

# Maastrichtian-paleogene benthic foraminifera from the Middle East and its distribution in the Tethys, a review

## Abstract

One hundred and nineteen hyaline benthic foraminiferal species and subspecies belonging to fifty seven genera are originally erected from the Maastrichtian and early Paleogene rocks of six countries in the Middle East which include countries like Egypt, Jordan, Saudi Arabia, Qatar, United Arab Emirates (UAE) and Pakistan. Some of these species are also found in other places like Libya, Tunisia, Nigeria, France, Spain, Arabian Sea, Atlantic Ocean. The present study deals with paleontology, stratigraphy, paleogeography and paleoecology of these taxa in the Middle East and other Tethyan Localities.

**Keywords:** paleogene, calcareous benthic foraminifera, Middle East, Tethys

Volume 7 Issue 6 - 2019

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**Received:** July 16, 2019 | **Published:** November 11, 2019

## Introduction

The present paper aims to highlight the paleontology, stratigraphy paleogeography, paleoecology and biogeography of the 119 Maastrichtian-early Paleogene calcareous benthic foraminiferal species and subspecies which were originally erected by many authors from six Middle East countries (Maps 1 & 2): (1) Egypt: Nakkady,<sup>1-3</sup> LeRoy,<sup>4</sup> Said & Kenawy,<sup>5</sup> Abdou & Abdel Kireem,<sup>6</sup> Anan,<sup>7-27</sup> Aly et al.,<sup>28</sup> (2) Jordan: Futyan,<sup>29</sup> (3) Saudi Arabia: Hasson<sup>30</sup> (4) Qatar: Hewaidy & Al-Hitmi<sup>31</sup> (5) UAE: Anan<sup>32-37</sup> and (6) Pakistan: Haque,<sup>38-40</sup> Nomura & Brohi,<sup>41</sup> and many studies are recorded some of these taxa in a wider geographic areas in the Tethys, from Atlantic to Indian Oceans via Mediterranean (Map 3).



**Map 1** Map of the six Middle East countries, from west to east: Egypt, Jordan, Saudi Arabia, Qatar, United Arab Emirates (UAE) and Pakistan.



**Map 2** Map of the five Arab Middle East countries with the locations of some diagnostic studied sections, which some species were erected: **Egypt** (1. Sinai, 2. El Sheikh Fadl, Mellaha, Wadi EdDakhl sections, 3. Fayoum, 4. Maqfi section (Farafra area), 5. Duwi section, 6. Luxor section), **Jordan** (7. Tell Burma section, 8. Wadi Arab section), **Saudi Arabia** (9. Rub' al Khali Basin), **Qatar** (10. Dukhan oil field), **United Arab Emirates, UAE** (11. Jabal Haft, J. Malaqet).

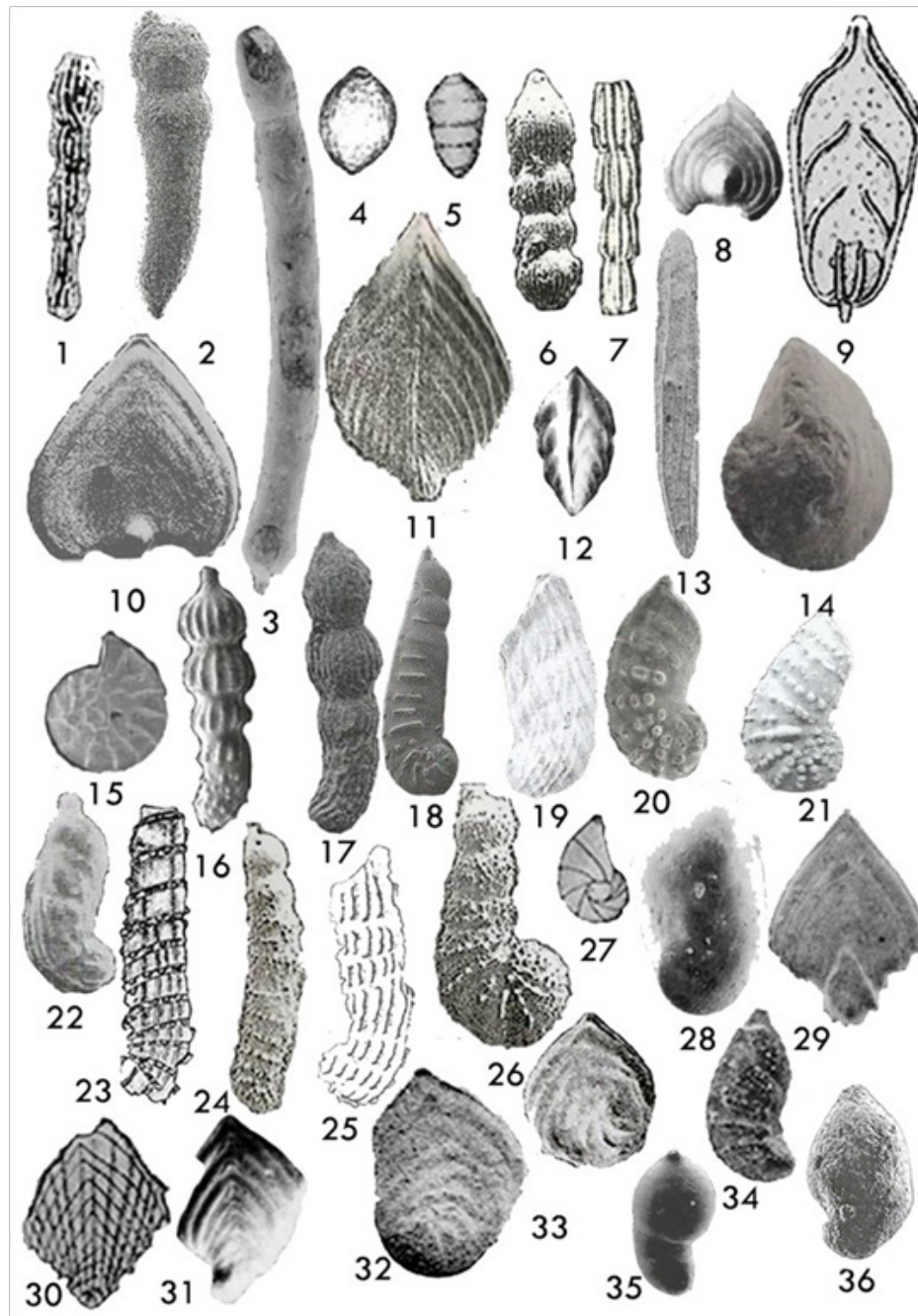


**Map 3** Paleogeographic map of the Early Paleogene (particularly Middle Eocene) including the location of the Middle East (Egypt and Arabia), after.

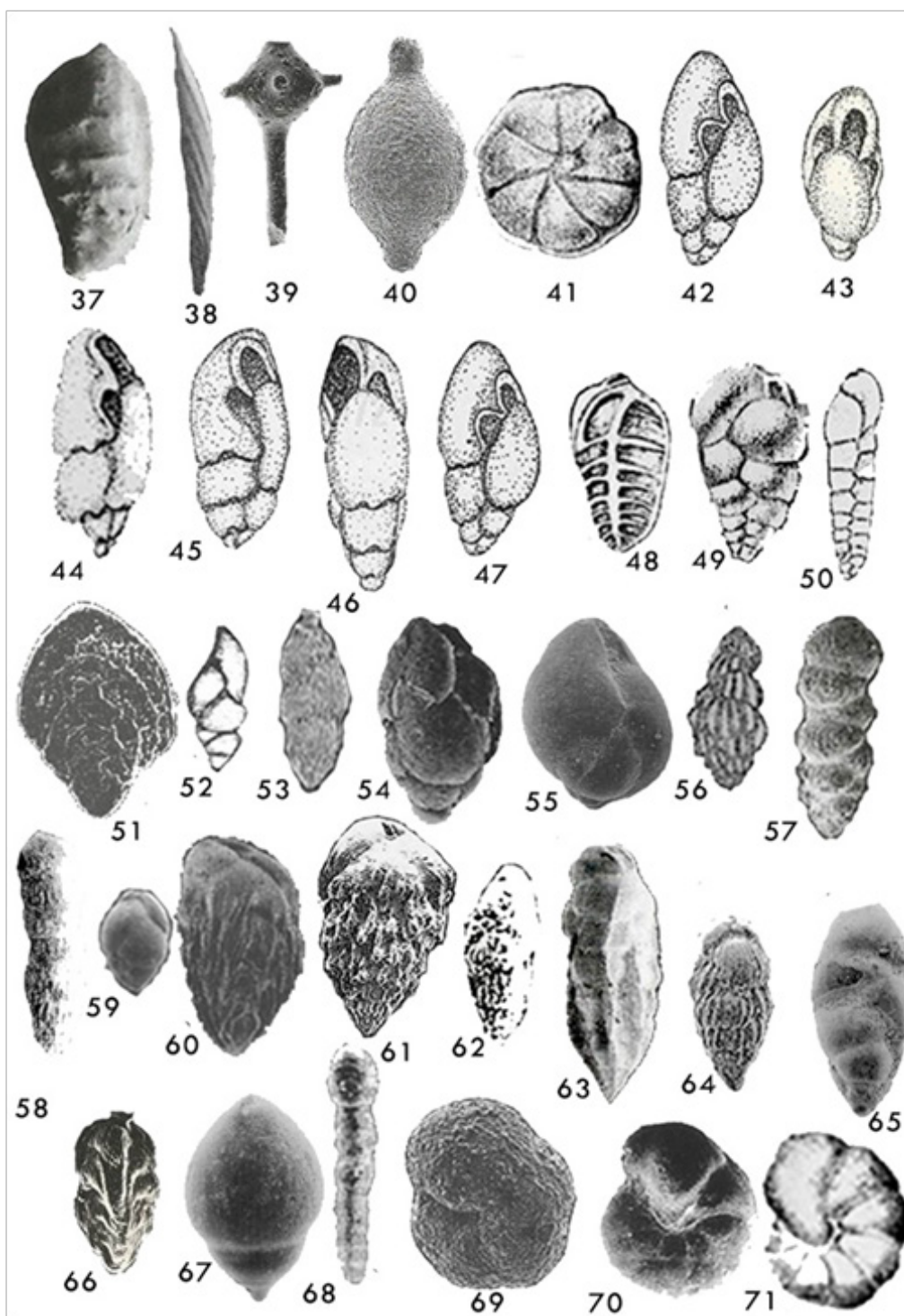
### Systematic paleontology

The taxonomy of Loeblich & Tappan<sup>42</sup> is followed here. One hundred and nineteen of the erected Maastrichtian and/or Paleogene

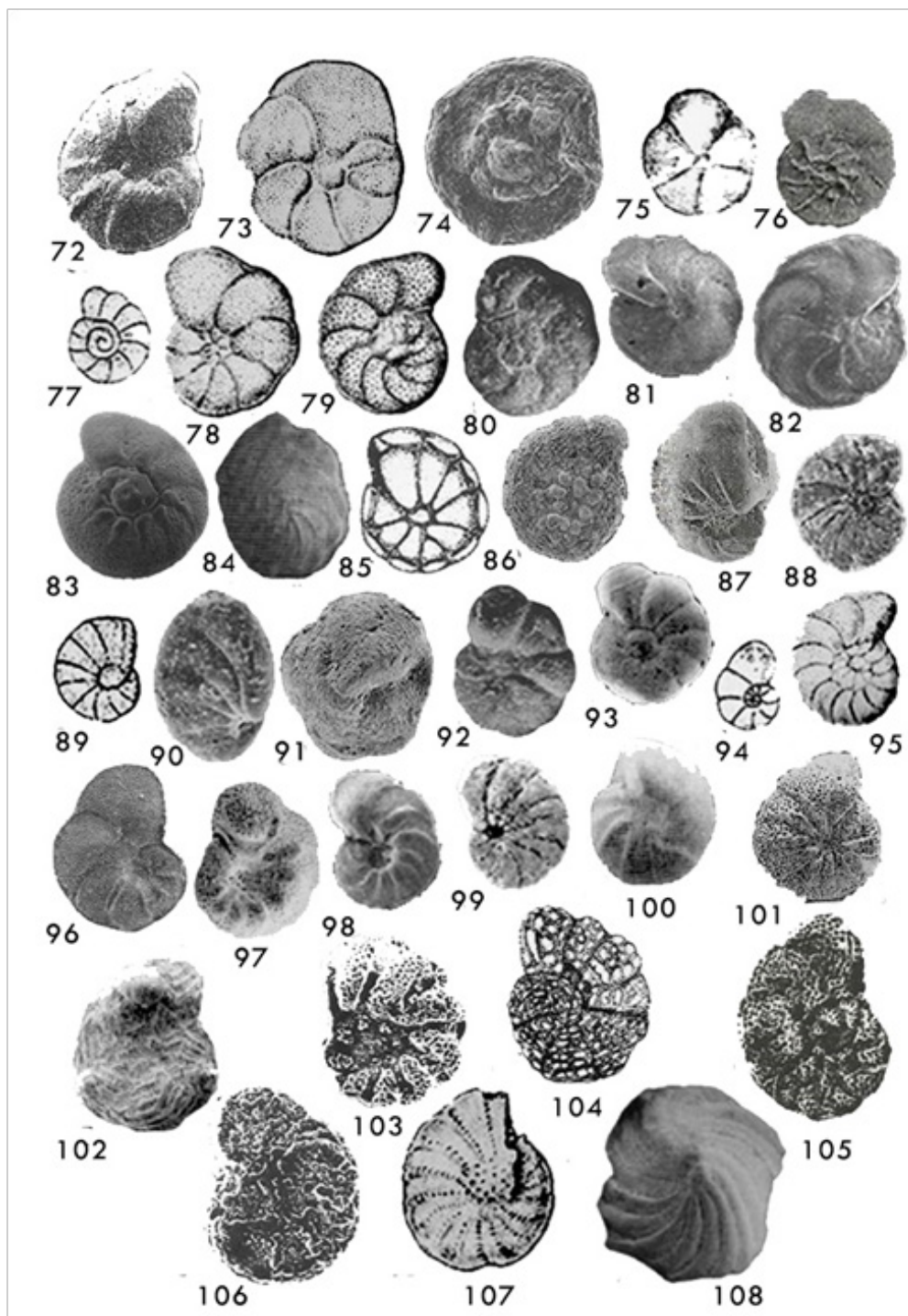
small benthic foraminiferal species and subspecies from six Middle East countries are illustrated in the Plates (1-3). The stratigraphic value of it is important in the paleobiogeographic correlations in the these countries and also some other Tethyan localities.



**Plate I Fig. 1)** *Dentalina Tappanae* (Said & Kenawy, 1956) x 35, **2)** *Laevidentalina hudaie* Anan, 2015 x 70, **3)** *L. salimi* Anan, 2009 x 50, **4)** *Pseudonodosaria bulla* (Said & Kenawy, 1956) x 35, **5)** *P. synaensis* (Ansary, 1954) x 50, **6)** *Pyramidulina robinsoni* (Futyán, 1976) x 75, **7)** *P. semispinosa* (LeRoy, 1953) x 40, **8)** *Frondicularia bignoti* Anan, 2002 x 50, **9)** *F. esnehensis* Nakkady, 1950 x 60, **10)** *F. nakkadyi* Futyán, 1976 x 25, **11)** *Frondicularia pickeringi* Futyán, 1976 x 45, **12)** *Tristix aubertae* Anan, 2002 x 30, **13)** *Amphimorphina youssefi* Anan, 1994 x 50, **14)** *Lenticulina ennakhali* Anan, 2010 x 50, **15)** *L. trompi* (Ansary, 1954) x 50, **16)** *Marginulinopsis hewaidyi* Aly, 2011 x 40, **17)** *M. karimae* Anan, 2009 x 40, **18)** *Percultazonaria abunnasri* Anan, 2015 x 140, **19)** *P. alii* Anan, 2015 x 50, **20)** *P. allami* Anan, 2015 x 60, **21)** *P. ameeri* Anan, 2015 x 30, **22)** *P. carri* (LeRoy, 1953) x 45, **23)** *P. intercostata* (Nakkady, 1950) x 40, **24)** *P. jordanensis* (Futyán, 1976) x 30, **25)** *P. longiscata* (Nakkady, 1950) x 25, **26)** *P. wadiarabensis* Futyán, 1976 x 35, **27)** *Saracenaria barnardi* Ansary, 1954 x 40, **28)** *S. leroyi* Anan, 1994 x 35, **29)** *Palmula ansaryi* Anan, 1994 x 25, **30)** *P. gahannamensis* (Ansary, 1954) x 50, **31)** *P. salimi* Anan, 2002 x 55, **32)** *P. undulata* Nakkady, 1950 x 40, **33)** *P. woodi* Nakkady, 1950 x 25, **34)** *Astacolus bifurcatus* LeRoy, 1953 x 40, **35)** *Hemirobulina bassiounii* Anan, 1994 x 50, **36)** *H. olae* Anan, 2015 x 40.



**Plate 2 Fig. 37)** *Vaginulinopsis boukharyi* Anan, 2010 × 45, **38)** *Citharina plummerae* Anan, 2001 × 50 **39)** *Ramulina elkhoudaryi* Anan, 2002 × 30, **40)** *R. futyani* Anan, 2015 × 70, **41)** *Höglundina esnaensis* (LeRoy, 1953) × 50, **42)** *Altistoma aegyptiaca* Abdou & Abdel Kireem, 1975 × 35, **43)** *A. compressa* Abdou & Abdel Kireem, 1975 × 30, **44)** *A. eocaenica* Abdou & Abdel Kireem, 1975 × 30, **45)** *A. fayoumensis* Abdou & Abdel Kireem, 1975 × 35, **46)** *A. megaapertura* Abdou & Abdel Kireem, 1975 × 35, **47)** *A. rayana* Abdou & Abdel Kireem, 1975 × 35, **48)** *Bolivina esnehensis* Nakkady, 1950 × 25, **49)** *B. daniana* Nakkady & Talaat, 1959 × 200, **50)** *B. woodi* Nakkady, 1950 × 75, **51)** *Aragonia semireticulata* (LeRoy, 1953) × 75, **52)** *Eouvigerina hofkeri* Said and Kenawy, 1956 × 110, **53)** *E. maqfensis* (LeRoy, 1953) × 75, **54)** *Neobulimina farafraensis* LeRoy, 1953 × 75, **55)** *Turrilina hassani* Anan, 2010 × 50, **56)** *Hopkinsina aegyptiaca* Ansary, 1954 × 50, **57)** *Orthokarstenia higazyi* (Nakkady, 1955) × 50, **58)** *O. nakkadyi* Anan, 2009 × 50, **59)** *Bulimina esnaensis* LeRoy, 1953 × 60, **60)** *B. farafraensis* LeRoy, 1953 × 80, **61)** *B. leroyi* Futyan, 1976 × 130, **62)** *B. misrensis* Ansary, 1954 × 90, **63)** *B. zikoi* Helal, 2002 × 150, **64)** *Uvigerina compressa* Ansary, 1954 × 70, **65)** *Uvigerinella nakkadyi* Anan, 1994 × 50, **66)** *Trifarina esnaensis* LeRoy, 1953 × 60, **67)** *Ellipsogladulina arafati* Anan, 2009 × 40, **68)** *Nodosarella minuta* Said & Kenawy, 1956 × 110, **69)** *Baggina eocaenica* Hewaidy & Al-Hitmi, 1994 × 100, **70)** *Valvulineria aegyptiaca* LeRoy, 1953 × 50, **71)** *V. critchettii* LeRoy, 1953 × 65.



**Plate 3** Fig.72) *Valvulineria pseudotumeyensis* Futyan, 1976 x75, 73) *Trochulina aegyptiaca* (LeRoy, 1953) x 40, 74) *T. lenticularis* Hewaidy and Al-Hitmi, 1994 x130, 75) *Eponides mariei* Said & Kenawy, 1956 x 50, 76) *Neoeponides duwi* (Nakkady, 1950) x 65, 77) *Cibicoides loeblichii* (Said & Kenawy, 1956) x 45, 78) *C. beadnelli* (LeRoy, 1953) x 50, 79) *C. decoratus* (LeRoy, 1953) x 50, 80) *C. farafraensis* (LeRoy, 1953) x 50, 81) *C. libycus* (LeRoy, 1953) x 50, 82) *C. pharaonis* (LeRoy, 1953) x 50, 83) *C. pseudoacutus* (Nakkady, 1950) x 60, 84) *Planulina berggreni* Anan, 2001 x 75, 85) *Epistomaria saudica* Hasson, 1985, x 130, 86) *Epistomaroides qatarica* Hewaidy & Al-Hitmi, 1994, x 130, 87) *Nonion fayoumensis* Ansary, 1954 x 60, 88) *N. maadiensis* Ansary, 1954 x 60, 89) *N. trompi* Ansary, 1954 x 60, 90) *Nonionella africana* LeRoy, 1953 x 50, 91) *Alabama cavellieri* Hewaidy & Al-Hitmi, 1994 x 150, 92) *Osangularia desertorum* (LeRoy, 1953) x 50, 93) *Anomalinoidea aegyptiacus* (LeRoy, 1953) x 50, 94) *A. esnehensis* (Nakkady, 1950) 60, 95) *A. desertorum* (LeRoy, 1953) x 55, 96) *A. fayoumensis* (Ansary, 1954) x 60, 97) *A. leroyi* Anan, 2008 x 55, 98) *A. zitteli* (LeRoy, 1953) x 55, 99) *Gyroidinoides aegyptiaca* (Ansary, 1954) x150, 100) *G. luterbacheri* Anan, 2004 x50, 101) *Angulogavelinella bandata* Futyan, 1976 x 65, 102) *Ornatonomalina ennakhali* Anan, 2011 x50, 103) *O. inflata* (Hasson, 1985) x75, 104) *O. ornata* (Hasson, 1985) x40, 105) *O. porosa* (Hasson, 1985) x70, 106) *O. rugosa* (Hasson, 1985) x 100, 107) *Elphidiella africana* (LeRoy, 1953) x55, 108) *Elphidium cherifi* Anan, 2010 x100.

Order Foraminiferida Eichwald, 1830

Suborder Lagenina Delage and Hérouard, 1896

Superfamily Nodosariacea Ehrenberg,<sup>43</sup>

Family Nodosariidae Ehrenberg,<sup>43</sup>

Subfamily Nodosariinae Ehrenberg,<sup>43</sup>

Genus *Dentalina* Risso,<sup>44</sup>

Type species *Nodosaria cuvieri* d'Orbigny,<sup>45</sup>

***Dentalina tappanae* (Said & Kenawy<sup>5</sup>)** (Pl. 1, fig. 1)

1956 *Chrysalogonium tappanae* Said & Kenawy,<sup>5</sup> p. 134, pl. 3, fig. 10.

2003 *Chrysalogonium tappanae*; Ali,<sup>46</sup> p. 119, pl. 7, fig. 6.

2011 *Dentalina tappanae*; Anan,<sup>17</sup> p. 17, pl. 1, fig. 10.

Remarks: The genus *Dentalina* has an elongated arcuate test with twenty longitudinal ribs. According to Anan,<sup>17</sup> this species belongs to the *Dentalina*. This species was recorded in Paleocene of Sinai and southern Egypt, as well as the Maastrichtian of Wadi Ed Dakhli section, west Gulf of Suez, Egypt.

Genus *Laevidentalina* Loeblich & Tappan,<sup>47</sup>

Type species *Laevidentalina aphelis* Loeblich & Tappan,<sup>48</sup>

***Laevidentalina hudaе* Anan<sup>37</sup>** (Pl. 1, fig. 2)

2015b *Laevidentalina hudaе* Anan,<sup>37</sup> p. 65, pl. 1, fig. 1.

Remarks: The Selandian species has apiculate proloculus, more widely cylindrical, less arcuate and ended by only two globular chambers than three or more semiglobular chambers. The middle-late Eocene *L. salimi* Anan<sup>34</sup> (p. 3, pl. 1, fig. 2) from Jabal Hafit (UAE) has more elongated test and less number of globular last two chambers than *L. hudaе*. *L. salimi* may be evolved from the Selandian *L. hudaе*. It was recorded from the Paleocene of J. Mundassa, UAE.

***Laevidentalina salimi* Anan<sup>34</sup>** (Pl. 1, fig. 3)

2009a *Laevidentalina salimi* Anan,<sup>34</sup> p. 3, pl. 1, fig. 2.

2011 *Laevidentalina salimi*; Anan,<sup>17</sup> p. 55, pl. 1, fig. 11.

Remarks: The Eocene species has an elongated, arcuate test with almost parallel sides, proloculus rounded and apiculate, wall hyaline with smooth surface, chambers nearly cylindrical and gradually grow, sutures flush limbate in the most uniserial chambers but slightly depressed in the last chambers. It was described from J. Hafit, UAE.

Genus *Pseudonodosaria* Boomgaard,<sup>49</sup>

Type species *Glandulina discreta* Reuss,<sup>50</sup> 1850

***Pseudonodosaria bulla* (Said & Kenawy<sup>5</sup>)** (Pl. 1, fig. 4)

1956 *Rectoglandulina bulla* Said & Kenawy,<sup>5</sup> p. 134, pl. 3, fig. 13.

Remarks: Loeblich & Tappan<sup>42</sup> noted that the genus *Pseudonodosaria* is considered as a senior synonym of genus *Rectoglandulina* Loeblich & Tappan.<sup>49</sup> This species was recorded from the Paleocene of Sinai, Egypt.

***Pseudonodosaria synaensis* (Ansary<sup>51</sup>)** (Pl. 1, fig. 5)

1954 *Pseudoglandulina synaensis* Ansary,<sup>51</sup> p. 313, pl. 1, fig. 14.

2013a *Pseudonodosaria synaensis*; Anan,<sup>20</sup> p. 51, pl. 1, fig. 1.

Remarks: The description of this Eocene species falls within the range of the genus *Pseudonodosaria* (Loeblich & Tappan)<sup>42</sup>. It was described from the Eocene of Sinai. It is, so far, an endemic species in Egypt.

Genus *Pyramidulina* Fornasini,<sup>52</sup>

Type species *Pyramidulina eptagona* Fornasini,<sup>52</sup>

***Pyramidulina robinsoni* (Futyan<sup>29</sup>)** (Pl. 1, fig. 6)

1976 *Nodosaria robinsoni* Futyan,<sup>29</sup> p. 525, pl. 82, figs. 5, 6.

Remarks: Loeblich & Tappan<sup>42</sup> noted that the genus *Pyramidulina* Fornasini has distinct longitudinal costae, with unornamented surface in the genus *Nodosaria* Lamarck. This Paleocene species has uniserial test with inflated chambers covered by 22-24 closed spaced fine longitudinal ribs, which become obsolete on the upper half of the last chamber. *P. robinsoni* differs from *N. limbata* d'Orbigny in having fine and distinct longitudinal ribs. It was described from Middle Paleocene of Tell Burma section, S. Jordan.

***Pyramidulina semispinosa* (LeRoy<sup>4</sup>)** (Pl. 1, fig. 7)

1953 *Nodosaria semispinosa* LeRoy,<sup>4</sup> p. 41, pl. 4, fig. 10.

2001 *Pyramidulina semispinosa*; Hewaidy & Strougo,<sup>53</sup> p. 15, pl. 1, fig. 19.

2008 *Pyramidulina semispinosa*; Anan,<sup>13</sup> p. 362.

Remarks: The early Eocene *P. semispinosa* was recorded only from Egypt.

Subfamily Frondiculariinae Reuss,<sup>54</sup>

Genus *Fronicularia* Defrance,<sup>55</sup>

Type species *Renulina complanata* Defrance,<sup>56</sup>

***Fronicularia bignoti* Anan<sup>10</sup>** (Pl. 1, fig. 8)

2002a *Fronicularia bignoti* Anan,<sup>10</sup> p. 632, fig. 2. 2.

2003 *Palmula* sp. Ali,<sup>45</sup> pl. 6, fig. 17.

2011 *Fronicularia bignoti*; Anan,<sup>17</sup> p. 55, pl. 1, fig. 12.

Remarks: This Paleocene-early Eocene species has large proloculus surrounded by four to five uniserial chevron-shaped chambers, and the first one of them completely surrounding the proloculus, smooth surface, and terminal protruding aperture. It differs from *F. nakkadyi* (Futyan) in having lesser number in chambers, which have four to five in *F. bignoti* than ten to thirteen in Futyan's species with its limbate flush sutures, and without two to three faint longitudinal ribs confined to the initial part of test in the latter species. It was recorded from the Paleocene of Duwi section, later from the early Eocene of southern Nile Valley sections, west Aswan, Egypt.

***Fronicularia esnehensis* Nakkady<sup>1</sup>** (Pl. 1, fig. 9)

1950 *Fronicularia esnehensis* Nakkady,<sup>1</sup> p. 685, pl. 89, fig. 23.

2012 *Fronicularia esnehensis*; Ismail,<sup>57</sup> p. 32, pl. 2, fig. 1.

Remarks: This species was recorded from the basal Esna shales (Paleocene) of Abu Durba section (south west Sinai), and Maastrichtian-Paleocene rocks of Esh El Mallaha section, west Gulf of Suez. It is, so far, an endemic to Egypt.

***Frondicularia nakkadyi* Futyan<sup>29</sup>** (Pl. 1, fig.10)

- 1976 *Frondicularia nakkadyi* Futyan,<sup>29</sup> p. 528, pl. 82, fig. 1.  
1985 *Frondicularia nakkadyi*; Luger,<sup>58</sup> p. 80, pl.4, fig. 3.  
2002a *Frondicularia nakkadyi*; Anan,<sup>10</sup> p. 633, fig. 2.4.  
2012 *Frondicularia nakkadyi*; Youssef & Taha,<sup>59</sup> pl. 3, fig.10.

Remarks: This species is distinguished by its large, flat, palmate test with smooth surface, but differs from the Paleocene *F. phosphatica* Russo in its lacking the central raised ridge which extends from proloculus to the aperture. It was described from Late Paleocene of Jordan, and from Maastrichtian-early Eocene of Egypt.

***Frondicularia pickeringi* Futyan<sup>29</sup>** (Pl. 1, fig.11)

- 1976 *Frondicularia pickeringi* Futyan,<sup>29</sup> p. 526, pl. 82, fig. 2.

Remarks: The Paleocene species has large, much compressed test distinctly rhomboidal in outline, periphery truncate in upper half of test, irregular with thin scattered transparent keel in lower half. Initial portion ornamented by two to five fine ribs which in some specimens extends towards the aperture. It was described from the late Paleocene at Tell Burma, S. Jordan.

Genus *Tristix* Mac Fayden,<sup>60</sup>

Type species *Rabdogonium liasinum*, Berthelin<sup>61</sup>

***Tristix aubertae* Anan<sup>10</sup>** (Pl. 1, fig.12)

- 2002a *Tristix auberti* Anan,<sup>10</sup> p. 634, fig. 2. 6.  
2011 *Tristix aubertae*; Anan,<sup>17</sup> p. 55, pl. 1, fig. 13.

Remarks: This species has triangular test face, flattened, concave triangular chambers and acute periphery. It was originally described from the Danian of Duwi section, Egypt. The Tunisian form is identical with Egyptian form.

Subfamily Plectofrondiculariinae Cushman,<sup>62</sup>

Genus *Amphimorphina* Neugeboren,<sup>63</sup>

Type species *Amphimorphina haueriana* Neugeboren,<sup>63</sup>

***Amphimorphina youssefi* Anan<sup>7</sup>** (Pl. 1, fig.13)

- 1994 *Amphimorphina youssefi* Anan,<sup>7</sup> p. 220, fig. 8. 7.  
2011 *Amphimorphina youssefi*; Anan,<sup>17</sup> p. 56, pl. 2, fig. 14.

Remarks: The species has an elongate test, early portion frondicularian but nodosarian and semi-circular in the later part, sutures slightly arched in early part, but straight and horizontal at later part, periphery sharply keeled with three keels on either sides running at the whole length of the test, two supplementary raised costae are recognized in the early part on either side, aperture terminal and rounded. *A. youssefi* was described from the middle Eocene of Fayoum (Egypt), and later from the late Eocene of J. Malaqet (UAE).

Family Vaginulindae Reuss,<sup>64</sup>

Subfamily Lenticulininae Chapman, Parr & Collins,<sup>65</sup> 1934

Genus *Lenticulina* Lamarck,<sup>66</sup>

Type species *Lenticulina rotulatus* Lamarck,<sup>66</sup>

***Lenticulina ennakhali* Anan<sup>36</sup>** (Pl. 1, fig.14)

- 2010c *Lenticulina ennakhali* Anan,<sup>36</sup> p. 20, fig. 2.

- 2011 *Lenticulina ennakhali*; Anan,<sup>17</sup> p. 56, pl. 2, fig. 14.

Remarks: The most outstanding characteristics of the Paleocene-early Eocene *L. ennakhali* when compared to other species of *Lenticulina* are the tapering last chamber in an elongate test ( $l/b=1.33$ ), flush sutures and sharp periphery with faint keel. *L. ennakhali* was described from Dakhla Shale of Abu Zenima section, Sinai, Egypt.

***Lenticulina trompi* (Ansary<sup>51</sup>)** (Pl. 1, fig.15)

- 1954 *Robulus trompi* Ansary,<sup>51</sup> p. 314, pl. 1, fig. 2.  
1992 *Lenticulina trompi*; Hussein,<sup>67</sup> p. 110, fig. 2. 6.  
2000 *Lenticulina trompi*; Abul-Nasr,<sup>68</sup> p. 72, fig. 15. 1, 2.  
2011 *Lenticulina trompi*; Aly et al.,<sup>28</sup> p. 90, pl. 2, fig. 8.  
2013a *Lenticulina trompi*; Anan,<sup>20</sup> p. 51, pl. 1, figs. 2-4.

Remarks: This Eocene species was described from Sinai, Fayoum, Nile Valley (Egypt), as well as from Jordan. Abul-Nasr (2000) noted that his *Lenticulina-Marginulina* lineage begins with *Lenticulina trompi*.

Genus *Marginulinopsis* Silvestri,<sup>69</sup> 1904

Type species *Cristellaria bradyi* Goës,<sup>70</sup> 1894

***Marginulinopsis hewaidyi* Aly<sup>28</sup>** (Pl. 1, fig.16)

- 2011 *Marginulinopsis hewaidyi* Aly et al.,<sup>28</sup> p. 92, pl. 3, fig. 2.

Remarks: This species differs from *M. infracompresa* (Thalman) in having a lot of spines on the last chamber, and long neck ornamented by spines as well.

*M. karimae* Anan<sup>34</sup> differs than *M. hewaidyi* in having more number of uniserial chambers, by its more longitudinal costal number extended continuously over the suture lines than independent costae on each chamber, and without faint nodes in the inter-costal space. It was recorded from the late Middle Eocene of Beni Suef, Nile Valley, Egypt.

***Marginulinopsis karimae* Anan<sup>34</sup>** (Pl. 1, fig.17)

- 2009a *Marginulinopsis karimae* Anan,<sup>34</sup> p. 6, pl. 1, fig. 8.

Remarks: The genus *Marginulinopsis* has numerous longitudinal costate surfaces, not nodes and beadlike tubercles surface in *Percultazonaria*. This species was recorded from late Eocene of J. Hafit, UAE.

Genus *Percultazonaria* Loeblich & Tappan,<sup>46</sup>

Type species *Cristellaria subaculeata* Cushman,<sup>71</sup>

***Percultazonaria abunnasri* Anan<sup>23</sup>** (Pl. 1, fig.18)

- 2015a *Percultazonaria abunnasri*, Anan,<sup>23</sup> p. 16, pl. 1, fig. 1.

Remarks: According to Loeblich & Tappan<sup>42</sup> the type species of the genus *Percultazonaria* was recorded from Holocene time, but it now ranges from Cretaceous to Holocene. According to Abul-Nasr<sup>68</sup> (figs. 9, 10) the two middle Eocene species: *P. abunnasri* and *P. benisuefensis* (*sensu* Hussein<sup>72</sup>) most probably have been evolved from two different stocks, which have progressive of raised costate ridges, in one hand: *Lenticulina trompi-Marginulinopsis* cf. *fragaria-Marginulina benisuefensis* (*sensu* Abul-Nasr<sup>68</sup>) lineage,

and raised nodes in another: *L. chitanii*-*M. brantlyi*-*M. waiparaensis* lineage, and these two lineages have been ended by the late Eocene *Margulinina costata*. It was recorded from Darat Formation of Wadi Tayiba section, Sinai, Egypt.

***Percultazonaria alii* Anan<sup>23</sup>** (Pl. 1, fig. 19)

2015a *Percultazonaria alii* Anan,<sup>23</sup> p. 16, pl. 1, fig. 2.

Remarks: This species differs from early Eocene *P. longiscata* of Nakkady by its interrupted ridges at the sutures. The more breadth test and raised ridges running across the sutures of the Sweden Paleocene *Astacolus paleocenicus* Brotzen<sup>73</sup> (1948) which often interrupted over the sutures, make it differs from the *P. alii*. It was recorded from Kurkur Naqb Dungul section, west Aswan, Egypt.

***Percultazonaria allami* Anan<sup>23</sup>** (Pl. 1, fig. 20)

2015a *Percultazonaria allami* Anan,<sup>23</sup> p. 17, pl. 1, fig. 3.

Remarks: This Paleocene-middle Eocene species has inner margin slightly curved, while the outer margin curved with keel. It was recorded from Beni Suef Formation of Warshet ErRukham section, Nile Valley, Egypt.

***Percultazonaria ameeri* Anan<sup>23</sup>** (Pl. 1, fig. 21)

2015a *Percultazonaria ameeri* Anan,<sup>23</sup> p. 17, pl. 1, fig. 4.

Remarks: This Paleocene species can be recognized by its large size test, and conspicuous sutural nodes along the coiled and inclined uniserial portions of the test. It was recorded from the Paleocene of the Maqfi section, Egypt.

***Percultazonaria carri* (LeRoy<sup>4</sup>)** (Pl. 1, fig. 22)

1953 *Margulinina carri* LeRoy,<sup>4</sup> p. 38, pl. 4, figs. 4, 5.

2001 *Margulinina carri*; Hewaidy & Strougo,<sup>52</sup> p. 17, pl. 2, fig. 9.

2015a *Percultazonaria carri*; Anan,<sup>23</sup> p. 20, pl. 1, fig. 8.

Remarks: This early Eocene species was recorded only in the central Egypt. It seems to be confined, so far, in Egypt.

***Percultazonaria intercostata* (Nakkady<sup>1</sup>)** (Pl. 1, fig. 23)

1950 *Margulinina wetherilli* Jones var. *intercostata* Nakkady,<sup>1</sup> p. 684, pl. 89, fig. 12.

1996 *Margulinina wetherilli intercostata*; Aref & Youssef,<sup>74</sup> p. 553, pl. 3, figs. 4, 5.

2015a *Percultazonaria intercostata*; Anan,<sup>23</sup> p. 21, pl. 1, fig. 10.

Remarks: This species was recorded from the Paleocene-Eocene in many parts in Egypt: Sinai, Luxor and Farafra area of Egypt. It seems that this species has mainly common feature with *P. tuberculata* (Plummer<sup>75</sup>) which make some confusion by some authors between these two species (*tuberculata* and *intercostata*). *P. intercostata* has spite fine parallel ridges beside its beaded tuberculate sutures, not only beaded tuberculate in Plummer's species.

***Percultazonaria jordanensis* (Futyan<sup>29</sup>)** (Pl. 1, fig. 24)

1976 *Margulinina jordanensis*, Futyan,<sup>29</sup> p. 525, pl. 81, figs. 5, 6.

2015a *Percultazonaria jordanensis*; Anan,<sup>23</sup> p. 21, pl. 1, fig. 11.

Remarks: This Paleocene species resembles the Eocene *P. wetherilli* Jones in its more compressed with larger initial coiled portion, less inflated chambers, lacks the last two inflated chambers

and depressed sutures. *P. jordanensis* was described from Tell Burma and Wadi Arab sections, Jordan.

***Percultazonaria longiscata* (Nakkady<sup>1</sup>)** (Pl. 1, fig. 25)

1950 *Margulinina wetherilli* Jones var. *longiscata* Nakkady,<sup>1</sup> p. 684, pl. 89, fig. 13.

2010b *Margulinina longiscata*; Anan,<sup>16</sup> p. 41, fig. 2.

2015a *Percultazonaria longiscata*; Anan,<sup>23</sup> p. 6, pl. 2, fig. 12.

Remarks: This Eocene species has elongated ridges, but interrupted at sutures, which are not raised or tubercled. It was recorded from Luxor, Farafra area and Duwi section, Egypt.

***Percultazonaria wadiarabensis* Futyan<sup>29</sup>** (Pl. 1, fig. 26)

1976 *Vaginulinopsis wadiarabensis* Futyan,<sup>29</sup> p. 524, pl. 81, figs. 7-9.

2015a *Percultazonaria wadiarabensis*; Anan,<sup>23</sup> p. 24, pl. 2, fig. 15.

Remarks: The genus *Percultazonaria* differs from *Vaginulinopsis* in more prominent early coil, and in its elevated, costate, nodose sutural ornamentation. This Paleocene species resembles *P. tuberculata* (Plummer<sup>75</sup>), but has a larger coiled initial portion, stouter and flanged test, spinose periphery and surface, 1-2 inflated uniserial chambers instead of 4-6 laterally compressed chambers in Plummer's species which are longer than high. It was recorded from Jordan and Egypt.

Genus *Saracenia* Defrance,<sup>56</sup>

Type species *Saracenia italica* Defrance,<sup>56</sup>

***Saracenia barnardi* Ansary<sup>51</sup>** (Pl. 1, fig. 27)

1954 *Saracenia barnardi* Ansary,<sup>51</sup> p. 315, pl. 2, fig. 3.

2013a *Saracenia barnardi*; Anan,<sup>20</sup> p. 51, pl. 1, figs. 5-6.

Remarks: It was described from the Eocene of Fayoum area, Egypt.

***Saracenia leroyi* Anan,<sup>7</sup>** (Pl. 1, fig. 28)

1994 *Saracenia leroyi* Anan,<sup>7</sup> p. 222, fig. 8. 14, 15.

2009a *Saracenia leroyi*; Anan,<sup>34</sup> p. 7, pl. 1, fig. 10.

Remarks: It was described from the middle Eocene of Fayoum and Sinai of Egypt, and later from the Eocene of J. Hafit, UAE.

Subfamily Palmulinae Saidova,<sup>76</sup>

Genus *Palmula* Lea,<sup>77</sup>

Type species *Palmula sagittaria* Lea,<sup>77</sup>

***Palmula ansaryi* Anan<sup>7</sup>** (Pl. 1, fig. 29)

1994 *Palmula ansaryi* Anan,<sup>7</sup> p. 222, fig. 8. 14, 15.

1998 *Palmula ansaryi*; Hussein,<sup>72</sup> p. 216, fig. 2a.

2002 *Palmula ansaryi*; Helal,<sup>78</sup> p. 114, pl. 2, fig. 6.

2011 *Palmula ansaryi*; Aly et al.,<sup>28</sup> p. 94, pl. 3, fig. 8.

2013a *Palmula ansaryi*; Anan,<sup>20</sup> p. 51, pl. 1, fig. 7.

Remarks: Eocene species was described from the middle Eocene in many sites from Egypt

***Palmula gahannamensis* (Ansary<sup>51</sup>)** (Pl. 1, fig. 30)

1954 *Flabellina gahannamensis* Ansary,<sup>51</sup> p. 313, pl.1, fig.1.

1998 *Palmula gahannamensis*; Hussein,<sup>72</sup> p. 216.

2013a *Palmula gahannamensis*; Anan,<sup>20</sup> p. 51, pl. 1, fig. 8.

Remarks: The Eocene *P. gahannamensis* was recorded in the Mokattam area and Warshet ErRukham, Beni Suef, Egypt.

***Palmula salimi* Anan<sup>10</sup> (Pl. 1, fig. 31)**

2002a *Palmula salimi* Anan,<sup>10</sup> p. 638, fig. 2. 7.

2011 *Palmula salimi*; Anan,<sup>17</sup> p. 59, pl. 2, fig. 20.

Remarks: Paleocene species was recorded from Duwi section. It is an excellent marker Paleocene species in Egypt.

***Palmula undulata* Nakkady<sup>1</sup> (Pl. 1, fig. 32)**

1950 *Palmula woodi* var. *undulata* Nakkady,<sup>1</sup> p. 685, pl. 89, fig. 25.

1986 *Palmula woodi undulata*; Anan & Hewaidy,<sup>79</sup> p. 22, pl. 2, fig. 9.

2009b *Palmula woodi undulata*; Anan,<sup>14</sup> p. 35, pl. 1, fig. 3.

Remarks: Nakkady (1950) recorded this subspecies from the Paleocene of Duwi section, and later from central Egypt.

***Palmula woodi* Nakkady<sup>1</sup> (Pl. 1, fig. 33)**

1950 *Palmula woodi* Nakkady,<sup>1</sup> p. 684, pl. 89, fig. 24.

1976 *Palmula woodi*; Aubert & Berggren,<sup>80</sup> p. 417, pl. 3, fig. 12.

1985 *Palmula woodi*; Luger,<sup>58</sup> p. 84, pl. 5, fig. 9.

1988 *Palmula w. woodi*; Anan & Sharabi,<sup>81</sup> p. 207, pl.1, fig. 26.

2003 *Palmula woodi*; Ali,<sup>45</sup> pl. 6, figs. 12,13.

2009b *Palmula w. woodi*; Anan,<sup>14</sup> p. 35, pl. 1, fig. 4.

Remarks: It was recorded from the Paleocene of Duwi section and has wide geographic distribution in Egypt, Jordan and Tunisia.

Subfamily Marginulininae Wedekind,<sup>82</sup>

Genus *Astacolus* de Montfort,<sup>83</sup>

Type species *Astacolus crepidulatus* de Montfort,<sup>83</sup>

***Astacolus bifurcatus* LeRoy<sup>4</sup> (Pl. 1, fig. 34)**

1953 *Astacolus bifurcatus* LeRoy,<sup>4</sup> p.19, pl. 4, figs.1, 2.

1993b *Astacolus bifurcatus*; Anan,<sup>84</sup> p. 658, pl. 2, fig.16.

2008 *Astacolus bifurcatus*; Anan,<sup>13</sup> p. 363, pl. 1, fig.3.

Remarks: This Maastrichtian-Paleocene species was recorded from many parts in Egypt and UAE.

Genus *Hemirobulina* Stache,<sup>85</sup> 1864

Type species *Cristellaria (Hemirobulina) arcuatula* Stache,<sup>85</sup>

***Hemirobulina bassiounii* Anan<sup>7</sup> (Pl. 1, fig. 35)**

1994 *Hemirobulina bassiounii* Anan,<sup>7</sup> p. 223, fig. 8.16.

2017 *Hemirobulina bassiounii*; Hewaidy et al.,<sup>86</sup> p. 85, pl. 3, fig. 30.

Remarks: This Eocene species was described from late middle Eocene of Egypt and J. Hafit, UAE.

***Hemirobulina olae* Anan<sup>37</sup> (Pl.1, fig. 36)**

2015b *Hemirobulina olae* Anan,<sup>37</sup> p. 71, pl. 1, fig. 8.

Remarks: Selandian species differs from the Paleocene-Early Eocene *H. hamuloides* (Brotzen) by its more inflated test, circular in cross section and rounded periphery. It was described by J. Mundassa, UAE.

Subfamily Marginulininae Wedekind,<sup>82</sup>

Genus *Vaginulinopsis* Silvestri,<sup>87</sup>

Type species *Vaginulina solute* Silvestri var. *carinata* Silvestri,<sup>88</sup>

***Vaginulinopsis boukharyi* Anan<sup>16</sup> (Pl. 2, fig. 37)**

2010b *Vaginulinopsis boukharyi* Anan,<sup>16</sup> p. 30, pl. 1, fig. 12.

2011 *Vaginulinopsis boukharyi*; Anan,<sup>17</sup> p. 59, pl. 2, fig. 22.

Remarks: This species has a large test, small involute planispiral stage, gradually increase 9-10 chambers in the uniserial later stage with horizontal raised sutures and dorsal end aperture. It was recorded from the Paleocene of J. Duwi.

Subfamily Vaginulininae Reuss,<sup>64</sup>

Genus *Citharina* d'Orbigny,<sup>45</sup>

Type species *Vaginulina (Citharina) strigillata* Reuss,<sup>64</sup>

***Citharina plummerae* Anan<sup>9</sup> (Pl. 2, fig. 38)**

2001 *Citharina plummerae* Anan,<sup>9</sup> p. 135, pl. 1, fig. 1.

2017b *Citharina plummerae*; Anan,<sup>25</sup> p. 280, fig. 6.17a.

2017 *Citharina plummerae*; Hewaidy et al.,<sup>86</sup> p. 85, pl. 3, fig. 22.

Remarks: It has wing-shaped flattened test with thin acuminate, globular to ovate proloculus, gradually increasing later uniserial chambers in breadth, numerous regular spaced longitudinal striae parallel to direction of growth, raised oblique curved sutures, protruding aperture at dorsal angle. It is an excellent marker Paleocene species in Egypt.

Family Polymorphinidae d'Orbigny,<sup>45</sup>

Subfamily Ramulininae Brady,<sup>89</sup>

Genus *Ramulina* Jones,<sup>90</sup> 1875

Type species *Ramulina laevis* Jones,<sup>90</sup>

***Ramulina elkhoudaryi* Anan<sup>11</sup> (Pl. 2, fig. 39)**

2002b *Ramulina elkhoudaryi* Anan,<sup>11</sup> p. 143, fig. 2. 2.

2014a *Ramulina elkhoudaryi*; Anan,<sup>21</sup> p. 66, pl. 1, figs. 3, 4.

Remarks: The Paleocene figured specimen *R. navarroana* of Youssef & Taha<sup>59</sup> (p. 15, pl. 4, fig. 19) is closely related to Anan's species *R. elkhoudaryi*. For that, the stratigraphic range of *R. elkhoudaryi* is extended from the Maastrichtian-Paleocene of Egypt.

***Ramulina futyani* Anan<sup>37</sup> (Pl. 2, fig. 40)**

2015b *Ramulina futyani* Anan,<sup>37</sup> p. 72, pl. 1, fig. 11.

Remarks: Paleocene species differs from *R. pseudoaculeata*



(Olsson) by its more globular and hispid test. It likes *P. globosa* (Montagu) in its globular test but differs in its hispid surface. It was recorded from the Selandian of J. Mundassa, UAE.

Suborder Robertinina Loeblich & Tappan,<sup>91</sup>

Superfamily Ceratobuliminaea Cushman,<sup>62</sup>

Family Epistominidae Wedekind,<sup>82</sup>

Subfamily Epistomininae Wedekind,<sup>82</sup>

Genus *Höglundina* Brotzen,<sup>73</sup>

Type species *Höglundina elegans* d'Orbigny,<sup>92</sup>

***Höglundina esnaensis* (LeRoy<sup>4</sup>)** (Pl. 2, fig. 41)

1953 *Epistomina esnaensis* LeRoy,<sup>4</sup> p. 29, pl. 5, figs 7-9.

1956 *Höglundina esnaensis*; Said & Kenawy,<sup>5</sup> p. 152, pl. 6, fig. 14.

2008 *Höglundina esnaensis*; Anan,<sup>13</sup> p. 363.

Remarks: Loeblich & Tappan<sup>42</sup> noted that the genus *Höglundina* differs from the genus *Epistomina* Terquem by its biconvex test and curved backward to the peripheral keel suture on spiral side with slightly elevation than the latter genus in its planoconvex test and limbate elevated sutures. This early Eocene species was recorded, so far, from Egypt.

Suborder Rotaliina Delage & Hérouard, 1896

Superfamily Bolivinaea Glaessner,<sup>93</sup>

Family Bolivinidae Glaessner,<sup>93</sup>

Genus *Altistoma* de Klasz & Rérat,<sup>94</sup>

Type species *Altistoma scalaris* de Klasz & Rérat,<sup>94</sup>

***Altistoma aegyptiaca* Abdou & Abdel Kireem<sup>6</sup>** (Pl. 2, fig. 42)

1975 *Altistoma aegyptiaca* Abdou & Abdel Kireem,<sup>6</sup> p. 48, pl. 1, fig. 1.

2000 *Altistoma aegyptiaca*; Shahin,<sup>95</sup> p. 201, fig.13. 1.

Remarks: This middle Eocene species was recorded, so far, from Fayoum area, and Sinai of Egypt.

***Altistoma compressa* Abdou & Abdel Kireem<sup>6</sup>** (Pl. 2, fig. 43)

1975 *Altistoma compressa* Abdou & Abdel Kireem,<sup>6</sup> p. 49, pl. 1, fig. 2.

***Altistoma eocaenica* Abdou & Abdel Kireem<sup>6</sup>** (Pl. 2, fig. 44)

1975 *Altistoma eocaenica* Abdou & Abdel Kireem,<sup>6</sup> p. 50, pl. 1, fig. 6.

2000 *Altistoma eocaenica*; Shahin,<sup>95</sup> p. 201, fig.13. 2.

***Altistoma fayoumensis* Abdou & Abdel Kireem<sup>6</sup>** (Pl. 2, fig. 45)

1975 *Altistoma fayoumensis* Abdou & Abdel Kireem,<sup>6</sup> p. 51, pl. 1, fig. 3.

1994 *Altistoma fayoumensis*; Anan,<sup>7</sup> p. 223.

***Altistoma megaapertura* Abdou & Abdel Kireem<sup>6</sup>** (Pl. 2, fig. 46)

1975 *Altistoma megaapertura* Abdou & Abdel Kireem,<sup>6</sup> p. 51, pl. 1, fig. 4.

***Altistoma rayana* Abdou & Abdel Kireem,<sup>6</sup>** (Pl. 2, fig. 47)

1975 *Altistoma rayana* Abdou & Abdel Kireem,<sup>6</sup> p. 52, pl. 1, fig. 5.

Remarks: All middle Eocene *Altistoma* species of Abdou & Abdel Kireem were recorded, so far, from Fayoum area, Egypt.

Genus *Bolivina* d'Orbigny,<sup>45</sup>

Type species *Bolivina plicata* d'Orbigny,<sup>45</sup>

***Bolivina esnehensis* Nakkady,<sup>1</sup>** (Pl. 2, fig. 48)

1950 *Bolivina esnehensis* Nakkady,<sup>1</sup> p. 688, pl. 89, fig. 17.

2009b *Bolivina esnehensis*; Anan,<sup>14</sup> p. 36.

Remarks: Eocene species was recorded from the Esna Shale of Sinai, Duwi and Luxor sections, Egypt.

***Bolivina daniana* Nakkady & Talaat, in Nakkady<sup>3</sup>** (Pl. 2, fig. 49)

1959 *Bolivina daniana* Nakkady,<sup>3</sup> p. 459, pl. 6, figs. 5, 6.

2009b *Bolivina daniana*; Anan,<sup>14</sup> p. 36.

Remarks: This Paleocene species was recorded, so far, in the Um Elghanayem section, Kharga Oasis of Egypt.

***Bolivina woodi* Nakkady<sup>1</sup>** (Pl. 2, fig. 50)

1950 *Bolivina woodi* Nakkady,<sup>1</sup> p. 687, pl. 89, fig. 15.

2009b *Bolivina woodi*; Anan,<sup>14</sup> p. 36.

Remarks: This Paleocene species was recorded from Esna Shale of Abu Durba (Sinai), Duwi and Luxor sections, Egypt.

Genus *Bolivinoidea* Cushman,<sup>62</sup>

Type species *Bolivina draco* Marsson,<sup>96</sup>

***Bolivinoidea draco aegyptiacus* Anan<sup>24</sup>**

2017a *Bolivinoidea draco aegyptiacus* Anan,<sup>24</sup> p. 3, pl. 1, fig. 1.

Remarks: The late Maastrichtian subspecies from Abu Zenima section, Sinai of Egypt differs from the other *Bolivinoidea draco* members by its small test, in possessing only well-developed two divergent longitudinal ribs along the smooth surface test, with another third rib in the central part between them, not two longitudinal parallel medial ribs in *B. d. draco* or reticulate ornamented surface in *B. d. dorreeni* Finlay. According to Anan<sup>24</sup> the figured specimen of *B. draco miliaris* is not related to his proposed *B. draco* lineage due to its lack of medial longitudinal ribs which characterized the three members of *B. draco* lineage.

Superfamily *Loxostomatacea* Loeblich & Tappan,<sup>97</sup>

Family *Loxostomatidae* Loeblich & Tappan,<sup>97</sup>

Genus *Aragonia* Finlay,<sup>98</sup>

Type species *Aragonia zelandica* Finlay,<sup>98</sup>

***Aragonia semireticulata* (LeRoy<sup>4</sup>)** (Pl. 2, fig. 51)

1953 *Bolivina semireticulata* LeRoy,<sup>4</sup> p. 20, pl. 8, fig. 26.

1956 *Bolivinoidea semireticulata*; Said & Kenawy,<sup>5</sup> p. 140, pl. 3, fig. 48.

1983 *Aragonia semireticulata*; Tjalsma & Lohmann,<sup>99</sup> p. 23, pl. 11, fig. 1.

2012 *Bolivinooides semireticulata*; Youssef & Taha,<sup>59</sup> pl. 4, fig. 14.

Remarks: This Eocene species belongs to the genus *Aragonia* as treated by Tjalsma & Lohmann<sup>99</sup> more than the other two genera *Bolivina* d'Orbigny<sup>45</sup> or *Bolivinooides* Cushman<sup>62</sup>. It was recorded from Egypt, and later from Atlantic Ocean.

Family Eouvigerinidae Cushman,<sup>62</sup>

Genus *Eouvigerina* Cushman,<sup>100</sup>

Type species *Eouvigerina americana* Cushman,<sup>100</sup>

***Eouvigerina hofkeri* Said & Kenawy<sup>5</sup>** (Pl. 2, fig. 52)

1956 *Eouvigerina hofkeri* Said & Kenawy,<sup>5</sup> p. 141, pl. 3, fig. 50.

Remarks: It was recorded in the Paleocene of Nekhl and Giddi sections, and in Maastrichtian of El Qusaima area, Sinai, Egypt.

***Eouvigerina maqfiensis* (LeRoy<sup>4</sup>)** (Pl. 2, fig. 53)

1953 *Uvigerina maqfiensis* LeRoy,<sup>4</sup> p. 52, pl. 8, fig. 2.

1988 *Uvigerina maqfiensis*; Keller,<sup>101</sup> p. 161, pl. 3, figs 11, 12.

2003 *Uvigerina maqfiensis*; Culver,<sup>102</sup> p. 194, fig. 11.

2011 *Eouvigerina maqfiensis*; Aly et al.,<sup>28</sup> p. 102, pl. 4, figs. 25.

Remarks: LeRoy<sup>4</sup> noted that his early Eocene *U. maqfiensis* tending to become uniserial in the later stage with a distinct a phialine lip on the cylindrical neck and finely hispid wall. The characters of the species most probably make it belongs to the genus *Eouvigerina* Cushman. This species was recorded from Egypt and Tunisia.

Superfamily Turritinacea Cushman,<sup>62</sup>

Family Turritinidae Cushman,<sup>62</sup>

Genus *Neobulimina* Cushman & Wickenden,<sup>103</sup>

Type species *Neobulimina canadensis* Cushman & Wickenden,<sup>103</sup>

***Neobulimina farafraensis* LeRoy<sup>4</sup>** (Pl. 2, fig. 54)

1953 *Neobulimina farafraensis* LeRoy,<sup>4</sup> p. 39, pl. 8, figs. 3, 4.

1996 *Stainforthia farafraensis*; Speijer et al.,<sup>104</sup> p. 125, pl. 1, fig. 7.

2005 *Neobulimina farafraensis*; Alegret et al.,<sup>105</sup> p. 528.

2008 *Neobulimina farafraensis*; Anan,<sup>13</sup> p. 363, pl. 1, fig. 4.

Remarks: The Paleocene-early Eocene species belongs to the genus *Neobulimina* as originally described by LeRoy, due its subglobular chambers, loop-shaped opening aperture which extending up the terminal face, without elongate fusiform test and prolocular apical spines as the genus *Stainforthia* Hofker. It was recorded from Egypt.

Genus *Turrilina* Andreae,<sup>106</sup> 1884

Type species *Turrilina alsatica* Andreae,<sup>106</sup>

***Turrilina hassani* Anan<sup>35</sup>** (Pl. 2, fig. 55)

2010a *Turrilina hassani* Anan,<sup>35</sup> p. 160, pl. 1, fig. 3.

2011 *Turrilina hassani*; Anan,<sup>17</sup> p. 61, pl. 2, fig. 26.

Remarks: The Eocene species differs from other *Turrilina* spp. by its opposite v-shaped aperture at the interiomarginal of the last chamber, and the last three chambers consist about  $\frac{7}{8}$  time of the whole test. It was recorded from middle-late Eocene of J. Hafit (UAE).

Superfamily Turritinacea Cushman,<sup>62</sup>

Family Stainforthiidae Reiss,<sup>107</sup>

Genus *Hopkinsina* Howe & Wallace,<sup>108</sup>

Type species *Hopkinsina danvillensis* Howe & Wallace,<sup>108</sup>

***Hopkinsina aegyptiaca* Ansary<sup>51</sup>** (Pl. 2, fig. 56)

1954 *Hopkinsina bortotara aegyptiaca* Ansary,<sup>51</sup> p. 323, pl. 1, fig. 10.

2013a *Hopkinsina aegyptiaca*; Anan,<sup>20</sup> p. 52, pl. 1, figs. 9, 10.

Remarks: This Eocene species was described from Fayoum and Sinai, and later from Qattamiya (Greater Cairo), Egypt.

Superfamily Buliminacea Jones,<sup>90</sup>

Family Siphogenerenoididae Saidova,<sup>109</sup>

Subfamily Siphogenerenoidinae Saidova,<sup>109</sup>

Genus *Orthokarstenia* Dietrich,<sup>110</sup>

Type species *Orthocerina ewaldi* Karsten,<sup>111</sup>

***Orthokarstenia higazyi* (Nakkady<sup>2</sup>)** (Pl. 2, fig. 57)

1955 *Siphogenerina higazyi* Nakkady,<sup>2</sup> p. 705, text-fig. 4.

1976 *Siphogenerinoides elnaggari* Futyan,<sup>29</sup> p. 527, pl. 82, figs. 3, 4, 10.

1988 *Orthokarstenia higazyi*; Anan & Sharabi,<sup>81</sup> p. 212, pl. 2, figs. 8, 9.

1993a *Orthokarstenia higazyi*; Anan,<sup>112</sup> p. 315.

1998 *Orthokarstenia higazyi*; Anan,<sup>8</sup> p. 372, figs. 8, 9.

2003 *Orthokarstenia higazyi*; Ali,<sup>45</sup> pl.7, fig. 15.

2012 *Orthokarstenia higazyi*; Ismail,<sup>57</sup> p.49, pl. 4, fig. 4.

2014b *Orthokarstenia higazyi*; Anan,<sup>22</sup> p. 69, pl.1, fig. 6.

Remarks: Paleocene species is characterized by its longitudinal ribs along the test, differs from the Maastrichtian *O. esnehensis* (Nakkady) by non-ribbed smooth test. It was described from Egypt, Jordan and UAE.

***Orthokarstenia nakkadyi* Anan<sup>14</sup>** (Pl. 2, fig. 58)

1998 Transitional form between *O. higazyi* (Nakkady) and *O. eleganta* (Plummer); Anan,<sup>8</sup> p. 368, fig. 3.7.

2000 *Rectuvigerina clavata* (Franzenau); Sztrákos,<sup>113</sup> p. 106, pl. 13, fig. 2.

2006 *Siphogenerinoides eleganta*; Ortiz & Thomas,<sup>114</sup> p. 132, pl. 11, fig. 4.

2007 *Siphogenerinoides eleganta*; Alegret & Ortiz,<sup>115</sup> p. 441, pl. 2, fig. 43.

2009b *Orthokarstenia nakkadyi*; Anan,<sup>14</sup> p. 37, pl. 1, fig. 7.

2014b *Orthokarstenia nakkadyi*; Anan,<sup>22</sup> p. 69, pl. 1, figs. 7-12.

Remarks: *Orthokarstenia nakkadyi* Anan<sup>14</sup> was recorded from the middle Paleocene (Selandian, P4a Zone) of Duwi section, Egypt, but Paleocene-early Eocene of the Esna Shale of Dababiya section by Alegret & Ortiz (2007). The Tethyan, *O. nakkadyi* was recorded

around the Ypresian/Lutetian transition in France (by Sztrákó<sup>113</sup>) and Spain (by Ortiz & Thomas<sup>115</sup>) beside Tunisia and Egypt.

Superfamily Buliminacea Jones,<sup>90</sup>

Family Buliminidae Jones,<sup>90</sup>

Genus *Bulimina* d'Orbigny,<sup>92</sup>

Type species *Bulimina marginata* d'Orbigny,<sup>92</sup>

***Bulimina esnaensis* LeRoy<sup>4</sup>** (Pl. 2, fig. 59)

1953 *Bulimina esnaensis* LeRoy,<sup>4</sup> p. 20, pl. 6, figs 11, 12.

2001 *Bulimina esnaensis*; Hewaidy & Strougo,<sup>52</sup> p. 17, pl. 2, fig. 16.

Remarks: This Eocene species was recorded, so far, in the Farafra area of Egypt.

***Bulimina farafraensis* LeRoy<sup>4</sup>** (Pl. 2, fig. 60)

1953 *Bulimina farafraensis* LeRoy,<sup>4</sup> p. 21, pl. 7, figs 26, 27.

1988 *Bulimina farafraensis*; Keller,<sup>101</sup> p. 161, pl. 3, figs. 13, 14.

1993 *Bulimina farafraensis*; Boltovskoy & Vera Ocampo,<sup>116</sup> p. 147, pl. 1, fig. 16.

1994 *Bulimina farafraensis*; Speijer,<sup>117</sup> p. 110, pl. 1, fig. 8.

2003 *Bulimina farafraensis*; Culver,<sup>102</sup> p. 189, fig. 8; p. 194, fig. 11.

2007 *Bulimina farafraensis*; Alegret & Ortiz,<sup>115</sup> p. 440, pl. 1, fig. 20.

2012 *Bulimina farafraensis*; Youssef & Taha,<sup>59</sup> pl. 4, fig. 15.

Remarks: The Eocene species was recorded in Egypt, Tunisia, Spain and Arabian Sea.

***Bulimina leroyi* Futyan<sup>29</sup>** (Pl. 2, fig. 61)

1976 *Bulimina leroyi* Futyan,<sup>29</sup> p. 530, pl. 82, figs. 11, 12.

Remarks: This early Eocene species has finer costae and these cover the lower third of the test.

***Bulimina misrensis* Ansary<sup>51</sup>** (Pl. 2, fig. 62)

1954 *Bulimina jarvisi misrensis* Ansary,<sup>51</sup> p. 322, pl.1, fig. 9.

1992 *Bulimina jarvisi misrensis*; Cherif et al.,<sup>118</sup> p. 50, pl. 3, fig. 9

2013a *Bulimina misrensis*; Anan,<sup>20</sup> p. 52, pl. 1, fig. 11.

Remarks: It was described from the late Eocene of Sinai (Egypt) and later from J. Hafit.

***Bulimina zikoi* Helal<sup>78</sup>** (Pl. 2, fig. 63)

2002 *Bulimina zikoi* Helal,<sup>78</sup> p. 118, pl. 3, figs. 3, 4.

Remarks: This species was described from the middle-late Eocene of Fayoum area, west Egypt.

Subfamily Uvigerininae Haeckel,<sup>119</sup>

Genus *Uvigerina* d'Orbigny,<sup>92</sup>

Type species *Uvigerina pygmaea* d'Orbigny,<sup>92</sup>

***Uvigerina compressa* Ansary<sup>51</sup>** (Pl. 2, fig. 64)

1954 *Uvigerina mediterranea compressa* Ansary,<sup>51</sup> p. 323, pl.1, fig.15.

1994 *Uvigerina compressa*; Anan,<sup>7</sup> p. 224, fig. 9.1.

2013a *Uvigerina compressa*; Anan,<sup>20</sup> p. 52, pl. 1, figs. 12, 13.

Remarks: This species was described from the Eocene rocks of Sinai, and later from Qattamiya area (Greater Cairo).

Subfamily Uvigerininae Haeckel,<sup>119</sup>

Family Uvigerinidae Haeckel,<sup>119</sup>

Subfamily Uvigerininae Haeckel,<sup>119</sup>

Genus *Uvigerinella* Cushman,<sup>100</sup>

Type species *Uvigerina (Uvigerinella) californica* Cushman,<sup>100</sup>

***Uvigerinella nakkadyi* Anan<sup>7</sup>** (Pl. 2, fig. 65)

1994 *Uvigerinella nakkadyi* Anan,<sup>7</sup> p. 224, fig. 9. 5.

2000 *Uvigerinella nakkadyi*; Shahin,<sup>95</sup> p. 200, fig. 12. 11, 12.

2007b *Uvigerinella nakkadyi*; Anan,<sup>33</sup> p. 73.

2011 *Uvigerinella nakkadyi*; Anan,<sup>17</sup> p. 62, pl. 3, fig. 29.

Remarks: This species was originally described from the Bartonian of Fayoum, from the Late Eocene-Oligocene of Sinai, Egypt (Shahin<sup>95</sup>), and later on Priabonian of J. Malaqet, UAE (Anan<sup>33</sup>).

Subfamily Angulogerininae Galloway,<sup>120</sup>

Genus *Trifarina* Cushman,<sup>121</sup> 1923

Type species *Trifarina bradyi* Cushman,<sup>121</sup>

***Trifarina esnaensis* LeRoy<sup>4</sup>** (Pl.2, fig. 66)

1953 *Trifarina esnaensis* LeRoy,<sup>4</sup> p. 52, pl. 8, figs. 5, 6.

1974a *Trifarina esnaensis*; Berggren,<sup>122</sup> p. 438, pl. 1, fig. 6.

1985 *Trifarina esnaensis*; Luger,<sup>58</sup> p. 108, pl. 7, fig. 11.

1988 *Trifarina esnaensis*; Keller,<sup>101</sup> p. 161, pl. 3, figs. 15, 16.

1993b *Trifarina esnaensis*; Anan,<sup>84</sup> p. 569, pl. 3, fig. 9.

2003 *Trifarina esnaensis*; Culver,<sup>102</sup> p.192, fig.10.

Remarks: Paleocene-Eocene species was recorded in the most facies of Egypt, UAE, Tunisia, North Atlantic.

Superfamily *Fursenkoinacea* Loeblich & Tappan,<sup>123</sup>

Family *Fursenkoinidae* Loeblich & Tappan,<sup>123</sup>

Genus *Fursenkoina* Loeblich & Tappan,<sup>123</sup>

Type species *Virgulina squamosa* d'Orbigny,<sup>92</sup>

***Fursenkoina dubia* (Haque<sup>38</sup>)**

1956 *Virgulina dubia* Haque,<sup>38</sup> p. 129, pl. 25, figs. 3, 4.

2019a *Fursenkoina dubia*; Anan,<sup>24</sup> p. 32, fig. 9a-d.

Remarks: Paleocene-early Eocene species is characterized by its elongate biserial twisted smooth chambers throughout the test with rounded to ovate in section. It was recorded, so far, from Pakistan and Egypt.

Superfamily *Pleurostomellacea* Reuss,<sup>124</sup>

Family *Pleurostomellidae* Reuss,<sup>124</sup>  
Subfamily *Pleurostomellinae* Reuss,<sup>124</sup>  
Genus *Ellipsoglandulina* Sivestri,<sup>125</sup>  
Type species *Ellipsoglandulina laevigata* Sivestri,<sup>125</sup>  
***Ellipsoglandulina arafati* Anan<sup>15</sup>** (Pl. 2, fig. 67)  
2009c *Ellipsoglandulina arafati* Anan,<sup>15</sup> p. 111, fig. 2.  
2011 *Ellipsoglandulina arafati*; Anan,<sup>17</sup> p. 62, pl. 3, fig. 30.  
Remarks: This early Eocene species was recorded from Abu Zenima section, Sinai, Egypt.  
Genus *Nodosarella* Rzehak,<sup>126</sup>  
Type species *Lingulina tuberosa* Gümbel,<sup>127</sup>  
***Nodosarella minuta* Said & Kenawy<sup>5</sup>** (Pl. 2, fig. 68)  
1956 *Nodosarella minuta* Said & Kenawy,<sup>5</sup> p. 145, pl. 4, fig. 30.  
1992 *Nodosarella minuta*; Ismail,<sup>128</sup> p. 238, pl. 2, fig. 5.  
2011 *Nodosarella minuta*; Anan,<sup>17</sup> p. 20, pl. 2, fig. 3.  
Remarks: This Paleocene species was recorded from Sinai, but Maastrichtian of Sufr El Dara, Red Sea coast, Egypt.  
Superfamily *Pleurostomellacea* Reuss,<sup>64</sup>  
Family *Pleurostomellidae* Reuss,<sup>64</sup>  
Subfamily *Pleurostomellinae* Reuss,<sup>64</sup>  
Genus *Pleurostomella* Reuss,<sup>64</sup>  
Type species *Dentalina subnodosa* Reuss,<sup>129</sup>  
***Pleurostomella haquei* Anan<sup>27</sup>**  
2019b *Pleurostomella haquei* Anan,<sup>27</sup> p. 175, pl. 1, fig. 10.  
Remarks: This Eocene Pakistanian species has elongate lax biserial test, and the final uniserial chamber inflated and nearly globular.  
***Pleurostomella osmani* Anan<sup>27</sup>**  
2019b *Pleurostomella osmani* Anan,<sup>27</sup> p. 176, pl. 2, fig. 15.  
Remarks: Maastrichtian Egyptian species has short test with subterminal elliptical aperture without tooth.  
Superfamily Discorbacea Ehrenberg,<sup>43</sup>  
Family Bagginidae Cushman,<sup>62</sup>  
Subfamily Baggininae Cushman,<sup>62</sup>  
Genus *Sakhiella* Haque,<sup>38</sup>  
Type species *Sakhiella nammalensis* Haque,<sup>38</sup>  
***Sakhiella nammalensis* Haque<sup>38</sup>**  
1956 *Sakhiella nammalensis* Haque,<sup>38</sup> p. 155, pl. 10, fig. 1.  
2002 *Sakhiella nammalensis*; Al-Hitmi,<sup>130</sup> p. 49, pl. 3, fig. 10.  
2019a *Sakhiella nammalensis*; Anan,<sup>26</sup> p. 32, pl. 1, fig. 10.  
Remarks: This Paleocene-early Eocene species has biconvex trochospiral test but with spiral side completely involute with an

extending aperture from umbilicus to the periphery covered with a distinct umbilical flap. It was recorded from Pakistan, and Qatar.

Superfamily Discorbacea Ehrenberg,<sup>43</sup>  
Family Bagginidae Cushman,<sup>62</sup>  
Subfamily Baggininae Cushman,<sup>62</sup>  
Genus *Baggina* Cushman,<sup>100</sup>  
Type species *Baggina californica* Cushman,<sup>100</sup>

***Baggina eoacaenica* Hewaidy & Al-Hitmi<sup>31</sup>** (Pl. 2, fig. 69)

1994 *Baggina eoacaenica* Hewaidy & Al-Hitmi,<sup>31</sup> p. 19, fig. 6. 9-11.

Remarks: This early Eocene species was recorded from Dukhan Field, Qatar.

Genus *Valvulineria* Cushman,<sup>100</sup>  
Type species *Valvulineria californica* Cushman,<sup>100</sup>

***Valvulineria aegyptiaca* LeRoy<sup>4</sup>** (Pl. 2, fig. 70)

1953 *Valvulineria aegyptiaca* LeRoy,<sup>4</sup> p. 53, pl. 9, figs. 21-23.

1993a *Valvulineria aegyptiaca*; Anan,<sup>112</sup> p. 316.

2008 *Valvulineria aegyptiaca*; Anan,<sup>13</sup> p. 364, pl. 1, fig. 5.

2012 *Valvulineria aegyptiaca*; Ismail,<sup>57</sup> p. 39, pl. 3, figs. 18,19.

Remarks: This Paleocene-early Eocene species was recorded from north and central Egypt, and also from UAE.

***Valvulineria critchetti* LeRoy<sup>4</sup>** (Pl. 2, fig. 71)

1953 *Valvulineria critchetti* LeRoy,<sup>4</sup> p. 53, pl. 3, figs. 20-22.

1992 *Valvulineria critchetti*; Ismail,<sup>128</sup> p. 236, pl. 2, fig. 2.

2011 *Valvulineria critchetti*; Aly et al.,<sup>28</sup> p. 108, pl. 6, fig. 2.

Remarks: This early Eocene species was recorded from the north and central Egypt. It seems confined in Egypt.

***Valvulineria nammalensis* Haque<sup>38</sup>**

1956 *Valvulineria nammalensis* Haque,<sup>38</sup> p. 159, pl. 7, fig. 10.

1993a *Valvulineria* sp. Anan,<sup>112</sup> p. 316, pl. 3, fig. 3.

2019a *Valvulineria nammalensis*; Anan,<sup>26</sup> p. 32, pl. 1, fig. 11a-d.

Remarks: This Paleocene-early Eocene species has two and a half dorsal whorl, 9-10 ventral chambers, and interiomarginal umbilical-extraumbilical aperture with broad thin apertural flap projecting over the umbilicus. It was recorded from Pakistan and UAE.

***Valvulineria pseudotumeyensis* Futyan,<sup>29</sup>** (Pl. 3, fig. 72)

1976 *Valvulineria pseudotumeyensis* Futyan,<sup>29</sup> p. 531, pl. 83, figs. 2-4.

Remarks: This early Eocene species is similar in shape to *Eponides elevatus* (Plummer), but much smaller (half diameter), subconical test and an angular periphery. It was recorded from Muwaqqar and Wadi Arab sections, Jordan.

Family Discorbidae Ehrenberg,<sup>43</sup>

Genus *Discorbis* Lamarck,<sup>66</sup>

Type species *Discorbis vesicularis* Lamarck,<sup>66</sup>

***Discorbis globiformis* Haque<sup>40</sup>**

1962 *Discorbis globiformis* Haque,<sup>40</sup> p. 21, pl. 1, figs. 3-5.

2002 *Discorbis globiformis*; Al-Hitmi,<sup>130</sup> p. 49, pl. 3, fig. 11.

2019a *Discorbis globiformis*; Anan,<sup>26</sup> p. 32, pl. 1, fig. 12a-c.

Remarks: This Maastrichtian-early Eocene species has gradually inflated chambers, highly trochospiral coil, umbilical region wide and covered by a long flap with smooth surface. It is recorded, so far, from Pakistan and Qatar.

Genus *Trochulina* d'Orbigny,<sup>45</sup>

Type species *Rotalina turbo* d'Orbigny,<sup>92</sup>

***Trochulina aegyptiaca* (LeRoy<sup>4</sup>) (Pl. 3, fig. 73)**

1953 *Rotorbinella aegyptiaca* LeRoy,<sup>4</sup> p. 48, pl. 7, figs 1-3.

2008 *Trochulina aegyptiaca*; Anan,<sup>13</sup> p. 365.

Remarks: Loeblich & Tappan<sup>42</sup> considered the genus *Rotorbinella* Bandy as a junior synonym of the genus *Trochulina* d'Orbigny. This Eocene species was recorded only in Farafra area of Egypt.

***Trochulina lenticularis* Hewaidy & Al-Hitmi<sup>31</sup> (Pl. 3, fig. 74)**

1994 *Trochulina lenticularis* Hewaidy & Al-Hitmi,<sup>31</sup> p. 20, fig. 7. 1-3.

Remarks: This early Eocene species was recorded from Dukhan Field, Qatar.

Family Eponididae Hofker,<sup>131</sup>

Genus *Eponides* de Montfort,<sup>132</sup>

Type species *Nautilus repandus* Fichtel & Moll,<sup>133</sup>

***Eponides mariei* Said & Kenawy,<sup>5</sup> (Pl. 3, fig. 75)**

1956 *Eponides mariei* Said & Kenawy,<sup>5</sup> p. 148, pl. 5, fig. 2.

1995 *Oridorsalis mariei*; Nomura & Brohi,<sup>41</sup> p. 229, pl. 2, fig. 2.

2012a *Eponides mariei*; Anan,<sup>18</sup> p. 25, pl. 1, fig. 13.

Remarks: It was recorded from the Maastrichtian-Danian rocks of Giddi section of Sinai, and later in Paleocene of Pakistan.

Family Discorbidae Ehrenberg,<sup>43</sup>

Genus *Neoeponides* Reiss,<sup>131</sup>

Type species *Rotalia schreibersii* d'Orbigny,<sup>134</sup>

***Neoeponides duwi* (Nakkady<sup>1</sup>) (Pl. 3, fig. 76)**

1950 *Discorbis pseudoscopos* var. *duwi* Nakkady,<sup>1</sup> p. 688, pl. 90, figs. 5-7.

1998 *Discorbis pseudoscopos duwi*; Anan,<sup>8</sup> p.373, fig.3. 11.

2003 *Neoeponides duwi*; Speijer,<sup>135</sup> p. 147, pl. 1, figs. 2-7.

2009b *Neoeponides duwi*; Anan,<sup>14</sup> p. 40, pl. 1, fig. 11.

Remarks: Nakkady<sup>1</sup> originally recorded this taxon from the base of the post-Cretaceous shales of Duwi section, Egypt, and later from northeast Sinai, Kharga Oasis and Red Sea coastal area of Egypt. Anan<sup>8</sup>

proposed the *Discorbis p. pseudoscopos* - *D. p. duwi* lineage from the Cretaceous ancestor *pseudoscopos* to the Paleocene descendent *duwi*. On the other hand, Speijer<sup>135</sup> considered *duwi* appears to have no phylogenetic relationship with *pseudoscopos*, but belongs to the genus *Neoeponides* due to his revision of the characters of Nakkady's holotype, and also raised the taxonomic rank of subspecies *duwi* to the species rank: *N. duwi*.

Superfamily Discorbinellacea Sigal,<sup>136</sup>

Family Parrelloididae Hofker,<sup>131</sup>

Genus *Cibicoides* Thalmann,<sup>137</sup>

Type species *Truncatolina mundula* Brady, Parker & Jones,<sup>138</sup>

***Cibicoides loeblichii* (Said & Kenawy<sup>5</sup>) (Pl. 3, fig. 77)**

1956 *Cibicides loeblichii* Said & Kenawy,<sup>5</sup> p. 155, pl. 7, fig. 11.

2012a *Cibicoides loeblichii*; Anan,<sup>18</sup> p. 25, pl. 1, fig. 15.

Remarks: Among other characters, the biconvexity of the genus *Cibicoides* make it differs from the planoconvex test of *Cibicides* de Montfort. This species was originally recorded from the Paleocene of Nekhl section (north Sinai), and later from Taba section (central east Sinai), Egypt. It seems, so far, it is confined in Egypt.

Superfamily Discorbinellacea Sigal,<sup>136</sup>

Family Parrelloididae Hofker,<sup>131</sup>

Genus *Cibicoides* Thalmann,<sup>137</sup>

Type species *Truncatolina mundula* Brady, Parker & Jones,<sup>138</sup>

***Cibicoides beadnelli* (LeRoy<sup>4</sup>) (Pl. 3, fig. 78)**

1953 *Cibicides beadnelli* LeRoy,<sup>4</sup> p. 23, pl. 10, figs 6-8.

1988 *Cibicides beadnelli*; Keller,<sup>101</sup> p. 165, fig. 4.

2008 *Cibicoides beadnelli*; Anan,<sup>13</sup> p. 365.

Remarks: Among other characters, the biconvexity of the genus *Cibicoides* Thalmann make it differs from the planoconvex test of the *Cibicides* de Montfort. This Eocene species *C. beadnelli* was recorded in the north and central Egypt, Tunisia, Libya, Mali and Spain.

***Cibicoides decoratus* (LeRoy<sup>4</sup>) (Pl. 3, fig. 79)**

1953 *Cibicides decoratus* LeRoy,<sup>4</sup> p. 23, pl. 6, figs 15-17.

1994 *Cibicides decoratus*; Speijer,<sup>117</sup> p. 114, pl. 2, fig. 3.

2003 *Cibicides decoratus*; Ali,<sup>45</sup> pl. 10, figs. 15-17.

2008 *Cibicoides decoratus*; Anan,<sup>13</sup> p. 365, pl. 1, fig. 6.

Remarks: This Paleocene-early Eocene species was recorded from north and central Egypt.

***Cibicoides farafraensis* (LeRoy<sup>4</sup>) (Pl. 3, fig. 80)**

1953 *Cibicides farafraensis* LeRoy,<sup>4</sup> p. 24, pl. 10, figs 1-3.

1956 *Cibicoides farafraensis*; Said & Kenawy,<sup>5</sup> p.154, pl. 7, fig. 6.

1985 *Cibicoides farafraensis*; Luger,<sup>58</sup> p. 112, pl. 9, fig. 3.

2008 *Cibicoides farafraensis*; Anan,<sup>13</sup> p. 365, pl. 1, fig. 7.

2011 *Cibicides farafraensis*; Aly et al.,<sup>28</sup> p. 112, pl. 7, fig. 4.

2012 *Cibicoides farafraensis*; Youssef & Taha,<sup>59</sup> pl. 5, figs. 11, 12.

Remarks: Berggren & Aubert<sup>80</sup> suggested that *C. howelli* (Toulmin) has closer relationship with *C. farafraensis* and seems to be equivalent. The figured *C. howelli* of Berggren & Aubert<sup>80</sup> with very acute periphery of the whole test including the last chamber differs from the semi-rounded last chamber periphery of *C. farafraensis*. These two species are treated here to be different. The early Eocene *C. farafraensis* was recorded in north and central Egypt. It seems, so far, be confined in Egypt.

#### ***Cibicoides libycus* (LeRoy<sup>4</sup>) (Pl. 3, fig. 81)**

1953 *Cibicides libycus* LeRoy,<sup>4</sup> p. 24, pl. 5, figs. 1-3.

1980 *Heterolepa libyca*; Saperson & Janal,<sup>139</sup> p. 404, pl. 2, fig. 4.

2001 *Heterolepa libyca*; Hewaidy & Strougo, p. 17, pl. 2, figs 25, 26.

2005 *Heterolepa libyca*; Sztrákos,<sup>140</sup> p. 189, pl. 9, fig. 9.

2008 *Cibicoides libycus*; Anan,<sup>13</sup> p. 365, pl. 1, fig. 8.

2012 *Heterolepa libyca*; Ismail,<sup>57</sup> p. 41, pl. 3, fig. 29.

Remarks: According to Loeblich & Tappan<sup>42</sup> the genus *Heterolepa* has a slit-like aperture extending about half of the distance to umbilicus and extending short distance across periphery on dorsal side, but without biumbonate test. *H. libyca* differs from the genus *Cibicoides* Thalmann by its biconvexity among other characters. Both *Cibicoides alleni* and *C. libycus* have conspicuous biumbonate test, as well as a low interiomarginal equatorial arch aperture. The Paleocene-early Eocene *C. libycus* is characterized by its depressed sutures in both sides than elevated and taper sutures in the dorsal side and slightly in the ventral side in *C. alleni* (Plummer). *C. libycus* was recorded from Egypt and later from Libya, Tunisia, France, Turkmenia, North and South Atlantic.

#### ***Cibicoides nammalensis* Haque<sup>58</sup>**

1956 *Cibicoides nammalensis* Haque,<sup>58</sup> p. 205, pl. 20, fig. 10.

2005 *Cibicoides nammalensis*; Sztrákos,<sup>140</sup> p. 226, pl. 15, fig. 35.

2019a *Cibicoides nammalensis*; Anan,<sup>26</sup> p. 32, pl. 2, fig. 14a-c.

Remarks: This early Eocene species has biconvex test with keel, about 10 chambers in the ventral side with umbo. It was recorded from Pakistan, France and Iraq.

#### ***Cibicoides pharaonis* (LeRoy<sup>4</sup>) (Pl. 3, fig. 82)**

1953 *Cibicides pharaonis* LeRoy,<sup>4</sup> p. 24, pl. 7, figs 9-11.

1988 *Cibicoides pharaonis*; Anan & Sharabi,<sup>81</sup> p. 215, pl. 2, fig. 20.

2001 *Cibicoides pharaonis*; Hewaidy & Strougo,<sup>52</sup> p. 17, pl. 2, figs 27, 28.

2007 *Cibicoides pharaonis*; Alegret & Ortiz,<sup>115</sup> p. 440, pl. 1, fig. 24.

2008 *Cibicoides pharaonis*; Anan,<sup>13</sup> p. 366, pl. 1, fig. 9.

Remarks: This Paleocene-early Eocene species was recorded from north and central Egypt.

#### ***Cibicoides pseudoacutus* (Nakkady<sup>1</sup>) (Fig. 5, fig. 83)**

1950 *Anomalina pseudoacuta* Nakkady,<sup>1</sup> p. 691, pl. 90, figs. 29-32.

1994 *Cibicoides pseudoacutus*; Speijer,<sup>117</sup> p. 54, pl. 7, fig. 6, p. 158, pl. 4, fig. 2.

2002 *Cibicoides pseudoacuta*; Galeotti & Coccioni,<sup>141</sup> p. 198, fig. 1.

2005 *Cibicoides pseudoacuta*; Guasti et al.,<sup>142</sup> p. 4, pl. 1, fig. 14.

2005 *Gavelinella pseudoacuta*; Sztrákos,<sup>140</sup> p. 214, pl. 9, fig. 14.

2006 *Gavelinella pseudoacuta*; Ernst et al.,<sup>143</sup> p. 98, pl. 1, figs. j, k.

2007 *Cibicoides pseudoacuta*; Alegret & Ortiz,<sup>115</sup> p. 440, pl. 2, fig. 2.

2012 *Anomalina pseudoacuta*; Ismail,<sup>57</sup> p. 40, pl. 3, fig. 24.

Remarks: The Paleocene-Eocene species is characterized by its fine beads, which surround a thick irregular spiral of translucent shell substance on ventral side. It was originally described by Nakkady<sup>1</sup> from the Cretaceous Chalk and post-Cretaceous in central Egypt. Later on, it is recorded from Paleocene-Eocene in Egypt.

Superfamily Planorbulinae Schwager,<sup>144</sup>

Family Planulinidae Bermúdez,<sup>145</sup>

Genus *Planulina* d'Orbigny,<sup>92</sup>

Type species *Planulina ariminensis* d'Orbigny,<sup>92</sup>

#### ***Planulina berggreni* Anan<sup>9</sup> (Pl. 3, fig. 84)**

2001 *Planulina berggreni* Anan,<sup>9</sup> p. 136, pl. 1, fig. 2.

2011 *Planulina berggreni*; Anan,<sup>17</sup> p. 62, pl. 3, fig. 31.

Remarks: This Danian species has large and semicircular test with flat sides, suture extending backward and beaded around umbilical area, but depressed in the last chamber, surface smooth, aperture slit-like at peripheral end. It was recorded from Duwi, Egypt.

Superfamily Asterigerinacea d'Orbigny,<sup>45</sup>

Family Epistomariidae Hofker,<sup>146</sup>

Subfamily Epistomariinae Hofker,<sup>146</sup>

Genus *Epistomaria* Galloway,<sup>147</sup>

Type species *Discorbina rimosa* Parker & Jones,<sup>148</sup>

#### ***Epistomaria saudica* Hasson<sup>149</sup> (Pl. 3, fig. 85)**

1985 *Epistomaria saudica* Hasson,<sup>149</sup> p. 356, pl. 2, figs. 4-6.

Remarks: This early Eocene species was recorded from of Rub' al Khali Basin wells, Saudi Arabia (SA).

Family Alfredinidae Singh & Kalia,<sup>150</sup>

Genus *Epistomarioides* Uchio,<sup>151</sup>

Type species *Discorbina polystomelloides* Parker & Jones,<sup>148</sup>

#### ***Epistomarioides qatarica* Hewaidy & Al-Hitmi<sup>31</sup> (Pl. 3, fig. 86)**

1994 *Epistomarioides qatarica* Hewaidy & Al-Hitmi,<sup>31</sup> p. 22, fig. 7, 7, 8.

Remarks: This early Eocene species was recorded from Ummer

Radhuma Formation of Qatar.  
Superfamily Nonionacea Schultze,<sup>152</sup>  
Family Nonionidae Schultze,<sup>152</sup>  
Subfamily Nonioninae Schultze,<sup>152</sup>  
Genus *Nonion* de Montfort,<sup>132</sup>  
Type species *Nonion faba* Fichtel & Moll,<sup>133</sup>  
***Nonion fayoumensis* Ansary<sup>51</sup>** (Pl. 3, fig. 87)  
1954 *Nonion fayoumensis* Ansary,<sup>51</sup> p. 317, pl. 1, fig. 4.  
2007 *Nonion fayoumensis*; Farouk,<sup>153</sup> p. 64, pl. 2, fig. 15.  
2013a *Nonion fayoumensis*; Anan,<sup>20</sup> p. 54, pl. 1, figs. 18-20.  
Remarks: This species was originally described from Eocene of Fayoum, and later from Sinai, Egypt.  
***Nonion maadiensis* Ansary<sup>51</sup>** (Pl. 3, fig. 88)  
1954 *Nonion maadiensis* Ansary,<sup>51</sup> p. 318, pl. 1, fig. 5.  
2013a *Nonion maadiensis*; Anan,<sup>20</sup> p. 54, pl. 1, figs. 21-24.  
Remarks: This Eocene species was originally described from Maadi area, and later from Qattamiya (Greater Cairo) and Sinai, Egypt. The *Nonion* sp. of Farouk<sup>153</sup> (p. 64, pl. 2, fig. 14) is considered here belongs to *N. maadiensis*.  
***Nonion trompi* Ansary<sup>51</sup>** (Pl. 3, fig. 89)  
1954 *Nonion trompi* Ansary,<sup>51</sup> p. 319, pl. 1, fig. 6.  
2013a *Nonion trompi*; Anan,<sup>20</sup> p. 54, pl. 1, figs. 25, 26.  
Remarks: This species was originally described from the Eocene rocks of Fayoum and Maadi area, Egypt.  
Genus *Nonionella* Cushman,<sup>100</sup>  
Type species *Nonionella miocenica* Cushman,<sup>100</sup>  
***Nonionella africana* LeRoy<sup>4</sup>** (Pl. 3, fig. 90)  
1953 *Nonionella africana* LeRoy,<sup>4</sup> p. 42, pl. 10, figs. 9-11.  
1956 *Nonionella africana*; Haque,<sup>38</sup> p. 114, pl. 6, figs. 1, 9.  
2008 *Nonionella africana*; Anan,<sup>13</sup> p. 366, pl. 1, fig. 10.  
2011 *Nonionella africana*; Aly et al.,<sup>28</sup> p. 113, pl. 7, fig. 8.  
Remarks: This Paleocene-Eocene species was recorded only in central Egypt and Pakistan.  
***Nonionella haquei* Anan<sup>26</sup>**  
1956 *Nonionella* sp. Haque,<sup>38</sup> p. 156, pl. 7, fig. 21.  
1956 *Nonionella* sp. Said & Kenawy,<sup>5</sup> p. 156, pl. 7, fig. 21.  
1960 *Nonionella* sp. Haque,<sup>39</sup> p. 24, pl. 6, fig. 2  
2019a *Nonionella haquei* Anan,<sup>26</sup> p. 33, pl. 2, fig. 15a-f.  
Remarks: This Paleocene-Eocene species has large biconvex test but not symmetrically developed, 12 chambers in the last formed whorl, a slit aperture on the periphery at the base of the last chamber. It was recorded, so far, from Pakistan and Egypt.

Superfamily Chilostomellacea Brady,<sup>154</sup>  
Family Alabaminidae Hofker,<sup>131</sup>  
Genus *Alabamina* Toulmin,<sup>155</sup>  
Type species *Alabamina wilcoxensis* Toulmin,<sup>155</sup>  
***Alabamina cavellieri* Hewaidy & Al-Hitmi,<sup>31</sup>** (Pl. 3, fig. 91)  
1994 *Alabamina cavellieri* Hewaidy & Al-Hitmi,<sup>31</sup> p. 23, fig. 7. 9-14.  
Remarks: This early Eocene species was recorded from Umm er Radhuma Formation of Qatar.  
Superfamily Chilostomellacea Brady,<sup>154</sup>  
Family Osangulariidae Loeblich & Tappan,<sup>156</sup>  
Genus *Osangularia* Brotzen,<sup>157</sup>  
Type species *Osangularia lens* Brotzen,<sup>157</sup>  
***Osangularia desertorum* (LeRoy<sup>4</sup>)** (Pl. 3, fig. 92)  
1953 *Parrella desertorum* LeRoy,<sup>4</sup> p. 43, pl. 3, figs. 17-19.  
2008 *Osangularia desertorum*; Anan,<sup>13</sup> p. 366.  
Remarks: Loeblich & Tappan<sup>42</sup> considered the genus *Parrella* Finlay fall within the species concept of the genus *Osangularia* Brotzen. This early Eocene species was recorded only in central Egypt.  
Superfamily Chilostomellacea Brady,<sup>154</sup>  
Family Heterolepidae Gonzáles-Donoso,<sup>158</sup>  
Genus *Anomalinoides* Brotzen,<sup>159</sup>  
Type species *Anomalinoides plummerae* Brotzen,<sup>159</sup>  
***Anomalinoides aegyptiacus* (LeRoy<sup>4</sup>)** (Pl. 3, fig. 93)  
1953 *Anomalina aegyptiaca* LeRoy,<sup>4</sup> p. 17, pl. 7, figs 21-23.  
1994 *Anomalinoides aegyptiacus*; Speijer,<sup>117</sup> p. 116, pl. 5, fig. 3.  
2001 *Anomalinoides aegyptiacus*; Hewaidy & Strougo,<sup>52</sup> p. 17, pl. 2, figs 33, 34.  
2007 *Anomalinoides aegyptiacus*; Alegret & Ortiz,<sup>115</sup> p. 438, pl. 1, fig. 13.  
2011 *Anomalinoides aegyptiacus*; Aly et al.,<sup>28</sup> p. 116, pl. 8, fig. 1.  
Remarks: Loeblich & Tappan<sup>42</sup> noted that the type specimen of *Anomalina* was lost; a petition was submitted to the ICZN for the suppression of it and retention of *Epistomaroides* Uchio<sup>151</sup> as a valid genus. Anan<sup>7</sup> noted that the characters of *fayoumensis* species belongs to the genus *Anomalinoides*. This Paleocene-early Eocene species was recorded only in central Egypt.  
***Anomalinoides esnehensis* (Nakkady<sup>1</sup>)** (Pl. 3, fig. 94)  
1950 *Anomalina scrobiculata* (Schwager) var. *esnehensis* Nakkady,<sup>1</sup> p.691, pl. 90, figs. 33, 34.  
2009b *Anomalinoides esnehensis*; Anan,<sup>14</sup> p. 42.  
Remarks: Nakkady<sup>1</sup> recorded this species from the Paleocene shales of Sinai, Luxor and Duwi sections, Egypt.

***Anomalinoides desertorum* (LeRoy<sup>4</sup>)** (Pl. 3, fig. 95)

1953 *Anomalina desertorum* LeRoy,<sup>4</sup> p.17, pl.7, figs.18-20.

1993 *Anomalina desertorum* Boltovskoy & Vera Ocampo,<sup>116</sup> p. 146.

2008 *Anomalinoides desertorum*; Anan,<sup>13</sup> p. 367, pl. 1, fig. 11.

Remarks: The Late Paleocene-early Eocene *A. desertorum* was recorded in central Egypt, and also Arabian Sea.

***Anomalinoides fayoumensis* (Ansary,<sup>51</sup>)** (Pl. 3, fig. 96)

1954 *Anomalina fayoumensis* Ansary,<sup>51</sup> p. 325, pl. 1, fig. 11.

2010a *Anomalinoides fayoumensis*; Anan,<sup>35</sup> p. 170, pl. 2, fig. 5.

2011 *Anomalinoides fayoumensis*; Aly et al.,<sup>28</sup> p. 116, pl. 8, fig. 5.

2013a *Anomalinoides fayoumensis*; Anan,<sup>20</sup> p. 55, pl. 1, figs. 27-29.

Remarks: This species was recorded from the Eocene rocks of Fayoum area, and later from Mokattam area ( Greater Cairo), Nile Valley and Siwa area of Egypt. It was also recorded in Jordan and UAE.

***Anomalinoides leroyi* Anan,<sup>13</sup>** (Pl. 3, fig. 97)

1953 *Anomalina* sp. K LeRoy,<sup>4</sup> p. 19, pl. 3, figs 26-28.

2008 *Anomalinoides leroyi* Anan,<sup>13</sup> p. 367, pl. 1, fig. 12.

2011 *Anomalinoides leroyi*; Anan,<sup>17</sup> p. 63, pl. 3, fig. 32.

Remarks: This latest Maastrichtian to Danian species was described from the Duwi section, central Egypt.

***Anomalinoides zitteli* (LeRoy<sup>4</sup>)** (Pl. 3, fig. 98)

1953 *Cibicides zitteli* LeRoy,<sup>4</sup> p. 25, pl. 6, figs 20-22.

1994 *Anomalinoides zitteli*; Speijer,<sup>117</sup> p. 118, pl. 5, fig. 1.

2001 *Anomalinoides zitteli*; Hewaidy & Strougo,<sup>52</sup> p. 17, pl. 2, figs 29, 30.

2007 *Anomalinoides zitteli*; Alegret & Ortiz,<sup>115</sup> p. 439, pl. 1, fig. 18.

Remarks: According to Loeblich & Tappan<sup>42</sup> the genus *Anomalinoides* Brotzen is distinguished by its low trochospiral test, central boss in spiral side and broad rounded periphery, while the genus *Cibicidoides* Thalmann has biconvex, biumbonate and trochospiral test, limbate curved suture on the spiral side and angular periphery. For that, the species *zitteli* belongs here to the genus *Anomalinoides*. This Paleocene-early Eocene species was recorded from north and central Egypt.

Family Gavelinellidae Hofker,<sup>160</sup>

Subfamily Gyroidinoidinae Saidova,<sup>109</sup>

Genus *Gyroidinoides* Brotzen,<sup>161</sup>

Type species *Rotalina nitida* Brotzen,<sup>161</sup>

***Gyroidinoides aegyptiaca* (Ansary<sup>51</sup>)** (Pl. 3, fig. 99)

1954 *Gyroidina aegyptiaca* Ansary,<sup>51</sup> p. 324, pl.1, fig.1.

2013a *Gyroidinoides aegyptiaca*; Anan,<sup>20</sup> p. 55, pl. 1, figs. 30-33.

Remarks: It was described from the Eocene of Fayoum, later from Qattamiya area, Egypt.

***Gyroidinoides luterbacheri* Anan,<sup>162</sup>** (Pl. 3, fig. 100)

2004 *Gyroidinoides luterbacheri* Anan,<sup>162</sup> p. 49, pl. 1, fig. 13.

2011 *Gyroidinoides luterbacheri*; Anan,<sup>17</sup> p. 63, pl. 3, fig. 33.

Remarks: This Paleocene species was described from the Danian-Selandian of Duwi section, Egypt.

Genus *Angulogavelinella* Hofker,<sup>163</sup>

Type species *Discorbina gracilis* Marsson,<sup>69</sup>

***Angulogavelinella bandata* Futyan,<sup>29</sup>** (Pl. 3, fig. 101)

1976 *Angulogavelinella bandata* Futyan,<sup>29</sup> p. 534, pl. 83, figs. 1-3.

Remarks: This Paleocene species was founded in the Danian of Tell Burma, south Jordan.

Family Rotaliidae Ehrenberg,<sup>164</sup>

Subfamily Culvillierinae Loeblich & Tappan,<sup>156</sup>

Genus *Ornatanomalina* Haque,<sup>38</sup>

Type species *Ornatanomalina geei* Haque,<sup>38</sup>

***Ornatanomalina ennakhali* Anan,<sup>17</sup>** (Pl. 3, fig. 102)

1996 *Ornatanomalina* sp. Anan,<sup>165</sup> p. 154, fig. 4. 10.

2011 *Ornatanomalina ennakhali*; Anan,<sup>17</sup> p. 63, pl. 3, fig. 34.

2013b *Ornatanomalina ennakhali*; Anan,<sup>166</sup> p. 115, pl. 3, fig. 5.

Remarks: This late early Eocene species differs from the type species *O. geei* and its subspecies *O. geei compressa* and other six Haque's species and subspecies<sup>38,39</sup> from Pakistan (*O. crookshanki*, *O. c. rugosa*, *O. glaessneri*, *O. hafeezi*, *O. elegantula* and *O. pustulosa*) by its discontinuous ribs, not rounded periphery and lacking the radial median ridges across the chamber surface. *O. ennakhali* Anan was recorded in the Ypresian of the Rus Formation, J. Hafit in UAE, and this contribution expands the lithostratigraphic level of the early Eocene rocks in Arabia from the upper part of Umm Er Radhuma Formation (in SA and Qatar) to Rus Formation (in UAE), but the latter formation falls within the lower Lutetian rather than the upper Ypresian by Hasson.<sup>30</sup>

***Ornatanomalina hafeezi* Haque,<sup>38</sup>**

1956 *Ornatanomalina hafeezi* Haque,<sup>38</sup> p. 201, pl. 18, fig. 6.

2019a *Ornatanomalina hafeezi*; Anan,<sup>26</sup> p. 33, pl. 2, fig. 17.

Remarks: This Pakistanian genus was considered by Loeblich & Tappan<sup>42</sup> as a senior synonym of the Saudian genus *Saudella* of Hasson (1985) and its representatives. This Eocene species was recorded from Pakistan, Saudi Arabia, Qatar (by Hewaidy<sup>167</sup>) and Nigeria (by Haynes & Nwabufu-Ene<sup>168</sup>).

***Ornatanomalina inflata* (Hasson<sup>30</sup>)** (Pl. 3, fig. 103)

1985 *Saudella inflata* Hasson,<sup>30</sup> p. 350, pl. 2, figs. 1-3.

Remarks: Loeblich & Tappan<sup>42</sup> considered the genus *Ornatanomalina* Haque from Pakistan as a senior synonym of *Saudella* Hasson<sup>30</sup> from SA, and considered *O. hafeezi* as a junior synonym of *O. geei* (the type species of the genus *Ornatanomalina*). This planispiral species was recorded from early Eocene Umm er Radhuma Formation in wells of Rub'al Khali Basin, Saudi Arabia (SA).



***Ornatanomalina ornata* (Hasson<sup>30</sup>)** (Pl. 3, fig. 104)

1985 *Saudella ornata* Hasson,<sup>30</sup> p. 348, pl. 1, figs. 6-9.

Remarks: This species has eleven chambers visible in the last whorl, periphery rounded in later chambers and blunt in earlier part of test, apertural face smooth bordered by a raised imperforate rim. It was recorded also from early Eocene of Umm er Radhuma Formation in the Rub'al Khali Basin wells, Saudi Arabia (SA).

***Ornatanomalina porosa* (Hasson<sup>30</sup>)** (Pl. 3, fig. 105)

1985 *Saudella porosa* Hasson,<sup>30</sup> p. 350, pl. 1, figs. 10-12.

Remarks: This species was recorded from early Eocene of SA.

***Ornatanomalina rugosa* (Hasson<sup>30</sup>)** (Pl. 3, fig. 106)

1985 *Saudella rugosa* Hasson,<sup>30</sup> p. 348, pl. 1, figs. 1-5.

Remarks: This species was recorded from early Eocene of SA.

Subfamily Pararotaliinae Reiss,<sup>169</sup>

Genus *Pararotalia* Le Calves,<sup>170</sup>

Type species *Rotalia inermis* Terquem,<sup>171</sup>

***Pararotalia khirthari* Haque,<sup>39</sup>**

1960 *Pararotalia khirthari* Haque,<sup>39</sup> p. 3, pl. 6, fig. 5.

2010a *Pararotalia khirthari*; Anan,<sup>35</sup> p. 171.

2019a *Pararotalia khirthari*; Anan,<sup>26</sup> p. 33, pl. 2, fig. 18.

Remarks: This middle-late Eocene species has low trochospiral test with axially pointed long spine for each chamber. It was recorded, so far, from Pakistan and UAE.

Family *Elphidiidae* Galloway,<sup>120</sup>

Subfamily *Elphidiinae* Galloway,<sup>120</sup>

Genus *Elphidiella* Cushman,<sup>172</sup>

Type species *Polystomella arctica* Parker & Jones in Brady,<sup>173</sup>

***Elphidiella africana* (LeRoy<sup>4</sup>)** (Pl. 3, fig. 107)

1953 *Elphidium africanum* LeRoy,<sup>4</sup> p. 28, pl. 3, figs 11, 12.

1998 *Elphidium africanum*; Haynes & Nwabufo-Ene,<sup>168</sup> p. 53.

2008 *Elphidium africanum*; Anan, p. 367.

Remarks: This Eocene species belongs here to the genus *Elphidiella* as treated previously by Berggren<sup>174</sup> and Haynes & Nwabufo-Ene.<sup>168</sup> It was recorded from Egypt, as well as Libya, Mali and Nigeria (central Africa).

Genus *Elphidium* de Montfort,<sup>132</sup>

Type species *Nautilus macellus* Fichtel & Moll,<sup>133</sup>

***Elphidium cherifi* Anan,<sup>35</sup>** (Pl. 3, fig. 108)

2010a *Elphidium cherifi* Anan,<sup>35</sup> p. 172, pl. 2, fig. 8.

2011 *Elphidium cherifi*; Anan,<sup>17</sup> p. 64, pl. 3, fig. 35.

Remarks: This middle to late Eocene species differs from the figured form *E. leave* of Cherif et al.,<sup>118</sup> (p. 52, pl. 4, fig. 18) by its backward extensions of the chambers in J. Hafit. It was recorded from late Eocene of J. Hafit, UAE.

## Paleogeography

The paleogeographic maps (partly or regionally) of Berggren,<sup>175</sup> Mintz,<sup>176</sup> Rosenbaum et al.,<sup>177</sup> show the Tethyan realm had been connected with the Indo-Pacific Ocean from the east and Atlantic Ocean to the west via Mediterranean Sea crossing the Middle East region during the Paleogene time (Figure 3). It is proved by the existence of the identified taxa from the Middle East in other localities in the Tethys. Accordingly, the following remarks can be added:

- i. Berggren<sup>175</sup> suggested that during the Paleogene, the fauna of the Mediterranean and the Indo-Pacific exhibit pronounced similarities, which indicate that the connection between the two areas was mentioned by a marine seaway, and the east Atlantic fauna was much more closely related to the fauna than it is today. In the western Atlantic a narrow connection between it and Pacific existed.
- ii. Haq & Aubry<sup>178</sup> noted that the North Africa and Middle East formed important parts of the Tethyan link between the Atlantic and Pacific Oceans during Paleogene.
- iii. Anan & Sharabi<sup>81</sup> noted that the genus *Orthokarstenia* is recorded only in the central and southern Egypt. Anan<sup>8,22</sup> concluded that all recorded members of the Maastrichtian-early Eocene genus *Orthokarstenia* in Egypt (*O. applinae*, *O. esnehensis*, *O. eleganta*, *O. higazyi*, *O. nakkadyi*) have been restricted from the north to the south of Lat. 27°N in Egypt. Anan<sup>22</sup> recorded his Paleocene-early Eocene species *Orthokarstenia nakkadyi*, so far, from many sites in the southern Tethys (Egypt and Tunisia) and also the northern Tethys (Spain and France).
- iv. Anan<sup>179</sup> concluded that the Tethyan realm during the middle-late Eocene extends to the southeast and connected with the Indo-Pacific realm via seaway separating Arabia from Iran-India region. Haynes & Nwabufo-Ene<sup>168</sup> suggested wider Tethyan connections, as far as the Carpathian and Pakistan.
- v. Rögl<sup>180</sup> noted that by the end of the Eocene the Tethys Ocean had already vanished, a new Indian Ocean was born, the western end of the Tethys was reduced to a Mediterranean Sea, Europe was still an archipelago and intercontinental seas covered large areas of the European platform and of western Asia. Between the stable Eurasian platform and the relics of the western Tethys, an elongate deep basins had formed and north of India a marine connection stretched to the west Pacific. Moreover, an important connection of the Tethys with the Polar Sea existed via the Turgai Strait, on the far side of the Oral Mts. These seaways around Asia and the connections with the Polar Sea enable warm-water exchanges and probably explain the sustained warm climate during the Late Eocene. For that the western end of relic Tethys connected Indo-Pacific and Atlantic Oceans.
- vi. Meulenkamp & Sissingh<sup>181</sup> noted that the Arabian Platform, still largely covered by the sea in early to middle Eocene times, was subject to a major regression in the middle to late Eocene.

The following paleontological remarks can be added:

- a. Most of the identified calcareous foraminiferal species from the Maastrichtian-Paleogene in the Middle East were erected from Egypt (84/119, about 70.5 %), 8 from Jordan (about 6.7 %), 8 from UAE (about 6.7 %), 5 from Saudi Arabia (about 4.2 %), 4 from Qatar (about 3.3 %) and 8 from Pakistan (about 6.7 %).

- b. The number of species were erected from the Middle East are 119 species: 32/119 species belong to Anan,<sup>7-10,13,15,17,23-27,34-37</sup> 24 species to LeRoy,<sup>4</sup> 12 species to Ansary,<sup>50</sup> 12 species to Nakkady,<sup>1-3</sup> 8 species to Futyan,<sup>29</sup> 8 species to Haque,<sup>38-40</sup> 6 species to Said & Kenawy,<sup>5</sup> 6 species to Abdou & Abdel Kireem,<sup>6</sup> 5 species to Hasson,<sup>30</sup> 4 species to Hewaidy & Al-Hitmi,<sup>31</sup> 1 species for each, Helal<sup>78</sup> and Aly et al.<sup>28</sup>
- c. Nine of the recorded species are observed in Tunisia, 3 in Libya, 3 in Spain, 3 in Atlantic Ocean, 3 in France and 1 in Arabian Sea.
- d. Seventy five species of the identified species, so far, are endemic to Egypt.
- e. Thirteen species of the Egyptian species are found also in other Tethyan localities, outside Arabia: Pakistan, Arabian Sea, Libya, Tunisia, France, Spain, Atlantic Ocean: *Tristix aubertae*, *Palmula woodi*, *Aragonia semireticulata*, *Orthokarstenia nakkadyi*, *Bulimina farafraensis*, *Trifarina esnaensis*, *Eponides mariei*, *Cibicidoides beadnelli*, *C. libycus*, *C. pseudoacutus*, *Nonionella africana*, *Anomalinoidea desertorum* and *Elphidiella africana*.
- f. Five species of the Saudian species, so far, are endemic to Saudi Arabia.
- g. Eight species of the Jordanian species, so far, are endemic to Jordan.
- h. Eight species of the Emeratian species, so far, are endemic to UAE: *Laevidentalina hudaie*, *L. salimi*, *Margulinopsis karimae*, *Hemirobulina olae*, *Ramulina futyani*, *Turrilina hassani*, *Ornatanomalina ennakhali* and *Elphidium cherifi*.
- i. Four species of the Qatari species, so far, are endemic to Qatar.
- j. Nine species were recorded in both Egypt and UAE: *Amphimorphina yousefi*, *Saracenaria leroyi*, *Astacolus bifurcatus*, *Hemirobulina bassiounii*, *Ramulina futyani*, *Uvigerinella nakkadyi*, *Trifarina esnaensis*, *Valvulinera aegyptiaca*, *A. fayoumensis*.
- k. Eight species were recorded in both Egypt and Tunisia: *Tristix aubertae*, *Palmula woodi*, *Orthokarstenia nakkadyi*, *Bulimina farafraensis*, *Trifarina esnaensis*, *Cibicidoides beadnelli*, *C. libycus* and *C. pseudoacutus* 12. Five species were recorded in both Egypt and Jordan: *Frondicularia nakkadyi*, *Lenticulina trompi*, *Palmula woodi*, *Orthokarstenia higazyi*, and *Anomalinoidea fayoumensis*.
- l. Four species were recorded in both Egypt and Libya: *Eponides mariei*, *Cibicidoides beadnelli*, *C. libycus* and *Elphidiella africana*.
- m. Six of Egyptian species have wide distribution in the Tethys (outside Arabia): *Orthokarstenia nakkadyi*, *Bulimina farafraensis*, *Trifarina esnaensis*, *Cibicidoides beadnelli*, *C. libycus* and *C. pseudoacutus*.
- n. *Palmula ansaryi* Anan<sup>7</sup> has wide geographic distribution in Egypt. It described from the Bartonian of many sections in Fayoum area (Guta I, III, and Naalun) and Sinai (Tayiba) sections by Anan.<sup>7</sup> Later on, it also recorded from the Greater (Bani Suef, Warshet ErRokham section) by Hussein<sup>72</sup> and by Helal<sup>78</sup> from Cairo area (Helwan and Giza Pyramid area) and Nile Valley and in Fayoum area (El-Nazia section). This species

seems confined to the Lutetian-Bartonian planktic foraminiferal zones of Berggren & Pearson<sup>182</sup> and equated the homogeneous benthic foraminifera *P. ansaryi* zone of Anan.<sup>7</sup> It considered an excellent marker for the Bartonian/Priabonian (middle/late Eocene) boundary in Egypt.

- o. The genus *Ornatanomalina* and its representatives have a wide geographic distribution in western Asia, earlier was recorded from Pakistan (Haque<sup>38</sup>) and later from Rub' Al Khali Basin of Saudi Arabia (Hasson<sup>30</sup>), and also in UAE after the record of the late Early Eocene species *Ornatanomalina ennakhali* Anan<sup>183</sup> from J. Hafit, UAE.
- p. The number differences of the recorded species between the different localities in the Middle East may be due to not detailed study, different environmental parameters and/or misidentification.

### Paleoecology and paleobathymetry

- a. LeRoy<sup>4</sup> noted that in certain respects the microfauna of the Esna Shale of Egypt exhibits an affinity with the Paleocene Midway Type fauna (MTF) assemblages of the United States Gulf Coast area. Said & Kenawy<sup>5</sup> described about 275 of foraminifera species from the Maastrichtian-Paleogene of the northern Sinai, Egypt. Berggren & Aubert<sup>184</sup> noted that the Paleogene of these fauna shows an affinity with the MTF (middle-outer neritic environment (50-200 m).
- b. Berggren & Aubert<sup>184</sup> considered the faunal assemblage of Maqfi section, Farafra area and the taxa of Said & Kenawy<sup>5</sup> in the northern Sinai of Egypt to be predominantly related to the MTF (middle-outer neritic environment, 50-200 m).
- c. Keller (1983) noted that general cooling trend between middle Eocene to early late Oligocene is indicated by the successive replacement of warm middle Eocene surface water species (planktic) by cooler Late Eocene intermediate water species. This is indicated by the coexistence of surface, intermediate and deep dwelling species group, suggest that increased thermal gradients developed between the equator and poles nearly coincident with the development of late psychrosphere.
- d. Cherif & EL Deeb<sup>185</sup> noted that arid climate at the close of the middle Eocene became markedly wetter and seems to have been accompanied by a cooling of the water temperature. Moreover, the climatic changes inferred from the Hafit area seems to have been widespread, at least in part of the Middle East.
- e. Anan & Hewaidy<sup>79</sup> considered the Nile Valley Facies is related to the MTF. It means that most northern and central Egypt, according to these authors, shows an affinity with the MTF, middle-outer neritic environment (50-200 m).
- f. Anan<sup>179</sup> noted that in the late Eocene time in the UAE and surrounding area had been located in the tropical and warm-temperate region based on many faunal environmental elements (presence of keel, accessory apertures, tubular spines in some planktic foraminiferal assemblage and high P/B ratio).
- g. Anan<sup>13</sup> noted that barren dark shale bed that rest on the top Maastrichtian horizon (K/T) in some Tethyan localities: Ain Dabadib (Anan & Sharabi<sup>81</sup>), Gabal Duwi (Anan<sup>10</sup>) and also in El Kef section in Tunisia (Keller<sup>101</sup>) is most probably indicative of low oxygenic level in that time.

- h. Anan<sup>16</sup> noted that his species *Vaginulinopsis boukharyi* is restricted in the Paleocene Tarawan Chalk of Duwi section, which may represent an endemic environment, reflects a sea-level fall, most probably, in the inner neritic environment (about 50 m) than middle-outer neritic environment (about 150-200 m) of Dakhla Shale below and Esna Shale above.
- i. Anan<sup>17</sup> noted that the probable environment for Sinai, Egypt (represented by Abu Zenima section) is outer neritic-upper bathyal (200-400 m), which is deeper than the other sites in Egypt: the north Western Desert area (represented by Jiran El Ful section), Farafra-Bahariya area (Maqfi section) and Nile Valley in central Egypt (Duwi section), are deposited in the middle-outer neritic environment (75-200 m).

## Conclusions

The analysis of the Maastrichtian-Paleogene foraminiferal species and subspecies from the Middle East led to the following conclusions:

- The paleontology, stratigraphy and paleogeographic remarks are presented to 119 diagnostic calcareous hyaline foraminiferal species have been erected from the Maastrichtian-Paleogene rocks from Egypt, Jordan, Saudi Arabia, Qatar, UAE and Pakistan in the Middle East.
- The number of species were erected from the Middle East are 119 species: 32/119 species belong to Anan,<sup>7-27</sup> 24 to LeRoy,<sup>4</sup> 12 to Ansary,<sup>50</sup> 12 to Nakkady,<sup>1-3</sup> 8 to Futyan,<sup>29</sup> 8 to Haque,<sup>38-40</sup> 6 to Said & Kenawy,<sup>5</sup> 6 to Abdou & Abdel Kireem,<sup>6</sup> 5 to Hasson,<sup>50</sup> 4 to Hewaidy & Al-Hitmi,<sup>31</sup> 1 species for each: Helal,<sup>78</sup> and also Aly et al.<sup>28</sup>
- Most of these identified species were erected from Egypt (84/119, about 70.5%). 16/84 species (14.1%) of the Egyptian species are found in other Tethyan localities, outside Arabia: Pakistan, Atlantic Ocean, Spain, France, Tunisia, Libya.
- Two/119 species are recorded from the Maastrichtian, 9 are recorded from the Maastrichtian-Paleocene, 23 are recorded from the Paleocene, and another 23 species are recorded from the Paleocene and continue to Eocene, while 62 species belong to Eocene time.
- Cherif & El Deeb<sup>118</sup> and Anan<sup>179</sup> noted that the distribution of the identified Paleogene species from Middle East most probably represent tropical-subtropical fauna.
- Anan & Hamdan<sup>186</sup> noted that an incursion of warm temperate water-mass on the foredeep was sporadic and intermittent throughout the Paleocene of J. Malaqet, UAE.
- Anan<sup>17</sup> noted that the probable environment for Sinai in the northern Egypt (represented by Abu Zenima section) is outer neritic-upper bathyal (200-400 m), which is deeper than the other sites in Egypt: the North Western Desert area (represented by Jiran El Ful section), Farafra Bahariya area (Maqfi) and Nile Valley (Duwi) in central Egypt, which are most probably deposited in the middle-outer neritic (75-200 m).

## Acknowledgments

None.

## Conflicts of interest

Author declares that there is no conflict of interest.

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