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RESEARCH ARTICLE

TAXONOMIC CONSIDERATION OF THE YPRESIAN BENTHIC FORAMINIFERAL SPECIES OF IRAN AND ITS PALEOGEOGRAPHIC DISTRIBUTION IN THE TETHYS

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ABSTRACT

An Ypresian Iranian twenty-five smaller benthic foraminiferal species belonging to twenty genera, were identified by which represent good example of the Southern Tethyan benthic foraminiferal assemblage. The present study deals with the modern taxonomical consideration of this assemblage. These taxa are: *Ammodiscus glabrata* Cushman & Jarvis, *Spiroplectinella knebeli, Pseudogaudryinella iranica* Anan, *Verneuilina aegyptiaca* Said & Kenawy, *Verneuilina luxorensis* Nakkady, *Dorothia bulletta* (Carsey), *Textularia nilotica* (Schwager), *Textularia punjabensis* Haque, *Textularia salahii* Anan, *Vulvulina advena* Cushman, *Lenticulina turbinata* (Plummer), *Percultazonaria fragaria* (Gümbel), *Orthokarstenia applinae* (Plummer), *Bulimina alazanensis* Cushman, *Bulimina midwayensis* Cushman & Parker, *Globobulimina pyrula* (d'Orbigny), *Uvigerina mediterranea* (Hofker), *Aragonia aragonensis* (Nuttall), *Nonionella auris* (D'Orbigny), *Anomalinoides acutus* (Plummer), *Cibicidoides proprius* Brotzen, *Cibicidoides vulgaris* Plummer, *Oridorsalis umbonatus* (Reuss), *Gyroidinoides girardanus* (Reuss), *Hanzawaia cubensis*. The Southern Tethyan assemblage of Iran indicates an open marine environment, which represents outer neritic environment, and shows an affinity with Midway-Type Fauna (MTF). These wide paleogeographic distribution indicate that the ancestral Tethys is connected with the ancestral Atlantic and Indian Oceans via Mediterranean Sea, as well as Arctic sea in that time.

KEYWORDS

Foraminifera, Early Paleogene, Iran, Middle East, Tethys

1. INTRODUCTION

The present study deals with the taxonomic consideration of Ypresian twenty-five species of three foraminiferal suborders: Textulariid (10 species), Lagenid (2 species) and Rotaliid (13 species) from the Khangiran Formation of Yaghol section (northeast Iran), which were introduced mainly (Figure 1) (VahdatiRad et al., 2016; Salahi, 2021).

These recorded species from Iran are correlated with the synchronous foraminiferal species from other neighbor Tethyan localities, e.g.: India, Pakistan, UAE, Jordan, Egypt, Tunisia, Nigeria (Southern Tethys), and also Spain, France, Italy, Hungaria, Germany (Northern Tethys) are shown in Figure 2. Some of these identified species were also recorded from USA and some other localities in the Atlantic Ocean.

2. MATERIAL AND METHODS

Twenty-five smaller benthic foraminiferal species belonging to twenty genera were recorded from the Ypresian Khangiran Formation of the Kopet-Dagh sedimentary basin, northeast of Iran (Figure 3) and southeast of Turkmenistan in the Middle East (VahdatiRad et al., 2016 and Salahi, 2021). The modern taxonomical consideration of this faunal assemblage is treated in this study.

Figure 1: Location map of the Yaghol section, northeast of Iran (VahdatiRad et al., 2016).

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Figure 2: Location map of Iran and other neighbor Asian and African Southern Tethys and also European Northern Tethyan countries.

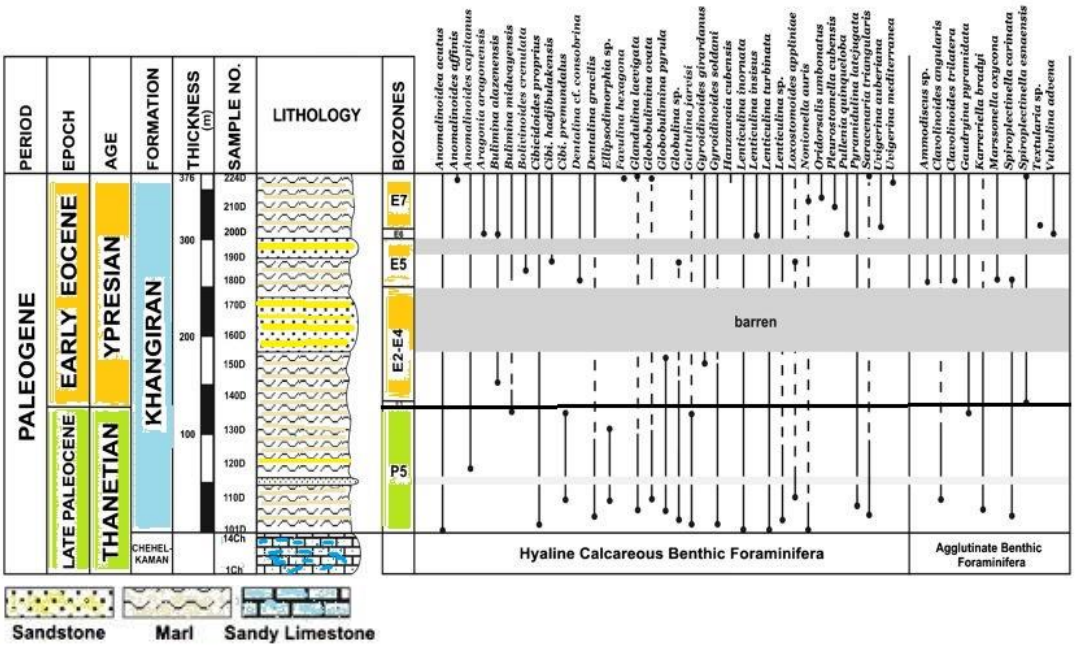
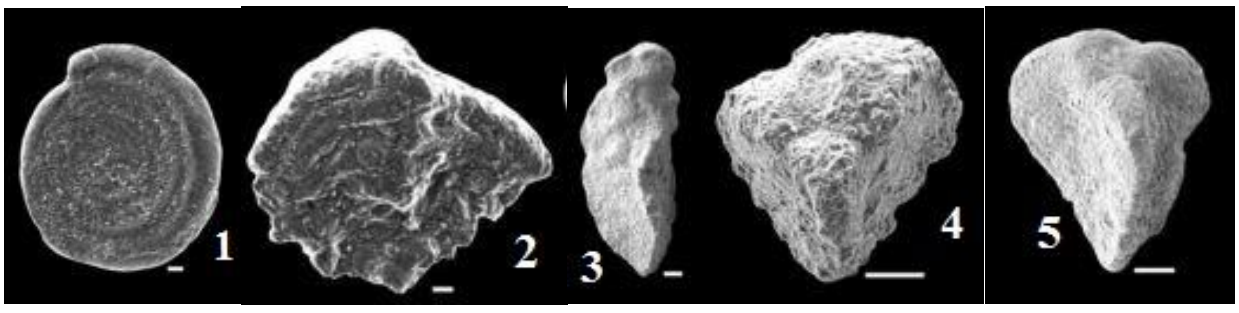


Figure 3: The stratigraphic log of the study section, and the stratigraphic distribution of the Ypresian identified benthic foraminiferal species (VahdatiRad et al., 2016).

3. Systematic Paleontology

The taxonomy of Loeblich & Tappan is followed here for twenty-five benthic foraminiferal species belonging to twenty genera were recorded from the Ypresian stratigraphic succession of Kopet-Dagh sedimentary basin of the Khangiran formation (northeast Iran) (Loeblich and Tappan, 1988). These identified species are illustrated in Plate (1). The stratigraphic distribution of the recorded foraminiferal species in the Ypresian of the Kopet-Dagh sedimentary basin of the Khangiran Formation (northeast Iran) (see Figure 3) (VahdatiRad et al., 2016; Salahi, 2021).

Figure 1. Ammodiscus glabrata Cushman & Jarvis (1928), 2. Spiroplectinella knebeli (LeRoy), 3. Pseudogaudryinella iranica Anan, 4. Verneuilina aegyptiaca Said & Kenawy, 5. Verneuilina luxorensis Nakkady, 6. Dorothia bulletta (Carsey), 7. Textularia nilotica (Schwager), 8. Textularia punjabensis Haque, 9. Textularia salahii Anan, 10. Vulvulina advena Cushman, 11. Lenticulina turbinata (Plummer), 12. Percultazonaria fragaria (Gümbel), 13. Orthokarstenia applinae (Plummer), 14. Bulimina alazanensis Cushman, 15. Bulimina midwayensis Cushman & Parker (1936), 16. Globobulimina pyrula (d'Orbigny, 1846), 17. Uvigerina mediterranea (Hofker), 18. Aragonia aragonensis (Nuttall), 19. Nonionella auris (d'Orbigny), 20. Anomalinoides acutus (Plummer) dorsal view, 21a,b. Cibicidoides proprius Brotzen, a. side view, b. dorsal view, 22. Cibicidoides vulgaris (Plummer), 23. Oridorsalis umbonatus (Reuss) dorsal view, 24a,b. Gyroidinoides girardanus (Reuss) a. side view, b. ventral view, 25a,b. Hanzawaia cubensis (Cushman & Bermúdez) a. side view, b. ventral view.



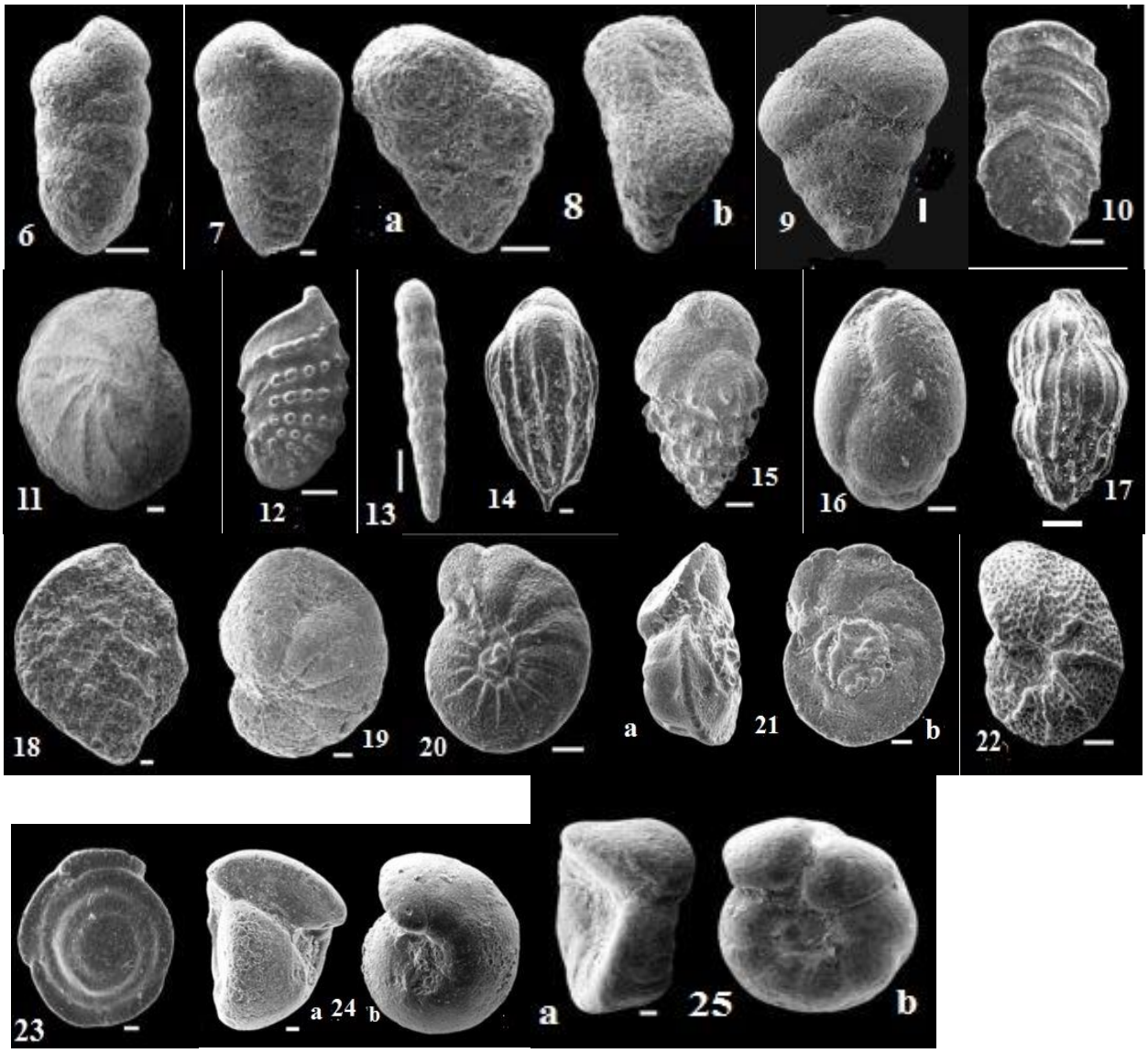


Plate 1 (scale bar 100 µm)

Order Foraminiferida Eichwald, 1830
Suborder Textulariina Delage & Hérouard, 1896
Genus *Ammodiscus* Reuss, 1962
Type species Ammodiscus *infimus* Bornemann, 1874

***Ammodiscus glabrata* Cushman & Jarvis, 1928 - (Plate 1, figure 1)**

1928 *Ammodiscus glabrata* Cushman and Jarvis, p. 86, pl. 12, fig. 6.
2016 *Ammodiscus* sp. VahdatiRad et al., p. 5, pl. 2, fig. 16. {illustrated specimen}
Remarks: This species was recorded from Trinidad, Tunisia (Aubert & Berggren, 1976) and Iran.

Genus *Spiroplectinella* Kisel'man, 1927
Type species *Spiroplecta wrightii* Silvestri, 1903

***Spiroplectinella knebeli* (LeRoy, 1953) - (Plate 1, figure 2)**

1953 *Spiroplectammina knebeli* (LeRoy,1953, p. 51, pl. 2, figs. 10, 11.
2016 *Spiroplectammina esnaensis* LeRoy - VahdatiRad et al., p. 5, pl. 2, fig. 20.
Remarks: This species was recorded from Egypt, Tunisia (Aubert & Berggren, 1976), Jordan (Futyan, 1976), UAE (Anan, 1993), Hungaria (Ozsvárt, 2007) and Iran.

Genus *Pseudogaudryinella* Cushman, 1936
Type species *Gaudryinella capitosa* Cushman, 1933, p. 52; 00.

***Pseudogaudryinella iranica* Anan, 2022- (Plate 1, figure 3)**

2022 *Pseudogaudryinella iranica* Anan, p. 14, pl. 1, fig. 5.
2016 *Clavulinoides angularis* (d'Orbigny) - VahdatiRad et al., p. 5, pl. 2, fig. 19.
2021 *Gaudryina* sp. Salahi, p. 314, pl. 4, fig. 23 (*non* fig. 28).
Remarks: This species is confined, so far, from Iran.

Genus *Verneuilina* d'Orbigny, 1839
Type species *Verneuilina tricarinata* d'Orbigny, 1840, p. 39.

***Verneuilina aegyptiaca* Said & Kenawy, 1956 - (Plate 1, figure 4)**

1956 *Verneuilina aegyptiaca* Said & Kenawy, p. 122, pl. 1, fig. 16.
2016 *Gaudryina pyramidata* (Cushman) - VahdatiRad et al., p. 5, pl. 2, fig. 17.
Remarks: This species was recorded from Egypt, Tunisia (Speijer, 1994), UAE (Anan, 1993), Spain (Ortiz and Thomas, 2006) and Iran.

***Verneuilina luxorensis* Nakkady, 1950 - (Plate 1, figure 5)**

1950 *Verneuilina luxorensis* Nakkady, p. 683, pl. 89, figs. 6,7.
2016 *Clavulinoides trilateral* (Cushman) - VahdatiRad et al., p. 5, pl. 2, fig. 18.
Remarks: The Early Eocene *V. luxorensis* differs from the Maastrichtian-Paleocene *V. aegyptiaca* by its pyramidal test, which is more compressed and much excavated on three lateral thin edges, and most probably *V. luxorensis* was developed from *V. aegyptiaca* in a *V. aegyptiaca* → *V. luxorensis* lineage. This species was originally recorded from Egypt, and later from Tunisia, Negev, UAE, Iraq and Iran.

Genus *Dorothia* Plummer, 1931
Type species *Gaudryina bulletta* Carsey, 1926, p. 28; OD.

***Dorothia bulletta* (Carsey, 1926) - (Plate 1, figure 6)**

1926 *Gaudryina bulletta* Carsey, p. 28, pl. 4, fig. 4.
1987 *Dorothia bulletta* (Carsey) - Anan, p. 220, pl. 1, fig. 3.

2016 *Karreriella bradyi* (Cushman) - VahdatiRad et al., p. 5, pl. 2, fig. 23.
Remarks: This species was recorded from USA, and later from Egypt, UAE (Anan, 1993) and Iran.

Genus *Textularia* Defrance, 1824
Type species *Textularia sagittula* Defrance, 1824

***Textularia nilotica* (Schwager, 1883) - (Plate 1, figure 7)**

1883 *Plecanium niloticum* Schwager, p. 115, pl. 26, fig. 14.
2016 *Textularia nilotica* (Schwager) - Anan, p. 361, fig. 3ae.
2016 *Spiroplectinella carinata* (d'Orbigny) - VahdatiRad et al., p. 5, pl. 2, fig. 21.
Remarks: This species was originally recorded from Egypt, Pakistan (Haque, 1956) and Iran.

***Textularia punjabensis* Haque, 1956 - (Plate 1, figure 8)**

1956 *Textularia punjabensis* Haque, p. 31, pl. 9, fig. 12
2016 *Textularia* sp. VahdatiRad et al., p. 5, pl. 2, fig. 22.
Remarks: This species was originally recorded from Pakistan, and later from India (Habibnia & Mannikeri, 1990), Egypt (Orabi & Zaky, 2016), France (Sztrákos, 2005) and Iran.

***Textularia salahii* Anan, 2022 - (Plate 1, figure 9)**

2021 *Textularia* sp. Salahi, p. 316, pl. 5, figs. 9, 10.
2022 *Textularia salahii* Anan, p. 28, pl. 2, fig. 34.
Remarks: This species is confined, so far, from Iran.

Genus *Vulvulina* d'Orbigny, 1826
Type species *Vulvulina capreolus* d'Orbigny, 1826

***Vulvulina advena* Cushman, 1926 - (Plate 1, figure 10)**

1926 *Vulvulina advena* Cushman, p. 32, pl. 4, figs. 9.
2016 *Vulvulina advena* Cushman - VahdatiRad et al., p. 5, pl. 2, fig. 24.
Remarks: This species was recorded from USA, and later Spain (Ortiz & Thomas, 2006) and Iran.
Suborder Lagenina Delage & Hérouard, 1896

Genus *Lenticulina* Lamarck, 1804
Type species *Lenticulites rotulatus* Lamarck, 1804

***Lenticulina turbinata* (Plummer, 1927) - (Plate 1, figure 11)**

1927 *Cristellaria turbinata* Plummer, p. 93, pl. 7, fig. 4.
2016 *Lenticulina turbinata* (Plummer) - VahdatiRad et al., 2016, p. 5, pl. 2, fig. 3.
Remarks: This species was originally recorded from USA, and later from Spain (Ortiz & Thomas, 2006), Tunisia (Aubert & Berggren, 1976) and Iran.

Genus *Percultazonaria* Loeblich & Tappan, 1968
Type species *Cristellaria subaculeata* Cushman, 1923

***Percultazonaria fragaria* (Gümbel, 1868) - (Plate 1, figure 12)**

1868 *Marginulina fragaria* Gümbel, p. 57, pl. 1, fig. 58.
2015 *Percultazonaria fragaria* (Gümbel) - Anan, p. 21, pl. 1, fig. 9.
2016 *Lenticulina* sp. VahdatiRad et al., p. 5, pl. 2, fig. 8.
Remarks: This Eocene species is characterized by its ornamented node surface and bead-like tubercles that are arranged in inclined lines in both closed planispiral involute part and last inclined short uniserial part. It was recorded from USA, Norwegian Sea (Hulsbos et al., 1989), France (Sztrákos, 2005), Slovenia (Cimerman et al., 2006), Bulgaria (Valchev et al., 2013), Slovakia (Zlinská, 2009), Egypt (Aly et al, 2011), UAE (Anan, 2009) and Iran.
Suborder Rotaliina Delage and Hérouard, 1896

Genus *Orthokarstenia* Dietrich, 1935
Type species *Orthocerina ewaldi* Karsten, 1858, p. 114.

***Orthokarstenia applinae* (Plummer, 1927) - (Plate 1, figure 13)**

1927 *Bolivina applini* Plummer, p. 69, pl. 4, fig. 1.
1998 *Orthokarstenia applinae* (Plummer) - Anan, p. 371, fig. 3.3.
2016 *Loxostomum applini* (Plummer) - VahdatiRad et al., p. 6, pl. 2, fig. 14.
Remarks: This species is regarded to belong to *Orthokarstenia* due to its triserial to biserial to uniserial arrangement of chambers. Anan (1988) regarded that the Paleocene-Early Eocene *O. applinae* (Plummer) is an evolutionary development from the Maastrichtian *O. oveyi* (Nakkady). The *O. applinae* has a wide geographic distribution, so far: USA, Sweden (Brotzen, 1948), Norwegian Sea (Hulsbos et al., 1989), Tunisia (Aubert & Berggren, 1976), Jordan (Futyan, 1976), UAE (Anan, 1993), Egypt (1998), Pakistan (Haque, 1956) and Iran.

Genus *Bulimina* d'Orbigny, 1826
Type species: *Bulimina marginata* d'Orbigny, 1826

***Bulimina alazanensis* Cushman, 1927 - (Plate 1, figure 14)**

1927 *Bulimina alazanensis* Cushman, p. 161, pl. 25, fig. 4.
2016 *Bulimina alazanensis* Cushman - VahdatiRad et al., 2016, p. 5, pl. 2, fig. 9.
Remarks: This species was originally recorded from USA, and later Brazil (de Mello, 2016), Spain (Ortiz & Thomas, 2006) and Iran

***Bulimina midwayensis* Cushman & Parker, 1936 - (Plate 1, figure 15)**

1936 *Bulimina arkadelphiana* var. *midwayensis* Cushman & Parker, p. 73, pl. 4, fig. 3.
2016 *Bulimina midwayensis* Cushman and Parker - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 10.
Remarks: This species was originally recorded from USA, and later Egypt (Said & Kenawy,1956), Tunisia (Aubert & Berggren, 1976), France (Sztrákos, 2005) and Iran.

Genus *Globobulimina* Cushman, 1927
Type species *Globobulimina pacifica* Cushman, 1927.

***Globobulimina pyrula* (d'Orbigny, 1846) - (Plate 1, figure 16)**

1846 *Bulimina pyrula* d'Orbigny, p. 184, pl. 11, fig. 9, 10.
2006 *Globobulimina pyrula* (D'Orbigny) - Ortiz & Thomas, p. 119, pl. 6, figs. 6, 7.
2016 *Globobulimina pyrula* (D'Orbigny) - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 11.
Remarks: The species has pyriform-shaped test, broadest at the base and tapering towards the apertural end. It is recorded from France, Spain (Ortiz & Thomas, 2006) and Iran.
Genus: *Uvigerina* d'Orbigny, 1826
Type species *Uvigerina pygmaea* d'Orbigny, 1826

***Uvigerina mediterranea* (Hofker, 1932) - (Plate 1, figure 17)**

1932 *Uvigerina mediterranea* Hofker, p. 118, fig. 32.
2016 *Uvigerina mediterranea* (Hofker) - VahdatiRad et al., p. 6, pl. 2, fig. 15.
Remarks: This species was recorded from Germany, and later Egypt (Ansary, 1955) and Iran.

Genus *Aragonia* Finlay, 1939
Type species *Aragonia zelandica* Finlay, 1939

***Aragonia aragonensis* (Nuttall, 1930) - (Plate 1, figure 18)**

1930 *Textularia aragonensis* Nuttall p. 280, pl. 23, fig. 6.
2006 *Aragonia aragonensis* (Nuttall) - Ortiz & Thomas, p. 112, pl. 4, figs. 1-3.
2016 *Aragonia aragonensis* (Nuttall) - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 12.
Remarks: This species was originally recorded from Mexico, and later Cuba (Cushman & Bermúdez, 1937), USA (Olsson, 1960), Atlantic Ocean (Tjalsma & Lohmann 1983), Trinidad (Bolli et al, 1994), Spain (Ortiz & Thomas, 2006), Italy (Proto Decima & De Biase, 1975), New Zealand (Finlay, 1939), Egypt (LeRoy, 1953) and Iran.

Genus: *Nonion* De Montfort, 1808
Type species *Nautilus faba* Fichtel and Moll, 1798

***Nonionella auris* (d'Orbigny, 1939) - (Plate 1, figure 19)**

1839 *Valvulina auris* d'Orbigny, p. 47, pl. 2, figs. 15-17.
2011 *Nonionella auris* (d'Orbigny) - Mohan et al., p. 59, pl. 8, fig. 12.
2016 *Nonionella auris* (d'Orbigny) - VahdatiRad et al., p. 6, pl. 2, fig. 13.
Remarks: This species was originally recorded from France, and later NW Atlantic Ocean (Mohan et al., 2011) and Iran.

Genus *Anomalinoides* Brotzen, 1942
Type species *Anomalinoides plummerae* Brotzen, 1942

***Anomalinoides acutus* (Plummer 1927) - (Plate 1, figure 20)**

1927 *Anomalina ammonoides* (Reuss) *acuta* Plummer, p. 142, pl. 10, fig. 2.
2006 *Anomalinoides acutus* (Plummer) - Ortiz & Thomas, p. 111, pl. 3, figs. 1, 2.

2016 *Anomalinoides acutus* (Plummer) - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 2.
Remarks: This species was recorded from USA, and later Mexico (Alegret & Thomas, 2001), Trinidad (Bolli et al, 1994), Belgium (Kaasschieter, 1961), Tunisia (Aubert & Berggren, 1976) and Iran.

Genus *Cibicidoides* Thalmann, 1939
Type species *Truncatulina mundula* Brady, Parker & Jones, 1890

***Cibicidoides proprius* Brotzen, 1948 - (Plate 1, figure 21a,b)**

1948 *Cibicidoides proprius* Brotzen, p. 78, pl. 12, figs. 3, 4.
2006 *Cibicidoides proprius* Brotzen - Ortiz & Thomas, p. 117, pl. 5, figs. 8, 9.
2016 *Cibicidoides proprius* Brotzen - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 4a, b.
Remarks: This species has acute periphery, planoconvex test, and uniform dorsal boss. It was originally recorded from Sweden, and later Belgium (Kaasschieter, 1961), Spain (Ortiz & Thomas, 2006), Hungaria (Ozsvárt, 2007), Trinidad (Bolli et al, 1994), Mexico (Alegret & Thomas, 2001) and Iran.

***Cibicidoides vulgaris* (Plummer, 1927) - (Plate 1, figure 22)**

1927 *Truncatolina vulgaris* Plummer, p. 145, pl. 10, fig. 3.
1975 *Cibicidoides vulgaris* (Plummer) - Berggren & Aubert, p. 134, pl. 19, fig. 6.
2016 *Anomalinoides capitanus* (Gümbel, 1868) - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 1.
Remarks: This species is characterized by its readily distinguished by the elevated sutures in the early chambers on both sides, and coarsely perforate wall. It was recorded from some localities in the Tethys USA and Argentina by Berggren & Aubert (1975), and from western side of Atlantic, and from Turkmenia in the eastern side (Berggren & Aubert, 1975), Egypt (Anan & Hewaidy, 1986), and Iran.

Genus *Oridorsalis* Andersen, 1961
Type species *Oridorsalis westi* Andersen, 1961

***Oridorsalis umbonatus* (Reuss 1851) - (Plate 1, figure 23)**

1851 *Rotalina umbonata* Reuss, p. 75, pl. 5, fig. 35.
2006 *Oridorsalis umbonatus* (Reuss) - Ortiz & Thomas, p. 124, pl. 9, fig. 9.
2016 *Oridorsalis umbonatus* (Reuss) - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 6.
Remarks: This species was recorded from Germany, Mexico (Cole, 1928), Trinidad (Bolli et al, 1994), Atlantic Ocean (Tjalsma & Lohmann, 1983), Belgium (Kaasschieter, 1961), Peru (Cushman & Stone, 1949), Ecuador (Cushman & Stainforth 1951), Egypt (LeRoy, 1953) and Iran.

Genus *Gyroidinoides* Brotzen, 1942
Type species *Rotalina nitida* Reuss, 1844

***Gyroidinoides girardanus* (Reuss 1851) - (Plate 1, figure 24a,b)**

1851 *Rotalina girardana* Reuss, p. 73, pl. 5, fig. 34.
2006 *Gyroidinoides girardanus* (Reuss) - Ortiz & Thomas, p. 119, pl. 7, fig. 8.
2016 *Gyroidinoides girardanus* (Reuss) - VahdatiRad et al., 2016, p. 6, pl. 2, fig. 5.
Remarks: This species is characterized by its conspicuous concave apertural face and by the overhanging lower edges of the ventral chambers. It was recorded from Germany, and later Trinidad (Cushman & Renz, 1946), Peru (Cushman & Stone, 1949), Spain (Ortiz & Thomas, 2006), Tunisia (Berggren & Aubert, 1976), Egypt (LeRoy, 1953) and Iran.

Genus *Hanzawaia* Asano 1944
Type species *Hanzawaia nipponica* Asano, 1944

***Hanzawaia cubensis* (Cushman & Bermúdez 1948) - (Plate 1, figure 25a,b)**

1948 *Boldia cubensis* Cushman & Bermúdez p. 74, pl. 11, figs. 15-16.
2006 *Hanzawaia cubensis* (Cushman and Bermúdez) - Ortiz & Thomas, p. 120, pl. 7, fig. 8.
2016 *Hanzawaia cubensis* (Cushman and Bermúdez) - VahdatiRad et al., p. 6, pl. 2, fig. 7.
Remarks: This species was recorded from Cuba and USA (Cushman, 1951), Spain (Ortiz & Thomas, 2006) and Iran.

4. PALEOGEOGRAPHY

Table (1) shows the paleogeographic distribution of the identified twenty-five benthic foraminiferal species in the Early Eocene succession of Yaghol section, northeast of Iran. Some remarks are presented:

1. The agglutinated species represents about 40% of the total recorded benthic species (10/25), these are: *Ammodiscus glabrata, Spiroplectinella knebeli, Pseudogaudryinella iranica*, *Verneuilina aegyptiaca*, *V. luxorensis*, *Dorothia bulletta*, *Textularia nilotica*, *T. punjabensis*, *T. salahii* and *Vulvulina advena*.

Table 1: Paleogeographic distribution of the Early Eocene benthic foraminifera in some Tethyan localities: 1. Iran, 2. India, 3. Pakistan, 4. UAE, 5. Jordan, 6. Egypt, 7. Tunisia, 8. Spain, 9. France, 10. Belgium, 11. Germany, 12. Hungaria, 13. Slovenia, 14. Atlantic, 15. Cuba, 16. Trinidad, 17. USA, 18. Mexico, 19. Ecuador, 20. Peru, 21. Brazil. Sp. No. = Species number, x=recorded, - not recorded.

Sp. No.	countries / species		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	*Ammodiscus*	*glabrata*	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	-
2	*Spiroplectinella*	*knebeli*	x	-	-	x	x	x	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-
3	*Pseudogaudryinell a*	*iranica*	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	*Verneuilina*	*aegyptiaca*	x	-	-	x	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-
5		*luxorensis*	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	*Dorothia*	*bulletta*	x	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
7	*Textularia*	*nilotica*	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8		*punjabensis*	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9		*salahii*	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	*Vulvulina*	*advena*	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-
11	*Lenticulina*	*turbinata*	x	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	x	-	-	-	-
12	*Percultazonaria*	*fragaria*	x	-	-	x	-	x	-	-	x	-	-	-	x	x	-	-	x	-	-	-	-
13	*Orthokarstenia*	*applinae*	x	-	x	x	x	x	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-
14	*Bulimina*	*alazanensis*	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	x
15		*midwayensis*	x	-	-	-	-	x	x	-	-	x	-	-	-	-	-	-	x	-	-	-	-
16	*Globobulimina*	*pyrula*	x	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	*Uvigerina*	*mediterrane a*	x	-	-	-	-	-	-	x	x	-	x	-	-	-	-	-	-	-	-	-	-
18	*Aragonia*	*aragonensis*	x	-	-	-	-	x	-	x	-	-	-	-	-	-	x	x	x	x	-	-	-
19	*Nonionella*	*auris*	x	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-
20	*Anomalinoides*	*acutus*	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	x	x	-	-	-
21	*Cibicidoides*	*proprius*	x	-	-	-	-	-	-	x	-	x	-	x	-	-	-	x	-	x	-	-	x
22		*vulgaris*	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
23	*Oridorsalis*	*umbonatus*	x	-	-	-	-	-	-	-	-	x	-	-	-	x	-	x	-	x	x	x	-
24	*Gyroidinoides*	*girardanus*	x	-	-	-	-	x	x	x	-	-	-	-	-	-	-	x	-	-	-	x	-
25	*Hanzawaia*	*cubensis*	x	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	x	-	-	-	-

2. The Lagenid calcareous species represents about 8% (2/25), these are: *Lenticulina turbinata* and *Percultazonaria fragaria.*

3. The Rotaliid calcareous species represents about 52% (13/25), these are: *Orthokarstenia applinae*, *Bulimina alazanensis*, *Bulimina midwayensis, Globobulimina pyrula*, *Uvigerina mediterranea*, *Aragonia aragonensis*, *Nonionella auris*, *Anomalinoides acutus*, *Cibicidoides proprius*, *Cibicidoides vulgaris, Oridorsalis umbonatus*, *Gyroidinoides girardanus* and *Hanzawaia cubensis*.

According to the previous statistics, more than one species have wide geographic distribution around the world. Many species are recorded from seven localities in the Tethys: *Percultazonaria fragaria, Orthokarstenia applinae*, *Cibicidoides proprius* and *Oridorsalis umbonatus*. Some other species are recorded from six localities: *Spiroplectinella knebeli, Anomalinoides acutus* and *Gyroidinoides girardanus*. *Verneuilina aegyptiaca* is recorded in five localities. Other species are recorded from four localities: *Dorothia bulletta*, *Lenticulina turbinata*, *Bulimina alazanensis* and *Hanzawaia cubensis*. Other species are recorded from three localities: *Ammodiscus glabrata, Textularia nilotica*, *T. punjabensis*, *Vulvulina advena*, *Bulimina midwayensis, Nonionella auris* and *Cibicidoides vulgaris. Verneuilina luxorensis* is recorded in two localities, while *Pseudogaudryinella iranica* and *Textularia salahii* are confined in Iran.

The Early Paleogene paleogeographic map is presented in fig. (4) show that the Tethyan realm had been connected with the Indo-Pacific Ocean from the east and the Atlantic Ocean to the west, which are accordance with some other authors (e. g. Moore et al., 1978; Haque and Aubrey, 1980; Adams et al., 1983; Rögl, 1999). This wide geographic distributional of the record assemblage emphasizes the interpretations that have been presented by different authors about the extended realms of Indo-Pacific with Atlantic via Tethys during the Early Eocene time.

5. Paleoenvironment

According to some of the identified species, such as and *Bulimina midwayensis, Orthokarstenia applini* and *Anomalinoides acutus* belong to the Midway-type fauna, and *Bulimina alazanensis* is typical bathyal species, while *Oridorsalis umbonatus* is common at lower bathyal settings (Berggren and Aubert, 1975; Alegret and Thomas, 2001). A group researchers noted that in the southern margin in the Tethys and specially including the outer-shelf deposits, the lower part of the Carbon Isotope Excursion (CIE) interval is associated with regional dysoxia (Aubry et al., 2007). A group researchers noted that the faunal changes indicate increasing water depth from lower part to near the Early Eocene boundary in the Kopet-Dagh section of the Khangiran Formation (VahdatiRad et al., 2016). It seems that the deep water environment appear to have been dominant throughout the Early Eocene of the study section of Iran, except some fluctuation (high and low Deeping) during this time (Figure 4).

Figure 4: The Early Paleogene paleogeographic map shows the open connections of the Tethys and the Atlantic Ocean (west) and Pacific Ocean (east).

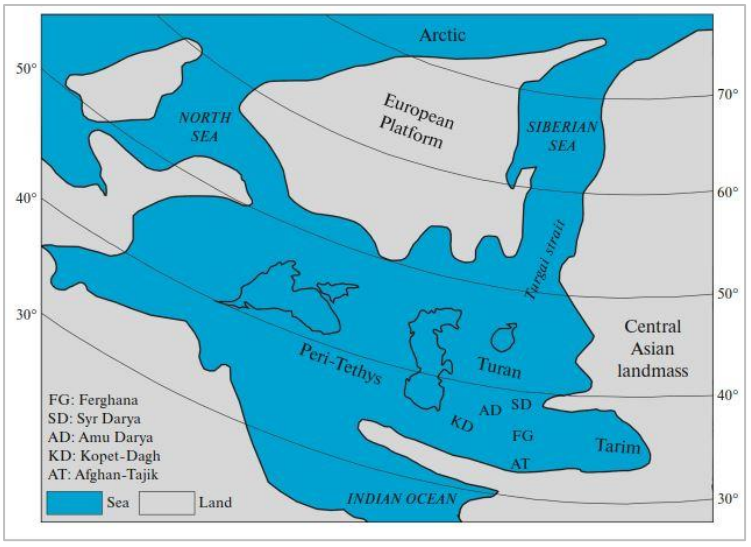


Figure 5: Communication systems of Arctic and Tethys basins through seaways during the early Paleogene (Salahi, 2021).

Salahi noted that the Paleogene deposits of the Kopet-Dagh Basin in NE Iran indicate that a link between basins of the Former Soviet Union and Central Asian regions existed during the Paleogene, and the studied area was covered by an epicontinental sea possessing the open connections to the Arctic Ocean (Figure 5) (Salahi, 2021).

6. Conclusions

The present study deals with the recording of twenty-five identified Ypresian species of agglutinated, Lagenid and Rotaliid calcareous foraminiferal genera from Iran. Two of the identified species are confined to Iran, but the others were recorded from many localities in the North America (USA, Mexico, Trinidad), Southern Tethys (Ecuador, Peru, Brazil, Argentina), Europe (Spain, France, Belgium, Germany, Hungaria, Slovenia, Italy), North Africa (Tunisia, Egypt, Nigeria), and Southwest Asia (Jordan, UAE, Iran, Pakistan, India). This study confirms again that the extended realms of the Tethys have extended from the Indo-Pacific to the Atlantic Oceans via Mediterranean Sea during the Ypresian time. The Southern Tethyan assemblage of Iran indicates an open marine environment, which represents outer neritic environment, and shows an affinity with Midway-Type Fauna (MTF), and seems that the neritic water environment appear to have been dominant throughout the study section of Iran, except some fluctuation (high and low Deeping) during this time.

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