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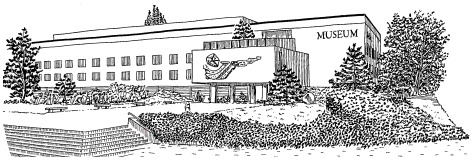

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Upper Cretaceous echinoids from the Galala Plateaux, North Eastern Desert, Egypt

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Abstract
Thirty echinoid species (15 regular and 15 irregular), belonging to 20 genera, are described from the Upper Cretaceous successions exposed at the Abu Darag (Northern Galala), Saint Paul, and Wadi El Dakhl sections (Southern Galala). Two new species are established: *Heterosalenia dakhlensis* and *Phymosoma kassabi*. Both are from the Coniacian of Wadi El Dakhl. The rank of the subspecies *Mecaster heberti* (COQUAND) *turonensis* (FOURTAU) is raised to the species level. The apical disc of the genus *Pedinopsis* COTTEAU, 1863 is illustrated for the first time.

Key words
Echinoids, Upper Cretaceous, Galala Plateaux, Eastern Desert, Egypt.

I. INTRODUCTION

Relatively, few studies were carried out on the taxonomy of the Cretaceous echinoids in Egypt in general. Initial pioneering work include FOURTAU (1898-1921), GREGORY (1906), STEFANINI (1918), and LAMBERT (1932). In addition to the description of some species by some authors as FAWZI (1959 & 1963), ABDEL AAL & MOHAMED (1987), KORA *et al*., 1993, 2001 & 2002, and KASSAB & ISMAEL (1994). Recent detailed studies are focused on the Upper Cretaceous echinioids from Sinai as ABDELHAMID (1997), ABDELHAMID & EL QOT (2001), and EL QOT (2006). A few work was carried out on the echinoids of the Eastern Desert in particular (e.g. GEYS, 1989 & 1992 and ABDELHAMID & AZAB, 2003). The present work aims to provide a more detailed systematic study of the Upper Cretaceous echinoids in the Galala Plateaux, Eastern Desert. For this purpose three sections were selected: the Abu Darag section (~ 90 km south of Suez city, opposite to the Abu Darag Lighthouse) at Latitude 29° 20'N and Longitude 32° 25'E, Saint Paul section at Latitude 28° 48'N and Longitude 32° 38'E, and Wadi El Dakhl section at Latitude 28° 42' N and Longitude 32° 25' E (Fig. 1).

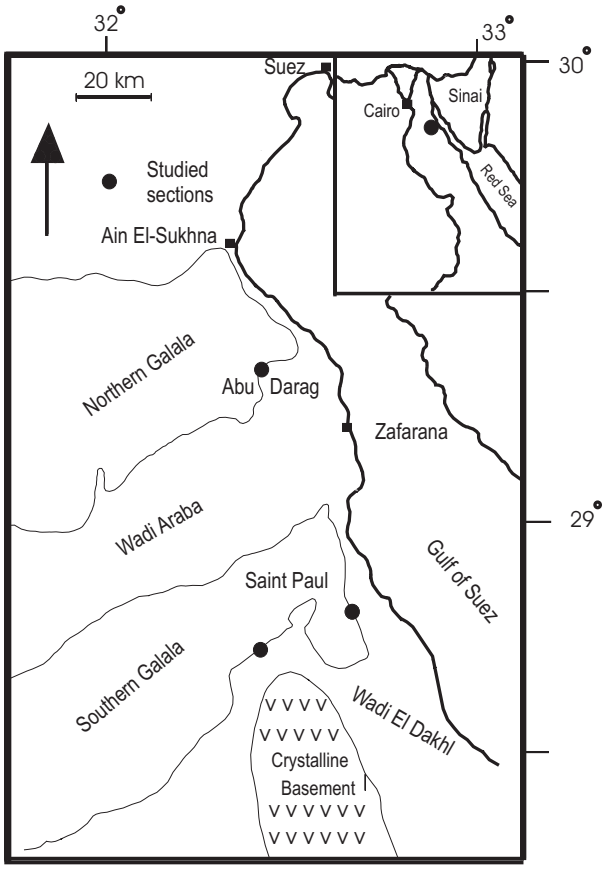

Fig. 1: Location map of the studied sections.

II. STRATIGRAPHY

Detailed stratigraphy of the Upper Cretaceous successions of the studied sections has been revealed in ABDEL-GAWAD *et al*. (2006 & 2007) and EL QOT (2008). ABDEL-GAWAD *et al*. (2006 & 2007) divided the concerned sequences into the Galala Formation (Cenomanian-Early Turonian), the Umm Omeiyid Formation (Middle Turonian), the Wata Formation (late Middle-Late Turonian), the Matulla Formation (Coniacian-Santonian), and the Sudr Chalk (Campanian-Maastrichtian). ABDEL-GAWAD *et al*. (2006 & 2007) and EL QOT (2008) recognized the biozones

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based on the ammonites as well as some selected taxa of other macroinvertebrates (e.g. Inoceramids, oysters, and echinoids). The three successions are subdivided biostratigraphically as follows: three ammonite zones and five zones based on other macrofauna from Abu Darag section, five ammonite and ten non-ammonite macrobiozones in Saint Paul section, and six ammonite and seven non-ammonite macrobiozones were established from Wadi El Dakhl (Figs. 2-4).

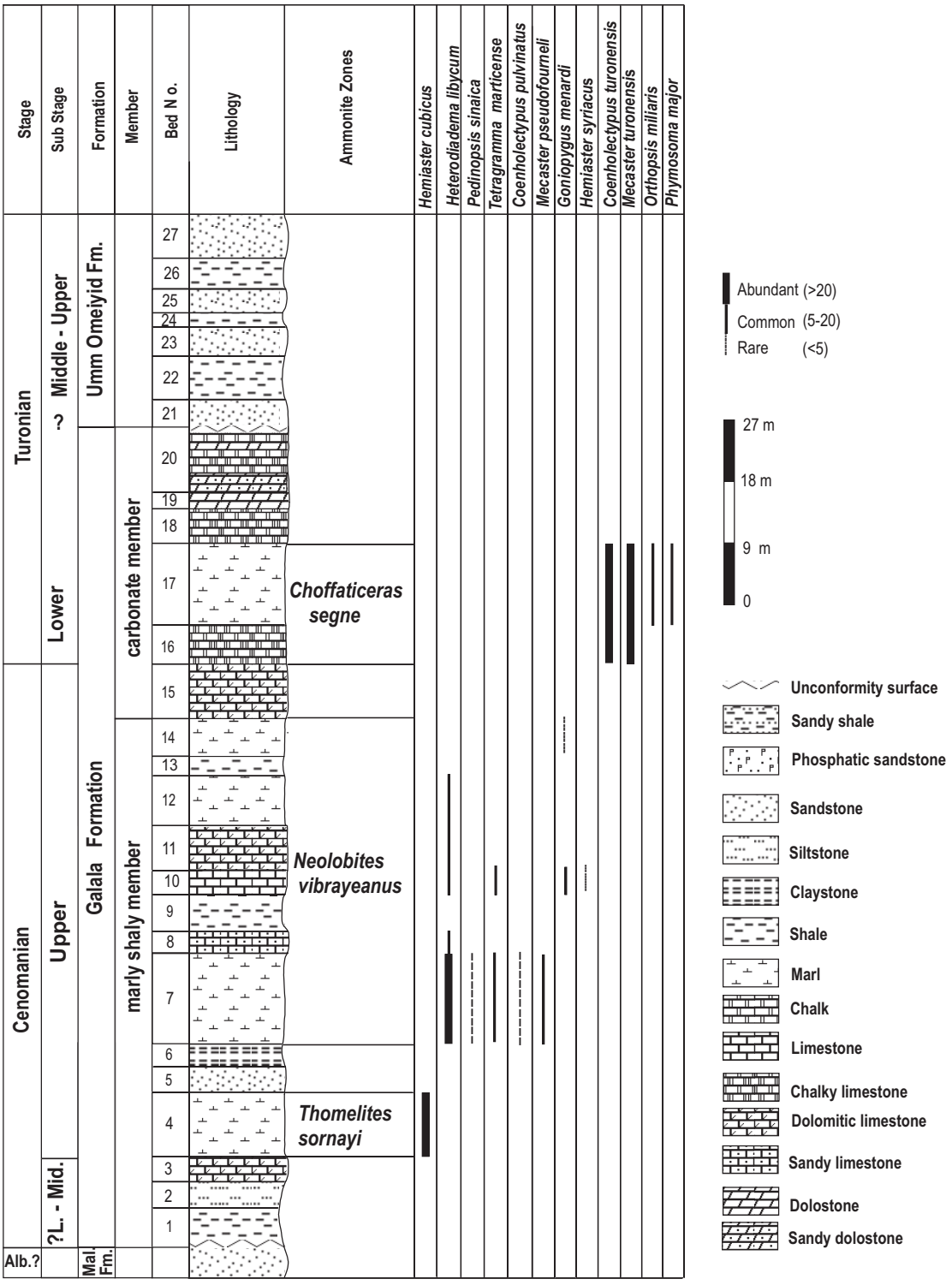


Fig. 2: Stratigraphy of the Cenomanian-Turonian succession of Abu Darag area (Lighthouse), and the stratigraphic distribution of the studied echinoids (modified after ABDEL-GAWAD *et al*., 2006).

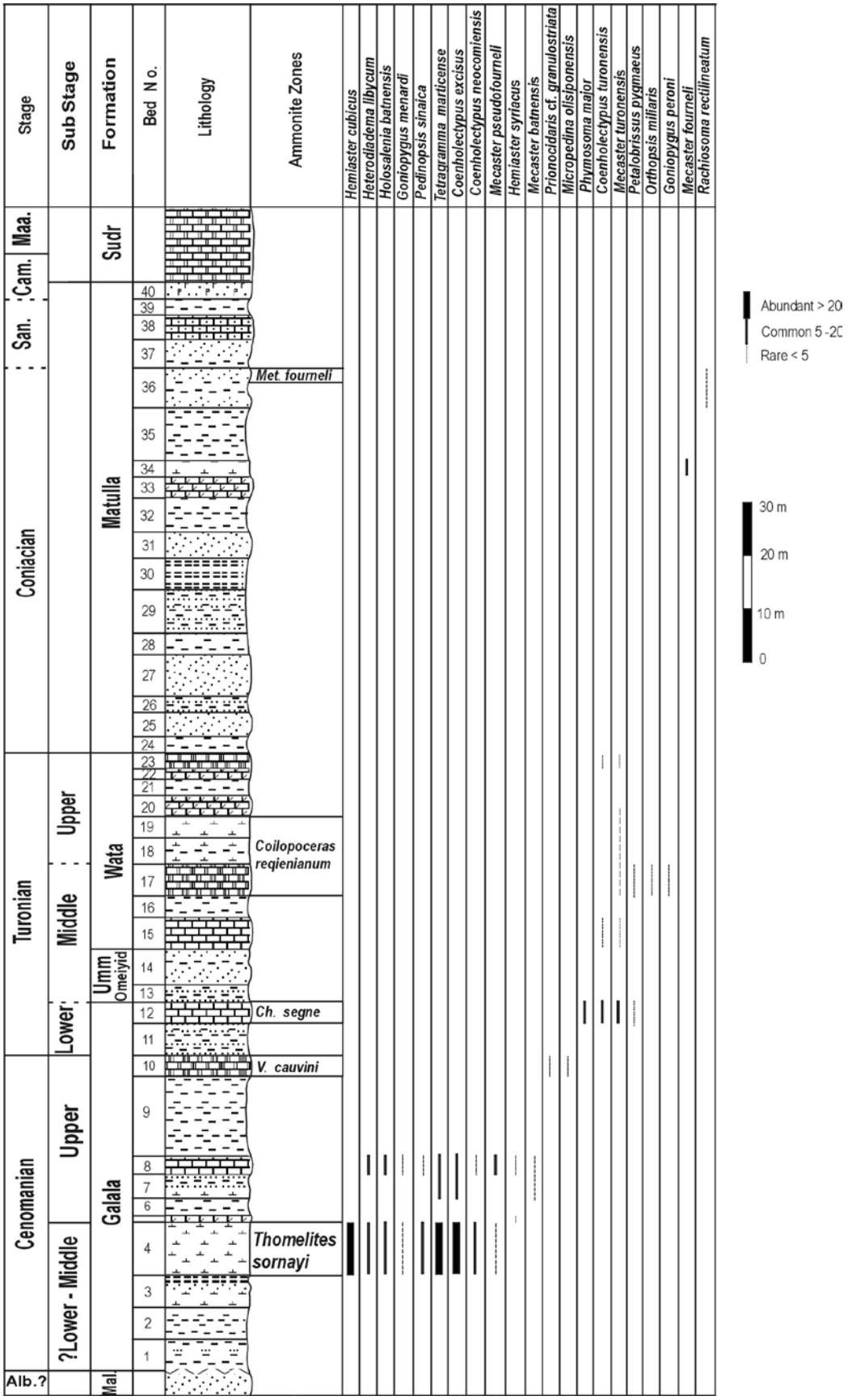


Fig. 3 : Stratigraphy of the Upper Cretaceous succession of Saint Paul section, and the stratigraphic distribution of the studied echinoids (modified after ABDEL-GAWAD *et al*., 2007).

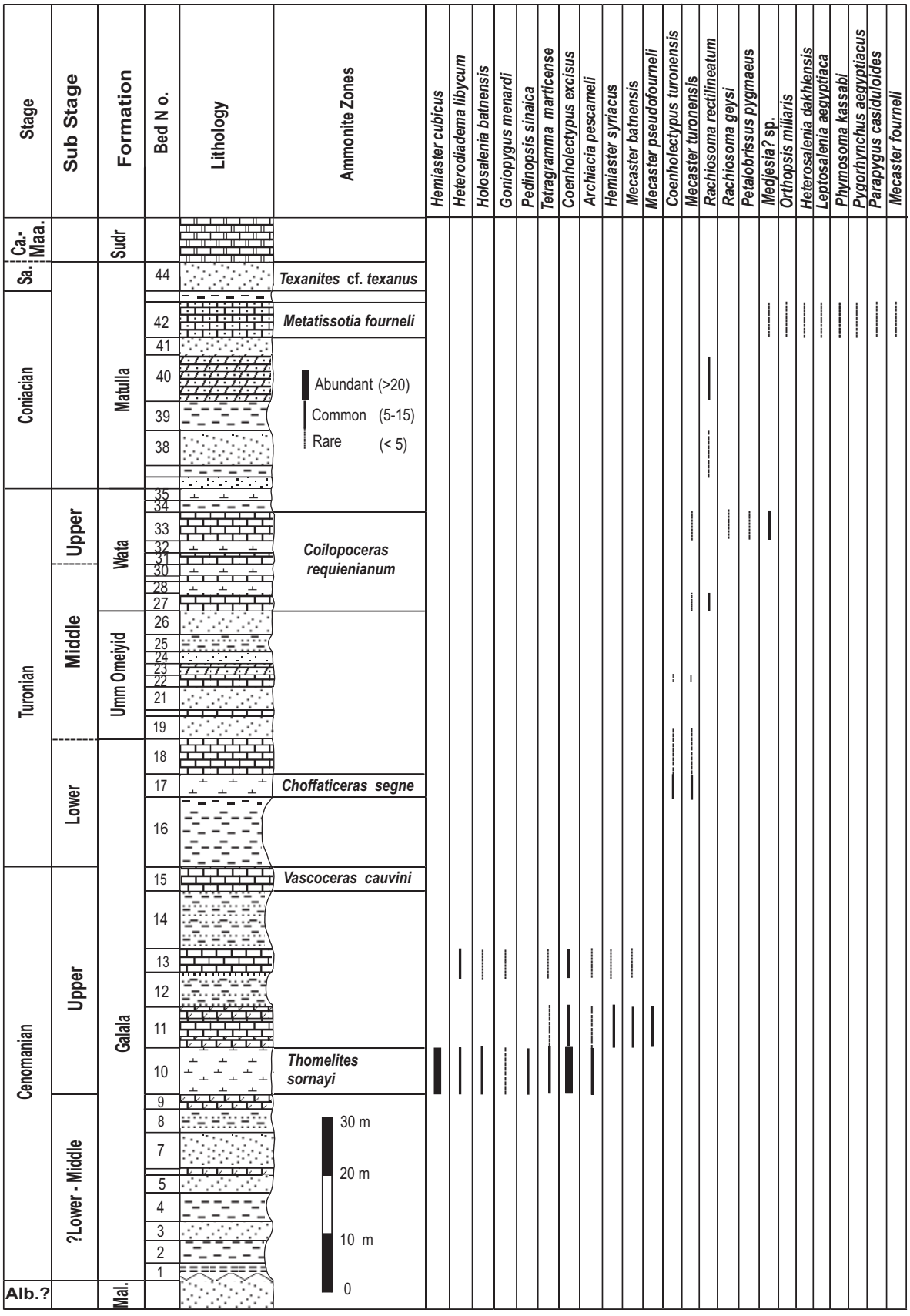


Fig. 4 : Stratigraphy of the Upper Cretaceous succession of Wadi El Dakhl area, and the stratigraphic distribution of the studied echinoids (modified after ABDEL-GAWAD *et al*., 2007).

III. SYSTEMATIC PALEONTOLOGY

The systematic classification of echinoids follows the classification of British Cretaceous echinoids as follows: Calycina, SMITH & WRIGHT (1990); Arbacioida, SMITH & WRIGHT (1993); Phymosomatoida, SMITH & WRIGHT (1993 & 1996), Holectypoida, SMITH & WRIGHT (1999); Holasteroida, SMITH & WRIGHT (2003). In addition to the classification used by SMITH & BENGTSON (1991: Cretaceous echinoids from North-Eastern Brazil), and SMITH (1995: Late Campanian-Maastrichtian echinoids from the United Arab Emirates-Oman Border region), the classification of the rest orders (Hemicidaroida and Cassiduloidea) follows that of DURHAM *et al*. (1966). The terminology used in the description of the taxa follows the glossary of DURHAM & WAGNER (1966). All linear measurements (taken with Vernier Caliper) are given in millimetres.

Abbreviations:

D = test diameter in regular echinoids; **dp** = diameter of peristome (in regular echinoids); **H** = test height; **L** = test length; **W** = test width; **Ls** = length of apical disc; **Ws** = width of apical disc; **LI** = length of petal I or V; **LII** = length of petal II or IV; **LIII** = length of ambulacral III up to the peripetalous fasciole; **Lk** = length of periproct; **Wk** = width of periproct; **Lp** = length of peristome; **Wp** = width of peristome; **Wa** = width of ambulacral area at the ambitus; **Wi** = width of interambulacral area at the ambitus; **Na** = number of tubercles in one column of ambulacrum; **Ni** = number of tubercles in one column of interambulacrum; **NI** = number of pore pairs in petal I or V; **NII** = number of pore pairs in petal II or IV; **NIII** = number of pore pairs in ambulacral III until fasciole, **BU** = Benha University, **DG** = Abu Darag, **SP** = Saint Paul, **DL** = Wadi El Dakhl. The studied echinoids are deposited in the collection of the Geological Museum, Geology Department, Faculty of Science, Benha University.

Phylum Echinodermata KLEIN, 1734
Subphylum HAECKEL *in* ZITTEL, 1895
Class Echinoidea LESKE, 1778
Subclass Cidaroidea CLAUS, 1880
Order Cidaroida CLAUS, 1880
Family Cidaridae GRAY, 1825
Tribe Cidarini GRAY, 1825
Subtribe Phyllacanthina SMITH & WRIGHT, 1989
Genus *Prionocidaris* AGASSIZ 1863
Type species: *Cidarites pistillaris* LAMARCK, 1816

Prionocidaris cf. *granulostriata* (DESOR, 1855)
Pl. I, fig. 1a-b

cf.1855. *Cidaris granulostriata* DESOR, p. 145, pl. 20, figs. 3-6.
cf.1989. *Prionocidaris granulostriata* (DESOR).– SMITH & WRIGHT, p. 92, pl. 29, figs. 1-2; text-fig. 18B (with additional synonymy).

Material: 1 specimen from Saint Paul (BU2006SP E1), Galala Formation, bed n°10.

Measurements:

n =1	D	H	H/D	Wa	Wi	Wa/Wi
	48	36	0.75	6	24	0.25

Remarks: The present specimen is closely similar to *Prionocidaris granulostriata* (DESOR) in its overall appearance, dimensions, and description as detailed described by SMITH & WRIGHT (1989). *P. granulostriata* differs from *P. morgani* (GAUTHIER) which was described by SMITH (1995) from the Maastrichtian of the United Arab Emirates and *P. schlumbergeri* (COTTEAU) which was described from the Cenomanian of Portugal by DE LORIOL (1887) in having a relatively higher test. In contrast, the test of *P. granulostriata* is less elevated than that of *P. vendocinensis* (AGASSIZ) of the Turonian-Santonian of Europe. As the specimen is relatively poorly preserved, the author referred it to *granulostriata* with reservation.

Subclass Euechinoidea BRONN, 1860
?Cohort Diadematacea DUNCAN, 1889
?Order Diadematoida DUNCAN, 1889
Family Heterodiadematidae SMITH & WRIGHT, 1993
Genus *Heterodiadema* COTTEAU, 1864
Type species: *Hemicidaris libyca* DESOR, 1846

Heterodiadema libycum (DESOR, 1846)
Pl. I, figs. 3a-b, 5a-b, 6

1846. *Hemicidaris libyca* DESOR *in* AGASSIZ & DESOR, p. 338.
1864. *Heterodiadema libycum* DESOR.– COTTEAU, p. 522, pl. 1124.
1921. *Heterodiadema libycum* DESOR.– FOURTAU, p. 16.
1925. *Heterodiadema libycum* DESOR.– BLANCKENHORN, p. 85, pl. 7, fig. 1.
1963. *Heterodiadema libycum* DESOR.– FAWZI, p. 5.
1975. *Heterodiadema libycum* (DESOR).– ZAGHBIB-TURKI, p. 6, pl. 1, fig. 4.
1980. *Heterodiadema libycum* (DESOR).– GEYS, p. 449, pl. 8.
1985. *Heterodiadema libycum* (DESOR).– BANDEL & GEYS, p. 97, pl. 4, figs. 6-7; pl. 5, figs. 1-2.
1990. *Heterodiadema libycum* (DESOR).– SMITH *et al*., p. 43, figs. 8c-g, 9-10. pl. 5, figs. 1-2.
1993. *Heterodiadema libycum* (DESOR).– NÉRAUDEAU *et al*., p. 283, pl. 1, figs. B-D.
1995. *Heterodiadema libycum* (DESOR).– NÉRAUDEAU *et al*., p. 406, fig. 3 (e).
2001. *Heterodiadema libycum* (DESOR).– ABDELHAMID & EL QOT, p. 7, fig. 3L-N.
2003. *Heterodiadema libycum* (DESOR).– ABDELHAMID & AZAB, p. 857, pl. 1, fig. Q.
2003. *Heterodiadema libycum* (AGASSIZ & DESOR).– BERNDT, p. 78, fig. 3/1a-c, 2a-b.

2006. *Heterodiadema libycum* (DESOR).– EL QOT, p. 132, pl. 30, figs. 6-9 (with full synonymy).
2006. *Heterodiadema libycum* (DESOR).– ABDEL-GAWAD *et al*., pl. 3, figs. 3, 6.
2007. *Heterodiadema libycum* (DESOR).– ABDEL-GAWAD *et al*., pl. 6, fig. 6a-b.

Material: 28 specimens from Abu Darag area (BU2005DG E1-28), Galala Formation, beds n° 7, 8 and 10-12; 17 specimens from Saint Paul (BU2006SP E2-18), Galala Formation, beds n° 4 and 8; and 13 specimens from Wadi El Dakhl (BU2007DL E1-13), Galala Formation, beds n° 10 and 13.
Measurements: Table 1
Remarks: *Heterodiadema libycum* shows a wide variation related to the size-reduction of primary tubercles above the ambitus and to the degree to which the apical disc penetrates into the posterior interambulacrum (for more discussion see ABDELHAMID & EL QOT, 2001 and EL QOT, 2006).
H. libycum differs from *H. buhaysensis* SMITH, 1995 from the Maastrichtian of Buhays (United Arab Emirates) in having a more reduced ambulacral and interambulacral tubercles adapically. In *H. libycum*, reduction of ambulacral tubercles starts just above the ambitus whereas in *H. buhaysensis*, the reduction of ambulacral tubercles starts closer to the apical disc. *H. auremense* DE LORIOL which has been erected based on material from the Cenomanian of Portugal differs from *H. libycum* in having a globular test (in DE LORIOL, 1987 for *H. auremense* H/D = 0.56-0.89; in *H. libycum* herein H/D = 0.0.41-0.57).
Occurrence: *Heterodiadema libycum* is common in the Cenomanian sediments of the Tethys, Middle Asia, West Africa and the Persian Gulf. It has been recorded from the Turonian of Jordan (BANDEL & GEYS, 1985), the Coniacian-Santonian of Gebel El-Hamra, Sinai (ABDELHAMID & EL QOT, 2001), and the Campanian of Belgium (GEYS, 1980) and Saudi Arabia (NÉRAUDEAU *et al*., 1995).

Cohort Echinacea CLAUS, 1876
Plesion (Order) Orthopsida MORTENSEN, 1942

Family Orthopsidae DUNCAN, 1889
Genus *Orthopsis* COTTEAU, 1864
Type species: *Cidarites miliaris* D'ARCHIAC, 1835

Orthopsis miliaris (D'ARCHIAC, 1835)
Pl. I, figs. 2a-c, 4

1835. *Cidarites miliaris* D'ARCHIAC, p. 179, pl. 11, fig. 8.
1846. *Diadema granulare* AGASSIZ *in* AGASSIZ & DESOR, p. 350.
1921. *Orthopsis miliaris* (D'ARCHIAC).– FOURTAU, p. 36.
1975. *Orthopsis miliaris* (D'ARCHIAC).– ZAGHBIB-TURKI, p. 32, pl. 1, figs. 22-24.
1985. *Orthopsis miliaris* (D'ARCHIAC).– GEYS, p. 143, pl. 5, figs. 8-10.
1990. *Orthopsis miliaris* (D'ARCHIAC).– ALI, p. 107, fig. 5/10.
1991. *Orthopsis miliaris* (D'ARCHIAC).– SMITH & BENGTSON, p. 30, pl. 8B-F; text-fig. 23 (with additional synonymy).
1992. *Orthopsis miliaris* (D'ARCHIAC).– GEYS, p. 148, pl. 2, figs. 14-16.
1995. *Orthopsis miliaris* (D'ARCHIAC).– NÉRAUDEAU *et al*., p. 410, fig. 3f-g.
1995. *Orthopsis miliaris* (D'ARCHIAC).– SMITH, p. 136, pl. 2, figs. 4, 5; pl. 3, figs. 1-9; text-figs. 12-14.
2001. *Orthopsis miliaris* (D'ARCHIAC).– ABDELHAMID & EL QOT, p. 18, fig. 15J.

Material: 6 specimens from Abu Darag area (BU2005DG E29-34), Galala Formation, bed n° 17; 2 specimens from Saint Paul (BU2006SP E19-20), Wata Formation, bed n° 17; and one specimen from Wadi El Dakhl (BU2007DL E14), Matulla Formation, bed n° 42.
Measurements: Table 2
Remarks: *Orthopsis miliaris* differs from *O. ovata* (COQUAND) from the Turonian of Algeria in having a lower test (for *miliaris* H/D ratio 44-49% compared to 63% of COQUAND'species) and wider peristome. *O. ruppelii* (DESOR) which was described by FOURTAU (1914) from the Cenomanian of Egypt differs from the present species in having a higher test and a relatively more developed primary tubercles. In agreement with GEYS (1985), SMITH & BENGTSON (1991) *O. granularis* (AGASSIZ) was regarded as junior synonym to *O. miliaris*. For more discussions concerning other synonyms and

Table 1

n =58	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	Ls	Ws	Ls/D	dp	dp/D
Range	22-42	10.5-19	0.40 - 0.57	4.5-9	7-14.5	0.57-0.65	16-22	14-18	8-17.5	6-10	0.35-0.45	7-10	0.24 -0.33
Mean	28.4	15.6	0.49	6.6	9.8	0.61	17.4	16.3	11.2	8	0.39	8.6	0.29

Table 2

n=9	D	H	H/D	Wa	Wi	Wa/Wi	Ls	Ls/D	Na	Ni	dp	dp/D
Range	18- 32	8-15.5	0.44-0.49	2.5-5	6-11.5	0.38-0.43	3.5-6	0.19-0.22	18-20	12-14	7.5-13	0.41-0.47
Mean	24.3	11.3	0.47	3.8	7.9	0.41	4.3	0.21	19	13	9.8	0.44

the differences between *O. miliaris* and other related species see GEYS (1985), SMITH & BENGTSON (1991), NÉRAUDEAU *et al*. (1995) and SMITH (1995).
Occurrence: *Orthopsis miliaris* has a remarkably large stratigraphic and geographic range (GEYS, 1992). The species is common in the Cenomanian-Maastrichtian sediments of Europe, North Africa, Middle East, USA (Texas). It was recorded from the Albian and the Cenomanian of Brazil (SMITH & BENGTSON, 1991).

Order Calycina GREGORY, 1900
Family Acrosaleniidae GREGORY, 1900
Genus *Heterosalenia* COTTEAU, 1861
Type species: *Heterosalenia martini* COTTEAU, 1861

***Heterosalenia dakhlensis* sp. nov.**
Pl. II, fig. 1a-d

Holotype: BU2007DL E15; Pl. II, fig. 1a-d.
Paratype: BU2007DL E16.
Locus typicus: Wadi El Dakhl, Southern Galala, Eastern Desert, Egypt.
Stratum typicum: Bed n° 42, Matulla Formation, *Metatissotia fourneli* Zone, Middle-Upper Coniacian.
Derivatio nominis: After Wadi El Dakhl, Southern Galala, Eastern Desert, Egypt.
Material: 2 specimens from Wadi EL Dakhl, (BU2007 DL E15-16), Matulla Formation, bed n° 42.
Measurements: Table 3
Diagnosis: *Heterosalenia* with two rows of well developed crenulated and perforated primary tubercles in interambular area. Adapical plates of interambulacral zones naked and without tubercles. Ambulacral plating is bigeminate above ambitus.
Description: Test of relatively large-sized for the genus, rounded in outline. Adapical surface flattened to feebly convex. Adoral surface flattened. Apical system relatively small and forming a distinct platform above the corona. Periproct displaced towards ocular I which is insert, all other oculars being exsert. Ambulacral area relatively narrow; wider adorally than near apical disc. Ambulacral plating bigeminate above ambitus. Poriferous zone narrow, uniserial throughout. Interporiferous zone with two rows of imperforated, crenulated primary tubercles adorally developed and becoming as large as interambulacral tubercles near the peristome. Interambulacral area with two rows of perforated, crenulated primary tubercles; these two rows being separated by numerous fine tubercles. Each column containing six to seven interambulacral plates; adapical plates naked and without tubercles. Peristome rounded and moderately large; gill slits moderately to well developed.
Remarks: The present species can be distinguished from the type species *Heterosalenia martini* COTTEAU from the Turonian of France in having the adapical plates of interambulacral area naked and without tubercles and in having a relatively larger test. *H. paquieri* SAVIN, 1902 from the Lower Aptian of France differs from the present species in having its periproct displaced towards the posterior genital and not towards ocular I similar to herein.

Family Saleniidae AGASSIZ, 1838
Subfamily Saleniinae AGASSIZ, 1838
Tribe Saleniini AGASSIZ, 1838
Genus *Leptosalenia* SMITH & WRIGHT, 1990
Type species: *Salenia prestensis* DESOR, 1856

***Leptosalenia aegyptiaca* (FOURTAU, 1914)**
Pl. II, fig. 2a-c

1914. *Salenia aegyptiaca* FOURTAU, p. 10, pl. 2, fig. 1.
2006. *Leptosalenia aegyptiaca* (FOURTAU).– EL QOT, p. 129, pl. 30, figs. 1-2.

Material: 3 specimens from Wadi EL Dakhl, (BU2007 DL E17-19), Matulla Formation, bed n° 42.
Measurements: Table 4
Remarks: ABDEL AAL & MOHAMED (1987) erected *Salenia zenima* based on material collected from the Santonian of Abu Zenima area, Sinai, Egypt. They distinguished their species from *Leptosalenia aegyptiaca* based on the ornamention of the interambulacra.
Occurrence: *Leptosalenia aegyptiaca* is restricted to the Coniacian-Santonian of Egypt.

Table 3

n =2	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	dp	dp/D
Range	33-39	17.5-20	0.51-0.53	4.5-5	13.5-14.5	0.31-0.34	32-36	5-6	14-18	0.42-0.46
Mean	36	18.75	0.52	4.8	14	0.33	34	5.5	16	0.44

Table 4

n =3	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	dp	dp/D
Range	11-13.5	7.5-8.7	0.57-0.62	1.2-1.6	3.9-5	0.31-0.34	22-24	4-6	5.5-7	0.46-0.51
Mean	12.5	8.1	0.61	1.5	4.3	0.33	23	5	6.2	0.49

Tribe Salenocidarini SMITH & WRIGHT, 1990
Genus *Holosalenia* SMITH & WRIGHT, 1990
Type species: *Salenia batnensis* PERON & GAUTHIER, 1879

***Holosalenia batnensis* (PERON & GAUTHIER, 1879)**
Pl. II, figs. 3, 4a-c

1879. *Salenia batnensis* PERON & GAUTHIER *in* COTTEAU *et al*., p. 183, pl. 13, figs. 7-13.
1889. *Salenia tunetana* THOMAS & GAUTHIER *in* GAUTHIER, p. 65, pl. 4, figs. 8-13.
1901. *Salenia tunetana* THOMAS & GAUTHIER.– FOURTAU, p. 42.
1914. *Salenia batnensis* PERON & GAUTHIER race *tunetana* THOMAS & GAUTHIER.– FOURTAU, p. 9.
1918. *Salenia batnensis* PERON & GAUTHIER var. *tunetana* THOMAS & GAUTHIER.– STEFANINI, p. 122, pl. 5, fig. 2a-c.
1985. *Salenia batnensis* PERON & GAUTHIER.– BANDEL & GEYS, p. 105, pl. 4, figs. 1-5.
1990. *Holosalenia batnensis* (PERON & GAUTHIER).– SMITH & WRIGHT, p. 134.
2001. *Holosalenia batnensis* (PERON & GAUTHIER).– ABDELHAMID & EL QOT, p. 5, fig. 3E-G.
2003. *Holosalenia batnensis* (PERON & GAUTHIER).– ABDELHAMID & AZAB, p. 855, pl. 1, fig. L.

Material: 15 specimens from Saint Paul (BU2006SP E21-35), Galala Formation, beds n° 4 and 8; and 11 specimens from Wadi EL Dakhl, (BU2007DL E20-30), Galala Formation, beds n° 10 and 13.
Measurements: Table 5
Remarks: In agreement with BANDEL & GEYS (1985), ABDELHAMID & EL QOT (2001), and ABDELHAMID & AZAB (2003), *Salenia tunetana* THOMAS & GAUTHIER, 1889 is regarded as a junior synonym of *Holosalenia batnensis*. *Salenia choffati* DE LORIOL, 1887 from the Cenomanian of Portugal seems to be closely related to the present species, but BANDEL & GEYS (1985) distinguished it from *batnensis* by its much smaller triangular poriferous depression, shape of its genital plates, narrower extrascorbicular surfaces, and its narrower ambulacra.

Occurrence: *Holosalenia batnensis* is restricted to the Cenomanian of North Africa and the Middle East.

Order Arbacioida GREGORY, 1900
Family Goniopygidae SMITH & WRIGHT, 1993
Genus *Goniopygus* AGASSIZ, 1838
Type species: *Goniopygus peltatus* AGASSIZ, 1838

***Goniopygus menardi* (DESMAREST, 1825)**
Pl. II, fig. 5a-b; Pl. III, fig. 2

1825. *Echinus Menardi* DESMAREST, p. 101.
1865. *Goniopygus Brossardi* COQUAND *in* COTTEAU, p. 732, pl. 1179, figs. 1-7.
1879. *Goniopygus Menardi* DESMAREST.– COTTEAU *et al*., p. 219.
1914. *Goniopygus Menardi* DESMAREST var. *Brossardi* COQUAND.– FOURTAU, p. 40.
1921. *Goniopygus Menardi* DESMAREST var. *Brossardi* COQUAND.– FOURTAU, p. 45.
1925. *Goniopygus Menardi* DESMAREST.– BLANCKENHORN, p. 84.
1989. *Goniopygus menardi* (DESMAREST).– ZAGHBIB-TURKI, p. 72.
1992. *Goniopygus menardi* (DESMAREST).– GEYS, p. 147, pl. 2, figs. 10-13.
1993. *Goniopygus menardi* (DESMAREST).– NÉRAUDEAU *et al*., p. 286, pl. 1, figs. I- K.
2001. *Goniopygus menardi* (DESMAREST).– ABDELHAMID & EL QOT, p. 18, fig. 5I-J.
2003. *Goniopygus menardi* (DESMAREST).– ABDELHAMID & AZAB, p. 862, pl. 3, figs. H-I.
2003. *Goniopygus menardi* (DESMAREST).– BERNDT, p. 81, fig. 3/5, 6a-b
2006. *Goniopygus menardi* (DESMAREST).– EL QOT, p. 140, pl. 32, figs. 5a-b, 6 (with extensive synonymy).

Material: 7 specimens from Abu Darag area (BU2005DG E35-41), Galala Formation, beds n° 10 and 14; 3 specimens from Saint Paul (BU2006SP E36-38), Galala Formation, beds n° 4 and 8; and 2 specimens from Wadi El Dakhl (BU2007DL E31-32), Galala Formation, beds n° 10 and 13.

Table 5

n =26	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	dp	dp/D	Ws/Ls	Lk/Wk
Range	10.5-23	6-16	0.54-0.81	1-2.3	3.5-8	0.21-0.29	16-24	6-8	3.5-7	0.36-0.48	0.83-1	0.8-1.2
Mean	17.7	12.4	0.69	1.6	5.7	0.26	20	6.7	6.2	0.44	0.96	1.0

Table 6

n =12	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	Ls	Ls/D	dp	dp/D
Range	9.5-27	5.5-17	0.50-0.64	1.2-5.5	2-10	0.50-0.60	12-14	6-8	5-12.5	0.39-0.55	4-11.5	0.41-0.44
Mean	19.2	11.3	0.58	3.1	5.6	0.57	13	7	8.5	0.44	7.8	0.43

Measurements : Table 6
Remarks : GEYS (1992) distinguished *Goniopygus menardi* from *G. coquandi* COTTEAU, 1865 from the Cenomanian of Algeria and *G. innesi* GAUTHIER *in* FOURTAU (1901) from the Santonian of Egypt. *G. coquandi* differs from *G. menardi* in having higher and spherical-shaped test, greater number of tubercles, and larger periproct. *G. innesi* differs from the present species in the structure of its apical disc and its poriferous zones in addition to its ambulacral tubercles fewer and larger than in *G. menardi*. *G. brossardi* COQUAND *in* COTTEAU (1865) from the Cenomanian of Algeria was regarded herein as a junior synonym of *G. menardi* in agreement with COTTEAU *et al*. (1879), BLANCKENHORN (1925), and EL QOT (2006).
Occurrence : *Goniopygus menardi* is a common Cenomanian species that characterizes the Cenomanian of Europe, North Africa and the Middle East.

Goniopygus peroni THOMAS & GAUTHIER, 1889
Pl. III, fig. 3a-b

1889. *Goniopygus Peroni* THOMAS & GAUTHIER *in* GAUTHIER, p. 86, pl. 5, figs. 17-23.
1905. *Goniopygus Peroni* THOMAS & GAUTHIER.– FOURTAU, p. 127, pl. 1, fig. 2.
1914. *Goniopygus Peroni* THOMAS & GAUTHIER.– FOURTAU, p. 40.
2006. *Goniopygus peroni* THOMAS & GAUTHIER.– EL QOT, p. 141, pl. 32, fig. 7a-b.

Material : 1 specimen from Saint Paul (BU2006SP E39), Wata Formation, bed n° 17.
Measurements : Table 7
Remarks : *Goniopygus peroni* differs from *G. menardi* (DESMAREST) recorded herein in being higher and in having a narrower interambulacral area (for *G. menardi* H/D = 0.50-0.63, Wa/Wi = 0.50-0.60 where for *G. peroni* is H/D = 0.64, Wa/Wi = 0.47).
Occurrence : *Goniopygus peroni* is restricted to the Turonian of Tunisia and Egypt.

Order Hemicidaroida BEURLEN, 1937
Family Pseudodiadematidae POMEL, 1883
Genus *Pedinopsis* COTTEAU, 1863
Type species : *Pedinopsis meridianensis* COTTEAU, 1863

Pedinopsis sinaica (DESOR, 1847)
Pl. III, figs. 6a-c, 7a-b

1847. *Pedina sinaica* DESOR *in* AGASSIZ & DESOR, p. 67.
1852. *Echinus syriacus* CONRAD *in* LYNCH, p. 212, pl. 1, fig. 1 ; pl. 22, fig. 127.
1914. *Pedinopsis sinaea* DESOR.– FOURTAU, p. 18, pl. 2, figs. 3-4.
1918. *Pedinopsis sinaea* DESOR.– STEFANINI, p. 125, pl. 5, fig. 3a-b.
1918. *Pedinopsis sinaea* DESOR var. *Figarii* STEFANINI, p. 129, pl. 5, fig. 4a-f.
1925. *Pedinopsis sinaica* DESOR.– BLANCKENHORN, p. 89.
1989. *Pedinopsis sinaica* (DESOR).– ZAGHBIB-TURKI, p. 68.
1990. *Pedinopsis* (*Sinaiopsis*) *sinaica* (DESOR).– SMITH *et al*., p. 54, figs. 12f-h, 15, 16.
2001. *Pedinopsis sinaica* (DESOR).– ABDELHAMID & EL QOT, p. 11, pl. 2, fig. 4E-F.
2003. *Pedinopsis sinaica* (DESOR).– ABDELHAMID & AZAB, p. 858, pl. 2, figs. C-E.

Material : 2 specimens from Abu Darag area (BU2005DG E42-43), Galala Formation, bed n° 7 ; 17 specimens from Saint Paul (BU2006SP E40-56), Galala Formation, beds n° 4, and 8 ; and 9 specimens from Wadi El Dakhl (BU2007DL E33-41), Galala Formation, bed n° 10.
Measurements : Table 8
Remarks : SMITH & WRIGHT (1993, p. 217-218) mentioned that the *Dumblea* CRAGIN, 1893 has a dicyclic apical disc, a very different style of tuberculation and a different style of ambulacral compounding. They added that the apical disc of *Pedinopsis* COTTEAU, 1863 remains unknown, and that *Pedinopsis* has a similar style of tuberculation and plate compounding to *Dumblea* CRAGIN, 1893. They excluded both genera from order Phymosomatoida MORTENSEN, 1904. In the present study, one specimen has a well preserved apical disc which shows a dicyclic arrangement (Pl. III, fig. 6). Consequently, *Pedinopsis* together with *Dumblea*

Table 7

n =1	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	Ls	Ls/D
	25	16	0.64	4.5	9.5	0.47	16	8	9	0.36

Table 8

n =28	D	H	H/D	Wa	Wi	Wa/Wi	Ls	Ws	Ls/D	dp	dp/D
Range	12.5-30.5	6-17.5	0.42-0.64	2-5.5	4.5-10.5	0.39-0.52	1.8-3	1.5-3	0.11-0.16	4.5-10	0.28-0.38
Mean	22.8	12.7	0.56	3.4	7.2	0.44	2.6	2.3	0.14	7.3	0.33

probably refer to family Pseudodiadematidae POMEL, 1883 in order Hemicidaroida BEURLEN, 1937.

Pedinopsis sinaica can be distinguished from *P. desori* (COQUAND, 1862) which has been erected based on material from the Cenomanian of Algeria in having biserial arrangement between ambitus and apical disc while in *P. desori* the biserial arrangement extends below the ambitus and apical disc, in addition to its different plating style. *P. spherica* SMITH *et al*., 1990 from the Cenomanian of Oman, differs from the present species in having a spherical and higher test and biserial arrangement of the poriferous zones extending below the ambitus to the apical disc. The very depressed test distinguishes *P. humilis* FOURTAU, 1921 from the present species.

Occurrence : *P. sinaica* was originally described based on material collected from the Cenomanian of Egypt. It was recorded from the Cenomanian of Algeria, Tunisia, Palestine, and Oman.

Order Phymosomatoida MORTENSEN, 1904
Family Diplopodiidae SMITH & WRIGHT, 1993
Genus *Tetragramma* AGASSIZ, 1840
Type species : *Cidarites variolare* BRONGNIART, 1822

***Tetragramma marticense* (COTTEAU, 1864)**
Pl. III, figs. 1a-b, 4, 5 ; text-fig. 5a

1864. *Pseudodiadema Marticense* COTTEAU, p. 507, pl. 1122.
1887. *Diplopodia Marticense* COTTEAU.– DE LORIOL, p. 41, pl. 7, figs. 1-5.
1889. *Diplopodia marticense* COTTEAU.– GAUTHIER, p. 72.
1901. *Diplopodia marticense* COTTEAU.– FOURTAU, p. 39.
1914. *Diplopodia marticense* COTTEAU.– FOURTAU, p. 15.
1937. *Tetragramma marticense* COTTEAU.– LAMBERT, p. 73.
2003. *Tetragramma marticense* (COTTEAU).– ABDELHAMID & AZAB, p. 858, pl. 2, figs. J- K.

Material : 6 specimens from Abu Darag area (BU2005DG E44-49), Galala Formation, beds n° 7 and 10 ; 27 from Saint Paul (BU2006SP E57-83), Galala Formation, beds n° 4, 7, and 8 ; and 9 from Wadi El Dakhl (BU2007DL E42-50), Galala Formation, beds n° 10, 11, and 13.
Measurements : Table 9
Remarks : GEYS (1989, p. 131) considered *Tetragramma marticense* as a junior synonym of *T. variolare* (BRONGNIART). SMITH & WRIGHT (1993, p. 224) mentioned that *T. marticense* may belong to the genus *Tiaromma* POMEL, 1883 rather than *Tetragramma* and they concluded that a proper biometric evaluation of growth in a population of the species is required to precise taxonomic position. In the present study, all the collected specimens (42 of variable sizes) show a biserial arrangement above ambitus which confirm that *T. marticense* belongs to the genus *Tetragramma* rather than *Tiaromma*. On the other hand, *T. marticense* can be distinguished from *T. variolare* where the latter differs in having a more convex adapical surface, sunken peristome, wider interambulacral extrascrobicular surface, and by the presence of two rows of secondary tubercles rather than the main four rows of interambulacral tubercles.
Occurrence : *T. marticense* was recorded from the Cenomanian of southern Europe (France and Portugal) and North Africa (Tunisia and Morroco).

Family Phymosomatidae POMEL, 1883
Genus *Phymosoma* HAIME, 1853
Type species : *Cidaris koenigii* MANTELL, 1822

***Phymosoma major* COQUAND, 1862**
Pl. III, fig. 8a-b, 9

1862. *Phymosoma major* COQUAND, p. 256, pl. 27, figs. 16-18.
1864. *Cyphosoma major* COQUAND.– COTTEAU, p. 596, pls. 1143-1144.
1879. *Cyphosoma majus* COQUAND.– COTTEAU *et al*., p. 93.
1880. *Cyphosoma majus* COQUAND.– COQUAND, p. 342.
1914. *Cyphosoma majus* COQUAND.– FOURTAU, p. 31.
1921. *Cyphosoma majus* COQUAND.– FOURTAU, p. 39.
1932. *Phymosoma majus* COQUAND.– LAMBERT, p. 95.
1975. *Phymosoma majus* COQUAND.– ZAGHBIB-TURKI, p. 29, pl. 1, figs. 13- 15.
1993. *Phymosoma majus* COQUAND.– NÉRAUDEAU *et al*., p. 290, pl. 3, figs. A-G.
2006. *Phymosoma major* COQUAND.– EL QOT, p. 136, pl. 31, fig. 3.

Material : 6 specimens from Abu Darag area (BU2005DG E50-55), Galala Formation, bed n° 17, 5 specimens from Saint Paul (BU2006SP E84-88), Galala Formation, bed n° 12.
Measurements : Table 10
Remarks : *Phymosoma major* can be easily distinguished from *P. abbatei* (GAUTHIER, 1898) in having four rows of primary tubercles in the interambulacral area beside its larger size and higher test. It differs also from *P. sinaeum* (FOURTAU, 1914) where the latter is characterized by having two internal and two external rows of secondary tubercles in each interambulacrum, in addition to the two main rows.
Occurrence : *Phymosoma major* is restricted to the Turonian of North Africa.

***Phymosoma kassabi* sp. nov.**
Pl. IV, fig. 1a-d

Holotype : BU2007DL E51 ; Pl. IV, fig. 1a-d.
Paratype : BU2007DL E52.
Locus typicus : Wadi El Dakhl, Southern Galala, Eastern Desert, Egypt.
Stratum typicum : Bed n° 42, Matulla Formation, *Metatissotia fourneli* Zone, Middle-Upper Coniacian.

Derivatio nominis: After Prof. Dr. A. S. KASSAB, Professor of Paleontology, Assuit University, who died in 2008.

Material: 2 specimens from Wadi El Dakhl (BU2007 DL E51-52), Matulla Formation, bed n° 42.

Measurements: Table 11

Diagnosis: Large *Phymosoma* with two rows of well developed, crenulated, imperforated primary tubercles in both ambulacral and interambulacral area. Biserial arrangement extending from the apical disc till the ambitus. Ambulacral plates 6-geminate. Poriferous zones undulating at and below the ambitus, straight adapically.

Description: Test of large-sized for the genus, rounded in outline. Adapical surface convex. Adoral surface flattened, not sunken around peristome. All apical disc plates lacking, leaving a large, pentagonal hole, projecting slightly into the posterior interambulacrum, and slightly longer than wide. Ambulacral area wide (77% of the width of interambulacral area), narrower adapically than near peristome. Poriferous zones narrow, undulating at and below the ambitus; biserial and straight adapically; ambulacral plates 6-geminate. Interporiferous zone with two rows of imperforated, crenulated primary tubercles as large as interambulacral tubercles. Interambulacral area with two rows of imperforated, crenulated primary tubercles in addition to two rows of secondary tubercles close to the adradial sutures. Peristome rounded and of medium-sized; gill slits well developed.

Remarks: The present species differs from *Phymosoma mansour* PERON & GAUTHIER, of the Santonian of Algeria and recorded from the Coniacian of Jordan by BANDEL & GEYS (1985), in having a narrower peristome, larger and lower test (measurements of PERON & GAUTHIER *in* COTTEAU *et al*., 1881: D = 29, H = 14, H/D = 0.48; BANDEL & GEYS, 1985: D = 35.5, H = 21, H/D = 0.59, dp/D = 0.44). *P. maresi* COTTEAU differs from the present species in having smaller size and 4-geminate ambulacral plates. *P. koenigi* (MANTELL) can be distinguished easily from *P. kassabi* in having a well developed secondary tubercles, where in large specimens (greater than 35 mm diameter) these can approach the size of the primary tubercles (SMITH & WRIGHT, 1996).

Genus *Rachiosoma* POMEL, 1883

Type species: *Cyphosoma delamarrei* DESHAYES, 1831

Rachiosoma geysi ABDELHAMID & EL QOT, 2001

Pl. III, figs. 10, 11; Pl. IV, figs. 3, 8

1985. *Rachiosoma major* (COQUAND).– BANDEL & GEYS, p. 110, pl. 7, figs. 6-7; pl. 8, figs. 1-2.
2001. *Rachiosoma geysi* ABDELHAMID & EL QOT, p. 14, fig. 5B-C.
2004. *Rachiosoma geysi* ABDELHAMID & EL QOT.– ABDEL-GAWAD *et al*., pl. 10, fig. 2.
2006. *Rachiosoma geysi* ABDELHAMID & EL QOT.– EL QOT, p. 137, pl. 31, figs. 6, 7, 9.

Table 9

n =42	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	Ls	Ws	Ls/D	dp	dp/D
Range	18-35.5	7-14	0.37-0.55	3-7	9.5-13	0.53-0.59	14-16	10-12	11.6-15.5	8-12	0.42-0.46	10-13	0.35-0.38
Mean	28.7	12.3	0.42	5.2	10.8	0.55	15.3	10.9	12.6	9	0.44	11.4	0.37

Table 10

n =11	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	Ls	Ls/D	dp	dp/D
Range	27-36	13-15.5	0.43-0.45	6-7.5	9.5-12.5	0.60-0.65	11-13	10-12	8-11	0.27-0.31	10-11.5	0.31-0.34
Mean	29.6	14.5	0.44	6.8	10.2	0.63	12	11	9.8	0.29	10.6	0.33

Table 11

n =2	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	Ls	Ls/D	dp	dp/D
Range	43-49	18-22	0.42-0.45	10	13	0.77	12-13	12-13	15	0.35	17	0.35-0.40
Mean	46	20	0.44	10	13	0.77	13	13	15	0.35	17	0.38

Table 12

n =5	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	dp	dp/D	Ls	Ls/D
Range	17.5-27.5	8-11	0.38-0.46	3-6	4-8.5	0.57-0.75	10-13	8-11	5.5-9.5	0.27-0.38	6-9.5	0.29-0.35
Mean	23.6	9.7	0.43	4.5	6.9	0.69	11	10	7.3	0.33	7.6	0.33

Material: 5 specimens from Wadi El Dakhl (BU2007 DL E53-57), Wata Formation, bed n° 33.
Measurements: Table 12
Remarks: *Rachiosoma major* of BANDEL & GEYS (1985) from the Coniacian of Jordan was referred to *Rachiosoma geysi* of ABDELHAMID & EL QOT (2001) being characterized by having uniserial poriferous zones and four rows of primary tubercles on each interambulacrum (for more discussion see ABDELHAMID & EL QOT, 2001 and EL QOT, 2006).
Occurrence: *Rachiosoma geysi* ABDELHAMID & EL QOT was recorded from the Coniacian of Jordan and the Turonian of Egypt.

Rachiosoma rectilineatum (PERON & GAUTHIER, 1881)
Pl. IV, figs. 2a-b, 4, 5; Text-fig. 5b

1881. *Cyphosoma rectilineatum* PERON & GAUTHIER *in* COTTEAU *et al*., p. 104, pl. 7, figs. 1-4.
1921. *Rachiosoma rectilineatum* PERON & GAUTHIER.– FOURTAU, p. 40.
1985. *Rachiosoma rectilineatum* (PERON & GAUTHIER).– BANDEL & GEYS, p. 111, pl. 8, figs. 3-7; pl. 9, fig. 1.
1992. *Rachiosoma rectilineatum* (PERON & GAUTHIER).– GEYS, p. 147, pl. 2, figs. 8-9.

Material: 2 specimens from Saint Paul (BU2006SP E89-90), the Matulla Formation, bed n° 36; and 21 specimens from Wadi El Dakhl (BU2007DL E58-78), 11 specimens from the Wata Formation bed n° 27 and 10 specimens from the Matulla Formation, beds n° 37, 38 and 40.
Measurements: Table 13
Remarks: *Rachiosoma rectilineatum* can be distinguished from *R. delamarrei* DESHAYES where the ambulacral plates are 4-geminate and the poriferous zones are straight in the former. In *R. delamarrei* the ambulacral plates are 5-geminate and the poriferous zones are slightly sinuous. In addition to, the secondary tubercles are more developed in the former. *R. irregulare* FOURTAU, 1921 differs from *R. rectilineatum* (PERON & GAUTHIER, 1881) in having a wider ambulacra at the apex, well-developed ambulacral tubercles adapically, and a relatively higher test. *Rachiosoma geysi* ABDELHAMID & EL QOT, 2001 differs from the present species in having four rows of well developed primary tubercles on each interambulacrum.
Occurrence: *Rachiosoma rectilineatum* has a relatively wide stratigraphical range, extended from basal Turonian (possibly uppermost Cenomanian) up to the Santonian (GEYS, 1992). It was recorded from Algeria, Egypt and Jordan.

Order uncertain
Family uncertain
Genus *Micropedina* COTTEAU, 1866
Type species: *Echinus olisiponensis* FORBES, 1850

Micropedina olisiponensis (FORBES, 1850)
Pl. IV, fig. 10

1850. *Echinus olisiponensis* FORBES *in* SHARPE, p.195, pl. 25, fig. 1.
1887. *Micropedina olisiponensis* FORBES.– DE LORIOL, p. 62, pl. 10, figs. 3-6.
1912. *Micropedina olisiponensis* FORBES.– FOURTAU, P. 156, pl. 2, fig. 2.
1981. *Micropedina olisiponensis* (FORBES).– AMARD *et al*., p. 88.
1991. *Micropedina olisiponensis* (FORBES).– SMITH & BENGTSON, p. 32, pl. 6A-I, figs. 24-25 (with additional synonymy).
1992. *Rachiosoma rectilineatum* (PERON & GAUTHIER).– GEYS, p. 143, pl. 1, figs. 8-14.
1993. *Micropedina olisiponensis* (FORBES).– NÉRAUDEAU *et al*., p. 278, pl. 1, figs. L-M; pl. 2, figs. A-D.
1997. *Micropedina olisiponensis* (FORBES).– NÉRAUDEAU & COURVILLE, p. 840, figs. 6/1, 8, 11.
2003. *Micropedina olisiponensis* (FORBES).– BERNDT, p. 80, fig. 3/4a-c.
2003. *Micropedina olisiponensis* (FORBES).– ABDELHAMID & AZAB, p. 854, pl. 1, fig. F.
2006. *Micropedina olisiponensis* (FORBES).– EL QOT, p. 129, pl. 30, figs. 1-2.

Material: 1 specimen from Saint Paul (BU2006SP E91), Galala Formation, bed n° 10.
Measurements:

n =1	D	H	H/D	Wa	Wi	Wa/Wi
	48	37	0.77	11	16	0.69

Remarks: SMITH & BENGTSON (1991) and GEYS (1992) synonymized *M. cotteaui* (COQUAND), *M. bipatellis* GREGORY with *M. olisiponensis*. Moreover, GEYS (1992) added *M. humei* FOURTAU to the synonyms of *M. olisiponensis*. ABDELHAMID & AZAB (2003) regarded *M. cotteaui* and *M. olisiponensis* as two separate species based on the difference in the structure of major ambulacral plates. While they agreed with

Table 13

n =23	D	H	H/D	Wa	Wi	Wa/Wi	Na	Ni	dp	dp/D	Ls	Ls/D
Range	14-36	6-15	0.35-0.48	2.5-8.5	4-12	0.55-0.77	10-14	8-12	5-11	0.29-0.38	5-11.5	0.28-0.37
Mean	21.2	10.5	0.44	4.8	7.7	0.68	11	8.5	8.5	0.35	8.1	0.34

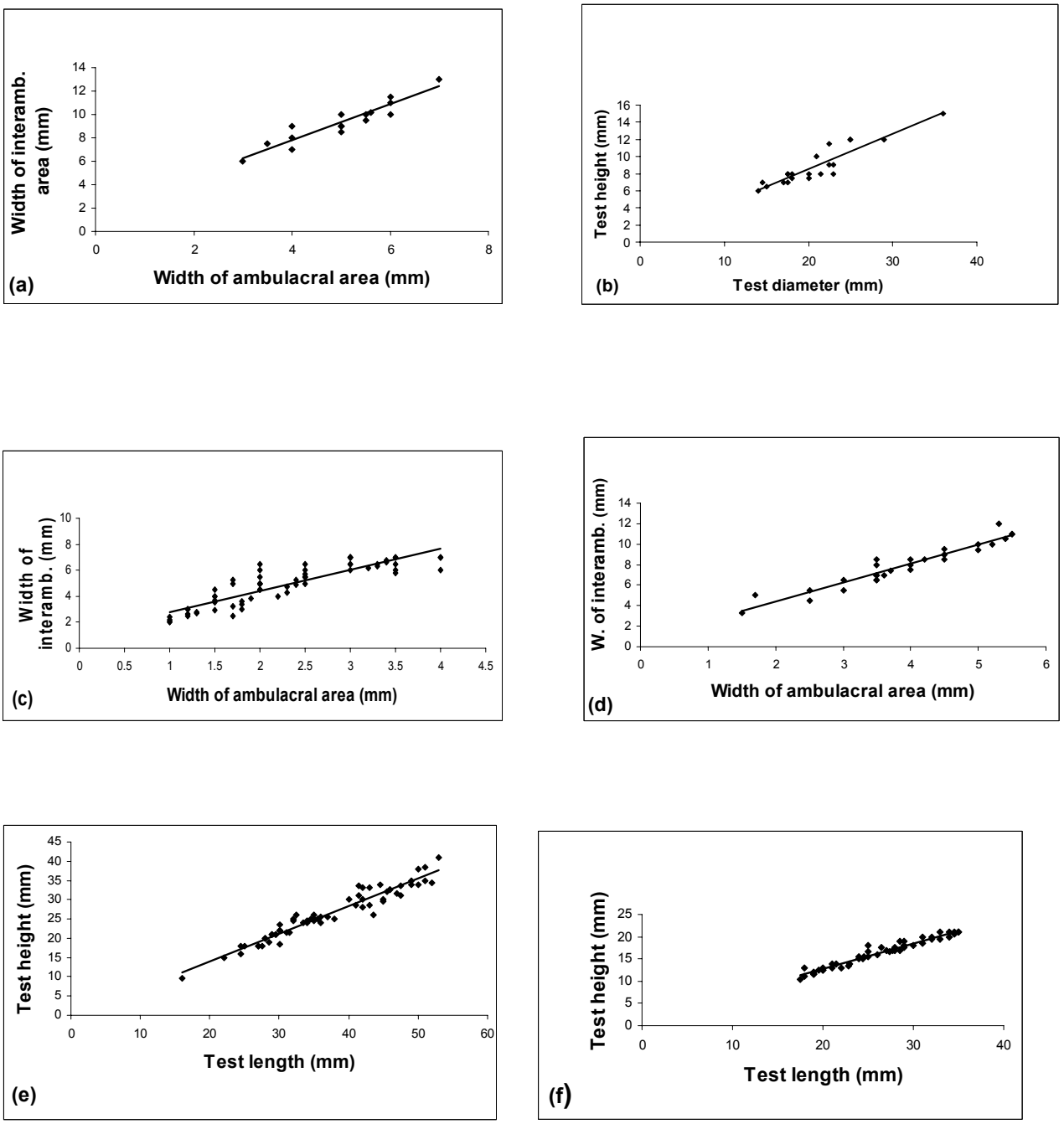


Fig. 5: Biometric data on (a): *Tetragramma marticense* (COTTEAU), (b): *Rachiosoma rectilineatum* (PERON & GAUTHIER), (c): *Coenholectypus excisus* (DESOR), (d): *Coenholectypus turonensis* (DESOR), (e): *Mecaster cubicus* (DESOR), (f): *Mecaster turonensis* (FOURTAU).

the prementioned authors in regarding *M. bipatellis* as junior synonym to *M. olisiponensis*. In my opinion, *M. cotteaui* differs from *M. olisiponensis* in having a higher and globular test whereas, the height excesseds its diameter (for *M. cotteaui* in COQUAND, 1862, p. 254 measurements are D: 14, H: 17, H/D = 1.21 compared to *M. olisiponensis* H/D are 0.7 in FORBES, 1850, 0.52 to 0.75 in SMITH & BENGTSON, 1991, 0.69 to 0.74 in EL QOT 2006) in addition to the differences mentioned by ABDELHAMID & AZAB (2003).

Micropedina olisiponensis was first described by FORBES (*in* SHARPE, 1850) from the Cenomanian of Portugal. NÉRAUDEAU & COURVILLE (1997) recorded *M. olisiponensis* from the Uppermost Cenomanian of Nigeria (*Vascoceras cauvini* Zone, *Nigeraceras gadeni* subzone). EL QOT (2006) recorded the species from the

same stratigraphic level (*V. cauvini* Zone) in Sinai. It has been recorded herein from the Uppermost Cenomanian of Saint Paul section (*V. cauvini* Zone). Therefore, *M. olisiponensis* seems to be restricted to the Uppermost Cenomanian of Egypt and Nigeria. Consequently, the species can be considered as indicative of the Uppermost Cenomanian being associated with the Tethyan *V. cauvini* Zone.

Occurrence: *M. olisiponensis* is considered a well known Cenomanian echinoid being recorded from Southern Europe, North Africa, western Africa, Middle East, south-central Asia (Caracorum), and Brazil.

Cohort Irregularia LATREILLE, 1825
Order Holectypoida DUNCAN, 1889
Suborder Holectypina DUNCAN, 1889
Family Holectypidae LAMBERT, 1900
Subfamily Coenholectypinae SMITH & WRIGHT, 1999
Genus *Coenholectypus* POMEL, 1883
Type species: *Holectypus macropygus* DESOR, 1842

***Coenholectypus excisus* (DESOR, 1847)**
Pl. IV, figs. 6, 7a-c; text-fig. 5c

1847. *Discoidea excisa* DESOR *in* AGASSIZ & DESOR, p. 90.
1861. *Holectypus excisus* DESOR.– COTTEAU & TRIGER, p. 368, pl. 62, figs. 1- 4.
1873. *Holectypus excisus* DESOR.– LARTET, p. 81.
1921. *Holectypus excisus* DESOR.– FOURTAU, p. 55.
1989. *Caenholectypus excisus* (DESOR).– ZAGHBIB-TURKI, p. 72.
1989. *Caenholectypus excisus* (DESOR).– NÉRAUDEAU & MOREAU, p. 312.
2001. *Caenholectypus excisus* (DESOR).– ABDELHAMID & EL QOT, p. 21, fig. 5O-P.
2003. *Caenholectypus excisus* (DESOR).– ABDELHAMID & AZAB, p. 864, pl. 4, figs. A-B.
2006. *Coenholectypus excisus* (DESOR).– EL QOT, p. 142, pl. 32, fig. 10a-c.

Material: 34 specimens from Saint Paul (BU2006SP E92-125), Galala Formation, beds n° 4, 7, and 8; and 43 specimens from Wadi El Dakhl (BU2007DL E79-121), Galala Formation, beds n° 10, 11 and 13.
Measurements: Table 14
Remarks: FOURTAU (1914, p. 44) distinguished between *Coenholectypus excisus* from the Cenomanian and that from the Santonian based on the relative extension of the adapical end of the periproct, which in the Santonian forms reaches the lower third of the distance between apical disc and ambitus and separated these forms as a race (race *roachensis*) from the Cenomanian forms in which the adapical end of periproct reaches the mid-distance between apical disc and ambitus. According to ABDELHAMID (1997, p. 146) the adapical extension of periproct shows the same degree of variation in both forms. Instead, he distinguished *C. excisus* race *roachensis* from *C. excisus* of the Cenomanian by the wider ambulacral areas, wider peristome and relatively higher test of the former. Moreovere, ABDELHAMID (1997) raised the race *roachensis* to subspecies rank. The large size of the periproct distinguishes *C. excisus* from all other species of *Coenholectypus* recorded herein.
Occurrence: *Coenholectypus excisus* is a common Cenomanian species in southern Europe, North Africa, and the Middle East.

***Coenholectypus neocomiensis* (GRAS, 1848)**
Pl. IV, figs. 9, 11; Pl. V, fig. 1

1848. *Holectypus Neocomiensis* GRAS, p. 326, pl. 2, figs. 19-20.
1852. *Holectypus planatus* ROEMER, p. 84, pl. 10, fig. 2.
1859. *Holectypus cenomanensis* GUERANGER *in* COTTEAU & TRIGER, p. 173, pl. 30, figs. 5-10.
1887. *Holectypus pennanus* WHITE, p. 256, pl. 27, figs. 18-20.
1898. *Holectypus cenomanensis* GUERANGER.– FOURTAU, p. 625.
1906. *Holectypus cenomanensis* GUERANGER.– GREGORY, p. 225.
1925. *Holectypus cenomanensis* GUERANGER.– BLANCKENHORN, p. 90.
1927. *Holectypus engerrandi* LAMBERT, p. 90.
1936. *Holectypus adkinsi* SMISER, p. 461, pl. 62, figs. 12-15.
1963. *Holectypus cenomanensis* GUERANGER.– FAWZI, p. 70.
1975. *Holectypus cenomanensis* GUERANGER.– ZAGHBIB-TURKI, p. 34, pl. 1, figs. 25-27, text-fig. 21a-b.
1989. *Caenholectypus cenomanensis* (GUERANGER).– NÉRAUDEAU & MOREAU, p. 312.
1991. *Coenholectypus neocomiensis* (GRAS).– SMITH & BENGTSON, p. 35, pl. 7D-I, text-fig. 27.
2001. *Caenholectypus cenomanensis* (GUERANGER).– ABDELHAMID & EL QOT, p. 19, fig. 5N.
2003. *Caenholectypus cenomanensis* (GUERANGER).– ABDELHAMID & AZAB, p. 864, pl. 3, figs. M-N.
2006. *Coenholectypus cenomanensis* (GUERANGER).– EL QOT, p. 142, pl. 32, fig. 9a-c (with additional synonymy).
2006. *Coenholectypus cenomanensis* (GUERANGER).– ABDEL-GAWAD *et al*., pl. 6, fig. 5.

Material: 6 specimens from Saint Paul (BU2006SP E126-131), Galala Formation, beds n° 4 and 8.
Measurements: Table 15

Table 14

n= 77	D	H	H/D	Wa	Wi	Wa/Wi	dp	dp/D	Lk	Lk/D	wk	wk/ Lk
Range	6.5-21.7	3-12	0.41-0.63	1-3.5	2.2-7	0.33-0.52	2.5-7	0.23-0.38	2.5-6	0.25-0.29	1.5-3.5	0.4-0.77
Mean	15.1	7.6	0.57	2.5	5.5	0.46	4.2	0.29	4.1	0.27	2.3	0.59

Remarks: I agree with SMITH & BENGTSON (1991) that *Holectypus planatus* ROEMER, *H. cenomanensis* GUERANGER, *H. pennanus* WHITE, *H. engerrandi* LAMBERT, and *H. adkinsi* SMISER are regarded as junior synonyms of *Coenholectypus neocomiensis*. *Coenholectypus portentosus* COQUAND differs from *C. neocomiensis* in having a larger and lower test. The large size of the periproct distinguishes *Coenholectypus excisus* (DESOR) from *C. neocomiensis*.

Occurrence: *Coenholectypus neocomiensis* is a common species in the Aptian to Cenomanian of Europe, North and West Africa, the Middle East, and North and South America (SMITH & BENGTSON, 1991).

Coenholectypus pulvinatus (DESOR, 1847)
Pl. V, fig. 4a-b

1847. *Discoidea pulvinatus* DESOR *in* AGASSIZ & DESOR, p. 89.
1901. *Discoidea pulvinata* DESOR.– FOURTAU, p. 44, pl. 1, figs. 10-12.
1914. *Holectypus pulvinatus* DESOR.– FOURTAU, p. 47, pl. 4, figs. 5-7.
1918. *Holectypus pulvinatus* DESOR.– STEFANINI, p. 137, pl. 5, fig. 6a-b.
2003. *Caenholectypus pulvinatus* (DESOR).– ABDELHAMID & AZAB, p. 866, pl. 4, figs. E-F.

Material: 3 specimens from Abu Darag area (BU2006DG E56-58), Galala Formation, bed n° 7.

Measurements: Table 16

Remarks: *Coenholectypus pulvinatus* is distinguished from other Cenomanian *Coenholectypus* species such as *C. neocomiensis* (GRAS, 1848), *C. excisus* (DESOR, 1847), *C. bairensis* (FOURTAU, 1912) by possessing small and inframarginal periproct, globular and higher test with steep ambitus, small and flush peristome. *C. larteti* (COTTEAU, 1869) differs from the present species in having a more flattened test.

Coenholectypus turonensis (DESOR, 1847)
Pl. V, figs. 2, 7; Text-fig. 5d

1847. *Holectypus turonensis* DESOR *in* AGASSIZ & DESOR, p. 146.
1879. *Holectypus Turonensis* DESOR.– COTTEAU *et al*., p. 87.
1921. *Holectypus turonensis* DESOR.– FOURTAU, p. 57.
1975. *Holectypus turonensis* DESOR.– AWAD & ISSAWI, pl. 2, fig. 9.
1993. *Caenholectypus turonensis* (DESOR).– NÉRAUDEAU, p. 20, pl. 3, fig. M; pl. 4, figs. A-B.
2004. *Coenholectypus turonensis* (DESOR).– ABDEL-GAWAD *et al*., pl. 10, figs. 7, 9
2006. *Coenholectypus turonensis* (DESOR).– EL QOT, p. 144, pl. 32, figs. 12-14.
2006. *Coenholectypus turonensis* (DESOR).– ABDEL-GAWAD *et al*., pl. 3, figs. 2, 5a-b.
2007. *Coenholectypus turonensis* (DESOR).– ABDEL-GAWAD *et al*., pl.7, fig. 7a-b.

Material: 22 specimens from Abu Darag area (BU2005DG E59-80), Galala Formation, beds n° 16 and 17; 9 specimens from Saint Paul (BU2006SP E132-140), Galala Formation, bed n° 12, the Wata Formation, beds n° 15 and 23; and 8 specimens from Wadi El Dakhl (BU2007DL E122-129), Galala Formation, beds n° 17 and 18, Umm Omeiyid Formation, bed n° 22.

Measurements: Table 17

Remarks: *Coenholectypus turonensis* (DESOR) differs from *C. serialis* (DESHAYES, 1847) in being higher and highly concave around the peristome. With respect to the stratigraphic range of these two species, COTTEAU (1861) indicated that they appear in the Turonian with *C. serialis* being confined to this level, whereas *C. turonensis* continues into the Santonian. In contrast, COTTEAU *et al*.

Table 15

n =6	D	H	H/D	Wa	Wi	Wa/Wi	dp	dp/D	Lk	Lk/D	wk	wk/ Lk
Range	17-21	8-10.5	0.40-0.50	2.5-3.5	5.5-8	0.38-0.54	4.5-6	0.26-0.30	3.7-5	0.21-0.25	2-3.5	0.50-0.70
Mean	19.8	9.6	0.46	3	6.8	0.43	5.3	0.28	4.3	0.23	2.6	0.60

Table 16

n =3	D	H	H/D	Wa	Wi	Wa/Wi	dp	dp/D	Lk	Lk/D	wk	wk/ Lk
Range	17-28.5	11-21.5	0.63-0.75	2.8-4.2	6.5-12.5	0.34-0.43	3.3-4	0.19-0.23	2.8-3.3	0.12-0.16	1.8-2.1	0.63-0.69
Mean	21	14.5	0.69	3.2	8.2	0.39	3.8	0.21	3	0.14	2	0.66

Table 17

n =39	D	H	H/D	Wa	Wi	Wa/Wi	dp	dp/D	Lk	Lk/D	wk	wk/D
Range	11-31	5-15.3	0.43-0.60	1.5-6	3.3-12	0.44-0.54	3-8	0.23-0.33	3-8	0.22-0.32	2-5.4	0.17-0.22
Mean	20.6	11.3	0.51	4.1	8.6	0.50	5.7	0.29	5.2	0.27	3.1	0.19

(1881) pointed out that *C. turonensis* was confined to the Turonian, and *C. serialis* to the Santonian.
Occurrence: *Coenholectypus turonensis* is very common in the Turonian of North Africa and France.

Order Cassiduloida CLAUS, 1880
Family Nucleolitidae AGASSIZ & DESOR, 1847
Genus *Pygorhynchus* AGASSIZ, 1839
Type species: *Catopygus obovatus* AGASSIZ, 1836

***Pygorhynchus aegyptiacus* (FOURTAU, 1913)**
Pl. V, figs. 6, 10

1913. *Trematopygus aegyptiacus* FOURTAU, p. 62, pl. 8, fig. 1.
1921. *Bothriopygus aegyptiacus* FOURTAU.– FOURTAU, p. 62, pl. 7, fig. 7.
1932. *Pygorhynchus aegyptiacus* FOURTAU.– LAMBERT, p. 193.
1997. *Pygorhynchus aegyptiacus* (FOURTAU).– ABDELHAMID, p. 147, fig. 5/12-14.
2001. *Pygorhynchus aegyptiacus* (FOURTAU).– ABDELHAMID & EL QOT, p. 22, fig. 6D.
2006. *Pygorhynchus aegyptiacus* (FOURTAU).– EL QOT, p. 146, pl. 33, figs. 3a-b, 4.

Material: 2 specimens from Wadi Dakhl (BU2007DL E130-131), Matulla Formation, bed n° 42.
Measurements: Table 18
Remarks: This species was established by FOURTAU (1913) based on material collected from the Santonian rocks of Wadi El Raha, Sinai Egypt and he referred it to the genus *Trematopygus*. FOURTAU (1921) transferred the species to the genus *Bothriopygus*. LAMBERT (1932) referred it to the genus *Pygorhynchus*. KIER (1962, p. 90) mentioned that this species probably belongs to *Parapygus*. KIER (1962, p. 84) suggested that the stratigraphic range of the genus *Pygorhynchus* is Neocomian to Albian. He referred all the species described by SZÖRÉNYI (1955) from the Senonian of Bakony to *Parapygus* because no drawings of the phyllodes (which probably were single-pored) have been included. ABDELHAMID (1997) recorded the present species from the Coniacian-Santonian of Wadi Sudr and Wadi Matulla and mentioned that his specimens have double-pored phyllodes. Consequently, he referred the species to *Pygorhynchus*. Moreover, *P. aegyptiacus* has been recorded from the Coniacian-Santonian of Gebel El-Hamra and Themed by ABDELHAMID & EL QOT (2001) and EL QOT (2006), respectively. This confirms the extention of the stratigraphic range of the genus *Pygorhynchus* forward to the Santonian. ABDELHAMID (1997) distinguished *P. aegyptiacus* from *P. schweinfurthi* (FOURTAU, 1909) from the Upper Campanian of the Western Desert by having more elongated and higher test, more anteriorly eccentric apex, more divergent petals II and IV, and oblique peristome.

Family Echinolampadidae GRAY, 1851
Genus *Parapygus* POMEL, 1883
Type species: *Botriopygus cotteauanus* D'ORBIGNY, 1856

***Parapygus casiduloides* GAUTHIER, 1889**
Pl. V, fig. 8

1889. *Parapygus casiduloides* GAUTHIER, p. 48, pl. 3, figs. 8-9.
1962. *Parapygus casiduloides* GAUTHIER.– KIER, p. 100, pl. 14, figs. 7-10; text-fig. 82.
2006. *Parapygus casiduloides* GAUTHIER.– EL QOT, p. 146, pl. 33, figs. 1-2.

Material: 1 specimen from Wadi Dakhl (BU2007DL E132), Matulla Formation, bed n° 42.
Measurements: Table 19
Remarks: According to KIER (1962), the genus *Parapygus* is very similar to *Pygorhynchus* and differs only in having single-pored phyllodes which are double-pored in the latter. He added that *Parapygus* is probably a descendant of *Pygorhynchus*, the latter occuring later in the Cretaceous and its single-pored phyllodes indicating that it is more advanced. According to LAMBERT & THIÉRY (1921, p. 352) the stratigraphic range of the genus *Parapygus* is Valanginian to Senonian, but KIER (1962) pointed out that he had seen all the pre-Turonian species and they possess double-pored phyllodes and consequently, should be referred to the genus *Pygorhynchus*. *Parapygus casiduloides* differs from

Table 18

n =2	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII
Range	30-37	25-29	17-20	0.78-0.83	0.54-0.57	12-19	10-16	8-15	44-48	42-46	44-46
Mean	33.5	27	18.5	0.81	0.56	15.5	13	11.5	46	44	45

Table 19

n =1	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK	Wk/Lk
	38	31	17	0.82	0.45	17	13	13	43	38	32	5	3	0.6

P. cotteauanus (d'ORBIGNY, 1856) from the Turonian of France mainly in being smaller and in having more developed petals. *P. coquandi* (COTTEAU, 1866) from the Santonian-Campanian of Algeria differs from the present species in having a more rounded outline.
Occurrence: *Parapygus casiduloides* seems to be restricted to the Coniacian-Santonian of Tunisia and Egypt.

Family Faujassiidae LAMBERT, 1905
Genus *Petalobrissus* LAMBERT, 1916
Type species: *Echinobrissus setifensis* COTTEAU, 1866

***Petalobrissus pygmaeus* (FOURTAU, 1921)**
Pl. V, fig. 12

1921. *Echinobrissus pygmaeus* FOURTAU, p. 67, pl. 9, fig. 5.
1925. *Clitopygus pygmaeus* FOURTAU.– LAMBERT & THIÉRY, p. 586.
1932. *Clitopygus pygmaeus* FOURTAU.– LAMBERT, p. 193.
2001. *Petalobrissus pygmaeus* (FOURTAU).– ABDELHAMID & EL QOT, p. 22, fig. 6G.
2006. *Petalobrissus pygmaeus* (FOURTAU).– EL QOT, p. 147, pl. 33, figs. 6-5

Material: 3 specimens from Saint Paul (BU2006SP E141-143), Galala Formation, bed n° 12, Wata Formation, bed n° 17; and 2 specimens from Wadi El Dakhl (BU2007DL E133-134), Wata Formation, bed n° 33.

Measurements: Table 20
Remarks: *Petalobrissus humei* (FOURTAU, 1906) which has been erected based on material collected from the Turonian of Sinai differs from *P. pygmaeus* in having a more rounded outline and a relatively higher test. *P. pygmaeus* shows much similarities to the American *P. cubensis* which described by SMITH & BENGTSON (1991) from Brazil, further study may clarify their relationship.
Occurrence: *P. pygmaeus* is restricted to the Turonian of Egypt.

Family Archiaciidae COTTEAU & TRIGER, 1869
Genus *Archiacia* AGASSIZ, 1847
Type species: *Archiacia sandalina* D'ORBIGNY, 1856

***Archiacia pescameli* GAUTHIER, 1901**
Pl. V, figs. 3, 5a-b

1901. *Archiacia pescameli* GAUTHIER *in* FOURTAU, p. 47, pl. 1, figs. 16-18.
1914. *Archiacia pescameli* GAUTHIER.– FOURTAU, p. 49.
1921. *Archiacia pescameli* GAUTHIER.– LAMBERT & THIÉRY, p. 358.
2003. *Archiacia pescameli* GAUTHIER.– ABDELHAMID & AZAB, p. 868, pl. 4, figs. I-J.

Material: 9 specimens from Wadi El Dakhl area (BU2007DL E135-143), Galala Formation, beds n° 10, 11 and 13.
Measurements: Table 21
Remarks: *Archiacia pescameli* is distinguished from *A. palmata* THOMAS & GAUTHIER, 1889 and *A. araidahensis* GAUTHIER, 1901 which were originally described from the Cenomanian of Tunisia and Egypt, respectively in having deep anterior marginal furrow, lower test, domal apex, and less eccentric apical disc. *A. saadensis* PERON & GAUTHIER, 1878 seems to be closely similar to the present species but ABDELHAMID & AZAB (2003) distinguished it from the present species by having deeper anterior furrow, more flattened test and smaller anterior interpetalous angle. *A. pescameli* differs from *A. aegyptiaca* FOURTAU, 1912 in having a deep furrow at the anterior marginal and less developed petals.
Occurrence: *Archiacia pescameli* was established from the Cenomanian of Saint Paul (GAUTHIER *in* FOURTAU, 1901) and recorded from the same locality by ABDELHAMID & AZAB (2003). It was recorded herein from Wadi El Dakhl. Consequently, *A. pescameli* seems to be restricted to the Southern Galala, Egypt.

Order Holasteroida DURHAM & MELVILLE, 1957
Family Hemipneustidae LAMBERT, 1917
Genus *Medjesia* JEFFERY, 1998
Type species: *Enallopneustes meslei* GAUTHIER, 1902

Table 20

n=5	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK
Range	16-22.5	13.8-21	8-12.4	0.87-0.93	0.49-0.55	4-8.1	3.6-7.8	4.2-8.4	24-32	21-28	22-30	2.8-4.1	1.5-2.5
Mean	18.4	16.7	10. 2	0.90	0.53	6.3	5.8	6.5	27	25	26	3.6	2.1

Table 21

n =9	L	W	H	W/L	H/L	LI	LII	NI	NII	LK	WK	Wk/Lk
Range	18.5-34	19-35	9-17.5	1-1.07	0.39-0.51	6.5-10	5-8	26-34	26-32	2.7-3	2-2.2	0.66-0.81
Mean	25	25.8	11.5	1.04	0.46	7.8	6.8	29	28	2.9	2.1	0.77

Medjesia? sp.
Pl. V, figs. 9, 11a-b

Material : 16 specimens from Wadi El Dakhl (BU2007DL E144-159), 14 specimens from the Wata Formation, bed n° 33, and 2 specimens from the Matulla Formation, bed n° 42.

Measurements : Table 22

Description : Test of medium sized, cordiform. Adapical surface convex. Adoral surface flattened. Apical disc elongated, slightly eccentric forwards. Frontal ambulacrum non-petaloid, deeply sunken. Poriferous zone very narrow ; pores rounded. Interporiferous zone wide. Paired ambulacra flush, non-petaloid to subpetaloid. Anterior paired petals longer and more divergent than the posterior ones. Pore series within petals are strongly assymetric ; pores in the anterior column are small and rounded near apex and become slightly elongated distally, whereas in the posterior column the inner pore elongated while the outer pore is slit-shaped and is about twice as elongated. Anterior poriferous zones narrower than the posterior ones. Interporiferous zone as wide as or slightly more than twice the width of the anterior poriferous zone. Two specimens show poorly preserved marginal orthofasciole. Peristome semi-lunar, large, eccentric anteriorly. Periproct large, oval and placed at the top of the posterior surface.

Remarks : The present material shows much similarities in its outline, dimensions, and description to *Pseudoholaster meslei* THOMAS & GAUTHIER which originally described from the Santonian of Tunisia by GAUTHIER (1889) and recorded by ABDELHAMID (1997), ABDELHAMID & EL QOT (2001) and EL QOT (2006) from Sinai, but it differs mainly in having a relatively poorly preserved marginal fasciole. According to SMITH (2009 ; personal communication) based on overall shape, petal structure, and inferred plastron plate arrangement, it is closely similar to genus *Medjesia* JEFFERY, 1998. Due to the apical disc of most specimens are poorly preserved, and the details of the apical disc plating is very important to confirm the identification of the genus. The author referred the present material questionably to *Medjesia*.

Order Spatangoida CLAUS, 1876
Family Hemiasteridae CLARK, 1917
Genus *Hemiaster* AGASSIZ, 1847

Type species : *Spatangus bufo* BRONGNIART, 1822

Hemiaster syriacus (CONRAD, 1852)
Pl. VI, fig. 3a-b

1852. *Holaster syriacus* CONRAD *in* LYNCH, p. 212, pl. 1, fig. 2.
1873. *Hemiaster orbignyanus* DESOR.– LARTET, p. 76 (non DESOR).
1918. *Hemiaster orbignyanus* DESOR var. *minor* STEFANINI, p. 155, pl. 5, figs. 12a-e, 13a-d.
1925. *Hemiaster syriacus* CONRAD.– BLANCKENHORN, p. 103, pl. 8, figs. 33-35.
1990. *Hemiaster syriacus* (CONRAD).– SMITH *et al*., p. 61, figs. 19a-d, 20.
1993. *Hemiaster syriacus* (CONRAD).– NÉRAUDEAU *et al*., p. 294, pl. 4, fig. H.
2001. *Hemiaster syriacus* (CONRAD).– ABDELHAMID & EL QOT, p. 28, fig. 7L.
2003. *Hemiaster* (*Mecaster*) *syriacus* (CONRAD).– BERNDT, p. 84, fig. 4/1a-c.
2006. *Hemiaster* (*Hemiaster*) *syriacus* (CONRAD).– EL QOT, p. 150, pl. 34, fig. 7.

Material : 3 specimens from Abu Darag area (BU2006DG E81-83), Galala Formation, bed n° 10 ; 4 specimens from Saint Paul (BU2006SP E144-147), Galala Formation, beds n° 5 and 8 ; and 6 specimens from Wadi El Dakhl (BU2007DL E160-165), Galala Formation, beds n° 11 and 13.

Measurements : Table 23

Remarks : The present species show much smiliarities to *H. orbignyanus* DESOR, 1853, *Hemiaster syriacus* was erected based on material from the Cenomanian of Syria, whereas the latter was originally described from the Turonian of France. BLANCKENHORN (1925) mentioned that *H. orbignyanus* has unequal petals like *H. syriacus*, but its petals are very narrow. I agree with SMITH *et al*. (1990) in regarding the specimens described as *H. orbignyanus* from the Middle East are thought to belong to *H. syriacus*.

Table 22

n =16	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK	Wk/Lk
Range	24-53	21.5-48	13.5-32	0.90-0.98	0.51-0.64	16-23	17.5-30	14.5-29	44-46	47-56	18-22	4.2-7	3.5-5	0.71-0.83
Mean	39.7	37.4	22.6	0.96	0.58	21.3	24.8	23.2	45	52	20	6.3	4.1	0.77

Table 23

n =13	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK
Range	16-25	15.5-23.5	10.5-17	0.88-0.97	0.58-0.69	4.5-6.5	6-9	8.5-11.5	20-26	24-32	15-18	2.1-3.2	1.6-2.4
Mean	21.7	19.8	14. 3	0.94	0.63	5.4	7.9	10.2	23.8	28	17	2.8	1.9

Occurrence: *H. syriacus* characterizes the Cenomanian of the Middle East, and North Africa.

Genus *Mecaster* POMEL, 1883

Type species: *Hemiaster fourneli* AGASSIZ *in* AGASSIZ & DESOR, 1847

Mecaster batnensis (COQUAND, 1862)
Pl. VI, fig. 1a-b

1862. *Hemiaster Batnensis* COQUAND, p. 248, pl. 26, figs. 6-8.
1914. *Hemiaster batnensis* COQUAND.– FOURTAU, p. 66.
1925. *Hemiaster saulcyanus* D'ORBIGNY var. *batnensis* COQUAND.– BLANCKENHORN, p. 101, pl. 8, figs. 31-32.
1937. *Hemiaster batnensis* COQUAND.– LAMBERT, p. 82.
1963. *Hemiaster batnensis* COQUAND.– FAWZI, p. 13.
1989. *Hemiaster batnensis* COQUAND.– ZAGHBIB-TURKI, p. 70.
1991. *Mecaster batnensis* (COQUAND).– SMITH & BENGTSON, p. 56, pl. 12, figs. A-L; pl. 13, figs. A-N; text-figs. 45 D-G, 46-49 (with additional synonyms).
1993. *Mecaster batnensis* (COQUAND).– NÉRAUDEAU *et al*., p. 294, pl. 4, fig. H.
2001. *Hemiaster batnensis* COQUAND.– ABDELHAMID & EL QOT, p. 24, fig. 6L-N.
2003. *Hemiaster* (*Mecaster*) cf. *batnensis* COQUAND.– BERNDT, p. 86, fig. 4/4a-c.
2003. *Hemiaster batnensis* COQUAND.– ABDELHAMID & AZAB, p. 871, pl. 5, figs. C-D.
2006. *Hemiaster* (*Mecaster*) *batnensis* COQUAND.– EL QOT, p. 152, pl. 33, fig. 11.

Material: 3 specimens from Saint Paul (BU2006SP E148-150), Galala Formation, beds n° 7 and 8; and 7 specimens from Wadi El Dakhl (BU2007DL E166-172), Galala Formation, beds n° 11 and 13.

Measurements: Table 24

Remarks: FISCHER *in* DURHAM *et al*. (1966) treated *Mecaster* as subgenus of *Hemiaster*. SMITH & BENGTSON (1991) regarded *Mecaster* as separate genus being characterized by having subequal petals and its laterally elongate apical disc in which the madreporite separates genital plates 1 and 4. While, in *Hemiaster* the posterior genital plates are not separated by the madreporite and all four genital plates are subequal in size. In addition, the posterior petals are truncated in comparison to the anterior pair and the apical disc lies posterior of center. According to SMITH & BENGTSON (1991) large numbers of species names exist for mid-Cretaceous belong to *Mecaster*. Based on apical disc plating and plastronal plating they distinguished four *Mecaster* groups among mid-Cretaceous species; *M. batnensis* (COQUAND) group, *M. scutigera* (FORBES) group, *M. cubicus* (DESOR) group, and *M. fourneli* (DESHAYES) group.

Occurrence: *Mecaster batnensis* is a common Cenomanian species but has also been recorded from the Turonian of Brazil and Texas (SMITH & BENGTSON, 1991). The species was recorded from North Africa, Somalia, Portugal, Jordan, and Brazil.

Mecaster cubicus (DESOR, 1847)
Pl.VI, figs. 2, 7; Text-fig. 5e

1847. *Hemiaster cubicus* DESOR *in* AGASSIZ & DESOR, p. 124.
1903. *Hemiaster cubicus* DESOR.– FOURTAU, p. 177, text-fig. 1.
1914. *Hemiaster cubicus* DESOR.– FOURTAU, p. 67, pl. 6, figs. 1-5.
1918. *Hemiaster cubicus* DESOR.– STEFANINI, p. 149.
1925. *Hemiaster cubicus* DESOR.– BLANCKENHORN, p. 99, pl. 8, figs. 1-5.
1963. *Hemiaster cubicus* DESOR.– FAWZI, p. 12, pl. 1, figs. 3-4.
1989. *Hemiaster cubicus* DESOR.– ZAGHBIB-TURKI, p. 70.
1990. *Hemiaster cubicus* DESOR.– SMITH *et al*., p. 64, figs. 19e-h, 21.
1991. *Mecaster cubicus* (DESOR).– SMITH & BENGTSON, p. 56.
1993. *Hemiaster cubicus* DESOR.– KORA *et al*., pl. 1, fig. 7.
2001. *Hemiaster cubicus* DESOR.– ABDELHAMID & EL QOT, p. 24, fig. 7A-B.
2001. *Hemiaster cubicus* DESOR.– KORA *et al*., pl. 3, figs. 7-8.
2003. *Hemiaster cubicus* DESOR.– ABDELHAMID & AZAB, p. 871, pl. 5, figs. E-H.
2006. *Hemiaster* (*Hemiaster*) *cubicus* DESOR.– EL QOT, p. 149, pl. 34, fig. 1a-b (with additional synonymy).
2006. *Hemiaster* (*Hemiaster*) *cubicus* DESOR.– ABDEL-GAWAD *et al*., pl. 3, fig. 8a-b.
2007. *Hemiaster* (*Hemiaster*) *cubicus* DESOR.– ABDEL-GAWAD *et al*., pl. 6, fig. 8a-b.

Material: 118 specimens from Abu Darag area (BU2005DG E84-201), Galala Formation, bed n° 4; 96 specimens from Saint Paul (BU2006SP E151-426), Galala Formation, bed n° 4; and 67 specimens from Wadi El Dakhl (BU2007DL E173-239), Galala Formation, bed n° 10.

Measurements: Table 25

Remarks: The wide variability of *Mecaster cubicus* led some authors (e.g. FOURTAU, 1903; STEFANINI, 1918; BLANCKENHORN, 1925) to subdivid it into three varieties (var. *depressus*, var. *cordiformis*, and var. *eccentricus*) based on the relative height and roundness of test and eccentricity of apical disc. ABDELHAMID & AZAB (2003) distinguished two forms; form "depressus" and form

Table 24

n =10	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK
Range	16.5-57	14.5-50	10-33	0.86-0.90	0.56-0.70	3.5-17.5	6.5-23	7-28	22-46	30-58	20-30	2.4-5.6	1.7-3.2
Mean	38.2	34.5	23.4	0.89	0.62	9.1	14.7	18.3	29	41	24	4.1	2.6

"cordiformis" rather than the typical form whereas form "depressus" is characterized by low test and form "cordiformis" has a high and subrounded test. They mentioned that the boundaries between these two forms and the typical form are intermixed. In my opinion, it is very difficult to distinguish between these different varieties and forms, as for large populations similar to the ones investigated herein the different forms are linked by transitional ones to make it hard to differentiate the species into different varieties or forms. *M. cubicus* is easily distinguished from the other *Mecaster* species by having a small extremely anteriorly eccentric peristome very close to the anterior margin, a deep frontal sulcus, and a small periproct.

Concerning the stratigraphic range of the species, it was regarded as a diagnostic echinoid characterizing the Upper Cenomanian of Egypt (for more discussion see EL QOT, 2006).

Occurrence: *M. cubicus* is considered a very common and diagnostic Upper Cenomanian echinoid in Egypt. It was recorded from Palestine (BLANCKENHORN, 1925), Tunisia (ZAGHBIB-TURKI, 1989), and Oman (SMITH *et al*., 1990).

Mecaster fourneli (DESHAYES, 1847)
Pl. VI, figs. 8, 9

1847. *Hemiaster fourneli* DESHAYES *in* AGASSIZ & DESOR, p. 123.
1921. *Hemiaster fourneli* DESHAYES.– FOURTAU, p. 87.
1925. *Hemiaster fourneli* DESHAYES.– BLANCKENHORN, p. 106, pl. 8, fig. 37a-b.
1932. *Hemiaster fourneli* DESHAYES.– LAMBERT, p. 140.
1975. *Hemiaster fourneli* DESHAYES.– ZAGHBIB-TURKI, p. 55, pl. 3, figs. 4-6; text-fig. 39a-b.
1991. *Mecaster fourneli* (AGASSIZ & DESOR).– SMITH & BENGTSON, p. 61, pl. 14, figs. A-M; pl. 15, figs. A-L; pl. 16, figs. E-F; text-figs. 45 K-L, 47, 48B, 50.
1997. *Hemiaster fourneli* DESHAYES.– ABDELHAMID, p. 154, fig. 7/4.
2001. *Hemiaster fourneli* DESHAYES.– ABDELHAMID & EL QOT, p. 25, fig. 7C-D.
2004. *Hemiaster* (*Mecaster*) *fourneli* DESHAYES.– ABDEL-GAWAD *et al*., pl. 10, figs. 12-13.
2006. *Hemiaster* (*Mecaster*) *fourneli* DESHAYES.– EL QOT, p. 152, pl. 34, figs. 2-3.
2007. *Hemiaster* (*Mecaster*) *fourneli* DESHAYES.– ABDEL-GAWAD *et al*., pl. 6, figs. 9-10.

Material: 6 specimens from Saint Paul (BU2006SP E247-252), Matulla Formation, bed n° 34; and 3 specimens from Wadi El Dakhl (BU2007DL E240-242), Matulla Formation, bed n° 42.

Measurements: Table 26

Remarks: *Mecaster fourneli* differs from *M. batnensis* (COQUAND) in having a more centrally apical disc and a relatively more convex adoral surface. In addition, the latter has a slightly more rounded outline and a relatively greater number of pores in the frontal ambulacrum (SMITH & BENGSTON, 1991). It differs also from *M. wetherbyi* DE LORIOL, 1887 of the Senonian in the United States where the latter is characterised by having a smaller apical disc and shorter posterior paired petals. SMITH & BENGTSON (1991) distinguished *M. texanum* (ROEMER) described from the Santonian-Campanian of

Table 25

n =281	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK	Wp/Lp
Range	16-53	14.5-49	9.7-41	0.88-10.1	0.64-0.71	3.8-21	5-25	9.5-35	20-52	24-60	18-31	2.5-4.5	2-3	1-2
Mean	36.2	28.8	27.1	0.94	0.67	12.6	14.4	19.3	38.7	43.8	24	3.2	2.2	1.32

Table 26

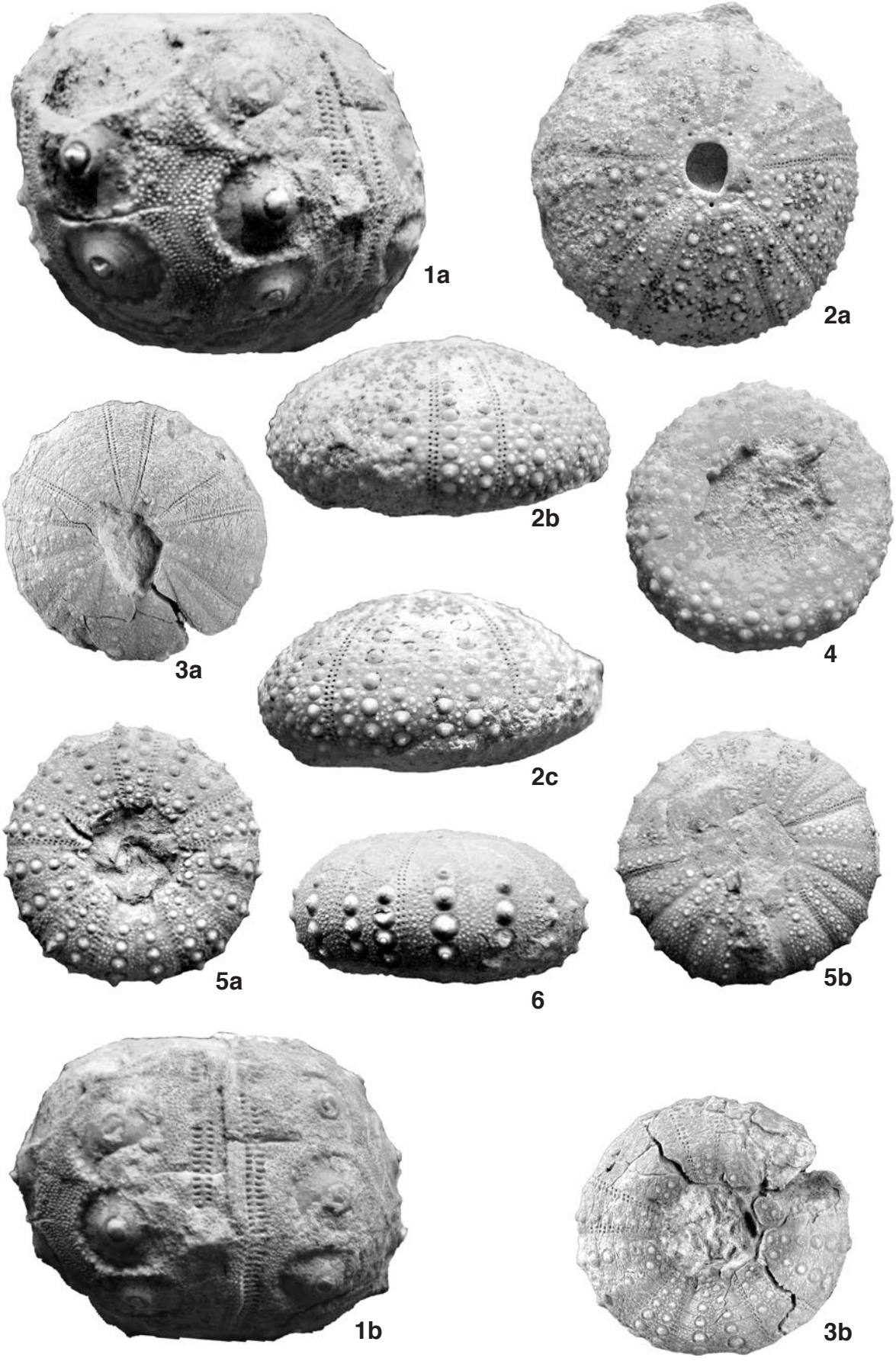
n =9	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK
Range	28-34.3	25-32.5	16-23	0.88-0.95	0.56-0.67	9.6-13	13.5-17	16-20	22-34	26-40	20-32	2.8-5	2-3
Mean	30.4	28.7	18.5	0.91	0.61	11.2	15.1	18.5	27	33	26	3.7	2.5

Plate I

Fig. 1a, b: *Prionocidaris* cf. *granulostriata* (DESOR); side views, Upper Cenomanian, Galala Formation, Saint Paul, x1.5.

Fig. 2a-c, 4: *Orthopsis miliaris* (D'ARCHIAC); a: adapical view, b, c: side views, Coniacian, Matulla Formation, Wadi El Dakhl, x2. 4: adoral view, Turonian, Wata Formation, Saint Paul, x3.

Fig. 3a-b, 5a-b, 6: *Heterodiadema libycum* (DESOR); 3a, 5b: adapical views, 3b, 5a: adoral views, 6: side view, Upper Cenomanian, Galala Formation, 3: Wadi El Dakhl; 5, 6: Abu Darag, x2.


1a
2a
2b
3a
4
2c
5a
6
5b
1b
3b

the United States from the present species as the former has a smaller peristome, more elongated apical disc, and a larger madreporite.

Occurrence: *Mecaster fourneli* ranges from the Turonian to the Campanian, but occurs predominantly in the Coniacian-Santonian. It was recorded from North Africa, the Middle East, and Brazil.

Mecaster pseudofourneli (PERON & GAUTHIER, 1878) Pl. VI, fig. 6a-b

1878. *Hemiaster pseudofourneli* PERON & GAUTHIER *in* COTTEAU *et al*., p. 113, pl. 4, figs. 5-8.
1912. *Hemiaster pseudofourneli* PERON & GAUTHIER.– FOURTAU, p. 168, pl. 3, fig. 4.
1914. *Hemiaster pseudofourneli* PERON & GAUTHIER.– FOURTAU, p. 82, pl. 8, fig. 1.
1925. *Hemiaster pseudofourneli* PERON & GAUTHIER.– BLANCKENHORN, p. 106, pl. 8, fig.38.
1932. *Hemiaster pseudofourneli* PERON & GAUTHIER.– LAMBERT, 123.
1963. *Hemiaster pseudofourneli* PERON & GAUTHIER.– FAWZI, p. 14.
1975. *Hemiaster pseudofourneli* PERON & GAUTHIER.– ZAGHBIB-TURKI, p. 52, pl. 2, figs. 24- 26; text-fig. 37a-e.
1993. *Mecaster pseudofourneli* (PERON & GAUTHIER).– NÉRAUDEAU *et al*., p. 262, pl. 4, figs. K, L.
1995. *Mecaster pseudofourneli* (PERON & GAUTHIER).– NÉRAUDEAU *et al*., p. 418, fig. 6 (d-e).
1997. *Mecaster pseudofourneli* (PERON & GAUTHIER).– NÉRAUDEAU & COURVILLE, p. 840, fig. 6/ 3, 7.
2001. *Hemiaster pseudofourneli* PERON & GAUTHIER.– ABDELHAMID & EL QOT, p. 28, fig. 7J- K.
2003. *Hemiaster pseudofourneli* PERON & GAUTHIER.– ABDELHAMID & AZAB, p. 872, pl. 5, figs. N- O.
2006. *Hemiaster pseudofourneli* PERON & GAUTHIER.– ABDEL-GAWAD *et al*., pl. 3, figs. 11- 12.

Material: 8 specimens from Abu Darag area (BU2005DG E202-209), Galala Formation, bed n° 7; 7 specimens from Saint Paul (BU2006SP E253-259), Galala Formation, beds n° 4 and 8; and 8 specimens from Wadi El Dakhl (BU2007DL E243-250), Galala Formation, bed n° 11.

Measurements: Table 27

Remarks: *Mecaster pseudofourneli* is distinguished from *M. fourneli* DESHAYES by its longer and deeper posterior paired petals and its more anteriorly displaced apical disc. In addition, the difference in the stratigraphic distribution of the two species. *M. pseudofourneli* was recorded only from the Cenomanian of North Africa, the Middle East, Niger, and Nigeria, whereas, *M. fourneli* ranges from the Turonian to the Campanian, but occurs predominantly in the Coniacian-Santonian of the North Africa and the Middle East. It was recorded also from the Turonian-Coniacian sediments of Brazil (SMITH & BENGTSON, 1991).

Mecaster turonensis (FOURTAU, 1921) Pl. VI, figs. 4a-b, 5; Text-fig. 5f

1921. *Hemiaster heberti* mutatio *turonensis* FOURTAU, p. 89, pl. 11, figs. 1-10.
2001. *Hemiaster heberti* COQUAND *turonensis* FOURTAU.– ABDELHAMID & EL QOT, p. 26, fig. 7G-H.
2004. *Hemiaster* (*Mecaster*) *heberti* COQUAND *turonensis* FOURTAU.– ABDEL-GAWAD *et al*., pl. 10, fig. 14a-b.
2006. *Hemiaster* (*Mecaster*) *heberti* COQUAND *turonensis* FOURTAU.– EL QOT, p. 153, pl. 34, fig. 6a-b.

Material: 23 specimens from Abu Darag area (BU2005DG E210-232), Galala Formation, beds n° 16 and 17; 34 specimens from Saint Paul (BU2006SP E260-293), Galala Formation, bed n° 12, Wata Formation, beds

Table 27

n =23	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK
Range	29-40	26-36	18-25	0.87-0.92	0.56-0.65	9.6-13	13.5-17	16-20	28-42	32-48	18-34	2.4-5	1.6-3
Mean	35.7	31.8	21.5	0.90	0.61	11.2	15.1	18.5	33	39	25	3.8	2.4

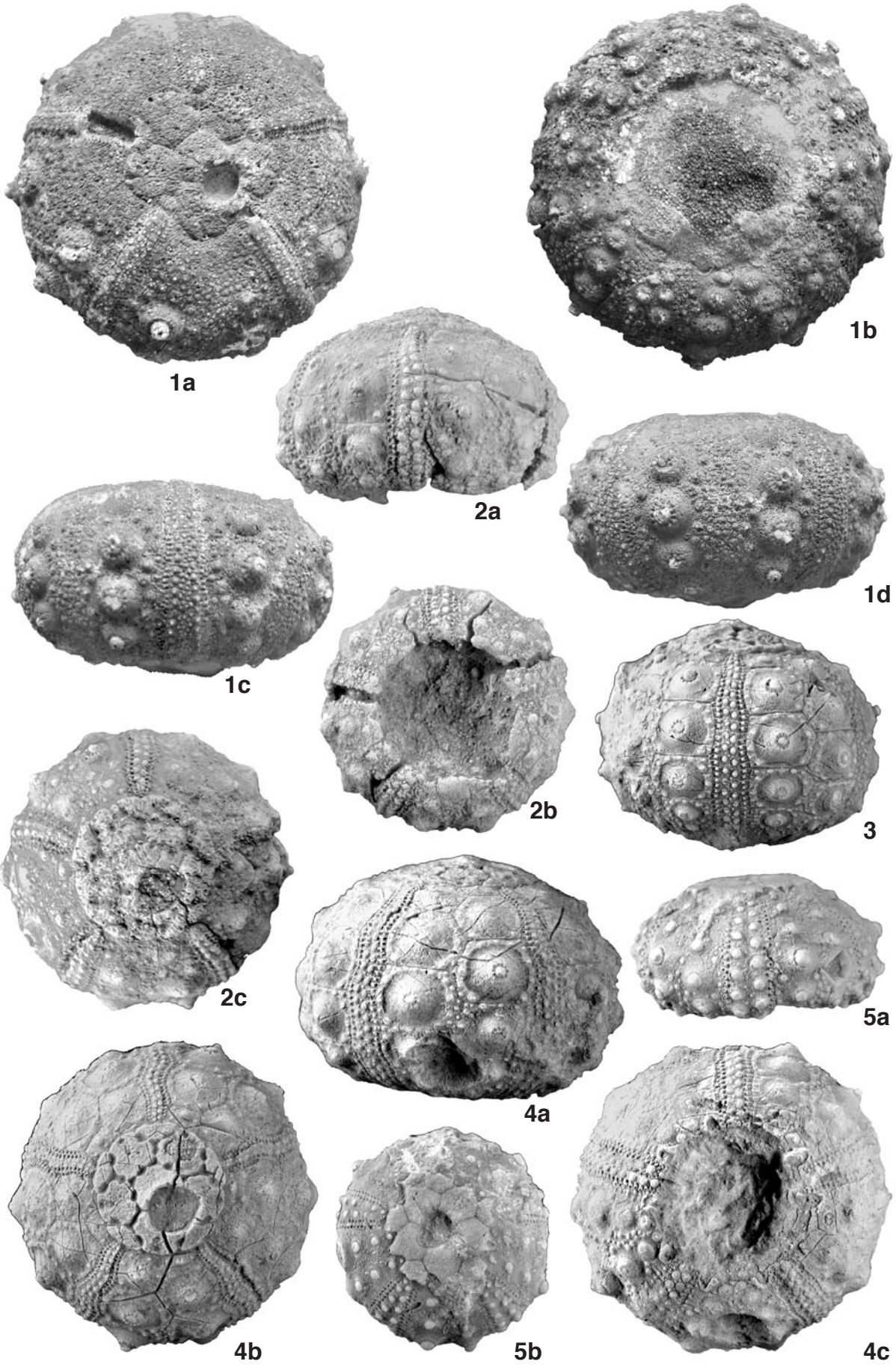
Plate II

Fig. 1a-d: *Heterosalenia dakhlensis* sp. nov.; a: adapical view, b: adoral view, c, d: side views, Coniacian, Matulla Formation, Wadi El Dakhl, a, b: x 1.75, c-d: x1.5.

Fig. 2a-c: *Leptosalenia aegyptiaca* (FOURTAU); a: side view, b: adoral view, c: adapical view, Coniacian, Matulla Formation, Wadi El Dakhl, a, c: x4, b: x3.5.

Fig. 3, 4a-c: *Holosalenia batnensis* (PERON & GAUTHIER); 3, 4a: side views, 4b: adapical view, 4c: adoral view, Upper Cenomanian, Galala Formation, Wadi El Dakhl, 3: x4; 4a-c: x3.5.

Fig. 5a-b: *Goniopygus menardi* (DESMAREST); a: side view, b: adapical view, Upper Cenomanian, Galala Formation, Wadi El Dakhl, x4.


1a
1b
2a
1d
1c
2b
3
2c
5a
4a
4b
5b
4c

n° 15, 17-19 and 23; and 18 specimens from Wadi El Dakhl (BU2007DL E251-267), Galala Formation, beds n° 17 and 18, Umm Omeiyid Formation, bed n° 22, and Wata Formation, beds n° 27 and 33.

Measurements: Table 28

Remarks: FOURTAU (1921) established *Hemiaster heberti* COQUAND mutatio *turonensis* from the Lower Turonian of some different localities in North Sinai. ABDELHAMID & EL QOT (2001) raised the rank to a subspecies and distinguished it from *heberti* sensu stricto by a higher test, wider and more developed petals. *Mecaster turonensis* is very abundant in the Lower Turonian *Choffaticeras segne* Zone of the three studied sections and it has been recorded from the same stratigraphic level of several localities in Sinai (EL QOT, 2006). This led the author to raise the rank of this subspecies to the species level to being indicative of the Turonian.

Occurrence: *Mecaster turonensis* is being associated with and occasionally occuring above the Lower Turonian *Choffaticeras segne* Zone in Egypt.

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Table 28

n =75	L	W	H	W/L	H/L	LI	LII	LIII	NI	NII	NIII	LK	WK	Wp/Lp
Range	17.5-35	16.5-32	10.5-21	0.87-99	0.61-69	6-10	7-12	8-13.2	14-28	19-33	11-20	1.8-3.2	1.3-2.4	1.2-1.7
Mean	21.3	20.7	12.5	0.96	0.65	8.1	9.2	9.7	22	27	15	2.3	1.7	1.4

Plate III

Fig. 1a-b, 4, 5: *Tetragramma marticense* (COTTEAU); 1a: adapical view, 1b: adoral view, 4, 5: side views, Upper Cenomanian, Galala Formation, Wadi El Dakhl, x2.

Fig. 2: *Goniopygus menardi* (DESMAREST); adapical view, Upper Cenomanian, Galala Formation, Abu Darag, x 1.5.

Fig. 3a-b: *Goniopygus peroni* THOMAS & GAUTHIER; a: side view, b: adapical view, Upper Turonian, Wata Formation, Saint Paul, x2.

Fig. 6a-c, 7a-b: *Pedinopsis sinaica* (DESOR); a: adapical views, 6b: adoral view, 6c: apical disc, 7b: side view, Upper Cenomanian, Galala Formation, Wadi El Dakhl, 6a-b, 7: x2; 6c: x2.5.

Fig. 8a-b, 9: *Phymosoma major* COQUAND; 8a, 9: adapical views, 8b: side view, Lower Turonian, Galala Formation, Saint Paul, x1.5.

Fig. 10, 11: *Rachiosoma geysi* ABDELHAMID & EL QOT; adapical views, Upper Turonian, Wata Formation, Wadi El Dakhl, 10: x2; 11: x3.

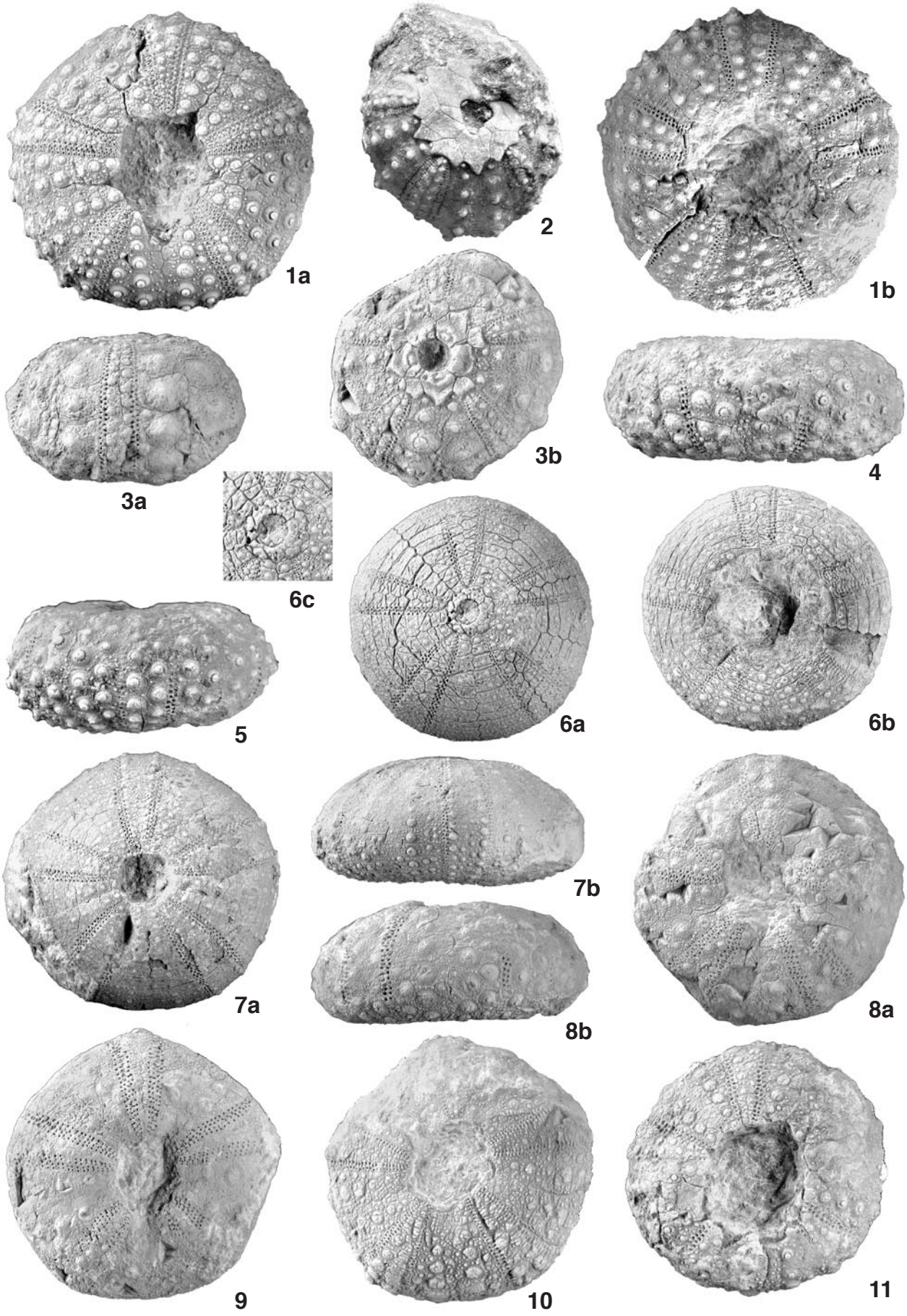
1a
2
1b
3b
3a
4
6c
6a
6b
5
7b
7a
8a
8b
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Plate IV

Fig. 1a-d : *Phymosoma kassabi* sp. nov. ; a : adapical view, b : adoral view, c, d : side views, Coniacian, Matulla Formation, Wadi El Dakhl, x1.5.

Fig. 2a-b, 4, 5 : *Rachiosoma rectilineatum* (PERON & GAUTHIER) ; 2a, 4 : adapical views, 2b, 5 : side views, 2 : Upper Turonian, Wata Formation, 4, 5 : Coniacian, Matulla Formation, Wadi El Dakhl, 2a, 5 : x2, 2b, 4 : x2.5.

Fig. 3, 8 : *Rachiosoma geysi* ABDELHAMID & EL QOT ; 3 : adoral view, 8 : side view, Upper Turonian, Wata Formation, Wadi El Dakhl, x2.5.

Fig. 6, 7a-c : *Coenholectypus excisus* (DESOR) ; 6 : posterior view, 7a : adoral view, b : side view, c : adapical view, Upper Cenomanian, Galala Formation, Wadi El Dakhl, 6 : x3, 7 : x3.5.

Fig. 9, 11 : *Coenholectypus neocomiensis* (GRAS) ; 9 : posterior view, 11 : adapical view, Upper Cenomanian, Galala Formation, Saint Paul, x2.5.

Fig. 10 : *Micropedina olisiponensis* (FORBES) ; Upper Cenomanian, Galala Formation, Saint Paul, x1.25.

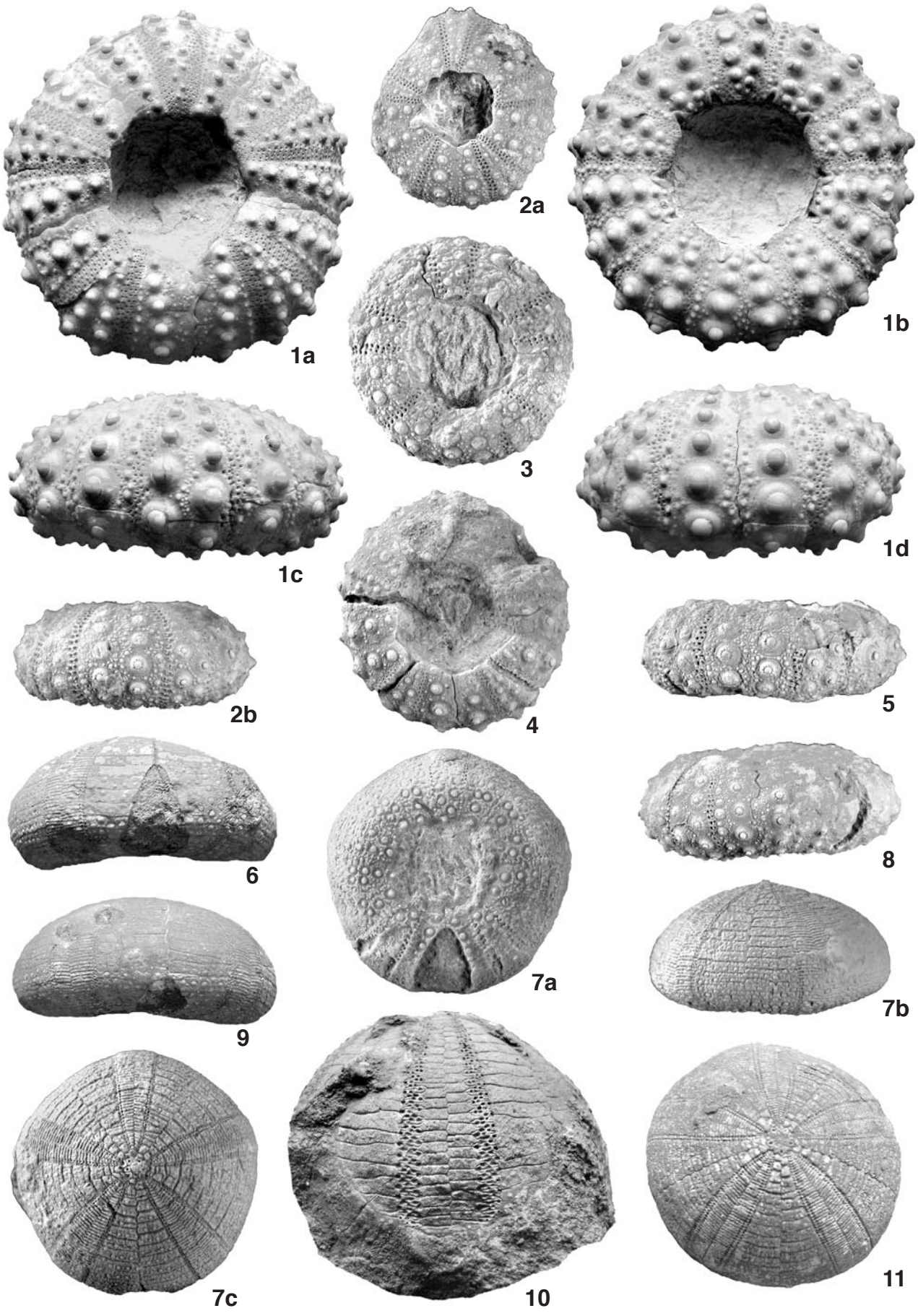
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Plate V

Fig. 1 : *Coenholectypus neocomiensis* (GRAS) ; adapical view, Upper Cenomanian, Galala Formation, Saint Paul, x2.5.

Fig. 2, 7 : *Coenholectypus turonensis* (DESOR) ; 2 : adapical view, 7 : adoral view, Lower Turonian, Galala Formation, Abu Darag, 2 : x3, 7 : x2.

Fig. 3, 5a-b : *Archiacia pescameli* GAUTHIER ; 3, 5b : adapical views, 5a : adoral view, Upper Cenomanian, Galala Formation, Wadi El Dakhl, 3 : x2.5, 5 : x2

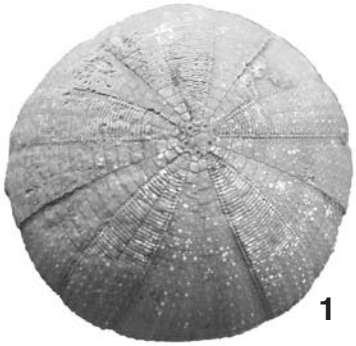
Fig. 4a-b : *Coenholectypus pulvinatus* (DESOR) ; a : side view, b : adoral view, Upper Cenomanian, Galala Formation, Abu Darag, x2.

Fig. 6, 10 : *Pygorhynchus aegyptiacus* (FOURTAU) ; 6 : adapical view, 10 : adoral view, Coniacian, Matulla Formation, Wadi El Dakhl, x1.5.

Fig. 8 : *Parapygus casiduloides* GAUTHIER ; adapical view, Coniacian, Matulla Formation, Wadi El Dakhl, x1.5.

Fig. 9, 11 : *Medjesia?* sp. ; 9, 11b : dapical views, 11a : adoral view, 11 : Upper Turonian, Wata Formation, 9 : Coniacian, Matulla Formation, Wadi El Dakhl, x1.5.

Fig. 12 : *Petalobrissus pygmaeus* (FOURTAU) ; adapical view, Turonian, Wata Formation, Saint Paul, x2.



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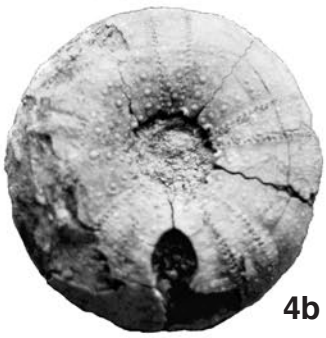

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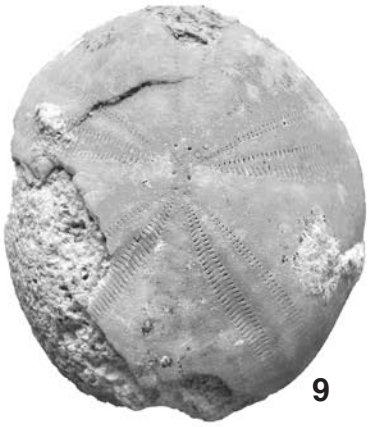

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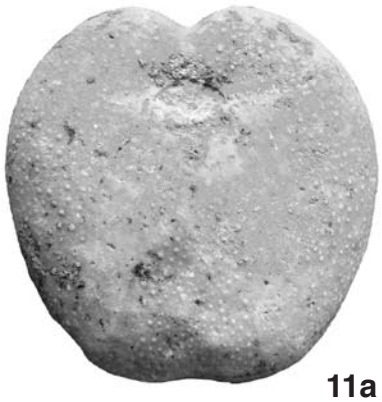

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Plate VI

Fig. 1a-b : *Mecaster batnensis* (COQUAND) ; a : adapical view, b : adoral view, Upper Cenomanian, Galala Formation, Saint Paul, x1.5.

Fig. 2, 7 : *Mecaster cubicus* (DESOR) ; 2 : adapical view, 7 : adoral view, Upper Cenomanian, Galala Formation, Abu Darag, x2.

Fig. 3a-b : *Hemiaster syriacus* (CONRAD) ; a : adapical view, b : adoral view, Upper Cenomanian, Galala Formation, Saint Paul, x1.5.

Fig. 4a-b, 5 : *Mecaster turonensis* (FOURTAU) ; 4a : adoral view, 4b, 5 : adapical views, Lower Turonian, Galala Formation, Saint Paul, 4a, 5 : x1.5, 4b : x2.

Fig. 6a-b : *Mecaster pseudofourneli* (PERON & GAUTHIER) ; a : adapical view, b : adoral view, Upper Cenomanian, Galala Formation, Saint Paul, a : x2, b : x1.5.

Fig. 8, 9 : *Mecaster fourneli* (DESHAYES) ; 8 : adapical view, 9 : adoral view, Coniacian, Matulla Formation, Saint Paul, x2.

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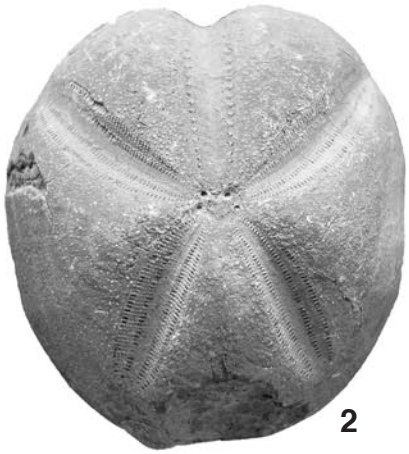
1b



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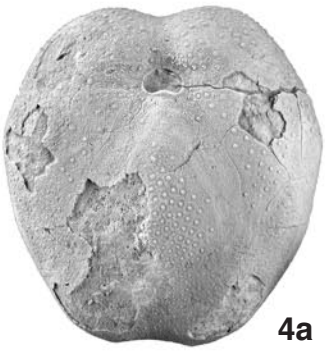

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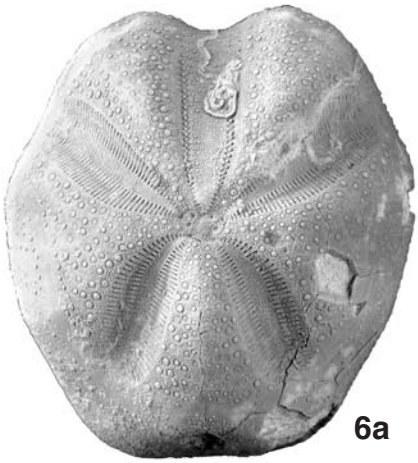

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