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RESEARCH PAPER

Geniculate coralline algae from the pliocene shagra formation at wadi abu dabbab, marsa, alam area, red sea coastal plain, egypt

Mostafa Mansour Hamad *

Department of Geology, Faculty of Science, Cairo University, Egypt

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Abstract

Abstract: The Pliocene succession in Wadi Abu Dabbab, Marsa Alam area, Red Sea coastal plain is litohstratigraphically subdivided into Gabir, Shagra and Samadai formations in addition to the Pleistocene raised beaches and coral reefs. Lithostratigraphically, in Wadi Abu Dabbab that represents the main investigated section where the Shagra Formation unconformably overlies the Pliocene Gabir Formation and unconformably underlies the Samadai Formation (Plio-Pleistocene age) and represented by mixed siliciclastics and carbonates succession. This formation is highly fossilifrous with coralline red algae in form of erect, in situ crusts, rhodoliths, as well as fragments and corals, bivalved shell fragments, bryozoans, large benthonic and palnktonic foraminifera. The coralline red algae and foraminifera are important constituents of Shagra Formation and highly abundant. This carbonate facies is dominated by different assemblage of coralline red algae in the forms of geniculated and nongeniculated coralline algae. The coralline algal limestone of Shagra Formation contains well preserved geniculate coralline algal species of genus *Amphiroa* that represents the main target of this study. The systematic study and the taxonomic investigations carried out on the coralline red algae led to the recognition of eleven geniculated coralline algal species that described for the first time in the studied area. The present paper documents eight coralline algal species of genus *Amphiroa* namely *Amphiroa anchiverricosa, A. ephedraea, A. fortis, A. fragilissima, A. prefragilissima, A. prerigida, A. rigida, A. tani,* and one new species *Amphiroa dabbabensis* Hamad for the first time as well as *Corallina prisca, Jania guamensis, Subterraniphyllum sp.*. The present geniculate coralline algal assemblage is associated with the nongeniculated and dasycladalean algae, this association points that the coralline algal reefal limestone of the Shagra Formation was deposited in the intertidal to shallow subtidal environments at a depth of 10-30 m in a shallow warm marine water environments under low energy conditions favorable for reefal growth and rhodoliths formation. The fossiliferous arkoses and conglomerates, alternating with the coralline algal limestone of Shagra and Samadai formations, were derived from the nearby Precambrian basement, transported by streams during short-lived pluvialepisodes and deposited in a very shallow intertidal- beach environment

Keywords: Geniculate Coralline Algae, Early Pliocene, Palaeoenvironment, Shagra Formation, Red Sea Coast, Egypt.

Introduction

Coralline red algae are important constituents of the shallow water marine carbonates and also cosmopolitan in distribution. The distribution of coralline algae is mainly controlled by ecological factors such as temperature, depth, salinity, substrate and energy (Adey &

* Corresponding author e-mail: mnhamad88@yahoo.com

MacIntyre, 1973; Braga & Martin, 1988; Bosence, 1983 & 1990). Corallines had a significant role in the composition of shallow marine sedimentary deposits all over the world (Woelkerling, 1988; Womersley, 1996, Rasser & Nebelsick 2003). Corallines architecturally have two groups, the nongeniculate and geniculate coralline forms (Wray, 1977, Woelkerling, 1988; Woelkerling et al. 1993Womersley, 1996, Kundal, 2011, Hrabovsky et al., 2015). While the thallus is missing in nongeniculate coralline forms, it is made up of inflexible, calcified segments known as intergenicula that alternate with more flexible, infrequently calcified segments known as genicula in geniculate coralline forms (Bassi et al. 2000). In Cenozoic shallow water marine environments, coralline algae are among the major carbonate producers (Iryu et al., 2012). Geniculated coralline algae e.g. genus *Amphiroa* and *Corallina* is generally cosmopolitan and commonly recorded in tropical and subtopical marine water environment. The present day *Corallina* occurs in association with *Amphiora* (Rasser & Pillar, 1996; Bassi, 1995 & 1998; Nebelsick et al., 2003). Both crustose (non-geniculated) and articulated (geniculated) coralline algae grow principally in normal, marine, saline water. Members of Corallinaceae are considered to be important Cenozoic reef builders in tropical and subtropical realms (Wray, 1977; Woelkerling, 1988; Littler et al., 1991; Woelkerling et al. 1993), both as frame- as frame-building organisms and as sediment producers.

The Pliocene - Pleistocene sequence in Mrasa Alam area, Red Sea coast is well exposed and widely distributed. It is represented predominantly by carbonate with subordinate mixed siliciclastic lithofacies types. The stratigraphy of the Red Sea coast have attracted the attentions of many workers so several straigraphical and paleontological studies have been carried out on the Pliocene -Pleistocene sequence in the Red Sea area and their neighboring areas, among the authors who dealt with are: Beadnell, 1924, Said 1962; Souaya, 1963, Akkad & Dardir, 1966; Cherif, 1966; Ghorab & Marzouk,1967; Cherif et al., 1977; El Gamal, 1971; Philobbos & El Haddad, 1983; Hermina et al., 1989; Youssef & Abu Khadra 1984; Mahran, 1990 & 1996; Philobbos et al. 1993; kheider & Felesteen 1991; Moussavian & Kuss, 1990; Said, 1990; Felesteen et al., 1994; Hamza, 1992; Nebelsick, 1992; Hathout & Orabi 1995; Pillar & Rasser 1993 &1996; Kora & Abdel-fattah, 2000; Nebelsick & Kroh, 2002; EL Sorogy *et al*, 2004 and Kora et al., 2013. The Pliocene carbonates of Wadi Abu Dabbab, Red Sea coast (Fig.1 a, b) are found to contain a highly abundant, richly diversified and well preserved coralline red algae that have been not described well.

Earlier studies and investigations on the calcareous red algae of the Miocene-Pleistocene succession at Zug El-Bohar, Wadi Wizr, Um Gheig section, south of Quseir was carried out by Souaya (1963). He recorded fourteen coralline red algal species. Later on, Khalifa & Boukhary (1982), described eight coralline red algal species from the Neoegne and Pleistocene stratigraphic succession in Marsa Alam area. They recorded ten speciecs of family orallinaceae (Coralline Algae) Of these algal species, *Amphiroa knoi, Jania johnsoni* and *Archaeolithothamnium alamensis*.The studied sequence is subdivided according to its coralline algae and larger foraminiferal content into three biozones; which are from top to bottom: 1. *Amphiroa knolli* Zone, 2. *Amphiroa prefragilissima* Zone and 1. Borelis melo Zone and assigned them to age ranged from Miocene to Pleistocene age .Khalifa (1984) described thirteen coralline algae from the Pliocene succession of the area south of Safaga (Red Sea, Egypt). And showed that the articulated coralline algae are represented by a single genus, *Amphiroa*. Among these species recorded , four species are new: *Amphiroa bassiounii* n.sp., *Amphiroa cameroni* n.sp., *Amphiroa siyatinensis* n.sp. and *Lithoporella berggrem* n.sp.

Hamad (2020) described 21 species from the Pliocene Shagra Formation at Wadi Wizr, south of Quseir area. He described seven non-geniculated coralline algal genera; *Lithothamnion*, *Mesophyllum*, *Spongites*, *Lithophyllum*, *Neogoniolithon*, *Sporolithon*, and *Lithoporella*, in addition to the geniculated *Corallina* sp. and the green algal *Halimeda* sp. He could be able to subdivide the Pliocene Shagra Formation based on the stratigraphic distribution of these algae into two local coralline algal assemblage zones from base to top: 1) *Neogoniolithon* sp. / *Mesophyllum lemoinaea* Assemlgae Zone and 2) *Lithothamnion saipanense / Lithophyllum prelichenoides* Assemblage Zone.

Recently Hamad & Orabi (2021) studied the coralline red algae of the Miocene Gharamul Formation, Abu Shaar El Qibli, Gulf of Suez region, and recognized twelve coralline algal species belonging mainly to five genera of three subfamilies (Mastrophoroideae, Lithophylloideae, and Melobesioideae) of Rhodophyta (Corallinaceae). The geniculate coralline algae there are relatively scarce and represented by a single genus *Corallina* sp. The Mastophoroids (*Neogonilithon* and *Spongites*) and Lithophylloids (*Lithophyllum*) are more dominant coralline algal species and dominate the shallower coralline algal assemblages. On the other hand, Melobesioids (*Mesophyllum* and *Lithothamnion*) and sporolithales (*Sporolithon*) are the most abundant components and diverse in the deeper-water assemblages.

The main target of this study is to make a full systematic, taxonomic investigations and identification of the geniculated coralline red algal taxa and their different growth forms as well as comparison of the present algal association with their counterparts of other coralline algal species in the circum of the Red Sea area, Indian Ocean and the Mediterranean. The detailed investigation of the Shagra Formation allowed recognizing of ten geniculated coralline algal species of genus *Amphiroa* namely *Amphiroa anchiverricosa, A. ephedraea, A. fortis, A. fragilissima, A. tani, A. rigida, A. prerigida A. prefragilissima,* and one new species *Amphiroa dabbabensis* Hamad for the first time as well as *Corallina prisca, Jania guamensis, Subterraniphyllum sp.* .Also this study allowed to recognize different microfacies associations and to deduce the main depositional events that prevailed during the deposition of that Pliocene sequence.

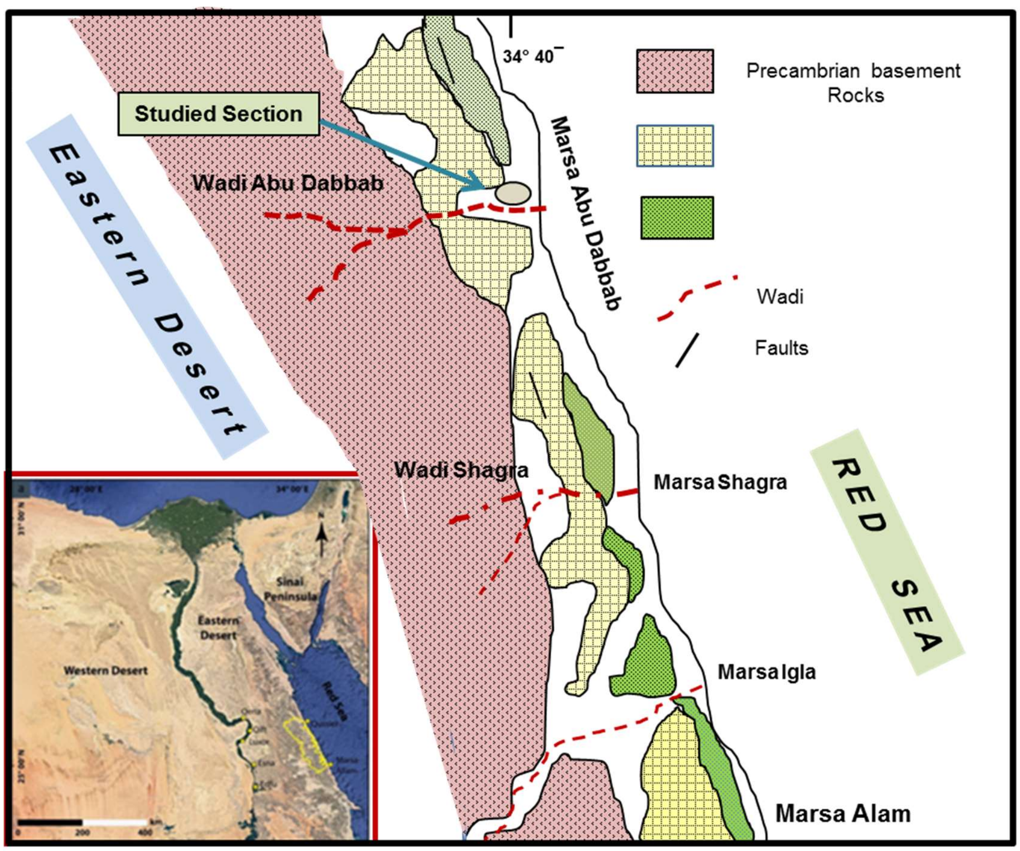

Figure 1. Simplified Geological map of the study area showing the location of the studied section (After the geological Egyptian Geological Survey, 1978)

Geological Setting

The Pliocene succession along the Egyptian Red Sea coastal plain varies in thickness from about 130 m at Wadi Samadai south of the Marsa Alam to more than 250 m at Wadi Wizr, south of the Quseir (Fig. 2). The outcrops are represented in the area by mixed siliciclastic and carbonate rocks exhibiting marked lateral lithological variations and interbedding thick evaporite unit. In the study area, the Pliocene rocks unconformably overlies the Precambrian basement, and are overlain unconformably by the Pleistocene reef-dominated deposits (Fig.2). The lithostratigraphic units recognized in the area of study are correlated with the lithostratigraphic classifications suggested by different authors that studied this succession along the Egyptian Red Sea coastal plain (Table 1). The characteristics of these units are summarized as follows:

Gabir Formation

This rock unit was first described and established in its type locality Wadi Gabir, north of Marsa Alam area by El Akkad & Dardir (1966) overlies conformably the Samh Formation and underlies conformably the Shagra Formation, Sometimes, it is unconformably overlain by the Plio-Pleistocene Samadai Formation. It is assigned to Pliocene age based on their macrofaunal content. In the present work the present author follows Said (1990) who extended the Gabir Formation to include the lower member of Shagra Formation, due to the lithologic similarities. In the study area, the thickness of this formation increases northward, being 45 m at Wadi Samadai, 90 m at Wadi Shagra and Wadi Wizr (Fig. 1). The Gabir Formation forms relatively high hills of yellowish to greyish brown color. At Wadi Shagra it is composed mainly of sandstones with several limestone, siltstone and shale beds (Fig. 2). The carbonate intervals are composed of moulds of bivalves and gastropods and disarticulated large oysters. These intervals increase appreciably at Wadi Wizr and Wadi Samadai. They are represented mainly by argillaceous and oolitic sandy limestones.

Shagra Formation

The Shagra Formation was firstly designated and established by El-Akkad & Dardir (1966) and emended by EL-Bassyony (1982) and El-Asmar, H. M. (1997) at Wadi Shagra 22 Km. north of Marsa Alam area. The Shagra Formation overlies conformably the lower Pliocene Gabir Formation, and underlies unconformably the Pliocene-Pleistocene Samadai Formation or the Pleistocene raised beaches and coral reefs. It is measured 46m in Wadi Shagra, decreasing to about 30 m at Wadi Samadai and to only 21 m at Wadi Wizr (Fig. 2). The Shagra Formation forms relatively low hills, nearer to the Red Sea Coast with a characteristic pink or pale yellow colour. This rock unit is predominantly composed of algal limestone intercalated with several arkosic sandstone and polymictic conglomerate beds. It is composed mainly of reddish to pink algal limestones with pink arkosic sandstone interbeds. The sandstones are hard, feldspathic and cliff-forming. The lower part of this formation is made up of reddish to pink algal limestones, pebbly and/or sandy, while the upper part is white sandy, occasionally reefal limestone containing several scleractinian corals and some clypeasteroids confirming the Pliocene age of the formation. Conglomerates and fossiliferous arkoses intercalating the algal limestone are highly fossiliferaous with echinoid fragments, molluscan shell debris and large benthic foraminifera indicating that depositional regime was a clear, shallow to very shallow warm marine environment favourable for reefal growth .

The Shagra Formation is correlated with the upper member of the Shagra Formation (El-

Akkad & Dardir, 1966). It could be matched Sharm El Arab Member of Sharga Formation of Phillops, (1989, 1993) and with Wizr Formation of ELBassyony (1982). Moreover, it could be equivalent to the upper part of the Shagra Formation described from Ras Banas area (Felesteen et al. 1994) and to shagra Formation at Wadi Wadi Wizer (Hamad, 2008) (Table 1). Kora & Abdel-Fattah (2000) recorded the *Lithophaga avitensis* / *Pecten* (*Pecten*) *acuticostatus* Zone from the lower part of the Shagra Formation and the *Clypeaster reticulates / Laganum depressum* Zone from its upper part and assigned them to a Late Pliocene age. The lithological composition and macrofaunal content suggest deposition in open marine conditions of warm and clear water of low salinity, shallow subtidal environment favourable for reef and algal growth.

Samadai Formation

The Plio-Pleistocene Samadai Formation was originally described and established by Philobbos et al. (1989) where it is recorded from all localities around Marsa Alam area. This formation developed with a total thickness ranged from 25 m at Wadi and 60 m Ras Samadai (Fig. 2),. It corresponds to the older organic reefs described by El-Akkad & Dardir (1966) and Said (1990), the Um Gheig Formation of El Bassyony (1982), ,and the Ras Ranga Formation of Felesteen et a l. The Samadai Formation unconformably overlying the inclined Shagra Formation and in other localities Gabir and even the Samh Formation, it is unconformably overlain by the Pleistocene raised beaches and coral reefs.

This formation shows great facies changes, both laterally and vertically, including two alternated and discontinuous facies of unfossiliferous and fossiliferous conglomerates. The unfossiliferous conglomerate facies is composed mainly of polymictic conlomerates represented by subrounded, poorly sorted pebbles, cobbles and boulders, rock fragments of granitic and dioritic composition derived from the basement rocks.

The fossiliferous polymictic conglomerate alternates and grades laterally into reefal limestones. It is yellowish brown, occasionally cross-bedded, slightly calcareous and contains some coral debris and molluscan shells. The reefal facies is yellowish to greyish in color, hard, cavernous, partly si licified and rich in coral debris.

This formation is highly fossiliferous containing molluscan shells, echinoids and corals of lndo- Pacific affinity. The stratigraphic position and the faunal content suggest a late Pliocene age for the formation. The Pliocene zone of *Borelis seclumberger;* (Reichel) as described by Souaya (1963) lies within this formation.

It is noteworthy of mention that the fossiliferous polymictic conglomerate and its fossil content suggests deposition in a littoral to beach environment with warm, clear water and normal salinity marine water environments. Whereas the alternating unfossiliferous conglomerate beds suggest deposition under fluviatile conditions in pluvial periods that interrupted an otherwise dry climate which is adequate for coral reef growth (Said 1990). Kora & Ab-del Fattah (2000) and Kora et al. (2013) concluded a deposition in very shallow subtidal environments of shoals and organic buildup conditions with short lived pluvial episodes, which continued to the Late Pleistocene.

Material and methods

The coralline algae described in this paper have been studied in thin sections from the hard, fossiliferous coralline reefal limestone samples belonging to The Pliocene Shagra Formation, Marsa Alam area, Red Sea coastal plain. Sixteen coralline algal thin sections were studied and investigated. Seventeen algal limestone samples marked in figure 2 yielded geniculated and non geniculated coralline red algae. The main target of the present work focused the study of the geniculated coralline red algae.

In describing the geniculate coralline red algae dimensions of cells and conceptacles were measured properly. The systematic part described here is based on the available anatomical features of the geniculate coralline algae, adopting the recent taxonomic concepts.

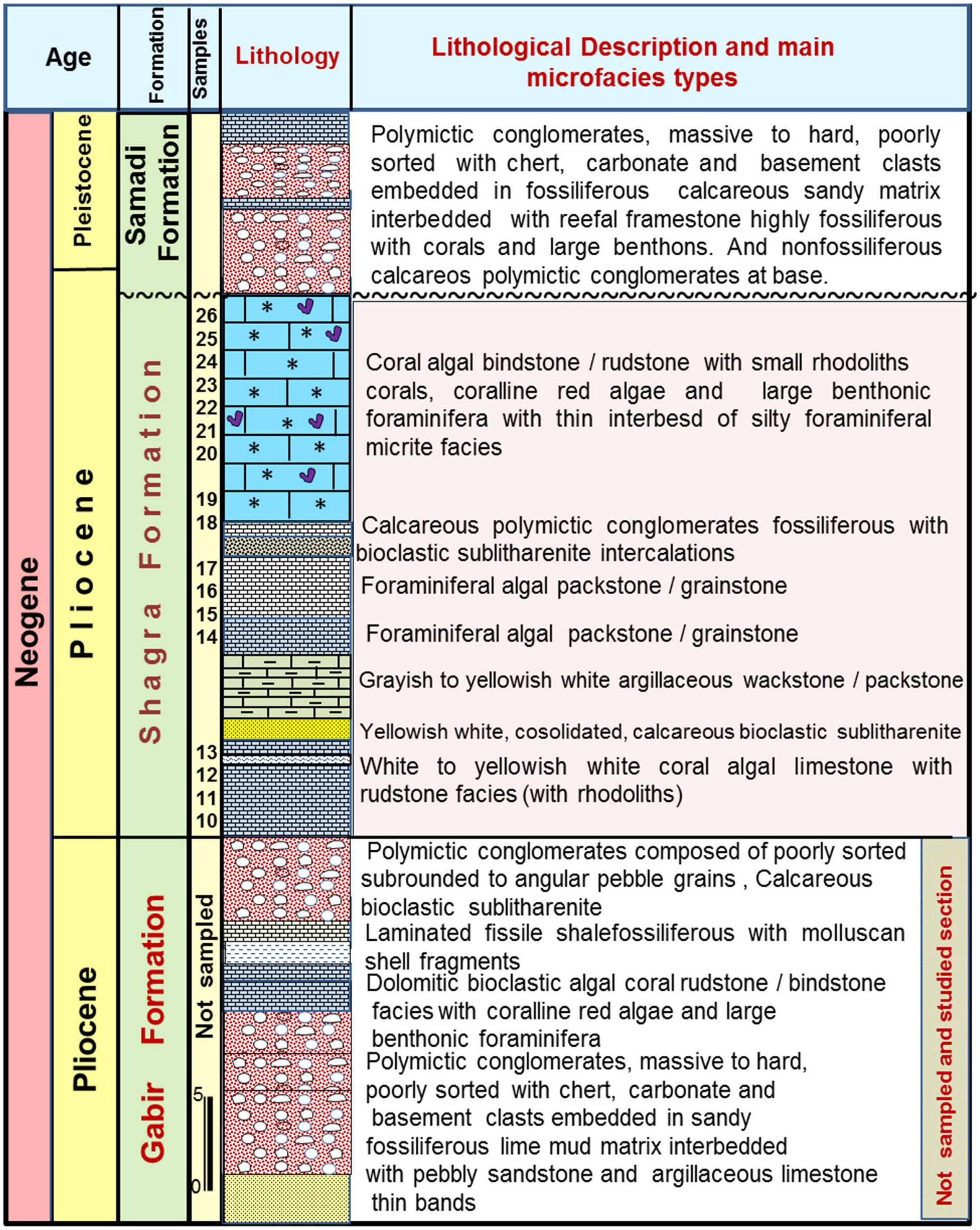

Figure 2. Stratigraphic surface section of the Pliocene sequence showing the main lithofacies types at Wadi Abu Dabbab, Marsa Alam, Red Sea Coast, Egypt

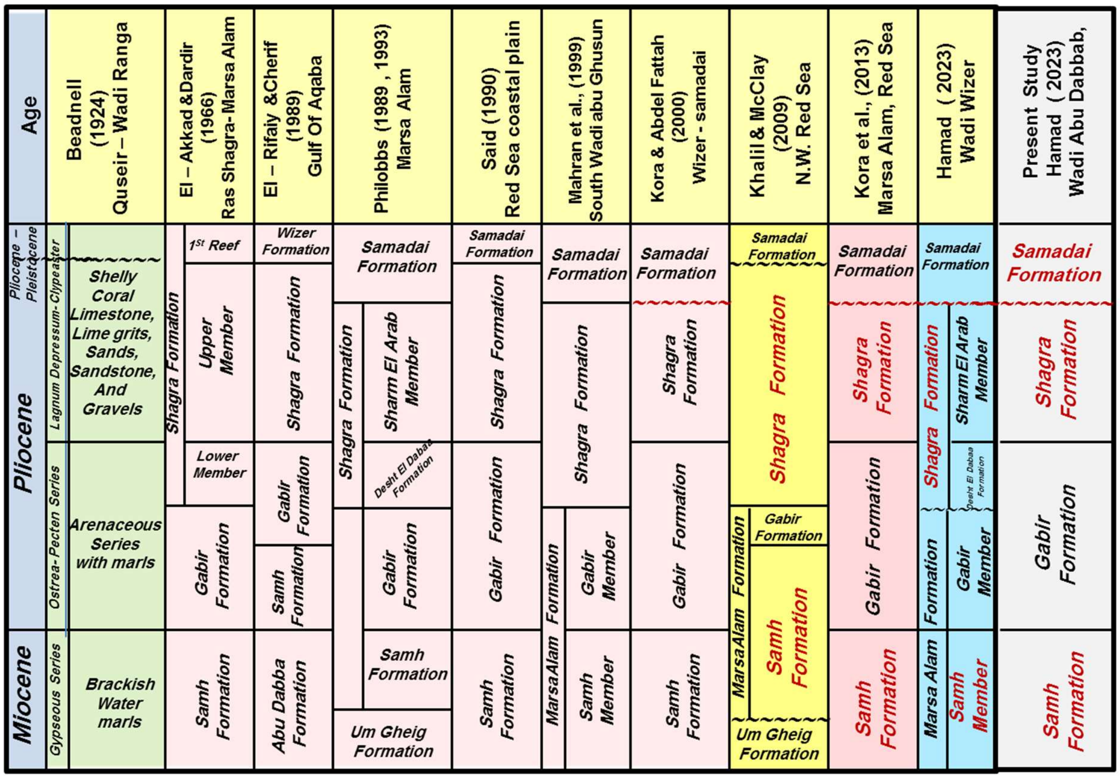

Table 1. Correlation chart showing the different Miocene - Pliocene lithostratigraphic units along the Red Sea coastal plain, Egypt. (Modified after Kora et al., 2013)

An open nomenclatural concept has been adopted because most of them are not safely referable to any previously described recent or fossil species. Specifically in absence of genicula and the rare occurrence of conceptacles make the assignment of these geniculate coralline forms is indeed very difficult. All the figured slides including the negatives of the figured specimens are stored in the museum of the personal collection of the authors in Geology Department, Faculty of Science, Cairo University, Egypt.

Systematic taxonomy

The geniculate coralline algal genera are identified based upon distinguishing characteristics given by Wray (1977), Bassi *et al.* (2000), Kundal and Humane (2006b), Kishore et al. (2011) and Kundal (2011). The following abbreviations are used for the dimensions of geniculate coralline red 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 Florideophyceae Cronquist, 1960
Subclass Corallinophycidae Le Gall and Saunders, 2007
Order Corallinales Silva and Johansen 1986

Family Corallinaceae Lamouroux, 1812
Subfamily Corallinoideae Gray, 1821
***Genus Amphiroa* Lamouroux, 1812**
***Amphiroa anchiverricosa* Johnson and Ferris**
(Pl. 3, Fig. 1)

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., *Amphiroa anchiverricosa,* Johnson and Ferris, Kundal and Mude, 2010, P. 74, Pl. 1, Fig. 7.
Material: Wadi Abu Dabbab, Marsa Alam Specimen No. WD23.
Dimensions (µm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD23	353.6-450	1L-1S 2L-1S	62- 63.5	24-18	8	8-11	Nil	Nil

Description: Intergeniculum and medulla, which range in shape from cylindrical to subcylindrical, has alternating formula between a single row of long and short cells. cells are rectangular. The lengths of long medullary cells and short medullary cells are respectively 62.5-63.5 m and 24-18 m, whereas the width of long medullary cells and short medullary cells are 8 m and 8-11 m respectively. Conceptacles are subspherical and well-preserved, measuring 69 m in width and 78 m in length in the cortical region.
Remarks: The present specimen demonstrates the alternation formula 1L and 1S, which means that one row of long cells alternates with one row of short cells. Such an alternation formula is a characteristic of *Amphiroa anchiverricosa*. This specimen is classified as *Amphiroa anchiverricosa* by Johnson and Ferris as a result. Such an alternation formula in the medulla is likewise a characteristic of Amphiroa averrucosa Kutzing. Priority is given to *Amphiroa anchiverricosa* Johnson and Ferris above *Amphiroa averrucosa* Kutzing. *Amphiroa averrucosa* Kutzing is therefore listed after *Amphiroa anchiverricosa* Johnson and Ferris in accordance with the principle of priority. The alternation formula 1L, 1S is also present in *Amphiroa gautemalense* Johnson and Kaska. *Amphiroa gautemalense* Johnson and Kaska is therefore categorized under *Amphiroa anchiverricosa* Johnson and Ferris in accordance with the principle of priority.

***Amphiroa ephedraea* Ishijima**
(Pl. I, Figs. 1 & 2, Pl.2, Fig.2, Pl.3, Fig.10)

Amphiroa ephedraea Ishijima: Ishijima,1954, P.53,Pl. 37, Fig. 2. *Amphiroa ephedraea* Ishijima, Kundal and Mude, 2010, P. 74, Pl. 1, Fig. 9.

Material: Wadi Abu Dabbab, Marsa Alam Specimen Nos. WD22and WD23.
Dimensions (µm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD22	183.6	2L-1S	61- 56.5	26-12.5	8-9	8-10	4-7	5-9
		3L-1S	54-48					
WD23	367	3L-1S		18-12	10	10-12	Nil	Nil

***Description*:** The intergenicular segments measure 651 to 1109 µm in length and 183 to 368 µm in width and flattened in shape. Core region is well developed, the intergenicula are cylindrical to subcylindrical and medullary region exhibit alternation formula 2L and 1S, to 3L, 1S (comprising 2 to 3 layers of long cells alternating with 1 layer of short cells). Cells of medullary core region arranged in curved rows and gradually merged into the cortical region

The long medullary cells and short medullary cells are measuring 61 - 56.5 µm and 26.5-12.5 µm respectively in length, while long medullary cells and short medullary cells are measuring 8-9 µm and 8-10 µm respectively in width. The cortical region is well preserved. Cells of the cortical region measuring , 4-7 µm in length and 5-9 µm in width. Conceptacles are not observed.

Remarks: The fragments in the present material have erect thallus, elongate to wedge-shaped medullary cells, and cylindrical to arching intergenicula. having the same alternation formula as *Amphiroa ephedraea* Ishijima: 2L, 1S, 3L, 1S All of the medullary cell characteristics and measurements of the currently available pieces closely resemble those of *Amphiroa ephedraea* Ishijima. They are referred to as *Amphiroa ephedraea Ishijima* as shown from the investigations.

***Amphiroa fortis* Johnson**
(Pl. 1, Fig. 5, Pl. 2, Fig.7)

Amphiroa fortis Johnson: Johnson, 1961, P. 939, Pl. 277, Figs. 8-9. *Amphiroa fortis* Johnson, Kundal and Mude, 2010, P. 74, Pl. 1, Fig.2.

Material: Wadi Abu Dabbab, Marsa Alam,Specimen Nos. WD22, WD23.
Dimensions (µm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD22	312.6	3L-1S	73- 12	22-18.5	8-10	12- 15	Nil	Nil
WD23	439	3L-1S	81-64	25- 19	8-14	8-10	Nil	Nil

Description: The intergenicula are cylindrical to subcylindrical, and the medulla exhibits the 3L, 1S alternation formula. The segments' widths range from 312 to 319 m. Cells are is rectangular. The long medullary cells and short medullary cells are, respectively, 73-12 mm and 22-18.5 mm respectively. while long medullary cells and small medullary cells are 8-10 µm and 12-15 µm respectively in width. Conceptacles and the cortical area are not visible.

Remarks: The specimens under disposal resemble to Amphiroa fortis Johnson in terms of their overall appearance, arrangement and dimensions of cells, specifically adhering to the alternation formula of 3L, 1S. Consequently, these specimens are identified as Amphiroa fortis Johnson. The specimens in our present study exhibit similarities to those described by Johnson (1957) from the Halimeda-rich facies of the Mariana Limestone during the Pleistocene period. The previous literature has referred to comparable variants as Amphiroa sp. 1, as documented by Saxena et al. (2001), originating from the limestone unit of Hut Bay Formation (Middle-Late Miocene) located in Little Andaman Island, situated in the Bay of Bengal, India. The Pleistocene marine limestone of Marin Island was studied by Johnsan in 1957.

***Amphiroa fragilissima* (Lannaeus) Lamouroux**
(PL. 1, Figs. 3 & 4; Pl. 2, Fig. 1)

Amphiroa fragilissima (Lannaeus) Lamouroux : Ishijima, 1954, p. 60-61, Pl. XXX, Figs. 2-3 d. *Amphiroa fragilissima* (Lannaeus) Lamouroux: Johnson 1957, pp. 238, pl. 3-7. *Amphiroa prefragilissima Lemoine*: Lemoine, 1966, Pl. 6, Figs. 76-77, P. 1-25. *Amphiroa fragilissima* (Lannaeus) Lamouroux : Kundal and Dharashivkar 2003a, p 253, figs. 1-5, pl. 3, figs. 4, *Amphiroa fragilissima* (Lannaeus) Lamouroux : Kundal and Mude, 2010, p.74, pl. 1, figs. 1, 6, 8.,

***Material*: ** Wadi Abu Dabbab, Marsa Alam, Specimen Nos. WD19 and WD 20.
***Dimensions (µm)*:**

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD19	438-414	4L-1S	67- 63.5	23-17	8-12	10-8	8-10	4-10
	340		75- 62					
WD19	460	4L-1S	62- 120	18-25	8	8	Nil	Nil
WD20		4L-1S		12-17	12	11-8	Nil	Nil

***Description*:** The intergenicular segments measure 631 to 809 µm in length and 340 to 460 µm in width. The intergenicula possess a cylindrical to subcylindrical shape, whereas the medulla demonstrates an alternation formula of 4L and 1S. Cells exhibit a rectangular shape. The length of long medullary cells ranges from 67 to 63 µm, but the length of short medullary cells ranges from 23 to 17 µm. Similarly, the width of long medullary cells ranges from 8 to 12 µm, while the width of short medullary cells ranges from 10 to 8 µm. The cortical region is well preserved and cell dimensions are 8-10 in length and 4-10 µm in width. Conceptacles not observed.
Remarks:The species of *Amphiroa* described herein is comparable to *Amphiroa fragilissima* (Linnaeus) Lamouroux illustrated by Johnson (1957) from the Pleistocene of Mariana limestone, Saipan. The characteristic features of *A. fragilissima* as defined by Johnson (1957) are the core region comprises of 3 to 6 layers of long cells alternating with 1 to 2 layers of short cells. However, the present specimens described here show larger size of both long and short cells are. Moreover, owing to lack of preservation of conceptacles, whereas our specimen also has branches characterized by a thin cortical thallus. The prsesnt specimen has an alternation pattern of 4L, 1S, similar to that observed in Amphiroa fragilissima (Lannaeus) Lamouroux. Hence, it is identified as *Amphiroa fragilissima* (Lannaeus) Lamouroux.

Amphiroa prefragilissima **Lemoine**
(Pl. 2, Fig. 6; Pl.3, Fig. 6)

Amphiroa prefragilissima Lemoine : Lemoine, 1966, Pl. 6, Figs. 76-77, P. 1-25. *Amphiroa prefragilissima* Lemoine*,* Kundal and Mude, 2010, p.76, pl. 1, fig. 7,
Material: Wadi Abu Dabbab, Marsa Alam, Specimen Nos. WD25.
Dimensions (µm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD25	323.6-	3L- 1S	76- 63.5	24-18	9-12	10-14	16	14
	240	4L- 1S	70- 68.5					
WD25	300-280	4L/1S		20-19	8-16	10-16	18	12

Description: The intergenicular segments measure 551 to 879 µm in length and 240 to 323 µm in width. Core region is composed of 3 to 4 layers of long cells alternating with 1 layer of short cells. The intergenicula are cylindrical to subcylindrical. The long medullary cells and short medullary cells are 76-63 µm and 24 - 18 µm respectively in length, while long medullary cells and short medullary cells are 9-12 µm and 10-14 µm respectively in width. The cortical region is preserved and cell dimensions are 16 µm in length and 14 µ in width. Conceptacles are not observed.
***Remarks*:** The present form is comparable to *Amphiroa regularis* described by Johnson (1964) from the Upper Miocene (Alifan Limestone) of Guam in having similar alternation of rows of long cells and short cells along with several layers of cells in the cortical region. However, the presently studied specimen differs from *A. regularis* Johnson and Ferris 1950 in having multiple layers of cells in cortical region, whereas, *A. regularis* possesses single layer of cortical cells.

Species of *Amphiroa* having similar affinities have been recorded from the Pleistocene of Saurashtra (Kundal et al., 2011). The present fragments show cylindrical to subcylindrical intergenicula and medulla exhibit alternation formula 3L,1S and 4L,1S shown by *Amphiroa prefragilissima* Lemoine . Therefore, they are described under *Amphiroa refragilissima* Lemoine .

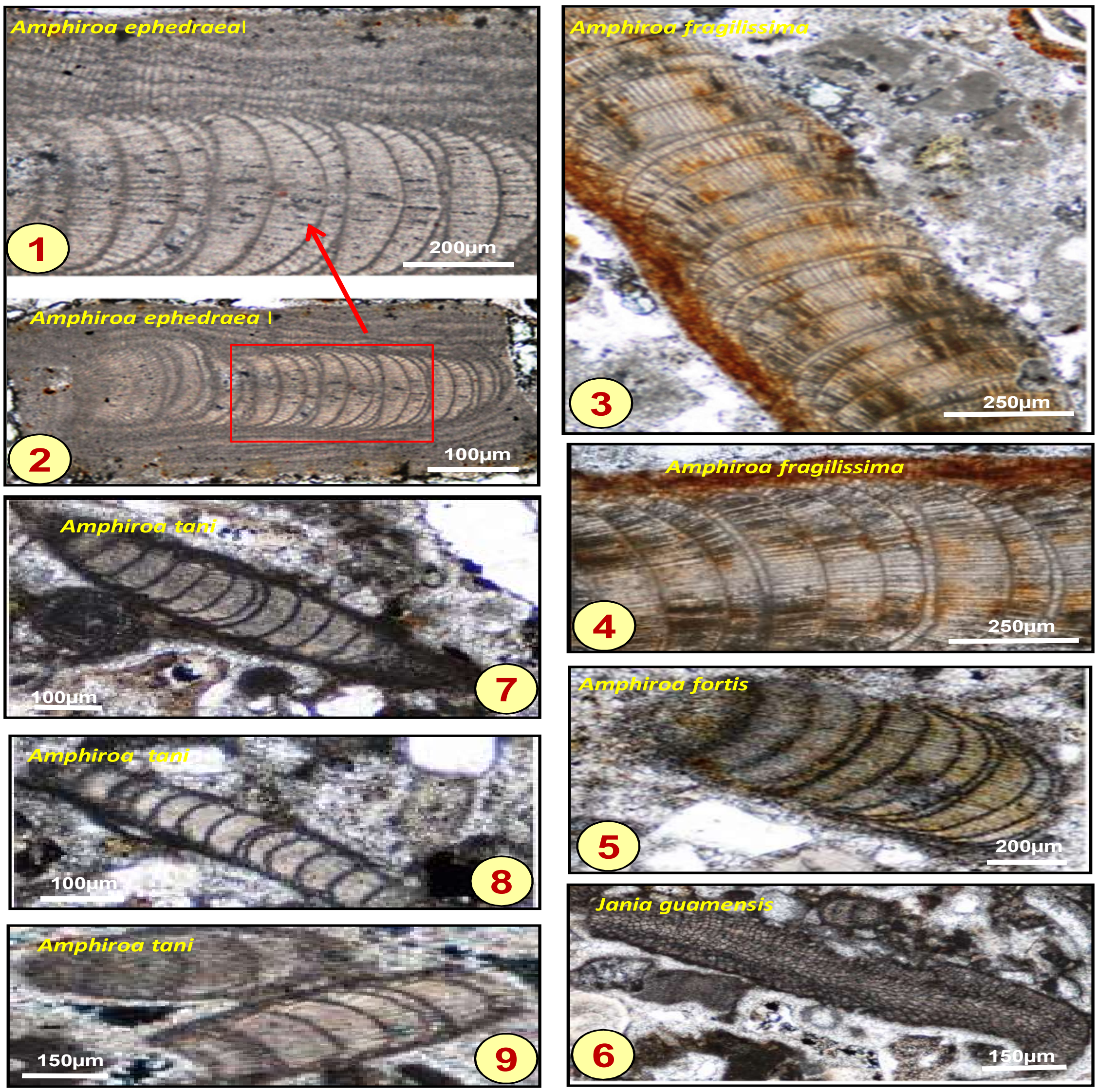

Plate 1. N. B. All the figured specimens were collected from Pliocene, Shagra Formation, Abu Dabbad section.)Figs. 1 & 2: *Amphiroa ephedraea* Ishijima, Specimen No. Ad 22-5, cylindrical intergeniculum in which rows of medullary core region with thick cortical thallus (Fig.2), and magnified thallus (Fig.1). Figs. 3 & 4: *Amphiroa praefragilissima* (Lannaeus) Lamouroux, Specimen No. Ad 22-4, cylindrical branched intergeniculum with cell fusions, showing also one row of short cells alternating with three rows of long cells and thin cortical thallus surface, Fig. 5: *Amphiroa fortis* Johnson, Specimen No. Ad 14-4, short cylindrical intergeniculum, showing one row of short cells alternating with two to three rows of long cells, with abraded cortical thallus. Fig. 6**:** *Jania guamensis* Johnson, Specimen No. Ad 14-4 cylindrical intergeniculum in which rows of core region join regularly. Figs. 7 & 8: *Amphiroa tani* Ishijima**.** Specimen Nos. Ad 14-4, intergeniculum with wedge shaped cell which join irregularly and cell fusions. Fig. 9: *Amphiroa gadhechiensis* Lemoine, Specimen Nos. Ad 14-4, intergeniculum with wedge shaped cell which join irregularly and cell fusions

Amphiroa rigida Lamouroux
(Pl. 2, Figs. 4 & 9)

Amphiroa rigida Lamouroux : Ishijima, 1954, P. 58-59, Pl. 35, Figs. 2a, b, *Amphiroa rigida* Lamouroux , Kundal and Mude, 2010, p.76, pl. 1, fig. 4,
Material: Wadi Abu Dabbab, Marsa Alam, Specimen Nos. WD16 and WD17.
Dimensions (m):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD17	451.6	2L/1S	61- 53.5	17.5-11	7	7-9	8-14	7-12
WD 16	550	2L/1S	60	37-24	7-12	8-10	19	17

Description: The length and width of the intergeniculum segments are 451 to 550 µm and 300 to 438 µm, respectively. Intergenicula exhibit a cylindrical to subcylindrical shape, while the medulla displays a 2L/1S alternation formula. Cell are rectangular. Long and short medullary cells have lengths of 61.5-53.5 µm and 17.5-11.5 µm respectively, while width of long medullary cells and small medullary cells are 7-14 µm and 7-9 µm respectively in width. Cortical cells vary in length from 8 to 14 µm and in width from 7 to 12 µm. Conceptacles not observed.
Remarks: The specimens under disposal are identified *as Amphiroa rigida* Lamouroux since they have the same alternation formula (2L, 1S) as that species. Pacific Amphiroa *rigida* Lamouroux had the same alternation formula, 2L, 1S, is also shown by Johnson and Ferris; however, *Amphiroa rigida* Lamouroux takes precedence over Amphiroa pacifica Johnson and Ferris. Amphiroa pacifica Johnson and Ferris will therefore no longer be recognized as an Amphiroa Lamouroux species. Asparagus kaskella Johnson and Kaska are also included in the alternation formula (2L, 1S or 3L, 1S) group in *Amphiroa rigida* Lamouroux. Johnson and Kaska's study on *Amphiroa gautemalense* demonstrates an alternation formula of 1L, 1S or 2L, 1S. Since all of these variations exhibit similarities to *Amphiroa rigida* Lamouroux, any specimens bearing the alternation formula, such as 2L and 1S, are now categorized under Amphiroa rigida Lamouroux.

Amphiroa prerigida Ishijima
(Pl.2, Fig.3 & Pl. 3, Fig. 9)

Amphiroa prerigida Ishijima : Ishijima, 1954, Pl. 37, Figs. 6, 7, 9 and 10. *Amphiroa prerigida* Ishijima, Kundal and Mude, 2010, p.76, pl. 1, fig. 3,
Material: Wadi Abu Dabbab, Marsa Alam, Specimen No. WD14 and WD19.
Dimensions (m):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD14	450.6	2L- 1S 3L-1S	95- 73.5	64.5-23	9	8-10	12-20	8-14
WD19	466	3L-1S	87-76	65-21	8	8-9	8-11	7-9

Description: Solitary worn fragment. Section slightly oblique. The intergeniculum is cylindrical to subcylindrical and medullary region exhibit alternation formula 2L/1S to 3L/1S (consisting of two to three layers (row) of long cells (L) alternating with one layer (row) of short cells (S). Cells are rectangular. The long medullary cells and short medullary cells are 95 -73.5 µm and 65 - 21 µm respectively in length, while long medullary cells and short medullary cells are 9 µm and 8-10 µm respectively in width. The length of cortical cells ranges from 12-20 µm and width ranges from 8- 14 µm. Conceptacles are not preserved.

Description: Worn fragments, slightly oblique section in the medullary area. The intergenicular segments measure 641 to 979 µm in length and 450 to 466 µm in width. The intergeniculum exhibits an alternation formula of 2L/1S to 3L/1S, which consists of one layer (row) of short cells alternating with two to three layers (rows) of long cells. The intergeniculum is cylindrical to subcylindrical. Rectangular cells are oserved. The long medullary cells and short medullary cells are 95 -73.5 µm and 65 - 21 µm respectively in length, while long medullary cells and short medullary cells are 9 µm and 8-10 µm respectively in width. The length of cortical cells ranges from 12-20 µm and width ranges from 8- 14 µm. Conceptacles are not preserved.
Remarks: The present specimens exhibit an overall appearance and arrangement of long and short cells where exhibiting two to three layers of long cells alternating with one layer (row) of short cells make up the alternation formula 2L/1S to 3L/1S. The present specimen demonstrates the similar alternation formula and similar characteristics with *Amphiroa prerigida* Ishijima, it is hence described as *Amphiroa prerigida* Ishijima.

Amphiroa tani Ishijima
(Pl. 1, Figs. 7& 8 &9)

Amphiroa tani Ishijima, 1954, p. 55-56, pi. 41, figs. 1-3.
Material: Wadi Abu Dabbab, Marsa Alam, Specimen Nos. WD18 and WD 23.
Dimensions (µm):

SN	WS	AF	LLMC	LSMC	WLMC	WSMC	LCC	WCC
WD 18	190	4L/1S	60- 73.5	13-14	10-12	7-8	Nil	Nil
		5L/1S	74					
WD23	280	5L/1S		10-13	8-10	8-9	Nil	Nil

Description: The intergenicular segments measure 540 to 940 µm in length and 280 to 190 µm in width Segments with well-developed core region composed of 4 to 6 layers of long cells alternating with I or rarely 2 layers of short cells. Core region and (cortical region clearly differentiated) ; length of the long cells of core region 55-65 µm and that of the short cells 25-30 µm.both long as well as short cells 8-10 µm in width. Cells of the cortical region 18-20 µm long and 5-8 µm in width. Conceptacles unknown.
Remarks: The specimen under disposal appears to represent the same species as described by Ishijima from the Miocene of Formosa. Isijima's material appears to have been badly abraded, whereas the Guam fragments are broken but have suffered little wear and consequently show details absent on the type material. However, the most characteristic features slender rather flexuous segments, virtual absence of a marginal cortical thallus, and flat tops of the medullary cell layers are the same. The cell dimensions are of the same magnitude, although slightly wider in the Guam specimens. The Formosa specimens have a formula of 3L-1S, 5L-1S, whereas most of the Guam specimens have 5L/ IS are very similar to the present material.so our specimens are identical to that of Ishijima (1954) specimens of *Amphiroa tani.* The forms described here are also closely comparable to those of Johnson (1964) from the Bonya Limestone (Early Miocene) of Guam and Saxena *et a!.* (2001, Plate 2, figs.1-4) from the limestone unit of Hut Bay Formation (Middle-Late Miocene) of Little Andaman Island, India.

Amphiroa dabbabensis Hamad , n. sp.
(Pl. 3, Figs. 5 & 7)

Etymology: Name derived from Wadi El-Dabbab, Marsa Alam, Red Sea, Egypt.
Type locality: Wadi Abu Dabbab section, see figure 1.
Occurrence: Shagra Formation, Bed No. 22, Sample No. 22; Shagra Formation, Bed No. 23,

Sample No. 26.
Holotype: Pl. 2, Fig. 1; Sample No. WD22 and WD 26.
Paratype: Pl. 2, Figs. 7-9; Sample No. 24.

SN	WS	AF	LLMC	WLMC	LSMC	WSMC	LCC	WCC
WD22	323.6	5L/1S	60- 63.5	23-14	12-14	8-10	Nil	Nil
		6L/1S	65- 70					
WD22	400-424	7L/1S		12- 15	20-22	10-12	20-23	12-14
	300		75-80					
WD26		6L/1S		12-14	19-21	10-14	19-22	11-15

Description: Available length of intergenicula is 424 to 300 µm and width is 280 µm. Segments with well-developed core region composed of 6 to 7 layers of long cells alternating with I layer of short cells, cells of the core region arching upwards, long cells measure 75-80 µm in length and 12-15 µm in width, short cells measuring 20-22 µm in length and 10-14 µm in width. Cortical cells are well developed, cells of the cortical region 19-22 µm long and 11-15 µm in width., composed of multiple layers of cells, running at right angle from the core region. Solitary conceptacle present in one specimen, uniporate, conceptacle width is 260 µm and height is 150 µm.
Remarks: The present specimen from Wadi Abu Dabbab, Marsa Alam area, clearly and consistently exhibit six to seven rows of long cells alternating with one row of short cells in medulla. Such clear and consistent alternation of long and shot row of cells has not been the characteristic feature of any of the known species of *Amphiroa* Lamouroux. Thereby the present specimens are described under a new species. The present form is comparable to *Amphiroa regularis* described by Johnson (1964) from the Upper Miocene of Guam in having similar alternation of rows of long cells and short cells along with several layers of cells in the peripheral region. However, the presently studied specimen differs from *A. regularis* Johnson and Ferris 1950 in having multiple layers of cells in cortical region, whereas, *A. regularis* possesses single layer of cortical cells. The present form resembles that of Johnson (1957) described as *Amphiroa fragilissima* (Linnaeus) Lamouroux from the Pleistocene sediments of Mariana Limestone, Saipan but differs in uniporated conceptacle that present in one specimen.

Genus Arthrocardia Decaisne emend. Areschoug, 1852
***Arthrocardia indica* Kundal and Humane, 2002**
(Pl. 3, Fig. 3)

Arthrocardia indica Kundal and Humane: Kundal and Humane, 2002, p. 95. Kishore et al., 2009, p. 192.
Material: Wadi Abu Dabbab, Marsa Alam, Specimen nos. MA17-4.
Dimensions (in µm):

SN	WS	LMC	WLC	LCC	WCC
WD24	259	87-98	8-10	Nil	Nil

Description: The intergenicular segments measure 441 to 579 µm in length and 259 to 260 µm in width Intergenicula cylindrical to subcylinderical. Cell rows of medullary core region join regularly and more or less flattened. Cell fusions is observed. Cortical region is not preserved and conceptacles are absent.
Remarks: The present specimens have similar measurments in length and width of medullary

core cell as that of *Arthrocardia indica* Kundal and Humane. Therefore, the present specimens are described *as Arthrocardia indica* Kundal and Humane.

Remarks: The medullary core cell measurements of the current specimens are comparable to those of *Arthrocardia indica* Kundal and Humane. Arthrocardia indica Kundal and Humane are the names given to the current specimens as a result.

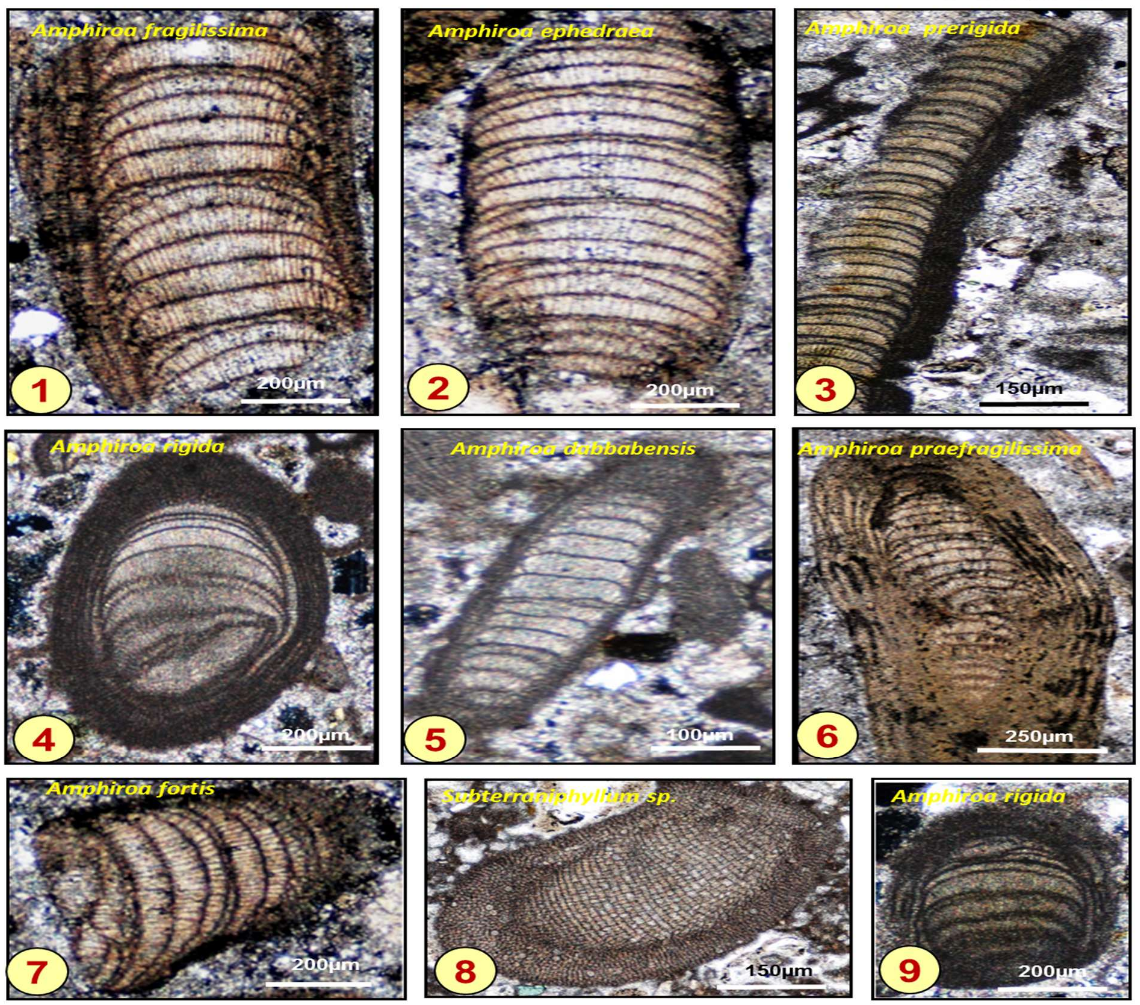

Plate 2. (N. B. All the figured specimens were collected from Pliocene, Shagra Formation, Wadi Abu Dabbad section. Fig. 1: *Amphiroa fragilissima* Lemoine, cylindrical intergeniculum, medullary core region join regularly, showing alternating formula of 4L/1S with thick cortical thallus. Fig. 2: *Amphiroa epherea*, cylindrical intergeniculum in which showing alternating formula of 3L/1S. Fig. 3: *Amphiroa praerigida* Lamouroux, cylindrical intergeniculum with cell fusions, showing alternating formula of 2L/1S to 1L/1S, with thin cortical thallus. Fig.4**:** *Amphiroa rigida* Lamouroux, oblique section showing branched intergeniculum showing alternating formula of 3L/1S to 2L/1S. Fig. 5**:** *Amphiroa dabbabensis Hamad***,** oblique section showing the intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 4L/1S, 6L/1S. Fig. 6: *Amphiroa praefragilissima* Lemoine, oblique section showing the intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 3L/1S, 4L/1S, with thick cortical thallus. Fig. 7: *Amphiroa fortis,* Cylindrical branched intergeniculum with wedge shaped cell which join irregularly and cell fusions, Fig. 8: *Subterraphylum* sp. cylindrical intergeniculum with wedge shaped cell which join irregularly and cell fusions. Fig. 9: *Amphiroa rigida* Lamouroux, cylindrical oblique branched intergeniculum exhibit alternation formula 2L/1S with cell fusions

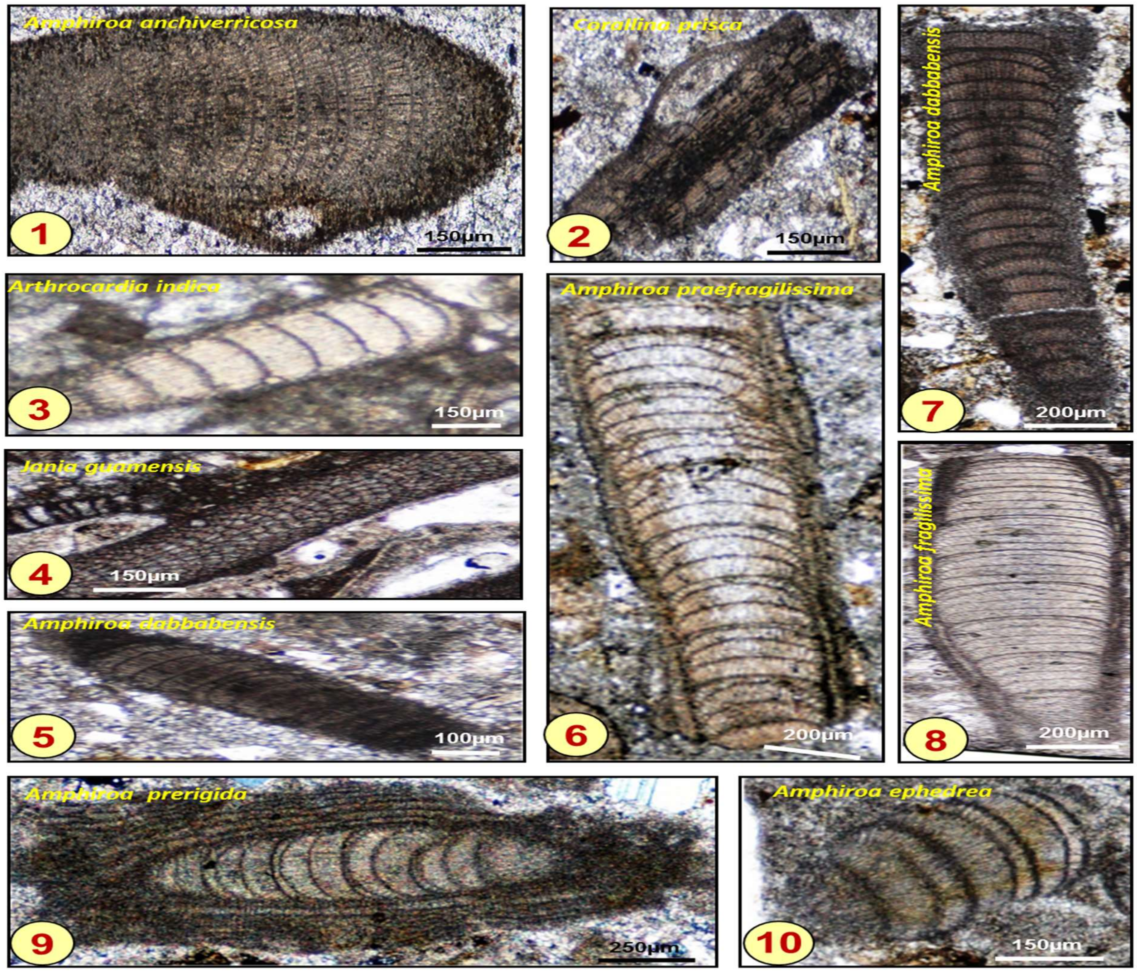

Plate 3. (N. B. All the figured specimens were collected from Pliocene, Shagra Formation, Wadi Abu Dabbab section: Fig. 1: *Amphiroa anchiverricosa* Johnson and Ferris, oblique section showing intergeniculum in which rows of medullary core region join regularly, with conceptacles. Fig. 2: *Corallina prisca* Rao, cylindrical branched and flattened intergeniculum with cell fusions, thin cortical thallus surface is well developed with conceptacles. Fig. 3: *Arthrocardia indica* Kundal and Humane: cylindrical branched intergeniculum, Cell rows of core region join regularly and more or less .Figs. 4: *Jania guamensis* Johnson, Intergeniculum sinuous, cell rows of core region join irregularly and core cells are wedge shaped, conceptacle are not recorded. Figs. 5 & 6:&7 *Amphiroa dabbabensis* Hamad ,n. sp., the intergenicula are cylindrical to subcylindrical and medullary cells exhibit alternation formula 4L, 1S to 5L/1S. Cells are rectangular, cortical thallus are observed, Fig. 8: *Amphiroa fragilissma* Johnson, intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 3L, 1S. Cells are rectangular, cortical thallus are not observed. Fig. 9: *Amphiroa rigida*, oblique section showing intergenicula with cylindrical to subcylindrical medullary cells with 3L, 1S, to 4L, 1S. Fig. 10: *Amphiroa ephedraea* Ishijima, The intergenicula are cylindrical to subcylindrical and medulla exhibit alternation formula 2L, 1S, 3L, 1S. Cells are rectangular

Genus Corallina Linnaeus, 1758
Corallina prisca Johnson
(Pl. 3, Fig. 2)

Corallina prisca Johnson: Johnson, 1957, pp. 239, pl. 37, fig. 4; pl. 40, fig. 10, p. 44, figs. 1-2. 7-11. *Corallina prisca* Johnson: Johnson, 1961a, p. 940. *Corallina prisca* Johnson: Johnson, 1961b, p. 70, pl. 14, fig. 1.,*Corallina prisca* Johnson, Misra, Jauhri, Kishore and Singh, 2002,

p. 725, pl. 1, fig. 4.*Corallina prisca* Johnson, Kundal and Humane, 2003, p. 269, pl.1, figs. 2,3,4; pl.2, fig. 1.

Material: Wadi Asalay, Marsa Alam, Specimen No. Ma22.
Dimensions (mm):

SN	WS	LMC	WMC	LCC	WCC
Ma22	338-430	64 -76	7-12	10	8

Description: The thallus shows erect growth habit. The intergenicula are slender, tapering and subrectangular cells and nearly cylindrical, commonly slightly flattened, measuring 350 to 1092 µm in length and 335 to430µm in width. largely medullary region surrounded by a thin layer of cortical cells. Cells near center of medullary region $64\mu m$ - $100\mu m$ by $7\mu m$ - $12\mu m$. Conceptacles present in one specimen, marginal conceptacle measuring 150 µm in width and 71µm in length. Cell fusions are prominent
Remarks: Only fragments of *Corallina* which are too poorly preserved to provide detailed taxonomic determinations were encounteredin the present material. On the basis of dimension of medullary core cells and cortical cells, the present specimen is described as *Corallina prisca* Johnson and because they show close similarities like dimension of medullary cells, gross appearance, as that of *Corallina prisca* Johnson.

Genus Jania Lamouroux, 1812
Jania guamensis Johnson
(Pl. 1, Fig. 6, Pl. 3, Fig. 4)

Jania guamensis Johnson: Johnson, 1964, p.G-36, pl.12, figs. 1- 3. *Jania guamensis* Johnson: Kundal and Wanjarwadkar, 2000, p.231, pl. 1, fig. 2, pl. 3, fig. 2. *Jania guamensis* Johnson, Kundal and Humane, 2006b, p. 633, pl.2, figs. 2-3. *Jania guamensis* Johnson, Mude and Kundal, 2012, p. 75, pl. 2, fig b.

***Material*:** Wadi Abu Dabbab, Marsa Alam, Specimen no. MA17-4.
***Dimensions (in µm)*:**

SN	WS	LMC	WMC	LCC	WCC
MA17-4	230-250	25 - 29	7-10	Nil	Nil

***Description*:** The thallus is erect, the intergenicula are subcylindrical to elongate, the medullary region displays irregular rows of cells, the medullary cells are elongated to wedge shaped, and the length of the medullary cells is 25 m while the width of the medullary cells is 10 m. The core region's cell rows join irregularly, and the core cells are wedge shaped, and cell fusions are clearly observed.
***Remarks*:** The present fragment is subcylindrical to elongate and length of medullary cells are comparable to that of *Jania guamensis* Johnson. Therefore, it is described under *Jania guamensis* Johnson.

Genus Subterraniphyllum Elliott, 1957
Subterraniphyllum sp.
(Pl. 2, Fig. 8)

Material: Wadi Asalay, Marsa Alam, Specimen no. MA17-4.
Dimensions (in µm):

SN	WS	LMC	WLC	LCC	WCC
MA17-4	378	78	6-4	Nil	Nil

Description: Intergenicula subcylindrical and circular, exhibiting bifurcation and composed of core region and cortical region. Cells in the core region rectangular to polygonal having thick cell wall. Cells in both core region and cortical region show cell fusions. Epithallial cells in one row but sparsely preserved and present only top right side of segment. Cortical cells rectangular but smaller than cells in the core and cortical region. Conceptacles are not recognized.
Remarks: The dimension of cells in both core and cortical region are as like that of *Subterraniphyllum thomasii* Elliott. The present material has not conceptacle like having lining cells like *Subterraniphyllum thomasii* Elliott documented by Vannucci *et al*. (2000) from late Eocene to Oligocene, Molare Formation, Italy. Therefore the present specimens are described as *Subterraniphyllum* sp. only.

Discussion

The coralline red algal assemblage recovered from the reefal limestone of Shagra Formation (Pliocene age) is dominated by geniculate corallines belonging to Subfamily Amphiroideae. It is noteworthy that the present algal assemblage contains variety of geniculate coralline red algae. Geniculate corallines are very abundant in many of the Miocene - Pliocene reefal limestone deposits and extant species are distributed worldwide in tropical and subtropical oceans. Geniculate coralline algae comparable to *Subterraniphyllum* (Subfamily Corallinoideae) have been rarely recorded from Shagra reefal limestone. The genus was recorded earlier from Upper Oligocene and Lower Miocene deposits (Bassi et al., 2000). It must be mentioned here that assignment of the form described in this paper under the genus *Subterraniphyllum* is questionable and tentative. On the other hand, stratigraphic distribution of the geniculate coralline algal genus, *Amphiroa* (Subfamily: Amphiroideae) ranges from Upper Cretaceous to Recent (Beckmann and Beckmann, 1966; Lemoine, 1939; Conti, 1950; Johnson, 1961; Poignant, 1977, 1979). However, majority of the forms of *Amphiroa* in the present assemblage are comparable to the Miocene (lshijima, 1954; Johnson, 1964; Johnson & Ferris, 1950) and Pliocene species (Johnson, 1957) recorded earlier.

The present paper reports eleven species of geniculate coralline algal assemblage comprises eight species belonging to five genera, namely *Arthrocardia indica*, *Corallina prisca*, *Jania guamensis*, and and seven species of genus *Amphiroa* sp. The present paper reports also eleven species of *Amphiroa* viz. A. *anchiverricosa, A. ephedraea, A. rigida, A. prerigida, A. fortis, A. fragilissima, A. tani, A. prefragilissima and one new species A. dabbabenesis.* Present geniculate coralline red algal assemblage is associated with the dasycladalean algae (not described here). Without indicating precise depth of deposition, Kora et al. (2009) surmised that the Shagra Formation was deposited in the inner-shelf environment. As corallines occupy a large depth range from 10 to 70 m (Littler *et al.,* 1986), the present geniculate algal assemblage is not indicative of precise depth of deposition and modern species of *Amphiroa* are widely distributed in the tropical ocean. They are usually delicate in nature and prefer shallow water (Johansen, 1981). However, the present assemblage is useful to denote energy conditions prevailing during the deposition of the Shagra Formation. The Shagra Formation has been dated as Pliocene on the basis of planktonic foraminifera (Kora et al. 2013) indicating that gradual shallowing to subtidal conditions occurred in Marasa Alam, red sea area during Pliocene that is evident by the presence of coral algal boundstone and occassional foraminiferal-algal molluscan grainstone-packstone lithofacies (Kora et al. 2013).

According to them the shallowing of the basin is attributed to sea floor tectonism in Marsa Alam, Red sea region, which uplifted most of the islands of the red sea group to near the present position. The shallow marine condition prevailed in the in Marsa Alam, Red sea during Pliocene. Considering the relevant micropalaeontological and strtigraphical evidence it can be concluded that the recovered coralline red algal forms from the reefal limestone unit of Shagra Formation thrived in a shallow marine condition. Based on the bathymetric data of coralline algae (Adey, 1979; Bosence, 1991) it can be assumed that in all probabilities these algal forms thrived in a shallow marine condition the association of geniculate coralline algal assemblage points out that the limestone of the Shagra Formation was deposited at a depth of 10-25 m in marine environment under low-energy conditions.

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References

Adey W. Ho 1979. Crustose coralline algae as micro-environmental indicators

Adey, W. H., MacIntyre, I. G. 1973. Crustose coralline algae: A re - evaluation in the geologic sciences. Geological Society of American Bulletin, 84: 883- 904.

Akkad, S. Dardir, A. 1966. Geology of the Red Sea coast in the area between Ras Shagra and Marsa Alam, with short not on result of exploratory work of Gabal El Rusas lead - Zinc deposits. Geological Survey of Egypt, No. 3, 67p.

Al-Rifaiy, I. A., Cherif, O. H. 1989. Paleogeographic significance of Pliocene and Pleistocene mega-invertebrates of the Red Sea and the Gulf of Aqaba.- J. Univ. Kuwait (Sci.), 16 (2):367-399.

Bassi, D., Woelkerling, W,J., Nebelsick, J.H., 2000. Taxonomy and biostratigraphical reassessment of Subterraniphyllum Elliott (Corallinales, Rhodophyta). Palaeontology, 43 (3): 405-425.

Beadnell, H. J. 1924. Report on the geology of the region of the Red Sea coast between Qusier and Wadi Ranga. Petroleum Research Bull., 13: 23p, Cairo.

Beckmann, J.P., Beckmann, R.C. 1966. Calcareous algae from the Cretaceous and Tertiary of Cuba. Shweizerische Paleontology, 85 :1-45.

Bosence, D. W. J., 1991. Coralline algae: mineralization, taxonomy and paleocology. In: Riding, J. (ed.). Calcareous Algae and Stromatolites. Springer Verlag, Heidelberg.

Conti, 1950

Conoco-EGPC 1987. Geological map of Egypt-NG 36 SE Gabal Hamata. Scale 1: 500000 Edited by Klitzsch, E., List, F., Pöhlmann, G.; Coral and the Egyptian General Petroleum Corporation, Cairo, Egypt

Dullo, W.-C., 1990. Facies, fossil record and age of Pleistocene reefs from the Red Sea (Saudi Arabia).- Facies 22, 1-46.

El-Akkad, S., Dardir, A., 1966. Geology of the Red Sea coast between Ras Shagra and Marsa Alam with short notes on the exploratory work at Gebel El-Rusas lead-zinc deposits.- Geol. Surv. Egypt Paper No. 35, 1-67.

El-Asmar, H. M., 1997. Quaternary isotope stratigraphy and paleoclimate of coral reef terraces, Gulf of Aqaba, South Sinai,Egypt.- Quaternary Science Reviews, 16: 911-924.

El-Asmar, H. M. and Abdel-Fattah, Z. A., 2000. Lithostratigraphy and facies development of the Neogene- Quaternary succession in the Marsa Alam area, Red Sea coastalplain, Egypt.- N. Jb. Geol. Paläont. Abh., 217 (3): 397-431.

El Moursi, M. (1993): Pleistocene evolution of the reef terraces of the Red Sea coastal plain between Hurghada and Marsa Alam, Egypt.- Journal of African Earth Sciences 17(1): 125-127.

El Moursi, M., Hoang, C.T., El-Fayoumy, I.F., Hegab, O. and Faure, H., 1994. Pleistocene evolution of the Red Sea coastal plain, Egypt: Evidence from uranium-series dating of emerged reef terraces.-

Quaternary Science Reviews 13: 345-359.
Elliott, G.F. 1957. Subterraniphyllum, a new Tertiary calcareous alga. epiphytic crustose Corallinaceae of the British Isles. By. Phycol. 1., 8: 343-408.
El-Akkad, S. and Dardir, A. (1966): Geology of the Red Sea coast between Ras Shagra and Marsa Alam with short notes on the exploratory work at Gebel El-Rusas lead-zinc deposits.- Geol. Surv. Egypt Paper No. 35: 1-67.
Hamad, M. M., 2008 a. Algal Biostratigraphy of some Lower Miocene Sequences, North Eastern Desert, Egypt. International Journal of algae, 10 (1):79 - 102.
Hamad, M. M. 2008 b. Coralline red algae from the Early Pliocene Shagra Formation at Wadi Wizer, Red Sea coast, Egypt. And their implications in biostratigraphy and paleoecology - International journal of Algae,10 (2): 179- 208
Hamad, M.M. 2020 .Coralline red algae from the Lower Pliocene Shagra Formation of Wadi Wizer, Red Sea coast, Egypt: Biofacies analysis, systematics and palaeoenvironmental implications, Geopersia, 10 (1): 1-21.
Hamad, M., Orabi H., 2021. Coralline Red Algae and Microfacies studies as environmental indicators: A case study from the Gharamul formation, Gulf of Suez Region, Egypt, Geopersia, 11(2): 411-430
Hathout, N, H., Orabi, H. O., 1995. Contribution to the lithofacies, geochemistry and paleoecology of some Miocene - Pliocene exposures in Marsa Alam area, Red Sea coast, Egypt. Egyptian Journal of Geology, 39 (2): 769 - 792.
Ishijima, W. 1954. Cenozoic coralline algae from Western Pacific, Tokyo. (Privately Printed).
Issawi, B., Francis, M., El Hinnawy, M., Mahanna, A., & El Deftar, I. 1971. Geology of Safaga - Qusier coastal plain and Rabab area, Egypt. Ann. Geological Survey of Egypt, 1: 1 -20.
Johnson, J. H. 1955. LowerTertiary Corallinae algae from Trinidad, British West Indies. Eclogae Geol. Helv., 48 (1): 69 - 78.
Johnson, J. H. 1957. Calcareous algae from Saipan Mariana Islands, part 3. Paleont. U.S.Geol. Surv. Prof. Pap., 208E: 209- 246.
Johnson, J. H. 1961. Fossil algae from Eniwetok, Funafuti, and Kita - Daito - Jima. Professional. Paper of U. S. Geoogical Survey, 260: 907 - 950.
Johnson, J. H. 1964. Miocene coralline algae from northern Iraq. Micropaleontology, 10 (4): 477- 485.
Johnson, J. H. 1965. Tertiary red algae from Borneo. Bull. British Mus (Natural History), Geology, 11 (6): 257- 280.
Khalifa, H., 1984. Pliocene coralline algae, south of Safaga (Red Sea, Egypt) -.Qatar Univ. Sci. Bull. (4): 185-204.
Khalifa, H., Boukhary, M. A., 1982. Coralline Algae from the Neoegne and Pleistocene Sequence of Mersa Alam, Red Sea, Egypt.- Qatar Univ. Sci. Bull. (2): 209-224.
Kishore, S., Singh, A.P., Jauhri, A.K., Misra, P.K., Singh, S.K., Lyngdoh, B.C. 2009. Coralline algae from the Prang Formation (Eocene) of the South Khasi Hills, Meghalaya, India.
Kishore, S., Singh, A.P., Jauhri, A.K., Singh, S.K., Misra, P.K., Tiwari, R.P. 2011. Middle Eocene calcareous algae from the Prang Formation of the Therria Area, East Khasi Hills, Meghalaya,
Kora, M. and Abdel-Fattah, Z., 2000. Pliocene and Plio-Pleistocene macrofauna from the Red Sea coastal plain (Egypt): Biostratigraphy and biogeography.- Geologica et Palaeontologica 34: 219-235.
Kora, M., Ayyad, A., El-Desouky, H., 2013. Microfacies and environmental interpretation of the Pliocene-Pleistocene carbonates in the Marsa Alam area, Red Sea coastal plain, Egypt. Journal of Environmental Sciences, 42 (1): 155 -182.
Kundal , P. 2010. Biostratigraphic, paleobiogeographic and Paleoenvironmental significance of calcareous algae, p.125-132. In: Applied Micropaleontology (Eds. Kundal, P. and Humane, S.K.), Special issue of Gondwana Geological Magazine, 25 (1).
Kundal, P. 2011. Generic distinguishing characteristics and stratigraphic ranges of fossil corallines: an update. Journal Geological Society of India, 78: 571-586.
Kutch, Gujarat. Geophytology, 9: 88-90.
Kundal, P. 2011. Generic distinguishing characteristics and stratigraphic ranges of fossil corallines: an update. Journal Geological Society of India, 78: 571-586.
Kundal, P. Humane, S. K. 2002. Geniculate coralline algae from Middle Eocene to Lower Miocene of Marsa Alam area, Gujarat, India. Gondwana Geological Magazine, 17(2): 89-101.
Kundal, P. Humane, S. K. 2003. *Corallina,* a geniculate coralline alga from Middle Eocene to Lower

Miocene of Marsa Alam area, Gujarat, India, p.261-275. In: Recent Developments in Indian Micropaleontology (Ed. Kundal, P.), Gondwana Geological Magazine, special volume 6.

Kundal , P. Humane, S. K. 2006a. Record of Metagoniolithon (Corallinales, Rhodophyta) from the Burdigalian of western India. Current Science, 91(2): 221-224.

Kundal, P. Humane, S. K., 2006b. Jania, a geniculate coralline alga from Middle Eocene to Lower Miocene of Marsa Alam area, Gujarat. Journal Geological Society of India, 68(4): 630-638.

Kundal , P., Humane, S. K., 2007a. Stratigraphic, paleobiogeograhic and paleoenvironmental significance of *Mesophyllum*, a nongeniculate coralline alga from western Marsa Alam area (Middle Eocene to Oligocene), India, p. 145-154. In: Micropaleontology: Application in Stratigraphy and Paleoceanography (Ed. Sinha, D.K.), Narosa Publishing House Pvt. Ltd., New Delhi.

Kundal, P., Mude, S. N. 2009. Geniculate coralline algae from the Neogene-Quaternary sediments in and around Porbandar, Southeast coast of India. Journal Geological Society of India, 74: 267-274.

Kundal, P., Kundal, M. P. 2011. Calcareous algae from Middle Eocene to early Miocene onshore sequence of Marsa Alam area Basin,western India: paleoenvironmental significance and hydrocarbon perspective, p. 251-259. In: Sedimentary Basins of India (Eds. Kundal, P. and Pophre, A.M.), Gondwana Geological Magazine Special Volume 12.

Kundal , P., Wanjarwadkar, K. M. 2000. Jania Lamouroux from the Late Paleocene Limestone of Middle Andaman Island, Andaman, India. Proceedings of XVI Indian Colloquium on Micropaleontology & Stratigraphy, NIO, Goa, Oil and Natural Gas Corporation Limited Bulletin 37:227-237.

Lemoine, M. P. 1966. Calcareous algae from the Cretaceous andTertiary of Cuba, Schweizerische Palaontologiscle Abhandlunge. V.85, pp. 1-42.

Littler, M. M., Littler, D. S., Hanisak, M. D. 1991. Deep water rhodoliths distribution, productivity, and growth form history at sites of formation and subsequent degradation. Jorunal of Marine Biology and Ecology, 150: 163-182 .

Littler, M.M., Littler, D.S, Blair, S.M., Norris, J.N. 1986. Deep- water plant communities from an uncharted seamount of San Salvador Island, Bahamas: distribution, abundance and primary productivity. Deep Sea Research, 33: 881-892.

Mahran, T. M., 1990. Sedimentology and general stratigraphy of the Pliocene sediments of the Red Sea coastal area., Egypt. Ph. D. Thesis, Assuit university, 345p.

Mahran, T. M., 2000. Cyclicity and sequence stratigraphy of syn-rift Late Neogene mixed carbonates-siliciclastics of the area between Wadi Zug El-Bohar and Wadi Dabr, Red Sea, Egypt.- Egypt . J. Geol., 44 (2): 237-275.

Mastrori lli, V. I. 1968. Caratteri Morphologici E structturali di on Esemplare Fertile Di “Subterraniphyllum” Elliott Rinvenuto Nell Oligocene Di Ponzone (Piemonte). Rivista Italiana di Paleontologia e Stratigrafia. 74 (4): 1275-1288.

Misra, P. K., Jauhri, A. K., Si ngh, S. K., Ki shore, S., Chowdhury, A. 2001. Coralline algae from the Oligocene of Marsa Alam area, Gujarat, India. Journal of the Palaeontological Society of India, 46:59-76.

Misra, P. K., Jauhri, A. K., Singh, S. K., Kishore, S. 2006. Coralline algae from Fulra Limestone (Middle Ecocene) of Marsa Alam area, Gujarat, western India. Journal Geological Society of India, 67 (4): 495-502.

Mude, S. N. Kundal, P. 2011. Subterraniphyllum thomasii Elliott, fossil calcareous alga: the Evolutionary link between geniculate and nongeniculate coralline algae: a hypothesis. Open Journal of Geology, 1: 51-55.

Mude, S. N. Kundal, P. 2012. Additional coralline algae from the Lower Miocene to Late Holocene sediments of the Porbandar Group, Gujarat. Journal Geological Society of India, 79: 69-76.

Mude, S. N., Kundal, P., and Shashikant D. R., 2021. Coralline Algae from the Late Pleistocene Miliolite Formation of Marsa Alam area, Western India- Journal Geological Society of India . 97: 1355-1364.

Singh, S. K., Kishore, S., Jauhri, A. K., Mi sra, P. K. 2011. Coralline algae from the Bermoti Member (Upper Oligocene) of the Maniyara Fort Formation of Marsa Alam area, Gujarat, India Revue de Paleobiologie, 30(1):177-190.

Philobbos, E. R.; El-Haddad, A. A., Mahran, T. M., 1989. Sedimentology of syn-rift Upper Miocene (?)-Pliocene sediments of the Red Sea area: A model from the environs of Marsa Alam, Egypt.-

Egypt. J. Geol., 33 (1-2): 201-227.
Rasser, M. W., Nebelsick, J. H. 2003. Provenance analysis of Oligocene autochthonous and allochthonous coralline algae: a quantitative approach towards reconstructing transported assemblages. Palaeogeography, Palaeoclimatology, Palaeoecology, 201(1-2): 89-111 .
Said, R., 1990. Cenozoic. In: Said, R. (Ed.), The Geology of Egypt. A. A. Balkema,
Souaya, F. J. 1963. Micropaleontology of four sections south of Qusier, Egypt, Micropaleontology, 9 (3): 233- 266 .
Souaya, F. J. 1963a. Micropaleontology of four sections south of Qusier, Egypt, Micropaleontology, 9 (3): 233 - 266.
Souaya, F. J. 1963b. On the calcareous algae (Melobesoideae) of Gebel Genefe (Cairo - Suez Road) with local zonation and some possible correlations. Journal of Paleontology, 37 (6): 1204 - 1216.
Strasser, A. and Strohmenger, Ch. (1997): Early diagenesis in Pleistocene coral reefs, southern Sinai, Egypt: response to tectonics, sea-level and climate.- Sedimenyology 44: 537-558.
Vannucci, G., Basso, D. and Fravega, P. 2000. New observation on the anatomy of the calcareous alga Subterraniphyllum Elliott. Rivista Italiana di Paleontologia e Stratigrafia, 106 (2): 237-246. Wanjarwadkar, K.M. 2000. Fossil calcareous algae and ichnofossils from Paleocene-Eocene sediments of Middle Andaman Island, Andaman. Unpublished Ph.D. Thesis, Dr. Babasaheb Ambedkar
Woelkerling, W. J. 1988. The Coralline red alage: an analysis of the genera and subfamilies of the nongeniculate Corallinaceae.- Oxford University Press, 268pp .
Woelkerling, W. J., Irvine, L. M., Harvey, A. S., 1993. Growth forms in non - geniculate coralline red algae (Corallinales, Rhodophyta). Austeralian Systematical Botany, 6: 277 - 293.
Wray, J.L. 1977. Calcareous Algae, Developments in Paleontology and Stratigraphy. Elsevier Scientific Publishing Corporation 4 .