Fossil Steginoporellid (Cheilostomata: Neocheilostomina), Bryozoa from the Tertiary sediments of Western Kachchh, Gujarat, India

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Five species of *Steginoporella* from the Palaeogene rocks of the Western Kachchh, Gujarat are described in this paper. Out of five steginoporellids, *S. mathuri* n.sp., *S. murachbanensis* n.sp. and *S. chiplonkari* n.sp. are new to science; *S. bhujensis* is already reported from this region; and *Steginoporella* sp. indet is reported for the first time in these rocks. All these species show Indo-Pacific affinities. The occurrence of *Steginoporella* from Middle Eocene to Early Miocene indicates that two stages of radiation had taken place in Kachchh. Phylogenetic analysis using PAST programme indicates that *S. mathuri* is very distinct from other species of *Steginoporella*; while *S. murachbanensis* and *S. bhujensis* form the same clade.

1. Introduction

Marine Tertiary rocks which are exposed in Western Kachchh, Gujarat (figure 1) occupy the shelf zone adjoining Mesozoic sequences. A complete succession from Palaeocene to Holocene occurs in this region (table 1). Stratigraphy of Kachchh was modified by Biswas (1992); lithostratigraphic classification proposed by him is adopted in the present study. Fossil bryozoan fauna has been collected from rocks belonging to the Harudi Formation (Middle Eocene, Lutetian), Fulra Formation (Middle Eocene, Bartonian), Maniyara Fort Formation (Rupelian–Chattian) and Khari Nadi Formation (Early Miocene, Aquitanian–Burdigalian) of the succession.

The Harudi Formation is richly fossiliferous consisting of three parts: calcareous shale with grey shale, ferruginous claystone and white nummulitic limestone. Bryozoans have been collected from ferruginous, gypseous clayey marlite band. The Fulra

Formation is best exposed at 1.7 km SW of Fulra village around Babia Hill, Waghpadhar, Kharai, Lakhpatt, Ber Nani and Harudi. Bryozoans are found in buff-coloured limestone and black argillaceous soft clay at Fulra, Kharai, and Waghpadhar and Lakhpatt sections. The Maniyara Fort Formation is subdivided into two parts: foraminiferal limestone and basal glauconitic siltstones are very well-exposed in Waior and Ramania streams and Bermoti River. The Miocene rocks unconformably rest over the Maniyara Fort Formation. They are classified into two stages Aquitanian and Burdigalian. Both these stages are represented by the rock-units, viz., Khari Nadi Formation and Chhasara Formation, respectively. Khari Nadi Formation is subdivided into three members: yellowish siltstone, fine-grained sandstone and brown gypseous claystone. The outcrops of Khari Nadi Formation are extensively exposed in between Haripar and Matanomadh along road side at Layyari (7 km NW of road); Goyala, Murachban and

Keywords. Bryozoa; Palaeogene; Steginoporellid; Kachchh (India).

Figure 1. Geological map of Western Kachchh, Gujarat (after Biswas 1992).

Waghot contain bryozoans and abundance of *Turritella* beds. Near Waghot village in the Waior–Cheropadi River, (near bridge) a huge cliff section which consists of fossiliferous yellow limestone nearly 1-m thick, a 4-m clay bed and yellow limestone at the top are exposed. Thin yellow limestone is rich in bivalves, gastropods and bryozoans. Many steginoporellids encrusted on molluscan shells were directly collected from the field. Further, 2 km from the Walaram Teerth Dham at Murachban near a small bridge, 1-m thick yellow limestone section of Khari Nadi Formation is exposed. This section is very rich in bryozoans

among all Miocene sections and yielded many fossil steginoporellid species. The occurrence of fossil Bryozoa from the Tertiary rocks of Kachchh was first reported by Tewari *et al.* (1960), Tewari and Srivastava (1967). Further, Guha and Gopikrishna (2004a, b, 2005a, b, c, d, e, 2007a, b, c, d) discovered rich and diverse bryozoan fauna from this region. Considering their diversity in these rocks, there is a need to update their systematics by conducting a bed-by-bed study. As an outcome of our research, the present communication describes five steginoporellid bryozoan species belonging to the family Steginoporellidae (Hincks 1884).

Table 1. *Stratigraphic classification of Tertiary sediments of Kachchh, Gujarat, India (after Biswas 1992).*

TIME IN M.Y.	SERIES		STAGES	LITHOSTRATIGRAPHY FORMATIONS	LITHOLOGY
10 20	MIOCENE	UPPER	MESSINIAN	SANDHAN --Unconformity--	Sandstones, minor limestones and shales.
			TORTONIAN		
		MIDDLE	SERRAVALIAN		
			LANGHIAN		
		LOWER	BURDIGALIAN	CHHASARA	Silty shales and impure limestones
			AQUITANIAN	KHARI NADI --	Variegated siltsontes and sandstones.
30	OLIGOCENE	UPPER	CHATTIAN	MANIYARA FORT	Foraminiferal limestone, shales and coral bioherms, lumpy claystones.
		LOWER	RUPELIAN		
40 50	EOCENE	UPPER	PRIABONIAN
		MIDDLE	BARTONIAN		
			LUTETIAN	HARUDI	Claystones/ limestones, coquina, etc.
		LOWER	YPRESIAN	--Unconformity--	
60 70	PALAEOCENE	UPPER	THANETIAN	NAREDI	Claystones/ limestones,
		LOWER	DANIAN	--Unconformity--	
				MATANOMADH	Volcanoclastics, shales and sandstones
				--Unconformity--	
70			DECCAN TRAP	Basalt	

2. Material and methods

Encrusters on bivalve and gastropod shells were directly collected from the field. About 250 g each of weathered, gently crushed limestone, mudstone and shells were treated with 50% concentrated H₂O₂ for 48–72 hours. Samples were gently washed over a set of standard sieves with mesh size (10–60 f), conventionally used in the foraminiferal analysis. Colonies and internodes of bryozoans were picked up from different fractions for identification.

Before identification, specimens were cleaned by soaking in dilute acetic acid (5%) solution as described by Zágorský and Vávra (2000). The orifices of autozooids and avicularium were cleaned with a very thin metallic needle. Colony surfaces were scrubbed in sodium nitrate solution and under tap water with a hard 0.2 mm brush. The specimens were identified and photographed with the help of JEOL/EO, Version-0.1SEM. Measurements were taken with 15X ocular micrometer in Nikon, SMZ-800 stereoscopic zoom microscope following

Plate 1. (a) *Steginoporella* sp. indet, complete colony; (b) *Steginoporella* sp. indet, enlarged view; (c) *Steginoporella* sp. indet, enlarged zooid; (d) *S. mathuri* n.sp., enlarged colony view; (e) *S. mathuri* n.sp., colony view and B-zooid; (f) *S. mathuri* n.sp., enlarged single A-zooid.

standard measuring techniques. All dimensions are in fractions of millimetre, the observed range expressed to the nearest 0.01 mm, and the mean and standard deviation calculated following the procedure described by Cheetham (1966). For conciseness, the following scheme of parameters is applied throughout the systematic part of this paper: Lz = length of zooid, lz = width of zooid, Lop = length of opesia, lop = width of opesia, N = number of zooids, mean = $\bar{x}$, standard deviation (SD), coefficient of variation (CV) and observed range.

The systematic part of this paper follows except otherwise indicated, the 'Treatise on Invertebrate Palaeontology' by Bassler (1953) along with the working list for the treatise recommended by Gordon (2005). The described types are housed in the Museum of Geology, P.G. Department of Geology, Government Institute of Science, Aurangabad under catalogue numbers as indicated in the text.

3. Systematic palaeontology

Suborder: Neocheilostomina d'Hondt, 1985

Infraorder: Flustrina Smitt, 1868

Superfamily: Microporoidea Gray, 1848

Family: Steginoporellidae Hincks, 1884

Genus: *Steginoporella* Smitt, 1873

S. mathuri n.sp., Plate 1d, e, f

Material: 20 specimens

Holotype: GIS/0001, Paratypes: GIS/B: 0002-0020

Dimensions:

Field no.	A-zooid	<i>R</i>	$\bar{x}$	<i>N</i>	<i>S</i>	<i>V_c</i>
GIS/ B 0001	Lz	0.063–0.087	0.0714	10	0.0034	4.76
	lz	0.036–0.048	0.0468	10	0.00167	3.56
	Lop	0.024–0.042	0.0273	10	0.00334	12.23
	lop	0.021–0.036	0.0249	10	0.0022	8.83
B-zooid	Lz	0.024–0.026	0.0260	4	0.0019	0.04
	lz	0.019–0.020	0.195	4	0.00094	0.048
	Lop	0.06–0.08	0.57	4	0.29	0.5
	lop	0.12–0.15	0.126	4	0.0026	0.02

Type horizon and locality: Fossiliferous yellowish limestone cliff section in Waior–Charopadi stream (near bridge), 1.5 km southeast of Waghot village.

Age: Lower Miocene (Aquitania)

Diagnosis: Bilaminar, encrusting colonies with subrectangular A-zooids. Broad and arched distal sclerite. Cryptocyst perforated, developed up to half height from the proximal, short polypide tube, B-zooids rare, large.

Description: Colony encrusting, bilaminar, A-zooids arranged in linear longitudinal rows, roughly elongate subrectangular, bordered by smooth, thick and raised mural rim, with distinct sutures, slightly tapering proximally. Distal sclerite raised, broad and slightly arched. Opesia roughly rectangular in outline; frontal with perforated cryptocyst developed up to half height from the proximal and ending in short polypide tube. B-zooids large, sparingly occurring, roughly rectangular, with wide arch shape opesial opening, condyles absent. Polypide tube short, located laterally either on the left or the right side. Opesiules and ovicells not observed.

Remarks: Present species closely resembles *S. bhujensis* (Guha and Gopikrishna 2007a, b, c, d; p. 806, pl. 1, figure 7 and pl. 2, figure 1). However, as compared to *S. bhujensis*, the present species differs in having broad and slightly arched distal sclerite, condyles absent, short polypedian tube and thin mural rim with distinct sutures. *S. arabica* (Braga and Bahr 2003; p. 255, pl. 1, figures 11–13) exhibits some resemblance to the present species; however, *S. arabica* has erect, flat or cylindrical colony, zooids are long and strictly rectangular, opesia quadrangular and cryptocyst is thinly porous. *S. magnilabris* (Busk), (Winston 1984; p. 10, figures 17, 18) differs from the present species in having more arched sclerite with distinct condyles and large, centrally placed polypide tube. *S. cucullata* (Reuss) (Zágoršek 2001; p. 528, pl. 5, figure 3) can be easily distinguished from the Indian material in its multiserial form, hexagonal zooids and semicircular opesia with short and arched sclerite.

Occurrence: Waghot (23°23'58"N, 68°41'55"E), 29 colony fragments from yellow limestone (Lower Miocene, Aquitania).

Etymology: The species is named in the honour of Late Dr D R Mathur for his pioneering work on Holocene Bryozoa.

S. murachbanensis n.sp., Plate 2(a, b)

Material: 11 specimens

Holotype: GIS/B-0021, Paratypes: GIS/B: 0022-0032

Plate 2. (a) *S. murachbanensis* n.sp., enlarged colony view; (b) *S. murachbanensis* n.sp., enlarged B and A-zooids; (c) *S. bhujensis* (Guha and Gopikrishna) Complete colony; (d) *S. bhujensis* (Guha and Gopikrishna 2007) enlarged zooid.

Dimensions:

Field no.	A-zooid	<i>R</i>	$\bar{x}$	<i>N</i>	<i>S</i>	<i>V_c</i>
GIS/ B 0004	Lz	0.025–0.027	0.0253	10	0.001923	0.76
	lz	0.017–0.018	0.197	10	0.000948	0.52
	Lop	0.5–0.8	0.56	10	0.028	0.05
	lop	0.12–0.14	0.129	10	0.002626	2.03
B-zooid	Lz	0.18–0.21	0.17	05	0.00830	4.88
	lz	0.10–0.11	0.103	05	0.001385	1.34
	Lop	0.18–0.20	0.186	05	0.1969	1.05
	lop	0.11–0.12	0.103	05	0.005130	4.98

Type horizon and locality: Fossiliferous limestone section of Chhasara Formation exposed in the stream near Kothara–Walaram Teerthdham Road Bridge, 2 km away from Walaram Teerthdham, Murachban.

Age: Upper Miocene (Burdigalian)

Diagnosis: Bilaminar, eschariform colonies with rectangular A-zooids. Broad distal sclerite. D-shaped opesia. B-zooids rare, large, rectangular. Condyles indistinct. Polypide tube very short.

Description: Colony bilaminar, eschariform. A-zooids arranged in longitudinal, linear rows, rectangular in outline, surrounded by raised, thick mural rim. Distal sclerite slightly raised, broad, somewhat arched. Opesia 'D'-shaped. Frontal with minutely perforated cryptocyst, developed half of the total length of zooid. Cryptocyst ending into very short collar-like polypedian tube. B-zooids rare, large, rectangular with wide roughly squarish opesial opening. Lateral condyles indistinct. Polypide tube if observed, very short, placed centrally. Opesiules and ovicells not observed.

Remarks: As compared with *S. bhujensis* (Guha and Gopikrishna 2007a, b, c, d; p. 806, pl. 1, figure 7 and pl. 2, figure 1), the present species differs in having rectangular zooids, slightly raised distal sclerite, descending cryptocyst with indistinct condyles and 'D'-shaped opesia. Present species clearly distinguished from *S. parvicella* (Canu and Bassler 1929; Taylor and Foster 1998; p. 67, figure 15) in having bilaminar growth habit, short median process, broad and slightly raised distal sclerite. *S. jacksonica* (Canu and Bassler 1920; p. 262, pl. 39, figures 9–16) differs from the Indian species in having long, narrow zooids with raised, distinct mural rim; B-zooids have raised thin distal sclerite. *S. rectangularia* (Canu and Bassler 1920; p. 263, pl. 40, figure 1) shows some resemblance to present species but differs in having distinct, raised mural rim, arched distal sclerite and prominent median process.

Occurrence: Murachban (23°30'10"N, 68°52'990"E) 23 colony fragments from yellow limestone (Lower Miocene, Burdigalian).

Etymology: The species is named after the type locality Murachban.

S. chiplonkari n.sp., Plate 3(a, b, c, d)

Material: 13 specimens

Holotype: GIS/B-0033, Paratypes: 0034-0046

Dimensions:

Field no.	A-zooid	<i>R</i>	$\bar{x}$	<i>N</i>	<i>S</i>	<i>V_c</i>
GIS/B 0006	Lz	0.054–0.084	0.0663	10	0.0079	11.91
	lz	0.014–0.051	0.0392	10	0.003	7.65
	Lop	0.018–0.033	0.027	10	0.002	7.40
	lop	0.024–0.033	0.0276	10	0.00117	4.2

Type horizon and locality: White nummulitic limestone horizon of the Maniyara Fort Formation, upstream direction of the Waior village in front of 'Jaypee Cement' factory in the stream.

Age: Upper Oligocene (Chattian).

Diagnosis: Erect, multiserial, cylindrical colonies with strictly rectangular autozooids. Oval opesia. Distal sclerite raised, thick, straight. Cryptocyst perforated. Polypedian tube slightly raised. Presence of A and B-zooids is not clear.

Description: Colony erect, multiserial, cylindrical. Autozooids long and strictly rectangular, arranged in longitudinal rows, bordered by thick, raised mural rim. Opesia oval, longer than wide, arched distally, slightly wide and roughly straight proximally. Distal sclerite raised, thick, straight. Cryptocyst perforated, half of the total zooidal length, slightly descending into opesia. Polypedian tube slightly raised into collar shape centrally. In few observed specimens, presence of A and B-zooids is not clear. Opesiules and ovicells not observed.

Remarks: *S. arabica* (Braga and Bahr 2003; p. 255, pl. 1, figures 11–13) exhibits close resemblance to present species, but differs in having erect flat growth habit, quadrangular opesia and indistinct opesiular indentations. *S. rectangularia* (Canu and Bassler 1920; p. 263, pl. 40, figure 1) shows superficial resemblance with present species, but in *S. rectangularia*, opesia is D-shaped. *S. jacksonica* (Canu and Bassler 1920; p. 262, pl. 39, figures 9–16) shows some resemblance with the present species but differs in having arched distal sclerite, D-shaped opesia and highly perforated cryptocyst. *S. jacksonica* is much similar to *S. rectangularia* as shown by Pouyet and David (1979a).

Plate 3. (a) *S. chiplonkari* n.sp., enlarged autozooid; (b) *S. chiplonkari* n.sp., enlarged colony; (c) *S. chiplonkari* n.sp., enlarged colony; (d) *S. chiplonkari* n.sp., Complete colony.

Occurrence: Waior (23°25'30"N, 68°41'58"E), 89 colony fragments from white nummulitic limestone (Upper Oligocene, Chattian).

Etymology: The species is named in the honour of great Indian palaeontologist Late Prof. G W Chiplonkar.

Steginoporella sp. indet, Plate 1(a, b, c)

Material: Single specimen. Preservation not fair.

Holotype: GIS/B-0047

Dimensions:

Field no.	A-zooid	<i>R</i>	$\bar{x}$	<i>N</i>	<i>S</i>	<i>V_c</i>
GIS/B 0020	Lz	0.051–0.6	0.0546	10	0.0051	9.34
	lz	0.007–0.03	0.0291	10	0.0024	8.24
	Wz	0.018–0.021	0.0207	10	0.00028	1.35
	Wz	0.018–0.024	0.0213	10	0.000648	3.04

Type horizon and locality: Argillaceous clay-stone in the type section on the southern flank of Babia hill near 'Pandhro mines', 2 km from Fulra village.

Age: Middle Eocene (Lutetian).

Description: Colony erect, multiserial, zooids arranged in longitudinal linear rows, tapering distally and elongate-oval proximally, somewhat flask-shaped, bordered by thin raised mural rim with distinct sutures. Opesia elliptical, wider than long, slightly arched, distal sclerite little raised. Polypide tube not raised, opesiules slit-like elongated unequal in size. Cryptocyst one-third of the total zooidal length, shallow, minutely perforated, raised towards opesia. In the observed specimen, presence of A and B-zooids is not clear. Ovicells not observed.

Remarks: The generic placement of this species is still doubtful because we could collect only one specimen. Gordon (*Pers. Commun.* 2012) remarked that its generic placement is problematic based on the limited information in the photos. Opesiules are possible in *Steginoporella* as shown by Harmer (1900) – it depends on the degree of fusion of the distal process with the zooid margins. However, the opesiules in this species appear to be more longitudinally elongate (assuming these are not fractures). One possibility is *Caleschar*; the finding of ovicells would confirm this. Concerning *Setosella* – the illustrations of the type species in the UK Synopsis (Hayward and Ryland 1977; Prenant and Bobin 1966), would rule out this possibility. The type species is small and encrusted with interzooidal avicularia and ovicells. Hence, provisionally being placed under *Steginoporella* as species indeterminate, because better preserved

material, is required to confirm the generic and specific name. Among all the species of *Steginoporella* described from various parts of the world, this form appears to be different; hence, this species is new. *S. brevis punctata* (Canu and Lecointre 1927; David and Pouyet 1979a; p. 770, pl. 2, figure 10; pl. 4, figure 6) shows some resemblance to the present species, but differs in the shape of zooids and opesia with small rounded opesiules. *S. turbarens* (Canu and Lecointre 1927; David and Pouyet 1979a; pl. 2, figure 6) differs from the present species in having semicircular, nearly D-shaped opesia and broad, thick mural rim.

Occurrence: Fulra (23°42'30"N, 68°47'12"E), one colony fragment from argillaceous clay (Middle Eocene, Lutetian).

S. bhujensis, Guha and Gopikrishna (2007b), (Plate 2c, d) *S. bhujensis*, Guha and Gopikrishna (2007b); p. 807, pl. 1, figure 7 and pl. 2, figure 1.

Material: 22 colonies

Plesiotype: GIS/B: 0048-0070

Dimensions:

Field no.	A-zooid	<i>R</i>	$\bar{x}$	<i>N</i>	<i>S</i>	<i>V_c</i>
GIS/B 0021	Lz	0.068–0.08	0.073	15	0.00151	0.26
	lz	0.088–0.104	0.094	15	0.00186	1.97
	Lop	0.002–0.00016	0.00187	15	0.00176	9.41
	lop	0.036–0.052	0.0453	15	0.00146	3.22

Description: Colony erect, bilaminar, eschariform. A-zooids arranged in longitudinal linear rows; subrectangular in outline, arched distally and narrowed proximally. Opesia crescent-shaped, distal sclerite moderately raised, thin and continues laterally into small indentations. Polypide tube centrally raised, collar-like structure, Cryptocyst half of total zooidal length, shallow, minutely perforated slightly sloping into opesia. B-zooids are rare, if present, distal mandibles broadly arched. Ovicells and opesiules, not observed.

Remarks: The present species is similar to *S. bhujensis* (Guha and Gopikrishna 2007a, b, c, d; p. 806, pl. 1, figure 7 and pl. 2, figure 1) in having subrectangular zooids, slightly raised distal sclerite, sloping cryptocyst with distinct lateral condyles.

Occurrence: Waior (23°25'30"N, 68°41'58"E), 22 colony fragments from white nummulitic limestone (Upper Oligocene, Chattian).

Distribution: Ramania stream, Waior and Chhasara.

4. Discussion

4.1 Affinities and endemism of the fauna

From Kachchh region, Guha and Gopikrishna (2007a, b, c, d) reported a rich and diverse assemblage of steginoporellid bryozoans. These genera are *Labioporella* (Harmer 1926), *Reniporella* (Guha and Gopikrishna 2004a, b) and *Steginoporella* (Smitt 1873). Among them, two species of *Labioporella* and one species each of *Steginoporella* and *Reniporella* have been reported. In the present study, we have reported five species of *Steginoporella*. These species are very diverse in morphological characters. However, all these species show very close affinity to Harmer's division (I), in which B-opercula has inverted U-shaped main sclerite and A-opercula undifferentiated or with two teeth on the main sclerite (Harmer 1900). Pouyet

and David (1979b) considered this group as IA in which they have included many species already discussed by Guha and Gopikrishna (2007a, b, c, d). In Kachchh region, we are reporting *Steginoporella* from the Middle Eocene (Lutetian), Lower Oligocene (Rupelian) Upper Oligocene (Chattian), and Early Miocene (Aquitanian and Burdigalian) periods (see table 2). So far, there is no record of steginoporellids or other bryozoans from the Middle Miocene–Pliocene sediments. Oyster bands occurring in the Sandhan Formation are to be critically searched for bryozoan encrustations. This clearly shows that in Kachchh region during the Tertiary period, two radiations occurred similar to the lower and middle Eocene of Central American province and a second radiation similar to the European Tethyan province during Upper Oligocene and early Miocene. However, the third

Table 2. *Distribution of Steginoporella in stratigraphic column of Western Kachchh.*

Time M. Y.	Series	Stages	Lithostratigraphy Formations	Distribution of <i>Steginoporilla</i>
Miocene	Upper	Messinian	Sandhan	Nil
		Tortonian		
	Middle	Serravallian	--Unconformity--	
		Langhian		
	Lower	Burdigalian	Chhasara	<i>S. murachbanensis</i>
		Aquitanian	Khari Nadi --Unconformity--	<i>Steginoporella mathuri</i>
Oligocene	Upper	Chattian	Maniyara Fort	<i>S. chiplonkari</i>
	Lower	Rupelian	--Unconformity--	<i>S. bhujensis</i>
Eocene	Upper	Priabonian		
	Middle	Bartonian	Fulra	<i>Steginoporella sp. indet</i>
		Lutetian	Harudi	Nil
	Lower	Ypresian	--Unconformity--	Nil
			Naredi	--Unconformity--
Palaeocene	Upper	Thanetian	Matanomadh --Unconformity--	Nil
	Lower	Danian	Deccan Traps	Basalt

stage of radiation in Australian province during the late Miocene and the Pliocene is either absent or overlooked in the search for bryozoans. The species we reported shows Indo-Pacific affinities. Therefore, from 35–20 m.y., the Kachchh region experienced warm tropical currents suitable for optimal intensification of bryozoans (Guha and Gopikrishna 2007a, b, c, d).

4.2 Phylogenetic analysis

Phylogenetic analysis was carried out using PAST (version-2.06). Four species of Steginoporellid Bryozoa have been taken for analysis. *Steginoporella* sp. indet has not been considered because its generic placement is not confirmed and is provisionally placed under *Steginoporella*. There are very few characters available in fossil Steginoporellid species. Important specific characters are chosen for data matrix. A matrix of 11 skeletal characters was prepared for all species of *Steginoporella*. Most of the characters are binary. Phylogram clearly shows one assemblage, which represents a set of similar morphological characters. Assemblage-I consists of two species namely: *S. murachbanensis* and *S. bhujensis*, the former species belongs to the Burdigalian and the latter to the Chattian. Both these species form the same clade and exhibit similarity in their growth habit, nature of condyles, distal sclerite, etc. However, *S. chiplonkari* occurs on a higher branch and has erect, cylindrical growth habit; distal sclerite straight and presence of A/B-zooids is not clear. Thus, this species is different from the species included by Pouyet and David (1979b) in group IA. *S. mathuri* which belongs to Aquitanian is far distant from the above three species of *Steginoporella*.

Branch length = 18, CI = 1, RI = 1.

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Appendix 1

Character coding of *Steginoporella*:

- A. **Colony form:** encrusting uniserial (0), encrusting multiserial (1), erect bifolite (2), erect vincularian/cellariiiform (3).
- B. **Shape of autozooids:** 1. rectangular, 2. sub-rectangular, 3. strictly rectangular.
- C. **Shape of Opesia:** 1. rectangular, 2. D-shaped, 3. oval, 4. crescentic.
- D. **B-Zooids:** 0. absent, 1. present.
- E. **Shape of distal sclerite of the B-zooid:** 0. absent, 1. broadly arched, 2. squarish.
- F. **Cryptocyst perforation:** minutely perforated (1), perforated (2).
- G. **Condyles:** absent (0), indistinct (1), distinct (2).
- H. **Polypedian tube:** missing (?), slightly raised (1), highly raised (2).
- I. **Mural rim:** thin raised (1), thick raised (2).
- J. **Distal sclerite:** less arched (1), straight (2), highly arched (3).
- K. **Projection of distal sclerite:** slightly raised (1), moderately raised (2), raised (3).

Appendix 2

Name of species	A	B	C	D	E	F	G	H	I	J	K
<i>S. mathuri</i>	2	2	1	1	1	2	0	1	2	1	1
<i>S. murachbanensis</i>	2	1	2	1	2	1	1	0	2	1	1
<i>S. chiplonkari</i>	3	3	3	0	0	2	0	1	2	2	3
<i>S. bhujensis</i>	2	2	4	1	2	1	2	2	2	3	2

Explanation of Plate 1

- a. *Steginoporella* sp. indet, complete colony
- b. *Steginoporella* sp. indet, enlarged view
- c. *Steginoporella* sp. indet, enlarged zooid
- d. *S. mathuri* n.sp., colony view and B-zooid
- e. *S. mathuri* n.sp., enlarged colony view
- f. *S. mathuri* n.sp., enlarged single A-zooid

Explanation of Plate 2

- a. *S. murachbanensis* n.sp., enlarged colony view
- b. *S. murachbanensis* n.sp., enlarged B and A-zooids
- c. *S. bhujensis* (Guha and Gopikrishna 2007b), complete colony
- d. *S. bhujensis* (2007b), enlarged zooid

Explanation of Plate 3

- a. *S. chiplonkari* n.sp., enlarged autozooid
- b. *S. chiplonkari* n.sp., enlarged colony
- c. *S. chiplonkari* n.sp., enlarged colony
- d. *S. chiplonkari* n.sp., complete colony

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