

RESEARCH ARTICLE

PALEONTOLOGY, STRATIGRAPHY AND PALEOGEOGRAPHY OF THE TETHYAN MAASTRICHTIAN-NEOGENE ROTALIID BENTHIC FORAMINIFERAL MEMBERS OF THE GENUS *PARAROTALIA*

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ABSTRACT

The modern taxonomical consideration is used for most diagnostic sixteen Maastrichtian-Neogene Rotaliid benthic foraminiferal species of the genus *Pararotalia* Le Calvez which has wide geographic distribution in many Tethyan sites: USA, Northern Tethys (England, France, Belgium, Holland, Germany, Italy, Poland, Slovenia, Romania) and Southern Tethys (Libya, Egypt, Tanzania, UAE, Pakistan, India). The Maastrichtian-Paleocene species is *P. tuberculifera* (Reuss). The Paleocene species is *P. macneili* Loeblich and Tappan. The Paleocene-Eocene species is *P. ishamae* Loeblich and Tappan. The Eocene species are: *P. audouini* (d'Orbigny), *P. clavezae* Loeblich & Tappan, *P. inermis* (Terquem), *P. khirthari* Haque, and *P. pakistanica* Anan. The Eocene-Oligocene species is *P. spinigera* (Le Calvez). The Oligocene species are: *P. byramensis* (Cushman), *P. curryi* Loeblich & Tappan, *P. parva* (Cushman) and *P. subinermis* Bhatia. The Neogene species are: *Pararotalia aculeata* (d'Orbigny), *P. armata* (d'Orbigny) and *P. loeblichii* Anan. One species is believed to be new: *Pararotalia loeblichii* Anan, n. sp. Eight species of them were recorded from USA (about 50%), 6 from Romania (about 37.5%), 5 from each of France, Egypt, UAE and Pakistan (about 31.5%), 3 from Poland (about 19%), 2 from Belgium, Italy and Slovenia (about 12.5%), 1 species from each of England, Libya and India (about 6%). The petaloid test and keeled peripheral margin are mostly represented warm water environment.

KEYWORDS

Foraminifera, *Pararotalia*, paleogeography, Maastrichtian, Paleogene, Neogene, Tethys.

1. INTRODUCTION

To erected the new genus *Pararotalia* with the genotype *Rotalina inermis* Terquem, while erected a new genus *Neorotalia*, with the genotype *Rotalia Mexicana* (Le Calvez, 1949; Bermudez, 1952). The studied both genotypes and considered that these two genera belong to a single genus; thus *Neorotalia* Bermudez is a synonym of *Pararotalia* Le Calvez (Hofker, 1957). The paleontological occurrence the genus *Pararotalia* and its sixteen species has been recorded originally from France and later from USA and some other Northern and Southern Tethyan localities. According the genus *Pararotalia* is characterized by its low trochospiral coil, biconvex test, chambers inflated centrally elevated on the spiral side, with a prominent umbilical shoulder surrounding a large solid umbilical plug, sutures depressed, gently curved back at the periphery on the spiral side, peripheral outline lobulate, aperture interiomarginal, extending obliquely up the apertural face to (Loeblich and Tappan, 1988).

2. STRATIGRAPHY

Based on the stratigraphic distribution of the Rotaliid benthic foraminiferal genus *Pararotalia*, which recovered indicate that the ten species of the assemblage were ranged from Late Paleocene to Middle Miocene: *P. armata*, *P. byramensis*, *P. clavezae*, *P. curryi*, *P. inermis*, *P. ishamae*, *P. macneili*, *P. parva*, *P. spinigera*, *P. subinermis* (Figure 1) and also *P. loeblichii* n. sp. The Miocene *P. aculeata*, the Middle-Late Eocene *P. khirthari* and *P. pakistanica*, Paleocene-Eocene *P. audouini* also Maastrichtian-Paleocene of the other species *P. tuberculifera* and are added to that assemblage by (Loeblich and Tappan, 1957; d'Orbigny, 1826).

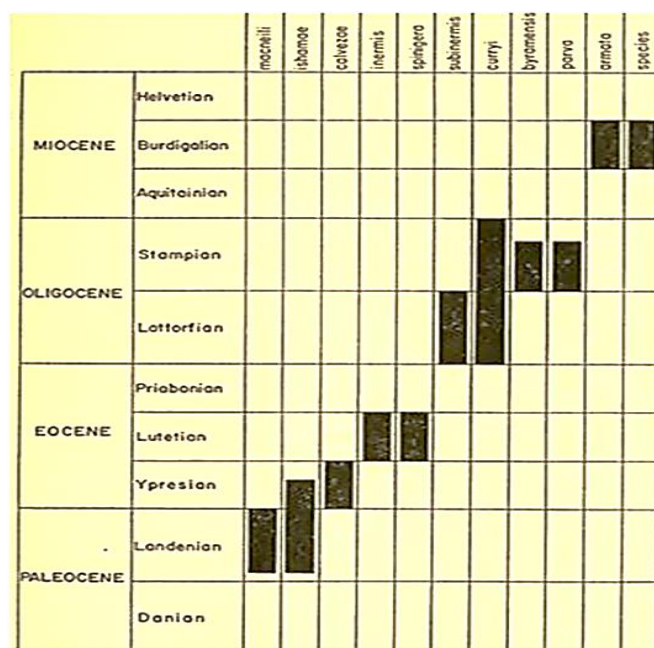


Figure 1: The stratigraphic ranges of the different species of *Pararotalia* (after Loeblich and Tappan, 1957).

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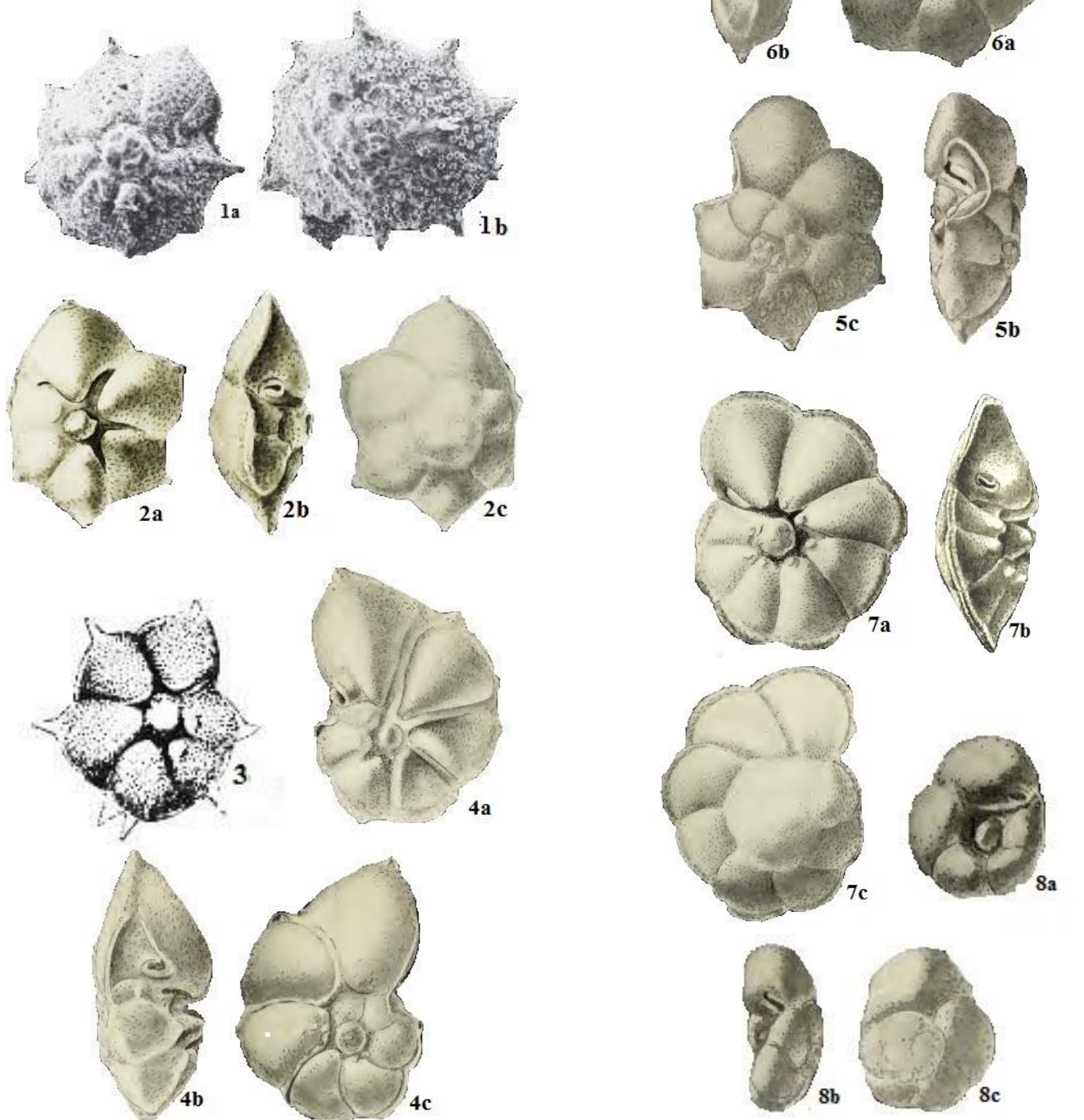
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3. TAXONOMY

Sixteen Maastrichtian-Neogene Rotaliid benthic calcareous foraminiferal species of the cosmopolitan genus *Pararotalia* are identified and illustrated in Plates 1, 2. The classification is followed in this study is of (Loeblich and Tappan, 1988). According to these authors the genus *Pararotalia* Le Calvez is characterized by its low trochospiral biconvex coil test, chambers flat to centrally elevated on the spiral side, commonly inflated and produced around the umbilicus, with a prominent umbilical shoulder surrounding a large solid umbilical plug of clear shell material, sutures gently curved back at the periphery on the spiral side, radial, depressed, and may be fissured on the umbilical side, periphery carinate, peripheral outline lobulate; surface smooth to pustulose; aperture interior marginal, extending obliquely up the apertural face.

Plate 1 (all figs x 140, a ventral view, b apertural view, c dorsal view, except 1b dorsal view)

Fig. **1a,b.** *Pararotalia aculeata* (d'Orbigny, 1846), **2a-c.** *P. armata* (d'Orbigny, 1826), **3.** *P. audouini* (d'Orbigny, 1826), **4a-c.** *P. byramensis* (Cushman, 1922), **5a-c.** *P. clavezae* Loeblich & Tappan (1957), **6a-c.** *P. curryi* Loeblich & Tappan (1957). **7a-c.** *P. inermis* (Terquem, 1882), **8a-c.** *P. ishamae* Loeblich & Tappan (1957).



Order Foraminiferida Eichwald, 1830

Suborder Rotaliina Delage & Hérouard, 1896

Superfamily Rotaliacea Ehrenberg, 1939

Family Rotaliidae Ehrenberg, 1839

Subfamily Pararotaliinae Reiss, 1963

Genus *Pararotalia* Le Calvez, 1949

Type species *Rotalia inermis* Terquem, 1882

- I. *Pararotalia aculeata* (d'Orbigny, 1846) - (Plate 1, figure 1a,b)** (= *Rotalina aculeata* d'Orbigny, 1846, p. 159, pl. 8, figs. 25-27). It was recorded from France (d'Orbigny, 1846), Romania (Szczechura, 2004) and Poland (Gonera, 2012).

- II. *Pararotalia armata* (d'Orbigny, 1826) - (Plate 1, figure 2a-c)** (= *Rotalia (Rotalie) armata* d'Orbigny, 1826, p. 273). It was recorded from France (d'Orbigny, 1826), Romania (Rusu et al., 2004), Slovenia (Cimerman et al., 2006) and United Arab Emirates, UAE (Anan, 2010).

- III. *Pararotalia audouini* (d'Orbigny, 1826) - (Plate 1, figure 3)** (= *Rotalia audouini* d'Orbigny, 1826, p. 273, no. 19). It has wide geographic distribution in Northern Tethys: France (d'Orbigny, 1826), Belgium (Kaasschieter, 1961), Poland (Pożaryska, 1977), Italy (Braga and Grünig, 1975), Slovenia (Cimerman et al., 2006), Romania (Rusu et al., 2004), and Southern Tethys: Libya (Barr and Berggren, 1980), Egypt (Anan, 1994), Tanzania (Pearson et al., 2004), UAE (Anan, 2010), Pakistan (Haque, 1960), and India (Jauhri, 1991) (Figure 2).



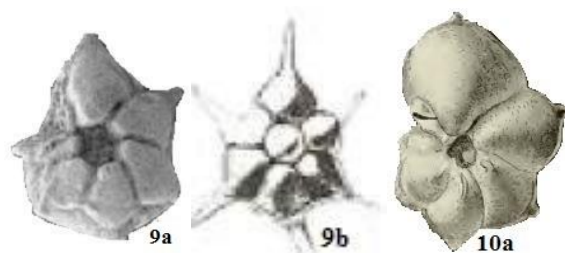
Figure 2: The paleogeographic distribution of the *Pararotalia* spp. in USA and other localities in Northern and Southern Tethys.

- IV. *Pararotalia byramensis* (Cushman, 1922) - (Plate 1, figure 4a-c)** (= *Rotalia byramensis* Cushman, 1922, p. 99, pl. 23, fig. 1).

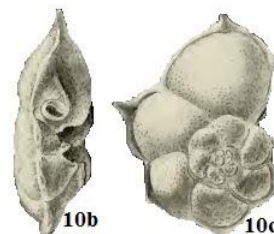
V. It was recorded, so far, from USA (Loeblich & Tappan, 1957) and Romania (Rusu et al., 2004).

- VI. *Pararotalia clavezae* Loeblich and Tappan, 1957 - (Plate 1, figure 5a-c)** (= *Pararotalia clavezae* Loeblich & Tappan, 1957, p. 12, pl. 2, figs. 3-7). It was recorded, so far, from USA (Loeblich & Tappan, 1957) and Romania (Rusu et al., 2004).

- VII. *Pararotalia curryi* Loeblich and Tappan, 1957 - (Plate 1, figure 6a-c)** (= *Pararotalia curryi* Loeblich & Tappan, 1957, p. 13, pl. 3, figs. 5-7). It was recorded, so far, from USA (Loeblich & Tappan, 1957).



- VIII. *Pararotalia inermis* (Terquem, 1882) - (Plate 1, figure 7a-c)** (= *Rotalia inermis* Terquem, 1882, p. 68, pl. 6, fig. 1a-c). This species was recorded from France (Terquem, 1882), Hungaria (Ozsvárt, 2007), Romania (Rusu et al., 2004), Pakistan (Haque, 1960) and India (Jauhri, 1991).

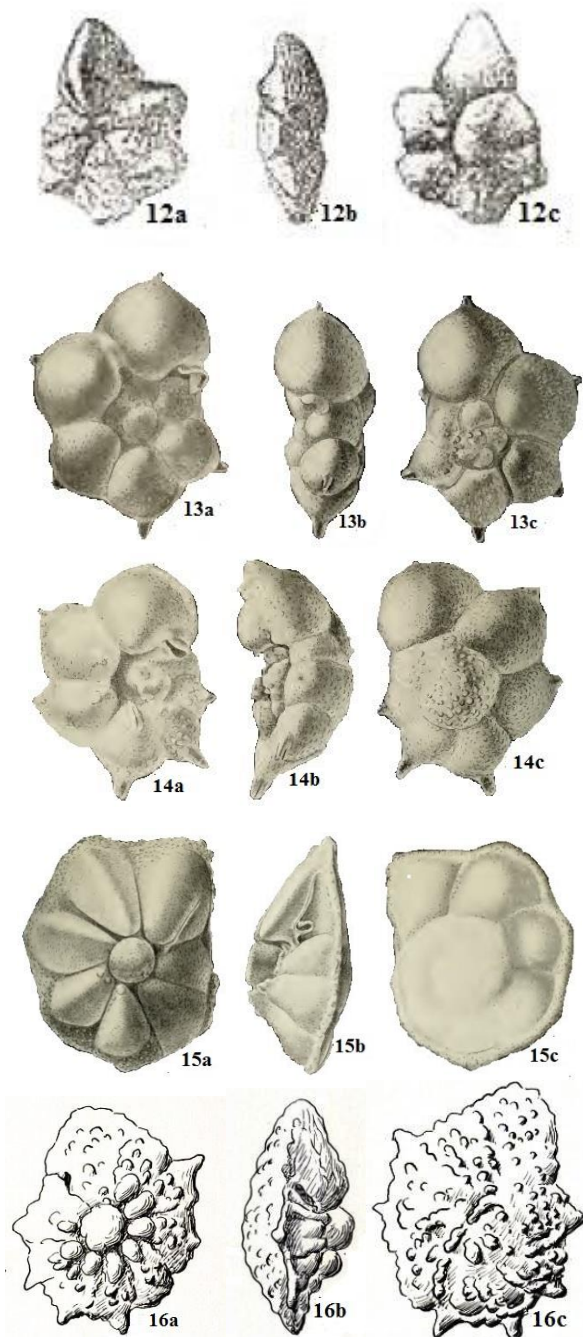


- IX. *Pararotalia ishamae* Loeblich and Tappan, 1956 - (Plate 1, figure 8a-c)** (= *Pararotalia ishamae* Loeblich & Tappan, 1957, p. 15, pl. 3, figs. 1-4). It was recorded, so far, from USA (Loeblich & Tappan, 1957).



Plate 2 (all figs x 140, a ventral view, b apertural view, c dorsal view)

Fig. 9a,b. *P. kirthari* Haque (1960), **10a-c.** *P. loeblichii* Anan, n. sp., **11a-c.** *P. macneili* Loeblich & Tappan (1957), **12a-c.** *P. pakistanica* Anan (2021), **13a-c.** *P. parva* (Cushman, 1923). **14a-c.** *P. spinigera* (Le Calvez, 1949) **15a-c.** *P. subinermis* Bhatia (1955), and **16a-c.** *P. tuberculifera* (Reuss, 1862).



I. ***Pararotalia khirthari* Haque, 1960 - (Plate 2, figure 9a,b)** (= *Pararotalia khirthari* Haque, 1960, p. 3, pl. 6, fig. 5). This diagnostic species was recorded, so far, from Pakistan (Haque, 1960), Tanzania (Pearson et al., 2004), and UAE (Anan, 2021).

- II. ***Pararotalia loeblichii* Anan, n. sp. - (Plate 2, figure 10a-c)** (= *Pararotalia* sp. Loeblich & Tappan, 1957, p. 21, pl. 5, fig. 3).
- III. Holotype: Illustrated specimen in Pl. 2, fig. 10 x 140
- IV. Dimensions: Length 42 mm, width 30 mm.
- V. Etymology: After the American Micropaleontologist Alfred R. Loeblich, Jr.
- VI. Depository: Spiral view of specimen (U.S.N.M. P58r2)
- VII. Age: Miocene.
- VIII. Remarks: The new species resembles *P. curryi*, but has more strongly keeled, more compressed, and has relatively higher chambers, and the umbilical side lacks a plug, The elevated chambers around the umbilicus somewhat resemble *P. spinigera* (Le Calvez), but its spiral side has less convex and less prominent peripheral spines. It was recorded, so far, from USA.
- IX. ***Pararotalia macneili* Loeblich and Tappan, 1957 - (Plate 2, figure 11a-c)** (= *Pararotalia macneili* Loeblich and Tappan, 1957, p. 16, pl. 2, figs. 1, 2). It was recorded, so far, from USA (Loeblich and Tappan, 1957).
- X. ***Pararotalia pakistanica* Anan, 2021 - (Plate 2, figure 12a-c)** (= *Pararotalia* (?) sp. Haque, 1960, p. 31, pl. 4, fig. 2; *P. pakistanica* Anan, 2021, p. 64, pl. 4, fig. 80). It was recorded, from Pakistan (Haque, 1960) and UAE (Cherif et al., 1992).
- XI. ***Pararotalia parva* (Cushman, 1923) - (Plate 2, figure 13a-c)** (= *Rotalia dentata* Parker & Jones var. *parva* Cushman, 1922, p. 139, pl. 35, figs. 1, 2). It is recorded, so far, from USA (Loeblich & Tappan, 1957).
- XII. ***Pararotalia spinigera* (Le Calvez, 1949) - (Plate 2, figure 14a-c)** (= *Globorotalia spinigera* (Terquem) Le Calvez, 1949, p. 39, pl. 6, figs. 97-99. It was recorded, so far, from USA (Loeblich and Tappan, 1957), Pakistan (Haque, 1960), Poland (Odrzywolska-Bienkova and Pozaryska, 1984) and UAE (Anan, 2010).
- XIII. ***Pararotalia subinermis* Bhatia, 1955 - (Plate 2, figure 15a-c)** (= *Pararotalia subinermis* Bhatia, 1955, p. 683, pl. 67, fig. 3). It was recorded, so far, from USA (Loeblich & Tappan, 1957), England (Bhatia, 1955) and Romania (Rusu et al. 2004).
- XIV. ***Pararotalia tuberculifera* (Reuss, 1862) - (Plate 2, figure 16a-c)** (= *Rotalia tuberculifera* Reuss, 1862, p. 313, p. 2, fig. 2). It was recorded from France (Reuss, 1862), Holland (Hofker, 1957), Belgium (Kaasschieter, 1961), and Poland (Pożaryska, 1965).

4. PALEO GEOGRAPHY

Some authors, e.g. Haynes & Nwabufu-Ene (1998), Anan, (2019) declared that the ancestral Tethys was connected with the ancestral Indian Oceans via Mediterranean Sea (Figure 3). The paleogeographic distribution of the Rotaliid *Pararotalia* spp. are expanded into many different parts of the Tethys: USA, Northern Tethys: England, France, France, Belgium, Holland, Germany, Italy, Poland, Slovenia, Romania, and Southern Tethys: Libya, Egypt, Tanzania, UAE, Pakistan, India (Table 1).

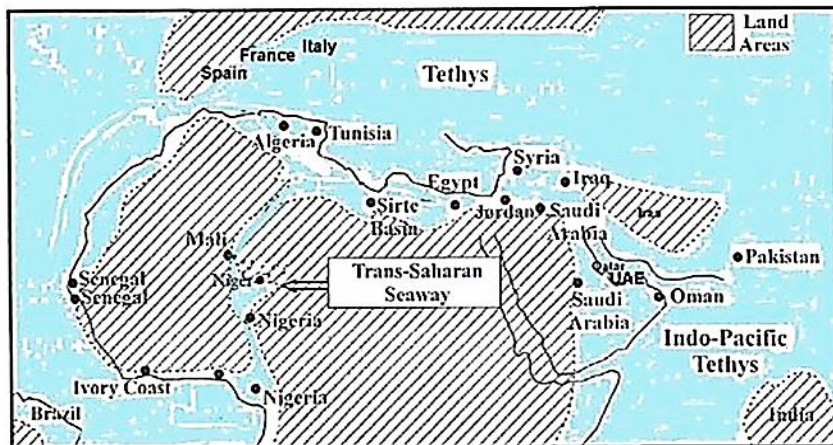


Figure 3: Paleocene paleogeographic map of some localities in the Tethys: Spain, Tunisia, Egypt, UAE, Pakistan and India (after Morsi et al., 2008).

Table 1: 1. USA, 2. England, 3. France, 4. Belgium, 5. Italy, 6. Poland, 7. Slovenia, 8. Romania, 9. Libya, 10. Egypt, 11. UAE, 12. Pakistan, 13. India.(x recorded, - not recorded)

Sp. No.	species	countries													
			1	2	3	4	5	6	7	8	9	10	11	12	13
1	<i>Pararotalia</i>	<i>aculeata</i>	-	-	x	-	-	x	-	x	-	-	-	-	-
2		<i>armata</i>	-	-	x	-	-	-	x	x	-	-	x	-	-
3		<i>audouini</i>	-	-	x	x	x	x	x	x	x	x	x	x	x
4		<i>byramensis</i>	x	-	-	-	-	-	-	-	-	-	-	-	-
5		<i>clavezae</i>	x	-	-	-	-	-	-	x	-	-	-	-	-
6		<i>curryi</i>	x	-	-	-	-	-	-	-	-	-	-	-	-
7		<i>inermis</i>	-	-	x	-	-	-	-	x	-	-	-	x	x
8		<i>ishamae</i>	x	-	-	-	-	-	-	-	-	-	-	-	-
9		<i>khirthari</i>	-	-	-	-	-	-	-	-	-	-	x	x	-
10		<i>loeblichii</i>	x	-	-	-	-	-	-	-	-	-	-	-	-
11		<i>macneili</i>	x	-	-	-	-	-	-	-	-	-	-	-	-
12		<i>pakistanica</i>	-	-	-	-	-	-	-	-	-	-	x	x	-
13		<i>parva</i>	x	-	-	-	-	-	-	-	-	-	-	-	-
14		<i>spinigera</i>	-	-	x	-	-	x	-	-	-	-	x	x	-
15		<i>subinermis</i>	x	x	-	-	-	-	-	x	-	-	-	-	-
16		<i>tuberculifera</i>	-	-	x	x	x	x	-	-	-	-	-	-	-

5. CONCLUSION

The analysis of paleontology, stratigraphy and paleogeographic remarks are presented for 16 diagnostic Rotaliid foraminiferal species of the genus *Pararotalia* were described from the Maastrichtian- Neogene rocks from many localities of the Tethys. The Miocene *P. armata* (d'Orbigny) and *P. loeblichii* n. sp., Oligocene *P. curryi* Loeblich and Tappan, *P. byramensis* (Cushman) and *P. subinermis* Bhatia Oligocene-Eocene *P. inermis* (Terquem), *P. parva* (Cushman) and *P. spinigera* (Le Calvez), Eocene *P. audouini* (d'Orbigny) *P. clavezae* Loeblich and Tappan, *P. khirthari* Haque and *P. pakistanica* Anan, Paleocene-Eocene *P. aculeata* (d'Orbigny) and *P. ishamae* Loeblich and Tappan, Paleocene *P. macneili* Loeblich and Tappan, and Maastrichtian-Paleocene *P. tuberculifera* (Reuss). The paleogeography distribution of these taxa from different Tethyan localities are from Atlantic to Pacific Oceans via Mediterranean and Indian Ocean. The unclosed record number of these species in different Tethyan localities may due to the lack of detailed study, land barriers, miss identification, and/or different paleoenvironmental conditions (temperature, depth, dissolved oxygen, salinity, etc.). The petaloid test and keeled peripheral margin are mostly represented warm water environment

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