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Original article

Paleocene–Early Eocene ostracodes from the Southern Galala Plateau (Eastern Desert, Egypt): Taxonomy, impact of paleobathymetric changes

Ostracodes du Paléocène–Éocène inférieur du Plateau de Sud Galala (Désert oriental, Égypte) : systématique, impact des changements paléobathymétriques

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Abstract

Ostracode faunas obtained from nine sections spanning the Paleocene–Early Eocene interval from a platform–basin transect in the Southern Galala Plateau area (Eastern Desert, Egypt) have been investigated. The study focuses on taxonomy and biostratigraphy of the ostracode assemblages across the P/E boundary, with supporting comments on paleoecology and paleobiogeography. The studied nine sections yielded 60 taxa belonging to 39 genera. Five species are new. The P/E transition is characterized by the appearance of new taxa rather than extinctions. During the Early and early Late Paleocene, the ostracode assemblages throughout the study area are largely similar, being dominated by middle–outer neritic taxa. In the late Late Paleocene and Early Eocene, changes in the paleobathymetry from deeper marine environments in the distal area in the south to shallower marine environments in the proximal area in the north become pronounced. Many of the recorded taxa have a wide geographic distribution throughout the Middle East and North Africa. Similarities with basins of West Africa are also found, reflecting faunal exchanges between this area and southern Tethys during the Paleocene and Early Eocene.

Résumé

Les faunes d'ostracodes obtenues de neuf coupes dans le Paléocène–Eocène inférieur le long d'un axe allant de la plateforme jusqu'au bassin dans le Plateau de Sud Galala (Désert oriental, Égypte) ont été étudiées. L'étude concerne la systématique et la biostratigraphie des associations d'ostracodes à la limite P/E, ainsi que quelques commentaires sur la paléoécologie et la paléobiogéographie. Les neuf coupes étudiées ont livré 60 espèces, appartenant à 39 genres. Cinq espèces sont nouvelles. Le passage P/E est caractérisé par l'apparition de nouveaux taxons plutôt que par des extinctions. Pendant le Paléocène inférieur et la partie inférieure du Paléocène supérieur, les associations d'ostracodes dans toute la région étudiée sont similaires, dominées par des taxa de la zone néritique moyenne à externe. Vers la fin du Paléocène supérieur et le début de l'Éocène inférieur, des changements notables dans la paléobathymétrie sont enregistrés entre les régions distales profondes au sud et les régions proximales peu profondes au nord. De nombreux taxons reconnus ont une large répartition paléogéographique au Moyen-Orient et en Afrique du Nord. Il existe quelques ressemblances avec les bassins de l'Afrique occidentale indiquant des échanges entre ceux-ci et le Sud de la Téthys pendant le Paléocène et l'Eocène inférieur.

Keywords: Paleocene; Lower Eocene; Ostracoda; Egypt; Taxonomy; Biostratigraphy; Paleobathymetry; Paleobiogeography

Mots clés : Paléocène ; Éocène inférieur ; Ostracodes ; Égypte ; Taxonomie ; Biostratigraphie ; Paléobathymétrie ; Paléobiogéographie

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1. Introduction

The Paleocene–Early Eocene successions in the Southern Galala Plateau area have been the subject of several studies concerning different microfossil groups for paleontological as well as biostratigraphical aspects (Abdel-Kireem and Abdou, 1979; Haggag, 1991; Strougo et al., 1992; Strougo and Faris, 1993; Faris, 1997; Gietl, 1998; Marzouk and Scheibner, 2003). These studies dealt with foraminifera and calcareous nannoplankton; none of them was concerned with ostracodes. Ostracodes are known to be a very useful tool in paleoenvironmental as well as paleogeographic interpretations. Since the 1980s, the importance of ostracodes in biostratigraphy has also been increasingly realized and many publications are now available. It is now widely recognized that ostracodes are amongst the valuable microfossils as a stratigraphic tool for age dating and correlations (Colin and Lethiers, 1988). In the present paper we study the ostracode taxonomy, biostratigraphy, paleoecology and paleobiogeography across the Paleocene/Eocene boundary (P/E boundary) in the Southern Galala area (Eastern Desert, Egypt). Nine sections are investigated in a north–south transect from carbonate platform sediments in the north (sections B2, B3) over slope sediments at the Bir Dakhl area (sections D2–D6) to basinal sediments at Wadi Tarfa in the south (sections T2, T1) (Fig. 1). Lithostratigraphic nomenclature used herein is based on Scheibner et al. (2001) (Fig. 2). A continuous ostracode

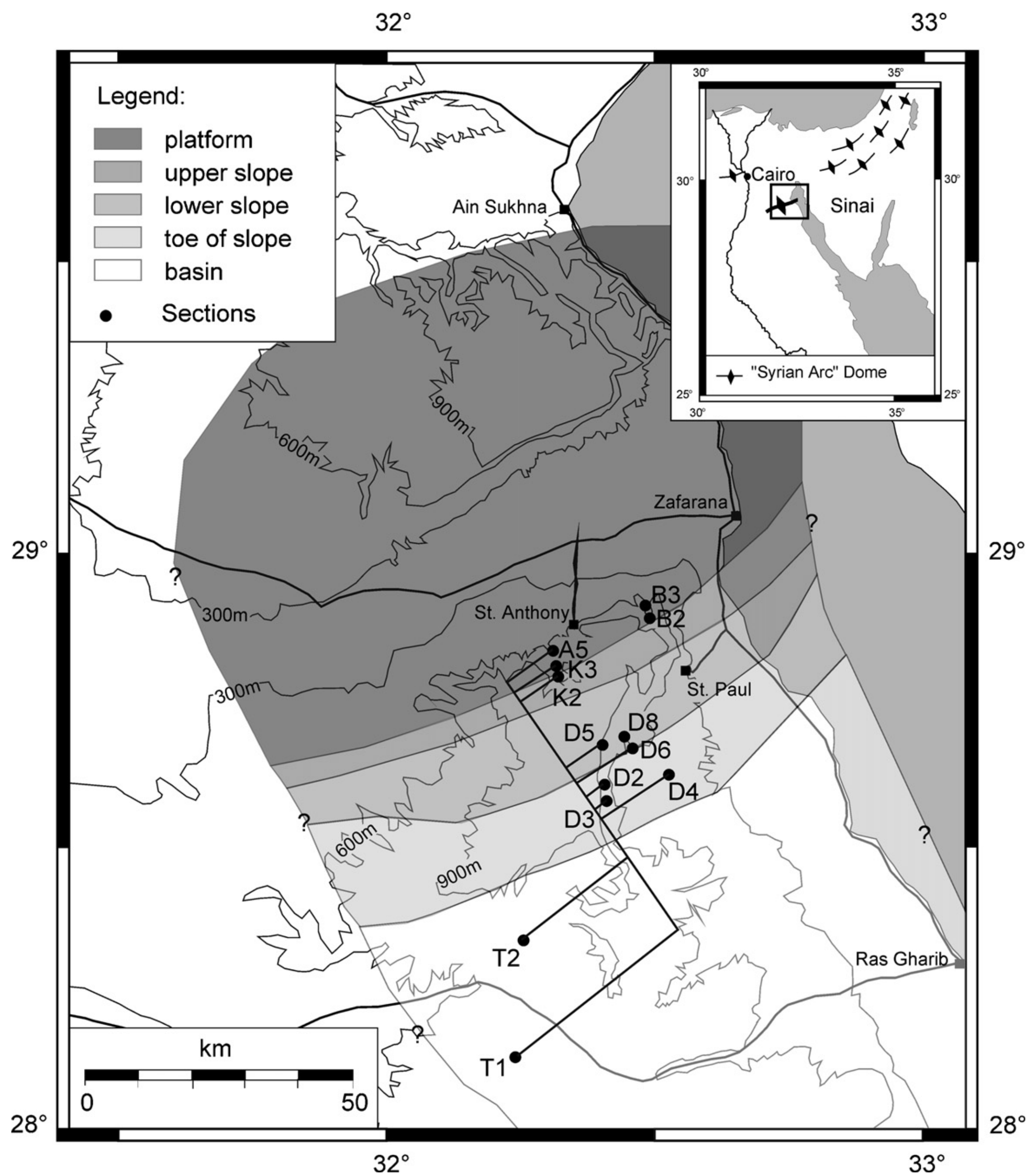


Fig. 1. The northern part of the Gulf of Suez showing locations of the sections.
Fig. 1. La partie septentrionale du Golfe de Suez montrant la localisation des coupes.

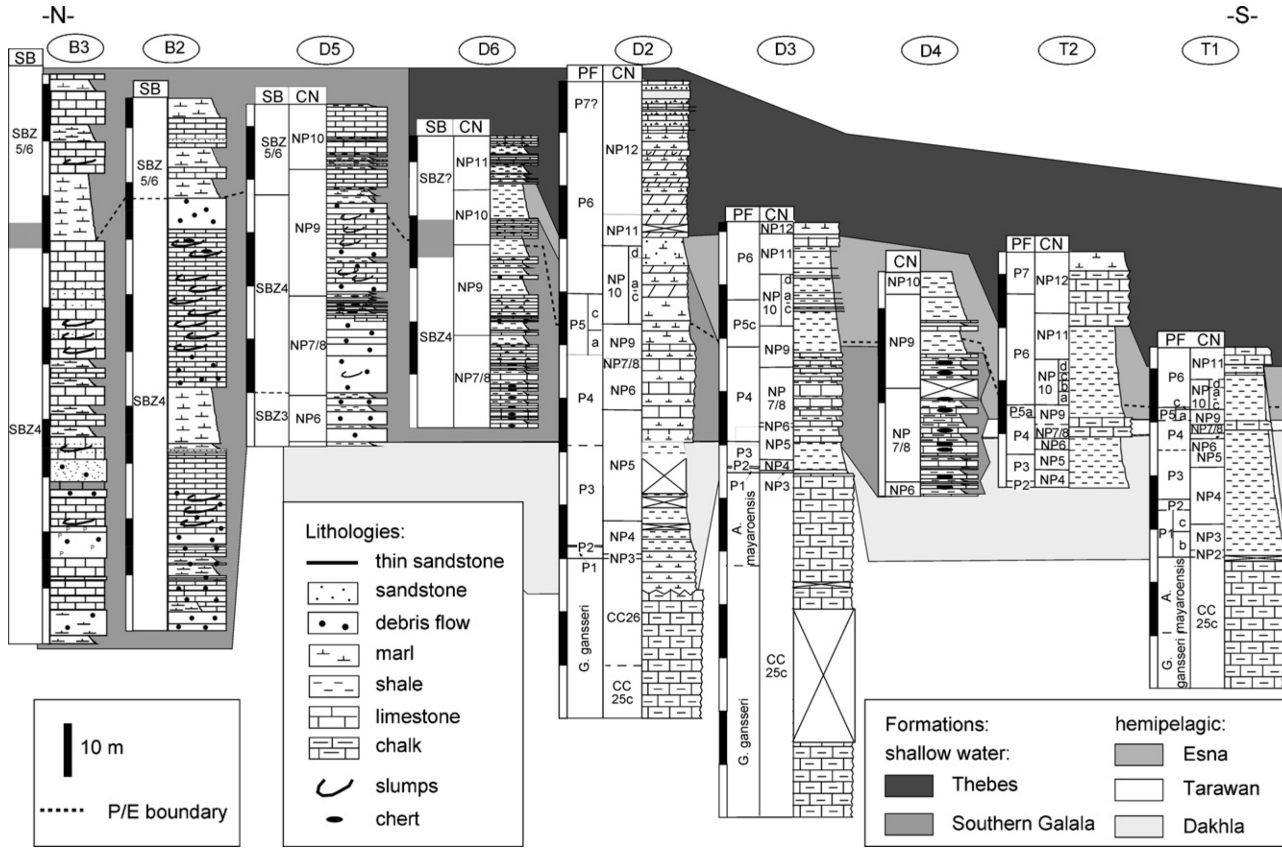


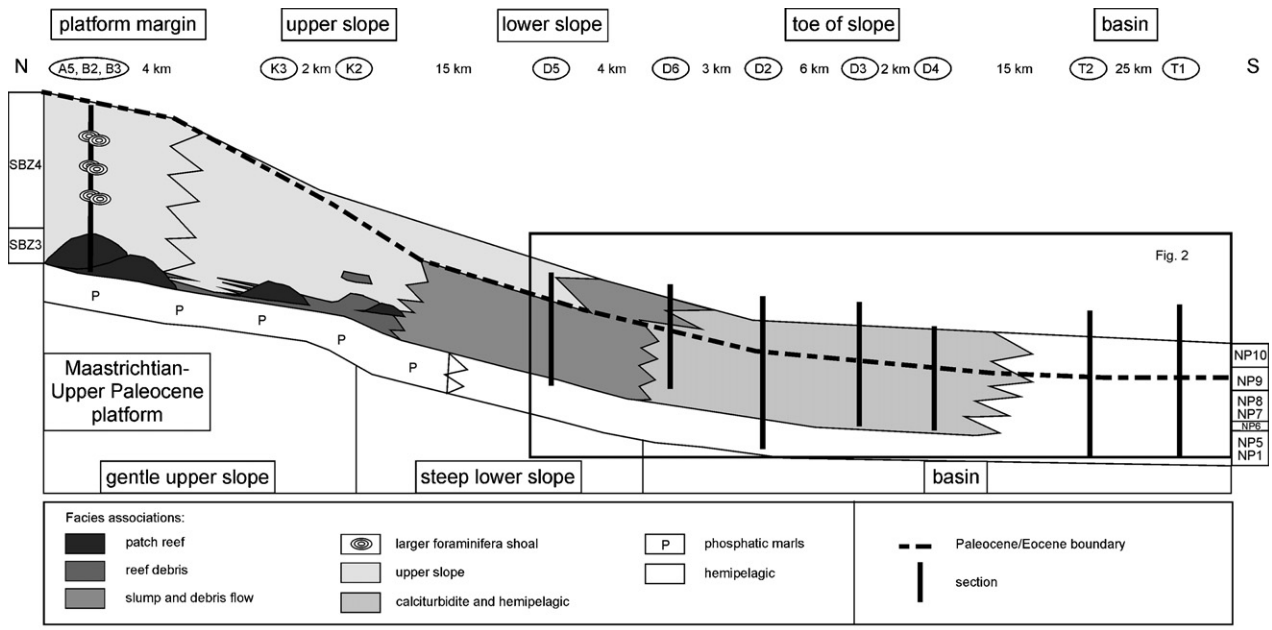
Fig. 2. Bio- and lithostratigraphic correlation of studied sections along a north-south transect.
Fig. 2. Corrélation bio- et lithostratigraphique des coupes étudiées le long d'un axe N-S.

record was yielded from two studied sections at Bir Dakhl (D2, D3) and also at Wadi Tarfa (T2, T1). Therefore, the interpretations and biostratigraphic evaluation in this paper are mainly based on these sections. The other sections (B2, B3, D4, D5, D6) have been considered as a source of additional taxonomic information.

The information about the Paleocene and Lower Eocene ostracodes of Egypt has increased substantially in recent years through several studies (Bassiouni et al., 1977; Boukhary et al., 1982; Khalifa et al., 1984; Bassiouni and Luger, 1990; Ismail, 1992, 1996; Elewa and Ishizaki, 1994; Aref, 1995; Morsi, 1999; Bassiouni and Morsi, 2000; Shahin, 2000, 2005; Speijer and Morsi, 2002; Morsi and Speijer, 2003; Elewa and Morsi, 2004; Ismail and Eid, 2004, 2005). Besides, the publications dealing with other Middle East areas (Salahi, 1966; Esker, 1968; Grékoff, 1969; Bassiouni, 1969a, 1970; Donze et al., 1982; Damotte and Fleury, 1987; Honigstein et al., 1991, 2002; Whatley and Arias, 1993; Keen et al., 1994; Honigstein and Rosenfeld, 1995; Said-Benzarti, 1998) are also indispensable. Works on the basins of West Africa such as Apostolescu (1961), Reyment (1963, 1981), Reyment and Reyment (1959, 1980), Foster et al. (1983), Neufville (1973), Carbonnel (1986), Okosun (1987), Carbonnel and Johnson (1989), Carbonnel et al. (1990), Carbonnel and Oyede (1991), Reyment and Aranki (1991), Digbehi et al. (1994), Carbonnel and Monciardini (1995), and Colin et al. (1998) have also been considered since many ostracode elements recorded there are also found in the south Tethyan areas.

2. Geologic framework

The Galala Mountains in the Eastern Desert, west of the Gulf of Suez, represent a southern branch of the Syrian Arc fold belt termed the Northern Galala/Wadi Araba High (NGWA; Kuss et al., 2000a). The Syrian Arc System was formed during the collision between the African and European plates, starting in Early Turonian times. A dextral transpressive reactivation of Mesozoic half-grabens resulted in a series of inverted, uplifted and folded grabens (Moustafa and Khalil, 1995). The NGWA High is separated by east-northeast trending faults (Bandel and Kuss, 1987) running perpendicular to the younger Gulf of Suez faults, which resulted from the Miocene opening of the Gulf. Similar to other Syrian Arc highs in Sinai Peninsula, the Galala mountain range strikes in a WSW–ENE direction (Kuss et al., 2000b). On the NGWA High, a mixed carbonate platform evolved during the Late Campanian to Eocene. The investigated sections follow a paleogeographical transect through five different facies belts running perpendicular to the former strike ranging from the platform in the north to the basin in the south: platform margin (I; sections B3, B2), upper slope (II), lower slope (III; sections D5, D6), toe of slope (IV; sections D2, D3, D4), and basin (V; sections T2, T1) (Fig. 3). The



Taxon		B3	B2	D5	D6	D2	D3	D4	T2	T1
Cristaeleberis reticulata	deep									x
Cytherelloidea attiyaensis										x
Ordoniya maanensis							x			x
Krithe echolsae						x	x	x	x	x
Ordoniya ordoniya						x	x		x	x
Reticulina sangalkamensis						x	x		x	x
Spinoleberis aff. *megiddoensis*						x	x		x	x
Cytherella sp.1 Honigstein & Rosenfeld					x			x	x	
Acanthocythereis? posterotriangulata	deep intermediate						x		x	
Phacorhabdotus inaequicostatus						x	x			x
Bairdia aegyptiaca						x				x
Soudanella laciniosa triangulata						x				x
Kefiella galalaensis				x	x	x		x	x	
Doricythereis martinii				x	x	x	x	x	x	x
Ordoniya hasaensis				x		x	x	x	x	x
Doricythereis jordanica nodoreticulata				x		x	x			x
Reticulina proteros		x			x	x	x	x	x	x
Bairdia ilaroensis		x	x			x	x		x	x
Actinocythereis? coronata		x				x	x		x	x
Parakrithe crolifa		x	x			x	x		x	x
Acanthocythereis? denticulata		x		x	x	x			x	x
Abyssocypris?adunca		x				x	x	x		x
Cytherella cf. *ventroconcava*	shallow intermediate		x	x	x		x	x		
Oertliella sp.		x					x			x
Paracosta parakefensis		x				x	x			x
Pontocyorella recurva		x		x		x	x		x	
Cytherella sinaensis						x	x		x	
Ordoniya bulaqensis						x	x		x	
Cytherella sp.1 Honigstein & Rosenfeld						x			x	
Urocythereis sp.									x	
Xestoleberis tunisiensis		x				x	x	x		
Bairdia aff. *septentrionalis*						x	x	x		
Bairdia sp.			x	x		x	x	x		
Acanthocythereis? sp.						x	x	x		
Loxoconcha sp.							x	x		
Haughtonileberis sp.		x				x	x			
Paracypris aff. *jonesi*		x	x				x			
Pokornyella pseudotriangularis		x				x	x	x		
Cytherella sp.1 Honigstein & Rosenfeld							x			
Cytherelloidea aff. *ozanana*							x			
Hornibrookella paramoosae						x	x			
Isalocopocythere teiskotensis						x	x			
Monoceratina reticulata							x			
Paracypris birdakhlensis						x	x			
Paragrenocythere cultrata						x	x			
Platella sp.							x			
Schizocythere salahii	shallow					x	x			
Tuberocytheridea sp.						x	x			
Acanthocythereis meslei cf. *paleocenica*				x		x				
Brachycythere? sp.						x				
Buntonia jordanica subjordanica						x				
Bythoceratina aff. *prothroensis*						x				
Hermanites? sp.						x				
Ordoniya? sp.							x			
Hornibrookella sp.						x				
Hornibrookella speijeri						x				
Horrificiella cf. *liebaui*						x				
Krithe sp.						x				
Neocyprideis sp.						x				
Pokornyella sp.2						x				
Pokornyella? sp.1						x				
Bythocypris cf. *gohrbandti*			x							

Fig. 3. Depth distribution of ostracode taxa in the study area.
Fig. 3. Répartition paléobathymétrique des ostracodes dans les coupes examinées.

evolution of the Paleocene carbonate platform margin and variation of the biotic content along the Southern Galala Mountains (Egypt) are related to varying processes and amounts of uplift and subsidence besides eustatic sea-level changes. Five tectono-sedimentary stages characterize the evolution of the Paleocene carbonate platform (Scheibner et al., 2003). The Maastrichtian to Selandian sea bottom topography (stages A–B) controlled the initial lateral facies distribution across the platform–basin transect (stage C). The combination of a significant eustatic drop in sea level and tectonic uplift of the Northern Galala/Wadi Araba High initiated the Late Paleocene platform progradation (stage C) in the Selandian (59 Ma). During the progradation phases of the carbonate platform (stages C and D; 59–56.2 Ma; NP5–NP8), the following facies belts developed: coral patch reefs and reef debris at the platform margin, well-bedded carbonates on the upper slope, slumps and debris flows on the lower slope, calciturbidites at the toe of slope, and hemipelagic sediments in the basin. During the retrogradational phase (stage E; 56.2 Ma–55.5 Ma; NP9), the combination of sea-level rise and differentiated subsidence of various parts of the platform resulted not only in a change of organisms at the platform margin from coral patch reefs to larger foraminiferal shoals, but also in a decrease in slump and debris-flow activity on the lower slope, and a decrease in calciturbidite activity at the toe of slope. As discussed by Scheibner et al. (2005), possible global causes, such as temperature changes may have also contributed to the environmental changes across the carbonate platform; in the Early Eocene, progradation of the platform took place again.

3. Material and methodology

The study area extends on the western side of the Gulf of Suez region from the northern rim of the Southern Galala Plateau in the north (sections A5, K2, K3, B2, B3) to Wadi Tarfa, south of the Southern Galala Plateau in the south (sections T2, T1), incorporating the area of Bir Dakhl (sections D2, D3, D4, D5, D6, D8) (Fig. 1). The studied ostracode material is extracted from 216 samples collected from nine sections measured along a north-south platform-basin transect (B2, B3, D2–D6, T2 and T1) (Figs. 2 and 3). The additional sections (A5, K2, K3 and D8) did not yield ostracode faunas and have been used only for depositional reconstruction. Sample spacing varied throughout the individual sections from 30 cm within shaley and marly sediments to 50 cm to 5 m in harder calcareous beds. About 100 g of dried rock was impregnated with a solution of Na_2CO_3 and washed after several days over a 0.063 mm sieve. Dirty residues underwent repeated washing. Clean residues were sieved and ostracodes were picked from the size fractions >250 μm. All picked specimens have been investigated and SEM-photographed by A.M. Morsi using the *Cam Scan* SEM of the University of Bremen, Germany, and are permanently stored among the collection of A.M. Morsi at the Geology Department, Faculty of Science, Ain Shams University (Cairo, Egypt). Reference numbers (MS-01–92) are given only to the illustrated specimens.

4. Systematic paleontology

The studied ostracode fauna are taxonomically classified into 60 species and subspecies assigned to 39 genera. Five species are newly introduced. The taxonomy is based on Hartmann and Puri (1974); later established genera are treated according to their authors.

Subclass OSTRACODA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PLATYCOPA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus ***Cytherella*** Jones, 1849

Cytherella sinaensis Morsi, 1999
Plate 1, Figs. 1, 2

1999. *Cytherella sinaensis* nov. sp.–Morsi, p. 33, Pl. 1, Figs. 4 and 6.

2000. *Cytherella sinaensis* Morsi–Morsi, p. 50, Pl. 1, Figs. 9, 10.

Material: 48 specimens.

Dimensions: L: 0.71–0.74 mm; H: 0.40–0.45 mm; W: 0.28 mm.

Occurrence: The present species was first described from the Maastrichtian and Paleocene of Sinai (Morsi, 1999, 2000). In the present study, *Cytherella sinaensis* is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3 and T2.

Cytherella cf. *ventroconcava* Neale and Singh, 1985
Plate 1, Figs. 3 and 4Figs. 3-5

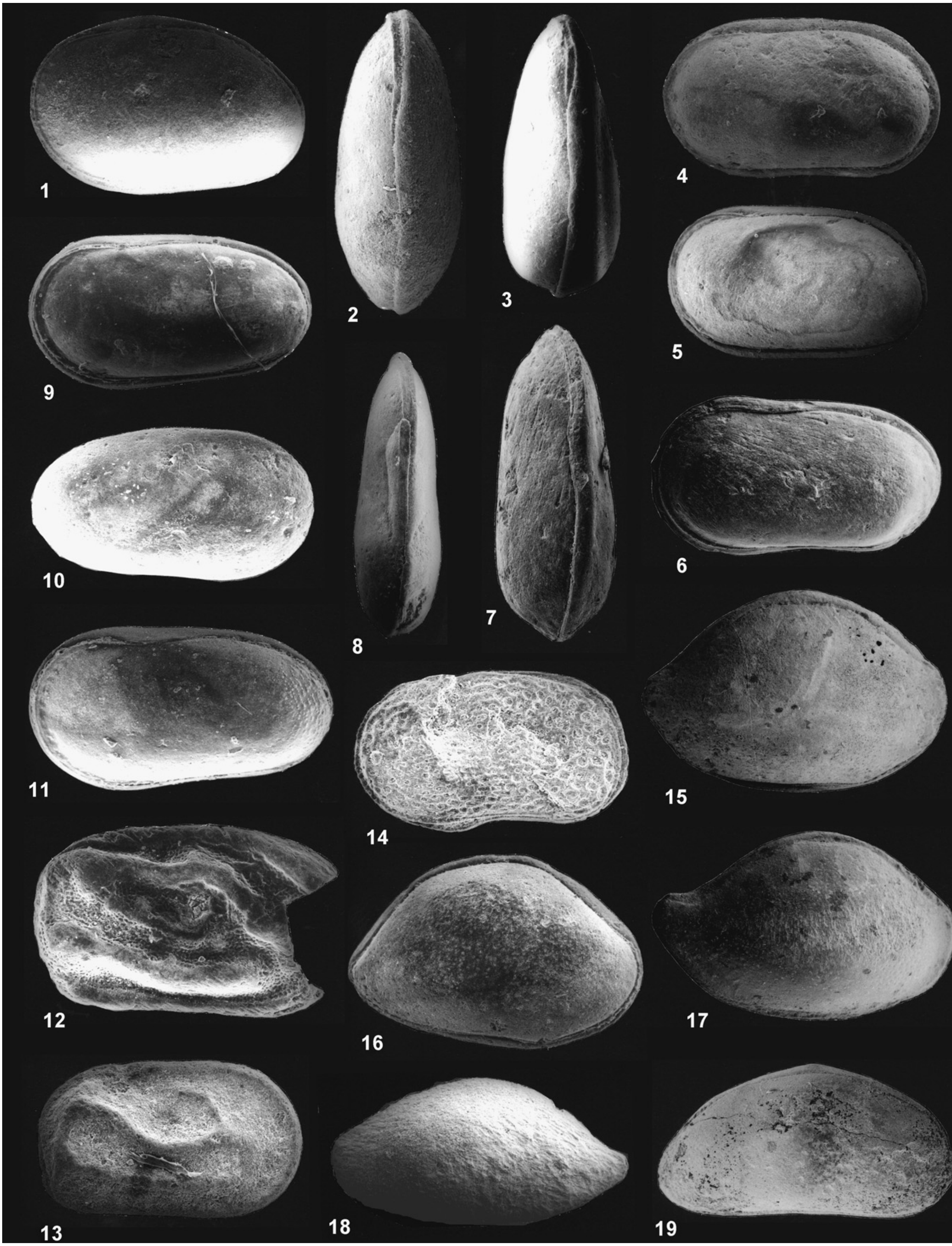
cf. 1985. *Cytherella ventroconcava* nov. sp.–Neale and Singh, p. 364, Pl. 41, Figs. 10–12.

1991. *Cytherella* cf. *ventroconcava* Neale and Singh–Honigstein et al., p. 98, Pl. 1, Fig. 1.

Material: 28 specimens.

Dimensions: L: 0.90–0.99 mm; H: 0.51–0.56 mm; W: 0.32–0.36 mm.

Remarks: The present species is similar to *Cytherella ventroconcava* Neale and Singh, 1985 from the Middle Eocene of Assam, India. *C. ventroconcava* deviates mainly in having a stronger concavity of the ventral margin and punctate lateral surface. In dorsal view, it is wedge-shaped with maximum width attained at posterior end, whereas in the present material the maximum width is situated at three fourths of length. The specimens assigned as *C.* cf. *lagenalis* Marlière by Morsi (1999) from the Paleocene of Sinai are also similar, but deviate in lacking the ventral margin concavity and exhibiting a more oblique posterior margin compared with the new species. *Cytherella lagenalis* Marliére, 1958, from the Montian of Belgium, is differentiated by having straight, perfectly parallel longitudinal margins, symmetrically rounded end margins, and a wedge-shaped dorsal outline, with greatest width at posterior end. *Cytherella tawica* Singh and Tewari (in Tewari and Singh, 1966), which was originally described from the Lower Eocene of India, is distinguished from the present species by its straight, anteriorly converging longitudinal margins which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render the posterior margin broader than the anterior margin.

Occurrence: Paleocene to Early Eocene, sections B3, B2, D2, D3, D5, T1 and T2.

Cytherella sp. 1 Honigstein and Rosenfeld, 1995

Plate 1, Figs. 6–11

1995. *Cytherella* sp. 1–Honigstein and Rosenfeld, p. 52, Pl. 1, Fig. 1.

Material: 50 specimens.

Dimensions: L: 0.98 mm (females), 0.88–0.94 mm (males); H: 0.53 mm (females), 0.47–0.50 (males); W: 0.38 mm (female), 0.26–0.28 mm (males).

Remarks: Sexual dimorphism is pronounced in the present material; assumed males are relatively smaller and thinner than assumed females.

Occurrence: The present species was recorded from the Paleocene of Israel (Honigstein and Rosenfeld, 1995). In the present study, it is recorded in the Late Paleocene (Thanetian) to Early Eocene (Ypresian) in sections D2, D3, T1 and T2.

Genus ***Cytherelloidea*** Alexander, 1929

Cytherelloidea attiyaensis Morsi, 1999

Plate 1, Fig. 12

1996. *Cytherelloidea monmouthensis* Jennings–Ismail, p. 42, Pl. 1, Fig. 4.

1999. *Cytherelloidea attiyaensis* nov. sp.–Morsi, p. 37, Pl. 1, Figs. 7–9.

Material: A single specimen.

Dimensions: L: 0.69 mm; H: 0.36 mm.

Occurrence: This species was previously recorded in the Maastrichtian and Early Paleocene of Sinai, Egypt. In the present study, it is found in the Late Paleocene (Selandian) in section T1.

Cytherelloidea aff. *ozanana* Sexton, 1951

Plate 1, Fig. 13

aff. 1951. *Cytherelloidea ozanana* nov. sp.–Sexton, p. 812, Pl. 117, Figs. 3, 6.

Material: Two specimens.

Dimensions: L: 0.62 mm; H: 0.36 mm.

Remarks: The present specimens resemble *Cytherelloidea ozanana* Sexton, 1951, which was originally described from the Early Campanian of the USA. It deviates in the aspect of the ventral rib, which is short and separated from the posterior node in *C. ozanana* but long and extends posteriorly to join the posterior node in our specimens.

Occurrence: Late Paleocene (Thanetian), section D3.

Genus ***Platella*** Coryell and Fields, 1937

Platella sp.

Plate 1, Fig. 14

Material: A single specimen.

Dimensions: L: 0.81 mm; H: 0.32 mm.

Remarks: The present species resembles both *Platella ewekoroensis* Foster, Swain and Petters, 1983 from the Late Paleocene of Nigeria and *Platella* sp. Bate, 1972 from the Late Cretaceous of West Australia. However, these two species are more elongate and lack the concentric arrangement of the surface pits shown by the present species. They also have asymmetrically rounded posterior margins unlike our species in which this margin is symmetrically truncate. *Platella* sp. Bate, 1972 has, moreover, a straight ventral margin tends to develop a ventral rib.

Occurrence: Late Paleocene (Thanetian), section D3.

Plate 1. L: length, W: width, RV: right view, LV: left view, DV: dorsal view. **Figs. 1, 2**. *Cytherella sinaensis* Morsi, 1999. Bir Dakhl, section D-2, sample D2-62: 1, carapace, MS-01, LV, L 0.73 mm; 2, carapace, MS-02, DV, W 0.28 mm. **Figs. 3–5**. *Cytherella* cf. *ventroconcava* Neale and Singh, 1985. Bir Dakhl, section D-2, sample D2-46: 3, carapace, MS-05, DV, W 0.36 mm; 4, carapace, MS-03, LV, L 0.99 mm; 5, carapace, MS-04, LV, L 0.90 mm. **Figs. 6–11**. *Cytherella* sp. 1 Honigstein and Rosenfeld, 1995. 6-7, 11, Bir Dakhl, section D-2: 6-7, sample D2-71, females, 6, carapace, MS-6, LV, L 0.98 mm; 7, carapace, MS-7, DV, W 0.38 mm; 11, sample D2-59, male, carapace, MS-11, LV, L 0.94 mm; 8-10. Wadi Tarfa, section T-2, sample T2-25, males: 8, carapace, MS-08, DV, W 0.28 mm; 9, carapace, MS-09, LV, L 0.93 mm; 10, carapace, MS-10, RV, L 0.88 mm. **Fig. 12**. *Cytherelloidea attiyaensis* Morsi, 1999. Wadi Tarfa, section T-1, sample T1-43, right valve, MS-12, external view, L 0.69 mm. **Fig. 13**. *Cytherelloidea* aff. *ozanana* Sexton, 1951. Bir Dakhl, section D-3, sample D3-46, right valve, MS-13, external view, L 0.62 mm. **Fig. 14**. *Platella* sp. Bir Dakhl, section D-3, sample D3-44, carapace, MS-14, LV, L 0.81 mm. **Fig. 15**. *Bairdia aegyptiaca* Bassiouni and Morsi, 2000. Bir Dakhl, section D-2, sample D2-90, carapace, MS-15, RV, L 1.40 mm. **Fig. 16**. *Bairdia ilaroensis* Reyment and Reyment, 1959. Bir Dakhl, section D-2, sample D2-57, carapace, MS-16, RV, L 1.04 mm. **Fig. 17**. *Bairdia* aff. *septentrionalis* Bonnema, 1941. Bir Dakhl, section D-2, sample D2-80, carapace, MS-17, RV, L 1.63 mm. **Fig. 18**. *Bairdia* sp. Bir Dakhl, section D-2, sample D2-62, left valve, MS-18, external view, L 0.84 mm. **Fig. 19.** *Bythocypris* cf. *gohrbandti* Esker, 1968. Bir Dakhl, section B-2, sample B2-37, carapace, MS-19, RV, L 1.04 mm.

Planche 1. L : longueur, W : largeur, RV : vue droite, LV : vue gauche, DV : vue dorsale. **Fig. 1, 2.** *Cytherella sinaensis* Morsi, 1999. Coupe D-2, échantillon D2-62 : 1, carapace, MS-01, LV, L 0,73 mm ; 2, carapace, MS-02, DV, W 0,28 mm. **Fig. 3–5**. *Cytherella* cf. *ventroconcava* Neale et Singh, 1985. Coupe D-2, échantillon D2-46 : 3, carapace, MS-05, DV, L 0,36 mm ; 4, carapace, MS-03, LV, L 0,99 mm ; 5, carapace, MS-04, LV, L 0,90 mm. **Fig. 6–11**. *Cytherella* sp. 1 Honigstein et Rosenfeld, 1995. 6-7, 11, Bir Dakhl, coupe D-2 : 6-7, échantillon D2-71, femelles, 6, carapace, MS-6, LV, L 0,98 mm ; 7, carapace, MS-7, DV, W 0,38 mm ; 11, échantillon D2-59, mâle, carapace, MS-11, LV, L 0,94 mm ; 8-10, Wadi Tarfa, coupe T-2, échantillon T2-25, mâles : 8, carapace, MS-08, DV, W 0,28 mm ; 9, carapace, MS-09, LV, L 0,93 mm ; 10, carapace, MS-10, RV, L 0,88 mm. **Fig. 12**. *Cytherelloidea attiyaensis* Morsi, 1999. Wadi Tarfa, Coupe T-1, échantillon T1-43, valve droite, MS-12, vue externe, L 0,69 mm. **Fig. 13**. *Cytherelloidea* aff. *ozanana* Sexton, 1951. Bir Dakhl, Coupe D-3, échantillon D3-46, valve droite, MS-13, vue externe, L 0,62 mm. **Fig. 14**. *Platella* sp. Bir Dakhl, Coupe D-3, échantillon D3-44, carapace, MS-14, LV, L 0,81 mm. **Fig. 15**. *Bairdia aegyptiaca* Bassiouni et Morsi, 2000. Bir Dakhl, Coupe D-2, échantillon D2-90, carapace, MS-15, RV, L 1,40 mm. **Fig. 16**. *Bairdia ilaroensis* Reyment et Reyment, 1959. Bir Dakhl, Coupe D-2, échantillon D2-57, carapace, MS-16, RV, L 1,04 mm. **Fig. 17**. *Bairdia* aff. *septentrionalis* Bonnema, 1941. Bir Dakhl, Coupe D-2, échantillon D2-80, carapace, MS-17, RV, L 1,63 mm. **Fig. 18**. *Bairdia* sp. Bir Dakhl, Coupe D-2, échantillon D2-62, valve gauche, MS-18, vue externe, L 0,84 mm. **Fig. 19**. *Bythocypris* cf. *gohrbandti* Esker, 1968. Bir Dakhl, Coupe B-2, échantillon B2-37, carapace, MS-19, RV, L 1,04 mm.

Suborder PODOCOPA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BAIRDIIDAE Sars, 1866
Genus ***Bairdia*** Mc'Coy, 1844

Bairdia aegyptiaca Bassiouni and Morsi, 2000
Plate 1, Fig. 15

1977. *Bairdia gliberti* Keij–Bassiouni et al., p. 1, Pl. 2, Figs. 10a–c.

2000. *Bairdia aegyptiaca* nov. sp.–Bassiouni and Morsi, p. 32, Pl. 2, Figs. 1, 2.

Material: Four specimens.

Dimensions: L: 1.40 mm; H: 0.94 mm; W: 0.70 mm.

Occurrence: The Late Paleocene (upper *velascoensis* Zone) and Early Eocene of Egypt (Bassiouni et al., 1977; Bassiouni and Morsi, 2000). Here, it is found in the Early Eocene (Ypresian) in sections D2 and T1.

Bairdia ilaroensis Reyment and Reyment, 1959
Plate 1, Fig. 16

1959. *Bairdia ilaroensis* nov. sp.–Reyment and Reyment, p. 61, Pl. 1, Figs. 1–7, Text-figs. 1a, b, 3a–m, 5a–h.

1981. *Bairdia ilaroensis* Reyment and Reyment–Reyment, p. 56, Pl. 9, Figs. 6, 7.

1983. *Bairdoppilata ilaroensis* (Reyment and Reyment)–Foster et al., p. 109, Pl. 1, Figs. 5, 7–11.

1987. *Bairdia ilaroensis* Reyment and Reyment–Okosun, p. 26, Pl. 20, Figs. 7, 9, 10.

1990. *Bairdia ilaroensis* Reyment and Reyment–Bassiouni and Luger, p. 780, Pl. 1, Fig. 15.

1990. *Bairdoppilata ilaroensis* (Reyment and Reyment)–Carbonnel et al., p. 674, Pl. 1, Fig. 19.

non 1991. *Bairdoppilata ilaroensis* (Reyment and Reyment)–Carbonnel and Oyede, p 69, Pl. 1, Fig. 1.

non 1992. *Bairdia ilaroensis* Reyment and Reyment–Ismail, p. 45, Pl. 1, Fig. 4.

1992. *Bairdia ilaroensis* Reyment and Reyment–El-Waer, p. 47, Pl. 4, Figs. 4 and 6–9Figs. 4-9.

1994. *Bairdia* gr. *ilaroensis* Reyment and Reyment–Keen et al., Pl. 16, Fig. 4.

?1996. *Bairdia ilaroensis* Reyment and Reyment–Bassiouni and Luger, p. 8, Pl. 1, Figs. 10–13.

1998. *Bairdoppilata ilaroensis* (Reyment and Reyment)–Colin et al., p. 291, Pl. 1, Figs. 4, 5.

2003. *Bairdia ilaroensis* Reyment and Reyment–Morsi and Speijer, p. 70, Pl. 1, Fig. 4.

Material: 117 specimens.

Dimensions: L: 0.91–1.04 mm; H: 0.59–0.69 mm; W: 0.48 mm.

Occurrence: The present species is widely known from the Maastrichtian–Early Eocene of many areas of West and North Africa. In Egypt, it was recorded from the Maastrichtian to Lower Eocene (Bassiouni and Luger, 1990; Morsi and Speijer, 2003). In the present study, it is found in the Paleocene to Early Eocene, sections B3, B2, D2, D3, T1 and T2.

Bairdia aff. *septentrionalis* Bonnema, 1941
Plate 1, Fig. 17

aff. 1941. *Bairdia septentrionalis* nov. sp.–Bonnema, p. 108, Pl. 2, Figs. 55–64; Pl. 3, Figs. 1–8.

1995. *Bairdia* sp. 1–Honigstein and Rosenfeld, p. 52, Pl. 1, Fig. 3.

1996. *Bairdoppilata* sp.–Ismail, p. 43, Pl. 1, Fig. 11.

1999. *Bairdia* aff. *septentrionalis* Bonnema–Morsi, p. 37, Pl. 1, Fig. 10.

2000. *Bairdia* aff. *septentrionalis* Bonnema–Morsi, p. 51, Pl. 1, Fig. 13.

Material: 23 specimens.

Dimensions: L: 1.25–1.63 mm; H: 0.78–0.90 mm; W: 0.82 mm.

Remarks: The present specimens deviate from *Bairdia septentrionalis* Bonnema, 1941, from the Cretaceous of north-eastern Holland, in having a broader anterior margin. *Bairdia gliberti* Keij, 1957 from the Eocene of Belgium and *Bairdia ilaroensis* Reyment and Reyment, 1959, which was originally described from the Maastrichtian of Nigeria, have a narrower anterior margin and broader, less caudate posterior end.

Occurrence: The present species was previously found in the Paleocene of southern Israel (Honigstein and Rosenfeld, 1995) and Maastrichtian and Paleocene of Egypt (Ismail, 1996; Morsi, 1999, 2000). In the present study, it is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian), sections D2, D3 and D4.

Bairdia sp.
Plate 1, Fig. 18

Material: 15 specimens.

Dimensions: L: 0.83 mm; H: 0.43 mm.

Remarks: The nearest species to the present species is *Bairdia* sp. 2 Donze et al., 1982 which was recorded in the Maastrichtian of the Kef section in Tunisia. Although they are both rather elongate, *Bairdia* sp. 2 Donze et al. shows a less symmetrical dorsal margin and a less caudate posterior end.

Occurrence: Paleocene to Early Eocene, sections B2, D2, D3, D4 and D5.

Family BYTHOCYPRIDIDAE Maddocks, 1969
Genus ***Bythocypris*** Brady, 1880
Bythocypris cf. *gohrbandti* Esker, 1968
Plate 1, Fig. 19

cf. 1968. *Bythocypris gohrbandti* nov. sp.–Esker, p. 32, Pl. 1, Fig. 14.

Material: Four specimens.

Dimensions: L: 1.04 mm; H: 0.57 mm; W: 0.43 mm.

Remarks: The present species exhibits close similarities with *Bythocypris gohrbandti* which was originally described from the Danian of Tunisia (Esker, 1968), and also recorded from Egypt (Bassiouni and Morsi, 2000). It differs only in having a more angled arch at the middle of the dorsal margin of the left valve. *Bythocypris windhami* Butler and Jones, 1957, which was first recorded in the Campanian of the USA, is also similar but deviates in having a broader posterior margin and the highest dorsal apex more anteriorly shifted.

Occurrence: The present material is recorded in the Paleocene, section B2.

Superfamily CYPRIDACEA Baird, 1845
Family CANDONIDAE Kaufmann, 1900
Subfamily PARACYPRIDINAE Sars, 1923
Genus ***Paracypris*** Sars, 1866

Paracypris birdakhlensis nov. sp.
Plate 2, Figs. 1–3

Etymology: Referring to the area of Bir Dakhl, the type locality for the species.

Holotype: One carapace (Plate 2, Fig. 1).

Paratypes: Four carapaces of which two are illustrated (Plate 2, Figs. 2, 3).

Type locality: Bir Dakhl area, section D3.

Type horizon: A shale bed, Southern Galala/Esna Formation, Late Paleocene (Thanetian), P4 zone (NP7/8), sample D3-46.

Diagnosis: An elongated bean-shaped *Paracypris* species with symmetrically arched dorsal margin and maximum length attained ventrally.

Dimensions: L: 0.88 mm (holotype), 0.77–0.88 mm (paratypes); H: 0.39 mm (holotype), 0.33–0.39 mm (paratypes); W: 0.29 mm (holotype), 0.28–0.29 mm (paratypes).

Description: Carapace bean-shaped, elongate in lateral view. Dorsal margin symmetrically arched, joined smoothly to end margins; dorsal margin of right valve consists of three parts, smoothly joined to each other. Ventral margin of left valve straight, slightly sinuous in right valve. Posterior margin narrowly rounded, ventrally situated; anterior margin broader, symmetrically rounded. Right valve clearly overreached by left valve, maximum overlap is dorsal. Greatest length attained shortly above ventral margin; greatest height central. Lateral surface smooth. In dorsal view, carapace elongated ovate; greatest thickness just behind the middle. Internal features not accessible. Sexual dimorphism not observed.

Discussion: *Paracypris sokotoensis* Reyment, 1981, which was originally described from the Paleocene of Nigeria, is the nearest to *Paracypris birdakhlensis* nov. sp. It is differentiated from the new species by its higher, rather angular dorsal margin, sinuous ventral margin, greater overlap of left valve over the right valve dorsally, and more acuminate posterior margin. *Paracypris nigeriensis* Reyment, 1960, which was erected from the Maastrichtian of Nigeria, is also similar to our new species. It differs, however, in being higher and having a broader, blunt posterior margin and flattened zones on both sides at the mid-point of dorsal margin. It also deviates in the aspects of overlap where the greatest overlap is attained anterodorsally, posterodorsally and ventrally while in the new species it is largest along the dorsal margin. *Paracypris eskeri* Bassiouni and Morsi, 2000, from the Paleocene and Early Eocene of Tunisia (Esker, 1968; Donze et al., 1982) and Egypt (Bassiouni and Luger, 1990; Bassiouni and Morsi, 2000), is mainly differentiated from *P. birdakhlensis* nov. sp. by its dorsal margin which consists of three flattened parts joined together at obtuse angles.

Occurrence: This species has been recorded in the Late Paleocene (Thanetian) interval in sections D2 and D3.

Paracypris aff. *jonesi* Bonnema, 1941
Plate 2, Figs. 4, 5

aff. 1941. *Paracypris jonesi* nov. sp.–Bonnema, p. 115, Pl. 3, Figs. 24–28.

1966. *Paracypris* n. sp.–Salahi, p. 7, Pl. 1, Figs. 29, 30, 34.

1968. *Paracypris jonesi* Bonnema–Esker, p. 282, Pl. 1, Fig. 13.

1990. *Paracypris jonesi* Bonnema–Bassiouni and Luger, p. 83, Pl. 2, Figs. 9, 11.

2000. *Paracypris jonesi* Bonnema–Bassiouni and Morsi, p. 37, Pl. 3, Figs. 1–4.

2005. *Paracypris jonesi* Bonnema–Ismail and Eid, p. 127, Pl. 2, Fig. 1.

Material: Five specimens.

Dimensions: L: 1.25–1.30 mm; H: 0.33 mm; W: 0.29 mm.

Remarks: *Paracypris jonesi* was originally described from the Maastrichtian of the Netherlands (Bonnema, 1941). The material recorded in the present study is strikingly similar to this species. However, it has been assigned as *Paracypris* aff. *jonesi* since the nominate species originally comes from the Maastrichtian of northern Europe which belonged to a different bioprovince during the Late Cretaceous–Paleogene.

Occurrence: This species was previously recorded in the Paleocene of Libya (Salahi, 1966), Tunisia (Esker, 1968) and the Paleocene to Early Eocene of Egypt (Bassiouni and Luger, 1990; Bassiouni and Morsi, 2000; Ismail and Eid, 2005). In the present material, it is found in the Paleocene and Early Eocene in sections B2 and D3.

Family PONTOCYPRIDIDAE Müller, 1894
Genus ***Abyssocypris*** van den Bold, 1974
Abyssocypris? *adunca* (Esker, 1968)
Plate 2, Fig. 6

1968. "*Bythocypris*" *adunca* nov. sp.–Esker, p. 321, Pl. 2, Figs. 10–12; Pl. 4, Fig. 4.

1982. *Abyssocypris*? *adunca* (Esker)–Donze et al., p. 281, Pl. 2, Figs. 3, 4.

1987. *Abyssocypris*? *adunca* (Esker)–Damotte and Fleury, p. 93, Pl., Fig. 10.

1990. "*Bythocypris*" *adunca* Esker–Bassiouni and Luger, p. 781, Pl. 2, Fig. 4.

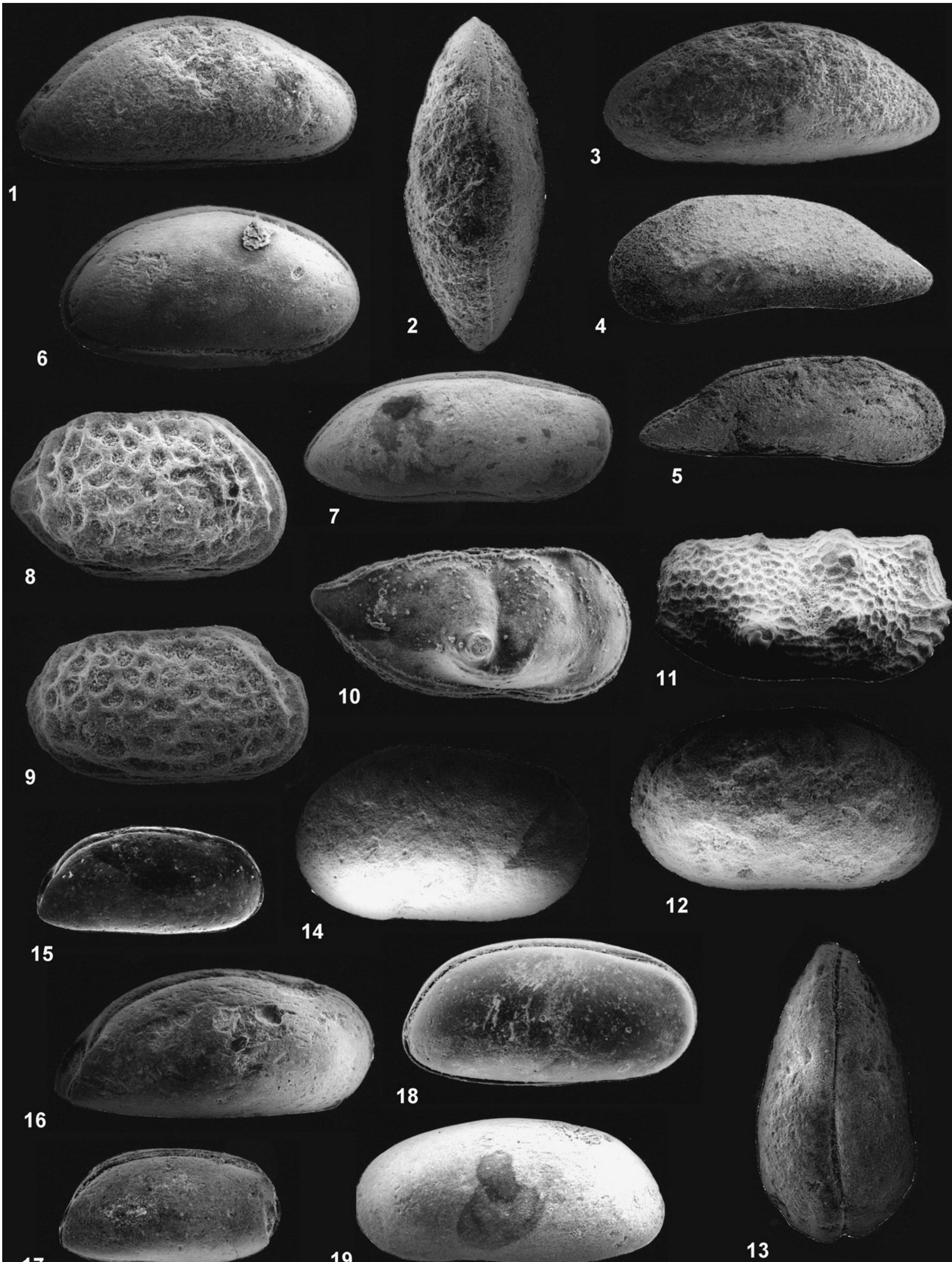
1998. *Abyssocypris? adunca* (Esker)–Said-Benzarti, Pl. 2, Fig. 13.

2000. "*Bythocypris*" *adunca* Esker–Bassiouni and Morsi, p. 33, Pl. 2, Fig. 3.

Material: 22 specimens.

Dimensions: L: 0.63–0.80 mm; H: 0.35–0.44 mm; W: 0.31 mm.

Occurrence: The species is known in the Late Campanian and Paleocene of Tunisia (Esker, 1968; Donze et al., 1982; Said-Benzarti, 1998), Early and Late Paleocene of Algeria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(Damotte and Fleury, 1987) and Late Paleocene and Early Eocene Egypt (Bassiouni and Luger, 1990; Bassiouni and Morsi, 2000). In the present material, it is found in the Late Paleocene (Thanetian) to Early Eocene (Ypresian), sections B3, D2, D3, D4 and T1.

Genus ***Pontocyprella*** Lyubimova, 1955

Pontocyprella recurva Esker, 1968

Plate 2, Fig. 7

1968. *Pontocyprella recurva* nov. sp.–Esker, p. 323, Pl. 1, Figs. 6, 7.

1982. *Pontocyprella recurva* Esker–Boukhary et al., Pl. 2, Fig. 10.

1982. *Pontocyprella recurva* Esker–Donze et al., p. 281, Pl. 2, Figs. 1, 2.

pars 1987. *Pontocyprella recurva* Esker–Damotte and Fleury, p. 93, Pl. 1, Fig. 12.

1990. *Pontocyprella recurva* Esker–Bassiouni and Luger, p. 785, Pl. 3, Fig. 12.

1992. *Pontocyprella recurva* Esker–El-Waer, p. 73, Pl. 57, Figs. 1–3.

1998. *Pontocyprella recurva* Esker–Said-Benzarti, Pl. 1, Fig. 13.

1999. *Pontocyprella recurva* Esker–Morsi, p. 38, Pl. 1, Fig. 12.

2000. *Pontocyprella recurva* Esker–Morsi, p. 51, Pl. 1, Fig. 14.

2000. *Pontocyprella recurva* Esker–Bassiouni and Morsi, p. 37, Pl. 3, Figs. 7, 8.

2004. *Pontocyprella recurva* Esker–Ismail and Ied, p. 101, Pl. 1, Fig. 8.

2005. *Pontocyprella recurva* Esker–Ismail and Ied, p. 127, Pl. 2, Fig. 2.

Material: 10 specimens.

Dimensions: L: 0.86–1.02 mm; H: 0.41–0.50 mm; W: 0.31 mm.

Occurrence: This species is known from the Maastrichtian–Paleocene of Tunisia (Donze et al., 1982; Said-Benzarti, 1998), Maastrichtian–Middle Paleocene of Algeria (Damotte and Fleury, 1987), Maastrichtian of Libya (El-Waer, 1992) and Maastrichtian–Early Eocene of Egypt (Boukhary et al., 1982; Bassiouni and Luger, 1990; Morsi, 1999, 2000; Bassiouni and Morsi, 2000; Ismail and Ied, 2004, 2005). In the present material, it is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian) from sections B3, D2, D3, D5 and T2.

Superfamily CYTHERACEA Baird, 1850

Family CYTHERIDAE Baird, 1850

Subfamily CYTHERINAE Baird, 1850

Genus ***Schizocythere*** Triebel, 1950

Schizocythere salahii Bassiouni and Luger, 1990

Plate 2, Figs. 8, 9

1966. *Schizocythere* n. sp. 1–Salahi, p. 20, Pl. 3, Figs. 22–24.

1990. *Schizocythere salahii* nov. sp.–Bassiouni and Luger, p. 814, Pl. 12, Figs. 6–8.

1992. *Schizocythere salahii* Bassiouni and Luger–El-Waer, p. 78, Pl. 12, Figs. 1–6.

Material: 10 specimens.

Dimensions: L: 0.49 mm (female), 0.57 mm (male); H: 0.33 mm (female), 0.31 mm (male).

Occurrence: This species was previously recorded in the Early–Middle Eocene of Libya (Salahi, 1966; El-Waer, 1992) and Late Paleocene to Early Eocene of Egypt (Bassiouni and Luger, 1990). Here, it is found in the Late Paleocene (Thanetian) and Early Eocene (Ypresian) in sections D2 and D3.

Plate 2. L: length, W: width, RV: right view, LV: left view, DV: dorsal view. **Figs. 1–3**. *Paracypris birdakhlensis* nov. sp. Bir Dakhl, section D-3, sample D3-46: 1 holotype, carapace, MS-20, RV, L 0.88 mm; 2-3 paratypes: 2, carapace, MS-21, DV, W 0.28 mm; 3, carapace, MS-22, LV, L 0.78 mm. **Figs. 4, 5**. *Paracypris* aff. *jonesi* Bonnema, 1941. Bir Dakhl, section B-2, sample B2-41: 4, carapace, MS-23, LV, L 1.30 mm; 5, carapace, MS-24, RV, L 1.25 mm. **Fig. 6**. *Abyssocybris*? *adunca* (Esker, 1968). Bir Dakhl, section D-2, sample D2-73, carapace, MS-25, RV, L 0.84 mm. **Fig. 7**. *Pontocyprella recurva* Esker, 1968. Bir Dakhl, section D-2, sample D2-87, male, carapace, MS-26, RV, L 1.02 mm. **Figs. 8, 9**. *Schizocythere salahii* (Bassiouni and Luger, 1990). Bir Dakhl, section D-2, sample D2-62; 8, carapace, female, MS-27, RV, L 0.49 mm; 9, carapace, male, MS-28, RV, L 0.56 mm. **Fig. 10**. *Bythoceratina* aff. *B.* cf. *prothroensis* Butler and Jones. Bir Dakhl, section D-2, sample D2-86, carapace, MS-29, RV, L 0.92 mm. **Fig. 11**. *Monoceratina reticulata* Bassiouni and Morsi, 2000. Bir Dakhl, section D-3, sample D2-56, carapace, MS-30, RV, L 0.70 mm. **Figs. 12–14**. *Neocyprideis* sp. Bir Dakhl, section D-2, sample D2-62, 12, carapace, MS-31, RV, L 0.79 mm; 13, carapace, MS-32, DV, W 0.40 mm; 14, carapace, MS-33, LV, L 0.79 mm. **Figs. 15, 16**. *Krithe echolsae* Esker, 1968. Bir Dakhl, section D-2, sample D2-79: 15, carapace, MS-34, RV, L 0.81 mm; 16, carapace, MS-35, RV, L 0.90 mm. **Fig. 17**. *Krithe* sp. Bir Dakhl, section D-2, sample D2-82, carapace, MS-36, RV, L 0.69 mm. **Figs. 18, 19**. *Parakrithe crolifa* Bassiouni and Luger, 1990. Bir Dakhl, section D-2, sample D2-80: 16, carapace, MS-37, RV, L 0.55 mm; 17, carapace, MS-38, LV, L 0.57 mm.

Planche 2. L : longueur, W : largeur, RV : vue droite, LV : vue gauche, DV : vue dorsale. **Fig. 1–3**. *Paracypris birdakhlensis* nov. sp. Bir Dakhl, Coupe D-3, échantillon D3-46 : 1 holotype, carapace, MS-20, RV, L 0,88 mm ; 2-3 paratypes : 2, carapace, MS-21, DV, W 0,28 mm ; 3, carapace, MS-22, LV, L 0,78 mm. **Fig. 4, 5**. *Paracypris* aff. *jonesi* Bonnema, 1941. Bir Dakhl, section B-2, Coupe B-2, échantillon B2-41 : 4, carapace, MS-23, LV, L 1,30 mm ; 5, carapace, MS-24, LV, L 1,25 mm. **Fig. 6**. *Abyssocybris*? *adunca* (Esker, 1968). Bir Dakhl, Coupe D-2, échantillon D2-73, carapace, MS-25, RV, L 0,84 mm. **Fig. 7**. *Pontocyprella recurva* Esker, 1968. Bir Dakhl, Coupe D-2, échantillon D2-87, mâle, carapace, MS-26, RV, L 1,02 mm. **Fig. 8, 9**. *Schizocythere salahii* (Bassiouni et Luger, 1990). Bir Dakhl, Coupe D-2, échantillon D2-62 : 8, carapace, femelle, MS-27, RV, L 0,49 mm ; 9, carapace, mâle, MS-28, RV, L 0,56 mm. **Fig. 10**. *Bythoceratina* aff. *B.* cf. *prothroensis* Butler et Jones. Bir Dakhl, Coupe D-2, échantillon D2-86, carapace, MS-29, RV, L 0,92 mm. **Fig. 11**. *Monoceratina reticulata* Bassiouni et Morsi, 2000. Bir Dakhl, Coupe D-3, échantillon D2-56, carapace, MS-30, RV, L 0,70 mm. **Fig. 12–14**. *Neocyprideis* sp. Bir Dakhl, Coupe D-2, échantillon D2-62 : 12, carapace, MS-31, RV, L 0,79 mm ; 13, carapace, MS-32, DV, W 0,40 mm ; 14, carapace, MS-33, LV, L 0,79 mm. **Fig. 15, 16**. *Krithe echolsae* Esker, 1968. Bir Dakhl, Coupe D-2, échantillon D2-79 : 15, carapace, MS-34, RV, L 0,81 mm ; 16, carapace, MS-35, RV, L 0,90 mm. **Fig. 17**. *Krithe* sp. Bir Dakhl, Coupe D-2, échantillon D2-82, carapace, MS-36, RV, L 0,69 mm. **Fig. 18, 19**. *Parakrithe crolifa* Bassiouni et Luger, 1990. Bir Dakhl, Coupe D-2, échantillon D2-80 : 16, carapace, MS-37, RV, L 0,55 mm ; 17, carapace, MS-38, LV, L 0,57 mm.

Family BYTHOCYTHERIDAE Sars, 1926
Genus ***Bythoceratina*** Hornibrook, 1952

Bythoceratina aff. *B.* cf. *prothroensis* (Butler and Jones, 1957)
Plate 2, Fig. 10
aff. 1982. *Bythoceratina* cf. *prothroensis* (Butler and Jones)–Donze et al., p. 296, Pl. 12, Figs. 6–8.

Material: A single specimen.

Dimensions: L: 0.92 mm; H: 0.44 mm.

Remarks: Only one carapace is found in our material. This carapace is closely related to the specimens figured as *Bythoceratina* cf. *prothroensis* (Butler and Jones, 1957) by Donze et al. (1982) from the Middle Maastrichtian of the Kef section in Tunisia. The present specimen deviates, however, in having the row of the ventrolateral tiny spines obtusely curved and posteriorly separated from the main venrtolateral spine, whereas in the Tunisian specimens, this row is acutely curved, ending posteriorly at the main venrtolateral spine. It has also fine tubercles on the anterior half of the carapace; these fine tubercles are not shown on the figures from Tunisia.

Occurrence: Early Eocene (Ypresian), zone P6 (NP10), section D2 (sample D2-86).

Genus ***Monoceratina*** Roth, 1928
Monoceratina reticulata Bassiouni and Morsi, 2000
Plate 2, Fig. 11
2000. *Monoceratina reticulata* nov. sp.–Bassiouni and Morsi, p. 41, Pl. 4, Figs. 7, 8.

Material: A single specimen.

Dimensions: L: 0.70 mm; H: 0.34 mm.

Occurrence: This species was recorded from the Lower Eocene of Egypt (Bassiouni and Morsi, 2000). In the present study, it is found in the Early Eocene (Ypresian), zone NP10, section D3 (sample D3-56).

Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus ***Neocyprideis*** Apostolescu, 1956

Neocyprideis sp.
Plate 2, Figs. 12–14

Material: Four specimens.

Dimensions: L: 0.74–0.79 mm; H: 0.40–0.47 mm; W: 0.39 mm.

Remarks: The present species exhibits similarities with *Neocyprideis rotundata* Bassiouni and Luger, 1996 from the Middle Eocene of Somalia which differs in having a relatively narrower anterior margin and less overlap of the left valve over the right valve mid-dorsally.

Occurrence: Latest Paleocene (Thanetian), subzone P5a, section D2 (sample D2-62).

Family KRITHIDAE Mandelstam, 1958
Subfamily KRITHINAE Mandelstam, 1958
Genus ***Krithe*** Brady, Crosskey and Robertson, 1874

Krithe echolsae Esker, 1968
Plate 2, Figs. 15, 16
1968. *Krithe echolsae* nov. sp.–Esker, p. 33, Pl. 3, Figs. 1–4.
1982. *Krithe echolsae* Esker–Boukhary et al., Pl. 2, Figs. 8, 9.
1982. *Krithe echolsae* Esker–Donze et al., p. 283, Fig. 4.
1987. *Krithe echolsae* Esker–Honigstein et al., p. 42, Pl. 1, Figs. 5, 6.
1990. *Krithe echolsae* Esker–Bassiouni and Luger, p. 795, Pl. 6, Figs. 10, 11.
1995. *Krithe echolsae* Esker–Honigstein and Rosenfeld, p. 53,
Pl. 1, Figs. 4, 5.
1999. *Krithe echolsae* Esker–Morsi, p. 38, Pl. 1, Figs. 13–15.
2000. *Krithe echolsae* Esker–Morsi, p. 56, Pl. 1, Figs. 16, 17.
2000. *Krithe echolsae* Esker–Bassiouni and Morsi, p. 43, Pl. 5, Figs. 2, 3.
2004. *Krithe echolsae* Esker–Ismail and Ied, p. 102, Pl. 1, Figs. 9, 10.

Material: 26 specimens.

Dimensions: L: 0.72–0.81 mm; H: 0.28–0.38 mm.

Occurrence: The present species is known from the Late Campanian to Paleocene of Tunisia (Esker, 1968; Donze et al., 1982; Said-Benzarti, 1998), Maastrichtian–Paleocene of Israel (Honigstein et al., 1987; Honigstein and Rosenfeld, 1995) and Egypt (Boukhary et al., 1982; Bassiouni and Luger, 1990; Morsi, 1999, 2000; Bassiouni and Morsi, 2000; Ismail and Ied, 2004). In the present work, it is found in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3, D4, T1 and T2.

Krithe sp.
Plate 2, Fig. 17

Material: Two specimens.

Dimensions: L: 0.69 mm; H: 0.36 mm.

Remarks: *Krithe* sp. differs from *Krithe echolsae* Esker, 1968 in having a steeper sloping posterior margin and relatively smaller size. *Krithe solomoni* Honigstein, 1984, from the Late Cretaceous of Israel, and the specimens assigned as *Krithe* cf. *solomoni* by Bassiouni and Luger (1990) from the Paleocene of the southern Egypt are also similar to the present species, but deviate in having concavity at their posterior margin with protruding ventral part.

Occurrence: Early Eocene (Ypresian), zone P6 (NP10), section D2 (sample D2-82).

Genus ***Parakrithe*** van Den Bold, 1958
Parakrithe crolifa Bassiouni and Luger, 1990
Plate 2, Figs. 18, 19
1979. *Krithe* sp.–Cronin and Khalifa, p. 410, Pl. 1, Figs. 26–17.
pars 1981. *Bythocypris kalambainaensis* nov. sp.–Reyment, p. 56, Pl. 1, Fig. 4.

1990. *Parakrithe crolifa* nov. sp.–Bassiouni and Luger, p. 796, Pl. 6, Figs. 13–22.

1995. *Parakrithe*? *kalambainaensis* Reyment–Honigstein and Rosenfeld, p. 53, Pl. 1, Fig. 7.

1999. *Parakrithe crolifa* Bassiouni and Luger–Morsi, p. 38, Pl. 1, Fig. 16.

2000. *Parakrithe crolifa* Bassiouni and Luger–Bassiouni and Morsi, p. 44, Pl. 5, Fig. 4.

2002. *Parakrithe crolifa* Bassiouni and Luger–Honigstein et al., p. 372, Pl. 1, Fig. 12.

2004. *Parakrithe crolifa* Bassiouni and Luger–Ismail and Ied, p. 103, Pl. 1, Figs. 11, 12.

2005. *Parakrithe crolifa* Bassiouni and Luger–Shahin, p. 759, Pl. 2, Fig. 17.

2005. *Parakrithe crolifa* Bassiouni and Luger–Ismail and Ied, p. 131, Pl. 2, Fig. 16.

Material: 38 specimens.

Dimensions: L: 0.55–0.62 mm; H: 0.27–0.30 mm.

Occurrence: The present species has been previously recorded from the Late Paleocene of Nigeria (Reyment, 1981), Paleocene–Eocene of Israel (Honigstein and Rosenfeld, 1995; Honigstein et al., 2002) and Maastrichtian to Middle Eocene of Egypt (Cronin and Khalifa, 1979; Bassiouni and Luger, 1990; Morsi, 1999; Bassiouni and Morsi, 2000; Ismail and Ied, 2004, 2005; Shahin, 2005). In the present work, it is found in the Paleocene to Early Eocene in sections B3, D2, D3, T1 and T2 (3).

Family HEMICYTHERIDAE Puri, 1953
Subfamily HEMICYTHERINAE Puri, 1953
Genus ***Hermanites*** Puri, 1955

Hermanites? sp.
Plate 3, Fig. 1

Material: A single specimen.

Dimensions: L: 0.65 mm; H: 0.35 mm.

Remarks: This species is tentatively assigned to the genus *Hermanites*. It has well-developed ventral and dorsal ridges, a strong muscle node and a lateral outline recalling this genus.

Occurrence: Late Paleocene (Thanetian), zone P4 (NP7/8), section D2 (sample D2-57).

Genus ***Hornibrookella*** Moos, 1965
Hornibrookella paramoosae nov. sp.
Plate 3, Figs. 2–5

1990. *Hornibrookella* cf. *H.* cf. *macropora* (Bosquet)–Bassiouni and Luger, p. 804, Pl. 9, Figs. 1, 2, 4.

2000. *Hornibrookella moosae* Bassiouni and Luger–Bassiouni and Morsi, p. 50, Pl. 6, Figs. 15–19.

Etymology: Referring to its close resemblance with *Hornibrookella moosae* Bassiouni and Luger, 1996.

Holotype: A female carapace (Plate 3, Fig. 2).

Paratypes: 11 carapaces of which three male carapaces are illustrated (Plate 3, Figs. 3–5).

Type locality: Bir Dakhl area, section D2.

Type horizon: A Marl bed, Southern Galala/Esna Formation, Early Eocene (Ypresian), zone P6 (NP11), sample D2-91.

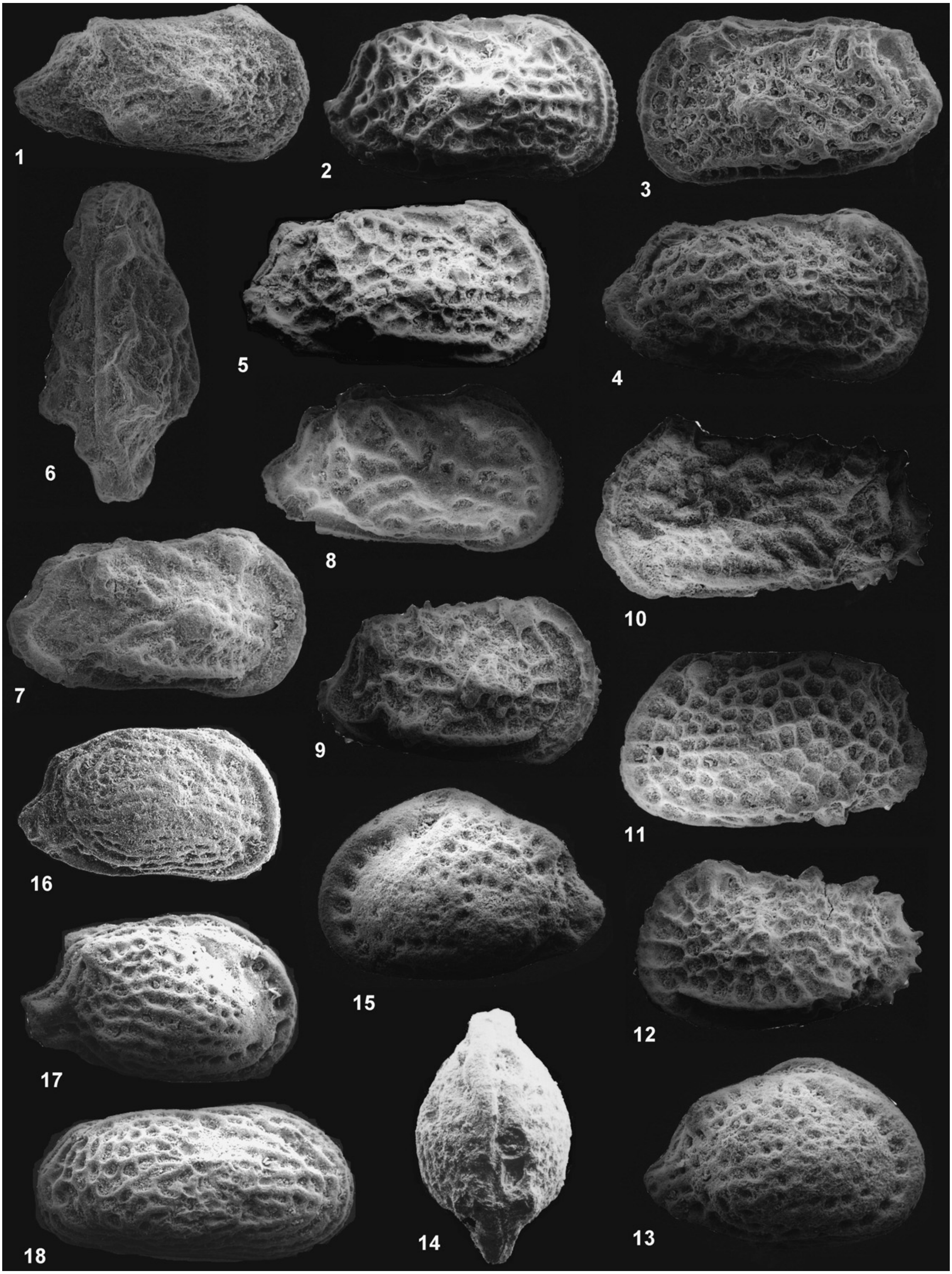
Diagnosis: A species of *Hornibrookella* with subrectangular lateral outline, reticulation muri aligned more or less radiating from muscle node and long ventral ridge extending from anteroventral corner to shortly in front of posterior margin.

Dimensions: Females: L: 0.74 mm (holotype), 0.75 mm (paratype); H: 0.41 mm (holotype), 0.41 mm (paratype); W: 0.40 mm (holotype), 0.39 mm (paratype); males: L: 0.67–0.72 mm; H: 0.37–0.39 mm, W: 0.37 mm (paratypes).

Description: Carapace of medium size, subrectangular in lateral outline. Maximum length immediately below middle, maximum height at eye tubercle, at about one fifth of length. Anterior margin broadly rounded, denticulate, posterior margin subtriangular, with concave dorsal part, and arched, denticulate ventral part which smoothly joins ventral margin. Ventral margin sinuous, smoothly joins anterior and posterior margin. Dorsal margin slightly sinuous, overreached by dorsal ridge in posterior part. Lateral surface ornamented by reticulation and ridges. Reticules rather aligned radiating from the well-developed muscle node; fossae variable in shape. Dorsal ridge begins above muscle node, rising posteriorly, obtusely bends parallel to dorsal margin, ends in front of posterodorsal corner by a short vertical branch. Ventral ridge long, begins above anteroventral corner, extends horizontally till mid-length, gradually rises behind the middle, ending shortly in front of posterior margin. Anterior marginal ridge present. Eye tubercle moderately developed. Left valve slightly larger than right valve; maximum overlap anterodorsal and posterodorsal. In dorsal view, carapace six-sided with compressed ends; maximum width at eye tubercle in front of middle. Internal features not accessible. Sexual dimorphism pronounced, assumed males are more elongate than assumed females.

Discussion: *Hornibrookella moosae* Bassiouni and Luger, 1996, from the Lower Eocene of Somalia, closely resembles *Hornibrookella paramoosae* nov. sp., especially in the reticulation pattern and course of the longitudinal ridges. However, it is relatively larger in size and is differentiated mainly by having a less elongate lateral outline and a shorter, posteriorly weaker-developed ventral ridge; in the new species the ventral ridge extends equally strong to end a short distance in front of posterior end, whereas in *H. moosae*, it becomes thin at posterior half dying out comparatively earlier. *Hornibrookella directa* Siddiqui, 1971, from the Lower Eocene of Pakistan, deviates by its weaker subcentral tubercle and having the reticules differently arranged. Moreover, the position of maximum length is more ventrally shifted in *H. directa* compared with *H. paramoosae* nov. sp. *Quadracythere laghaghiroboensis* (Apostolescu, 1961) exhibits resemblance to the present new species. However, it is subquadrate in lateral view and has a shorter, straight ventral ridge, while in our species, the lateral outline is subrectangular and the ventral ridge bends upwardly in its posterior half.

Occurrence: This species was previously recorded in the (?) latemost Paleocene (late *velascoensis* Zone) and Early Eocene of Egypt (Bassiouni and Luger, 1990; Bassiouni and Morsi, 2000). Here, it is found in the Early Eocene (Ypresian) in sections D2 and D3.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Hornibrookella speijeri nov. sp.
Plate 3, Figs. 6–8

Etymology: After R. Speijer, Katholieke Universiteit Leuven, Belgium.

Holotype: One carapace (Pl. 3, Fig. 8).

Paratypes: 16 carapaces of which two are illustrated (Plate 3, Figs. 6, 7).

Type locality: Bir Dakhl area, section D2.

Type horizon: A shale bed, Southern Galala/Esna Formation, Late Paleocene (Thanetian), subzone P5a (NP9a), sample D2-62.

Diagnosis: A species of *Hornibrookella* with thickened longitudinal muri aligned more or less radiating from muscle node region.

Dimensions: Female: L: 0.64 mm; H: 0.36 mm; W: 0.30 mm (holotype); males: L: 0.66–0.68 mm; H: 0.35–0.36 mm; W: 0.29 mm (paratypes).

Description: Carapace of medium size, subrectangular when seen in lateral view. Maximum length almost central, maximum height at eye tubercle, at about one fourth of length in females and one fifth of length in males. Anterior margin broadly rounded, denticulate, posterior margin subtriangularly protruding, with concave dorsal part, and arched, denticulate ventral part which smoothly joins ventral margin. Ventral margin straight to slightly concave, bends anteriorly downward to join anterior margin. Dorsal margin straight to slightly arched, overreached by dorsal ridge in posterior part, and builds cardinal angles in left valve with anterior and posterior margins. Lateral surface ornamented by reticulation and ridges. Reticulation is made up of thickened longitudinal muri aligned more or less radiating from muscle node region and vague intersecting muri. Dorsal ridge begins almost above muscle node, rising posteriorly, obtusely bends parallel to dorsal margin, ends in front of posterior cardinal angle by a short thick vertical branch. Ventral ridge begins above anteroventral corner, extends horizontally towards posterior, gradually rises behind the middle. Anterior marginal ridge thick extends marginally from eye tubercle, ends ventrally at about one third of length. Eye tubercle moderately developed; muscle node well-developed. Left valve slightly larger than right valve; maximum overlap anterodorsal and posterodorsal. In dorsal view, carapace outline irregular; maximum width at two thirds of length. Internal features not accessible. Sexual dimorphism pronounced, assumed males are more elongate than assumed females.

Discussion: Both *Hornibrookella moosae* Bassiouni and Luger, 1996, and *H. paramoosae* nov. sp. resemble the present species in the general trend of reticulation, i.e. divergence from the muscle node area, and the course of longitudinal ridges. They differ in having thinner reticulation muri with deeper fossae, a weaker-developed muscle node and a sinuous dorsal margin. In dorsal view, they have a six-sided outline with maximum length at muscle node in front of middle line, whereas in the new species, the dorsal outline is irregular and the maximum length is attained at two thirds of length. *Hornibrookella moosae* has, moreover, shorter ventral ridge and a quadrate lateral outline unlike the present new species which is more elongate in lateral view.

Occurrence: Late Paleocene (Thanetian) to Early Eocene (Ypresian) in sections D2 and D3.

Hornibrookella sp.
Plate 3, Fig. 9

Material: A single specimen.

Dimensions: L: 0.76 mm; H: 0.46 mm.

Remarks: The onle available specimen differs from *Hornibrookella moosae* Bassiouni and Luger, 1996, *H. paramoosae* nov. sp. and *H. speijeri* nov. sp. in having a different reticulation pattern and developing pore-cones on lateral surface.

Occurrence: Late Paleocene (Thanetian), subzone P5a, section D2 (sample D2-62).

Plate 3. L: length, W: width, RV: right view, LV: left view, DV: dorsal view. **Fig. 1**. *Hermanites*? sp. Bir Dakhl, section D-2, sample D2-57, carapace, MS-39, RV, L 0.65 mm. **Figs. 2–5**. *Hornibrookella paramoosae* nov. sp. Bir Dakhl, section D-2, sample D2-91: 2, holotype, female, carapace, MS-40, RV, L 0.74 mm; 3-5, paratypes, males, 3, carapace, MS-41, LV, L 0.67 mm, 4, carapace, MS-42, RV, L 0.72 mm, 5, carapace, MS-43, RV, L 0.72 mm. **Figs. 6–8**. *Hornibrookella speijeri* nov. sp. Bir Dakhl, section D-2, sample D2-62: 6-7, paratypes, 6, carapace, MS-44, DV, W 0.30 mm, 7, carapace, MS-45, RV, L 0.66 mm; 8, holotype, carapace, MS-46, RV, L 0.64 mm. **Fig. 9**. *Hornibrookella* sp. Bir Dakhl, section D-2, sample D2-62, carapace, MS-47, RV, L 0.76 mm. **Fig. 10**. *Horrificiella* cf. *liebaui* Bassiouni and Luger, 1996. Bir Dakhl, section D-2, sample D2-62, carapace, MS-48, LV, L 0.91 mm. **Fig. 11**. *Isalocopocythere teiskotensis* (Apostolescu, 1961). Bir Dakhl, section D-2, sample D2-62, carapace, MS-49, LV, L 0.91 mm. **Fig. 12**. *Paragrenocythere cultrata* (Apostolescu, 1961). Bir Dakhl, section D-2, sample D2-62, carapace, MS-50, LV, L 0.81 mm. **Figs. 13–15**. *Pokornyella pseudotriangularis* nov. sp. Bir Dakhl, section D-2, sample D2-62: 13, holotype, carapace, MS-51, RV, L 0.61 mm; 14-15, paratypes, 14, carapace, MS-52, DV, W 0.27 mm, 15, carapace, MS-53, LV, L 0.64 mm. **Fig. 16**. *Pokornyella*? sp. 1. Bir Dakhl, section D-2, sample D2-62, carapace, MS-54, LV, L 0.66 mm. **Fig. 17**. *Pokornyella* sp. 2. Bir Dakhl, Coupe D-2, sample D2-76, carapace, MS-55, RV, L 0.64 mm. **Fig. 18**. *Urocythereis* sp. Bir Dakhl, section D-2, sample D2-62, carapace, MS-56, RV, L 0.72 mm.

Planche 3. L : longueur, W : largeur, RV : vue droite, LV : vue gauche, DV : vue dorsale. **Fig. 1**. *Hermanites*? sp. Coupe D-2, échantillon D2-57, carapace, MS-39, RV, L 0,65 mm. **Fig. 2–5**. *Hornibrookella paramoosae* nov. sp. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-91 : 2, holotype, femelle, carapace, MS-40, RV, L 0,74 mm ; 3-5, paratypes, mâles, 3, carapace, MS-41, LV, L 0,67 mm, 4, carapace, MS-42, RV, L 0,72 mm, 5, carapace, MS-43, RV, L 0,72 mm. **Fig. 6–8**. *Hornibrookella speijeri* nov. sp. Bir Dakhl, Coupe D-2, échantillon D2-62 : 6-7, paratypes, 6, carapace, MS-44, DV, W 0,30 mm 7, carapace, MS-45, RV, L 0,66 mm; 8, holotype, carapace, MS-46, RV, L 0,64 mm. **Fig. 9**. *Hornibrookella* sp. Bir Dakhl, Coupe D-2, échantillon D2-62, carapace, MS-47, RV, L 0,76 mm. **Fig. 10**. *Horrificiella* cf. *liebaui* Bassiouni et Luger, 1996. Bir Dakhl, Coupe D-2, échantillon D2-62, carapace, MS-48, LV, L 0,91 mm. **Fig. 11**. *Isalocopocythere teiskotensis* (Apostolescu, 1961). Bir Dakhl, Coupe D-2, échantillon D2-62, carapace, MS-49, LV, L 0,91 mm. **Fig. 12**. *Paragrenocythere cultrata* (Apostolescu, 1961). Bir Dakhl, Coupe D-2, échantillon D2-62, carapace, MS-50, LV, L 0,81 mm. **Fig. 13–15**. *Pokornyella pseudotriangularis* nov. sp. Bir Dakhl, Coupe D-2, échantillon D2-62 : 13, holotype, carapace, MS-51, RV, L 0,61 mm ; 14-15, paratypes, 14, carapace, MS-52, DV, W 0,27 mm, 15, carapace, MS-53, LV, L 0,64 mm. **Fig. 16**. *Pokornyella*? sp. 1. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-62, carapace, MS-54, LV, L 0,66 mm. **Fig. 17**. *Pokornyella* sp. 2. Bir Dakhl, section D-2, sample D2-76, carapace, MS-55, RV, L 0,64 mm. **Fig. 18**. *Urocythereis* sp. Bir Dakhl, Coupe D-2, échantillon D2-62, carapace, MS-56, RV, L 0,72 mm.

Genus ***Horrificiella*** Liebau, 1975

Horrificiella cf. *liebaui* Bassiouni and Luger, 1996

Plate 3, Fig. 10

cf. 1996. *Horrificiella liebaui* nov. sp.–Bassiouni and Luger, p. 45, Pl. 13, Figs. 10–15.

Material: A single specimen.

Dimensions: L: 0.91 mm; H: 0.50 mm.

Remarks: The present species resembles *Horrificiella liebaui* Bassiouni and Luger, 1996 from the Middle Eocene of Somalia. However, it deviates in being more elongate and having a stronger developed ventral ridge.

Occurrence: Late Paleocene (Thanetian), subzone P5a, section D2 (sample D2-62).

Genus ***Isalocopocythere*** Carbonnel, Alzouma and Dikouma, 1990

Isalocopocythere teiskotensis (Apostolescu, 1961)

Plate 3, Fig. 11

1961. *Leguminocythereis*? *teiskotensis* nov. sp.–Apostolescu, p. 824, Pl. 10, Figs. 206–208.

1963. *Leguminocythereis teiskotensis* Apostolescu–Barsotti, p. 1528, Pl. 2, Fig. 15.

1966. *Quadracythere* sp.–Salahi, p. 25, Pl. 5, Fig. 4.

1976. *Leguminocythereis teiskotensis* Apostolescu–Ficcarelli, p. 735, Pl. 90, Fig. 10.

1980. *Alocopocythere circumampla* nov. sp.–Al-Furaih, p. 23, Pl. 15, Figs. 1–4.

1980. *Alocopocythere tridens* nov. sp.–Al-Furaih, 1980, p. 26, Pl. 18, Figs. 1–4.

1981. *Alocopocythere*? *teiskotensis* (Apostolescu)–Reyment, p. 59, Pl. 4, Fig. 1.

1983. *Leguminocythereis*? *teiskotensis* Apostolescu–Foster et al., p. 115, Pl. 4, Figs. 7, 8.

1983. *Schizocythere*? sp.–Foster et al., p. 116, Pl. 10, Figs. 4, 5.

1990. *Alocopocythere* (*Isalocopocythere*) *immodica* (Al-Furaih)–Carbonnel et al., p. 679, Pl. 2, Figs. 19–21; Pl. 4, Figs. 1, 16.

1991. *Alocopocythere* (*Isalocopocythere*) *teiskotensis* (Apostolescu)–Damotte, p. 9, Pl. 2, Figs. 1, 2.

1994. *Alocopocythere teiskotensis* (Apostolescu)–Keen et al., Pl. 16.2, Fig. 9.

1998. *Isalocopocythere teiskotensis* (Apostolescu)–Colin et al., p. 305, Pl. 4, Figs. 12–22.

Material: 13 specimens.

Dimensions: L: 0.67–0.91 mm; H: 0.44–0.54 mm; W: 0.42–0.51 mm.

Remarks: Carbonnel et al. (1990) and Colin et al. (1998) considered *Isalocopocythere immodica* (Al-Furaih, 1980) to be conspecific with *Isalocopocythere teiskotensis* (Apostolescu, 1961). *Isalocopocythere tridens* and *I. circumampla* (Al-Furaih, 1980) were also considered by Colin et al. (op. cit.) as synonyms for *I. teiskotensis*. Among the three species of Al-Furaih (1980), *I. tridens* and *I. circumampla* are identical with the illustrations of Apostolescu (1961) for *I. teiskotensis* and are both treated herein as synonyms for *I. teiskotensis*. *I. immodica,* on the other hand, exhibits deviations, especially with respect to dorsal ridge and the lateral surface inflation. The dorsal ridge in *I. immodica* makes a highly convex arch that overreaches the dorsal margin, whereas in *I. teiskotensis* it rises upwards posteriorly till the mid-length, then bends forming a straight posterior part running parallel to the dorsal margin. Moreover, *I. immodica* is more inflated compared with *I. teiskotensis* when seen in dorsal view.

Occurrence: The present species was first described from the Late Maastrichtian–Paleocene of Mali (Apostolescu, 1961; Damotte, 1991; Colin et al., 1998), Paleocene of Libya (Barsotti, 1963; Salahi, 1966) and Saudi Arabia (Al-Furaih, 1980), Late Paleocene of Nigeria (Ficarelli, 1976; Reyment, 1981; Foster et al., 1983) and Niger (Carbonnel et al., 1990). In the present work, it has been recorded in the Late Paleocene (Thanetian), sections D2 and D3.

Genus ***Paragrenocythere*** Al-Furaih, 1975

Paragrenocythere cultrata (Apostolescu, 1961)

Plate 3, Fig. 12

1961. *Bradleya cultrata* nov. sp.–Apostolescu, p. 816, Pl. 12, Figs. 238–240.

1963. *Bradleya cultrata* Apostolescu–Barsotti, p. 1527, Pl. 2, Fig. 17.

1966. *Bradleya* aff. *cultrata* Apostolescu–Salahi, p. 22, Pl. 4, Fig. 22.

1981. *Bradleya* aff. *cultrata* Apostolescu–Reyment, p. 61, Pl. 5, Figs. 7–9; Pl. 6, Figs. 1L, 1R.

1983. *Bradleya*? sp. aff. *B. cultrata* Apostolescu–Foster et al., p. 117, Pl. 9, Figs. 7, 9, 10.

pars 1983. *Quadracythere*? *praecrassa* (Apostolescu)–Foster et al., p. 129, Pl. 9, Figs. 13, 14; Pl. 11, Figs. 1, 2; non Pl. 10, Figs. 1, 2.

1987. *Phalcocythere cultrata* (Apostolescu)–Okosun, p. 34, Pl. 12, Figs. 9, 10, 13.

1990. *Phalcocythere cultrata* (Apostolescu)–Bassiouni and Luger, p. 806, Pl. 9, Figs. 13–20.

1990. *Phalcocythere cultrata* (Apostolescu)–Carbonnel et al., p. 679, Pl. 3, Figs. 1–7.

1991. *Phalcocythere cultrata* (Apostolescu)–Damotte, p. 11, Pl. 2, Figs. 15, 16.

1998. *Paragrenocythere cultrata* (Apostolescu)–Colin et al., p. 316, Pl. 8, Figs. 1–6.

2000. *Paragrenocythere cultrata* (Apostolescu)–Bassiouni and Morsi, p. 52, Pl. 7, Figs. 4, 5.

Material: Five specimens.

Dimensions: L: 0.78–0.81 mm; H: 0.43–0.48 mm; W: 0.51 mm.

Occurrence: *Paragrenocythere cultrata* (Apostolescu) was described from the Maastrichtian to Late Paleocene of Mali (Apostolescu, 1961; Damotte, 1991; Colin et al., 1998), Late Paleocene of Ivory Coast and Niger (Carbonnel et al., 1990) Late? Paleocene of Nigeria (Reyment, 1981; Foster et al., 1983; Okosun, 1987), Paleocene of Libya (Barsotti, 1963; Salahi, 1966) and Late Paleocene (*M. velascoensis* Zone) and Early Eocene of the southern Egypt (Bassiouni and Luger, 1990; Bassiouni and Morsi, 1990). In the present material it is found in the Late Paleocene (Thanetian) to Early Eocene (Ypresian) in sections D2 and D3.

Genus ***Pokornyella*** Oertli, 1956

Pokornyella pseudotriangularis nov. sp.

Plate 3, Figs. 13–15

Etymology: Pseudo- (Greek): prefix to -triangularis, to express the close similarity with *Pokornyella triangularis*.

Holotype: One carapace (Plate 3, Fig. 13).

Paratypes: 10 carapaces of which two are illustrated (Plate 3, Figs. 14, 15).

Type locality: Bir Dakhl area, section D2.

Type horizon: A shale bed, Southern Galala/Esna Formation, Late Paleocene (Thanetian), subzone P5a (NP9a), sample D2-62.

Diagnosis: A *Pokornyella* species with a subtriangular lateral outline characterized by broad obliquely rounded anterior margin, a caudate posterior margin and a reticulate lateral surface.

Dimensions: L: 0.61 mm (holotype), 0.59–0.64 mm (paratypes); H: 0.41 mm (holotype), 0.40–0.43 mm (paratypes); W: 0.25–0.28 mm (paratypes).

Description: Carapace subtriangular in lateral view. Dorsal margin convex, in left valve higher than in right valve, steeply slopes towards posterior end; anterodorsal and posterodorsal cardinal angles observed. Anterior margin broad obliquely rounded towards ventral margin. Posterior margin narrow, concave in dorsal part, prolonged in ventral part giving rise to a caudal process. Ventral margin broadly concave smoothly joined to anterior margin anteriorly and to caudal process posteriorly. Maximum length above ventral margin, at position of caudal process; maximum height at eye tubercle. Eye tubercle weakly developed. Ornamentation consists of reticulation with medium-sized, mostly subrounded fossae variably covering lateral surface, a row of large quadrangular reticules just behind anterior margin, and a short, angular rib at posterodorsal corner. Left valve slightly larger than right valve overlapping it prominently at anterodorsal corner; smaller overlap present also ventrally and posterodorsally. In dorsal view, carapace outline oval with compressed ends; maximum width central. Internal features not accessible. Sexual dimorphism not clear.

Discussion: *Pokornyella triangularis* Ducasse, 1967, from the Middle Eocene of the North-Aquitaine Basin (SW France), is a very closely similar species to *P. pseudotriangularis* nov. sp. The two species have the same outline, aspects of overlap and components of ornamentation. *P. triangularis* differs only in having the reticules covering the lateral surface arranged in longitudinal rows, whereas in the new species they are distributed more or less homogeneously on the lateral surface. *P. talencensis* Ducasse, 1967, from the Early and Middle Eocene of the North-Aquitaine Basin, differs from both species by having a more angular dorsal margin and lacking the posterodorsal rib. It has, as in *P. triangularis*, the lateral surface reticules arranged in longitudinal rows.

Occurrence: Late Paleocene (Thanetian) to Early Eocene (Ypresian), sections B3, D2 and D4.

Pokornyella? sp. 1

Plate 3, Fig. 16

Material: 18 specimens.

Dimensions: L: 0.65 mm (female), 0.66 (male); H: 0.40 mm (female), 0.35 mm (male); W: 0.26 mm (female), 0.24 (male).

Remarks: The present species is questionably assigned to the genus *Pokornyella* by its close resemblance to *Pokornyella* cf. *inaequipunctata* figured by Bassiouni (1969b) from the Upper Eocene of Egypt; the latter species differs only in having a punctate rather than reticulate lateral surface and a posteriorly angular dorsal rib. *Pokornyella*? sp. 1 Guernet, Bourdillon De Grissac and Roger, 1991, from the Oligocene of Oman, is also similar to the males of the present species in outline and surface ornamentation. It differs in lacking the ventral lineation and the caudate posterior margin found in our species and having a small crescentric riblet posterodorsally that lacks in our specimens. The specimen assigned as "*Meridionalicythere*" sp. Bassiouni and Luger, 1996, from the Middle Eocene of Somalia, is also similar but deviates in being somewhat longer and having thinner longitudinal reticulation muri.

Occurrence: Late Paleocene (Thanetian) to Early Eocene (Ypresian), sections D2 and D3.

Pokornyella sp. 2

Plate 3, Fig. 17

Material: A single specimen.

Dimensions: L: 0.64 mm; H: 0.43 mm.

Remarks: *Pokornyella*? sp. 1, which is also recorded in the present study, differs from the present species in being less inflated and having reticulation with shallower fossae and thicker longitudinal muri diverging from the center, covering the entire lateral surface. It has also a thin, broadly convex posterodorsal rib, whereas this rib is shorter, thicker and angularly bent in the present species. Moreover, the caudal process in *Pokornyella*? sp. 1 is shorter compared with the present species. *Pokornyella* sp. Faure and Guernet, 1988, from the Late Eocene of France has a similar outline but exhibits reticulation with different arrangements that covers the whole lateral surface and lacks the angularly bent posterodorsal rib found in the present species.

Occurrence: Early Eocene (Ypresian), zone P6 (NP10), section D2 (sample D2-76).

Genus ***Urocythereis*** Puri, 1953

Urocythereis sp.

Plate 3, Fig. 18

Material: 13 specimens.

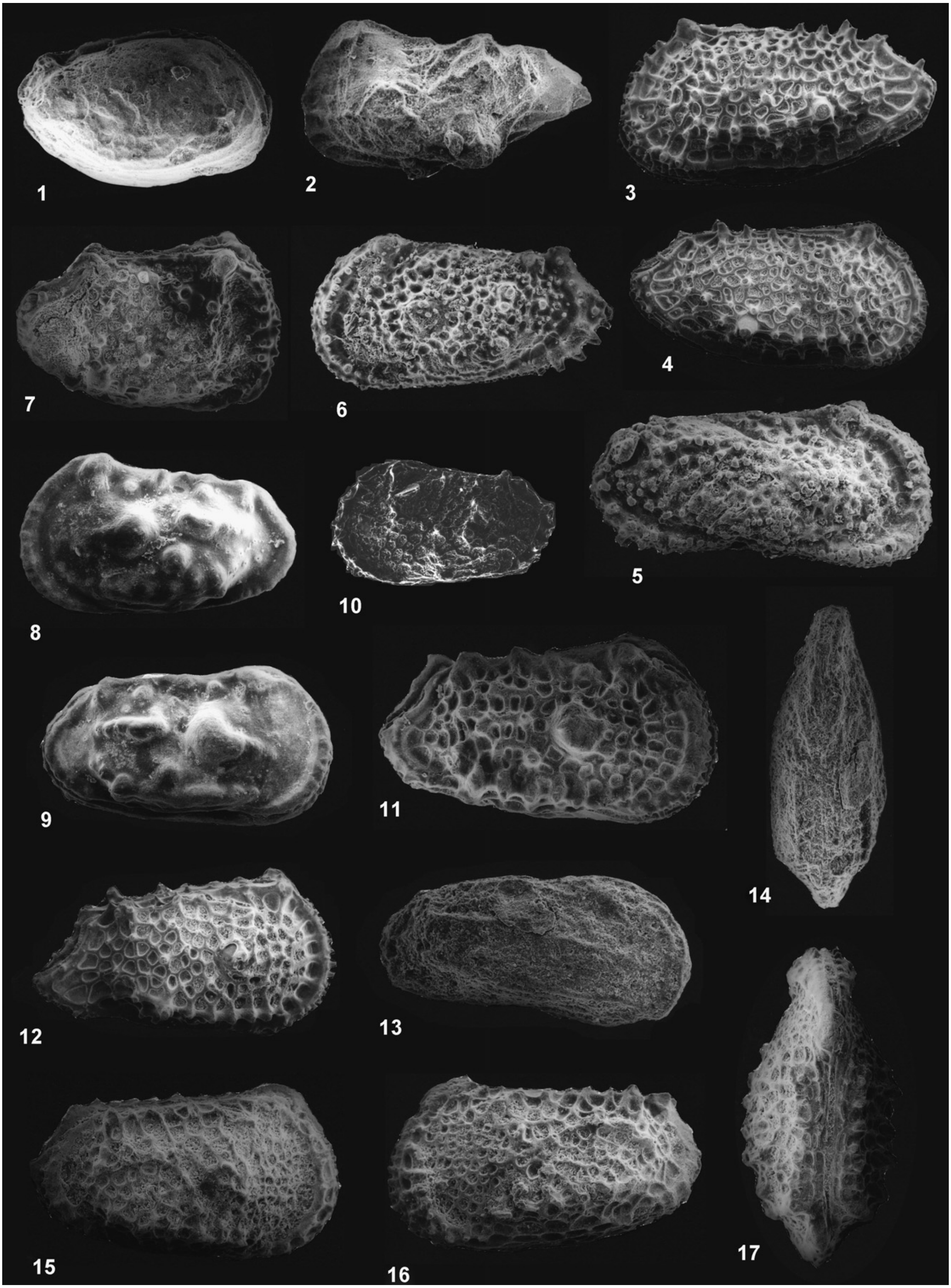
Dimensions: L: 0.71–0.77 mm; H: 0.30–0.38 mm.

Remarks: The present species resembles the specimens assigned as *Urocythereis favosa* (Roemer, 1838) by Bassiouni (1965) from the Pliocene of Egypt in lateral outline and general surface sculpture, but differs in the arrangement of surface reticulation.

Occurrence: Late Paleocene (Thanetian) to Early Eocene (Ypresian), sections D2, D3 and D4.

Family LOXOCONCHIDAE Sars, 1866

Genus ***Loxoconcha*** Sars, 1866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Loxoconcha sp.
Plate 4, Fig. 1
Material: Two specimens.
Dimensions: L: 0.58 mm; H: 0.36 mm.
Remarks: The present species is only represented by two carapaces. Because of the bad state of preservation it was not possible to make neither a reliable description nor useful comparisons with other taxa.
Occurrence: Early Eocene (Ypresian), sections D3 and D4.

Family PARACYTHERIDEIDAE Müller, 1894
Genus ***Tuberocytheridea*** Gründel, 1975
Tuberocytheridea sp.
Plate 4, Fig. 2
Material: Three specimens.
Dimensions: L: 0.61 mm; H: 0.32 mm.
Remarks: The present species exhibits great similarities with *Tuberocytheridea* cf. *gujaratensis* (Khosla and Pant, 1989) as illustrated by Bassiouni and Luger (1996) from the Middle Eocene of Somalia. The latter species differs, however, in having a straight dorsal margin and clearly less high posterodorsal process. *Tuberocytheridea grignonensis* Keij, 1957, from the Lutetian of Belgium, is also similar but has a stronger lateral surface ornamentation, a rather straight dorsal margin and a more pronounced riblet connecting the eye tubercle with the posteroventral spine.
Occurrence: Late Paleocene to Early Eocene, sections D2 and D3.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948

Genus ***Acanthocythereis*** Howe, 1963
Acanthocythereis? *denticulata* Esker, 1968
Plate 4, Figs. 3, 4
1968. *Acanthocythereis denticulata* nov. sp.–Esker, p. 328, Pl. 2, Figs. 6, 7; Pl. 4, Fig. 1.
1982. *Acanthocythereis? denticulata* (Esker)–Donze et al., p. 293, Pl. 11, Figs. 1–4.
1987. *Acanthocythereis*? *denticulata* (Esker)–Damotte and Fleury, p. 97, Pl. 3, Fig. 11.
1990. *Megommatocythere denticulata* (Esker)–Bassiouni and Luger, p. 825, Pl. 7, Fig. 7.
?1991. *Megommatocythere* cf. *denticulata* (Esker)–Honigstein et al., p. 105, Pl. 2, Figs. 11, 12.
?1995. *Megommatocythere* cf. *denticulata* (Esker)–Honigstein and Rosenfeld, p. 53, Pl. 1, Fig. 8.
1999. *Megommatocythere denticulata* (Esker)–Morsi, p. 41, Pl. 2, Fig. 15.
2000. *Megommatocythere denticulata* (Esker)–Bassiouni and Morsi, p. 58, Pl. 8, Fig. 17.
?2002. *Megommatocythere* cf. *denticulata* (Esker)–Honigstein et al., p. 378, Pl. 3, Fig. 13.
?pars 2004. *Megommatocythere denticulata* (Esker)–Ismail and Ied, p. 108, Pl. 3, Fig. 3.
?2005. *Megommatocythere denticulata* (Esker)–Shahin, p. 361, Pl. 3, Fig. 13.
2005. *Megommatocythere denticulata* (Esker)–Ismail and Ied, p. 138, Pl. 3, Fig. 14.
Material: 72 specimens.
Dimensions: L: 1.11–1.15 mm; H: 0.56–0.57 mm.
Remarks: Closely similar specimens have been recorded from the Paleocene to Middle Eocene of Israel, (Honigstein et al., 1991, 2002; Honigstein and Rosenfeld, 1995) and Maastrichtian–Paleocene of Sinai in Egypt (Ismail and Ied, 2004; Shahin, 2005). They deviate from the typical *A.*? *denticulata* Esker in being remarkably shorter.

Plate 4. L: length, W: width, RV: right view, LV: left view, DV: dorsal view. **Fig. 1**. *Loxoconcha* sp. Bir Dakhl, section D-3, sample D3-59, carapace, MS-57, RV, L 0.58 mm. **Fig. 2**. *Tuberocytheridea* sp. Bir Dakhl, section D-2, sample D2-55, carapace, MS-58, LV, L 0.61 mm. **Figs. 3, 4**. *Acanthocythereis*? *denticulata* Esker, 1968. Bir Dakhl, section D-2, sample D2-60: 3, carapace, MS-59, LV, L 1.15 mm; 4, carapace, MS-60, RV, L 1.11 mm. **Fig. 5**. *Acanthocythereis meslei* cf. *paleocenica* Bassiouni and Luger, 1990. Bir Dakhl, section D-2, sample D2-91, male, carapace, MS-61, RV, L 0.62 mm. **Fig. 6**. *Acanthocythereis*? *posterotriangulata* (Morsi, 1999). Bir Dakhl, section D-2, sample D2-91, female, carapace, MS-62, LV, L 0.79 mm. **Fig. 7**. *Acanthocythereis*? sp. Wadi Tarfa, section T-2, sample T2-37, carapace, MS-63, RV, L 0.90 mm. **Figs. 8, 9**. *Actinocythereis*? *coronata* (Esker, 1968). Wadi Tarfa, section T-2, sample T2-55: 8, female, carapace, MS-64, LV, L 0.86 mm; 9, male, carapace, MS-65, RV, L 1.03 mm. **Fig. 10**. *Cristaeleberis reticulata* Bassiouni, 1970. Wadi Tarfa, section T-1, sample T1-44, female, carapace, MS-66, LV, L 0.61 mm. **Fig. 11**. *Doricythereis jordanica nodoreticulata* (Bassiouni, 1970). Bir Dakhl, section D-2, sample D2-70, female, carapace, MS-67, RV, L 1.16 mm. **Fig. 12**. *Doricythereis martinii* (Bassiouni, 1970). Bir Dakhl, section D-2, sample D2-60, female, carapace, MS-68, RV, L 1.25 mm. **Figs. 13, 14**. *Haughtonileberis* sp. Bir Dakhl, section D-2, sample D2-70, carapace, MS-69, L 0.66 mm, W 0.24 mm, 13 RV, 14 DV. **Figs. 15–17**. *Kefiella galalaensis* nov. sp. Bir Dakhl, section D-2, sample D2-89, paratypes, males: 15, carapace, MS-70, RV, L 0.88 mm; 16, carapace, MS-71, LV, L 0.86 mm; 17, carapace, MS-72, DV, W 0.46 mm.

Planche 4. L : longueur, W : largeur, RV : vue droite, LV : vue gauche, DV : vue dorsale. **Fig. 1**. *Loxoconcha* sp. Bir Dakhl, Coupe D-3, échantillon D3-59, carapace, MS-57, RV, L 0,58 mm. **Fig. 2**. *Tuberocytheridea* sp. Bir Dakhl, Coupe D-2, échantillon D2-55, carapace, MS-58, LV, L 0,61 mm. **Fig. 3, 4**. *Acanthocythereis? denticulata* Esker, 1968. Bir Dakhl, Coupe D-2, échantillon D2-60 : 3, carapace, MS-59, LV, L 1,15 mm ; 4, carapace, MS-60, RV, L 1,11 mm. **Fig. 5**. *Acanthocythereis meslei* cf. *paleocenica* Bassiouni et Luger, 1990. Bir Dakhl, Coupe D-2, échantillon D2-91, mâle, carapace, MS-61, RV, L 0,62 mm. **Fig. 6**. *Acanthocythereis? posterotriangulata* (Morsi, 1999). Bir Dakhl, Coupe D-2, échantillon D2-91, femelle, carapace, MS-62, LV, L 0,79 mm. **Fig. 7**. *Acanthocythereis?* sp. Wadi Tarfa, Coupe T-2, échantillon T2-37, carapace, MS-63, RV, L 0,90 mm. **Fig. 8, 9**. *Actinocythereis? coronata* (Esker, 1968). Wadi Tarfa, Coupe T-2, échantillon T2-55 : 8, femelle, carapace, MS-64, LV, L 0,86 mm ; 9, mâle, carapace, MS-65, RV, L 1,03 mm. **Fig. 10**. *Cristaeleberis reticulata* Bassiouni, 1970. Wadi Tarfa, Coupe T-1, échantillon T1-44, femelle, carapace, MS-66, LV, L 0,61 mm. **Fig. 11**. *Doricythereis jordanica nodoreticulata* (Bassiouni, 1970). Bir Dakhl, Coupe D-2, échantillon D2-70, femelle, carapace, MS-67, RV, L 1,16 mm. **Fig. 12**. *Doricythereis martinii* (Bassiouni, 1970). Bir Dakhl, Coupe D-2, échantillon D2-60, femelle, carapace, MS-68, RV, L 1,25 mm. **Fig. 13, 14**. *Haughtonileberis* sp. Bir Dakhl, Coupe D-2, échantillon D2-70, carapace, MS-69, L 0,66 mm, W 0,24 mm, 13 RV, 14 DV. **Fig. 15–17**. *Kefiella galalaensis* nov. sp. Bir Dakhl, Coupe D-2, échantillon D2-89, paratypes, males : 15, carapace, MS-70, RV, L 0,88 mm ; 16, carapace, MS-71, LV, L 0,86 mm ; 17, carapace, MS-72, DV, L 0,46 mm.

Occurrence: The species was originally described from the Early Paleocene of Tunisia (Esker, 1968). It is also reported from the Late Maastrichtian to Early Paleocene from the same area (Donze et al., 1982), the Early–Middle Paleocene of Algeria (Damotte and Fleury, 1987) and the Paleocene and Lower Eocene of Egypt (Bassiouni and Luger, 1990; Morsi, 1999; Bassiouni and Morsi, 2000; Ismail and Eid, 2005). Here, it is found in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections B3, D2, D5, D6, T1 and T2.

Acanthocythereis meslei cf. *paleocenica* Bassiouni and Luger, 1990

Plate 4, Fig. 5

cf. 1990. *Acanthocythereis meslei paleocenica* nov. ssp.–Bassiouni and Luger, p. 822, Pl. 14, Figs. 15–19.

2002. *Acanthocythereis meslei paleocenica* Bassiouni and Luger–Honigstein et al., p. 378, Pl. 3, Fig. 12.

Material: 11 specimens.

Dimensions: L: 0.62 mm (female), 0.66–0.67 mm (males); H: 0.32 mm (female), 0.30–0.32 mm (males); W: 0.20 mm (female).

Remarks: A specimen identical with our material was illustrated by Honigstein et al. (2002) from the Early Eocene of Israel. Our specimens as well as the specimen illustrated by Honigstein et al. (op. cit) resemble *Acanthocythereis meslei paleocenica* Bassiouni and Luger, 1990 from the Paleocene of southern Egypt in the outline and arrangement of surface reticulation. However, they deviate in having a larger number of more prominent tubercles on the reticulation muri. It is probable that this deviation represents a younger subspecific variation.

Occurrence: The present subspecies was recorded by Honigstein et al. (2002) from the Early Eocene of Israel. In the present study, it is also found in the Early Eocene (sections D2 and D5).

Acanthocythereis? *posterotriangulata* (Morsi, 1999)

Plate 4, Fig. 6

1990. *Oertliella*? sp.–Bassiouni and Luger, p. 831, Pl. 18, Figs. 6–10.

1995. *Oertliella*? cf. *frescoensis* (Apostolescu)–Honigstein and Rosenfeld, p. 58, Pl. 3, Fig. 8.

1999. *Oertliella posterotriangulata* nov. sp.–Morsi, p. 41, Pl. 3, Figs. 1–5.

2000. *Oertliella*? sp. Bassiouni and Luger–Bassiouni and Morsi, p. 35, Pl. 9, Figs. 12–15.

2003. *Oertliella posterotriangulata* Morsi–Morsi and Speijer, p. 75, Pl. 4, Figs. 36, 37.

Material: 37 specimens.

Dimensions: L: 0.72–0.79 mm (females), 0.79 mm (male); H: 0.37–0.40 mm (females), 0.35 mm (male); W: 0.32 mm (female), 0.31 mm (male).

Remarks: The present species is assigned to the genus *Acanthocythereis* for its outline similarity with many species of this genus. However, this assignment remains questionable since it is based merely on external resemblance. The specimens assigned in the present study as *Acanthocythereis meslei* cf. *paleocenica* Bassiouni and Luger, 1990 has a very closely similar outline, but deviate from the present species in being thinner, relatively smaller and having a papillate surface with a different arrangement of reticules especially at the area behind the muscle node; in the present species the reticules behind the muscle node are strongly developed, whereas in *Acanthocythereis meslei* cf. *paleocenica* they are weaker developed and are arranged in parallel rows which curve towards posteroventral margin.

Occurrence: The species was previously found in the Paleocene and Early Eocene of Egypt (Bassiouni and Luger, 1990; Morsi, 1999; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003) and Paleocene of southern Israel (Honigstein and Rosenfeld, 1995). In the present material, it is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D5, T1 and T2.

Acanthocythereis? sp.

Plate 4, Fig. 7

Material: Four specimens.

Dimensions: L: 0.90 mm; H: 0.57 mm.

Remarks: The present specimens are questionably assigned to the genus *Acanthocythereis* since they exhibit remblance to *Acanthocythereis*? *meslei meslei* Donze and Oertli (*in* Donze et al., 1982) from the Maastrichtian of Tunisia, especially with respect to the presence of stalked, strongly-developed eye tubercles, ventral and dorsal longitudinal ridges which end posteriorly at prominent spines, lateral surface reticulation and scattered small tubercles. However, they are remarkably shorter, differ in outline and have the lateral surface reticulation weaker-developed than in *Acanthocythereis*? *meslei meslei*.

Occurrence: Late Paleocene (Selandian) to Early Eocene (Ypresian), section T2.

Genus ***Actinocythereis*** Puri, 1953

Actinocythereis? coronata (Esker, 1968)

Plate 4, Figs. 8, 9

1968. *Cythereis coronata* nov. sp.–Esker, p. 323, Pl. 1, Figs. 1–3; Pl. 4, Fig. 5.

1970. *Mauritsina arabica* nov. sp.–Bassiouni, p. 21, Pl. 2, Figs. 8, 9.

1982. *Mauritsina coronata* (Esker)–Boukhary et al., Pl. 1, Figs. 5–8.

1982. *Actinocythereis*? *coronata* (Esker)–Donze et al., p. 291, Pl. 9, Figs. 7–10; Pl. 14, Fig. 8.

1987. *Actinocythereis*? *coronata* (Esker)–Damotte and Fleury, p. 96, Pl. 3, Figs. 8, 9.

1990. *Mauritsina coronata* (Esker)–Bassiouni and Luger, p. 812, Pl. 11, Figs. 13–15.

1992. *Mauritsina coronata* (Esker)–Ismail, p. 46, Pl. 1, Fig. 9.

1995. *Mauritsina coronata* (Esker)–Honigstein and Rosenfeld, p. 58, Pl. 3, Fig. 10.

1996. *Mauritsina coronata* (Esker)–Ismail, p. 44, Pl. 2, Figs. 6, 7.

1998. *Actinocythereis*? *coronata* (Esker)–Said-Benzarti, Pl. 2, Figs. 21, 22.

1999. *Mauritsina coronata* (Esker)–Morsi, p. 39, Pl. 2, Fig. 4.

2000. *Mauritsina coronata* (Esker)–Morsi, p. 57, Pl. 2, Fig. 11.

2000. *Mauritsina coronata* (Esker)–Bassiouni and Morsi, p. 29, Pl. 8, Figs. 1, 2.

2002. *Mauritsina coronata* (Esker)–Honigstein et al., p. 376, Pl. 3, Fig. 4.

2003. *Mauritsina coronata* (Esker)–Morsi and Speijer, p. 74, Pl. 3, Fig. 29.

2004. *Mauritsina coronata* (Esker)–Ismail and Ied, p. 104, Pl. 2, Fig. 3.

2005. *Mauritsina coronata* (Esker)–Ismail and Ied, p. 134, Pl. 3, Fig. 4.

Material: 23 specimens.

Dimensions: L: 0.86–0.89 mm (females), 1.03 mm (male); H: 0.52–0.55 mm (females), 0.56 mm (male); W: 0.44 mm (female).

Occurrence: This species is known for the Late Campanian to Late Paleocene of Tunisia (Esker, 1968; Donze et al., 1982; Said-Benzarti, 1998), Maastrichtian to "Middle" Paleocene of east Algeria (Damotte and Fleury, 1987), Maastrichtian of Libya (Keen et al., 1994), Paleocene to Early Eocene of Israel (Honigstein and Rosenfeld, 1995; Honigstein et al., 2002), and Jordan (Bassiouni, 1970) and Maastrichtian to Early Eocene of Egypt (Boukhary et al., 1982; Bassiouni and Luger, 1990; Ismail, 1992, 1995; Morsi, 1999, 2000; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003; Ismail and Ied, 2004, 2005). In the present material, it is found in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections B3, D2, D3, T1 and T2.

Genus ***Cristaeleberis*** Bassiouni, 1970

Cristaeleberis reticulata Bassiouni, 1970

Plate 4, Fig. 10

1970. *Cristaeleberis reticulata* nov. sp.–Bassiouni, p. 26, Pl. 3, Figs. 5–7.

1982. *Cristaeleberis reticulata* Bassiouni–Boukhary et al., Pl. 2, Figs. 5–7.

?1984. *Cristaeleberis reticulata* Bassiouni–Honigstein, p. 34, Pl. 10, Figs. 1–4; Pl. 15, Figs. 19, 20.

1984. *Cristaeleberis reticulata* Bassiouni–Khalifa et al., Pl. 2, Figs. 1a, b.

1999. *Cristaeleberis reticulata* Bassiouni–Morsi, p. 41, Pl. 2, Fig. 11.

Material: A single female specimen.

Dimensions: L: 0.61 mm; H: 0.33 mm.

Occurrence: The species was originally described from the "Middle" Paleocene of Jordan (Bassiouni, 1970). It is also known from the Paleocene of Egypt (Boukhary et al., 1982; Khalifa et al., 1984; Morsi, 1999). In the present material, it is recorded in the Late Paleocene (Selandian), zone P4 (NP5) in section T1 (sample T1-44).

Genus ***Doricythereis*** Gründel, 1976

Doricythereis jordanica nodoreticulata (Bassiouni, 1970)

Plate 4, Fig. 11

1968. *Cythereis* sp.–Esker, p. 326, Pl. 12, Figs. 1, 2.

1970. *Mauritsina jordanica nodoreticulata* nov. ssp.–Bassiouni, p. 20, Pl. 1, Figs. 3, 4; Pl. 2, Figs. 6, 7.

1982. *Mauritsina jordanica* Bassiouni–Boukhary et al., Pl. 2, Figs. 3, 4.

?1982. *Doricythereis* cf. *jordanica nodoreticulata* (Bassiouni)–Donze et al., p. 291, Pl. 9, Fig. 6.

1990. *Mauritsina jordanica nodoreticulata* Bassiouni–Bassiouni and Luger, p. 812, Pl. 11, Figs. 16, 17.

?1998. *Doricythereis* cf. *jordanica nodoreticulata* (Bassiouni)–Said-Benzarti, Pl. 2, Fig. 7.

1999. *Mauritsina jordanica nodoreticulata* Bassiouni–Morsi, p. 39, Pl. 2, Fig. 6.

2000. *Mauritsina jordanica nodoreticulata* Bassiouni–Bassiouni and Morsi, p. 29, Pl. 8, Fig. 3.

2003. *Mauritsina jordanica nodoreticulata* Bassiouni–Morsi and Speijer, p. 74, Pl. 3, Fig. 30.

2005. *Mauritsina jordanica nodoreticulata* Bassiouni–Shahin, p. 761, Pl. 3, Fig. 2.

Material: 27 specimens.

Dimensions: L: 1.07–1.16 mm (females), 1.19 mm (male); H: 0.60–0.62 mm (females), 0.59 mm (male).

Occurrence: This subspecies was previously recorded from the Paleocene of Tunisia (Esker, 1968) and Jordan (Bassiouni, 1970) and Paleocene-Lower Eocene of Egypt (Boukhary et al., 1982; Bassiouni and Luger, 1990; Morsi, 1999; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003; Shahin, 2005). Very closely similar specimens were illustrated from the Maastrichtian–Paleocene of Tunisia (Donze et al., 1982; Said-Benzarti, 1998). In the present material, it is found in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3, D5 and T1.

Doricythereis martinii (Bassiouni, 1970)

Plate 4, Fig. 12

1970. *Mauritsina martinii* nov. sp.–Bassiouni, p. 21, Pl. 1, Figs. 1, 2.

1977. *Mauritsina martinii* Bassiouni–Bassiouni et al., p. 5, Pl. 1, Fig. 4b.

1982. *Mauritsina martinii* Bassiouni–Boukhary et al., Pl. 1, Fig. 2.

1995. *Mauritsina jordanica nodoreticulata* Bassiouni–Honigstein and Rosenfeld, p. 56, Pl. 3, Figs. 1, 2.

1999. *Mauritsina martinii* Bassiouni–Morsi, p. 40, Pl. 2, Figs. 7–9.

2000. *Megommatocythere* sp.–Bassiouni and Morsi, p. 59, Pl. 8, Fig. 18.

2002. *Mauritsina jordanica nodoreticulata* Bassiouni–Honigstein et al., p. 375, Pl. 3, Fig. 1.

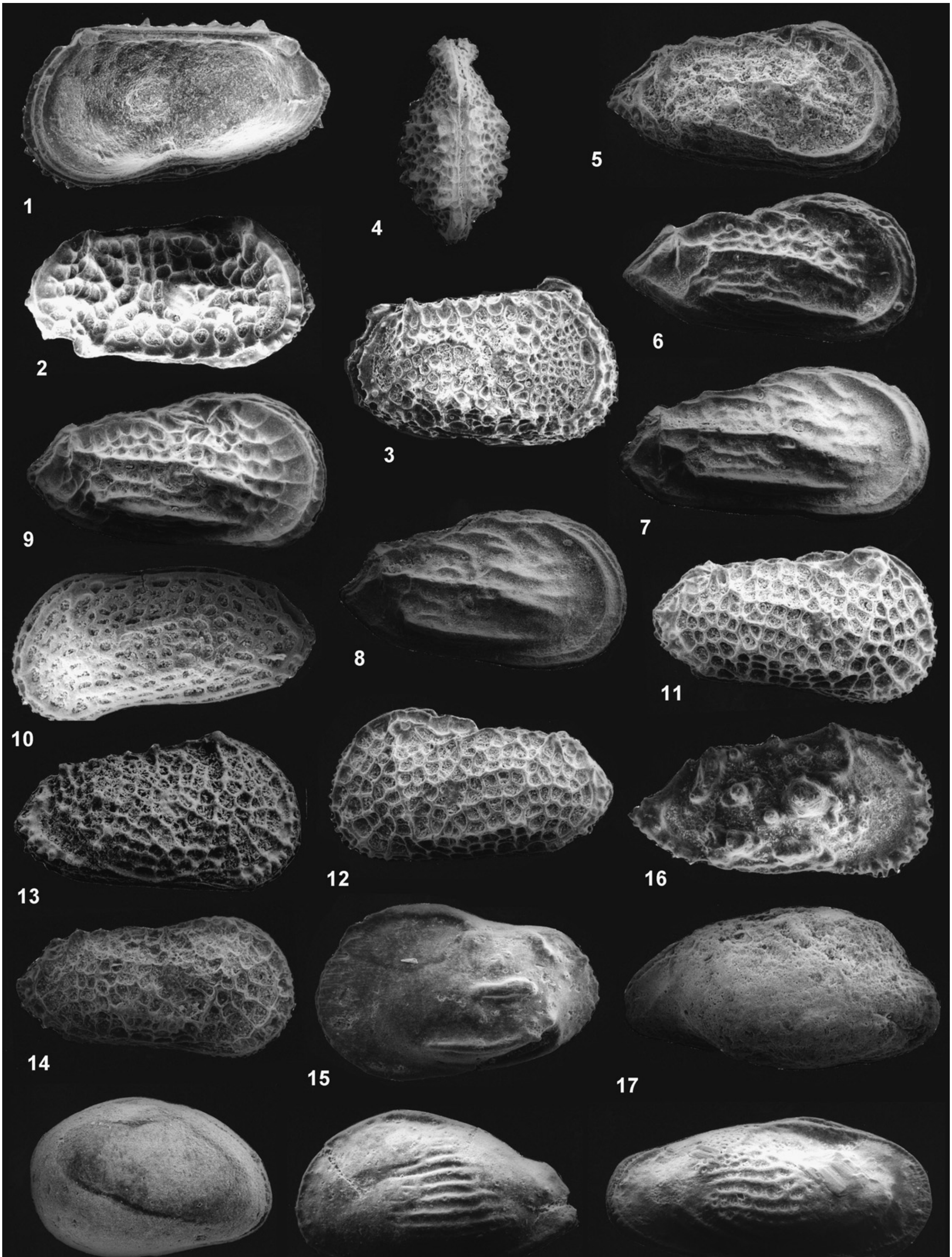
2004. *Mauritsina jordanica nodoreticulata* Bassiouni–Ismail and Ied, p. 105, Pl. 2, Figs. 1, 2.

2005. *Mauritsina jordanica nodoreticulata* Bassiouni–Ismail and Ied, p. 134, Pl. 3, Figs. 6, 7.

Material: 266 specimens.

Dimensions: L: 1.15–1.40 mm; H: 0.64–0.68 mm.

Occurrence: The present species is known for the Early Eocene of Jordan (Bassiouni, 1970) and the Paleocene to Early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Eocene of Egypt (Bassiouni et al., 1977; Boukhary et al., 1982; Morsi, 1999; Bassiouni and Morsi, 2000; Ismail and Eid, 2004, 2005). It was also found in the Paleocene–Early Eocene of Israel by Honigstein and Rosenfeld (1995) and Honigstein et al. (2002). In the present work, it is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3, D4, D5, D6, T1 and T2.

Genus ***Haughtonileberis*** Dingle, 1969

Haughtonileberis sp.

Plate 4, Figs. 13, 14

Material: Seven specimens.

Dimensions: L: 0.66–0.67 mm; H: 0.30–0.32 mm; W: 0.24 mm.

Remarks: The present species resembles *Haughtonileberis radiata* Dingle, 1969, from the Upper Eocene–Upper Oligocene of South Africa (Dingle, 1976). The latter species deviates, however, in having a more acuminate posterior end and a longer dorsal rib that begins below the eye position, whereas in our specimens this rib begins behind the eye tubercle. It has, moreover, fine longitudinal riblets, especially on the anterior part of lateral surface, which are lacking in the present species. *Haughtonileberis fissilis* Dingle, 1969, from the upper Senonian of South Africa, is also similar to the present species. It differs in relatively less elongate and having a weaker surface reticulation.

Occurrence: Late Paleocene (Thanetian) to Early Eocene (Ypresian), sections B3, D2 and D3.

Genus ***Kefiella*** Donze and Said, 1982

Kefiella galalaensis nov. sp.

Plate 4, Figs. 15–17 and Plate 5, Figs. 1, 3, 4

Derivatio nominis: Referring to the Galala Plateau, where this species is described.

Holotype: Female carapace (Plate 5, Fig. 3).

Paratypes: 60 specimens of which three male carapaces (Plate 4, Figs. 15–17), a male left valve (Plate 5, Fig. 1) and a female carapace (Plate 5, Fig. 4) are illustrated.

Locus typicus: Bir Dakhl area, section D2.

Stratum typicum: A Marl bed, Southern Galala/Esna Formation, Early Eocene (Ypresian), zone P6 (NP11), sample D2-89.

Diagnosis: A species of the genus *Kefiella* with surface reticules fining at anterior part of lateral surface and a short, thin, arched median rib.

Dimensions: L: 0.88 mm (holotype), 0.86–0.93 mm (paratypes); H: 0.54 mm (holotype), 0.47–0.56 mm (paratypes); W: 0.47 mm (holotype), 0.46 mm (paratype).

Description: Carapace medium-sized, subrectangular in lateral view. Anterior margin broadly rounded, posterior margin narrower with rounded lower part and a straight upper part. Dorsal margin straight, weakly inclined posteriorly; in left valve, it joins posterior margin at an obtuse cardinal angle and anteriorly builds a hinge ear at connection with anterior margin. Ventral margin almost straight, gently rising posteriorly. Maximum length median, maximum height at eye tubercle. Sculpture composed of reticulation, small spines and differently developed

Plate 5. L: length, W: width, RV: right view, LV: left view, IV: internal view. **Figs. 1, 3, 4**. *Kefiella galalaensis* nov. sp. Bir Dakhl, section D-2, sample D2-89: 1, paratype, male, right valve, MS-73, IV, L 0.89 mm; 3, holotype, female, carapace, MS-74, RV, L 0.90 mm; 4, paratype, female, carapace, MS-75, DV, W 0.47 mm. **Fig. 2**. *Oertliella* sp. Bir Dakhl, section D-3, sample D3-58, carapace, MS-76, RV, L 1 mm. **Fig. 5**. *Ordoniya ordoniya* (Bassiouni, 1970). Bir Dakhl, section D-2, sample D2-41, carapace, MS-77, RV, L 0.78 mm. **Fig. 6**. *Ordoniya bulaqensis* Bassiouni and Luger, 1990. Wadi Tarfa, section T-2, sample T2-08, female, carapace, MS-78, RV, L 0.80 mm. **Figs. 7, 8**. *Ordoniya hasaensis* (Bassiouni, 1970). Wadi Tarfa, section T-2, sample T2-34: 7, male, carapace, MS-79, RV, L 1.01 mm; 8, female, carapace, MS-80, RV, L 0.86 mm. **Fig. 9**. *Ordoniya maanensis* (Bassiouni, 1970). Bir Dakhl, section D-3, sample D3-51, carapace, MS-81, RV, L 1.04 mm. **Fig. 10**. *Ordoniya*? sp. Bir Dakhl, section D-2, sample D2-62, carapace, MS-82, LV, L 0.79 mm. **Figs. 11, 12**. *Paracosta parakefensis* Bassiouni and Luger, 1990. Wadi Tarfa, section T-2, sample T2-47: 11, male, carapace, MS-83, RV, L 1 mm; 12, female, carapace, MS-84, LV, L 0.88 mm. **Fig. 13**. *Reticulina proteros* Bassiouni, 1969a. Bir Dakhl, section D-2, sample D2-75, female, carapace, MS-85, RV, L 0.85 mm. **Fig. 14**. *Reticulina sangalkamensis* (Apostolescu, 1961). Bir Dakhl, section D-3, sample D3-48, female, carapace, MS-86, RV, L 0.89 mm. **Fig. 15**. *Phacorhabdotus inaequicostatus* Colin and Donze, 1982. Bir Dakhl, section D-3, sample D3-29, carapace, MS-87, LV, L 0.66 mm. **Fig. 16**. *Spinoleberis* aff. *megiddoensis* Honigstein, 1984. Bir Dakhl, section D-2, sample D2-3, carapace, MS-88, RV, L 0.82 mm. **Fig. 17**. *Brachycythere*? sp. Bir Dakhl, section D-2, sample D2-100, carapace, MS-89, RV, L 1.05 mm. **Fig. 18**. *Buntonia jordanica subjordanica* Bassiouni and Morsi, 2000. Wadi Tarfa, section T-2, sample T2-61, male, carapace, MS-90, RV, L 0.61 mm. **Fig. 19**. *Soudanella laciniosa triangulata* Apostolescu, 1961. Wadi Tarfa, section T-1, sample T1-64, carapace, MS-91, LV, L 0.86 mm. **Fig. 20**. *Xestoleberis tunisiensis* Esker, 1968. Bir Dakhl, section D-2, sample D2-60, carapace, MS-92, RV, L 0.51 mm.

Planche 5. L : longueur, W : largeur, RV : vue droite, LV : vue gauche, IV : vue interne. **Fig. 1, 3, 4**. *Kefiella galalaensis* nov. sp. Bir Dakhl, Coupe D-2, échantillon D2-89 : 1, paratype, mâle, valve droite, MS-73, IV, L 0,89 mm ; 3, holotype, femelle, carapace, MS-74, RV, L 0,90 mm ; 4, paratype, femelle, carapace, MS-75, DV, W 0,47 mm. **Fig. 2**. *Oertliella* sp. Bir Dakhl, Coupe D-3, échantillon D3-58, carapace, MS-76, RV, L 1 mm. **Fig. 5**. *Ordoniya ordoniya* (Bassiouni, 1970). Bir Dakhl, Coupe D-2, échantillon D2-41, carapace, MS-77, RV, L 0,78 mm. **Fig. 6**. *Ordoniya bulaqensis* Bassiouni et Luger, 1990. Wadi Tarfa, Coupe T-2, échantillon T2-08, femelle, carapace, MS-78, RV, L 0,80 mm. **Figs. 7, 8**. *Ordoniya hasaensis* (Bassiouni, 1970). Wadi Tarfa, Coupe T-2, échantillon T2-34 : 7, mâle, carapace, MS-79, RV, L 1,01 mm ; 8, femelle, carapace, MS-80, RV, L 0,86 mm. **Fig. 9**. *Ordoniya maanensis* (Bassiouni, 1970). Bir Dakhl, Coupe D-3, échantillon D3-51, carapace, MS-81, RV, L 1,04 mm. **Fig. 10**. *Ordoniya*? sp. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-62, carapace, MS-82, LV, L 0,79 mm. **Fig. 11, 12**. *Paracosta parakefensis* Bassiouni et Luger, 1990. Wadi Tarfa, section T-2, Coupe T-2, échantillon T2-47 : 11, mâle, carapace, MS-83, RV, L 1 mm ; 12, femelle, carapace, MS-84, LV, L 0,88 mm. **Fig. 13**. *Reticulina proteros* Bassiouni, 1969a. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-75, femelle, carapace, MS-85, RV, L 0,85 mm. **Fig. 14**. *Reticulina sangalkamensis* (Apostolescu, 1961). Bir Dakhl, section D-3, Coupe D-3, échantillon D3-48, femelle, carapace, MS-86, RV, L 0,89 mm. **Fig. 15**. *Phacorhabdotus inaequicostatus* Colin et Donze, 1982. Bir Dakhl, section D-3, Coupe D-3, échantillon D3-29, carapace, MS-87, LV, L 0,66 mm. **Fig. 16**. *Spinoleberis* aff. *megiddoensis* Honigstein, 1984. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-3, carapace, MS-88, RV, L 0,82 mm. **Fig. 17**. *Brachycythere?* sp. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-100, carapace, MS-89, RV, L 1,05 mm. **Fig. 18**. *Buntonia jordanica subjordanica* Bassiouni et Morsi, 2000. Wadi Tarfa, section T-2, Coupe T-2, échantillon T2-61, mâle, carapace, MS-90, RV, L 0,61 mm. **Fig. 19**. *Soudanella laciniosa triangulata* Apostolescu, 1961. Wadi Tarfa, section T-1, Coupe T-1, échantillon T1-64, carapace, MS-91, LV, L 0,86 mm. **Fig. 20**. *Xestoleberis tunisiensis* Esker, 1968. Bir Dakhl, section D-2, Coupe D-2, échantillon D2-60, carapace, MS-92, RV, L 0,51 mm.

ribs. Reticulation moderately coarse, variable in shape, fining at anterior part of lateral surface, followed anteriorly by a row of coarse reticules along well-developed anterior marginal rib; in front of this marginal rib a similar row of reticules borders anterior margin. Posterior margin occupied by a marginal rim; both end margins decorated with small spines. Ventral rib well-developed, occupied by seven small tubercles. Median rib thin, convex, begins behind subcentral tubercle, ends almost below posterodorsal corner. Dorsal rib weak, carrying a row of 6-7 small spines. Left valve slightly larger than right valve; greatest overlap at anterodorsal and posterodorsal corners. Subcentral tubercle pronounced. Outline in dorsal view suboval with compressed ends; maximum width shortly behind middle. Hinge of right valve consists of a small anterior tooth, a smooth median groove and a strong smooth posterior tooth situated at the posterior dorsal angle. Marginal zone of moderate width. Inner margin and line of concrescence coincide. Selvage developed. Other features not observed. Sexual dimorphism not observed. Sexual dimorphism pronounced; assumed females are shorter than assumed males.

Discussion: The type species for the genus, *Kefiella maresi* Donze and Said, 1982 (*in* Donze et al., 1982), which was first described from the Maastrichtian of Tunisia, is similar to *Kefiella galalaensis* nov. sp. However, it is differentiated from the present new species by displaying shorter longitudinal ventral and dorsal ribs, stronger muscle node and thicker reticulation muri. The reticules aligned at the anterior margin in *K. maresi* are wide more than high, while in the present species the height of the individual reticules is larger than their width. Moreover, *K. maresi* shows longitudinal striations ventrally; these striations are lacking in *K. galalaensis* sp. nov.

Occurrence: Late Paleocene (Selandian) to Early Eocene (Ypresian), sections D2, D3, D6, T1 and T2.

Genus ***Oertliella*** Pokorny, 1964

Oertliella sp.

Plate 5, Fig. 2

Material: Four specimens.

Dimensions: L: 1.00 mm; H: 0.53 mm.

Remarks: Only few specimens are present among the present material. They resemble *Oertliella khargaensis* Bassiouni and Luger, 1990, from the Maastrichtian of Egypt. However, the specimens lack the strong spines found in *O. khargaensis* and show deviations in the detail of surface reticulation.

Occurrence: Early Eocene (Ypresian), sections B3, D3 and T1.

Genus ***Ordoniya*** Al-Sheikhly, 1985

Ordoniya ordoniya (Bassiouni, 1970)

Plate 5, Fig. 4

1970. *Hazelina ordoniya* nov. sp.–Bassiouni, p. 31, Pl. 4, Figs. 4–8.

1982. *Hazelina ordoniya* Bassiouni–Donze et al., p. 284, Pl. 3, Figs. 2, 3.

1984. *Hazelina ordoniya* Bassiouni–Khalifa et al., Pl. 1, Fig. 7.

1985. *Ordoniya (Ordoniya) ordoniya* (Bassiouni)–Al-Sheikhly p. 246, Text-Fig. 3; Pl. 1, Figs. 1–11; Pl. 2, Figs. 1, 3, 4.

1990. *Ordoniya ordoniya* (Bassiouni)–Bassiouni and Luger, p. 832, Pl. 16, Figs. 7, 8, 10.

1992. *Hazelina ordoniya* Bassiouni–Ismail, p. 50, Pl. 2, Fig. 6.

1999. *Ordoniya ordoniya* (Bassiouni)–Morsi, p. 41, Pl. 3, Figs. 1–5.

2000. *Ordoniya ordoniya* (Bassiouni)–Morsi, p. 62, Pl. 3, Fig. 7.

2000. *Ordoniya ordoniya* (Bassiouni)–Bassiouni and Morsi, p. 35, Pl. 9, Figs. 16, 17.

2003. *Ordoniya ordoniya* (Bassiouni)–Morsi and Speijer, p. 75, Pl. 4, Fig. 38.

2004. *Ordoniya ordoniya* (Bassiouni)–Ismail and Ied, p. 109, Pl. 3, Figs. 9, 10.

Material: 74 specimens.

Dimensions: L: 0.65–0.78 mm; H: 0.36–0.43 mm; W: 0.29–0.33 mm.

Occurrence: The present species was previously recorded from the "Early to Middle" Paleocene of Jordan (Bassiouni, 1970), Late Maastrichtian to Early Paleocene of Tunisia (Donze et al., 1982) and Maastrichtian to Early Eocene of Egypt (Khalifa et al., 1984; Bassiouni and Luger, 1990; Ismail, 1992; Morsi, 1999, 2000; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003; Ismail and Ied, 2004). Here, it is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3, T1 and T2.

Ordoniya bulaqensis Bassiouni and Luger, 1990

Plate 5, Fig. 6

1990. *Ordoniya bulaqensis* nov. sp.–Bassiouni and Luger, p. 832, Pl. 16, Figs. 5–9, 11–15.

1995. *Ordoniya bulaqensis* Bassiouni and Luger–Honigstein and Rosenfeld, p. 54, Pl. 2, Figs. 1, 2.

1996. *Ordoniya bulaqensis* Bassiouni and Luger–Ismail, p. 45, Pl. 3, Figs. 11, 12.

1999. *Ordoniya bulaqensis* Bassiouni and Luger–Morsi, p. 42, Pl. 3, Figs. 8–11.

2000. *Ordoniya bulaqensis* Bassiouni and Luger–Bassiouni and Morsi, p. 61, Pl. 9, Fig. 18.

2002. *Ordoniya bulaqensis* Bassiouni and Luger–Honigstein et al., p. 378, Pl. 4, Fig. 2.

2003. *Ordoniya bulaqensis* Bassiouni and Luger–Morsi and Speijer, p. 75, Pl. 4, Fig. 39.

2005. *Ordoniya ordoniya* (Bassiouni)–Ismail and Ied, p. 138, Pl. 3, Figs. 15, 16.

Material: 15 specimens.

Dimensions: L: 0.80–0.83 mm (females), 0.87 mm (male); H: 0.40–0.44 mm (females), 0.41 mm (male).

Occurrence: This species was reported from the Paleocene to Early–Middle Eocene of Israel (Honigstein and Rosenfeld, 1995; Honigstein et al., 2002) and Paleocene to Early Eocene of Egypt (Bassiouni and Luger, 1990; Ismail, 1996; Morsi, 1999; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003; Ismail and Eid, 2005). In this study, it is found in the Late Paleocene (Selandian–Thanetian) in sections D2, D3 and T2.

Ordoniya hasaensis (Bassiouni, 1970)

Plate 5, Figs. 7, 8

1970. *Hazelina hasaensis* nov. sp.–Bassiouni, p. 33, Pl. 5, Figs. 5, 6.

1977. *Hazelina hasaensis* Bassiouni–Bassiouni et al., p. 3, Pl. 1, Figs. 12a–c.

1991. *Ordoniya hasaensis* (Bassiouni)–Honigstein et al., p. 104, Pl. 2, Fig. 5.

1999. *Ordoniya hasaensis* (Bassiouni)–Morsi, p. 42, Pl. 3, Fig. 13.

2002. *Ordoniya hasaensis* (Bassiouni)–Honigstein et al., p. 378, Pl. 4, Fig. 3.

2004. *Ordoniya hasaensis* (Bassiouni)–Ismail and Ied, p. 109, Pl. 3, Figs. 5, 6.

Material: 86 specimens.

Dimensions: L: 0.85–1.01 mm (females), 0.94 mm (male); H: 0.47–0.53 mm (females), 0.47 mm (male).

Occurrence: This species is known from the Late Paleocene of Jordan (Bassiouni, 1970), latest Paleocene–Early Eocene of Egypt (Bassiouni et al., 1977; Morsi, 1999; Ismail and Ied, 2004) and Early–Middle Eocene of Israel (Honigstein et al., 1991, 2002). In the present material, it is found in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3, D5, T1 and T2.

Ordoniya maanensis (Bassiouni, 1970)

Plate 5, Fig. 9

1970. *Hazelina maanensis* nov. sp.–Bassiouni, p. 33, Pl. 5, Figs. 1, 2.

1977. *Hazelina maanensis* Bassiouni–Bassiouni et al., p. 3, Pl. 1, Fig. 13.

1995. *Ordoniya maanensis* (Bassiouni)–Honigstein and Rosenfeld, p. 56, Pl. 2, Fig. 4.

2000. *Ordoniya burmaensis* (Bassiouni)–Bassiouni and Morsi, p. 61, Pl. 9, Figs. 19, 20.

2000. *Ordoniya maanensis* (Bassiouni)–Bassiouni and Morsi, p. 61, Pl. 10, Figs. 1–3.

2002. *Ordoniya maanensis* (Bassiouni)–Honigstein et al., p. 378, Pl. 4, Fig. 1.

Material: 69 specimens.

Dimensions: L: 0.93–1.04 mm; H: 0.49–0.53 mm.

Occurrence: Bassiouni (1970) described this species for the first time from the Early Eocene of Jordan. It has also been reported from the latest Paleocene (upper *velascoensis* Zone) and Early Eocene of Egypt (Bassiouni et al., 1977; Bassiouni and Morsi, 2000) and Paleocene and Early Eocene of Israel (Honigstein and Rosenfeld, 1995; Honigstein et al., 2002). In the present material, it is found in the Early Eocene (Ypresian) in sections D3, T1 and T2.

Ordoniya? sp.

Plate 5, Fig. 10

Material: A single carapace.

Dimensions: L: 0.79 mm; H: 0.38 mm.

Remarks: The present species is represented in our material only by a single specimen questionably allied to the genus *Ordoniya* Al-Sheikhly, 1985. It closely resembles the specimen figured by Bassiouni and Luger (1996) from the Middle Eocene of Somalia as *Ordoniya* sp. aff. *Ordoniya acies* (Esker, 1968). It deviates only in having a shorter median rib and relatively wider reticulation mesh.

Occurrence: Latest Paleocene (Thanetian), subzone P5a (NP9a), section D2 (sample D2-62).

Genus ***Paracosta*** Siddiqui, 1971

Paracosta parakefensis Bassiouni and Luger, 1990

Plate 5, Figs. 11, 12

1990. *Paracosta parakefensis* nov. sp.–Bassiouni and Luger, p. 834, Pl. 19, Figs. 10, 13–23.

1999. *Paracosta parakefensis* Bassiouni and Luger–Morsi, p. 43, Pl. 3, Figs. 14, 15.

2000. *Paracosta parakefensis* Bassiouni and Luger–Bassiouni and Morsi, p. 36, Pl. 10, Figs. 4, 5.

2003. *Paracosta parakefensis* Bassiouni and Luger–Morsi and Speijer, p. 76, Pl. 4, Figs. 43–46, Pl. 5, Figs. 47–49.

2004. *Paracosta parakefensis* Bassiouni and Luger–Ismail and Ied, p. 111, Pl. 4, Figs. 4, 5.

2005. *Paracosta parakefensis* Bassiouni and Luger–Ismail and Ied, p. 139, Pl. 4, Figs. 1–4.

Material: 184 specimens.

Dimensions: L: 0.88–0.99 mm (females), 1.00 mm (male); H: 0.49–0.55 mm (females), 0.46 mm (male); W: 0.39 mm (female).

Occurrence: The species was previously recorded from the Late Paleocene to Early Eocene of southern Egypt (Bassiouni and Luger, 1990; Morsi, 1999; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003; Ismail and Ied, 2004, 2005). The present material comes from the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections B3, T1, D2, D3, T1 and T2.

Genus ***Reticulina*** Bassiouni, 1969a

Reticulina proteros Bassiouni, 1969a

Plate 5, Fig. 13

1969a. *Carinocythereis* (*Reticulina*) *scitula proteros* nov. ssp.–Bassiouni, p. 11, Pl. 1, Fig. 8; Pl. 2, Figs. 6, 7.

1982. *Reticulina proteros* Bassiouni–Donze et al., p. 287, Pl. 5, Figs. 7, 8.

1984. *Reticulina proteros* Bassiouni–Khalifa et al., Pl. 2, Figs. 8a, b.

1987. *Reticulina proteros* Bassiouni–Damotte and Fleury, p. 95, Pl. 2, Figs. 17–19.

1990. *Reticulina proteros* Bassiouni–Bassiouni and Luger, p. 836, Pl. 20, Figs. 16–21.

1991. *Reticulina proteros* Bassiouni–Honigstein et al., p. 104, Pl. 2, Fig. 7.

1995. *Reticulina proteros* Bassiouni–Honigstein and Rosenfeld, p. 60, Pl. 3, Figs. 5, 6.

1998. *Reticulina proteros* Bassiouni–Said-Benzarti, Pl. 3, Fig. 18.

1999. *Reticulina proteros* Bassiouni–Morsi, p. 43, Pl. 3, Fig. 17.

2000. *Reticulina proteros* Bassiouni–Bassiouni and Morsi, p. 36, Pl. 10, Figs. 6–8.

2000. *Reticulina proteros* Bassiouni–Shahin, p. 303, Pl. 7, Fig. 2.

2002. *Reticulina proteros* Bassiouni–Honigstein et al., p. 376, Pl. 5, Fig. 51.

2003. *Reticulina proteros* Bassiouni–Morsi and Speijer, p. 76, Pl. 3, Figs. 7, 8.

2005. *Reticulina proteros* Bassiouni–Ismail nd Eid, p. 140, Pl. 4, Figs. 5, 6.

Material: 97 specimens.

Dimensions: L: 0.85–0.87 (females), 1.00 mm (male); H: 0.53 mm (female), 0.49 mm (male).

Occurrence: This species is known from the Paleocene east Algeria (Damotte and Fleury, 1987), Paleocene to Early Eocene of Jordan (Bassiouni, 1969a) and Tunisia (Donze et al., 1982; Said-Benzarti, 1998), Paleocene and Middle Eocene of Israel (Honigstein et al., 1991, 2002; Honigstein and Rosenfeld, 1995) and Late Paleocene (*velascoensis* Zone) and Early Eocene of Egypt (Bassiouni and Luger, 1990; Morsi, 1999; Shahin, 2000; Morsi and Speijer, 2003; Ismail and Eid, 2005). Here, it is found in the Late Paleocene (Thanetian) to Early Eocene (Ypresian) in sections B3, D2, D3, D4, D6, T1 and T2.

Reticulina sangalkamensis (Apostolescu, 1961)
Plate 5, Fig. 14

1961. *Bradleya*? *sangalkamensis* nov. sp.–Apostolescu, p. 818, Pl. 14, Figs. 280–290.

1987. *Paleocosta sangalkamensis* (Apostolescu)–Okosun, p. 28, Pl. 2, Figs. 1–3.

1990. *Reticulina sangalkamensis* (Apostolescu)–Bassiouni and Luger, p. 836, Pl. 20, Figs. 11, 13–15.

1999. *Reticulina sangalkamensis* (Apostolescu)–Morsi, p. 43, Pl. 3, Figs. 18, 19.

2000. *Reticulina sangalkamensis* (Apostolescu)–Bassiouni and Morsi, p. 36, Pl. 10, Figs. 9, 10.

2003. *Reticulina sangalkamensis* (Apostolescu)–Morsi and Speijer, p. 77, Pl. 5, Fig. 52.

2004. *Reticulina sangalkamensis* (Apostolescu)–Ismail and Ied, p. 112, Pl. 4, Figs. 6, 7.

2005. *Reticulina sangalkamensis* (Apostolescu)–Ismail and Ied, p. 140, Pl. 4, Fig. 7.

Material: 132 specimens.

Dimensions: L: 0.86–0.89 mm (females), 0.84 mm (male); H: 0.47–0.50 mm (females), 0.42 mm (male); W: 0.36 mm (female), 0.35 mm (male).

Occurrence: The present species was previously recorded from the Early Paleocene of Senegal (Apostolescu, 1961), Paleocene of Nigeria (Okosun, 1987) and Late Paleocene to Early Eocene of Egypt (Bassiouni and Luger, 1990; Morsi, 1999; Morsi and Speijer, 2003; Ismail and Ied, 2004, 2005). In the present material, it is found in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections D2, D3, T1 and T2.

Genus ***Phacorhabdotus*** Howe and Laurencich, 1958
Phacorhabdotus inaequicostatus Colin and Donze, 1982
Plate 5, Fig. 15

1982. *Phacorhabdotus inaequicostatus* nov. sp. Colin and Donze–Donze et al., p. 296, Pl. 13, Fig. 11.

1995. *Phacorhabdotus inaequicostatus* Colin and Donze– Honigstein and Rosenfeld, Pl. 1, Figs. 9–11.

1999. *Phacorhabdotus inaequicostatus* Colin and Donze– Morsi, p. 54, Pl. 1, Figs. 9–11.

2004. *Phacorhabdotus inaequicostatus* Colin and Donze– Ismail and Ied, p. 114, Pl. 4, Figs. 1, 2.

2005. *Phacorhabdotus inaequicostata* Colin and Donze– Shahin, p. 764, Pl. 4, Figs. 13, 14.

Material: Six specimens.

Dimensions: L: 0.65–0.66 mm; H: 0.40–0.41 mm.

Occurrence: This species was recorded from the latest Campanian and Maastrichtian of Tunisia (Donze et al., 1982), Paleocene of southern Israel (Honigstein and Rosenfeld, 1995) and Egypt (Morsi, 1999; Ismail and Ied, 2004; Shahin, 2005). In the present work, it is only found in the Late Paleocene (Selandian) interval in sections D2, D3 and T1.

Genus ***Spinoleberis*** Deroo, 1966
Spinoleberis aff. *megiddoensis* Honigstein, 1984
Plate 5, Fig. 16

aff. 1984. *Spinoleberis megiddoensis* nov. sp.–Honigstein, p. 33, P1. 14, Figs. 5–9; P1. 15, Figs. 21, 22.

Material: 13 specimens.

Dimensions: L: 0.82–0.86 mm; H: 0.41–0.46 mm.

Remarks: The only available valve is very closely similar to *Spinoleberis megiddoensis* Honigstein, 1984 from the Santonian–Campanian of Israel. It deviates only in having a smaller tubercle in front of the vertical bend of the dorsal ridge and possessing a vertical riblet supporting the eye tubercle; this riblet is not shown in the illustrations of Honigstein for the nominate *S. megiddoensis*.

Occurrence: Late Paleocene (Selandian), sections D2, D3, T1 and T2.

Subfamily BRACHYCYTHERINAE Puri, 1954
Genus ***Brachycythere*** Alexander, 1933

Brachycythere? sp.
Plate 5, Fig. 17

Material: Six specimens.

Dimensions: L: 1.01–1.05 mm; H: 0.50–0.53 mm; W: 0.53 mm.

Remarks: The present species is represented by few, poorly preserved specimens. They recall the brachcytherids and are therefore questionably assigned to the *genus Brachycythere*.

Occurrence: Early Eocene (Ypresian), section D2.

Subfamily BUNTONIINAE Apostolescu, 1961
Genus ***Buntonia*** Howe, 1935
Buntonia jordanica subjordanica Bassiouni and Morsi, 2000
Plate 5, Fig. 18

1998. *Buntonia jordanica* Bassiouni–Said-Benzarti, Pl. 1, Fig. 17.

2000. *Buntonia jordanica subjordanica* nov. ssp.–Bassiouni and Morsi, p. 64, Pl. 11, Figs. 5–8.

2003. *Buntonia jordanica subjordanica* Bassiouni and Morsi–Morsi and Speijer, p. 78, Pl. 5, Figs. 4, 5.

2005. *Buntonia jordanica subjordanica* Bassiouni and Morsi–Ismail and Eid, p. 143, Pl. 5, Figs. 4–6.

Material: 12 specimens.

Dimensions: L: 0.58–0.59 mm (females), 0.61–0.63 mm (males); H: 0.36–0.38 (females), 0.28–0.30 mm (males).

Occurrence: The species was previously described from the Early Eocene in Tunisia (Said-Benzarti, 1998) and Egypt (Bassiouni and Morsi, 2000; Morsi and Speijer, 2003; Ismail and Eid, 2005). Here, it is also found in the Early Eocene (Ypresian) in sections D2 and T2.

Genus ***Soudanella*** Apostolescu, 1961

Soudanella laciniosa triangulata Apostolescu, 1961

Plate 5, Fig. 19

1961. *Soudanella laciniosa triangulata* nov. ssp.–Apostolescu, p. 810, P1. 7, Figs. 130–135.

1963. *Soudanella* cf. *S. laciniosa triangulata* Apostolescu–Barsotti, p. 1525, P1. 3, Fig. 20.

?1966. *Buntonia (Buntonia) virgulata* Apostolescu–Salahi, p. 10, P1. 2, Fig. 10.

1969. *Soudanella laciniosa triangulata* Apostolescu–Grékoff, p. 17, P1. 3, Fig. 44.

1970. *Soudanella laciniosa triangulata* Apostolescu–Bassiouni, P1. 3, Figs. 11a–c.

non 1973. *Soudanella laciniosa triangulata* Apostolescu–Neufville, Pl. 6.11, Figs. 1a–c.

1977. *Soudanella laciniosa triangulata* Apostolescu–Bassiouni et al., p. 2, P1.3, Figs. 2–5.

1982. *Soudanella laciniosa triangulata* Apostolescu–Donze et al., p. 295, P1. 12, Figs. 2, 3.

1987. *Soudanella laciniosa triangulata* Apostolescu–Okosun, p. 56, P1. 6, Figs. 15, 17–19.

1990. *Soudanella laciniosa triangulata* Apostolescu–Bassiouni and Luger, p. 847, P1. 24, Fig. 18.

1992. *Soudanella laciniosa triangulata* Apostolescu–Ismail, p. 51, P1. 2, Fig. 10.

1995. *Soudanella laciniosa triangulata* Apostolescu–Aref, p. 128, P1. 1, Fig. 12.

1998. *Soudanella laciniosa triangulata* Apostolescu–Said-Benzarti, Pl. 2, Fig. 3.

2000. *Soudanella laciniosa triangulata* Apostolescu–Bassiouni and Morsi, p. 67, Pl. 12, Fig. 6.

2004. *Soudanella laciniosa triangulata* Apostolescu–Ismail and Ied, p. 115, Pl. 5, Figs. 14, 15.

2005. *Soudanella laciniosa triangulata* Apostolescu–Shahin, p. 765, Pl. 4, Fig. 15.

2005. *Soudanella laciniosa triangulata* Apostolescu–Ismail and Eid, p. 145, Pl. 5, Fig. 11.

Material: 13 specimens.

Dimensions: L: 0.81–0.86 mm; H: 0.45–0.46 mm.

Remarks: Following Apostolescu's first description (1961) of this subspecies, *Soudanella laciniosa triangulata* is mainly differentiated from the nominate subspecies *Soudanella laciniosa laciniosa* by its triangulate outline with pointed posterior end. We agree here with Colin et al. (1998) in following the interpretation of Carbonnel (1986) for *Soudanella laciniosa triangulata* as having a smooth anterior part unlike the nominate subspecies *Soudanella laciniosa laciniosa* which has an ornamented anterior part. This interpretation is identical with the illustrations of Apostolescu (1961) for the present subspecies. Neufville (1973) illustrated specimens as *Soudanella laciniosa laciniosa* from the Paleocene of Brazil. Although the Brasilian specimens have a similar outline to *Soudanella laciniosa laciniosa* they differ in having the anterior part ornamented with ribs parallel to the margin.

Occurrence: The subspecies is known from the Early Paleocene of Senegal, Late Paleocene of Nigeria and Libya, and Late Paleocene to Early Eocene of Tunisia, Jordan and Egypt. In the present work, it is recorded in the Early Eocene (Ypresian) in sections D2, T1 and T2.

Family XESTOLEBERIDIDAE Sars, 1928

Genus ***Xestoleberis*** Sars, 1866

Xestoleberis tunisiensis Esker, 1968

Plate 5, Fig. 20

1968. *Xestoleberis tunisiensis* nov. sp.–Esker, p. 332, Pl. 2, Figs. 13, 14; Pl. 4, Fig. 2.

1998. *Xestoleberis tunisiensis* Esker–Said, p. 263, Pl. 29, Figs. 10–12.

1982. *Xestoleberis tunisiensis* Esker–Donze et al., p. 282, Pl. 2, Fig. 9.

1987. *Xestoleberis tunisiensis* Esker–Damotte and Fleury, p. 94, Pl. 1, Figs. 17, 18.

1990. *Xestoleberis tunisiensis* Esker–Bassiouni and Luger, p. 847, Pl. 25, Figs. 1–7.

1992. *Xestoleberis tunisiensis* Esker–Ismail, p. 51, Pl. 2, Fig. 8.

1996. *Xestoleberis tunisiensis* Esker–Bassiouni and Luger, p. 73, Pl. 24, Figs. 14, 17.

2000. *Xestoleberis tunisiensis* Esker–Bassiouni and Morsi, p. 68, Pl. 12, Figs. 11–14.

2003. *Xestoleberis tunisiensis* Esker–Morsi and Speijer, p. 78, Pl. 5, Fig. 57.

Material: 22 specimens.

Dimensions: L: 0.51 mm; H: 0.35 mm; W: 0.33 mm.

Occurrence: This species is known from the Late Campanian to Early Paleocene of Tunisia, Maastrichtian of Algeria, Maastrichtian to Early Eocene of Egypt and Eocene of Somalia. Here, it is recorded in the Late Paleocene (Selandian) to Early Eocene (Ypresian) in sections B3, D2, D3 and D4.

5. Biostratigraphy

In the present paper, the biostratigraphic zonal scheme (NP-Zones) of Martini (1971) for calcareous nannoplankton, that of Berggren et al. (1995, 2000) for planktonic foraminifera, and that of Serra-Kiel et al. (1998) for larger foraminifera –

shallow benthic zonation (SBZ) – are adopted. In terms of calcareous nannoplankton biostratigraphy, the Paleocene–Eocene boundary, which is now delineated by the base of the Carbon Isotopic Excursion (CIE) associated with the onset of the PETM, correlates with the NP9a/NP9b zonal boundary (Aubry et al., 2000a), with the NP9/NP10 zonal boundary, or with a level in between (e.g. Monechi et al., 2000). This discrepancy is due to a taxonomic controversy over representatives of the *Rhomboaster–Tribrachiatus* lineage, including the zonal marker *Tribrachiatus* (or *Rhomboaster*) *bramlettei* (cf. Aubry et al., 2000b; Von Salis et al., 2000). In terms of planktic foraminiferal biostratigraphy, this P/E boundary correlates with a level in the middle part of Zone P5 (*Morozovella velascoensis* Partial Range Zone of Berggren et al., 1995). The base of Subzone P5b (*Morozovella allisonensis* total range Zone) coincides with the onset of the CIE and thus, with the P/E boundary (Speijer et al., 2000). In the shallow benthic zonation, the P/E boundary is determined in our sections between SBZ4 and SBZ5 (Scheibner et al., 2005).

5.1. Ostracode stratigraphic distribution

Distribution charts for the ostracode fauna in the studied sections have been made (Figs. 4–12). A continuous record is displayed only at Bir Dakhl and Wadi Tarfa. The sections at the northern rim of the Southern Galala (B2, B3) give scarce fauna. Therefore, they are not biostratigraphically discussed, but are only used as a source for additional taxonomic information.

5.1.1. Bir Dakhl

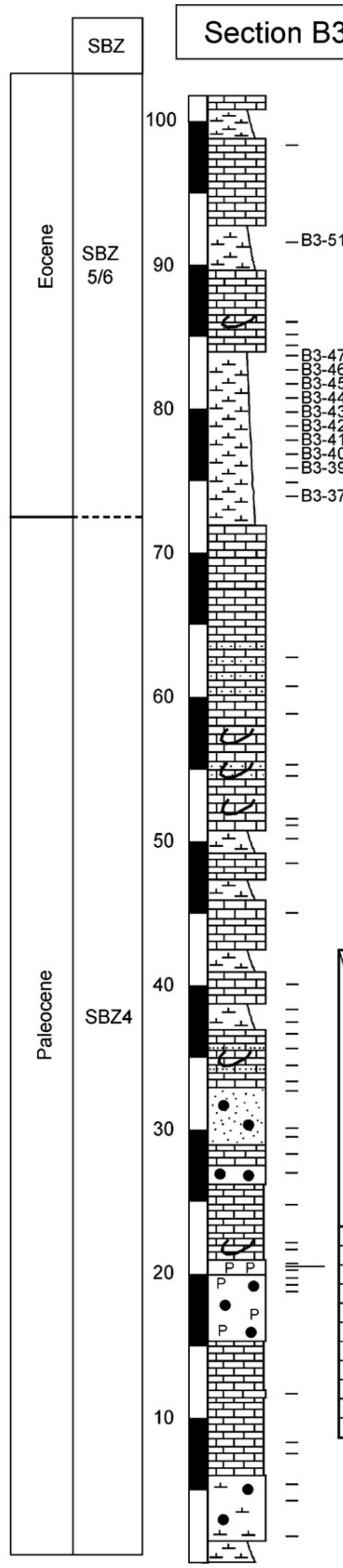
From the five sections of Bir Dakhl (D2–D6), we identified a total of 55 taxa (Figs. 6–10). An almost continuous record was found in two sections (D2, D3) (Figs. 8 and 9), thus allowing biostratigraphic evaluation. Most of the taxa recorded in these two sections extend from the Paleocene to the Lower Eocene. The exceptions are *Cytherelloidea* aff. *ozanana, Hermanites?* sp., *Isalocopocythere teiskotensis*, *Ordoniya bulaqensis*, *Phacorhabdotus inaequicostatus* and *Spinoleberis* aff. *megiddoensis* which disappear within the Paleocene part of the sections. At the level equivalent to the calcareous nannoplankton zone NP7/NP8, the assemblage changes abruptly by the first occurrence of *Abyssocypris*? *adunca*, *Cytherella* sp. 1 Honigstein and Rosenfeld, 1995, *Cytherelloidea* aff. *ozanana*, *Hornibrookella speijeri*, *Isalocopocythere teiskotensis, Ordoniya hasaensis*, *Paracypris birdakhlensis*, *Parakrithe crolifa*, *Pokornyella*? sp. 1 and *Pontocyprella recurva*. In section D2, another faunal turnover occurs at the P/E transition. This turnover is characterized by more pronounced introduction of new taxa rather than the disappearance of older ones. At this level *Acanthocythereis*? *denticulata*, *Bairdia* sp., *Hornibrookella* sp., *Horrificiella* cf. *liebaui*, *Neocyprideis* sp., *Paragrenocythere cultrata*, *Pokornyella pseudotriangularis*, *Schizocythere salahii*, *Ordoniya*? sp. and *Urocythereis* sp. first appear characterizing the end of the Paleocene. Of these, *Hornibrookella* sp., *Horrificiella* cf. *liebaui*, *Neocyprideis* sp. and *Ordoniya*? sp. are merely found at the P/E boundary interval. In section D3, the P/E boundary level is not significant, where only one taxon, *Paracosta parakefensis*, first appears. Higher up in the Lower Eocene part of the two sections, *Acanthocythereis meslei* cf. *paleocenica*, *Actinocythereis*? *coronata*, *Bairdia aegyptiaca*, *Bairdia* sp., *Brachycythere*? sp., *Buntonia jordanica subjordanica*, *Bythoceratina* aff. *B*. cf. *prothroensis, Hornibrookella paramoosae*, *Krithe* sp., *Loxoconcha* sp., *Monoceratina reticulata*, *Ordoniya maanensis, Paracypris* aff. *jonesi, Pokornyella* sp. 2 and *Soudanella laciniosa triangulata* appear for the first time.

5.1.2. Wadi Tarfa

From the investigated two sections of Wadi Tarfa (T2, T1), 30 ostracode taxa have been retrieved (Figs. 11 and 12). Of these, many have a long vertical range, extending from the Paleocene to the Lower Eocene. Other taxa showing shorter ranges and indicating a turnover between the Paleocene and Lower Eocene are also present. The ostracode faunal transition from the Paleocene to the Lower Eocene is gradual. Only four ostracode taxa disappear before the P/E boundary; these are *Cristaeleberis reticulata*, *Ordoniya bulaqensis*, *Phacorhabdotus inaequicostatus* and *Spinoleberis* aff. *megiddoensis*. Above the P/E boundary, a larger number of taxa gradually first appears at different levels within the Eocene part of the sections. Arranged according to their sequence of appearance, these are *Cytherella* sp. 1 Honigstein and Rosenfeld, *Reticulina proteros*, *Oertliella* sp., *Bairdia aegyptiaca*, *Abyssocypris*? *adunca*, *Ordoniya maanensis*, *Soudanella laciniosa triangulata* and *Buntonia jordanica subjordanica*.

5.1.3. Comparison between Bir Dakhl and Wadi Tarfa

We found 60 different taxa in total of which 27 taxa were observed in the sections of both areas. The largest number of taxa is displayed in the area of Bir Dakhl (55 taxa) compared with the area of Wadi Tarfa (30 taxa). In the Early and early Late Paleocene parts of the sections, the assemblages recorded in the two areas are similar and are dominated by the occurrence of taxa such as *Acanthocythereis*? *posterotriangulata*, *Doricythereis jordanica nodoreticulata*, *Kefiella galalaensis*, *Ordoniya ordoniya, O. bulaqensis*, *Phacorhabdotus inaequicostatus*, *Reticulina sangalkamensis* and *Spinoleberis* aff. *megiddoensis*. In the late Late Paleocene (NP7/NP8), new taxa represented by *Abyssocypris*? *adunca*, *Cytherella* sp. 1 Honigstein and Rosenfeld, 1995, *Cytherelloidea* aff. *ozanana*, *Hornibrookella speijeri*, *Paracypris birdakhlensis*, *Pontocyprella recurva*, *Isalocopocythere teiskotensis, Pokornyella*? sp. 1, *Parakrithe crolifa* and *Ordoniya hasaensis* first appear at Bir Dakhl in the north. In the south, at Wadi Tarfa, no new ostracode taxa have been yielded in this level. At Bir Dakhl, the end of the Paleocene is recognized in section D2 by the first appearance of several other taxa such as *Horrificiella* cf. *liebaui, Neocyprideis* sp., *Paragrenocythere cultrata*, *Pokornyella posterotriangulata* and *Schizocythere salahii*, whereas in section D3 and in the sections of Wadi Tarfa, no significant first appearances or extinctions are observed. Above the P/E boundary, the recorded assemblages become already different between the two areas. Although most of the taxa found in Wadi Tarfa are also present in Bir Dakhl, many other taxa characterizing the P/E boundary at Bir Dakhl extend also higher up into the Lower Eocene of this area, e.g. *Paragrenocythere cultrata*



Samples \ Species	*Bairdia ilaroensis*	*Bythocypris* cf. *gohrbandti*	*Paracypris* aff. *jonesi*	*Cytherella* cf. *ventroconcava*	*Bairdia* sp.	*Parakrithe crolifa*
B2-41			3		3	2
B2-40					1	
B2-39		1		1		
B2-37		3	1			
B2-25	1					

Fig. 5 (cont.)

Samples \ Species	*Cytherella* cf. *ventroconcava*	*Bairdia ilaroensis*	*Paracosta parakefensis*	*Abyssocypris? adunca*	*Pontocyprella recurva*	*Parakrithe crolifa*	*Actinocythereis? coronata*	*Acanthocythereis? denticulata*	*Paracypris* aff. *jonesi*	*Xestoleberis tunisiensis*	*Reticulina proteros*	*Haughtonileberis* sp.	*Pokornyella pseudotriangularis*	*Oertliella* sp.
B3-51		4					2		1					
B3-47						1	1						1	1
B3-46		1					1					1		
B3-45		3				1			3	3	1			
B3-44		3	1	1		4	2	2						
B3-43			4	2			1							
B3-42		1		2			1							
B3-41		2				5								
B3-40	1	3			1									
B3-39	1	6		1										
B3-37	2	1	1											

Fig. 4: section B3

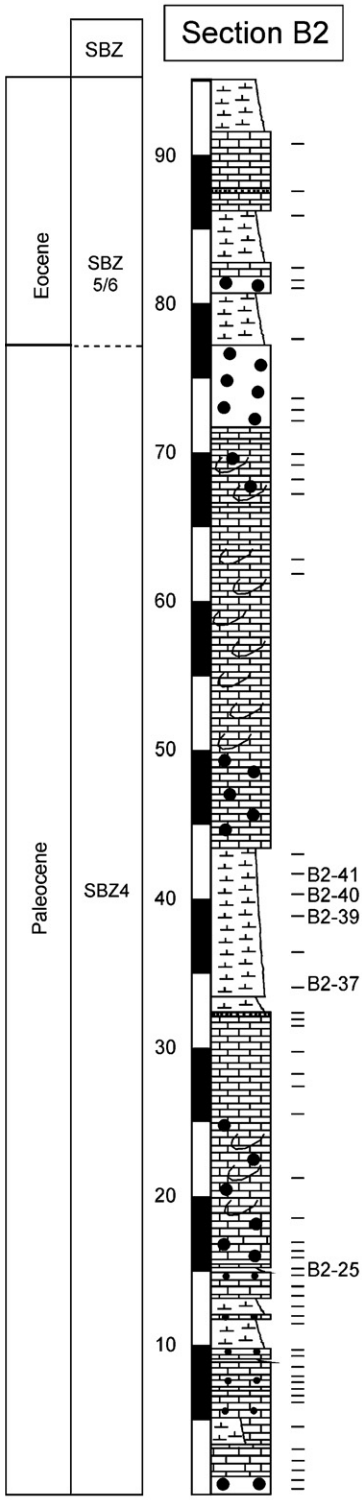
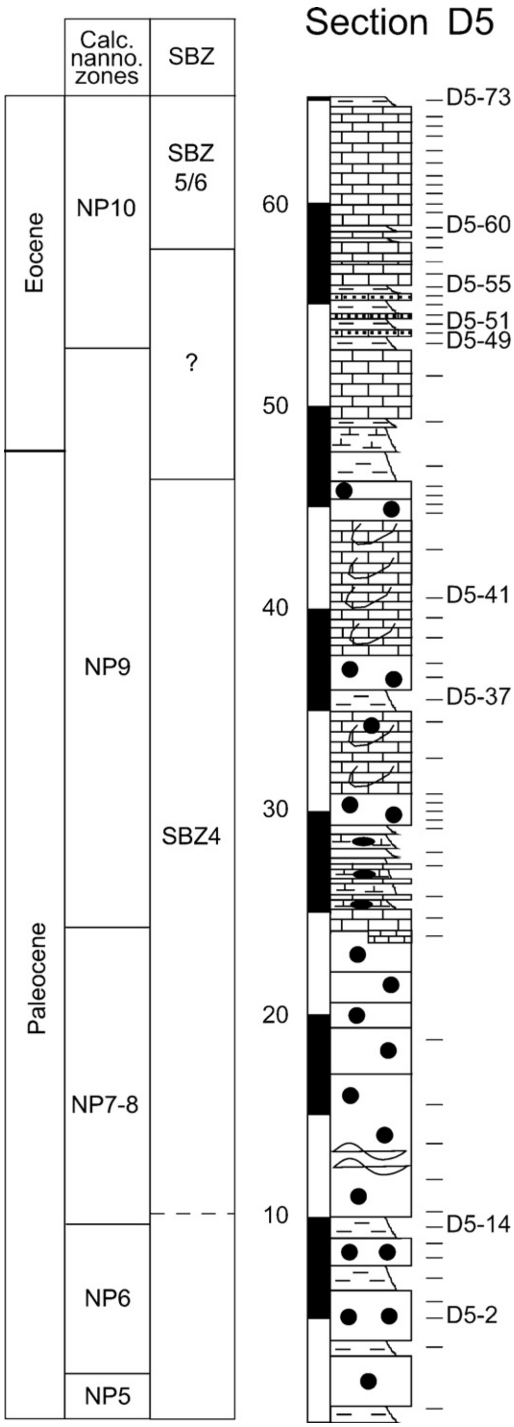


Fig. 5: section B2

Figs. 4 and 5. (4) Stratigraphic distribution of the ostracodes in section B3. (5) Stratigraphic distribution of the ostracodes in section B2.

Figs. 4 and 5. (4) Répartition stratigraphique des ostracodes dans la coupe B3. (5) Répartition stratigraphique des ostracodes dans la coupe B2.



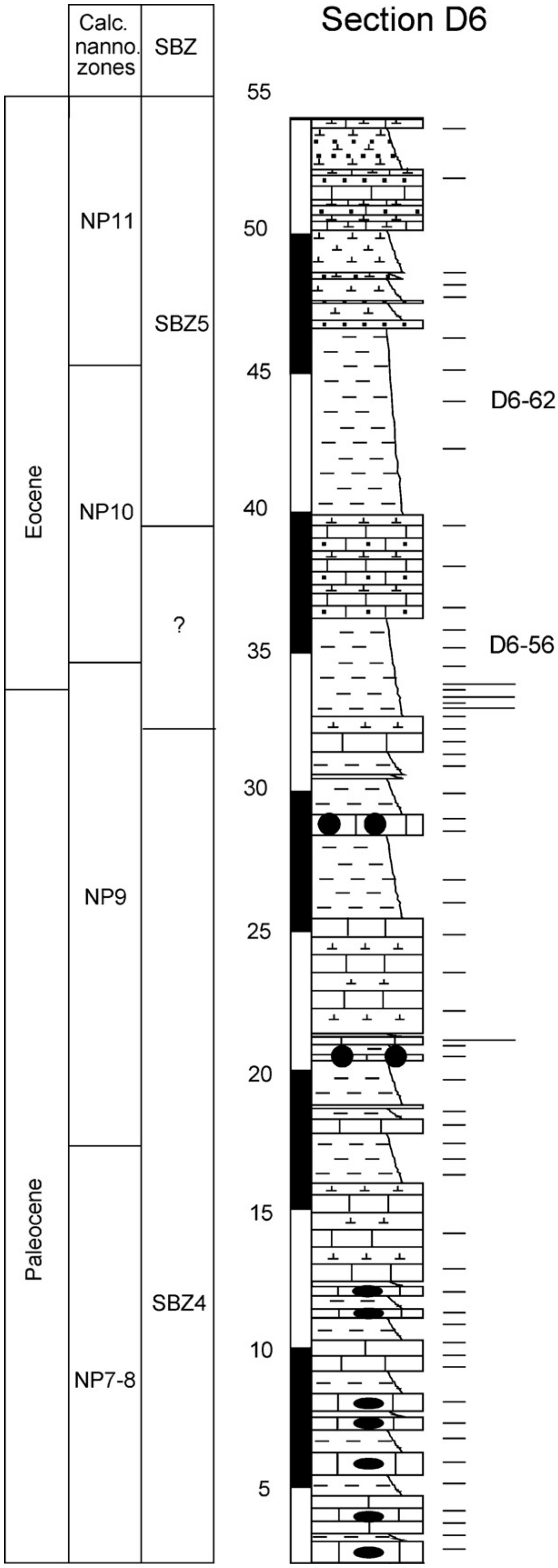
Samples \ Species	*Acanthocythereis? posterotriangulata*	*Cytherella* cf. *ventroconcava*	*Acanthocythereis? denticulata*	*Ordoniya hasaensis*	*Doricythereis jordanica nodoreticulata*	*Doricythereis martinii*	*Bairdia* sp.	*Acanthocythereis meslei* cf. *paleocenica*	*Pontocyprella recurva*
D5-73		1					1	1	1
D5-60							2		
D5-55							1		
D5-51					1	2			
D5-49		1	1	1					
D5-41		1							
D5-37		3							
D5-14				1					
D5-02	2								

Fig. 6. Stratigraphic distribution of the ostracodes in section D5.
Fig. 6. Répartition stratigraphique des ostracodes dans la coupe D5.

and *Schizocythere salahii*. Additionally, more taxa including *Acanthocythereis meslei* cf. *paleocenica*, *Bairdia aegyptiaca*, *Bairdia* sp., *Brachycythere*? sp., *Buntonia jordanica subjordanica*, *Bythoceratina* aff. *B.* cf. *prothroensis, Hornibrookella paramoosae, Krithe* sp., *Loxoconcha* sp., *Monoceratina reticulata*, *Ordoniya maanensis, Paracypris* aff. *jonesi*, *Pokornyella* sp. 2, and *Soudanella laciniosa triangulata* first appear higher up in the Lower Eocene at Bir Dakhl. Among these, only *Bairdia aegyptiaca, Buntonia jordanica subjordanica*, *Ordoniya maanensis* and *Soudanella laciniosa triangulata* are also present at the same leval at Wadi Tarfa.

5.2. Biostratigraphical implications

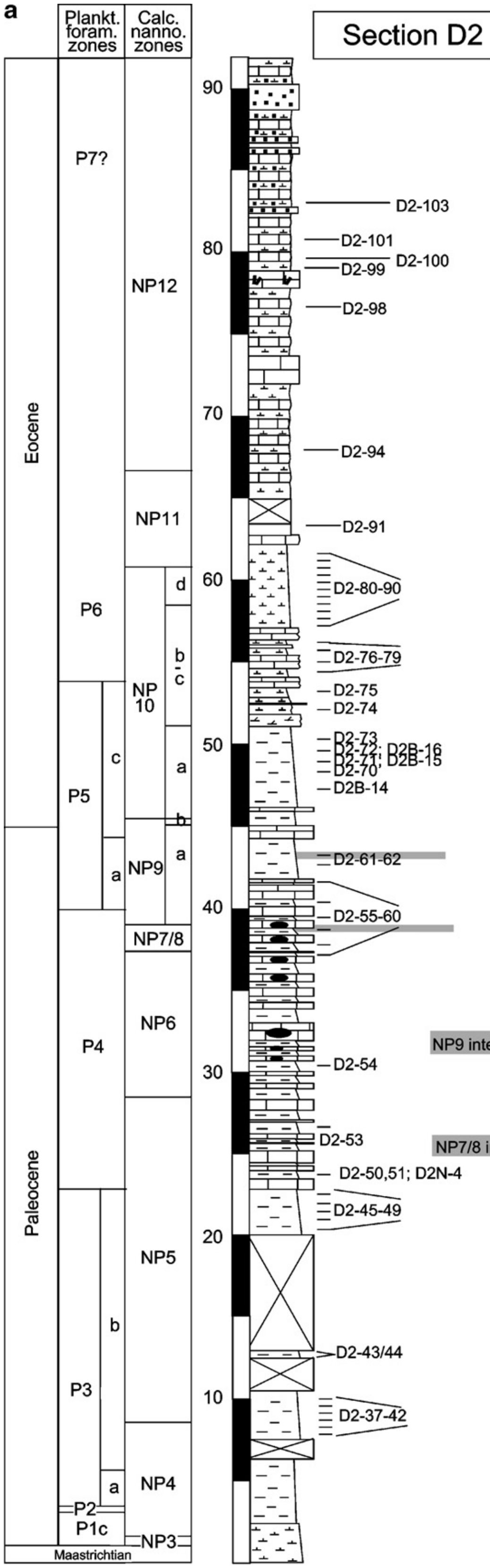
Stratigraphic ranges of the taxa recorded in this study in Egypt (Table 1), as well as in the Middle East and elsewhere in North and West Africa (Table 2), show that most of them have long stratigraphic ranges from Paleocene to Early Eocene,



Samples \ Species	*Acanthocythereis? denticulata*	*Doricythereis martinii*	*Kefiella galalaensis*	*Reticulina proteros*
D6-62	1	1	1	1
D6-56	1			

Fig. 7. Stratigraphic distribution of the ostracodes in section D6.
Fig. 7. Répartition stratigraphique des ostracodes dans la coupe D6.

a



	Samples \ Species	*Doricythereis jordanica nodoreticulata*	*Kefiella galalaensis*	*Spinoleberiss aff. megiddoensis*	*Cytherella sinaensis*	*Bairdia ilaroensis*	*Ordoniya ordoniya*	*Acanthocythereis? posterotriangulata*	*Ordoniya bulaqensis*	*Phacorhabdotus inaequicostatus*	*Paracosta parakefensis*	*Cytherella* cf. *ventroconcava*	*Ordoniya hasaensis*	*Doricythereis martinii*	*Pontocyprella recurva*	*Tuberocytheridea* sp.	*Hermanites?* sp.	*Isalocopacythere teiskotensis*	*Haughtonileberis* sp.	*Pokornyella?* sp.
	D2-103																			
	D2-101				2						1									
	D2-100				4		1				5									
	D2-99				4		3				1									
	D2-98				3															
	D2-94					1														
	D2-91				1	1		1			11		2	4						
	D2-90		2		1	3					8		4	10						
	D2-89		6			1					5		2	7						
	D2-88	3				2					2		1	4	1					
	D2-87		3												1					
	D2-86		3			1							3	2						
	D2-85		1								1		3							
	D2-84										3		1	3						
	D2-83										2			1						
	D2-82	1	2								3			3						
	D2-80		2								3			4						
	D2-79	2				2					1		3							
	D2-78	1	1			2		1			1			9						
	D2-76		2			2					2		3							
	D2-75					3	2				4		2	9						
	D2-74	2				2					4			2						
	D2-73										2		4	1						
	D2b-16												1							
	D2-72																			
	D2b-15							1					4							
	D2-71					3					9			5						
	D2-70					1	2	1					3	1					2	1
	D2b-14					1														
NP9 interval	D2-62					3							1	1				6	1	9
	D2-61													2						
	D2-60					2							1							
	D2-59		1			2														
	D2-58		2											1	1					
NP7/8 inter.	D2-57					2								3			1	2	2	6
	D2-56				1									1						
	D2-55													1		2				
	D2-54					2														
	D2-53		1		1															
	D2N-4						1													
	D2-51				1	1	1													
	D2-50	1																		
	D2-49					1	1													
	D2-48						1													
	D2-47														1					
	D2-46					2			2			1	3							
	D2-45		3				3	2			1	1	1	1						
	D2-44				1		1			1	2									
	D2-43	2	1				1													
	D2-42						1													
	D2-41	1		1	2	2	4		3	2	1									
	D2-40		1				2													
	D2-39		4		2	2	4	3												
	D2-38	3	3	1	7	4	4													
	D2-37	1	4																	

Fig. 8. Stratigraphic distribution of the ostracodes in section D2.
Fig. 8. Répartition stratigraphique des ostracodes dans la coupe D2.

b

Samples \ Species	*Cytherella* sp.1 Honigstein & Rosenfeld	*Reticulina proteros*	*Bairdia* aff. *septentrionalis*	*Xestoleberis tunisiensis*	*Reticulina sangalkamensis*	*Paracypris birdakhlensis*	*Neocyprideis* sp.	*Paragrenocythere cultrata*	*Hornibrookella* sp.	*Horrificiella* cf. *liebaui*	*Ordoniya*? sp.	*Hornibrookella speijeri*	*Pokornyella pseudotriangularis*	*Urocythereis* sp.	*Acanthocythereis*? *denticulata*	*Schizocythere salahii*	*Bairdia* sp.	*Parakrithe crolifa*	*Actinocytheris*? *coronata*	*Abyssocypris*? *adunca*	*Krithe echolsae*	*Pokornyella* sp.2	*Krithe* sp.	*Bythoceratina* aff. *B. prothroensis*	*Bairdia aegyptiaca*	*Hornibrookella paramoosae*	*Acanthocythereis meslei* cf. *paleocenica*	*Brachycythere*? sp.	*Buntonia jordanica subjordanica*	*Soudanella laciniosa triangulata*
D2-103																											1			
D2-101																														
D2-100																	1									2	4	4	1	3
D2-99																3										6	4	2	5	3
D2-98																1														
D2-94																														
D2-91															1											2	1			
D2-90		1													2					2					2					
D2-89		1													1															
D2-88															2															
D2-87	1		1												3															
D2-86															1									1	1					
D2-85	2	2												1					1											
D2-84																				1										
D2-83	2																													
D2-82	1														3															
D2-80	1		3												1			2					2							
D2-79	1	1																			1									
D2-78			1	1									2		3							1								
D2-76																														
D2-75	2	1			3										3						1									
D2-74	2	1																5												
D2-73		1													2															
D2b-16																														
D2-72															1															
D2b-15																														
D2-71	2	1													4															
D2-70					6							5	1		4			1	1	2										
D2b-14		1																												
D2-62				5		2	4	2	1	1	1	9	4	9	1	9	2													
D2-61																														
D2-60			1	2	2																									
D2-59	2	1	2																											
D2-58	1	1																												
D2-57																														
D2-56																														
D2-55																														
D2-54																														
D2-53																														
D2N-4																														
D2-51																														
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Fig. 8. (*Continued*).

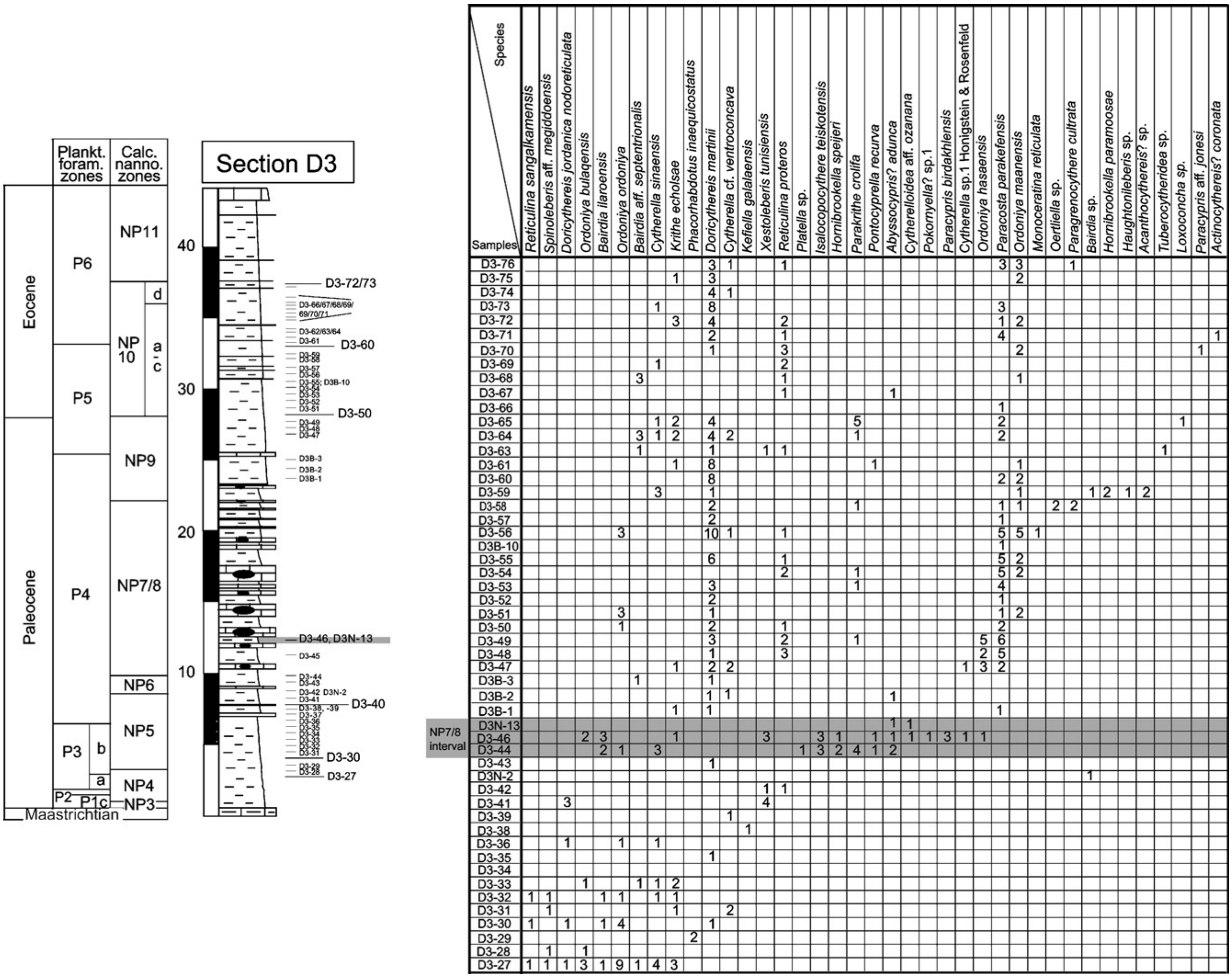


Fig. 9. Stratigraphic distribution of the ostracodes in section D3.
Fig. 9. Répartition stratigraphique des ostracodes dans la coupe D3.

or even since the Campanian–Maastrichtian. However, some taxa have occurrences restricted either to the Paleocene or the Early Eocene intervals and could be used to characterize these stratigraphic intervals. Among the several taxa recorded in the Paleocene, two species (*Isalocopocythere teiskotensis* and *Cristaeleberis reticulata*) are only known in this interval and have not yet been recorded in Early Eocene deposits in Egypt or elsewhere (Tables 1 and 2). Four species (*Cytherella sinaensis*, *Cytherelloidea attiyaensis*, *Bairdia* aff. *septentrionalis*, *Phacorhabdotus inaequicostatus*) are known from Maastrichtian deposits of Egypt, but never found higher than the Paleocene. Of these, *Phacorhabdotus inaequicostatus* was recorded in Tunisia as old as the Campanian. Seven taxa, namely *Acanthocythereis meslei* cf. *paleocenica, Bairdia aegyptiaca*, *Buntonia jordanica subjordanica*, *Hornibrookella paramoosae*, *Monoceratina reticulata*, *Paragrenocythere cultrata* and *Schizocythere salahii* may be used as indicators for the Early Eocene interval. Among the many taxa first appearing in association with the P/E boundary, these taxa do not occur below the uppermost part of the *velascoensis* zone (subzone P5b) anywhere else in Egypt (Tables 1 and 2) and their first appearance seems to be associated with an ostracode faunal change across the P/E boundary.

6. Paleoenvironmental implications

We investigated the Late Paleocene–Early Eocene ostracode fauna extracted from the studied nine sections (Figs. 2 and 3). A continuous ostracode record was yielded from Bir Dakhl area in the north (sections D2, D3; Figs. 8 and 9) and Wadi Tarfa area in the south (sections T2, T1; Figs. 11 and 12). In the Lower and lower Upper Paleocene, the ostracode faunal assemblages in the sections from these two areas are largely similar. They are dominated by the occurrence of taxa characterizing the middle to outer shelf such as *Acanthocythereis*? *posterotriangulata*, *Doricythereis jordanica nodoreticulata*, *Ordoniya ordoniya*, *O. bulaqensis*, and *Phacorhabdotus inaequicostatus* (Table 3). In the upper Upper Paleocene at Bir Dakhl (sections D2, D3), shallowing events are observed in two levels. The first one lies at the level equivalent to the calcareous nannoplankton zone NP7/NP8, where inner shelf taxa (*Isalocopocythere teiskotensis* and *Schizocythere salahii*) (Table 3) with others

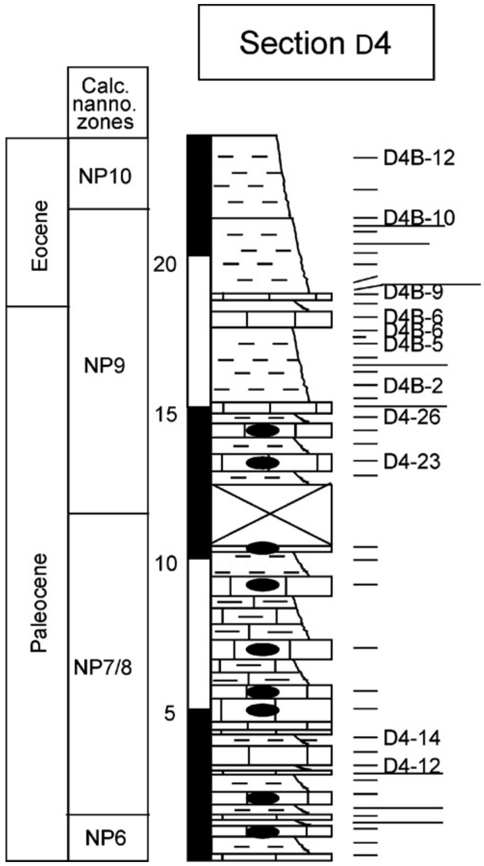
Table 1
Stratigraphic distribution of the recorded ostracode species in different parts of Egypt; **1**. Bassiouni and Luger (1990), **2**. Bassiouni and Morsi (2000), **3**. Bassiouni et al. (1977), Hassan et al. (1977), Cronin and Khalifa (1979), Boukhary et al. (1982), **4**. Morsi and Speijer (2003), Ismail and Eid (2005), **5**. Ismail (1992), **6**. Ismail (1996), **7**. Morsi (1999, 2000), Ismail and Ied (2004), Shahin (2005); biozonal definitions after Toumarkine and Luterbacher (1985)

Tableau 1
Répartition stratigraphique des espèces d'ostracodes trouvées dans les différentes régions d'Égypte ; **1**. Bassiouni et Luger (1990), **2**. Bassiouni et Morsi (2000), **3**. Bassiouni et al. (1977), Hassan et al. (1977), Cronin et Khalifa (1979), Boukhary et al. (1982), **4**. Morsi et Speijer (2003), Ismail et Eid (2005), **5**. Ismail (1992), **6**. Ismail (1996), **7**. Morsi (1999, 2000), Ismail et Ied (2004), Shahin (2005); définitions des biozones d'après Toumarkine et Luterbacher (1985)

Species	Central-South Egypt (1)	Farafra (2)	Nile Valley (3)	S. Eastern Desert (4)	Esh El-Mallaha (5)	Sinai (6)
Cytherella sinaensis						Paleocene
Cytherelloidea attiyaensis						Maast.-Early Paleocene
Bairdia aegyptiaca		l. velascoensis - E. Eocene	E. Eocene			
Bairdia ilaroensis	M. Maastrichtian-subbotinae			Early Eocene		
Bairdia aff. *septentrionalis*						Maastrichtian- Paleocene
Abyssocypris? *adunca*	velascoensis	l. velascoensis - E. Eocene	E. Paleocene			
Paracypris aff. *jonesi*	praecursoria-edgari	l. velascoensis - E. Eocene		Paleocene-E. Eocene		
Pontocyprella recurva	praecursoria-pseudomenardii	l. velascoensis - E. Eocene	E. Paleocene	Paleocene		Maastrichtian- E. Paleocene
Schizocythere salahii	Early Eocene					
Monoceratina reticulata		Early Eocene				
Krithe echolsae	praecursoria-pseudomenardii	l. velascoensis	Paleocene			Maastrichtian- L. Paleocene
Parakrithe crolifa	praecursoria-velascoensis	l. velascoensis - E. Eocene	M. Eocene	Paleocene		Maastrichtian-Paleocene
Hornibrookella paramoosae	l. velascoensis	Early Eocene				
Paragrenocythere cultrata	l. velascoensis-E. Eocene	Early Eocene				
Acanthocythereis? *denticulata*	praecursoria-pseudomenardii	l. velascoensis - E. Eocene		E. Eocene		Paleocene
Acanthocythereis? *posterotriangulata*	praecursoria	l. velascoensis - E. Eocene		L. Paleocene		Paleocene
Actinocythereis? *coronata*	praecursoria-l. velascoensis	Early Eocene	Paleocene-E. Eocene	Paleocene-E. Eocene	Maastricht.-Paleocene	Maastricht.-Paleocene
Cristaeleberis reticulata			Paleocene			Paleocene
Doricythereis jordanica nodoreticulata	praecursoria-pseudomenardii	Early Eocene	L. Paleocene			Paleocene-E. Eocene
Doricythereis martinii		l. velascoensis - E. Eocene	E. Eocene	L. Paleocene		L. Paleocene-E. Eocene
Ordoniya ordoniya	praecursoria-angulata	E. Eocene	Paleocene-E. Eocene	E. Eocene	Maastricht.-Paleocene	Maastricht.-Paleocene
Ordoniya bulaqensis	praecursoria- velascoensis	l. velascoensis - E. Eocene		Paleocene-E. Eocene		Paleocene
Ordoniya hasaensis			E, Eocene			L. Paleocene-E. Eocene
Ordoniya maanensis		E. Eocene	E. Eocene			
Paracosta parakefensis	velascoensis-edgari	l. velascoensis - E. Eocene		Paleocene-E. Eocene		Early Paleocene
Reticulina proteros	praecursoria-velascoensis	l. velascoensis - E. Eocene	L. Paleocene-E. Eocene	L. Paleocene-E. Eocene		L. Paleocene-E. Eocene
Reticulina sangalkamensis	angulata-edgari	l. velascoensis - E. Eocene		Paleocene-E. Eocene		L. Paleocene-E. Eocene
Phacorhabdotus inaequicostatus						Paleocene
Buntonia jordanica subjordanica		l. velascoensis - E. Eocene		E. Eocene		
Soudanella laciniosa triangulata	l. velascoensis	E. Eocene	E. Eocene	E. Eocene		
Xestoleberis tunisiensis	praecursoria-edgari	l. velascoensis - E. Eocene	Paleocene-E. Eocene	E. Eocene	Maastricht.-Paleocene	

Table 2
Stratigraphic distribution of the recorded ostracode species outside Egypt; **1**. Reyment and Reyment (1959), Apostolescu (1961), Reyment (1963, 1981), Foster et al. (1983), Ficarelli (1976), Carbonnel et al. (1990), Damotte (1991), Colin et al. (1998), **2**. Damotte and Fleury (1987), **3**. Esker (1968), Donze et al. (1982), Said-Benzarti (1998), **4**. Barsotti (1963), Salahi (1966), El-Waer (1992), Keen et al. (1994), **5**. Honigstein and Rosenfeld (1995), Honigstein et al. (1991, 2002), **6**. Bassiouni (1970), **7**. Al-Furaih (1980); biozonal definitions after Toumarkine and Luterbacher (1985)
Tableau 2
Répartition stratigraphique des espèces d'ostracodes trouvées en dehors d'Égypte ; **1**. Reyment et Reyment (1959), Apostolescu (1961), Reyment (1963, 1981), Foster et al. (1983), Ficarelli (1976), Carbonnel et al. (1990), Damotte (1991), Colin et al. (1998), **2**. Damotte et Fleury (1987), **3**. Esker (1968), Donze et al. (1982), Said-Benzarti (1998), **4**. Barsotti (1963), Salahi (1966), El-Waer (1992), Keen et al. (1994), **5**. Honigstein et Rosenfeld (1995), Honigstein et al. (1991, 2002), **6**. Bassiouni (1970), **7**. Al-Furaih (1980); définitions des biozones d'après Toumarkine et Luterbacher (1985)

Species	West Africa (1)		Algeria (2)	Tunisia (3)	Libya (4)	Israel (5)	Jordan (6)	Saudi Arabia (7)
	Coastal basins	Internal basins						
Cytherella sp. 1 Honig. and Rosen.						Paleocene		
Bairdia ilaroensis	Maast.-Paleocene	Maast.-Paleocene			Maast.-Paleocene			
Bairdia aff. *septentrionalis*						Paleocene		
Paracypris aff. *jonesi*				Paleocene	Paleocene			
Abyssocypris? *adunca*			Paleocene	L. Campanian-Paleeocene				
Pontocyprella recurva			Maast. - M. Paleocene	Maast. - Paleocene	Maastrichtian			
Schizocythere salahii					Early-Middle Eocene			
Krithe echolsae				L. Campanian-Paleeocene		Maast. - Paleocene		
Parakrithe crolifa		L. Paleocene				Paleocene-Eocene		
Isalocopocythere teiskotensis	Late Paleocene	L. Maast.-Paleocene			Paleocene			Paleocene
Paragrenocythere cultrata	Late Paleocene	L. Maast.-Paleocene			Paleocene			
Acanthocythereis meslei cf. *paleocenica*						Early Eocene		
Acanthocythereis? *denticulata*			E. to M. Paleocene	L. Maast. E. Paleocene				
Acanthocythereis? *posterotriangulata*						Paleocene		
Actinocythereis? *coronata*			Maast.-"E.-M."Paleocene	L. Campanian-L. Paleocene	Maastrichtian	Paleocene- E. Eocene	Paleocene-E. Eocene	
Cristaeleberis reticulata							Middle Paleocene	
Doricythereis jordanica nodoreticulata				Paleocene			Middle Paleocene	
Doricythereis martinii						Paleocene- E. Eocene	Early Eocene	
Ordoniya ordoniya				L. Maast. E. Paleocene			E. - M. Paleocene	
Ordoniya bulaqensis						Paleocene-E.-M. Eocene		
Ordoniya hasaensis						Early-Middle Eocene	Late Paleocene	
Ordoniya maanensis						Paleocene-E. Eocene	Early Eocene	
Reticulina proteros			Paleocene	Paleocene-E. Eocene		Paleocene-M. Eocene	Paleocene-E. Eocene	
Reticulina sangalkamensis	Early Paleocene							
Phacorhabdotus inaequicostatus				L. Campanian - Maast.		Paleoceme		
Buntonia jordanica subjordanica				Early Eocene				
Soudanella laciniosa triangulata	Early Paleocene			L. Paleocene-E. Eocene	Late Paleocene		L. Paleocene-E. Eocene	
Xestoleberis tunisiensis			Maastrichtian	L. Campanian-l. Paleocene				

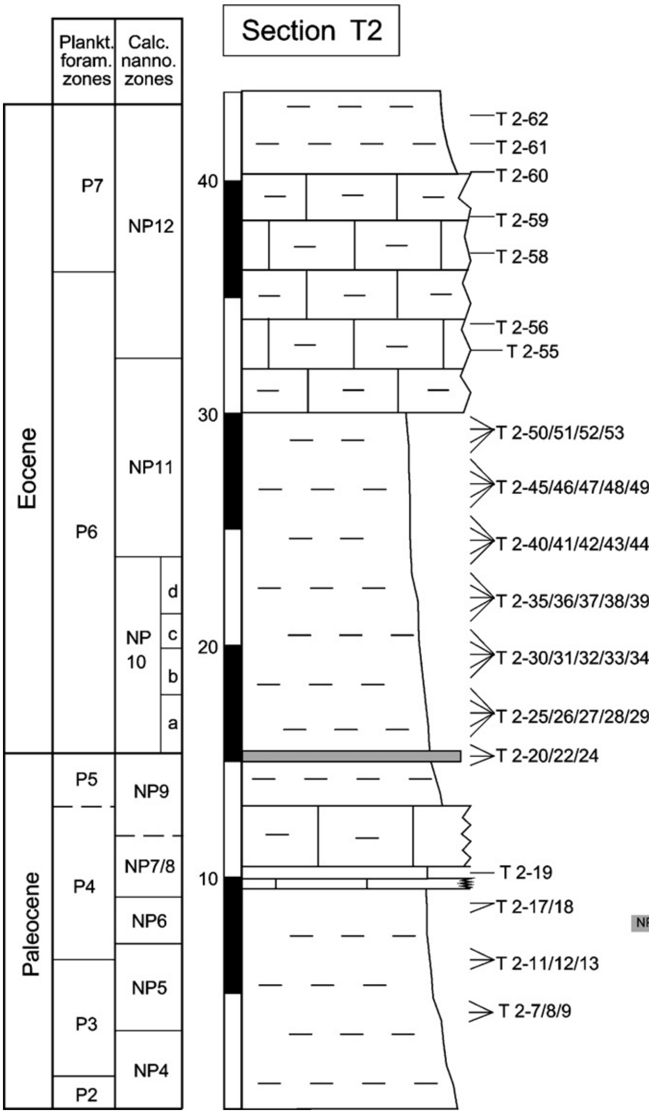


Samples \ Species	*Bairdia* aff. *septentrionalis*	*Doricythereis martinii*	*Pokornyella pseudotriangularis*	*Krithe echolsae*	*Xestoleberis tunisiensis*	*Bairdia* sp.	*Acanthocythereis*? sp.	*Reticulina proteros*	*Actinocythereis*? *coronata*	*Loxoconcha* sp.
D4b-12		1							1	
D4b-10				2						
D4b-09					3					1
D4b-06		1					1		2	
D4b-05								1		
D4b-02		1				1	1			
D4-26			1		1					
D4-23				1						
D4-14	2		1							
D4-12	2	1								

← reworking (D4b-09)

Fig. 10. Stratigraphic distribution of the ostracodes in section D4.
Fig. 10. Répartition stratigraphique des ostracodes dans la coupe D4.

belonging to shallow marine genera (*Platella* sp., *Cytherelloidea* aff. *ozanana* and *Pokornyella*? sp. 1) dominate. The second shallowing event is observed at the end of the Paleocene (NP9a) in section D2, being indicated by the occurrence of *Isalocopocythere teiskotensis*, *Paragrenocythere cultrata* and *Schizocythere salahii* (Table 3), together with others assigned to shallow marine genera such as *Hornibrookella* and *Pokornyella*, or even transitional (brackish or hypersaline) such as *Neocyprideis*. These shallowing events are not clearly evidenced by the faunal composition in the sections of Wadi Tarfa (T2, T1). This is possibly due to the proximal position of the Bir Dakhl area to the carbonate platform in the north. In the Lower Eocene, the difference in the bathymetry between the Bir Dakhl and Wadi Tarfa area is still perceptible. The occurrence of inner shelf taxa represented by *Hornibrookella paramoosae*, *Paragrenocythere cultrata* and *Schizocythere salahii* in the Lower Eocene sections at Bir Dakhl and their absence in the equivalent levels at Wadi Tarfa could be similarly attributed to the relative shallower position of Bir Dakhl area compared with Wadi Tarfa area during the Early Eocene time. Similar assemblages were previously recognized in Egypt by Bassiouni and Luger (1990) and also recorded by Morsi and Speijer (2003). In central and southern Egypt, Bassiouni and Luger (1990) defined a deeper supraregional (Mediterranean) suite of taxa referred to as South Tethyan Type (STT) to which the deeper Paleocene associations at Bir Dakhl and the Paleocene–Lower Eocene associations at Wadi Tarfa can be assigned, and shallower, more regional suits of taxa termed as Esna Type (EST) and Afro-Tethyan Type (ATT) to which the shallow marine associations in the Upper Paleocene as well as the Lower Eocene associations at Bir Dakhl can be assigned. A similar decrease in water depth at the end of the Paleocene is indicated in sections D6 and D8 (Figs. 1 and 3) by benthic foraminifers. During the Paleocene, a mixture of Midway and Velasco-type taxa (e.g. Speijer, 1994) indicates a water depth of about 400–500 m, whereas the dominance of Midway taxa in the latest Paleocene indicates a water depth of about 200 m (Scheibner et al., 2003). The occurrence of EST and ATT taxa on the expense of STT taxa at Bir Dakhl during the Late Paleocene and Early Eocene took place in response to more pronounced paleobathymetric changes. The changes in depth at Wadi Tarfa were probably not enough to afford suitable conditions for the shallow EST and ATT taxa. Besides eustatic sea-level changes, variations in the biotic content along the Southern Galala Mountains are related to varying processes and amounts of uplift and subsidence. The earliest shallowing event observed in the sections of Bir Dakhl at the level equivalent to NP7/NP8 would be related to progradation of the carbonate platform during this time (Scheibner et al., 2003). The later shallowing event induced at the level equivalent to NP9a is an impact of differential subsidence. The differences in subsidence have been attributed to rotational movement along a listric fault located at the northern rim of the Southern Galala that led to an



	Samples \ Species	*Pontocyprella recurva*	*Bairdia ilaroensis*	*Acanthocythereis? denticulata*	*Cytherella sinaensis*	*Spinoleberis* cf. *megiddoensis*	*Ordoniya bulaqensis*	*Ordoniya ordoniya*	*Kefiella galalaensis*	*Ordoniya hasaensis*	*Doricythereis martinii*	*Urocythereis* sp.	*Actinocythereis? coronata*	*Cytherella* sp.1 Honigstein & Rosenfeld	*Reticulina sangalkamensis*	*Krithe echolsae*	*Parakrithe crolifa*	*Reticulina proteros*	*Ordoniya maanensis*	*Paracosta parakefensis*	*Acanthocythereis? posterotriangulata*	*Cytherella* cf. *ventroconcava*	*Soudanella laciniosa triangulata*	*Buntonia jordanica subjordanica*
	T2-62																	1		5				2
	T2-61									2			1					3		2	7			4
	T2-60																			5	2		2	
	T2-59							1					2					1			1		3	
	T2-58												1		1									
	T2-56																					1		
	T2-55												3							1				
	T2-53			1							1		1	2	2			6	4	1	1	1		
	T2-52			1				1			1								3	4	1			
	T2-51													2					1	4				
	T2-50													1	4				4	1				
	T2-49									1					2				4	1	1			
	T2-48			4					1		6							12	4	9				
	T2-47			1							3							10	4	9				
	T2-46																			1				
	T2-45										2			1	4			7	6					
	T2-44									1	2				5				1					
	T2-43			2							4				3				1					
	T2-42			1						3					3									
	T2-41														3		1		2					
	T2-40		2	4							3			2	4		1							
	T2-39		1								1			1					1					
	T2-38		1						1		2			1	3			1	1					
	T2-37		3								1	2			3									
	T2-36		2	2						2	2	1				1								
	T2-35									1	1				1									
	T2-34									3	2			1	3									
	T2-33										1													
	T2-32			1						2	3				2									
	T2-31										2			1	2									
	T2-30									2	1			1	4									
	T2-29								1					1			1							
	T2-28		4	2						1	5			3	3	1	1							
	T2-27		1							1	3				5									
	T2-26			2						1	3		1	1	4									
	T2-25										3			2	1									
	T2-24										3			1	1									
NP9 interval	T2-22			1							2		1											
	T2-20										2													
	T2-18										3													
	T2-17									1														
	T2-13		2																					
	T2-12			1																				
	T2-11										1	1												
	T2-09							2	2		2													
	T2-08				1	1	3	4	1	1														
	T2-07	1	1	2																				

Fig. 11. Stratigraphic distribution of the ostracodes in section T2.
Fig. 11. Répartition stratigraphique des ostracodes dans la coupe T2.

increase in subsidence at the platform margin and uplift at the platform slope (Fig. 13; Scheibner et al., 2003).

7. Paleobiogeography

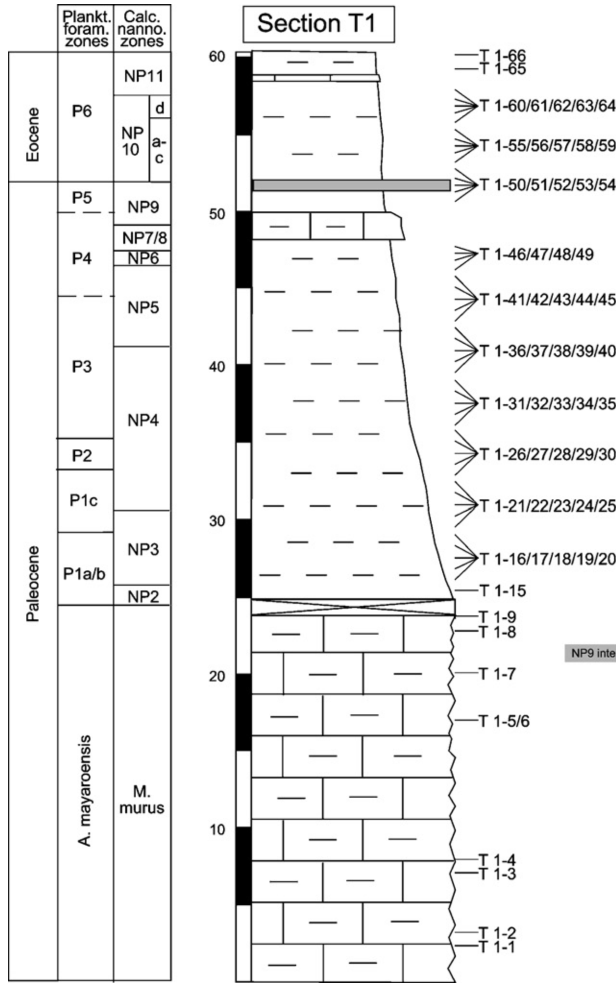
A very comprehensive documentation of the P/E ostracode associations is now available in a large number of publications and can be used for paleogeographic reconstructions in a more regional framework. During the Paleocene–Early Eocene, Egypt was situated in the central part of the well-documented South Tethyan bioprovince which incorporated North Africa and the Middle East. Several important studies concerning the distribution and paleobiogeographic synthesis of ostracodes of this province during this interval have been made (Reyment and Reyment, 1980; Bassiouni and Luger, 1990; Damotte, 1995; Keen et al., 1994; Bassiouni and Morsi, 2000; Elewa, 2002; Luger, 2003; Morsi and Speijer, 2003; Shahin, 2005).

7.1. *Paleogeographic distribution*

Paleogeographic distribution of the Late Paleocene–Early Eocene ostracode species in different countries is listed in Table 2. It shows that many among the large number of taxa recorded in the Paleocene–Lower Eocene successions have a wide geographic distribution along different southern Tethys areas extending from Jordan in the east to Algeria in the west. Many species are also found in different areas in West Africa, and indicate faunal exchange between the South Tethyan Province and the West African basins during this interval.

7.1.1. *Middle East and Saudi Arabia*

Among the ostracode fauna recorded in Middle East countries, 14 species are in common with the present material. Of these, Honigstein and Rosenfeld (1995), Honigstein et al. (1991, 2002) recorded the following 13 species in Israel: *Cytherella* sp. 1 Honigstein and Rosenfeld, 1995, *Bairdia* aff. *septen-*



	Samples \ Species	*Cytherelloidea attiyaensis*	*Ordoniya ordoniya*	*Kefiella galalaensis*	*Doricythereis jordanica nodoreticulata*	*Acanthocythereis? posterotriangulata*	*Bairdia ilaroensis*	*Doricythereis martinii*	*Phacorhabdotus inaequicostatus*	*Cristaeleberis reticulata*	*Actinocythereis? coronata*	*Reticulina sangalkamensis*	*Cytherella* sp.1 Honigstein & Rosenfeld	*Cytherella* cf. *ventroconcava*	*Krithe echolsae*	*Spinoleberis* aff. *megiddoensis*	*Parakrithe crolifa*	*Ordoniya hasaensis*	*Reticulina proteros*	*Acanthocythereis? denticulata*	*Oertliella* sp.	*Bairdia aegyptiaca*	*Abyssocypris? adunca*	*Ordoniya maanensis*	*Paracosta parakefensis*	*Soudanella laciniosa triangulata*
	T1-66												1						4					1		
	T1-65							2											5				1			
	T1-64							1				2							4					3	5	2
	T1-63							2									1							3		
	T1-62						1	2				10	2					2					1			
	T1-61						1	1				2						1								
	T1-60											1						2								
	T1-59				1	1	2	2				17								2						
	T1-58											3	1					3		2						
	T1-57							3				5								1						
	T1-56							3				4	2				1			2						
	T1-55						1	1				2	1					1				1				
	T1-54						2	3				5					1	3			1					
	T1-53					1		5			1	1							2	3						
NP9 interval	T1-52																		1							
	T1-51			2				1																		
	T1-50												1													
	T1-49																		1							
	T1-48						1	1					1													
	T1-47						3											1								
	T1-46		3	6		3						1		2	1	3	1									
	T1-45		2			2	2									3										
	T1-44		2	1		2	3		1	1	3	2	1													
	T1-43	1	4	2	2	4	3	1																		

Fig. 12. Stratigraphic distribution of the ostracodes in section T1.
Fig. 12. Répartition stratigraphique des ostracodes dans la coupe T1.

trionalis, *Krithe echolsae*, *Parakrithe crolifa*, *Actinocythereis*? *coronata*, *Doricythereis martinii*, *Acanthocythereis meslei* cf. *paleocenica*, *Acanthocythereis*? *posterotriangulata*, *Ordoniya bulaqensis*, *Ordoniya hasaensis*, *Ordoniya maanensis*, *Reticulina proteros* and *Phacorhabdotus inaequicostatus*. In Jordan, Bassiouni (1970) recorded nine among the many ostracode taxa he described in common with the present material: *Actinocythereis*? *coronata*, *Doricythereis jordanica nodoreticulata*, *Doricythereis martinii*, *Cristaeleberis reticulata*, *Ordoniya ordoniya*, *Ordoniya hasaensis*, *Ordoniya maanensis*, *Reticulina*

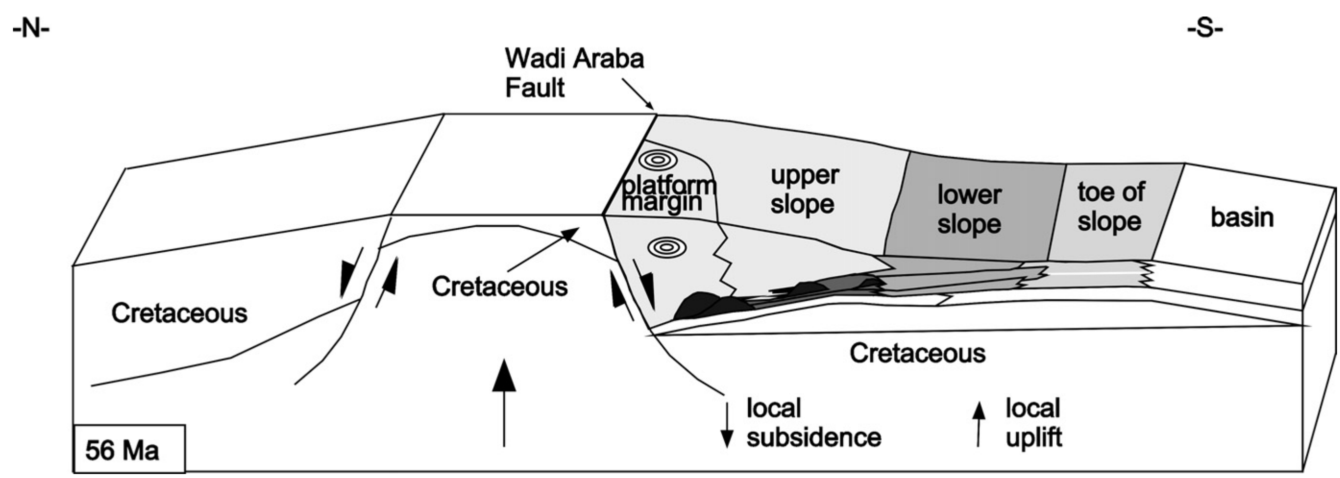


Fig. 13. Tectonic framework that controlled deposition during Paleocene along the Southern Galala Mountains (after Scheibner et al., 2003).
Fig. 13. Situation tectonique contrôlant le dépôt pendant le Paléocène dans les Massifs du Galala Sud (d'après Scheibner et al., 2003).

Table 3
Paleobathymetric distribution of the ostracode species encountered in the Bir Dakhl and Wadi Tarfa areas. Bathymetric assignments are compiled from Donze et al. (1982), Bassiouni and Luger (1990), Morsi (1999), Bassiouni and Morsi (2000), Morsi and Speijer (2003)
Tableau 3
Répartition paléobathymétrique des espèces d'ostracodes trouvées dans les régions de Bir Dakhl et Wadi Tarfa ; interprétations bathymétriques d'après Donze et al. (1982), Bassiouni et Luger (1990), Morsi (1999), Bassiouni et Morsi (2000), Morsi et Speijer (2003).

Bir Dakhl	Wadi Tarfa	Paleobathymetry
Cytherella sinaensis	*Cytherella sinaensis*	Shelf
Cytherella sp. 1 Honigstein & Rosenfeld	*Cytherella* sp. 1 Honig. and Ros.	Shelf
	Cytherelloidea attiyaensis	Shelf
Bairdia aegyptiaca	*Bairdia aegyptiaca*	Inner - outer shelf
Bairdia ilaroensis	*Bairdia ilaroensis*	Inner - outer shelf
Bairdia aff. *septentrionalis*	*Bairdia* aff. *septentrionalis*	Inner - outer shelf
Paracypris aff. *jonesi*		Inner - outer shelf
Abyssocypris? adunca	*Abyssocypris? adunca*	Outer shelf
Pontocyprella recurva	*Pontocyprella recurva*	Outer shelf
Schizocythere salahii		Inner shelf
Krithe echolsae	*Krithe echolsae*	Outer shelf
Parakrithe crolifa	*Parakrithe crolifa*	Inner - outer shelf
Hornibrookella paramoosae		Inner shelf
Isalocopocythere teiskotensis		Inner shelf
Paragrenocythere cultrata		Inner shelf
Acanthocythereis? *denticulata*	*Acanthocythereis*? *denticulata*	Outer shelf
Acanthocythereis? posterotriangulata	*Acanthocythereis? posterotriangulata*	Outer shelf
Actinocythereis? *coronata*	*Actinocythereis*? *coronata*	Outer shelf - upper bathyal
	Cristaeleberis reticulata	Middle-outer shelf
Doricythereis jordanica nodoreticulata	*Doricythereis jordanica nodoreticulata*	Outer shelf - upper bathyal
Doricythereis martinii	*Doricythereis martinii*	Outer shelf - upper bathyal
Ordoniya ordoniya	*Ordoniya ordoniya*	Outer shelf
Ordoniya bulaqensis	*Ordoniya bulaqensis*	Outer shelf
Ordoniya hasaensis	*Ordoniya hasaensis*	Outer shelf
Ordoniya maanensis	*Ordoniya maanensis*	Outer shelf
Paracosta parakefensis	*Paracosta parakefensis*	Outer shelf
Reticulina proteros	*Reticulina proteros*	Middle shelf - upper bathyal
Reticulina sangalkamensis	*Reticulina sangalkamensis*	Middle - outer shelf
Phacorhabdotus inaequicostatus	*Phacorhabdotus inaequicostatus*	Outer shelf-upper bathyal
Buntonia jordanica subjordanica	*Buntonia jordanica subjordanica*	Shelf
Soudanella laciniosa triangulata	*Soudanella laciniosa triangulata*	Outer shelf
Xestoleberis tunisiensis		Inner - outer shelf

proteros and *Soudanella laciniosa triangulata*. From Saudi Arabia, Al-Furaih (1980) reported a large number of ostracode species of which only *Isalocopocythere teiskotensis* has been found in the present area.

7.1.2. North Africa

Among the ostracode fauna found in the present study area, 17 species were also previously reported in other North African countries. In Libya, eight species in common with the present area were previously recorded by Barsotti (1963), Salahi (1966), El-Waer (1992) and Keen et al. (1994). These species are *Bairdia ilaroensis*, *Paracypris* aff. *jonesi*, *Pontocyprella recurva*, *Isalocopocythere teiskotensis*, *Paragrenocythere cultrata*, *Actinocythereis*? *coronata*, *Schizocythere salahii* and *Soudanella laciniosa triangulata*. In Tunisia, thirteen among the ostracode taxa described by Esker (1968), Donze et al. (1982) and Said-Benzarti (1998) are also recorded in the present study area: *Abyssocybris*? *adunca*, *Paracypris* aff. *jonesi*, *Pontocyprella recurva*, *Krithe echolsae*, *Actinocythereis*? *coronata*, *Acanthocythereis*? *denticulata*, *Doricythereis jordanica nodoreticulata*, *Ordoniya ordoniya*, *Reticulina proteros*, *Phacorhabdotus inaequicostatus*, *Buntonia jordanica subjordanica*, *Soudanella laciniosa triangulata* and *Xestoleberis tunisiensis*. From these, Damotte and Fleury (1987) recorded *Abyssocybris*? *adunca*, *Pontocyprella recurva*, *Actinocythereis*? *coronata*, *Acanthocythereis*? *denticulata*, *Reticulina proteros* and *Xestoleberis tunisiensis* also in east Algeria.

7.1.3. West Africa

Among the species recorded in the present study area, six species (*Bairdia ilaroensis*, *Parakrithe crolifa*, *Isalocopocythere teiskotensis*, *Paragrenocythere cultrata*, *Reticulina sangalkamensis* and *Soudanella laciniosa triangulata*) were reported from West African basins (Table 2). Of these, three species (*Bairdia ilaroensis*, *Isalocopocythere teiskotensis* and *Paragrenocythere cultrata*) were recorded in internal basins (Mali, Niger, Chad, NW Nigeria) as well as coastal basins (Senegal, Ghana, Ivory Coast, Togo, Benin and SW Nigeria). One species, Parakrithe crolifa, was reported only from the internal basins while two species, *Reticulina sangalkamensis* and *Soudanella laciniosa triangulata*, were reported only in the coastal basins. Of the fore mentioned taxa, *Isalocopocythere teiskotensis* and *Paragrenocythere cultrata* belong to the shallow (epineritic) Afro-Tethyan Type (ATT) which Bassiouni and Luger (1990) proposed for marine ostracode associations recorded in southern Egypt, while *Reticulina sangalkamensis* and *Soudanella laciniosa triangulata* were assigned to the deeper (outer to middle neritic) Esna Type (EST).

7.1.4. South America

Forms similar to *Soudanella laciniosa triangulata* were reported from Brazil (Neufville, 1973; Stinnesbeck and Reyment, 1988; Fauth et al., 2005). In Argentina, Bertels (1969) noted species of *Soudanella* and *Anticythereis* which were considered to have affinities with West African forms.

7.2. Paleobiogeographic implications

The above outlined paleobiogeographic distribution as well as records in previous studies implicate and support several points concerning the relationships and affinities of the Egyptian ostracode fauna with other regions during the Paleocene–Early Eocene:

- During the Paleocene–Early Eocene, Egypt was a part of the South Tethyan bioprovince which stretched along an east–west transect in North Africa and the Middle East. Along this province, the geography of the shorelines facilitated east–west migrations.
- Although Saudi Arabia is situated in the neighbourhoods and the ostracode faunal assemblages recorded there by Al-Furaih (1980) exhibit similarities at the generic level expressed by the occurrence of *Hornibrookella*, *Isalocopocythere* and *Paragrenocythere*, much less similarity is pronounced at the species level. Among the present recorded fauna, only *Isalocopocythere teiskotensis* was previously recorded in Saudi Arabia. Bassiouni and Luger (1990) attributed the dissimilarity to biostratigraphical reasons.
- The recorded ostracode fauna of this interval are different from the fauna recorded on the northern Tethys side. This dissimilarity was also noted by many authors (e.g. Keen et al., 1994; Morsi, 1999; Morsi and Speijer, 2003). As explained by Babinot (1988) and Babinot and Colin (1988), this may be owing to depth which stood as a barrier to exchange of continental shelf ostracode species between the North and South Tethyan bioprovinces as they are mostly benthic organisms which lack pelagic larva.
- The taxa in common with the basins of West African basins include two kinds: shallow marine species belonging to the shallow, epineritic Afro-Tethyan Type (ATT) of Bassiouni and Luger (1990), and species which they assigned to the deeper, outer to middle neritic Esna Type (EST).
- The epineritic species including *Isalocopocythere teiskotensis* and *Paragrenocythere cultrata* migrated to the southern entities of the Tethys northward via the shallow Trans-Saharan seaway (Barsotti, 1963; Reyment and Reyment, 1980; Bassiouni and Luger, 1990; Carbonnel et al., 1990; Keen et al., 1994; Morsi, 1999; Bassiouni and Morsi, 2000; Morsi and Speijer, 2003).
- The predominantly deeper dwelling ostracodes like *Reticulina sangalkamensis* and *Soudanella laciniosa triangulata* possibly migrated northward around the West African Coast (Bassiouni and Luger, 1990).
- Affinities of the present ostracode fauna with Paleocene–Early Eocene South American ostracode fauna are weakly pronounced and represented only by the occurrence of forms related to *Soudanella laciniosa triangulata* which Neufville (1973) and Stinnesbeck and Reyment (1988) recorded in the Paleocene of Brazil.

8. Conclusions

Taxonomic study of the ostracode faunas retrieved from nine stratigraphic sections spanning the Paleocene–Early Eocene interval from a platform–basin transect in the Southern Galala Plateau area (Eastern Desert, Egypt) yielded 60 species and subspecies assigned to 39 genera. Five species are new, *Paracypris birdakhlensis*, *Hornibrookella paramoosae*, *Hornibrookella speijeri*, *Kefiella galalaensis* and *Pokornyella pseudotriangularis*. The effect of the P/E boundary event on the recorded ostracode fauna is delineated by the first appearance of new taxa more than by extinctions. Only two taxa, *Isalocopocythere teiskotensis* and *Cristaeleberis reticulata*, are restricted to the Paleocene. On the other side, seven taxa, *Acanthocythereis meslei* cf. *paleocenica*, *Bairdia aegyptiaca*, *Buntonia jordanica subjordanica, Hornibrookella paramoosae*, *Monoceratina reticulata*, *Paragrenocythere cultrata* and *Schizocythere salahii* do not occur below the uppermost part of the *velascoensis* zone (subzone P5b), neither in the present study nor anywhere else in Egypt. Besides eustatic sea-level changes, variations in the biotic content along the Southern Galala plateau are related to varying processes and amounts of uplift and subsidence. During the Early and early Late Paleocene, the ostracode associations throughout the study area are largely homogenous, being dominated by middle-outer neritic associations. During the late Late Paleocene and Early Eocene, changes in the paleobathymetry from deeper marine environment in the distal area at Wadi Tarfa in the south to shallower marine environment in the proximal area at Bir Dakhl in the north are pronounced. In the late Late Paleocene, two shallowing events are observed at Bir Dakhl in the north: an event at the level equivalent to NP7/NP8 related to progradation of the carbonate platform during this time (Scheibner et al., 2003), and a later event induced at the level aquivalent to NP9a as an impact of differential subsidence. The differences in subsidence is attributed to rotational movement along a listric fault located at the northern rim of the Southern Galala that led to an increase in subsidence at the platform margin and uplift at the platform slope (Scheibner et al., 2003). These shallowing events are not clearly evidenced by the faunal composition in the south at Wadi Tarfa, possibly due to the distal position of this area from the carbonate platform in the north. In the Early Eocene, the difference in the bathymetry between the Bir Dakhl and Wadi Tarfa area is still perceptible by the occurrence of *Hornibrookella paramoosae*, *Paragrenocythere cultrata* and *Schizocythere salahii* in the at Bir Dakhl and their absence in the equivalent levels at Wadi Tarfa. Paleobiogeographically, many of the recorded taxa have a wide geographic distribution throughout the Middle East and North

Africa, which are assigned to the South Tethyan bioprovince. Similarities with internal and coastal basins of West Africa are also confirmed, reflecting faunal exchange between this area and Southern Tethys during the Paleocene and Early Eocene.

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