

# Quaternary Brazilian equatorial margin benthic foraminifera

## Abstract

Fifty-three smaller benthic foraminiferal species belonging to thirty-three genera are recorded from Quaternary benthic foraminiferal species of Brazilian Equatorial Margin (Core ANP 1011). Twenty-two of the assemblage are illustrated and believed here as new: *Massilina braziliica* Anan, n. sp., *Quinqueloculina braziliica*, *Miliolinella braziliica*, *Pyrgo braziliensis*, *Pyrgo braziliica*, *Triloculina braziliica*, *Triloculinella braziliica*, *Nodosaria braziliica*, *Amphicoryna braziliica*, *Lagena braziliica*, *Pygmaeosestron braziliica*, *Lagenosolenia braziliica*, *Bolivina braziliica*, *Bolivinita braziliica*, *Cassidulina braziliica*, *Cassidulinoides braziliica*, *Globocassidulina braziliica*, *Globobulimina braziliica*, *Neouvigerina braziliica*, *Uvigerinita braziliensis*, *Valvulineria braziliica* and *Cibicidoides braziliica* Anan, n. sp. A comparative correlation between the south Equator of Brazilian and south Equator of Tanzanian taxa is presented.

**Keywords:** quaternary, holocene, benthic foraminifera, Brazil, Tanzania, equator, paleogeography, neritic, bathyal, environment, ecology.

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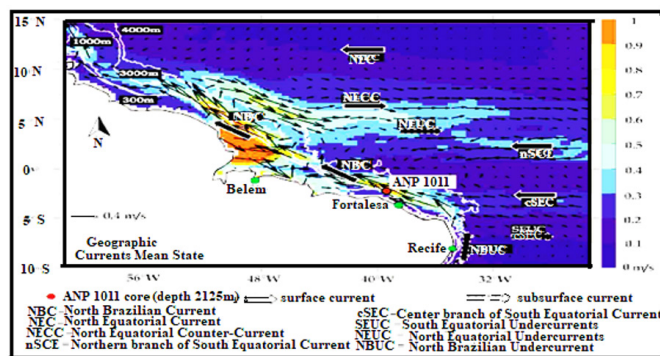
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## Introduction

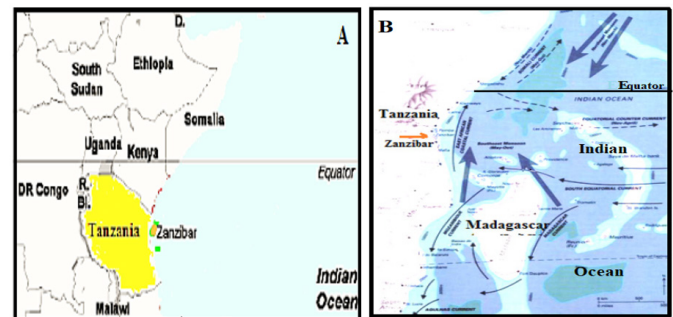
This study is based on the total one hundred and sixty-two benthic foraminiferal tests from Core ANP 1011 in the Ceará Basin, east Brazilian Equatorial Margin, South Atlantic Ocean (Figure 1). This fauna is compared with south Equator Zanzibar Archipelago of Tanzania, west Indian Ocean (Figure 2). Rich and well-preserved two hundred and twenty-two agglutinated and calcareous equatorial benthic foraminiferal species from these two localities: 53 species from Brazil (~33%), 109 species of Tanzania (~67%) made it possible to treat them with modern taxonomical consideration. Following the Code of Zoological Nomenclature, a taxonomic revision of Brazilian species is redescribed and treated here as new.



**Figure 1** Location map of the core ANP 1011 in the Ceará Basin showing the surface circulation in the Brazilian Equatorial Margin, the physiography of the study area, and current arrows are superimposed on their speed.<sup>1</sup>

## Material of study

One hundred and sixty-two well preserved of small benthic foraminiferal species belong to suborders Spirillinina, Miliolina, Lagena, and Rotaliina are recorded from two localities in the south Equator (Core ANP 1011 in the Ceará Basin, east Brazilian Equatorial Margin of South Atlantic Ocean, and south Equator Zanzibar Archipelago of Tanzania, west Indian Ocean), which are treated here with modern taxonomical consideration, and 22 Brazilian species of them are illustrated and considered here as a new.<sup>1,2</sup>



**Figure 2** A) Location map of Tanzania, south of Equator, B) the Western Indian Ocean current system and monsoon phases. The red arrow indicates the location of Zanzibar (after Thissen).<sup>2</sup>

## Systematic paleontology

The taxonomy of Loeblich & Tappan<sup>3</sup> is followed here for 162 Quaternary-Holocene benthic foraminiferal species, which belonging to 58 genera from two south Equator in Brazil (east South America) and Tanzania (east Africa). Fifty-three of them are recorded from core ANP 1011 in the Ceará Basin, east Brazilian Equatorial Margin of South Atlantic Ocean, and twenty-two of them are considered here as a new, and illustrated in Figure 3.<sup>4,5</sup>

## Order foraminiferida eichwald, 1830

### I. Suborder Miliolina Delage & Hérouard, 1896

1. *Massilina braziliica* Anan, n. sp. (= *Massilina* sp. – Noucoucok et al<sup>1</sup>, p. 4, Figure 3.2, LMA-00358).

Etymology: after the State of Brazil.

Diagnosis: Flattened smooth test, length/width, l/w (~2/1), elongated chambers, acute periphery, terminal aperture.

Remarks: It is distinguished by more length than width smooth test (l/w ~2/1), acute periphery, short apertural neck.

2. *Quinqueloculina brazilica* Anan, n. sp. (= *Quinqueloculina* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.10, LMA-00366)

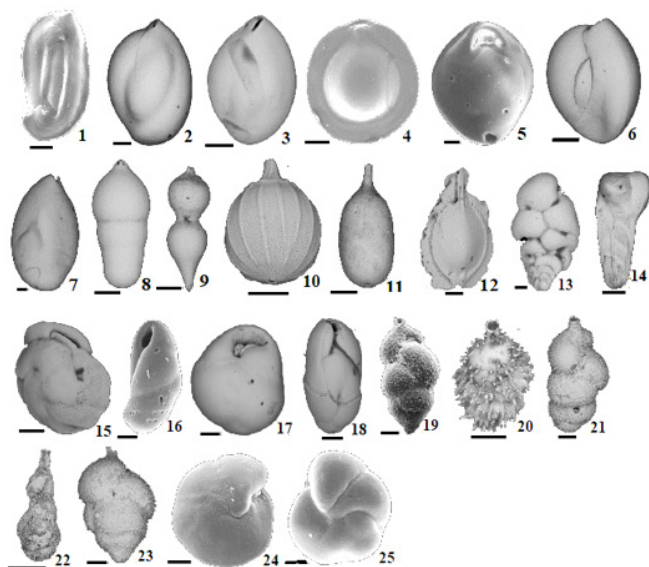


Plate I (Scale bar = 100 µm)

**Figure 3.1.** *Massilina brazilica* Anan, n. sp., 2. *Quinqueloculina brazilica*, 3. *Miliolinella brazilica*, 4. *Pyrgo brazilensis*, 5. *Pyrgo brazilica*, 6. *Triloculina brazilica*, 7. *Triloculinella brazilica*, 8. *Nodosaria brazilica*, 9. *Amphicoryna brazilica*, 10. *Lagena brazilica*, 11. *Pygmaeosestron brazilica*, 12. *Lagenosolenia brazilica*, 13. *Bolivina brazilica*, 14. *Bolivinita brazilica*, 15. *Cassidulina brazilica*, 16. *Cassidulinoides brazilica*, 17. *Globocassidulina brazilica*, 18. *Globobulimina brazilica*, 19. *Neouvigerina auberiana* (d'Orbigny<sup>4</sup>), 20. *Neouvigerina brazilica*, 21. *Neouvigerina hispida* (Schwager<sup>5</sup>), 22. *Neouvigerina proboscidea* (Schwager<sup>5</sup>), 23. *Uvigerinita brazilica*, 24. *Valvulinera brazilica*, 25. *Cibicidoides brazilica* Anan, n. sp.

Diagnosis: Ovate smooth test, middle third and fourth chambers are distinctly protruded, elongate aperture provided with simple tooth slightly produced distinguished by more length than width ( $l/w \sim 3/2.5$ ) ovoid smooth test, protruded middle third and fourth chambers.

Remarks: The two quinqueloculine species *Q. brazilica* and *Q. tanzanica* Anan<sup>6</sup> have protruded middle third and four chambers, but the Brazilian species differs from the Tanzanian species by rounded periphery and elongate aperture instead of acute periphery and circular aperture.

3. *Miliolinella brazilica* Anan, n. sp. (= *Miliolinella* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.3, LMA-00359).

Diagnosis: The genus *Miliolinella* Wiesner has chambers added alternately as in *Massilina* Schlumberger, but differs from it by have slightly more than two chambers in the final whorl. *Miliolinella brazilica* is distinguished by ovate smooth test ( $l/w \sim 3/2.5$ ), rounded periphery, an arch, terminal aperture on the final chamber, with high apertural flaplike tooth.

Remarks: The Brazilian species differs from the Tanzanian species *Miliolinella zanzibarensis* Anan<sup>6</sup> by more elongated test instead of circular test, more visible number of chambers, and higher apertural flaplike tooth.

4. *Pyrgo brazilensis* Anan, n. sp. (= *Pyrgo* aff. *P. depressa* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.7, LMA-00363).

Diagnosis: Ovate smooth test, circular in out line, the second large chamber includes the first visible globular smaller one, acute angular periphery, depressed suture, tight ovate aperture with short bifid tooth.

Remarks: It differs from *P. depressa* by tighter ovoid aperture.

5. *Pyrgo brazilica* Anan, n. sp. (= *Pyrgo* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.9, LMA-00365).

Diagnosis: Ovate smooth test, semi-circular in out line, rounded periphery, slightly depressed suture, crescentic aperture in the last whorl with broad bifid tooth.

Remarks: It is distinguished from the other species by crescentic aperture in the last whorl with broad bifid tooth.

6. *Triloculina brazilica* Anan, n. sp. (= *Triloculina* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.13, LMA-00369).

Diagnosis: Ovate smooth test, subtriangular in equilateral section, the first chamber visible between the last two chambers gradually added, rounded periphery, slightly depressed suture, large rounded terminal aperture of the final chamber.

Remarks: It differs from the Tanzanian *Triloculina ennagari* Anan<sup>7</sup> by smooth test than fine granulated porcelaneous wall, and larger opening aperture.

7. *Triloculinella brazilica* Anan, n. sp. (= *Triloculinella* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.14, LMA-00370).

Diagnosis: Elongate smooth subcircular outline test, three visible final chambers, rounded periphery, subcircular arch aperture at the end of the final chamber with broad apertural flap.

Remarks: The Brazilian species differs from the Tanzanian *Miliolinella tanzanica* Anan<sup>7</sup> by more elongated test than width, and smaller opening arch aperture.

## II. Suborder Lagenina Delage & Hérouard, 1896

8. *Nodosaria brazilica* Anan, n. sp. (= *Nodosaria* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.20, LMA-00376).

Diagnosis: Elongate smooth test, ovate proloculus followed by uniserial and rectilinear semi-globular chambers gradually added, rounded periphery, sutures slightly depressed, terminal radiate aperture produced on neck.

Remarks: The Brazilian species is distinguished by three uniserial chambers after the ovate proloculus. It differs from the type species *Nodosaria radricula* (Linne)<sup>8</sup> by less depressed sutures.

9. *Amphicoryna brazilica* Anan, n. sp. (= *Amphicoryna* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.21, LMA-00377).

Diagnosis: Elongate smooth test with apical base, early chambers in a compressed astacolone coil and later uniserial rectilinear globular chambers of circular transverse section, limbate depressed sutures, terminal radiate aperture at the end of a pronounced neck.

Remarks: It is characterized by smooth test with two rectilinear uniserial chambers after astacolone coil early chambers, and limbate depressed sutures.

10. *Lagena brazilica* Anan, n. sp. (= *Lagena* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.17, LMA-00373).

Diagnosis: Test unilocular globular, surface with 14-16 longitudinal ribs, terminal rounded aperture with neck.

Remarks: The Brazilian species differs from the Tanzanian *Lagena chileana* Anan<sup>9</sup> by lesser number of the longitudinal ornamented ribs (16 than 22), longer apertural neck, and without collar around base of apertural neck.

**11. *Pygmaeoseistrion brazilica* Anan, n. sp.** (= *Lagena hispidula* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.16, LMA-00372).

Diagnosis: This species is related here to the genus *Pygmaeoseistrion* Patterson & Richardson<sup>10</sup> due to smooth to finely hispid surface without costae. It has unilocular ellipsoid elongated test, and narrow elongated neck.

Remarks: This Brazilian species has closely morphological features with Miocene Chilean *Pygmaeoseistrion parvuliporum* of Finger<sup>11</sup>, but differs from the it in lacking hispid chamber and neck.

**12. *Lagenosolenia brazilica* Anan, n. sp.** (= *Lagenosolenia* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.19, LMA-00375).

Diagnosis: Flask like elongate smooth test, carinate periphery, oval aperture produced on long neck.

Remarks: The Brazilian species differs from the type species *Lagenosolenia soulei* McCulloch<sup>12</sup> by carinate periphery.

### III. Suborder Rotaliina Delage & Hérouard, 1896

**13. *Bolivina brazilica* Anan, n. sp.** (= *Bolivina britannica* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.24, LMA-00380).

Diagnosis: Biserial smooth test, crescentic early chambers and inflated later chambers with occasional pores, rounded periphery, depressed sutures, basal aperture.

Remarks: The Brazilian species differs from *Bolivina britannica* Macfadyen<sup>13</sup> by crescentic early chambers, and more inflated later chambers with occasional pores.

**14. *Bolivinita brazilica* Anan, n. sp.** (= *Bolivinita* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.26, LMA-00382).

Diagnosis: Biserial elongate coniform smooth test, subparallel margins, triangular in cross section, acute periphery, oblique slightly depressed sutures, elliptical aperture extending up the apertural face with a rim bordering the opening.

Remarks: The Brazilian species is distinguished by triangular in cross section, extending up elliptical aperture to apertural face, and without apiculate proloculus.

**15. *Cassidulina brazilica* Anan, n. sp.** (= *Cassidulina* sp. - Noucoucouk et al<sup>1</sup>, p. 5, Figure 3.1, LMA-00390).

Diagnosis: Ovoid smooth test with umbonal boss, subangular periphery, biserial chambers arranged planispirally enrolled, slightly depressed sutures, narrow long arched slit aperture at the base of apertural face parallel to the peripheral margin.

Remarks: The Brazilian species differs from the type species of the genus *Cassidulina laevigata* d'Orbigny by less regular lenticular test and added chambers.

**16. *Cassidulinoides brazilica* Anan, n. sp.** (= *Cassidulinoides* sp. - Noucoucouk et al<sup>1</sup>, p. 5, Figure 3.2, LMA-00391).

Diagnosis: Elongate smooth test, rounded periphery, biserial arranged chambers overlapped onto the opposite side at the periphery, slightly depressed sutures, subterminal aperture with large loop shape.

Remarks: The Brazilian species has closed relationship with Miocene *Cassidulinoides californiensis* Bramlette<sup>14</sup>, but differs by smaller test size, and more elongated aperture than semi-rounded shape.

**17. *Globocassidulina brazilica* Anan, n. sp.** (= *Globocassidulina* sp. - Noucoucouk et al<sup>1</sup>, p. 5, Figure 3.4, LMA-00393).

Diagnosis: Semi-globular smooth test, subcircular outline in side view, rounded periphery, biserial arranged enrolled chambers, slightly depressed oblique sutures, large oval curved aperture extending up the apertural face.

Remarks: The Brazilian species resembles the Miocene Chilean species *Globocassidulina subglobosa* (Brady)<sup>15</sup>, but differs by more lobulate test, and larger oval aperture.

**18. *Globobulimina brazilica* Anan, n. sp.** (= *Globobulimina* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.28, LMA-00384).

Diagnosis: Elongate smooth test, more length than width (l/w ~2/1), ovate in outline, circular in section, triserial arrangement but the last whorl covers nearly all of the previous chambers, slightly depressed oblique sutures, elongate loop shaped aperture.

Remarks: The Brazilian species differs from *Globobulimina affinis* (d'Orbigny)<sup>16</sup> by narrower width, and larger elongated loop shaped aperture.

**19. *Neouvigerina auberiana* (d'Orbigny)<sup>16</sup>** (= *Uvigerina auberiana* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.29, LMA-00385).

Remarks: This species belongs here to the genus *Neouvigerina* Thalmann<sup>17</sup> due to its triserial early stage becoming irregular uniserial in the late stage, terminal rounded aperture on elongated neck, and finally hispid ornamented surface. It was recorded also in Recent coasts of Cuba, Jamaica, and Chile of Finger.<sup>11</sup>

**20. *Neouvigerina brazilica* Anan, n. sp.** (= *Uvigerina peregrina* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.30, LMA-00386).

Diagnosis: This species belongs here to genus *Neouvigerina* Thalmann<sup>17</sup> due to its triserial early stage becoming irregular uniserial in the late stage, terminal rounded aperture on elongated neck, and coarsely hispid ornamented surface.

Remarks: This species differs from the other species of *Neouvigerina* in its coarsely spinose ornamented surface. It differs from *Uvigerina peregrina* Cushman<sup>18</sup> in coarsely spinose surface than longitudinal ribs along the chambers.

**21. *Neouvigerina hispida* (Schwager)<sup>5</sup>** (= *Uvigerina* cf. *U. hispida* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.32, LMA-00388).

Remarks: It belongs here to genus *Neouvigerina* Thalmann.<sup>17</sup> It differs from *N. auberiana* in rounded early triserial stage.

**22. *Neouvigerina proboscidea* (Schwager)<sup>5</sup>** (= *Uvigerina proboscidea* - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.31, LMA-00387).

Remarks: This species belongs here to the genus *Neouvigerina* Thalmann.<sup>17</sup> It differs from the other previously noted (*N. auberiana* and *N. hispida*) in its looser coiling early triserial stage.

**23. *Uvigerinita brazilica* Anan, n. sp.** (= *Uvigerina* sp. - Noucoucouk et al<sup>1</sup>, p. 4, Figure 3.33, LMA-00389).

Diagnosis: This Brazilian species belongs here to the genus *Uvigerinita* Anan<sup>19</sup>, which characterized by triserial test, conical in shape, circular cross-section, two and a half times as long as broad, surface ornamented with low density and evenly distributed hispidity all over the chambers, sutures depressed; aperture terminal with well-developed neck.

Remarks: It is distinguished from the others species of *Uvigerinita* by conical test shape. Moreover, the different species of the genus *Uvigerinita* are recorded, tell now, to USA, Mexico, Nigeria, Egypt, Kazakhstan, Australia and now Brazil (Figure 4).



**Figure 4** The geographic distribution of the different species of the genus *Uvigerinita* Anan (2024): USA, Mexico, Nigeria, Egypt, Kazakhstan and Australia.

**24. *Cibicidoides brazilica* Anan, n. sp.** (= *Cibicidoides* aff. *bradyi* - Noucoucouk et al<sup>1</sup>, p. 5, Figure 3.22, LMA-00411).

**Diagnosis:** Lenticular biconvex trochospiral smooth test, seven nearly triangular chambers in the ventral side, depressed curved sutures, nearly lobulate periphery without keel, tight umbilicus, low interiomarginal aperture and equatorial arch at the base of the apertural face.

**Remarks:** This species is distinguished by tight umbilicus, seven nearly triangular chambers, diagnostic curved sutures. It differs from *Cibicidoides bradyi* (Trauth)<sup>20</sup> by less numbers of chambers, less lenticular periphery, more curved sutures.

**25. *Valvulineria brazilica* Anan, n. sp.** (= *Cibicidoides* aff. *Mundulus* - Noucoucouk et al<sup>1</sup>, p. 5, Figure 3.23, LMA-00412).

**Diagnostic:** This Brazilian species belongs here to the genus *Valvulineria* (Cushman) mainly due to last chamber covered the umbilical area, which extending from the umbilical end of the chamber nearly to the periphery. It has lenticular biconvex trochospiral smooth finely perforated test, acute periphery with faint keel, 9-10 chambers in the ventral side, tight umbilical area, slightly depressed sutures, low interiomarginal aperture and equatorial arch at the base of the apertural face bordered by a small lip.

**Remarks:** This species differs from *Cibicidoides mundulus*<sup>21</sup> mainly by covered umbilical area of extending the last chamber over the umbilicus.

### Geographic distribution

The geographic distribution of the recorded Quaternary-Holocene benthic foraminiferal assemblage from the two localities: 1} Ceará Basin (Core ANP 1011), east Brazilian Equatorial Margin, South Atlantic Ocean (53 species), and 2} south Equator Zanzibar Archipelago of Tanzania, west Indian Ocean (109 species) presents in Table 1.

**Table 1** Quaternary-Holocene benthic foraminifera: 1. Core ANP 1011 in the Ceará Basin, Brazilian Equatorial Margin (east South America), 2. Equator Zanzibar Archipelago of Tanzania (east Africa), x =recorded, ⊙=illustrated

Sp. No.	Quaternary-Holocene benthic foraminiferal species			Sp. No.	Quaternary-Holocene benthic foraminiferal species		
		1	2			1	2
1	<i>Hormosina globulifera</i> Brady, 1879		x	2	<i>Ammobaculites exiguus</i> Cushman & Brönn, 1948		x
3	<i>Spiroplectinella tanzanica</i> Anan, 2025		x	4	<i>Sahulia tanzanica</i> Anan, 2025		x
5	<i>Sahulia kerimbaensis</i> Said, 1949		x	6	<i>Textularia agglutinans</i> d'Orbigny, 1839		x
7	<i>Textularia foliacea</i> Heron-Allen & Earland, 1915		x	8	<i>T. occidentalis</i> Heron-Allen & Earland, 1915		x
9	<i>Textularia porrecta</i> Brady, 1884		x	10	<i>Textularia zanzibarica</i> Anan, 2025		x
11	<i>Siphonotextularia flintii</i> (Cushman, 1911)	x		12	<i>Siphonotextularia thissenae</i> Anan, 2025		x
13	<i>Siphoniferoides africana</i> Anan, 2025		x	14	<i>Clavulina difformis</i> Brady, 1884		x
15	<i>Clavulina multicamerata</i> Chapman, 1907		x	16	<i>Spirillina decorata</i> Brady, 1884	x	
17	<i>Fischerina africana</i> Anan, 2025		x	18	<i>Vertebrulina striata</i> d'Orbigny, 1826		x
19	<i>Spiroloculina africana</i> Anan, 2025		x	20	<i>Spiroloculina antillarum</i> d'Orbigny, 1839		x
21	<i>Spiroloculina attenuata</i> Cushman & Todd, 1944		x	22	<i>Spiroloc. corrugata</i> Cushman & Todd, 1944		x
23	<i>Cycloforina aboshomari</i> Anan, 2025		x	24	<i>Cycloforina abuzaidi</i> Anan, 2025		x
25	<i>Cycloforina bushrae</i> Anan, 2025		x	26	<i>Cycloforina exmouthensis</i> (Parker, 2009)		x
27	<i>Cycloforina semiplicata</i> (McCulloch, 1977)		x	28	<i>Massilina brazilica</i> Anan, n. sp.		⊙
29	<i>Quinqueloculina abohanii</i> , Anan, 2025		x	30	<i>Quinqueloculina brazilica</i> Anan, n. sp.		⊙
31	<i>Quinqueloculina eburnea</i> (d'Orbigny, 1839)		x	32	<i>Quinqueloculina plicosa</i> (Costa, 1856)		x
33	<i>Quinqueloculina tanzanica</i> Anan, 2025		x	34	<i>Quinqueloculina trigonula</i> Terquem, 1876		x
35	<i>Quinqueloculina zanzibarica</i> Anan, 2025		x	36	<i>Affinetrina africana</i> Anan, 2025		x
37	<i>Miliolinella brazilica</i> Anan, n. sp.	⊙		38	<i>Miliolinella bassiounii</i> Anan, 2025		x
39	<i>Miliolinella suborbicularis</i> (d'Orbigny, 1839)		x	40	<i>Miliolinella subrotunda</i> (Montagu, 1803)	x	
41	<i>Miliolinella tanzanica</i> Anan, 2025		x	42	<i>Miliolinella thissenae</i> Anan, 2025		x
43	<i>Miliolinella zanzibarensis</i> Anan, 2025		x	44	<i>Pseudomassilina macilenta</i> (Brady, 1884)		x
45	<i>Pyrgo reticulata</i> (Heron-Allen & Earland, 1915)		x	46	<i>Pyrgo brazilensis</i> Anan, n. sp.		⊙
47	<i>Pyrgo brazilica</i> Anan, n. sp.	⊙		48	<i>Pyrgo denticulata</i> (Brady, 1884)		x
49	<i>Pyrgo oblonga</i> (d'Orbigny, 1839)		x	50	<i>Pyrgo murrhina</i> (Schwager, 1866)		x
51	<i>Pyrgo lucernula</i> (Schwager, 1866)	x		52	<i>P. quadrata</i> (Heron-Allen & Earland, 1930)		x

53	<i>Triloculina asymmetrica</i> (Said, 1949)	x	54	<i>Triloculina bertheliniana</i> (Brady, 1884)	x
55	<i>Triloculina brazillca</i> Anan, n. sp.	⊖	56	<i>Triloculina cherifi</i> Anan, 2025	x
57	<i>Triloculina ennaggari</i> Anan, 2025	x	58	<i>Triloculina ennakhali</i> Anan, 2025	x
59	<i>Triloculina fichteliana</i> d'Orbigny, 1839	x	60	<i>Triloculina serrulata</i> (Wiesner, 1923)	x
61	<i>Triloculina sommeri</i> Tinoco, 1955	x	62	<i>Triloculina terquemiana</i> (Brady, 1884)	x
63	<i>Triloculina thissenae</i> Anan, 2025	x	64	<i>Triloculina trigonula</i> (Lamarck, 1804)	x
65	<i>Triloculinella brazillca</i> Anan, n. sp.	⊖	66	<i>Triloculinella usamai</i> Anan, 2025	x
67	<i>Sigmoihauerina bradyi</i> (Cushman, 1917)	x	68	<i>Sigmoihauerina involuta</i> (Cushman, 1946)	x
69	<i>Sigmoilopsis schumbergeri</i> (Silvestri, 1904)	x	70	<i>Articulina scrobiculata</i> (Brady, 1884)	x
71	<i>Rupertianella rupertiana</i> (Brady, 1881)	x	72	<i>Pseudohauerina dissidens</i> (McCulloch, 1977)	x
73	<i>Pseudohauerina fragilissima</i> (Brady, 1884)	x	74	<i>Pseudohauerina moradi</i> Anan, 2025	x
75	<i>Borelis schlumbergeri</i> (Reichel, 1937)	x	76	<i>Peneroplis pertusus</i> (Forskål, 1775)	x
77	<i>Peneroplis planatus</i> (Fichtel & Moll, 1798)	x	78	<i>Amphisorus hemprichii</i> Ehrenberg, 1839	x
79	<i>Sorites orbiculus</i> Forsskål, 1775	x	80	<i>Tollmannia catesbyi</i> Thissen, 2014	x
81	<i>Lenticulina vortex</i> (Fichtel & Moll, 1798)	x	82	<i>Nodosaria brazillca</i> Anan, n. sp.	⊖
83	<i>Amphicoryna brazillca</i> Anan, n. sp.	⊖	84	<i>Lagena brazillca</i> Anan, n. sp.	⊖
85	<i>Pygmaeoseistron brazillca</i> Anan, n. sp.	⊖	86	<i>Lagena arquata</i> Buchner, 1940	x
87	<i>Lagenosolenia brazillca</i> Anan, n. sp.	⊖	88	<i>Fissurina circularis</i> Todd, 1954	x
89	<i>Bolivina brazillca</i> Anan, n. sp.	⊖	90	<i>Bolivina interjuncta</i> Cushman, 1926	x
91	<i>Bolivinita brazillca</i> Anan, n. sp.	⊖	92	<i>Bolivinita quadrilatera</i> (Schwager, 1866)	x
93	<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	x	94	<i>B. simpsoni</i> (Heron-Allen & Earland, 1915)	x
95	<i>Brizalina striatula</i> (Cushman, 1922)	x	96	<i>Loxostomina costulata</i> (Cushman, 1922)	x
97	<i>Loxostomina yahiai</i> Anan, 2025	x	98	<i>Sagrinella lobata</i> (Brady, 1881)	x
99	<i>Cassidulina brazillca</i> Anan, n. sp.	⊖	100	<i>Cassidulinoides brazillca</i> Anan, n. sp.	⊖
101	<i>Globocassidulina brazillca</i> Anan, n. sp.	⊖	102	<i>Globocassidulina subglobosa</i> (Brady, 1881)	x
103	<i>Globobulimina affinis</i> (d'Orbigny, 1839)	x	104	<i>Globobulimina brazillca</i> Anan, n. sp.	⊖
105	<i>Neouvirgerina brazillca</i> Anan, n. sp.	⊖	106	<i>Neouvirgerina peregrina</i> (Cushman, 1923)	⊖
107	<i>Neouvirgerina proboscidea</i> (Schwager, 1866)	⊖	108	<i>Neouvirgerina hispida</i> (Schwager, 1866)	⊖
109	<i>Uvirgerinita brazilensis</i> Anan, n. sp.	⊖	110	<i>Pavonina flabelliformis</i> d'Orbigny, 1826	x
111	<i>Cancriis bubnanensis</i> (McCulloch, 1977)	x	112	<i>Cancriis farouki</i> Anan, 2025	x
113	<i>Eponides repandus</i> (Fichtel & Moll, 1798)	x	114	<i>Rosalina alwasabii</i> Anan, 2025	x
115	<i>Siphonina tubulosa</i> Cushman, 1924	x	116	<i>Siphoninoides echinatus</i> (Brady, 1879)	x
117	<i>Valvobifarina mackinnonii</i> (Millett, 1900)	x	118	<i>Discorbinella minuta</i> Buzas et al, 1977	x
119	<i>Chilostomella globata</i> Gallow&Heminw, 1941	x	120	<i>Oridorsalis umbonatus</i> (Reuss, 1851)	x
121	<i>Osangularia culter</i> (Parker & Jones, 1865)	x	122	<i>Cancriis nuttalli</i> (Palmer & Bermúdez, 1936)	x
123	<i>Valvulineria brazillca</i> Anan, n. sp.	⊖	124	<i>Valvulineria glabra</i> Cushman, 1927	x
125	<i>Rosalina bradyi</i> (Cushman, 1915)	x	126	<i>Melonis barleeianum</i> (Williamson, 1858)	x
127	<i>Melonis pompilioides</i> (Fichtel & Moll, 1798)	x	128	<i>Pullenia bulloides</i> (d'Orbigny, 1846)	x
129	<i>Pullenia obliquiloculata</i> (Parker&Jones, 1865)	x	130	<i>Cibicidoides brazillca</i> Anan, n. sp.	⊖
131	<i>Cibicidoides kullenbergi</i> (Parker, 1953)	x	132	<i>Cibicidoides lobatulus</i> (Walker Jacob, 1798)	x
133	<i>Cibicidoides wuellerstorfi</i> (Schwager, 1866)	x	134	<i>C. incrassatus</i> (Fichtel & Moll, 1798)	x
135	<i>Cibicidoides cicatricosus</i> (Schwager, 1866)	x	136	<i>C. pseudolobatulus</i> Perelis & Reiss, 1975	x
137	<i>Cibicidella variabilis</i> (d'Orbigny, 1826)	x	138	<i>Planorbulina mediterranensis</i> d'Orbigny, 1826	x
139	<i>Planorbulina larvata</i> Parker & Jones, 1865	x	140	<i>Cymbal. bermudezi</i> (Sellier de Civrieux, 1976)	x
141	<i>Cymbaloporetta bulloides</i> (d'Orbigny, 1839)	x	142	<i>Acervulina mabahethi</i> (Said, 1949)	x
143	<i>A. tubulifera</i> (Heron-Allen & Earland, 1915)	x	144	<i>Epistomaroides punctulatus</i> (d'Orbigny, 1826)	x
145	<i>Amphistegina bicirculata</i> Larsen, 1976	x	146	<i>Amphistegina lessonii</i> Deshayes, 1830	x
147	<i>Amphistegina papillosa</i> Said, 1949	x	148	<i>Nonion fabum</i> (Fichtel & Moll, 1798)	x
149	<i>Nonionoides grateloupi</i> (d'Orbigny, 1839)	x	150	<i>Anomalinaella glabrata</i> Cushman, 1924	x
151	<i>Gyroidina neosoldanii</i> Brotzen, 1936	x	152	<i>Neorotalia calcar</i> (d'Orbigny, 1830)	x
153	<i>Ammonia convexa</i> (Collins, 1958)	x	154	<i>Ammonia faceta</i> He, Hu & Wang, 1965	x
155	<i>Challengerella bradyi</i> Billman et al, 1980	x	156	<i>Elphidium jenseni</i> (Cushman, 1924)	x
157	<i>Elphidium limbatum</i> (Chapman, 1907)	x	158	<i>Elphidium macellum</i> (Fichtel & Moll, 1798)	x
159	<i>E. milletti</i> (Heron-Allen & Earland, 1915)	x	160	<i>E. striatopunctatum</i> (Fichtel & Moll, 1798)	x
161	<i>Elphidium voorthuyseni</i> Haake, 1962	x	162	<i>Heterostegina depressa</i> d'Orbigny, 1826	x

The recorded species were recorded originally from two localities in the south Equator (Figure 5).



**Figure 5** Geographic location of the two studied countries Brazil Tanzania, south Equator.

An additional remark of the paleogeographic distribution of the recorded species can be presented:

- i. 15 arenaceous species totally record from Tanzania. Most probably this assemblage was neglected by the author.
- ii. *Spirillina decorata* which represents the Suborder Spirillinina is recorded in Brazil only.
- iii. 63 of miliolid species are recorded in both studied localities in the south Equator Tanzania and Brazil.
- iv. Only 8 of Lagenid species are recorded in both localities.
- v. The other 74 benthic species of the studied localities belong to the Suborder Rotaliina.
- vi. 22 species from Brazil are treated here as new species: 7 Miliolid species, 5 Lagenid species, and 10 Rotaliid species.
- vii. Never any species is recorded in the two studied localities, which may due to the misidentification of some species.

### Environment and ecology

- i. Bathymetry is the main driver of foraminiferal abundance (Figure 6).
- ii. Benthic foraminifera can be differentiated by microhabitats in epifaunal, which live in the upper 1 cm of sediment, and infaunal, which burrow into soft sediment below 1 cm of the sediment. According to Noucoucouk et al<sup>1</sup> increase of infaunal foraminifera (e.g. *Uvigerina*, *Globocassidulina*, *Melonis*) in the study area suggests reduction in the organic matter input, and probably, increased bacterial density and depletion in dissolved oxygen in the sediment.
- iii. Some of the recorded species occurring in neritic or neritic-bathyal environment (Table 2).

#### Some of other remarks are added:

- i. The distribution patterns of foraminiferal taxa reflect the ecological adaptations and display useful information for the reconstruction of fossil environments.
- ii. The most abundant calculated foraminiferal groups in the study

area based on the number of the all identified species belongs to the Rotaliid species, followed by Miliolids and Lagenids, and lesser by agglutinated species.

- iii. According to Noucoucouk et al,<sup>1</sup> the total of five water masses exert influence in the study area, from the surface to the 2,125 m water depth where the core ANP 1011 was obtained: 1) Tropical Water (the surface water TW, 0–150 m), 2) South Atlantic Central Water (SACW, 150–500 m), 3) Antarctic Intermediate Water (the intermediate water AAIW, 500–1,300 m), 4) Upper Circumpolar Water (the intermediate water UCPW, 500–1,300 m), and 5) North Atlantic Deep Water (the deep water NADW, 1,300–3,500 m) (Figure 1).
- iv. The Zanzibar Archipelago is strongly influenced by the 1) warm, westward-flowing South Equatorial Current, and 2) the northward-flowing East African Coastal Current (Figure 2).
- v. The highly percentage of the recorded benthic foraminiferal assemblage of Tanzania (109/162, ~67%) may related to their own particular environmental conditions, mainly the warm westward-flowing South Equatorial Current.<sup>22</sup>
- vi. 63 of miliolid species in the south Equator Tanzania and Brazil, higher that miliolid Recent foraminifera species (44) in the in the Mediterranean and Red seas (after Anan).<sup>23</sup>
- vii. Few species. e.g., *Neouvigerina auberiana*,<sup>4</sup> *Neouvigerina hispida* (Schwager<sup>5</sup>), *Neouvigerina proboscidea*<sup>5</sup> were recorded around the study area of Brazil, like the Caribbean (Cuba and Jamaica), south Pacific (Chile), and west Europe (France and Germany), which indicates an open transportation of the water currents between these localities.

**Table 2** The probable environment for some recorded genera in the studied area: Brazil and Tanzania, south Equator: I. Inner Neritic (50m water depth), O. Outer Neritic (200m water depth), U. Upper Bathyal (500m water depth), M. Middle, L. Lower Bathyal

Neritic	Bathyal			
	I	O	U	M L
Ammobaculites				
Textularia				
Clavulina				
Spiroplectinella				
Pyrgo				
Triloculina				
Milliolinella				
Fissurina				
Nodosaria				
Lenticulina				
Bolivina				
Cassidulina				
Cassidulinoides				
Globobulimina				
Cibicidoides				
Melonis				
Quinqueloculina				
Spiroloculina				
Lagena				
Valvulineria				
Elphidium				

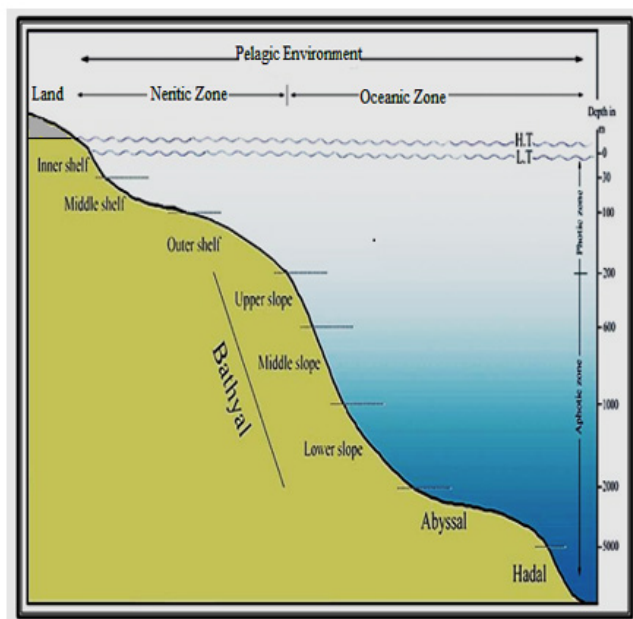


Figure 6 Subdivisions of marine environments.<sup>22</sup>

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## Conflicts of interest

The author declares that there are no conflicts of interest.

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