

RESEARCH ARTICLE

NEW MODERN BENTHIC SHELF FORAMINIFERA OF THE MEDITERRANEAN SEA

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ABSTRACT

This study has focused on the distribution and systematic paleontology are presented with more emphasis on their modern nomenclatural aspects and ecology of 27 new Recent foraminiferal species, belonging to 22 genera, were identified from three marine bodies in western, central and eastern Mediterranean Sea. 17 species of them (~63%) are recorded from Western Mediterranean Sea (WMS), 7 species (~26%) from Central Mediterranean Sea (CMS), while only 3 species (~11%) from Eastern Mediterranean Sea (EMS). Eight species of them are belonging to the Suborder Textulariina, 6 to Miliolina, 2 to Lagenina and 11 species to Rotaliina. These new species are: *Turritellera cimerni*, *Reophax langeri*, *Haplophragmoides mediterraneus*, *Spiroplectinella milkeri*, *Sahulia saidi*, *Textularia kaminskii*, *T. mediterraneus*, *T. schmiedli*, *Spirophthalmidium milkeri*, *Spiroloculina schmiedli*, *Siphonaperta mallorcaensis*, *Lachlanella alboranensis*, *Affinetrina alboranensis*, *A. alboranica*, *Tollmannia aegeana*, *Globulina alboranica*, *Siphovigerina oranica*, *Uvigerinatella mediterranea*, *Trimosina mallorcaensis*, *Sigmavirgulina oranica*, *Mississippina alboranensis*, *M. alboranensis*, *Rosalina mallorcaensis*, *Discorbinoidea oranica*, *D. alboranensis*, *Falsocibicides levantina* and *Elphidium alboranica*.

KEYWORDS

Recent foraminifera, Mediterranean Sea

1. INTRODUCTION

Many authors (i.e., Cimerman & Langer, 1991; Abu-Zied et al, 2008; Milker

& Schmiedl, 2012) had been engaged in the paleontology and paleoenvironmental investigations of littoral benthic foraminiferal species of west, central and eastern Mediterranean Sea (Figure 1).



Figure 1. Location map of different localities in the studied coasts of western, central and eastern Mediterranean Sea (after: Cimerman & Langer, 1991; Abu-Zied et al, 2008; Milker & Schmiedl, 2012, with some modifications).

2. MATERIAL OF STUDY

Geographic distribution of twenty seven well preserved of agglutinated, porcelaneous and hyaline benthic foraminiferal species are recorded and illustrated from three main localities along the Mediterranean Sea, which are treated here with modern taxonomical consideration.

3. SYSTEMATIC PALEONTOLOGY

The taxonomy of Loeblich & Tappan (1988) is followed here for the new twenty seven Recent benthic foraminiferal species, which belonging to 22 genera. The recorded species are illustrated in Plate 1.

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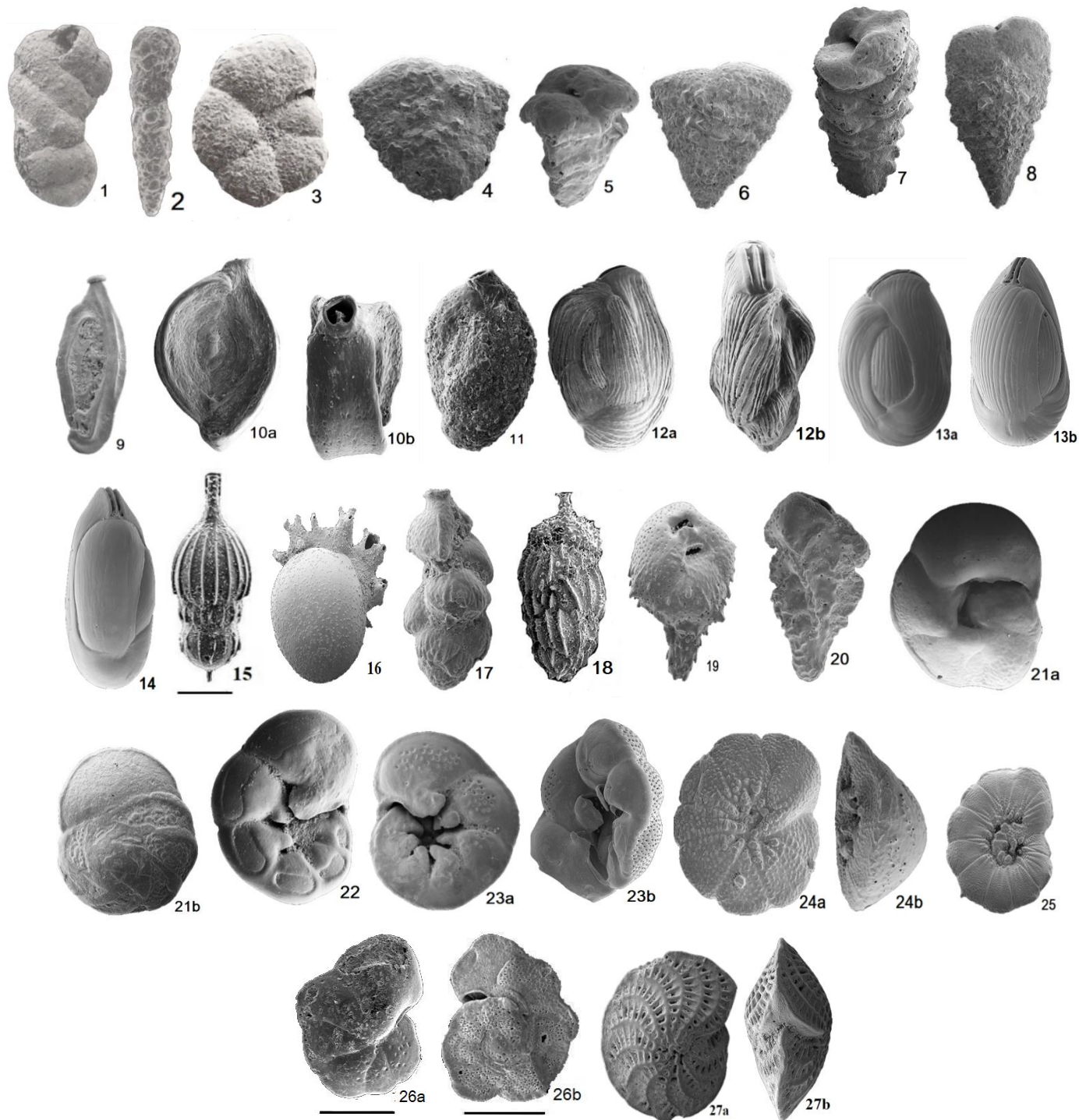
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Plate 1

(Scale bars are 100 µm, a. side or ventral view, b. apertural view)

Fig. 1. *Turritellella cimermanni*, 2. *Reophax langeri*, 3. *Haplophragmoides mediterraneensis*, 4. *Spiroplectinella milkeri*, 5. *Sahulia saidi*, 6. *Textularia kaminskii*, 7. *T. mediterraneensis*, 8. *T. schmiedli*, 9. *Spirophthalmidium milkeri*, 10. *Spiroloculina schmiedli*, 11. *Siphonaperta mallorcaensis*, 12.

Lachlanella alboranensis, 13. *Affinetrina alboranensis*, 14. *A. alboranica*, 15. *Tollmannia aegeana*, 16. *Globulina alboranica*, 17. *Siphovigerina oranica*, 18. *Uvigerinatella mediterranea*, 19. *Trimosina mallorcaensis*, 20. *Sigmavirgulina oranica*, 21. *Mississippina alboranensis*, 22. *M. alboranensis*, 23. *Rosalina mallorcaensis*, 24. *Discorbinooides oranica*, 25. *D. alboranica*, 26. *Falsocibicides levantina*, 27. *Elphidium alboranica*.



Order: Foraminiferida Eichwald, 1830

I. Suborder Textulariina Delage & Hérouard, 1896

1. *Turritellella cimermanni* Anan, n. sp. (= *Turritellella* sp. 1 - Cimerman & Langer, 1991, p.17, pl. 3, fig.10).

Etymology: after Mag. Franc Cimerman, Paleontological Institut Ivana Rakovca, Yugoslavia.

Diagnosis: It is a species of the genus *Turritellella* with elongate finely agglutinated high-spired coiled tubular test, an irregular coiled tubular second chamber followed the proloculus, aperture at the open end of the tube.

Remarks: It is distinguished by an irregular coiled tubular second chamber

followed the proloculus.

2. *Reophax langeri* Anan, n. sp. (= *Reophax* sp. 1 - Cimerman & Langer, 1991, p. 18, pl. 4, fig. 5).

Etymology: after Dr. Martin R. Langer, Geologisch-Palaontologisches Institut der Universität Basel, Switzerland.

Diagnosis: It is a species of the genus *Reophax* with elongate coarsely agglutinated grained test, 8 elliptical chambers gradually increasing in size as added, aperture terminal.

Remarks: It is distinguished by its coarsely agglutinated wall with 8 chambers gradually increasing in size as added.

3. *Haplophragmoides mediterraneus* Anan, n. sp. (= *Haplophragmoides* sp. 1 - Cimerman & Langer, 1991, p. 18, pl. 4, fig. 10).

Etymology: after the Mediterranean Sea.

Diagnosis: It is a species of the genus *Haplophragmoides* with semicircular involute planispiral finely agglutinated test, 5 chambers gradually increasing in size as added, rounded periphery, radial depressed sutures, and low arched aperture at the base of the apertural face.

Remarks: It is characterized by its 5 chambers with finely agglutinated involute planispiral test.

4. *Spiroplectinella milkeri* Anan, n. sp. (= *Spiroplectinella* sp. 1 - Milker & Schmiedl, 2012, p. 34, fig. 9. 22). Etymology: after Yvonne Milker, Geological-Paleontological Institute and Museum (GPI u. M.), University of Hamburg, Germany.

Diagnosis: It is a species of the genus *Spiroplectinella* with coarsely agglutinated subtriangular test, planispiral initial stage followed by biserially arranged chambers laterally compressed and increasing in size as added, acute periphery, depressed sutures, and low arched aperture at the base of the apertural face.

Remarks: It further differs from *S. sagittula* (Defrance) due to the lower number of chambers, more shorter in length, and more wider biserial stage.

5. *Sahulia saidi* Anan, n. sp. (= *Sahulia* cf. *kerimbaensis* (Said) - Milker & Schmiedl, 2012, p. 38, fig. 10. 13, 14).

Etymology: after Prof. Rushdi Said, late Chairman of the Egyptian Geological Survey.

Diagnosis: It is a species of the genus *Sahulia* with coarsely agglutinated subtriangular test, biserial throughout and forming a low cone with wit a subacute peripheral margin, chambers increasing in size as added and are broad and low, sutures depressed straight, aperture basal and bordered by a lip.

Remarks: This species differs from *S. kerimbaensis* (Said) due to less biserially chamber's number, less angular periphery, and more regular straight sutures.

6. *Textularia kaminskii* Anan, n. sp. (= *Textularia* sp. Kaminski et al., 2002, p. 171, pl. 1, fig. 7; *Spiroplectinella* sp. 2 - Milker & Schmiedl, 2012, p. 34, fig. 9. 23, non fig. 9.24).

Etymology: after Prof. Michel Kaminski, King Fahd University of Petroleum and Minerals, Saudi Arabia (SA).

Diagnosis: It is a species of the genus *Textularia* with coarsely agglutinated regular triangular test, chambers are biserially arranged, and rapidly increasing in size as added, acute periphery, depressed sutures, low arch basal aperture at the base of the apertural face.

Remarks: This species is characterized by regular triangular test with only biserially arranged chambers, without an initial planispiral early stage.

7. *Textularia mediterraneus* Anan, n. sp. (= *Textularia pseudorugosa* Lacroix - Milker & Schmiedl, 2012, p. 40, fig. 10. 23, non 24).

Etymology: after the Mediterranean Sea.

Diagnosis: It is a species of the genus *Textularia* with finely agglutinated elongate test, chambers are biserially arranged, and gradually increasing in size as added, subacute periphery, depressed sutures, low slit basal aperture at the base of the apertural face.

Remarks: This species differs from *Textularia pseudorugosa* by its elongate subacute test with complete developed apertural lip, than wedge-shaped subrhomboidal test with weakly developed apertural lip.

8. *Textularia schmiedli* Anan, n. sp. (= *Spiroplectinella* sp. 2 - Milker & Schmiedl, 2012, p. 34, fig. 9. 24).

Etymology: after Gerhard Schmiedl, Geological-Paleontological Institute and Museum (GPI u. M.), University of Hamburg, Germany.

Diagnosis: It is a species of the genus *Textularia* with coarsely agglutinated elongate triangular test (length/width 2/1), chambers are biserially arranged, and rapidly increasing in size as added, subrounded periphery, depressed sutures, low arch basal aperture at the base of the apertural face.

Remarks: This species differs from *T. kaminskii* by elongate triangulat test and more rounded periphery, than regular triangular test and acute

periphery of the latter.

II. Suborder Miliolina Delage & Hérouard, 1896

9. *Spirophthalmidium milkeri* Anan, n. sp. (= *Spirophthalmidium* sp. 1 - Milker & Schmiedl, 2012, p. 47, fig. 12.12).

Etymology: after Yvonne Milker, Geological-Paleontological Institute and Museum (GPI u. M.), University of Hamburg, Germany.

Diagnosis: It is a species of the genus *Spirophthalmidium* with fusiform porcelaneous flattened test, two chambers per whorl followed the proloculus, carinate periphery, terminal aperture on a long neck bordered by a distinct rim.

Remarks: This species is distinguished by elongate fusiform test, and terminal ovate aperture with long neck bordered by a distinct rim.

10. *Spiroloculina schmiedli* Anan, n. sp. (= *Spiroloculina* sp. 3 - Milker & Schmiedl, 2012, p. 49, fig. 13.12-13).

Etymology: after Gerhard Schmiedl, Geological-Paleontological Institute and Museum (GPI u. M.), University of Hamburg, Germany.

Diagnosis: It is a species of the genus *Spiroloculina* with fusiform bicocave porcelaneous test, acute periphery, rounded aperture with short bifid tooth.

Remarks: This species is characterized by bicocave porcelaneous test.

11. *Siphonaperta mallorcaensis* Anan, n. sp. (= *Siphonaperta* sp. 2 - Milker & Schmiedl, 2012, p. 52, fig. 14.1-4).

Etymology: after Mallorca shelf, West Mediterranean Sea.

Diagnosis: It is a species of the genus *Siphonaperta* with fusiform porcelaneous test, which coating with fine-grained fine-grained agglutinated material, rounded terminal aperture on a short neck with a short bifid tooth

Remarks: This species is distinguished by coating fine-grained agglutinated test, with short bifid tooth in terminal short neck aperture.

12. *Lachlanella alboranensis* Anan, n. sp. (= *Lachlanella* sp. 1 - Milker & Schmiedl, 2012, p. 56, fig. 14.27, 28).

Etymology: after Alboran Platform, West Mediterranean Sea.

Diagnosis: It is a species of the genus *Lachlanella* with ovate porcelaneous test, ornamented by longitudinal costae, elongate aperture with long simple tooth.

Remarks: This species is characterized by costate ornamentated ovate test, elongate aperture with long simple tooth.

13. *Affinetrina alboranensis* Anan, n. sp. (= *Affinetrina* sp. 1 - Milker & Schmiedl, 2012, p. 56, fig. 16.14, 15).

Etymology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Affinetrina* with subovate porcelaneous ornamented test by longitudinal costae, three visible chambers arranged in triloculine, rounded periphery, elongate aperture with long simple tooth.

Remarks: This species is characterized by costate ornamentated subovate test, elongate aperture with long simple tooth.

14. *Affinetrina alboranica* Anan, n. sp. (= *Affinetrina* sp. 2 - Milker & Schmiedl, 2012, p. 56, fig. 16.14, 16-18).

Etymology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is another species of the genus *Affinetrina* with subovate porcelaneous smooth test with three visible chambers, rounded periphery, elongate aperture with long simple tooth.

Remarks: This species differs from *A. alboranensis* by its smooth surface.

III. Suborder Lagenina Delage & Hérouard, 1896

15. *Tollmannia aegeanea* Anan, n. sp. (= *Amphicoryna scalaris* (Batsch) - Abu-Zied et al., 2008, p. 51, pl. 1, fig. 22).

Etymology: after Aegean Sea, Eastern Mediterranean Sea.

Stratigraphic level: Core SLA-9 (Aegean Sea, 260 m depth), LGM to Recent times (Figs. 1, 2)

Diagnosis: Test has elongate three chambers increase rapidly in breadth as added with apiculate base, final chamber comprising half the length of

the test, sutures depressed, surface with longitudinal ribs, and aperture terminal with pronounced long neck.

Remarks: This new species differs from the Miocene *T. haidari* Anan (2024) by three than two chambers, and from *T. omari* Anan (2024) by its equal width/long than more long/width of last third chamber, and longer elevated neck.

16. *Globulina alboranica* Anan, n. sp. (= *Globulina gibba* d'Orbigny var. *punctata* d'Orbigny - Milker & Schmiedl, 2012, p. 56, fig. 18.36).

Etiology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Globulina* with ovoid hyaline test, ornamented surface with pustules, terminal radiate aperture and covered by a fistulose overgrowth.

Remarks: This species is characterized by terminal radiate aperture and covered by a fistulose overgrowth.

IV. Suborder Rotaliina Delage & Hérouard, 1896

17. *Siphovigerina oranica* Anan, n. sp. (= *Siphovigerina* sp. 1 - Cimerman & Langer, 1991, p. 64, pl. 66, figs. 1, 2; *Siphovigerina?* sp. 1 - Milker & Schmiedl, 2012, p. 89, fig. 20.27).

Etiology: after Oran Bight shelf, Algeria, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Siphovigerina* with elongate hyaline triserial-biserial arranged umbrella-like test, initial stage starts with tight triserial and followed by loosely triserially arranged, but ended with loosely biserially arranged, rounded periphery, surface ornamented with irregularly longitudinal ridges, terminal rounded aperture ended by a short neck and bordered by a lip.

Remarks: This species is characterized by tight triserial to loosely biserially arranged with rounded peripheral test, ornamented with irregularly longitudinal ridges, terminal aperture with neck.

18. *Uvigerinatella mediterranea* Anan, n. sp. (= *Uvigerina peregrina* Cushman - Abu-Zied et al., 2008, p. 52, pl. 2, fig. 20).

Diagnosis: It is a species of the genus *Uvigerinatella* with triserial elongate and stout test, about 2½ times as long as broad chambers inflated with ornamented lower part by longitudinal ribs, but papillose towards the latest chambers, sutures depressed, aperture terminal and produced on a spinose neck.

Remarks: The new species belong here to the Genus *Uvigerinatella* Anan (2024) due to its mixed ornamented test with non regular longitudinal ribs in the lower part, and papillose toward the latest part of the test.

19. *Trimosina mallorcaensis* Anan, n. sp. (= *Trimosina* sp.1 - Milker & Schmiedl, 2012, p. 92, fig. 21.8, 9).

Etiology: after Mallorca shelf, east of Spain, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Trimosina* with triserial hyaline test with pyramidal lateral view and subtriangular apertural view, chambers increasing in size as added with finely hispid with lateral ribs, slit-like primary aperture at the apertural face bordered by a narrow rim, while secondary aperture larger with arch-shaped opening.

Remarks: This species is characterized by two apertures primary and secondary at the apertural face, and ornamented by finely hispid with lateral ribs.

20. *Sigmavirgulina oranica* Anan, n. sp. (= *Sigmavirgulina* sp. 1; Cimerman & Langer, 1991, p. 64, pl. 67, figs. 3-7; *Sigmavirgulina* sp. 1 - Milker & Schmiedl, 2012, p. 93, fig. 21.13).

Etiology: after Oran Bight shelf, Algeria, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Sigmavirgulina* with V-shaped triangular elongate biserially coarsely perforated test, acutely angled periphery, depressed sutures, oval aperture bordered by a lip.

Remarks: This species is characterized by V-shaped triangular elongate biserially coarsely perforated test, and acutely angled periphery.

21. *Eponides alboranica* Anan, n. sp. (= *Eponides* sp.1 - Milker & Schmiedl, 2012, p. 95, fig. 21.22, 23).

Etiology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Eponides* with finely perforated calcareous subrounded plano-biconvex smooth test with peripheral keel, pustulate spiral side, backward curved and thickened raised sutures on

dorsal side, but oblique and depressed on umbilical side, interiomarginal-extraumbilical large arched slit aperture.

Remarks: This species is characterized by interiomarginal-extraumbilical large arched slit aperture.

22. *Mississippina alboranensis* Anan, n. sp. (= *Mississippina* sp. 1 - Milker & Schmiedl, 2012, p. 95, fig. 21.26-27).

Etiology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Mississippina* with subrounded finely perforated calcareous unequally biconvex subacute smooth test, six chambers are visible in the final whorl increasing in size as added, sutures are depressed and curved on both sides, umbilical-interiomarginal arch aperture and covered by large umbilical flap.

Remarks: This species is characterized by umbilical-interiomarginal arch aperture and covered by large umbilical flap.

23. *Rosalina mallorcaensis* Anan, n. sp. (= *Rosalina* sp. 1 - Milker & Schmiedl, 2012, p. 99, fig. 22.19-21).

Etiology: after Mallorca shelf, east of Spain, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Rosalina* with concave-convex trochospiral test, seven densely perforate and crescentic chambers rapidly increasing in size as added on the spiral side, sutures thickened backward curved on the spiral side but depressed and curved on the umbilical side, aperture interiomarginal-extraumbilical low arch with a distinct lip.

Remarks: This species is characterized by concave-convex trochospiral test with seven densely perforate crescentic chambers, and interiomarginal-extraumbilical low arch aperture with a distinct lip.

24. *Discorbinoides oranica* Anan, n. sp. (= *Discorbinoides* sp. 1 - Milker & Schmiedl, 2012, p. 100, fig. 23.7-9).

Etiology: after Oran Bight shelf, Algeria, west Mediterranean Sea.

Diagnosis: It is a species of the genus *Discorbinoides* with low conical trochospiral and nearly planoconvex test, depressed umbilical area with pustules, sutures depressed in ventral side but flush in dorsal side, aperture is a low interiomarginal-extraumbilical slit at the periphery.

Remarks: This species is distinguished by planoconvex test, and depressed umbilical area with pustules.

25. *Discorbinoides alboranica* Anan, n. sp. (= *Discorbinoides?* sp. 2 - Milker & Schmiedl, 2012, p. 101, fig. 23.10-11).

Etiology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is another species of the genus *Discorbinoides* with large umbilical area ornamented with pustules and granules and radial striae extending from the periphery to the umbilical region.

Remarks: This species differs from *D. oranica* by its larger and deeper umbilical area with pustules and granules.

26. *Falsocibicides levantinea* Anan, n. sp. (= *Cibicides lobatulus* (Walker & Jacob) - Abu-Zied et al., 2008, p. 53, pl. 3, figs. 1, 2).

Etiology: after Aegean Sea, Eastern Mediterranean Sea.

Diagnosis: Test large smooth trochospiral planoconvex, 7 chambers in the last whorl increasing rapidly in size as added, sutures radial slightly curved and depressed on both sides, peripheral lobulate, aperture a large elongated interiomarginal and extend somewhat onto the spiral side with faint lip.

Remarks: This species differs from the Miocene *F. chileana* Anan (2024) by less lobulate periphery, less chamber numbers in the whorl, and tighter umbilical area.

27. *Elphidium alboranica* Anan, n. sp. (= *Elphidium* sp. 4 - Cimerman & Langer, 1991, p. 80, pl. 91, figs. 5, 6; *Elphidium* sp. 1 - Milker & Schmiedl, 2012, p. 122, fig. 27. 25-26).

Etiology: after Alboran Platform, west Mediterranean Sea.

Diagnosis: It is another species of the genus *Elphidium* with involute planispiral test, 16 narrow numerous chambers are gradually increasing in size as added, lenticular acute periphery, backwards curved raised sutures, primary aperture consists of a row of interiomarginal opening.

Remarks: This species is distinguished by narrow numerous chambers, and backwards curved raised sutures.

4. GEOGRAPHY DISTRIBUTION

The geography of the many littoral coasts in the study area of the Mediterranean Sea (MS) is very interest which indicates an open marine environment between these localities due to more open active surface water (Fig. 2). The current activity not only transported taxa, but also brought in refractory organic matter to the seafloor, which were in turn affected by sedimentary and, ultimately, by climatic factors. Most of the recorded species are distributed not only in neighboring localities, but also far from it. According to the present study, the foraminiferal assemblage has more favorable environment in the WMS than other sites in the CMS and EMS which may due to more open active inflowing surface water from the Atlantic Ocean. Additional remarks are presented:

- Most recorded new species are endemic to the original erection.
- Some species are distributed along other geographic localities in the Mediterranean Sea: *Textularia kaminskii* and *Elphidium alboranica*.
- Most species (~63%) are recorded from WMS, followed by CMS (~26%), while only (~11%) from EMS.



Figure 2. Generalized surface circulation pattern in topographic units of the MS (after Cimerman & Langer, 1991).

5. ENVIRONMENT AND ECOLOGY

All the recorded littoral inner neritic continental shelf benthic foraminiferal species in this study have an excellent preservation of the tests, in spite that these different localities are distinguished by their own particular environmental conditions (Figure 3).

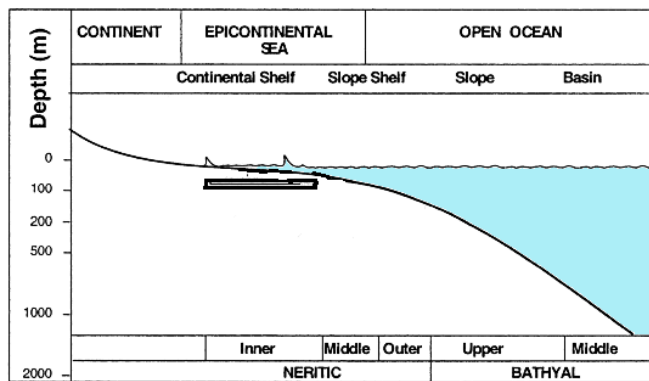


Figure 3. The environmental settings of shallow littoral (inner neritic) of recorded foraminiferal species in the MS.

Benthic foraminiferal distribution is controlled by a combination of food availability and oxygenation, the amount of organic flux to the sea floor mainly governs the occurrence of benthic species in the sediments. Due to their small size and abundance, they are the most widely used fossil organisms for environmental interpretation, as organisms whose living members provide ecological data and as composition of the wall shells that are an indicator of temperatures and other geographic features. Additional remarks can be presented:

1. The studied area represents a classical example of a mixed carbonate-silicate ramp system.
 - Agglutinated foraminifera tend to increase in cooler environment, which means that increase in shallow-water environments and also in deeper environment.
 - The favor precipitation of calcareous binding material for the porcelaneous tests that thriving in shallow and warm environment.
 - The high abundance of Rotaliid benthic foraminiferal assemblage indicate an open connection to the MS which supports the open flow direction of the surface current in all directions (see Figure. 2).

6. CONCLUSIONS

The present study deals with the recording of new twenty-seven Recent species from three main shelf marine localities in the western, central and eastern Mediterranean Sea. Most of these species are recorded from the western part of the sea. Eleven species of them are belonging to the Rotaliid taxa, eight to Textulariina, six to Miliolina, while only two to Lagenina.

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