Earth and Planetary Science
https://ojs.nassg.org/index.php/eps

RESEARCH ARTICLE

Taxonomical Consideration, Phylogeny and Paleobiogeography of Some Argentinian Ypresian Benthic Foraminiferal Species

Haidar Salim Anan

Al Azhar University-Gaza, P.O Box 1277, Gaza, Palestine

ARTICLE INFO

Article history
Received: 19 February 2023
Revised: 7 April 2023
Accepted: 18 April 2023
Published Online: 28 April 2023

Keywords:
Paleontology
Eocene
Lineage
Paleogeography
Paleoenvironment
Argentina
Tethys

ABSTRACT

Rich and well preserved Argentinian taxa made it possible to correlate them with those previously identified species in the coeval sequence in different Tethyan North America, Europe and Middle East localities. This study deals with new information on paleontology and lineages of fourteen Argentinian Ypresian benthic foraminiferal species from the Punta Torcida Formation, lower-middle Eocene (Ypresian-lower Lutetian), Tierra del Fuego Island and Fuegian continental shelf, which belongs to twelve genera: *Laevidentalina*, *Lagenoglandulina*, *Tollmannia*, *Tristix*, *Leticuzonaria*, *Palmula*, *Leroyia*, *Marginulina*, *Ramulina*, *Orthokarstenia*, *Rectuvigerina* and *Pleurostomella*. Ten of the illustrated species are believed to be new: *Laevidentalina jannoui*, *Lagenoglandulina argentinica*, *Tollmannia argentinica*, *Leticuzonaria argentinica*, *Palmula americana*, *Leroyia argentinica*, *Marginulina argentinica*, *Ramulina subornata*, *Ramulina morsii* and *Rectuvigerina argentinica* sp. nov. The paleoenvironment of the Argentinian taxa would have been a shelf sea of normal salinity, where muds were deposited under low energy and low oxygen conditions, as is suggested by the dominance of infaunal morphotypes and excellent preservation of the tests, whereas intercalated sandstones reflect moderate energy and oxic conditions, bearing microfossil assemblages displaced from shallower settings.

1. Introduction

In this study, the fourteen recorded Eocene benthic foraminiferal species have been originally from Argentina by Jannou et al. [1,2]. It was followed by some other authors from the Southern and Northern Tethyan localities [3-17].

The present study deals with the taxonomic consideration of fourteen Argentinian Ypresian species of the two suborders Lagenid and Rotaliid of small benthic

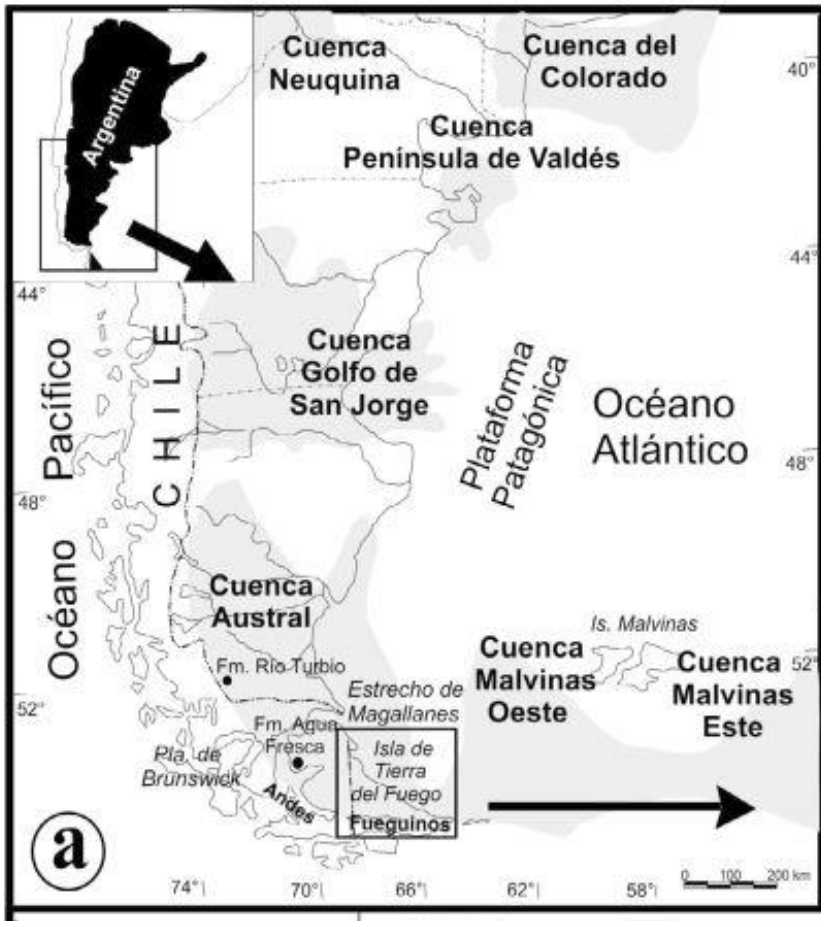
*Corresponding Author:
Haidar Salim Anan,
Al Azhar University-Gaza, P.O Box 1277, Gaza, Palestine;
Email: profanan@gmail.com; alazhar@alazhar-gaza.edu

DOI: http://dx.doi.org/10.36956/eps.v2i1.815

foraminifera from the Punta Torcida Formation, lower-middle Eocene (Ypresian-lower Lutetian), Tierra del Fuego Island and Fuegian continental shelf (Figure 1). The present study aims at throwing light on: 1) to present together many data scattered in the literature for the members of nine Lagenid foraminiferal genera: *Laevidentalina, Lagenoglandulina, Tollmannia, Tristix, Leticuzonaria, Palmula, Leroyia, Marginulina, Ramulina,* and three Rotaliid foraminiferal genera: *Orthokarstenia, Rectuvigerina, Pleurostomella* under a unifying theme, 2) to detect its paleontology, stratigraphy and paleogeographic distribution of the different species of that genera, 3) to discuss the taxonomic status of the Argentinian species with the other related species, in the other localities in the Tethys, 4) to present ten species, which are believed to be new: *Laevidentalina jannoui*, *Lagenoglandulina argentinica*, *Tollmannia argentinica, Leticuzonaria argentinica, Palmula americana, Leroyia argentinica, Marginulina argentinica, Ramulina subornata, Ramulina morsii* and *Rectuvigerina argentinica*. The recorded species from Argentina and other localities in the Tethys are distributed in a wide paleogeographic area in the world throughout the open Tethys in the Ypresian time.

2. Material of Study

The identified Argentinian benthic foraminifera are recorded from the Punta Torcida Formation, lower-middle Eocene (Ypresian-lower Lutetian), Tierra del Fuego Island and Fuegian continental shelf, which yielded 161 species of benthic foraminifera. Twenty-four of these species have a tight relation with many diagnostic Tethyan species recorded from USA, Europe and south Mediterranean Sea localities. Following the Code of Zoological Nomenclature, a taxonomic revision of ten of the Argentinian species are re-described its morphological features, which considered here as a new species: *Laevidentalina jannoui, Lagenoglandulina argentinica, Tollmannia argentinica, Leticuzonaria argentinica, Palmula americana, Leroyia argentinica, Marginulina argentinica, Ramulina subornata, Ramulina morsii* and *Rectuvigerina argentinica.*



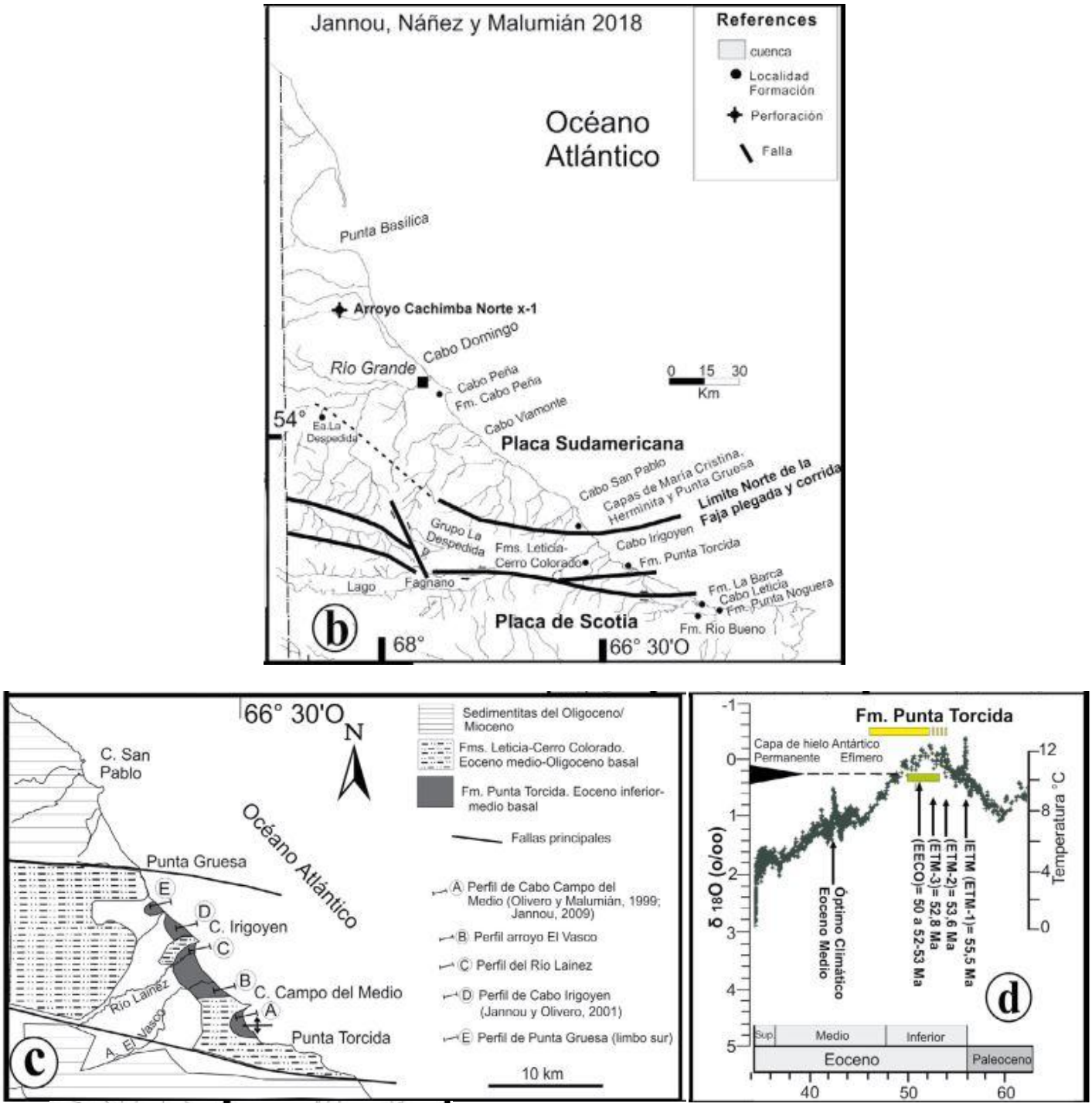


Figure 1. a) Location map of the study area (in box) of south Argentina in the Southern America, South Atlantic Ocean, b) details of the study area, c) geological map of de la Isla Grande de Tierra del Fuego, d) the temperature curve δ 18O depends on the benthic foraminifera in the Punta Torcida Formation [2].

3. Taxonomy

The taxonomy of Loeblich & Tappan [3] is followed here for the recorded twenty-four benthic foraminiferal species belonging to twelve genera, which were recorded from the Ypresian of Argentina and other Tethyan countries, and illustrated in Plate 1.

Order Foraminiferida Eichwald, 1830

Suborder Lagenina Delage & Hérouard, 1896

Genus *Laevidentalina* Loeblich & Tappan, 1986

Type species *Laevidentalina aphelis* Loeblich & Tappan, 1955

***Laevidentalina jannoui* Anan, sp. nov.** (Plate 1, Figure 1) (= *Dentalina* sp.—Jannou [1], p. 177, Figure 6F; *Laevidentalina* sp. B—Jannou et al. [2]., p. 36, Plate 2, Figure 6) ● {illustrated specimen}.

Holotype: Illustrated specimen in Plate 1, Figure 1.

Dimension: Length 1.1 mm.

Etymology: In the honor of the micropaleontologist Jannou in Argentine Mining Geological Service.

Type locality and sample: Formación Punta Torcida, CCM: Mbros. PTa & PTb, SEGEMAR 2850, CM-2L. (SEGEMAR = Servicio Geológico Minero Argentino)

Stratigraphic level: Ypresian (Early Eocene).

Diagnosis: This species is characterized by an elongate and arcuate test with gradually growing, smooth surface, parallel sides, nearly globular chambers, globular pro-loculus and apiculate, flush sutures in the lower part but depressed in the upper part, aperture terminal.

Remarks: The Argentinian Ypresian *Laevidentalina jannoui* n. sp. is most probably evolved from the Pale-

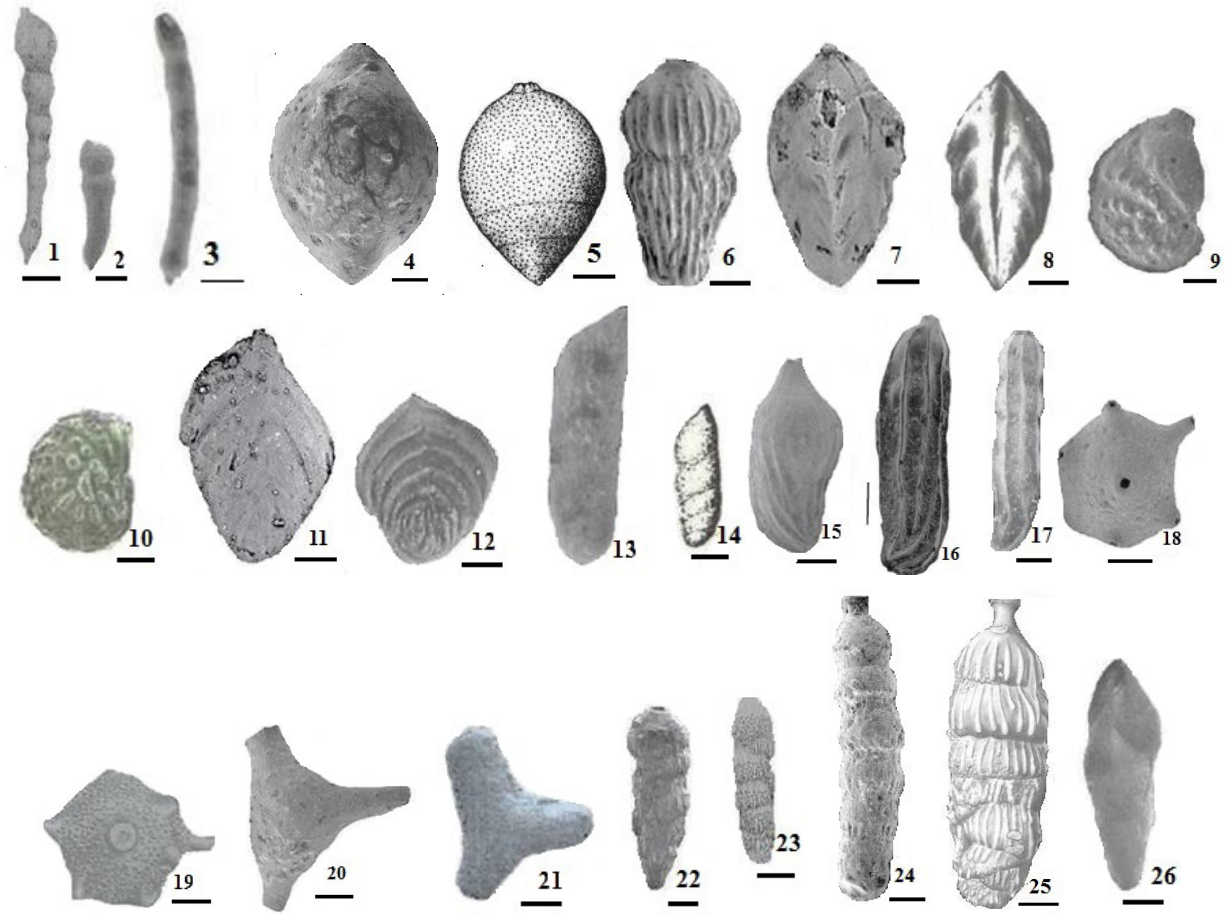


Plate 1. Figure 1. *Laevidentalina jannoui* Anan, sp. nov., 2. *Laevidentalina hudae* Anan [4], 3. *Laevidentalina salimi* Anan [5], 4. *Lagenoglandulina argentinica* Anan, sp. nov., 5. *Lagenoglandulina annulata* (Stache [6]), 6. *Tollmannia argentinica* Anan, sp. nov, 7, 8. *Tristix aubertae* Anan [7], (7. from Argentina, 8. from Egypt), 9. *Leticuzonaria argentinica* Anan, sp. nov., 10. *Leticuzonaria misrensis* Anan [8], 11. *Palmula americana* Anan, sp. nov., 12. *Palmula sagittaria* Lea [9], 13. *Leroyia argentinica* Anan, sp. nov., 14. *Leroyia aegyptiaca* Anan [10], 15. *Marginulina argentinica* Anan, sp. nov., 16, 17. *Marginulina costata* [11], (16. from Egypt, 17. from Argentina), 18. *Ramulina subornata* Anan, sp. nov., 19. *Ramulina ornata* Cushman [12], 20. *Ramulina morsii* Anan, sp. nov., 21. *Ramulina ismaili* Anan [13], 22. *Orthokarstenia higazyi* [14], 23. *Orthokarstenia eleganta* [15], 24. *Rectuvigerina argentinica* Anan, sp. nov., 25. *Rectuvigerina multicostata* Cushman & Jarvis [16], 26. *Pleurostomella acuta* Hantken [17]. (scale bar = 100 μm)

ocene *L. hudae* Anan [4] (Plate 1, Figure 2), (from Jabal Mundassa, United Arab Emirates, UAE) and considered here as the ancestor of the Middle-Late Eocene *L. salimi* Anan [5] (Plate 1, Figure 3) (from Jabal Hafit, UAE) (Figure 2) in the *Laevidentalina hudae* → *L. jannoui* → *L. salimi* lineage.

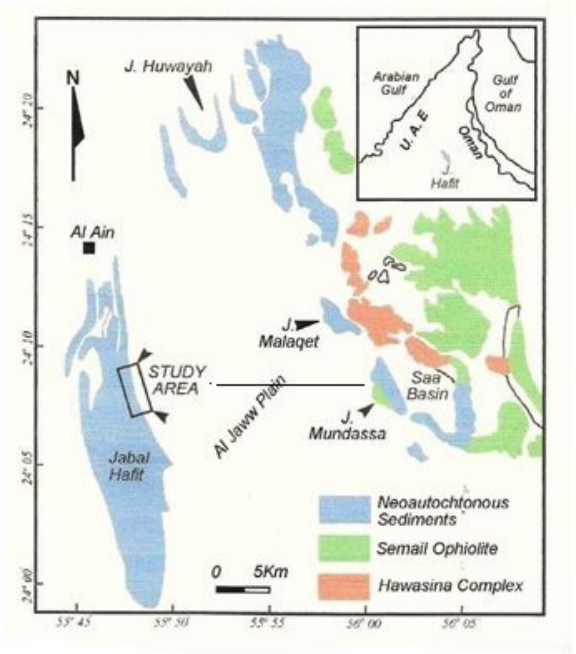


Figure 2. Location map of Jabal Mundassa and Jabal Hafit, Al Ain area, UAE (the type sections of *Laevidentalina hudae* and *L. salimi*).

Genus *Lagenoglandulina* A. Silvestri, 1923

Type species: *Glandulina subovata* = *Lagenoglandulina annulata* (Stache, 1864)

***Lagenoglandulina argentinica* Anan**, sp. nov. (Plate 1, Figure 4) (= *Lagenoglandulina* A. Silvestri [18], p. 12; *Lagenoglandulina* sp.—Jannou et al. [2], p. 36, Plate 3, Figure 3).

Holotype: Illustrated specimen in Plate 1, Figure 4.

Dimension: Length 0.55 mm, width 0.40 mm.

Etymology: After the State of Argentina.

Type locality and sample: Formación Punta Torcida, CM-13a, SEGEMAR 2873.

Stratigraphic level: Ypresian

Diagnosis: Test ovate and circular in section with few rectilinear chambers, which increase rapidly in breadth as added and strongly overlap the earlier chambers, sutures obscure in the early part, surface finally scattered knobs, aperture terminal and radiate at the end of a short cylindrical neck.

Remarks: *Lagenoglandulina argentinica* differs from *L. annulata* (Plate 1, Figure 5) in its finally scattered knobs on the surface than the smooth surface of the holotype. The members of this genus were recorded from Caribbean, Italy, New Zealand, and now from Argentina.

Genus *Tollmannia* Sellier de Civrieux and Dessauvagie, 1965

Type species: *Lingulina costata* subsp. *tricarinata* Tollmann, 1954 = *Lingulina costata* d'Orbigny, 1846.

***Tollmannia argentinica* Anan**, sp. nov. (Plate 1, Figure 6) (=Lingulina sp.—Jannou[1], p. 101, Figure 6L; *Amplectoductina multicostata* (Galloway & Morrey)—Jannou et al. [2], p. 20, Plate 2, Figure 12).

Holotype: Illustrated specimen in Plate 1, Figure 6.

Dimensions: Length 4.8 mm, width 2.5 mm.

Etymology: After the State of Argentina.

Type locality and sample: Formación Punta Torcida, CI-20, SEGEMAR 2856.

Stratigraphic level: Ypresian

Diagnosis: Test large up to 4.5 mm in length, circular to ovate in section, chambers increase rapidly in breadth as added and strongly overlap previous chambers, final chamber comprising one-third the length of the test, sutures horizontal, moderately depressed, surface with longitudinal ribs that may completely cross the chambers, aperture terminal, circular, bordered by an elevated lip.

Remarks: The genus has longitudinal costae, and nearly circular in section. The *Tollmannia argentinica* sp. nov. is characterized by an elongated test, globular-semi globular uniserial chambers, longitudinal ribs on the surface, and a rounded aperture with the small elevated neck. The Early Eocene *T. argentinica* most probably may develop into the youngest Miocene species *T. costata* (d'Orbigny).

Genus *Tristix* Macfadyen, 1941

Type species *Rhabdogonium liasinum* Berthelin, 1879

***Tristix aubertae* Anan**, 2002 (Plate 1, Figures 7, 8) (=*Tristix auberti* Anan [7], p. 634, Figure 2. 6; *Tristix aubertae* Anan - Anan [19], p. 304, Plate 1, Figure 2; *Tristix* sp.—Jannou [1], p. 179, Figure 7I; *Tristix* sp.—Jannou et al. [2], p. 44, Plate 3, Figure 4).

Type locality and sample in Argentina: Formación Punta Torcida, PTma-2, SEGEMAR 2874.

Remarks: The Argentinian Ypresian figured specimen of Jannou et al. [2], is conspecific to the Egyptian Paleocene *T. aubertae* (triangular test face, flattened, concave triangular chamber). It means that this species has wide geographic distribution from the Southern Tethys (Egypt) to Southern Atlantic (Argentina), which proves the open sea water between these wide areas (Figure 3).

Genus *Leticuzonaria* Anan, 2021

Type species *Leticuzonaria hodae* Anan, 2021

***Leticuzonaria argentinica* Anan**, sp. nov. (Plate 1, Figure 9) (= *Marginulina asperuliformis* [20]—Jannou [1], p. 179, Figure 7P (*non* Figures 7N, 7O); *Marginulina asper-*

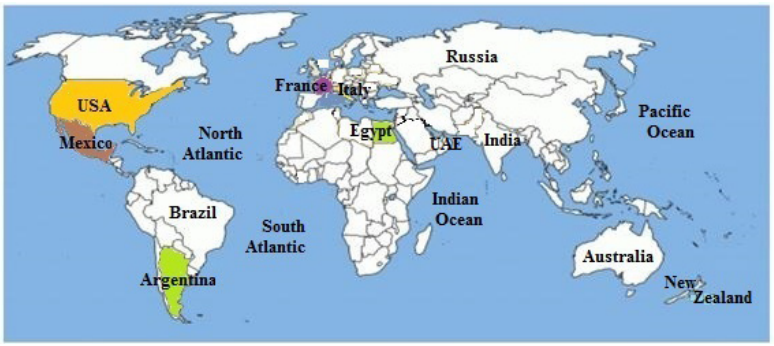


Figure 3. A map of the world showing the geographic distribution of some benthic foraminiferal species in many different countries: North America (USA, Mexico), South America (Argentina), West Europe (France, Italy, Hungaria), North Africa (Egypt), Southwest Asia (UAE), South Pacific Ocean (New Zealand).

uliformis (Nuttall)—Jannou et al. [2], p. 38, Plate 2, Figure 16.

Holotype: Illustrated specimen in Plate 1, Figure 9.

Dimension: Length 0.55 mm.

Etymology: After the Argentina State.

Type locality and sample: Formación Punta Torcida, AV-5, SEGEMAR 2860.

Stratigraphic level: Ypresian.

Diagnosis: The Ypresian figured specimen of Jannou et al. [2] (p. 38, Plate 2, Figure 16) belongs here to the genus *Leticuzonaria* Anan [8], Plate 1, Figure 10), not to *Marginulina* with the slightly coiled initial stage, followed by uniserial inflated chambers.

Remarks: The new species *Leticuzonaria argentinica* differs from *L. hodae* Anan [8] (from Egypt) by lacking a spinose surface and elongated last chamber, and protruding development of the aperture.

Genus *Palmula* Lea, 1833

Type species *Palmula sagittaria* Lea, 1833

***Palmula americana* Anan**, sp. nov. (Plate 1, Figure 11) (= *Palmula* sp. cf. *P. magallanica* Todd & Kniker [21]Jannou [1]), p. 179, Figure 7B; *Palmula* sp. cf. *P. magallanica* Todd & Kniker—Jannou et al. [2]), p. 38, Plate 2, Figure 23) .

Holotype: Illustrated specimen in Plate 1, Figure 11.

Dimension: Length 1.5 mm, width 0.75 mm.

Etymology: After the geographic location from South America.

Type locality and sample in Argentina: Formación Punta Torcida, PTma-2, SEGEMAR 2867. Stratigraphic level: Ypresian.

Diagnosis: This species has large, elongate and flattened test, enrolled planispiral early stage, later uncoiled and rectilinear, broad and chevron shaped chambers, which increasing gradually in breadth, periphery rounded, sutures slightly depressed, surface smooth, aperture terminal and radiate.

Remarks: This species is characterized by a compressed palmate test with small coiled stage, and distinct slightly raised sutures. It differs from the holotype of the genus *Palmula sagittaria* (Plate 1, Figure 12) (after Loeblich & Tappan [3]) in its elongated larger test, smaller early planispirally stage, and slightly depressed sutures than raised.

Genus *Leroyia* Anan, 2020

Type species *Leroyia aegyptiaca* Anan, 2020

***Leroyia argentinica* Anan**, sp. nov. (Plate 1, Figure 13) (= *Lenticulina* sp.—Jannou [1], p. 179, Figure 6K—*Marginulina* ex gr. *M. hochstetteri* Stache [6]—Jannou et al. [2], p. 38, Plate 2, Figure 17).

Holotype: Illustrated specimen in Plate 1, Figure 13.

Dimensions: Length 0.55 mm, width 0.15 mm.

Etymology: After the state of Argentina.

Type locality and sample: Formación Punta Torcida, CM-4a, SEGEMAR 2855, CM-145.

Stratigraphic level: Ypresian.

Diagnosis: This Ypresian species has elongate test, minute indistinct early coiled stage, later 7-10 uniserial inflated chambers, which increasing in length as added, sutures slightly depressed and moderately oblique, peripheral margins rounded, surface smooth, aperture radiate extended at dorsal angle.

Remarks: It seems that the Ypresian new species *L. argentinica* was evolved from Thanetian-Ypresian *L. aegyptiaca* (from Egypt) in the *L. aegyptiaca* → *L. argentinica* lineage.

Genus *Marginulina* d'Orbigny, 1826

Type species *Marginulina raphanus* d'Orbigny, 1826

***Marginulina argentinica* Anan,** sp. nov. (Plate 1, Figure 15) (= *Lenticulina* sp.—Jannou [1], p. 179, Figure 6U; *Marginulina* sp.—Jannou et al. [2], p. 38, Plate 2, Figure 21).

Holotype: Illustrated specimen in Plate 1, Figure 15.

Dimension: Length 0.66 mm, width 0.33 mm.

Type locality and sample: Formación Punta Torcida, CM-180, SEGEMAR 2865.

Stratigraphic level: Ypresian.

Diagnosis: The *Marginulina argentinica* is characterized by a short test, slightly coiled initial stage, uniserial later stage with inflated chambers, surface with about 20 longitudinal costae, extended over the sutures, straight and slightly depressed sutures in the uniserial part, but indistinct in the initial part, aperture terminal on a long neck.

Remarks: This species differs from the *Marginulina costata* (Batsch [11], Plate 1, Figures 16, 17) by smaller test, more inflated uniserial stage, and more numbers of longitudinal costae. Most probably Early Eocene *L. argentinica* was developed into Middle-Late Eocene *L. costata* in the *M. argentinica* → *M. costata* lineage.

***Marginulina costata* (Batch, 1791)** (Plate 1, Figures 16, 17) (=*Nautilus (Orthoceras) costatus* Batsch [11], p. 2, Plate 1, Figure 1; *Marginulina costata* (Batsch)—Anan [22], 1994, p. 223, Figure 8. 17, 18; *Dentalina elgansoensis* Todd & Kniker [21]—Jannou et al. [2], p. 33, Plate 2, Figures 3,4).

Remarks: This species was recorded in the Middle-Late Eocene of Egypt [22], but only in the Middle Eocene of UAE [5], and now is recorded in the Early Eocene of Argentina (Formación Punta Torcida, CM-1a).

Genus *Ramulina* Jones, 1875

Type species *Ramulina laevis* Jones, 1875

***Ramulina subornata* Anan**, sp. nov. (Plate 1, Figure 18) (= *Ramulina* sp. cf. *globulifera* Brady [23]),—Jannou [1], p. 104, Figure 7F).

Holotype: Illustrated specimen in Plate 1, Figure 18.

Dimension: Length 2. 8 mm.

Etymology: Unornate, smooth.

Type locality and sample: Formación Punta Torcida, AV mbro. PTa, AV-1, SEGEMAR 2871.

Stratigraphic level: Ypresian.

Diagnosis: This Ypresian species has a globular chamber with sixth rounded spinose projections with numerous radiate tubular processes, surface is smooth, not ornate.

Remarks: This species (from Argentina) differs from the American *R. ornata* Cushman [12] (Plate 1, Figure 19) by its smooth surface, not spinose projections on the surface, and 6 homogeneous distribution of the arms.

***Ramulina morsii* Anan**, sp. nov. (Plate 1, Figure 20) (=*Ramulina* sp.—Jannou [1], p. 104, Figure 7G; *Ramulina* sp.—Jannou et al. [2], p. 24, Plate 3, Figure 2).

Holotype: Illustrated specimen in Plate 1, Figure 20.

Dimension: Length 5.0-5.5 mm.

Etymology: In the honor of Prof. A. Morsi, Department of Geology, Ain Shams Univ., Egypt.

Type locality and sample: Formación Punta Torcida, AV mbro. PTa, AV-1, SEGEMAR 2872.

Stratigraphic level: Ypresian.

Diagnosis: This Ypresian species has radiating three triangular tubular thick extinctions of the chamber, and mainly with small projections surface.

Remarks: *Ramulina morsii* n. sp. (from Argentina) differs from *R. ismaili* Anan [13] (p. 2, Figure 2. 6) (from Egypt) by less thick elongate tapering tubular projection, and ornamented surface. The Maastrichtian–Paleocene *R. ismaili* (Plate 1, Figure 21) most probably was developed to the Early Eocene *R. morsii* in its ornamented globular body and thicker elongated tapering three tubular arms. It seems that *R. ismaili* was developed to *R. morsii* in the *R. ismaili* → *R. morsii* lineage.

Suborder Rotaliina Delage & Hérouard, 1896

Genus *Orthokarstenia* Dietrich, 1935

Type species *Orthocerina ewaldi* Karsten, 1858

Orthokarstenia higazyi [14] (Plate 1, Figure 22) (= *Siphogenerina higazyi* Nakkady [14], p. 705, text-Figure 4; *Orthokarstenia higazyi* (Nakkady)—Anan & Sharabi [24], p. 212, Plate 2, Figures 8, 9; *Loxostomina* sp. aff. *L. eleganta* [15]—Jannou et al. [2]), p. 24, Plate 3, Figure 16 (*non* Figures 13-15).

Remarks: Anan [8] noted that the cosmopolitan Thanetian-Ypresian *O. eleganta* [15] has mainly smooth surface (without ribs, but with indistinct and irregularly longitudinal striation in the very earliest portion of the test), while the Paleocene species *O. higazyi* [14] has longitudinal costae covers all of the chambers. The existed of longitudinal costae separates the Paleocene *O. higazyi* from the smooth test surfaces of both the Maastrichtian *O. esnehensis* [25], and the Paleocene-Early Eocene *O. eleganta* (Plate 1, Figure 23). It is, so far recorded from Egypt, Jordan, UAE and Argentina.

Genus *Rectuvigerina* Mathews, 1945

Type species *Siphogenerina multicostata* Cushman & Jarvis, 1929

***Rectuvigerina argentinica* Anan**, sp. nov. (Plate 1, Figure 24) (= *Stilostomella* sp. Jannou et al. [2], p. 42, Plate 3, Figure 19).

Holotype: Illustrated specimen in Plate 1, Figure 24.

Dimension: Length 0.62 mm, width 0.13 mm.

Etymology: After the State of Argentina.

Type locality and sample: Formación Punta Torcida, CM-151, SEGEMAR 2889.

Stratigraphic level: Ypresian.

Diagnosis: *Rectuvigerina jannoui* Anan, sp. nov. has elongate and slightly arcuate hyaline test, small involute triserial early stage followed by elongata uniserial stage, gradually grow globular to discoidal chambers, short ribs at the base of the chambers, proloculus globular, but not apiculate, sutures slightly depressed in early stage, but depressed in later stage, aperture terminal on neck with a phialine lip.

Remarks: The *Rectuvigerina jannoui* differs from the holotype *R. multicostata* Cushman & Jarvis [16] (Plate 1, Figure 25) by non-ribbed ornamented test without crossing the sutures, doesn't have an intervening biserial stage, and more number (6 instead of 3) of elongated uniserial stage.

Genus *Pleurostomella* Reuss, 1860

Type Species *Dentalina subnodosa* Reuss, 1860

***Pleurostomella acuta* Hantken, 1875** (Plate 1, Figure 26) (= *Pleurostomella acuta* Hantken [17], 1875, p. 37, Plate 13, Figure 18 - Anan [26], p. 174, Plate 1, Figure 1—Jannou et al. [2], p. 31, Plate 5, Figures 33, 34).

Type locality and sample: Formación Punta Torcida, CM-134, SEGEMAR 2975.

Remarks: This cosmopolitan species has an elongate test, and is circular in cross-section, with biserial early-stage chambers increasing gradually in size, and final pair of chambers with extremely inflated, sutures slightly depressed and strongly curved, wall calcareous hyaline smooth, aperture terminal with the large oval opening of the final chamber, and characterized by its diagnostic apertural tooth. It was recorded from the Maastrichtian-Paleocene of the Atlantic Ocean [27,28], Thanetian-Ypresian of France [29], Italy [30] and USA [31], Ypresian from Argentina [2], but Lutetian-Bartonian from Hungaria [32].

4. Paleogeography

The identified species have wide geographic distribution: North Atlantic (USA, Mexico, Caribbean), South Atlantic (Argentina), Europe (France, Germany, Hungaria, Italy), Northeast Africa (Egypt), Southwest Asia (Jordan), and Southwest Pacific (New Zealand) (see Figure 3).

Moreover, the paleogeographic maps recorded by many authors [33-36] show the Tethyan realm had been connected with the Atlantic Ocean from west to the Indo-Pacific Ocean to the east, via the Mediterranean Sea, crossing the Middle East region during the Paleogene time. Another author [37-39] expressed that the extended realms of the

Table 1. Paleogeographic distribution of the Early Eocene twenty-four Lagenid and Rotaliid benthic foraminiferal species in the Punta Torcida Formation (Early Eocene), Tierra del Fuego Island and Fuegian continental shelf and other Tethyan localities.

Sp. No.	species		countries 1	2	3	4	5	6	7	8	9	10	11	12
1	*Laevidentalina*	*jannoui*	x	-	-	-	-	-	-	-	-	-	-	-
2		*hudae*	-	-	-	-	-	-	-	-	-	-	x	-
3		*salimi*	-	-	-	-	-	-	-	-	-	-	x	-
4	*Lagenoglandulina*	*argentinica*	x	-	-	-	-	-	-	-	-	-	-	-
5		*annulata*	-	x	-	-	-	x	x	-	-	-	-	x
6	*Tollmannia*	*argentinica*	x	-	-	-	-	-	-	-	-	-	-	-
7	*Tristix*	*aubertae*	x	-	-	-	-	-	-	-	x	-	-	-
8	*Leticuzonaria*	*argentinica*	x	-	-	-	-	-	-	-	-	-	-	-
9		*misrensis*	-	-	-	-	-	-	-	-	x	-	-	-
10	*Palmula*	*americana*	x	-	-	-	-	-	-	-	-	-	-	-
11		*sagittaria*	-	-	x	-	-	-	-	-	-		-	-
12	*Leroyia*	*argentinica*	x	-	-	-	-	-	-	-	-	-	-	-
13		*aegyptiaca*	-	-		-	-	-	-	-	x	-	-	-
14	*Marginulina*	*argentinica*	x	-	-	-	-	-	-	-	-	-	-	-
15		*costata*	x	-	-	-	x	-	-	-	x	-	-	-
16	*Ramulina*	*subornata*	x	-	-	-	-	-	-	-	-	-	-	-
17		*ornata*	-	-	x	-	-	-	-	-	-	-	-	-
18		*morsii*	x	-	-	-	-	-	-	-	-	-	-	-
19		*ismaili*	-	-	-	-	-	-	-	-	x	-	-	-
20	*Orthokarstenia*	*higazyi*	-	-	-	-	-	-	-	-	x	x	-	-
21		*eleganta*	x	-	x	-	-	-	-	-	-	-	-	-
22	*Rectuvigerina*	*argentinica*	x	-	-	-	-	-	-	-	-	-	-	-
23		*multicostata*	-	-	x	-	-	-	-	-	-	-	-	-
24	*Pleurostomella*	*acuta*	x	-	-	-	-	-	-	x	-	-	-	-

1. Argentina, 2. Caribbean, 3. USA, 4. Atlantic Ocean, 5. France, 6. Germany, 7. Italy, 8. Hungaria, 9. Egypt, 10. Jordan, 11. UAE, 12. New Zealand. Sp. No. = Species number, x=recorded,—not recorded.

Tethys have extended from the Indo-Pacific to the Atlantic Oceans and the Mediterranean Sea during the Late Cretaceous to Paleogene times, and the fauna exhibit pronounced similarities (Figure 4).

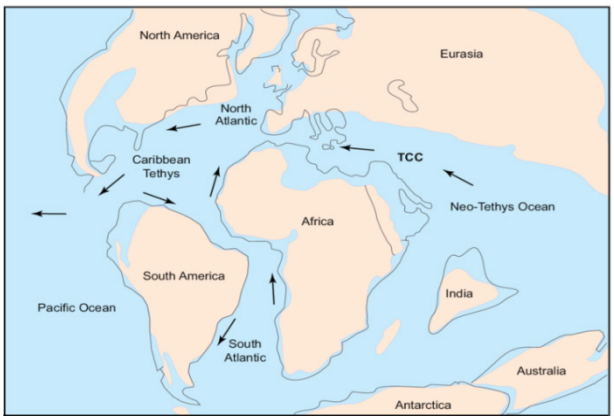


Figure 4. Paleogeography of the Neo-Tethys Ocean during the Maastrichtian-Ypresian time showing the flow direction of the Tethyan Circumglobal Current (TCC) from east to west, and the location of North and South America, Eurasia, Africa, India and Australia [40].

5. Paleoecology and Paleoenvironment

Jannou [1] noted that the small, weakly calcified tests and marked infaunality of the benthic calcareous foraminiferal assemblages, added to the occurrence of acarininid planktic foraminifera, suggest relatively warm waters, correlatable with the post maximum thermal Eocene-3 (~52 Ma). Jannou et al. [2] noted that the paleoenvironment of South Argentina would have been a shelf sea of normal salinity, where muds were deposited under low energy and low oxygen conditions, as is suggested by the dominance of infaunal morphotypes and excellent preservation of the tests, whereas intercalated sandstones reflect moderate energy and oxic conditions, bearing microfossil assemblages displaced from shallower settings. The foraminifera taxa in the study section of Argentina have similarities with those of the Eocene of the Austral basin, Australia, New Zealand and the Antarctic, reflecting the southern nature of the microfauna. Anan [41] noted that the probable environment of northern Egypt is outer neritic-upper bathyal, while deeper in central Egypt, are deposited in the middle-outer neritic. The *Lenticuzonaria misrensis*, *Tristix aubertae*, *Leroyia aegyptiaca*, *Orthokarstenia higazyi* were recorded from central and southern Egypt, which located in the Nile Valley Facies (NVF), of Issawi et al. [42], which has middle-outer neritic environmental facies by some authors (e.g. Nakkady [43], LeRoy [44]) and considered here to be related to the Midway-Type Fauna (MTF) of Berggren & Aubert [45]. Hayward et al. [46] noted the paleobathymetric distribution of Pleurostomella acuta in present-day depth ranges of sites in the lower bathyal to middle abyssal.

6. Conclusions

The present study deals with the recording of twenty-four diagnostic identified Early Eocene species of Lagenid and Rotaliid calcareous foraminiferal genera which needs a taxonomic revision to accommodate the modern nomenclature among more than 160 species of Argentina. Ten out of these species are believed here as new: *Laevidentalina jannoui, Lagenoglandulina argentinica, Tollmannia argentinica, Leticuzonaria argentinica, Palmula americana, Leroyia argentinica, Marginulina argentinica, Ramulina subornata, Ramulina morsii* and *Rectuvigerina argentinica* sp. nov. Some of the identified species are confined to Argentina, but some others were recorded from many localities in North America (USA, Mexico), Europe (France, Italy) North Africa (Egypt), Southwest Asia (Jordan) and South Pacific (New Zealand). The extended realms of the Tethys have extended from the Indo-Pacific to the Atlantic Oceans via the Mediterranean Sea during the Ypresian time, and the fauna exhibit pronounced similarities.

Acknowledgement

The author would like to express his sincere appreciation to the editor of EPS for continuous efforts, and unknown reviewer for improving the original manuscript and contributing valuable comments. I am also indebted to my daughter Dr. Huda Anan for help in the development of the figures and plate.

Conflict of Interest

There is no conflict of interest.

References

[1] Jannou, G.E., 2009. Microfósiles Marinos del Eoceno inferior, Isla Grande de Tierra Del Fuego, Argentina: bioestratigrafía, paleoambiente y paleobiogeografía (Spanish) [Marine microfossils of the lower Eocene, Isla Grande de Tierra Del Fuego, Argentina: biostratigraphy, paleoenvironment and paleobiogeography] [PhD thesis]. Biblioteca Digital, Universidad de Buenos Aires (UBA), Facultad de Ciencias Exactas Naturales (FCEN). p. 1-228.

[2] Jannou, G.E., Náñez, C.A., Malumián, N., 2022. Foraminíferos bentónicos de la Formación Punta Torcida, Eoceno inferior-medio (YpresianoLutetiano inferior), Isla Grande de Tierra del Fuego y plataforma

continental fueguina (Spanish) [Benthic foraminifera from the Punta Torcida Formation, Lower-Middle Eocene (Lower Ypresian-Lutetian), Isla Grande de Tierra del Fuego and Tierra del Fuego continental shelf]. Serie Contribuciones Técnicas. Geología Regional. 9, 53.

[3] Loeblich, A.R., Tappan, H., 1988. Foraminiferal genera and their classification. Springer: Berlin.

[4] Anan, H.S., 2015. Paleocene Lagenid benthic foraminifera of Jabal Mundassa, Al Ain Area, United Arab Emirates. Egyptian Journal of Paleontology. 15, 61-83.

[5] Anan, H.S., 2009. Paleontology and stratigraphical distribution of suborder Lagenina (benthic foraminifera) from the Middle-Late Eocene Mazyad Member of the Dammam Formation in Jabal Hafit, Al Ain area, United Arab Emirates, northern Oman Mountains. Revue de Paléobiologie. 28(1), 1-18.

[6] Stache, G., 1864. Die Foraminiferen der tertiären Mergel des Whaingaroa-Hafens (Prov. Auckland), Novara-Expedition, 1857-1859 (German) [The foraminifera of the tertiary marls of Whaingaroa Harbor (Prov. Auckland), Novara Expedition, 1857-1859]. Geologische Theil. 1(2), 159-304.

[7]Anan, H.S., 2002. Stratigraphy and paleobiogeography of some Frondicullariinae and Palmulinae benthic foraminiferal genera in the Paleocene of Egypt (Misr). Neues Jahrbuch fur Geologie und Palaontologie Monatshefte. 10, 629-640.

[8] Anan, H.S., 2021. *Lenticuzonaria*: A new Tethyan Lagenid benthic foraminiferal genus. Earth Sciences Pakistan (ESP). 5(1), 33-36.

[9] Lea, I., 1833. Contributions to geology. Carey, Lea and Blanchard: Philadelphia. pp. 227.

[10] Anan, H.S., 2020. *Leroyia:* a new Tethyan Lagenid benthic foraminiferal genus. Earth Sciences Pakistan (ESP). 4(2), 53-57.

[11] Batsch, A.I.G.C., 1791. Sechs Kupfertafeln mit Conchylien des Seesandes, gezeichnet und gestochen von A. J. G. K. Batsch, Jena (German) [Six copper plates with sea sand conchylia, drawn and engraved by A. J. G. K. Batsch, Jena]. Iena: Academische Buchhandlung. Available from: https://www.digitale-sammlungen.de/en/details/bsb10231112

[12] Cushman, J.A., 1938. Additional new species of American Cretaceous foraminifera. Contribution from the Cushman Laboratory Foraminiferal Research Sharon. 14, 31-50.

[13] Anan, H.S., 2022. On the variability of benthic foraminiferal species of the genus *Ramulina* in the Tethys. Journal of Foraminiferal Research. 52(3), 1-7.

[14] Nakkady, S.E., 1955. The stratigraphic implication of the accelerated tempo of evolution in the Mesozoic-Cenozoic transition of Egypt. Journal of Paleontology. 29(4), 702-706.

[15] Plummer, H.J., 1927. Foraminifera of the Midway Formation in Texas. Bulletin University of Texas. 2644, 3-206.

[16] Cushman, J.A., Jarvis, P.W., 1929. New foraminifera from Trinidad. Contributions from the Cushman Laboratory for Foraminiferal Research. 5, 6-17.

[17] Hantken, M., 1875. Die Fauna der *Clavulina szaboi* Schichten, I. Theil: Foraminiferen. Mitt. Jb. k. Ungaren (German) [The fauna of the *Clavulina szaboi* strata, Part I: Foraminifera. Mitt. Jb. k. Hungarian]. Geological Anstalt. 4, 1-93.

[18] Silvestri, A., 1923. Microfauna pliocenica rizopodi reticolari di Capocolle presso Forli (Italian) [Pliocene microfauna reticular Rhizopods of Capocolle near Forli]. Atti della Pontificia Accademia della Scienze Nuovi Lincei, Roma (1922-1923). 76, 70-77.

[19] Anan, H.S. (editor), 2007. Paleontological and biostratigraphical remarks on some diagnostic Tethyan benthic foraminifera. 2nd International Conference on the Geology of the Tethys; Cairo University, Cairo. p. 303-308.

[20] Nuttall, W.L.F., 1930. Eocene foraminifera from Mexico. Journal of Paleontology. 4, 271-293.

[21] Todd, R., Kniker, H.T., 1952. An Eocene foraminiferal fauna from the Agua Fresca Shale of Magallanes Province, southernmost Chile. Cushman Foundation for Foraminiferal Research: Ithaca. pp. 1-28.

[22] Anan, H.S., 1994. Benthic foraminifera around Middle/Upper Eocene boundary in Egypt. Middle East Research Center, Ain Shams University, Earth Science Series. 8, 210-233.

[23] Brady, H.B., 1879. Notes on some of the Reticularian Rhizopoda of the "Challenger" Expedition: Part 2. Additions to the knowledge of porcelaneous and hyaline types. Quaternary Journal of Microscopical Science, New Series. 19, 261-299.

[24] Anan, H.S., Sharabi, S.A., 1988. Benthonic foraminifera from Upper Cretaceous-Lower Tertiary rocks of northwest Kharga Oasis, Egypt. Middle East Research Center, Ain Shams University, Earth Science Series. 2, 191-218.

[25] Nakkady, S.E., 1950. A new foraminiferal fauna from the Esna Shale and Upper Cretaceous chalk of Egypt. Journal of Paleontology. 24(6), 675-692.

[26] Anan, H.S., 2019. On the variability of benthic foraminiferal species of the genus Pleurostomella in the Tethys. Journal of Microbiology & Experimentations.

7(3), 173-181.

[27] Mohan, K., Gupta, A.K., Bhaumik, A.K., 2011. Distribution of deep-sea benthic foraminifera in the Neogene of Blake Ridge, NW Atlantic Ocean. Journal of Micropalaeontology. 30(1), 33-74.

[28] Alegret, L., Thomas, E., 2013. Benthic foraminifera across the Cretaceous/Paleogene boundary in the Southern Ocean (ODP Site 690): Diversity, food and carbonate saturation. Marine Micropaleontology. 105, 40-51.

[29] Sztrákos, K., 2000. Eocene foraminifers in the Adour Basin (Aquitaine, France): biostratigraphy and taxonomy. Revue de Micropaléontologie. 43(1-2), 71-172.

[30] Proto Decima, F., de Biase, R., 1975. Foraminiferi bentonici del Paleocene, dell' Eocene inferiore e medio. Foraminiferi bentonici del Paleocene ed Eocene della sezione di Possagno (Italian) [Benthic foraminifera from the Paleocene, lower and middle Eocene. Paleocene and Eocene benthic foraminifera of the Possagno section]. Schweizerische Paläontologische Abhandlungen. 97, 87-98.

[31] Hulsbos, R.E., 1986. Eocene benthic foraminifers from the upper continental rise off New Jersey, Deep Sea Drilling Project Site 605. Initial Reports of the Deep Sea Drilling Project, Washington (U.S. Govt. Printing Office). 93, 525-538.

[32]Ozsvárt, P., 2007. Middle and Late Eocene benthic foraminiferal fauna from the Hungarian Paleogene Basin: Systematics and paleoecology. Hantken Press: Budapest. pp. 129.

[33] Anan, H.S., 1995. Late Eocene Biostratigraphy of Jabals Malaqet and Mundassa of Al Ain region, United Arab Emirates. Revue de Micropaleontologie. 38(1), 3-14.

[34] Haq, B.U., Aubry, M.P., 1978. Early Cenozoic calcareous nannoplankton biostratigraphy and palaeobiogeography of North Africa and the Middle East and Trans-Tethyan correlations. The Geology of Libya. Academic Press: London. pp. 271-304.

[35] Mintz, L.W., 1981. Historical geology, the science of a dynamic earth, 3rd edition, Merrill Publication Company: Princeton. pp. 611.

[36] Rosenbaum, G., Lister, G.S., Duboz, C., 2002. Relative motions of Africa, Iberia and Europe during Alpine orogeny. Tectonophysics. 359(1-2), 117-129.

[37] Aubert, J., Berggren, W.A., 1976. Paleocene benthonic foraminiferal biostratigraphy and paleoecology of Tunisia. Bulletin du Centre de Recherches Pau- SNPA. 10(2), 379-469.

[38] Adams, C.G., Gentry, A.W., Whybrow, P.J., 1983. Dating the terminal Tethys event. Utrecht Micropaleontological Bulletin. 30, 273-298.

[39] Anan, H.S., 2017. Paleontology, paleogeography and paleoenvironment of the Paleocene benthic foraminiferal species of Plummer in the Tethys: A review. Journal of Tethys. 5(3), 272-296.

[40] Abed, A.M., 2013. The eastern Mediterranean phosphorite giants: An interplay between tectonics and upwelling. GeoArabia. 18(2), 67-94.

[41] Anan, H.S., 2011. Paleontology, paleoenvironments, palaeogeography and stratigraphic value of the Maastrichtian-Paleogene and recent foraminiferal species of Anan in the Middle East. Egyptian Journal of Paleontology. 11, 49-78.

[42] Issawi, B., 1999. The phanerozoic geology of Egypt: A geodynamic approach. Egyptian Geological Survey: Cairo. pp. 1-462.

[43] Nakkady, S.E., 1950. A new foraminiferal fauna from the Esna Shale and Upper Cretaceous chalk of Egypt. Journal of Paleontology. 24(6), 675-692.

[44] LeRoy, L.W., 1953. Biostratigraphy of Maqfi section, Egypt. Geological Society of American Memoir. 54, 1-73.

[45] Berggren, W.A., Aubert, J., 1975. Paleocene benthonic foraminiferal biostratigraphy, paleobiogeography and paleoecology of Atlantic-Tethyan regions: Midway-type fauna. Palaeogeography, Palaeoclimatology, Palaeoecology. 18(2), 73-192.

[46] Hayward, B.W., Kawagata, S., Sabaa, A., et al., 2012. The last global extinction (Mid-Pleistocene) of deep-sea benthic foraminifera (Chrysalogoniidae, Ellipsoidinidae, Glandulonodosariidae, Plectofrondiculariidae, Pleurostomellidae, Stilostomellidae), their Late Cretaceous–Cenozoic history and taxonomy. Cushman Foundation for Foraminiferal Research. 43, 1-408.