly wider. Very faint, ill-preserved fine spiral threads present, noticeable only at a few places in a couple of specimens. They occur between the axial ribs, restricted to bottom of furrows. Aperture ovate and oblong. Columellar lip shows development of callus.

**Remarks:** The slightly greater axial angle distinguishes this form from *Lyria jugosa* (*vide supra*). The axial ribs in this variety are crowded; as a result, the furrows separating them are narrower. Moreover, posterior ends of the axial ribs do not terminate in sharp points as in *Lyria jugosa*.

Therefore, a step-like appearance of the individual whorls is lacking.

The specimens under consideration are identical with the holotype of *Lyria eodelessertiana*, from the Quilon Beds of Kerala (No. 16,464 in the Central Fossil Repository, G.S.I., Kolkata; Dey 1962, p. 85; plate 6, figures 2 and 6).

According to Dey (1962) this form is an ancestral form of *Voluta delessertiana* Petit, now living off the Malagassy coast.

**Distribution:** Quilon Beds of Kerala.

**Occurrence:** (1) *Turritella* Bed at the top of Khari Nadi Formation, 2 km west of Haripar in the bed of Khari River. (2) A limestone intercalation belonging to *Miogypsina globulina-thecidaeformis* zone within the Claystone member, Chhasra Formation, in the bed of Khari River, about 1 km northeast of Chhasra.

Superfamily: Conacea  
 Family: Conidae  
 Genus: *Conus*  
 Subgenus: *Lithoconus*

*Conus (Lithoconus) ineditus* (Michelotti 1861) Sacco, 1893

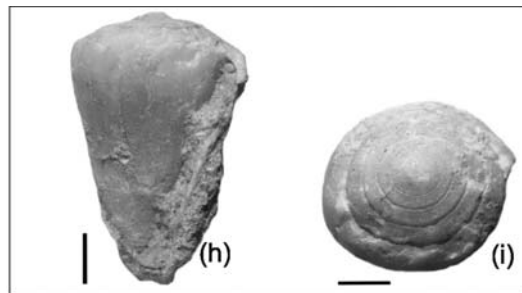


Figure 3(h-i). *Conus (Lithoconus) ineditus* (Michelotti) Sacco. (h) Topotype no. MACS G 4988, in adapertural view, (i) Paratype no. MACS G 4989, axial view, showing sparse spiral threads. Bar scale = 10 mm.

1893 *Lithoconus ineditus* Michelotti: Sacco, p. 80, plate 3, figures 16–24.

1925 *Conus (Lithoconus) ineditus* Michelotti: Vredenburg, p. 87, plate 1, figures 12–14.

**Material:** Two specimens.

**Plesiotype:** MACS G 4988.

**Paratype:** MACS G 4989.

**Dimension:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width
MACS G 4988	52.9 mm	5.1 mm	47.8 mm	39.0 mm
MACS G 4989	52.2 mm	6.0 mm	46.8 mm	34.9 mm

**Description:** Both specimens silicified casts; one nearly complete, other partially preserved. Protoconch not preserved in both. Spire, coelocoid in nature, very short, consisting of seven whorls; making just a tenth of entire height. Shelves of whorls carry two closely spaced, very fine, spiral threads occupying exactly central portion of ramp of each whorl; leaving two broad, flat, blank strips to anterior and posterior to them (figure 3i). Sparsely distributed axial sulci seen in last whorl, intervened by very wide areas, which before crossing the shoulder take an obtuse turn towards aperture and continue on the ramp. Small dents are produced where sulci cross shoulder.

**Remarks:** When compared with *C. (L.) ineditus* from the Nari Beds (Oligocene) of Bhagothoro Hill, Sind Pakistan (Vredenburg, p. 87; plate 1, figures 12–14), the specimens agree in all essential respects.

This species is very closely related to *Conus (Lithoconus) malaccanus* Hwass, a Recent form.

**Distribution:** Nari Beds of Sind, Miocene of Liguria and Myanmar.

**Occurrence:** A limestone band within the *Miogypsina globulina-thecidaeformis* zone of the Claystone member, Chhasra Formation in the bed of Khari River, about 1 km northeast of Chhasra.

*Conus (Lithoconus) literatus* Linnaeus

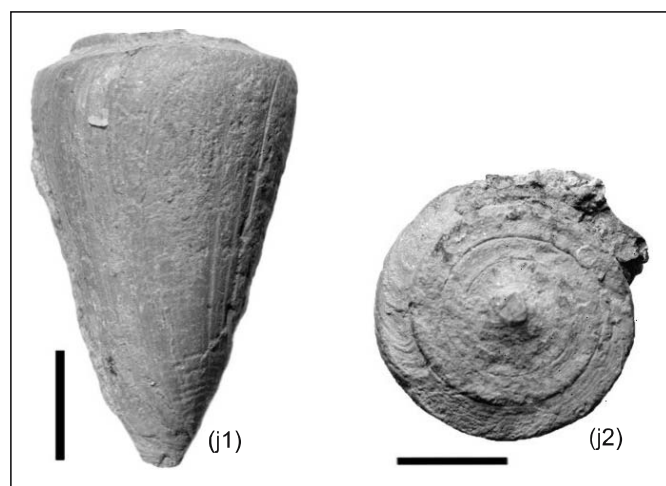


Figure 3(j). *Conus (Lithoconus) literatus* Linnaeus; Topotype no. MACS G 4990. j1: abapertural view. Note that the axial sulci turn to right, with an acutely circular curve and continue on the shelf with a short, sigmoidal pattern. j2: axial view, showing two fine spiral sulci on shelves of the whorls. Bar scale = 10 mm.

1839 *Conus brevis*, J de C Sowerby, plate 26, figure 33 [*non Conus brevis* Sow.? In d'Archiac and Haime, p. 336, plate 34, figure 6, (1854), *non Conus brevis* Sowerby? Cossmann and Pissaro, p. 18, plate I, figures 21, 22, (1909) *non Conus (Lithoconus) literatus* Linné, Noetl, p. 359, plate 23, figures 12–14].

1839 *Conus militaris*: J de C Sowerby, plate 26, figure 34.

1839 *Conus catenulatus*: J de C Sowerby, plate 26, figure 35.

*non Conus militaris* J de C Sow.? in d'Archiac and Haime, p. 336, plate 34, figure 5 (1854).

*non Conus militaris* J de C Sow.? in d'Archiac and Haime, p. 336, plate 34, figure 6 (1854).

1925 *Conus (Lithoconus) brevis* Sowerby: Vredenburg, p. 89–92.

1950 *Conus (Lithoconus) literatus* Linn.: Eames, p. 233–252.

1962 *Conus (Lithoconus) brevis* Sowerby: Dey, p. 103.

**Material:** Three specimens.

**Topotype:** MACS G 4990.

**Paratype:** MACS G 4991.

**Dimension:**

Field no.	Height of the shell	Height of spire	Height of last whorl	Maximum width
MACS G 4990	41.5 mm	3.0 mm	38.5 mm	23.3 mm
MACS G 4991	40.0 mm	2.9 mm		26.0 mm

**Description:** Moderate sized specimens. Almost entire height of shell is that of last whorl. Spire flat excepting short coeloconoid apical portion. Protoconch, distinctly globular, preserved in one specimen; showing first four whorls forming very low, small cone; rest of the spire is flat consisting of shelves of all the remaining whorls. Six very fine, spiral sulci, separated by lirae of matching strength in axial view (figure 3-j2). In last whorl, sulci turn to right before meeting the shoulder, with acutely circular curve and continue on the shelf with short, sigmoidal pattern. Spiral striae seen in anterior region of last whorl, close to the aperture.

**Remarks:** The distinctly flat spire of this species distinguishes it from *C. (L.) ineditus* (*vide supra*). Besides, course of axial sulci is different in both the forms. In case of *C. (L.) ineditus* these sulci produce small dents where they cross the shoulder and then continue on the ramp. While, in case of *C. (L.) literatus*, these sulci turn to right before meeting the shoulder and continue on the shelf with a short, sigmoidal pattern.

Specimens belonging to this form coming from the Miocene Beds of Kachchh were described by

Sowerby under three different names, viz., *Conus brevis*, *Conus catenulatus* and *Conus militaris*. Vredenburg (1925, p. 89) observed that variations within all these three forms are so common, that identifying them together under a single specific term, *Conus (Lithoconus) brevis* is justified. Eames (1950) pointed out that this form is specifically identified with living from *L. literatus* occurring in the eastern seas.

Comparison of the present specimen with *Conus literatus* from the Encyclopedia of shells (Dance 1977, p. 208) shows that a flat spire with the oldest whorls forming a summit and general form of the shell are common and the specimens are identified as fossil representatives of *C. (L.) literatus*.

**Distribution:** Miocene of Sri Lanka and Quilon Beds of Kerala.

**Occurrence:** (1) A limestone band within the *Miogypsina globulina-thecidaeformis* zone of the Claystone member, Chhasra Formation in the bed of Khari River, about 1 km northeast of Chhasra. (2) A limestone band within the Claystone member, Chhasra Formation, on the bank of Kankawati River, 0.5 km south of Khirsara.

### 3. Discussion

#### 3.1 Affinities and age of the fauna

Till now, 55 gastropod species were known to occur in the Miocene sediments of Kachchh (Vredenburg 1925, 1928; Pascoe 1964). The present contribution adds 16 forms, taking the total number of gastropod species to 71 (table 2). It was imperative to revise systematic positions of certain forms in the light of taxonomic changes subsequent to Vredenburg's work. Such emendations were required in case of 33 forms, out of which 15 gastropods are present in the collection procured by the present workers and have found place in the systematic description given above.

Vredenburg (1925, 1928) had studied molluscs from the Tertiary rock formations of Sind, Kachchh and Kathiawar together. He referred the marine Miocene formations in Kachchh and Kathiawar as the 'Gaj Beds', in view of their equivalence with the Gaj Beds of Sind Province, now in Pakistan. For assigning age, he took into consideration his observation that his 'Lower Gaj' and 'Upper Gaj' faunas do not differ sufficiently, yet are distinct; and are referable to the faunas of Rembang and Njalindung series of Indonesia (Martin 1879). As Martin had assigned Aquitanian and Burdigalian ages respectively to Rembang and Njalindung molluscs, Vredenburg inferred that the Miocene rock formations of Sind, Kachchh and Kathiawar are of Lower Miocene age, the 'Lower Gaj' fauna being Aquitanian and the 'Upper Gaj' Burdigalian.

While proposing a new lithostratigraphic classification, Biswas (1992) also assigned an Aquitanian age for his Khari Nadi Formation and a Burdigalian age for the Chhasra Formation based on the foraminiferal zones, recognized in these two formations by Raju (1974). Occurrence of *Miogypsina tani* and other associated foraminifera ascribe an Aquitanian age to the Khari Nadi Formation. Similarly *Archaias malabaricus*, *Austrotrillina howchini* and certain other miogypsinids indicate a Burdigalian age for the Chhasra Formation. Not only do these findings corroborate the ages suggested by Vredenburg, but also imply that the Khari Nadi and Chhasra Formations of Biswas correspond respectively to the Lower and Upper Gaj Series of Vredenburg (1925, 1928).

The present study substantiates the remarkable affinity of Kachchh faunas with Rembang and Njalindung faunas. Out of 71 gastropod species now known to occur in the Miocene rocks in Kachchh (table 2), 17 species occur in the Miocene rocks of Java and Sumatra, while one occurs in the Miocene of Timor. Also, there are two species which have closely related forms in the Miocene of Java. Thus, the total count is 20 species out of 71 (i.e., 28.2%).

From the geographical distribution of various species provided by Vredenburg (1925, 1928) and Dey (1962), it is deduced that only five Kachchh species are common to the Miocene formations of various basins in Europe, while only seven species are shared by the Miocene rocks of Myanmar.

#### 3.2 Endemism of the fauna

A perusal of the spatial and temporal distribution of 71 gastropod species (table 2), shows that a sizeable proportion of them is shared by the Gaj Beds of Sind (Pakistan), Ashapura Clay of Kathiawar, Quilon Beds of Kerala and Miocene sediments of Sri Lanka. All these rock formations are absolutely correlated and are located around the western coast of the Indian subcontinent. Out of them, Gaj Beds of Sind and Ashapura Clay of Kathiawar are geographically very close to Kachchh. The Kachchh gastropod fauna has 19 forms common with the Gaj Beds of Sind, nine forms common with the Ashapura Clay member, 15 forms common with the Quilon Beds, while five species are common with the Miocene of Sri Lanka. Moreover, there are as many as five species, which are common only to Nari Beds (Oligocene) and four species to the Mekran Series (Pliocene) of Pakistan, underlying and overlying the Gaj Beds. In addition, there are 24 forms out of 71 (i.e., 34%), which are not known to occur outside the formations just mentioned. Moreover, there are nine species (i.e., 13%), which are known to occur only in the Miocene of Kachchh. It implies that there are 33 species (i.e., 47%) restricted to the Lower Miocene rock formations in the western part of the Indian subcontinent. Thus this assemblage has a regional aspect. There is an overall paucity of cosmopolitan forms. All these facts lucidly evince that this gastropod fauna is essentially endemic.

#### 3.3 Relationship with the Quilon fauna

There had been some debate over the relationship between the Gaj fauna and fauna of the Quilon Beds of Kerala. An account of molluscs from the Quilon Beds, along with that from the Jaffna Beds and Kudremalai Beds of Sri Lanka, was provided by Davies (1923), who assigned a Vindobonian age to these beds. In fact, *Archaias malabaricus* (= *Orbitolites malabarica* Carter), a foraminifer index fossil of Burdigalian age was recorded from the Quilon sediments by Carter as early as in 1854. However, Davies overlooked the significance of this discovery.

Eames (1950) restudied the collection described by Davies (1923) and revised the nomenclature of fossil forms. He found a close relationship of the Quilon Miocene assemblage with that from the

Table 2. Checklist of fossil gastropods from the Miocene sediments of Kachchh, Gujarat State, India.

- 
1. *Tectus loryi* (d'Archiac and Haime) comb. nov. [= *Trochus* (*Tectus*) *loryi* (d'Archiac and Haime) of Vredenburg].<sup>▲•</sup>  
Distribution: Lower Gaj Beds of Sind, Miocene of Sri Lanka.
  2. *Tectus cognatus* (J de C Sowerby) comb. nov. [= *Trochus* (*Tectus*) *cognatus* (J de C Sowerby) of Vredenburg].<sup>▲</sup>  
[Closely related to the extant form *Tectus obeliscus*.]  
Distribution: Ashapura Clay member of Kathiawar, Quilon Beds of Kerala.
  3. *Clanculus pascoei* Dey.\*  
[Closely related to the extant form *Clanculus corallinus*.]  
Distribution: Quilon Beds of Kerala.
  4. *Angaria* (*Angaria*) *delphinus* (Linné).\*  
[An extant form.]  
Distribution: Quilon Beds of Kerala, Miocene of Java, Pliocene of Timor.
  5. *Turritella assimilis* J de C Sowerby.<sup>•</sup>  
Distribution: Mekran Series of Pakistan, Miocene of Java.
  6. *Turritella desmarestina* de Basterot.<sup>•</sup>  
Distribution: Nari Beds of Baluchistan and Sind, Oligocene of south-western France and northern Italy.
  7. *Turritella heberti* d'Archiac and Haime.<sup>•</sup>  
Distribution: Gaj Beds of Sind.
  8. *Turritella narica* Vredenburg.\*  
Distribution: Nari Beds of Sind and Baluchistan.
  9. *Turritella narica* Vredenburg var. *baluchistanensis* Vredenburg.\*  
Distribution: Nari Beds of Sind and Baluchistan.
  10. *Turritella pseudobandongensis* Vredenburg.<sup>•</sup>  
Distribution: Gaj Beds of Sind.
  11. *Zaria angulata* (J de C Sowerby) comb. nov. [= *Turritella angulata* (J de C Sowerby) of Vredenburg].<sup>•▲</sup>  
Distribution: Gaj Beds of Sind, Ashapura Clay member of Kathiawar, Miocene of Java (rep. var. *djadjariensis*), Miocene of Myanmar, Mekran Series of Pakistan and Karikal Beds of the eastern coast of India.
  12. *Protoma kayalensis* (Dey) comb. nov. [= *Turritella kayalensis* of (Dey)].<sup>•▲</sup>  
Distribution: Quilon Beds of Kerala.
  13. *Mathilda quadricarinata* Broch.<sup>•</sup>  
[An extant form.]  
Distribution: Miocene of Italy.
  14. *Architectonica affinis* (J de C Sowerby) [= *Solarium affine* (J de C Sowerby) of Vredenburg].<sup>▲</sup>  
[Closely related to the extant forms *Solarium maximum* Philippi and *S. quadriiceps* Hinds.]  
Distribution: Gaj Beds of Sind; Quilon Beds of Kerala.
  15. *Tenagodus granti* (J de C Sowerby) comb. nov. [= *Siliquaria granti* (J de C Sowerby) of Vredenburg].<sup>▲•</sup>  
[Very closely related to, almost identical with *Tenagodus trochlearis* Mörch.]  
Distribution: Miocene of Kachchh.
  16. *Ptychocerithium pseudocorrigatum* d'Orbigny.<sup>•</sup>  
Distribution: Miocene of Sri Lanka.
  17. *Ptychocerithium rude* (J de C Sowerby) [= *Cerithium* (*Ptychocerithium*) *rude* (J de C Sowerby) of Vredenburg].<sup>▲</sup>  
Distribution: Gaj Beds of Sind, Ashapura Clay member of Kathiawar and Quilon Beds of Kerala.
  18. *Clava kachchhensis* (Vredenburg) comb. nov. [= *Cerithium* (*Vergatus*) *kachchhense* of Vredenburg].<sup>▲•</sup>  
So far reported only from the Miocene of Kachchh.
  19. *Clathrus gajensis* (Vredenburg) comb. nov. [= *Scala* (*Clathrus*) *gajensis* (Vredenburg)].<sup>▲</sup>  
So far reported only from the Miocene of Kachchh.
  20. *Cirsotrema subtenuilamella* (d'Archiac and Haime) comb. nov. [= *Scala* (*Cirsotrema*) *subtenuilamella* (d'Archiac and Haime) of Vredenburg].<sup>•▲</sup>  
Distribution: Gaj Beds of Sind.
  21. *Calyptrea chinensis* [Linnaeus].<sup>•</sup>  
[An extant form.]  
Distribution: Oligocene and Miocene of Europe.
  22. *Strombus sedanensis* Martin.<sup>•</sup>  
Distribution: Gaj Beds of Sind, Ashapura Clay member of Kathiawar, Miocene of Sri Lanka, Rembang Series of Java.
-

Table 2. (Continued).

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23. *Strombus (Gallinula) columba* Lamarck.●  
Distribution: Gaj Beds of Sind.
24. *Rimella subrimosa* (d'Orb) Vredenburg [= *Dientomochilus (Varicospira) subrimosus* (d'Orb.) of Dey].\*  
[Closely related to *Rimella cancellata*.]  
Distribution: Quilon Beds of Kerala.
25. *Rimella subrimosa* (d'Orb) Vredenburg var. *narica* Vredenburg.\*  
Distribution: Nari Beds of Pakistan.
26. *Tibia profusus* (Vredenburg) comb. nov. [= *Rostellaria profusus* (Vredenburg)].▲●  
So far reported only from the Miocene of Kachchh.
27. *Tibia curta* (Sowerby) comb. nov. [= *Rostellaria curta* Sowerby of Vredenburg].\*▲  
[An extant form.]  
Distribution: Mekran Beds of Pakistan.
28. *Tibia indica* Dey.\*  
Distribution: Quilon Beds of Kerala.
29. *Terebellum (Terebellum) terebellum* Linn. [= *T. subulatum* var. *obtusum* (J de C Sowerby) of Vredenburg].▲  
[An extant form.]  
Distribution: Gaj Beds of Sind, Quilon Beds of Kerala, Middle Miocene of Nias(?), Miocene of Saonek of Besar, Miocene and Pliocene of Java, Saipan, Pliocene of North Sumatra, Pleistocene of Billiton and Farsan Islands, Miocene of Eucla Basin and Barrow Island, W. Australia.
30. *Xenophora terpstrai* Dey.\*  
Distribution: Quilon Beds of Kerala.
31. *Cypraea prunum* J de C Sowerby.●  
[Related to the extant form *C. mappa*.]  
Distribution: *C. simplieissima* Martin from the Rembang Series of Java (Aquitanian) and *C. willcoxi* Dall from Miocene of Florida are synonyms.
32. *Cypraea prunum* J de C Sowerby var. *nasuta* Sowerby.●  
Distribution: Gaj Beds of Sind and Ashapura Clay member of Kathiawar.
33. *Cypraea (bernayia) humerosa* J de C Sowerby.●  
Distribution: Gaj Beds of Sind and Ashapura Clay member of Kathiawar.
34. *Natica obscura* J de C Sowerby.●  
[Closely related to the extant form *Natica pellistigrina* Chemn.]  
So far reported only from the Miocene of Kachchh.
35. *Natica pellistigrina* Chemn.●  
So far reported only from the Miocene of Kachchh.
36. *Globularia (Globularia) carlei* (Finlay) [= *Globularia (Cernina) carlei* (Finlay) of Dey = *Ampullina (Cernina) callosa* J de C Sowerby of Vredenburg].▲  
[Closely related to the extant form *Natica fluctuata* Sowerby.]  
Distribution: Ashapura Clay member of Kathiawar, Quilon Beds of Kerala, Miocene of Kenya.
37. *Cassis mammillaris* (Grateloup) comb. nov. [= *Cassidea mammillaris* var. *pedemontana* Sacco. of Vredenburg].▲●  
[Closely related to the extant form *Cassis flammea* Linn.]  
Distribution: Miocene of Liguria.
38. *Phallium sculpta* (J de C Sowerby) comb. nov. [= *Cassidea (Bezoardica) sculpta* (J de C Sowerby) of Vredenburg].▲●  
[Related to the extant form *Phallium strigata* (Gmelin).]  
Distribution: Karikal Beds of the eastern coast of India, under the name *Bezoardica strigata*.
39. *Semicassis (Semicassis) pila* (Reeve) var. Martin. comb. nov. [= *Cassis (Semicassis) pila* (Reeve) var. Martin. of Dey].\*▲  
Distribution: Quilon Beds, Upper Miocene of Sumatra and East Borneo, Upper Miocene (?) and Pliocene of Java, North Sumatra, South-west New Guinea, Timor and Ceram.
40. *Semicassis (Semicassis) quilonensis* (Dey) comb. nov. [= *Cassis (Semicassis) quilonensis* Dey].\*▲  
[Closely related to the extant form *Cassis booleyi* Sow.]  
Distribution: Quilon Beds of Kerala.
41. *Ranella (Biplex) bufo* J de C Sowerby.●  
[Closely related to the extant form *Ranella pulchra* Gray.]  
Distribution: Gaj Beds of Sind, Tertiary of Java.
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Table 2. (Continued).

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42. *Ficus pamotanensis* (Martin) comb. nov. var. *kachchhensis* Vredenburg. [= *Pirula pamotanensis* (Martin), var. *kachchhensis* Vredenburg].<sup>▲•</sup>  
[Related to the extant form *P. investigatoris* Smith.]  
Distribution: Miocene of Java.
43. *Muricopsis exhexagonus* (J de C Sowerby) Vredenburg.<sup>•</sup>  
[Closely related to the extant form *Murex cristatus*.]  
Distribution: Gaj Beds of Sind.
44. *Nassa* (*Hebra*) *bonneti* Cossmann var. *kachchhensis*.<sup>•</sup>  
Distribution: Karikal Beds (under the name *Nassa bonneti* Cossmann).
45. *Cantharus bucklandi* (d'Archiac) comb. nov. [= *Tritonidea* (*Cantharus*) *bucklandi* (d'Archiac) of Vredenburg].<sup>▲•</sup>  
[Closely related to the extant form *Cantharus carythrostomatus*.]  
Distribution: Gaj Beds of Sind.
46. *Volema* (*Melongena*) *cornuta* (Agassiz) [= *Melongena cornuta* Agassiz of Vredenburg].<sup>▲•</sup>  
Distribution: Miocene of Europe.
47. *Volema* (*Melongena*) *lainei* (Basterot) [= *Melongena lainei* (Basterot) of Vredenburg].<sup>▲•</sup>  
Distribution: Gaj Beds of Sind, Cosmopolitan in the Miocene of Europe.
48. *Fasciolaria nodulosa* (J de C Sowerby) Dey [= *Siphonalia* (*Kelletia*) *nodulosa* (J de C Sowerby) of Vredenburg].<sup>▲</sup>  
Distribution: Quilon Beds of Kerala.
49. *Nassarius granosus* (J de C Sowerby) comb. nov. [= *Hindsia granosa* (J de C Sowerby) of Vredenburg].<sup>▲•</sup>  
Distribution: Gaj Beds of Sind, Tertiary of Java under the name *Tritonium batavianum*.
50. *Pleuroploca laeviscula* (J de C Sowerby) comb. nov. [= *Fasciolaria* (*Pleuroploca*)? *laeviscula* (J de C Sowerby) of Vredenburg].<sup>▲•</sup>  
[Related to the extant form *Fasciolaria coronata*.]  
So far reported only from the Miocene of Kachchh.
51. *Athleta* (*Volutospina*) *dentata* J de C Sowerby.<sup>•</sup>  
[Related to the extant form *Volutospina antiscalaris*.]  
Distribution: Gaj Beds of Sind (represented by a variety of this species, viz., *A.* (*Volutospina*) *dentata* J de C Sowerby var. *sykesi* d'Archiac and Haime).
52. *Lyria eodelessertiana* Dey.\*  
[Closely related to the extant form *Lyria delessertiana* (Petit).]  
Distribution: Quilon Beds of Kerala.
53. *Lyria jugosa* (J de C Sowerby)  
Distribution: Gaj of Sind and Kathiawar, Quilon Beds of Kerala, Lower Miocene of Java.
54. *Oliva* (*Oliva*) *australis* (Dulcos) var. *indica* Vredenburg [*Oliva* (*Strephona*) *australis* (Dulcos) var. *indica* Vredenburg].<sup>▲•</sup>  
[Variety of the extant form *Oliva australis*.]  
Distribution: Quilon Beds of Kerala, Miocene of Garo Hills and Myanmar, Miocene and Pliocene of Java, Pliocene of SW New Guinea.
55. *Olivancillaria* (*Agaronia*) *nebulosa* Lamarck var. *pupa* (J de C Sowerby).<sup>•</sup>  
[Closely related to the extant form *Oliva nebulosa*.]  
Distribution: Gaj Beds of Sind, Quilon Beds of Kerala, Miocene of Sri Lanka, Garo Hills and Turin, Oligocene and Miocene of Myanmar.
56. *Mitra chinensis* Gray var. *subscrobiculata* d'Orbigny.<sup>•</sup>  
[Closely related to the extant form *Mitra chinensis* Gray.]  
Distribution: Tertiary of Garo Hills and Meghalaya.
57. *Mitra* (*Chrysame*) *sowerbyi* d'Orbigny.<sup>•</sup>  
[Related to the extant form *Mitra ambigua*, *M. adusta* and *M. caligena*.]  
Distribution: Quilon Beds of Kerala, Lower Miocene of Java.
58. *Turbinella affinis* J de C Sowerby.<sup>•</sup>  
Distribution: Gaj Beds of Sind, Ashapura Clay member of Kathiawar.
59. *Conus* (*Lithoconus*) *ineditus* (Michelotti) Sacco.\*  
Distribution: Nari Beds Sind, Miocene of Liguria and Myanmar.
60. *Conus* (*Lithoconus*) *odengensis* (Martin).<sup>•</sup>  
[Related to the extant form *Lithoconus malaccanus*, *L. quercinus* and *L. eburneus*.]  
Distribution: Quilon Beds, Miocene of Java, Myanmar and Meghalaya, Pliocene of North Sumatra.
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Table 2. (Continued).

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61. *Conus (Lithoconus) litteratus* (Linnaeus) Noetling [= *Conus (Lithoconus) brevis* (J de C Sowerby) of Vredenburg].<sup>▲</sup>  
[An extant form.]  
Distribution: Quilon Beds of Kerala, Miocene of Sri Lanka.
62. *Conus (Leptoconus) marginatus* (J de C Sowerby).<sup>●</sup>  
[Related to the extant form *Leptoconus sieboldi*.]  
So far reported only from the Miocene of Kachchh.
63. *Turris ickei* (Martin) comb. nov. [= *Pleurotoma ickei* (Martin) of Vredenburg].<sup>▲●</sup>  
[Related to the extant form *Pleurotoma virgo*.]  
Distribution: Miocene of Java, Myanmar.
64. *Gemmula congener* (Smith) comb. nov. var. *mekranica* Vredenburg [= *Pleurotoma (Gemmula) congener* (Smith)] var. *mekranica* Vredenburg].<sup>▲●</sup>  
[Closely related to the extant form *Gemmula congener*.]  
Distribution: Mekran Series of Pakistan, Miocene of Java and Sumatra.
65. *Hemipleurotoma bonneti* (Cossmann) comb. nov. [= *Pleurotoma (Hemipleurotoma) bonneti* (Cossmann) of Vredenburg].<sup>▲●</sup>  
Distribution: Prome series of Myanmar and Karikal Formation.
66. *Crassispira kachchhensis* (Vredenburg) comb. nov. [= *Drillia (Crassispira) kachchhensis* (Vredenburg)].<sup>▲●</sup>  
[Related to the extant form *Crassispira sinensis*.]  
So far reported only from the Miocene of Kachchh.
67. *Surcula tuberculata* (Gray).<sup>●</sup>  
Distribution: Mekran Series of Pakistan, Quilon Beds of Kerala.
68. *Terebra (Terebra) reticulata* (J de C Sowerby) [= *Terebra (Myurella) reticulata* (J de C Sowerby) of Vredenburg].<sup>▲●</sup>  
Distribution: Quilon Beds, Miocene of Java, Pliocene of Timor (*Terebra indica* Martin).]
69. *Terebra (Terebra) kachchhensis* (Vredenburg) [= *Terebra (Myurella) kachchhensis* (Vredenburg)].<sup>▲●</sup>  
So far reported only from the Miocene of Kachchh.
70. *Scaphander javanus* Martin.<sup>●</sup>  
[Related to the extant form *Scaphander lignarius*.]  
Distribution: Miocene of Java.
71. *Atys protocylindrica* Vredenburg.<sup>●</sup>  
[Related to the extant form *Atys cylindrica*.]  
So far reported only from the Miocene of Kachchh.
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\* – Being reported for the first time, ▲ – taxonomic position rectified, ● – not represented in the authors' collection.

Miocene rocks of Sind, Kachchh and Kathiawar. He also considered the presence of *A. malabaricus* crucial. Obviously, he justifiably advocated a Burdigalian age for the Quilon Beds instead of Vinobonian. Later, a comprehensive study of fossil molluscs from the Quilon Beds was undertaken by Dey (1962). Notwithstanding the opinion of Eames (1950) and occurrence of *Archaias malabaricus*, he relied more on an anomiid, which he identified as *Placenta (Placuna) lamellata* Dey (1962, p. 42, plate 3, figures 3, 6). Kulkarni et al (2009) have found that *P. (I.) lamellata* Dey, in reality, is a species of the subgenus *Indoplacuna* of the genus *Placuna*. They also discovered its occurrence in the Chhasra Formation and discussed at length how this species confirms a Burdigalian age for the Quilon Beds.

The present study has also brought forth occurrence of nine Quilon gastropod species in the Miocene rocks of Kachchh, eight of which are not reported so far from any other rock formation than these two. The total number of the gastropod

species common to these two formations has now become 15. This supports the amendment in the age of the Quilon Beds, and strengthens the affinity between the faunas of the Chhasra Formation and the Quilon Beds.

### 3.4 Relationship with extant fauna

It has been the observation of stratigraphers that in a Tertiary sequence, younger the formation, greater is the percentage of the modern species. Therefore, one would expect representatives of the extant forms in the present assemblage. The present assemblage includes as many as five species that occur in the Recent sea waters. Also, there are 14 species in the assemblage that have allied forms in the modern oceans, whereas 15 forms have closely related modern representatives.

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