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AMPHIROA, A GENICULATE CORALLINE ALGA, FROM THE NEOGENE-QUATERNARY SEDIMENTS OF THE PORBANDAR AREA, GUJARAT

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ABSTRACT

The Neogene-Quaternary sediments of the Porbandar area contain well-preserved geniculate coralline algal species of genus *Amphiroa*. The present paper documents 07 coralline algal species of genus *Amphiroa,* namely *Amphiroa anchiverricosa, A. ephedraea, A. fortis, A. fragilissima, A. rigida, A. prefragilissima,* and *A. prerigida* from these sediments. *Amphiroa* is associated with various nongeniculate coralline algal species and this association points that the Dwarka Formation was deposited in marine tropical environment with high energy conditions at depths ranging from the intertidal to 60 m, the Adatiana Member of Miliolite Formation was deposited under shallow marine tropical environment with moderate to low-energy conditions, and bathymetry fluctuating from intertidal to 60m and the Porbandar Calcarenite Member of the Chaya Formation was deposited under tropical to subtropical marine environment with bathymetry in the range of 40m to 60m having moderate to low energy conditions.

Keywords: Geniculate coralline algae, *Amphiroa*, Neogene-Quaternary, Palaeoenvironment, Porbandar, Gujarat

INTRODUCTION

The Neogene-Quaternay sediments of the Porbandar area are represented by limestones, calc-arenites, calc-rudites and marls. These sediments have been classified as the Gaj Formation (lower Miocene), Dwarka Formation (early-middle Miocene), Miliolite Formation (early middle-late Pleistocene) and Chaya Formation (late Pleistocene-late Holocene) (Mathur *et al.,* 1988). However in the study area the Gaj Formation is not encountered (Fig. 1, Table 1). The Miliolite Formation is split into two members, Dhobaliya Talav Member (early middle Pleistocene) and Adatiana Member (middle to late Pleistocene). Pandey *et al.* (2007) classified the Chaya Formation into three different members as Okha Shell Limestone, Aramda Reef Member and Porbandar Calcarenite Member. Rocks of the Chaya Formation are included under Porbandar Calcarenite Member with late Pleistocene to late Holocene age. In the present paper, authors have followed the stratigraphic work of Mathur *et al.,* 1988, with some modifications after recent publications (Fig.1, Table 1).

In the present paper 07, geniculate coralline algal species, namely *Amphiroa anchiverricosa, A. ephedraea, A. fortis, A. fragilissima, A. rigida, A. prefragilissima* and *A. prerigida* are recorded from the Neogene-Quaternary sediments of the Porbandar area. Distribution of geniculate coralline alga, *Amphiroa*, from different Indian stratigraphic horizons is given in table 2.

ACC quarry is located 6 to 7 km on coastal highway near Chhaddeshwar mandir, Ratanpur village (Fig. 2a). Here three types of limestones belonging to the Porbandar Calcarenite Member (Chaya Formation) are exposed. At the base 2 m dirty white limestone is exposed followed by 0.5 m white limestone and 3.5 m of dirty white limestone. Three samples were collected from three different units having sample nos., CHR (dirty white limestone), CHR1 (white limestone) and CHR2 (dirty white limestone). White limestone has yielded 04 geniculate coral-

Table 1: Classification of Neogene-Quaternary sequence of Porbandar area, Saurashtra, (Modified after Mathur *et al.,* 1988, Bhatt, 2000 & 2003, Pandey *et al.,* 2007).

Stratigraphic Unit	Lithology	Age
ALLUVIUM AND COASTAL DEPOSITS	Freshwater alluvium (sands, clays) Coastal deposits (Lime mud; rann clays with carbonaceous material /marine shells; unconsolidated calcareous sands)	Holocene
PORBANDAR GROUP		
Chaya Formation		
Porbandar Calcarenite Member	Semiconsolidated to consolidated limestone (calcirudites); shell limestone;coral reef , oyster beds and calcarenites with megafossils	Late Pleistocene to Late Holocene
Miliolite Formation		
Adatiana Member	Pelletoid limestone (calcarenites)	Middle to Late Pleistocene
Dhobaliya Talav Member	Alternating sequence of pelletoid limestone and fine-grained limestone (micrites)	Early Middle Pleistocene
Dwarka Formation	Flaggy; arenaceous limestone with recrystalli-sed shells;clays	Early to Middle Miocene
Gaj Formation, Laterite and Deccan Trap		

Table2: *Amphiroa* Lamouroux, from different Indian stratigtaphic horizons.

Authors	Species of *Amphiroa*	Stratigraphic horizons
Sastry, Rao and Iqbaluddin (1963)	*Amphiroa* sp.	Nerinea beds of Pondichery, South India.
Chatterji and Gururaja (1972)	*Amphiroa* sp. and *A. prefragilissima*	Chitmala Limestone, Archipalago Series, Little Andaman
Gowda (1978)	*Amphiroa* sp.	Cretaceous rocks from Trichinopoly Group, South India
Misra and Kumar (1988)	*Amphiroa veragurense, A. guatemalense* and *A. elliotti*	Upper Cretaceous rocks from Trichinopoly Group, South India
Chandra, Saxena and Ghosh (1999)	*Amphiroa fragilissima, A. prefragilissima* and *A. medians*	Kakana Formation (Middle Pliocene) of Car Nicobar Island.
Misra, Jauhri, Singh, Kishore and Chowdhury (2001)	*Amphiroa* sp.	Maniyara Fort Formation of Kachchh, Gujarat
Kundal and Humane (2002)	*Amphiroa anchiverricosa*	Maniyara Fort Formation, Chhasra Formation and Khadi Nadi Formation of Kachchh, Gujarat
Kundal and Dharashivkar (2003a)	*Amphiroa anchiverricosa, A. badvei, A. dwarkaensis, A. foliacea, A. fragilissima, A. gadhechiensis, A. krishnai* and *A. pacifica*	Lower Pliocene sediments from Dwarka-Okha area, Gujarat
Kundal and Dharashivkar (2005)	*Amphiroa* Sp.	Rhodoliths from Aramda Reef Member (late Pleistocene to Holocene), Chaya Formation, Dwarka –Okha area, Gujarat
Misra, Jauhri, Singh, Kishore, Rajanikanth (2006)	*Amphiroa guatemalense, A. foliacea and A. kaskaella*	Early Creataceous, Uttatur Group, South India
Kalita and Gogoi (2006)	*Amphiroa* sp.	Late Palaeocene Lakadong Limestone, Meghalaya

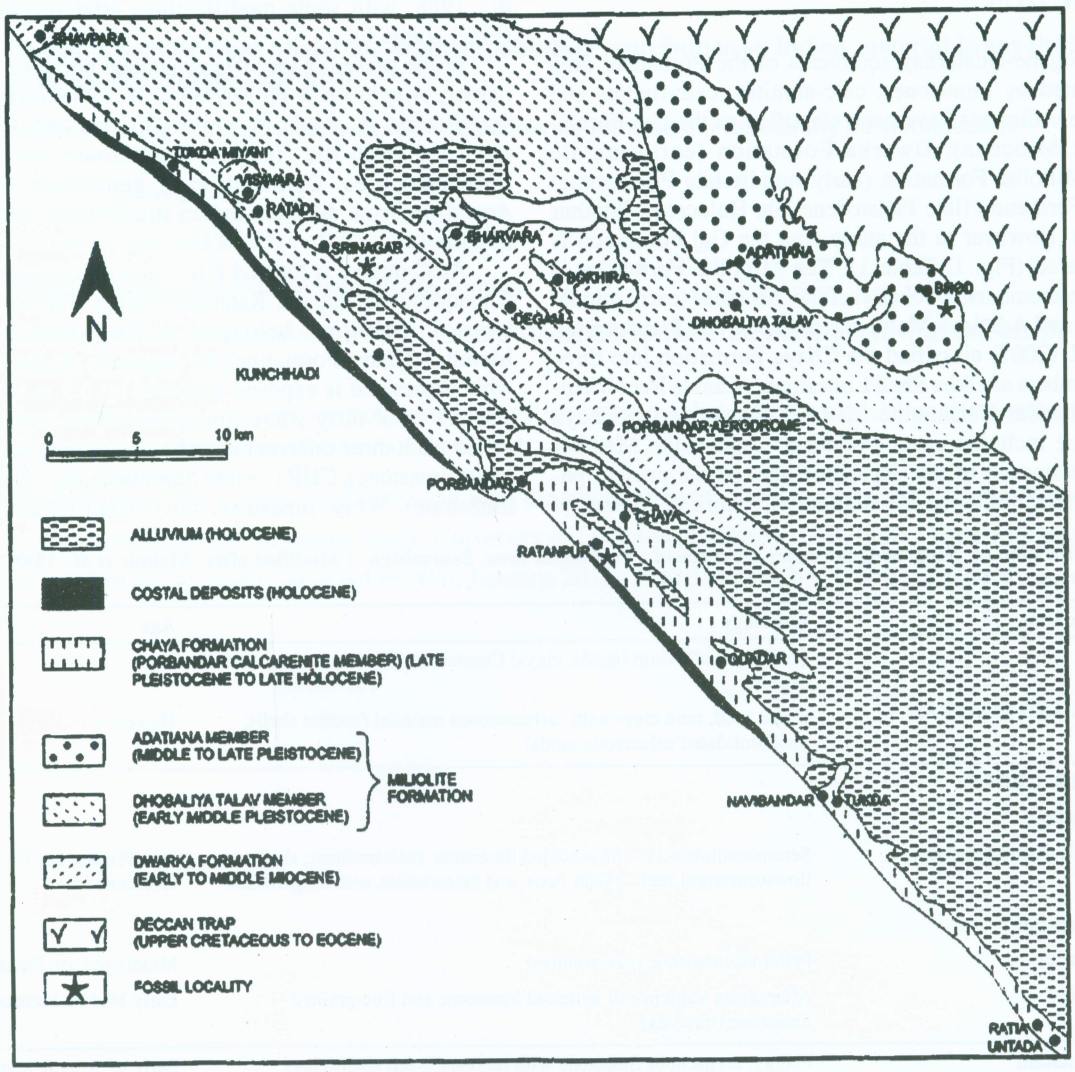


Fig. 1. Geological Map of the Porbandar area (After Mathur et al., 1988).

line algal species, namely *Amphiroa ephedraea*, *A. fortis*, *A. rigida*, and *A. fragilissima*. The Adatiana Member of Miliolite the Formation containing geniculate coralline algae is exposed at Bhod village (Fig. 2b), 20 km NE of Porbandar on Porbandar-Rajkot highway and 4-5 km west side of the road. It consists of dirty white limestone (calcarenite), which is 1 m in thickness and has yielded geniculate coralline algal species, *Amphiroa ephedraea*. The Dwarka Formation is exposed around Srinagar area (Fig. 2d) as a continuous strip running parallel to the coastal line. Srinagar village is located north side of coastal highway and it is nearly 20 km away from Porbandar. The main lithological unit of this formation is a hard compact limestone, which is highly arenaceous in nature. In this section 1.50 m arenaceous brownish limestones is overlain by 0.5 m thick massive limestone. Samlpes S1, S2 were taken from arenaceous brownish limestone and S3 was collected from massive limestone. The sample number S1 and S2 have yielded *A. fragilissima*, *A. ephedraea*, *A. rigida*, *A. prefragilissima*, and *A. prerigida*. There is an inlier of Dwarka Formation at Bhavpara village (Fig. 2c), 35 km NW of Porbandar on NE side of Porbandar-Dwarka road. In this section, 0.5 m Deccan Trap is succeeded by 1 m whitish/pinkish clays and 0.5 m brownish limestone. The clays and limestone belong to the Dwarka Formation. Samples BP (clays) and BP1 (brownish, pinkish limestone) were collected and BP1 yielded geniculate coralline algal species namely, *Amphiroa anchiverricosa*, *A. ephedraea*, *A. fragilissima* and *A. rigida*.

PREVIOUS WORK ON CORALLINE ALGAE FROM SAURASHTRA

Kundal and Dharashivkar (2003a, b) documented 8 species of *Amphiroa*, 8 species of *Lithothamnion* and 2 species of *Mesophyllum* from Neogene-Quaternary sediments of Dwarka-Okha area. Further, Kundal and Dharashivkar (2005) recorded rhodoliths from Aramda Reef Member (late Pleistocene to Holocene) of the Chaya Formation from the Dwarka-Okha area and documented presence of coralline algal genera such as *Lithoporella*, *Lithothamnion*, *Lithophyllum*, *Porolithon*,

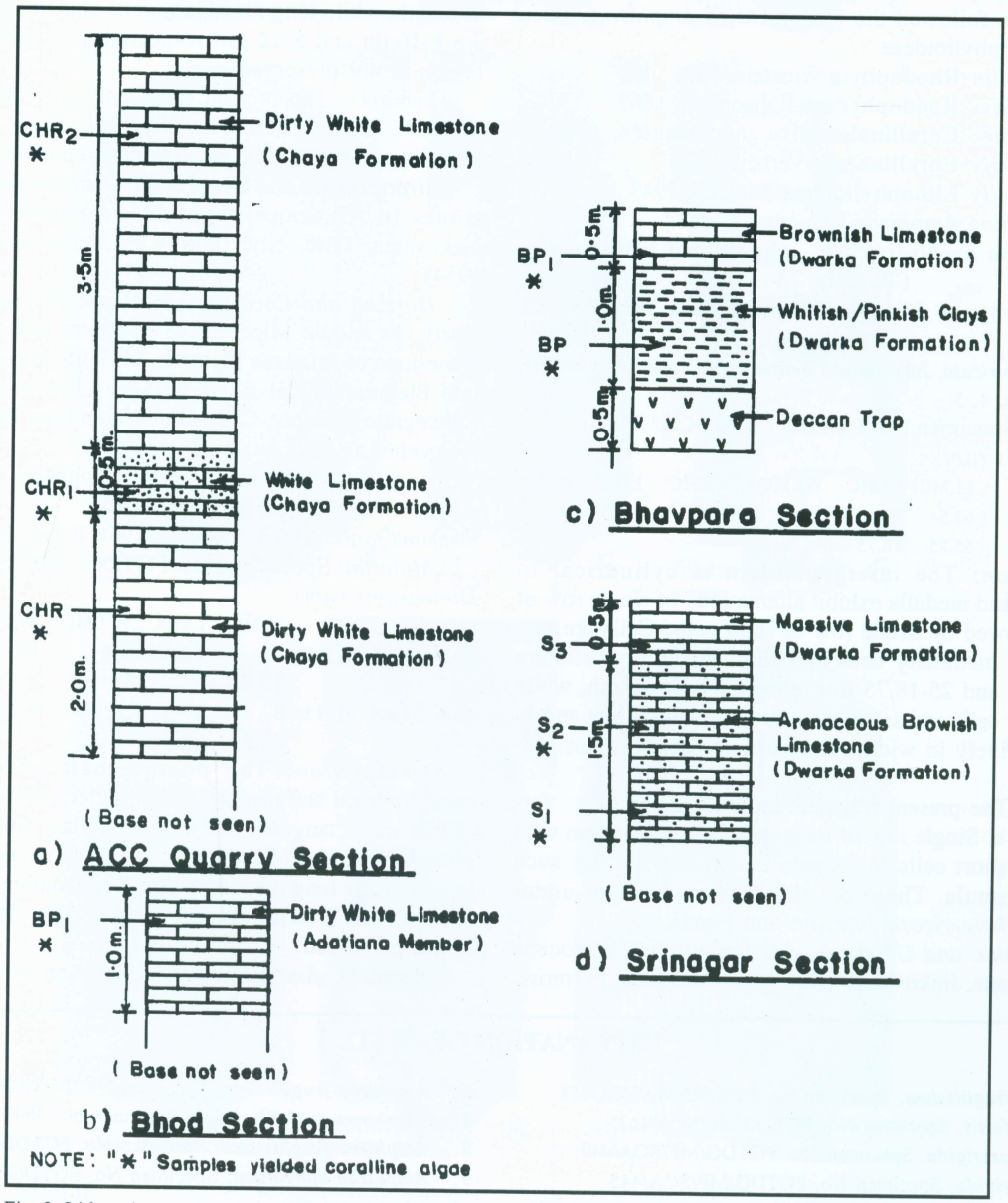


Fig. 2. Lithocolumns showing position of samples yielding coralline algae.

Sporolithon and *Amphiroa* in the rhodoliths.

Kundal and Mude (2009a, b) described and illustrated 6 nongeniculate and 9 geniculate coralline algal species from the Neogene-Quaternary sediments of the Porbandar area. Very recently, Mude and Kundal (2010) documented genicula, which are rarely preserved as fossil, from Neogene-Quaternary sediments of the Porbandar area.

SYSTEMATIC DESCRIPTION

The following abbreviations are used for the dimensions of geniculate coralline algal species: SN – Specimen Number, WS – Width of Segment / Fragment, AF – Alternation formula, LLMC – Length of long medullary cells, WLMC – Width of long medullary cells, LSMC – Length of short medullary cells, WSMC – width of short medullary cells, LCC – Length of cortical cells, WCC – width of cortical cells. Previously, *Amphiroa*, a geniculate alga was placed under subfamily Amphiroidae of family Corallinaceae. However, Bailey (1999) and Harvey *et al.* (2003) have transferred *Amphiroa* under subfamily Lithophylloideae of family Corallinaceae. Misra *et al.*, (2006) have followed the placement of *Amphiroa* under subfamily Lithophylloideae.

Division **Rhodophyta** Wittstein, 1901
Class **Rhodophyceae** Rabenhorst, 1863
Order **Corallinales** Silva and Johansen, 1986
Family **Corallinaceae** Verheij, 1993
Subfamily **Lithophylloideae** Setchell, 1943
Genus ***Amphiroa*** Lamouroux, 1812

Amphiroa anchiverricosa Johnson and Ferris
(Pl. I, fig. 7)

Amphiroa anchiverricosa Johnson and Ferris: Ishijima, 1954, P. 61-62, Pl. 39, Figs. 1-3.

Amphiroa anchiverricosa, Johnson and Ferris: Kundal and Dharashivkar, 2003a, Pl. 1, Figs. 4, 5.

Material: Specimen No. PGTDG / MF/ SCA/ 443

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
443	287.5	1L, 1S	62.5-65.25	25-18.75	8	8-12	Nil	Nil

Description: The intergeniculum is cylindrical to subcylindrical and medulla exhibit alternation of single row of long cells followed by single row of short cells. Cells are rectangular. Long medullary cells and short medullary cells are 62.5-65.25 μm and 25-18.75 μm respectively in length, while long medullary cells and small medullary cells are 8 μm and 8-12 μm respectively in width. The cortical region is not preserved.

Remarks: The present fragment exhibits alternation formula 1L; 1S i. e. Single row of long cells is in alternation with single row of short cells. *Amphiroa anchiverricosa* has such alternation formula. Therefore this fragment is put under *Amphiroa anchiverricosa* Johnson and Ferris.

Stratigraphic and Geographic Distribution: Pleistocene Ryukyu limestone, Jinkoshi, Koshun-gun, Takao-shu, Formosa, Western Pacific (Ishijima, 1954), Lower Pliocene of Dwarka Okha area, Gujarat (Kundal and Dharashivkar, 2003a).

Horizon and Locality: Limestone of Dwarka Formation (early to middle Miocene) at Bhavpara village.

Amphiroa ephedraea Ishijima
(Pl. I, fig. 9)

Amphiroa ephedraea Ishijima: Ishijima,1954, P.53,Pl. 37, Fig. 2

Material: Specimen Nos. PGTDG / MF/ SCA/ 400, 447, 448

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
400	325	2L,1S, 3L,1S	62.5-56.25	25-12.5	8	8-10	Nil	Nil
447	162.5	2L,1S, 3L,1S	75-62.5	25	8	8-10	Nil	Nil
448	387.5	2L,1S, 3L,1S	56.25-50	18.75	10	10-12	Nil	Nil

Description: The intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 2L, 1S, 3L, 1S. Cells are rectangular. The long medullary cells and short medullary cells are 100-62.5 μm and 62.5-12.5 μm respectively in length, while long medullary cells and small medullary cells are 8-10μm and 8-12 μm respectively in width. The cortical region is not preserved.

Remarks: The present fragments have alternation formula 2L, 1S, 3L, 1S like *Amphiroa ephedraea* Ishijima. Therefore, they are identified as *Amphiroa ephedraea* Ishijima.

Stratigraphic and Geographic Distribution: Pliocene limestones in Hinazan Conglomerate Formation exposed at Nekoyama, Taito- city, Taito -Cho, Formosa, Japan (Ishijima, 1954).

Horizon and Locality: Limestone of Dwarka Formation (early to middle Miocene) at Bhavpara and Srinagar village. Limestone of Adatiana Member, Miliolite Formation (middle to late Pleistocene) at Bhod village; Limestone of Porbandar Calcarenite Member, Chaya Formation (late Pleistocene to late Holocene) at ACC quarry at Ratanpur.

Amphiroa fortis Johnson
(Pl. I, fig. 2)

Amphiroa fortis Johnson: Johnson, 1961, P. 939, Pl. 277, Figs. 8-9.

Material: Specimen Nos. PGTDG / MF/ SCA/ 462, 463

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
462	412.5	3L,1S	75-12.5	12.5	16	12-16	Nil	Nil
463	312.5	3L,1S	87.5-62.5	25-18.75	8-10	8-10	Nil	Nil

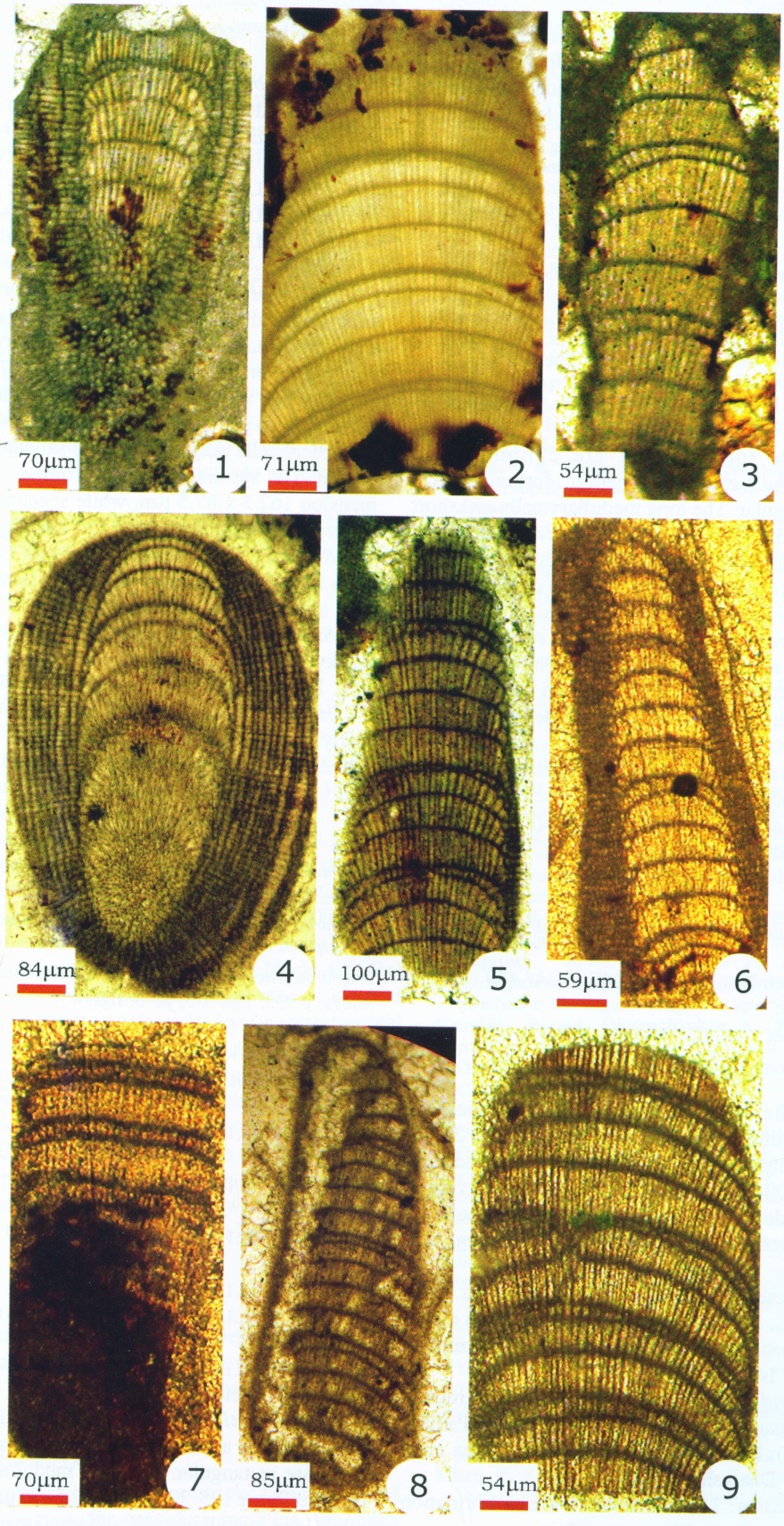
Description: The intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 3L, 1S . Cells are rectangular. The long medullary cells and short medullary cells are 62.5-12.5 μm and 25-12.5 μm respectively in length, while long medullary cells and small medullary cells are 8-16 μm and 8-16 μm respectively in width. The cortical region is not preserved.

Remarks: *Amphiroa fortis* Johnson is characterized by

EXPLANATION OF PLATE I

1. ***Amphiroa fragilissima***, Specimen No. PGTDG/MF/SCA/458
2. ***Amphiroa fortis***, Specimen No. PGTDG/MF/SCA/463
3. ***Amphiroa prerigida***, Specimen No. PGTDG/MF/SCA/449
4. ***Amphiroa rigida***, Specimen No. PGTDG/MF/SCA/445
5. ***Amphiroa prefragilissima***, Specimen No. PGTDG/MF/SCA/464
6. ***Amphiroa fragilissima***, Specimen No. PGTDG/MF/SCA/399
7. ***Amphiroa anchiverricosa***, Specimen No. PGTDG/MF/SCA/443
8. ***Amphiroa fragilissima***, Specimen No. PGTDG/MF/SCA/456
9. ***Amphiroa ephedraea***, Specimen No. PGTDG/MF/SCA/400

Plate I



alternation formula 3L, 1S. The present fragments exhibit alternation formula 3L, 1S. Therefore, they are described under *Amphiroa fortis* Johnson.

Stratigraphic and Geographic Distribution: Late Eocene of Eniwetok, Marshall Islands, Pacific Ocean (Johnson, 1961).

Horizon and Locality: Limestone of Porbandar Calcarenite Member (Chaya Formation; late Pleistocene to late Holocene) at ACC quarry at Ratanpur.

Amphiroa prefragilissima Lemoine

(Pl. I, Fig. 5)

Amphiroa prefragilissima Lemoine : Lemoine, 1966, Pl. 6, Figs. 76-77, P. 1-25.

Material: Specimen Nos. PGTDG / MF/ SCA/ 464, 465

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
464	325-250	3L,1S, 4L,1S	75	25	10-12	12-14	Nil	Nil
465	312.5-187.5	3L,1S, 4L,1S	62.5	18.75	8	8-10	16	14

Description: The intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 3L,1S, 4L,1S. Cells are rectangular. The long medullary cells and short medullary cells are 62.5-75 μm and 18.75-25 μm respectively in length, while long medullary cells and small medullary cells are 8-12 μm and 8-14 μm respectively in width. The cortical region is preserved and cell dimensions are 16 x 14 μm.

Remarks: The present fragments show cylindrical to subcylindrical intergenicula and medulla exhibit alternation with alternation formula 3L,1S, 4L,1S shown by *Amphiroa prefragilissima* Lemoine. Therefore, they are described under *Amphiroa prefragilissima* Lemoine .

Stratigraphic and Geographic Distribution: Tertiary Sediments of Cuba, Middle to Upper Miocene, (Lemoine, 1966).

Horizon and Locality: Limestone of Dwarka Formation (early to middle Miocene) at Srinagar.

Amphiroa prerigida Ishijima

(Pl. I, fig. 3)

Amphiroa prerigida Ishijima : Ishijima, 1954, Pl. 37, Figs. 6, 7, 9 and 10.

Material: Specimen No. PGTDG / MF/ SCA/ 449

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
449	475	2L,1S, 3L,1S	100-75	62.5-25	10	10	Nil	Nil

Description: The intergeniculum is cylindrical to subcylindrical and medulla exhibit alternation formula 2L,1S, 3L, 1S. Cells are rectangular. The long medullary cells and short medullary cells are 100-75μm and 62.5-25 μm respectively in length, while long medullary cells and small medullary cells are 10μm and 10μm respectively in width. The cortical region is not preserved.

Remarks: The present fragment exhibits alternation formula 1L,1S, 2L,1S, 3L, 1S. *Amphiroa prerigida* Ishijima exhibits the same alternation formula. Therefore, it is described as *Amphiroa prerigida* Ishijima.

Stratigraphic and Geographic Distribution: Miocene limestone of Babukutsu, Taito-cho, Formosa, Western Pacific, Japan (Ishijima 1954); Lower Pliocene of Dwarka Okha area, Gujarat (Kundal and Dharashivkar, 2003a).

Horizon and Locality: Limestone of Dwarka Formation (early to middle Miocene) at Bhavpara village.

Amphiroa rigida Lamouroux

(Pl. I, fig. 4)

Amphiroa rigida Lamouroux : Ishijima, 1954, P. 58-59, Pl. 35, Figs. 2a, b

Material: Specimen Nos. PGTDG / MF/ SCA/ 444, 445, 446, 466

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
444	87.5	2L,1S	62.5-50	18.75-12.5	8	8	Nil	Nil
445	550	2L,1S	60	24	8-10	8-10	8-12	8
446	337	2L,1S	50	37.5	16	16	20	16
466	387-287	2L,1S	87.5	25	8-12	8-16	Nil	Nil

Description: The intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 2L, 1S. Cells are rectangular. The long medullary cells and short medullary cells are 87.5-50 μm and 12.5-27.5 μm respectively in length, while width of long medullary cells and small medullary cells are 8-16 μm and 8-16 μm respectively in width. The length of cortical cells ranges from 8-20 μm and width ranges from 8-16 μm. The specimen no. 466, consist of conceptacle with dimension 162.5 x 87.5 μm, while specimen no. 446, exhibits of conceptacles with dimension 227 x 62.5 μm and 112.5 x 75 m.

Remarks: The present fragments exhibit alternation formula 2L, 1S like *Amphiroa rigida* Lamouroux and therefore they are described as *Amphiroa rigida* Lamouroux.

Stratigraphic and Geographic Distribution: Pleistocene Ryukyu limestone exposed near North valley Tako, Takooshu, Formosa, Western Pacific, Japan (Ishijima, 1954).

Horizon and Locality: Limestone of Dwarka Formation (early to middle Miocene) at Bhavpara and Srinagar villages; Limestone of Porbandar Calcarenite Member ,Chaya Formation (late Pleistocene to late Holocene) at ACC quarry.

Amphiroa fragilissima (Linnaeus) Lamouroux

(Pl. I, figs. 1,6,8)

Amphiroa fragilissima (Linnaeus) Lamouroux: Ishijima, 1954, p. 60-61, Pl. XXX, Figs. 2-3 d

Amphiroa fragilissima (Linnaeus) Lamouroux: Johnson 1957, pp. 238, pl. 3-7

Amphiroa fragilissima (Linnaeus) Lamouroux: Kundal and Dharashivkar 2003a, p 253, figs. 1-5, pl. 3, figs. 4

Material: Specimen Nos. PGTDG / MF/ SCA/ 399, 456, 457, 458, 459, 460, 461

Dimensions (μm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
399	237.5-212.5	4L,1S	50	25-18.75	12	16-12	8	4
456	300-250	4L,1S	75-68.75	25-18.75	8	10-8	Nil	Nil
457	350-300	4L,1S	75-62.5	25	8	10-8	Nil	Nil
458	350	4L,1S	62.5	12.5	8	10-8	Nil	Nil
459	300-250	4L,1S	50-40	16	16-12	20-16	Nil	Nil
460	300	4L,1S	62.5	25	12	16-12	20	10
461	337.5	4L,1S	125-100	12.5	8	8	12	8

Description: The intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 4L, 1S. Cells are rectangular. The long medullary cells and short medullary cells are 125-50 μm and 12.5 -25 μm respectively in length, while long medullary cells and small medullary cells are 8-12μm and 8-20 μm respectively in width. The cortical region is pre-

served and cell dimensions are 8-20 x 4-10 µm.

Remarks: The present species exhibits alternation formula 4L, 1S like *Amphiroa fragilissima* (Linnaeus) Lamouroux. Therefore, it is described under *Amphiroa fragilissima* (Lannaeus) Lamouroux.

Stratigraphic and Geographic Distribution: Miocene limestone of Babukutsu, Taito-cho, Formosa, Western Pacific, Japan (Ishijima 1954), Pleistocene marine Limestone of Marina Island (Johnsan, 1957) and Lower Pliocene of Dwarka–Okha area, India (Kundal and Dharashivkar, 2003a)

Horizon and Locality: Limestone of Dwarka Formation (early to middle Miocene) at Bhavpara and Srinagar villages ; Limestone of Porbandar Calcarenite Member, Chaya Formation (late Pleistocene to late Holocene) at ACC quarry.

DISCUSSION AND CONCLUSIONS

In the present paper, 07 geniculate coralline algal species namely *Amphiroa anchiverricosa, A. ephedraea, A. fortis, A. fragilissima* and *A. rigida, A. prefragilissima, A. prerigida* have been documented from Neogene-Quaternary sediments of Porbandar area. The stratigraphic divisions of the species are as under:

Name of the Species	DF	AM (MF)	PCM (CF)
Amphiroa anchiverricosa	P	A	A
Amphiroa ephedraea	P	P	P
Amphiroa fortis	A	A	P
Amphiroa fragilissima	P	A	P
Amphiroa rigida	P	A	P
Amphiroa prefragilissima	P	A	A
Amphiroa prerigida	P	A	A

(Note: P-Present, A-Absent, DF-Dwarka Formation, AM(MF)-Adatiana Member of Miliolite Formation, PCM (CF)- Porbandar Calcarenite Memebr of Chaya Formation)

The species of *Amphiroa* do not indicate the precise depositional environment. However, *Amphiroa* occurs in association with nongeniculate coralline algal species which have already been documented by Kundal and Mude (2009a). The nongeniculate coralline algal species are very useful to deduce depositional environment. Kundal and Mude (2009a) based on various nongeniculate coralline algal species inferred that the Dwarka Formation was deposited in marine tropical environment with high energy conditions at depths ranging from the intertidal to 60 m, the Adatiana Member of Miliolite Formation was deposited under shallow marine tropical environment with moderate to low-energy conditions, and bathymetry fluctuating from intertidal to 60m and the Porbandar Calcarenite Member of Chaya Formation was deposited under tropical to subtropical marine environment with bathymetry in the range of 40m to 60m having moderate to low energy conditions.

REPOSITORY

The thin sections are deposited in PG Department of Geology; Rashtrasant Tukadoji Maharaj, Nagpur University in care of the PK, as these thin sections were prepared for the Ph.D. work of the SNM.

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