CHAPTER I

INTRODUCTION and PREVIOUS WORK

Chapter I

Introduction & Previous Work

1-Introduction

Studying of the Cretaceous rocks in the last years especially in Sinai attracted the attention of geologists and stratigraphers to explore the different regions for oil potentiality and ore deposits. A few work had been carried out on the stratigraphy of the three measured sections (Gebel Ekma, East Themed area, and Gebel Yelleg) and mostly based on foraminifera; Cherif *et al.* (1989a, b), Ammar & Afifi (1992), Orabi & Ismail (1993), Ziko *et al.* (1993), El-Sheikh (1999), and Ismail (2000). Except the recording of some species by Moon & Sadek (1921) from Gebel Yelleg, and the description of some species by Fourtau (1904-1921) and Abbass (1962, 1963) from the different localities no detailed paleontological studies of macrofossils on the studied sections were carried out.

1. 1. Location of the studied sections:

a- Gebel Ekma

Gebel Ekma is located on the south-western part of Sinai to the south of Gebel Nezzazat and lies between Latitudes 28° 37`- 28° 41` N and Longitude 33° 12`- 33° 17` E.

b- East Themed area

The area of study is located to the East of Themed Village and bounded by Latitudes 29° 38`-29° 42` N and Longitudes 34° 24`- 34° 36` E (Figure 1).

c- Gebel Yelleg

This is the largest and most prominent of all the isolated hills in this part of northern Sinai. It is roughly oval in shape, measuring fifty kilometres long and twenty kilometres wide lying with its longer axis running north-east to south-west. Gebel Yelleg Massif represents one of the great elongated asymmetric

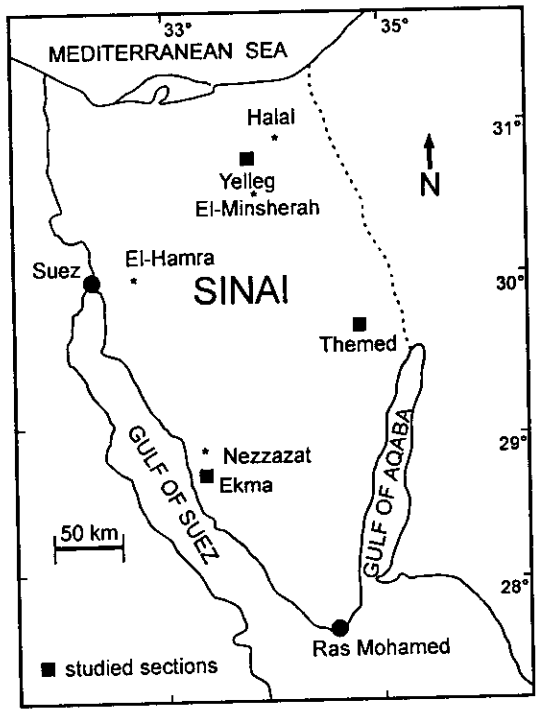


Figure1. Location map of the studied sections.

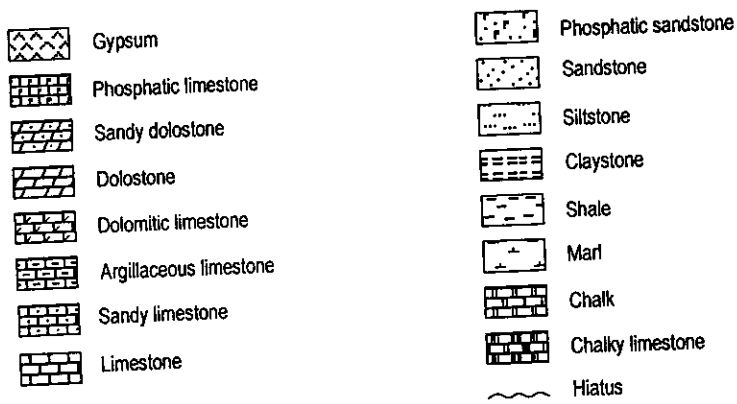


Figure 2. Lithologic symbols used

domes of Cretaceous rocks (Moon & Sadek 1921). It lies between Latitudes 30° 15`- 30° 30` N and Longitudes 33° 15`- 33° 47` E. The studied area is located at the south-east side of the Yelleg Massif between Wadi Um Said and Wadi Um Hathab.

1. 2. Aim of the work

The present work aims to achieve the following:

1. Recognition of the lithostratigraphic units of the Upper Cretaceous succession of the measured sections.
2. Detailed taxonomic studies of the collected bivalves, gastropods, cephalopods, and echinoids from the three sections.
3. Construction of the biozones based on the identified ammonites and some diagnostic taxa from other macrofossils as well as the characteristic larger foraminifera. Providing a complete and integrated biostratigraphy using all possible elements of macrofossils. Correlate the proposed zones with those zones proposed by other authors in different localities in Egypt and in some related and neighbouring countries as well as with the standard zones as far as possible.
4. Discussion of the paleoecology of the studied fauna and consequently determination of the paleoenvironments prevailed during the deposition of the Upper Cretaceous succession in the studied sections.
5. Studying the palaeobiogeographic distribution of the studied macrofossils.

1. 3. Material and methods

To achieve the above objectives, several field trips were performed during seasons 1999-2001 which led to measurement and detalied field description of three stratigraphic sections representing nearly a complete Upper Cretaceous succession (Cenomanian-Maastrichtian). The studied sections have been chosen to reflect the change in the facies from the south to the north in Sinai (Figure 1). The macrofaunal assemblages especially, bivalves, gastropods, cephalopods, and echinoids were collected bed-by-bed throughout the Upper

Cretaceous succession of the three measured sections. For foraminiferal examination, samples were collected from shale, marl, and chalky limestone, along the stage boundaries. The Matulla Formation of Gebel Ekma, was sampled for microfauna at intervals of 50 cm. The Themed Formation of the other two localities and the basal part of the Sudr Formation were sampled by the same method. Samples for larger foraminifera were collected at Gebel Yelleg. The laboratory studies were carried out in both the Geology Department, Faculty of Science, Zagazig University, Benha Branch, Benha, Egypt and Institute of Paleontology, Würzburg University, Würzburg, Germany.

All the studied material is deposited at the Geology Department, Faculty of Science, Zagazig University, Benha Branch (B. U. F. G.), Egypt.

2-Previous Work

Previous studies concerning the Upper Cretaceous rocks of Egypt are copious. Those dealing with the Upper Cretaceous sediments of Sinai are numerous, but the taxonomic studies especially with macrofossils are few. The most important contributions related to the present study are summarized in the following paragraphs.

The most important early macrofaunal studies of the Upper Cretaceous rocks of Egypt had been carried out by Gregory (1898), Bullen Newton (1898), Quaas (1902), Wanner (1902), Dacqué (1903), Fourtau (1904-1921), Douvillé (1910, 1912, 1928), Eck (1914), and Greco (1915-1918).

Moon & Sadek (1921) studied the topography and geology of northern Sinai and gave the first available good knowledge about this area.

Awad (1952) identified and described 18 nerinidae species from different localities in Sinai of them 6 were new.

Farag & Shata (1954) studied the geology of El-Minsherah area and classified its succession based on the megafossils from older to younger;

Jurassic (Middle Jurassic), Lower Cretaceous (Nubian Sandstone), Cenomanian, Turonian, Lower Senonian (Santonian), Upper Senonian (Campanian-Maastrichtian), Transitional beds (Esna Shale), and Lower Eocene.

Awad & Fawzi (1956) divided the Cenomanian deposits of Gebel El-Minsherah into six macrofaunal horizons and they correlated the fauna of El-Minsherah with that of El-Nezzazat area.

Abbass (1962, 1963) published two monographs on the Egyptian Cretaceous pelecypods and gastropods respectively, where he described 154 pelecypod and 71 gastropod species. Among them 54 pelecypod and 47 gastropod species are new, in addition, he mentioned their stratigraphic ranges with emphasis on their distribution in various Egyptian localities.

Fawzi (1963) studied 135 megainvertebrate species (91 bivalves, 29 gastropods, 2 cephalopods, and 13 echinoids) collected from different Cenomanian outcrops in Egypt, among them 12 species and 4 varieties are new.

El-Shinnawi (1967) studied the Lower Senonian ammonites of Wadi Sudr, western Sinai, where he described two new species and two new varieties belong to *Tissotia* Douville, 1890 and *Paratissotia* Hyatt, 1903.

Awad & Issawi (1975) erected the first macro-biostratigraphic framework of the Cretaceous-Paleocene of Egypt. They suggested seventeen biozones for the Upper Cretaceous (Cenomanian-Maastrichtian).

Lewy (1975) described five local Coniacian ammonite zones from Israel and Sinai, where the lower three zones (CA1-3) are attributed to the Early Coniacian and the upper two zones (CA4-5) are Late Coniacian in age.

Kora & Hamama (1987a, b) suggested five macrofossil biozones from the Cenomanian-Turonian succession of Gebel Gunna and four zones from the Senonian succession of Bir Safra area, respectively.

Cherif *et al.* (1989a, b) studied the stratigraphy and foraminiferal content of

the Upper Cretaceous successions of Gebel Mukattab, Gebel Qabiliat, Gebel Nezzazat, and Gebel Ekma. They divided the Upper Cretaceous succession into five lithostratigraphic units; Raha Formation (Early-Late Cenomanian), Abu Qada Formation (Early Turonian), Wata Formation (Middle Turonian), Matulla Group (Late Turonian-Santonian), and Sudr Chalk (Campanian-Maastrichtian).

Malchus (1990) studied the Egyptian Cretaceous oysters with respect to taxonomy, and stratigraphic and geographic distribution. He described 34 species among them one family, two subfamilies, four genera, four subgenera, and five species are new.

Kassab (1991b, 1994) listed and described thirty-six ammonite species from the Upper Cenomanian to the Middle Coniacian successions of north Eastern Desert and suggested seven ammonite zones for this interval.

Abdel-Gawad & Gameil (1992) described twenty-five gastropod species from the Cenomanian of Gebel Nezzazat.

Abdel-Gawad & Zalat (1992) recorded eighty-three macrofaunal species (belong to eight phyla) from the Upper Cretaceous sequence at Gebel El-Hamra and Gebel Um Heriba, Mitla Pass, west central Sinai

Abdel-Gawad *et al.* (1992) studied the biostratigraphy of the Cenomanian-Turonian sequence of Gebel Nezzazat, west central Sinai based on the macrofossils. According to them the boundary between the Cenomanian (Raha Formation) and the Turonian (Wata Formation) delinated at the first appearance of *Choffaticeras segne* (Solger) and the Turonian ends at the last occurrence of *Coilopoceras* sp..

Ammar & Afifi (1992) studied the stratigraphy and depostional environment of the Cretaceous rocks of several sections in North Sinai (Gebel El-Minsherah, G. Yelleg, G. Falik, and G. Maaza). They subdivided the Cretaceous sequence of Gebel Yelleg overlying the fluvial Early Cretaceous (Malha Formation) into three formations; Risan Aneiza Formation (Aptian-

Albian), Halal Formation (Albian-Cenomanian), and Wata Formation (Turonian). They proposed a reef complex facies representing the Halal Formation of Gebel Yelleg, whereas they considered the buildups located in Gebel Yelleg arguing this to the numerous occurrences of rudist boundstones alternating with dolomites.

Kora *et al.* (1993) identified sixty-nine macrofaunal species from the Cenomanian-Lower Turonian successions of some localities in west central Sinai and they recognized five macrofossil zones for this interval.

Orabi (1993) illustrated and figured thirty-one macrofaunal species from the Cenomanian-Turonian of Wadi Watir and Wadi Taba, southeastern Sinai.

Orabi & Ismail (1993) recorded eighteen ostracod species from the Cenomanian-Turonian of the same aforementioned localities of Cherif *et al.* (1989a, b).

Ziko *et al.* (1993) studied the stratigraphy of the Upper Cretaceous-Lower Tertiary of the Themed area. They divided its Cretaceous sequence lithostratigraphically into four formations; Galala Formation (Cenomanian), Wata Formation (Turonian), Themed Formation (Coniacian-Santonian), and Sudr Formation (Campanian-Maastrichtian). They proposed the Themed Formation as a new Formation based on the more carbonate ratio rather than the more clastic Matulla Formation of the same age. This sequence was subdivided into eleven biostratigraphic zones (Table 3) based on the macrofaunal content.

Kassab &Ismael (1994, 1996) described the macroinvertebrates collected from the Upper Cretaceous succession exposed in Gebel Musbaa Salama, east of Abu Zeneima, Sinai, where they recognized four biozones for the Cenomanian-Santonian rocks.

Abdelhamid (1995) studied the Cretaceous echinoids, which were collected from the Cretaceous succession of some different localities in Egypt (six localities; in north Eastern Desert, north Western Desert, and Sinai). He

described 83 echinoid species belonging to 30 genera and 11 orders among them six species were new and seven species were recorded for the first time from Egypt. The generic name of five species was emended. The mode of life and the paleobiology of the studied echinoids were deduced from their functional morphology.

Abdallah *et al.* (1996a) subdivided the Cretaceous sequence exposed at Gebel Halal, north Sinai into five lithostrtatigraphic units from base to top; Malha Formation (pre Aptian?), Risan Aneiza Formation (Aptian? – Albian), Halal Formation (Cenomanian), Wata Formation (Turonian), and Themed Formation (Coniacian-Santonian). They concluded that Malha Formation is of fluvial origin, Risan Aneiza Formation was deposited in near shore environment, Halal and Wata formations were deposited in inner shelf, where the Themed Formation was deposited in open marine conditions.

Abdallah *et al.* (1996b) classified the Cretaceous sequence exposed at Gebel Safariat, southwest Sinai into five lithostratigraphic units from base to top; Malha Formation (Early Cretaceous), Raha Formation (Cenomanian), Wata Formation (Turonian), Matulla Formation (Coniacian-Santonian), and Sudr Chalk (Campanian-Maastrichtian).

Abed *et al.* (1996) classified the Cretaceous sequence exposed at Gebel Arif El-Naga, north eastern Sinai into Malha Formation (Early Cretaceous), Halal Formation (Cenomanian), Abu Qada Formation (Early Turonian), Wata Formation (Late Turonian), Themed Formation (Coniacian-Santonian), and Sudr Formation (Campanian-Maastrichtian).

Kuss & Bachmann (1996) studied the stratigraphic and sedimentological data of the marine Aptian-Maastrichtian strata from Sinai and some neighbouring areas (north Eastern Desert of Egypt and Southern Israel) to reconstruct and illustrate the paleogeographic evolution of their Cretaceous sedimentary successions. They concluded that the sedimention was mainly controlled by transgressions, terrigenous input and tectonic patterns (basin

subsidence and inversion). The stratigraphic frame is based on ammonites, planktic and benthic foraminifera. Detailed paleogeographic maps have been drawn for eight Cretaceous stages (Aptian-Maastrichtian), which led to subdivision of the Cretaceous successions into eight successive scenarios of sedimentation.

Abdelhamid (1997) described 21 (five regular and sixteen irregular) echinoid species from the Turonian-Santonian of Wadi Sudr and Wadi Matulla, west central Sinai. Among the studied fauna one species; *Gitolampas sudrensis* is considered new in addition six species were recorded for the first time from Egypt. He recognized four echinoid horizons (two from the Turonian and two from the Coniacian-Santonian) and correlated them with other megafossil zones and associations, proposed by other authors in this stratigraphic interval. He studied the effect of facies on some selected fossils and discussed the paleobiogeographic distribution of the studied fauna.

El Qot (1998) studied the Cretaceous sequence exposed at Gebel El-Minsherah and Gebel El-Hamra based on macro- and microfossils. He described 128 macrofossil species; 59 bivalves, 20 gastropods, and 49 echinoids.

El-Sheikh & Hewaidy (1998) studied the Early-Middle Cretaceous larger foraminifera from some different localities in northern Egypt. They recognized four zones (the first zone is assigned to Early Aptian, the second Late Aptian, the third Early-Middle Cenomanian, and the last one is refered to the Late Cenomanian), where *Orbitolina concava* = *Praealveolina cretacea tenius* Zone is regarded as Early-Middle Cenomanian and *Biconcava bentori* = *Thomasinella punica* Zone is regarded as Late Cenomanian.

El-Sheikh, *et al.* (1998) studied the stratigraphy and paleoecology of the Cenomanian-Santonian sequence of Gebel El-Minsherah and Gebel El-Hamra, where they suggested eleven zones based on macrofossils and seven foraminiferal zones in Gebel El-Minsherah and eight zones based on

macrofossils and five foraminiferal zones in Gebel El-Hamra.

Lüning *et al.* (1998) discussed the sequence stratigraphy of the Upper Cretaceous of central-east Sinai based on detailed sedimentological, biostratigraphical and paleoecological investigations of thirteen Turonian-Maastrichtian sections.

Abdel-Gawad (1999a) studied the biostratigraphy and facies of the Turonian in west central Sinai. He recognized three ammonite zones, where *Chofaticeras segne – Thomasites* sp. Zone and *Mammites nodosoides* Zone as Early Turonian and *Coilopoceras* sp. Zone indicates a Late Turonian age.

Abdel-Gawad (1999b) identified fifty five macrofossil species (gastropods, bivalves, ammonites, and echinoids) from the Coniacian-Santonian sequence exposed at Wadi Matulla. Among them six ammonite species are systematically described. He suggested four ammonite horizons (three from the Middle Coniacian and the fourth was regarded to be basal Santonian) and seven benthic assemblages.

El Shazly (1999) described 18 bivalve and 9 gastropod species from the Coniacian-Santonian rocks of Wadi Sudr and Wadi Matulla, west central Sinai.

El-Sheikh (1999) studied the Coniacian-Late Campanian boundaries in Sinai (Gebel Ekma, East Themed area, El-Sheikh Attia, and Wadi Matulla) based on foraminifera, where he recognized three planktonic biozones and two benthonic biozones. One regarded as Coniacian, one Early Santonian, and the other three are of Late Campanian age.

Abdel-Gawad (2000) identified thirty-six gastropod species from the Middle Coniacian rocks of central Sinai, among them two species were new.

Ismail (2000) studied the stratigraphy and micropaleontology of the western part of the Gulf of Aqaba (Themed area, El-Sheikh Attia, and Taba-Nuweiba area), East Sinai. He recognized five formations representing the Upper Cretaceous rocks of the Themed area; Raha Formation (Late

Cenomanian), Abu Qada Formation (Early Turonian), Wata Formation (Late Turonian), Themed Formation (Coniacian-Santonian), and Sudr Chalk (Campanian-Maastrichtian).

Abdallah *et al.* (2001) studied the stratigraphy of the Cenomanian and Turonian Sequence of El Giddi Pass, north west Sinai, Egypt, where they recognized five ammonite zones (2 from the Cenomanian and 3 from the Turonian) in addition, they discussed the Cenomanian/Turonian boundary.

Abdelhamid & El Qot (2001) described forty-six echinoid species (22 regular and 24 irregular) from the Cenomanian-Santonian sequence of Gebel El-Minsherah and Gebel El-Hamra. Among the studied fauna three species were new and four species were recorded for the first time from Egypt. The family reference of the genus *Loriolia* Neumayer, as well as the generic assignment of four species are changed. The range of two species is changed.

Aly & Abdel-Gawad (2001) identified and described nineteen ammonite species from the Upper Cenomanian-Lower Turonian, which were collected from different localities in North and Central Sinai. They recognized six ammonite zones (three from Upper Cenomanian and three from the Lower Turonian). According to them the Cenomanian-Turonian boundary is placed at the first appearance of *Pseudaspidoceras flexuosum* Powell.

Bauer *et al.* (2001) studied the sequence stratigraphy of the Cenomanian-Santonian rocks of eastern Sinai, where they classified it into five formations; Halal Formation (Middle Albian-Cenomanian), Raha Formation (Middle Albian-Cenomanian), Abu Qada Formation (uppermost Lower Turonian-lowermost Upper Turonian), Wata Formation (Upper Turonian), and Matulla Formation (Uppermost Turonian-Santonian).

El-Hedeny *et al.* (2001) described ten plicatulid species from the Coniacian-Santonian (Matulla Formation) of Wadi Sudr, Sinai of which four are new.

Kora *et al.* (2001a) studied the stratigraphy and microfacies of some

Cenomanian- Turonian successions of some localities in the Gulf of Suez region. The study led to recognition of three important events took place in the Gulf of Suez region during the Cenomanian and Turonian time: an Early to Middle Cenomanian event, a Late Cenomanian-Early Turonian event and Middle to Late Turonian event.

Kora *et al.* (2001b) identified seventy-three macrofaunal species from the Cenomanian- Turonian successions of some localities in the Gulf of Suez region, they recognized five macrofossil zones for this interval.

Abdel-Gawad & Gameil (2002) described 61 bivalve species from the Cenomanian-Turonian succession of Gebel Nezzazat.

Abdelhamid & El Qot (2002) described forty six bivalve species from the Upper Cretaceous sequence of Gebel El-Minsherah and Gebel El-Hamra.

El-Hedeny (2002) described 10 ammonite species from the Cenomanian-Coniacian from west-central Sinai and recognized 6 ammonite zones.

Kora *et al.* (2002) studied the stratigraphy and paleoecology of the Senonian macrofauna from west-central Sinai, where they recognized five macrofossil zones for this interval.

Zakhera (2002a) described forty-eight gastropod species from the Upper Cretaceous of the Northern and Southern Galala (Eastern Desert). Among them four new species and fifteen species were recorded for the first time from Egypt.

Zakhera (2002b) recorded two new inoceramid species; one from the Raha Formation of Wadi El-Siq, west central Sinai and the second from the Duwi Formation of South Saint Paul, Eastern Desert.

Zakhera & Kassab (2002) studied the integrated macro-biostratigraphy of the Cenomanian-Turonian transition at Wadi El-Siq, west central Sinai. They recognized seven ammonite zones (three from the Upper Cenomanian and four from the Turonian) and six bivalve zones (three from the Cenomanian and three from the Turonian).

CHAPTER II

STRATIGRAPHY

Chapter II

Stratigraphy

This Chapter deals with the studying of the lithostratigraphy, biostratigraphic zonation based on macrofossils and larger foraminifera, integration and correlation of the proposed zones, and discussion of the stage boundaries of the Upper Cretaceous succession exposed at Gebel Ekma, East Themed area, and Gebel Yelleg (Figure 1).

1. Lithostratigraphy

The Upper Cretaceous rocks in the three studied sections can be subdivided into eight lithostratigraphic units as follows;

1. *Galala Formation* (Late Albian – Late Cenomanian)
2. *Raha Formation* (Early – Late Cenomanian)
3. *Abu Qada Formation* (Late Cenomanian – early Middle Turonian)
4. *Buttum Formation* (Early – early Middle Turonian)
5. *Wata Formation* (Early – Late Turonian)
6. *Matulla Formation* (?Late Turonian – Campanian)
7. *Themed Formation* (Coniacian – Santonian?)
8. *Sudr Chalk* (Campanian – Maastrichtian)

1. 1. *Galala Formation* (Late Albian – Late Cenomanian)

The term Galala Formation was first proposed by Abdallah & El Adindani (1963). It was subdivided by Awad & Abdallah (1966) into two members a lower marly and shaly member and an upper limestone member. The term Galala Formation is used herein to describe the Cenomanian sequences of both Gebel Yelleg and the East Themed area, which are characterised by their higher carbonate ratio, which agrees with the description of the Galala Formation rather than with that of the Raha Formation. The Galala Formation has relatively a higher

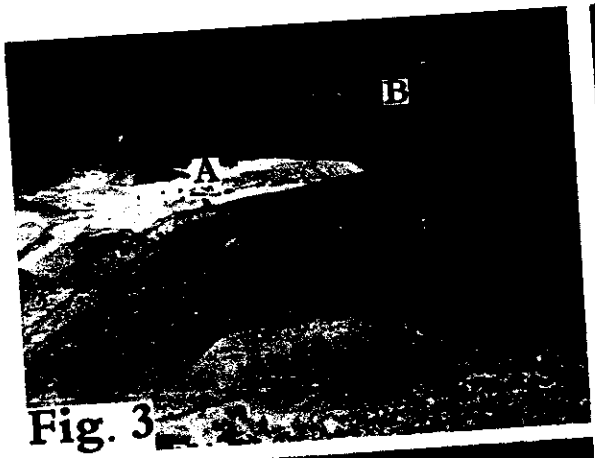


Fig. 3

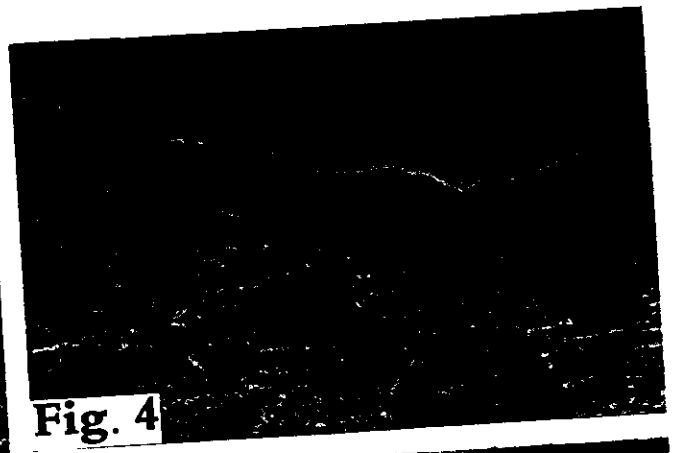


Fig. 4

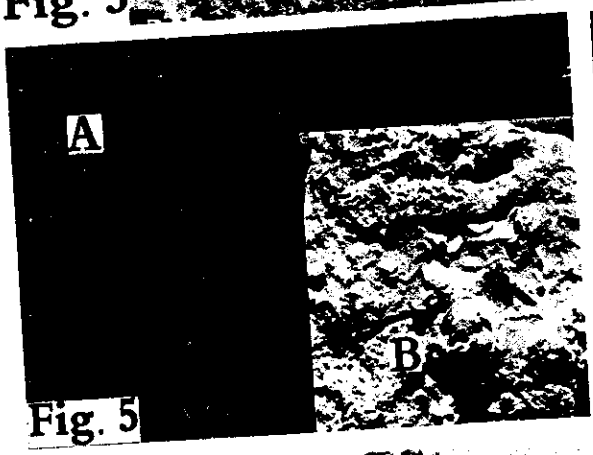


Fig. 5

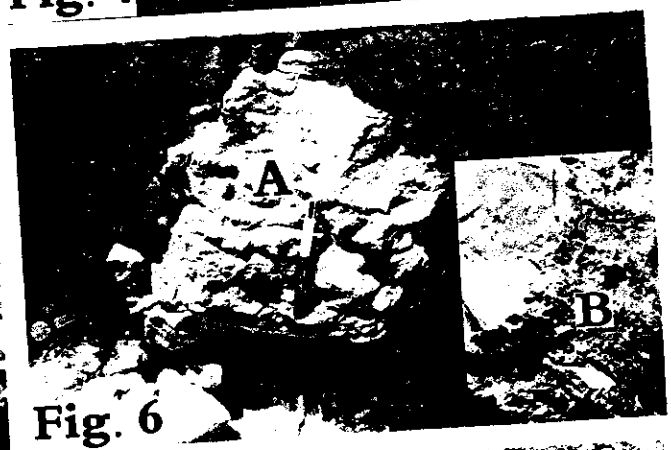


Fig. 6

Fig. 7

Fig. 8

Figure 3. The Galala Formation (B) overlies the Malha Formation (A) at the core of Gebel Yelleg.

Figure 4. The upper part of the Galala Formation at Gebel Yelleg.

Figure 5. A: *Orbitolina* limestone bed (*Orbitolina conica* T.R.Z.) basal Cenomanian, Galala Formation, Gebel Yelleg; B: Close up view.

Figure 6. A: Argillaceous limestone bed yielding *Praealveolina cretacea* (d'Archiac) forming *Praealveolina cretacea* T.R.Z., Middle Cenomanian, Galala Formation, Gebel Yelleg; B: Close up view.

Figure 7. *Eoradiolites liratus* (Conrad) forming rudistone (*Eoradiolites liratus* T.R.Z.) Lower Cenomanian Galala Formation, Gebel Yelleg.

Figure 8. *Chondrodonta* bed, Middle Cenomanian, Galala Formation, Gebel Yelleg.

siliciclastic ratio than the Halal Formation, which has been described by Said (1971) at Gebel El-Halal.

In the East Themed area, the Galala Formation overlies the Malha Formation (Early Cretaceous) at Khashm El-Tarif area and conformably underlies the Abu Qada Formation (Late Cenomanian–Early Turonian). It is composed mainly of dolomitic limestone, argillaceous limestone and marl intercalations with a few shale and siltstone interbeds, and attains a thickness of 60 m. The lower part (30 m of marl and nodular dolomitic limestone contain very poorly preserved bivalve and gastropod moulds), is attributed to the ?Early Cretaceous - Early/Middle Cenomanian (transition unit), based on the typical Cenomanian fauna is from bed no. 3 (5 m thick yellowish white marl). This bed contains at its base, for 2 m the *Ceratostreon flabellatum* Zone (Figure 12). Within 1 m above this zone there are two oyster banks of *Ilymatogyra africana* (Lamarck), which is considered to be of Middle - Late Cenomanian in age (Malchus 1990, Aqrabawi 1993, Seeling & Bengtson 1999). Accordingly, the Galala Formation in the East Themed area is ?Early Cretaceous - Late Cenomanian in age. The upper part of this formation is highly fossiliferous and yields the oysters *Ceratostreon flabellatum* (Goldfuss), *Rhynchostreon suborbiculatum* (Lamarck), *Ilymatogyra africana* (Lamarck), *Chondrodonta joannae* (Choffat) and the rudist *Praeradiolites biskraensis* (Coquand). It is very rich with gastropods and yields *Nerinea gemmifera* Coquand, *Pterocera incerta* d'Orbigny, *Pterodonta deffisi* Thomas & Peron, *Harpagodes heberti* (Thomas & Peron), *Mrhilaia haugi* Pervinquière, *Checchiaia sanfilippoi* Maxia. The only ammonite recorded is *Neolobites vibrayeanus* (d'Orbigny). *Heterodiadema libycum* (Desor) is the most important echinoid recorded.

In Gebel Yelleg, the Galala Formation overlies the Malha Formation (Early Cretaceous) (Figure 3) and conformably underlies the Wata Formation of the Turonian age. The Galala Formation in Gebel Yelleg has a relatively higher carbonate ratio (Figure 4) compared to that of the Themed area and exhibits a reef facies (Ammar & Afifi 1992). It measures 422 m and is composed mainly of

dolostone, dolomitic limestone, and argillaceous limestone intercalated with marl and shale; in addition, rudist boundstone and rudstone occurs, which are very characteristic of the lower part (Figure 7). The middle part contains four characteristic chert bands. The Galala Formation at Gebel Yelleg is highly fossiliferous, the most abundant fauna beside the aforementioned at the East Themed area are *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) *vesiculosa* (J. Sowerby), *Gyrostrea delettrei* (Coquand), *Ambigostrea pseudovillei* Malchus, *Rastellum carinatum* (Lamarck), *Eoradiolites liratus* (Conrad), *Aptyxiella subaequalis* (d'Orbigny), *Coenholectypus cenomanensis* (Gueranger), *Hemiaster* (*Hemiaster*) *gabrielis* Peron & Gauthier, corals, and coralline sponges. It yelids a more diagnostic larger foraminifera *Orbitolina conica* (d'Archiac) of the Lower Cenomanian (Figure 5) and *Praealveolina cretacea* (d'Archiac) of the Middle Cenomanian (Figure 6). The lowermost part (33 m of marl, limestone, and shale), form the *Ceratostreon flabellatum – Pterocera incerta* Acme Zone assigned to the Late Albian whereas it underlies the basal Cenomanian *Orbitolina conica* Zone. Therefore, the Galala Formation in Gebel Yelleg belongs to the Late Albian - Late Cenomanian interval.

1. 2. *Raha Formation* (Early – Late Cenomanian)

This rock unit was established by Ghorab (1961) at its type locality at the Raha Scarp, Raha Plateau, west-central Sinai. It was subdivided by Ghorab (1961) into two members (Abu Had Member and Mallaha Sand Member). The Raha Formation represents the whole Cenomanian sequence of Gebel Ekma, south western Sinai. It overlies the Malha Formation of Early Cretaceous age and it is conformably underlain the Abu Qada Formation of Early to early Middle Turonian age (Figures. 9, 10).

Cherif *et al.* (1989a) subdivided the Cenomanian rock sequence (Raha Formation) of Gebel Ekma into three members; Abu Had Member (118 m) at the

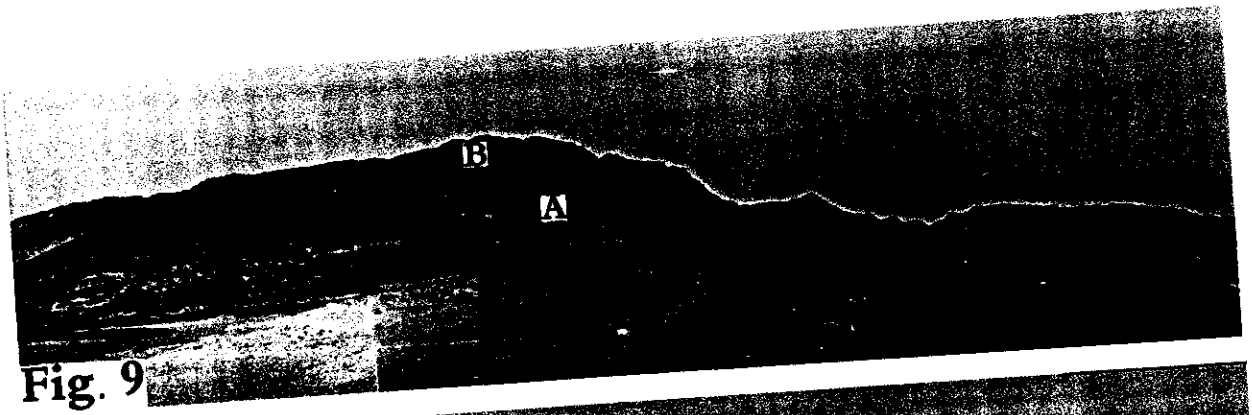


Fig. 9

Fig. 10

Fig. 11

Fig. 12

Figure 9. The Upper Cretaceous sequence (B) overlies the Malha Formation (A) at Gebel Ekma.
Figure 10. Panorama showing; (A) Top of Raha Formation, (B) Abu Qada Formation, (C) Wata Formation, (D) Matulla Formation, and (E) Sudr Formation, Gebel Ekma.
Figure 11. Lower part of the Raha Formation at Gebel Ekma.
Figure 12. *Ceratostreon flabellatum* bank, *Ceratostreon flabellatum* Zone, Galala Formation, East Themed area.

base, Mukattab Member (41 m) in the middle, and Ekma Member (50 m) at the top. Two of those members, the Mukattab Member (dolomitic limestones) and the Ekma Member (siliciclastics) were new.

In the present study, the Raha Formation attains a thickness of 137 m and it is composed of a succession of shale, marl, and sandstone intercalations with some limestone interbeds (Figure 11). This succession is topped by a hard, cliff–forming limestone bed of 10 m thickness, which represents the maximum limestone bed thickness in the whole Cenomanian rocks.

The Raha Formation herein corresponds more or less to the Abu Had Member of Ghorab (1961) but cannot be subdivided into the aforementioned members of Cherif *et al.* (1989a). The cliff-forming limestone bed yielded a late Late Cenomanian fauna of the *Vascoceras cauvini* – *Pseudaspidoceras pseudonodosoides* – *Rubroceras alatum* Assemblage Zone. This unit is followed directly by marl interbedded by a shale bed, which yielded lower Turonian ammonites of the two *Choffaticeras* zones. This marl is overlain by a succession of shale and sandstone.

Cherif *et al.* (1989a) stated that the Ekma Member is composed of a soft marl, shale and sandstone, and overlies the hard cliff-forming Mukattab Member. They added that this member is absent in two sections (Gebel Mukattab and Gebel Qabiliat), is devoid of foraminifera in the other two studied sections (Gebel Nezzazat and Gebel Ekma), that it yields some oyster banks at G. Nezzazat, but is unfossiliferous at G. Ekma (i.e. they have no evidence that the Ekma Member belongs to the Cenomanian). From the above discussion, it is clear that Cherif *et al.* (1989a) included the Lower Turonian, which consists of the same lithology (marl, shale and sandstone), in the Cenomanian succession under their new member Ekma Member. This sequence actually overlies the hard, cliff-forming, topmost Cenomanian unit, which was introduced by them as the Mukattab Member.

The Raha Formation is relatively rich in macrofossils. The most abundant faunal elements include *Ceratostreon flabellatum* (Goldfuss), *Rhynchostreon*

suborbiculatum (Lamarck), *Ilymatogyra africana* (Lamarck), *Ambigostrea pseudovillei* Malchus, *Costagyra olisiponensis* (Sharpe), *Barbatia aegyptiaca* (Fourtau), *Parasea faba faba* (Sowerby), *Maghrebella forgemoli* (Coquand), *Tenea delettrei* (Coquand), *Cimolithium tenouklense* (Coquand), *Pyrazus valeriae* (Verneuil & Lorière), *Campanile* (*Campanile*) *ganesha* (Noetling), *Nerinea olisiponensis* (Sharpe), *Colombellina* (*Colombellina*) *fusiformis* Douvillé, *Tylostoma cossoni* Thomas & Peron, *Tylostoma pallaryi* (Peron & Fourtau), *Pterodonta deffisi* Thomas & Peron, *Harpagodes heberti* (Thomas & Peron), *Heterodiadema buhaysensis* Smith, *Heterodiadema libycum* (Desor), *Coenholectypus cenomanensis* (Gueranger), *Hemiaster* (*Hemiaster*) *gabrielis* Peron & Gauthier, corals, and coralline sponges. Among the ammonites recorded from this unit, *Rubroceras alatum* (Cobban, Hook & Kennedy), which is recorded for the first time from outside New Mexico. The most common ammonites recorded are *Neolobites vibrayeanus* (d'Orbigny), *Vascoceras cauvini* Chudeau, and *Vascoceras* cf. *durandi* (Thomas & Peron), in addition the nutiloid *Angulithes mermeti* (Coquand) was recorded.

1. 3. *Abu Qada Formation* (Late Cenomanian – early Middle Turonian)

Ghorab (1961) established this rock unit at its type locality, Wadi Abu Qada in west-central Sinai to describe a sequence of grey marl characterizing the upper Cenomanian rocks, and assigned it a Cenomanian age. Cherif *et al.* (1989a) attributed the Raha Formation to the whole Cenomanian and the Abu Qada Formation to the Early Turonian.

In the East Themed area, the Abu Qada Formation conformably overlies the Galala Formation and conformably underlies the Buttum Formation of Early to early Middle Turonian (Issawi *et al.* 1999). It is composed mainly of marl and shale intercalations with some limestone interbeds, and attains a thickness of 65 m. It yields *Ilymatogyra africana* (Lamarck), *Costagyra olisiponensis* (Sharpe), and *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) *vesiculosa* (J. Sowerby), *Phelopteria*

1. 5. *Wata Formation* (Early – Late Turonian)

This formation was, first proposed by Ghorab (1961) at Wadi Wata, west-central Sinai. The Wata Formation conformably overlies the Galala Formation at Gebel Yelleg, the Buttum Formation in the East Themed area, and the Abu Qada Formation in Gebel Ekma. In Gebel Ekma, the Wata Formation consists of a sequence of chalky limestone, dolomitic limestone, sandy limestone and argillaceous few shale and marl interbeds.

At Gebel Yelleg, the Wata Formation is composed of three members. The lower carbonate member consists of sandy limestone, dolomitic limestone, chalky limestone and argillaceous limestone. The middle clastic member consists of marl, shale, claystone, and siltstone and is topped by a red sandstone unit. The upper carbonate member is composed of chalky limestone, dolomitic limestone with two beds of shale and marl at its middle part.

In the East Themed area the Wata Formation is composed of a sequence of chalky limestone, dolomitic limestone, argillaceous limestone, and marl (Figure 19), in addition to some chert bands, which are very characteristic of the middle part.

The Wata Formation attains its maximum thickness at the East Themed area, where it measures 121 m. In Gebel Yelleg, it reaches 102 m, while its minimum thickness is at Gebel Ekma, where it attains 48 m. In all the studied sections the Wata Formation yielded the late Middle – early Late Turonian ammonite *Coilopoceras requienianum* (d'Orbigny).

At the East Themed area, the Wata Formation is more fossiliferous than that of Gebel Ekma and Gebel Yelleg, yielding *Tylostoma* (*Tylostoma*) *globosum* Sharpe, *Durania gaensis* (Dacquè), *Praeradiolites ponsianus* (d'Archiac) *aegyptiacus* Douvillé, caprinids, *Trochactaeon salomonis* (Fraas) in the lower part, *Cucullaea* (*Idonearca*) *trigona* (Seguenza) and *Rachiosoma geysi* Abdelhamid & El-Qot in its middle part, while *Nerinea requieniana* d'Orbigny and coralline sponges characterise the upper part.

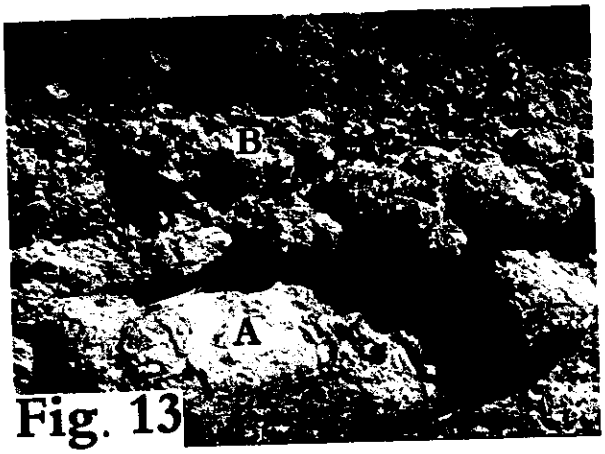


Fig. 13

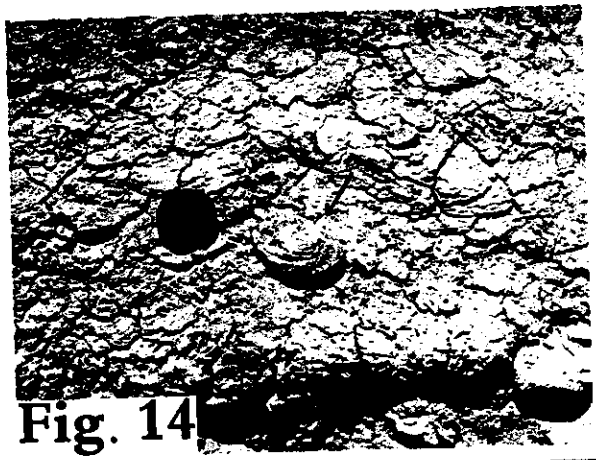


Fig. 14

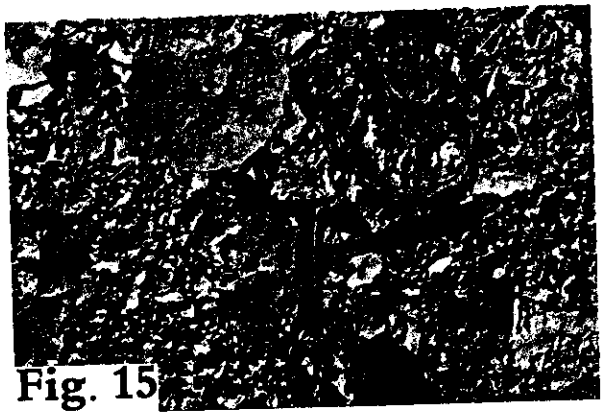


Fig. 15

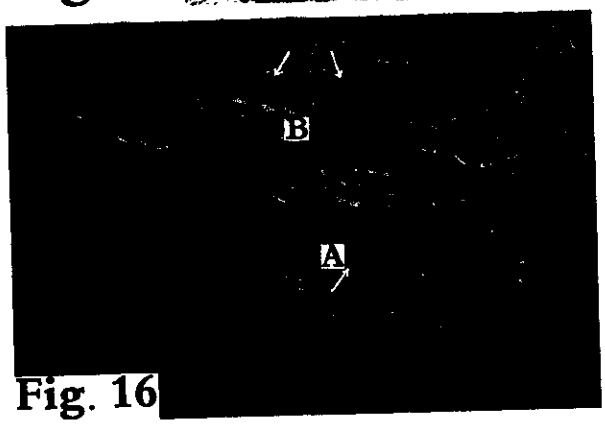


Fig. 16

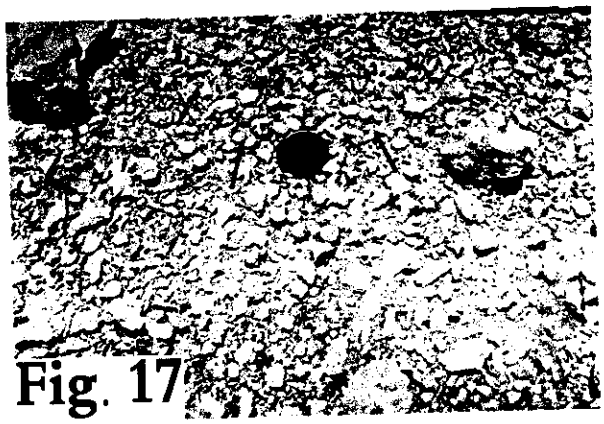


Fig. 17

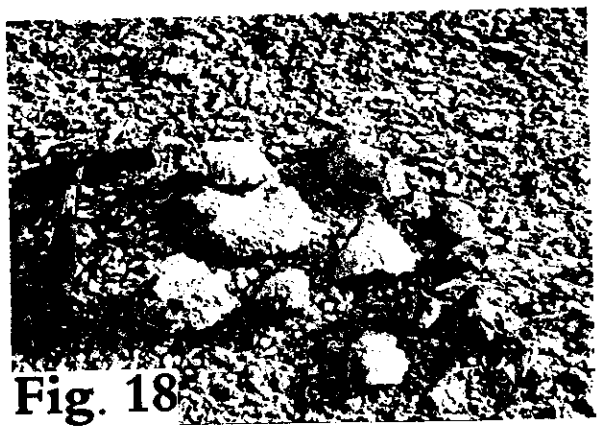


Fig. 18

Figure 13. A: *Ceratostreon flabellatum* (Goldfuss), *Rhynchostreon suborbiculatum* (Lamarck) forming the *Ceratostreon flabellatum - Rhynchostreon suborbiculatum* Zone, Raha Formation, Gebel Ekma.

Figure 14. *Costagyra olisiponsnsis* (Sharpe) in life position, *Costagyra olisiponsnsis* Zone, Upper Cenomanian, Raha Formation, Gebel Ekma.

Figure 15. *Choffaticeras quaasi - Choffaticeras securiforme* C.R.Z., Lower Turonian, Abu Qada Formation, East Themed area.

Figure 16. A: *Vascoceras harttii* (Hyatt), B: *Choffaticeras segne* (Solger) forming *Vascoceras harttii - Choffaticeras segne* C.R.Z., Lower Turonian, Abu Qada Formation, East Themed area.

Figure 17. *Phymosoma abbatei* (Gauthier), in the *Phymosoma abbatei – Tylostoma* (*T.*) *cossoni* Zone, Middle Turonian, Wata Formation, Gebel Ekma.

Figure 18. *Coilopoceras requienianum* T.R.Z., Wata Formation Gebel Ekma.

In Gebel Yelleg, the middle clastic member of the Wata Formation is the most fossiliferous member and yields *Hemiaster* (*Mecaster*) *heberti* (Coquand) *turonensis* Fourtau, *Coenholectypus turonensis* (Desor), *Durania arnaudi* (Choffat), *Praeradiolites ponsianus* (d'Archiac) *aegyptiacus* Douvillé, and *Praeradiolites irregularis* Douvillé. The Lower Carbonate Member and the Upper Carbonate Member yield only the ammonites of the *Choffaticeras segne – Thomasites rollandi* Zone and *Coilopoceras requienianum* Zone respectively.

In Gebel Ekma, it yields *Tylostoma* (*Tylostoma*) *cossoni* Thomas & Peron and *Rachiosoma irregulare* Fourtau, in additio to *Phymosoma abbatei* (Gauthier) (Figure 17), which was recorded from the three localities.

The age of the Wata Formation is late Middle to Late Turonian at Gebel Ekma and the East Themed area, based on its position overlying the Abu Qada Formation (Early-early Middle Turonian) at Gebel Ekma and the Buttum Formation at the East Themed area. It yields *Coilopoceras requienianum* (d'Orbigny) in its upper part (Figure 18). In Gebel Yelleg, it ranges from Early to early Late Turonian age based on the occurrence of *Choffaticeras segne – Thomasites rollandi* Zone in the basal part and *Coilopoceras requienianum* Zone in its uppermost part.

1. 6. *Matulla Formation* (?Late Turonian – Late Campanian)

The Matulla Formation was established by Ghorab (1961) at Wadi Matulla, west-central Sinai. Issawi *et al.* (1981) raised the rank of the Matulla Formation to a group status in Wadi Feiran, west-central Sinai, where they subdivided it into two formations; a lower Nubia Formation and an upper Duwi Formation. Cherif *et al.* (1989b) confirmed the use of the Matulla Group rather than a formation status of this rock unit in west-central Sinai and subdivided it into three formations (a lower Taref Sandstone, a middle Qusseir Variegated Shale, and an upper Duwi Formation), and assigned it to the Late Turonian – Late Campanian. Abu Khadrah *et al.* (1990) divided the Matulla Formation in west-central Sinai, into three units (a lower, middle, and upper unit). Orabi & Ramadan (1995) divided the Matulla

Formation at Wadi Feiran and Wadi Abuira, west-central Sinai, into three members (sandy member, shaly member and phosphatic member) (Figure 21). Abdel-Gawad (1999b) divided the formation at its type locality into three units (lower clastic unit, middle carbonate unit, and upper shale unit).

In Gebel Ekma, the Matulla Formation represents the ?Late Turonian – Late Campanian succession. It overlies the Wata Formation (late Middle to Late Turonian) and underlies conformably the Sudr Formation (Figure 10) of Late Campanian – Maastrichtian age based on oysters and planktonic foraminifera (Cherif *et al.* 1989b, El Sheikh 1999). It is composed mainly of shale with intercalations of sandstone, marl, and limestone (ranked according to their relative abundance) and attains a thickness of 131.5 m. It is sandy at the base, shaly in the middle, while phosphates characterise the upper part. The present author prefers the Formation rather than the Group status for this rock unit and agrees with Orabi & Ramadan (1995) in subdividing it into three Members (sandy mbr., shaly mbr., and phosphatic mbr.). The sandy mbr. (beds 18 – 21) consists of sandstone and shale alternations and attains a thickness of 41 m. This member is barren of both macrofossils and foraminifera and was considered by Cherif *et al.* (1989b) to be Late Turonian – Coniacian in age. These authors included this member in the Matulla Group under the name of Taref Sandstone Formation as discussed above and considered the Wata Formation to belong to the Middle Turonian. This view is adopted in the present study, where the facies of this member agrees more with the siliciclastic facies of the Matulla Formation rather than with the carbonate facies of the Wata Formation. Based on the fact that the underlying Wata Formation yields the late Middle to early Late Turonian *Coilopoceras requienianum* (d'Orbigny) at two levels (beds no. 16 and 17), and the overlying member (shaly mbr.) yields a Coniacian fauna. It is clear that, this member is of ?Late Turonian - Coniacian age (Transition Unit) and the underlying Wata Formation is of late Middle – early Late Turonian age. The Matulla Formation (particularly the shaly and phosphatic members) is highly fossiliferous and yielded the following fauna; *Pycnodonte*

(*Costeina*) *costei* (Coquand), *Nicaisolopha nicaisei* (Coquand), *Nicaisolopha tissoti* (Thomas & Peron), *Ambigostrea bretoni* (Thomas & Peron), *Plicatula ferryi* Coquand, *Caricella stromboides* (Munier-Chalmas), *Leptosalenia aegyptiaca* (Fourtau), *Parapygus cassiduloides* Gauthier, *Petalobrissus waltheri* (Gauthier), *Hemiaster* (*Mecaster*) *fourneli* Deshayes, and the first record in North Africa and the Middle East of the Early Santonian *Cladoceramus undulatoplicatus* (Roemer). It is worth to mention that, the shaly member yielded poorly preserved Middle to Upper Coniacian ammonites [*Subtissotia africana* (Peron) and *Metatissotia fourneli* (Bayle)].

1. 7. *Themed Formation* (Coniacian – Santonian)

This rock unit was established by Ziko *et al.* (1993) at Garf El Themed area, east-central Sinai, based on its more calcareous nature compared to the Matulla Formation of Ghorab (1961). At Garf El Themed area (type locality), the Themed Formation is composed mainly of marl intercalated with shale, limestone and sandstone and has a thickness of 41 m (Figure 20). The Themed Formation as defined by Ziko *et al.* (1993) attains a thickness of 115 m, because they included the topmost Turonian rocks which consists of chalky limestone and dolomitic limestone yielding *Cucullaea* (*Idonearca*) *trigona* (Seguenza), and *Rachiosoma geysi* Abdelhamid & El Qot, which form the *Cucullaea* (*Idonearca*) *trigona* – *Rachiosoma geysi* Zone. This zone is equivalent to the *Trigonarca* sp. Zone of Ziko *et al.* (1993), which they considered to be of Coniacian age. Moreover, if these limestones contain a Coniacian fauna this part must belong to the underlying Wata Formation rather than deserving separation as a new formation, because they represent the continuation of the carbonate facies of the underlying Wata Formation. In the present study, the topmost part of these limestones contain a bed with *Nerinea requieniana* d'Orbigny of Turonian age. This bed is topped by a coralline sponge horizon, and there is about 5 m thick bed of unfossiliferous dolomitic limestone. The latter is followed by 3 m yellowish grey shale that inturn

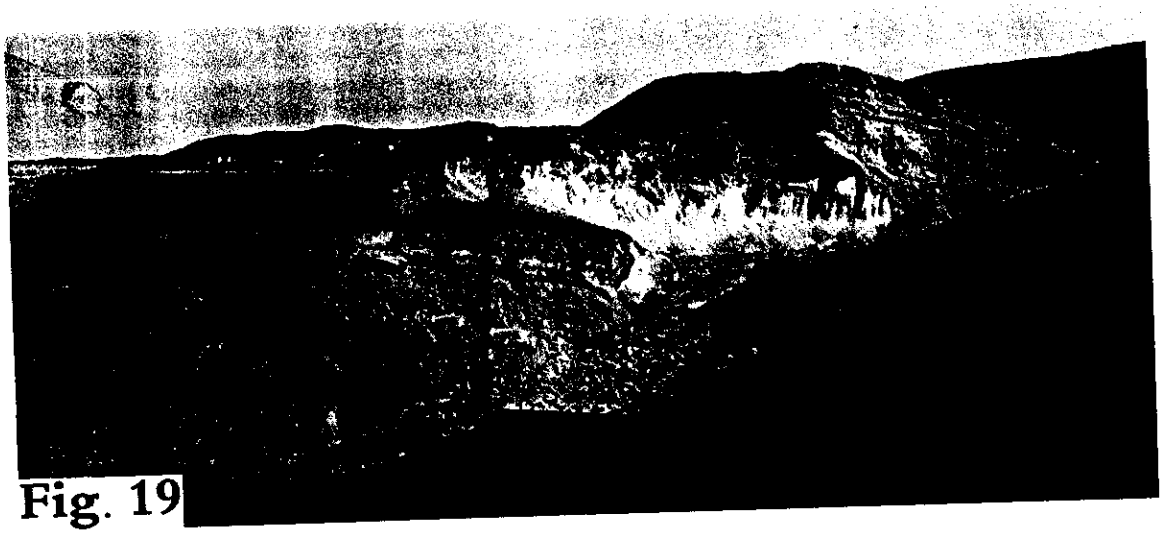


Fig. 19

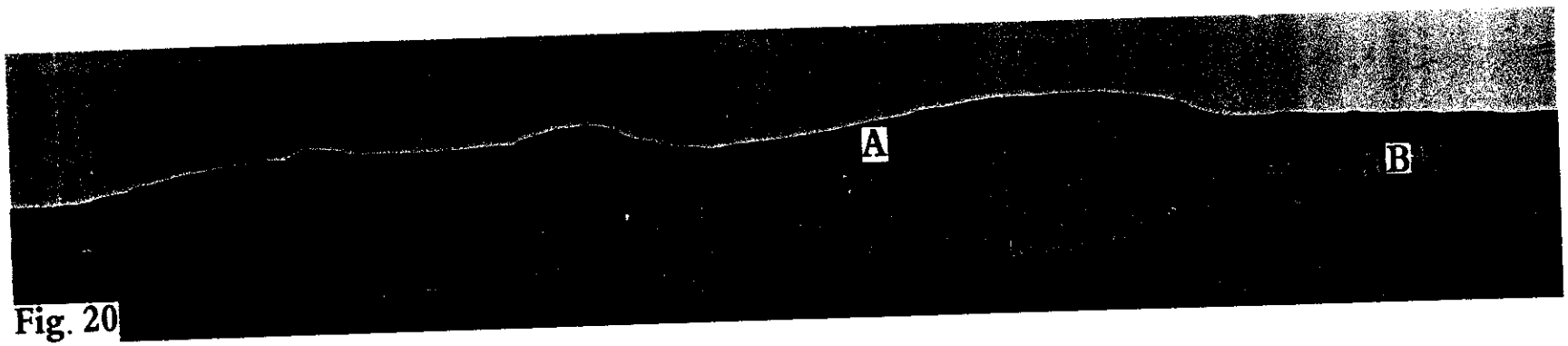


Fig. 20

Figure 19. Panorama showing the middle part of the Wata Formation, East Themed area.
Figure 20. Panorama showing the Themed Formation (A) overlies the Wata Formation (B) at Gerf El-Themed area.

is topped by yellowish white marl yielding the following Coniacian – Santonian fauna; *Hemiaster* (*Mecaster*) *fourneli* Deshayes, *Petalobrissus waltheri* (Gauthier); *Oscillopha dichotoma* (Bayle), and *Plicatula ferryi* Coquand, corresponding to two zones (Figure 22). These two zones are followed by the *Pycnodonte* (*Costeina*) *costei* Zone. Except the upper part of the Themed Formation (12 m above the *P. costei* Zone) is unfossiliferous, and according to its stratigraphic position is considered to be Late Coniacian – Santonian? in age. The Themed Formation is highly fossiliferous and yields besides the aforementioned fauna *Cucullaea* (*Idonearca*) *maresi* (Coquand), *Aporrhais fourneli* (Coquand), and *Helicaulax themedensis* (Abbass).

In Gebel Yelleg, the Themed Formation is much reduced in thickness and unconformably overlies the Wata Formation. It measures 15 m thickness and consists of alternations of marl and shale, which are topped by a cliff–forming sandy limestone. From the ammonite data a hiatus between the Wata and the Themed formations (Turonian/Coniacian boundary) can be easily determined. Within 0.5 m above the chalky limestone of the topmost Turonian rocks, that yields *Coilopoceras requienianum* (d'Orbigny) of the late Middle – early Late Turonian there is a yellowish white marl yielding *Metatissotia ewaldi* (von Buch) of the Middle – Late Coniacian. Based on the fact that *Coilopoceras requienianum* is not uppermost Upper Turonian, this indicates that there is a hiatus comprising the latest Turonian to Early Coniacian. This marl (*M. ewaldi* Zone) is followed by a 3 m of shale, at the top of which there are thin and thick fragments of recrystallized shells that probably represent inoceramid shells whose accurate identification is very difficult. Above this shale there are a marl and a limestone bed which correspond to the *Cucullaea* (*Idonearca*) *maresi* Zone and the *Pycnodonte* (*Costeina*) *costei* – *Oscillopha dichotoma* – *Plicatula ferryi* Zone respectively (Figure 23). These two zones are considered to be of Late Coniacian – Santonian ? in age according to their stratigraphic position forming the topmost part of the Themed Formation,

which underlies the Sudr Chalk of the Campanian-Maastrichtian age (Ziko *et al.* 1993).

Consequently, the age of the Themed Formation is Coniacian – Santonian ? in both G. Yelleg and the East Themed area.

1. 8. *Sudr Chalk* (Campanian – Maastrichtian)

This rock unit was first proposed by Ghorab (1961). It forms the top of the Cretaceous succession in all the studied sections. It is composed of snow-white, massive chalk with minor marl, shale and limestone interbeds. It is poorly fossiliferous with respect to macrofossils, yielding only *Pycnodonte* (*Phygraea*) *vesicularis vesicularis* (Lamarck), but it is very rich in microfossils especially planktic foraminifera (see Cherif *et al.* 1989b, Ziko *et al.* 1993, and El-Sheikh 1999). The age of this unit is Campanian – Maastrichtian in all studied sections. In Gebel Yelleg and the East Themed area, it overlies the Themed Formation of the Coniacian – Santonian ?, while in Gebel Ekma it conformably overlies the Matulla Formation of the ?Late Turonian–Late Campanian (Figure 10). The planktonic foraminifera (Cherif *et al.* 1989b, El Sheikh 1999) and the occurrence of the oysters; *Nicaisolopha nicaisei* (Coquand) and *Ambigostrea bretoni* (Thomas & Peron) in the phosphatic member indicate that the Matulla Formation ranges to the Late Campanian and the Sudr Chalk is of Late Campanian - Maastrichtian age.

2. Biostratigraphic Zonation

2. 1. *Gebel Ekma*

The Upper Cretaceous sequence of Gebel Ekma can be subdivided into the following zones (Figure 21).

Ammonite zones.

The ammonite zones are arranged from base to top as follow:

Neolobites vibrayeanus Total Range Zone

Vascoceras cauvini – Pseudaspidoceras pseudonodosoides – Rubroceras alatum Assemblage Zone

Choffaticeras segne Total Range Zone

Choffaticeras sinaiticum Total Range zone

Coilopoceras requienianum Total Range Zone.

Biozones based on other macrofossils.

Based on other macrofossils thirteen zones are constructed and arranged from older to younger as follow:

Ceratostreon flabellatum – Rhynchostreon suborbiculatum Acme Zone

Tenea delettrei – Ichthyosarcolites sp. – corals Acme Zone

Ambigostrea pseudovillei – Ilymatogyra africana Acme Zone

Costagyra olisiponensis Acme Zone

Hemiaster (*Mecaster*) *heberti turonensis – Coenholectypus turonensis* Acme Zone

Phymosoma abbatei – Tylostoma (T.) cossoni Acme Zone

Rachiosoma irregulare Acme Zone

Pycnodonte (*Costeina*) *costei* Acme Zone

Hemiaster fourneli – Petalobrissus waltheri Acme Zone

Cladoceramus undulatoplicatus Total Range Zone

Nicaisolopha tissoti Total Range Zone

Nicaisolopha nicaisei – Ambigostrea bretoni Total Range Zone

Pycnodonte (*Phygraea*) *vesicularis vesicularis* Acme Zone.

2. 2. *East Themed Area*

The Upper Cretaceous sequence in the East Themed area can be subdivided into the following zones (Figure 22).

Ammonite zones.

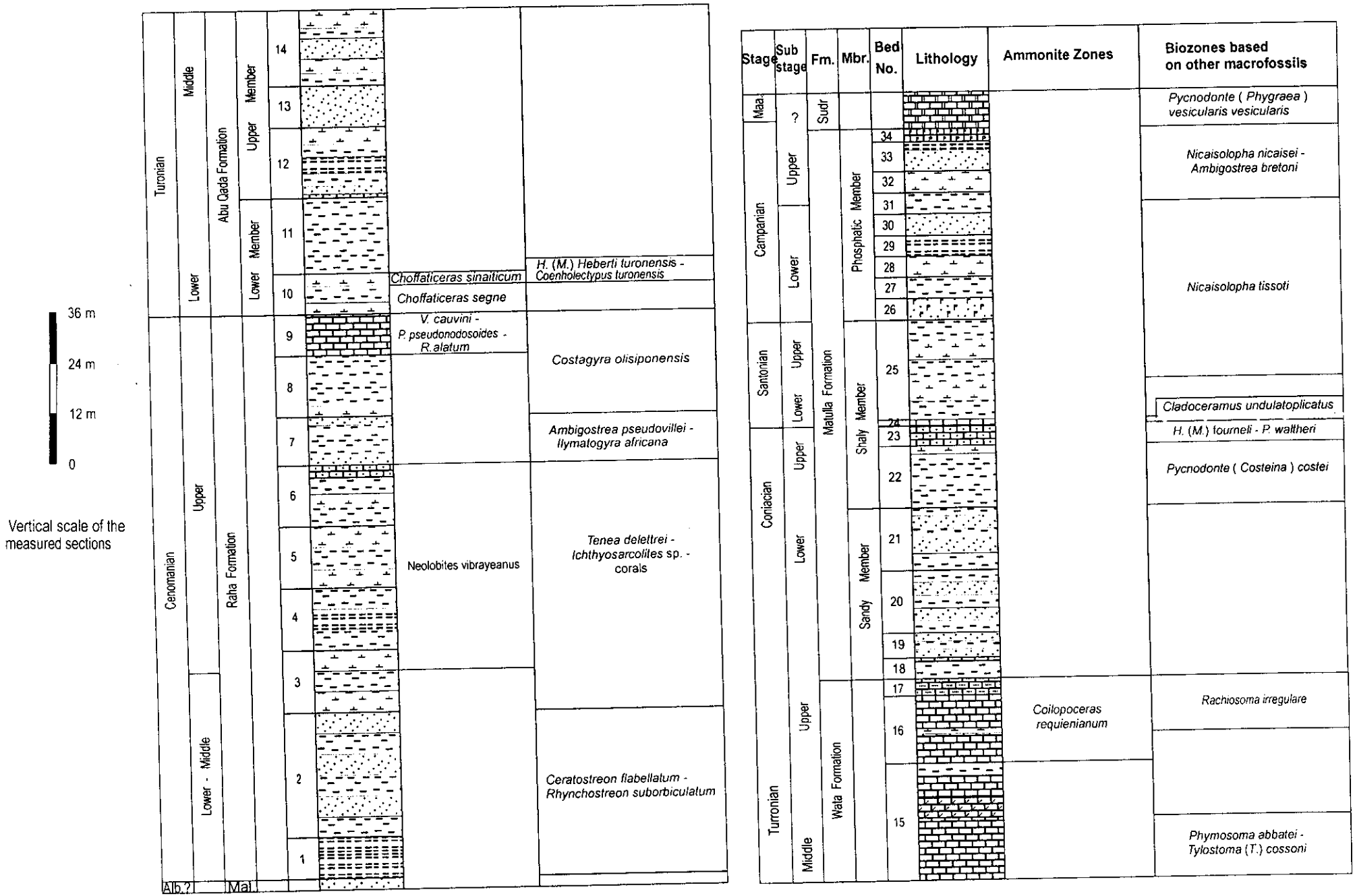


Figure 21 Stratigraphy of the Upper Cretaceous succession of Gebel Ekma and the integration between the ammonite zones and biozones based on other macrofossils

The ammonite zones are arranged from base to top as follow:

Neolobites vibrayeanus Total Range Zone

Vascoceras cauvini Total Range Zone

Choffaticeras quaasi – Choffaticeras securiforme Total Range Zone

Choffaticeras segne – Vascoceras harttii Total Range Zone

Choffaticeras sinaiticum – Thomasites rollandi Total Range Zone

Coilopoceras requienianum Total Range Zone.

Biozones based on other macrofossils.

Based on other macrofossils fourteen zones are constructed and arranged from older to younger as follow:

Ceratostreon flabellatum Acme Zone

Nerinea gemmifera – Praeradiolites biskraensis – corals Acme Zone

Ilymatogyra africana Acme Zone

Costagyra olisiponensis Total Range Zone

Pycnodonte (Phygraea) vesicularis vesiculosa – Inoceramus ex gr. *pictus* Interval Zone

Hemiaster (Mecaster) heberti turonensis – Coenholectypus turonensis Acme Zone

Phymosoma abbatei – Tylostoma (T.) globosum Acme Zone

Durania gaensis – Praeradiolites ponsianus aegyptiacus – caprinidae Assemblage Zone

Trochacteon salomonis Total Range Zone

Cucullaea (Idonearca) trigona – Rachiosoma geysi Acme Zone

Nerinea requieniana – coralline Sponge Total Range Zone

Hemiaster (Mecaster) fourneli – Petalobrissus waltheri Acme Zone

Oscillopha dichotoma – Plicatula ferryi Total Range Zone

Pycnodonte (Costeina) costei Total Range Zone.

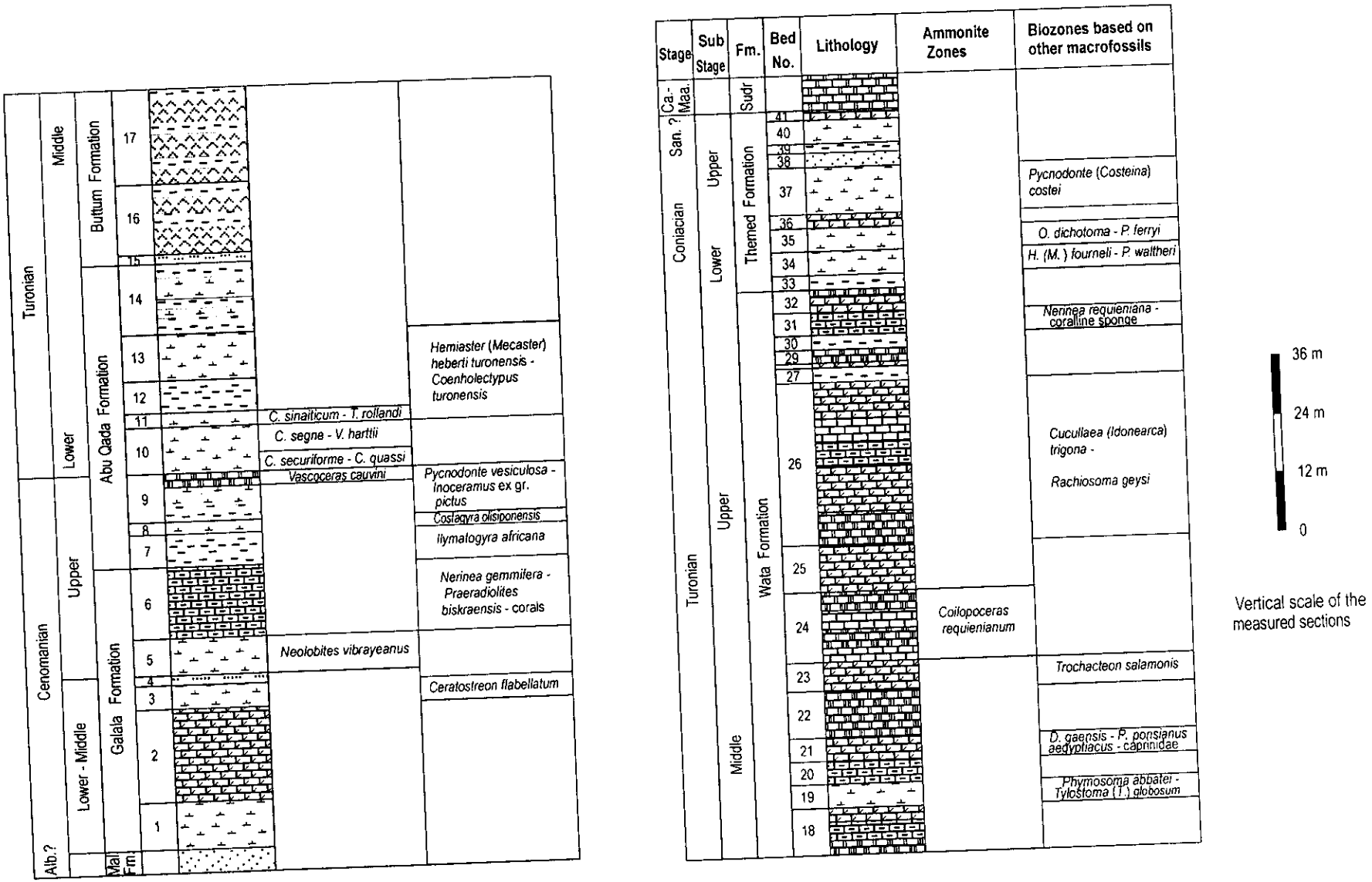


Figure 22. Stratigraphy of the Upper Cretaceous succession of the East Themed area, and the integration between the ammonite zones and the biozones based on other macrofossils

2. 3. *Gebel Yelleg*

The Upper Cretaceous sequence of Gebel Yelleg could be subdivided into the following zones (Figure 23).

Ammonite zones.

The ammonite zones are arranged from base to top as follow:

Neolobites vibrayeanus Total Range Zone

Choffaticeras segne – Thomasites rollandi Total Range Zone

Coilopoceras requienianum Total Range Zone

Metatissotia ewaldi Total Range Zone.

Biozones based on other macrofossils and larger microfossils.

Based on other macrofossils thirteen zones are constructed in addition to two larger foraminferal zones, the proposed zones are arranged from older to younger as follow:

Ceratostreon flabellatum – Pterocera incerta Acme Zone

Orbitolina conica Total Range Zone

Eoradiolites liratus Total Range Zone

Gyrostrea delettrei – Rhynchostreon suborbiculatum – Hemiaster (Hemiaster) gabrielis Acme Zone

Praealveolina cretacea Total Range Zone

Nerinea gemmifera – Praeradiolites biskraensis – corals Acme Zone

Ambigostrea pseudovillei – Ilymatogyra africana Acme Zone

Costagyra olisiponensis Acme Zone

Pycnodonte (Phygraea) vesicularis vesiculosa – Rastellum carinatum Total Range Zone

Hemiaster (Mecaster) heberti turonensis – Coenholectypus turonensis Acme Zone

Phymosoma abbatei – Tylostoma (T.) globosum Acme Zone

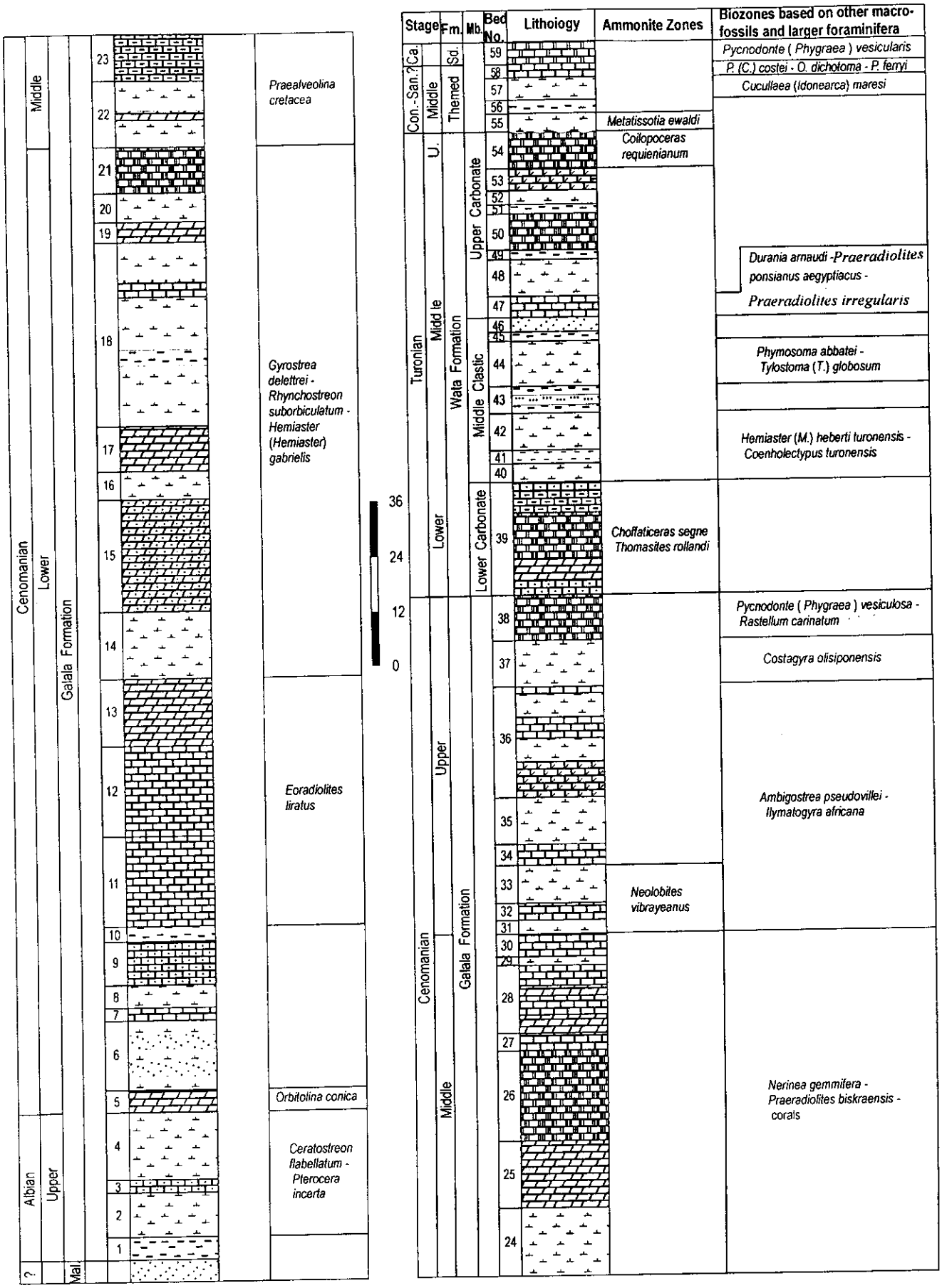


Figure 23. Stratigraphy of the Upper Cretaceous succession of Gebel Yelleg, and the integration between the ammonite zones and biozones based on other macrofossils and larger foraminifera

Durania arnaudi – Praeradiolites ponsianus aegyptiacus – Praeradiolites irregularis Assemblage Zone

Cucullaea (*Idonearca*) *maresi* Total Range Zone

Pycnodonte (*Costeina*) *costei – Oscillopha dichotoma – Plicatula ferryi* Assemblage Zone.

Pycnodonte (*Phygraea*) *vesicularis vesicularis* Acme Zone.

Zonal stratigraphy

The identified ammonites enabled the subdivision of the Upper Cretaceous succession of the studied sections into seven ammonite zones. The proposed zones, correlated with the standard ammonite zonation and other ammonite zones of adjacent and Tethyan regions are shown in Table. 4. The integration between these ammonite zones and the biozones, which are proposed based on other macrofossils and larger foraminifera are shown in Figures 21 - 23.

3. 1. Ammonite zonation

Neolobites vibrayeanus Total Range Zone

The zone is defined by the total range of the zonal species. It ranges in thickness from 8 m in the East Themed area to 15 m in Gebel Yelleg, and 50 m at Gebel Ekma. The associated faunal elements in addition to the oysters *Ilymatogyra africana* (Lamarck) and *Ceratostreon flabellatum* (Goldfuss) are *Barbatia aegyptiaca* (Fourtau), *Protocardia hillana* (J. Sowerby), *Parasea faba faba* (Sowerby), *Maghrebella forgemoli* (Coquand), *Arctica* spp., *Tenea delettrei* (Coquand), *Heterodiadema libycum* (Desor), *Coenholectypus cenomanensis* (Gueranger), and *Angulithes mermeti* (Coquand). The *Neolobites vibrayeanus* Zone is widely known from the lower Upper Cenomanian, just below the *Metoicoceras geslinianum* Zone (Kennedy & Juignet 1981). The *Neolobites vibrayeanus* Zone is in part equivalent to the standard *Calycoceras guerangeri* Zone, due to the co-

The three *Choffaticeras* zones of the present study have been recorded by many authors from different localities of Egypt as *Choffaticeras segne* Zone (Kassab, 1991b, 1994, Aly & Abdel–Gawad, 2001). The genera *Choffaticeras* and *Thomasites* are restricted to the Lower Turonian (Wright *et al.* 1996). Consequently, these three *Choffaticeras* zones are of Early Turonian age.

***Coilopoceras requienianum* Total Range Zone**

This zone is defined by the total range of *Coilopoceras requienianum* (d'Orbigny), which is the only ammonite recorded from this interval in the present study. It attains a maximum thickness of 20 m at Gebel Ekma (Figure 18), in the East Themed area, the thickness is 15 m, while a minimum thickness of 8 m is present at Gebel Yelleg. This zone is considered by many authors to be Late Turonian in age (Lewy 1975, 1989, Lewy & Raab 1976, Lewy *et al.* 1984, Luger & Gröschke 1989, Kassab 1991b, 1999, Kassab & Obaidalla 2001, and El-Hedeny 2002). This zone was correlated by the most of the aforementioned authors with the European *Romaniceras devrianum* Zone on the basis of the common occurrence of *C. requienianum* (d'Orbigny). Lewy (1989) recorded this species from a level above the *R. devrianum* Zone. Therefore, the *C. requienianum* Zone is considered to be late Middle – early Late Turonian in age, based on the fact that the *R. devrianum* zone is of late Middle Turonian age (Hardenbol *et al.* 1998). The *requienianum* Zone is considered the Latest Turonian ammonite zones recorded from Egypt till now. The two biozones [*Cucullaea* (*Idonearca*) *trigona* – *Rachiosoma geysi* Acme Zone and *Nerinea requieniana* – coralline Sponge Total Range Zone] recognised in the present study, in the East Themed area, overliying the *requienianum* Zone confirm that the *requienianum* Zone is not uppermost Turonian.

***Metatissotia ewaldi* Total Range Zone**

It is defined by the total range of *Metatissotia ewaldi* (von Buch). The zone is considered equivalent to the European *Peroniceras (Peroniceras) tridorsatum* Zone based on the common occurrence of *Metatissotia ewaldi* (von Buch). *M. ewaldi* has been recorded from the Middle Coniacian of France, northern Spain and Austria (Luger & Gröschke 1989). It has been recorded at the same level in the *Metatissotia fourneli* Zone from the Eastern Desert of Egypt (Kassab 1991b) and from Wadi Matulla (Abdel-Gawad 1999b). Lewy & Raab (1976) recorded *M. ewaldi* from the upper Upper Coniacian. Consequently, the zone is assigned to be Middle – Late Coniacian in age.

3. 2. Zonation based on other macrofossils and larger foraminifera

The studied Upper Cretaceous succession could be subdivided into twenty biozones based on the identification of some characteristic macrofossils other than ammonites and into two larger foraminiferal zones. The proposed zones were correlated with other zones proposed by some authors in Egypt in different localities and with standard zones as far as possible and also with the ammonite zones proposed in the present study (Tables 1-4).

***Ceratostreon flabellatum – Pterocera incerta* Acme Zone**

This is the lowest zone recognised in the present study from Gebel Yelleg. Associated fauna with this zone are *Harpagodes heberti* (Thomas &Peron), *Colombellina (C.) fusiformis* Douvillé, *Nucula (N.) margaritifera* Douvillé, and *Tetragramma variolare* (Brongniart). This zone is equivalent to the lower *Ostrea flabellata* horizon that was recorded by Awad & Fawzi (1956) in Gebel El - Minsherah and the lower part of the *Ceratostreon flabellatum – Gyrostrea delettrei* horizon of El-Sheikh *et al.* (1998) from the same aforementioned locality. In Gebel

Yelleg, it measures 33 m and is of Late Albian age, based on the fact that it underlies the *Orbitolina conica* Zone of the basal Cenomanian.

Orbitolina conica Total Range Zone

The *Orbitolina conica* Zone is the second biozone recorded from Gebel Yelleg and it is considered herein the first Cenomanian zone. This zone can be correlated with the *Orbitolina* cf. *concava* was recorded by El Sheikh *et al.* (1998) and *Orbitolina concava* zone of El-Sheikh & Hewaidy (1998). It can be correlated also with the lower part of the Rudists - *Orbitolina* Horizon of Hamza *et al.* (1994). It measures 5 m thick in Gebel Yelleg, which is composed of *Orbitolina* limestone (Figure 5). Tröger & Kennedy in Rawson *et al.* (1996) mentioned that the FO (first occurrence) of *O.* (*Orbitolina*) *concava concava* and *O.* (*O.*) *conica* indicate Albian/Cenomanian boundary in the Tethyan shelf carbonate successions. Therefore, this zone is of early Early Cenomanian age and its lower limit marks the Albian/Cenomanian boundary.

Eoradiolites liratus Total Range Zone

This zone is defined by the total range of the index species. It is composed of rudist boundstone and rudstone (Figure 7), which are very characteristic for the Lower Cenomanian especially in the northern part of Sinai. The zone is very well developed in G. Yelleg, where the buildups are located (Ammar & Afifi 1992). It measures 55 m and consists mainly of *Eoradiolites liratus* Conrad. The associated fauna are *Praeradiolites biskraensis* Coquand, *Neithea dutrugei* (Coquand), *Neithea* sp., *Arctica picteti* (Coquand), *Siliqua humei* Fourtau, and *Leptosalenia* sp.. This zone is equivalent to the Rudists Zone of Ziko *et al.* (1993). It is equivalent to the upper part of the rudists - *Orbitolia* horizon of Hamza *et al.* (1994), and the lower part of the rudists – *Hemiaster gabrielis* horizon of El - Sheikh *et al.* (1998) from Gebel El-Minsherah.

***Gyrostrea delettrei – Rhynchostreon suborbiculatum – Hemiaster gabrielis* Acme Zone**

This zone is characterized by the presence of numerous individuals of the three zonal species. It is the highest fossiliferous zone in Gebel Yelleg and attains a thickness of 117 m. The most dominant fossils are *Barbatia aegyptiaca* (Fourtau), *Pseudoptera anomala* (Sowerby), *Granocardium productum* (Sowerby), *Tenea delettrei* (Coquand), *Maghrebella forgemoli* (Coquand), *Pterodonta deffisi* Thomas & Peron, *Coenholectypus excisus* (Desor), and *Globoropora africana* Thomas & Peron. This zone is equivalent to the *Rhynchostreon mermeti – Hemiaster gabrielis* horizon of El-Sheikh *et al.* (1998) at Gebel El-Hamra. It is equivalent also to the upper part of the rudists – *Hemiaster gabrielis* horizon and the lower part of the *Rhynchostreon mermeti – Neolobites fourtaui* Zone that was recorded by the same authors from Gebel El-Minsherah.

***Praealveolina cretacea* Total Range Zone**

The zone is defined by the total range of *Praealveolina cretacea* (d'Archiac), and it attains a thickness of 25 m (Figure 6). Within this zone there is a 2 m thick argillaceous limestone bed (Figure 8), flooded with large *Chondrodonta joannae* (Choffat) (*Chondrodonta* Bed). This zone is equivalent to the *Praealveolina cretacea tenius* Zone of El-Sheikh & Hewaidy (1998). The zonal species *P. cretacea* belongs to the Middle - Upper Cenomanian (Schröder & Neumann 1985, Hardenbol *et al.* 1998). The presence of this zone underlying the *Nerinea gemmifera – Praeradiolites biskraensis* – corals Acme Zone, which is overlain by *Neolobites vibrayeanus* zone of the early Late Cenomanian. Thus, this zone is of Middle Cenomanian age in Gebel Yelleg.

***Nerinea gemmifera – Praeradiolites biskraensis* – corals Acme Zone**

This zone is highly fossiliferous, being very rich in gastropods, especially *Nerinea gemmifera* Coquand, corals, coralline sponge and rudists (mostly of *Praeradiolites biskraensis* Coquand). In Gebel Ekma, it is represented by *Tenea delettrei – Ichthyosarcolites* sp. – corals Acme Zone, being associated with the *Neolobites vibrayeanus* Zone of the early Late Cenomanian. It overlies the *Praealveolina cretacea* Zone and underlies the *Neolobites vibrayeanus* Zone in Gebel Yelleg. In the East Themed area, in contrast, it overlies the *Neolobites vibrayeanus* Zone. Therefore, this zone is of late Middle - early Late Cenomanian age. It varies in thickness from 15 m in the East Themed area, about 60 m in Gebel Ekma to 75 m in Gebel Yelleg. The most dominant taxa are *Aptyxiella subaequalis* (d'Orbigny), *Tylostoma cossoni* Thomas & Peron, *Mrhilaia haugi* Pervinquière, *Aporrhais dutrugei* (Coquand); *Nayadina* (*N.*) *gaudryi* Thomas & Peron, *Lucina* cf. *masylaea* Coquand, *Ichthyosarcolites* sp.; *Heterodiadema libycum* (Desor), *Coenholectypus cenomanensis* (Gueranger), *Hemiaster*(*Hemiaster*) *syriacus* (Conrad); *Thecosmilia tommasii* Prever, and *Aspidiscus cristatus* (Lamarck). The zone is equivalent to the gastropod horizon of Awad & Fawzi (1956) from Gebel El-Minsherah and to the *Strombus incertus* Zone and the *Nerinea gemmifera* Acme Zone of Ziko *et al.* (1993).

***Ambigostrea pseudovillei – Ilymatogyra africana* Acme Zone**

This zone is very characteristic for the Late Cenomanian and can be easily traced in the field, being a 7 – 15 m thick shale bed full of *Ilymatogyra africana* (Lamarck), which is mostly associated with *Ambigostrea pseudovillei* Malchus. This zone is equivalent to the *Exogyra africana – Neolobites fourtaui* Zone of Awad & Issawi (1975), the *Ceratostreon flabellatum – Ilymatogyra africana* Acme Zone of Ziko *et al.* (1993), and the *Ceratostreon flabellatum – Ilymatogyra africana* of Abdel-Gawad (1999a), *Ilymatogyra* (*A.*) *africana – Neolobites*

vibrayeanus Zone of Kora *et al.* (2001b). It is also equivalent to the *Ostrea africana, Ostrea flabellata, Dosinia, Venus* and *Neolobites* horizon that was noted by Awad & Fawzi (1956). It is also equivalent to the lower part of the *Exogyra (C.) olisiponensis – Ilymatogyra africana* Zone of Kora & Hamama (1987a), and the *Costagyra olisiponensis – Ilymatogyra africana* horizon of El-Sheikh *et al.* (1998). The zone is mostly present above the lower Upper Cenomanian *Neolobites vibrayeanus* Zone. Occasionally, as in Gebel Yelleg, the upper part of the *vibrayeanus* Zone is associated with this zone. Thus, it is considered to be of Late Cenomanian age.

***Costagyra olisiponensis* Acme Zone**

The zone is represented by a 3 - 10 m thick marl or argillaceous limestone bed very rich in *Costagyra olisiponensis* (Sharpe). It is defined by the acme of the zonal species in both Gebel Ekma and Gebel Yelleg, where is defined by the total range of its index species in the East Themed area. The zone is equivalent to the *Exogyra (C.) olisiponensis* Zone of Kora *et al.* (2001b). It is equivalent to the lower part of the *Exogyra olisiponensis – Pycnodonte vesiculosa* Zone of Ziko *et al.* (1993), and the *Pycnodonte vesiculosum – Exogyra olisiponensis* of Abdel-Gawad (1999). It is equivalent to the upper part of *Exogyra (C.) olisiponensis – Ilymatogyra africana* Zone of Kora & Hamama (1987a), and the *Costagyra olisiponensis – Ilymatogyra africana* horizon of El-Sheikh *et al.* (1998). It can also be correlated with the second *Ostrea* and lamellibranch horizon of Awad & Fawzi (1956).

***Pycnodonte (Phygraea) vesiculosa – Rastellum carinatum – Inoceramus* ex gr. *pictus* Assemblage Zone**

This is the latest Cenomanian zone based on macrofossils other than ammonites recorded in the present study. The zone ranges from 3 to 10 m thick. In the East Themed area, it is represented by the *Pycnodonte (Phygraea) vesiculosa* –

Inoceramus ex gr. *pictus* Interval Zone, where it is defined by the interval from the last appearance of *Costagyra olisiponensis* (Sharpe) to the first appearance of *Choffaticeras quaasi – Choffaticeras securiforme* Total Range Zone. This zone includes the acme of *Pycnodonte vesiculosa* (J. Sowerby), which coincides with the total range of *Inoceramus* ex gr. *Pictus* (J. de C. Sowerby). The latter species is recognised here for the first time from Egypt. In Gebel Yelleg, it is represented by the *Pycnodonte vesiculosa – Rastellum carinatum* Concurrent Range Zone. This zone is not recognised at Gebel Ekma, as the *Costagyra olisiponensis* Zone (Figure 14) continues till the basal Turonian. This assemblage zone is equivalent to the upper part of *Pycnodonte vesiculosum – Exogyra olisiponensis* Zone of Abdel–Gawad (1999), and *Exogyra olisiponensis – Pycnodonte vesiculosa* Zone of Ziko *et al.* (1993).

***Hemiaster (Mecaster) heberti turonensis – Coenholectypus turonensis* Acme Zone**

This zone ranges in thickness from 10 to 20 m and yields, besides the two index species, *Plicatula auressensis* (Coquand), *Lima itieriana* Pictet & Roux, *Phelopteria gravida* (Coquand), *Pseudoptera themedensis* sp. nov., *Phymosoma majour* Faurtau, and *Orthopsus ovata* (Coquand). The zone is equivalent to the *Hemiaster heberti turonensis* horizon at Gebel El-Hamra and the lower part of the *Phymosoma abbatei – Hemiaster heberti turonensis* horizon from Gebel El-Minsherah (El-Sheikh *et al.* 1998). It can be correlated with the lower part of the *Cyphosoma abbatei – Holectypus turonensis* Zone of Awad & Issawi (1975). The lower part of the zone coincides with the *Choffaticeras sinaiticum* Zone. This zone is therefore of Early Turonian age.

***Phymosoma abbatei — Tylostoma (T.)* spp. Acme Zone**

The zone is characterised by numerous individuals of *Phymosoma abbatei* (Gauthier), *Tylostoma (T.) globosum* Sharpe in Gebel Yelleg and the East Themed area. In Gebel Ekma *T. (T.) globosum* is replaced by *Tylostoma (T.) cossoni* Thomas & Peron. The zone ranges in thickness from 5 to 15 m and yields, apart from the aforementioned taxa *Pholadomya pedernalis* Roemer. This zone is equivalent to the *Phymosoma abbatei* horizon at Gebel El-Hamra and the upper part of the *Phymosoma abbatei – Hemiaster heberti turonensis* horizon at Gebel El-Minsherah (El-Sheikh *et al.* 1998). It can be correlated with the upper part of the *Cyphosoma abbatei – Holectypus turonensis* Zone of Awad & Issawi (1975). Its age is assigned to be Middle Turonian, as it overlies Early Turonian fauna.

***Durania* spp.— *Praeradiolites* spp. Assemblage Zone**

This zone is characterised by the abundance of rudists, which are represented in some localities by *Durania,* in others by *Praeradiolites* and in yet others by both, associated with or without caprinidaes. The most abundant species recorded from this zone are *Durania arnaudi* Choffat, *D. gaensis* Dacqué, and *Praeradiolites ponsianus* (d'Archiac) *aegyptiacus* Douvillé. In the East Themed area, it is represented by the total range of the assemblage *Durania gaensis – Praeradiolites ponsianus aegyptiacus* – caprinids, while in Gebel Yelleg it is represented by the *Durania arnaudi – Praeradiolites ponsianus aegyptiacus – Praeradiolites irregularis* Assemblage Zone and attains a thickness of 5 m in both localities. This zone has been recorded in Egypt by many authors either as the *Durania humei* Zone (Awad & Issawi 1975, Kora & Hamama 1987a) as the *Durania* sp. Zone (Ziko *et al.* 1993) or as the large rudists horizon (El-Sheikh *et al.*1998). Awad & Issawi (1975) considered this zone to be Early Turonian in age. Kora & Hamama (1987a) in contrast recognised that this zone overlies the *Coilopoceras requienianum* Zone and considered it to be latest Turonian. Parnes (1987) recorded and erected some *Radiolites* species from the basal Upper Turonian of Gebel El-

Risha, north-East Sinai. In Israel this zone is considered to be Middle Turonian in age (Lewy 1989). In all studied sections the zone underlies the *Coilopoceras requienianum* Zone. Aly & Abdel –Gawad (2001) reached to the same conclusion, but they considered it to be Late Turonian in age. Based on the *requienianum* Zone is of late Middle – early Late Turonian in age, this rudists assemblage zone is of Middle Turonian age.

***Trochacteon salomonis* Total Range Zone**

The zone is defined by the total range of the index species, *Trochacteon salamonis* Fraas and measures 5 m thickness in the East Themed area. It is equivalent to the *Acteonella salomonis* Zone of Awad & Issawi (1975). These authors considered it to be Late Turonian in age, whereas in the present study, its age is to be late Middle Turonian, because it underlies the late Middle - early Late Turonian *Coilopoceras requienianum* Zone and overlies the rudists of the aforementioned zone in the East Themed area.

***Cucullaea (Idonearca) trigona – Rachiosoma irregulare – Rachiosoma geysi* Acme Zone**

This zone yields, besides numerous individuals of the three index species [*Cucullaea* (*Idonearca*) *trigona* (Seguanza), *Rachiosoma irregulare* Fourtau, and *Rachiosoma geysi* Abdelhamid & El-Qot] *Petalobrissus pygmaeus* Fourtau, and *Goniopygus peroni* (Thomas & Gauthier). It attains a thickness of 35 m in the East Themed area and represented by *Cucullaea* (*Idonearca*) *trigona –Rachiosoma geysi* Acme Zone. In Gebel Ekma, it measures 15 m and represented by *Rachiosoma irregulare* Zone. The zone is equivalent to the *Trigonarca* sp. Zone of Ziko *et al.* (1993) from the Themed area, which regarded to be of Coniacian age. It is considered herein to be Late Turonian in age, because it overlies the *Coilopoceras*

Cladoceramus undulatoplicatus Total Range Zone

This standard, world-wide, Lower Santonian zone is recorded in the present study for the first time from the Middle East and North Africa. It is defined by the total range of the index species *Cladoceramus undulatoplicatus* Roemer and attains a thickness of 1.5 m. The most common associated faunal elements are *Spondylus fimbriatus* Goldfuss, *Caricella stromboides* (Munier- Chalmas), and *Parapygyus casiduloides* (Thomas & Gauthier). *Spondylus fimbriatus* Goldfuss is present cemented to the shell of the index species (Pl. 13, Fig. 2). Dhondt & Dieni (1990) have been recorded and discussed in detail this association. These authors mentioned that complete specimens, especially in the groups with large shells such as *Platyceramus* and *Cladoceramus* are very rare, and originated this to preservational problems and preparation difficulties. Lamolda & Hancock in Rawson *et al.* (1996) indicated that three inoceramid species have been used to define the Coniacian/Santonian boundary, the widespread species, *Cladoceramus undulatoplicatus* Roemer, the north Temperate *Sphenoceramus pachti-cardissoides* group and the north African Species *Platyceramus siccensis*. They added that, the North African species, is not known oustide North Africa. Abdel-Gawad (1999b) recorded *Pl. siccensis* from the Lower Santonian of Gebel Nezzazat.

Nicaisolopha tissoti Total Range Zone

This zone is characterised by the total range of its index species *Nicaisolopha tissoti* (Thomas & Peron). This index species has a wide stratigraphic range (Coniacian - Campanian) Malchus (1990). In Gebel Ekma, the zone is 40 m thick and is considered to be Late Santonian – Early Campanian in age because it is enclosed between the Lower Santonian *Cladoceramus undulatoplicatus* Zone and the Upper Campanian *Nicaisolopha nicaisei – Ambigostrea bretoni* Zone. In the present study, the lower part of this zone coincides with the *Dicarinella concavata* Zone of El-Sheikh (1999). Rawson *et al.* (1996) and Hardenbol *et al.* (1998)

indicated that the highest occurrance of *Dicarinella concavata* marks the Santonian/Campanian boundary. This confirms a Late Santonian - Early Campanian age of this zone.

***Nicaisolopha nicaisei – Ambigostrea bretoni* Total Range Zone**

The zone is defined by the total range of the two index species, *Nicaisolopha nicaisei* (Coquand) and *Ambigostrea bretoni* (Thomas & Peron), which attains thickness of 18 m at Gebel Ekma. Malchus (1990) recorded *A. bretoni* (Thomas & Peron) from the Upper Campanian rocks of Wadi Qena, Eastern Desert of Egypt and indicated that, it has a long stratigraphic range (Coniacian – Maastrichtian). Moreover, *N. nicaisei* (Coquand) ranges from the Upper Campanian to the Lower Maastrichtian (Malchus 1990, Aqrabawi 1993). Consequently, this zone is considered of Late Campanian in age in Gebel Ekma. Planktonic foraminifera confirmed the late Campanian age of this zone, because it coincides with the Late Campanian *Globotruncana rosetta* Zone of EL-Sheikh (1999).

***Pycnodonte (Phygraea) vesicularis vesicularis* Acme Zone**

The *Pycnodonte* (*Phygraea*) *vesicularis vesicularis* Zone is the youngest zone recorded in the present study. It is defined by the maximum abundance of the index species. The zone is considered by some authors to be Campanian in age (Issawi *et al.* 1981, Kora & Hamama 1987b), but it has also been considered Maastrichtian in age and equivalent to the *Exogyra overwegi* Zone, which prevails in the central and southern parts of the Western Desert of Egypt (Awad & Issawi 1975). In particular in Gebel Ekma, this zone is considered Campanian – Maastrichtian in age, being recorded from the Upper Campanian rocks of the Matulla Formation and from the lower part of the massive, snow-white chalk of the Sudr Chalk of the Upper Campanian – Maastrichtian age based on planktonic foraminifera.

4. Integration and correlation

The studied macrofossil faunas of the Upper Cretaceous sucessions from the three measured sections show a Tethyan affinity and a trans-Mediterranian distribution with links to North Africa, East Asia, Western Europe, West Africa, North America. Integration of the proposed zones in the three measured sections is shown in Figures 21–23. Correlation of the lithostratigraphic units of the three sections is shown in Figure. 24. The proposed ammonite zones are correlated in Table 1; correlation of the other macrofossil zones and larger foraminiferal zones is shown in Table 2. The biozones proposed by different authors for different localities in Egypt are correlated in Table 3. The zones in the present study are correlated with the standard ammonite zonation and the suggested biozones of some neighbouring regions in Table. 4.

5. The stage boundaries

5. 1. Albian/Cenomanian boundary

In Gebel Ekma, the contact between the Early Cretaceous (Malha Formation) and the Cenomanian is marked by the Cenomanian transgression, which is indicated by the Cenomanian oysters *Ceratostreon flabellatum* (Goldfuss), and *Rhynchostreon suborbiculatum* (Lamarck). *C. flabellatum* has a long stratigraphic range, as it is originally described from the Cenomanian of Germany; and distributed in the Albian – Cenomanian (Dhondt 1982). It ranges from the Albian to the Senonian, but is widly distributed in the Cenomanian – Turonian (Freneix 1972). It is considered to be Aptian ?, Albian – Cenomanian in age (Malchus 1990, Aqrabawi 1993, Seeling & Bengtson 1999). The latter species has not been recorded elsewhere from levels below the Cenomanian. Therefore, the Early Cretaceous/Cenomanian boundary is located at the base of bed no. 1 (glauconitic claystone and shale), which coincides with the base of the *Ceratostreon flabellatum*

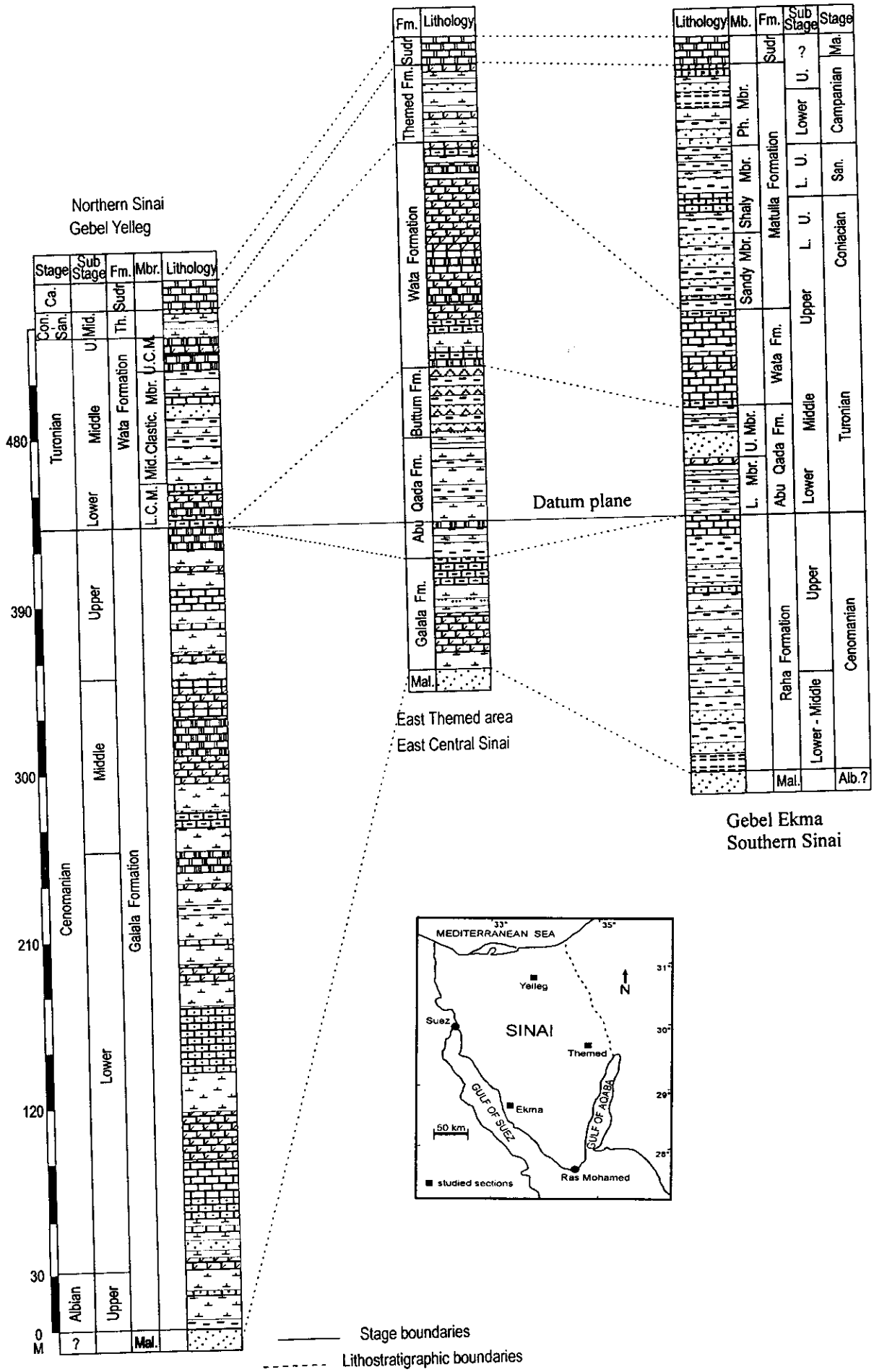


Figure 24. Lithostratigraphic and chronostratigraphic correlation of the studied sections

Table 1. Biostratigraphic correlation of the proposed ammonite zones

Age		Gebel Ekma	East Themed Area	Gebel Yelleg
Coniacian	Middle– Late			*Metatissotia ewaldi* Total Range Zone
Turonian	Middle- Late	*Coilopoceras requienianum* Total Range Zone	*Coilopoceras requienianum* Total Range Zone	*Coilopoceras requienianum* Total Range Zone
	Early	*Choffaticeras sinaiticum* Total Range Zone *Choffaticeras segne* Total Range Zone	*Choffaticeras sinaiticum – Thomasites rollandi* Total Range Zone *Choffaticeras segne –Vascoceras harttii* Total Range Zone *Choffaticeras securiforme – Choffaticeras quaasi* Total Range Zone	*Choffaticeras segne – Thomasites rollandi* Total Range Zone
Cenomanian	Late	*Vascoceras cauvini– Pseudaspidoceras pseudonodosoides – Rubroceras alatum* Assemblage Zone *Neolobites vibrayeanus* Total Range Zone	*Vascoceras cauvini* Total Range Zone *Neolobites vibrayeanus* Total Range Zone	*Neolobites vibrayeanus* Total Range Zone

able 2. Biostratigraphic correlation of the proposed zones based on other macrofossils and larger foraminifera

Age			Gebel Ekma	East Themed Area	Gebel Yelleg
Campanian			*Pycnodonte (Phygraea) vesicularis* Acme Zone		*Pycnodonte (Phygraea) vesicularis* Acme Zone
		Late	*Ambigostrea bretoni – Nicaisolopha nicaisei* Total Range Zone		
		E.			
San.		L.	*Nicaisolopha tissoti* Total Range Zone		
		E.	*Cladoceramus undulatoplicatus* Total Range Zone		
Coniacian		Mid. – L.	*Hemiaster fourneli – Petalobrissus waltheri* Acme Zone *Pycnodonte (Costeina) costei* Acme Zone	*Pycnodonte (Costeina) costei* Total Range Zone	*Pycnodonte (Costeina) costei – Oscillopha dichotoma – Plicatula ferryi* Assemblage Zone *Cucullaea (Idonearca) maresi* Acme Zone
		Early		*Oscillopha dichotoma – Plicatula ferryi* Assemblage Zone *Hemiaster (Mecaster) fourneli – Petalobrissus waltheri* Acme Zone	
Turonian		Late	*Rachiosoma irregulare* Acme Zone	*Nerinea requieniana* – coralline sponge Total Range Zone *Cucullaea (Idonearca) trigona – Rachiosoma geysi* Acme Zone *Trochactaeon salomonis* Total Range Zone	
		Middle	*Phymosoma abbatei – Tylostoma (T.) cossoni* Acme Zone	*Durania gaensis – Praeradiolites ponsianus aegyptiacus* – caprinidae Assembelage Zone *Phymosoma abbatei – Tylostoma (T.) globosum* Acme Zone	*Durania arnaudi – Praeradiolites ponsianus aegyptiacus – Praeradiolites irregularis* Assemblage Zone *Phymosoma abbatei – Tylostoma (T.) globosum* Acme Zone
		Early	*Hemiaster (Mecaster) heberti turonensis – Coenheolctypus turonensis* Acme Zone	*Hemiaster (Mecaster) heberti turonensis – Coenheolctypus turonensis* Acme Zone	*Hemiaster (Mecaster) heberti turonensis – Coenheolctypus turonensis* Acme Zone
Cenomanian		Late	*Costagyra olisiponensis* Acme Zone *Ambigostrea pseudovillei – Ilymatogyra africana* Acme Zone *Tenea delettrei – Ichthyosarcolites* sp. – corals Acme Zone	*Pycnodonte (Phygraea) vesiculosa Inoceramus* ex gr. *pictus* Interval Zone *Costagyra olisiponensis* Total Range Zone *Ilymatogyra africana* Acme Zone *Nerinea gemmifera – Praeradiolites biskraensis* – corals Acme Zone	*Pycnodonte (Phygraea) vesiculosa – Rastellum carinatum* Total Range Zone *Costagyra olisiponensis* Acme Zone *Ambigostrea pseudovillei – Ilymatogyra africana* Acme Zone
		Mid.			*Nerinea gemmifera – Praeradiolites biskraensis* – corals Acme Zone *Praealveolina cretacea* Total Range Zone
		Early	*Ceratostreon flabellatum – Rhynchostreon suborbiculatum* Acme Zone	*Ceratostreon flabellatum* Acme Zone	*Gyrostrea delettrei – Rhynchostreon suborbiculatum – Hemiaste (H.) gabrielis* Acme Zone *Eoradiolites liratus* Total Range Zone *Orbitolina conica* Total Range Zon
Albian		Late			*Ceratostreon flabellatum – Pterocera incerta* Acme Zone

Table 3. Correlation of the proposed macrofossils biozones that dealt with the Late Cretaceous in Egypt

Age		Awad & Issawi (1975)	Kora & Hammama (1987a, b)	Luger & Gröschke (1989)	Kassab (1991, 1994)	Ziko *et al.* (1993)	Abdel-Gawad (1999a,b)	El-Hedeny (2002)
Maastrichtian		*Trigonarca gauldrina* *Libycoceras bersensis* *Exogyra overwegi – Libycoceras ismaeli or Pycnodonta vesicularis* *Isocardia chargensis* *Inoceramus regularis – Roudairae drui* *Lopha villei* *Neara* sp. – *Arca (Tr.) multidentata*						
C.		*Ostrea cornuarietis*	*Py.(Phygraea) vesicularis*					
San.		*Lopha dichotoma – Plicatula ferryi*	*L. (A.) dichotoma – Plicatula ferryi*			*L. dichotoma – Plicatula ferryi*	*Texanites* sp. (b)	
Coniacian		*Natica bulbiformis*	*H. neoceratites – Plesiotissotia michaleti* *Tissotia tissoti*		*Metatissotia fourneli*	*Echinobrissus waltheri* *Trigonarca*	*Metatissotia fourneli* (b)	*Metatissotia fourneli*
Turonian	Late	*Cyphosoma abbatei – Holectypus turonensis* *Acteonella salomonis Meretrix faba – Arca tumida*	*Durania humei* *Coilopoceras requienianum*		*Coilopoceras requienianum*	*Durania*	*Coilopoceras* sp.	*Coilopoceras requienianum*
	Early	*Hemitissotia* sp. – *Pseudotissotia* sp. *Durania humei*	*Choffaticeras segne* *Mammites nodosoides*	*Mammites* sp. *Fasgesia* cf. *superstes* *V. durandi*	*Choffaticeras segne* *Pseudaspid-oceras flexuosum*	Large Ammonites	*Mammites nodosoides* *Thomasites* sp. *Ch. segne*	*Choffaticeras segne* *Vascoceras proprium*
Cenomanian	Late	*Exogyra suborbiculata – Ostrea mermeti* *Exogyra africana – Neolobites fourtaui* *Exogyra olisiponensis – Hemiaster pseudofourneli*	*Exogyra olisiponensis – Ilymatogyra africana*	*Vascoceras cauvini* *V. rumeaui* *V. gamai* *Metengono-ceras* cf. *acutum* *Neolobites vibrayeanus*	*Vascoceras cauvini* *Metoicoceras geslinianum* *Neolobites vibrayeanus*	*Exogyra olisiponensis – Pycnodonte vesiculosa* *Ceratostreon flabellatum – Ilymatogyra africana* *Nerinea gemmifera* *Strombus incertus* *Rhynchostreon suborbiculatum* rudists	*Pycnodonte vesiculosa – Exogyra olisiponensis* *Ilymatogyra africana – Ceratostreon flabellatum* *Neolobites vibrayeanus*	*Vascoceras cauvini* *Neolobites vibrayeanus*

Table 4. Interregional correlationof the Upper Cretaceous zones of Sinai, Egypt.

Age		Stand.ammonites zones of Southern Europe in (Hardenbol *et al.*, 1998)	Tunisia (Robaszynski *et al.*, 1993) (1) & Chancellor *et al.*, 1994 (2)	Algeria (Amard *et al.*,1981)	Israel (Lewy,1989)	Sinai, Egypt (Present study)	
						Ammonite zones	Zones based on other macrofossils and larger foraminifera
Maastrichtian	Late	*Anapachydiscus terminus* *Anapachydiscus fresvillensis*					*Pycnodonte (Phygraea) vesicularis vesicularis*
	Early	*Pachydiscus neubergicus /P.tridens ? / P. epiplectus*					*Ambigostrea bretoni – Nicaisolopha nicaisei*
Campaanian	Late	*Nostoceras hyatti*					
	Middle	*Bostrychoceras polyplocum* *Hoplitoplacenticeras marroti / Hoplitoplacenticeras vari*					*Nicaisolopha tissoti*
	Early	*Menabites delawarensis* *Placenticeras bidorsatum*					
Santonian	Late	*Placenticeras polyopsis*					*Cladoceramus undulatoplicatus*
	Early						
Coniacian	Late	*Paratexanites serratomarginatus*			*Metatissotia fourneli – Protexanites*	*Metatissotia ewaldi*	*Pycnodonte (Costeina) costei*
	Middle	*Gauthiericeras margae* *Peroniceras tridorsatum*			*Heterotissotia neoceratites* *Barroisiceras onilahyense*		
	Early	*Forreteria petrocoriensis*			*Plesiotissotia Sinaitica* *Placenticeras kaffrarium*		*Oscillopha dichotoma – Plicatula ferryi* *H. (Mecaster) fourneli – Petalobrissus waltheri*
Turonian	Late	*Subprionocyclus neptuni*	*Hemitissotia morreni* (2)		*Coilopoceras requienianum*	*Coilopoceras requieniamum*	*Nerinea requieniana* – coralline sponge *Cucullaea (Idonearca) trigona – R. irregulare – R. geysi*

Age		Stand.ammonites zones of Southern Europe in (Hardenbol *et al.*, 1998)	Tunisia (Robaszynski *et al.*, 1993) (1) & Chancellor *et al.*, 1994 (2)	Algeria (Amard *et al.*,1981)	Israel (Lewy,1989)	Sinai ,Egypt (Present study)	
						Ammonite zones	Zones based on other macrofossils and larger foraminifera
Turonian	Middle	*Romaniceras deverianum*	*Romaniceras deverianum* (2)		*Romaniceras deverianum*	*Coilopoceras requienianum*	
					Collignoniceras woollgari		*Trochactaeon salomonis*
		Romaniceras ornatissimum			*Coilopoceras* sp.		
		Romaniceras kallesi	*Romaniceras kallesi* (2)		*Romaniceras ornatissimum*		*Durania* spp. – *Praeradiolites* spp.
		Kamerunoceras turoniense			*Neoptychites cephalotus*		*Phymosoma abbatei* – *Tylostoma* spp.
	Early	*Mammites nodosoides*	*Mammites nodosoides* (2)		*Lecointriceras fleuriausianum*		*Hemiaster* (*M.*) *heberti turonensis* – *Coenheolctypus turonensis.*
					Choffaticeras luciae trisellatum		
			Thomasites rollandi (2)	*Hoplitoides*	*Choffaticera quassi*	*Choffaticeras sinaiticum* – *Thomasites rollandi*	
				Vascoceratidae (*Nigeraceras, Vascoceras*)	*Choffaticeras securiforme*		
					Vascoceras pioti	*Choffaticeras segne* – *Vascoceras harttii*	
		Watinoceras coloradoense	*Pseudaspidoceras flexuosum* (1, 2)	*Wrightoceras, Bauchioceras*	*Pseudaspidoceras footeanum*	*C. securiforme* – *Choffaticer quassi*	
Cenomanian	Late	*Neocardioceras juddii*	*Pseudaspidoceras Pseudonodosoides Euomphaloceras* cf. *septemseriatum*		*Metoicoceras geslinianum* – *Costagyra olisiponensis* – *Neolobites vibrayeanus* *Euomphaloceras* *Pseudocalycoceras haugi* *Neolobites fourtaui*	*V. cauvini* – *P. pseudonodosoides* – *R. alatum*	
		Metoicoceras geslinianum		*V. gamai*			*Pycnodonte vesiculosa* – *Rastellum carinatum* –*Inoceramus* ex gr. *pictus*
		Calycoceras naviculare / *Eucalycoceras pentagonum*		*Neolobites, Calycoceras*			*Costagyra olisiponensis*
			Eucalycoceras pentagonum	*Neolobites vibrayeanus*		*Neolobites vibrayeanus*	*Ambigostrea pseudovillei* – *Ilymatogyra africana*
							Nerinea gemmifera – *Praeradiolites biskraensis* – corals
	Middle	*Acanthoceras jukesbrownei*	*Acanthoceras amphibolum*				*Praealveolina cretacea*
		Acanthoceras rhotomagense	*Paraconlinoceras* aff. *barcusi*				
		Cunningtoniceras inerme	*Acanthoceras* cf. *rhotomagense*				
			Cunningtoniceras inerme				
	Early	*Mantelliceras dixoni*	*Mantelliceras dixoni*		*Mantelliceras*		*Gyrostrea delettrei* – *Rhynchostreon suborbiculatum* – *H. gabrielis*
		Mantelliceras mantellei	*M.* cf. *mantellei*				*Eoradiolites liratus*
			Mantelliceras cobbani				*Orbitolina conica*
			M. azregensis				
Alb.	Late	*Stoliczkaia dispar*	*Mortoniceras* (*Durnovarites*) sp.				*Ceratostreon flabellatum* – *Pterocera incerta*

Cucullaea (*Idonearca*) *trigona* – *Rachiosoma geysi* Zone can be correlated with the *Rachiosoma irregulare* Acme Zone in Gebel Ekma. This indicates that the *C. requienianum* Zone does not correspond to the topmost Turonian. Due to the absence of typical Early Coniacian of both macro and microfauna in the present study the Turonian/Coniacian boundary can not be determined.

5. 4. Coniacian/Santoniam boundary

According to Lamolda & Hancock (in Rawson *et al.* 1996) six criteria are proposed for the Coniacian/Santonian boundary; FO of *Texanites* (*Texanites*), FO of *Sigalia carpathica*, FO of *Dicarinella asymetrica*, FO of *Platyceramus siccensis*, FO of *Cladoceramus undulatoplicatus*, and FO of *Sphenoceramus pachti*. They selected the lowest occurrence of *Cladoceramus undulatoplicatus* as a primary marker for the Coniacian/Santonian boundary and *Sigalia carpathica* as a secondary marker.

Consequently, the Coniacian/Santonian boundary is located at the base of the bed no. 24 within the shaly member of the Matulla Formation in Gebel Ekma, at the level of the FO of *Cladoceramus undulatoplicatus* (Roemer), which is recorded for the first time from North Africa and The Middle East, while in both Gebel Yelleg and the East Themed area the Coniacian/Santonian boundary can not be determined due to the absence of typical Early Santonian fauna.

5. 5. Santonian/Campanian boundary

The Santonian/Campanian boundary is defined based on oysters and planktonic foraminifera. A Late Campanian age is assigned to the base of the *Nicaisolopha nicaisei* – *Ambigostrea bretoni* Total Range Zone, which coincides with the Late Campanian *Globotruncana rosetta* Zone of El-Sheikh (1999). The second zonal species, *A. bretoni* (Thomas & Peron), has a long stratigraphic range (Coniacian - Maastrichtian), but it is recorded from Upper Campanian rocks in Wadi Qena (Malchus 1990). Moreover *N. nicaisei* (Coquand) is restricted to the Upper

Campanian – Lower Maastrichtian (Malchus 1990, Aqrabawi 1993). El-Sheikh (1999) recorded the *Dicarinella concavata* Zone from the sequence of shale and marl (lower part of the *Nicaisolopha tissoti* Zone), which underlies the phosphatic sandstone (base of the phosphatic member of the Matulla Formation at Gebel Ekma) and attributed it to the Lower Santonian. He suggested a hiatus corresponding to most of the Santonian and to the Lower Campanian. This conclusion is adopted herein, because Hancock & Gale (in Rawson *et al.* 1996) considered the LO (last occurrence) of *Dicarinella asymetrica* (Sigal) and *D. concavata* (Brotzen) to be the most used foraminiferal criteria for the Santonian/Campanian boundary. The first occurrence of *N. nicaisei* is in the shale bed, which is 32 m above the top of the *concavata* Zone. This indicate that the lower 32 m of the phosphatic member are of Early Campanian age, while the upper 13 m are of Late Campanian in age. Therefore, the Santonian/Campanian boundary is located at the base of the phosphatic sandstone bed (base of the phosphatic member), which yields numerous shark teeth. This contact coincides with the LO of *Dicarinella concavata.* In the other two localities the boundary can not be determined due to the absence of typical Late Santonian fauna.

5. 6. Campanian/Maasterichtian boundary

In the present study except for *Pycnodonte* (*Phygraea*) *vesicularis vesicularis* (Lamarck) no macrofossils were collected from the Sudr Chalk. This formation is considered to be Campanian – Maastrichtian in age at many localities in Egypt (Kora & Hamama 1987b, Cherif *et al.* 1989b, Abdel-Gawad 1990, Ziko *et al.* 1993, and Ismail 2000). In Gebel Ekma, it overlies the Upper Campanian rocks of the Matulla Formation, which is determined by both oysters and planktonic foraminifera as discussed before.

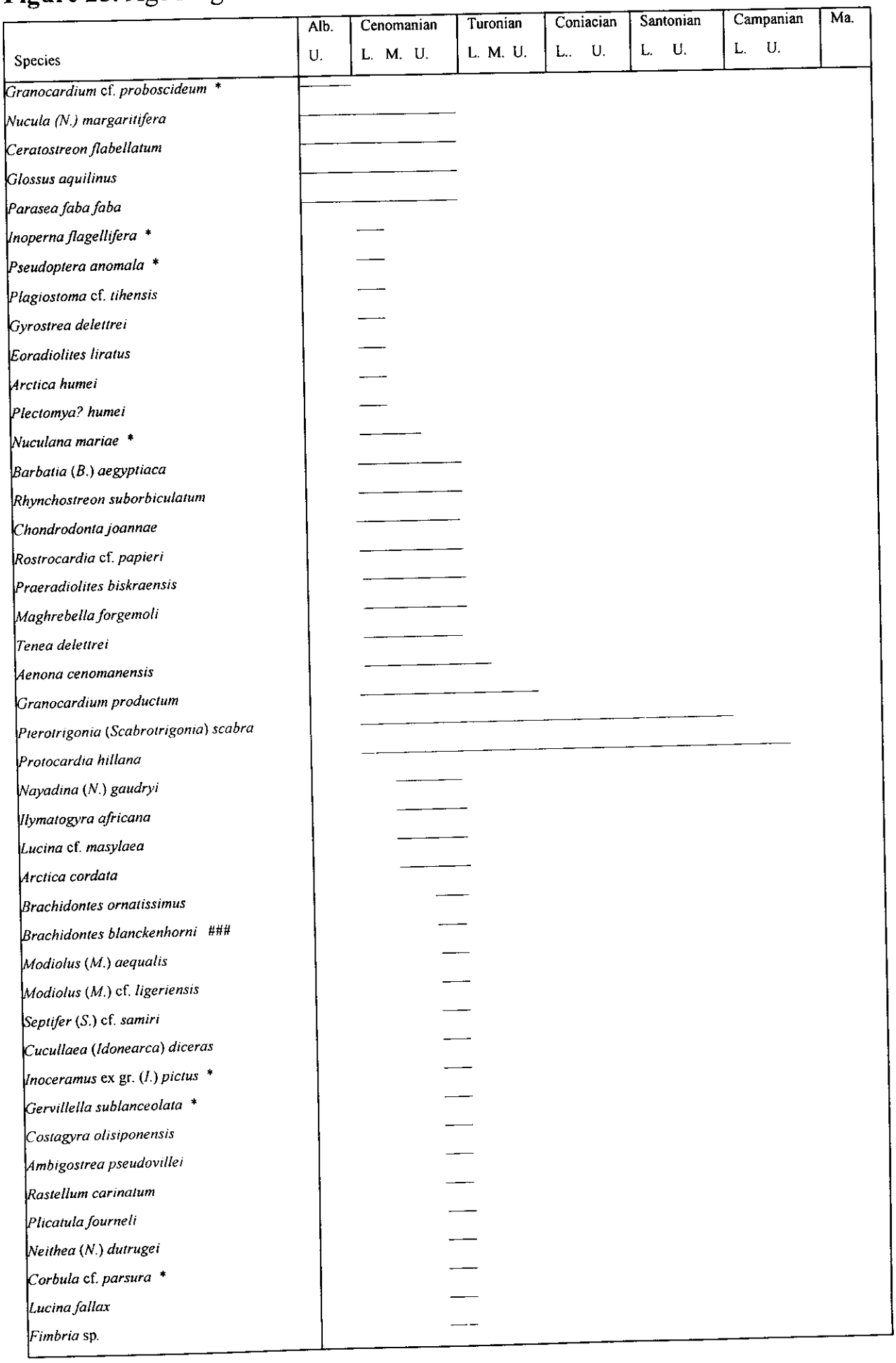
The FO of *Gansserina ganssari* (Bolli) is considered to mark the Campanian/Maastrichtian boundary (Odin *in* Rawson *et al.* 1996 and Hardenbol *et al.* 1998). Therefore, the Campanian/Maastrichtian boundary is determined at

Gebel Ekma at the base of the *Gansserina ganssari* Zone which overlies the *Globotruncana aegyptiaca* Zone as recognized by Cherif *et al.* (1989b) at the same locality.

6- Age range of the studied macrofossils.

The age range recorded for the studied macrofossils are shown in figures 25- 28

Figure 25. Age range recorded for the identified bivalves in the present study



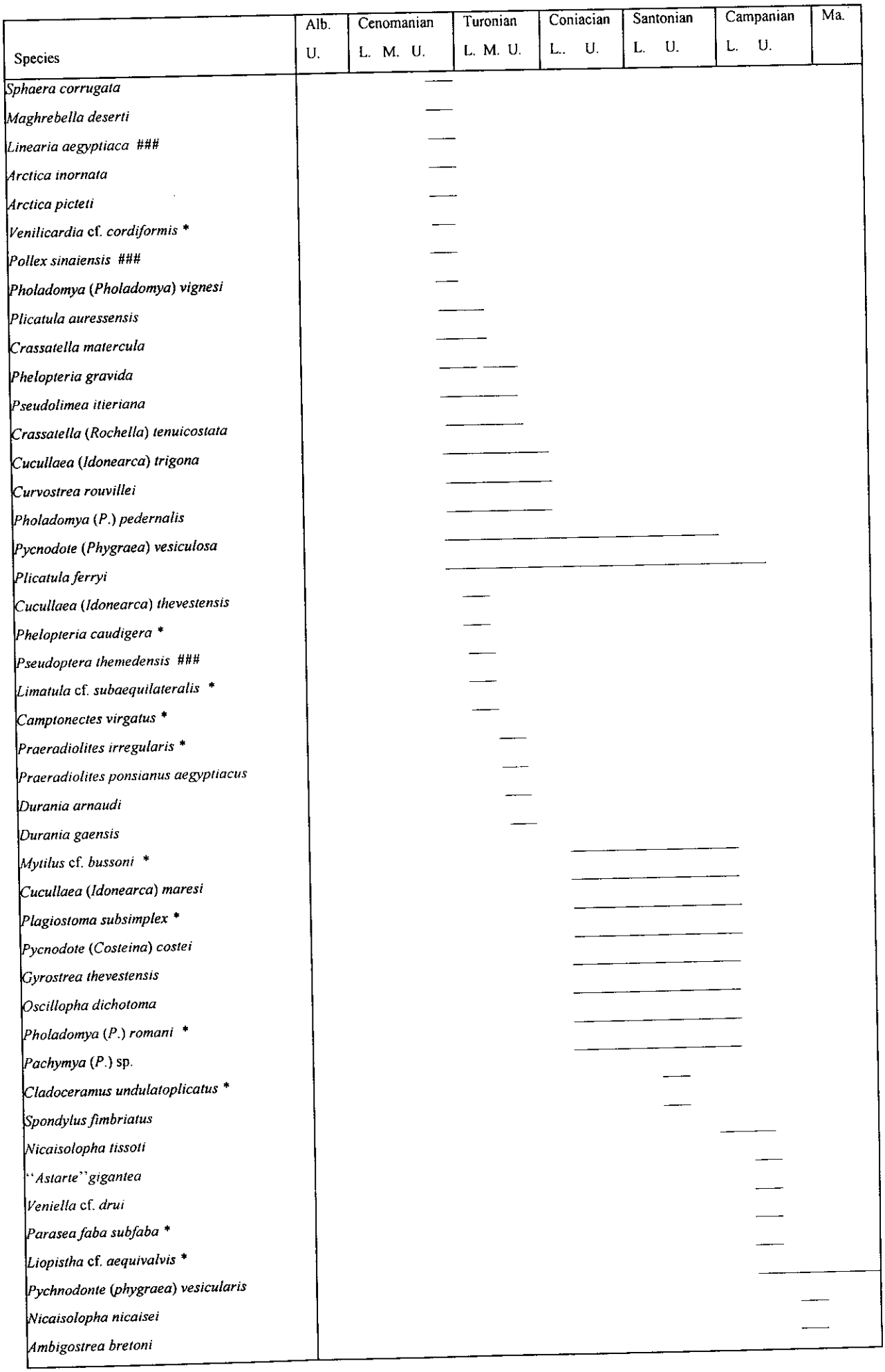

Species
Alb.
U.
Cenomanian
L. M. U.
Turonian
L. M. U.
Coniacian
L.. U.
Santonian
L. U.
Campanian
L. U.
Ma.
Sphaera corrugata
Maghrebella deserti
Linearia aegyptiaca ###
Arctica inornata
Arctica picteti
Venilicardia cf. cordiformis *
Pollex sinaiensis ###
Pholadomya (Pholadomya) vignesi
Plicatula auressensis
Crassatella matercula
Phelopteria gravida
Pseudolimea itieriana
Crassatella (Rochella) tenuicostata
Cucullaea (Idonearca) trigona
Curvostrea rouvillei
Pholadomya (P.) pedernalis
Pycnodote (Phygraea) vesiculosa
Plicatula ferryi
Cucullaea (Idonearca) thevestensis
Phelopteria caudigera *
Pseudoptera themedensis ###
Limatula cf. subaequilateralis *
Camptonectes virgatus *
Praeradiolites irregularis *
Praeradiolites ponsianus aegyptiacus
Durania arnaudi
Durania gaensis
Mytilus cf. bussoni *
Cucullaea (Idonearca) maresi
Plagiostoma subsimplex *
Pycnodote (Costeina) costei
Gyrostrea thevestensis
Oscillopha dichotoma
Pholadomya (P.) romani *
Pachymya (P.) sp.
Cladoceramus undulatoplicatus *
Spondylus fimbriatus
Nicaisolopha tissoti
"Astarte" gigantea
Veniella cf. drui
Parasea faba subfaba *
Liopistha cf. aequivalvis *
Pychnodonte (phygraea) vesicularis
Nicaisolopha nicaisei
Ambigostrea bretoni

Figure 26. Age range recorded for the identified gastropods in the present study

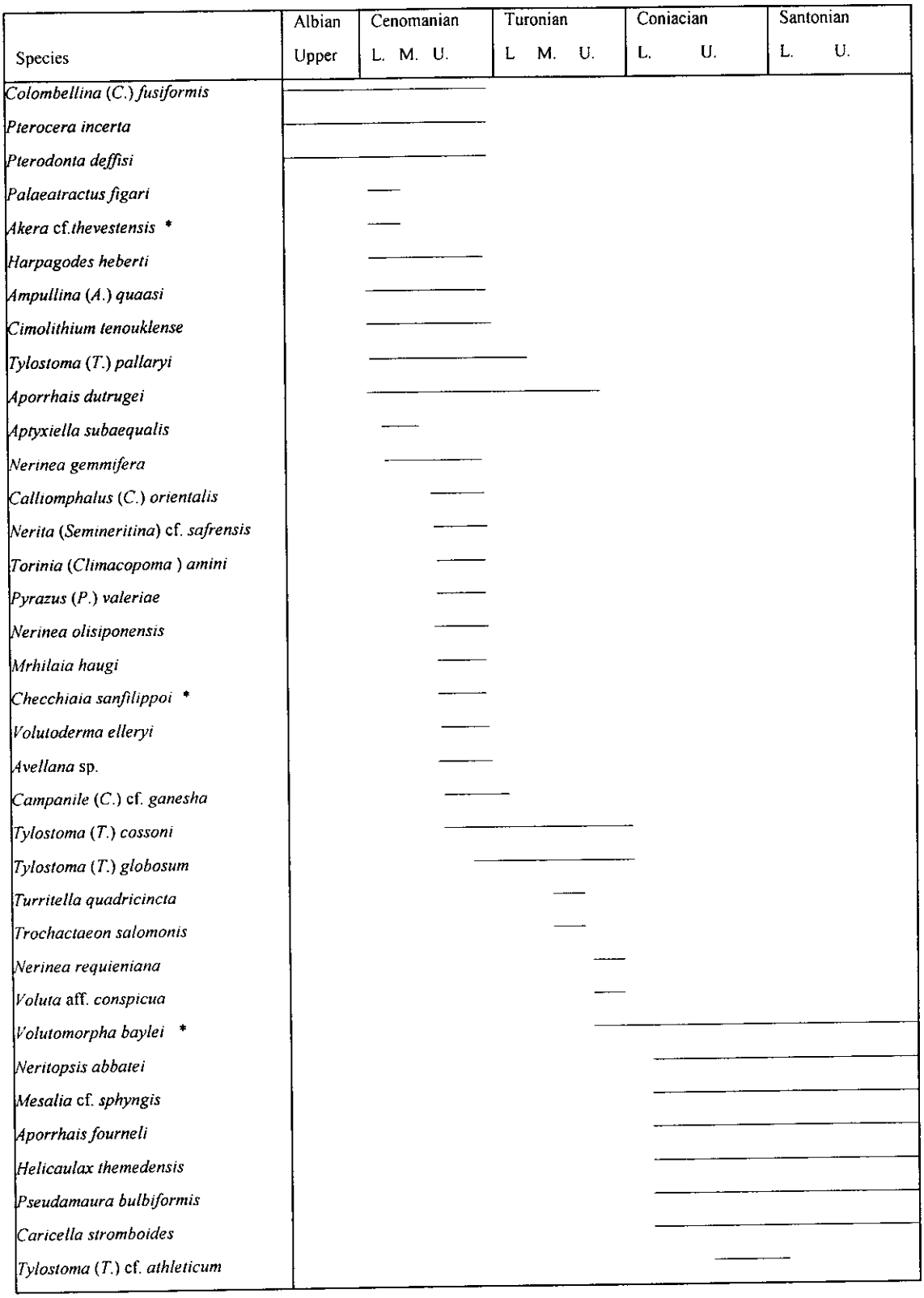
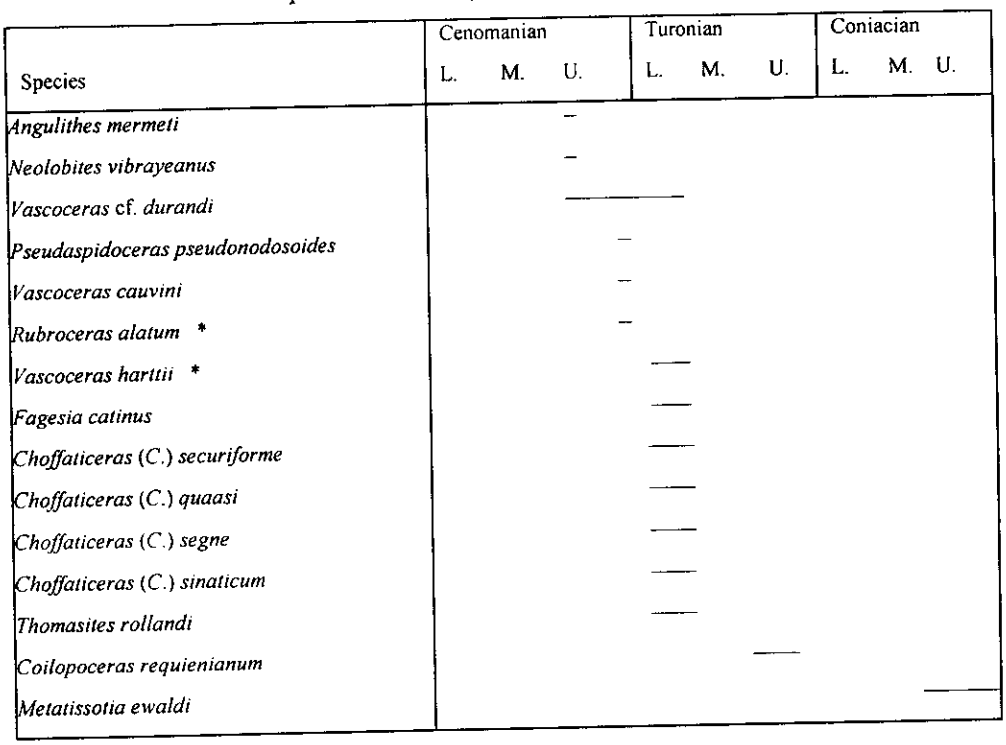


Figure 27. Age range recorded for the identified cephalopods in the present study



Chapter III

Systematic Paleontology

This chapter deals with the systematic classification of more than 6000 specimens, which are collected from the Upper Cretaceous succession exposed at Gebel Ekma, East Themed area, and Gebel Yelleg, Sinai, Egypt. The studied specimens belong to 172 macrofossil species and subspecies, which are identified, classified, described, and discussed in details. Most of the studied fauna belong to Mollusca (Bivalvia, Gastropoda, and Cephalopoda) and Echinoidea. Bivalves constitute the main bulk of the studied taxa, where it is represented by 89 species belonging to 61 genera, 34 families, 13 orders, 3 subclasses. Gastropods; 36 species belonging to 30 genera, 19 families, 4 orders, 2 subclasses. Cephalopods; 15 species belonging to 10 genera, 7 families, 2 orders. Echinoids; 32 species (16 regular and 16 irregular) belonging to 16 genera, 15 families, 10 orders, 1 subclass.

Four bivalves are new; *Brachidontes blanckenhorni* from the Upper Cenomanian of the East Themed area, *Pseudoptera themedensis* from the Lower Turonian of the East Themed area, *Linearia aegyptiaca*, and *Pollex sinaiensis* from the Upper Cenomanian of Gebel Ekma. Twenty-five species were recorded from Egypt for the first time, two of them are the first documentation of the ammonite *Rubroceras* from outside New Mexico and the first documentation, for North Africa and the Middle East, of the standard Lower Santonian *Cladoceramus undulatoplicatus* (Roemer). The generic name of *Siliqua humei* Fourtau, 1917 is changed here to *Plectomya* de Loriol, 1868 rather than to the genus *Siliqua* Megerle von Mühlfeld, 1811. As well as the generic name of *Venus delettrei* Coquand, 1862 which is changed here to *Tenea* Conrad, 1870 and consequently, the family Veneridae changed to family Arcticidae Newton, 1891.

The collected corals, corraline sponges, and bryozoa are outside the scope of the present study.

Mode of preservation.

The studied specimens show different modes of preservation, whereas bivalves like oysters, rudists, Pectinidae, *Plicatula*, *Nayadina* and some of the Nuculidae, Mytilidae, Arcidae, Cucullaeidae, Inoceramidae, Bakevelliidae, and Limidae are preserved as original shells. Some bivalves are mostly preserved as external moulds such as *Pholadomya* and *Plectomya*. Most of the remaining bivalves are preserved as internal moulds.

Gastropods are commonly preserved as internal moulds, some specimens especially of Turritellidae, Aporrhaidae, *Nerinea*, *Tylostoma*, *Pseudamaura*, and *Volutoderma* are preserved as original shells and rarely as external moulds.

Ammonites are preserved as internal moulds, while some specimens of the nautiloid *Angulithes mermeti* are preserved as original shell. Echinoids are preserved as original shells.

The identified macrofossils are photographed and illustrated on 34 plates.

1- Bivalvia

The systematic classification of the bivalves followed is that of Amler *et al.* (2000). The terminology for the morphological features of the bivalves follows the glossary presented by Cox (1969) in the Treatise on Invertebrate Paleontology, part N (Bivalvia). The terminology for the morphological features of the oysters follows that of Stenzel (1971); that of the shell microstructure Malchus (1990) and Aqrabawi (1993).

All linear measurements (taken with Vernier Caliper) are given in millimeters.

Abbreviations used are as follows:

n = number of measured specimens;

L = shell length;

H = shell height;

C = thickness of articulated shell;

nr = number of ribs;

The age mentioned hierein represents the age recorded in the present study, while the stratigraphic range of the species is discussed in detalis in the discussion of the species.

The identification of the rudists in the present study is based only on the general morphology. Most of the studied specimens are represented by attached valves (A V).

Phylum Mollusca Cuvier, 1795

Class Bivalvia Linné, 1758

Subclass Palaeotaxodonta Korobkov, 1954

Order Nuculoida Dall, 1889

Superfamily Nuculacea Gray, 1824

Family Nuculidae Gray, 1824

Genus *Nucula* Lamarck, 1799

Subgenus *Nucula* Lamarck, 1799

***Nucula (Nucula) margaritifera* Douvillé, 1916**

Pl. 1, Figs. 1-2, 5-6

1916 *Nucula margaritifera* sp. nov. - Douvillé, p. 177, pl. 21, figs. 19-21.

1916 *Nucula simplex* Deshayes - Douvillé, p. 177, pl. 21, fig. 22 [non Deshayes].

1962 *Nucula (Nucula) margaritifera* Douvillé - Abbass, p. 7, pl. 1, figs.1-7.

1963 *Nucula awadensis* sp. nov. - Fawzi, p. 19, pl. 1, figs. 8-10.

1992 *Nucula margaritifera* Douvillé - Abdel-Gawad & Zalat, pl. 2, fig. 1.

1998 *Nucula awadensis* Fawzi- El Qot, p. 55, pl. 1, figs. 1-2.

1998 *Nucula margaritifera* Douvillé - El Qot, p. 56, pl. 1, figs. 3-4.

2002 *Nucula* (*Nucula*) *margaritifera* Douvillé - Abdel-Gawad & Gameil, p. 77, pl. 1, fig. 1.

Material and occurrence. 8 specimens from Gebel Ekma, Raha Formation, beds no. 5 and 6; 8 specimens from the East Themed area, Galala Formation, bed no. 6 and 11 specimens from Gebel Yelleg, Galala Formation, beds no. 4 and 16.

Measurements (in mm).

n=27	L	H	C	H/L	C/L	C/H
Range	9-34	6-20	4.6-11.3	0.45-0.72	0.33-0.51	0.59-0.79
Mean	21.4	14.1	7.8	0.64	0.41	0.65

Description. Shell oval, small- to medium-sized, equivalved. Umbo opisthogyrate, situated nearly one-third of the shell-length from the posterior end. Anterior flank nearly straight or slightly convex and gently inclined; posterior flank, in contrast shorter, steeper and slightly concave. The shell is rounded anteriorly and angular posteriorly. The ventral margin is strongly convex. The ornamentation consists of wide and low commarginal ridges separated by narrower interspaces. Some specimens showing traces of radial striae which cross the commarginal ridges.

Age. Late Albian-Cenomanian.

Distribution in Egypt. Gebel Manzour, G. El-Minsherah G. El-Hamra, and G. Nezzazat.

Discussion. *Nucula* (*Nucula*) *tarfayensis* Freneix, 1972 from the Albian of Morocco is distinguished from the present species by having a higher shell (H/L = 0.86 - 0.97). Abbass (1962) discussed the differences between the present species, *Nucula stantoni* Stephenson, 1923 and *Nucula ovata* Mantell (in Woods 1899: pl. 3, figs. 16-21; pl. 4, fig. 1). Douvillé (1916) described two species of *Nucula*; *N. margaritifera* Douvillé, 1916 and *N. simplex* Deshayes, 1842. The present author agrees with Abbass (1962) in regarding *Nucula simplex* Deshayes, 1842 as figured by Douvillé (1916) to belong to the present

species. Fawzi (1963) erected *Nucula awadensis* based on material from the Upper Cenomanian of Gebel El-Minsherah. In the present study, *N. margaritifera* and *N. awadensis* were recorded from the same bed in the East Themed area. In addition intermediate forms occur. Moreover, El Qot (1998) recorded *N. awadensis* from its type locality as the present material, and found that *N. awadensis* lies within the range of variation of *N. margaritifera*. Therefore, *N. margaritifera* and *N. awadensis* are regarded as synonyms, the specific differences mentioned by Fawzi (1963) being a matter of variation.

Douvillé (1916) established *Nucula margaritifera* from the Albian of Gebel Manzour. It was recorded from the same stratigraphic level and locality by Abbass (1962). Recently, Abdel-Gawad & Zalat (1992), El Qot (1998), and Abdel-Gawad & Gameil (2002) recorded it from the Cenomanian. The record of this species from the Cenomanian in the present study confirms its extended range.

Superfamily Nuculanacea Adams & Adams, 1858

Family Nuculanidae Adams & Adams, 1858

Genus *Nuculana* Link, 1807

Subgenus *Nuculana* Link, 1807

***Nuculana* cf. *mariae* (d'Orbigny, 1844)**

Pl. 1, Figs. 3a-b, 4

cf.1844 *Nucula mariae* sp. nov. - d'Orbigny, p. 169, pl. 301, figs. 4-6.

cf.1899 *Nuculana mariae* (d'Orbigny) - Woods, p. 6, pl. 1, figs. 25-27.

Material and occurrence. 3 specimens from Gebel Ekma, Raha Formation, beds no. 2.

Measurements (in mm).

n=3	L	H	C	H/L	C/L	C/H
Range	5.8-8	3.3-4.7	2.9-4.4	0.57-0.66	0.50-0.55	0.79-0.94
Mean	6.8	4.1	3.6	0.61	0.52	0.87

Description. The specimens small-sized, oval, moderately inflated, equivalved, inequilateral, rounded anteriorly and pointed posteriorly. Umbones pointed, opisthogyrate. Ventral margin considerably curved. The specimens are internal moulds which show no traces of ornamentation.

Age. Early-Middle Cenomanian.

Distribution outside Egypt. France and England.

Remarks. The specimens resemble *Nucula mariae* which originally described by d'Orbigny (1844). They closely resemble *Nuculana mariae* (d'Orbigny) as figured by Woods (1899), but Woods' specimens are ornamented with numerous commarginal ribs.

Subclass Pteriomorphia Beurlen, 1944

Superorder Isofilibranchia (Iredale, 1939) Pojeta, 1971

Order Mytiloida Ferussac, 1822

Superfamily Mytilacea Rafinesque, 1815

Family Mytilidae Rafinesque, 1815

Subfamily Mytilinae Rafinesque, 1815

Genus *Mytilus* Linné, 1758

***Mytilus* cf. *bussoni* Collignon, 1971**

Pl. 1, Fig. 7a-b

cf. 1971 *Mytilus bussoni* sp. nov. - Collignon, p. 24 (166), pl. 4, figs. 8-9.

Material and occurrence. 43 specimens from the East Themed area, Themed Formation, bed no. 34.

Measurements (in mm).

n=43	L	H	C	H/L	C/L	C/H
Range	26-46	13-22.3	10-15.5	0.44-0.52	0.28-0.39	0.56-0.72
Mean	35.7	17.8	12.2	0.48	0.33	0.67

Description. Shell small to medium-sized, mytiliform, equivalved, strongly inequilateral. Hinge margin usually straight but convex in some specimens.

Postero-dorsal margin strongly convex and broadly rounded. Posterior margin rounded. Antero-ventral margin straight to slightly concave mesially. Umbones terminal. The shell attains its maximum thickness near the umbones. Most of the collected specimens are internal moulds without any trace of ornamentation but some specimens with remnants of the shell show fine, numerous and closely spaced commarginal lines.

Age. Coniacian-Santonian.

Discussion. The present specimens closely resemble *Mytilus bussoni* Collignon, 1971 which he erected based on material from the Maastrichtian of the Sahara, Algeria. The present material differs in having a relatively longer hinge margin. The latter in some specimens straight, in others convex. The illustrations given by Collignon seem to show a slightly more convex hinge margin. The same author distinguished his new species from *Mytilus indifferens* Coquand, 1862 from the Mornasien (Turonian) of Algeria by its more strongly pointed umbo.

Genus *Brachidontes* Swainson, 1840

***Brachidontes blanckenhorni* sp. nov.**

Pl. 1, Figs. 8a-b, 9a-c

?1934 *Septifer lineatus* (Sowerby) - Blanckenhorn, p. 207, pl. 10, fig. 51.

Holotype. BUFG2003I 1; Pl. 1, Fig. 9a-c.

Paratypes. BUFG2003I 2-4.

Locus typicus. East Themed area, Sinai, Egypt.

Stratum typicum. Bed no. 6, top of the *Neolobites vibrayeanus* Zone, Galala Formation, Upper Cenomanian.

Derivatio nominis. After M. Blanckenhorn.

Material and occurrence. 4 specimens from the East Themed area, Galala Formation, bed no. 6; 1 specimen from Gebel Yelleg, Galala Formation, bed no. 16.

Measurements (in mm).

n=5	L	H	C	H/L	C/L	C/H
Range	12-24	5-10.5	4-9.5	0.39-0.46	0.33-0.46	0.80-1.0
Mean	17.9	8.2	7.9	0.43	0.40	0.94

Diagnosis. *Brachidontes* with a well-marked, broad sulcus in front of and below the umbonal ridge which extends from the beak to the ventral margin. Ventral margin convex posteriorly, nearly straight anteriorly and strongly concave medially. Shell covered with numerous, closely spaced bifurcating radial ribs of varying strength.

Description. Shell small to medium-sized, elongated, modioliform to oblong in outline, inflated, equivalved, strongly inequilateral. Umbones small, subterminal, strongly prosogyrate. Umbonal ridge prominent and broadly rounded. A well-marked, broad sulcus in front of and below the umbonal ridge extends from the beak to the ventral margin. Anterior margin narrowly rounded. Posterior margin broadly rounded. Postero-dorsal margin gently inclined and very broadly curved. Ventral margin convex posteriorly, nearly straight anteriorly and strongly concave medially. Valve margin crenulated. Shell covered with numerous, closely spaced radial ribs of varying strength; the coarsest ribs are on the umbonal inflation, the finest and weakest ones cover the radial depression. Several short ribs close to the anterior margin, below the beak are relatively coarse. These radials may bifurcate at almost any distance from the beak. The radial ribs are crossed by faint commarginal lines, the latters very well visible in the radial depression.

Age. Late Cenomanian.

Discussion. Blanckenhorn (1934: p. 207, pl. 10, fig. 51) described very similar material from the Lower Cenomanian and Santonian of Palestine as *Septifer lineatus* (J. de C. Sowerby). However, the specimen illustrated by Blanckenhorn differs from *S. lineatus* as described by Woods (1900: p. 106, pl. 18, figs. 1-12) and Abdel-Gawad (1986: p. 138, pl. 28, fig. 1), which has a terminal umbo, is

larger and more inflated (Woods' dimensions: L=28-49, C=15-29, C/L=0.47-0.63). The subterminal umbo as well as the similarity in size (L=18-20, C=8-10), outline and ornamentation of Blanckenhorn's specimen to the present specimens indicate that it is more related to the present new species rather than to *S. lineatus*.

The present species differs from *B. ornatissimus* (d'Orbigny) in being more elongated, having a concave rather than straight ventral margin, a radial depression and in having generally more numerous ribs. In addition, the ribs in *B. ornatissimus* divaricate and bifurcate, whereas in *B. blanckenhorni* they only bifurcate.The present species differs from *Mytilus plucher* Goldfuss (1837: p. 177, pl. 138, fig. 8) in having a more elongated shell. It is distinguished also from *B. filisculptus* (Cragin, 1893) in Stephenson (1952: p. 83, p. 20, figs. 19-21) in being smaller, more elongated, and in the radial sulcus being more finely ribbed than that of the latter. *Brachidontes* (*Septifer*) *abbassi* Abbass, 1962, which was erected on material from the Turonian of Abu Roash, Egypt, differs from the present species in being smaller and more inflated (L = 5.5 mm, H = 11 mm, C= 6 mm, C/L = 1.09 and C/H = 0.55).

***Brachidontes ornatissimus* (d'Orbigny, 1844)**

Pl. 1, Fig. 10a-c

1844 *Mytilus ornatus* sp. nov. - d'Orbigny, p. 283, pl. 342, figs. 10-12.

1848 *Mytilus ornatissimus* d'Orbigny - d'Orbigny, p. 767.

1890 *Modiola ornatissima* d'Orbigny - Peron, p. 245, pl. 27, fig. 17.

1912 *Modiola* (*Brachidontes*) *ornatissima* d'Orbigny - Pervinquière, p. 127.

1917 *Modiola* (*Brachidontes*) *ornatissima* d'Orbigny - Fourtau, p. 17.

1918 *Modiola* (*Brachidontes*) *ornatissima* d'Orbigny - Greco, p. 25 (207).

2002 *Brachidontes* (*Brachidontes*) *samiri* (Abbass)- Abdel-Gawad & Gameil, p. 82, pl. 1, fig. 13 (non Abbass).

2002 *Septifer* sp. - Abdelhamid & El Qot, p. 262, pl. 1, figs. 3-4.

Material and occurrence. 10 specimens from Gebel Ekma, Raha Formation, bed no. 5.

Measurements (in mm).

N=10	L	H	C	H/L	C/L	C/H
Range	14-20	8.5-12	5-8	60-65	0.36-0.45	0.59-0.73
Mean	6.6	10.9	7.5	0.63	0.39	0.65

Description. Shell small- to medium-sized, mytiliform to modioliform in outline, moderately inflated, equivalved, strongly inequilateral. Umbones small, subterminal, strongly prosogyrate. Umbonal ridge prominent and narrowly rounded near the crest. Anterior margin very narrowly rounded above the mid-height. Antero-ventral margin oblique, broadly rounded anteriorly and posteriorly. Posterior margin slightly rounded. Postero-dorsal margin oblique and broadly rounded. Dorsal and ventral margins nearly straight but not parallel to each other. The shell margin is crenulated. Shell is ornamented with numerous radial ribs, which vary in strength; the coarsest ribs occur on the inflated umbo, and the finest ones are in front of and below the umbonal ridge, close to the anterior extremity. Below the beak there are some short, relatively coarse ribs. These radial ribs may bifurcate on any part of the shell. This bifurcation is clearly visible in the area with the coarsest ribs. The radial ribs divaricate below and above the umbonal ridge.They are crossed by faint commarginal growth lines.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Abu Edeimat and G. Nezzazat.

Distribution outside Egypt. France, Algeria, and Tunisia.

Discussion. The two *Brachidontes* species described herein are intermediate in characters between *Brachidontes* Swainson, 1840 and *Musculus* Röding, 1798; on one hand they have a crenulated margin as is the case in *Musculus* and the radial ribbing especially in *B. blanckenhorni*, is considerably finer in the sulcus than in other parts of the shell. On the other hand, they have subterminal

umbones and the radial ribbing, although varying in strength, extends across the whole valve. In this respect they more closely resemble *Brachidontes*.

The present specimens agree very well with *Brachidontes ornatissimus* (d'Orbigny, 1844) which was originally described from the Turonian of Sarthe, France. They are also very similar to specimens illstrated by Peron (1890) from the Cenomanian of Tunisia. With respect to the stratigraphic range of the species, it was erected from the Turonian of France and was recorded by Peron (1890) from the Cenomanian and Santonian of both Tunisia and Algeria. In Egypt it is restricted to the Cenomanian (see Fourtau 1917, Greco 1918). Consequently, it ranges from the Cenomanian to the Santonian age.

Subfamily Lithophaginae Adams & Adams, 1857

Genus *Inoperna* Conrad in Kerr, 1875

***Inoperna flagellifera* (Forbes, 1846)**

Pl. 1, Figs. 11a-c, 13-14

1846 *Mytilus* (*Modiolus*) *flagelliferus* sp. nov. - Forbes, p. 152, pl. 16, fig. 9.

1871 *Modiola flagellifera* Forbes - Stoliczka, p. 379, pl. 24, figs. 1-2.

1900 *Modiola flagellifera* Forbes - Woods, p. 99, pl. 17, figs. 1-2.

1986 *Inoperna flagellifera* (Forbes) - Abdel-Gawad, p. 138, pl. 27, fig. 4.

2002 *Panopea* sp. - Abdelhamid & El Qot, p. 284, pl. 7, figs. 4-5.

Material and occurrence. 3 incomplete specimens from Gebel Yelleg, Galala Formation, bed no. 18; 3 incomplete specimens from Gebel El-Hamra, the Raha Formation,bed no. 2.

Measurements (in mm).

N=6	L	H	C	H/L	C/L	C/H
Range	>22.2-32	10-14.7	9.7-15	0.39-0.57	0.44-0.47	0.97-1.2
Mean	27.2	12.9	12.4	0.48	0.46	1.09

Description. Shell very elongated, slightly curved, compressed, somewhat enlarged posteriorly. Dorsal margin almost straight, and running nearly parallel

with the slightly concave ventral margin. Umbones obtuse, nearly terminal, with a faintly marked oblique carina extending to the postero-ventral extremity. Ornamentation consisting of flagelliform ribs, which are broad near the dorsal margin, and directed obliquely backwards.

Age. Early Cenomanian.

Distribution. The present species was recorded from the Albian of England (Woods 1900), Turonian of Bohemia, Senonian of Sweden, Austria, Bulgaria and the Upper Cretaceous of Southern India. Abdel-Gawad (1986) recorded it from the uppermost Maastrichtian of the Middle Vistula Valley of Poland. Consequently, *Inoperna flagellifera* Forbes has a wide stratigraphic range, occuring from the Albian to the Maastrichtian.

Subfamily Modiolinae Keen, 1958

Genus *Modiolus* Lamarck, 1799

Subgenus *Modiolus* Lamarck, 1799

Modiolus (*Modiolus*) *aequalis* (J. Sowerby, 1818)

Pl. 1, Fig. 12a-b

1818 *Modiola aequalis* sp. nov. - J. Sowerby, p. 18, pl. 210, fig. 2.

1838 *Mytilus concentricus* sp. nov. - Goldfuss, p. 178, pl. 138, fig. 5.

1866 *Modiola capitata* sp. nov. - Zittel, p. 80, pl. 12, fig. 1 a-d.

1900 *Modiola aequalis* Sowerby - Woods, p. 92, pl. 15, figs. 8-14.

1912 *Modiola aequalis* Sowerby - Pervinquière, p. 124.

1912 *Modiola capitata* Zittel - Pervinquière, p. 124, pl. 8, fig. 10 a-b.

1937 *Modiola aequalis* Sowerby - Lehner, p. 207, pl. 24, figs. 5-6.

1963 *Modiola capitata* Zittel - Fawzi, p. 27.

1971 *Modiolus capitatus* Zittel - Collignon, p. 25 (167), pl. 4, fig. 10.

1981 *Modiolus capitatus* Zittel - Amard *et al.*, p. 71, pl. 2, fig. 1 a-b; pl. 8, fig. 6 a-b.

1996 *Modiolus* (*Modiolus*) *capitatus* Zittel - El-Mahallawy, p. 79, pl. 1, fig. 9.

Material and occurrence. 6 specimens from Gebel Ekma, Raha Formation, beds no. 4, 5 and 9.

Measurements (in mm).

N=6	L	H	C	H/L	C/L	C/H
Range	24.5-42.5	12-22	10.5-15.3	0.48-0.57	0.36-0.43	0.70-0.88
Mean	37.2	17.3	12.4	0.53	0.40	0.77

Description. Shell small to medium-sized, modiliform, equivalved, moderately to strongly inflated, strongly inequilateral. Posterior umbonal ridge prominent. Umbones obtuse, subterminal, prosogyrate, situated distinctly behind the anterior end. Dorsal margin short and feebly convex. Antero-dorsal margin narrowly rounded. Postero-dorsal margin broadly curved. Ventral margin with shallow median concavity. Ornamentation consisting of smooth, fine commarginal growth lamellae, separated by wider interspaces, the latter occupied by finer commarginal threads.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Shabrawit and G. Nezzazat.

Distribution outside Egypt. Southern Europe and North Africa.

Discussion. The present material closely resembles *Modiola aequalis* J. Sowerby, *Mytilus concentricus* Goldfuss and *Modiola capitata* Zittel. The present author agrees with Lehner (1937) that *Mytilus concentricus* Goldfuss and *Modiola capitata* Zittel are junior synonyms of *Modiola aequalis* Sowerby. *M. aepualis* as described by Woods (1900) and Lehner (1937) differs from the holotype in having a higher shell. *M. aepualis* is highly variable species and has a broad stratigraphic range, from the "Néocomian" (Pervinquière 1912) to the Paleocene age (Amard *et al.* 1981).

Modiolus (*Modiolus*) cf. *ligeriensis* (d'Orbigny, 1844)

Pl. 2, Fig. 1a-b

cf. 1844 *Mytilus ligeriensis* sp. nov. - d'Orbigny, p. 274, pl. 340, figs. 1-2.

cf. 1889 *Modiola radiata* Münster - Holzapfel, p. 221, pl. 25, fig. 16 (non Münster).

cf. 1900 *Modiola ligeriensis* d'Orbigny - Woods, p. 96, pl. 16, figs. 4-6.

cf. 1918 *Modiola Ligeriensis* d'Orbigny - Greco, p. 25 (207).

Material and occurrence. 2 specimens from the East Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

n=2	L	H	C	H/L	C/L	C/H
Range	33.5-51	20-28.5	17.5-23.3	0.56-0.60	0.46-0.52	0.82-0.88
Mean	42.3	24.3	20.4	0.58	0.49	0.85

Description. Shell medium to large-sized, modiliform, equivalved, strongly inequilateral; median part of the shell from the umbo to the posterior extremity strongly inflated; dorsal part compressed and postero-dorsal margin broadly rounded. Ventral to the umbonal ridge there is a shallow depression. Umbones obtuse, subterminal. Ornamentation is represented by commarginal ridges separated by wider interspaces. The latter are occupied by numerous very fine radial riblets, which are best developed on the postero-dorsal part of the shell.

Age. Late Cenomanian.

Distribution in Egypt. Wadi Araba.

Distribution outside Egypt. France and England.

Discussion. The present specimens are very similar to *Mytilus ligeriensis* which originally was described by d'Orbigny (1844). They are closely resemble *Modiola ligeriensis* (d'Orbigny) as described by Woods (1900) from the Upper Greensand of England. The present material also closely resembles Holzapfel's description of *Modiola radiata* Münster. The present material, however is characterised by having a slightly higher shell than d'Orbigny and Woods' material. It is for this reason that the present material is referred to *ligeriensis* with reservation. The present species can distinguished easily from *M. aequalis*

(J. Sowerby) in having a more anteriorly placed umbo and radial riblets between the commarginal ornamentation.

Family Septiferidae Scarlato & Starobogatov, 1979

Genus *Septifer* Recluz, 1848

***Septifer* (*Septifer*) aff. *samiri* (Abbass, 1962)**

Pl. 2, Fig. 2a-b

aff. 1962 *Brachidontes* (*Septifer*) *samiri* sp. nov. - Abbass, p. 33, pl. 3, fig. 3.

aff. 1994 *Septifer* (*Septifer*) *samiri* (Abbass) - Kassab & Ismael, p. 236, fig. 4/10.

aff. 2002 *Septifer samiri* (Abbass) - Abdelhamid & El Qot, p. 261, pl. 1, fig. 2.

Material and occurrence. 1 incomplete specimens from the Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

n=1	L	H	C	H/L	C/L	C/H
	>20	12	6.5	0.60	0.33	0.54

Age. Late Cenomanian.

Remarks. The studied specimen resembles *Brachidontes* (*Septifer*) *samiri* Abbass which originally was described from the Cenomanian of Gebel Abu Edeimat, Sinai, Egypt. It is also similar to specimens of this species that were recorded by Kassab & Ismael (1994) and by Abdelhamid & El Qot (2002).

Order Arcoida Stoliczka, 1871

Superfamily Arcacea Lamarck, 1809

Family Arcidae Lamarck, 1809

Subfamily Arcinae Lamarck, 1809

Genus *Barbatia* Gray, 1842

Subgenus *Barbatia* Gray, 1842

Barbatia (*Barbatia*) *aegyptiaca* (Fourtau,1917)

Pl. 2, Figs. 3-5

1917 *Arca aegyptiaca* sp. nov. - Fourtau, p. 6, pl. 2, fig. 12.

1962 *Arca* (*Barbatia*) *aegyptiaca* (Fourtau) - Abbass, p. 16, pl. 2,fig. 1-2.

1981 *Barbatia* (*Barbatia*) *aegyptiaca* (Fourtau) - Collignon, p. 264, pl. 8, fig. 3.

2002 *Barbatia aegyptiaca* (Fourtau) - Abdelhamid & El Qot, p. 261, pl. 1, fig. 1.

Material and occurrence. 4 specimens from Gebel Ekma, Raha Formation, bed no. 5, and 17 specimens from the East Themed area, Galala Formation,beds no. 6, and 2 specimens from Gebel Yelleg, Galala Formation, beds no. 14 and 16.

Measurements (in mm).

N=23	L	H	C	H/L	C/L	C/H
Range	17.5-56.5	11-34.5	9-30.5	0.47-0.70	0.39-0.55	0. 66-0.97
Mean	36.3	21.6	17.1	0.64	0.48	0.78

Description. Shell medium-sized, ovoid, elongated, equivalved, inequilateral. Umbones placed one-fourth of shell length from the anterior end. Hinge line short, and inclined anteriorly. Posterior part of shell higher than the anterior one which is much reduced. Ventral margin feebly convex. Ornamentation consisting of numerous, fine, radial ribs separated by narower interspaces. These radials are crossed by faint commarginal lines, with which they produce a reticulate pattern.

Age. Cenomanian.

Distribution in Egypt. Bir Abu El-Meisa, Wadi Um Hemaiet, Gebel El-Minsherah, and G. El-Hamra.

Distribution outside Egypt. Iran.

Family Cucullaeidae Stewart, 1930

Genus *Cucullaea* Lamarck, 1801

Subgenus *Idonearca* Conrad, 1862

***Cucullaea (Idonearca) diceras* (Seguenza, 1882)**

Pl. 2, Figs. 6-8

1882 *Arca diceras* sp. nov. - Seguenza, p. 96, pl. 14, fig. 1 a-b.

1912 *Arca* (*Trigonarca*?) *diceras* Seguenza - Pervinquière, p. 102, pl. 7, figs. 23a-b, 25-26.

1917 *Arca diceras* Seguenza - Fourtau, p. 8.

1918 *Arca* (*Trigonarca*) *diceras* Seguenza - Greco, p. 29 (211), pl. 3 (29), figs. 14-15.

1937 *Arca* (*Trigonarca*) *diceras* Seguenza - Trevisan, p. 48, pl. 2, figs. 12-13.

1962 *Arca* (*Idonearca*) *diceras* (Seguenza) - Abbass, p. 23, pl. 2, fig. 10.

1963 *Arca* (*Trigonarca*) *diceras* Seguenza - Fawzi, p. 22.

1996 *Cucullaea* (*Idonearca*) *diceras* (Seguenza) - El-Mahallawy, p. 76, pl. 1, figs. 5-6.

2002 *Trigonarca diceras* Seguenza - Abdel-Gawad & Gameil, p. 81, pl. 1, fig. 10.

Material and occurrence. 23 specimens from Gebel Ekma, Raha Formation, bed no. 9.

Measurements (in mm).

n=23	L	H	C	H/L	C/L	C/H
Range	29.5-62	21.5-47	18-40.5	0.58-0.81	0.47-0.71	0.67-1.0
Mean	46.2	37	31.9	0.71	0.62	0.85

Description. The specimens medium- to large-sized, subtriangular to subtrapezoidal, longer than high, strongly inflated, equivalved, inequilateral, the anterior part shorter than the posterior one. Umbones prominent, broad, incurved. Hinge line nearly straight mesially and converging slightly towards the ventral margin anteriorly. Teeth well differentiated; small and numerous

median teeth, larger and fewer lateral teeth. Anterior margin vertically truncated, posterior margin obliquely truncated, both forming an angle with the ventral margin. The studied material consists of internal moulds, some of them showing traces of moderate to strong radial ribs, the latter separated by narower interspaces.

Age. Late Cenomanian.

Distribution in Egypt. Bassa Tebaide, Wadi Araba, W. Hazaal, Gebel Gunna, G. Shabrawit, and G. Nezzazat.

Distribution outside Egypt. Algeria, Tunisia, Italy, and Sicily.

Cucullaea (Idonearca) maresi (Coquand, 1880)

Pl. 2, Figs. 9-13

1880 *Arca Maresi* sp. nov. - Coquand, p. 130.

1880 *Arca Teutobochus* sp. nov. - Coquand, p. 129.

1890 *Arca Maresi* Coquand - Peron, p. 257, pl. 27, figs. 24-25.

1890 *Arca Teutobochus* Coquand - Peron, p. 259, pl. 27, figs. 26-27.

1903 *Cucullaea* cf. *Maresi* Coquand - Dacqué, p. 371, pl. 36, fig. 4.

1904 *Arca Maresi* Coquand - Fourtau, p. 321.

1912 *Arca* (*Trigonarca*?) *Maresi* Coquand - Pervinquière, p. 105.

1917 *Arca Maresi* Coquand - Fourtau, p. 10.

Material and occurrence. 3 specimens from Gebel Ekma, Matulla Formation, shaly member, bed no. 25; 38 specimens from the East Themed area, Themed Formation, beds no. 34, 35; and 40 specimens from Gebel Yelleg, Themed Formation, bed no. 57.

Measurements (in mm).

n=81	L	H	C	H/L	C/L	C/H
Range	28-63	22-55	19-58	0.74-1.0	0.56-1.05	0.68-1.06
Mean	46.1	37.1	31.9	0.87	0.76	0.83

Description. Shell medium- to large-sized, varying in outline from triangular to trapezoidal, strongly to very strongly inflated, equivalved, inequilateral. Umbones prominent, broad, incurved, widely separated, with a sharply defined, strong internal rib extending to the postero-ventral corner. This internal rib corresponds to a marked deep radial furrow in internal moulds. Distance between umbones moderately to very wide, hinge line nearly straight mesially and inclined towards the ventral margin at the two extremities. Central teeth numerous and small, lateral teeth few and large. Anterior margin shorter than the posterior one and forming an approximately right angle with the hinge line. Ventral margin nearly straight to slightly curved. Posterior margin nearly straight, forming an obtuse angle with the hinge line and a rounded acute angle with the ventral margin. The shell is ornamentated with numerous commerginal ribs, which are crossed by very fine, closely spaced radial ribs. The surface of internal moulds carries traces of moderate to strong radial ribs, the latter are commonly well preserved near the ventral margin. These radials are separated by interspaces nearly as wide as the ribs themselves.

Age. Coniacian – Santonian.

Distribution in Egypt. Abu Roash.

Distribution outside Egypt. Algeria and Tunisia.

Discussion. The present author agrees with Pervinquière (1912) and considers *Arca maresi* Coquand, 1880 and *Arca teutobochus* Coquand, 1880 as synonyms their only difference being that *teutobochus* is more inflated. In the present study the two forms as well as intermediate ones are recorded from the same bed in Gebel Yelleg and the East Themed area.

Cucullaea (*Idonearca*) *maresi* (Coquand) is easily distinguished from *Arca* (*Trigonarca*) *tumida* d'Orbigny which has been recorded from the Santonian of Abu Roash by Abbass (1962) in having a strongly inflated shell, the convexity may exceed its length (C/L= 0.56- 1.05), while Abbass' specimen has a C/L ratio of 26%. Pervinquière (1912) in his discussion of this species, mentioned

that it is very common in the Coniacian of Tunisia. He added that Peron specified the Santonian age of the Algerian material of Coquand as Coniacian and Santonian. Therefore, the present species is ranging in age from the Turonian to the Santonian.

Cucullaea (Idonearca) thevestensis (Coquand, 1862)

Pl. 2, Figs. 14-15; Pl. 3, Fig. 1

1862 *Arca Tevesthensis* sp. nov. - Coquand, p. 212, pl. 15, figs. 9-10.

1891 *Arca Thevestensis* Coquand - Peron, p. 257.

1912 *Arca* (*Trigonarca*?) *Thevestensis* Coquand - Pervinquière ,p. 104, pl. 7, figs. 22, 27a, b.

1917 *Arca thevestensis* Coquand - Fourtau, p. 12.

1934 *Arca* (*Trigonarca*?) *thevestensis* Coquand - Blanckenhorn, p. 211.

Material and occurrence. 5 specimens from the East Themed area, Abu Qada Formation, bed no. 11.

Measurements (in mm).

n=5	L	H	C	H/L	C/L	C/H
Range	26-43	21-40	19.5-33	0.81-0.93	0.74-0.77	0.83-93
Mean	36.4	33.1	26.6	0.87	0.76	0.88

Description. The specimens medium-sized, triangular, strongly inflated, equivalved, inequilateral. Umbones prominent, broad, incurved, widely separated, with a sharply defined, strong internal rib extending to the postero-ventral angle. This internal rib corresponds to a marked deep radial furrow in internal moulds. The distance between umbones moderately to very wide, hinge line nearly straight mesially and inclined towards the ventral margin at the two extremities. Teeth well differentiated into central teeth which are numerous and small, and a few and large lateral teeth. Anterior margin shorter than the posterior one and forming an approximately right angle with the hinge line at about. Ventral margin nearly straight to slightly curved. Posterior margin nearly

straight, forming an obtuse angle with the hinge line and a rounded acute angle with the ventral margin. All specimens are internal moulds, which carry traces of strong radial ribs. The latter are very well preserved near the ventral margin, and separated by relatively narrower interspaces.

Age. Early Turonian.

Distribution in Egypt. West Gharamul.

Distribution outside Egypt. Algeria, Tunisia, Italy, and Syria.

Discussion. According to Peron (1891: p. 257) *thevestensis* is the correct name for *tevesthensis* Coquand [nom. corr. Peron (1891: p. 257)]. *Cucullaea* (*Idonearca*) *diceras* Seguenza is distinguished from the present species in having a more elongated shell. *C.* (*I.*) *trigona* Seguenza has a less inflated shell and less prominent umbones.

The present species predominates in the Cenomanian of North Africa, Italy, and Syria, but it was recorded also from the Lower Turonian of Tunisia and Syria. Its occurrence in the Lower Turonian of the East Themed area confirms the extension of this species to this level.

Cucullaea (*Idonearca*) *trigona* (Seguenza, 1882)

Pl. 3, Fig. 2a-b

1882 *Arca trigona* sp. nov. - Seguenza, p. 98, pl. 13, fig. 6, 6a.

1912 *Arca* (*Trigonarca*?) *trigona* Seguenza - Pervinquière ,p. 103, pl.7, figs. 20-21.

1918 *Arca* (*Trigonarca*) *trigona* Seguenza - Greco, p. 28 (210), pl. 2 (29), figs. 12-13.

1937 *Arca* (*Trigonarca*) *trigona* Seguenza - Trevisan, p. 47, pl. 2, fig. 10.

1963 *Arca* (*Trigonarca*) *trigona* Seguenza - Fawzi, p. 21.

2001 *Trigonarca trigona* (Seguenza) – Abdallah *et al.*, pl. 2, fig. 1.

Material and occurrence. 14 specimens from Gebel Ekma;2 from the Raha Formation, beds no. 4, 5; 2 specimens from the Abu Qada Formation, bed no.

10 and 10 specimens from the Wata Formation, beds no. 16 and 17. 64 specimens from the East Themed area; 1 from Abu Qada Formation, bed no. 9 and 63 from the Wata Formation, bed no. 26.

Measurements (in mm).

n=78	L	H	C	H/L	C/L	C/H
Range	17-40	12-33.5	6.4-24	0.60-0.84	0.38-0.65	0.53-73
Mean	32.1	22.6	16.3	0.72	0.51	0.64

Description. Shell small- to medium-sized, subtriangular to trapezoidal, moderately to strongly inflated, equivalved, inequilateral. Umbones moderately prominent, incurved. Umbonal ridge subangular. Cardinal area triangular in shape, covered with about five sharply incised, roughly chevron-shaped ligamental grooves. Hinge narrow, nearly straight mesially. Teeth well differentiated; numerous and small in the middle they grade into a few, large lateral teet. Anterior margin subtruncated grading into the very broadly rounded ventral margin. Postero-dorsal slope steep and straight, postertior margin strongly inclined with respect to the dorsal margin. Ornamentation consisting of numerous, strong commarginal ribs which are crossed by very fine, closely spaced radial ribs.

Age. Late Cenomanian – Late Turonian.

Distribution in Egypt. Bassa Tebaide, Wadi Araba, Gebel El-Minsherah, G. Shabrawit, and El Giddi Pass.

Distribution outside Egypt. Algeria, Tunisia, Italy, and Sicily.

Discussion. The present material shows the typical hinge characters of the genus *Cucullaea*. The shell ornamentation is identical with that of subgenus *Idonearca*. *C.* (*Idonearca*) *diceras* Seguenza is easily distinguished from *C.* (*Idonearca*) *trigona* in being larger, more elongated, more inflated and in having more prominent umbones.

The present species widely distributed in the Cenomanian of North Africa and Italy, but it was recorded also from the Lower Turonian of Tunisia by

Pervinquière (1912). In the present study it was recorded from the Upper Cenomanian to the Upper Turonian.

Superorder Eupteriomorphia Boss, 1982

Order Pterioida Newell, 1965

Suborder Pteriina Newell, 1965

Superfamily Ambonychiidae Miller, 1877

Family Inoceramidae Giebel, 1852

Genus *Inoceramus* J. Sowerby, 1814

***Inoceramus* ex gr. *Inoceramus pictus* J. de C. Sowerby, 1829**

Pl. 3, Figs. 3-5

1829 *Inoceramus pictus* sp. nov. - J. de C. Sowerby, p. 215, pl. 604, fig. 1.

1910 *Inoceramus pictus* Sowerby - Woods, p. 279, pl. 49, figs. 5- 6; text-fig. 36.

1982 *Inoceramus pictus* Sowerby - Keller, p. 64.

Material and occurrence. 3 specimens from the East Themed area, Abu Qada Formation, bed no. 9.

Age. Late Cenomanian.

Remarks. The three specimens lack the hinge, and although they have been collected from the same bed they differ in outline. However, the general shape of the shell and the ornamentation falls within the range of *Inoceramus* ex gr. *Inoceramus pictus* J. de C. Sowerby, 1829 from the Upper Greensand of England.

Genus *Cladoceramus* Seitz, 1961

***Cladoceramus undulatoplicatus* (Roemer, 1849)**

Pl. 3, Figs. 6-9

1849 *Inoceramus undulato-plicatus* sp. nov. - Roemer, p. 402.

1852 *Inoceramus undulato-plicatus* Roemer - Roemer, p. 59, pl. 7, fig. 1.

1990 *Cladoceramus undulatoplicatus* (Roemer) - Dhondt & Dieni, p. 155, pl. 1,

fig. 1; pl. 2, figs.1-2; pl. 3, fig. 6; text-figs. 2-3;5-7 (with extensive synonymy).

Material and occurrence. Numerous shell fragments and 1 internal mould from Gebel Ekma, Matulla Formation, shaly member, bed no.24.

Age. Early Santonian.

Remarks. The material closely resembles *Cladoceramus undulatoplicatus* (Roemer) which has been described in detail by Dhondt & Dieni (1990). It shows the characteristic ornamentation of this species, i.e. radially diverging folds. Dhondt & Dieni (1990) in their disscussion of the species mentioned that, inoceramids have partly aragonitic shells; the hinge and other internal shell features belonging to this aragonitic part are normally dissolved during diagenesis. They added that, complete specimens, especially in the groups with large shells such as *Platyceramus* and *Cladoceramus*, are very rare. As a consequence, most inoceramid work is based on external shell characteristics only.

Lamolda & Hancock in Rawson *et al.* (1996) indicated that three inoceramid species have been used to define the Coniacian-Santonian boundary, the widespread *Cladoceramus undulatoplicatus* Roemer, the north temperate *Sphenoceramus pachticardissoides* group, and the North African species *Platyceramus siccensis*. They added that the latter species, is not known outside North Africa. Abdel-Gawad (1999b) recorded *Pl. siccensis* from the Lower Santonian of Gebel Nezzazat. Consequently, the record of *C. undulatoplicatus* Roemer herein is the first record of this standard, zonal species from the Middle East and North Africa.

Superfamily Pteriacea Gray, 1847

Family Bakevelliidae King, 1850

Genus *Gervillella* Waagen, 1907

***Gervillella sublanceolata* (d'Orbigny, 1850)**

Pl. 3, Figs. 10-11

1850 *Avicula sublanceolata* sp. nov. - d'Orbigny, p. 119.

1905 *Gervillia sublanceolata* (d'Orbigny) - Woods, p. 74, pl. 10, figs. 14-16; pl. 11, fig. 1; and text-figs. 7, 8.

Material and occurrence. 8 incomplete specimens from Gebel Ekma, Raha Formation, bed no. 5.

Measurements (in mm).

n=8	L	H	H/L
Range	>33->40	12.2-14	0.35-0.37
Mean	37	13	0.36

Age. Late Cenomanian.

Remarks and description. All specimens are incomplete but characterised by being medium- to large-sized and longitudinally elongated. Posterior wing narrow and obtuse; anterior auricle small, acutely pointed. Beaks almost terminal. Hinge line long forming an obtuse angle with the posterior margin. Surface of the shell ornamented with only growth-lamellae.

The present specimens agree with the description of *Gervillella sublanceolata* (d'Orbigny) in Woods (1905) from the Lower Greensand of England.

Genus *Phelopteria* Stephenson, 1952

Phelopteria caudigera (Zittel, 1866)

Pl. 3, Figs. 12a-c, 13

1866 *Avicula caudigera* sp. nov. - Zittel, p. 89, pl. 12, fig. 12a-c.

1889 *Avicula*? *caudigera* Zittel- Holzapfel, p.226, pl. 27, fig. 19.

1972 *Phelopteria caudigera* (Zittel) - Freneix, p. 75.

Material and occurrence. 6 specimens from Gebel Yelleg, Wata Formation, beds no. 39, 40.

Measurements (in mm).

n=6	L	H	C	H/L	C/L	C/H
Range	42-48	46-49	21-23	1.02-1.09	0.44-0.55	0.43-0.50
Mean	45	47.5	22	1.06	0.50	0.47

Description. The specimens medium-sized, quadrangular in outline, inequivalved, inequilateral, moderately inflated. Hinge line straight and inclined with respect to the main body axis. Umbones broad, slightly prominent and situated about one-third of shell length from the anterior end; umbonal cavity wide and deep. Wings large, triangular in shape; posterior wing more extended; anterior wing separated from the main part of the shell by a deep sulcus. Maximum inflation of the studied specimens near the umbo. Ornamentation consisting of fine commarginal lines.

Age. Early Turonian.

Distribution outside Egypt. Austria, Germany and Africa.

Discussion. *Phelopteria caudigera* (Zittel) is distinguished from *Phelopteria gravida* (Coquand) by its quadrangular outline, higher shell, wide and deeper umbonal cavity, and a more strongly inclined the main body axis with respect to hinge line. It is distinguished from *Phelopteria dalli* (Stephenson, 1936) by its shorter hinge line, a more anteriorly placed umbo, strongly inclined hinge line and a deeper sulcus separating the anterior wing from the main body of the shell.

Phelopteria atra (Coquand, 1862), which has a relatively similar outline and stratigraphic range differs from the present species in having a more elongated shell, more strongly inclined hinge, and a narrower and shallower umbonal cavity.

Freneix (1972) in the discussion of her new species *Phelopteria marocana*, mentioned that *Phelopteria caudigera* is restricted in Africa to the Senonian age.

Phelopteria gravida (Coquand, 1862)

Pl. 4, Figs. 1a-b, 2a-b

1862 *Avicula gravida* sp. nov. - Coquand, p. 216, pl. 13, figs. 17- 18.

1912 *Avicula gravida* Coquand - Pervinquière, p.109.

1917 *Avicula* cf. *gravida* Coquand - Fourtau, p. 16.

1934 *Avicula gravida* Coquand - Blanckenhorn, p. 178, pl. 7, fig. 2/a-b.

1962 *Pteria* (*Electroma*) *tihensis* sp. nov. - Abbass, p. 38, pl. 5, fig. 5.

?1972 *Phelopteria marocana* sp. nov. - Freneix, p. 73, pl. 3, fig. 3a-c, text.-fig. 4a-b.

2002 *Phelopteria tihensis* Abbass- Abdel Gawad & Gameil, p. 83, pl. 1, fig. 18.

2002 *Pteria tihensis* Abbass - Abdelhamid & El Qot, p. 262, pl. 1, figs. 7-8.

Material and occurrence. 43 specimens from the East Themed area; 8 specimens from the Galala Formation, bed no. 6, 35 from the Abu Qada Formation, beds no. 9, 11, 12. 2 specimens from Gebel Ekma; 1 specimen from Abu Qada Formation, bed no. 10, and 1 specimen from the Wata Formation, bed no. 16.

Measurements (in mm).

n=45	L	H	C	H/L	C/L	C/H
Range	46-77	45-82	22-38	0.95-1.09	0.48-0.60	0.46-0.61
Mean	61.2	61.3	30.1	1.0	0.52	0.51

Description. Shell medium- to large-sized, subquadrangular to nearly rounded, moderately inflated, extended obliquely in a postero-ventral direction. Inequilateral, inequivalved; the left valve is slightly more inflated than the right one. Hinge line straight and forms an acute angle (55°-70°) with the main body axis. With the anterior margin of the anterior ear it forms an acute angle below which there is a shallow byssal concavity. The posterior ear is larger and its posterior margin forms an obtuse angle with the hinge line. The umbones are broad, slightly prominent and situated anteriorly; the maximum inflation of the

shell is near the umbones. The ornamentation is represented by commarginal growth lines, which are separated by wider interspaces.

Age. Late Cenomanian-Middle Turonian.

Distribution in Egypt. Gebel Tih, G. Nezzazat, and G. El-Hamra.

Distribution outside Egypt. Algeria,Tunisia, Scicly, Calabrien, and the Middle East.

Discussion. Coquand (1862) erected *Avicula gravida* on specimens from the Mornasien (Lower Turonian) of Algeria. Fourtau (1917) recorded the species from the Upper Cenomanian of Gebel Tih, Sinai, Egypt. Abbass (1962) established *Pteria* (*Electroma*) *tihensis* based on specimens from the same prementioned locality (Gebel Tih). Abbass (1962) distinguished his new species from *gravida* by its subcircular outline and the hinge line is inclined to the main body axis. In the specimen that was measured by Coquand (1862) the length equals its height which is 65 mm, Abbass'specimen in contrast, higher than long (L = 52 mm; H = 54 mm). Pervinquière (1912) and Blanckenhorn (1934) in their description of *Ph. gravida* mentioned that the hinge line forms an angle with main body axis (the angle as measured by Blanckenhorn ranges from 50° to 60°). Therefore, it is clear that *Ph. tihensis* Abbass is a junior synonym of *Ph. gravida*.

Freneix (1972) established *Phelopteria marocana* from the Upper Albian of Morroco, based on a single incomplete left valve that is very similar to *Ph. gravida*. The text-fig. 4a of Freneix (1972) of *Phelopteria marocana* is not identical with the fotographed specimen (pl. 3, fig. 3a-c), which is very close to *Ph. gravida*. Consequently, *Phelopteria marocana* regarded as a questionable synonym of *Ph. gravida* and may ranges from the ?Upper Albian, Cenomanian to the Coniacian. *Ph. gravida* differs from *Ph. dalli* (Stephenson, 1936) by its large size, more rounded outline, and more anteriorly placed umbo.

Genus *Pseudoptera* Meek, 1837

Pseudoptera anomala (J. de C. Sowerby, 1836)

Pl. 4, Figs. 3a-c

1836 *Avicula anomala* sp. nov. - J. de C. Sowerby, p. 240, 342, pl. 17, fig. 18.

1846 *Avicula anomala* Sowerby - d'Orbigny, p. 478, pl. 392, figs. 1-3.

1905 *Pteria* (*Pseudoptera*) *anomala* (Sowerby) - Woods, p. 64, pl. 9, figs. 2-4.

1937 *Gervilleia anomala* Sowerby - Trevisan, p. 52, pl. 3, fig. 1.

?1952 *Pseudoptera serrata* sp. nov. - Stephenson, p. 71, pl. 13, fig. 6.

1957 *Pseudoptera anomala* (Sowerby) - Dartevelle & Frerneix, p. 65, pl. 8, fig. 8.

1959 *Pseudoptera anomala* (Sowerby) *orbignyi* subsp. nov. - Frerneix, p. 31.

1972 *Pseudoptera anomala* (Sowerby) - Frerneix, p. 76.

Material and occurrence. 1 incomplete specimen and 1 incomplete left valve from Gebel Yelleg, Galala Formation, bed no. 18.

Measurements (in mm).

N=2	L	H	C	H/L	C/L	C/H
Range	>22-32	16-26	12	0.63-0.72	0.52	0.75
Mean	27	22	12	0.68	0.52	0.75

Description. Shell medium-sized, thin, subtrigonal, moderately inflated, strongly inequivalved. Left valve with angular, scarcely protruding umbo. Anterior ear of moderate size, convex much heigher than long. Posterior ear large and united to the whole of the postero-dorsal margin of the valve. Ornamentation consisting of numerous radial ribs which are straight or slightly undulating, and extend over the larger part of the valve. Numerous, regular commarginal growth lines cross these radial ribs. On the two ears a similar ornamentation occurs, but the commarginal lines cut the ribs obliquely. At the intersection of the radial ribs and these commarginal lines small spines originate, which are very well developed on the anterior ear.

Age. Early Cenomanian.

Distribution outside Egypt. Europe and North Africa.

Discussion. The present material closely resembles *Avicula anomala* J. de C. Sowerby which recorded from the Cenomanian of Le Mans, France by d'Orbigny (1846). It is also close to *Pseudoptera serrata* Stephenson (1952) from the Cenomanian of Texas and to *Pteria* (*Pseudoptera*) *anomala* (J. de C. Sowerby) of Woods (1904) from the Upper Greensand of England. The present specimens appear to be distinct in having fewer, stronger, more prominent and more spiny radial ribs.

Woods (1904) had not seen the right valve; the right valve of the present specimen being similar ornamented to the left valve described by Woods. The same author considered *P. anomala* (Sowerby) which recorded by d'Orbigny (1846) distinct from Sowerby's species in having a larger apical angle; fewer, stronger, and more spiny ribs. Freneix (1959) regarded *P. anomala* of d'Orbigny as a subspecies of *anomala* Sowerby, *P. anomala orbignyi*.

Freneix (1972) established *Pseudoptera anomala tarfayensis* as a new subspecies differing in having a higher posterior carina, finer radial ribs and more prominent growth lines. She added that *P. anomala* is a very variable species with respect to shape, elevation of carina, and ornamentation.

Stephenson (1952) established four new species from the Cenomanian of Texas and mentioned that *P. serrata* Stephenson is closest to the genotype *P. anomala* and distinguished it from the other three species by the presence of serrated ribs. The present author regards *P. serrata* to be close to Sowerby's species and possibly a junior synonym of *P. anomala*.

P. anomala is widely distributed in the Upper Albian-Lower Cenomanian of Europe and Cenomanian of Africa.

***Pseudoptera themedensis* sp. nov.**

Pl. 4, Figs. 4a-b, 5a-b, 7

Holotype. BUFG2003II1; Pl. 4, Fig. 4a-b.

Paratypes. BUFG2003II2-3; Pl. 4, Figs. 5a-b, 7.

Locus typicus. East Themed area, east-central Sinai, Egypt.

Stratum typicum. Bed no. 11, *Choffaticeras sinaiticum – Thomasites rollandi* Zone, Lower Turonian.

Derivatio nominis. After the East Themed area, where the material has been collected.

Material and occurrence. 3 specimens from the East Themed area, Abu Qada Formation, bed no. 11.

Measurements (in mm).

N=3	L	H	C	H/L	C/L	C/H
Range	>18-22	8.5-14	21-38	0.48-0.53	1.1-1.33	2.5-2.7
Mean	23	24.75	11.9	0.51	1.2	2.6

Diagnosis. *Pseudoptera* with an anterior ear much higher than long. Posterior ear short and compressed. Anterior ear ornamented with numerous radial ribs; remaining shell smooth except for regular growth lines.

Description. Shell medium-sized, elongated, subtrigonalin outline, very oblique, inequivalved, moderately to strongly inflated, extended obliquely in a postero-ventral direction. Umbo of left valve pointed, acute and situated near the anterior end. Maximum inflation of the shell near the umbo. Anterior ear of moderate size, relatively sharp and much higher than long. Posterior ear small to moderate in size, short and compressed. The two valves and the posterior ear are ornamented only with numerous, regular commarginal growth lines. Ornamentation of the anterior ear consisting of numerous radial ribs which are straight or slightly undulating. These radials are crossed by numerous, growth lines, the latter cut the radial ribs obliquely.

Age. Early Turonian.

Discussion. The present species is similarly ornamented as *Pseudoptera hornensis* Stephenson (1952: p. 71, pl. 15, fig. 12-14.) from the Cenomanian of

Texas, but is distinguished in being more inflated, having a higher, sharp carina, and more prominent umbo.

Pseudoptera haldonensis Woods (p. 66, pl. 9, fig. 5-10) from the Upper Greensand of England differs from the present species in being smaller, and by having a very large, well developed posterior wing.

Pseudoptera anomala (J. de C. Sowerby) is distiguished from *P. themedensis* by its well developed, more extended posterior wing, lower anterior carina and in the presence of numerous radial ribs that cover the whole shell surface. In *P. themedensis*, in contrast, the radial ribs are restricted to the anterior wing or carina and completely absent in the remanent shell surface.

Family Malleidae Lamarck, 1818

Genus *Nayadina* Munier-Chalmas, 1864

Subgenus *Nayadina* Munier-Chalmas, 1864

***Nayadina (Nayadina) gaudryi* Thomas & Peron, 1891**

Pl. 4, Figs. 6, 9

1891 *Nayadina Gaudryi* sp. nov. - Thomas & Peron *in* Peron, p. 200, pl. 26, figs. 4-15.

1917 *Nayadina Gaudryi* Peron & Thomas - Fourtau, p. 58.

1918 *Naiadina Gaudryi* Thomas & Peron - Greco, p. 17, pl. 3 (19), figs. 5-10.

1962 *Naiadina gaudryi* Peron & Thomas - Abbass, p. 84, pl. 12, fig. 2.

1963 *Naiadina gaudryi* Thomas & Peron - Fawzi, p. 26, pl. 2, fig. 2.

2002 *Nayadina* (*Nayadina*) *gaudryi* Peron & Thomas - Abdelhamid & El Qot, p. 263, pl. 1, figs. 9-10.

Material and occurrence. 13 specimens from the East Themed area, Galala Formation, bed no. 6, and 6 specimens from the same formation of Gebel Yelleg, bed no. 29.

Measurements (in mm).

n=19	L	H	C	H/L	C/L	C/H
Range	18-64	28.5-77.5	14-37.2	1.14-1.72	0.49-0.62	0.21-0.52
Mean	29.6	40.6	16.1	1.38	0.59	0.41

Description. Shell medium- to large-sized, very variable in form and outline, subequivalved, inequilateral, usually elongated in the antero-ventral direction. Umbo terminal. Ligamental area triangular, will exposed to exterior with broad, deeply concave ligamental pit occupying most of its width. Imprint of addductor muscle scar rather small with projecting lower margin, semi-circular in outline and placed in relativelly ventral position to subcentral. Ornamentation consisting of growth laminae, which may be smooth or irregularly crenulated.

Age. Middle-Late Cenomanian.

Distribution in Egypt. Wadi Abu Qada, Gebel El-Minsherah, G. Dhalfa, and G. El-Hamra.

Distribution outside Egypt. Tunisia.

Order Limoida (Rafinesque, 1815) Waller, 1978

Superfamily Limacea Rafinesque, 1815

Family Limidae Rafinesque, 1815

Genus *Limatula* Wood, 1839

Limatula cf. *subaequilateralis* (d'Orbigny, 1847)

Pl. 4, Fig. 8a-b

cf. 1847 *Lima subaequilateralis* sp. nov. - d'Orbigny, p. 558, pl. 423, figs. 1-5.

cf. 1871 *Radula* (*Limatula*) *subaequilateralis* d'Orbigny - Stoliczka, p. 415.

cf. 1904 *Lima* (*Limatula*) *subaequilateralis* d'Orbigny - Woods, p. 49, pl. 7, figs. 16-17.

Material and occurrence. 1 right valve from the East Themed area, Abu Qada Formation, bed no. 10.

Measurements (in mm).

N=1	L	H	C	nr	H/L	C/L	C/H
	14	18.5	6	16	1.32	0.43	0.32

Description. Shell small-sized, oval in outline, subequilateral. Anterior ear not well preserved, the posterior one of moderate size and apparently smooth. Ornamentation consisting of 16 moderately strong radial ribs, separated by very broad, wide and shallow interspaces. The latter are occupied by eight very fine radial riblets, which are well observable only anteriorly. The ribs are most conspicuous towards the center of the valve and seem to be wider anteriorly. The radial ribs are crossed by very fine commarginal threads, which are well seen on the posterior ear.

Age. Early Turonian.

Distribution outside Egypt. France, England, and Southern India.

Discussion. The specimen resembles in outline and ornamentation *Lima subaequilateralis* d'Orbigny, 1847 from the Cenomanian of Le Mans, France. It also closely resembles *Lima* (*Limatula*) *subaequilateralis* d'Orbigny as figured by Woods (1904). But It seems to differ in having secondary radial riblets between the primary ribs.

The present specimen also somewhat resembles to *Lima* (*Limatula*) sp. in Woods (1904: p. 52, pl. 7, fig. 23) in having the same ribbing pattern, but its ribs are more closely packed around the median line, whereas in Woods' specimen the ribs anteriorly of the median line are closer together and distinctly stronger than the others. In addation, Woods' specimen has a longer hinge line.

Genus *Plagiostoma* J. Sowerby, 1814

Plagiostoma subsimplex (Thomas & Peron, 1891)

Pl. 5, Figs. 1-2

1891 *Lima subsimplex* sp. nov. - Thomas & Peron *in* Peron, p. 219, pl. 27, figs.

7-10.

1912 *Lima* (*Plagiostoma*) *subsimplex* Thomas & Peron - Pervinquière, p. 148.

Material and occurrence. 2 incomplete specimens from the East Themed area, Themed Formation, bed no. 35.

Measurements (in mm).

N=2	L	H	C	H/L	C/L	C/H
Range	>38->42	46-48	16-19.6	1.13-1.14	0.52	0.46
Mean	+40	47	17.8	1.14	0.52	0.46

Age. Coniacian -Santonian.

Remarks. The present material is closely similar to *Lima subsimplex* Thomas & Peron with respect to shape and ornamentation. The species was originally described from the Turonian and Santonian of Tunisia, of the two specimens one of them exhibits the same ornamentation as that from the Santonian of Tunisia figured by Peron (1891: pl. 27, fig. 7) which carries spinose radial ribs on the anterior and posterior sides, while the main part of the shell is covered only by commarginal growth lines except near the umbo where radial ribs are present. The second specimen seems to be similar to those described by Thomas & Peron from the Turonian (Peron, 1891: pl. 27, figs. 8-10) where the whole surface is covered by radial ribs, which seem to be more spinose on the anterior and posterior parts.

Pervinquière (1912) pointed out that in Tunisia the species is common from the Lower Turonian to the Lower Senonian (Coniacian). It is recorded herein from Egypt for the first time.

Plagiostoma cf. *tihensis* (Abbass, 1962)

Pl. 5, Fig. 3a-b

cf. 1962 *Lima* (*Plagiostoma*) *tihensis* sp. nov. - Abbass, p. 47, pl. 8, figs. 1-2, 4-5.

Material and occurrence. 1 specimen from Gebel Yelleg, Galala Formation, bed no. 18.

Measurements (in mm).

n=1	L	H	C	H/L	C/L	C/H
	72	63	23.6	0.88	0.33	0.37

Remarks and Description. The specimen large-sized, suboval in outline, compressed, elongated in an antero-ventral direction, inequilateral, length exceeding height. Umbo subterminal and pointed. Antero-dorsal margin concave, remaining margins convex and continuous with the convex ventral margin. The present specimen is an internal mould and bears no elements of ornamentation. It closely resembles *Lima* (*Plagiostoma*) *tihensis* Abbass (1962) in size and outline. According to Abbass (1962) the species is ornamented with numerous, fine radial threads, which become stronger on the anterior part of the shell. These radials are crossed by finer commarginal growth lines.

Age. Early Cenomanian.

Distribution in Egypt. Gebel Tih.

Genus *Pseudolimea* Arkell, 1932

Pseudolimea itieriana (Pictet & Roux, 1852)

Pl. 5, Figs. 4-6

1852 *Lima Itieriana* sp. nov. - Pictet & Roux, p. 484, pl. 40, fig. 5a-f.

1890 *Lima Numidica* Thomas & Peron *in* Peron, p. 217, pl. 27, fig. 2.

1912 *Lima Itieriana* Pictet & Roux - Pervinquière, p. 146, pl. 9, figs. 8-9.

1937 *Lima Itieriana* Pictet & Roux - Trevisan, p. 59, pl. 2, fig. 14a-b.

1962 *Lima* (*Radula*) *cenomanensis* sp. nov. - Abbass, p. 48, pl. 8, fig. 6-7.

?1963 *Lima* aff. *numidica* Thomas & Peron - Fawzi, p. 31.

Material and occurrence. 10 specimens from Gebel Ekma; 3 from the Raha Formation, bed no. 9; 4 from the Abu Qada Formation, bed no. 10 and 3

specimens from the Wata Formation, bed no. 16. 16 specimens from the East Themed area, Abu Qada Formation, beds no. 9, 10, and 11.

Measurements (in mm).

N=23	L	H	C	nr	H/L	C/L	C/H
Range	8-20.5	9-22.5	7-11.5	32-42	1.07-1.21	0.53-0.74	0.49-0.67
Mean	14.29	15.89	9.03	36	1.12	0.66	0.60

Description. Shell small-sized, subquadrangular or somewhat oval in outline, moderately convex, equivalved, inequilateral, slightly higher than long, faintly convex anteriorly. Beaks pointed and situated close to the middle of the long cardinal area. Antero-dorsal margin long and nearly straight. Postero-dorsal margin relatively short and nearly straight. Ears of small to moderate size. Ornamentation consisting of strong radial ribs, separated by deep interspaces of nearly equal in their width to the ribs themselves. Each rib consists of three radial riblets, of which the median one is strongest and highest. The radial ribs decrase in the strength on both ears.The radial ribs are crossed by numerous, fine commarginal threads. The shell margin is crenulated.

Age. Late Cenomanian-Middle Turonian.

Distribution in Egypt. El-Hadhira and ?Gebel Shabrawit.

Distribution outside Egypt. Algeria, Tunisia, and Scicly.

Discussion. The present author agrees with Pervinquière (1912) and Trevisan (1937) and considers *Lima numidica* Thomas & Peron, 1890 from the Cenomanian of Algeria and Tunisia as a junior synonym.

Lima (*Radula*) *cenomanensis* Abbass, 1962 closely resembles of the present species in its outline and ornamentation and consequently is also regarded as a junior synonym.

Order Ostreoida Férussac, 1822 (=Ostreina Waller, 1978)

Superfamily Ostreacea Rafinesque, 1815

Family Gryphaeidae Vyalov, 1936

Subfamily Pycnodonteinae Stenzel, 1959

Genus *Pycnodonte* Fischer de Waldheim, 1835

Subgenus *Costeina* Vyalov, 1965

***Pycnodonte (Costeina) costei* (Coquand, 1869)**

Pl. 5, Figs. 7-8

1869 *Ostrea costei* sp. nov. - Coquand, p. 108, pl. 26, figs. 3-5; pl. 38, figs. 13-14.

1903 *Ostrea costei* Coquand - Dacqué, p. 368, pl. 34, figs. 9-10.

1904 *Ostrea costei* Coquand - Fourtau, p. 293, pl. 2, figs. 4-6; pl. 3, fig. 1.

1917 *Ostrea costei* Coquand - Fourtau, p. 32.

1962 *Ostrea* (*Crassostrea*) *costei* (Coquand) - Abbass, p.78, pl.10, fig. 9.

1986 *Pycnodonte* (*Costeina*) *costei* (Coquand) - Freneix & Viaud, p. 34, pl. 2, figs. 15.

1990 *Pycnodonte* (*Costeina*) *costei* (Coquand) - Malchus, p. 149, pl. 3, figs. 4, 6-7; pl. 4, figs. 1-3.

1992 *Pycnodonte* (*Costeina*) *costei* (Coquand) - Abdel-Gawad & Zalat, pl. 5, fig. 5.

2002 *Pychnodonte* (*Costeina*) *costei* (Coquand) - Abdelhamid & El Qot, p. 267, pl. 2, fig. 6.

Material and occurrence. 3 specimens from Gebel Ekma, the Matulla Formation, bed no. 17; 43 specimens from the East Themed area, Themed Formation, bed no. 37, and 48 specimens from Gebel Yelleg, Themed Formation, bed no. 58.

Measurements (in mm).

N=85	L	H	C	H/L	C/L	C/H
Range	25-153	30.5-128	10.3-63	0.73-1.30	0.10-0.46	0.10-0.48
Mean	86.5	88.4	33.5	1.0	0.28	0.27

Description. Shell medium- to large-sized, thick, variable in outline but mostly subrounded. Left valve slightly to strongly convex. Right valve flat to slightly convex, or concave. Umbo small, projecting, but not prominent. Attachment area ranging from very small to large. Posterior lobe marked by a wide and deep furrow, which descends from the umbo. Ligamental area relatively large and mostly longer than high. Adductor muscle scar subrounded to rounded in a posterior to subcentral position. Ornamentation consisting of imbricating commarginal laminae, which are widely spaced. These laminae are occasionally crossed by radial ribs.

Age. Coniacian-Santonian.

Distribution in Egypt. Abu Roash, Wadi Askhar, W. Sudr, Gebel Um Heriba, G. El-Minsherah, and G. El-Hamra.

Distribution outside Egypt. Algeria, Tunisia, France, Israel, and Tadjikistan.

Discussion. Fourtau (1917) mentioned a great similarity between *Ostrea costei* Coquand from the Upper Cretaceous and *Ostrea gigantica* Solander from the Upper Eocene.

Subgenus *Phygraea* Vyalov, 1936

Pycnodonte (Phygraea) vesicularis vesicularis (Lamarck, 1806)

Pl. 5, Fig. 9a-b; Text-Fig. 29A

1806 *Ostrea vesicularis* sp. nov. - Lamarck, p. 160.

1871 *Gryphea vesicularis* (Lamarck) - Stoliczka, p. 465, pl. 42, figs. 2-4; pl. 43, fig. 1; pl. 45, figs. 7-12.

1912 *Pycnodonta vesicularis* Lamarck - Pervinquière, p. 195.

1913 *Ostrea vesicularis* Lamarck - Woods, p. 360, pl. 55, figs. 4-9; text-figs.

143-182.

1917 *Ostrea vesicularis* Lamarck - Fourtau, p. 55.

1918 *Pycnodonta vesicularis* Lamarck - Greco, p. 110 (130), pl. 13 (12), figs. 1-5.

1962 *Pycnodonte vesicularis* (Lamarck) - Abbass, p. 71, pl. 10, figs. 1-2.

1972 *Pycnodonte* (*Pycnodonte*) *vesicularis vesicularis* (Lamarck) - Freneix, p. 105, pl. 10, figs. 5-7.

1986 *Pycnodonte* (*Phygraea*) *vesiculare* (Lamarck) - Abdel-Gawad, p 162, pl. 38, fig. 5; pl. 39, figs. 5-7.

1986 *Pycnodonte* (*Phygraea*) *vesicularis vesicularis* (Lamarck) - Freneix & Viaud, p. 33, pl. 2, figs. 11-14.

1987b *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) – Kora & Hamama, pl. 1, figs. 9-10.

1990 *Pycnodonte* (*Phygraea*) *vesiculare* (Lamarck) - Malchus, p. 146, pl. 2, figs. 8-10; pl. 3, figs. 1-3, 5.

1992 *Pycnodonte* (*Phygraea*) *vesiculare* (Lamarck) - Abdel-Gawad & Zalat, pl. 5, fig. 9.

1993 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) - Dhondt, p. 242.

1993 *Pycnodonte* (*Phygraea*) *vesiculare* (Lamarck) - Aqrabawi, P. 80, pl. 5, fig. 3; p. 107, text-fig. 53.

1995 *Pycnodonte* (*Pycnodonte*) *vesicularis* (Lamarck) - Strougo, p. 10, fig. 3/9-10.

1995 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) - Kassab & Zakhera, p. 330, pl. 2, figs. 4-5.

1996 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) - El-Mahallawy, p. 94, pl. 2, fig. 9; pl. 3, figs. 1-3, 5.

1997 *Pycnodonte* (*Pycnodonte*) *vesicularis* (Lamarck) - Asan, p. 89, pl. 6, figs. 1-3.

2002 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) - Abdelhamid & El Qot, p.

267, pl. 2, fig. 5.

2002 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) – Kora *et al.*, pl. 3, figs. 4-5.

Material and occurrence. 72 specimens from Gebel Ekma, Sudr Chalk and 4 specimens from the same formation of Gebel Yelleg.

Measurements (in mm).

n=76	L	H	C	H/L	C/L	C/H
Range	23-71	30-92	16-44	1.0-1.42	0.44-0.89	0.39-0.68
Mean	43.4	58.6	28.7	1.26	0.62	0.54

Description. Shell varying in outline from high-oval, pear-shaped, to nearly rounded, commonly higher than long; variable in size from small to large, inequivalved. Left valve strongly convex. Right valve almost entirely concave, in some specimens nearly flat. Form and direction of the umbo generally depending on the mode of attachement but mostly prominent and strongly incurved. Attachement area varying in size from large to completely absent. Posterior lobe consisting of a small triangular area marked by a wide radial groove extending from below the umbo to the postero-ventral margin. Adductor impression rounded or slightly oval and in a posterior to subcentral position. Shell essentially smooth except for commarginal growth laminae, which are irregularly spaced.

Age. Campanian-Maastrichtian.

Distribution in Egypt. El-Bahariya Oasis, El-Farafra Oasis, Dakhla Oasis, Gebel Mellah, Wadi Um Damarana, Abu Shaar, W. Dib, Abu Roash, G. Hammam Faraun, G. Um Heriba, Ain Amur, G. El -Minsherah, and G. El-Hamra.

Distribution outside Egypt. This species has a wide geographic distribution and has been reported from Europe, Africa, Asia, and South and North America.

Discussion. Nomenclaturally the genus *Pycnodonte* have been treated in the literature alternatively as feminine and neuter nouns as shown in the list of

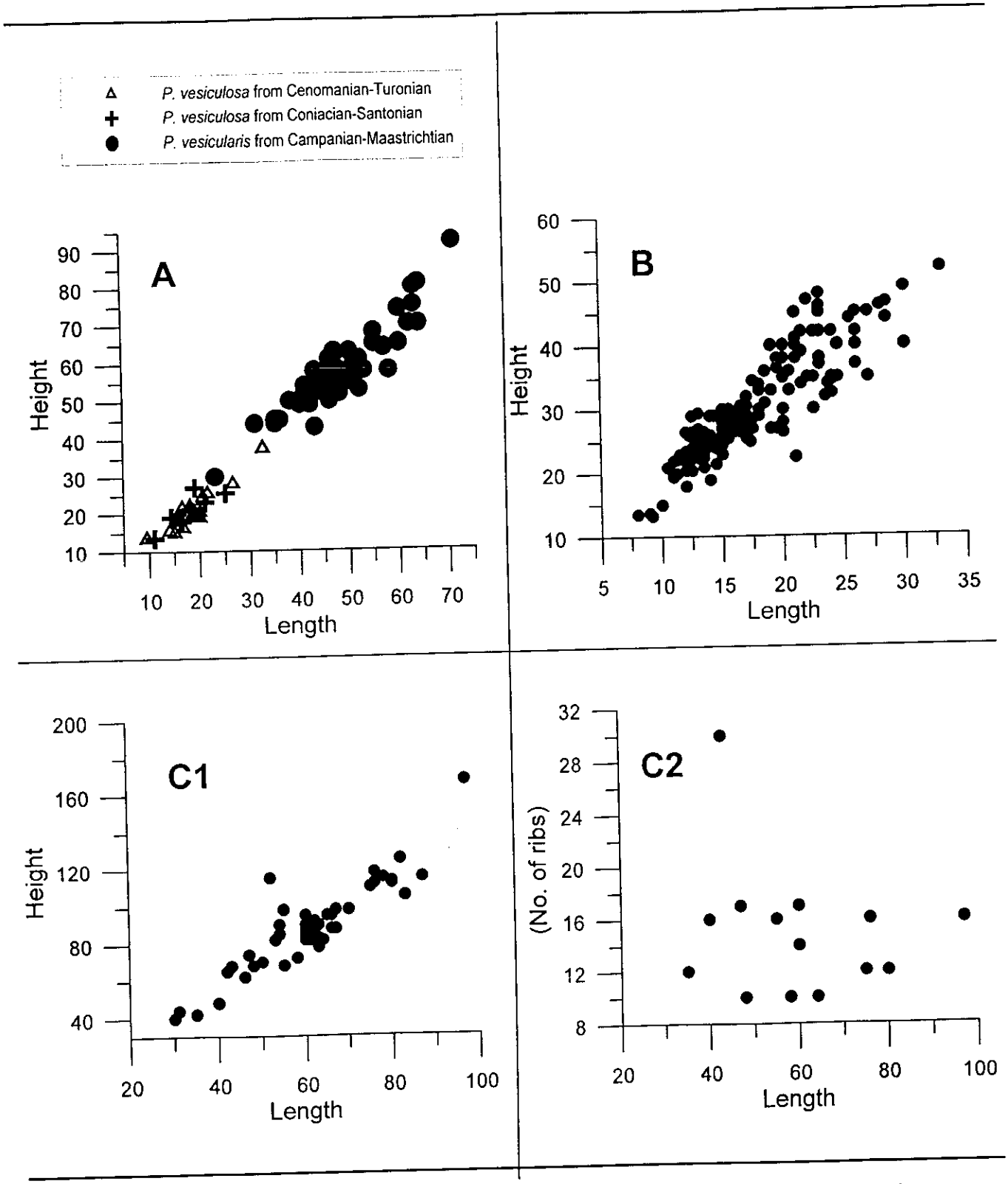


Figure 29. Biometric data on *Pycnodonte (Phygraea) vesicularis vesicularis and Pycnodonte (Phygraea) vesicularis vesculosa* (A), and *Ilymatogyra africana* (B), and *Costagyra olisiponensis* (C).

synonymies. Dhondt (1993) stated that, grammatically, *-odonte* stands for the Greek *odontos*, genitive of *odous* (tooth). As *odous* is a feminine word, therefore, the correct form is *Pycnodonte* (*Phygraea*) *vesicularis*.

Malchus (1990) distinguished six forms of *P. vesicularis* based on shape and stratigraphic position, i. e. F. *nikitini* (Coniacian to Santonian), 'form typica' (Santonian to Maastrichtian), F. *hippopodium* and F. *proboscideum* (only from the Santonian). He introduced F. *communis* and F. *humilis* as two new forms and stated that F. *humilis* rarely occurs together with F. *communis* from the Coniacian to the Upper Campanian, but is more abundant in the Maastrichtian. Malchus (1990) mentioned that the latter two forms only occur in Egypt, while the four previous forms occur only outside Egypt.

Dhondt (1993) mentioned that *P. vesicularis* is a very widely distributed species, and that its cemented mode of life, resulted in a wide variety of shapes, often in the same environment. According to her *P. hippopodium* (Nilsson), *P. clavatum* (Nilsson), *P. proboscideum* (d'Archiac), and the six new species introduced by Sobetski (1982), i. e. *P. frejdlini*, *P. transcaspicum*, *P. intermedium*, *P. adhaesum*, *P. consimile*, and *P. singulare* are junior synonyms of *P. vesicularis* (Lamarck).

Abbass (1962) mentioned that this species ranges from the Coniacian to the Maastrichtian, and added that specimens from the various horizons showing no differences except in size, whereby the mean size of the adults increases gradually as we ascend in the succession.

Pycnodonte hypoptera (Wanner) which characterize the Danian of the southern part of the Western Desert can be differentiated from *P. vesicularis* by its larger size, its narrow and more pointed umbo (Abed 1970).

Freneix (1972) stated that the present species has a wide geographic and stratigraphic range (Coniacian-Danian). Strougo (1995) and Asan (1997) confirmed the occurrence of the species in the Paleocene of Egypt.

***Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck, 1806)**

***vesiculosa* (J. Sowerby, 1813)**

Pl. 5, Figs. 10a-b, 11a-b; Text-Fig. 29A

1813 *Gryphea vesiculosa* sp. nov. - J. Sowerby, p. 93, pl. 369.

1871 *Gryphea vesiculosa* Sowerby - Stoliczka, p. 466, pl. 39, figs. 1-2.

1890 *Ostrea vesiculosa* Sowerby - Peron, p. 126.

1904 *Ostrea Vesiculosa* Sowerby - Fourtau, p. 290.

1912 *Pycnodonta vesiculosa* Sowerby - Pervinquière, p. 195.

1913 *Ostrea vesiculosa* (Sowerby) - Woods, p. 374, pl. 55, figs. 10-14; pl. 56, fig. 1.

1917 *Ostrea vesicularis* Lamarck race *vesiculosa* Sowerby - Fourtau, p. 56.

1918 *Pycnodonta vesicularis* Lamarck var. *vesiculosa* Sowerby - Greco, p. 13 (195), pl. 2 (18), fig. 12.

1937 *Pycnodonta vesicularis* Lamarck mut. *vesiculosa* Sowerby - Trevisan, p. 79, pl. 2, figs. 15-16.

1963 *Pycnodonta vesiculosa* Sowerby - Fawzi, p. 49, pl. 5, figs. 1-2.

1972 *Pycnodonte* (*Pycnodonte*) *vesicularis* (Lamarck) *vesiculosa* (Sowerby) - Freneix, p. 102, pl. 10, figs. 1-3; text-figs. 11-12.

1972 *Pycnodonte* (*Pycnodonte*) *vesicularis* (Lamarck) *subvesiculosa* Renngarten - Freneix, p. 105, pl. 10, fig. 4; text-figs. 11-12.

1984 *Pycnodonte vesiculosa* (Sowerby) - Dhondt, p. 859.

1986 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) *pseudovesiculosa* (Couffon) - Freneix & Viaud, p. 30, pl. 1, figs. 3-6.

1986 *Pycnodonte* (*Phygraea*) *vesiculosa* (Sowerby) - Freneix & Viaud, pl. 1, fig. 7.

1986 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) *parvula* subsp. nov - Freneix & Viaud, p. 31, pl. 2, figs. 1-7.

1986 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) forme *hippopodium* (Nilsson) - Freneix & Viaud, p. 32, pl. 2, figs. 10.

1990 *Pycnodonte* (*Phygraea*) *vesiculosum* (Sowerby) - Malchus, p. 145, pl. 2, figs. 8-10; pl. 3, figs. 1-3, 5.

1993 *Pycnodonte* (*Phygraea*) *vesiculosum* (Sowerby) - Aqrabawi, p. 79, pl. 5, figs. 15-16.

1995 *Pycnodonte* (*Phygraea*) *vesiculosum* (Sowerby) - Abdel-Gawad, p. 170, pl. 3, fig. 1.

1996 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) *pseudovesiculosa* Couffon - El-Mahallawy, p. 99, pl. 4, figs. 6-7.

1996 *Pycnodonte* (*Phygraea*) *vesicularis* (Lamarck) *parvula* Freneix & Viaud - El-Mahallawy, p. 101, pl. 4, figs. 4-5.

1999 *Pycnodonte* (*Phygraea*) *vesiculosa* (Sowerby) - Seeling & Bengtson, p. 761, fig. 11a-c.

Material and occurrence. 40 specimens from the East Themed area, Galala Formation, beds no. 9, 11, and 13; 8 specimens from the Themed Formation, bed no. 34; and 23 specimens from Gebel Ekma, Matulla Formation, shaly member, bed no. 25.

Measurements (in mm).

N=71	L	H	C	H/L	C/L	C/H
Range	9.5-32.5	13.5-37.5	6-18	0.95-1.43	0.44-0.79	0.39-0.61
Mean	18.47	21.25	10.67	1.14	0.58	0.51

Description. Shell small- to medium-sized, oval to subrounded, some specimens longer than high, but most higher than long, but mostly higher than long. Left valve moderately to to strongly convex, usually with clear posterior sulcus of variable strength. Posterior part often convex and separated from the remainder of the valve by the aforementioned sulcus. Right valve flat or concave. Umbo affected by the mode of attachement but commonly sharp, prominent, more or less incurved. Attachement area variable in size from large to absent. Adductor muscle scar oval to rounded. Left valve covered with

commarginal growth laminae which are irregularly spaced. In some right valves these growth laminae are crossed by radial striations.

Age. Cenomanian- Santonian.

Distribution in Egypt. Sinai, Gebel Shabrawit, and North Galala-Plateau.

Distribution outside Egypt. Europe, Africa, Middle East, India, and Brazil.

Discussion. There is much confusion among authors who studied *Pycnodonte* (*Phygraea*) *vesicularis* and *Pycnodonte* (*Phygraea*) *vesiculosa*. Some of them regarded *P. vesicularis* (Lamarck) and *P. vesiculosa* (Sowerby) as two separate species (Stoliczka 1871, Woods 1913, Dhondt 1984, Freneix & Viaud 1986, Malchus 1990, Aqrabawi 1993, Dhondt *et al.* 1999, and Seeling & Bengtson, 1999). *P. vesicularis* being characterised by its thick, large shell, whereas *P. vesiculosa* is distinguished by a less incurved, more pointed umbo, small attchement area and a greater height-length ratio. With respect to their stratigraphic position, *P. vesiculosa* ranges from (? Aptian) Albian to Cenomanian, but occurs mainly in the Cenomanian, and *P. vesicularis* ranges from the (?Albian) Cenomanian to the Maastrichtian but has the peak of its distribution in the Senonian. Fourtau (1917) considered *P. vesiculosa* as a ''race'' of *P. vesicularis*. Greco (1918) considered *P. vesiculosa* as variety of *P. vesicularis*. Trevisan (1937) regarded *P. vesiculosa* as a ''mutation'' of *P. vesicularis*. Couffon (1936) erected the new subspecies *P. vesicularis pseudovesiculosa*. Renngarten (1964) erected *P. subvesiculosa* to accommodate small *P. vesicularis* specimens from the Caucasus. Freneix (1972) differentiated *P. vesicularis* into three subspecies, i. e. *P. vesicularis vesiculosa* from the Cenomanian, *P. vesicularis subvesiculosa* from the Coniacian, and *P. vesicularis vesicularis* from the Campanian. Freneix & Viaud (1986) differentiated *P. vesicularis* into; *P. vesicularis pseudovesiculosa*, *P. vesicularis parvula*, *P. vesicularis* forme *hippopodium*, and *P. vesicularis vesicularis*, whereas they introduced *P. vesicularis parvula* as a new subspecies to describe specimens with maximum height 30 mm from the Upper Cenomanian and

Lower Turonian of France. Abdel-Gawad (1995) realized that *P. vesiculosum* from the Upper Cenomanian of Gebel Al Akhdar in Libya is similar to small-sized *P. vesiculare* which characterizes the Coniacian marls of North Africa and Sinai. According to him *P. vesiculare* has a thicker shell and radial ornamentation on its right valve. Abdel- Gawad (1995) regarded *P. vesiculosum* as a local index fossil for the uppermost Cenomanian of Egypt. El-Mahallawy (1996) divided *P. vesicularis* into six subspecies; *P. vesicularis vesicularis*, *P. vesicularis hippopodium* (Nilsson, 1827), *P. vesicularis nikitini* (Arkhanguelsky, 1905), *P. vesicularis pseudovesiculosa* (Couffon, 1936), *P. vesicularis parvula* Freneix & Viaud, 1986, and *P. vesicularis proboscideum* (d'Archiac, 1837), whereby *pseudovesiculosa* and *parvula* occur in the Cenomanian, *nikitini* in the Coniacian-Santonian, and the remining three subspecies in the Campanian.

In the present study different forms of the species were recorded from the same bed in the Upper Cenomanian of the East Themed area, some of them being longer than high, others higher than long, the attachment area varying from large to completely absent. In addition some right valves from the aforementioned bed show radial striations (Pl. 5, Fig. 11b). The same forms were recorded from the Lower Turonian (beds no. 11 and 13) and Lower Coniacian of the same locality. Moreover, identical specimens (Figure 29A) were recorded from the Santonian of Gebel Ekma. Consequently, the present author favours the division of *P. vesicularis* in two subspecies, *P. vesicularis vesiculosa* and *P. vesicularis vesicularis*. *P. vesicularis vesiculosa* is characterized by relatively thin and small-sized shells and ranges in age from the Cenomanian to the Santonian. *P. vesicularis vesicularis* in turn is characterized by thick and large shells and is Campanian-Danian in age.

Subfamily Exogyrinae Vyalov, 1936

Tribe Exogyrini Vyalov, 1936

Genus *Costagyra* Vyalov, 1936

***Costagyra olisiponensis* (Sharpe, 1850)**

Pl. 6, Figs. 1, 2a-b, 3-4; Text-Figs. 14, 29C

1850 *Exogyra Olisiponensis* sp. nov. - Sharpe, p. 185, pl. 19, figs. 1-2.

1862 *Ostrea Overwegi* sp. nov. - Coquand, p. 226, pl. 19, figs. 1-6 (non v. Buch).

1869 *Ostrea Olisiponensis* Sharpe - Coquand, p. 125, pl. 45, figs. 1-7.

1869 *Ostrea Overwegi* Coquand, p. 140, pl. 44, figs. 1-9; pl. 46, figs. 14-15.

1904 *Ostrea Olisiponensis* (Sharpe) - Fourtau, p. 283, figs. 3-5.

1912 *Exogyra Olisiponensis* Sharpe - Pervinquière, p. 174, pl. 13, figs. 4-5, 9.

1918 *Exogyra Olisiponensis* Sharpe - Greco, 5 (187), pl. 1 (17), figs. 12-14.

1937 *Exogyra olisiponensis* Sharpe - Trevisan, p. 67, pl. 4, figs. 2-6.

1962 *Exogyra olisiponensis* Sharpe - Abbass, p. 69, pl. 9, fig. 10.

1963 *Exogyra olisiponensis* Sharpe - Fawzi, p. 45, pl. 4, figs. 6-7.

1971 *Exogyra olisiponensis* Sharpe - Collignon, p. 174 (32), pl. F, fig. 5.

1972 *Exogyra olisiponensis* Sharpe - Freneix, p. 89, pl. 5, fig. 6a-c.

1981 *Exogyra* (*Costagyra*) *olisiponensis* (Sharpe) - Amard *et al.*, p. 83, pl. 3, figs. 1-2; pl. 4, figs. 1-2.

1981 *Freneixostrea* aff. *digitata* (Sowerby) - Amard *et al.*, p. 85, pl. 4, figs. 3-7.

1987a *Exogyra* (*Costagyra*) *olisiponensis* Sharpe – Kora & Hamama, pl. 1, figs. 1-2.

1990 *Exogyra* (*Costagyra*) *olisiponensis* Sharpe - Malchus, p. 134, pl. 10, figs. 1-6 (with full synonymy).

1993 *Exogyra* (*Costagyra*) *olisiponensis* Sharpe - Aqrabawi, p. 67, pl. 4, figs. 3-5; pl. 5, figs. 1-2.

1993 *Exogyra* (*Costagyra*) *olisiponensis* Sharpe – Kora *et al.*, pl. 2, fig. 9.

1995 *Exogyra* (*Costagyra*) *olisiponensis* Sharpe - Abdel-Gawad, p. 168, fig. 3/

2-6.

1996 *Costagyra olisiponensis* (Sharpe) - El- Mahallawy, p. 106, pl. 6, figs. 1-5.

1999 *Costagyra olisiponensis* (Sharpe) - Dhondt *et al.*, pl. 1, figs. 6-7.

1999 *Exogyra* (*Costagyra*) *olisiponensis* Sharpe - Seeling & Bengtson, p. 756, fig. 9a-c.

2001b *Exogyra* (*Costagyra*) *olisiponensis* Sharpe – Kora *et al.*, pl. 1, fig. 4.

2001 *Costagyra olisiponensis* (Sharpe) – Abdallah *et al.*, pl. 2, fig. 7.

2002 *Exogyra* (*Costagyra*) *olisiponensis* (Sharpe) – Abdel Gawad & Gameil, p. 85, pl. 2, figs. 5-7.

2002 *Exogyra* (*Costagyra*) *olisiponensis* (Sharpe) – Abdelhamid & El Qot, p. 268, pl. 3, fig. 1.

Material and occurrence. 39 specimens from Gebel Ekma, the Raha Formation, beds no. 4, 5, 6, 8, and 9; 19 specimens from the East Themed area, Galala Formation, bed no. 8; and 54 specimens from Gebel Yelleg, beds no. 31, and 37.

Measurements (in mm).

n=112	L	H	C	H/L	C/L	C/H
Range	30-97	40-167	17-67	1.2-1.72	0.55-0.98	0.39-0.73
Mean	64.3	98.5	41.7	1.38	0.74	0.58

Description. Shell medium- to large-sized, very thick, varying in outline from high-oval or pear-shaped to subrounded, mostly higher than long, inequivalved, inequilateral. Left valve strongly convex. Right valve flat, slightly convex or more rarely concave. Umbo strongly curved. Attachment area variable in size from absent or very small to very large. Ligamental area relatively small and high. Relict chomata concentrated on the margins of the right valve. Adductor muscle scar relatively large, oval, with a slight dorsal indeutation and situated postero-dorsally. Left valve ornamented with a few strong radial ribs, usually spinous; these radials are crossed by scaly growth lamellae. Right valve ornamented with strong scaly growth lamellae, partly crossed by fine radial ribs.

Age. Late Cenomanian.

Distribution in Egypt. Wadi Hawashiya, West Gharamul, W. Araba, El-Baharyia Oasis, Gebel Um Rayig, G. Tih, W. Abu Qada, G. Qabaliat, W. Budrah, W. Thaggadi, G. El-Minsherah, G. Nezzazat, G. Yelleg, G. El-Hamra, and El Giddi Pass.

Distribution outside Egypt. Southern Europe, the Middle East, North Africa, Nigeria, Angola, Peru, and Brazil.

Discussion. The variability in the general shell shape, thickness, the size of attachment area, ribbing, spines and scaliness of the growth lamellae in *Costagyra olisiponensis* (Sharpe) led some authors (e.g. Trevisan 1937) to differentiate this species into different varieties (var. *oxyntas* Coquand, var. *ecostata* Seguanza) apart from the forma typica. Others erected new species (see the synonymy list of Malchus 1990) yet others misidentified the species as another species (e.g. *Ostrea overwegi* Coquand, 1862 non v. Buch; *Ostrea oxyntas* Coquand, 1880). Moreover, Amard *et al.* (1981) erected the new genus *Freneixostrea* based on some right valves of *Costagyra olisiponensis* Sharpe. However, these variabilities are related to paleoecological factors (Malchus 1990, Aqrabawi 1993).

The species is geographically widely distributed and its stratigraphic range is from the Albian to the Coniacian, but it is very abundant in the Cenomanian (Freneix 1972).

Genus *Ceratostreon* Bayle, 1878

Ceratostreon flabellatum (Goldfuss, 1833)

Pl. 6, Figs. 5-6, 7a-b, 8a-b; Text-Figs. 13A, 30A

1833 *Exogyra flabellata* sp. nov. - Goldfuss, p. 38 pl. 87, fig. 6.

1917 *Ostrea flabellata* Goldfuss - Fourtau, p. 37.

1918 *Exogyra flabellata* Goldfuss - Greco, p. 11 (193), pl. 2 (18), figs. 9-11.

1937 *Exogyra flabellata* Goldfuss - Trevisan, p. 77, pl. 5, figs. 11-12.

1955 *Exogyra complicata* sp. nov. - Mahmoud, p. 111, pl. 7, figs. 1-10; pl. 8, figs. 1-12; text-figs. 52-54.

1962 *Exogyra flabellata* Goldfuss - Abbass, p. 66, pl. 9, figs. 4-6.

1963 *Exogyra flabellata* Goldfuss - Fawzi, p. 43, pl. 4, figs. 10-12.

1972 *Ceratostreon flabellatum* (Goldfuss) - Freneix, p. 91, pl. 5, figs. 8-9.

1981 *Ceratostreon flabellatum* (Goldfuss) - Amard *et al.*, p. 84, pl. 3, figs. 4-7.

1981 *Ceratostreon flabellatum* (Goldfuss) - Collignon, p. 269, pl. 8, fig. 14.

1990 *Amphidonte* (*Ceratostreon*) *flabellatum* (Goldfuss) - Malchus, p. 111, pl. 14, figs. 4-11; pl. 5, figs. 1-7.

1992 *Ceratostreon flabellatum* (Goldfuss) - Abdel-Gawad & Zalat, pl. 2, figs. 9-11.

1993 *Amphidonte* (*Ceratostreon*) *flabellatum* (Goldfuss) - Aqrabawi, p. 63, pl. 2, figs. 2-5.

1993 *Ceratostreon flabellatum* (Goldfuss) – Kora *et al.* Pl. 2, figs. 6-7.

1996 *Ceratostreon flabellatum* (Goldfuss) - El-Mahallawy, p. 111, pl. 7, figs. 5-14; pl. 8, figs. 1-12.

1999 *Amphidonte* (*Ceratostreon*) *flabellatum* (Goldfuss) - Seeling & Bengtson, p. 755, fig. 8a-d.

2001b *Amphidonte* (*Ceratostreon*) *flabellatum* (Goldfuss) – Kora *et al.* Pl. 2, figs. 6-7.

2001 *Ceratostreon flabellatum* (Goldfuss) – Abdallah *et al.*, pl. 2, fig. 8-9

2002 *Ceratostreon flabellatum* (Goldfuss) – Abdel Gawad & Gameil, p. 86, pl. 2, fig. 8.

2002 *Ceratostreon flabellatum* (Goldfuss) - Abdelhamid & El Qot, p. 269, pl. 3, fig. 2.

Material and occurrence. 69 specimens from Gebel Ekma, the Raha Formation, beds no. 2-6; 26 specimens from the East Themed area, Galala Formation beds no. 3, 6; and 275 from Gebel Yelleg, Galala Formation, beds no.2-4, 14, 16, 18, 24, 33, 35, and 36.

Measurements (in mm).

N=370	L	H	C	nr	H/L	C/L	C/H
Range	10-48	17-67	4.7-30	28-58	1.07-2.36	0.22-0.42	0.33-0.70
Mean	27.4	39.8	18.6	34	1.83	0.33	0.52

Description. Shell variable in size from small to relatively large, highly variable in outline, inequivalved. Left valve larger than the right one, strongly convex, with well defined spiral keel dividing the outer surface of the valve into a posterior concave and anterior convex part. Right valve mostly flat and occasionally convex (then with a stronger keel than the left valve). Umbo twisted, opisthogyrate. Chomata crenulate to vermiculate, developed along periphery of the valve. Adductor muscle scar nearly subrounded, located posteriorly to subcentrally. Ornamentation consisting of strong radial ribs; these ribs are closer to each other dorsally and posteriorly and fine radial threads may be developed between them; small spines may be irregularly developed towards the margin.

Age. Late Albian-Cenomanian.

Distribution in Egypt. Gebel Shabrawit, Wadi Araba, Ain Areyida, Bir Abu El-Meisa, El-Baharyia Oasis, W. Tarfa, W. Hawashiya, Saint Paul, G. Tih, G. Abu Edeimat, W. Abu Qada, W. Budrah, West Thal, G. Qabaliat, G. Nezzazat, W. Qena, G. Um Heriba, G. El-Minsherah, G. El-Hamra, and El Giddi Pass.

Distribution outside Egypt. This species has a wide geographic distribution and has been reported from Europe, Africa, Asia, North and Central America and Brazil.

Discussion. The present author agrees with Malchus (1990) and considers *Exogyra complicata* Mahmoud, 1955 from the Albian of Gebel Maghara within the range of variation of *Ceratostreon flabellatum*. The great morphological variability of this species led many authors to divide it into some varieties and forms. Seguanza (1882) divided it into five varieties; var. *dilatata*, var. *trigona*, var. *ecostata*, var. *crassiplicata* and var. *semilunata*. Fawzi (1963) recognized

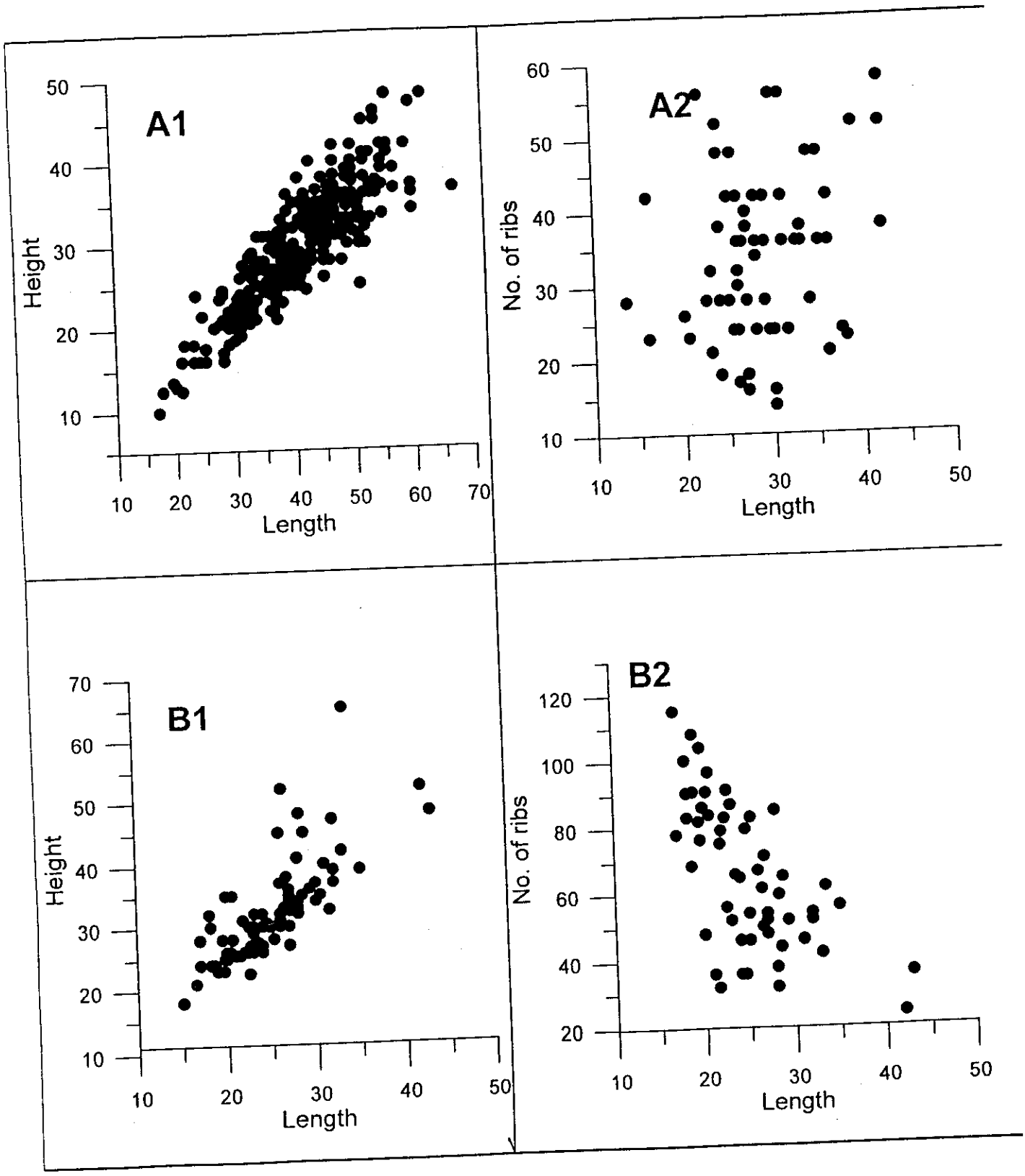


Figure 30. Biometric data on *Ceratostreon flabellatum* (A), and *Rhynchostreon suborbiculatum* (B).

two varieties "form typique" and the new variety *excavata*. Malchus (1990) recognized three forms for this species; forma typica, forma musa and forma intermedia. El-Mahallawy (1996) classified the species into six forms (Form A-F). It is very difficult to distinguish between these different varieties and forms, because in very large populations similar to the ones investigated herein the different forms are linked by transitional ones to make it impossible to differentiate the species into different varieties or forms (Figure 30A).

The species is geographically widely distributed and ranges from the Albian to the Senonian (Freneix 1972). It is particularly widespread in the Cenomanian of Africa and Europe.

Genus *Ilymatogyra* Stenzel, 1971

Ilymatogyra africana (Lamarck, 1801)

Pl. 7, Figs. 1-7, 8a-b; Text-Fig. 29B

1801 *Gryphaea africana* sp. nov. - Lamarck, p. 399, pl. 139, figs. 5-6.

1852 *Exogyra densata* sp. nov. - Conrad, p. 224, pl. 18, fig. 102.

1862 *Ostrea auressensis* sp. nov. - Coquand, p. 233, pl. 22, figs. 12-13.

1917 *Ostrea africana* Lamarck - Fourtau, p. 27.

1918 *Exogyra Africana* Lamarck - Greco, p. 9 (191), pl. 2 (17), figs. 5-6.

1937 *Exogyra africana* Lamarck - Trevisan, p. 72, pl. 3, fig. 18; pl. 5, figs. 1-4.

1962 *Exogyra africana* Lamarck - Abbass, p. 65, pl. 9, figs. 2-3.

1963 *Exogyra africana* Lamarck - Fawzi, p. 37, pl. 2, figs. 8-9.

1987a *Ilymatogyra africana* (Lamarck) – Kora & Hamama, pl. 1, fig. 3.

1990 *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) "forma typica" - Malchus, p. 121, pl. 6, figs. 6-16; pl. 7, figs. 1-5, 7, 10, 13, 21; pl. 8, figs. 4.

1990 *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) "forma crassa" - Malchus, p. 121, pl. 7, fig. 6, 8-9, 11-12, 14-20; pl. 8, figs. 1-3.

1992 *Ilymatogyra africana* (Lamarck) - Abdel-Gawad & Zalat, pl. 2, figs. 12-13.

1993 *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) - Aqrabawi, p. 70, pl. 2, figs. 6-11; pl. 3, figs. 1-3.

1993 *Ilymatogyra africana* (Lamarck) – Kora *et al.*, pl. 2, fig. 1.

1996 *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) - El-Mahallawy, p. 122, pl. 9, figs. 6-7, 9-10.

1999 *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) - Dhondt *et al.*, pl. 1, figs. 1-2.

1999 *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) - Seeling & Bengtson, p. 758, fig. 9d-g.

2001b *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck) – Kora *et al.*, pl. 1, fig. 1.

2001 *Ilymatogyra africana* (Lamarck) - Abdallah *et al.*, pl. 2, fig. 10.

2002 *Ilymatogyra africana* (Lamarck) - Abdel Gawad & Gameil, p. 86, pl. 2, fig. 9.

2002 *Ilymatogyra africana* (Lamarck) - Abdelhamid & El Qot, p. 269, pl. 3, fig. 3.

Material and occurrence. 94 specimens from Gebel Ekma, Raha Formation, beds no. 3-7; 175 specimens from the East Themed area, Galala Formation, beds no. 3, 6-7, and 9; and 73 specimens from Gebel Yelleg, Galala Formation beds no. 31, 33, 35, and 36.

Measurements (in mm).

n=342	L	H	C	H/L	C/L	C/H
Range	8-33	13.3-52	6-23.5	1.33-2.3	0.60-1.11	0.38-0.68
Mean	21	38.5	14.2	1.8	0.82	0.53

Description. Shell small- to medium-sized, variable in outline from oval or elongated-oval to semi- tear-shaped, inequivalved, inequilateral. Left valve variable but commonly strongly convex. Right valve flat to slightly convex. Umbo variable from weakly to strongly twisted and appearing to be related to the size of the attachment area; if the attachment area is small most specimens exhibit a curved to helicoidal umbo. Keel blunt to rounded and well developed.

Ligamental area variable in size but often large. Adductor muscle imprint kidny-shaped and situated postero-centrally. Left valve ornamented with regular, scaly or smooth growth lamellae. Right valve covered with closely spaced, fine growth-lamellae.

Age. Middle-Late Cenomanian.

Distribution in Egypt. Ain Areyida, Bir Abu El-Meisa, Gebel Thelmet, Wadi Tarfa, G. Ataqa, G. Shabrawit, W. Araba, W. Tih, G. Edeimat, W. Abu Qada, G. Um Rayig, W. Budrah, W. Thal, W. Thaggadi, G. Safariat, G. Qabaliat, G. El-Minsherah, G. El-Halal, G. Nezzazat, G. Um Heriba, G. El-Hamra, and El Giddi Pass.

Distribution outside Egypt. Southern Europe, Middle East, North Africa, Niger, Nigeria, Gabon, Somalia, Madagascar, South and Central America.

Discussion. Malchus (1990) differentiated two forms of this species; forma *typica* and forma *crassa*, based on the variability in the general form of the shell, and on some other morphological features. The forma *crassa* is generally larger in size, less convex, elongated in outline, has a weaker keel and exhibits more scaly growth lamellae on the left valve, which in most cases form a wave-like sculpture. He pointed out that the two varieties are tied to different facies; whereas forma typica occurs in clay and silt-rich marls, forma *crassa* occurs in sandy marls and marly limestones. The present author agrees with the opinion of Malchus and attributes the wide variability of *Ilymatogyra africana* to ecological factors. In soft substrate (shale of the bed no. 7 of the East Themed area) the typical form and forms near to it dominate, whereas in firm substrates (e.g. the sandy limestone bed no. 6 of Gebel Ekma; dolomitic limestone bed no. 36 of Gebel Yelleg) the variability is very high (Pl. 7, Figs. 1-7, 8a-b). In the opinion of the present author the differentiation of this species into two forms is very difficult when very large population are studied as there are many intermediate forms (Figure 29B).

Due to the high variability of *Ilymatogyra africana* many authors had problems distinguishing between *I. africana* and *Gyrostrea delettrei* (Coquand, 1862). For instance, Collignon (1971: p. 173, pl. F (6), figs. 2-4) misidentified *G. delettrei* from the Senonian of Algeria as *Exogyra africana*, quoting in the synonymy list *Ostrea africana* Lamarck of Coquand (1862: p. 233, pl. 22, figs. 12-13). However, this information is erroneous, as Coquand (1862) described his new species *Ostrea* as *auressensis*, but not as *africana*. The new species of Coquand (1862: p. 233, pl. 22, figs. 12-13) has been regarded as a synonym of *Ilymatogyra africana* by many authors and by Coquand himself in 1869. Malchus (1990) considered *G. delettrei* of Pervinquière (1912) from the Cenomanian of Tunisia and that recorded by Greco (1918) from Egypt as synonyms to his new forma *crassa* (see the disscussion of *G. delettrei*).

I. africana is geographically very widely distributed species and considered a diagnostic species characterising the Middle and Upper Cenomanian.

Genus *Rhynchostreon* Bayle, 1878

Rhynchostreon suborbiculatum (Lamarck, 1801)

Pl. 7, Figs. 9a-b, 10a-b, 11a-b; Pl. 8, Figs. 1a-b, 2a-b, 3a-b, 4; Text-Figs. 12, 13B, 30B

1801 *Gryphaea suborbiculata* sp. nov. - Lamarck, p. 398, pl. 23, figs. 11-13.

1819 *Gryphaea columba* sp. nov. - Lamarck, p. 198.

1862 *Ostrea Mermeti* sp. nov. - Coquand, p. 234, pl. 23, figs. 3-5.

1871 *Exogyra suborbiculata* Lamarck - Stoliczka, p. 462, pl. 35, figs. 1-4.

1873 *Ostrea Mermeti* Coquand - Lartet, p. 60, pl. 10, figs. 8-16.

1891 *Exogyra suborbiculata* Lamarck - Peron, p. 119, pl. 23, figs. 11-13.

1904 *Ostrea suborbiculata* Lamarck - Fourtau, p. 289.

1912 *Exogyra columba* Lamarck - Pervinquière, p. 180.

1913 *Exogyra columba* (Lamarck) - Woods, p. 413, text-figs. 243-248.

1917 *Ostrea Mermeti* Coquand - Fourtau, p. 40.

1918 *Exogyra columba* Lamarck - Greco, p. 7 (189), pl. 1 (17), figs. 15-18; pl. 2, figs. 1-4.

1937 *Exogyra columba* Lamarck mut. *minor* - Trevisan, p. 69, pl. 3, figs. 14-17.

1962 *Exogyra suborbiculata* (Lamarck) - Abbass, p. 68, pl. 9, figs. 7-8.

1963 *Exogyra columba* Lamarck - Fawzi, p. 40, pl. 3, fig. 1-10.

1971 *Exogyra columba* Lamarck - Collignon, p. 175 (33), pl. F, figs. 7.

1972 *Rhynchostreon columbum columbum* (Lamarck) - Freneix, p. 88, pl. 5, fig. 3a-b.

1986 *Rhynchostreon suborbiculatum* (Lamarck) - Frenix & Viaud, p. 37, pl. 3, figs. 8-12.

1990 *Rhynchostreon mermeti* (Coquand) - Malchus, p. 128, pl. 8, figs. 15-17; pl. 9, figs. 1-4 (= forma typica); figs. 5-12 (= forma minor).

1992 *Rhynchostreon mermeti* (Coquand) - Abdel-Gawad & Zalat, pl. 2, figs. 4-8.

1993 *Rhynchostreon mermeti* (Coquand) - Aqrabawi, p. 74, pl. 3, figs. 4-12.

1993 *Rhynchostreon suborbiculatum* (Lamarck) – Kora *et al.*, pl. 2, fig. 2.

1996 *Rhynchostreon suborbiculatum* (Lamarck) - El-Mahallawy, p. 124, pl. 10, figs. 1-4.

1999 *Rhynchostreon mermeti* (Coquand) - Dhondt *et al.*, pl. 1, fig. 4.

1999 *Rhynchostreon* (*Rhynchostreon*) *mermeti* (Coquand) - Seeling & Bengtson, p. 759, fig. 10a-b.

2001b *Rhynchostreon suborbiculatum* (Lamarck) – Kora *et al.*, pl. 1, fig. 6.

2001 *Rhynchostreon mermeti* (Coquand) - Abdallah *et al.*, pl. 2, figs. 11-12.

2002 *Rhynchostreon suborbiculatum* (Lamarck) - Abdel Gawad & Gameil, p. 87, pl. 2, fig. 10.

2002 *Rhynchostreon mermeti* (Coquand) - Abdelhamid & El Qot, p. 271, pl. 3, fig. 4.

Material and occurrence. 89 specimens from Gebel Ekma, Raha Formation, beds no. 2-6, and 9; 65 specimens from the East Themed area, Galala

Formation, bed no. 6; and 137 specimens from Gebel Yelleg, Galala Formation, beds no. 14, 16, 18, 20, 22, 24, 33, 35, and 36.

Measurements (in mm).

N=291	L	H	C	nr	H/L	C/L	C/H
Range	15-63.5	18-69.5	12.5-37.5	30-118	1.09-1.67	0.48-1.0	0.38-0.79
Mean	25.5	29.6	18.3	65	1.32	0.76	0.59

Description. Shell varying in size from small- to large-sized, variable in outline from oval to nearly rounded; inequivalved, mostly higher than long. Umbo variable from moderately to strongly twisted, but commonly helicoidally coiled. Left valve cup-like. Right valve flat to concave with commarginal ribs. Ligamental area variable in size and shape, mostly small and narrow. Adductor muscle imprint large, subrounded, and situated postero-ventrally. Vermiculate relict chomata moderately developed. Ornamentation of the left valve varying between radial ribs and growth squamae.

Age. Cenomanian.

Distribution in Egypt. El-Bahariya Oasis, Ain Areyida, Bir Abu El-Meisa, Wadi Dara, W. Um Hemaiet, W. Hawashiya, Saint Paul, Gebel Tanka, G. Tih, W. Abu Qada, G. Safariat, G. Qabaliat, W. Budrah, W. Esba, W. Thaggadi, W. Araba, G. El-Hamra, G. El-Minsherah, G. Nezzazat, and El Giddi Pass.

Distribution outside Egypt. The species is geographically widely distributed in Southern Europe, Africa, Asia, and South America (Peru and Brazil).

Discussion. The wide variability with respect to ribbing, degree of twisting of the umbo, and shell outline caused much confusion among the authors, who studied species of *Rhynchostreon*. Peron (1891) and Fourtau (1904) considered *R. suborbiculatum* (Lamarck) *R. columbum* (Lamarck), and *R. mermeti* (Coquand) as synonyms with *R. suborbiculatum* having priority. Pervinquière (1912) and Fawzi (1963) also concluded that these three species are synonyms but they placed them under *R. columbum* arguing that *columbum* has been used by the majority of later authors and the older *suborbiculatum* was poorly-known

name. Woods (1913) and Malchus (1990) in contrast, regarded *R. mermeti* as related to North Africa and the other two species to Europe. Moreover, *R. suborbiculatum* and *R. columbum* were regarded to be conspecific by many authors. For instance, Stoliczka (1871) Frenix & Viaud (1986), and Malchus (1990) used *R. suborbiculatum*, whereas Woods (1913) and Freneix (1972) used *R. columbum* using the same argument as Pervinquière and Fawzi. Trevisan (1937) regarded *R. Columbum* and *R. mermeti* to be conspecific.

Lartet (1873) divided *R. mermeti* into the six varieties *communis*, *rugosa*, *carinata*, *major*, *sulcata*, and *minor*. Fawzi (1963) divided *R. columbum* into the four varieties *suborbiculatum* Lamarck, *mermeti* Coquand; and the new varieties *truncata* and *ovalis* apart from *R. columbum* forma *typica*. Freneix (1972) distinguished *R. columbum* into two subspecies; *R. columbum columbum* (Lamarck) and *R. columbum* (Lamarck) *mermeti* (Coquand). Frenix & Viaud (1986) divided *R. suborbiculatum* into three forms; *typica*, *intermedia*, and *minor*. The forma *minor* is characterised by its small size (height of shell <25 mm) and occurs in the Middle Cenomanian and ranging to the Santonian-Campanian, while the other two forms first appeared in the Upper Cenomanian and ranges to Middle Turonian. Malchus (1990) classified *Rhynchostreon mermeti* into two forms; forma *typica* and forma *minor*, the latter being characterised by a small size and variable L/H ratio. The same author related the differences between these two forms to the substrate; forma *minor* dominates in calcareous sandstone, sandy marl, marly limestone, and glauconitic sandstone, whereas forma typica dominates in silty to clayey, calcareous and glauconitic marl. Moreover, Malchus (1990) mentioned that it is very diffcult to clarify small specimens (22 mm < H > 33 mm) into these two forms. Seeling & Bengtson (1999) stated that the great similarities between *R. mermeti* and *R. suborbiculatum* make it difficult to separate the two species, especially when dealing with small specimens, as in Sergipe (Brazil).

1869 *Ostrea Rediviva* sp. nov. - Coquand, p. 154, pl. 42, figs. 8-11; pl. 54, figs. 18-30.

1912 *Liostrea Rouvillei* Coquand - Pervinquière, p. 168.

1917 *Ostrea Rouvillei* Coquand - Fourtau, p. 50.

1918 *Liostrea Rouvillei* Coquand - Greco, p. 4 (186), pl. 1 (17), figs. 6-11.

1962 *Ostrea* (*Crassostrea*) *rouvillei* (Coquand) - Abbass, p.74, pl. 11, fig. 8.

1963 *Liostrea rouvillei* Coquand - Fawzi, p. 36, pl. 2, fig. 7.

1972 *Liostrea rouvillei* (Coquand) - Freneix, p. 97, text- fig. 10a-d.

1990 *Curvostrea rouvillei* (Coquand) - Malchus, p. 154, pl. 14, figs. 1-7, 16.

1996 *Curvostrea rouvillei* (Coquand) - El-Mahallawy, p. 161, pl. 19, fig. 5.

1999 *Curvostrea rouvillei* (Coquand) - Seeling & Bengtson, p. 761, fig. 12a-b.

2002 *Liostrea rouvillei* (Coquand) - Abdel Gawad & Gameil, p. 88, pl. 2, fig. 11.

Material and occurrence. 7 specimens from Gebel Ekma; 1 from the Raha Formation, bed no. 6; 1 specimen from Abu Qada Formation, bed no. 10; and 5 specimens from the Wata Formation, bed no. 16. 13 from the East Themed area; 3 from the Abu Qada Formation, bed no. 11, and 10 specimens from the Wata Formation, bed no. 26. 18 specimens from Gebel Yelleg, Wata Formation, beds no. 42 and 43.

Measurements (in mm).

n=38	L	H	C	H/L	C/L	C/H
Range	11.5-40.5	14-57	6.5-15	1.1-1.7	0.35-0.59	0.26-0.46
Mean	26.2	38.6	8.4	1.33	0.46	0.34

Description. Shell small to medium-sized; varying in outline from high-oval, tongue-shaped, flat, plate-shaped to slightly curved, drop-shaped, higher than long, inequilateral, mostly inequivalved. Left valve flat to slightly convex. Right valve less convex to slightly concave. Umbo small, not prominent. Attachement area small. Ligamental area triangular and relatively small. Adductor muscle imprint oval to nearly circular and situated postero-ventrally.

Relict chomata seen only antero-dorsally. Ornamentation consisting of fine commarginal growth lines and closely spaced stepped lamellae developed at irregular intervals. In some forms, these elements are crossed by fine radial striations.

Age. Late Cenomanian-Turonian.

Distribution in Egypt. Gebel Shabrawit, Wadi Araba, G. El-Minsherah, W. Thal, W. Sifa, G. Um Rayig, G. Nezzazat, G. Qabiliat, W. Qena, and El-Bahariya Oasis.

Distribution outside Egypt. North and Central Africa, The Middle East, Europe, India, and South America.

Discussion. Stenzel (1971, p. N. 1168) placed *Curvostrea* Vyalov, 1936 in his group of genera of uncertain systematic position, because the internal characters of the shell were not known. Recently, Malchus (1990) assigned the genus to the new Subfamily Liostreinae within the Family Ostreidae Rafinesque, 1815.

The present author agrees with Malchus (1990) and Seeling & Bengtson (1999) and considers *Ostrea rediviva* Coquand, 1869 as a synonym of *Curvostrea rouvillei*. With respect to the stratigraphic range of the species, it ranges from the Cenomanian to the Senonian.

Tribe Flemingostreini Stenzel, 1971

Genus *Gyrostrea* Mirkamalov, 1963

***Gyrostrea delettrei* (Coquand, 1862)**

Pl. 8, Figs. 7a-b, 8-10

1862 *Ostrea Delettrei* sp. nov. - Coquand, p. 224, pl. 18, figs. 1-7.

1869 *Ostrea Delettrei* Coquand - Coquand, p. 143, pl. 46, figs. 16-18; pl. 47, figs. 1-6; pl. 48, figs. 1-5.

1873 *Ostrea delettrei* Coquand - Lartet, p. 67, pl. 11, fig. 16.

1891 *Ostrea Delettrei* Coquand - Peron, p. 131.

1904 *Ostrea Delettrei* Coquand - Fourtau, p. 282.

Freneix (1972) described *G. delettrei tarfayensis* as a new subspecies from the Upper Albian-Lower Turonian of Tarfaya, Morocco. This subspecies lies within range of variation of *G. delettrei* as illustrated by Coquand (1962, 1969). Freneix (1972) pointed out that the species predominates in North Africa from Morocco to Egypt, but occurs also in the Cenomanian of Niger, Turonian of Nigeria, and Turonian-Senonian of Congo. Collignon (1971) recorded *G. delettrei* from the Senonian of Algeria. From the above discussion it is clear that *G. delettrei* is a diagnostic species of the Cenomanian of North Africa, but its total range is from the Late Albian to the Senonian. Future work may show that *Gyrostrea antwani* Malchus is a junior synonymy of the present species.

Gyrostrea thevestensis (Coquand, 1862)

Pl. 9, Figs. 1a-b, 2a-b

?1859 *Ostrea Boucheroni* sp. nov. - Coquand, p. 1007.

1862 *Ostrea Tevesthensis* sp. nov. - Coquand, p. 227, pl. 19, figs. 7-13.

1869 *Ostrea Boucheroni* Coquand - Coquand, p. 85, pl. 31, figs. 1-3; pl. 37, figs. 1-16; pl. 38, fig. 20.

1891 *Ostrea Boucheroni* Coquand - Peron, 142.

1904 *Ostrea Boucheroni* Coquand - Fourtau, p. 291.

1913 *Ostrea Boucheroni* Coquand - Woods, p. 391, pl. 60, figs. 1-15.

1917 *Ostrea roachensis* sp. nov. - Fourtau, p. 50, pl. 3, fig. 1.

1962 *Ostrea* (*Crassostrea*) *boucheroni* (Coquand) - Abbass, p.76, pl.10, figs. 3, 6-8.

1990 *Curvostrea tevesthensis* (Coquand) - Malchus, p. 156.

1990 *Gyrostrea (Vatonnei) roachensis* (Fourtau) - Malchus, p. 168, pl. 15, figs. 9-11; pl. 16, figs. 1-9; pl. 17, figs. 2-3.

1992 *Gyrostrea roachensis* (Fourtau) - Abdel-Gawad & Zalat, pl. 5, fig. 3.

1996 *Crassostrea boucheroni* (Coquand) - El-Mahallawy p. 134, pl. 12, figs. 3, 8.

1996 *Curvostrea tevesthensis* (Coquand) - El-Mahallawy, p. 162, pl. 19, figs. 6-7.

2002 *Gyrostrea roachensis* (Fourtau) - Abdelhamid & El Qot, p. 271, pl. 3, fig. 6.

Material and occurrence. 23 specimens from Gebel Ekma, Matulla Formation, shaly member, bed no. 22 and 25 specimens from the Themed area, Themed Formation, bed no. 34.

Measurements (in mm).

N=48	L	H	C	H/L	C/L	C/H
Range	22.5-54	29.5-81	6.6-18.5	1.06-1.84	0.33-0.54	0.27-0.41
Mean	36.3	52.9	13.2	1.37	0.41	0.32

Description. Shell medium- to large-sized, varying in outline from oval, pear-shaped to rounded, subequivalved to inequivalved. Right valve less convex than left valve. Anterior and posterior margins nearly straight to convex grading the convex ventral margin. Umbo slightly to moderately twisted posteriorly. Ligamental area variable in size but commonly large, varying in shape from ostreoid to gyrostreoid. Resilifer long and deep, bordered by bourrelets. Chomata confined to dorsal region. Adductor muscle scar reniform or kidney-shaped and situated postero-ventrally. Ornamentation consisting of imbricated commarginal lamellae of nearly equal width.

Age. Coniacian - Santonian.

Distribution in Egypt. Wadi Askhar El-Baharyia, W. Araba, W. Qena, Abu Roash, W. Matulla, Dakhla Oasis, Gebel El-Hamra, and G. El-Minsherah.

Distribution outside Egypt. Noth Africa and Southern Europe.

Discussion. According to Dhondt (in Malchus 1990) the holotype of *boucheroni* is very poorly preserved, the umbo and the postero-dorsal margin being broken. As the specimen is difficult to identify and may be a *Pycnodonte* sp., consequently, Malchus (1990) replaced *Ostrea boucheroni* Coquand, 1859 by *Ostrea thevestensis* Coquand, 1862.

He also included *Ostrea (Crassostrea) boucheroni* of Abbass (1962) in the synonymy of *Ostrea roachensis* Fourtau, 1917. The present author follows Malchus (1990) because *thevestensis* is, in contrast to *boucheroni* well described and illustrated. However, *O. roachensis* Fourtau, 1917 is regarded herein to lie within the range of variation of *O. thevestensis* Coquand.

The present species shows a close similarity to many species from the same stratigraphic level such as *Gyrostrea cortex* (Conrad, 1857); *G. antwani* Malchus, 1990, *Crassostrea canaliculata* Zakhera & Kassab, 1999, and ? *Flemingostrea lenticularis* Zakhera & Kassab, 1999. Further study may resolve the relationship between *thevestensis* and these species.

The high variability of the species caused much confusion among authors, who studied this species similarly to case of *G. delettrei* described before. The present author attributed the differences in the ligamental area as due to the mode of attachment. As the position and shape of the adductor scar closely resembles that of members of the genus *Gyrostrea*, *Ostrea thevestensis* Coquand is consequently referred to this genus.

Genus *Nicaisolopha* Vyalov, 1936

Nicaisolopha nicaisei (Coquand, 1862)

Pl. 9, Figs. 3a-b, 4-5, 6a-b; Text-Fig. 31A

1862 *Ostrea Nicaisei* sp. nov. - Coquand, p. 232, pl. 22, figs. 5-7.

1869 *Ostrea Nicaisei* Coquand - Coquand, p. 34, pl. 6, figs. 1-17.

1891 *Ostrea Nicaisei* Coquand - Peron, p. 178.

1904 *Ostrea Nicaisei* Coquand - Fourtau, p. 301.

1917 *Ostrea Nicaisei* Coquand - Fourtau, p. 43, pl. 6, figs. 1-4.

1917 *Alectryonia Nicaisei* Coquand - Greco, p. 116 (136), pl. 14 (13), figs. 2-3.

1971 *Nicaisolopha nicaisei* (Coquand) - Stenzel, p. N1164, fig. J137/1a-h.

1990 *Nicaisolopha nicaisei* (Coquand) - Malchus, p. 174, pl. 19, figs. 17, 19; pl. 20, figs. 1-8.

1993 *Nicaisolopha nicaisei* (Coquand) - Aqrabawi, p. 86, pl. 6, figs. 1-5.

1995 *Nicaisolopha nicaisei* (Coquand) – Kassab & Zakhera, p. 332, fig. 3/3.

1996 *Nicaisolopha nicaisei* (Coquand) - El-Mahallawy, p. 143, pl. 13, figs. 3-5.

1999 *Nicaisolopha nicaisei* (Coquand) - Dhondt *et al.*, pl. 1, figs. 9, 10.

2002 *Nicaisolopha nicaisei* (Coquand) - Kora *et al.*, pl. 3, fig. 8.

Material and occurrence. 22 specimens from Gebel Ekma, Matulla Formation, phosphatic member, bed no. 26.

Measurements (in mm).

n=22	L	H	C	H/L	C/L	C/H
Range	22.5-42.5	24-60	4.5-17	1.0-1.60	0.18-0.46	0.17-0.33
Mean	36.6	44.5	11.2	1.36	0.31	0.23

Description. Shell medium-sized, varying in outline from subcircular or high-ovate to subtriangular, higher than long, subequivalved. Left valve flat to convex. Right valve flat or slightly concave, occasionally slightly convex. Umbo more or less orthogyrate and not pointed. Attachment area variable, very small to large. Ligamental area low and long; resilifer of left valve shallowly excavated and slightly longer than bourrelets; resilifer of right valve flat. Adductor muscle imprint reniform, deeply concave at its dorsal margin, about twice as long as high, placed postro-ventrally to subcentrally. Chomata variable, from moderately developed to hardly noticable. Sculpture composed of a few, wavy, radial folds. These radials occasionally dichotomize.

Age. Late Campanian.

Distribution in Egypt. Gebel Mellaha, Wadi Abu Ratam, W. Um Hemaiet, W. Askhar El-Bahariya, W. Qena, G. Qabaliat, W. Matulla, and W. Sudr.

Distribution outside Egypt. North Africa and the Middle East.

Discussion. The genus *Nicaisolopha* Vyalov, 1936 has been attributed to the Subfamily Lophinae Vyalov, 1936 by Stenzel (1971: p. N1164). Malchus (1990: p. 171) referred it to his new subfamily Liostreinae based on its compact-foliated shell microstructure and assumed that the Cenozoic Lophinae

developed independently from similar Mesozoic forms for which he proposed the new family Palaeolophidae based on his new genus *Palaeolopha*. The internal and external morphological characters of this genus are identical with those of the subfamily Lophinae. The genus *Nicaisolopha* has a compact-foliated shell microstructure (Malchus 1990). According to Stenzel (1971: p. N1096) shell structure is more important than most other features. Consequently, the genus referred, in accordance with Malchus (1990), to the subfamily Liostreinae Malchus, 1990.

Nicaisolopha nicaisei (Coquand) is widely distributed in the Campanian-Maastrichtian sediments of North Africa and the Middle East.

Nicaisolopha tissoti (Thomas & Peron, 1891)

Pl. 9, Figs. 7a-b, 8; Pl. 10, Figs. 1a-b, 2a-b; Text-Fig. 31A

1891 *Ostrea Tissoti* sp. nov. - Thomas & Peron *in* Peron, p. 196, pl. 24, figs. 1-7.

1903 *Alectryonia Tissoti* Thomas & Peron- Dacqué, p. 365, pl. 34, figs. 11-12.

1917 *Ostrea Tissoti* Thomas & Peron - Fourtau, p. 54, pl. 5, figs. 1-5.

1990 *Nicaisolopha tissoti* (Peron & Thomas) - Malchus, p. 174, pl. 19 , fig. 7-16, 18.

1996 *Nicaisolopha tissoti* (Peron & Thomas) - El-Mahallawy, p. 145, pl. 13, figs. 6-8.

2001 *Cameleolopha* (*Hyotissocameleo*) *tissoti* (Peron & Thomas) - Zakhera *et al.*, p. 85, fig. 7.

Material and occurrence. 182 specimens from Gebel Ekma, Matulla Formation; 63 specimens from the shaly member, bed no. 25 and 119 specimens from the phosphatic member, bed no. 26.

Measurements (in mm).

n=182	L	H	C	H/L	C/L	C/H
Range	11.6-34.5	14-40	2.5-15.5	1.12-1.28	0.20-0.48	0.16-0.41
Mean	23.4	26.6	8.9	1.2	0.32	0.26

Description. Shell small- to medium-sized, varying in outline from nearly orbicular to ovate to subtriangular, subequivalved. Left valve slightly to moderately convex. Right valve flat, slightly concave, in some specimens slightly convex. Umbo small, orthogyrate or slightly oblique. Attachment area varying between small and large. Ligamental area triangular, relatively long, with a resilifer twice as broad as both bourrelets or slightly more so. Anterior bourrelet longer than the posterior one. Anachomata, catachomata and relictchomata absent to well developed. Adductor muscle imprint reniform, deeply concave at its dorsal margin, about twice as long as high, and situated postero-ventrally. Sculpture composed of a few to several, occasional dichotomizing radial ribs.

Age. Late Santonian-Early Campanian.

Distribution in Egypt. Abu Roash, Wadi Tarfa, W. Abu Ratama, Southern Galala, W. Matulla, and Gebel Qabiliat.

Distribution outside Egypt. Algeria and Tunisia.

Discussion. Vyalov (1936) erected the genera *Nicaissolopha* and *Cameleolopha* on the same page (p. 20) and considered *Ostrea nicassei* Coquand (1862) and *Ostrea cameleo* Coquand (1869) respectively as the type species of the two genera. In the description of the two genera Vyalov (1936) mentioned nothing about internal characters and only stating "Section *Nicaissolopha* sect. n.; type: *N. nicassei* Coquand. Sculpture consistant en plis vages" . "Section *Cameleolopha* sect. n.; type: *C. cameleo* Coquand. Sculpture consistant en côtes peu nombreuses, dichotomes." Stenzel (1971) described only the external characters (size, outline and ribbing) of *Cameleolopha* and did not remark on the internal characters (ligament, chomata, and position and shape of

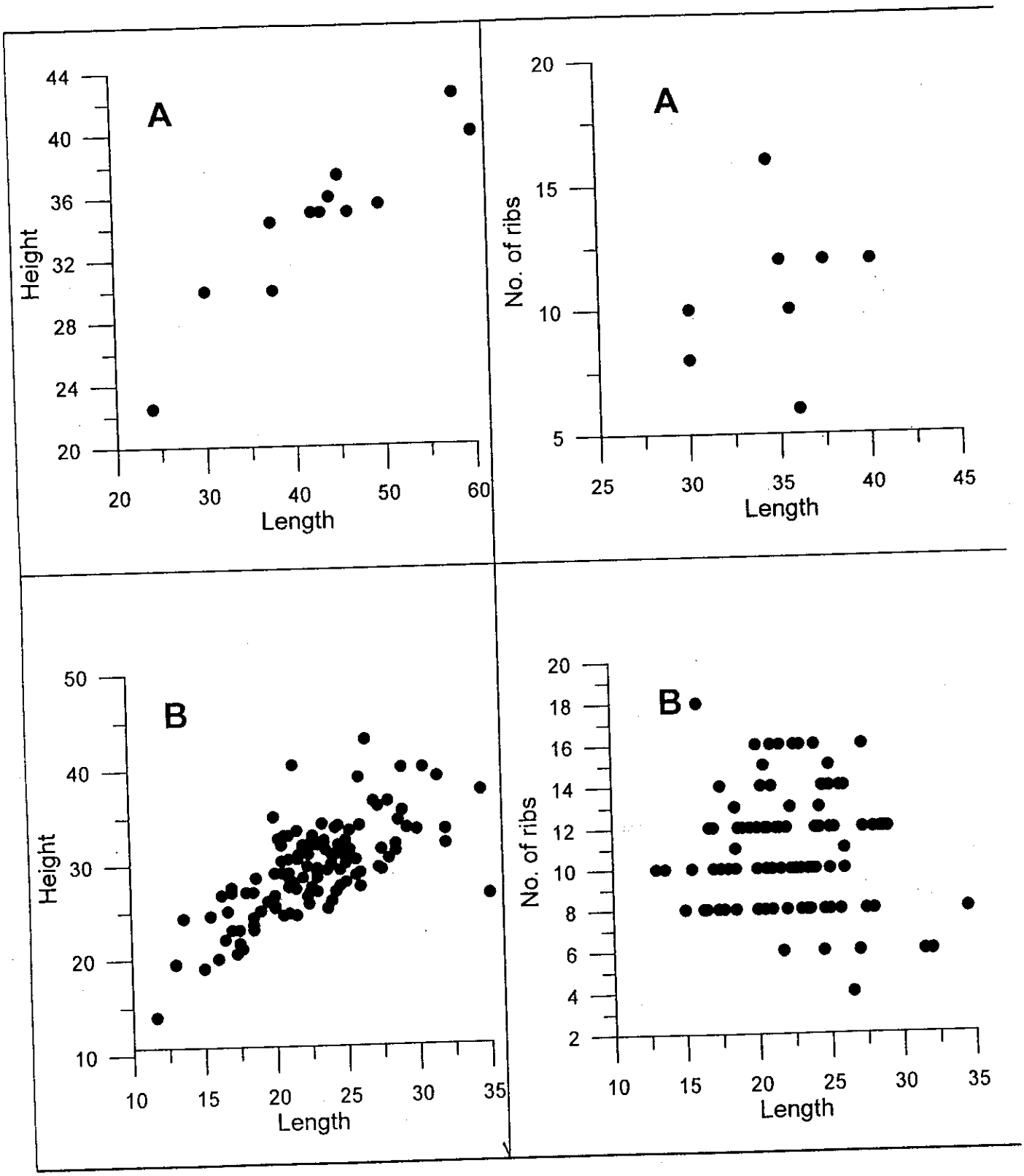


Figure 31. Biometeric data on *Nicaisolopha nicaisei* (A), and *Nicaisolopha tissoti* (B).

adductors). Coquand (1869), in the description of his new species *C. cameleo* did not mention chomata. Moreover, the two valve interiors illustrated by Coquand (1869: pl. 54, figs. 9, 10) show no chomata. Malchus (1990) recorded both *Nicaisolopha nicaisei* and *N. tissoti* (Thomas & Peron) from Egypt and placed the genus *Nicaisolopha* in his new subfamily Liostreinae rather than the subfamily Lophinae, based on its shell microstructure as discussed before. According to Malchus (1990) *Cameleolopha* may be a synonym of *Nicaisolopha*. El-Mahallawy (1996) recorded both these *Nicaisolopha* species from west-central Sinai. She did not mention any chomata and the ribs were not dichotomous. Zakhera *et al.* (2001) erectecd the subgenus *Hyotissocameleo* of the genus *Cameleolopha* and referred *Ostrea tissoti* Thomas & Peron to it, based on the dichotomous ribbing and the presence of chomata. They added that, on the basis of weak chomata in some species of *Cameleolopha*, the shape and position of the adductor muscle, and the ornamenation, *Cameleolopha* and *Hyotissocameleo* came from the same ancestors, which were probably the Neocomian "*Ostrea*" *loriolis* Coquand and/or "*Ostrea*" *cornuelis* Coquand followed by the Albian "*Ostrea*" *complicata* Mahmoud and the Cenomanian *Lopha syphax* Coquand. In the present study numerous (182) individuals of *N. tissoti* and 22 specimens of *N. nicaisei* (Figure 31A-B) were collected from Gebel Ekma. In some individuals of *N. tissoti* the ribs dichotomize, but the most of them have simple radial folds, and the chomata (relict and cata) range from well developed to completely absent. In *N. nicaisei*, the ribbing is the same as in *N. tissoti* but the dichotomous ribs are rarer (in only two out of 22 specimens). Some specimens have weakly to moderately developed chomata. However, both *N. nicaisei* and *N. tissoti* have the typical internal characters of the genus *Nicaisolopha* as described by Stenzel (1971). Moreover, *N. nicaisei* which is the type species, shows weakly chomata and rarely dichotomous ribbing. According to Stenzel (1971: p. N1095) internal features of oysters commonly are of greater taxonomic significance than external ones. Therefore, the present author agrees

with Malchus (1990) and atributtes *N. tissoti* to the genus *Nicaisolopha* rather than to *Cameleolopha* as considered by Zakhera *et al.* (2001).

N. tissoti differs from *N. nicaisei* in being smaller, thin-shelled, and in having a weak wavy plicate radial sculpture, and inconspicuous growth lamellae. Aqrabawi (1993) pointed out that young specimens of *N. nicaisei* can be similar to *N. tissoti.*

Tribe Ambigostreini Malchus, 1990

Genus *Ambigostrea* Malchus, 1990

***Ambigostrea bretoni* (Thomas & Peron, 1891)**

Pl. 10, Figs. 3-4

1891 *Ostrea Bretoni* sp. nov. - Thomas & Peron *in* Peron, p. 197, pl. 25, figs. 37-39.

1990 *Ambigostrea bretoni* (Peron & Thomas) - Malchus, p. 179, pl. 21, figs. 13-25.

1996 *Ambigostrea bretoni* (Peron & Thomas) - El-Mahallawy, p. 163, pl. 20, figs. 6, 9-11.

Material and occurrence. 31 specimens from Gebel Ekma, Matulla Formation, phosphatic member, bed no. 26.

Measurements (in mm).

n=31	L	H	C	H/L	C/L	C/H
Range	12.3-24.5	20-34.5	4-11.5	1.34-1.67	0.24-0.38	0.18-0.36
Mean	17.8	28.3	6.4	1.52	0.29	0.26

Description. Shell relatively small, oval to suboval, higher than long, inflated, subequivalved to inequivalved. Left valve slightly flat to strongly convex. Right valve flat to slightly concave. Attachment area relatively large. Umbo pointed, orthogyrate; umbonal cavity very small to absent in some specimens. Ligamental area narrow, high, consisting of a triangular, broad, deep resilifer, flanked by equal, narrow, flat bourrelets. Relict chomata developed dorsally,

pustulose chomata developed all over the shell margins. Ornamentation consisting of numerous radial ribs intersected by irregular commarginal striations.

Age. Late Campanian.

Distribution in Egypt. Wadi Qena and Gebel Qabiliat.

Distribution outside Egypt. Tunisia and ?Libya.

Discussion. Malchus (1990) erected the genus *Ambigostrea* and placed it in his new tribe Ambigostreini and considered his new species *Ambigostrea pseudovillei* as the type species of this genus. According to its external morphology the genus *Ambigostrea* seems to be closely related to the subfamily Lophinae, but based on its simple-foliated microstructure Malchus (1990) attributed it as well as all radially (on one or both valves) ribbed *Lopha*-like oysters with simple-foliated microstructure to his new subfamily Liostrinae. Malchus (1990) erected also *A. dominici* and *A. pseudovillei* from the Cenomanian of Egypt. *A. bretoni* differs from these two species in being smaller and having a strongly convex shell, an additional difference being the stratigraphic position. The type material of *A. bretoni* comes from the Danian of Tunisia (Peron, 1891). According to Malchus (1990) *A. bretoni* is of Coniacian - Maastrichtian age, considering the stratum typicum as Maastrichtian, and regarding *Alectryonia destefanii* Parona, 1923 from the Coniacian - Santonian of Libya as a synonym. So far, *A. bretoni* has not been recorded from Egypt from levels below or above the Campanian.

Ambigostrea pseudovillei Malchus, 1990

Pl. 10, Figs. 5a-b, 6, 7a-b, 8-10; pl. 11, figs. 1a-b, 2a-b; Text-Fig. 32A

1990 *Ambigostrea pseudovillei* sp. nov. - Malchus, p. 178, pl. 21, figs. 4-12.

1990 *Ambigostrea dominici* sp. nov. - Malchus, p. 179, pl. 21, figs. 1-3.

1996 *Ambigostrea dominici* Malchus - El-Mahallawy, p. 164, pl. 20, figs. 1-5.

1996 *Ambigostrea pseudovillei* Malchus - El-Mahallawy, p. 166, pl. 20, figs. 7-

8.

? 1999 *Ambigostrea* sp. - Seeling & Bengtson, p. 762, fig. 11d.

Material and occurrence. 66 specimens from Gebel Ekma, Raha Formation, bed no. 6, and 12 specimens from Gebel Yelleg, Galala Formation, bed no. 31.

Measurements (in mm).

n=78	L	H	C	H/L	C/L	C/H
Range	10-37	17.5-43	5-15	1.1-1.84	0.36-0.52	0.26-0.39
Mean	23.3	27.8	9.1	1.42	0.41	0.32

Description. Shell small to medium-sized, triangular to oval, higher than long, feebly inflated, subequivalved to inequivalved. Left valve moderately convex to flat. Right valve flat, slightly concave, in some specimens slightly convex. Umbo relatively blunt, opisthogyrate. Umbonal cavity absent. Ligamental area higher than long, triangular, pointed and oftenly slightly curved. Adductor muscle scar kidney- to comma-shaped and situated postero-ventrally to postero-centrally. Relict chomata often well developed dorsally, catachomata moderately to well developed at least till the height of the adductor scar. Ornamentation consisting of simple or sometimes dichotomous radial ribs, which vary widely in number (16-48) and strength. At the umbo the ribs are fine or absent, becoming coarse ventrally. The radials are crossed by irregular, fine, commarginal growth striations.

Age. Late Cenomanian.

Distribution in Egypt. Wadi Qena, El-Bahariya Oasis and Gebel Qabiliat.

Distribution outside Egypt. ? Brazil.

Discussion. Malchus (1990) erected the genus *Ambigostrea* and designated his new species *A. pseudovillei* from the Cenomanian of Wadi Qena as the type species. He also erected a second species, *A. dominici*, based on only six left valves from El Bahariya Oasis from nearly the same stratigraphic level. According to him, the latter species differs from the first one mainly in having

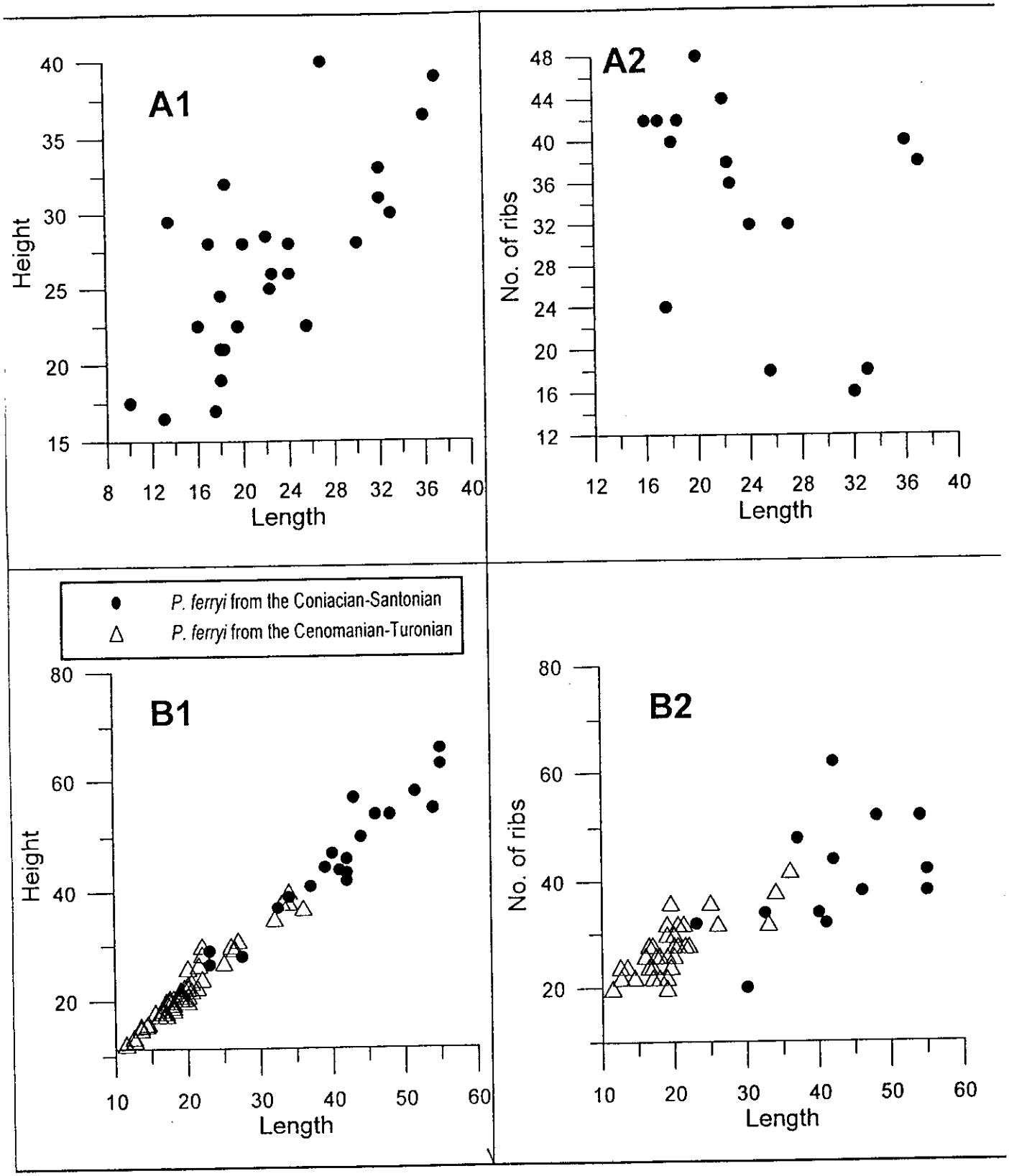


Figure 32. Biometric data on *Ambigostrea pseudovillei* (A), and *Plicatula ferryi* (B).

many fine radial ribs. He remarked that in older marine Cenomanian sediments of Wadi Qena poorly preserved forms transitional between *A. pseudovillei* and *A. dominici* might exist, while in younger sediments there is only *A. pseudovillei*. For the present study both forms (10 specimens belong to *dominici* and 41 specimens belong to *pseudovillei*) and 15 intermediate specimens have been collected from a single bed in the lower Upper Cenomanian (*Neolobites vibrayeanus* Zone) in Gebel Ekma. In Gebel Yelleg, only *A. pseudovillei* is present at the same stratigraphic level. This suggests that *A. pseudovillei* and *A. dominici* are only two variants of the same species with *pseudovillei* having priority. Whereas *A. pseudovillei* forma *typica* is characterized by having thick and few radial ribs, forma *dominici* is characterized by numerous fine radial ribs. In large population (Figure 32A), as at Gebel Ekma, it is very difficult to distinguish between these two forms, the number of ribs and consequently their thickness varying very widely (16-48). As *pseudovillei* has the priority, *A. dominici* is considered a junior synonym of *A. pseudovillei*.

Subfamily Lophinae Vyalov, 1936

Genus *Oscillopha* Malchus, 1990

***Oscillopha dichotoma* (Bayle, 1849)**

Pl. 11, Figs. 3, 4a-b

1849 *Ostrea dichotoma* sp. nov. - Bayle, p.365, pl. 18, figs. 17-18.

1869 *Ostrea dichotoma* Bayle - Coquand, p. 99, pl. 27, figs. 1-6.

1903 *Alectryonia semiplana* Sowerby - Dacqué, p. 366, pl. 34, figs. 1-4.

1904 *Ostrea dichotoma* Bayle - Fourtau, p. 294, pl. 4, figs. 1-2.

1912 *Alectryonia dichotoma* Bayle - Pervinquière, p. 206, pl. 14, figs. 19-21.

1917 *Ostrea dichotoma* Bayle - Fourtau, p. 35, pl. 5, fig. 8.

1917 *Alectryonia dichotoma* Bayle - Greco, p. 144 (164).

1962 *Lopha dichotoma* (Bayle) - Abbass, p. 81, pl. 11, fig. 2.

1987b *Oscillopha* (*Actinostreon*) *dichotoma* (Bayle) – Kora & Hamama, pl. 1,

fig. 5.

1990 *Oscillopha dichotoma* (Bayle) - Malchus, p. 103, pl. 1, figs. 5-9 .

1992 *Oscillopha dichotoma* (Bayle) - Abdel-Gawad & Zalat, pl. 5, fig. 6.

1993 *Oscillopha dichotoma* (Bayle) - Aqrabawi, p. 90, text-fig. 46a-c.

1996 *Oscillopha dichotoma* (Bayle) - El-Mahallawy, p. 158, pl. 19, fig. 1.

2002 *Oscillopha dichotoma* (Bayle) – Kora *et al.*, pl. 3, fig. 1.

2002 *Oscillopha dichotoma* (Bayle) - Abdelhamid & El Qot, p. 272, pl. 4, fig. 2

Material and occurrence. 83 specimens from the East Themed area, Themed Formation, bed no. 35, and 6 specimens from the same formation at Gebel Yelleg, bed no. 58.

Measurements (in mm).

N=89	L	H	C	H/L	C/L	C/H
Range	27.5-74	39-120	7.5-57	1.32-1.69	0.23-0.78	0.17-0.51
Mean	52.3	81.2	28.3	1.53	0.43	0.35

Description. Shell medium- to large-sized, oval to suboval, higher than long, subequivalved. Umbo slightly to strongly twisted posteriorly. Ligamental area longer than high, triangular and relatively large in size. Resilifer relatively long and deep. Adductor muscle scar relatively large, deep, kidney-shaped to suboval and situated postero-ventrally. Ornamentation consisting of a variable number of strong radial ribs, separated by deep V-shaped furrows nearly as wide as the ribs themselves. These ribs are crossed by imbricated commarginal lamellae.

Age. Coniacian-Santonian.

Distribution in Egypt. Abu Roash, Wadi Sudr, Saint Antony, W. Askhar El-Bahariya, W. Matulla, Gebel El-Hamra and G. El-Minsherah.

Distribution outside Egypt. Europe, North Africa, Madagascar, Middle East and Iran.

Discussion. Malchus (1990: p. 101) assumed that the Cenozoic Lophinae developed independently from similar Mesozoic forms, for which he proposed the new family Palaeolophidae based on his new genus *Palaeolopha*, with the

Rhaetic *Ostrea haidingeriana* Emmrich, 1853 as the type species. The new family was separated from Recent *Lopha* chiefly by its strongly lenticular simply-foliated shell microstructure ('simple-foliated calcite with structural chambers, sometimes filled with chalky substance') and by the rarity of chomata. According to Hautmann (2001: p. 359) a consistent separation of both groups is not possible on basis of these characters. Moreover, he added that *Palaeolopha* is considered a junior synonym of *Actinostreon* Bayle, 1878. Consequently, the genus *Oscillopha* Malchus, 1990 is referred to family Ostreidae, subfamily Lophinae.

Different views exist concerning the taxonomic status of *Ostrea semiplana* J. de C. Sowerby, 1825, *Ostrea armata* Goldfuss, 1833, and *Ostrea dichotoma* Bayle, 1849. Dacqué (1903) regarded these three oysters as synonyms and referred them to *semiplana* which has priority. Fourtau (1904) considered these oysters as three different species depending mainly on the difference in outline and ornamentation. Woods (1912) considered *armata* as a synonym of *semiplana* and included *O. dichotoma* from the Santonian of Abu Roash which Dacqué (1903) had misidentified as *Alectryonia semiplana*, in his list of synonymies but did not include *dichotoma*. Aqrabawi (1993) regarded *O. dichotoma* as very similar to *Ostrea armata* Goldfuss (1833: p. 12, pl. 76, fig. 3) from the Greensand of Westfalia, Germany and included it in his list of synonymies. As the description by Goldfuss (1833) matches that of *O. dichotoma*. Aqrabawi (1993) included *O. armata* in synonymy list and used *Oscillopha dichotoma* without reason. *O. armata* in Goldfuss (1833) shows only an external left valve, but *O. armata* Goldfuss in Holzapfel (1889) shows well developed chomata, a smaller ligamental area and shallower resilifer than that of *Oscillopha dichotoma*. Thus, *O. armata* is morphologicaly relatively similar to *Hyotissa semiplana* J. de C. Sowerby, 1825 but there is a clear difference, which is the position of the adductor muscle scar, which in *O. armata* of Holzapfel (1889: p. 253, pl. 28, figs. 1-2) is postero-ventrally. In

contrast, all the figures. of *H. semiplana* in Woods (1912: p. 379, pl. 56, figs. 17-19; pl. 57, figs. 1-13; pl. 58, figs. 1-5 and text-figs. 183-193) show the position of adductor scar is postero-dorsally except the specimen on pl. 58, fig. 4b where it is postero-centrally. Moreover, Stenzel (1971) introduced the new genus *Hyotissa* based on its vesicular shell structure and placed it in the subfamily Pycnodontinae Stenzel, 1959. He considered *Ostrea semiplana* as being related to this genus. Consequently, the present author regards the oysters; *O. armata*, *O. semiplana*, and *O. dichotoma* as three different species.

The phylogenetic relationship between *O. dichotoma* and forms near to it was discussed by Fourtau (1917), who considered the Cenomanian *Ostrea syphax* Coquand, 1854 to be the ancestral form of *Ostrea dichotoma* of the Santonian. According to Abbass (1962) the greatest elongation in *Ostrea syphax* is near the dorsal margin, while in *Lopha dichotoma* it lies near the ventral margin.

Aqrabawi (1993: p. 58, pl. 1, figs. 1-7) erected *Oscillopha wala* from the Turonian of Wadi Wala, Central Jordan, and distinguished his new species from *O. dichotoma* by its narrower form and by the short sharp ribs that tend to curve toward both posterior and anterior ends. He also distinguished *O. dichotoma* from *Oscillopha figari* (Fourtau, 1904).

Oscillopha dichotoma ranges from the Coniacian to the Campanian age.

Genus *Rastellum* Faujas-Saint-Fond, 1799

Rastellum carinatum (Lamarck, 1806)

Pl. 11, Figs. 5a-b, 6-7

1806 *Ostrea carinata* sp. nov. - Lamarck, p. 166.

1871 *Ostrea* (*Alectryonia*) *carinata* Lamarck - Stoliczka, p. 468, pl. 48, fig. 5; pl. 49, figs. 1-2.

1913 *Ostrea diluviana* Linneaus - Woods, p. 342, text-figs. 98-108, 110-114, 116, 122-123, 127-133, 135-138, non figs. 115, 118-119, 124-125; text-

fig. 109.

1918 *Alectryonia* (*Arctostrea*) *diluviana* Linneaus - Greco, p. 14 (196), pl. 2 (18), fig. 14, non fig. 13.

1971 *Rastellum* (*Arctostrea*) *carinatum* (Lamarck) - Stenzel, p. N1165, fig. J139 /2a-c.

1986 *Rastellum* (*Arctostrea*) *carinatum* (Lamarck) - Freneix & Viaud, p. 49, pl. 6, fig. 1.

1992 *Rastellum* (*Arctostrea*) *carinatum* (Lamarck) - Abdel-Gawad *et al.*, p. 324.

1993 *Rastellum carinatum* (Lamarck) - Aqrabawi, p. 94, text- fig. 47: a-d, f-g.

2001b *Rastellum* (*Arctostrea*) *carinatum* (Lamarck) - Kora *et al.*, pl. 1, fig. 5.

2002 *Rastellum* (*Arctostrea*) *carinatum* (Lamarck) – Abdel Gawad & Gameil, p. 88, pl. 2, fig. 13.

Material and occurrence. 28 specimens from Gebel Yelleg, Raha Formation, bed no. 38.

Measurements (in mm).

n=28	L	H	C	H/L	C/L	C/H
Range	17-35	55-78	30-35	2.1-3.45	1.0-1.76	0.44-0.58
Mean	23.7	67.5	33.6	2.86	1.35	0.51

Description. Shell medium to large-sized, crescentic to sickle- or comma-shaped with well developed posterior ear and poorly developed anterior ear, subequivalved. Umbones small, with a slight to moderate posterior curvature. Triangular ligament-pit slightly curved. Margins of the valves strongly carinated with sharp pointed tips forming zigzag valve edges, commissure strongly serrated. Sculpture composed of many angular ribs that extend from the median ridge to the margin; the ribs may cary sharp spines.

Age. Late Cenomanian.

Distribution in Egypt. Wadi Araba, Gebel Nezzazat, and W. Abu Had.

Distribution outside Egypt. Cosmopolitan.

Discussion. Stenzel (1971) subdivided the genus *Rastellum* into the subgenera *R.* (*Arctostrea*) and *R.* (*Rastellum*) and mentioned that the distiction between *R.* (*Arctostrea*) and *R.* (*Rastellum*) is uncertain. Therefore, the present author follows Aqrabawi (1993) and afrains from placing *Ostrea carinata* Lamarck into one of these subgenera. *R. carinatum* is a cosmopolitan species and ranges from the Upper Néocomian to the Cenomanian, but it is restricted to the Cenomanian of Africa (Freneix & Viaud 1986).

Family Chondrodontidae Freneix, 1959

Genus *Chondrodonta* Stanton, 1901

Chondrodonta joannae (Choffat, 1886)

Pl. 12, Figs. 1, 12; Text-Fig. 8

1886 *Ostrea Joannae* sp. nov. - Choffat, p. 34, pl. Osteridae 1, figs. 1-7; pl. Osteridae 2, figs. 8-9.

1917 *Chondrodonta Joannae* Choffat - Fourtau, p. 13.

1934 *Ostreavicula* n. g. *dayi* n. sp. - Blanckenhorn, p. 179, pl. 7, figs. 3, 4.

1934 *Chondrodonta joannae* (Choffat)- Blanckenhorn, p. 204.

1971 *Chondrodonta* (*Chondrodonta*) *joannae* (Choffat) - Stenzel, p. N1198, fig. J149/1a-b.

1992 *Chondrodonta joannae* (Choffat) - Dhondt & Dieni, p. 212, figs. 2-3.

1993 *Chondrodonta joannae* (Choffat) - Dhondt & Dieni, p. 210, pl. 14, figs. 1-3; pl. 15, figs. 1-10; pl. 16, figs. 1-5; pl. 17, Figs. 1-5; pl. 18, figs. 1-7; pl. 19, figs. 1-5; text-figs. 15-17 (with extensive synonymy).

Material and occurrence. 12 incomplete specimens from the East Themed area, Galala Formation, bed no. 6; and 57 specimens from Gebel Yelleg, Galala Formation, beds no. 11, 19, 21, 23, 25, 27, 30, 32, and 34.

Measurements (in mm).

n=69	L	H	C	H/L	C/L	C/H
Range	17-86	55-130	11-37	1.42-3.53	0.38-0.63	0.20-32
Mean	51.6	97.4	33.2	2.26	0.45	0.24

Description. Shell medium to large-sized, variable in outline. Right valve convex, somewhat smaller than the left one. Left valve slightly concave to flat. Umbonal area often deflected laterally. Plane of commissure silghtly undulating. The surface of the shell plicated, plicae starting in the umbonal region, some are straight but the most diverge laterally, their number increasing strongly through division or intercalation. The plications are sharp and angular, the intercostal areas narrow and deep.

Age. Cenomanian.

Distribution in Egypt. Gebel Shabrawit.

Distribution outside Egypt. Southern Europe, Somalia, the Middle East, Oman, and western Pakistan.

Discussion. The high morphologic variability of *Chondrodonta joannae* (Choffat) led many authors to established new taxa which actually are junior synonyms. Among those are Blanckenhorn (1934) who erected *Ostreavicula dayi* as new genus and new species from the Turonian of Syria, which was included by Freneix & Lefévre (1968) in the genus *Chondrodonta*. However, this fact not included in the *Treatise* (Cox *in* Moore 1969: p. N865) whereas the genus *Ostreavicula* Blanckenhorn, 1934 was regarded as being of uncertain affinity. Boehm (1895) created two new taxa, *Ostrea schiosensis* and *Terquemia forojuliensis*, which were placed with *Chondrodonta* by Stanton (1901) and Freneix & Lefévre (1968). Dhondt & Dieni (1993) regarded the two species of Boehm and *O. dayi* are synonyms of *Chondrodonta joannae*.

Stenzel (1971) recognised three subgenera of *Chondrodonta*; *C.* (*Chondrodonta*), *C.* (*Freneixita*), and *C.* (*Cleidochondrela*). The present material consists either of articulated valves or of single valves in which the

hinge is not visible. For this reason the present author follows Dhondt & Dieni (1993) and places the present species only at the generic level.

Dhondt & Dieni (1993), in their disscussion of the stratigraphic range of *Chondrodonta joannae*, mentioned that the rudist beds, in which *C. joannae* occurs, formerly have been dated as Late Cenomanian to Turonian in age, but that new stratigraphic data suggest that the species is present only in Late (but not latest) Cenomanian. In the present study, *C. joannae* has been recorded from the *Nerinea gemmifera - Praeradiolites biskraensis* - corals Acme Zone of the Late Cenomanian of the East Themed area. In Gebel Yelleg, where the reefal facies is very well represented. It has been recorded from the *Eoradiolites liratus* Zone of the Early Cenomanian till just below the topmost Cenomanian. Russo *et al.* (1991) recorded *C. joannae*, associated with *Eoradiolites liratus* (Conrad, 1852), from the Early-Middle Albian of Somalia. According to Dhondt & Dieni (1993) these *C. joannae* beds are Cenomanian in age, arguing that *E. liratus* does not occur as early as the Albian. While Dhondt & Dieni (1993) statement holds true for the occurrence of *liratus* in Egypt, the older age of the Somalia material can not be refuted, because *E. liratus* does, in fact, occur also in the Albian (Coord *et al.* in Hardenbol *et al.* 1998). Thus, *C. joannae* appears to occur from the Albian to the Cenomanian.

Superfamily Plicatulacea Watson, 1930

Family Plicatulidae Watson, 1930

Genus *Plicatula* Lamarck, 1801

***Plicatula auressensis* Coquand, 1862**

Pl. 12, Figs. 2a-c, 3-4

1862 *Plicatula auressensis* sp. nov. - Coquand, p. 222, pl. 16, figs. 14-16.

1862 *Plicatula Reynesi* sp. nov. - Coquand, p. 222, pl. 17, figs. 1-2.

1912 *Plicatula Auressensis* Coquand - Pervinquière, p. 156, pl. 11, figs. 2-18.

1917 *Plicatula auressensis* Coquand - Fourtau, p. 20.

1934 *Plicatula reynesi* Coquand - Blanckenhorn, p. 193.

1937 *Plicatula auressensis* Coquand -Trevisan, p. 60, pl. 3, figs. 5-10.

1962 *Plicatula auressensis* Coquand - Abbass, p. 61, pl. 7, figs. 17-19.

1962 *Plicatula reynesi* Coquand - Abbass, p. 62, pl. 7, figs. 8-14

1963 *Plicatula auressensis* Coquand - Fawzi, p. 32.

1972 *Plicatula auressensis* Coquand - Freneix, p. 82, pl. 4, figs. 7-10.

1996 *Plicatula auressensis* Coquand - El-Mahallawy, p. 83, pl. 1, fig. 11.

1996 *Plicatula reynesi* Coquand - El-Mahallawy, p. 89, pl. 2, fig. 6.

Material and occurrence. 45 specimens from Gebel Ekma, 28 from the Raha Formation ,beds no.4-6 and 9; 17 specimens from the Abu Qada Formation, bed no. 10. 32 specimens from the East Themed area, Abu Qada Formation, beds no. 9 and 11.

Measurements (in mm).

N=77	L	H	C	nr	H/L	C/L	C/H
Range	12.7-40	14-37	4.5-9.3	10-18	0.92-1.33	0.23-0.38	0.21-0.35
Mean	22.1	22.6	5.5	14.47	1.1	0.30	0.26

Description. Shell small- to medium-sized, inequivalved, mostly inequilateral, varying in outline from oval, triangular or pear-shaped to nearly rounded. Anterior margin concave. Posterior margin convex. Right valve mostly convex. Left valve either flat, convex, or concave. Umbo low and small. Attachment area variable in size. Ornamentation consisting of strong, relatively few radial ribs, occasionally carrying long spines near the ventral margin. These radials are crossed by commarginal lamellae at irregular intervals. The radial ribs may bifurcate at two-thirds of the distance from the umbo to the ventral margin.

Age. Late Cenomanian-Early Turonian.

Distribution in Egypt. El-Bahariya Oasis, Gebel Safariat, Wadi Esba, W. Saifa, G. Nezzazat, G. Qabaliat, G. El-Minsherah, and G. El-Hamra.

Distribution outside Egypt. The Middle East, North Africa, Angola, Madagascar, Niger, Cameron, Southern Europe, and Southern America.

Discussion. Coquand (1862) erected *Plicatula auressensis* and *Plicatula reynesi* from the same stratigraphic level (''Rhotomagien'' = Cenomanian) with *auressensis* being oval in outline and *reynesi* being rounded and having finer radials. Based on the high variability of the present material within the same beds (beds no. 9 and 10 of G. Ekma; beds no. 9 and 11 of the East Themed area) the present author agrees with Pervinquière (1912), Fourtau (1917), Fawzi (1963), and Freneix (1972) that *P. reynesi* is a synonym of *P. auressensis*.

The species ranging from the Albian to the Senonian, is widespread in the Cenomanian.

Plicatula ferryi Coquand, 1862

Pl. 12, Figs. 5-6, 7a-b, 8, 9a-b, 10; Text-Fig. 32B

1862 *Plicatula Ferryi* sp. nov. - Coquand, p. 221, pl. 16, figs. 7-10.

1880 *Plicatula Batnensis* sp. nov. - Coquand, p. 162, (photo Heinz: pl. 3).

1891 *Plicatula Batnensis* Coquand - Peron, p. 205, pl. 26, fig. 16.

1891 *Plicatula Ferryi* Coquand - Peron, p. 207, pl. 26, figs. 18-19.

1903 *Plicatula Ferryi* Coquand - Dacqué, p. 361.

1904 *Plicatula Batnensis* Coquand - Fourtau, p. 312.

1904 *Plicatula Ferryi* Coquand - Fourtau, p. 313, pl. 3, figs. 2-3.

1912 *Plicatula Ferryi* Coquand - Pervinquière ,p. 160, pl. 9, fig. 22a-b; pl. 12, figs. 6-14.

1912 *Plicatula Batnensis* Coquand - Pervinquière, p. 162, pl. 9, fig. 21a-c.

1917 *Plicatula batnensis* Coquand - Fourtau, p. 22.

1917 *Plicatula Ferryi* Coquand - Fourtau, p. 22.

1934 *Plicatula ferryi* Coquand - Blanckenhorn, p. 194.

1962 *Plicatula ferryi* Coquand - Abbass, p. 63, pl. 7, figs. 1-5, 26.

1963 *Plicatula* aff. *batnensis* Coquand - Fawzi, p. 33.

1972 *Plicatula* cf. *batnensis* Coquand - Freneix, p. 83, pl. 4, fig. 12a-b.

1987b *Plicatula ferryi* Coquand - Kora & Hamama, pl. 1, fig. 6.

1992 *Plicatula ferryi* Coquand - Abdel-Gawad & Zalat, pl. 5, fig. 2.

1996 *Plicatula batnensis* Coquand - El-Mahallawy, p. 84, pl. 2, fig. 1.

1996 *Plicatula ferryi* Coquand - El-Mahallawy, p. 86, pl. 1, fig. 12.

1998 *Plicatula ferryi* Coquand - El-Sheikh *et al.*, pl. 2, fig. h.

2001 *Plicatula ferryi* Coquand - El-Hedeny *et al.*, p. 299, fig. 3/a-d.

2002 *Plicatula ferryi* Coquand - Kora *et al.*, pl. 2, fig. 8.

Material and occurrence. 20 specimens from Gebel Ekma; 10 from the Raha Formation, beds no. 4-6, 2 specimens from the Wata Formation, bed no. 17, and 8 specimens from the Matulla Formation, beds no. 25 and 26. 110 specimens from the East Themed area; 85 specimens from the Abu Qada Formation, beds no. 9, 11, 12, 25 and 41 non measured specimens from the Themed Formation, beds no. 35 and 37. 3 specimens from Gebel Yelleg, Themed Formation, bed no. 58.

Measurements (in mm).

n=133	L	H	C	nr	H/L	C/L	C/H
Range	11.4-56.5	12.3-66	3.6-19.5	20-62	1.0-1.32	0.15-0.50	0.14-0.40
Mean	32.4	36.7	8.2	42	1.20	0.27	0.22

Description. Shell varying in size from small to large, varying in outline from triangular, pear-shaped, or oval to subrounded, equilateral, slightly to moderately inflated, slightly inequivalved, with the right valve slightly more convex than the left one. Umbo low, not terminal and obscured in some specimens by the attachment area. Attachment area variable in size. Ventral margin rounded and crenulated. Ornamentation consisting of numerous radial ribs separated by wider interspaces. These ribs are crossed by commarginal growth lamellae. At their points of intersection scaly tubercles are produced, which commonly become spinose on the ventral part of the shell.

Age. Late Cenomanian - Early Campanian.

Distribution in Egypt. Abu Roash, El-Bahariya Oasis, Wadi Dakhl, W. Dib, W. Tarfa, G. Abu Edeimat, W. Um Hamaiet, W. Sudr, Bir Safra, Saint Paul, W.

Rigbeh, Ain Areydah, G. Um Heriba, G. Nezzazat, G. Qabaliat, and G. El-Hamra.

Distribution outside Egypt. Nortrh Africa and the Middle East.

Discussion. The great similarity of *Plicatula ferryi* Coquand, 1862 and *P. batnensis* Coquand, 1880 led Abbass (1962) to consider *P. batnensis* as a variety of *P. ferryi*. According to him *batnensis* differs only in being more inflated. Peron (1891) and Pervinquière (1912) recorded *P. ferryi* from the Turonian-Campanian of Tunisia. Pervinquière (1912) recorded *P. batnensis* from the Cenomanian and Lower Turonian of Tunisia.

After examining numerous individuals that belong to both aforementioned forms from the Cenomanian to Campanian, the present author noticed that *ferryi* differs only in having a relatively large attachement area and in being generally larger. Considering that the two forms have nearly the same morphology and that there is a gradually increase in size stratigraphically from the Cenomanian-Turonian forms to the Coniacian-Santonian ones (Figure 32B) the present author agrees with Abbass (1962) and considers *P. batnensis* as a junior synonym of *P. ferryi*. Consequently, *P. ferryi* is regarded as an ecomorph of *P. batnensis*.

Plicatula fourneli Coquand, 1862

Pl. 12, Figs. 11, 13

1862 *Plicatula Fourneli* sp. nov. - Coquand, p. 220, pl. 16, figs. 5-6.

1904 *Plicatula Fourneli* Coquand - Fourtau, p. 311.

1912 *Plicatula Fourneli* Coquand - Pervinquière, p. 153, pl. 10, figs. 2-6.

1917 *Plicatula Fourneli* Coquand - Fourtau, p. 22.

1918 *Plicatula Fourneli* Coquand - Greco, p. 21 (203).

1934 *Plicatula fourneli* Coquand - Blanckenhorn, p. 193.

1937 *Plicatula Fourneli* Coquand - Trevisan, p. 62, pl. 3, fig. 11a-c.

1962 *Plicatula fourneli* Coquand - Abbass, p. 59, pl. 7, fig. 15.

1972 *Plicatula fourneli* Coquand - Freneix, p. 83, pl. 4, fig. 11.

1996 *Plicatula fourneli* Coquand - El-Mahallawy, p. 87, pl. 2, fig. 5.

2002 *Plicatula fourneli* Coquand - Abdel Gawad & Gameil, p. 84, pl. 1, fig. 21.

Material and occurrence. 4 specimens from Gebel Ekma, Raha Formation, beds no. 5, 6.

Measurements (in mm).

N=4	L	H	C	nr	H/L	C/L	C/H
Range	14-23	15.5-26	4.3-7.2	18	1.1-1.18	0.24-0.33	0.21-0.28
Mean	20	22.6	5.6	18	1.15	0.29	0.25

Description. Shell small- to medium-sized, pear-shaped, usually higher than long, inequivalved, inequilateral, anterior margin concave, while the posterior margin convex. Dorsal valve less convex than ventral one. Ornamentation consisting of fine, tuberculated radial ribs, separated by interspaces, three to five times the width of the ribs. The inter-radial spaces are occupied by three to five secondary radial ribs which are crossed by commarginal threads.

Age. Late Cenomanian.

Distribution in Egypt. Saint Paul, Wadi Dakhl, and Sinai.

Distribution outside Egypt. Nortrh Africa, Niger, Nigeria, the Middle East, and Sicily.

Discussion. *Plicatula fourneli* Coquand was erected on material from the Cenomanian of Algeria and until now has not been recorded from younger beds in Egypt. Freneix (1972) recorded it from the Cenomanian and Lower Turonian of Morocco and pointed out that it occurs within rocks of the same age in Niger and Nigeria. Blanckenhorn (1934) recorded it from the Cenomanian and Santonian of Palestine. Consequently, the present species is widespread in the Cenomanian but may extend to the Santonian.

Order Pectinoida Newell & Boyd, 1995 (= Pectinina Waller, 1978)

Superfamily Pectinacea Wilkes, 1810

Family Pectinidae Wilkes, 1810

Genus *Camptonectes* Agassiz in Meek, 1864

Camptonectes virgatus (Nilsson, 1827)

Pl. 12, Figs. 14-15

1827 *Pecten virgatus* sp. nov. - Nilsson, p. 22, pl. 9, fig. 15.

1862 *Pecten virgatus* Nilsson - Coquand, p. 299.

? 1871 *Pecten* (*Camptonectes*) *curvatus* Geinitz - Stoliczka, p. 433, pl. 31, figs. 15-16; pl. 41, figs. 4-6.

1882 *Pecten dichotomus* sp. nov. - Seguenza, p. 150, pl. 15, fig. 4.

1889 *Pecten virgatus* Nilsson - Holzapfel, p. 229, pl. 26, figs. 7-9.

1902 *Pecten*(*Camptonectes*) *curvatus* Geinitz - Woods, p. 159, pl. 29, fig. 7; pl. 37, fig. 16.

1912 *Pecten* (*Camptonectes*) *virgatus* Nilsson - Pervinquière, p. 143.

1937 *Pecten* (*Camptonectes*) *dichotomus* Seguanza - Trevisan, p. 58, pl. 3, fig. 4.

1937 *Pecten* (*Camptonectes*) *virgatus* Nilsson - Lehner, p. 184, pl. 23, fig. 6, pl. 24, fig. 6.

1984 *Camptonectes virgatus* (Nilsson) - Dhondt, p. 849.

1986 *Camptonectes* (*Camptonectes*) *virgatus* (Nilsson)- Abdel-Gawad, p. 151, pl. 32, fig. 16.

1993 *Camptonectes virgatus* (Nilsson) - Dhondt & Dieni, p. 188, pl. 4, fig. 12.

Material and occurrence. 3 specimens from East Themed area, Abu Qada Formation; 1 specimen from bed no. 10; 1 incomplete right valve and 1 left valve from bed no. 11.

Measurements (in mm).

n=3	L	H	H/L
Range	9.5-30	10.3->32	0.93-1.08
Mean	20.8	21.5	1.02

Age. Early Turonian.

Remarks. The studied material was identified mainly based on the characteristic ornamentation, which shows the typical divaricate striae of *Camptonectes*. The left valve is identical in the general shape and ornamentation to *Pecten virgatus* Nilsson as described by Holzapfel (1889). In contrast, the right valves are identical to *Pecten* (*Camptonectes*) *dichotomus* Seguanza from the Cenomanian of Sicily (Trevisan 1937). As specimens of the two species occur in the same bed (bed no. 11) the present author agrees with Dhondt & Dieni (1993) and considers *C. dichotomus* as a junior synonym of *C. virgatus*.

There is much confusion among authors (e.g. Stoliczka 1871, Holzapfel 1889, and Woods 1902) about *Camptonectes virgatus* (Nilsson) and *C. curvatus* (Geinitz, 1843). The main reason for this is the gradually variation in the thickness of the radial ribs. Moreover, Stoliczka (1871) in his description of *C. curvatus* mentioned that the radiating striae of the right valve are, as a rule, finer than those on the left valve. The great similarity between the present material and *C. curvatus* as illustrated by Stoliczka (1871) and Woods (1902) suggests that *C. curvatus* may also be a synonym of *C. virgatus*. However, to clarify this point more material from different localities is needed.

C. virgatus is widely distributed in shallow water deposits of the Cenomanian - Maastrichtian (Dhondt &Dieni 1993: p. 188, text-fig. 2).

Subfamily Neitheinae Sobetskij, 1960

Genus *Neithea* Drouet, 1824

Subgenus *Neithea* Drouet, 1824

***Neithea* (*Neithea*) *dutrugei* (Coquand, 1862)**

Pl. 12, Figs. 16-17

1862 *Janira Dutrugei* sp. nov. - Coquand, p. 219, pl. 13, figs. 1-2.

1918 *Pecten* (*Neithea*) *Dutrugei* Coquand - Greco, p. 24 (206), pl. 3 (19), figs.7-9 .

1973 *Neithea* (*Neithea*?) *dutrugei* (Coquand) – Dhondt, p. 59, pl. 4, fig. 3; pl. 5, fig 4.

1984 *Neithea* (?) *dutrugei* (Coquand) - Dhondt, p. 851.

1992 *Neithea dutrugei* (Coquand) - Abdel-Gawad & Zalat, pl. 2, fig. 3.

1993 *Neithea* (*Neithea*) *dutrugei* (Coquand) - Dhondt & Dieni, p. 190, pl. 4, fig. 17.

2002 *Neithea dutrugei* (Coquand) - Abdelhamid & El Qot, p. 263, pl .2, fig. 1.

Material and occurrence. 3 specimens from Gebel Ekma, Raha Formation; 2 right valves from beds no. 4 and 5 and 1 incomplete left valve from bed no. 6.

Measurements (in mm).

N=2	L	H	H/L
Range	22-23	23-25	1.05-1.09
Mean	22.5	24	1.07

Description. Shell small- to medium-sized, oval to triangular, inequilateral, inequivalved. Right valve slightly concave. Left valve strongly convex. Umbo incurved. Ventral margin strongly convex, crenulated. Ornamentation consisting of strong, tripartite principal ribs. Every two principal ribs enclose five intercalated ribs, of which the middle one is more strongly developed. These radials are crossed by commarginal striae.

Age. Late Cenomanian.

Distribution in Egypt. Wadi Araba, Gebel Um Heriba, G. El-Minsherah and G. El-Hamra.

Distribution outside Egypt. *Neithea dutrugei* (Coquand) is a typical Tethyan species characterising the Cenomanian to the Campanian of North Africa, the Middle East, and Southern Europe.

Family Spondylidae Gray, 1826

Genus *Spondylus* Linné, 1758

Spondylus fimbriatus Goldfuss, 1835

Pl. 13, Figs. 1a-b, 2

1835 *Spondylus fimbriatus* nobis - Goldfuss, p. 97, pl. 106, fig. 2.

1847 *Spondylus dutempleanus* sp. nov. - d'Orbigny, p. 672, pl. 460, figs. 6-11.

1889 *Spondylus dutempleanus* d'Orbigny - Holzapfel, p. 244, pl. 27, figs. 8-10.

1901 *Spondylus dutempleanus* d'Orbigny - Woods, p. 125, pl. 22, figs. 11-14; pl. 23, figs. 1-5.

1962 *Spondylus dutempleanus* d'Orbigny - Abbass, p. 57, pl. 6, figs. 18-23.

1986 *Spondylus dutempleanus* d'Orbigny - Abdel-Gawad, p. 156, pl. 35, figs. 1-3.

1990 *Spondylus fimbriatus* Goldfuss - Dhondt & Dieni, p. 169, pl. 1, fig. 1; pl. 3, figs. 1-6; text-figs. 2-3, 8-9 (with full synonymy).

Material and occurrence. 4 specimens from Gebel Ekma, Matulla Formation, shaly member, bed no. 24.

Measurements (in mm).

4	L	H	C	H/L	C/L	C/H
Range	12.7-47	14-64	5.5-24	0.92-1.33	0.43-0.51	0.39-0.46
Mean	31.1	38.6	16.5	1.16	0.47	0.42

Description. Shell small to medium-sized; oval to rounded in outline; mostly equilateral to inequilateral depending on the shape of the attachement area, inequivalved. Left valve generally convex. Right valve varying from flat to strongly convex. Ornamentation consisting of numerous, irregularly placed and rarely straight radial ribs with narrow intercostal grooves; primary ribs separated by a variable number of narrower secondary ones.

Age. Early Santonian.

Distribution outside Egypt. Europe and Southern India.

Discussion. In Europe, *Spondylus fimbriatus* Goldfuss ranges from the Cenomanian to the Maastrichtian. Abbass (1962) recorded *Spondylus dutempleanus* d'Orbigny from the Campanian of El-Bahariya Oasis, Western Desert of Egypt. Dhondt & Dieni (1990) considered *S. dutempleanus*

d'Orbigny, 1847 as a junior synonym of *S. fimbriatus* Goldfuss. At Gebel Ekma, the species is associated with *Cladoceramus undulatoplicatus* Roemer and some specimens are cemented to its shell. For an extensive description and discussion see Dhondt & Dieni (1990).

Subclass Heteroconchia Hertwig, 1895

Superorder Palaeoheterodonta Newell, 1965

Order Trigonioida Dall, 1889

Superfamily Trigoniacea Lamarck, 1819

Family Trigoniidae Lamarck, 1819

Genus *Pterotrigonia* Van-Hoepen, 1929

Subgenus *Scabrotrigonia* Dietrich, 1933

***Pterotrigonia* (*Scabrotrigonia*) *scabra* (Lamarck, 1819)**

Pl. 13, Figs. 3-5

1819 *Trigonia scabra* sp. nov. - Lamarck, p. 63.

1819 *Trigonia crenulata* sp. nov. - Lamarck, p. 63.

1844 *Trigonia limbata* sp. nov. - d'Orbigny, p. 156, pl.298, figs. 1-4.

1871 *Trigonia scabra* Lamarck - Stoliczka, p. 314, pl. 15, figs. 24-26; pl. 16, figs. 35-40.

1880 *Lyriodon ethra* sp. nov. - Coquand, p. 388.

1912 *Trigonia ethra* Coquand - Pervinquière, p. 218, pl. 15, figs. 4-7.

1912 *Trigonia scabra* Lamarck - Pervinquière, p. 220, pl. 15, figs. 1-3.

1916 *Trigonia orientalis* sp. nov. - Douvillé, p. 168, pl. 21, figs. 14-15 (non Forbes, 1846).

1917 *Trigonia ethra* Coquand - Fourtau, p. 59.

1918 *Trigonia ethra* Coquand - Greco, p. 30 (212), pl. 4 (20), figs. 1-3.

1937 *Trigonia ethra* Coquand - Trevisan, p. 81, pl. 5, fig. 13a-b.

1962 *Trigonia scabra* Lamarck - Abbass, p. 89, pl.15, figs.1-3, 5, 7-9, 3a, 5a, 7a.

1962 *Trigonia limbata* d'Orbigny - Abbass, p. 91, pl. 15, figs. 4, 6.

1993 *Pterotrigonia* (*Scabrotrigonia*) *scabra* (Lamarck) - Dhondt & Dieni, p. 222.

1996 *Pterotrigonia* (*Scabrotrigonia*) *scabra* (Lamarck) - El- Mahallawy, p. 170, pl. 22, figs. 2-3.

1996 *Pterotrigonia* (*Scabrotrigonia*) aff. *limbata* (d'Orbigny) - El- Mahallawy, p. 171, pl. 22, fig. 4.

2002 *Pterotrigonia* (*Scabrotrigonia*) *ethra* Coquand - Abdel-Gawad & Gameil, p. 89, pl. 2, fig. 14.

2002 *Pterotrigonia* (*Scabrotrigonia*) *limbata* (d'Orbigny) - Abdelhamid & El Qot, p. 273, pl. 4, fig. 3.

2002 *Pterotrigonia* (*Scabrotrigonia*) sp. - Abdelhamid & El Qot, p. 273, pl. 4, fig. 4.

2002 *Pterotrigonia* (*Scabrotrigonia*) *scabra* (Lamarck) – Kora *et al.*, pl. 2, fig. 12.

Material and occurrence. 14 specimens from Gebel Ekma; 2 specimens from the Raha Formation, beds no. 5 and 6; and 12 specimens from the Matulla Formation, shaly member, beds no. 23-25. 1 specimen from the East Themed area, Galala Formation, bed no. 6. 10 specimens from Gebel Yelleg; 8 specimens from the Galala Formation, beds no. 13-14, 16, and 22, and 2 specimens from the Themed Formation, bed no. 58.

Measurements (in mm).

n=25	L	H	C	nr	H/L	C/L	C/H
Range	10-44.4	9.3-44.6	5-23	12-22	0.88-1.06	0.46-0.72	0.46-0.67
Mean	33.8	34.1	15.7	15	0.99	0.59	0.59

Description. Shell small- to medium-sized, boat-shaped, postero-dorsal margin concave, anterior one convex and grading into the convex ventral margin. Umbo opisthogyrate. Ornamentation consisting of strong sub-concentric ridges separated by wider interspaces which are crossed by fine radial threads. The

latter produce tubercles at their points of intersection with the sub-concentric ridges.

Age. Cenomanian-Santonian.

Distribution in Egypt. Gebel Manzour, G. Nezzazat, W. Matulla, W. Feiran, G. El-Minsherah, and G. El-Hamra.

Distribution outside Egypt. Southern Europe, North Africa, Somalia, Madagascar, India, Kazakhastan, and Oman.

Discussion. Douvillé (1916) erected *Trigonia orientalis*, a junior homonym of *T. orientalis* Forbes, 1846. The present author agrees with Abbass (1962), who considered *T. orientalis* Douvillé as a synonym of the present species. Abbass (1962) regarded *Trigonia ethra* Coquand, 1880 as a synonym of *T. limbata* d'Orbigny and mentioned that *T. limbata* differs from *T. ethra* mainly in that the ribs on the anterior side are crenulated. According to Stoliczka (1871) *T. limbata* and *T. scabra* are very closely allied, and are difficult to separate. Dhondt & Dieni (1993) considered *P.* (*Scabrotrigonia*) *limbata* and *P.* (*Scabrotrigonia*) *scabra* as synonyms and thought that *P.* (*Scabrotrigonia*) *crenulata* (Lamarck) might also be identical with these two taxa. Abbass (1962) had already placed *crenulata* in the synonymy of *P. scabra*. The present author agrees with Abbass (1962) and Dhondt & Dieni (1993) and considers *P. scabra*, *P. crenulata*, *P. limbata* and *T. orientalis* Douvillé as synonyms with *Pterotrigonia* (*Scabrotrigonia*) *scabra* (Lamarck) having priority.

The species is widely distributed in shallow water deposits of the Albian-Maastrichtian age (Dhondt & Dieni 1993).

Superorder Heterodonta Neumayer, 1883

Order Myoida Stoliczka, 1870

Suborder Myina Stoliczka, 1870

Superfamily Myacea Lamarck, 1809

Family Corbulidae Lamarck, 1818

Subfamily Corbulinae Gray, 1823

Genus *Corbula* Bruguière, 1797

Corbula cf. *parsura* Stoliczka, 1871

Pl. 13, Figs. 6-7, 8a-b

cf. 1871 *Corbula parsura* sp. nov. - Stoliczka, p. 44, pl. 1, figs. 23-24; pl. 16, figs. 3-4.

Material and occurrence. 8 specimens from Gebel Ekma, Raha Formation, bed no. 5.

Measurements (in mm).

N=8	L	H	C	H/L	C/L	C/H
Range	6.5-12	5.8-11	4.8-9	0.87-1.0	0.74-0.88	0.86-0.95
Mean	9.9	8.7	7.7	0.93	0.82	0.91

Description. Shell small-sized, subtrigonal, strongly inflated, slightly longer than hight, inequilateral, inequivalved. Right valve larger and more convex than left one. Umbones prominent, incurved, nearly orthogyrate and situated somewhat anteriorly. Anterior margin rounded. Posterior margin slightly truncated. Ventral margin convex and meeting the anterior margin in an even curve, but forming an acute angle with the posterior one. The two valves have a different ornamentation; the right valve exhibits strong commarginal ribs separated by narrow grooves; the left valve is nearly smooth.

Age. Late Cenomanian.

Distribution outside Egypt. Southern India.

Discussion. The present material closely resembles *Corbula parsura*, which was established by Stoliczka (1871) based on material from Southern India. The present specimens assigned to the species only tentatively, because they are larger than the Indian specimens. *Corbula peroni* Fourtau, 1917 from the Turonian of Abu Roash of Egypt differs in ornamentation and in having a more elongated shell. *C. parsura* differs from *Corbula* (*C.*) *magharensis* Abbass, 1962 from the Albian of El-Maghara area, Egypt, in having a greater height-

length ratio and a more inflated shell. In addition, *C.* (*C.*) *magharensis* exhibits fine ribs. *Corbula elegans* J. de C. Sowerby, 1827 of Woods (1908: p. 216, pl. 34, figs. 23-28) has a similar outline and the same ornamentation on the right valve. It differs from the present species in being smaller and in the left valve being ribbed, the ribs being finer than those of the right valve.

Order Hippuritoida Newell, 1965

Superfamily Megalodontacea Morris & Lycett, 1853

Family Dicerocardiidae Kutassy, 1934

Genus *Rostrocardia* Freneix, 1972

***Rostrocardia* cf. *papieri* (Coquand, 1880)**

Pl. 13, Figs. 9, 10a-b

cf. 1880 *Isocardia papieri* sp. nov - Coquand, p. 114, pl. 4.

cf. 1912 *Anisocardia papieri* Coquand - Pervinquière, p. 235, pl. 17, figs. 20-22.

cf. 1918 *Anisocardia papieri* Coquand - Greco, p. 46 (228), pl. 5 (21), fig. 3.

cf. 1937 *Anisocardia* cf. *papieri* Coquand - Trevisan, p. 91, pl. 4, fig. 1.

cf. 1963 *Anisocardia papieri* Coquand - Fawzi, p. 59.

cf. 1972 *Rostrocardia papieri* (Coquand) - Freneix, p. 174, pl. 18, figs. 6-8; text-figs. 43A-B.

cf. 1981 *Anisocardia papieri* (Coquand) - Amard *et al.*, p. 79, pl. 6, fig. 4.

Material and occurrence. 13 specimens from Gebel Ekma, Raha Formation, beds no. 4-6; 18 specimens from Gebel Yelleg, Galala Formation, beds no. 14 and 16.

Measurements (in mm).

N=16	L	H	C	H/L	C/L	C/H
Range	8-17	8.5-19	6-16	1.06-1.17	0.73-0.99	0.67-0.87
Mean	14.3	15.9	12.8	1.11	0.87	0.78

Age. Cenomanian.

Distribution in Egypt. Gebel Shabrawit, Wadi Araba, and G. El-Minsherah.

Distribution outside Egypt. North Africa and southern Europe.

Remarks. Freneix (1972) erected the genus *Rostrocardia* with *Isocardia papieri* Coquand, 1880 as the type species and placed it in the Family Dicerocardiidae Kutassy, 1934 of the Superfamily Glossacea Gray, 1847 of the Order Veneroida Adams & Adams, 1856. According to Amler *et al.* (2000) Family Dicerocardiidae belongs to the Superfamily Megalodontacea Morris & Lycett, 1853 of the Order Hippuritoida Newell, 1965.

The present specimens are attributed to *Rostrocardia papieri* (Coquand) based on their triangular outline, inflated, equivalved and inequilateral shell and prominent, coiled and strongly prosogyrate umbones. The material consists of internal moulds, but some of them show traces of numerous, fine, closely spaced commarginal growth lines. These characters closely resemble the specimens of *Anisocardia papieri* as described from the Cenomanian of Tunisia by Pervinquiére (1912) and from the Cenomanian of Egypt by Greco (1918) and Fawzi (1963). Moreover, the dimensions of the present specimens agree with those recorded by Fawzi (1963) from the Cenomanian of Egypt, and mostly with those of Freneix (1972). The present author only tentatively places the specimens in *papieri*, because the valves of the only specimen measured by Pervinquière (1912) are of equal convexity and height = 30 mm, while the length is 35 mm.

Ferneix (1972) erected variety *denseconcentrica* from the Upper Albian of Morocco. According to her the species is widely distributed in the Cenomanian of North Africa and the Upper Albian of Tarfaya, Morocco.

Superfamily Hippuritacea Gray, 1848

Family Radiolitidae Gray, 1848

Subfamily Radiolitinae Gray, 1848

Genus *Eoradiolites* Douvillé, 1909

Eoradiolites liratus (Conrad, 1852)

Pl. 13, Figs. 13-15; Text-Fig. 7

1852 *Hippurites liratus* sp. nov. - Conrad, p. 234, pl. 7, figs. 47-48.

1910 *Eoradiolites lyratus* Conrad - Douvillé, p. 70, pl. 1, figs. 2-4; pl. 4, fig. 6; pl. 5, fig. 3.

1912 *Eoradiolites lyratus* Conrad - Douvillé, p. 244, pl. 14 (1), figs. 3-11; pl. 16 (3), fig. 8.

1917 *Eoradiolites liratus* Conrad - Fourtau, p. 97

1934 *Eoradiolites syriacus* Conrad - Blanckenhorn, p. 225, pl. 11, figs. 93-96.

1998 *Eoradiolites lyratus* (Conrad) - Masse *et al.*, p. 54, pl. 9, figs. 1-4.

Material and occurrence. 78 specimens from Gebel Yelleg, Galala Formation, beds no. 11-13.

Remarks. Shell medium- to large-sized, strongly inequivalved, attached valve (AV) conical-elongate, free valve (FV) small, operculiform, concave to flat. AV ornamented with numerous longitudinal ribs, FV is ornamented with fine concentric laminations.

Age. Early Cenomanian

Distribution in Egypt. Sinai.

Distribution outside Egypt. North Africa, Somalia, the Middle East, Italy.

Discussion. The present specimens agree well with those originally described by Conrad, 1852. They are also identical to that described by Douvillé (1910, 1912) and Masse *et al.* (1998). According to Coord *et al.* (in Hardenbol *et al.* 1998) the species ranges from the Middle Albian to the late Early Cenomanian.

Genus *Praeradiolites* Douvillé, 1912

Praeradiolites biskraensis (Coquand, 1880)

Pl. 14, Figs. 1, 3

1880 *Sphaerulites biskraensis* sp. nov. - Coquand, p. 194.

1890 *Radiolites biskraensis* Coquand - Peron, p. 286, pl. 28, figs. 17-19.

1912 *Praeradiolites biskraensis* Coquand - Pervinquière, p. 307, pl. 21, fig. 10; pl. 23, figs. 3-4.

Material and occurrence. 12 specimens from the East Themed area, Galala Formation, bed no. 6 and 23 specimens from Gebel Yelleg, Galala Formation, beds no. 25, 28, 30, in addition to numerous fragments from both localities.

Age. Cenomanian.

Distribution outside Egypt. North Africa.

***Praeradiolites irregularis* Douvillé, 1910**

Pl. 14, Fig. 2

1910 *Praeradiolites irregularis* sp. nov. - Douvillé, p. 74, pl. 4, fig. 4-5.

1934 *Praeradiolites irregularis* Douvillé - Blanckenhorn, p. 227.

Material and occurrence. 2 poorly preserved, incomplete specimens from Gebel Yelleg, Wata Formation, bed no. 47.

Age. Middle Turonian.

Distribution outside Egypt. Lebanon.

Remarks. The specimens seem to be similar to that originally described by Douvillé (1910) and recorded by Blanckenhorn (1934) from the Cenomanian and Turonian of Lebanon.

***Praeradiolites ponsianus* (d'Archiac, 1835) *aegyptiacus* Douvillé, 1910**

Pl. 13, Figs. 11-12

1835 *Sphaerulites ponsiana* sp. nov. - d'Archiac, p. 182, pl. 16, fig. 6.

1848 *Radiolites ponsiana* d'Archiac - d'Orbigny, p. 210, pl. 552.

?1903 *Sphaerulites peroni* sp. nov. - Dacqué, p. 375, pl. 36, fig. 1-2.

1910 *Praeradiolites ponsianus* d'Archiac var. *aegyptiacus* var. nov. - Douvillé, p. 48, pl. 3, figs. 6-7.

1912 *Praeradiolites ponsianus* d'Archiac race *aegyptiacus* - Douvillé, p. 248, pl. 15 (2), figs. 1-2.

1912 *Praeradiolites ponsianus* d'Archiac - Pervinquière, p. 308.

1993 *Praeradiolites ponsianus* (d'Archiac) *aegyptiacus* Douvillé, Kora *et al.*, pl. 1, fig. 11.

Material and occurrence. 9 incomplete specimens from Gebel Yelleg, Wata Formation, bed no. 47.

Age. Middle Turonian.

Remarks. The present specimens are closely similar to *Praeradiolites ponsianus* d'Archiac var. *aegyptiacus*, which was originally described by Douvillé (1910).

Distribution in Egypt. Abu Roash and western Sinai.

Distribution outside Egypt. Algeria and Southern Europe.

Subfamily Sauvagesiinae Douvillé, 1908

Genus *Durania* Douvillé, 1908

***Durania arnaudi* (Choffat, 1891)**

Pl. 14, Figs. 4-5

1891 *Biradiolites arnaudi* sp. nov. - Choffat, p. 203, 210-211.

1902 *Biradiolites arnaudi* Choffat - Choffat, p. 138, pl. 6; pl. 7.

1910 *Durania arnaudi* Choffat - Douvillé, p. 50, pl. 3, fig. 1.

1912 *Durania arnaudi* (Choffat) - Douvillé, p. 252, pl. 16 (3), fig. 1.

1912 *Durania arnaudi* (Choffat) – Pervinquière, p. 321, pl. 22, fig. 9.

Material and occurrence. 63 incomplete specimens from Gebel Yelleg, Wata Formation, bed no. 47.

Age. Middle Turonian.

Distribution in Egypt. Abu Roash

Distributio outside Egypt. Lebanon.

***Durania gaensis* (Dacqué, 1903)**

Pl. 14, Fig. 6

1903 *Radiolites gaensis* sp. nov. - Dacqué, p. 374, pl. 35, figs. 7-9.

1910 *Durania gaensis* Dacqué - Douvillé, p. 50, pl. 3, figs. 2-5.

1912 *Durania gaensis* Dacqué - Douvillé, p. 253, pl. 15 (2), figs. 4-7.

1912 *Durania gaensis* Dacqué - Pervinquière, p. 322, pl. 22, figs. 6-7.

Material and occurrence. 1 nearly complete left valve and numerous fragments from the East Themed area, Wata Formation, bed no. 21.

Age. Middle Turonian.

Distribution in Egypt. Abu Roash.

Distribution outside Egypt. Tunisia.

Remarks. The specimens seem to be similar to that was originally described by Dacqué (1903) from the Cenomanian of Abu Roash.

Order Veneroida H. Adams & A. Adams, 1856

Superfamily Lucinacea Fleming, 1828

Family Lucinidae Dall, 1901

Subfamily Lucininae Fleming, 1828

Genus *Lucina* Bruguière, 1797

Lucina fallax Forbes, 1846

Pl. 14, Figs. 7-8, 9a-b, 10a-b

1846 *Lucina fallax* sp. nov. - Forbes, p. 143, pl. 17, fig. 8.

1871 *Lucina fallax* Forbes - Stoliczka, p. 256, pl. 13, fig. 13 & 15-17;pl. 14, figs. 3-5, 7-8.

1963 *Lucina* aff. *fallax* Forbes - Fawzi, p. 66.

Material and occurrence. 4 specimens from Gebel Ekma, the Raha Formation, bed no. 5 and 6.

Measurements (in mm).

n=4	L	H	C	H/L	C/L	C/H
Range	10.4-14.1	10.4-13.9	5.5-7	0.94-1.0	0.50-0.53	0.50-0.55
Mean	12.9	12.7	6.8	0.98	0.51	0.53

Description. Shell small-sized, subcircular to circular, equivalved, subequilateral, moderately inflated. Umbones small, prosogyrate, pointed, slightly prominent, placed medially. Ornamentation consisting of numerous, low commarginal growth lines, separated by narrower interspaces. The commarginal lines and their interspaces are crossed by very fine radial threads.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Shabrawit and G. El- Minsherah.

Distribution outside Egypt. Southern India.

Discussion. Stoliczka (1871) subdivided *Lucina fallax* Forbes based on the form and thickness of the shell into four varieties. The present material can be divided into two varieties. The specimen from bed no. 6 shows clearly the two elements of ornamentation and is about as thick as long, which represents the third variety of Stoliczka (1871: pl. 14, figs. 7-8). Specimens from bed no. 5 show only the commarginal growth lines and are very similar to forma typica (Stoliczka 1871: pl. 14, figs. 3-5), but differ in having a slightly more inflated shell.

Lucina pisum J. de. C. Sowerby, 1836 of Woods (1907: p. 156, pl. 24, figs. 16-19) can be easily distinguished from *Lucina fallax* in being smaller and having a more strongly inflated shell. The present species differs from *Lucina nicaisei* Coquand (1862: p. 203, pl. 12, figs. 5-6) from the Albian of Algeria, which has a similar outline and size, in having a shorter lunule, more prosogyrate umbones and numerous fine radial threads crossing the commarginal lines. *L. cenomanensis* Abbass (1962: p. 108, pl. 22, fig. 1) has a similar ornamentation but differs from *L. fallax* in being larger, more inflated and slightly more elongated.

Lucina cf. *masylaea* Coquand, 1862

Pl. 14, Figs. 11, 12a-b

cf. 1862 *Lucina Masylaea* Coquand, p. 203, pl. 12, figs. 7-8.

cf. 1917 *Lucina nicaisei* Coquand mut. *masylaea* Coquand- Fourtau, p. 77.

Material and occurrence. 1 specimen from Gebel Ekma, Raha Formation, bed no. 3; 2 specimens from the East Themed area, Galala Formation, bed no. 6, and 2 specimens from Gebel Yelleg, Galala Formation, bed no. 29.

Measurements (in mm).

N=5	L	H	C	H/L	C/L	C/H
Range	30-44.5	31-40.5	12-22	0.89-1.03	0.40-0.49	0.39-0.58
Mean	37.7	35.4	17.2	0.95	0.45	0.49

Description. Shell medium- to large-sized, nearly circular, equivalved, moderately inflated. Umbones moderate to large, prominent, prosogyrate. Lunule long, wide and deep. Ornamentation consisting of numerous, fine, regular, closely spaced, commarginal growth lines.

Age. Middle-Late Cenomanian.

Distribution in Egypt. Gebel Qabaliat.

Distribution outside Egypt. Algeria.

Discussion. The specimens closely resemble in outline and ornamenation *Lucina masylaea* Coquand, 1862, which was originally described based on material from the Upper Cenomanian of Algeria, but they differ in being larger. For this reason they have been referred to this species with some doubts. The present material differs from *Lucina cenomanensis* Abbass (1962: p. 108, pl. 22, fig. 1), which has a similar outline, by its less inflated shell and its ornamentation the interspaces separating the commarginal lines being crossed by fine radial threads in *L. cenomanensis*. *L. masylaea* differs from *L. fallax* in being larger and less inflated, its C/L ratio being 0.40 - 0.49 in contrast to 0.50 - 0.53 for *L. fallax*.

Family Fimbriidae Nicol, 1950

Genus *Fimbria* Megerle von Mühlfeld, 1811

Fimbria sp.

Pl. 15, Fig. 1a-c

Material and occurrence. 1 specimen from the East Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

n=1	L	H	C	H/L	C/L	C/H
	64	50	31.5	0.78	0.49	0.63

Description. Shell large, oval shaped, equivalved, longer than high. Anterior margin rounded, forming an angle with the hinge margin and passing gradually into the crenulated ventral margin with which it forms a regular curve. Umbones prosogyrate. Ornamentation consisting of commarginal and radial elements which form a reticulate pattern. The commarginal elements are slightly wider than the radials ones. The radial ribs are much more pronounced near the anterior and posterior margins of the shell, while the commarginal ribs dominante in the middle of the flank.

Age. Late Cenomanian.

Discussion. The diagnostic reticulate ornamenation and the general shape of shell closely resemble the genus *Fimbria* (Cox *in* Moore 1969: p. N513). The present specimen differs from *Fimbria alpaghina* (Catullo, 1827) from rudist limestones of Italy (Dhondt & Dieni 1993: p. 224, pl. 20, figs. 1-12) in being more elongated shell, having more prosogyrate umbones and wider commarginal ribs.

Genus *Sphaera* J. Sowerby, 1822

Sphaera corrugata J. Sowerby, 1822

Pl. 15, Figs. 2, 3a-b

1823 *Sphaera corrugata* J. Sowerby, p. 42, pl. 335.

1907 *Sphaera corrugata* Sowerby - Woods, p. 157, pl. 24, fig. 24; pl. 25, figs. 1-2; text-fig. 26.

1916 *Sphaera corrugata* Sowerby - Douvillé, p. 160, pl. 20, figs. 8-9.

1981 *Sphaera corrugata* Sowerby - Canerot & Collignon, p. 235, pl. 2, fig. 8a-b; pl. 3, fig. 10.

Material and occurrence. 8 specimens from Gebel Ekma, Raha Formation, beds no. 3-6, and 9; 23 specimens from the East Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

n=31	L	H	C	H/L	C/L	C/H
Range	29-91	26-81	22.3-74	0.87-0.93	0.75-0.83	0.84-0.92
Mean	58.5	55.7	47	0.90	0.79	0.88

Description. Shell large, strongly inflated, subglobular, slightly inequilateral; slightly longer than high. Anterior margin rounded, forming an angle with the hinge margin and passing gradually into the ventral margin with which it forms a regular curve. Umbones large, prominent, curved anteriorly. Ornamentation consisting of strong commarginal ridges, which are crossed by faint radial ribs.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Maghara.

Distribution outside Egypt. England.

Discussion. *Sphaera corrugata* was originally described and recorded by all aforementioned authors in the synonymy list from the Early Cretaceous. In the present study, it was recorded from the Upper Cenomanian of Gebel Ekma and the East Themed area. Thus, the present species ranges from the "Neocomian" to the Late Cenomanian.

Superfamily Carditacea Fleming, 1820

Family Carditidae Fleming, 1820

Subfamily Carditesinae Chavan, 1969

Genus *Maghrebella* Freneix, 1972

***Maghrebella deserti* (Douvillé, 1916)**

Pl. 15, Figs. 4, 5a-b

1916 *Cardita Dupini* d'Orbigny var. *deserti* var. nov. - Douvillé, p. 162, pl. 21, figs. 1-2.

1962 *Venericardia deserti* (Douvillé) - Abbass, p. 114, pl. 17, figs. 5-7.

1972 *Maghrebella deserti* (Douvillé) - Freneix, p. 131.

2002 *Venericardia deserti* (Douvillé) - Abdelhamid & El Qot, p. 276, pl. 5, fig. 2.

Material and occurrence. 1 specimen from Gebel Ekma, Raha Formation, bed no. 6 and 1 specimen from the East Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

N=2	L	H	C	nr	H/L	C/L	C/H
Range	7-10.7	7.5-10.7	4.7	21	1.0-1.07	0.44-0.67	0.44-0.63
Mean	8.8	9.1	4.7	21	1.04	0.56	0.54

Description. Shell small, triangular, tumid, strongly inequilateral. Umbones prominent, prosogyrate and situated anteriorly. Ventral margin broadly rounded and convex. Ornamentation consisting of narrow and relatively high radial ribs separated by wider interspaces. These radial ribs carry small tubercles.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Manzour and G. El-Minsherah.

Discussion. Freneix (1972) referred *Cardita deserti* Douvillé, 1916 to her new genus *Maghrebella*. The present specimens have a less inflated shell than the specimen of Abbass (1962), and are smaller than Douvillé's material. *Maghrebella deserti* was originally described and later resampled (Abbass 1962), from the "Vraconian" (=Latest Albian) of Gebel Manzour. Recently, it

was recorded by the present author (in Abdelhamid & El Qot, 2002) from the Cenomanian of Gebel El-Minsherah.

Maghrebella forgemoli (Coquand, 1862)

Pl. 15, Figs. 6-8

1862 *Cardita Forgemoli* sp. nov. - Coquand, p. 199, pl. 14, figs. 14-15.

1862 *Cardita Delettrei* sp. nov. - Coquand, p. 200, pl. 14, figs. 18-19.

1862 *Cardita Beuquei* sp. nov. - Coquand, p. 200, pl. 14, figs. 1-2.

1890 *Cardita Beuquei* Coquand - Peron, p. 264.

1912 *Cardita Forgemoli* Coquand - Pervinquière, p. 238, pl. 17, figs. 5-12.

1917 *Cardita Forgemoli* Coquand - Fourtau, p. 71.

1918 *Cardita Forgemoli* Coquand - Greco, p. 32 (214), pl. 4 (20), figs. 4-7.

1937 *Cardita Forgemoli* Coquand -Trevisan, p. 94, pl. 7, figs. 10-13.

1962 *Cardita* (*Pteromeris*) *forgemoli* Coquand - Abbass, p. 112, pl. 17, figs. 10-12.

1963 *Cardita forgemoli* Coquand - Fawzi, p. 61, pl. 5, figs. 9-10.

1972 *Maghrebella forgemoli* (Coquand) - Freneix, p. 131.

1992 *Venericardia forgemoli* (Coquand) - Abdel-Gawad& Zalat, pl. 3, fig. 4.

1996 *Maghrebella forgemoli* (Coquand) - El- Mahallawy, p. 172, pl. 22, fig. 6.

2001 *Venericardia forgemoli* (Coquand) - Abdallah *et al.*, pl. 2, fig. 16

2002 *Venericardia* (*Venericardia*) *forgemoli* (Coquand) – Abdel Gawad & Gameil, p. 89, pl. 2, figs. 15-16.

2002 *Venericardia forgemoli* (Coquand) - Abdelhamid & El Qot, p. 276, pl. 5, fig. 3.

Material and occurrence. 14 specimens from Gebel Ekma, Raha Formation, beds no. 2-5, and 9; 1 specimen from the East Themed area, Galala Formation, bed no. 6; and 13 specimens from Gebel Yelleg, Galala Formation, bed no. 16.

Measurements (in mm).

N=28	L	H	C	nr	H/L	C/L	C/H
Range	10.3-25.5	12.3-27.5	9.1-28.7	16-35	0.96-1.29	0.72-1.17	0.64-1.04
Mean	18.16	19.62	16.2	23	1.14	0.86	0.77

Description. Shell small- to medium-sized, triangular to subtrapezoidal, mostly higher than long, strongly inflated, very inequilateral, enlarged posteriorly. Umbones prominent, strongly prosogyrate and situated anteriorly. Lunule moderately developed. Ventral margin convex and gradually merging into the anterior and posterior margins. Ornamentation consisting of strong radial ribs, separated by relatively wider interspaces.

Age. Cenomanian.

Distribution in Egypt. Gebel Shabrawit, Wadi Araba, G. El-Minsherah, G. Tih, G. El-Hamra, and G. Nezzazat.

Distribution outside Egypt. North Africa, the Middle East and Italy.

Discussion. The present author agrees with Pervinquière (1912), Fourtau (1917), Greco (1918), Abbass (1962), and Fawzi (1963) in considering *Cardita delettrei* Coquand, 1862 and C. *beuquei* Coquand, 1862 are junior synonyms of the present species.

Freneix (1972) erected the genus *Maghrebella*, referred it to subfamily Carditesinae, distinguished it from the genus *Pseudocardia* by its markedly strong radial striations and placed *Cardita forgemoli* Coquand, 1862 in the genus *Maghrebella*.

Superfamily Crassatellacea Ferussac, 1822

Family Astartidae d'Orbigny, 1844

Subfamily Astartinae d'Orbigny, 1844

Genus *Astarte* J. Sowerby, 1816

"*Astarte*" *gigantea* Deshayes, 1842

Pl. 15, Fig. 9a-c

1842 *Astarte gigantea* sp. nov. - Deshayes *in* Leymerie, p. 5, pl. 4, fig. 3.

1846 *Astarte gigantea* Deshayes - d'Orbigny, p. 58, pl. 258, figs. 1-6.

1962 *Astarte* (*Tridonta*) *gigantea* (Deshayes) - Abbass, p. 103, pl. 16, figs. 8, 10-12, 15a.

Material and occurrence. 2 incomplete specimens from Gebel Ekma, Matulla Formation, Phosphatic Member, bed no. 26.

Measurements (in mm).

n=2	L	H	C	H/L	C/L	C/H
Range	16.5-19	>15->17	7.5-8	0.89-0.91	0.39-0.48	0.44-0.53
Mean	17.8	16	7.8	0.90	0.44	0.49

Description. Shell small, subtriangular, moderately inflated, equivalved, inequilateral. Beakes prominent, prosogyrate, situated anteriorly, and slightly incurved. Lunule deep, oval, tapering ventrally. Antero-dorsal margin concave below the umbo. Postero-dorsal margin straight to slightly convex. Both anterior and posterior margins rounded and convex. Ventral margin broadly rounded. Ornamentation consisting of strong commarginal ribs, separated by concave interspaces which are equal or slightly narrower in width.

Age. Early Campanian.

Distribution in Egypt. Wadi Araba, Eastern Desert.

Distribution outside Egypt. France.

Discussion. The present material closely resembles *Astarte* (*Tridonta*) *gigantea* (Deshayes) as described by d'Orbigny (1846), but it differs in being smaller. It is identical with that described by Abbass (1962) from the Maastrichtian of Wadi Araba, Eastern Desert of Egypt. The species is attributed herein with some doubts to the genus *Astarte* based on the general form of the shell and its diagnostic ornamentation. Unfortunately, the specimens are articulated, so that no information about internal characters is available.

Family Crassatellidae Férussac, 1822

Subfamily Crassatellinae Férussac, 1822

Genus *Crassatella* Lamarck, 1799

***Crassatella matercula* Mayer-Eymar, 1896**

Pl. 15, Figs. 10-11

1896 *Crassatella matercula* sp. nov. - Mayer-Eymar, p. 369, pl. 9, fig. 4.

1902 *Crassatella zitteli* sp. nov. - Wanner, p. 121, pl. 18, figs. 3-4

1902 *Crassatella zitteli* Wanner - Quaas, p. 208, pl. 23, figs. 22-29; pl. 32, figs. 8-9.

1904 *Crassatella zitteli* Wanner - Fourtau, p. 328, pl. 2, fig. 3.

1917 *Crassatella matercula* Mayer-Eymar - Fourtau, p. 75.

1917 *Crassatella matercula* Mayer-Eymar - Greco, p. 131 (151), pl. 16 (15), figs. 8-18.

1962 *Crassatella* (*Scambula*) *matercula* Mayer-Eymar - Abbass, p. 99, pl. 16, figs. 17-20.

Material and occurrence. 2 specimens from Gebel Ekma, Raha Formation, bed no. 9 and 22 specimens from the East Themed area, Abu Qada Formation,bed no. 11.

Measurements (in mm).

n=24	L	H	C	H/L	C/L	C/H
Range	14.4-28.5	11.3-25.5	7-15	0.65-0.95	0.47-0.60	0.54-0.76
Mean	21.7	17.7	10.5	0.84	0.55	0.63

Description. Shell small- to medium-sized, subtrapozoidal, equivalved, inequilateral. Umbones terminal, prosogyrate and situated anteriorly. Posterior umbonal ridge sharp; lunule deep and oval. Escutcheon long and deep. Antero-dorsal margin below umbo feebly concave; postero-dorsal margin straight to slightly inclined. Ventral margin convex and broadly rounded. Ornamentation consisting of numerous, fine commarginal growth lines, separated by relatively narrower interspaces.

Age. Late Cenomanian-Early Turonian.

Distribution in Egypt. Wadi Um Rockam and Kharga Oasis.

Discussion. The present material consists of articulated valves in which the hinge is not visible, consequently the species is placed only at the generic level and the author afrains from placing the species into one of the subgenera of the genus *Crassatella*. The present author agrees with Fourtau (1917), Greco (1917), and Abbass (1962) that *Crassatella zitteli* Wanner, 1902 is as a synonym of *C. matercula*. C. *desvauxi* Coquand, 1862 from the Santonian of Algeria, which has a relatively similar outline, can be easily distinguished from the present species by its large size (L=60 mm, H=35). Abbass (1962) distinguished this species from C. *minima* and C. *dubia* of Seguanza, 1882 and from *Astarte elongata* d'Orbigny of Woods (1906: p. 102, pl. 14, figs. 2-3).

The present species has been recorded by all previous authors from the Upper Senonian (Campanian and Maastrichtian). Its occurrence from the Upper Cenomanian and Lower Turonian represents the first record from this level in Egypt.

Subgenus *Rochella* Freneix, 1972

***Crassatella (Rochella) tenuicostata* (Seguenza, 1882)**

Pl. 15, Figs. 12a-b, 13, 14

1882 *Astarte tenuicostata* sp. nov. - Seguenza, p. 136, pl. 7, fig. 8.

1891 *Astarte subnumismalis* sp. nov. - Thomas & Peron *in* Peron, p. 268, pl. 28, figs. 7-8.

1891 *Astarte seguenzae* sp. nov. - Thomas & Peron *in* Peron, p. 269, pl. 28, figs. 9-10.

1904 *Astarte lefebvrei* sp. nov. - Peron & Fourtau *in* Fourtau, p. 325, pl. 3, figs. 4-6.

1917 *Astarte lefebvrei* Peron & Fourtau - Fourtau, p. 72.

1937 *Astarte seguenzae* Thomas & Peron - Trevisan, p. 96, pl. 4, fig. 9-19.

1962 *Astarte* (*Tridonta*) *tenuicostata* (Seguenza) - Abbass, p. 102, pl. 16, figs. 9, 13-14.

1993 *Astarte* (*Tridonta*) *tenuicostata* (Seguenza) - Orabi, pl. 1, fig. 8.

1972 *Crassatella* (*Rochella*) *seguenzai* (Thomas & Peron) - Freneix, p. 138, pl. 12, figs. 7-12; text-fig. 27.

2002 *Crassatella* (*Crassatella*) *seguenzai* (Thomas & Peron) – Abdel Gawad & Gameil, p. 90, pl. 2, fig. 18; pl. 3, figs. 1-2.

2002 *Crassatella* (*Rochella*) *seguenzai* (Thomas & Peron) - Abdelhamid & El Qot, p. 277, pl. 5, figs. 5-6.

Material and occurrence. 10 specimens from Gebel Ekma; 8 specimens from the Raha Formation, beds no. 5 and 6; 1 specimen from the Abu Qada Formation, bed no. 10; and 1 specimen from the Wata Formation, bed no. 16. 4 specimens from the East Themed area, Abu Qada Formation, beds no. 9 and 11.

Measurements (in mm).

N=14	L	H	C	H/L	C/L	C/H
Range	7.7-14.5	7.3-12.5	3.5-6.2	0.86-0.95	0.42-0.55	0.45-0.63
Mean	10.5	9.8	4.9	0.88	0.51	0.54

Description. Shell small, subtriangular, equivalved, inequilateral, slightly truncated posteriorly. Umbones prominent, prosogyrate and placed slightly anterior of the middle. Antero-dorsal margin concave below the umbo. Postero-dorsal margin straight to slightly convex. Anterior and posterior margins rounded. Ventral margin strongly convex. Internal margins of valves internally crenulated. Ornamentation consisting of moderate to strong commarginal ribs, separated by concave interspaces which are often wider than the ribs. These interspaces occasionally occupied by fine radial riblets.

Age. Late Cenomanian-Middle Turonian.

Distribution in Egypt. Abu Roash and Gebel El-Hamra.

Distribution outside Egypt. Sicily, Algeria,Tunisia and Morocco.

Discussion. The present author agrees with Abbass (1962) who regarded *Astarte tenuicostata* Seguenza, 1882, *A. subnumismalis* Thomas & Peron, 1891, *A. seguenzae* Thomas & Peron, 1891, and *A. lefebvrei* Peron & Fourtau, 1904 are synonyms with *A. tenuicostata* has priority.

The present species is widespread in the Cenomanian and Turonian of North Africa and Sicily.

Superfamily Cardiacea Lamarck, 1809

Family Cardiidae Lamarck, 1809

Subfamily Cardiinae Lamarck, 1809

Genus *Granocardium* Gabb, 1868

Granocardium cf. *proboscideum* (J. Sowerby, 1817)

Pl. 16, Fig. 1a-b

cf. 1817 *Cardium proboscideum* sp. nov. - J. Sowerby, p. 127, pl. 156, fig. 1.

cf. 1908 *Cardium* (*Granocardium*) *proboscideum* Sowerby - Woods, p. 205, pl. 32, figs. 18-19; pl. 33, figs. 1-3.

Material and occurrence. 1 right valve from Gebel Yelleg, Galala Formation, bed no. 4.

Measurements (in mm).

n=1	L	H	C	H/L
	27	30.5	14	1.13

Age. Latest Albian.

Remarks. The most conspicuous feature of the present specimen is its ornamentation, which is closely similar that of Sowerby's specimen and identical with that of *Cardium* (*Granocardium*) *proboscideum* Sowerby of Woods (1908). The ornamentation consists of strong radial ribs, which bear prominent, angular, laterally compressed tooth-like projections; in the spaces between the strong ribs there are two smaller ribs with similar but smaller tooth-

like projections. Based on the limited material and relatively small size the specimen is referred to *proboscideum* with reservation.

The specimen differs from *Granocardium quinquecostatum* Douvillé, 1916 from the Albian of Gebel El-Maghara in having narrower interspaces between the strong radial ribs and only two intercalated fine radial ribs, instead of four as in the case of the latter species.

***Granocardium productum* (J. de C. Sowerby, 1832)**

Pl. 16, Figs. 2a-b, 3

1832 *Cardium productum* sp. nov. - J. de C. - Sowerby, p. 417, pl. 39, fig. 15.

1850 *Cardium olisiponensis* sp. nov. - Sharpe, p. 181, pl. 14, fig. 4a-b.

1871 *Cardium* (*Trachycardium*) *productum* Sowerby - Stoliczka, p. 217, pl. 11, figs. 15-16.

1889 *Granocardium productum* (Sowerby) - Holzapfel, p. 179, pl. 17, figs. 1-5.

1912 *Cardium* (*Trachycardium*) *productum* Sowerby - Pervinquière, p. 259, pl. 19, figs. 25-27.

1917 *Cardium productum* Sowerby - Fourtau, p. 81.

1937 *Cardium* (*Trachycardium*) *productum* Sowerby - Trevisan, p. 102.

1962 *Granocardium hassani* sp. nov. - Abbass, p. 122, pl. 20, figs. 2-3.

1963 *Cardium* aff. *productum* Sowerby - Fawzi, p. 70.

1993 *Granocardium productum* (Sowerby) - Dhondt & Dieni, p. 229, pl. 14, figs. 4-9.

1996 *Granocardium productum* (Sowerby) - El-Mahallawy, p. 181, pl. 23, fig. 2.

1997 *Granocardium productum* (Sowerby) - Asan, p. 92, pl. 9, figs. 8-10.

2002 *Granocardium productum* (Sowerby) - Abdelhamid & El Qot, p. 277, pl. 5, figs. 7-8.

Material and occurrence. 1 specimen from Gebel Ekma, Raha Formation ,bed no. 6. 9 specimens from the East Themed area; 7 specimens from the Galala

Formation, beds no. 6, and 2 specimens from the Wata Formation, bed no. 19. 2 specimens from Gebel Yelleg; 1 from the Galala Formation, bed no. 20 and 1 from the Wata Formation, bed no. 44.

Measurements (in mm).

N=12	L	H	C	H/L	C/L	C/H
Range	16-70	17-92	13-95	1.05-1.36	0.78-1.38	0.74-1.05
Mean	40.4	57	43.6	1.23	1.18	0.87

Description. Shell medium- to large-sized, oval, pear-shaped or subquadrangular, higher than long, strongly inflated, slightly inequilateral, more or less equally truncated anteriorly and posteriorly. Umbones prominent, orthogyrate, incurved. Hinge nearly straight and wide. Anterior and posterior margins convex and crenulated. Ventral margin strongly convex and crenulated. Ornamentation consisting of radial ribs, which are very well preserved near the ventral margin.

Age. Cenomanian-Midlle Turonian.

Distribution in Egypt. Wadi Um Hemaiet, Saint Antony, Gebel Shabrawit, G. El-Minsherah and Ain El-Wadi, and G. El-Hamra.

Distribution outside Egypt. Europe, Africa and Asia.

Discussion. Dhondt & Dieni (1993) recognised the close similarity of *Granocardium hassani* Abbass, 1962 to the present species and regarded the former as a possible junior synonym. The present author agrees with them and considers *G. hassani* a junior synonym of *G. productum*. The present species is a cosmopolitan taxon and has a wide stratigraphic range (Cenomanian to Maastrichtian).

Subfamily Protocardiinae Keen, 1951

Genus Protocardia Beyrich, 1845

***Protocardia hillana* (J. Sowerby, 1813)**

Pl. 16, Figs. 4-6

1813 *Cardium Hillanum* sp. nov. – J. Sowerby, p. 41, pl. 14.

1871 *Protocardium hillanum* Sowerby - Stoliczka, p. 219, pl. 12, figs. 8- 10; pl. 13, figs. 1-3.

1890 *Protocardia Hillana* Sowerby - Peron, p. 276.

1902 *Protocardia hillana* Sowerby - Quaas, p. 218, pl. 34, figs. 18, ?19.

1904 *Protocardia Hillana* Sowerby - Fourtau, p. 331.

1908 *Protocardia Hillana* (Sowerby) - Woods, p. 197, pl. 31, fig. 6a-c; pl. 32, figs. 1-6.

1934 *Protocardia hillana* Sowerby - Blanckenhorn, p. 244.

1962 *Protocardia hillana* (Sowerby) - Abbass, p. 123, pl. 21, figs. 1, 3, 13.

1963 *Protocardia hillana* (Sowerby) - Fawzi, p. 73, pl. 6, fig. 2.

1992 *Protocardia hillana* (Sowerby) - Abdel-Gawad & Zalat, pl. 3, fig. 5.

1997 *Protocardia hillana* (Sowerby) - Asan, p. 93, pl. 9, figs. 11-12.

2001 *Protocardia hillana* (Sowerby) - Abdallah *et al.*, pl. 2, fig. 17.

2002 *Protocardia hillana* (Sowerby) - Abdel Gawad & Gameil, p. 92, pl. 3, fig. 10.

2002 *Protocardia hillana* (Sowerby) - Abdelhamid & El Qot, p. 279, pl. 6, fig. 1.

Material and occurrence. 25 specimens from Gebel Ekma; 20 specimens from the Raha Formation, beds no. 4-6 and 8 and 5 specimens from the Matulla Formation, Phosphatic Member, bed no. 26. 20 specimens from the East Themed area, Abu Qada Formation beds no. 5 and 9. 8 specimens from Gebel Yelleg, Galala Formation, beds no. 16 and 31.

Measurements (in mm).

n=53	L	H	C	nr	H/L	C/L	C/H
Range	7.5-49	7-48	4.5-32	11-20	0.91-0.98	0.58-0.68	0.61-0.69
Mean	27.4	26.7	15.5	15	0.95	0.62	0.63

Description. Shell small to medium-sized, subrounded to oval, nearly equilateral, length oftenly slightly excceding height. Anterior margin either

fairly convex and forming a rounded angle with the antero-dorsal margin, or very convex and passing gradually into the strongly convex ventral margin. The posterior margin is truncated, slightly convex and forms an obtuse angle with the postero-dorsal margin. Umbones of moderate size and placed medially. Hinge long and slightly arched. Ornamentation represented by numerous, fine, very regular commarginal ribs, which cover the shell except for the posterior flank which is ornamented with strong radial ribs separated by wider interspaces.

Age. Early Cenomanian-Early Campanian.

Distribution in Egypt. Gebel Maghara, Ain Arydiha, Saint Paul, Abu Roash, G. Shabrawit, G. El-Minsherah, G. Um Heriba, Ain El-Wadi, G. El-Hamra, G. Nezzazat, and El Giddi Pass.

Distribution outside Egypt. Europe, Africa and Asia.

Discussion. Abbass (1962) established *Protocardia shabrawitensis* from the Cenomanian of Gebel Shabrawit. Abbass' species can be easily distinguished from *P. hillana* by its higher shell, larger size (L=57, H=62, and C=50) and the greater area which ornamented with radial ribs. Moreover, the radial ribs are greater in number (15-30; Abdelhamid & El Qot 2002) and finer than in *P. hillana*. The present author noticed that in *P. hillana* the radial ribs increase in number with increasing size of the shell; in small specimens (Asan 1997) there are 8-12, in medium-sized ones (Woods 1908, Abbass 1962) 10-15, and in the present material, there are 11-20 ribs.

This species ranges in Egypt and elsewhere from the Aptian to the Maastrichtian.

Superfamily Tellinacea de Blainville, 1814

Family Tellinidae de Blainville, 1814

Subfamily Tellininae de Blainville, 1814

Genus *Aenona* Conrad, 1870

Aenona cenomanensis **(Abbass, 1962)**

Pl. 16, Figs. 7-8

1962 *Tellina cenomanensis* sp. nov. - Abbass, p. 154, pl. 23, fig. 11.

1996 *Aenona cenomanensis* (Abbass) - El-Mahallawy, p. 186, pl. 23, fig. 6.

2002 *Aenona cenomanensis* (Abbass) - Abdelhamid & El Qot, p. 282, pl. 6, fig. 6.

Material and occurrence. 3 specimen from Gebel Ekma, Raha Formation, bed no. 6. 5 specimens from the East Themed area; 2 specimens from the Galala Formation, bed no. 6 and 3 specimens from the Abu Qada Formation, bed no. 11. 1 specimen from Gebel Yelleg, Galala Formation, bed no.14.

Measurements (in mm).

n=9	L	H	C	H/L	C/L	C/H
Range	21.3-34	17.5-25	6.5-11	0.63-0.82	0.20-0.35	0.33-0.49
Mean	29.9	21	8.6	0.74	0.30	0.41

Description. The specimens small- to medium-sized, oval to subelliptical in outline, thin, compressed, longer than hight, nearly equilateral, inequivalved; left valve larger than the right one. Umbones orthogyrate and placed almost medially. Lunule and escutcheon narrow, lunule markedly shorter than escutcheon. Anterior and posterior margins of nearly equal convexity.Ventral margin convex and smooth. Ornamentation consisting of fine, closely spaced commarginal striations.

Age. Cenomanian-Early Turonian.

Distribution in Egypt. Wadi Tih, Gebel Qabaliat, G. El- Minsherah, and G. El-Hamra.

Discussion. El-Mahallawy (1996) referred the present species to genus *Aenona* Conrad, 1870 based on the markedly compressed, nearly equilateral shell. *Tellina* (*Palaeomoera*) *inconspicua* Sowerby, 1846 in Stoliczka (1871: p. 129, pl. 4, figs. 6-8) differs from the present species in that the anterior part is somewhat longer than the posterior one.

Genus *Linearia* Conrad, 1860

Linearia aegyptiaca sp. nov.

Pl. 16, Fig. 9a-b

2002 *Palaeomoera* sp. - Abdel-Gawad & Gameil, p. 93, pl. 3, figs. 11-12.

Holotype. BUFG2003I 1; Pl. 16, Fig. 9a-b.

Paratype. BUFG2003I 3.

Locus typicus. Gebel Ekma, southern Sinai, Egypt.

Stratum typicum. Bed no. 5, *Neolobites vibranyus* Zone, Upper Cenomanian.

Derivation of name. After Egypt.

Material and occurrence. 3 specimens from Gebel Ekma, Raha Formation, beds no. 5; 1 specimen from the East Themed area, Galala Formation, bed no. 6; and 1 specimen from Gebel Yelleg, Galala Formation, bed no. 33.

Measurements (in mm).

n=5	L	H	C	H/L	C/L	C/H
Range	10.5-20.5	8-14.2	5-8	0.69-0.76	0.37-0.41	0.50-0.62
Mean	17.8	11.9	7	0.74	0.39	0.57

Diagnosis. Shell small, ovate, with broad, orthogyrate, nearly mesial umbones. Ornamentation consisting of numerous, prominent commarginal ribs, which are crossed by numerous, fine radial ribs, equally distributed across the whole surface of the shell.

Description. Shell small, ovate, moderately convex, with flattend flanks, longer than high, nearly equilateral. Umbones broad, orthogyrate, nearly mesial. Both anterior and posterior margins equally convex. Ventral margin convex and smooth. Ornamentation consisting of numerous, prominent regular commarginal ribs, separated by wider interspaces. These ribs are crossed by numerous, fine radial ribs, these radials are equally distributed on the whole surface of the shell. At the intersections of both types of ribs small, oval to rounded tubercles occur.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Nezzazat.

Discussion. The specimens are tentatively referred to the genus *Linearia* Conrad, 1860 based on the general shape of the shell, the position of the umbones, and the characteristic ornamentation. The ornamentation of the specimens differs somewhat from that of the both two known subgenera of *Linearia*; *Linearia* Conrad, 1860 and *Liothyris* Conrad, 1875. Consequently, the present material may belong to a new subgenus. However, before a new subgenus is established information about the hinge and other internal characters is necessary.

The present species is similar to *Tellina* (*Linearia*) sp. (Woods 1907: p. 177, pl. 27, figs. 14-16) in outline, which differs in having radial ribs only on the posterior and anterior flanks. In addition, the commarginal ribs are more numerous and less prominent.

Superfamily Arcticacea Newton, 1891

Family Arcticidae Newton, 1891

Genus *Arctica* Schumacher, 1817

***Arctica cordata* (Sharpe, 1850)**

Pl. 16, Figs. 10a-b, 11

1850 *Cyprina cordata* sp. nov. - Sharpe, p. 182, pl. 15, fig. 2.

1862 *Cyprina africana* sp. nov. - Coquand, p. 202, pl. 11, figs. 18-19.

1891 *Cyprina cordata* Sharpe - Peron, p. 292.

1904 *Cyprina cordata* Sharpe - Fourtau, p. 332.

1912 *Cyprina cordata* Sharpe - Pervinquière, p. 223, pl. 16, figs. 1-2.

1917 *Cyprina cordata* Sharpe - Fourtau, p. 62.

1918 *Cyprina cordata* Sharpe - Greco, p. 41 (223).

1934 *Cyprina cordata* Sharpe - Blanckenhorn, p. 248.

1963 *Cyprina cordata* Sharpe - Fawzi, p. 54.

1981 *Arctica cordata* (Sharpe) - Amard *et al.*, p. 78, pl. 1, fig. 7.

Material and occurrence. 9 specimens from Gebel Ekma, Raha Formation, beds no. 2, 5 and 6, and 8 specimens from Gebel Yelleg, Galala Formation, beds no. 24, 29 and 37.

Measurements (in mm).

N=17	L	H	C	H/L	C/L	C/H
Range	26-51	24-41	17-34	0.76-0.92	0.49-0.73	0.60-0.83
Mean	42.5	32.7	27.1	0.83	0.61	0.72

Description. The specimens medium- to large-sized, ovate to subtriangular, equivalved, moderately inflated, moderatelly to strongly inequilateral. Umbones prominent, broad and strongly prosogyrate; the distance between umbones moderate to very wide. Antero-dorsal margin concave below the umbo. Postero-dorsal margin long and slightly convex. Anterior margin narrowly rounded and strongly convex. Posterior margin relatively broadly and moderately convex. Ventral margin broadly rounded and strongly convex. All specimens are internal moulds show no elements of ornamentation.

Age. Middle-Late Cenomanian.

Distribution in Egypt. Wadi Gharamul, W. Um Hemaiet, Gebel Shabrawit G. Qabaliat, Gebel Tih, G. Abu Edeimat, G. El-Minsherah, and G. Nezzazat.

Distribution outside Egypt. Algeria,Tunisia, Lebanon, Portugal, and Italy.

Discussion. The present author agrees with Peron (1890), Pervinquière (1912), Fourtau (1917), Greco (1918), and Fawzi (1963) that *Cyprina africana* Coquand, 1862 is a junior synonym of *Arctica cordata* (Sharpe, 1850).

The present species differs from other *Arctica* species recorded herein in having a more prominent umbones, a wider distance between the umbones, a more prominent umbonal ridge and a strongly convex anterior margin.

Arctica humei (Cox)

Pl. 16, Fig. 12a-b

1962 *Cyprina humei* Cox - Abbass, p. 131, pl. 18, fig. 11.

1998 *Arctica humei* (Cox) - El Qot, p. 105, pl. 8, figs. 8-9.

Material and occurrence. 1 specimen from Gebel Yelleg, Galala Formation, bed no. 14.

Measurements (in mm).

n=1	L	H	C	H/L	C/L	C/H
	41	36.5	31	0.89	0.76	0.85

Age. Early Cenomanian.

Distribution in Egypt. Wadi Abu Agag, Gebel El-Minsherah, and G. El-Hamra.

Remarks. The present specimen closely resembles *Cyprina humei* Cox which, has been described by Abbass (1962) from the Cenomanian of Wadi Abu Agag, Eastern Desert of Egypt. It is also identical with *Arctica humei* (Cox) recorded by El Qot (1998) from G. El-Minsherah, and G. El-Hamra. *Arctica humei* differs from other *Arctica* species recorded in the present study in having a more inflated shell.

Arctica inornata (d'Orbigny, 1844)

Pl. 16, Fig. 13; pl. 17, fig. 1a-b

1844 *Cyprina inornata* sp. nov. - d'Orbigny, p. 99, pl. 272, figs. 1-2.

1903 *Cyprina inornata* d'Orbigny - Pervinquière, p. 48.

1912 *Cyprina inornata* d'Orbigny - Pervinquière, p. 222.

1918 *Cyprina inornata* d'Orbigny - Greco, p. 44 (226), pl. 5 (21), fig. 1.

1963 *Cyprina inornata* d'Orbigny - Fawzi, p. 53.

Material and occurrence. 3 specimens from the East Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

n=3	L	H	C	H/L	C/L	C/H
Range	35-37	30-32	18.5-27	0.86-0.92	0.53-0.73	0.62-0.84
Mean	36	31.7	22.6	0.88	0.63	0.71

Description. The specimens are of medium-sized, ovate to nearly subrounded, equivalved, inequilateral, moderately inflated. Umbones broad, moderately prominent, strongly prosogyrate and situated anteriorly. Antero-dorsal margin slightly concave below the umbo. Postero-dorsal margin slightly convex. Remaining margins strongly convex, ventral margin more broadly so. All specimens are internal moulds which exhibit no trace of ornamentation.

Age. Late Cenomanian.

Distribution in Egypt. Wadi Araba and Gebel Nezzazat.

Distribution outside Egypt. France, Tunisia, and Palestine.

Remarks. The present material closely resembles *Cyprina inornata* which was originally described by d'Orbigny from the Aptian of France. It is identical with that recorded by Greco (1918) from the Cenomanian of Egypt.

The present species differs from other *Arctica* species recorded in the present study in having less prominent umbones and a shallower antero-dorsal margin. *Arctica inornata* was erected from the Aptian and was recorded by Pervinquière from the same stratigraphic level in Tunisia. So far, the species is restricted to the Cenomanian in Egypt.

Arctica picteti (Coquand, 1862)

Pl. 17, Figs. 2a-b, 3

1862 *Crassatella Picteti* sp. nov. - Coquand, p. 199, pl. 13, figs. 10-11.

1890 *Cyprina Picteti* Coquand - Peron, p. 293.

1912 *Cyprina Picteti* Coquand - Pervinquière, p. 223, pl. 16, figs. 6-8.

1937 *Cyprina Picteti* Coquand - Trevisan, p. 88, pl. 6, figs. 15-18.

1963 *Cyprina picteti* Coquand var. *allongata* var. nov.- Fawzi, p. 55, pl. 5, fig. 6a-b.

1998 *Arctica picteti* (Coquand) - El Qot, p. 105, pl. 8, figs. 10-11.

Material and occurrence. 8 specimens from Gebel Ekma, Raha Formation, beds no. 4 and 5, and 2 specimens from Gebel Yelleg, Galala Formation, bed no. 31.

Measurements (in mm).

n=10	L	H	C	H/L	C/L	C/H
Range	37.5-57	29-43	22.5-38	0.70-0.77	0.57-0.67	0.77-0.88
Mean	43.5	32.9	27.5	0.74	0.60	0.82

Description. Shell medium to large sized-sized, subtriangular to ovate, strongly inflated, equivalved, strongly inequilateral. Umbones broad, prominent, strongly prosogyrate and situated anteriorly. Antero-dorsal margin concave below the umbo. Postero-dorsal margin slightly convex. Anterior margin rounded, curving rapidly to gradually pass into the broadly rounded and convex ventral margin. Posterior margin broadly rounded. A faint carina extends from the umbo to the postero-ventral end. Ornamentation consisting of numerous, strong commarginal ribs.

Age. Late Cenomanian.

Distribution in Egypt. Gebel El-Minsherah and G. El-Hamra.

Distribution outside Egypt. Algeria,Tunisia, and Italy.

Discussion. *Arctica tealbiensis* (Woods, 1907) which shows a similar outline and ornamentation differs from the present species in being larger and relatively higher. *A. picteti* differs from *Arctica saussuri* (Brongniart, 1821) as described by Woods (1906: p. 131, pl. 19, figs. 7-13) in being more elongated. Fawzi (1963) distinguished his new variety; var. *allongata* from *A. picteti* forma *typica* in being more elongated. The present species resembles *Arctica moreti* (Mahmoud, 1955) of Abbass (1962), but differs in having a greater height-length ratio and more prominent umbones. *A. picteti* can be easily distinguished from all other *Arctica* species recorded in the present study in being more elongated. The present species is very abundant in the Cenomanian of North Africa.

Genus *Tenea* Conrad, 1870

Tenea delettrei (Coquand, 1862)

Pl. 17, Figs. 4-9; Text-Fig. 33B

1862 *Venus Delettrei* sp. nov. - Coquand, p. 194 , pl. 8, figs. 3-4.

1862 *Venus Forgemoli* sp. nov. - Coquand, p. 194, pl. 8, figs. 7-8.

1912 *Dosinia Delettrei* Coquand - Pervinquière, p. 270, pl. 20, figs. 4-8.

1917 *Dosinia Delettrei* Coquand - Fourtau, p. 87.

1917 *Dosinia Delettrei* var. *Forgemoli* Coquand - Fourtau, p. 87, pl. 7, fig. 8.

1918 *Dosinia Delettrei* Coquand - Greco, p. 49 (231), pl. 5 (21), figs. 6-10.

1934 *Dosinia delettrei* Coquand - Blanckenhorn, p. 250.

1937 *Dosinia Delettrei* Coquand - Trevisan, p. 113, pl. 7, figs. 29-31.

1937 *Dosinia Forgemoli* Coquand - Trevisan, p. 114, pl. 7, figs. 32-33.

1962 *Dosinia delettrei* (Coquand) - Abbass, p. 151, pl. 23, figs. 8-9.

1962 *Dosinia forgemoli* (Coquand) - Abbass, p. 152, pl. 23, figs. 6-7.

1963 *Dosinia delettrei* (Coquand) - Fawzi, p. 76, pl. 6, figs. 5-6.

1963 *Dosinia delettrei* var. *forgemoli* (Coquand) - Fawzi, p. 76, pl. 6, fig. 7.

1992 *Dosinia delettrei* (Coquand) - Abdel-Gawad & Zalat, pl. 3, fig. 3.

1994 *Dosinia delettrei* (Coquand) - Kassab & Ismael, p. 238, fig. 5 (13).

1996 *Dosinobia delettrei* (Coquand) - El-Mahallawy, p. 195, pl. 24, fig. 6.

1996 *Dosinobia forgemoli* (Coquand) - El-Mahallawy, p. 196, pl. 24, figs. 4-5.

2002 *Dosinia delettrei* (Coquand) - Abdel-Gawad & Gameil, p. 94, pl. 3, figs. 21-22.

2002 *Dosinobia delettrei* (Coquand) -Abdelhamid & El Qot, p. 283, pl. 6, figs. 7-8.

2002 *Dosinobia forgemoli* (Coquand) - Abdelhamid & El Qot, p. 283, pl. 6, fig. 9; pl. 7, fig. 1.

Material and occurrence. 65 specimens from Gebel Ekma, Raha Formation, beds no.3-6 and 9; 57specimens from the East Themed area, Galala Formation,

beds no. 5 and 6; and 6 specimens from Gebel Yelleg, Galala Formation, bed no. 16.

Measurements (in mm).

n=128	L	H	C	H/L	C/L	C/H
Range	9-35.5	8.5-38.8	4.5-16.6	0.91-1.32	0.45-0.71	0.41-0.63
Mean	21.6	22.8	11.5	1.13	0.55	0.52

Description. Shell small- to medium-sized, circular to suborbicular in outline, compressed, inequilateral, equivalved. Umbones prosogyrate, moderately prominent. Hinge with broad deeply bifid 3b and chevron-shaped 2b. Lunule small and deep. Escutcheon long, deep, narrow and extending to the middle of the postero-dorsal margin. Antero-dorsal margin concave below the umbo. Postero-dorsal margin slightly convex. Anterior and posterior margins strongly convex and forming a continuous curve with the rounded ventral margin. Ornamentation consisting of low, numerous, closely spaced commarginal growth lines.

Age. Cenomanian.

Distribution in Egypt. El-Bahariya Oasis, Gebel Ataqa, Ain Areyida, Bir Abu El-Meisa, Wadi Hawashiya, W. Abu Elefiah, G. Shabrawit, W. Araba, G. Qabaliat, G. Nezzazat, G. El-Minsherah, W. Karam, and G. El-Hamra.

Distribution outside Egypt. North Africa, the Middle East, and Italy.

Discussion. As seen from the list of synonymies, all authors after Coquand referred the species to the genus *Dosinia* Scopoli, 1777, except El-Mahallawy (1996) who placed it in the genus *Dosinobia* Finlay & Marwick, 1937 within the subfamily Dosininae Deshayes, 1853. In the opinion of the present author the general form of the shell is more closely resembling that of members of the family Arcticidae Newton, 1891 and the genus *Tenea* Conrad, 1870 more so than the genera *Dosinia* and *Dosinobia* of the family Veneridae. As all collected specimens are either internal moulds or articulated valves and as this is also true of all illustrations given by previous authors, the hinge and other internal

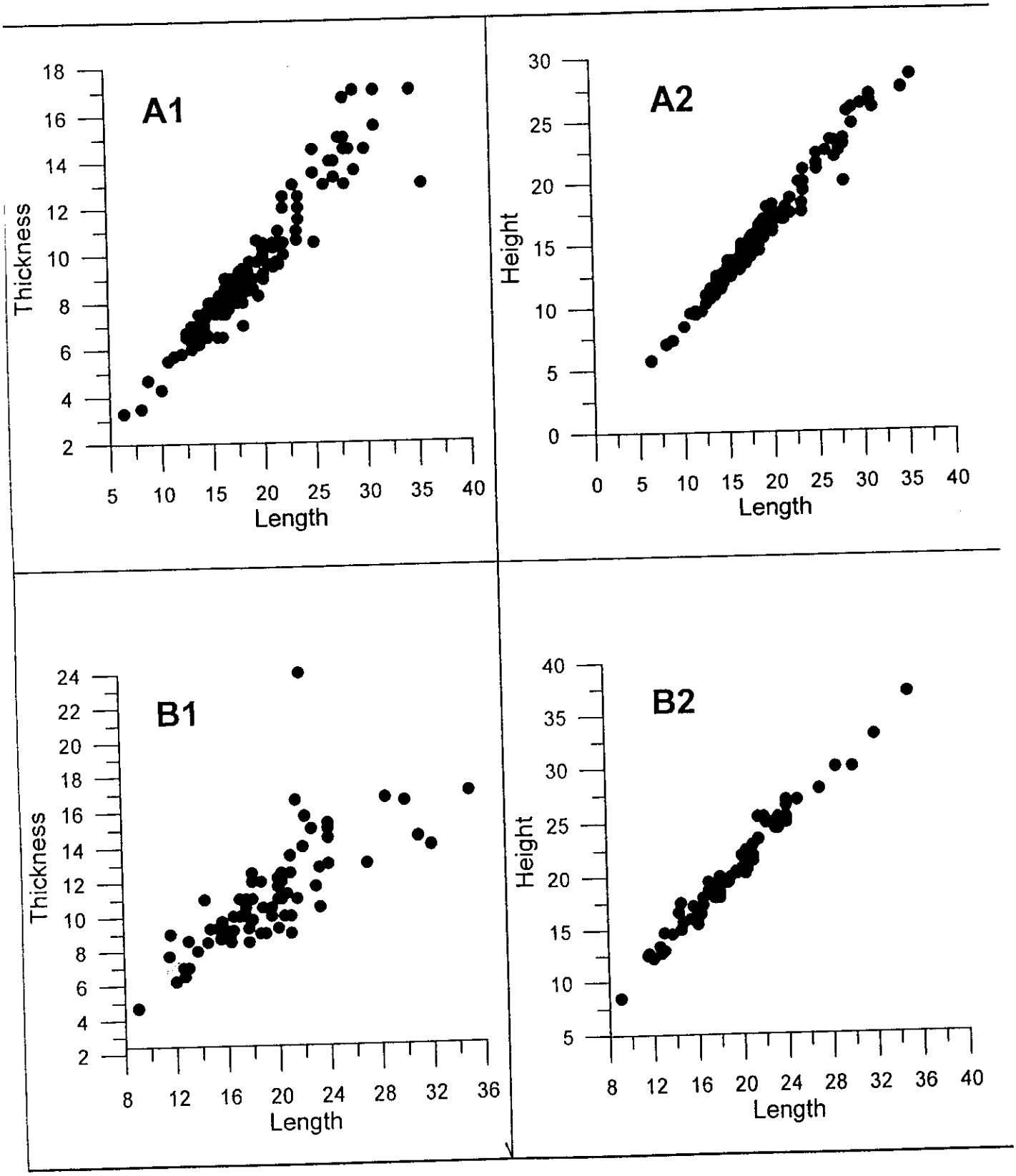


Figure 33. Biometric data on *Parasea faba faba* (A), and *Tenea delettrei* (B).

characters of the species were unknown. For this reason, a polished section of the hinge was made (Pl. 17, Fig. 9) which indicated that the hinge is closely similar to that of the genus *Tenea*. Thus, the species is referred to the genus *Tenea*.

Abbass (1962) distinguished this species from other North American Cretaceous species such as *Dosinia gyrata* and *Dosinia inflata* which were erected by Gabb (1864). According to Abbass (1962) *Dosinia delettrei* Coquand (1862) and *Dosinia forgemoli* Coquand (1862) differ mainly in shell shape which is orbicular in the former and higher than long in the latter. He added that this distinction is probably due to sexual dimorphism as both forms are found in the same bed. Pervinquière (1912), Greco (1918), Blanckenhorn (1934), and Kassab & Ismael (1994) considered *D. forgemoli* as a synonym of *D. delettrei*. In the opinion of Fourtau (1917) and Fawzi (1963) *D. forgemoli* is a variety of *D. delettrei*. El-Mahallawy (1996) regarded these two forms which she recorded from the same bed at both Gebel Qabaliat and Gebel Nezzazat as separate species. In the present study, the two forms were recorded from the same bed at Gebel Ekma (beds no. 3-6 and 9) and the East Themed area (beds no. 5 and 6). The same is the case at Gebel El-Minsherah and Gebel El-Hamra (Abelhamid & El Qot 2002). Therefore, the present author agrees with Pervinquière (1912), Fourtau (1917), Greco (1917), Blanckenhorn (1934), Fawzi (1963), and Kassab & Ismael (1994) that the two forms are only two varieties of the same species, linked by intermediates (Figure 33B).

Tenea delettrei (Coquand) is very abundant in the Cenomanian of North Africa and the Middle East.

Genus *Veniella* Stoliczka, 1870

Veniella cf. *drui* (Munier-Chalmas, 1881)

Pl. 17, Figs. 10-11

cf. 1881 *Roudaireia Drui* sp. nov. - Munier-Chalmas, p. 76, pl. 4, figs. 1-7; pl.

consisting of commarginal striae. The specimens have been identified based on the close similarity of the shell in general form, outline and ornamentation, which are identical with *Venilicardia cordiformis* (d'Orbigny) as figured by Amard *et al.* (1981).

Age. Late Cenomanian.

Distribution outside Egypt. France and Algeria.

Family Pollicidae Stephenson, 1953

Genus *Pollex* Stephenson, 1953

Pollex sinaiensis sp. nov.

Pl. 17, Figs. 13, 14a-b

Holotype. BUFG2003II2; Pl. 17, Fig. 14a-b.

Paratype. BUFG2003II3; Pl. 17, Fig. 13.

Locus typicus. Gebel Ekma, southern Sinai, Egypt.

Stratum typicum. Bed no. 5, *Neolobites vibranyus* Zone, Upper Cenomanian.

Derivation of name. After Sinai.

Material and occurrence. 5 specimens from Gebel Ekma, Raha Formation, bed no. 5.

Measurements (in mm).

n=5	L	H	C	H/L	C/L	C/H
Range	22.5-31	12.5-16	7.5-12	0.48-0.56	0.32-0.40	0.60-0.75
Mean	26	14.1	9.8	0.53	0.36	0.69

Diagnosis. Shell small- to medium-sized, strongly truncated posteriorly. A sharp, angular umbonal ridge descends from the umbo to the postero-ventral margin. Umbones broad, not prominent, incurved, prosogyrate. Ornamentation consisting of numerous, regular, closely spaced commarginal growth lines.

Description. Shell small- to medium-sized, elongated, plump, subelliptical in outline, equivalved, strongly inequilateral, moderately to strongly inflated and strongly truncated posteriorly. A sharp, angular umbonal ridge descends from

the umbo to the postero-ventral margin. Umbones broad not prominent, incurved, prosogyrate and situated anteriorly. Anterior slope is rather steep and broadly excavated antero-dorsally. Postero-dorsal slope gentle and broadly excavated. External ligament opisthodetic and measures 7mm long in the holotype. Ventral margin smooth and nearly straight. Ornamentation consisting of numerous, regular, closely spaced commarginal growth lines.

Age. Late Cenomanian.

Discussion. All specimens are articulated, but a polished section through the hinge (Pl. 17, Fig. 13) shows that it agrees with that of the genus *Pollex* Stephenson, 1953. The species is similar in the general shape, outline, dimensions, umbones, external ligament to *Pollex obesus* which was originally described by Stephenson (1952: p. 94, pl. 23, figs. 14-20). However, it differs mainly in possessing a sharp, angular umbonal ridge descending from the umbo to the postero-ventral margin and showing a well developed truncation posteriorly. *Pollex*? *angulatus* Stephenson (1952: p. 95, pl. 23, figs. 12-13) is closely similar to the present species in outline and ornamentation and also exhibit both the posterior truncation and sharp umbonal ridge, but differs in having radial ribs on the posterior area, while in *Pollex sinaiensis* the whole surface of the shell is covered only with commarginal growth lines.

Superfamily Glossacea Gray, 1847

Family Glossidae Gray, 1847

Genus *Glossus* Poli, 1795

***Glossus aquilinus* (Coquand, 1862)**

Pl. 17, Figs. 15, 16a-b

1862 *Isocardia aquilina* sp. nov. - Coquand, p. 209, pl. 9, figs. 11-12.

1890 *Isocardia aquilina* Coquand - Peron, p. 303.

1904 *Isocardia aquilina* Coquand - Fourtau, p. 334.

1912 *Anisocardia aquilina* Coquand - Pervinquière, p. 234, pl. 17, figs. 18-19.

1917 *Anisocardia aquilina* Coquand - Fourtau, p. 65.

1918 *Anisocardia aquilina* Coquand - Greco, p. 44 (226), pl. 5 (21), fig. 2.

1934 *Anisocardia aquilina* Coquand - Blanckenhorn, p. 247.

1963 *Anisocardia aquilina* Coquand - Fawzi, p. 58.

1981 *Glossus aquilinus* (Coquand) - Amard *et al.*, p. 105, pl. 14, fig. 9.

1996 *Anisocardia* (*Collignonicardia*) *aquilina* (Coquand) - El- Mahallawy, p. 189, pl. 23, figs. 8-9.

1998 *Glossus simplex* (Mahmoud) - El Qot, p. 106, pl. 9, fig. 1.

1998 *Glossus solimani* (Abbass) - El Qot, p. 107, pl. 9, figs. 2-4.

2001 *Anisocardia aquilina* Coquand - Abdallah *et al.*, pl. 2, figs. 19-20.

Material and occurrence. 7 specimens from the East Themed area, Galala Formation, bed no. 6; and 9 specimens from Gebel Yelleg, Galala Formation, beds no. 4 and 16.

Measurements (in mm).

N=16	L	H	C	H/L	C/L	C/H
Range	19.5.41	19.2-41.5	16.5-28.5	0.92-1.01	0.72-0.79	0.75-0.86
Mean	37.6	33.7	31.6	0.96	0.76	0.82

Description. Shell small to medium-sized, cordiform, strongly inflated, equivalved, inequilateral. Umbones prominent, coiled and strongly prosogyrate. Postero-dorsal margin strongly convex. Antero-dorsal margin concave below the umbo. Anterior margin gently convex. Ventral margin smooth and faintly convex. Ornamentation consisting of fine, numerous, closely spaced commarginal growth lines.

Age. Late Albian-Cenomanian.

Distribution in Egypt. Gebel Shabrawit, Wadi Araba, W. Dakhl, Ain Areidah, Saint Paul, G. Tih, G. Qabiliat, G. El-Minsherah, G. El-Hamra, and El Giddi Pass.

Distribution outside Egypt. North Africa, the Middle East, and Italy.

Discussion. The present author agrees with Amard *et al.* (1981) that *Isocardia aquilina* Coquand, 1862 belongs to the genus *Glossus* Poli, 1795 (=*Isocardia* Lamarck, 1799) rather than to *Anisocardia* Munier - Chalmas, 1863 as many authors thought (see list of synonymies). The placement in the genus *Glossus* is supported by the prominent, coiled and strongly prosogyrate umbones, in addition to the cordiform outline. As all specimens are articulated and this also the case for all previously illustrated specimens nothing is known about the hinge and other internal characters. A cross-section through the hinge showed a close resemblance to the hinge of genus *Glossus*. Cox *in* Moore 1969 mentioned that the stratigraphic range of the genus *Glossus* (=*Isocardia*) is Paleocene - Recent. However, the present author assumes that the genus extends back into the Cretaceous, at least back to the Cenomanian.

Superfamily Veneracea Rafinesque, 1815

Family Veneridae Rafinesque, 1815

Subfamily Tapetinae Adams & Adams, 1857

Genus *Paraesa* Casey, 1952

***Parasea faba faba* (J. de C. Sowerby, 1827)**

Pl. 18, Figs. 1, 3; Text-Fig. 33B

1827 *Venus Faba* sp. nov. - J. de C. Sowerby, p. 129, pl. 567, fig. 3.

1836 *Venus* (*?*) *sublaevis* sp. nov. - J. de C. Sowerby, p. 243, 342, pl. 17, fig. 5.

1836 *Venus immersa* sp. nov. - J. de C. Sowerby, p. 242, 342, pl. 17, fig. 6.

1862 *Venus Reynesi* sp. nov. - Coquand, p. 193, pl. 7, figs. 11-12.

1889 *Tapes faba* Sowerby - Holzapfel, p. 165, pl. 13, figs. 7-10.

1890 *Venus Reynesi* Coquand - Peron, p. 307, pl. 29, figs. 13-14.

1904 *Venus Reynesi* Coquand - Fourtau, p. 337.

1908 *Cyprimeria* (*Cyclorisma*) *faba* (Sowerby) - Woods, p. 187, pl. 29, figs. 7-13.

1908 *Cyprimeria* (*Cyclorisma*) *sublaevis* (Sowerby) - Woods, p. 189, pl. 29, fig.

14.

1908 *Cyprimeria* (*Cyclorisma*) *immersa* (Sowerby) - Woods, p. 189, pl. 29, fig. 15.

1912 *Venus* (?) *Reynesi* Coquand - Pervinquière, p. 274.

1917 *Venus Reynesi* Coquand - Fourtau, p. 89.

1918 *Venus Reynesi* Coquand - Greco, p. 47 (229), pl. 5 (19), fig. 4.

1934 *Venus reynesi* Coquand - Blanckenhorn, p. 251, pl. 13, fig. 151; pl. 14, fig. 154.

1962 *Meretrix faba* (Sowerby) - Abbass, p. 146, pl. 22, fig. 21.

1963 *Venus reynesi* Coquand - Fawzi, p. 80, pl. 6, fig. 8.

1972 *Parasea faba faba* (Sowerby) - Freneix, p. 178, pl. 18, figs. 10-12 & text-fig. 46.

1992 *Meretrix faba* (Sowerby) - Abdel-Gawad & Zalat, pl. 3, fig. 2.

1996 *Parasea faba faba* (Sowerby) - El-Mahallawy, p. 199, pl. 24, figs. 7, 10.

2002 *Meretrix faba* (Sowerby) - Abdelhamid & El Qot, p. 284, pl. 7, figs. 2-3.

Material and occurrence. 137 specimens from Gebel Ekma, Raha Formation, beds no. 2-6, and 9; 3 specimens from the East Themed area, Galala Formation, bed no. 5; and 14 specimens from Gebel Yelleg, Galala Formation, beds no. 4, 14, 18, and 24.

Measurements (in mm).

N=154	L	H	C	H/L	C/L	C/H
Range	6.3-35.5	5.7-28.5	3.3-17	0.78-1.0	0.40-0.66	0.48-0.72
Mean	19.3	15.8	8.7	0.87	0.50	0.59

Description. Shell small to medium-sized, oval in outline, equivalved, inequilateral. Umbones small, prominent, prosogyrate and placed anteriorly. Antero-dorsal margin below the umbo concave, anterior margin convex. Postero-dorsal margin slightly convex and gently inclined. Ventral margin smooth and convex. Ornamentation consisting of numerous, regular, commarginal ribs separated by interspaces of nearly equal width.

Age. Cenomanian.

Distribution in Egypt. Ain Areyida, Wadi Hawashiya, W. Abu Elefiah, Gebel Shabrawit, W. Araba, G. Tih, G. El-Minsherah, G. El-Halal, G. Nezzazat, G. Qabaliat and G. El-Hamra.

Distribution outside Egypt. North Africa, the Middle East, and Europe.

Discussion. The present author agrees with Abbass (1962) who regarded *Venus reynesi* Coquand, 1862 as a synonym of the present species. The author agrees also with Freneix (1972) and considers both *Venus* (*?*) *sublaevis* and *V. immersa* of J. de C. Sowerby (1836) are junior synonyms of *Parasea faba faba* as the latter has priority. *Parasea faba faba* is widespread in the Albian of Europe and Morocco, and is very abundant in the Cenomanian of Egypt. Freneix (1972) mentions its occurrence in the Cenomanian - Turonian deposits of Morocco. Consequently, the species ranges from the Albian to the Turonian.

Parasea faba (Sowerby) *subfaba* (d'Orbigny, 1850)

Pl. 18, Fig. 2

1850 *Tapes subfaba* sp. nov. - d'Orbigny, p. 237.

1972 *Parasea faba* (Sowerby) *subfaba* (d'Orbigny) - Freneix, p. 180, pl. 18, figs. 13-14.

Material and occurrence. 1 specimen from Gebel Ekma, Matulla Formation, phosphatic member, bed no. 26.

Measurements (in mm).

n=1	L	H	C	H/L	C/L	C/H
	21	18	10	0.86	0.48	0.56

Age. Early Campanian.

Remarks. *Parasea faba* (Sowerby) *subfaba* (d'Orbigny, 1850) differs from *Parasea faba faba* (Sowerby) mainly in possessing smaller and less prominent umbones. The ribs are finer and more numerous. The occurrence of this

subspecies in the Campanian of Gebel Ekma confirms Freneix (1972) who pointed out that, the subspecies is widely distributed in the Senonian of Europe, but only from the Turonian and the Campanian of Africa.

Superorder Anomalodesmata Dall, 1889

Order Pholadomyoida Newell, 1965

Superfamily Pholadomyacea Gray, 1847

Family Pholadomyidae Gray, 1847

Genus *Pholadomya* J. de C. Sowerby, 1823

Subgenus *Pholadomya* J. de C. Sowerby, 1823

***Pholadomya (Pholadomya) pedernalis* Roemer, 1852**

Pl. 18, Figs. 4, 5a-b

1852 *Pholadomya pedernalis* sp. nov. - Roemer, p. 45, pl. 6, fig. 4.

1912 *Pholadomya pedernalis* Roemer - Pervinquière, p. 288, pl. 21, figs. 5-7.

1934 *Pholadomya pedernalis* Römer - Blanckenhorn, p. 261.

1962 *Pholadomya pedernalis* Römer - Abbass, p. 161, pl. 24, fig. 4.

1992 *Pholadomya pedernalis* Roemer - Abdel-Gawad & Zalat, pl. 3, fig. 9.

2002 *Pholadomya pedernalis* Roemer - Abdel-Gawad & Gameil, p. 97, pl. 4, figs. 9-10.

2002 *Pholadomya pedernalis* Römer - Abdelhamid & El Qot, P. 284, pl. 7, fig. 6.

Material and occurrence. 47 specimens from Gebel Ekma, Wata Formation, beds no. 16 and 17. 40 specimens from the East Themed area, Abu Qada Formation, beds no. 9, 11 and 13. 12 specimens from Gebel Yelleg, Wata Formation, beds no. 39, 44 and 54.

Measurements (in mm).

N=99	L	H	C	H/L	C/L	C/H
Range	26-58	16.5-39	12.5-31	0.52-0.83	0.38-0.69	0.69-0.86
Mean	41.7	31.5	25.4	0.73	0.54	0.78

Description. Shell medium-sized, elongated-ovate, equivalved, strongly inequilateral. Umbones broad, incurved, not prominent and placed anteriorly. Anterior end nearly as high as the posterior one. Ventral margin convex, meeting the anterior and the posterior margins in even curves. Ornamentation consisting of numerous strong commarginal ribs, separated by interspaces nearly half the width of the ribs. These ribs are crossed by relatively few in number, faint radial ribs separated by wider interspaces. Faint tubercles are produced at the intersection between the radials and the commarginal ribs.

Age. Late Cenomanian-Turonian.

Distribution in Egypt. Wadi Karam, Gebel Um Heriba, G. El-Minsherah and G. El-Hamra.

Distribution outside Egypt. Texas, Southern Europe, North Africa, and the Middle East.

Discussion. Abbass (1962) distinguished this species from some European species, such as *Pholadomya elliptica* Sturm (1900), *P. parvula* Roemer of Leymerie (1846: pl. 10, fig. 19) and *P. bulgarica* Toula (1889) as well as from some North American species such as *P. papyracea* Meeck & Hayden of Stanton (1893: pl. 26, fig. 1) and *P. sublevis* Stephenson, 1923.

Pervinquière (1912) recorded *P. pedernalis* from the Lower Turonian of Tunisia and he mentioned its occurrence in the Aptian of France and Algeria, and the "Vraconian"(= Latest Albian) of Texas. In Egypt the species was recorded from the Cenomanian (Abbass 1962, Abdel-Gawad & Zalat 1992), the Turonian (Abdelhamid & El Qot 2002), and from the Cenomanian and Santonian (Ziko *et al.* 1993). Therefore, the species ranges from the Aptian to the Santonian.

***Pholadomya (Pholadomya) romani* Amard, Collignon & Roman, 1981**

Pl. 18, Figs. 6a-b, 7

1981 *Pholadomya* (*Pholadomya*) *romani* sp. nov. - Amard, Collignon &

Roman, p. 105, pl. 15, figs. 1-2.

Material and occurrence. 2 specimens from Gebel Ekma, Matulla Formation, Shaly Member, bed no. 23. 24 specimens from the East Themed area, Themed Formation, beds no. 34 and 35.

Measurements (in mm).

n=26	L	H	C	H/L	C/L	C/H
Range	38-79	25-52	22-39	0.59-0.76	0.45-0.56	0.76-0.85
Mean	54.9	34.5	25.2	0.71	0.50	0.81

Description. Shell medium- to large-sized, elongated-ovate, equivalved, strongly inequilateral. Umbones broad, incurved, not prominent and placed anteriorly. Anterior end nearly as high as the posterior one. Ventral margin convex, undulating and meeting both the anterior and the posterior margins in even curves. Ornamentation consisting of 14-18 strong radial ribs separated by wider interspaces. The radial ribs of the two valves meet at the ventral margin and cause its wavy or undulating course. These radials are crossed by numerous, fine commarginal growth lines.

Age. Coniacian-Santonian.

Distribution outside Egypt. Algeria.

Discussion. *Pholadomya* (*P.*) *romani* Amard *et al.*, 1981 can easily distinguished from *P. pedernalis* Roemer, 1852 which has a similar outline by its characteristic ornamentation, which is represented by strong radial ribs, in contrast to the strong commarginal ribs crossed by few, faint radials of *P. pedernalis*. The present species differs from *P. pedisulcata* Stoliczka, 1871 in having more and stronger radial ribs which covere most of the shell surface, while in Stoliczka's species these radials are strong only on the anterior part of the shell. Moreover, *P. pedisulcata* has a more elongated shell (H/L = 0.45; H/L of *P. romani* = 0.59-0.76). Amard *et al.* (1981) erected this species on material from the Maastrichtian of Tinerhert-W and Tademait-E, Algeria. In the present

study it has been recorded from the Coniacian of Gebel Ekma and the Coniacian-Santonian of the East Themed area.

Pholadomya (Pholadomya) vignesi Lartet, 1877

Pl. 18, Fig. 8

1877 *Pholadomya Vignesi* sp. nov. - Lartet, p. 126, pl. 11, fig. 9.

1890 *Pholadomya Vignesi* Lartet - Blanckenhorn, p. 94, pl. 5, figs. 14-17.

1912 *Pholadomya Vignesi* Lartet - Pervinquière, p. 290, pl. 21, figs. 8-9.

1917 *Pholadomya Vignesi* Lartet - Fourtau, p. 93, pl. 7, fig. 6.

1934 *Pholadomya vignesi* Lartet - Blanckenhorn, p. 261.

1962 *Pholadomya vignesi* Lartet - Abbass, p. 157, pl. 24, figs. 7-8.

1963 *Pholadomya vignesi* Lartet - Fawzi, pl. 86.

1981 *Pholadomya* (*Procardia*) *vignesi* - Amard *et al.*, p. 82, pl. 2, figs. 3-4.

1981 *Pholadomya* (*Procardia*) *vignesi* Lartet - Collignon, p. 269, pl. 8, fig. 13.

2002 *Pholadomya vignesi* Lartet – Abdel Gawad & Gameil, p. 97, pl. 4, fig. 11.

2002 *Pholadomya vignesi* Lartet - Abdelhamid & El Qot, p. 286, pl. 7, figs. 7-8.

Material and occurrence. 1 specimen from Gebel Ekma, the Raha Formation ,bed no. 3, and 11 specimens from the East Themed area, Galala Formation, bed no. 5.

Measurements (in mm).

N=12	L	H	C	H/L	C/L	C/H
Range	34-41	33.5-37	23-31.5	0.90-0.99	0.68-0.77	0.69-0.85
Mean	37.5	36.4	27.2	0.93	0.72	0.76

Description: The specimens medium-sized, subtrigonal or oblong, relatively short, slightly longer than high. Umbones prominent, incurved and placed anteriorly. Anterior part shorter and higher than the posterior one. Anterior margin convex, postero-dorsal margin sloping gently from the umbo. Ventral margin strongly convex, meeting the posterior and anterior margin at even curves. Ornamentation consisting of strong commarginal ribs separated by

narrower interspaces and crossed by few, strong radial ribs. The latter are well developed in the middle part of the shell. At the intersection of the commarginal and radial ribs elongate to oval tubercles occur which become less prominent near the ventral margin.

Age. Late Cenomanian.

Distribution in Egypt. Ain Areyida, Gebel Shabrawit, G. Gederat, Bir Abu El-Meisa, G. Nezzazat, G. El-Minsherah, and G. El-Hamra.

Distribution outside Egypt. North Africa, Angola, Gabon, Madagascar, the Middle East, Iran and Portugal.

Discussion. The present species differs from *P. pedernalis* Roemer, 1852 in being less elongated, the anterior part being higher than the posterior one, and the commarginal and radial ribs being numerous and strong.

The species is widespread in the Cenomanian, and was recorded from the Turonian of Madagascar.

Genus *Pachymya* J. de C. Sowerby, 1826

Subgenus *Pachymya* J. de C. Sowerby, 1826

Pachymya (*Pachymya*) sp.

Pl. 18, Fig. 9a-b

Material and occurrence. 2 specimens from Gebel Yelleg, Themed Formation, bed no. 58.

Measurements (in mm).

N=2	L	H	C	H/L	C/L	C/H
Range	106-115	50-58	43-46	0.47-0.50	0.40-0.41	0.79-0.86
Mean	110.5	54	44.5	0.49	0.41	0.83

Age. Coniacian-Santonian.

Remarks. The specimens large, oblong, strongly inequilateral, moderately to strongly inflated. Umbones broad, slightly protruding, orthogyrate, moderately incurved. Posterior umbonal ridge prominent and running diagonally to the

postero-ventral corner. Ventral margin more or less straight. The specimens are smooth internal moulds. The two speimens closely resemble in the general shape members of the genus and subgenus *Pachymya*. An identification at the species level is not possible.

Superfamily Pandoracea Rafinesque, 1815

Family Laternulidae Hedley, 1918

***Plectomya* de Loriol, 1868**

***Plectomya? humei* (Fourtau, 1917)**

Pl. 18, Figs. 10a-b, 11a-b, 12

1917 *Siliqua Humei* sp. nov. - Fourtau, p. 92, pl. 1, fig. 7.

1962 *Siliqua humei* Fourtau - Abbass, p. 165, pl. 24, fig. 14.

2001 *Siliqua humei* Fourtau - Abdallah *et al.*, pl. 2, fig. 3.

2002 *Siliqua humei* Fourtau - Abdelhamid & El Qot, p. 281, pl. 6, fig. 5.

Material and occurrence. 4 specimens from Gebel Yelleg, Galala Formation, beds no. 13 and 14.

Measurements (in mm).

N=4	L	H	C	H/L	C/L	C/H
Range	30-36	13-24	8.3-11	0.53-0.67	0.26-0.33	0.48-0.59
Mean	32.75	18.62	9.41	0.59	0.30	0.53

Description. The specimens small- to medium-sized, elongated, equivalved, inequilateral, anterior part shorter and lower than posterior one. Umbones prosogyrate and placed anteriorly. Lunule short and narrow. Ligament deep and four times the length of the lunule. Antero-dorsal margin slightly concave and steeply inclined, postero-dorsal margin almost horizontal. Ventral margin slightly convex. Ornamentation consisting of 15-26 commarginal ribs, separated by shallow commarginal grooves.

Age. Early Cenomanian.

Distribution in Egypt. Dungul Oasis, Wadi Tih, Gebel El-Minsherah, G. El-Hamra, and El Giddi Pass.

Discussion. The species is assigned to the genus *Plectomya* de Loriol, 1868 rather than to the genus *Siliqua* Megerle von Mühlfeld, 1811, because the present material, which is identical with that described by Fourtau (1917) and Abbass (1962) as *Siliqua humei*, is characterized by more broad and prominent umbones. The genus *Siliqua* as defined by Cox *in* Moore (1969) is characterised by having internal ribs. The present material and that previously collected from Gebel El-Minsherah and Gebel El-Hamra (Abdelhamid & El Qot 2002), some of them with the shell and some being well preserved internal moulds, show no traces of internal ribbing. The lack of information on the hinge and other internal characters make the accurate generic assignement of this species very difficult. The general shape of the specimens and their ornamentation more closely resemble that of the Laternulidae Hedley, 1918 than of the Culthellidae Davies, 1935. For this reason, the species is tentatively placed with genus *Plectomya*.

The species differs from *Solecurtus* (*Azor*) *acteon* d'Orbigny of Woods (1909: p. 219, pl. 35, figs. 5, 6) from the Cenomanian of England, which has a similar outline and ornamentation, mainly in having more anteriorly placed and more prominent umbones.

The species was originally described from the Maastrichtian of the Dungul Oasis by Fourtau (1917), and later on recorded from the Cenomanian (Abbass 1962, Abdallah *et al.* 2001, and Abdelhamid & El Qot 2002). Consequently, it ranges from the Cenomanian to the Maastrichtian.

Order Septibranchia Pelseneer, 1889

Superfamily Poromyacea Dall, 1886

Family Poromyidae Dall, 1886

Genus *Liopistha* Meek, 1864

Liopistha cf. *aequivalvis* (Goldfuss, 1841)

Pl. 18, Fig. 13

cf. 1841 *Corbula aequivalvis* nobis - Goldfuss, p. 250, pl. 151, fig. 15a, b.

cf. 1889 *Liopistha aequivalvis* Goldfuss - Holzapfel, p. 150, pl. 9, figs. 4-6.

cf. 1937 *Liopistha aequivalvis* (Goldfuss) - Lehner, p. 161, pl. 25, fig. 30.

cf. 1986 *Liopistha* (*Liopistha*) *aequivalvis* (Goldfuss) - Abdel-Gawad, p. 184, pl. 43, figs. 1, 2.

cf. 1988 *Liopistha aequivalvis* (Goldfuss) - Dhondt & Jagt, p. 187, pl. 1, figs. 1-7; pl. 2, fig. 1a-e.

Material and occurrence. 1 right valve from Gebel Ekma, Matulla Formation, Phosphatic Member, bed no. 26.

Measurements (in mm).

N=1	L	H	C	H/L
	22.3	19	7.5	0.85

Description. Shell small, oval, inequilateral. Umbo prominent, incurved. Ventral margin convex. Ornamentation consisting of 15 radial ribs separated by interspaces nearly twice to three times the width of the ribs. These radial ribs are crossed by faint commarginal growth lines. Fine tubercles are produced at the intersection between the radial ribs and the growth lines.

Age. Early Campanian.

Discussion. The present specimen is very similar to *Liopistha aequivalvis* (Goldfuss, 1841) from Europe and Asia, but differs mainly in having fewer radial ribs (15), separated by wider interspaces. According to Dhondt & Jagt (1988) the number of ribs of *L. aequivalvis* varies from 19 to 40 and explained this variation due to a combination of ecological and preservational factors. They added that the ribbing is related to the nature of the substrate. In coarse sediments such as sand and greensand the ribs are fewer, stronger and more subdivided than in fine-grained sediments such as chalk or marl. The same authors discussed also the ontogenetic increase in the number of ribs.

2- Gastropoda

The systematic classification of the gastropods is following that of Moore (1960) for Archaeogastropoda and Wenz (1938) for Mesogastropoda and Caenogastropoda. The terminology used is mainly that of Cox (1960). All linear measurements (taken with Vernier Caliper) are given in millimeters.

Abbreviations used are:

n = number of measured specimens;

H = shell height;

D = maximum diameter of the shell;

HL = height of last whorl;

HA = height of aperture;

WA = width of aperture;

PA = pleural angle (in degrees);

nr = number of axial ribs;

ns = number of spiral lines;

nw = number of whorls.

Class Gastropoda Cuvier, 1797

Subclass Prosobranchia Milne-Edwards, 1848

Order Archaeogastropoda Thiele, 1925

Suborder Trochina Cox & Knight, 1960

Superfamily Trochacea Rafinesque, 1815

Family Trochidae Rafinesque, 1815

Subfamily Angariinae Thiele, 1924

Genus *Calliomphalus* Cossmann, 1888

***Calliomphalus* (*Calliomphalus*) *orientalis* (Douvillé, 1916)**

Pl. 19, Fig. 1

1916 *Metriomphalus? orientalis* sp. nov. - Douvillé, p. 145, pl. 18, fig. 31.

1992 *Calliomphalus* (*Calliomphalus*) *orientalis* (Douvillé) - Abdel-Gawad & Gameil, p. 71, fig. 2/1.

1998 *Calliomphalus* (*Calliomphalus*) *orientalis* (Douvillé) - El Qot, p. 120, pl. 10, figs. 5-6.

Material and occurrence. 3 specimens from Gebel Ekma, Raha Formation, bed no. 9.

Measurements (in mm).

n=3	H	D	HL	HA	WA	PA	nw	D/H	HL/H	WA/HA
Range	7-23.5	14.3-22.5	4.3-15.5	7.5-13	6.7-12	95°-105°	3-4	0.96-2.04	0.61-0.66	0.89-0.92
Mean	14.3	18.4	8.9	10.3	9.4	101°	3.3	1.49	0.64	0.91

Description. The specimens small, turbiniform, spire conical. Whorls convex in outline, their width nearly twice their height. Body whorl forming more than half of the shell height. All specimens are internal moulds, which show no trace of ornamentation, but specimens studied by the author from other localities in Sinai ornamented with twelve tuberculated spiral cords. Aperture nearly circular.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Manzour, G. Nezzazat, G. El- Minsherah and G. El-Hamra.

Discussion. The present specimens agree in size and shell shape with *Calliomphalus* (*C.*) *orientalis* (Douvillé, 1916) which was originally described from the Upper Vraconian (= Latest Albian) of Gebel Manzour, Sinai, Egypt. They agree also with specimens recorded by Abdel-Gawad & Gameil (1992) from Gebel Nezzazat and by El Qot (1998) from Gebel El- Minsherah and Gebel El-Hamra. Abdel-Gawad & Gameil (1992) distinguished this species from *C.* (*C.*) *dichotomous* (Alth, 1850) by its less convex whorls and the possession of tubercles. They also distinguished it from *C.* (*C.*) *biomstrofensis* (Griepenkerl, 1889) where the latter has a large number of spiral cords separated by narrow interspaces.

Suborder Neritopsina Cox & Knight, 1960

Superfamily Neritacea Rafinesque, 1815

Family Neritopsidae Gray, 1847

Subfamily Neritopsinae Gray, 1847

Genus *Neritopsis* Garteloup, 1832

Neritopsis abbatei Peron & Fourtau, 1904

Pl. 19, Figs. 2a-c

1904 *Neritopsis Abbatei* sp. nov. - Peron & Fourtau *in* Fourtau, p. 265, pl. 1, figs. 17-18.

1916 *Neritopsis Abbatei* Peron & Fourtau - Greco, p. 118 (60), pl. 15 (7), fig. 7a-c.

Material and occurrence. 1 specimen from the East Themed area, Themed Formation, bed no. 34.

Measurements (in mm).

n = 1	H	D	HL	PA	Nw	D/H	HL/H
Range	18	16.5	16	76°	3	0.92	0.97

Age. Coniacian - Santonian.

Distribution in Egypt. Wadi Um Rockam.

Description. The specimen small, globose. Spire obtuse, slightly protruding. Body whorl relatively large, evenly convex and forming the main part of the shell. Aperture nearly circular and relatively large. The specimen is an internal mould but traces of the shell which show an ornamentation of tuberculated spiral cords.

Discussion. The specimen agrees with the description and dimensions of *Neritopsis abbatei* Peron & Fourtau which was originally described from the Campanian of Wadi Um Rockam. It seems to differ in being larger. It also closely resembles the material recorded by Greco (1916). Greco (1916) recorded the species from the Maastrichtian, it is recorded herein from the

Coniacian-Santonian. Consequently, its stratigraphic range is from the Coniacian to the Maastrichtian.

Family Neritidae Rafinesque, 1815

Genus *Nerita* Linné, 1758

Subgenus *Semineritina* Cossmann, 1925 (=*Seminerita* Wenz, 1938)

***Nerita* (*Semineritina*) cf. *safrensis* (Abbass, 1963)**

Pl. 19, Fig. 3a-b

cf. 1963 *Seminerita safrensis* sp. nov. - Abbass, p. 29, pl. 1, figs. 7, 8.

Material and occurrence. 1 specimen from Gebel Ekma, Raha Formation, bed no. 9.

Measurements (in mm).

n = 1	H	D	HL	PA	nw	D/H	HL/H
	9.5	19.5	8	136°	2	2.05	0.84

Age. Late Cenomanian.

Distribution in Egypt. Gebel Safra.

Remarks. The specimen is poorly preserved, but closely resembles in outline and dimensions *Seminerita safrensis* Abbass, which was originally described from Gebel Safra, Sinai. The species differs from *Otostoma* (*O.*) *divaricatum* (d'Orbigny) which was recorded by Albanesi & Busson (1974: p. 291, pl. 21, figs. 1-2) from Algeria and from Gebel Nezzazat by Abdel-Gawad & Gameil (1992: p. 72, fig. 2: 9) in having a wider and larger shell.

Order Mesogastropoda Thiele, 1927

Superfamily Cerithicea Fleming, 1822

Family Turritellidae Clark, 1851

Genus *Mesalia* Gray, 1842

***Mesalia* cf. *sphyngis* Greco, 1916**

Pl. 19, Figs. 4-5

cf. 1916 *Mesalia sphyngis* sp. nov. - Greco, p. 127 (69), pl. 16 (8), figs. 3-5.

cf. 1999 *Mesalia sphyngis* Greco - El Shazly, p. 826, pl. 5, figs. 1, 5, 14.

cf. 2000 *Mesalia quartercarinata* Greco - Abdel-Gawad, pl. 1, fig. 13.

cf. 2002 *Mesalia sphyngis* Greco – Kora *et al.*, pl. 4, fig. 1.

Material and occurrence. 2 incomplete specimens from the East Themed area, Themed Formation, bed no. 34.

Age: Coniacian-Santonian.

Distribution in Egypt. Wadi Abu Elefieh, Saint Paul, W. Matulla and Magmar.

Remarks. The specimens are incomplete and identified mainly based on their characteristic ornamentation, which is composed of four to five strong spiral cords separated by relatively wider interspaces. The latter are occupied by numerous, fine axial riblets. The specimens closely resemble those originally described by Greco (1916) from the Coniacian of Wadi Abu Elefieh and Saint Paul. Abdel-Gawad (2000: p. 1515, pl. 1, figs. 12, 13) identified two forms, *Mesalia quartercarinata* (*sphyngis* var. *quartercarinata* Greco) and *Mesalia* cf. *quartercarinata* whereby the former taxon possesses four spiral cords, while the latter is characterised by having four spiral cords in the early whorls and five to six spirals in the latter whorls.

Genus *Turritella* Lamarck, 1799

Turritella quadricincta Goldfuss, 1844

Pl. 19, Fig. 6a-b

1844 *Turritella quadricincta* sp. nov. - Goldfuss, p. 106, pl. 196, figs. 16, 17c.

1902 *Turritella quadricincta* Goldfuss - Quaas, p. 246, pl. 25, figs. 36-37.

1927 *Turritella quadricincta* Goldfuss - Blanckenhorn, p. 141, pl. 3, figs. 38-39.

1974 *Turritella quadricincta* Goldfuss - Albanesi & Busson, p. 292, pl. 21, fig. 5.

Material and occurrence. 2 incomplete specimens from Gebel Yelleg, Wata Formation, bed no. 44.

Age. Middle Turonian.

Distribution in Egypt. Western Dersert.

Distribution outside Egypt. Libya, Algeria, Palestine, and southern Europe.

Remarks. The specimens are incomplete and identified mainly based on their characteristic ornamentation, which is composed of four strong spiral cords separated by wider interspaces. The latter are occupied by numerous fine axial riblets. The specimens agree with those described by Quaas (1902) from the Maastrichtian of the Western Desert of Egypt and that decribed by Blanckenhorn from the Senonian of Palestine. They resemble also that recorded by Albanesi & Busson (1974) from Algeria. The species ranges from the Turonian to the Masstrichtian.

Family Architectonicidae

Genus *Torinia* Gray, 1842

Torinia (*Climacopoma*) *amini* Abbass, 1963

Pl. 19, Fig. 7

1963 *Torinia* (*Climacopoma*) *amini* sp. nov. - Abbass, p. 43, pl. 1, fig. 1.

1998 *Torinia* (*Climacopoma*) *amini* Abbass - El Qot, p. 121, pl. 10, figs. 7-8.

Material and occurrence. 4 specimens from Gebel Ekma, Raha Formation, bed no. 9.

n = 4	H	D	HL	PA	nw	D/H	HL/H
Range	6.9-15	13.2-19.5	2.7-6.8	83°-89°	3	1.35-2.68	0.39-0.51
Mean	9	16.2	4.4	86°	3	1.92	0.45

Age. Late Cenomanian.

Distribution in Egypt. East of Darb El-Sheikh, Gebel El-Minsherah, and G. El-Hamra.

Remarks. The specimens small, of low conical shape, its width may exceed twice its height. The specimens are internal moulds, but agree in the their general shape and dimensions with *Torinia* (*Climacopoma*) *amini* Abbass, 1963. They agree also with material recorded by El Qot (1998) from the Upper Cenomanian of both Gebel El-Minsherah and Gebel El-Hamra.

Family Procerithiidae Cossmann, 1906

Subfamily Metacerithiinae Cossmann, 1906

Genus *Cimolithium* Cossmann, 1906

***Cimolithium tenouklense* (Coquand, 1862)**

Pl. 19, Fig. 8

1862 *Turritella Tenouklense* sp. nov. - Coquand, p. 176, pl. 4, fig. 6.

1889 *Cerithium Tenouklense* Coquand - Peron, p. 66, pl. 20, fig. 2.

1912 *Cerithium Tenouklense* Coquand - Pervinquière, p. 16, pl. 1, figs. 20-22.

1916 *Cerithium* (*Cimolithium*) *Tenouklense* Coquand - Greco, p. 154 (96), pl. 19 (11), figs. 3-5.

1927 *Cerithium tenouklense* Coquand - Blanckenhorn, p. 162, pl. 8 (4), figs. 77-80.

1963 *Cerithium tenouklense* Coquand - Fawzi, p. 100, pl. 7, fig. 9.

1971 *Cimolithium tenouklense* Coquand - Collignon, p. 149.

1974 *Cimolithium tenouklense* (Coquand) - Albanesi & Busson, p. 295, pl. 22, fig. 1.

1992 *Cimolithium tenouklense* (Coquand) - Abdel-Gawad & Gameil, p. 76, fig. 3/7-8.

1998 *Cimolithium tenouklense* (Coquand) - El Qot, p. 122, pl. 10, figs. 9-10.

1999 *Cimolithium tenouklense* (Coquand) - El Shazly, p. 827, pl. 5, fig. 13.

2001b *Cimolithium tenouklense* (Coquand) - Kora *et al.*, pl. 3, fig. 2.

2001 *Cimolithium tenouklense* (Coquand) - Abdallah *et al.*, pl. 1, fig. 1.

2002a *Cimolithium tenouklense* (Coquand) – Zakhera, p. 310, fig. 5/1.

2002 *Cimolithium tenouklense* (Coquand) - Kora *et al.*, pl. 4, fig. 3.

Material and occurrence. 40 specimens from Gebel Ekma; 31 from the Raha Formation, beds no. 2 and 9, and 9 specimens from the Abu Qada, bed no. 10.

N = 40	H	D	HL	HA	WA	PA	nw	D/H	HL/H	WA/HA
Range	30-70	15-35	6-17	12-20	9-13	25°-55°	4-10	0.45-0.75	0.08-0.31	0.60-78
Mean	28.6	28.56	11.27	15	11.43	37°	6.57	0.61	0.21	0.71

Description. The specimens small- to medium-sized, highly turriculate. Spire long, consisting of about 6-8 whorls, which are convex in outline; whorl width nearly twice the height. All specimens are internal moulds which show no traces of ornamentation. Aperture rectangular.

Age. Late Cenomanian-Early Turonian.

Distribution in Egypt. Gebel Shabrawit, G. El-Minsherah, G. Nezzazat G. Um Heriba, G. El-Hamra, El Giddi Pass, and Wadi Tarfa.

Distribution outside Egypt. North Africa, Somalia, Madagascar, and the Middle East.

Discussion. As the specimens are internal moulds no trace of their ornamentation is preserved. Abdel-Gawad & Gameil (1992) pointed out that specimens with preserved shells are ornamented with rounded tubercles arranged in a spiral manner. The species is widespreade in the Cenomanian of North Africa but it ranges to the Maastrichtian.

Family Potamididae

Subfamily Potamidinae

Genus *Pyrazus* Montfort, 1910

Subgenus *Pyrazus* Montfort, 1910

Pyrazus (*Pyrazus*) *valeriae* (Verneuil & Lorière, 1868)

Pl. 19, Figs. 9-11

1868 *Cerithium Valeriae* sp. nov. - Verneuil & Lorière, p. 11, pl. 2, fig. 1.

1916 *Pyrazus Valeriae* Verneuil & Lorière - Douvillé, p. 136, pl. 18, figs. 6-8.

1992 *Pyrazus valeriae* (Verneuil & Lorière) - Abdel-Gawad & Gameil, p. 74, fig. 2/11-12.

1998 *Pyrazus valeriae* (Verneuil & Lorière) - El Qot, p. 124, pl. 10, figs. 11-13.

Material and occurrence. 14 specimens from Gebel Ekma, Raha Formation, beds no. 5, 6, 9 and 10 specimens from the East Themed area, Galala Formation, bed no. 6.

Measurements (in mm).

n = 24	H	D	HL	HA	WA	PA	nw	nr	D/H	HL/H	WA/HA
Range	28-50	12.5-25	7-22	6-10	4-7	23°-35°	4-8	8-10	0.42-0.65	0.25-0.35	0.68-0.99
Mean	36.7	19.65	14.53	8.37	5.87	30°	5.8	9	0.51	0.30	0.82

Description. Shell small- to medium-sized, turriculate. Spire acute and relatively long. Body whorl accounting for about 1/3 of shell height. Ornamentation consisting of 8-10 axial ribs, which are crossed by 7-12 spiral lines. Aperture nearly oval.

Age. Late Cenomanian.

Distribution in Egypt. Gebel Manzour, G. Nezzazat, G. El-Minsherah, and G. El-Hamra.

Distribution outside Egypt. Spain.

Discussion. The present species differs from *Pyrazus stantoni* Hassan & Abdelgawad, 1995 from the sandstone series of Abu Roash, which has five strong and additional finer spiral lines, in having finer spiral lines of similar strength. It differs also from *Pyrazus* (*Echinobathra*) *magharensis* Abbass, 1963 (nr = 11-12, ns = 20-25) in having fewer axial ribs and spiral lines (nr = 8-10, ns = 7-12).

This species was established by Verneuil & Lorière (1868) from the Lower Cretaceous of Spain. It was also recorded from the Albian of Gebel Manzour by Douvillé (1916). Recently, it was recorded from the Cenomanian of Gebel Nezzazat by Abdel-Gawad & Gameil (1992) and from Gebel El- Minsherah and Gebel El-Hamra by El Qot (1998).

Family Cerithiidae Fleming, 1828

Subfamily Campanilinae Wenz, 1840

Genus *Campanile* Bayle, 1884

Subgenus *Campanile* Bayle, 1884

***Campanile* (*Campanile*) cf. *ganesha* (Noetling, 1897)**

Pl. 19, Figs. 12, 14

cf. 1897 *Nerinea Ganesha* sp. nov. - Noetling, p. 58, pl. 15, figs. 1-2; pl. 16, figs. 1-2.

cf. 1916 *Nerinea Ganesha* Noetling - Greco p. 121(63), pl. 15 (7), figs. 10-11.

cf. 1971 *Nerinea* (*ptygmatis*) *ganesha* Noetling - Collignon, p. 159, pl. C, fig. 5.

cf. 1974 *Campanile* (*Campanile*) *ganesha* (Noetling) - Albanesi & Busson, p. 299.

Material and occurrence. 13 incomplete specimens from Gebel Ekma; 6 from the Raha Formation, bed no. 9 and 7 from the Abu Qada Formation, bed no. 10.

Age. Late Cenomanian-Early Turonian.

Distribution in Egypt. Wadi Um Rockam.

Distribution outside Egypt. India, Algeria, Libya and Lebanon.

Remarks. All specimens are incomplete internal moulds, which closely resemble in their morphology to *Campanile* (*Campanile*) *ganesha* (Noetling) which was recorded by Greco (1916) from the Maastrichtian of Egypt and by Collignon (1971) from the Maastrichtian of Algeria. In the present study it was recorded from the Late Cenomanian and Early Turonian.

Superfamily Nerineacea

Family Nerineidae Zittel, 1878

Genus *Nerinea* Deshayes, 1827

***Nerinea gemmifera* Coquand, 1862**

Pl. 19, Fig. 13

1862 *Nerinea gemmifera* sp. nov - Coquand, p. 177, pl. 4, fig. 4.