

Holothurian Sclerites from the Upper Part of Ajlun Group (Late Cretaceous) of Salhoub Area, North Jordan

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ABSTRACT

In this study, 16 species belonging to 7 genera of holothurian sclerites are studied from the Late Cretaceous (Late Cenomanian-Turonian) Shuayb and Wadi As-Sir Formations of Salhoub area, North Jordan. Holothurian sclerites include one new genus and 13 new species. Two species are included in the genus *Calclamna* (Frizzell and Exline, 1955), 3 new species of the genus *Calclamella* (Frizzell and Exline, 1955), one new species of the genus *Eocaudina* (Martin, 1952), 4 new species of the new genus *Hexapriscoapedatus* n.g., a new species of the genus *Spinopriscoapedatus* (Kozur and Sadeddin, 1990), 4 new species of the genus *Prisculatrites* (Deflandre-Rigaud, 1962) and one species *Tripuscucumis multiformis* of Late Cenomanian (Al-Tamimi et al., 2001). Holothurian sclerites are divided into three assemblages based on their stratigraphic position in the studied section. This study and earlier ones (Sadeddin and Saqqa, 1997; Al-Tamimi et al., 2001; Sadeddin and Al-Tamimi, 2006) show the frequent-diverse and good preservation record of holothurian sclerites in the Late Cretaceous of Ajlun Group. This is a good inference to the stratigraphic significance of holothurians in the Late Cretaceous times in Jordan.

Keywords: Holothurian sclerites, Late Cretaceous, N. Jordan, Shuayb Fm., Wadi As-Sir Fm., Ajlun Group, Late Cenomanian-Turonian.

1. INTRODUCTION

Holothuroidea (sea cucumbers) are an abundant and diverse group of marine invertebrates. They are an extinct class of echinoderms which includes about 1400 living species and 160 genera (Kerr and Kim, 2001). Recent holothurians can be considered as successful benthic group as they are found at all depths in marine realm and are distributed over all latitudes from Polar Regions to tropics. Holothurian body fossils are very rare. The majority of holothurian fossil record comprises disjunctive skeletal remains mainly as sclerites. In 1955, isolated holothurian sclerites have been classified as taxa by Frizzell and Exline and placed in largely artificial families. The nomenclature of sclerites in this work is according to this artificial taxonomy, which is solely based on their morphological features and form genera and species according to the external shape alone. Up to

the time of the *Treatise* (Frizzell and Exline, 1966) most studied holothurian faunas were from the Carboniferous, Triassic and Jurassic (Gilliland, 1993). To our knowledge, only few contributions have been made to study sclerites in the Cretaceous and Cenozoic rock sequences. The present paper is a contribution to Late Cretaceous holothurian sclerites, which have been barely studied.

2. HISTORICAL REVIEW

In 1957, Frizzell and Exline described *Rigaudites tallaili* from the Campanian of Travis County (Texas, USA). Müller (1964, 1969, 1978 and 1989), Nestler (1965, 1975, 1982 and 1995) and Herrig et al., (1994, 1996) described several sclerites taxa from the Early Maastrichtian rocks of the Rügen island of Germany. Hüchel (1970) made a short description of well preserved holothurian body fossils from the Cenomanian fish shale of the Hjoula in Lebanon. Soodan (1972a and b) erected the genera *Protocaudina* and *Achistrum* from Late Cretaceous rocks of Kutch in India. Zeleznik (1985) mentioned frequent presence of holothurian

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sclerites in many horizons of the grey limestone of Halembaye of Early to Late Maastrichtian age. Holothurian sclerites of the Santonian - Campanian age were reported by Lommerzheim (1991) from drilling material number 1001 of Muensterland, NW Germany. Undescribed forms of the genera *Rigaudites*, *Priscopedatus* and *Feddenella* from Turonian rocks of Kent in England were reported and illustrated by Gilliland (1993). Voigt (1993) and Reich (1995) described sclerites from the Late Maastrichtian limestone boulders from N-Germany. Reich (1997) gave an overview of the fossil record of the holothurian sclerites from Ordovician to Neogene found in glacial erratic boulders sampled from Northern Germany and Sweden. For the first time in Jordan Sadeddin and Saqqa (1997) described and illustrated Late Cretaceous holothurian sclerites from the Shuayb Formation in Jarash area (North Jordan). In the former work, holothurian sclerites were included two new genera (*Pentapriscopedatus*, *Madwarites* n.gen.) and 7 new species (*Calclamna turoniansis* n.sp., *Pentapriscopedatus irregularis* n.sp., *Priscularites spinosus* n. sp., *Priscularites subquadratus* n.sp., *Spinopriscopedatus cruciformis* n.sp., *Spinopriscopedatus curvus* n.sp., and *Madwarites subquadratus* n.sp.). Al-Tamimi et al., (2001) described holothurian sclerites assemblage from early Late Cretaceous rocks of Al-Mastabah area N-Jordan. The assemblage includes 11 new species (*Paracomcumarites frontis*, *Priscopedatus multiforminis*, *Priscularites margostapedus*, *Spinopriscopedatus hummari*, *S. jordanicus*, *S. n. sp. aff. S. unispinosus*, *Regaudites globosus*, *R. parvus*, *R. reschii*, *R. subovalis*, and *R. yarmoukensis*) belong to 3 families and 6 genera. The *Pravuscucumis deekei* was described by Reich (2001) as a new species relates to a new genus of the family Stichopitidae (Frizzell and Exline 1955) from the Turonian of the Baltic Sea region. Reich (2003) described two new sclerites species of a new genus *Tripuscucumis* from the Early Maastrichtian chalk of Jasmund Peninsula/ Rügen (N-Germany). This new genus includes two new species: *Tripuscucumis solveigae* and *T. multiforminis*. Recently, Sadeddin and Al-Tamimi (2006) erected two new genera, *Septapedatus palestiniansis* and *Octopedatus densusmaculis* from the Late Cenomanian rocks of Shuayb Formation.

3. AIM OF STUDY

The present study is a continuation of the work published earlier to explore holothurian sclerites fossil record in Late Cretaceous carbonate sequence from North Jordan (Sadeddin and Saqqa, 1997; Al-Tamimi et al.,

2001; Sadeddin and Al-Tamimi, 2006). It is aimed to follow up holothurian sclerites record from the upper parts of Ajlun Group, and strengthen the knowledge about their stratigraphic distribution in the Arabia.

Geological Setting of Ajlun Group

In the Early Cretaceous time, Jordan was subjected to continental conditions due to tectonic uplift that caused a northward retreat of the epicontinental Tethys Sea.

Sandstones of the Kurnub Group are laid down prior to the deposition of marine carbonates of Ajlun Group in Late Cretaceous times. In the Early Cenomanian, most of Jordan was a part of a broad Tethys platform because of sea-level rise. Carbonate sedimentation of Ajlun Group started in the beginning of the late Albian and lasted to the end of the Turonian or may be end of Coniacian (?). Prevailed climatic conditions, sea-level fluctuations and seafloor configuration were greatly affected the lithotype and thicknesses of Ajlun Group (Powell, 1989). In north Jordan, nearshore-tidal-open platform marine conditions were responsible for carbonate sedimentation of Ajlun Group (Powell, 1989).

The rock sequence of Ajlun Group is divided into five formations (Masri, 1963). These are from bottom to top: Naur, Fuheis, Hummar, Shuayb and Wadi As-Sir Formations. Naur Formation consists mainly of hard massive limestone, dolomitic limestone and dolomite interbedded with soft, olive green-yellow green marl and marly limestone. The thickness of Naur formation is almost variable. Parker (1970) mentioned a thickness of about 220 m. in the type locality area of Naur, SW Amman. According to Powell (1989, 35), the maximum thickness of the formation approximates 148 m. in Wadi Mujib, thinning out to 40 m. in Ras an Naqb in the south and reaches about 15m. at Jabal Waqf As Swan in the east (see also Abed, 2000, 199). Whereas, Abdelhamid (1995) reported a thickness of nearly 180 m in the vicinity of Jarash in the north. Fuheis Formation consists chiefly of soft marl and marly limestone interbedded with thin-medium bedded shelly to nodular limestone. In some localities, beds of oyster-rich coquina are also occurring. The Formation varies in thickness from 30 m. in boreholes in Hamza gas field (Dilley, 1985 in Powell, 1989) to nearly 90 m. in the north (Wolfart, 1959; Masri, 1963; Macdonald, 1965). Nodular structure is prominent in both of Naur and Fuheis formations. In the study area, the Hummar Formation starts with a few meters of marly limestone abundant with gastropods and pelecypods,

followed by successive layers of medium-thick bedded gray to whitish crystalline limestone, dolomitic limestone and dolomite that change near the top to marly limestone. The thickness of the formation is about 65 m. in Wadi Shuayb, Suweileh and Hummar areas, but thins southwards to about 10 m. in Wadi Mujib area (Powell, 1989). A section in Hummar Formation with about 40 m. thickness, was described by Abdelhamid (1995) in Ajlun area. Shuayb Formation is mainly soft and yellow. Its basal part (~50 m.) consists of alternative layers of marl and nodular limestone with abundant gastropods, pelecypods and ammonites. The upper part (~30 m.) consists of thinly-laminated beds of limestone, marly limestone and marl. Wadi As-Sir Formation stands as a prominent mapping unit in Ajlun Group. It is characterized by step-like steepened cliffs with a gray-brownish weathered surface. The formation consists of well bedded massive limestone, dolomitic limestone and dolomite, with subsidiary sandy limestone and marl. Chert beds and nodules are common in the middle and upper parts of the formation (Powell, 1989). Abed (1982) described a section in Wadi As-Sir Formation, northwest of Suweileh, starting at the base with well bedded micrite changes upward to foraminiferal peloids and shelly packstone to grainstone facies. The thickness of the described section was about 90 m. Khalil (1985) was studied in detail Wadi As-Sir Formation in Ajlun-Irbid area. He recognized two rudistid bioherm masses near the upper parts of the formation particularly, in Ishtafina area. These bioherms are overlain by thinly-bedded limestone with mud cracks and fine-grained dolomite (Al-Taybeh area), a sign for a transition from deep water sedimentation conditions to more shallow water conditions. The thickness of Wadi As-Sir Formation ranges from 146 m. in Wadi Mujib to about 16 m. in Zakimat Al Hasah (Powell, 1989). In Jarash area, Abdelhamid (1995) said that the thickness of the formation varies from ~70 m. (north of Thagrat Asfur) to 220 m. (south of Inba). Wadi As-Sir Formation was deposited inside a broad and shallow marine carbonate platform which affected by shallow subsiding basins and swells. The formation marks the maximum extent of marine transgressive pulses during Cenomanian to Late Turonian and Middle Coniacian times (Powell, 1989). The Cenomanian/Turonian boundary interval of Ajlun Group has been recognized on the basis of ammonites (Freund and Raab, 1996; Nazzal and Mustafa, 1993). Schultze et al. (2004) studied the biostratigraphic

framework of Ajlun Group in different locations from Western Jordan, by using local ammonite zones and correlated them with the ammonite zones in Southern Europe (Fig. 1). They found that the lower part of Shuayb Formation is characterized by the presence of *Vascoceras cauveni* associated with *Metoioceras geslinianum* and *Burroceras transitorium*. This assemblage overlies the youngest occurrence of *N. vibrayeanus*. Thus, it indicates a latest Cenomanian age, in correlation with the *geslinianum* and *judii* zones of Southern Europe. The occurrence of *Vascoceras cauveni* in the marls of the middle part of Shuayb Formation indicates an Early Turonian age (lower *coloradoense* zone) for this part of the formation. Juvenile specimens of *Choffaticeras pavillieri* and *C. quaasi* occurred in the uppermost beds of the middle part of Shuayb Formation, can be correlated with *nodosoides* zone of latest Early Turonian age. The upper parts of Shuayb and lower parts of Wadi As-Sir Formations are characterized by the presence of the ammonite association: *Thomasites rollandi*, *Fagesia lenticularis*, *Choffaticeras quaasi* and *C. luciae*, which can be correlated with *woollgari*. This will give an early Middle Turonian age to this part of Ajlun Group. The research area of the present work, is a part of the biostratigraphic zonation of Schultze et al. (2004).

Study Area

Salhoub area locates about 21km. northwest of Amman, on the main road to Irbid across Suweileh (Fig. 2). A geological section in the upper parts of Ajlun Group were carefully described and sampled (Fig. 3). The section represents a fresh road cut on the eastern side of Wasfi et-Tall forest. It encounters tilted and well bedded strata from the Shuayb and Wadi As-Sir Formations (Late Cenomanian-Turonian).

Description of Measured Section

The measured section starts with yellow-grayish yellow, thin to medium bedded, soft-medium hard, fossiliferous and nodular marly limestone intercalated with soft marl and thinly bedded fossiliferous limestone of Shuayb Formation (Late Cenomanian – Middle Turonian). The thickness of Shuayb Formation reaches about 84 m. At least, two marker horizons of coquina were recognized at different levels above hardground surfaces.

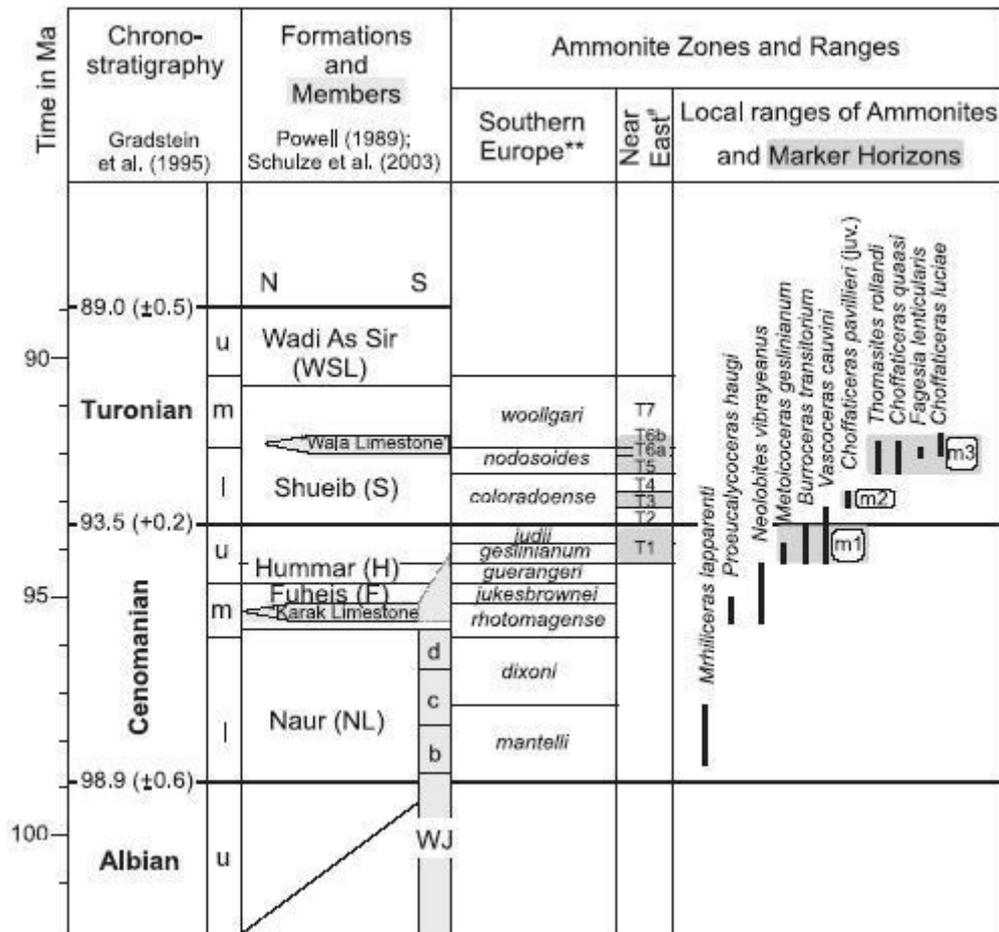


Fig. 1 (Tamimi and Saqqa).

Fig. 1. Correlation between local ammonite ranges and ammonite zones from southern Europe. Zonation of ammonite were made in all rock units of Ajlun Group (Schultze et al., 2004).

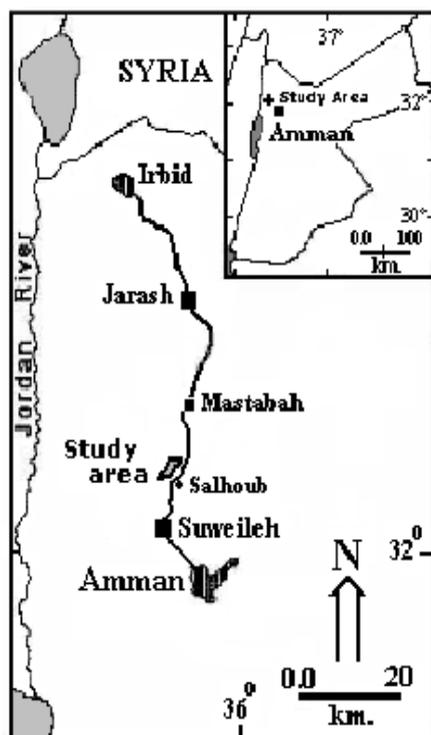


Fig. 2. (Tamimi and Saqqa).

Fig. 2. Location Map of study area.

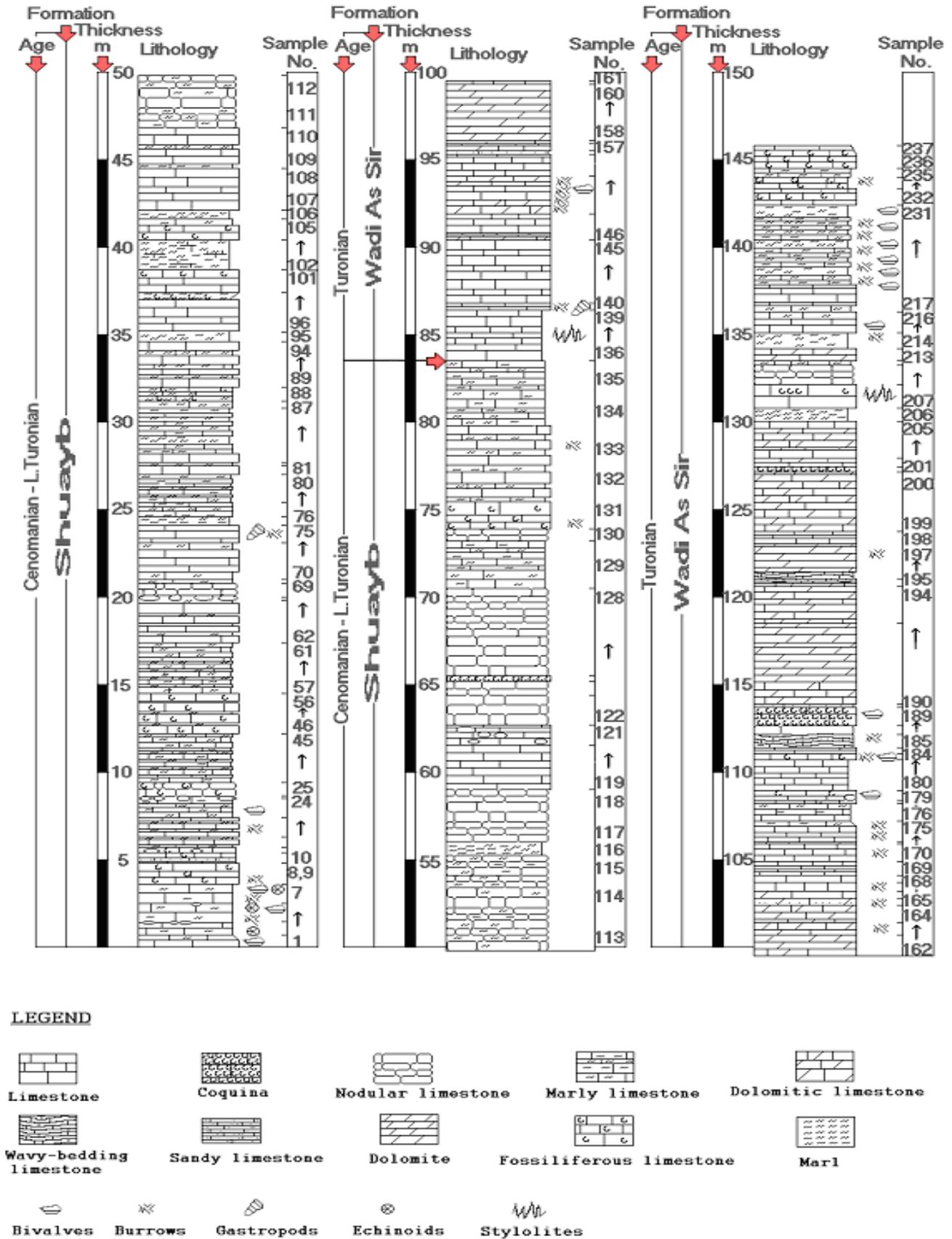


Fig. 3. *Tamimi and Saqqa*
 Fig. 3. Columnar section in Shuayb and Wadi As-Sir Formations (Cenomanian-Turonian).

The coquina consist chiefly of oyster shells, pelecypods, gastropods and possibly echinoidal remains. The upper part of the section is about 61m thick, and relates to Wadi As-Sir Formation (Middle to Late Turonian). The boundary between the two formations is demarcated by a profound change in lithology from thinly bedded and soft yellow marlstone to medium-thickly bedded, medium hard, light gray-whitish shelly limestone. Limestone and marl beds are thinning upward near the top with a remarkably nodular texture. Current - and wave ripples, cross lamination, burrows and stylolite are common sedimentary features.

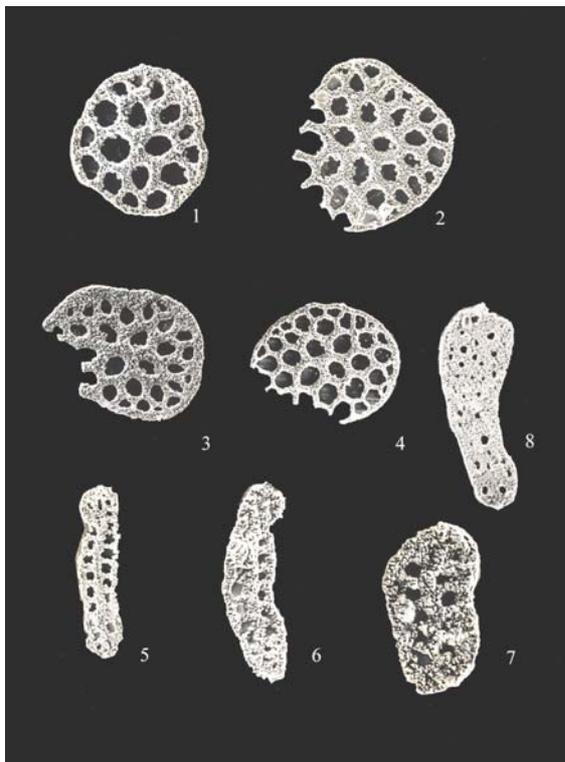


Fig. 4. (Tamimi and Saqqa)

Fig. 4 .1. *Calclamna cf. bekanerensis* Soodan; sample SA 109, rep.no. 48/XVI, x 130.

(2 – 4). *Calclamna cf. turoniansis* Sadeddin and Saqqa; no.2: sample SA 109, rep.no. 30/XV, x120; no.3: sample Sa 130, rep.no.23/XVI, x 150; no.4: sample SA 109, rep.no. 51/XVI, x 200.

5. *Calclamnella elongata* n.sp.; sample SA 81, rep.no. 33/XV, x 120.

6. *Calclamnella* sp.1.; sample SA 24, rep.no.25 /XV, x 160.

7. *Calclamnella* sp. 2.; sample SA 5, rep.no. 14/XVI, x200.

8. *Eocaudina insolica* n.sp.; sample SA72,

rep.no.34/XV, x 120.

4. MATERIAL AND METHOD

More than 230 samples have been collected bed by bed from the measured section (Fig. 3). Holothurian sclerites are separated from limestone and marly limestone rock samples by diluted (15 %) acetic acid, and from soft marl by diluted hydrogen peroxide. The fraction 90 μm to 125 μm was used in this study. A Cambridge-type Scanning Electron Microscope (SEM) homed in the Department of Physics, Mu'tah University, Jordan, was applied for photographing the holothurian sclerites. The holothurian sclerites are present in the samples 4 to 178, but they are more abundant in samples 4, 5, 24, 72, 81, 109, 139 and 178. The provided illustrations of holothurian sclerites were chosen from the rich residues of the former eight samples. The original material is stored in the Department of Earth and Environmental Sciences, Yarmouk University, Irbid, Jordan.

Systematic Description

Phylum: Echinodermata

Class: Holothuroidea

Family: Calclamniidae Frizzell and Exline, 1955

Genus: *Calclamna* Frizzell and Exline, 1955

Calclamna cf. bekanerensis Soodan, 1980

Fig. 4: 1

Locality: At the highway Irbid-Amman, 2 km. northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Early Turonian), sample SA109.

Description: Sclerite in form of perforate plate, outline subrounded to oval, periphery slightly scalloped; perforation 21 in number, 4 large central perforations arranged in cruciform pattern, 13 additional perforations arranged uniformly in one ring around the 4 central holes, 4 additional perforations of very small size, spread on peripheral part, shape of perforations is oval to subrounded; greater diameter 260 μm .

Remarks: *Calclamna cf. bekanerensis* is similar to *Calclamna bekanerensis* Soodan (1980) but it differs in having less number of perforations and in its smaller size.

Calclamna cf. turoniansis Sadeddin and Saqqa, 1997

Fig. 4: 2-4

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Hummar Limestone and Shuayb Marl (Late Cenomanian), sample SA81.

Description: Sclerite in form of a perforate plate; outline subrounded, to suboval; perforations of unequal size, 4 central in form of cross, nearly of equal size, subrounded, oval to suboval, surrounded by 21-32 holes, irregularly distributed, varying in size and shape; greatest diameter 260-381µm.

Remarks: *Calclamna cf. turoniansis* is similar to *Calclamna turoniansis* Sadeddin and Saqqa (1997) but it differs in larger number of additional perforations.

Genus: *Calclamnella* Frizzell and Exline, 1955

Calclamnella elongata n. sp.

Fig. 4: 5

Holotype: one specimen on fig. 3, no. 5, rep.no. 33/XV

Paratypes: 3 specimens two of them are broken; 34-36/XV

Derivation of Name: According to its elongate outline.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA81.

Diagnosis: Sclerite has two rows of (11 to 12) finely denticulate perforations separated by median raised flange. Outline subrectangular Length four times width.

Description: Sclerite in form of an elongate perforated plate, outline subrectangular, length four times of width, periphery undulated on both sides, both ends rounded to slightly rounded; pierced by two rows of subrectangular to irregular finely denticulate perforations, separated by median raised flange, perforations slightly offset, 11 to 12 perforations in a fully formed row; length 333µm, greater width 76µm.

Remarks: *Calclamnella elongata* n. sp. shows some similarity with *C. irregularis* Schlumberger (1890) but differs in its larger size (twice the size of *C. irregularis*), less undulating outline, perforations are finely denticulate and of larger number.

Calclamnella sp. 1

Fig. 4: 6

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA24.

Description: Sclerite in form of elongate plate; outline

subrectangular, length 4.5 times width, one end bluntly pointed, other end curved and slightly bended, one long side broadly convex and slightly undulated, the other slightly concave and smoother; bad sieve plate preservation and sediment contaminations hinder clear description of perforations, pierced by two rows of subcircular to irregular perforations of different size, opposite to slightly offset, at least from 7 to 12 perforations in a fully formed row, length 278µm, greater width 65µm.

Calclamnella sp. 2

Fig. 4: 7

Locality: At the highway Irbid-Amman, 2 km. northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA5.

Description: Sclerite in form of slightly elongate sieve plate, outline subquadrate, length about 2 times width, periphery generally smooth, one side almost straight and the other one slightly undulated, both ends slightly rounded; perforations 5-6 in fully formed row, slightly offset and partly filled with sediment (hindered clear description of the perforations), length 195µm, greater width 105µm.

Genus: *Eocaudina* Martin, 1952

Eocaudina insolica n. sp.

Fig. 4: 8

Holotype: one specimen on fig. 3, no. 8, rep.no. 37/XV

Paratypes: 2 specimens; 38, 39/XV Derivation of Name: According to its insole shape.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA72.

Diagnosis: Sclerite has elongated smooth insole outline. Perforations more than 40 of different size, shape and arranged in curvilinear rows.

Description: Sclerite in form of thin perforate plate, outline elongate, insole shaped, periphery smooth; perforations more than 40, of different size and shape mostly of small size, arranged in more than two rows of curvilinear shape, neither cruciform character of central holes nor bilateral symmetry of plate present; length 383µm, greater width 133µm.

Remarks: *Eocaudina insolica* n. sp. is unlike all other species of the genus by its insole shape, large number and distribution of perforations.

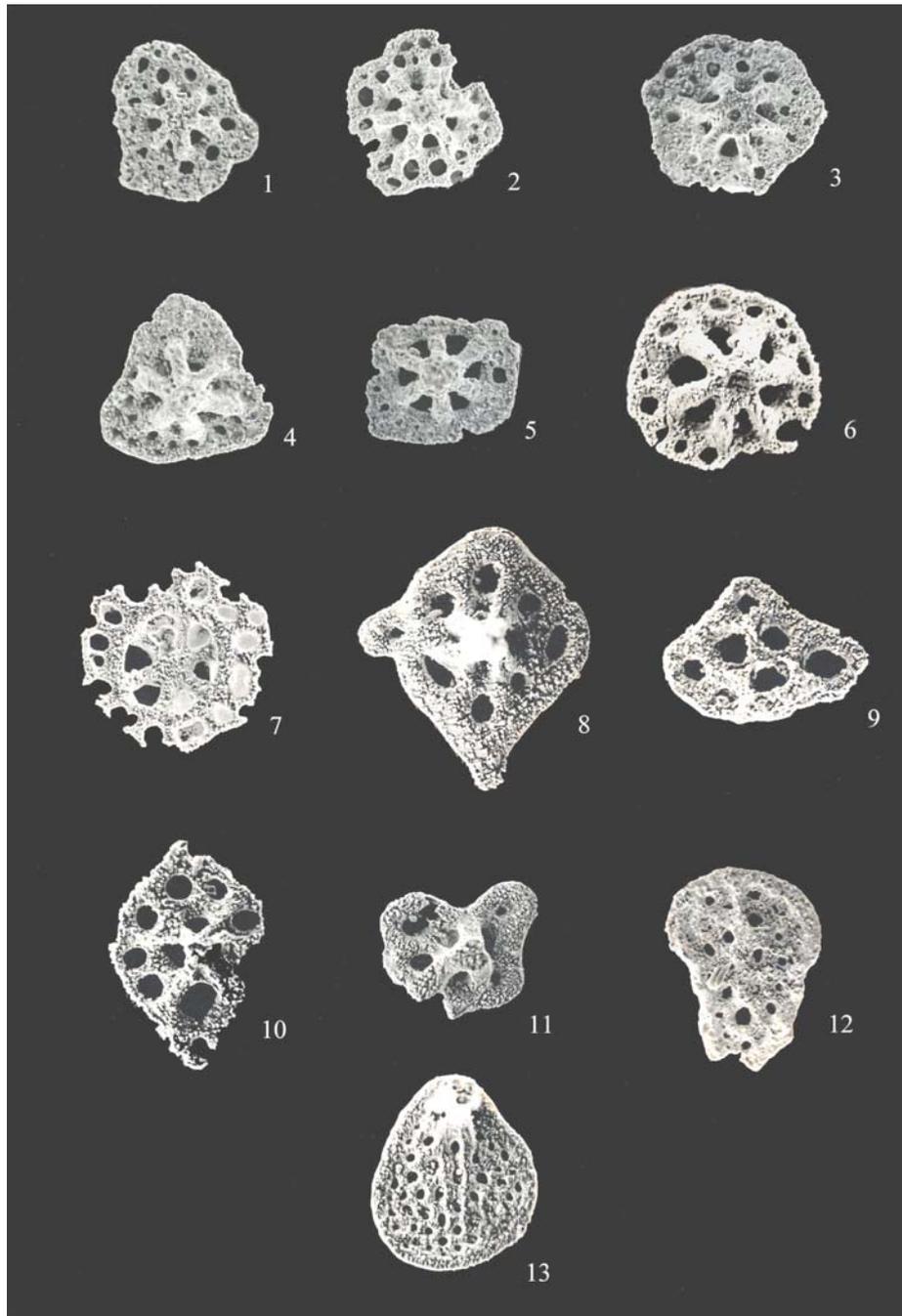


Fig. 5 (Tamimi and Saqqa).

- Fig. 5 (1-3).** *Hexapriscoopedatus reichi* n.g.n.sp., Sample SA 5, rep.no. I/XVII/7, 11,13, x 200
4. *Hexapriscoopedatus subtriangularis* n.sp., sample SA 5, rep.no. I/XVII/1, x 200.
5. *Hexapriscoopedatus subquadratus* n.sp.; sample SA178, rep.no. 1/XVII/9, x 200.
6 and 7. *Hexapriscoopedatus subcircularis* n.sp.; no.5: sample SA178, rep.no. 19/XV, no.6: lower view, x 250.
8. *Spinopriscoopedatus salhoubensis* n.sp.; sample SA109, rep.no. 52/XVI, x 200.
9. *Prisculatrites subtriangularis* n.sp.; sample SA 109, rep.no. 46/XVI, x 230.
10. *Prisculatrites lansulatus* n.sp.; sample SA109, rep.no. 53/XVI, x 200.
11. *Prisculatrites lobatus* n.sp.; sample SA5, rep.no. 1/XVI, x 175.
12. *Prisculatrites* sp.; sample SA4, rep.no. 19/XVI, x230.
13. *Tripuscucumis multiforamini* (Sadeddin) in Al-Tamimi et al., 2001, sample SA139, rep.no. 12/XVI., x 200.

Family: Priscopedatidae Frizzell and Exline, 1955

Genus: *Hexapriscoopedatus* n. g.

Type species: *Hexapriscoopedatus reichi* n. gen., n. sp.
From the Late Cenomanian to Early Turonian, Salhoub area, North Jordan.

Derivation of Name: From having 6 footed stirrup.

Genus diagnosis: sclerite in form of tables, consisting of perforate disk, with stirrup and/or spire; outline irregular, pentagonal, subtriangular, subquadratic, subcircular to circular; with very large circular central hole mostly covered by a conical 6 footed stirrup, central hole surrounded regularly to irregularly by 14-21 smaller perforations varying in size and shape; greater diameter ranges from 132 to 150µm.

Remarks: *Hexapriscoopedatus* n. g. differs from all other genera of the family Priscopedatidae in having 6 footed stirrup. *Hexapriscoopedatus* n. g. has been illustrated but not described by Reich 2001, pl. 1, figs. 14a-c.

***Hexapriscoopedatus reichi* n. sp.**

Fig. 5: 1-3

Holotype: The specimen on fig. 5, no. 3, rep. no. 1/XVII/13.

Paratypes: 4 specimens two of them are broken; 1/XVII/9-12.

Derivation of Name: In honor of Dr. Mike Reich, Geologisch-Paläontologisches Institut, Ernst-Moritz-Arndt-Universität, Greiswald, Germany.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA5.

Diagnosis: Sclerite robust plate of irregular to subpentagonal outline, large rounded to subrounded central hole covered by low 6 footed stirrup fused to the periphery of the central hole; central hole surrounded by 21 perforations of different size and shape.

Description: Sclerite in a form of robust sieve plate, with stirrup (spire broken directly above stirrup); outline irregular to subpentagonal periphery fairly undulated; 6 footed low stirrup fused together in a conical shape mostly cover a large circular central hole and welded to the periphery of the central hole; central hole large rounded to subrounded, surrounded by 21 circular (6 being opposite to every pillar), subcircular to elongate smaller perforations varying in size; greater diameter 140 µm.

Remarks: *Hexapriscoopedatus reichi* n. sp. differs from

all other species of the genus by its irregular outline and the distribution of secondary perforations.

***Hexapriscoopedatus subtriangularis* n. sp.**

Fig. 5: 4

Holotype: the specimen on fig. 5, no. 4, rep. no. 1/XVII/1.

Paratypes: 3 specimens all of them are broken; 1/XVII/2-4.

Derivation of Name: According to the subtriangular outline of the sclerite.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA5.

Diagnosis: Sclerites show subtriangular to triangular outline; very large rounded to subrounded central hole covered by low thickly 6 footed stirrup fused to the plate between plate outer margin and central hole; central hole surrounded by 18 small perforations of different shape.

Description: Sclerites in a form of robust sieve plate, with stirrup and/or spire (spire broken directly above stirrup); outline subtriangular to triangular; periphery slightly undulated; very large circular central hole mostly covered by 6 thickly footed stirrup, fused together in a conical shape above central hole and welded to the plate between periphery of the central hole and outer margin of the plate; surrounded irregularly by 18 circular to subcircular smaller perforations varying in size, 3 of the 6 pillars ends at plate by one perforation; greater diameter 145µm.

Remarks: *Hexapriscoopedatus subtriangularis* n. sp. differs from all other species of the genus by its triangular outline.

***Hexapriscoopedatus subquadratus* n. sp.**

Fig. 5: 5

Holotype: The specimen on fig. 5, no. 5, rep. no. 29/XVII/8.

Paratypes: 2 specimens; 29/XVII/6,7.

Derivation of Name: Its name is according to the subquadratic outline of this sclerite.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Limestone of Wadi As-Sir Formation (Late Turonian), sample SA178.

Diagnosis: Sclerites show subrectangular to subquadratic outline; very large rounded to subrounded central hole covered by low 6 footed stirrup fused to the periphery of the central hole; central hole surrounded regularly

by 17 mostly small size perforations of different shape.

Description: Robust sieve plate, with stirrup (spire broken directly above stirrup); outline subrectangular to subquadratic; periphery smooth to slightly **undulated**; disk with very large circular central hole covered by a large conical 6 footed stirrup, the 6 footed stirrup welded at the margin of the central hole; central hole surrounded regularly by 17 mostly very small size perforations varying in shape; greater diameter 150µm.

Remarks: *Hexapriscoapedatus subquadratus* n. sp. is unlike any other species of this genus, by its subquadratic outline of sclerites; number, arrangement and very small size of most of the additional perforations.

***Hexapriscoapedatus subcircularis* n. sp.**

Fig. 5: 6, 7

Holotype: The specimen on fig. 5, no. 6, rep. no. 29/XVII/5

Paratypes: 4 specimens one of them is broken; 29/XVII/1-4.

Derivation of Name: According to its subcircular outline of the sclerite.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Limestone of Wadi As-Sir Formation (Late Turonian), sample SA178.

Diagnosis: Sclerites show circular to subcircular outline; very large rounded to subrounded central hole, covered by 6 footed stirrup of high conical shape, 6 pillars fused at the periphery of the central hole; central hole surrounded regularly by 15 mostly subcircular perforations arranged in one ring parallel to plate margin.

Description: Sclerite in form of a perforated robust plate, with stirrup and/or spire (spire broken directly above stirrup); outline circular to subcircular; periphery slightly undulated, disk with very large circular central hole surrounded by 15 mostly subcircular perforations varying in size, regularly distributed around central hole in one ring parallel to plate margin; central hole mostly covered by 6 footed stirrup, fused together in a high conical shape and welded to the plate along margin of central hole; greater diameter 132µm.

Remarks: *Hexapriscoapedatus subcirculus* n. sp. differs from all other species of this genus by its circular to subcircular nature of the plate, the distribution of

secondary perforations, the very large central hole, and the high conical shape of the 6 footed stirrup.

Genus: *Spinopriscoapedatus* Kozur and Sadeddin, 1990
***Spinopriscoapedatus salhoubensis* n. sp**

Fig. 5: 8

Holotype: The specimen on fig. 5, no. 8, rep. no. 52/XVI

Paratypes: One specimen; 51/XVI

Derivation of Name: According to the name of the type locality area.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Early Turonian), sample SA109

Diagnosis: Sclerites show smooth subrhomboidal outline with four edges; two successive edges occupied by two spines of different shape and size; moderately large central hole mostly covered by a 4 footed stirrup, surrounded by 8 large to medium rounded to oval perforations arranged in one ring and one small perforation located on the shorter spine.

Description: Sclerite in a form of subrhombic perforated plate, two spines, one long with bluntly end, and one shorter (lobe like) with well rounded end, periphery smooth to very slightly undulated; disc pierced by a moderately large central hole mostly covered by a 4 footed stirrup, surrounded by a row of 8 large to medium rounded to oval additional perforations, one small additional hole located on the base of the short spine; greater diameter 225µm.

Remarks: *Spinopriscoapedatus salhoubensis* n. sp. has similarity to *S. hummari* Sadeddin in Al-Tamimi et al., 2001, but it differs in smoother and subrhomboidal outline, number and distribution of perforations, in its smaller stirrup and central hole, and the characters of the spines.

Genus: *Prisculatrites* Deflandre-Rigaud, 1962

***Prisculatrites subtriangularis* n. sp.**

Fig. 5: 9

Holotype: The specimen on fig. 5, no. 9, rep. no. 46/XVI

Paratypes: 3 specimens one is broken; 42-45/XVI

Derivation of Name: According to the subtriangular shape of the sclerite.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Early Turonian), sample SA109

Diagnosis: Sclerites characterized by unique subtriangular outline, number and distribution of

additional perforations.

Description: Outline subtriangular with two slightly depressed sides and third is convex, plate pierced by one large oval to subrounded central hole; 3 footed stirrup partly cover the central hole; 5 additional perforation of different sizes, arranged in one row around central one, 2 situated at 2 corners of the triangle, other 3 along the longer convex side; greater diameter 170µm.

Remarks: *Prisculatrites subtriangularis* n. sp. unlike all other species of the genus *Prisculatrites* in having subtriangular outline and in distribution of the additional perforations.

***Prisculatrites lansulata* n. sp.**

Fig. 5: 10

Holotype: The specimen on fig. 5, no. 10, rep. no. 53/XVI

Paratypes: 2 specimens; 54-55/XVI

Derivation of Name: According the lancet shape of the sieve plate.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly Limestone of Shuayb Formation (Early Turonian), sample SA109

Diagnosis: Sclerites characterized by unique lancet outline; large central hole surrounded by 8 rounded to subrounded additional perforations.

Description: Subrhomboidal (lancet) outline, periphery smooth - slightly undulated, with a projection at one corner; large central hole partially covered by 3 footed stirrup; central hole surrounded by 8 rounded to subrounded additional perforations, 7 along the margin and one at one corner; greater diameter 200µm.

Remarks: *Prisculatrites lansulata* n. sp. differs from all other species of the genus *Prisculatrites* in having rhomboidal (lancet) outline.

***Prisculatrites lobatus* n. sp.**

Fig. 5: 11

Holotype: The specimen on fig. 5, no. 11, rep. no. 1/XVI

Paratypes: 4 specimens three of them are broken; 2-5/XVI

Derivation of Name: Species named after the lobed outline of the sieve plate.

Locality: At the highway Irbid-Amman, 2 km northwest Salhoub village, North Jordan.

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA5

Diagnosis: Sclerites characterized by lobed irregular outline and three ticked footed stirrup; large central hole surrounded by 4 subrounded perforations of different sizes arranged in one row.

Description: Sieve plate shows lobed irregular outline, sides three concave and one convex, with two depressed toward central hole and one longer arched side, only one of these lobes slightly prolonged; central hole large almost covered by 3 thick footed moderately elevated stirrup; central hole surrounded by 4 rounded to subrounded additional perforations of different size; greater diameter 160µm.

Remarks: *Prisculatrites lobatus* n. sp. unlike all other species of the genus *Prisculatrites* in having irregular lobated outline with thick 3 thickly footed stirrup.

***Prisculatrites* sp.**

Fig. 5: 12

Distribution: Marly limestone of Shuayb Formation (Late Cenomanian), sample SA4.

Remarks: Only one specimen probably of a new species of *Prisculatrites*, it differs from all other species of the genus in having well developed marginal rim.

Genus: *Tripuscucumis* Reich, 2003

***Tripuscucumis multiforminis* Sadeddin in Al-Tamimi et al., 2001**

Figs. 5: 13

2001 *Priscopedatus multiforminis* Sadeddin in Al-Tamimi et al., 472-474, figs. 4: 8-13.

Locality: At the highway Irbid-Amman, 2 km to the northwest of Salhoub village, North Jordan.

Distribution: Shuayb Marl (Middle Turonian), sample SA139. In the Hummar Limestone of the Late Cenomanian by Al-Tamimi et al. (2001).

Description: Sclerite in form of tables; disc perforate with stirrup, outline pear shaped, circular, subcircular, subquadratic, suboval; periphery smooth to very slightly undulated; perforations numerous; one large eccentric hole (adjacent to the margin, totally covered by a marginal 3 footed stirrup, and, 52 small perforations varying in size and shape, arranged in 1-2 marginal rings, and the remaining are uniformly distributed; stirrup 3 footed, low, small; spire long, consist of 3 long thin pillars, circular in thin section; greatest diameter 165µm.

Remarks: The original description of the stirrup of this species by Al-Tamimi et al., 2001, 472-474, figs. 4.8-13, has been inadvertently as 4 footed described.

3. DISCUSSION AND CONCLUSIONS

The Late Cenomanian – Late Turonian carbonate sequence of Shuayb and Wadi As-Sir Formations is characterized by a high diversity of new holothurian sclerite assemblages. Sixteen species belonging to 7 genera are described for the first time from the studied sequence. The investigated holothurian sclerites include one new genus and 13 new species. Two species belong to the genus *Calclamna* (Frizzell and Exline, 1955), 3 new species of the genus *Calclamnella* (Frizzell and Exline, 1955), one new species of the genus *Eocaudina* (Martin, 1952), 4 new species of the new genus *Hexapriscopeidatus* n. g., a new species of the genus *Spinopriscopeidatus* (Kozur and Sadeddin, 1990), 4 new species of the genus *Prisculatrites* (Deflandre-Rigaud, 1962), one species *Tripuscucumis multiforminis* of Late Cenomanian (Al-Tamimi et al., 2001). The high diversity and abundance of the newly introduced taxa were typically in Shuayb Formation. The explored holothurian sclerites can be divided into three assemblages based on their stratigraphical position in the examined section. The first assemblage encounters the lower part of Shuayb Formation and consists of *Hexapriscopeidatus reichi* n. sp. of n. g., *H. subtriangularis* n. sp., *Prisculatrites lobatus* n. sp., *P. sp.1*, *Eocaudina insolica*, *Calclamna cf. turoniansis*, *Calclamnella elongate* n. sp., *C. sp.1* and *C. sp.2*. The lower part of Shuayb Formation is characterized by the presence of local ammonite taxa which is correlated with *geslinianum* and *judii* ammonite zones of southern Europe (Schultze et al., 2004). The ammonite zones designate Late Cenomanian age. Accordingly, the lower part of Shuayb Formation and the first holothurian sclerites assemblage are of the same age. The second assemblage characterizes the upper part of

the Shuayb Formation and comprises four taxa, *Spinopriscopeidatus salhoubensis* n. sp., *Prisculatrites subtriangularis* n. sp., *P. lansulata* n. sp. and *Calclamna cf. bekanernsis*. The ammonite taxa present in this part of the formation, correspond to *coloradoensis* and *nodosoides* ammonite zones of Southern Europe and designate an Early Turonian age (Schultze et al., 2004). Consequently, the upper part of Shuayb Formation and its content of the second holothurian sclerites assemblage have an Early Turonian age. The third assemblage occurs in the rocks of Wadi As-Sir Formation and includes three taxa, *Hexapriscopeidatus subquadratus* n. sp., *H. subcircularis* n. sp., and *Tripuscucumis multiforminis*. Wadi As-Sir Formation includes ammonite zones identical with Middle to Late Turonian ammonite zones of Southern Europe (Schultze et al., 2004). Therefore, the third holothurian assemblage and the studied part of Wadi As-Sir Formation must have a similar age. From previous, one can realize how the different forms of sclerites are evolved and distributed in the carbonate sequence according to their ages.

To ascertain the biozonation prospect of holothurian sclerites, further investigations on their fossil assemblages in the whole Upper Cretaceous rock sequence are highly recommended locally and on regional scale.

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CENOMANIAN		TURONIAN					STAGE
Late		Early	Middle	Late		Substage	
F u h e i s			Wadi As-sir			Studied Formations	
I	II	III	IV	V		S-Europe Ammonite Zones	
4	5	24	72	81	109	139	178
							Sample No.
							In this study described holothurian taxa
—	X	—	—	—	—	—	—
—	X	—	—	—	—	—	—
—	—	—	—	—	—	—	X
—	—	—	—	—	—	—	X
—	—	—	—	—	—	X	—
—	—	—	—	X	—	—	—
—	—	—	—	X	—	—	—
—	X	—	—	—	—	—	—
X	—	—	—	X	—	—	—
—	—	—	—	—	—	—	—
—	—	X	—	—	—	—	—
—	—	—	—	X	—	—	—
—	—	—	X	—	—	—	—
—	—	—	—	—	—	—	—
—	X	—	—	—	—	—	—

Fig. 6. Tamimi & Saqqa.

Fig. 6. Distribution and stratigraphic relationships of studied holothurian sclerites based on five ammonite zones (I-V) of Schulze et. al. (2004). I: *geslinianum*, II: *judii*, III: *coloradoense*, IV: *nodosoides* and V: *woollgari*.

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(Frizzell and Exline, 1955)

(Frizzell and Exline, 1955) *Calclamna*

Eocaudina (Martin, 1952)

Calclamnella

(Kuzur and

(*Hexapriscopeidatus* n.g.) . .

(Deflandre-Rigaud,

Spinopriscopeidatus Sadeddin, 1990)

Tripuscucumis (Al-Tamimi et al., 2001)

Prisculatriles 1962)

multiforaminis

(Sadeddin and Saqqa, 1997; Al-Tamimi et al., 2001;

Sadeddin and Al-Tamimi, 2006)

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