

ZIBELINE INTERNATIONAL™
PUBLISHING

ISSN: 2521-0890 (Print)

ISSN: 2521-0491 (Online)

CODEN: GBEBB6



REVIEW ARTICLE

PALEONTOLOGY AND PALEOGEOGRAPHY OF THE TETHYAN AGGLUTINATED BENTHIC FORAMINIFERAL SPECIES OF THE GENUS *SPIROPLECTINELLA*

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ARTICLE DETAILS

Article History:

Received 15 July 2022

Accepted 24 August 2022

Available online 30 August 2022

ABSTRACT

Thirty three small diagnostic benthic foraminiferal species of the Textulariid genus *Spiroplectinella* are common in the Late Cretaceous-Neogene rocks from many Tethyan localities: North Atlantic (USA, Mexico, Caribbean), South America (Brazil, Argentina, Chile, Venezuela, Ecuador), Europe (North Sea, Norway, Spain, France, Poland, Czech, Italy, Hungary, Slovenia, Croatia, Romania, Bulgaria, Ukraine, Turkmenistan), North Africa (Tunisia, Egypt), Southwest Asia (Turkey, Jordan, Iraq, UAE, Iran, Pakistan) and Indian Ocean (Australia, Antarctic Basin). These diagnostic species are: *Spiroplectinella adamsi*, *baudouiniana*, *carinata*, *chicoana*, *costata*, *cretosa*, *dalmatina*, *dentata*, *deperdita*, *desertorum*, *elongata*, *esnaensis*, *excolata*, *hamdani*, *henryi*, *israelski*, *jarvisi*, *knebeli*, *laevis*, *longa*, *nuttalli*, *paleocenica*, *paracarinata*, *pectinatiforma*, *plummerae*, *praelonga*, *richardi*, *rossae*, *semicomplanata*, *sigmoidina*, *subhaeringensis*, *wilcoxensis* and *wrightii*. The paleontology, stratigraphy, paleoenvironment and paleogeographic distribution of them in the Tethys are presented.

KEYWORDS

Foraminifera, Cretaceous, Paleogene, Neogene, paleontology, stratigraphy, paleogeography, Paleocology, paleoenvironment.

1. INTRODUCTION

The rich and diverse Late Cretaceous-Paleogene Tethyan benthic foraminiferal assemblages include different species of the Textulariid genus *Spiroplectinella*, (Pl. 1, figure 1- this study) with early planispiral coil and lozenge shaped in section, than large early planispiral coil and broadly rounded margins in the genus *Spiroplectammina* (Pl. 1, figure 2), or large planispiral coil in early stage and later long and narrow biserial stage in the genus *Bolivinopsis* (Pl. 1, figure 3) (Kisel'man, 1972; Cushman, 1927; Yakovlev, 1891). According to Mikhalevich, the genus *Spiroplectammina* has elongated test, may be widened at the upper part, consists of planispirally coiled initial part and following uncoiled straight biserial part, aperture basal, interiomarginal, at least initially, but often in the adult also, single or multiple (Mikhalevich, 2004). The paleontological occurrence of thirty-three recorded species belonging to the genus *Spiroplectinella* has been reported and have a wide geographic distribution in many Tethyan localities in the Tethys throughout the Late Cretaceous (Figure 1) and Middle Eocene (Figure 2). As a whole, these taxa are rarely described and scattered in the micropaleontological literature, that's why this study is dedicated. The author has examined many representatives of the genus *Spiroplectinella*, which has different length and width, and existed in different Tethyan localities, in Europe (France, Italy, Austria, Slovenia, Hungary), Southern Tethys (Egypt, UAE, Iran, Pakistan - Figure 3), and North and South America (USA, Mexico, Trinidad, Venezuela, Ecuador, Brazil, Argentina, Chile - Figure 4). The intent of this study is to bring together many data scattered in the literature under a unifying theme, and to detect its paleontology, stratigraphy, paleobathymetry, paleoenvironment and paleogeographic distribution of

them in the Tethys (Table 1) throughout the Late Cretaceous-Early Paleogene (Figures 1, 2).

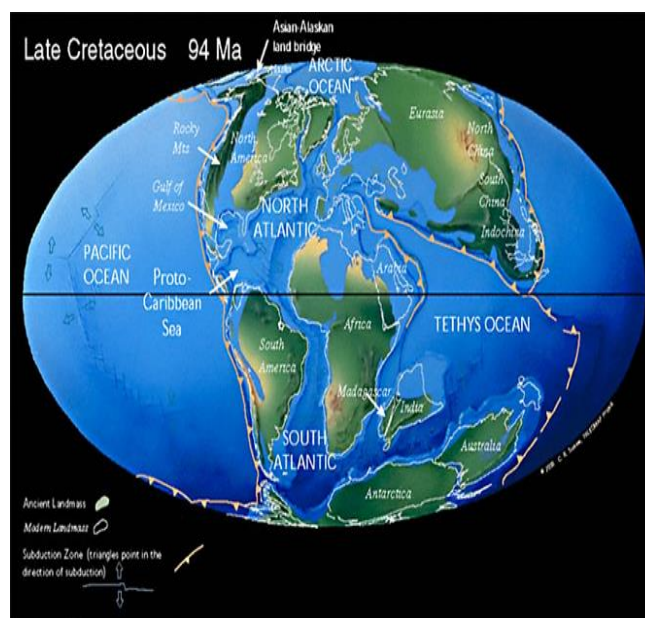


Figure 1: The paleogeographic distribution of the Tethys in the Late Cretaceous (about 94 Ma).

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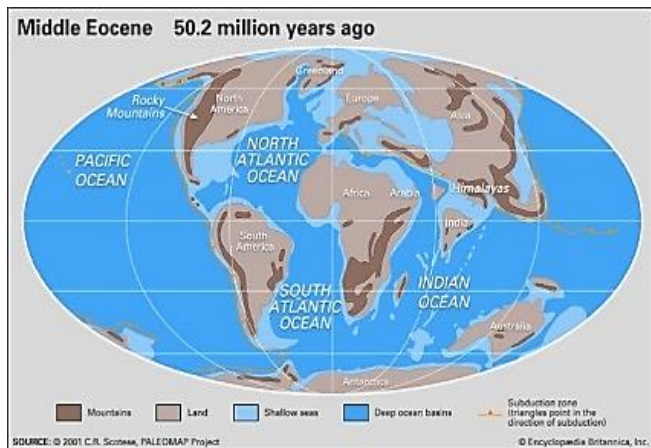


Figure 2: The paleogeographic distribution of the Tethys in the Middle Eocene (about 50.2 Ma).



Figure 3: The paleogeographic distribution of different species of the genus *Spiroplectinella* in Europe (Spain, France, Germany, Italy, Poland, Austria, Ukraine, Czech, Slovenia, Hungary, Romania, Bulgaria, Croatia), North Africa (Tunisia, Egypt) and West Asia (Turkey, Jordan, Iraq, UAE, Iran, Pakistan).



Figure 4: The paleogeographic distribution of different species of the genus *Spiroplectinella* in North America (USA, Mexico) and South America (Trinidad, Venezuela, Ecuador, Brazil, Argentina, Chile).

2. SYSTEMATIC PALEONTOLOGY

Thirty-three species of benthic foraminiferal genus *Spiroplectinella* were identified following the taxonomic classification of Kaminski and the illustrated taxa have been shown in Plates (1, 2) (Kaminski, 2014).

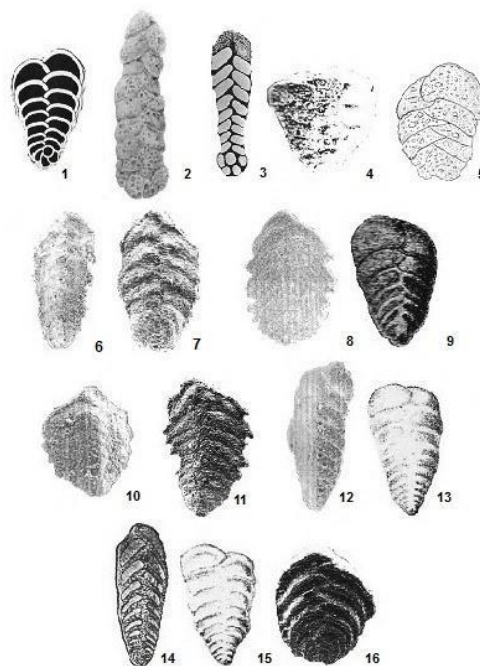


Plate 1: Figure 1. *Spiroplectinella* Kisel'man (1972), 2. *Spiroplectammina* Cushman (1927), 3. *Bolivinopsis* Yakovlev (1891), 4. *Spiroplectinella* adamsi (Lalicker, 1935), 5. *S. baudouiniana* (d'Orbigny, 1840), 6. *S. carinata* (d'Orbigny, 1846), 7. *S. chicoana* (Lalicker, 1935), 8. *S. costata* (Huss, 1966), 9. *Spiroplectinella* cretosa (Cushman, 1932), 10. *S. dalmatina* (de Witt Puyt, 1941), 11. *Spiroplectinella* dentata (Alth, 1850), 12. *S. deperdita* (d'Orbigny, 1846), 13. *S. desertorum* (LeRoy, 1953), 14. *S. elongata* (Davis, 1941), 15. *S. esnaensis* (LeRoy, 1953), 16. *S. excolata* (Cushman, 1926).

Class Foraminifera d'Orbigny, 1826

Subclass Monothalamana Pawlowski, Holzmann and Tyszka, in Kaminski 2014

Order Allogromiida Hartog, in Harmer and Shipley 1906

Suborder Spiroplectamminina Mikhalevich 1992

Superfamily Spiroplectamminoidea Cushman 1927

Family Spiroplectamminidae Cushman 1927

Subfamily Spiroplectammininae Cushman 1927

Genus *Spiroplectinella* Kisel'man 1972

Type species: *Spiroplecta wrightii* Silvestri 1903

***Spiroplectinella adamsi* (Lalicker, 1935) - Pl. 1, figure 4**

1935 *Spiroplectammina adamsi* Lalicker, p. 39, pl. 6, figures 1, 2. {illustrated species}

1990 *Spiroplectammina adamsi* Lalicker - Willems, p. 390, pl. 2, figure 5.

Remarks: This Paleocene-Oligocene species was recorded from USA, North Sea, UAE, Iraq, Chile (Lalicker, 1935; Willems, 1990; Cherif et al., 1992; Abawi and Hani, 2005; Marchant, 2011).

***Spiroplectinella baudouiniana* (d'Orbigny, 1840) - Pl. 1, figure 5**

1840 *Textularia baudouiniana* d'Orbigny, p. 46, pl. 4, figures 29, 30.

1965 *Spiroplectammina baudouiniana* d'Orbigny - Pozaryska, p. 48, pl. 2, figure 5.

Remarks: This Campanian-Paleocene species has rhomboidal transverse section of the test, sharp margins, location of the maximum bulge of the test along its length axis. It was recorded, so far, in France and Poland (d'Orbigny, 1840; Pozaryska, 1965; Gawor-Biedowa, 1992).

***Spiroplectinella carinata* (d'Orbigny, 1846) - Pl. 1, figure 6**

1846 *Textularia carinata* d'Orbigny, p. 247, pl. 14, figures 32-34.

1959 *Spiroplectammina carinata* (d'Orbigny) - Nakkady, p. 456, pl. 1, figure 1.

Remarks: The species has oval compressed test, limbate raised sutures and irregular marginal keel. It was recorded in Danian of Egypt, Oligocene of UAE, Early Middle Eocene of Spain, Early Eocene of Iran and Eocene-Miocene of Bulgaria (Nakkady, 1959; Cherif et al., 1992; Ortiz and Thomas, 2006; VahdatiRad et al., 2016; Darakchieva et al., 2019).

***Spiroplectinella chicoana* (Lalicker, 1935) - Pl. 1, figure 7**

1935 *Spiroplectammina chicoana* Lalicker, p. 7, pl. 1, figure 8, 9.

1994 *Quasispiroplectammina chicoana* Lalicker - Bolli et al., p. 82, figure 21, 28, 29.

Remarks: This species has elongated test with irregular periphery. It was recorded from Campanian-Paleocene of USA, Mexico, Poland, Trinidad, France (Lalicker, 1935; Sliter, 1968; Gawor-Biedowa, 1992; Bolli et al., 1994; Sztrákos, 2005).

***Spiroplectinella costata* (Huss, 1966) - Pl. 1, figure 8**

1966 *Spiroplectammina costata* Huss, p. 33, pl. 6, figures 18, 19.

1995 *Spiroplectammina costata* Huss - Bubík, p. 87, pl. 15, figure 1.

Remarks: Gawor-Biedowa (1992) considered the specimen *S. chicoana* of Hanzlíková (1972, pl. 9, figure 7) belongs to the species *S. costata* as it has identical shape of the test, and sutural thickenings elongated into spines. It was recorded, so far, from Poland and Czech (Morgiel and Olszewska, 1981; Birkenmajer and Gedl, 2017; Bubík, 1995).

***Spiroplectinella cretosa* (Cushman, 1932) - Pl. 1, figure 9**

1932 *Spiroplectammina laevis* (Roemer) var. *cretosa* Cushman, p. 87, pl. 11, figure 3.

1972 *Spiroplectammina cretosa* Cushman - Hanzlíková, p. 47, pl. 10, figure 9.

Remarks: Hanzlíková (1972) noted that the species *S. cretosa* was recorded as *S. laevis* from the European Campanian-Maastrichtian platform of Netherland (Hofker, 1966). It was recorded from USA, Czech (Cushman, 1932; Hanzlíková, 1972).

***Spiroplectinella dalmatina* (de Witt Puyt, 1941) - Pl. 1, figure 10**

1941 *Textularia dalmatina* de Witt Puyt, p. 45, pl. 1, figures 4, 5.

1975 *Spiroplectammina dalmatina* de Witt Puyt - Braga and Grünig, p. 102.

2007 *Spiroplectammina dalmatina* de Witt Puyt - Zivkovic and Glumac, p. 304, pl. 2, figure 10.

Remarks: This Eocene species has tapering test and acute periphery with faint keel, raised center of the test, and raised sutures. It was recorded from Italy, Slovenia, Croatia (Braga and Grünig, 1975; Cimerman et al., 2006; Zivkovic and Glumac, 2007).

***Spiroplectinella dentata* (Alth, 1850) - Pl. 1, figure 11**

1850 *Textularia dentata* Alth, p. 262, pl. 13, figure 13.

1932 *Spiroplectammina dentata* Alth - Cushman and Jarvis, p. 14, pl. 3, figure 7.

1994 *Spiroplectinella dentata* Alth - Bolli et al., p. 83, figure 22.4-7.

Remarks: Hanzlíková (1972) noted that neither the original species, nor subsequent descriptions do record the arrangement of the earliest portion of the test and assigned by her to the genus *Semivulvulina* (biserially arranged test throughout), until the originals have been revised. This Maastrichtian-Paleocene cosmopolitan species was recorded in many Tethyan localities: USA, Egypt, Czech, Italy, UAE, Trinidad, Poland, Tunisia, France, Iraq (Alth, 1850; Cushman and Jarvis, 1932; Said and Kenawy, 1956; Anan, 2015; Proto Decima and De Biase, 1975; Aubert and Berggren, 1976; Bejaoui et al., 2019; Anan, 1993a, 2015; Hanzlíková, 1972; Bolli et al., 1994; Bubík, 1995; Sztrákos, 2005; Sharbazheri, 2008).

***Spiroplectinella deperdita* (d'Orbigny, 1846) - Pl. 1, figure 12**

1846 *Textularia deperdita* d'Orbigny, p. 244, pl. 14, figure 23-25.

2019 *Spiroplectammina deperdita* d'Orbigny - Darakchieva et al., p. 11, pl. 1, figure 6.

Remarks: The species has elongated test with small planispiral initial and biserial late portion, which comprises 8-9 pairs of broad, low, flattened chambers, gradually increasing towards the apertural end, sutures are

depressed and slightly oblique, periphery thin and sharp, aperture arch-shaped and low. It was recorded in the Middle Eocene-Oligocene of Bulgaria, but Eocene of Hungary (Darakchieva et al., 2019; Ozsvárt, 2007).

***Spiroplectinella desertorum* (LeRoy, 1953) - Pl. 1, figure 13**

1953 *Spiroplectammina desertorum* LeRoy, p. 50, pl. 1, figures 19, 20.

2011 *Spiroplectinella desertorum* LeRoy - Aly et al., p. 83, pl. 1, figure 7.

Remarks: This Eocene species has tapering initial end to greatest width at the apertural extremity, slightly convex downward sutures, semiacute periphery, smoothly finished wall. It differs from *S. paleocenica* Cushman by being less thick through the median portion and lacking the slightly upturned sutures. It is, so far, an endemic to Egypt.

***Spiroplectinella elongata* (Davis, 1941) - Pl. 1, figure 14**

1941 *Textularia mississippiensis* var. *elongata* Davis, p. 151, pl. 24, figures 21, 22.

1956 *Textularia mississippiensis* var. *elongata* Davis - Haque, p. 30, pl. 9, figures 3, 13.

Remarks: This species belongs to the genus *Spiroplectinella* due to its planispiral initial stage and biserial end stage. It was recorded from Eocene-Oligocene in USA and Pakistan (Davis, 1941; Haque, 1956).

***Spiroplectinella esnaensis* (LeRoy, 1953) - Pl. 1, figure 15**

1953 *Spiroplectammina esnaensis* LeRoy, p. 50, pl. 1, figures 11, 12.

Remarks: The Paleocene-Early Eocene *S. esnaensis* (LeRoy) species was recorded in Egypt, Tunisia, France and Iran (LeRoy, 1953; Speijer, 1994; Aly et al., 2011; Anan, 2016; Hewaidy et al., 2017; Aubert and Berggren, 1976; Sztrákos, 2005; VahdatiRad et al., 2016).

***Spiroplectinella excolata* (Cushman, 1926) - Pl. 1, figure 16**

1926 *Textularia excolata* Cushman, p. 585, pl. 15, figure 9.

1932 *Spiroplectammina excolata* Cushman - Cushman and Jarvis, p. 14, pl. 3, figures 9, 10.

1994 *Spiroplectinella excolata* Cushman - Bolli et al., p. 84, figure 22. 8, 17.

Remarks: Tjalsma and Lohmann (1983) as well as Darakchieva et al. (2019) treated the *S. excolata* (Cushman) as a junior synonym of *S. subhaeringensis* (Grzybowski), while the present author considered *S. excolata* as a separate species. It was recorded from USA (Cushman, 1926), Italy (Proto Decima and Bolli, 1982), Trinidad (Kaminski et al., 1988; Bolli et al., 1994) and Romania (Filipescu and Kaminski, 2008).

***Spiroplectinella hamdani* (Anan, 1993) - Pl. 2, figure 17**

1993b *Spiroplectammina hamdani* Anan, p. 652, pl. 1, figure 14.

2005 *Spiroplectinella hamdani* Anan - Anan, p. 79, pl. 1, figure 2.

Remarks: This Maastrichtian species is characterized by its large coiled early stage, elongate later biserial stage and high raised sutures. It was recorded, so far, from UAE and Egypt (Anan, 1993b; 2005, respectively).

***Spiroplectinella henryi* (LeRoy, 1953) - Pl. 2, figure 18**

1953 *Spiroplectammina henryi* LeRoy, p. 45, pl. 2, figures 14, 15.

2003 *Spiroplectinella henryi* (LeRoy) - Ali, p. 124, pl. 4, figures 9, 10.

Remarks: The Maastrichtian-Paleocene species is characterized by its sharply rounded initial portion, raised sutures, and strongly arched downward and acute periphery. It was recorded in many localities of Egypt Libya (LeRoy, 1953; Said and Kenawy, 1956; Ali, 2003; Anan, 2011; Hewaidy et al., 2014; Berggren, 1974).

***Spiroplectinella israelskyi* (Hillebrandt, 1962) - Pl. 2, figure 19**

1962 *Spiroplectammina israelskyi* Hillebrandt, p. 30, pl. 1, figures 5-7.

1993 *Spiroplectammina israelskyi* Hillebrandt - Kuhnt and Kaminski, p. 75, pl. 6, figure 3.

Remarks: This Maastrichtian species differs from *S. dentata* in its more elongate test and lack the peripheral spines. It also differs from *S. laevis* in being less tapered and in having invaginations between the chambers along the periphery in the biserial part. It was recorded from Austria, Spain and Italy (Hillebrandt, 1962; Kuhnt and Kaminski, 1993; Kaminski et al., 2008).

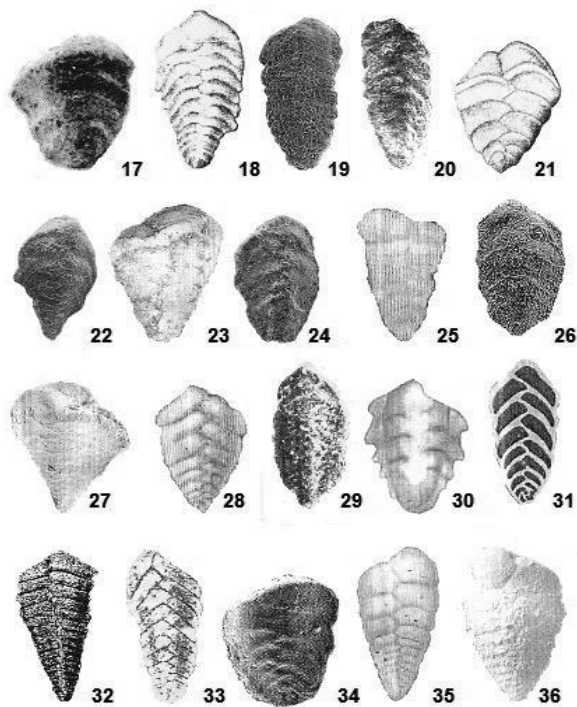


Plate 2: Figure 17. *Spiroplectinella hamdani* (Anan, 1993), 18. *S. henryi* (LeRoy, 1953), 19. *S. israeli* (Hillebrandt, 1962), 20. *S. jarvisi* (Cushman, 1939), 21. *S. knebeli* (LeRoy, 1953), 22. *S. laevis* (Roemer, 1841), 23. *S. longa* (Said and Kenawy, 1956), 24. *S. nuttalli* (Lalicker, 1935), 25. *S. paleocenica* (Cushman, 1947), 26. *S. paracarinata* (Said and Kenawy, 1956), 27. *S. pectinatiformis* (Balakhmatova, 1965), 28. *S. plummerae* (Cushman, 1948), 29. *S. praelonga* (Reuss, 1845), 30. *S. richardi* (Martin, 1943), 31. *S. rossae* (Plummer, 1933), 32. *S. semicomplanata* (Carsey, 1926), 33. *S. sigmoidina* (Lalicker, 1935), 34. *S. subhaeringensis* (Grzybowski, 1896), 35. *S. wilcoxensis* (Cushman and Ponton, 1932), 36. *S. wrightii* (Silvestri, 1903).

***Spiroplectinella jarvisi* (Cushman, 1939) - Pl. 2, figure 20**

1939 *Spiroplectammina jarvisi* Cushman, p. 90, pl. 16, figure 1.

1994 *Quasispiroplectammina jarvisi* (Cushman) - Bolli et al., p. 83, figure 22. 1, 2.

Remarks: Bolli et al. (1994) noted that *S. israeli* may be a junior synonym of *S. jarvisi*. This Paleocene species was recorded from USA (Cushman, 1939), Trinidad (Bolli et al., 1994), Pacific Ocean (Nomura and Takata, 2005) and Brazil (Mello, 2016).

***Spiroplectinella knebeli* (LeRoy, 1953) - Pl. 2, figure 21**

1953 *Spiroplectammina knebeli* LeRoy, p. 51, pl. 2, figure 10, 11.

2003 *Spiroplectinella knebeli* (LeRoy) - Ali, p. 124, pl. 4, figures 14, 15.

Remarks: This Maastrichtian-Paleocene species has small coiled planispiral stage, biserial chambers low, sutures slightly raised and curved downward and broad convex apertural face. It was recorded in Egypt, Tunisia, Jordan and UAE (Futyan, 1976; Aubert and Berggren, 1976; LeRoy, 1953; Ali, 2003; Hewaidy et al., 2017; Anan, 2020; Anan, 1993a).

***Spiroplectinella laevis* (Roemer, 1841) - Pl. 2, figure 22**

1841 *Textularia laevis* Roemer, p. 97, pl. 15, figure 17.

1968 *Spiroplectammina laevis* (Roemer) - Sliter, p. 46, pl. 2, figure 9.

2011 *Spiroplectinella laevis* (Roemer) - Anan, p. 296, pl. 1, figure 1.

Remarks: *Spiroplectinella laevis* has tapering test with acute periphery, raised ridges at the suture lines which forming a raised zigzag line along the center of the test. It has been originally described from the Cretaceous of Germany, and later on from USA, Mexico, Spain, Czech, Indian Ocean, Iraq and Egypt (Sliter, 1968; Sharbazheri, 2008; Jaff and Lawa, 2019; Kuhnt and Kaminski, 1993; Quilty, 2002; Bubík, 1995; Anan, 2011; Hewaidy et al., 2014).

***Spiroplectinella longa* (Said and Kenawy, 1956) - Pl. 2, figure 23**

1956 *Spiroplectammina knebeli longa* Said and Kenawy, p. 122, pl. 1, figure 12.

2014 *Spiroplectinella longa* (Said and Kenawy) - Hewaidy et al., p. 20, pl. 4, figure 1.

Remarks: This Maastrichtian-Paleocene species differs from *S. knebeli* in having a longer test and having more later biserial chambers. It is, so far, an endemic to Egypt.

***Spiroplectinella nuttalli* (Lalicker, 1935) - Pl. 2, figure 24**

1935 *Spiroplectammina nuttalli* Lalicker, p. 43, p1. 6, figures 3, 4.

1955 *Bolivinospis nuttalli* (Lalicker) - Ansary, p. 19, p1. 1, figure 7.

2005 *Spiroplectinella nuttalli* (Lalicker) - Anan, p. 20, pl. 1, figure 6.

Remarks: This Eocene species is characterized by large triangular test with acute periphery. It was originally described from Venezuela, Ecuador, Egypt and UAE (Lalicker, 1935; Cushman and Stainforth, 1951; Ansary, 1955; Anan, 2005).

***Spiroplectinella paleocenica* (Cushman, 1947) - Pl. 12, figure 25**

1947 *Spiroplectammina paleocenica* Cushman, p. 81, pl. 17, figure 17.

1951 *Spiroplectammina paleocenica* Cushman - Cushman, p. 7, pl. 1, figure 27.

Remarks: Test very small, evenly tapering from the slightly rounded initial end to the greatest width at the apertural end, wall finely arenaceous, smoothly finished; aperture a slight, low opening at the base of the inner margin of the last-formed chamber. It is, so far, an endemic to USA (Cushman, 1947, 1951).

***Spiroplectinella paracarinata* (Said and Kenawy, 1956) - Pl. 2, figure 26**

1956 *Spiroplectammina paracarinata* Said and Kenawy, p. 122, pl. 1, figure 13.

2012 *Spiroplectinella paracarinata* (Said and Kenawy) - Anan, p. 63, pl. 1, figure 6.

Remarks: Anan (2012) recognized five phylogenetic lineages based mainly on the change in shell morphological characters of some benthic foraminifera in the Maastrichtian-early Eocene succession, particularly around the K/T and P/E boundaries in Egypt and other parts in the Tethys, and one of them is the lineage of the Maastrichtian-Paleocene *S. knebeli* to Early Eocene *S. paracarinata*. The latter species has mainly more elongation test to its width, less flaring later chambers and less curved sutures than *S. knebeli*. It was described from Egypt (Said and Kenawy, 1956; Anan, 2012, 2020) and UAE (Anan, 1996).

***Spiroplectinella pectinatiformis* (Balakhmatova, 1964) - Pl. 2, figure 27**

1969 *Textularia pectinatiforma* (Balakhmatova) - Kraeva and Zernetskij, p. 28, pl.8, figure 13a, 6. 2019 *Spiroplectinella pectinatiforma* (Balakhmatova) - Darakchieva et al., p.12, pl.1, figure 8.

Remarks: The test of this species is pyramid-shape, flattened, elliptical in cross section, the initial portion is small and unclearly planispiral, the later one is biserial consisting of numerous, narrow chambers gradually increasing in size, periphery with thin keel, aperture is arch-shaped, interiomarginal, wall is finely agglutinated with smooth surface. It is known from the Upper Eocene of Ukraine, and Oligocene of Bulgaria (Darakchieva et al., 2019).

***Spiroplectinella plummerae* (Cushman, 1948) - Pl. 2, figure 28**

1927 *Textularia carinata* d'Orbigny, var. *expansa* Plummer, p. 67, pl. 3, figure 3.

1948 *Spiroplectammina plummerae* Cushman, p. 226, pl. 16, figure 2.

1982 *Ammobaculites expansus* (Plummer) - Proto Decima and Bolli, p. 116.

2017 *Spiroplectinella expansa* (Plummer) - Anan, p. 274, figure 6. 1.

Remarks: This Paleocene-Eocene subspecies of Plummer (1927) was later renamed to *S. plummerae* due to foraminiferal homonym *Spiroplectammina expansa* by LeRoy, 1941 (ICZN 2000). It has somewhat elongate test, triangular outline compressed test with sharply angular margin, chambers numerous, sutures distinct and depressed, gently curved and somewhat oblique, limbate toward the axis of the test, but

tapering toward the margin, wall finely arenaceous and smoothly finished. It was recorded in the Paleocene from USA (Cushman, 1948), Eocene from Turkey (Öztemür, 1959), Italy (Proto Decima and Bolli, 1982) and Egypt (Anan, 2017).

***Spiroplectinella praelonga* (Reuss, 1845) - Pl. 2, figure 29**

1845 *Textularia praelonga* Reuss, p. 39, pl. 12, figure 14.

1981 *Spiroplectammina praelonga* (Reuss) - Morgiel and Olszewska, p. 14, pl. 4, figure 5.

Remarks: This species has elongated test, rhomboidal in section, small planispiral initial stage then numerous and quadrate biserial chambers alternately arranged. It was recorded from Romania, Poland (Morgiel and Olszewska, 1981; Neagu, 1968).

***Spiroplectinella richardi* (Martin, 1943) - Pl. 2, figure 30**

1943 *Spiroplectammina richardi* Martin, p. 104, pl. 5, figure 3.

1951 *Spiroplectammina richardi* Martin - Israelsky, p. 13, pl. 4, figures 1-16.

Remarks: Test roughly triangular inside view and compressed laterally, peripheral margin sharply keeled with wide serrated flange, wall finely arenaceous with large amount of cement giving rough surface. It was recorded from USA (Israelsky, 1951) and Mexico (Miranda-Martinez and Carreño, 2008).

***Spiroplectinella rossae* (Plummer, 1933) - Pl. 2, figure 31**

1933 *Spiroplectammina rossae* Plummer, p. 66, pl. 5, figure 1-3.

1951 *Spiroplectammina rossae* Plummer - Cushman, p. 5, pl. 1, figure 15, 16.

Remarks: This Paleocene species has small elongate compressed test, biserial chambers sloping from the axis on each side at an angle of about 45° and gently curved downward along the outer edge, sutural limbations strongly elevated on each side of the center, aperture a rather high arch at the base of the septal face. It is an endemic to USA (Plummer, 1933, Cushman, 1951).

***Spiroplectinella semicomplanata* (Carsey, 1926) - Pl. 2, figure 32**

1926 *Textularia semicomplanata* Carsey, p. 25, pl. 3, figure 4.

1972 *Spiroplectammina semicomplanata* Carsey - Hanzlíková, p. 48, pl. 10, figures 2-4.

Remarks: This species differs from *S. chicoana* in being thicker more rapidly tapering and in having a more even periphery. It was recorded from USA, Czech and Italy (Hanzlíková, 1972; Beckmann, 1982).

***Spiroplectinella sigmoidina* (Lalicker, 1935) - Pl. 2, figure 33**

1935 *Spiroplectammina sigmoidina* Lalicker, p. 7, pl. 1, figures 10, 11.

1968 *Spiroplectammina sigmoidina* Lalicker - Sliter, p. 46, pl. 2, figure 12.

Remarks: Sliter (1968) noted that this species differs from *S. chicoana* by its narrower test, more regular periphery and smoother surface. It was recorded, so far, from USA (Lalicker, 1935) and Mexico (Sliter, 1968).

***Spiroplectinella subhaeringensis* (Grzybowski, 1896) - Pl. 2, figure 34**

1896 *Textularia subhaeringensis* Grzybowski, p. 285, pl. 9, figures 13, 16.

2005 *Spiroplectammina subhaeringensis* (Grzybowski) - Sztrákó, p. 184, pl. 2, figure 1.

Remarks: This species has equal length and width test, very small planispiral initial portion comprising 3-4 chambers, late portion is biserial and consists of 4-5 pairs of chambers, increasing very rapidly in size, periphery is subacute, with a very narrow keel, wall is finely agglutinated, aperture is interiomarginal fissure. The species was recorded from the Eocene of Poland (Grzybowski, 1896; Bubík, 1995), Central America (Tjalsma and Lohmann, 1983), France (Sztrákó, 2005), Hungary (Ozsvárt, 2007), Paleocene of UAE (Anan, 2015) and lower Oligocene of Bulgaria (Darakchieva et al., 2019).

***Spiroplectinella wilcoxensis* (Cushman and Ponton, 1932) - Pl. 2, figure 35**

1932 *Spiroplectammina wilcoxensis* Cushman and Ponton, p. 51, pi. 7, figure 1.

1951 *Spiroplectammina wilcoxensis* Cushman and Ponton - Cushman, p. 6, pl. 1, figures 21-23.

Remarks: Test broad, periphery subacute, chambers low and broad in the early portion, gradually and rather regularly increasing in height as added, later ones slightly inflated; sutures slightly depressed especially in the later portion, gently curved, wall arenaceous but rather smoothly finished, aperture a low curved opening at the base of the apertural face. It was recorded from USA and Poland (Cushman, 1951; Pozaryska, 1965).

***Spiroplectinella wrightii* (Silvestri, 1903) - Pl. 2, fig. 36**

1903 *Spiroplecta wrightii* Silvestri, p. 59, figures 1-6.

1972 *Spiroplectinella wrightii* (Silvestri) - Kisel'man, p. 135, figure 1.

1988 *Spiroplectinella wrightii* (Silvestri) - Loeblich and Tappan, p. 112, pl. 120, figures 1-16.

2014 *Spiroplectinella wrightii* (Silvestri) - Spezzaferri et al., p. 55, pl. 3, figure 6.

Remarks: This Paleocene-Holocene species has early planispiral coil followed by biserial chambers increases rapidly in breadth, lozenge shaped in section with faint marginal keel, wall coarsely agglutinated. It was recorded from Romania, Russia and Norway (Silvestri, 1903; Kisel'man, 1972; Spezzaferri et al., 2014).

3. PALEOGEOGRAPHY

The paleogeographic maps (partly or regionally) of some authors, i. e. a group researcher show the Tethyan realm had been connected with the Indo-Pacific Ocean from the east and Atlantic Ocean to the west via Mediterranean Sea crossing the Middle East region during the Maastrichtian-Paleogene time (Mintz, 1981; Rosenbaum et al., 2002). Haq and Aubry noted that the North Africa and Middle East formed important parts of the Tethyan link between the Atlantic and Pacific Oceans during Paleogene (Haq and Aubry, 1978). Anan concluded that the Tethyan realm during the Middle-Late Eocene extends to the southeast and connected with the Indo-Pacific realm via seaway separating Arabia from Iran-India region (Anan, 1995). Haynes and Nwabufor-Ene suggested wider Tethyan connections, as far as the Carpathian and Pakistan (Haynes and Nwabufor-Ene, 1998). Rögl noted that the end of the Eocene the Tethys Ocean had already vanished, a new Indian Ocean was born, and the western end of the Tethys was reduced to a Mediterranean Sea (Rögl, 1999). Europe was still an archipelago and intercontinental seas covered large areas of the European platform and of western Asia. Most of the recorded agglutinated species of the genus *Spiroplectinella* were erected from USA (15/33, about 45%), 12 from Egypt (about 36%), 8 from Poland (about 24%), 6 from France and also UAE (about 18%), 5 from Czech and Bulgaria (about 15%), 4 species for each of Mexico, Caribbean and Italy (about 12%). The number differences of the recorded species between the different localities in the Tethys may be due to one or more parameters: the deficiency of available literatures, differences in ecological or environmental conditions (depth, salinity, water temperature, dissolved oxygen, nutrient, land barrier) and not homogeneity in the generic or species concept according to different authors.

4. PALEOECOLOGY AND PALEOENVIRONMENT

Van der Zwaan indicates that *Spiroplectinella carinata* has no tolerance for variations in oxygen content and salinity, and it is present in outer shelf (70-100) meter sediments and prefers muddy substrate (Barbin and Keller-Gninig, 1991) (Van der Zwaan, 1982). These authors consider the carinate species of *Spiroplectammina* as deepest waters indicators with respect to the non-carinate ones. A group researchers infer those certain hydrographic properties (low oxygen, high CO₂, low pH, and thus more corrosive waters) favor the development of agglutinated assemblages (Miller et al., 1982). They also reported that the "Flysch-type Assemblage, FTA" (as described by Gradstein and Berggren, 1981) result from the exclusion of calcareous benthic foraminifera below a local CCD (Calcareous Compensation Depth). The local tectonic and sedimentological vents may have been important in the replacement of agglutinated assemblages in the Canadian margin and the North Sea. Corliss postulated that the mode of life of a taxon can be deduced from the morphology of its test and the endobenthic species (e.g. *Spiroplectammina*, *Spiroplectinella*) live under the water/sediment interface and they burrow through the sediments, where they can tolerate less oxygenated conditions (Corliss, 1985). Jones noted that the FTA represents upper slope depth (500 m), middle slope (500-1000 m) and basin floor (1000-1500 m) in the Viking Graben in the North Sea (Jones, 1988). Loeblich and Tappan noted that *S. dentata* (Alth) had a coarse-grained wall texture, agglutinated skeletal fragments and quartz grains ranging from 2-60 µm

(Loeblich and Tappan, 1989). Kuhnt and Kaminski considered some calcareous agglutinated species (e.g. *Spiroplectamina*, *Spiroplectinella*) are dominated by epifaunal detritus-feeders (Kuhnt and Kaminski, 1993). A strong increase of this genus is observed in the early upper portion of the K/T boundary clay of the Basque Basin in Northern Spain. Bubík also considered some genera (e.g. *Spiroplectamina*, *Spiroplectinella*) belong to those of calcareous agglutinated foraminifers with cement (Bubík, 1995). Orabi noted that the species of the genus *Spiroplectinella* belong to the calcareous agglutinated group which composed of calcareous grains with different sizes and cemented by calcareous material (Orabi, 1995).

Miranda-Martinez and Carreño noted that *S. richardi* has upper depth limits in the outer shelf biofacies, the continental slope environment at an upper bathyal water depth of 500 m of the Early Eocene rocks, Tepetate Formation of Mexico (Miranda-Martinez and Carreño, 2008). A group researchers noted that the calcareous agglutinated foraminiferal genus *Spiroplectinella* is interpreted as of shelf environment (Hewaidy et al., 2014). A group researchers considered some agglutinated genera (e.g. *Spiroplectamina*, *Spiroplectinella*) belongs to characteristics bathyal-abysal environment, high terrigenous sedimentation rate and associated organic flux (Bejaoui et al., 2019).

Table 1: The Distribution of The Benthic Foraminiferal Species of The Genus *Spiroplectinella* in and Some Tethyan Localities. 1: USA, 2: Mexico, 3: Caribbean, 4: South America, 5: Spain, 6: France, 7: Poland, 8: Germany, 9: Italy, 10: Czech, 11: Hungary, 12: Slovenia, 13: Croatia, 14: Romania, 15: Bulgaria, 16: Turkey, 17: Tunisia, 18: Egypt, 19: Iraq, 20: Jordan, 21: UAE, 22: Iran, 23: Pakistan (Θ=Illustrated Species, X=Recorded Species).

Sp. no	Benthic Foraminiferal Species of The Genus <i>Spiroplectinella</i>	Tethyan Localities																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	<i>Adamsi</i>	x			x															x		Θ		
2	<i>Baudouiniana</i>						x	Θ																
3	<i>Carinata</i>					x	x	x							Θ				x			x	x	
4	<i>Chicoana</i>	x	x	Θ			x	x																
5	<i>Costata</i>							Θ			x													
6	<i>Cretosa</i>										Θ													
7	<i>Dalmatina</i>									x					Θ									
8	<i>Dentata</i>	x		Θ			x	x		x	x							x	x				x	
9	<i>Deperdita</i>						x					x				Θ								
10	<i>Desertorum</i>																		Θ					
11	<i>Elongata</i>	x																						Θ
12	<i>Esnaensis</i>						x											x	Θ				x	
13	<i>Excolata</i>	x		Θ						x					x									
14	<i>Hamdani</i>																		x			Θ		
15	<i>Henryi</i>																		Θ					
16	<i>Israelski</i>	x				x				Θ														
17	<i>Jarvisi</i>	x		Θ	x																			
18	<i>Knebeli</i>																	x	Θ		x	x		
19	<i>Laevis</i>	x	x			x			x		x								Θ	x				
20	<i>Longa</i>																		Θ					
21	<i>Nuttalli</i>				x															x		Θ		
22	<i>Paleocenica</i>	Θ																						
23	<i>Paracarinata</i>																		Θ			x		
24	<i>Pectinatiforma</i>															Θ								
25	<i>Plummerae</i>	Θ								x							x							
26	<i>Praelonga</i>							Θ	x						x									
27	<i>Richardi</i>	Θ	x																					
28	<i>Rossae</i>	Θ																						
29	<i>Semicomplanata</i>	x								x	Θ													
30	<i>Sigmoidina</i>	x	Θ																					
31	<i>Subhaeringensis</i>						Θ	x				x				x								
32	<i>Wilcoxensis</i>	Θ						x																
33	<i>Wrightii</i>															Θ								

5. CONCLUSIONS

The analysis of paleontology, stratigraphy and paleogeographic remarks are presented for 33 diagnostic agglutinated foraminiferal species of the genus *Spiroplectinella* described from the Late Cretaceous-Early Paleogene rocks from many localities of the Tethys. The paleogeography distribution of these taxa from different Tethyan localities are from Atlantic to Pacific via Mediterranean and Indian Ocean: in North America (USA, Mexico), Central America (Caribbean), South Atlantic (Brazil, Argentina, Chile Venezuela, Ecuador), Europe (North Sea, Norway, Spain, France, Poland, Netherland, Austria, Italy, Czech, Hungary, Croatia, Slovenia, Romania, Bulgaria, Moravia, Russia, Ukraine, Turkmenistan), North Africa (Tunisia, Libya, Egypt), Southwest Asia (Turkey, Iraq, Jordan,

UAE, Iran), and Indian Ocean (Pakistan, Australia-Antarctic Basin). The high diversity of the identified species is recorded from USA followed by North Africa (Egypt), Europe (Poland and France) and southwest Asia (UAE). Some species has wide geographic distribution, which have 5 or more localities like: *Spiroplectinella dentata* (9 localities), *S. laevis* (8 localities), *S. carinata* (7), *S. chicoana* (5); but 4 localities for other some species: *S. esnaensis*, *S. excolata*, *S. knebeli*, *S. subhaeringensis*, while the other species were existed in three or two localities, or an endemic to the original locality. 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..).

ACKNOWLEDGMENTS

The author is greatly indebted to the editor and other colleagues in the GBR. I am indebted to my daughter Dr. Huda Anan for the development of the figures and plates.

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