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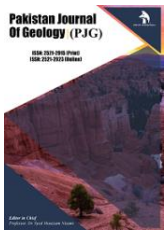

REVIEW ARTICLE

TEN TETHYAN PHYLOGENETIC LINEAGES OF CAMPANIAN TO RECENT FORAMINIFERA

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ABSTRACT

Ten phylogenetic lineages were produced by gradualistic evolutionary trends which observed within many planktic and benthic foraminiferal genera or species throughout the Campanian to Recent forms in the Tethys. These trends are: 1) *Praemurica inconstans* (Subbotina) > *P. arabica* Anan > *P. uncinata* (Bolli). 2) *Turborotalia cerroazulensis* (Cole) > *T. semicunialensis* Anan > *T. cunialensis* (Toumarkine and Bolli), 3) *Gaudryina arabica* Anan > *G. salimi* Anan, > *G. ameeri* Anan, 4) *Clavulina misrensis* Anan, n. sp. > *C. pseudoparisensis* Anan > *C. angularis* d'Orbigny, 5) *Annulofrondicularia bignoti* Anan > *A. tunisica* Anan > *A. annularis* d'Orbigny, 6) *Tristix liasina* (Berthelin) > *T. aubertae* Anan > *T. sztrakosae* Anan, 7) *Orthokarstenia higazyi* (Nakkady) > *O. nakkadyi* Anan > *O. eleganta* (Plummer), 8) *Bolivinoides miliaris* Hiltermann and Koch > *B. draco* (Marsson) > *B. aegyptiaca* Anan, 9) *Uvigerina jacksonensis* Cushman > *Uvigerinita hispida* (Schwager) > *Uvigerinatella peregrina* (Cushman), 10) *Ornatanomalina pakistanica* Anan > *Ornatodella pustulosa* (Haque) > *Saudella ornata* Hasson. One of the recorded species is treated here as new: *P. arabica and Clavulina misrensis.* These lineages help, not only to define the major faunal changes at Cretaceous/Tertiary (K/T), Paleocene/Eocene (P/E), and Eocene/Miocene (E/M) boundaries, but also to emphasis the stratigraphic importance of them in different Tethyan localities.

KEYWORDS

Planktic and Benthic foraminifera, Lineages, Paleontology, Stratigraphy, Cretaceous, Paleogene, Neogene, Recent

1. INTRODUCTION

The genus and species are facies-linked, and migrated from elsewhere as the favorable habitat expanded due to alternation in the environmental parameters. Minor differences in the morphology of the test, wall structure, size, ornamentation, and type of periphery are recognized as being of decisive generic or specific value. Many attempts have been made to interpret the phylogeny of more than planktic and benthic foraminiferal genera and species, which could have evolved from earlier stratigraphic level and used in nine phylogenetic lineages by many authors: i.e. (Nakkady, 1950, 1955; Hunter et al., 1988; Anan, 1988, 2004, 2010, 2012, 2014, 2017, 2020; Fara and Langer, 2004).

2. STRATIGRAPHIC LEVEL

Lemon (1990) noted that a lineage of one species gradually evolves from another by a progressive shift in one or more phylogenetic parameters is a process of speciation (Phyletic Gradualism, Anagenesis), which produced a mixed morphologic character between the descendent and the ancestral species in time (Figure 1).

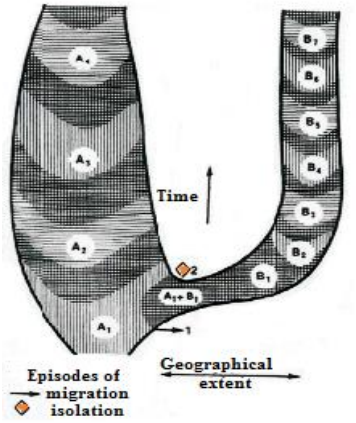

Figure 1: Phylogenetic gradualism model of speciation (After Lemon, 1990).

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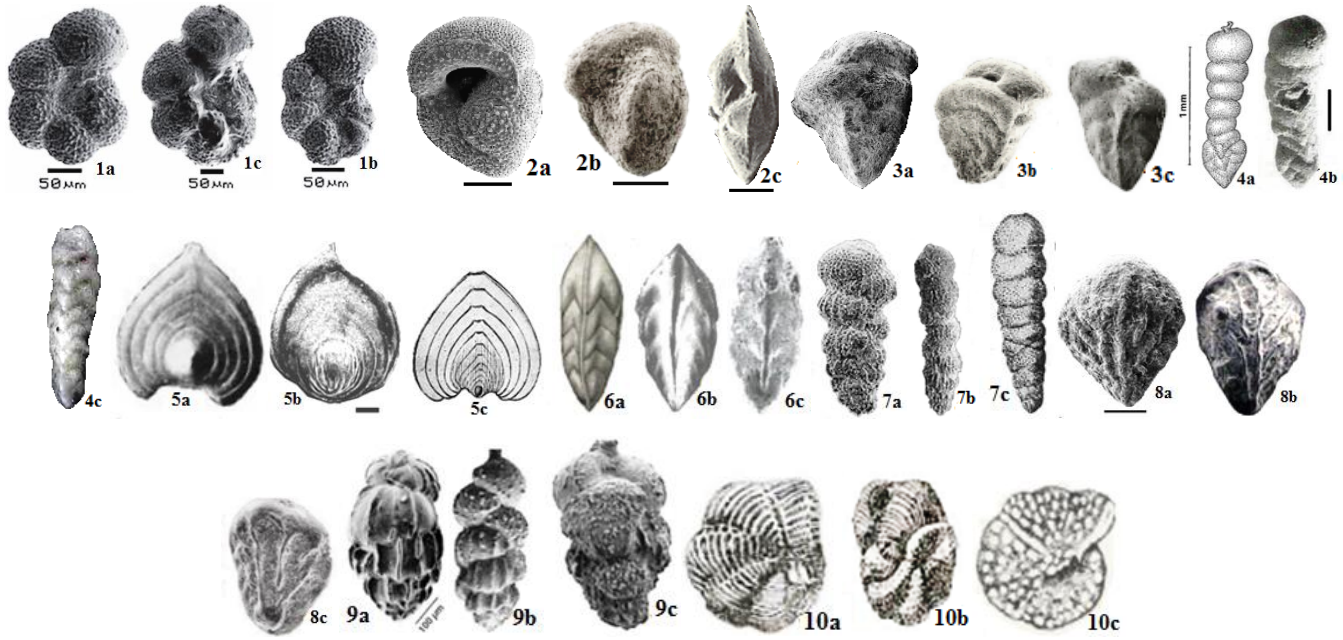
3. Taxonomy

The classification offor planktic fauna and Loeblich andfor benthic fauna are followed in this study (Olsson et al., 2006; Pearson et al., 2006; Tappan, 1988). The recorded fauna are illustrated in Plate (1).

Plate 1 (Scale bars =100µm, except 1a-c)

Figure. 1a. *Praemurica inconstans* (Subbotina, 1953)**, 1b.** *P. arabica* Anan, 2016, **1c.** *P. uncinata* (Bolli, 1957); **2a.** *Turborotalia cerroazulensis* (Cole,1928), **2b.** *T. semicunialensis* Anan, 2023, **2c.** *T. cunialensis* (Toumarkine and Bolli, 1970; **3a.** *Gaudryina arabica* Anan (2022a), **3b.** *G. salimi* Anan (2022a), **3c.** *G. ameeri* Anan (2012); **4a.** *Clavulina misrensis* Anan, n. sp., **4b.** *C. pseudoparisensis* Anan (1984); **4c.** *C. angularis* d'Orbigny (1826); **5a.** *Annulofrondicularia bignoti* (Anan, 2002), **5b.** *A. tunisica* Anan (2025), **5c.** *A. annularis* (d'Orbigny (1846); **6a.** *Tristix liasina* (Berthelin, 1879), **6b.** *T. aubertae* Anan (2022b), **6c.** *T. sztrakosae* Anan (2022b); **7a.** *Orthokarstenia higazyi* (Nakkady, 1955), **7b.** *O. nakkadyi* Anan (2009), **7c.** *O. eleganta* (Plummer, 1927); **8a.** *Bolivinoides miliaris* Hiltermann and Koch (1950), **8b.** *B. draco* (Marsson, 1878), **8c.** *B. aegyptiaca* Anan (2017); **9a.** *Uvigerina jacksonensis* Cushman (1925), **9b.** *Uvigerinita hispida* (Schwager, 1866), **9c.** *Uvigerinatella peregrina* (Cushman, 1923); **10a.** *Ornatanomalina pakistanica* Anan (2021), **10b.** *Ornatodella pustulosa* (Haque, 1956), **10c.** *Saudella ornata* Hasson (1985).



Order Foraminiferida (Eichwald, 1830)

Suborder Globigerinina Delage and Hérouard, 1896

Genus *Praemurica* Olsson, Hemleben, Berggren and Liu (1992)

***Praemurica* lineage**

1a. *Praemurica inconstans* (Subbotina, 1953), middle Danian-early Selandian (P1b-P3a). Cosmopolitan.

1b. *P. arabica* Anan, n. sp. (=*Praemurica* sp. - Anan (2016), p. 313, fig. 5.9).

Holotype: Plate 1, fig. 1b.

Etymology: after the United Arab Emirates, UAE (Fig. 2A).

Stratigraphic level: Sample 8 Danian (Bed 1) late Danian, - sample 11, 12 (Bed 3) early Selandian of Jabal Mundassa, Al Ain area, UAE (Fig. 2B, C).

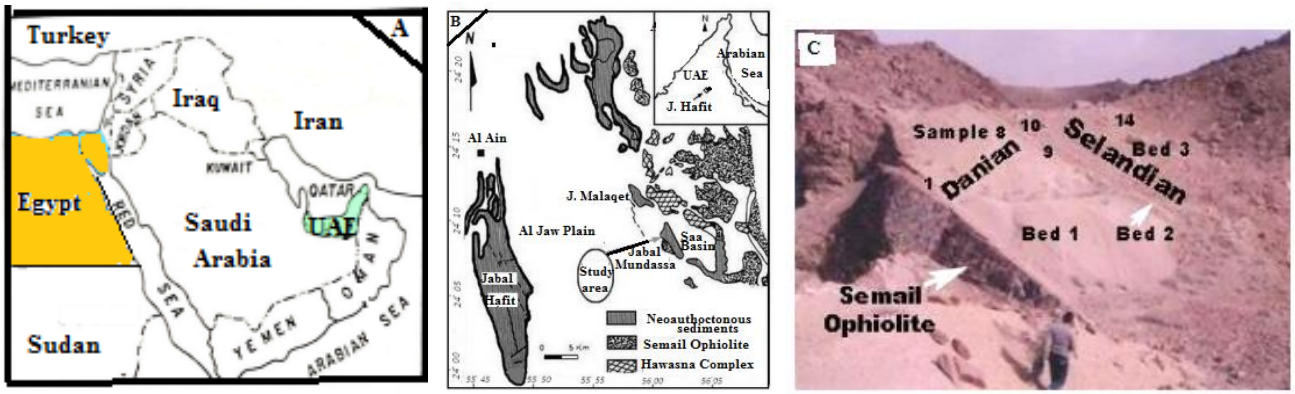


Figure 2: A) Location map of UAE, B) Jabal Mundassa, east of Al Jaw Plain, Al Ain area, C) lithostratigraphic section of the study section, J. Mundassa.

Diagnosis: This Paleocene species represents a transitional form between *P. inconstans* (=*P. trinidadensis*) and *P. uncinata.* The initial chambers of the last whorls have development of subconical-shaped chambers (as *P. uncinata*), followed by inflated chambers (as *P. inconstans*).

Remarks: It has more elongated test, compressed triangle initial chambers on the ventral side of the last whorl and inflated later chambers.

1c. *P. uncinata* (Bolli, 1957), late Danian-early Selandian (P2-P3a). Cosmopolitan.

Genus *Turborotalia* Cushman and Bermúdez, 1949

***Turborotalia* lineage**

***2*a.** *Turborotalia cerroazulensis* (Cole, 1928), Middle-Late Eocene (E11-E16). Cosmopolitan.

***2*b.** *T. semicunialensis* Anan, 2023a. Late Eocene (E15). UAE, Egypt, Tanzania, India.

***2*c.** *T. cunialensis* (Toumarkine and Bolli, 1970). Late Eocene (E16). Cosmopolitan.

Suborder Textulariina Delage and Hérouard, 1896

Genus *Gaudryina* d'Orbigny, 1926

I. *Gaudryina* lineage

***3*a.** *Gaudryina arabica* Anan, 2022a. Maastrichtian. UAE.

***3*b.** *G. salimi* Anan, 2022a. Late Paleocene. Atlantic Ocean.

***3*c.** *G. ameeri* Anan, 2012. Early Eocene. Egypt.

Genus *Clavulina* d'Orbigny, 1826

II. *Clavulina* lineage

***4*a.** *Clavulina misrensis* Anan, n. sp. (=*Clavulina angularis* of Weidich, 1988, pl. 2.a). Recent. Red Sea of Egypt.

Holotype: Plate 1, fig. 3a.

Etymology: after Misr (Arabic name of Egypt) (see Fig. 2A).

Stratigraphic level: Recent.

Diagnosis: Test triserial angular early stage, followed by completely rounded inflated uniserial chambers, suture depressed, aperture terminal with neck.

Remarks: This species is distinguished by its rounded inflated uniserial portion of the test, than rounded upper uniserial portion of *C. pseudoparisensis* Anan, or completely angular uniserial portion of *C. angularis* d'Orbigny.

***4*b.** *C. pseudoparisensis* Anan, 1984. Recent. Egypt, Saudi Arabia (SA), Yemen, Qatar.

***4*c.** *C. angularis* d'Orbigny, 1826. Recent. Cosmopolitan.

Suborder Lagenina Delage and Hérouard, 1896

Genus *Annulofrondicularia* Keijzer, 1945

III. *Annulofrondicularia* lineage

***5*a.** *Annulofrondicularia bignoti* (Anan, 2002). Paleocene. Egypt.

***5*b.** *A. tunisica* Anan, 2025. Paleocene-Early Eocene. Tunisia.

***5*c.** *A. annularis* (d'Orbigny, 1846). Eocene-Miocene. France, Romania.

Genus *Tristix* MacFadyen, 1941

IV. *Tristix* lineage

***6*a.** *Tristix liasina* (Berthelin, 1879). Jurassic-Eocene. America and Europe.

***6*b.** *T. aubertae* Anan, 2002. Paleocene. Egypt.

***6*c.** *T. sztrakosae* Anan, 2022b. Middle Eocene. France.

Genus *Orthokarstenia* Dietrich, 1935

V. *Orthokarstenia* lineage

***7*a.** *Orthokarstenia higazyi* (Nakkady, 1955). Paleocene. Egypt.

***7*b.** *O. nakkadyi* Anan, 2009. Middle Paleocene - Middle Eocene. Egypt, Tunisia, France, Spain.

***7*c.** *O. eleganta* (Plummer, 1927). Paleocene-Middle Eocene. USA, Tunisia, Egypt, SA

Suborder Rotaliina Delage and Hérouard, 1896

Genus *Bolivinoides* Cushman, 1927

VI. *Bolivinoides* lineage

***8*a.** *Bolivinoides miliaris* Hiltermann and Koch, 1950. Late Campanian-L. Maastrichtian. Germany, Poland, Egypt, Palestine, Iraq.

***8*b.** *B. draco* (Marsson, 1878). Maastrichtian. Cosmopolitan: Mexico, Spain, Austria, Belgium, Denmark, England, Germany, Netherland, Poland, Slovenia, Tunisia, Libya, Egypt, Palestine, Iraq, UAE, Pakistan, Australia, New Zealand.

***8*c.** *B. aegyptiaca* Anan, 2017 (=*Bolivinoides draco aegyptiacus* Anan, 2017). Late Maastrichtian. Egypt.

VII. Uvigerinid lineage

Genus *Uvigerina* d'Orbigny, 1826

***9*a.** *Uvigerina jacksonensis* Cushman, 1925. Eocene. USA, Libya, Egypt.

Genus *Uvigerinita* Anan, 2024

***9*b.** *Uvigerinita hispida* (Schwager, 1866. Pliocene. Indian Ocean.

Genus *Uvigerinatella* Anan, 2024

***9*c.** *Uvigerinatella peregrina* (Cushman, 1923). Miocene. USA, Mexico, Chile, France, Nigeria, Japan.

VIII. Rotaliid lineage

Genus *Ornatanomalina* Haque, 1956

***10*a.** *Ornatanomalina pakistanica* Anan, 2021. Early Eocene. Pakistan.

Genus *Ornatodella* Anan, 2023b

***10*b.** *Ornatodella pustulosa* (Haque, 1956). Early Eocene. Pakistan.

Genus *Saudella* Hasson, 1985

***10*c.** *Saudella ornata* Hasson, 1985. Early Eocene. Saudi Arabia.

4. PALEOGEOGRAPHY

The recorded twenty-seven planktic and benthic foraminiferal species related to thirteen genera are distributed all over the world: North and South America (USA, Mexico), South America (Chile), Europe (England, Spain, France, Austria, Belgium, Denmark, Germany, Netherland, Poland, Slovenia, Romania), Africa (Tunisia, Libya, Egypt, Nigeria), Asia (Palestine, Iraq, Saudi Arabia, Yemen, UAR, Qatar, Pakistan), Atlantic and Indian Ocean, and also Pacific Ocean (Japan, Australia, New Zealand) (Figure. 3).

Figure 3: The Paleogene paleogeographic map of the Tethyan Ocean (after, Salahi, 2021).

5. Conclusion

This study deals with gradualistic evolutionary ten trends of Campanian to Recent thirty planktic and benthic foraminiferal species belong to fourteen genera, and show an increasing phylogenetic plasticity through modifications of different morphological features (i.e. test and chamber sizes, ornamentation, periphery), which first appearing in the ancestors, followed by a transitional form to an end descendants in a successive stratigraphic levels. These ten trends applied throughout fourteen foraminiferal genera: *Praemurica, Turborotalia*, *Gaudryina*, *Clavulina*, *Annulofrondicularia*, *Tristix*, *Orthokarstenia*, *Bolivinoides*, *Uvigerina, Uvigerinita, Uvigerinatella, Ornatanomalina, Ornatodella* and *Saudella*. The species used in those evolutionary trends are originally erected from wide geographic localities in the Northern and Southern Tethys: North and South America, Atlantic Ocean, Europe, Africa, Asia, Indian and Pacific Oceans.

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