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ASPIDISCUS CRISTATUS (LAMARCK) FROM THE CENOMANIAN SEDIMENTS OF WADI QUSEIB, EAST SINAI, EGYPT

D. K. PANDEY[1], FRANZ T. FÜRSICH[2], M. GAMEIL[3] and W. S. AYOUB-HANNAA[2]

[1] UNIVERSITY OF RAJASTHAN, JAIPUR 302004, INDIA
[2] FRIEDRICH-ALEXANDER-UNIVERSITÄT ERLANGEN-NÜRNBERG
GEOZENTRUM NORDBAYERN, FACHGRUPPE PALÄOUMWELT, LOEWENICHSTR 28, D-91054 ERLANGEN, (GERMANY)
[3] GEOLOGY DEPARTMENT, FACULTY OF SCIENCE, CAIRO UNIVERSITY, CAIRO (EGYPT)
e-mail: <dhirendrap@hotmail.com>

ABSTRACT

Aspidiscus cristatus (Lamarck) has been described and illustrated from three coral-bearing horizons of the Cenomanian sedimentary succession of Wadi Quseib, East Sinai, Egypt. The new specimens show well-preserved internal microarchitectures, which corroborate its assignment to family Latomeandridae Alloiteau, 1952. The stratigraphic range of *Aspidiscus cristatus* suggests that it can be used as index for the Middle to early Late Cenomanian. Based on the morphology of *Aspidiscus cristatus* and its consistent record, it is suggested here that the coral had a narrow facies range, being adapted to a free mode of life on soft, marly to argillaceous substrate, in low-energy environments subjected to high rates of sedimentation.

Keywords: *Aspidiscus Cristatus*, Taxonomy, Stratigraphic distribution, Cenomanian Galala Formation, Wadi Quseib, Sinai, Egypt

INTRODUCTION

The scleractinian genus *Aspidiscus* is one of the dominant colonial coral genera in the Cenomanian (Upper Cretaceous) rocks of many peri-Mediterranean countries. The dome-shaped colony resembles the feast cake made by the Egyptians and hence it is informally called "feast cake" by Egyptian palaeontologists. Its unique shape, morphological features, short stratigraphic range, and wide distribution around the Mediterranean has drawn the attention of palaeontologists to evaluate its significance in stratigraphic correlation and for palaeoenvironmental reconstructions. The genus appeared in the Late Albian of Egypt and by the Middle Cenomanian had spread to Egypt, Libya, Tunisia, Algeria, Qatar, Bahrain, Jordan, Greece, Albania, Spain, France, Italy, and Germany (Beauvais, 1992). It has also been recorded from Uruguay tentatively (see Gill and Lafuste, 1987; Gill and Chikhi, 1991 for the global distribution of the genus). In the present paper, the taxon is described and illustrated in detail, based on the material collected from the Cenomanian of Wadi Quseib, East Sinai, Egypt. In addition, its systematic classification, geographic occurrence, and palaeoecological significance has also been discussed.

STRATIGRAPHY OF THE UPPER CRETACEOUS ROCKS OF THE WADI QUSEIB AREA

Marine Cretaceous sedimentary rocks cover around 40% of the surface area of Egypt. These rocks are exposed with various thicknesses in several localities of the Sinai Peninsula. The Cenomanian-Turonian succession of Sinai exhibits lateral facies and thickness changes (Shata, 1956; Kuss, 1989; Said, 1990; Darwish, 1994). In northern Sinai, these deposits consist almost exclusively of shallow-marine carbonates, whereas towards the south, they become more siliciclastic.

Lithostratigraphically, the Upper Cretaceous rocks of Wadi Quseib (near the Gulf of Aqaba, Fig. 1A) have been divided into four formations (Fig. 1B). These rocks contain a rich benthic and pelagic fauna. Corals occur in the Cenomanian Galala Formation and have been collected from three beds in the middle and upper part of the formation.

The rocks, outcropping at the northwestern side of the Gulf of Aqaba, are of very limited distribution being restricted to grabens, and pull-apart basins (Abdel-Khalek *et al*., 1993). The Cenomanian-Turonian succession is 268 m thick and has been subdivided into three formations; the Galala (Cenomanian), Abu Qada (Lower-Middle Turonian), and Wata formations (Upper Turonian) in ascending order (Fig. 1B). The Galala Formation unconformably overlies multicoloured kaolinitic, ferruginous sandstones of the Malha Formation (Lower Cretaceous). It is conformably overlain by fossiliferous shales and limestones of the Abu Qada Formation. The Abu Qada Formation is followed upward by the Wata and Matulla formations respectively. The latter is of Coniacian-Santonian age (Fig. 1B).

The Galala Formation attains a thickness of 112 m and can be divided into three informal members (Fig. 2). The lower shale member is 33 m thick and consists of green, glauconitic, fissile shale with thin gypsum veinlets. This part grades upwards into nodular marly limestone, forming a gradational contact with the overlying middle siliciclastic/carbonate member (Fig. 2).

The middle siliciclastic/carbonate member is 56 m thick and is composed of dolomitic, fossiliferous limestones interbedded with fossiliferous shales and marls. The basal calcareous part contains fragments of the bivalve *Chondrodonta joannae* (Choffat, 1886), rudists, corals, coralline sponges, and the trace fossil *Thalassinoides.*

The siliciclastic shale beds contain oysters, rudists, coralline sponges (*Actinostromarianina* sp.) and some gastropods. *Aspidiscus cristatus* (Lamarck) occurs associated in this middle part. This part grades upward into nodular, marly limestone containing *Neolobites vibrayeanus* (d'Orbigny, 1841) of early Late Cenomanian age.

The upper carbonate member is 23 m thick and is composed mainly of greyish-yellow, hard, thick-bedded, fossiliferous, dolomitic limestone. The basal 5 m are nodular, cavernous, and bioturbated, whereas the remaining 18 m are bedded and cliff-forming. The uppermost part, which marks

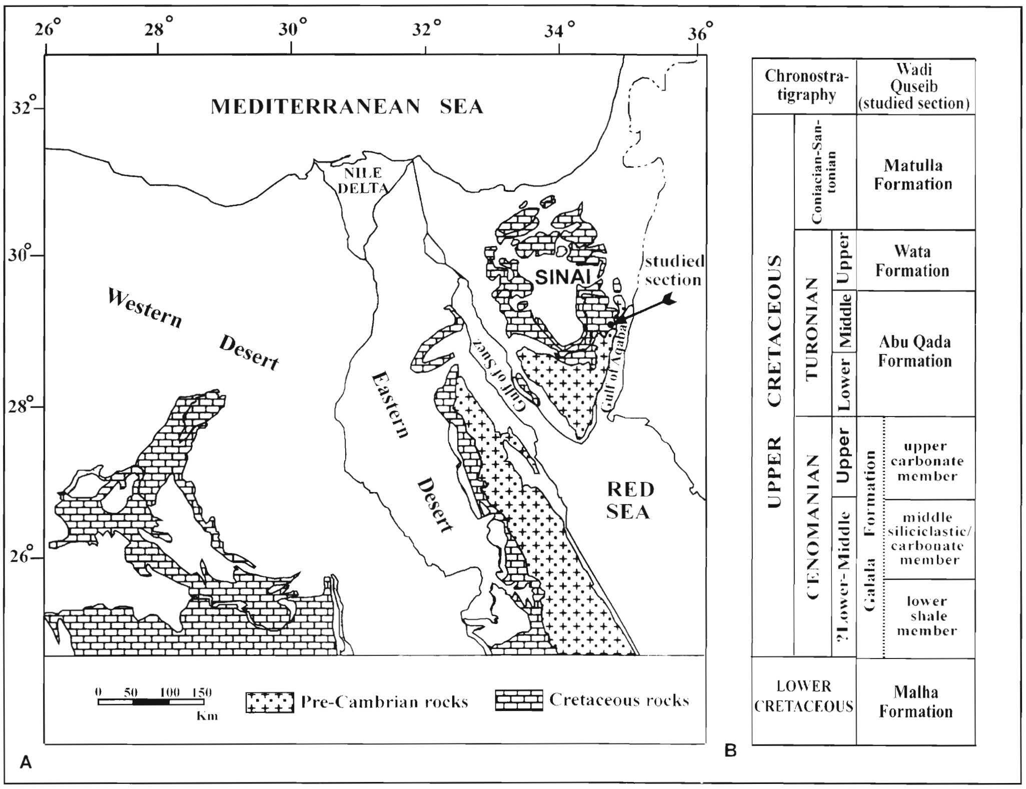


Fig. 1. A. Locality map. B. Lithostratigraphic units of the Upper Cretaceous rocks at Wadi Quseib.

the end of Cenomanian, is again rich in corals, rudists, coralline sponges, and *Chondrodonta joannae*.

The Cenomanian-Turonian boundary is placed at the first appearance of the ammonite *Choffaticeras* (*Choffaticeras*) *segne* (Solger, 1903) within the basal part of the Abu Qada Formation. The boundary also coincides with the extinction, at least in Egypt, of the Late Cenomanian oysters *Costagyra olisiponensis* (Sharpe, 1850) and *Rastellum carinatum* (Lamarck, 1806).

MATERIAL AND METHOD

19 moderately well-preserved coral specimens have been collected from the Cenomanian Galala Formation of the study area. The specimens have been photographed; subsequently thin-sections have been prepared for studying the internal micro-architecture. The material has been deposited in the Museum of Geology Department, Menoufiya University under collection numbers MGDMU: WQ.C. 1-19. For the terminology of the monticules, the terms given by Bosellini (1999, p. 225, fig. 4) have been followed. The measurements of the corallum taken in the present work have been shown in Fig. 3.

SYSTEMATIC PALAEONTOLOGY

Abbreviations: D: diameter of corallum;
H: height of corallum;
c-c: distance between two adjacent corallite centers;
ds: density of septa per 1mm;
dt: density of trabeculae per 1 mm;
Ls: maximum length of series;
Ws: maximum width of series;
Dd: maximum density of dissepiments.

Suborder **Microsolenina** Morycowa and Roniewicz, 1995

Family **Latomeandridae** Alloiteau, 1952

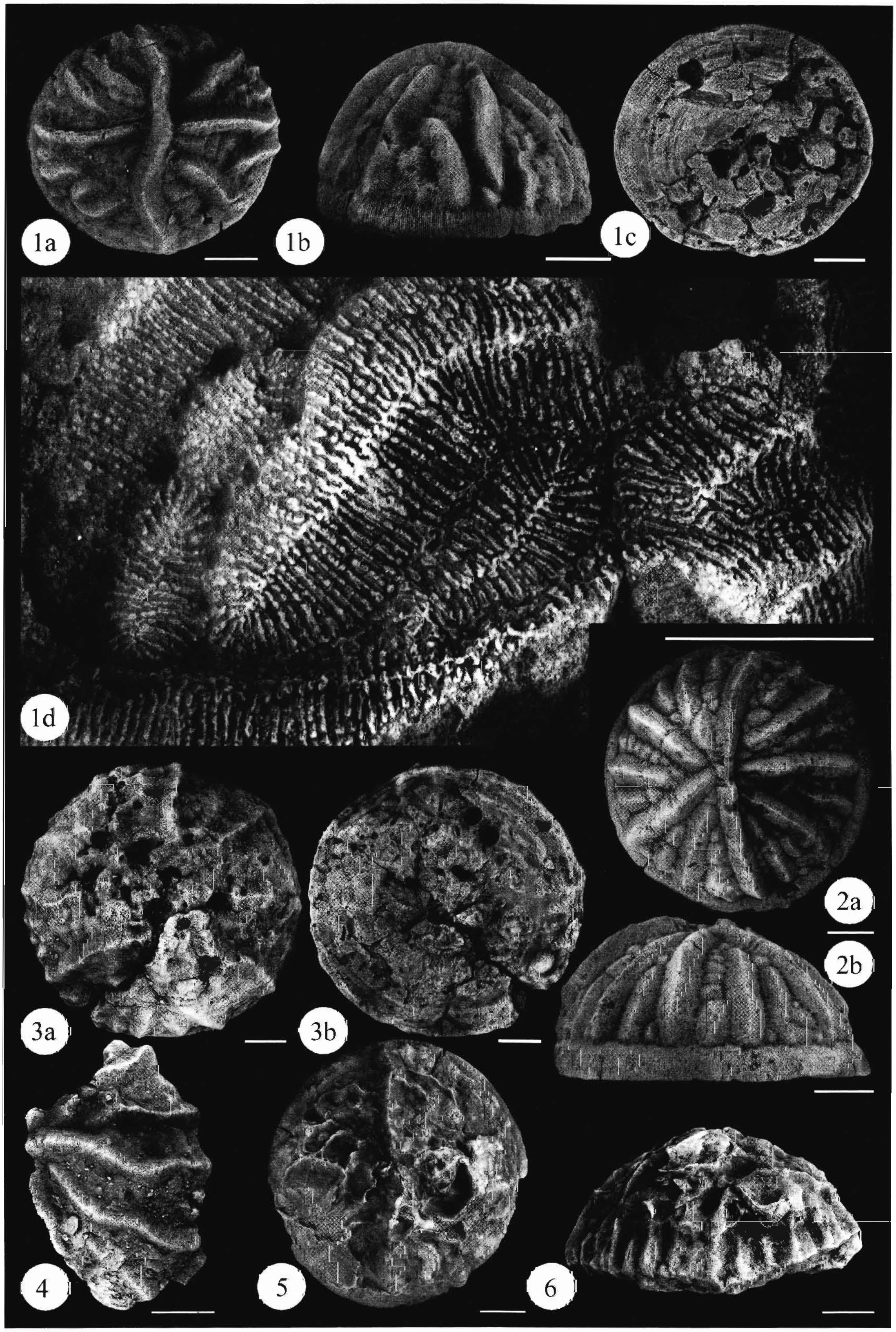
Remarks: The genus *Aspidiscus* König, 1825 has been

EXPLANATION OF PLATE I

1-6. ***Aspidiscus cristatus*** (Lamarck, 1801) from the middle siliciclastic/ carbonate member of the Galala Formation (Cenomanian) of Wadi Quseib, East Sinai, Egypt.

1. MGDMU: WQ.C.1. a: Upper surface view showing sinuous median crest. Scale bar 10 mm. b: Side view showing symmetrical convexity and distinct peripheral crown. Scale bar 10 mm. c: Lower surface with concentric rugae. Scale bar 10 mm. d: Magnified view of upper surface showing calicular centers arranged between crest and row of oval monticules and pennular septa. Note beaded distal margin of septa and outline of pennular structures in plan view. Scale bar 5 mm.
2. MGDMU: WQ.C.2. Scale bar 10 mm. a: Upper surface view showing arched median crest. Note arrangement of crests in hexameral system. The monticules are of early ontogenetic origin and the formation of crests is of later ontogenetic origin. b: Side view showing distinct peripheral crown. Note asymmetric convexity of the upper surface.
3. MGDMU: WQ.C.3. Scale bar 10 mm. a: Upper surface view. b: Lower surface view. Note paired borings.
4. Upper surface of a fragmented colony. Note that in this colony the monticule stage is not represented. The calicular centers are arranged between two crests. MGDMU: WQ.C.4. Scale bar 10 mm.
5. Upper surface view. Note upper surface encrusted with oysters. MGDMU: WQ.C.9. Scale bar 10 mm.
6. Side view showing encrustation by oysters. MGDMU: WQ.C.5. Scale bar 10 mm.

Plate I



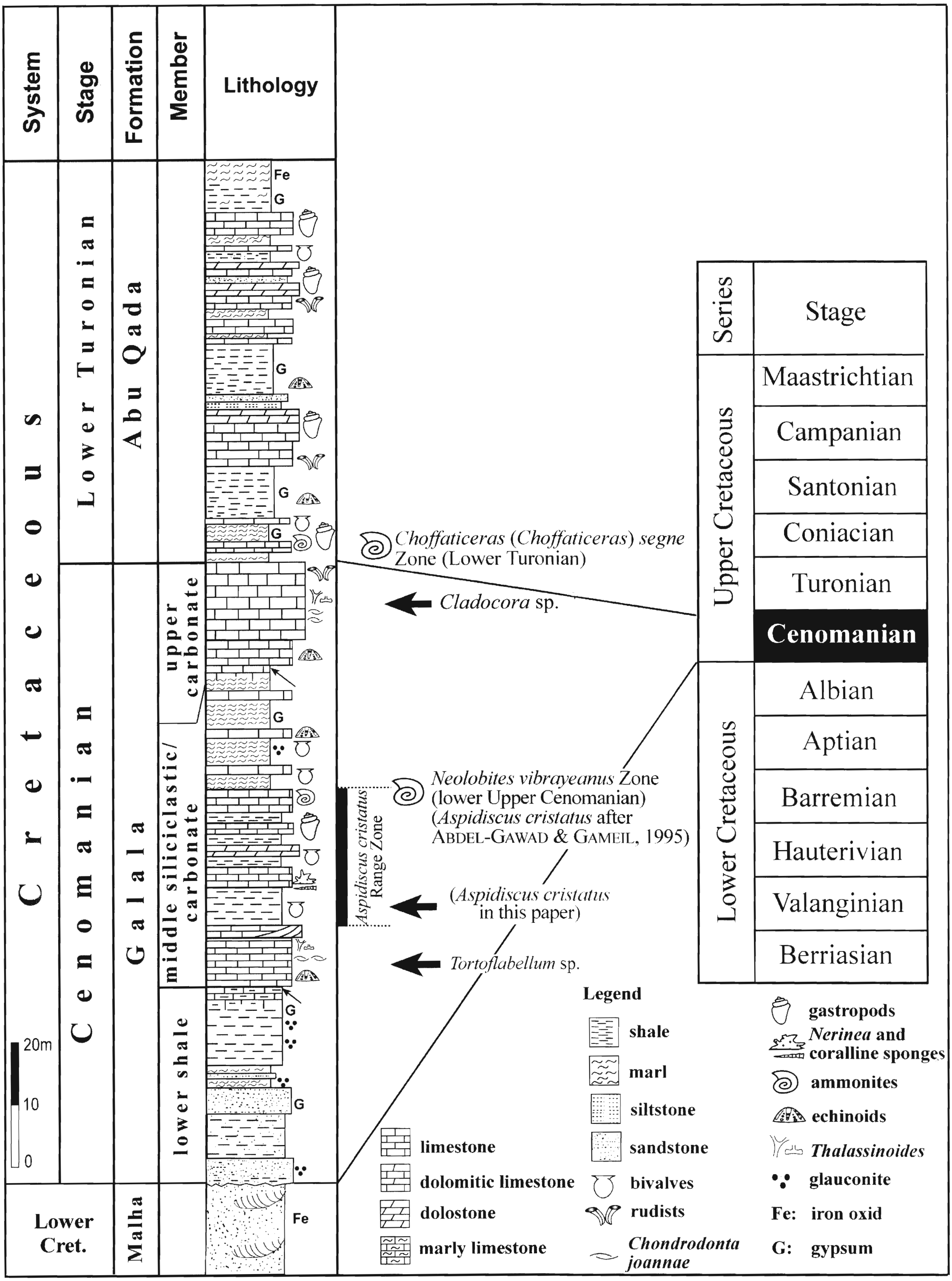


Fig. 2. Litholog of the Cenomanian Galala Formation at Wadi Quseib. Coral horizons have been arrowed.

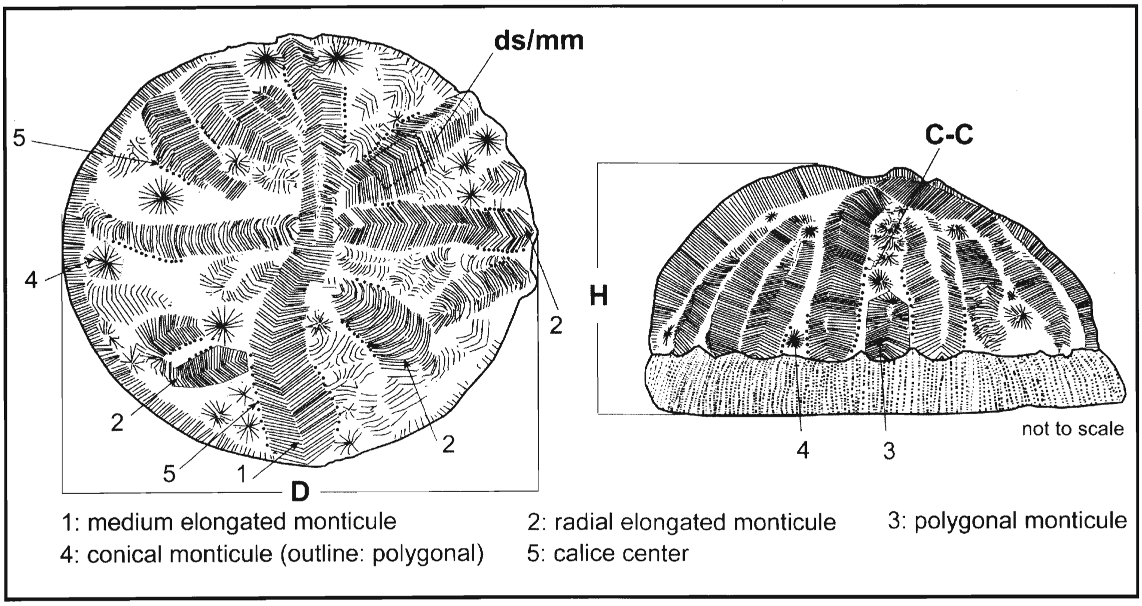


Fig. 3. Sketch showing measurements of the corallum taken in the present work.

assigned to different families from time to time. Vaughan and Wells (1943: 134) and (Wells, 1956, F 387) assigned the genus to the family Cyclolitidae d' Orbigny 1851. Alloiteau (1952, p. 663, pl. 9, fig. 12), Chevalier (1987), and Abdel-Gawad & Gameil (1995, p. 22) grouped the genus with the family Funginellidae Alloiteau, 1952. Subsequently, Morycowa and Roniewicz (1995, p. 378, table 1), based on having upward directed pennulae and proximally diminishing septal perforations, assigned it to the family Latomeandridae.

Table 1: Dimensions of *Aspidiscus cristatus* (Lamarck, 1801) in mm.

Specimen Nr.	D	H	c-c	ds	dt
MGDMU:WQ.C.2	59.9/58.3	29	0.8-1.8	8 per mm	7 per mm
MGDMU:WQ.C.1	51.3/46.3	29.1	1.0-1.8	7 per mm	6-7 per mm

Lately, Baron-Szabo (2002, p. 142) assigned it to the family Cunnolitidae Alloiteau, 1952. The obvious reason for the assignment to different families was either its shape or free living mode of life, meandroid/subthamnasterioid growth structure, or septal microstructure.

The septa in the distal part show all essential characters of the family Microsolenidae, such as fenestrate with pennular structures; however, due to re-crystallization of the proximal part of the corallum in the present collection, the internal characters are not preserved. Thus we do not see the proximally diminishing pores as illustrated by Gill and Lafuste (1987, p. 928) and mentioned by Morycowa and Roniewicz (1995, p. 378). The proximally diminishing pores of septa were used by Morycowa and Roniewicz (1995, p. 378) to assign the genus to the family Latomeandridae Alloiteau, 1952, a view which is followed here.

Genus ***Aspidiscus*** König, 1825

Type species: *Aspidiscus shawi* (= *Cyclolites cristata* Lamark, 1801) (*Cyclophyllia* Milne Edward and Haime, 1848); Cenomanian of Tingitano, Algeria.

Remarks: Gill and Lafuste (1987, p. 921) rightly pointed out that this Cenomanian genus is very attractive in shape and can be easily identified in the field. The genus *Helladastraea* Avnimelech, 1947 was included as junior synonymy of *Aspidiscus* (see Wells 1956: F387, also in the revised treatise, which is in progress). Avnimelech (1948) considered *Helladastraea* as subgenus of *Aspidiscus*. Similarly, the genus *Siniastraea* Avnimelech, 1947 has been put in the category of uncertain systematic position (see Wells 1956, F437) and the author (Avnimelech, 1948) proposed the genus *Siniastraea* for the Jurassic forms. The status of these genera is still not clear.

Aspidiscus cristatus (Lamarck, 1801)
(Pl. I, figs. 1-6; Pl. II, figs. 1a-c, 2a-d)

Cyclolites cristata Lamarck, 1801, p. 369.
Aspidiscus cristatus (Lamarck).- Felix, 1914, p. 107.
Aspidiscus cristatus (Lamarck).- Renz, 1930, p. 8, pl. 2, fig. 1.
Aspidiscus cristatus (Lamarck).- Llueca, 1932, p. 347, pl. 1, figs. 5-6.
Aspidiscus cristatus (Lamarck).- Alloiteau, 1952, p. 663, pl. 9, fig. 12.
Aspidiscus cristatus (Lamarck).- Thomas and Omara, 1957, p. 152, pls. 4-5.
Aspidiscus cristatus (Lamarck).- Gill and Lafuste, 1987, p. 926, pl. 1, figs. 1-9 (non. fig. 10), 11-14; pl. 2, figs. 1-10; text-figs. 1- 3a, 5.
Aspidiscus cristatus (Lamarck).- Gill & Chikhi, 1991, p. 349, fig. 1-2.
Aspidiscus cristatus (Lamarck).- Abdel-Gawad and Gameil, 1995, p. 23, pl. 9, fig. 6.
Aspidiscus cristatus (Lamarck).- Baron-Szabo, 2002, p. 144, text-fig. 53A.

Material: 10 specimens from the middle siliciclastic/carbonate member of the Cenomanian Galala Formation of Wadi Quseib (MGDMU: WQ.C.1-10), East Sinai, Egypt.

Description: Corallum colonial, cupolate with a concave lower surface and a convex upper surface, circular in outline, hydnophoroid. Peripheral crown distinct, margin sharp, covered with septa running at right angle to the margin and continuing over the lower surface for a narrow zone as costae. Lower surface covered with thin holotheca with concentric growth rugae and folds (a concentric fold is seen in specimen MGDMU: WQ.C.1-10 without any attachment area. Upper surface covered with a curved or sinuous median elongated monticule (crest or colline- like) that divides the surface into two sub-equal halves. Radial elongated monticules more or less bilaterally symmetrical on both sides of the median elongated monticule. Radially arranged conical and polygonal monticules occurring between the elongated monticules. Calice centers, which are arranged in series along valleys, limited by either conical or polygonal monticules on one side and elongated monticule on the other side or by elongated monticules on both sides. Elongated monticules distinct, tectiform, successively increasing in number towards periphery. Monticules subcircular, polygonal to elongated in outline. Median elongated monticule and other radial elongated monticules together with conical or polygonal monticules hexamerally arranged. Calice centers moderately distinct. Septa thin, few (4-8), pennular, fenestrate distally, running at right angle to the crest and limited by a synapticulothecal wall. Both symmetrical and mi-pennulae conspicuous, concave upward (Pl. II, figs. 1-2), with arch-shaped to straight margin, continuing around the innermost trabecula. Menianae continuous to discontinuous, margin with very fine denticles (9 per 0.5 mm) (Pl. II, figs. 2b-c). Dissepiments present, vesicular. Synapticulae occurring along the wall, which coincides with the peak of monticules. Columella indistinct, columellar fossa slightly elongated in the direction of valley.

Remarks: The lower surface of the specimens is bored and the holotheca is eroded in a few places exposing the costae underneath. In specimen MGDMU: WQ.C.1-10, due to erosion of the concentric fold of the lower surface, apparently an oval-shaped monticule-like structure has formed (Pl. I, fig. 1c). The conical monticules on the upper surface represent initial ontogenic stage of elongated monticules. Gill and Lafuste (1987, p. 926, figs. 1-3) studied the variability in the position of crests (=elongated monticules, according to Bosellini, 1999), monticules and calices in specimens of *Aspidiscus cristatus* Lamarck, from different localities. The different species of the genus *Apidiscus* have been distinguished on the basis of position of crests (elongated monticules) and monticules. The three specimens described herein show a long median elongated monticules, which divides the central dome into two equal halves. In this respect, the specimens match well with this species. Gill and Lafuste (1987) excellently illustrated the micro-architecture, particularly the pennular structures. The morphology of the pennular structures corresponds to that of the present specimens. However, the "spoon-like terminal pennula" Gill and Lafuste (1987, p. 928, fig. 8) is not always seen. The outline of that pennula varies from one septum to another and its size may be reduced to a finely denticulated line at the margin.

DISCUSSION

The elongated monticule - conical monticule ratio has been used to distinguish different species of the genus *Aspidiscus*. For instance, *Aspidiscus cristatus* is dominated by elongated monticules with a few conical monticules. In contrast, *Aspidiscus felixi* Renz (1930; Vaughan and Wells, 1943, p. 309, pl. 17, figs. 7, 7a; Baron-Szabo, 2002, p. 145, text-fig. 53B) has densely packed conical monticules with no elongated monticule. *Aspidiscus montgrinensis* Solé (in Bataller 1937) has short elongated monticules and scattered conical monticules, which increase in *Aspidiscus franchii* Zuffardi-Comerci (1921) and become elongated monticules.

The most important diagnostic feature of the genus is the position of the conical monticules in the valleys. In some cases, the conical monticules dominate the entire central dome with no elongated monticule present. In these forms the monticules are elevated with the calicular pits located at the summit of the monticules (see Gill and Lafuste 1987, p. 927, fig. 4). These monticules show a crater-like appearance (i.e. conical shape with opening at the summit), which is completely different from the normal form of *Aspidiscus*.

Temporal and spatial distribution: *Aspidiscus cristatus* has been recorded from the Cenomanian (Upper Cretaceous) of Algeria (Alloiteau, 1952, p. 663; Gill and Chikhi, 1991), Afghanistan (Gill and Lafuste, 1987), Greece (Renz, 1930), Tunisia (Alloiteau, 1952, p. 664) and Spain (Baron-Szabo, 2002). For more palaeogeographic distribution of *Aspidiscus cristatus*, see Gill and Lafuste (1987, p. 929, fig. 9) and Beauvais (1992, p. 243). In Egypt, it is also known from the Cenomanian of Sinai and the western side of the Gulf of Suez. In Sinai, *Aspidiscus cristatus* has been recorded from the Nezzazt Mountain in the southwestern part (Thomas and Omara, 1957; Abdel-Gawad and Gameil, 1995), from Risan Aneiza in the central part (Avnimelech, 1947), from the El-Themed area in the central-eastern part, and from El-Minsherah Mountain in the northern part (Abdel-Gawad and Gameil, 1995). *Aspidiscus* sp., recorded from the Albian of northern Sinai by Abdel-Gawad and Gameil (1995), is poorly preserved and it is clearly not similar to *Aspidiscus cristatus*. On the western side of the Gulf of Suez, the species has been recorded from the Middle Cenomanian of Wadi Araba by Awad (1961).

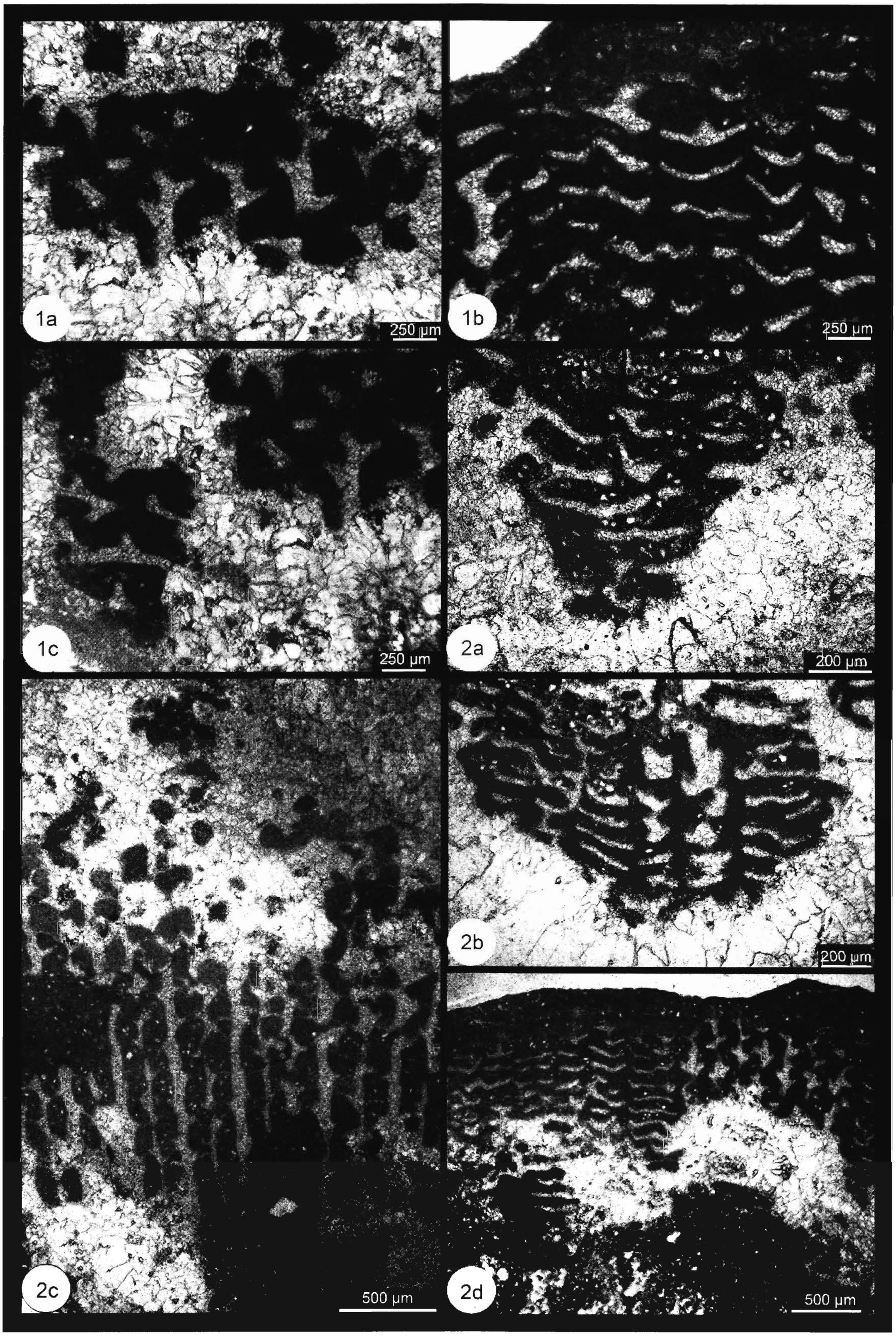
The specimens described in the present paper have been collected from Wadi Quseib in the eastern part of Sinai from a horizon 20 m below the early Late Cenomanian ammonite *Neolobites vibrayeanus* Zone (Fig. 2). In contrast, Abdel-Gawad and Gameil (1995) recorded *Aspidiscus cristatus*, which occurs in abundance in the Nezzazt Mountain section, within the early Late Cenomanian *Neolobites vibrayeanus* Zone. The stratigraphic range of *Aspidiscus cristatus* has been considered to be restricted to the Middle Cenomanian (Gill and Chikhi, 1991, p. 349). However, the record of *Aspidiscus cristatus* by

EXPLANATION OF PLATE II

1-2. ***Aspidiscus cristatus*** (Lamarck, 1801) from the middle siliciclastic/carbonate member of the Galala Formation (Cenomanian) of Wadi Quseib, East Sinai, Egypt.

1. MGDMU: WQ.C.9. a: Magnified longitudinal thin-section showing mi-pennulae. b: Magnified longitudinal thin-section parallel to septal plane showing rows of concave upward oriented pennular structures. c: Magnified transverse thin-section showing mi-pennulae. Note the change in the upward direction of the pennular structures on the two sides of the crest or monticule.
2. MGDMU: WQ.C.5. a: Magnified longitudinal thin-section. Note regular pores (fenestrate) in septa on the two sides of the photograph, and very fine denticles of the margin of menianae in the central part of the photograph. b: Magnified longitudinal thin-section. Note arch-shaped pennular structures with very fine denticles, together forming a broad valley (central part) between two monticules (on the sides). c: Magnified longitudinal thin-section partially parallel to the septum showing regular pores (upper part) and partially right angle to the septa showing mi-pennulae, dissepiments and fine denticles of the margin of menianae. d: Magnified longitudinal thin-section showing regular distribution of concave upward pennular edges, fine denticles of the margin of menianae on the left side of the photograph parallel to septum and mi-pennulae on the right side of the photograph right angle of the spetal plane. Note the sharp junction between two orientations of septa within a monticule.

Plate II



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Abdel-Gawad and Gameil (1995) suggests that it ranges stratigraphically, at least in Egypt, from the Middle to the early Late Cenomanian. The geographic distribution of *Aspidiscus cristatus* around the Mediterranean (Gill and Chikhi, 1991, p. 349) may also corroborate to the data on palaeogeographic settings of the sedimentary basins yielding this taxa during the Cretaceous period.

Palaeoecological remarks: *Aspidiscus cristatus*, described from Wadi Quseib, has a dome-shaped colony with a flat or slightly concave lower surface and is circular in plan-view. The base is covered with a holotheca, which shows concentric folds and grooves.

In contrast to the majority of scleractinian corals, which require a hard substrate for attachment, some corals are adapted to free living (unattached) mode of life on soft substrate. Since *Aspidiscus cristatus* lacks an attachment area, it seems to have been adapted to rest freely on soft substrates (Gill and Chikhi, 1991). However, the colony may have attached itself at least during its early ontogeny stage to hard objects such as, detrital grains or fossil fragments. At later ontogenetic stages, the concave to flat lower surface must have provided stability to the colony. The concentric folds of the holotheca may have served to prevent any lateral movement. The meandroid colony with its convex upper surface is a most suitable adaptation to cope with a high rate of sedimentation. The convex upper surface of the corallum should have facilitated the removal of sediment (Hubbard, 1972, 1973; Hubbard and Pocock, 1972; Wijsman-Best, 1972; Wijsman-Best, 1974a, b; Pandey *et al.*, 2000, p. 14). In Egypt, most of the specimens of the genus *Aspidiscus* are found in marly facies. In contrast, the Cenomanian rocks of Abu Roash, near Cairo, consisting of fossiliferous sandstone and sandy limestone, are devoid of *Aspidiscus cristatus*. The species has also not been recorded from Cenomanian sandstones of Bahariya Oases in the Western Desert. Therefore, *Aspidiscus cristatus* seems to be highly facies-restricted and adapted to low energy, fine-grained, soft substrates and a high rate of sedimentation

Most of the specimens of *Aspidiscus cristatus* are highly bioeroded, both on upper and lower surfaces (Pl. I, figs. 1c, 3a, b). A few specimens are also encrusted by oysters (Pl. I, figs. 4-6) and serpulids. These features record a subsequent increase in energy level, sufficient to dislodge the colonies.

CONCLUSIONS

1. The present record of *Aspidiscus cristatus* (Lamarck) from the Wadi Quseib section adds to the previous records of the species in Sinai.
2. The well-preserved internal microarchitectures corroborate its assignment to family Latomeandridae Alloiteau.
3. The stratigraphic range *Aspidiscus cristatus* earlier considered to be restricted to the Middle Cenomanian (Gill and Chikhi, 1991, p. 349), is extended to the early Late Cenomanian (Abdel-Gawad and Gameil, 1995), at least in Egypt.
4. The morphology of *Aspidiscus cristatus* and its consistent records from soft, fine-grained sediments suggest that species had a narrow facies range resting freely on soft marly or argillaceous substrates, in low-energy environments and high rate of sedimentation.

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ANNOUNCEMENT

Prof. S.K. Singh Memorial Gold Medal

The Palaeontological Society of India has instituted a gold medal in honour of the late Prof. S.K. Singh, former Chief Editor and Head of the Department of Geology, University of Lucknow. The Gold Medal shall be awarded to the best paper published in the Journal of the Palaeontological Society of India in each calender year. The first medal will be awarded to the best of the papers published in the year 2010. The award carries a medal and a citation and will be announced in the meeting of the general body of the society in the first week of March.