

# The Late Bathonian gastropod fauna of Kutch, western India—a new assemblage

SHILADRI S. DAS<sup>1</sup>, SUBHENDU BARDHAN<sup>2</sup> and TAPES C. LAHIRI<sup>3</sup>

<sup>1</sup>Indian Statistical Institute, Geological Studies Unit, 203 Barrackpore Trunk Road, Calcutta-700035, India

<sup>2</sup>Department of Geological Sciences, Jadavpur University, Calcutta-700032, India

<sup>3</sup>Palaeontology Division 1, Geological Survey of India, 15 Kyd Street, Calcutta-700016, India

Received 2 December 1998; Revised manuscript accepted 7 September 1999

**Abstract.** The Middle Jurassic sediments of Kutch have been known all over the world as a veritable storehouse of diverse fauna, particularly ammonites. The present investigation has brought to light a rich haul of gastropods hitherto unknown in Kutch. The present assemblage includes eleven new species belonging to nine genera. They are: *Colpomphalus jumarensis* sp. nov.; *Emarginula karuna* sp. nov.; *Helicacanthus chanda* sp. nov.; *Riselloidea tagorei* sp. nov.; *R. elongata* sp. nov.; *Onkospira kutchensis* sp. nov.; *Proconulus jadavpuriensis* sp. nov.; *Neritopsis (Neritopsis) patchamensis* sp. nov.; *N. (Hayamiella) sankhamala* sp. nov.; *Hayamia mitra* sp. nov. and *Globularia spathi* sp. nov.

The assemblage shows strong Tethyan affinity at generic level, but species display marked endemism since Kutch belongs to a distinct Indo-Madagascan Faunal Province. The present finding refines and widens the spatiotemporal distribution of these genera.

**Key words:** Gastropoda, Kutch, Middle Jurassic, systematics, western India

## Introduction

The marine Jurassic sediments of Kutch were deposited in a newly emerging basin that developed as an extension of the Tethys during separation of Africa and India consequent to the rifting of the Gondwana Superplate (Biswas, 1982, 1991). The Jurassic rocks yield many diverse shallow marine taxa. The fossils are numerous and remarkably well preserved. Amongst them the ammonites attract the most attention of palaeontologists. Among the ammonites many are time-diagnostic forms that provide finer time resolution and help in establishing regional standard biozonations and inter-continental correlation with Europe and other areas. The faunal horizons that yield gastropods, may be assigned to an age ranging from the Late Bathonian to Tithonian.

Many classic studies on this biota, e.g., Cephalopoda (Waagen, 1873–75; Spath, 1927–33), Bivalvia (Kitchin, 1900; Cox, 1940, 1952), Brachiopoda (Kitchin, 1900) and corals (Gregory, 1893, 1900) were made by great masters of the last and this centuries. It is rather surprising that the vast gastropod fauna from the different sections of the mainland and 'islands' of Kutch escaped their notice, notwithstanding the scanty reports of a few gastropod species (Maithani, 1967; Mitra and Ghosh, 1979).

In this present endeavour, we describe 11 new species of the Bathonian, some of which continue to the base of the Middle Callovian. The present study covers a large number

of specimens systematically collected in the field with a precise stratigraphic background by us and other members of the Palaeontological Laboratory, Department of Geological Sciences, Jadavpur University.

These species belong to nine genera of seven families. They are *Colpomphalus jumarensis* sp. nov.; *Emarginula karuna* sp. nov.; *Helicacanthus chanda* sp. nov.; *Riselloidea tagorei* sp. nov.; *R. elongata* sp. nov.; *Onkospira kutchensis* sp. nov.; *Proconulus jadavpuriensis* sp. nov.; *Neritopsis (Neritopsis) patchamensis* sp. nov.; *N. (Hayamiella) sankhamala* sp. nov.; *Hayamia mitra* sp. nov.; and *Globularia spathi* sp. nov. They show strong Tethyan affinity at generic level, especially with Europe (see Knight *et al.*, 1960). Biogeographic distributions of the other Kutch biota suggest prevalence of faunal migrational pathways across the Tethys particularly with Europe (Hallam, 1982; Krishna and Cariou, 1990; Kayal and Bardhan, 1998). The faunas are, however, marked by strong provincialism at species level. The sediments developed due to repeated marine transgression-regression cycles in a basin that emerged from the breakup of Gondwana Superland and was surrounded by East Africa, Madagascar and western India (see also Fürsich *et al.*, 1991). This newly formed basin acted as the Eden of evolution for many immigrant faunas that invaded it (Dutta *et al.*, 1996). Rapid diversification of various taxa marks a strong endemism of fauna which constitutes what is called the Indo-Madagascan or Ethiopian Faunal Province. This record of

new taxa widens our knowledge about spatiotemporal distribution of the Jurassic gastropod fauna, which are less comprehensively known and poorly documented in the existing literature.

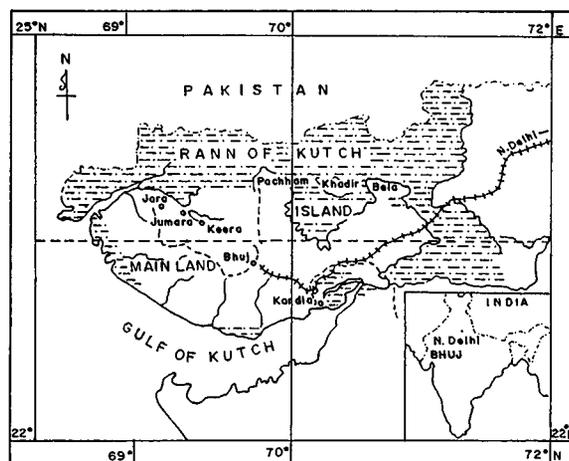
It should be noted here that recent advances in the studies of suprageneric classification of gastropods have drawn attention to some lacunae in the earlier traditional classifications (e.g. Wenz, 1938—44; Knight *et al.*, 1960). Many higher taxonomic categories are now considered to be paraphyletic, e.g., the Archaeogastropoda (e.g. Hickman and McLean, 1990), and poorly delineated. Major revisionary works are now available for many important groups including their extinct taxa, e.g., on Naticidae and Trochidae (see Kabat, 1991; Hickman and McLean, 1990). Some new schemes have deployed cladistic methodology emphasising the role of derived (apomorphic) conditions and included large character sets. But excessive weight has been given to the characters related to soft parts. The systematic position of many extinct lineages remain still problematic since shell characters may be convergent (Hickman and McLean, 1990). Thus a large amount of uncertainty still prevails in respect of the classification of fossil gastropods. Under such circumstances our endeavour has been to largely retain the general framework (subordinal level and above) of classification given in the Treatise on Invertebrate Paleontology (Knight *et al.*, 1960) while effecting some family or subfamily level changes with regard to certain Kutch taxa in the light of modern classification. In this context the following brief discussion would clarify the taxonomic hierarchies followed in the present study. Particular attention should be drawn to our categorisation of the genera *Riselloidea* and *Onkospira* under the family Trochidae instead of Amberleyidae of the earlier classification and the genus *Helicacanthus* under Turbinidae instead of Nododelphinulidae following Hickman and McLean (1990). Dealing in detail with the shell characters of Amberleyidae, Hickman and McLean (1990) have been very explicit in pointing to the trochid innovations in its shell morphology that are shared with the living species. Of the many trochid subfamilies recognised by them the subfamily Eucyclinae is of particular interest; it covers erstwhile Amberleyidae (Family) and Amberleyinae (Subfamily) and has been divided into three tribes among which the Tribe Eucyclini comprises only the fossil trochids of Middle Triassic to Oligocene age. While discussing this subfamily they have also dealt with those shell characters of the three tribes that separate them from other trochid subfamilies. The historical treatment presented by them clearly demonstrates the weak foundation on which the Amberleyidae of Wenz (1938) and Cox's (*in* Knight *et al.*, 1960) eucycline taxa and superfamily Amberleyacea stand. Similar detailed character analyses that include hard part features have resulted in the placement of erstwhile Nododelphinulidae in the subfamily Angariinae (family Turbinidae) and Proconulinae tentatively under Calliostomatinae (Trochidae) taking into account the assignments which have also been followed here. The scheme used here is logical under rather conflicting positions presently prevailing in fossil gastropod taxonomy and leaves room for more detailed work on an improved, widely acceptable classification.

## Stratigraphy

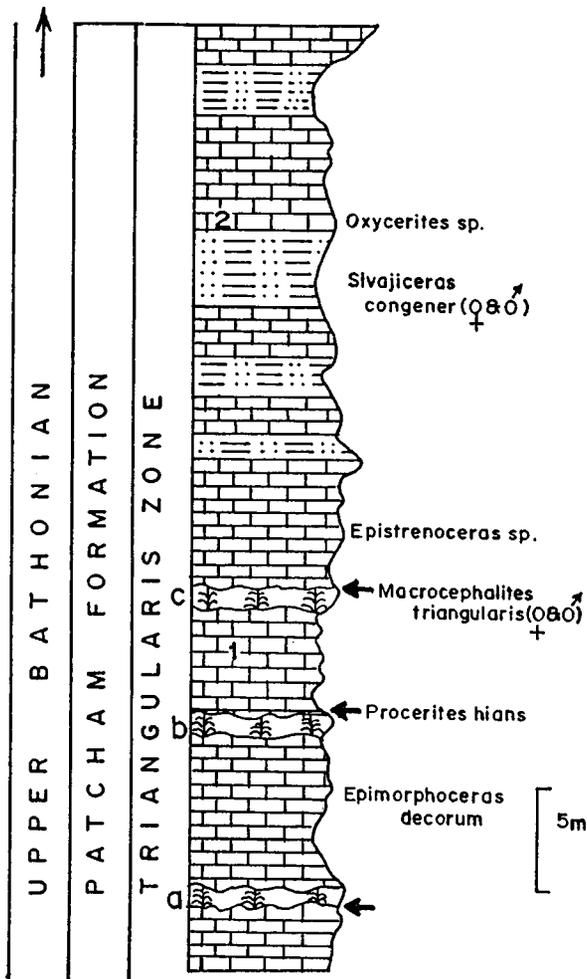
The Mesozoic rocks occupy nearly half of the area in Kutch, covering the mainland as well as three Rann 'islands', and lie nonconformably on the Pre-Cambrian basement (Biswas and Deshpande, 1968). On the mainland the Mesozoic rocks are represented by: Patcham Formation, Chari Formation, Katrol Formation, Bhuj Formation and Deccan Trap in ascending order (for details see Mitra *et al.*, 1979). The thick pile of sediments exceeds more than 3,000 m (Biswas, 1991) and has been regionally folded into three parallel anticlines running northwest-southeast. The Jurassic rocks are best developed in the central anticline (Wynne, 1872; Rajnath, 1932; Poddar, 1959). A set of zones of culmination is observed along the anticlines. These zones of culmination crop out as topographical domes at Jara, Jumara, Nara, Keera etc. (Figure 1) where the inliers of older rocks belonging to the Patcham and Chari Formations mainly occur at the core.

The present gastropod faunas come mainly from the different levels of the Patcham Formation which is partially exposed at Jumara, the locality for the stratotype of the Chari Formation. The Middle Jurassic sediments of the 'islands' belts are included in the formations equivalent to the Patcham Formation and even older ones (Biswas, 1977; Fürsich *et al.*, 1994). Here gastropods occur sporadically, becoming locally abundant at Kuar Bet near Patcham 'island'. The gastropod assemblage of this area appears to be quite distinct from that of Jumara and is dominated mainly by *Katosira* Koken. This level, judged by the associated fauna and stratigraphic position, may represent the Bajocian (see also Fürsich *et al.*, 1994) and these gastropods are therefore not included in the present study.

The exposed sequence of the Patcham Formation at Jumara, which is about 47 m thick, consists of alternations of two distinct lithofacies (Beds 24–26 of Rajnath, 1932; Beds 1–2 of Bardhan *et al.*, 1994) (Figure 2). The lower facies is an alternation between coralline rudstone and cream-coloured



**Figure 1.** Geographic location of Kutch with Keera and Jumara, the type area of the Chari Formation. The patterned area is the Rann of Kutch.



**Figure 2.** Stratigraphic distribution of key ammonite taxa within the Patcham Formation of Jumara. Key: 1, Coralline limestone (rudstone) alternating with white to brown-coloured limestone (wackestone). Arrows indicate occurrences of different gastropod species. 2, Repeated alternations between white and cream-coloured limestone (wackestone and marl).

wackestone. Biostromes of diverse corals appear at several levels where gastropods are most abundant. The coral biostromes occur in the form of parallel-sided, thin tabular beds. They dominantly consist of largely intact fossils with or without interstitial mud (Dutta *et al.*, 1996). There are large varieties of corals (Gregory, 1900; Pandey and Fürsich, 1993), most of them being in life attitude. Besides corals and gastropods, many other taxa including ammonites also characterise this horizon. The facies is marked by the first appearance of *Macrocephalites* Zittel in Kutch. Judging by its faunal content and a recently found excellent time-diagnostic ammonite, *Epistrenoceras* Bentz (Kayal and Bardhan, 1998), this lower part of the Patcham Formation can safely be assigned to the late Bathonian. The upper facies is, on the other hand, an alternation between cream-coloured wackestone and mud. It supports sparse fauna including gastropods. Only some fragmentary perisphinctid

Upper Bathonian		Lower Callovian	Middle Callovian	Age	
Patcham		Chari		Formation	
Triangularis	Chrysoolithicus	Formosus	Indosabauda	Reissi	Zone
					Species
-----					<i>Proconulus jadavpuriensis</i>
-----					<i>Emarginula karuna</i>
-----					<i>Colpomphalus jumarensis</i>
-----					<i>Neritopsis</i> (N.) <i>patchamensis</i>
-----					<i>Neritopsis</i> (H.) <i>sankhamala</i>
-----					<i>Hayamia mitra</i>
-----					<i>Globularia spathi</i>
-----					<i>Riselloidea tagorei</i>
-----					<i>R. elongata</i>
-----					<i>Onkospira kutchensis</i>
-----					<i>Helicacanthus chanda</i>

**Figure 3.** Range chart of different species of gastropods in Kutch. Zones are modified after Dutta (1992).

ammonites belonging to *Procerites* Siemiradzki have been reported from it. This also suggests a late Bathonian age (see also Callomon, 1993; Dutta *et al.*, 1996). Recently, Dutta (1992) made a substantial revision of the standard zonations within the Bathonian-Callovian Stages of Kutch. We follow here the biostratigraphic scheme of Dutta (1992) with modification, and stratigraphic distribution of the present gastropod species is shown in Figure 3 (after Bardhan *et al.*, 1994 with modification).

### Systematic Paleontology

All the materials studied are deposited in the Department of Geological Sciences, Jadavpur University, Calcutta, India (JU). Measurements are not provided since specimens are plentiful for most of the species, over three hundred in the case of *Riselloidea tagorei*. These can be provided upon request.

Subclass Prosobranchia  
Order Archaeogastropoda  
Suborder Macluritina  
Superfamily Euomphalacea  
Family Helicotomidae  
Genus *Colpomphalus* Cossmann, 1916

*Type species.*—*Straparollus altus* d'Orbigny, 1853; original designation.

***Colpomphalus jumarensis* sp. nov.**

Figure 4-1, 2

*Material*.—Seven specimens. JUM/g 19-22, 594-596. Specimen JUM/g 19 is designated holotype; the rests are paratypes. JUM/g 19-22 were collected from Bed 1, Jumara and JUM/g 594-596 from Bed 2, Keera (see Bardhan *et al.*, 1994).

*Diagnosis*.—Average-sized *Colpomphalus* (6 to 10 mm high); whorls 4 to 5 in number, gradate with wide sloping concave ramp; ornamentation of three strong spiral carinae, irregularly spaced and middle one relatively weaker, close to first one; prominent collabral ridges prosocline on ramp.

*Description*.—Shell small in size, maximum height about 10 mm; thick, phaneromphalous; highly depressed and turbiniform with height about half of shell diameter. Apical angle ranges between 120° and 130°. Whorls 4 to 5 in number including protoconch and separated in early stage by weakly grooved suture which becomes conspicuous in later ontogeny. Protoconch poorly preserved, seemingly consists of one and a half smooth, planispiral whorls. Spire very low, conical, obtusely pointed owing to near-planispiral coiling of early whorls. Spire occupies one-fourth of shell height. Body whorl very large, width slightly greater than twice of height; shell rapidly increases in diameter. Whorls gradate with wide sloping ramp, which is concave at upper whorl surface. Outer whorl surface inclined abapically. Body whorl consists of three revolving carinae, which are irregularly spaced. First one situated in ramp margin while third carina at base of whorl forms umbilical border, second carina is close to first. First and third are stronger than second. Umbilical wall steep. Transverse, prosocline ridges fine to sharp, intersect carinae and form pointed tubercles at junctions. Tubercles are variable in number, 20 to 25 on body whorl. Aperture subquadrangular, width of aperture is greater than height. Columellar and basal lips form an angulation at their junction.

*Discussion*.—Relatively low spire, concave upper whorl surface, tuberculate periphery and angular peristome place the present species securely within the genus *Colpomphalus*. It however, differs from *Colpomphalus exsertus* (Hudleston, 1893) (Knight *et al.*, 1960, fig. 106, 7) from the Bajocian of England mainly in shell ornamentation. *C. exsertus* is ornamented with two revolving carinae and fine collabral threads; conversely, the present species has three strong revolving carinae and strong collabral ridges which are prosocline on ramp. Besides, the present species has fewer whorls and a relatively more protruded spire.

The general shell outline, apertural shape, little raised spire and number of whorls of the present species are comparable with those of the Lower Jurassic (Middle Aalenian) *Colpomphalus baugieri* (d'Orbigny) (1853, p. 307, pl. 321, figs. 13-16) (see also Fischer, 1997, p. 121, pl. 24, figs. 1a-c) of Niort, France. But the European form is stratigraphically older and relatively smaller in size. It is less coarsely ornate and is characterised by numerous fine spiral striae, which are lacking in the present species.

*Colpomphalus altus* (d'Orbigny) (1853, p. 314, pl. 332, figs.

5-8) (also see Fischer, 1997, p. 124, pl. 22, figs. 5a-c), the type species, is a contemporaneous species from France and is based on a monotypic holotype which is broken and immature and hence comparison is very difficult. Its restored diameter is about 8 mm and thus appears to be smaller. It appears similarly but less strongly ornate, basal ornamentation consisting of numerous striae which are conspicuous by their absence in the Kutch species.

*Etymology*.—After Jumara area of Kutch, Gujarat, where the species occurs.

Suborder Pleurotomariina  
Superfamily Fissurellacea  
Family Fissurellidae  
Subfamily Emarginulinae  
Genus ***Emarginula*** Lamarck, 1801

*Type species*.—*Emarginula conica* Lamarck, 1801; original designation.

***Emarginula karuna* sp. nov.**

Figure 4-3-5

*Material*.—Five specimens. JUM/g 71-75. Specimen JUM/g 71 is designated holotype; the rest are paratypes. Specimens are mostly broken, but their original shells are preserved. All were collected from Bed 1 of Jumara.

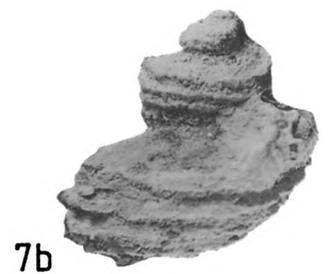
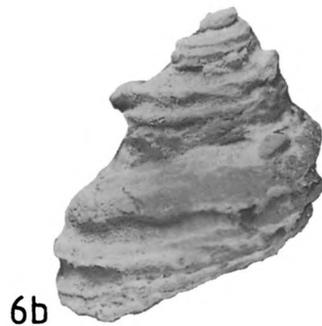
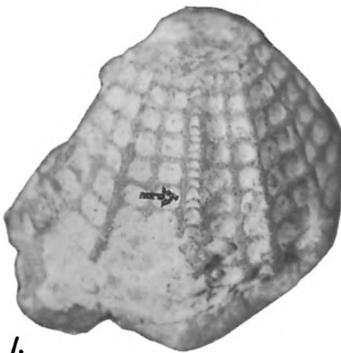
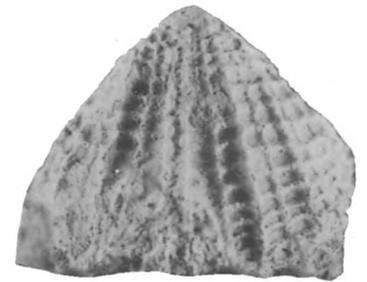
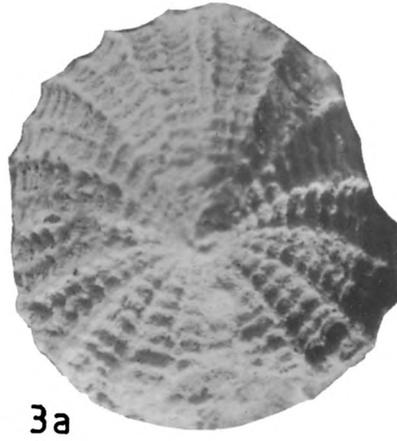
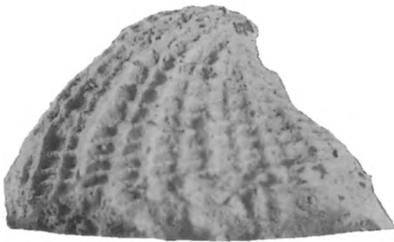
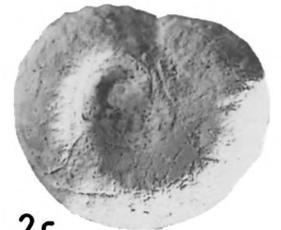
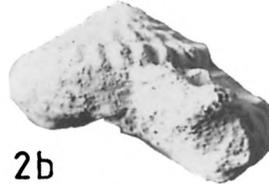
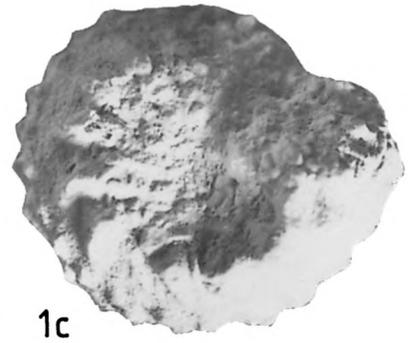
*Diagnosis*.—Averaged-sized *Emarginula* (8 to 13 mm high); shell short; apex slightly curved; narrow, raised selenizone extending more than three-fourths of shell height from base; in transverse section, shell nearly flattened along selenizone. Shell ornamented with strong, closely spaced axial ribs intersected by relatively weaker spiral cords; weaker axial rib intercalates between two stronger ribs; very fine, dense, transverse and crescent-shaped ribs with concavity towards aperture subdivide selenizone.

*Description*.—Shell short, maximum height achieved 13 mm; cap-shaped. Apex curved pointing to rear, protoconch missing. Shell convex, slightly flattened along selenizone. Narrow, slightly raised selenizone between two ridges extending more than three-fourths of shell height from base.

Shell ornamented with strong axial ribs intersected by relatively weaker spiral cords resulting in reticulation. Weaker axial rib intercalates between two stronger ribs. This secondary axial rib is similar in strength or may be sometimes weaker than spiral cords. Very fine, dense and transverse ribs subdivide selenizone to form lunula. They are crescentic in shape with a concavity towards the aperture. All collabral and longitudinal elements are weak in early ontogeny. Peristome ovate.

*Discussion*.—*Emarginula karuna* sp. nov. is similarly ovate and elevated as *Emarginula (Emarginula) conica* Lamarck (Knight *et al.*, 1960, figs. 140, 1a-c), the type species, which is a Recent form. But it differs mainly in ornamentation being characterised by axial ribs of variable strength. Moreover, selenizone is not depressed.

*Emarginula (Tauschia) orthogonia* Tausch, 1890 (Knight *et al.*, 1960, figs. 140, 11a-b), resembles the present form in



having similarly raised selenizone, but can be distinguished by stronger collabral ribs and absence of fine axial threads between the two stronger ones. Apex of the *E. (T.) orthogonia* is also more strongly curved.

*Emarginula (Altomarginula) desnoyersi* Eudes-Deslongchamps, 1842 (Knight *et al.*, 1960, figs. 140, 7a-b), is a Bathonian form that differs in shell size and ornamentation. The present species is larger in size, less elevated with raised selenizone and bears spiral elements, which the European form lacks.

The present species differs from *Emarginula (Emarginula) vadanaei* Toni, 1912 (Szabo, 1980, pl. 4, figs. 10-11; Conti and Monari, 1991, pl. 7, figs. 7-14), in shell size, ornamentation and curvature of the apex. The Bakony and Turkey specimens are smaller in size. Although they have similar slightly elevated selenizone, it extends for only about one-third of the shell height while in the present form it extends more than three-fourths of the shell height from the base. Furthermore, the present species is ornamented with strong longitudinal ribs and its apex is less curved.

*Emarginula lepsuisi* Gemmellaro, 1878 is another comparable Jurassic form. It can, however, be differentiated from the Kutch form by its convex shell along the selenizone and fewer ribs (see also Szabo, 1980).

*Etymology*.—The species is named in honour of late Karun Chandra Mitra, a renowned palaeontologist of the Department of Geological Sciences of Jadavpur University.

Suborder Trochina  
Superfamily Trochacea  
Family Turbinidae  
Subfamily Angariinae

Genus *Helicacanthus* Dacq in Wenz, 1938

*Type species*.—*Turbo thurmanni* Pictet and Campiche, 1863; original designation.

*Helicacanthus chanda* sp. nov.

Figures 4-6, 7; 5-1, 2

*Material*.—Ten specimens, JUM/g 35-44. JUM/g 35 is designated holotype; the rest are paratypes. All specimens have their original shell preserved. Only two specimens are intact and the rest are lacking mostly their apical parts. All were collected from Bed 1, Jumara.

*Diagnosis*.—Average-sized *Helicacanthus* (about 18 mm high); height greater than diameter; a broad nearly flat ramp on upper surface, outer whorl concave; dense, fine prosoclinal striae on whorls and within umbilicus; both

carinae and cords may be granulated.

*Description*.—Shell of medium size, maximum height about 18 mm; thick, phaneromphalous turbiniform with height slightly greater than diameter. Apical angle ranges between 47° and 54°. Whorl at least 4 in number including protoconch and separated by strongly grooved suture. Protoconch dome-shaped, consisting of one and a half smooth whorls. Spire low, conical occupying about one-third of shell height. Body whorl large, rapidly increases in diameter, width slightly greater than height. A broad, nearly flat ramp on upper surface of whorls. Outer face of whorls narrow, slightly concave, bordered by two strong spiral carinae, first one being stronger. Prominent spiral cords 3 to 4 in number appear after second angulation and are restricted at base. Cords and occasionally carinae show regular granulation. Dense prosoclinal striae present on whorls and also within umbilicus. Aperture orbicular in outline, both outer and inner lips thick and base rounded.

*Discussion*.—The characteristic shell outline, presence of two strong carinae on outer whorls and apertural shape assure its generic position. The present species is distinguishable from the type species *Helicacanthus thurmanni* (Pictet and Campiche, 1863), (Knight *et al.*, 1960, fig. 204, 2) from the Aptian of Switzerland by its slender form and in ornamental features. The type species is ornamented with numerous spiral cords, which are present between the carinae and also within the umbilicus, whereas in the present species spiral cords are restricted only at the base and umbilicus is ornamented with dense axial threads.

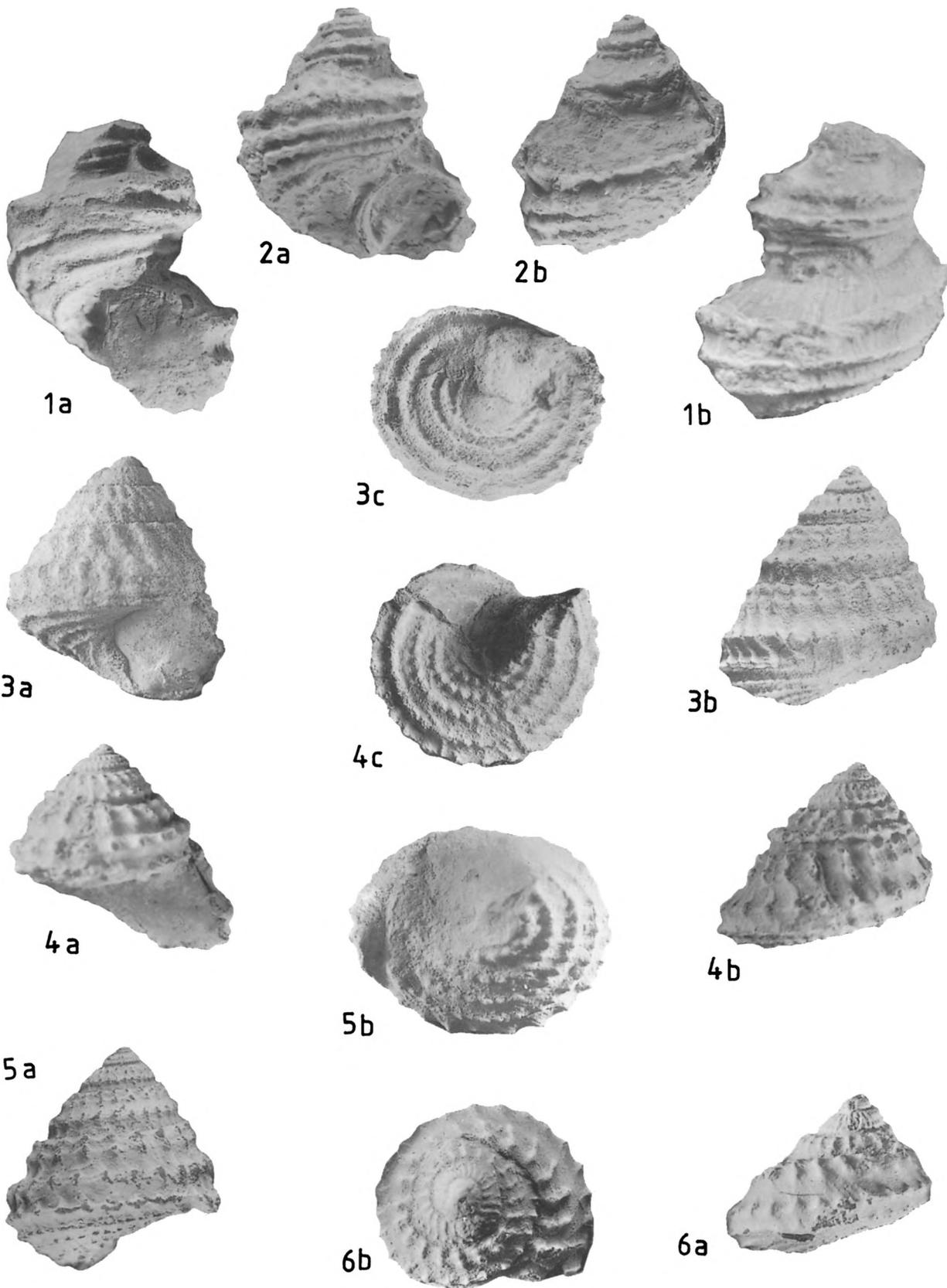
Cox and Arkell (1948-50) mentioned but did not describe one species of this genus, *Helicacanthus tegulatus* (Lycett) (1863, p. 102, pl. XLV, figs. 17, 18), from the Bathonian Forest Marble of England. Besides this, the present form is the second oldest species of the genus which otherwise ranges from the Upper Jurassic to Lower Cretaceous (see Knight *et al.*, 1960).

*Etymology*.—The species is named in honour of late S.K. Chanda, a famous sedimentologist of the Department of Geological Sciences, Jadavpur University

Family Trochidae  
Subfamily Eucyclinae  
Genus *Riselloidea* Cossmann, 1909

*Type species*.—*Risellopsis subdisjuncta* Cossmann, 1908; original designation.

← **Figure 4.** 1, 2. *Colpomphalus jumarensis* sp. nov. ×3. 1a-c. Holotype, from Bed 1, Jumara, JUM/g 19, apical, abapertural and basal views. Note strong collabral ridges and presence of three spiral carinae on body whorl (1b). 2a-c. Paratype, from Bed 2, Keera, JUM/g 595, apical, apertural and basal views. 3-5. *Emarginula karuna* sp. nov. Bed 1, Jumara, ×4. 3a-c. Holotype, JUM/g 71, protoconch missing; apical and two lateral views. 4. Paratype, apical part damaged, JUM/g 72, oblique lateral view showing selenizone (see arrow). 5. Paratype, both apical part and peristome damaged, JUM/g 73, oblique lateral view. 6, 7. *Helicacanthus chanda* sp. nov. from Bed 1, Jumara ×3. 6a, b. Holotype, complete shell, JUM/g 35, apertural and abapertural views. 7a, b. Paratype, complete shell, umbilicus showing axial ornamentation (7a), JUM/g 36, apertural and abapertural views.



***Riselloidea tagorei* sp. nov.**

Figure 5-3-6

**Material.**—Over 300 specimens. JUM/g 148 is designated holotype; JUM/g 145-147 and JUM/g 149-166 are paratypes. Most of the specimens have their original shell preserved. All were collected from Bed 1, Jumara.

**Diagnosis.**—Medium to large-sized *Riselloidea* (10 to 15 mm high). Species shows wide intraspecific variation in shell profile with height greater than diameter changing to diameter greater than height; whorls cyrtocooid to straight; axial elements stronger than spiral ones; three spiral tuberculate carinae of variable strength and 3 to 4 basal cords with granulation.

**Description.**—Shell medium to large in size, maximum height being achieved 15 mm; weakly cyrtocooid to straight; trochiform and anomphalous. Apical angle ranges between 55° to 95°. Shell diameter may be greater or smaller than height. Whorls 4 to 5 in number including protoconch, which consists of two smooth, rounded whorls. Spire conical, low to moderately high, occupying one-fourth to one-third of shell height. Whorls regularly expanded, may be separated by relatively deep-channelled suture. Shell ornamented with three revolving carinae, third one is stronger than other two. First inter area forming a ramp, larger than that of second one which may sometimes be depressed. Relatively weak, prosoclinal riblets intersect carinae and produce pointed tubercles at crossing points. Axial elements running suture to suture, 20 in number on body whorl. Base weakly convex with 3 to 4 strong spiral cords with regular granulation resulting from interception of fine axial growth lines. Peristome is prosocline with thickened columellar lip. Aperture quadrangular to subquadrangular with angulations at middle carina and suture; outer lip thin.

**Discussion.**—Cossmann (1909) proposed the genus *Riselloidea* and designated his *Risellopsis subdisjuncta* Cossmann, as the type species. The present species resembles the type species in ornamentation and other general features but is relatively larger and has a rounded base.

The present species is very close to *Riselloidea biarmata* (Münster, 1844) (Cox and Arkell, 1948-50, p. 58; Knight *et al.*, 1960, fig. 203, 8) from the Great Oolite Series, England and the Middle Jurassic of Germany. However, it has a wide range of variation particularly in shell outline and larger shell size, quadrangular apertural outline, prosoclinal peristome and convex base. Moreover, it is ornamented with three tuberculate carinae whereas *R. biarmata* bears only two rows of tubercles.

Conti and Fischer (1982) described two new *Riselloidea* species from the Middle Jurassic sequence of Italy. These

species are very small in size and differ in some morphological aspects from the present species. *Riselloidea martariensis* Conti and Fischer (1982, pl. 3, figs. 11a-d, 12) differs, besides being small, in having a convex whorl outline and more depressed suture and in variation in number of axial elements.

*Riselloidea subreticularis* Conti and Fischer (1982, pl. 3, figs. 13a-d, 14), a smaller species than *R. martariensis*, resembles the present form in shell outline, but has a larger aperture, less dense axial ribs and convex whorl outline. In *R. subreticularis*, spiral cords appear only in the last whorl, while they are present right from the early whorls except for the protoconch, in the present species.

*R. reticularis* (Cossmann in Piette, 1864-91) (also see Conti and Fischer, 1982), a Bathonian species, has a close correspondence with the present species. It has comparable radial elements but differs mainly in having 4 spiral carinae instead of three and 5 to 7 basal cords instead of 3 to 4 in the present species. Further, we are not aware of any kind of intraspecific variation within *R. reticularis*.

*Riselloidea multistriata* (Böckh) (1874, p. 110, pl. VI, fig. 5) (also see Szabo, 1982, pl. 3, figs. 3-6) has a comparable size, but its convex whorls and dense, fine collabral cords distinguishes it from the Kutch form. Moreover, in *R. multistriata* basal cords are fine and more numerous, about 8 against 3 to 4 in the present population.

**Etymology.**—After the great Indian poet, R.N. Tagore.

***Riselloidea elongata* sp. nov.**

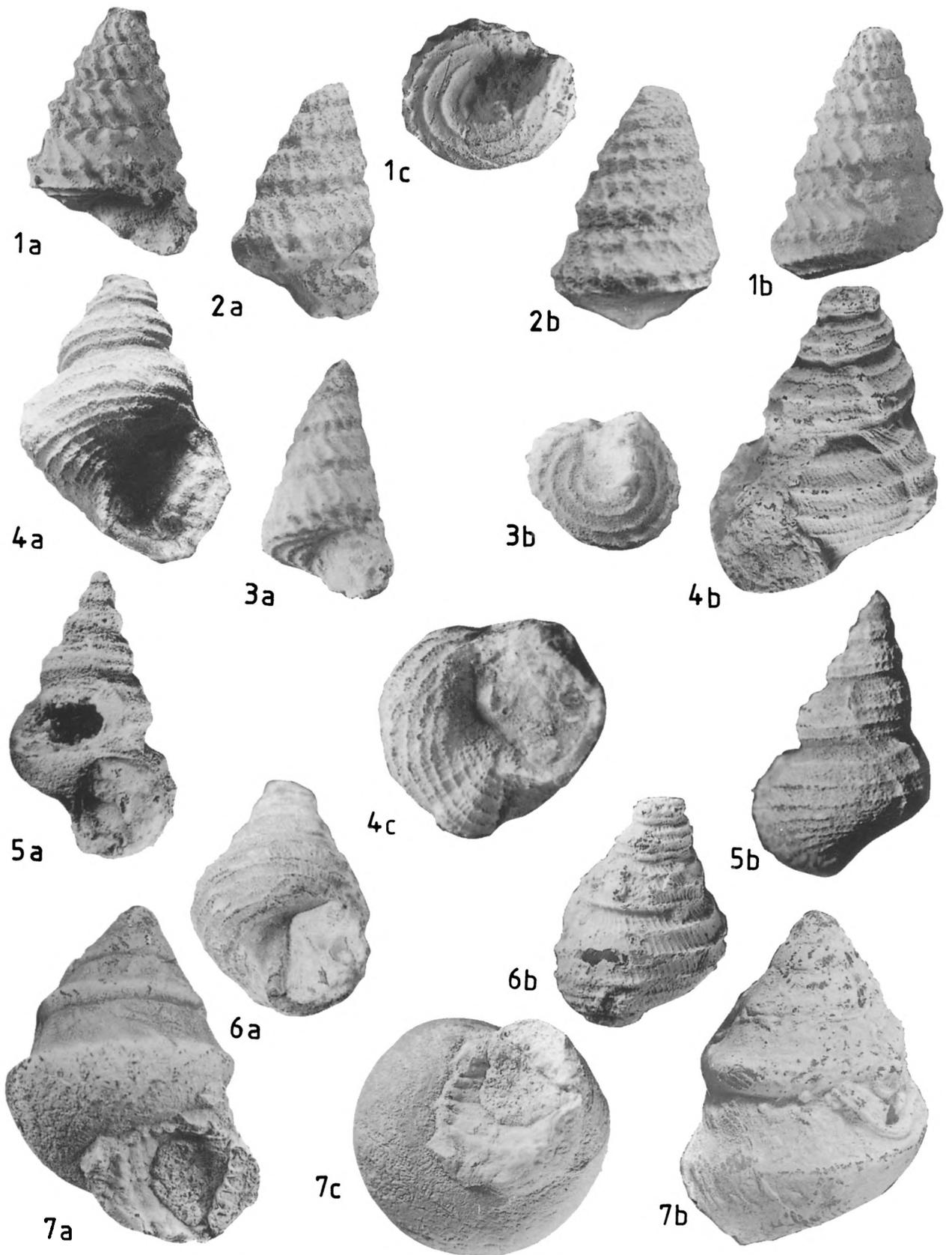
Figure 6-1-3

**Material.**—Seven specimens, JUM/g 138-144. Specimen JUM/g 138 is designated holotype; the rest are paratypes. The specimens have their original shell preserved. The present collection has been made from Bed 1, Jumara.

**Diagnosis.**—Large-sized *Riselloidea* (about 15 mm high); shell slender, height being twice shell diameter; whorls straight conical and numerous; base flat to weakly convex; two spiral, tuberculate carinae of equal strength, 3 to 4 basal cords with no granulation.

**Description.**—Shell slender, large, maximum height achieved 15 mm; anomphalous, trochiform; straight conical in outline, with height about twice the shell diameter. Apical angle ranges from 20° to 25°. Whorls numerous, seven in number including protoconch, which consists of two smooth and rounded whorls. Spire moderately long, occupying about half of shell height. Shell ornamented with two spiral carinae, more or less of equal strength, each bordering suture. Axial elements are weakly prosocline, running suture to suture. They are 20 in number on body whorl. Feeble tubercles are formed at intersecting points of trans-

← **Figure 5.** 1, 2. *Helicacanthus chanda* sp. nov. from Bed 1, Jamara, ×3. **1a, b.** Paratype, JUM/g 38, apertural and abapertural view; abapertural view (1b) showing dense axial striae. **2a, b.** Paratype, almost complete, JUM/g 39, apertural and abapertural views. Note granulated basal cords in apertural view (2a). **3-6.** *Riselloidea tagorei* sp. nov. from Bed 1, Jumara, ×3. **3a-c.** Holotype, complete shell, JUM/g 148, apertural, abapertural and basal views. **4a-c.** Paratype, complete shell, JUM/g 157, apertural, abapertural and basal views. **5a, b.** Paratype, complete shell, JUM/g 147, abapertural and basal views. **6a, b.** Paratype, complete shell, JUM/g 159, abapertural and apical views.



verse and longitudinal elements. Base flat to weakly convex with 3 to 4 faint spiral cords. No granulation on cords at crossing points when intersected by very feeble axial growth lines. Aperture almost circular to subquadrangular; columellar lip thickened by callus; base narrow and slightly rounded.

*Discussion.*—*Riselloidea elongata* sp. nov. comes from the same stratigraphic level and geographic locality as *Riselloidea tagorei* sp. nov. These two species are comparable in having more or less similar size, conical and straight-walled shell outline, and nearly flattened base. *R. elongata* however, differs from *R. tagorei* in being more slender and high-spired. It has also more whorls and less shell rugosity, with only two rows of tubercles instead of three in *R. tagorei*. Besides, basal cords of *R. elongata* lack granulations, which are typical of *R. tagorei*.

The Kutch species has a close resemblance with *Riselloidea biarmata* (Münster, 1844), described from the Great Oolite Series, England and the Middle Jurassic, Germany (Cox and Arkell, 1948–50, p. 58, Knight *et al.*, 1960, fig. 203, 8). The present species, however, can be distinguished by its larger size, slender shape and absence of granulation on the basal cords.

The present species resembles *Riselloidea periniana* (d'Orbigny) (1853, p. 266, pl. 310, figs. 12, 13) (also see Fischer, 1997, p. 103, pl. 21, fig. 24) from the Plansbachian of France. Both species have a similar higher shell outline, high spire and surface ornamentation with two rows of tuberculate carinae. However, the older European form is smaller in height, having deeply grooved suture and more oblique axial riblets. Moreover, it has granulation at the basal cords, a feature which is absent in the present species.

*Etymology.*—After its elongated shape.

#### Genus *Onkospira* Zittel, 1873

*Type species.*—*Turbo ranellatus* Quenstedt, 1858; Original designation.

#### *Onkospira kutchensis* sp. nov.

Figure 6-4-6

*Material.*—Twenty-six specimens. JUM/g 45-70. JUM/g 45 is designated holotype; the rest are paratypes. All the specimens have their original shell preserved. Only two specimens are intact with the rest lacking their apical part. All were collected from Bed 1, Jumara.

*Diagnosis.*—Average-sized *Onkospira* (13 to 25 mm high);

whorls 5 in number including protoconch; spire short; strong spiral cords, 3 to 4 in number throughout ontogeny, basal cords 7 to 8; axial threads very fine, may be absent in some variants; two strong prosoclinal varices on each whorl, showing slight offset in successive whorls.

*Description.*—Shell medium in size, maximum height achieved about 25 mm; thick, anomphalous and turbiniform with shell diameter about half of shell height. Apical angle ranges between 25° and 32°. Whorls 5 in number including protoconch. Protoconch consists of two smooth and rounded whorls. Spire highly elevated and about half of shell height. Whorls regularly expanding, strongly to slightly convex with sloping ramp. Suture impressed. Surface ornamented with 3 to 4 strong spiral cords throughout ontogeny and fine prosoclinal threads. Both are cancellate at their junction. Second and third cords from suture relatively stronger. Two strong prosoclinal varices located on each whorl and show slight offset on successive whorls. Last varix situated just behind outer lip. Basal cords are relatively fine and closely spaced, 7 to 8 in number. Aperture oval with its height slightly greater than width. Outer lip rounded and inner lip arcuate and reflected. Both lips are thick.

*Discussion.*—The turbiniform shell outline, convex whorl sides, predominance of spiral ornamentation and presence of varices are the characteristic features of *Onkospira*. From the above morphological description the generic position of the present species seems secure. So far, species of *Onkospira* have been reported from Europe and Japan ranging in age from the Upper Jurassic to Lower Cretaceous. The discovery of the present species brings down the lower limit of stratigraphic range of *Onkospira* as far as the Upper Bathonian.

The present form resembles *Onkospira gracilis* Zittel, 1873 (Knight *et al.*, 1960, fig. 203, 1) reported from the Tithonian of the Czech Republic. But *O. gracilis* is characterised by strongly convex, more numerous whorls, prominent collabral riblets and varices showing alignment on successive whorls.

The present species differs from *Onkospira haipensis* described by Kase (Kase, 1984, pl. 11, figs. 9–12) mainly in shell ornamentation. In some variants of *O. haipensis*, spiral cords are strong and tubercles are present at the intersection.

*Etymology.*—After Kutch, western India, from where the specimens have been collected.

? Subfamily Calliostomatinae

Genus *Proconulus* Cossmann, 1918

← **Figure 6.** 1-3. *Riselloidea elongata* sp. nov. from Bed 1, Jumara, ×3. 1a-c. Holotype, JUM/g 138, apical part damaged; apertural, abapertural and basal views; note two rows of spiral carinae and basal cords lacking granulation. 2a, b. Paratype, apical part damaged, JUM/g 139; apertural and abapertural views. 3a, b. Paratype, complete shell, JUM/g 141, apertural and basal views. 4-6. *Onkospira kutchensis* sp. nov. from Bed 1, Jumara, ×3. 4a-c. Holotype, apical part damaged, original shell preserved, JUM/g 45, apertural, abapertural and basal views; note slight offset of varices in last two whorls (4b). 5a, b. Paratype, complete shell, JUM/g 46, apertural and abapertural views. 6a, b. Paratype, apical part damaged, original shell preserved, JUM/g 47, apertural and abapertural views. 7a-c. *Proconulus jadavpuriensis* sp. nov. from Bed 1, Jumara, ×3, Holotype, complete shell, JUM/g 76, apertural, abapertural and basal views; note abapertural view showing very fine opisthocline threads near aperture.

*Type species.*—*Trochus guillieri* Cossmann, 1885; original designation.

***Proconulus jadavpuriensis* sp. nov.**

Figures 6-7; 7-1, 2

*Material.*—Sixty-two specimens. JUM/g 76-137. Specimen JUM/g 76 is designated holotype; the rest are paratypes. Most of the specimens are intact and have the original shell preserved. JUM/g 81-86 were collected from Bed 7 and the rest are from Bed 1 of Jumara.

*Diagnosis.*—Average-sized *Proconulus* (15 to 20 mm high); smooth shell; whorls less numerous; flat in early stage, feebly concave later, periphery marked by angular keel; base feebly convex.

*Description.*—Shell small, maximum height 20 mm; anomphalous, thick, conical; acute juvenile whorls; trochiform with height slightly greater than diameter. Apical angle ranges between 50° and 60°; whorls less numerous, five in number including protoconch, separated by impressed suture. Protoconch conical, consists of two smooth, rounded whorls. Spire moderately high, occupying about one-third of shell height. Whorls flat or feebly concave in early stage, concavity increases during ontogeny. Periphery is sharply angulate like a carina, which occurs just above suture. Body whorl large with diameter slightly greater than height. Shell smooth except for some fine prosocline threads, especially prominent near aperture of adult specimens; base rounded. Aperture circular to subquadrangular, width of aperture slightly greater than height, base of aperture rounded. Both outer and inner lips thick, collumellar part has a thick callus.

*Discussion.*—The shell shape of the present species has a close correspondence with some species of *Epulotrochus* Cossmann, especially *E. epulus* (d'Orbigny, 1850). Szabo (1981), while describing the Hungarian Lower to Middle Jurassic gastropods, also observed the same similarities. Some smooth variants of his *Proconulus epuliformis* Szabo (1981, pl. 1, figs. 6-8) shows a striking resemblance to *E. epulus*. Szabo (1981) and Kase (pers. comm., 1992) acknowledged the need for a revision of these genera. The present species has thick callus and from the nature of the nucleus whorl and ornaments it is retained within *Proconulus*.

Present study includes numerous specimens, which enable us to examine both ontogenetic and intraspecific variations. The population shows low intraspecific variability.

The present species shows a resemblance in shell shape to *Proconulus rimosus* Szabo (1981, pl. 1, figs. 9-13), though the latter species has a wide range of variation in this respect. However, *P. rimosus* is an ornamental form with prominent spiral elements, which are even tuberculated in the early stage. The present species has a smooth shell except for some fine, faded axial threads which appear only at the adult stage in some variants. It is further characterised by slightly concave whorl and marked angular keel just above the suture.

*Proconulus jadavpuriensis* sp. nov. closely resembles

*Proconulus brutus* (d'Orbigny) (1853, p. 283, pl. ccxv, figs. 13-16) (Cossmann, 1885, p. 285, pl. vii, figs. 23, 24; Cox and Arkell, 1948-50, p. 59; also see Fischer, 1997, p. 112, pl. 19, figs. 6, 7) described from the Great Oolite of England. The latter species has a similar shell and apertural shape with a convex base, but differs in shell ornamentation, being characterised by five strongly tuberculate spiral bands and a very obscure suture while the present species has a smooth shell and very impressed suture. Besides, the present species has a concave whorl outline.

*Proconulus epuliformis* has a more or less similar whorl outline and smooth or feebly ornamented shell but differs in having a high conical shell, more numerous whorls and flattened base. Moreover, the present species is characterised by a well marked angular keel and impressed suture.

*P. jadavpuriensis* sp. nov. exhibits some degree of resemblance to the upper Bajocian species *Proconulus acanthus* (d'Orbigny) (1853, p. 273, pl. 312, figs. 9-12) (also see Fischer, 1997, p. 107, pl. 19, figs. 4a, b, 5) described from Port-en-Bessin (Calvados) in overall shell outline with angular periphery, size and apical angle. However, the present species differs from the latter in having a distinctly concave whorl outline, impressed suture and smooth shell except for some prosocline threads near the aperture, while the latter is distinguished by straight whorl outline and finely granular spiral cords.

*Etymology.*—After Jadavpur University.

Suborder Neritopsina  
Superfamily Neritacea  
Family Neritopsidae  
Subfamily Neritopsinae  
Genus ***Neritopsis*** Grateloup, 1832  
Subgenus ***Neritopsis*** s. str.

*Type species.*—*Neritopsis moniliformis* Grateloup, 1832; original designation.

***Neritopsis (Neritopsis) patchamensis* sp. nov.**

Figure 7-3-5

*Material.*—Eight specimens. JUM/g 1-3, 5, 8-11. Holotype, JUM/g 1; the rest are paratypes. The specimens have their original shell preserved and were collected from Bed 1 of Jumara.

*Diagnosis.*—Small *Neritopsis* (8 to 11 mm high); whorls rounded with wide, gently sloping ramp; spire slightly protruding; whorls cancellated, both axial and spiral cords of equal strength, axial cords numerous (12 to 16) on body whorl; aperture very large, axially ovate with slight angulation near suture.

*Description.*—Shell small in size, maximum height about 11 mm, moderately thick, subglobose; height of shell about three-fourths of shell diameter. Apical angle ranges between 110° and 120°. Whorls rounded with wide gently sloping ramp, slightly angulate at suture. Protoconch not well discernible, but appears to be smooth and consisting of about two whorls. Spire short, body whorl very large and

increases rapidly in diameter. Suture impressed, running along a furrow. Whorls cancellated throughout later ontogeny, resulting from intersection of axial and spiral cords of equal strength. Axial cords 12 to 16 in number on body whorl, prosocline in beginning but becoming gentler during ontogeny. Spiral cords 10 to 14 in number on body whorl and irregularly spaced. Aperture very large, axially ovate and slightly angulate near suture; inner lip slightly thickened by callus accompanied by a shallow furrow running parallel to it and resulting in a pseudoumbilicus.

*Discussion.*—*Neritopsis (Neritopsis) patchamensis* sp. nov. shows some degree of resemblance to the Lower and Middle Jurassic forms from Europe (Szabo, 1982; Conti and Szabo, 1989). It differs from *Neritopsis (Neritopsis) papodensis* Szabo (1982 pl. 1, figs. 6–9) in having a less protruded spire and less convex whorl surface with relatively broader ramp. It is coarsely ornate with stronger axial elements than in *N. (N.) papodensis*.

The present species, although it resembles strongly *Neritopsis abbas* Huddlestone (1894, p. 341, pl. XXVII, figs. 11a–c) (also see Conti and Szabo, 1989, pl. 1, figs. 10–11) in shell shape, is much smaller in size with a less protruded spire. In *N. abbas*, spiral cords dominate with very faint axial growth lines near the aperture, but in the present species, axial elements are equally prominent and cut across the spiral cords resulting in a conspicuous cancellate ornamentation.

*Neritopsis (Neritopsis) spinigera* Szabo (1982, pl. 1, figs. 10–18) has been described on the basis of mostly damaged specimens. It, however, can be distinguished by its bicarinate ornamentation, long spine and fewer and stronger axial elements.

The Middle Jurassic (Bajocian–Bathonian) form *Neritopsis (Neritopsis) bajocensis* d'Orbigny (1852, p. 223, pl. 300, figs. 8–10; Fischer, 1997, p. 86, pl. 17, figs. 14a–c, 15a–c) can be compared with the present form in general globose shape and apertural outline. Close examination reveals that in the present species the height is less than the diameter while in the European form it is just the reverse. Further, the Kutch species has strongly cancellated ornamentation in the later ontogeny resulting from intersection of equally strong axial and spiral cords, but the European form has dominant spiral cords with very feeble axial elements. Besides, the Kutch species is less than half the size of *N. (N.) bajocensis*.

*Etymology.*—Refers to the Patcham Formation in which the species is exclusively confined.

#### Subgenus *Hayamiella* Kase, 1984

*Type species.*—*Neritopsis (Hayamiella) japonica* Kase, 1984; original designation.

#### *Neritopsis (Hayamiella) sankhamala* sp. nov.

Figure 7–6, 7

*Material.*—Ten specimens, JUM/g 4, 6, 7, 12–18. JUM/g 6 is designated holotype; the rest are paratypes. The specimens have their original shell preserved. The present collection has been made from Bed 1 of Jumara.

*Diagnosis.*—Small size for genus (6 to 8 mm high); narrow ramp, whorls bordered by subcarinate angulation; spire slightly protruding, suture impressed with a subsutural channel; cancellate ornamentation, axial element developed into varices, irregularly spaced, 6 to 9; spiral cords 9 to 13; prominent tubercles at intersection of spiral and axial elements; aperture circular to slightly axially ovate.

*Description.*—Shell small in size, maximum height achieved 8 mm; low-spired and naticiform. Shell diameter greater than height. Apical angle ranges between 105° and 122°. Narrow ramp, whorls bordered by subcarinate angulation. Protoconch seemingly smooth but number of whorls not discernible, may consist of more than one whorl, spire slightly protruding. Body whorl large, rapidly widening. Suture impressed with a prominent subsutural channel. Cancellate ornamentation with much stronger axial elements. Varices become stronger and interspace increases ontogenetically. Varices 6 to 9 in number on body whorl and orthocline. Spiral cords 9 to 13, strength varies, stronger ones irregularly intercalate with finer cords. Fine but prominent tubercles appear at intersection of spiral cords and varices. Aperture very large, near circular to slightly ovate axially; inner lip with narrow callus. Furrow running parallel to inner lip, resulting in a pseudoumbilicus.

*Discussion.*—Kase (1984) erected a subgenus *Hayamiella* within the genus *Neritopsis* and described *N. (H.) japonica* Kase (p. 84, pl. 8, figs. 6a–c, 17) from the Upper Aptian of Japan as type species. He distinguished *Neritopsis* s. str. from *Hayamiella* on the basis of the presence of spiral cords, larger shell size and wider shell outline. He also admitted that distinction may not be very clear as there exist some intermediate forms (see also Hayami, 1960). The present species is characterised by small shell size, globose shape and coarsely cancellated ornamentation with much stronger axial elements, but it has a wider shell outline. Because of the similarities in many diagnostic characters we place the present species within the subgenus *Hayamiella*.

The present species has similarities with the type species *N. (H.) japonica* in many important morphological characters like small shell size, globose shape and cancellated ornamentation, so that their inclusion within the same subgenus is justified. However, *N. (H.) sankhamala* is still smaller in size, wider in outline and having fewer but stronger axial elements than *N. (H.) japonica*. Moreover, the type species comes from a higher stratigraphic horizon (Aptian).

The present species is closer to *Neritopsis (Neritopsis) patchamensis* sp. nov., but is relatively smaller in diameter with a narrower ramp area. Its axial elements are stronger and fewer on body whorl. Besides, it differs in having subcarinate angulation, tubercles, a circular aperture and a subsutural channel.

*Neritopsis (Hayamiella) sankhamala* sp. nov. is comparable to some European forms. It is close in size to *Neritopsis dumortieri* Conti and Szabo (1989, pl. 1, figs. 12–13) from the Southern Alps. This European species is based on the monotypic holotype, which is a damaged specimen. *N. dumortieri* bears three rows of spiral carinae and transverse elements of equal strength. Long hollow spines are present at the intersection point. The present species, on the other



2a



1b



2b



3a



1a



3b



3c



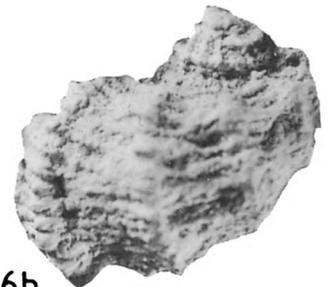
5



6a



4



6b



7a



7c



7b

hand, possesses strong varices and small tubercles.

*Neritopsis (Neritopsis) spinigera* Szabo (1982, pl. 1, figs. 10–18) differs mainly in having a more closely ornate form with long spines and more protruded spire.

The present species shows a remarkable correspondence in size, shape and ornamentation to *Neritopsis (Neritopsis) elegantissima* Hönes (1853, p. 763) (Szabo, 1982, pl. 1, figs. 1–3), but closer examination reveals that the Kutch form has a circular aperture, varices 6 to 9 in number, subcarinate angulation and tubercles. Moreover, *N. (N.) elegantissima* comes from a much older horizon of the Lower Jurassic (U. Sinemurian).

*Neritopsis (Hayamiella) sankhamala* sp. nov. has a close resemblance to *Neritopsis guerrei* Hébert and Deslongchamps (1860, p. 185, pl. I, figs. 4a–d) described from the Great Oolite of England (see also Cox and Arkell, 1948–50, p. 64). One variant even appears to be more close in having similar distant and unevenly placed axial elements. The present species, however, can be distinguished by its relatively distant spiral cords, stronger varices and presence of prominent tubercles.

*Etymology*.—Refers to an Indian ornament—a chain of small and globular gastropod shells

#### Genus *Hayamia* Kase, 1980

*Type species*.—*Hayamia rex* Kase, 1980 (in Kase and Maeda, 1980); original designation.

#### *Hayamia mitra* sp. nov.

Figure 8-1–3

*Material*.—Five specimens, JUM/g 31–34, 597. JUM/g 31 is designated holotype, the rest are paratypes. JUM/g 32, 33 are internal moulds, the holotype and one of the paratypes (JUM/g 597) represent composite state of preservation. JUM/g 34 with shell remains. JUM/g 31, 33 were collected from Bed 1, JUM/g 597, from Bed 6, JUM/g 32, from Bed 7 of Jumara; JUM/g 34 from Bed 2, Keera (see Bardhan *et al.*, 1994).

*Diagnosis*.—Medium-sized *Hayamia* (about 24 mm high); height less than diameter, spire slightly protruding, suture impressed with prominent subsutural channel, aperture large; prominent, numerous spiral cords with finer subordinate ones in between.

*Description*.—Shell medium-sized, maximum height achieved 24 mm; phaneromphalous; moderately thick, ovate and naticiform in outline with height of shell is about three-fourth of shell diameter. Apical angle ranges between 120° and 160°. Whorls rapidly expanding, convex in

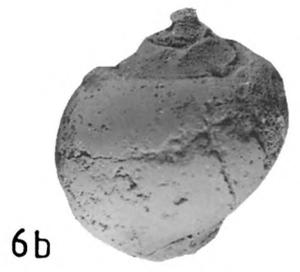
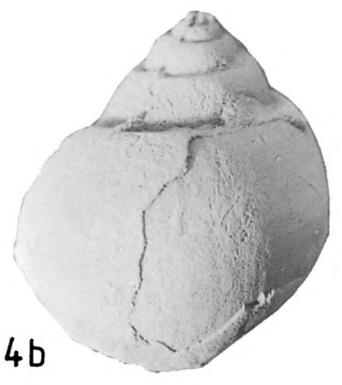
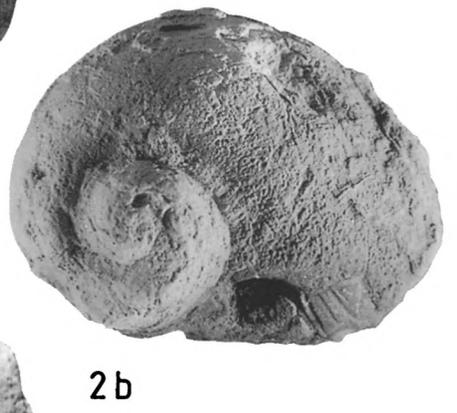
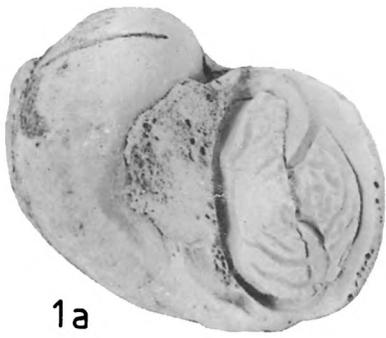
outline; whorls make two and a half volutions. Protoconch is not well discernible. Spire slightly protruding, about one-eighth of shell height. Body whorl very large, increases rapidly in diameter with a wide and weakly convex sutural ramp. Suture impressed with subsutural channel. Shell is ornamented with prominent and widely spaced spiral cords and several subordinate ones in interspaces; spiral elements are intercepted by very faint axial growth lines observed particularly near peristome; internal mould smooth. Aperture very large, elliptical in outline and expanded in direction oblique to axis. Height of aperture slightly greater than width. Both outer and inner lips thin and entire. Thin and somewhat obscure callus covers inner lip. Operculum thick, solid and elliptical in outline, its outer surface ornamented with both radial and concentric elements, abaxial part broken, but its adaxial margin has a curvaceous chevron shaped-outline.

*Discussion*.—Kase (1980) introduced the genus *Hayamia* (Kase and Maeda, 1980, pl. 35, figs. 3–10) in the family Neritopsidae from the Lower Cretaceous of central Japan to distinguish it from *Neritopsis*. The genus also includes some previously described Jurassic and Cretaceous species of *Neritopsis*. The main features which characterise *Hayamia* are spiral striae with or without costellae, absence of parietal tubercles and an elliptical operculum lacking any quadrangular process at the adaxial edge; although there is a certain amount of similarity with *Neritopsis*, these features probably confer an independent status to the genus. While *Hayamia* is included in the subfamily Neritopsinae, it has opercular feature resembling that of *Naticopsis* belonging to the subfamily Naticopsinae. Thus, it appears that *Hayamia* occupies an intermediate position between *Neritopsis* and *Naticopsis*. The actual phylogenetic relationship among the three genera is not yet clear (Kase, pers. comm., 1999) and has to be worked out by detailed study of properly weighted characters linking and separating them. In consonance with its genus the Kutch species *Hayamia mitra* sp. nov. has also a similar status and presently we place the species provisionally under the subfamily Neritopsinae.

The Kutch species displays some resemblance to the type species *Hayamia rex* Kase (in Kase and Maeda, 1980, pl. 35, figs. 5–10) in size and surface ornamentation. But it differs from the latter in its overall shape with shell diameter measuring more than height, less protruded spire and slightly asymmetric elliptical operculum. *Hayamia chosiensis* Kase (in Kase and Maeda, 1980, pl. 35, figs. 3–4) also bears some similarity with the present species, but differs in having more dense spiral striae, more protruded spire and circular aperture with curved angulation at the adapical part.

*Etymology*.—The species is named in honour of late K.C. Mitra, a renowned palaeontologist in the Department of

— **Figure 7.** 1, 2. *Proconulus jadavpuriensis* sp. nov. from Bed 1, Jumara,  $\times 3$ . 1a, b. Paratype, broken at apical part, JUM/g 77, apertural and basal views. 2a, b. Paratype, peristome slightly damaged, JUM/g 79, apertural and abapertural views. 3–5. *Neritopsis (Neritopsis) patchamensis* sp. nov. from Bed 1, Jumara,  $\times 3$ . 3a–c. Holotype, JUM/g 1, apertural, abapertural and apical views; apical view showing closely spaced axial cords. 4. Paratype, JUM/g 3, apical view. 5. Paratype, body whorl broken, JUM/g 9, abapertural view. 6, 7. *Neritopsis (Hayamiella) sankhamala* sp. nov. from Bed 1, Jumara,  $\times 4$ . 6a, b. Holotype, JUM/g 6, apical and abapertural views showing distant and strong axial cords. 7a–c. Paratype, young shell, JUM/g 16, apertural, abapertural and apical views.



Geological Sciences of Jadavpur University.

Order Caenogastropoda  
 Superfamily Naticacea  
 Family Naticidae  
 Subfamily Globulariinae  
 Genus *Globularia* Swainson, 1840

*Type species.*—*Ampullaria sigaretina* Lamarck, 1804; original designation.

*Globularia spathi* sp. nov.

Figure 8-4—6

*Material.*—Eight specimens. JUM/g 23-30. Holotype, JUM/g 23; the rest are paratypes. Three specimens are intact and rest are broken. Mostly internal moulds, in three specimens (JUM/g 23, 24, 25) part of the original shell is preserved. JUM/g 23 was collected from Bed 1, JUM/g 24, 26-30 from Bed 7 of Jumara and JUM/g 25 from Keera.

*Diagnosis.*—Medium-sized *Globularia* (about 30 mm high); spire relatively high; suture impressed throughout; umbilicus narrowly open, sheath narrow; aperture subelliptical; ornamented with fine prosoclinal growth lines conspicuous near aperture.

*Description.*—Shell of medium size, maximum height about 30 mm; globose, moderately thick, phaneromphalous and naticiform in outline with height slightly smaller than diameter. Apical angle ranges from 95° to 106°. Whorls at least five in number, separated by deeply channelled suture bordered by sharp periphery. Protoconch not discernible. Spire relatively high, obtusely conical, occupying about one-fourth to one-sixth of shell height. Body whorl with height slightly higher than diameter. Whorls convex, angulation present near suture. Whorl surface ornamented with fine prosoclinal growth lines conspicuous near aperture. Aperture wide, subelliptical in outline, with height nearly twice width, acute above and broadly rounded below. Parietal area covered by thick callus. Umbilicus narrowly opens; sheath narrow.

*Discussion.*—In a recent major taxonomic revision of the family Naticidae, Kabat (1991) has stabilised many family and genus level names. He removed *Natica fluctuata* G.B. Sowerby, 1825 from *Globularia* and designated it as the type species of *Cernina* Gray, 1847.

This is the largest naticiform species collected from Kutch. *Globularia (Nangulania) puruensis* (Martin, 1914) (Wenz, 1941, fig. 2933) has a very short spire, both axial and spiral threads and a large aperture. In the present species, the spire is comparatively long, only prosoclinal growth lines are present

as surface ornamentation and the aperture is smaller than that of *G. (N.) puruensis*.

The present species can be compared with *Globularia (Globularia) izumiensis* Kase (1990, figs. 2.16-22, 2.25). Kase's species has a shell diameter greater than the height, low spire, and weakly impressed suture in early whorls. Further, it has a flattened upper whorl surface and subovate aperture. In contrast, the present species has a shell diameter smaller than its height, a more protruding spire, and a strongly impressed suture all through during growth. Aperture is subelliptical and whorls have a convex upper surface with angulation near the suture.

The present species resembles *Globularia rupellensis* (d'Orbigny) (1852, p. 203, pl. 293, figs. 1-3) (see Fischer, 1997, p. 77, pl. 16, figs. 1a, b, 2) from the Oxfordian—Kimmeridgian of Europe in general shell outline, apical angle, apertural shape etc. But the European form is much larger, the largest being about three times that of the present species. However, the obvious difference lies in the nature of the ornamentation. *G. rupellensis* is characterised by spiral striae with punctuation along their alignment, whereas the Indian species is ornamented with fine prosoclinal growth lines. Moreover, the suture of the present species remains deeply impressed all through ontogeny.

The present species is comparable with *Globularia zangis* (d'Orbigny) (1852, p. 198, pl. 291, figs. 10-11) (also see Fischer, 1997, p. 74, pl. 15, fig. 9) from the Callovian of France but differs in having a smaller shell size, higher apical angle and flatter outer whorl surface in early ontogeny. The ornamental aspects, however, cannot be compared since the holotype of the European form is an internal mould.

A close correspondence can be observed between the present species and *Globularia?* sp. described by Sohl (1965, pl. 4, figs. 10-15) from the Middle Jurassic Carmel Formation of Utah, North America. Sohl's specimens are undoubtedly *Globularia* with the diagnostic narrow sheath. Sohl compared them with some British Jurassic gastropods (Cox and Arkell, 1948-50, p. 83). His form is similarly high-spired like the present species, but is smaller and less globose. The smoothness of the American specimens, however, may be attributed to complete silicification, which might have destroyed the finer details of ornamentation.

*Etymology.*—Named in honour of L.F. Spath, a famous palaeontologist.

#### Acknowledgements

The authors wish to express their deep gratitude to Tomoki Kase, National Science Museum, Tokyo, Japan for his critical reading of an earlier version of the manuscript and valuable suggestions. Dr. Kase also helped in making

← **Figure 8. 1-3.** *Hayamia mitra* sp. nov. ×2. **1a-c.** Holotype, JUM/g 31, from Bed 1, Jumara, apertural, abapertural and apical views; mostly internal mould, part of shell remains near aperture, apical part damaged, well preserved operculum. **2a, b.** Paratype, internal mould, from Bed 1, Jumara, JUM/g 33, abapertural and apical views. **3.** Paratype, from Bed 2, Keera, JUM/g 34, with shell remains, showing spiral ornaments of variable strength, abapertural view. **4-6.** *Globularia spathi* sp. nov. ×2. **4a, b.** Holotype, from Bed 1, Jumara, JUM/g 23, mostly shell remains, showing axial ornamentation; apertural and abapertural views. **5.** Paratype, from Bed 7, Jumara, JUM/g 24, abapertural view. **6a, b.** Paratype, young shell, internal mould, from Bed 7, Jumara, JUM/g 26, apertural and abapertural views.

critical comments on the final version of the manuscript and providing valuable reference materials that helped in improving the paper. The authors also thank the late Sukomal K. Chanda, Jadavpur University, Calcutta, India, for his useful discussion. Deep appreciation is also due to Debabrata Pramanick who kindly made available his material for the present study. Amitava Kayal, Debahuti Mukherjee, Sudipta K. Jana and Kalyan Haldar, Jadavpur University helped at various stages in both field and laboratory works. One of us (S.B.) received financial aid from the Department of Science and Technology, India. One of the authors (SSD) is grateful to the Indian Statistical Institute, Calcutta, for use of its facilities.

### References

- Bardhan, S., Datta, K., Jana, S. K. and Pramanik, D., 1994 : Dimorphism in *Kheraiceris* Spath from the Callovian Chari Formation, Kutch, India. *Journal of Paleontology*, vol. 68, no. 2, p. 287-293.
- Biswas, S. K., 1977 : Mesozoic rock-stratigraphy of Kutch, Gujarat. *Quarterly Journal of the Geological, Mineralogical and Metallurgical Society of India*, vol. 49, p. 1-51.
- Biswas, S. K., 1982 : Rift basins in western margin of India and their hydrocarbon prospects with special reference to Kutch basin. *Bulletin of the American Association of Petroleum Geologists*, vol. 66, p. 1497-1513.
- Biswas, S. K., 1991 : Stratigraphy and sedimentary evolution of Mesozoic basin of Kutch, Western India. In, Tandon, S. K., Pant, C. C. and Casshyap, S. M. eds., *Sedimentary Basins of India, Tectonic Context*. p. 74-103. Gyanodaya Prakashan, Nainital.
- Biswas, S. K. and Deshpande, S. V., 1968 : Basement of the Mesozoic sediments of Kutch, Western India. *Bulletin Geological, Mining and Metallurgical Society of India*, no. 40, p. 1-7.
- Böckh, J., 1874 : Die geologische Verhältnisse des südlichen Theiles des Bakonys, II. Theil. *Mitteilungen aus dem Jahrbuch der K. Ungarischen geologischen Anstalt*, vol. 3, p. 1-180, pls. 1-7.
- Callomon, J. H., 1993 : On *Perisphinctes congener* Waagen, 1875, and the age of the Patcham Limestone in the Middle Jurassic of Jumara, Kutch, India. *Geologische Blätter von NO-Bayern, Erlangen*, vol. 43, p. 227-246.
- Conti, M. A. and Fischer, J. C., 1982 : La faune à gastropodes du Jurassique moyen de Case Canepine (Umbria, Italie), systématique, palaeobiogéographie, palaeoécologie. *Geologica Romana*, vol. 21, p. 125-183.
- Conti, M. A. and Monari, S., 1984 : A Middle Jurassic bivalve and gastropod fauna from Umbria (Central Italy). *Geologica Romana*, vol. 23, p. 175-216.
- Conti, M. A. and Monari, S., 1991 : Bivalve and gastropod fauna from the Liassic Ammonitico Rosso Facies in the Bilecik area (Western Pontides, Turkey). *Geologica Romana*, vol. 27 p. 245-301.
- Conti, M. A. and Szabo, J., 1989 : A revision of Jurassic gastropod fauna from Cape San Vigilio (S-Alps, Italy), published by M. Vacek (1886). *Fragmenta Mineralogica et Palaeontologica*. vol. 14, p. 29-40.
- Cossmann, M., 1885 : Contribution à l'étude de la faune de l'étage Bathonien en France (Gastropodes). *Mémoires de la Société Géologique de France, Troisième Série*, vol. 3, p. 1-374, pls. 1-18.
- Cossmann, M., 1909 : *Essais de Paléoconchologie comparée*. Vol. 8, 248 p., 4 pls. Paris.
- Cossmann, M., 1916 : *Essais de Paléoconchologie comparée*. Vol. 10, 292 p., 12 pls. Paris.
- Cossmann, M., 1918 : *Essais de Paléoconchologie comparée*. Vol. 11, 388 p., 10 pls. Paris.
- Cox, L. R., 1940 : The Jurassic lamellibranch fauna of Kutch (Cutch). *Memoirs of the Geological Survey of India, Palaeontologia Indica*, ser. 9, vol. 3, part 3, p. 1-157, pls. 10.
- Cox, L. R., 1952 : The Jurassic lamellibranch fauna of Cutch (Kutch), no. 3, Families Pectinidae, Amusiidae, Plicatulidae, Limidae, Ostreidae and Trigonidae (Suppl.). *Memoirs of the Geological Survey of India, Palaeontologia Indica*, ser. 9, vol. 3, part 4, p. 1-128, pls. 12.
- Cox, L. R. and Arkell, W. J., 1948-50 : A survey of the Mollusca of the British Great Oolite series. *Palaeontographical Society (Monograph)*, no. 102, p. 1-48, no. 103, p. 49-105.
- Dutta, K., 1992 : *Facies, fauna and sequence : an integrated approach in the Jurassic Patcham and Chari Formations, Kutch, India*. Unpublished Ph. D. dissertation, Jadavpur University, 167 p., Calcutta.
- Dutta, K., Bhaumik, D., Jana, S. K. and Bardhan, S., 1996 : Age, ontogeny and dimorphism of *Macrocephalites triangularis* Spath—The oldest macrocephalid ammonite from Kutch, India. *Journal Geological Society of India*, vol. 47, p. 447-458.
- Eudes-Deslongchamps, J. A., 1842 : Mémoire sur les Mélanies fossiles des terrains secondaires du Calvados. *Mémoires de la Société linnéenne de Normandie*, vol. 7, p. 215-230, pl. 12.
- Fischer, J. C., 1997 : *Révision critique de la Paléontologie Française*, vol. 2, Gastropodes Jurassiques, 300 p., 38 pls., Masson, Paris, Milan, Barcelone.
- Fürsich, F. T., Oschmann, W., Jaitly, A. K. and Sing, I. B., 1991 : Faunal response to transgressive-regressive cycles : example from the Jurassic of western India. *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 85, p. 149-159.
- Fürsich, F. T., Pandey, D. K., Callomon, H., Oschmann, W. and Jaitly, A. K., 1994 : Contribution to the Jurassic of Kutch, Western India. II. Bathonian stratigraphy and depositional environment of the Sadhara Dome, Pachchham Island. *Beringeria*. vol. 12, p. 95-125.
- Gemmellaro, G. G., 1878 : Sui fossili del calcare cristallino delle Montagne del Casale e di Bellampo nella provincia di Palermo. In, *Sopra alcune faune giuresi e liassiche della Sicilia (1872-1882)*. Parte VIII. *Giornale di Scienze Naturali ed Economiche*, vol. 13, p. 233-424, pls. 21-31, Palermo.
- Gratoloup, J.P.S.de., 1832 : Description d'un genre nouveau de coquille, appelé *Neritopsis*. *Actes de la société linnéenne de Bordeaux*, vol. 5, p. 125-131.
- Gray, J. E., 1847 : A list of the genera of Recent Mollusca, their synonyma and types. *Proceedings of the Zoological Society of London*, vol. 15, no. 179, p. 129-219.
- Gregory, J. W., 1893 : The Jurassic fauna of Cutch, The Echinoidea. *Memoirs of the Geological Survey of India, Palaeontologia Indica*, ser., 9, vol. 2, part 1, p. 1-11,

- pls. 1-2.
- Gregory, J. W., 1900: The Jurassic fauna of Cutch, The corals. *Memoirs of the Geological Survey of India, Palaeontologia Indica*, ser., 9, vol. 2, part 2, p. 12-196, pls. 2A, 3-27.
- Hallam, A., 1982: Patterns of speciation in Jurassic *Gryphaea*. *Palaeobiology*, vol. 138, p. 735-743.
- Hayami, I., 1960: Lower Liassic gastropods from the Higashinagano Formation in west Japan. *Japanese Journal of Geology and Geography*, vol. 31, p. 99-106, pl. 9.
- Hébert, E. and Deslongchamps, E., 1860: Mémoire sur les fossiles de Montreuil-Bellay. *Mémoires de la Société linnéenne de Normandie*, vol. 5, p. 153-240, pls. 21-31.
- Hickman, C. S. and McLean, J. H., 1990: Systematic revision and suprageneric classification of trochacean gastropods. *Science Series Natural History Museum of Los Angeles County*, no. 35, p. 1-169.
- Hörnes, M. in Hauer, F., 1853: Ueber die Gliederungen der Trias- Lias- und Juragebilde in den nordöstlichen Alpen. *Jahrbuch Kais. Kön. Geologischen Bundesanst.*, vol. 4, p. 715-784.
- Hudleston, W. H., 1887-96: A monograph of the British Jurassic Gastropoda. Part 1. The Inferior Oolite Gasteropoda. *Palaeontographical Society (Monograph) of London*, 509 p., 44 pls.
- Kabat, A.R., 1991: The classification of the Naticidae (Mollusca: Gastropoda): review and analysis of the supraspecific taxa. *Bulletin of the Museum of Comparative Zoology, Harvard University*, vol. 152, no. 7, p. 417-449.
- Kase, T., 1984: *Early Cretaceous marine and brackish-water Gastropoda from Japan*, 263 p., 31 pls. National Science Museum, Tokyo.
- Kase, T., 1990: Late Cretaceous gastropods from the Izumi Group of Southwest Japan. *Journal of Palaeontology*, vol. 64, no. 4, p. 563-578.
- Kase, T. and Maeda, H., 1980: Early Cretaceous Gastropoda from the Chosi district, Chiba Prefecture, central Japan. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series*, no. 118, p. 291-324.
- Kayal, A. and Bardhan, S., 1998: *Epistrenoceras* Bentz (Ammonoidea) from the Middle Jurassic of Kutch (western India): a new record and its chronostratigraphic implication. *Canadian Journal of Earth Sciences*, vol. 35, no. 8, p. 931-935.
- Kitchin, F.L., 1900: The Jurassic fauna of Cutch. The Brachiopoda. *Memoirs of the Geological Survey of India, Palaeontologia Indica*, ser., 9, vol. 3, part 1, 87 p., 15 pls.
- Knight, J.B., Cox, L.R., Keen, A.M., Batten, R.L., Yochelson, E.L. and Robertson, R., 1960: Systematic description. In, Moore, R.C. ed., *Treatise on Invertebrate Paleontology, Part I, Mollusca 1*, p. 1169-324, The University of Kansas Press and the Geological Society of America.
- Krishna, J. and Cariou, E., 1990: Ammonoid faunal exchange during Lower Callovian between the Indo-East African and Submediterranean Provinces: Implications for the long distance east-west correlations. *Newsletter on Stratigraphy*, vol. 23, part. 2, p. 109-122.
- Lamarck, J.-B. P.-A. de Me. de., 1801: *Système des Animaux sans vertèbres*. The author: Deterville. 432 p. Paris.
- Lamarck, J.-B. P.-A. de M. de., 1804: Suite des mémoires sur les fossiles des environs de Paris. *Annales de Muséum National d'Histoire Naturelle*, vol. 5, p. 28-36.
- Lycett, J., 1863: Supplementary monograph on the Mollusca from the Stonesfield Slates, Great Oolite, Forest Marble and Cornbrash. *Palaeontographical Society (Monograph) of London*, 129 p., 31-45 pls., London.
- Maithani, J.B.P., 1967: Some new species of Jurassic gastropods and lamibranchs from the Habo dome, Kutch and their usefulness in correlation. *Records of the Geological Survey of India*, vol. 95, part 2, p. 491-524.
- Martin, K., 1914: Die Fauna des Obereocäns von Nanggulan, auf Java. A. Gastropoda. *Sammlungen des Geologischen Reichsmuseums in Leiden, Neue Folge*, vol. 2, p. 107-178.
- Mitra, K.C., Bardhan, S. and Bhattacharya, D., 1979: A study of Mesozoic stratigraphy of Kutch, Gujarat with special reference to rock stratigraphy and biostratigraphy of Keera dome. *Bulletin of Indian Geologists' Association*, vol. 12, p. 129-143.
- Mitra, K.C. and Ghosh, D.N., 1979: Jurassic turritelas from Kutch, Gujarat. *The Quarterly Journal of the Geological, Mining and Metallurgical Society of India*, vol. 51, nos. 3-4, p. 119-122.
- Münster, G. in Goldfuss, A., 1841-44: *Petrefacta Germaniae*, vol. 3, IV +120 p. Düsseldorf.
- Orbigny, A. d., 1850-60: *Paléontologie française, terrains jurassiques. Tome 2, Gastropodes*, 621 p., atlas, pls. 235-428, Paris.
- Pandey, D.K. and Fürsich, F.T., 1993: Contribution to the Jurassic of Kachchh, western India. I The coral fauna. *Beringeria*, vol. 10, p. 3-69, Wurzburg.
- Pictet, F. and Campiche, G., 1861-64: Description des fossiles du terrain crétacé des environs de Sainte-Croix, 2. *Matériaux Paléont. suisse*, série 3, 752 p., pls. 49-98, Geneve
- Piette, E., 1864-91: *Paléontologie française. Terrains jurassiques*, Gastropodes. Masson éd., 535 p., 92 pls., Paris.
- Poddar, M.C., 1959: Stratigraphy and oil possibilities in Kutch, Western India. *Proceedings, Symposium on the Development of Petroleum Resources of Asia and the Far East*, 148 p.
- Quenstedt, F., 1858: *Der Jura*. 842 p., 100 pls. Tübingen.
- Rajnaath, 1932: A contribution to the stratigraphy of Cutch. *The Quarterly Journal of the Geological, Mining and Metallurgical Society of India*, vol. 4, p. 161-174, 11 pls.
- Spath, L.F., 1927-33: Revision of the Jurassic cephalopod fauna of Kachh (Cutch). *Memoirs of the Geological Survey of India, Palaeontologia Indica, New Series* 9, vol. 2, p. 1-945.
- Sohl, N.E., 1965: Marine Jurassic gastropods, central and southern Utah. *U. S. Geological Survey Professional Paper* 503-D, p. D1-29, pls. 1-5.
- Sowerby, G.B., 1825: *A Catalogue of the Shells Contained in the Collection of the Late Earl of Tankerville*, 92 p. London.
- Swainson, W., 1840: *A Treatise on Malacology; or, Shells and Shell-fish*. 419 p. London.
- Szabo, J., 1980: Lower and Middle Jurassic gastropods from the Bakony Mountains (Hungary). Part II., Pleurotomariacea and Fissurellacea (Archaeogastropoda).

- Annales historico-naturale Musei nationalis Hungarici*, vol. 72, p. 49-71, pls. 1-4.
- Szabo, J., 1981: Lower and Middle Jurassic gastropods from the Bakony Mountains (Hungary). Part III., Patellacea and Trochacea (Archaeogastropoda). *Annales historico-naturale Musei nationalis Hungarici*, vol. 73, p. 55-67, pls. 1-2.
- Szabo, J., 1982: Lower and Middle Jurassic gastropods from the Bakony Mountains (Hungary). Part IV., Neritacea, Craspedostomatacea and Amberleyacea (Archaeogastropoda). *Annales historico-naturale Musei nationalis Hungarici*, vol. 74, p. 17-33, pls. 1-3.
- Tausch, L., 1890: Zur Kenntniss der Fauna der "grauen Kalke" der Sudalpen. *Abhandlungen der K.K. Geologischen Reichsanstalt*, vol. 15, no. 2, p. 1-42.
- Toni, A., 1912: La fauna liasica di Vedana (Belluno). pt. 2.: Molluschi. *Abhandlungen der Schweizerischen Paläontologischen Gesellschaft*, vol. 38, p. 33-52.
- Waagen, W., 1873-75: Jurassic fauna of Kutch. The Cephalopoda, *Memoirs of the Geological Survey of India, Palaeontologia Indica*, ser., 9, part 1, p. 1-247, 60 pls.
- Wenz, W., 1938-44: Gastropoda. Allgemeiner Teil und Prosobranchia. In, O.H. Schindewolf ed., *Handbuch der Paläozoologie*, Band 6, p. 1-1639. Borntraeger, Berlin.
- Wynne, A.B., 1872: Memoir on the Geology of Kutch, to accompany a map compiled by A.B. Wynne and F. Fedden, during the season 1867-68 and 1868-69. *Memoir of Geological Survey of India*, vol. 9, pt. 1.
- Zittel, K.A., 1873: Die Gastropoden der Stramberger Schichten. *Paläontographica*, supplement, vol. 2, p. 193-373, pls. 40-52.