Chapter 7

TAXONOMY, BIOSTRATIGRAPHY, AND PHYLOGENY OF OLIGOCENE CIPEROELLA N. GEN.

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ABSTRACT

Ciperoella Olsson and Hemleben n. gen. is erected for Oligocene spinose species that have a neogloboquadrinid-type wall texture and 4½-5 similarly sized chambers in the final whorl. Four species are recognized as distinct, namely Ciperoella anguliofficinalis (Blow), Ciperoella angulisuturalis (Bolli), Ciperoella ciperoensis (Bolli), and Ciperoella fariasi (Bermúdez). Their taxonomy, phylogeny, and biostratigraphy is discussed.

INTRODUCTION

Ciperoella new genus is characterized by having 4½-5 chambers in the ultimate whorl and a Neogloboquadrina-type wall texture characterized by an underlying ruber/sacculifer or sacculifer wall with elongate parallel ridges and short incomplete cross ridges. The new genus evolved in the upper Eocene. Its species, described from uppermost Eocene and Oligocene horizons are well known to workers and were generally included in the genus Globigerina. However, our studies of wall texture show that the wall of Globigerina is completely different from the species now included in the new genus Ciperoella. Globigerina differs in having a higher concentration of smaller diameter pores and a smoother wall without reticulations (see Chapters 3 and 6, this volume). The species of Ciperoella are common in the Oligocene in both deep sea sequences and land sections including the type region of the Oligocene Chattian and Rupelian stages in Boreal northwest Europe (Hooyberghs and De Meuter, 1972; Hooyberghs and others, 1992), and the species C. angulisuturalis is an important biostratigraphic marker. Ciperoella shares features with Globoturborotalita, from which it evolved, with respect to wall texture and aperture shape but differs in having 4½-5 instead of 4-4½ chambers in the final whorl and a somewhat more reticulate wall. Globoturborotalita gnaucki provides an evolutionary intermediate between the groups. The concept of Ciperoella is typified by small 5-chambered forms described by Bolli (1954) and (1957) as subspecies of Globigerina (G. ciperoensis and G. ciperoensis angulisuturalis) from the Cipero Formation of Trinidad. Blow (1969) recognized a fourth related species that he named Globigerina anguliofficinalis. Note that G. angustiumbili-
cata (Bolli) is now regarded as a species of Tenuitella because it has a microperforate wall (Chapter 16, this volume). Forms previously assigned to ‘angustiumblicata’ can be variably placed in C. anguliofficinalis or Tenuitella angustiumblicata depending on the wall texture. Kennett and Srinivasan (1983) regarded the 4 taxa as distinct species of Globigerina (Globigerina), while Bolli and Saunders (1985) retained the sub-species naming system. McGowran and Li (1993) placed angulisuturalis, together with several other Eocene and Oligocene taxa in Hofker’s genus Globoturborotalita, thus extending the range of this genus into the Paleogene. Rögl’s (1994) treatment of the ciperoensis group places them in Globigerina. Olsson and others (2006) placed gnaucki Howe and Wallace (1932) and anguliofficinalis in Globoturborotalita. Under the taxonomy presented in this atlas, gnaucki is retained in Globoturborotalita (Chapter 8, this volume), while anguliofficinalis is referred to the new genus Ciperoella.

There have been several views on the phylogeny of the group, including from Blow and Banner/Blow, who changed opinion over the years. Blow and Banner (1962) suggested that Bolli’s species angulisuturalis evolved from ciperoensis, and ciperoensis from ouachitaensis. Blow (1969), however, derived angulisuturalis from anguliofficinalis, while Globigerina officinalis was regarded as the ancestor of anguliofficinalis. Of these species, only G. officinalis is retained in the genus Globigerina (Chapter 6, this volume). Kennett and Srinivasan (1983) proposed a line of descendants from angustiumblicata - ciperoensis - angulisuturalis. This can now be ruled out due to the microperforate affinity of angustiumblicata s.s. According to Blow (1979), “Globigerina” angulisuturalis and “G.” ciperoensis evolved from a common ancestor, “G.” anguliofficinalis, which was morphologically intermediate between the two. Our view, after Aze and others (2011) and based on new morphological observations, is that Ciperoella is a monophyletic clade. The first species, C. anguliofficinalis, evolved from Globoturborotalita gnaucki, gave rise to C. ciperoensis and subsequently to C. angulisuturalis (Figure 7.1). Ciperoella fariasi represents a large and somewhat uncoiled form of C. ciperoensis. As pointed out by Blow (1969) the tendency towards forms with 5 full chambers in the final whorl increases in younger species. The stratigraphic range of Ciperoella is complicated by Rögl’s (1969) taxon “Globigerina” ottnangiensis, described from the lower Miocene of the Paratethys region (see discussion below under Ciperoella anguliofficinalis). The species is here synonymized under C. anguliofficinalis based purely on morphological arguments, although we recognize further work on Miocene sequences may provide additional support for distinguishing the two.

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\begin{array}{|c|c|c|c|c|}
\hline
\text{Epoch} & \text{Form} & \text{Berggren} & \text{Berggren} & \text{Kend} & \text{Kend}\text{nett}\text{ and }\text{Srinivasan}\text{, }1983;\text{ WPBP, }2011=\text{Wade}\text{ and }\text{others, }2011. \\
\hline
\text{Miocene} & \text{Ciperoella} & \text{Ciperoell}\text{a} & \text{Ciperoelle} & \text{Ciperoelle} & \text{Ciperoelle}\text{a} \\
\hline
\text{Early} & \text{Ciperoell}\text{a} & \text{Ciperoelle} & \text{Ciperoelle} & \text{Ciperoelle} & \text{Ciperoelle}\text{a} \\
\hline
\text{Late} & \text{Ciperoell}\text{a} & \text{Ciperoelle} & \text{Ciperoelle} & \text{Ciperoelle} & \text{Ciperoelle}\text{a} \\
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\end{array}
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Chapter 7 - Ciperoella

SYSTEMATIC TAXONOMY

Order FORAMINIFERIDA d’Orbigny, 1826
Superfamily GLOBIGERINOIDEA
Carpenter, Parker, and Jones, 1862
Family GLOBIGERINIDAE Carpenter, Parker, and Jones, 1862

Genus Ciperoella Olsson and Hemleben n. gen.


DESCRIPTION.
Type of wall: Normal perforate, spinose, Neogloboquadrina-type wall texture with underlying ruber/ sacculifer or sacculifer wall with elongate parallel ridges. Pore concentrations range from around 25-60 pores/50 μm² test surface area and pore diameters from around 0.9-2.5 μm.

Test morphology: Test low trochospiral, lobulate in outline, chambers globular to ovoid. In the final whorl, 4½-5 chambers; aperture umbilical bordered by a thin rim.

ETYMOLOGY.— Named after the type species.

DISTINGUISHING FEATURES.— Ciperoella n. gen. has an underlying ruber/sacculifer wall with elongate parallel ridges and short incomplete cross ridges, a wall texture like that in the nonspinose Neogloboquadrina. Porosity ranges from about 25-60 pores per 50 μm² area. Several species are typically small in size (<200 μm). When well-preserved they can appear ‘shiny’ and translucent under the light microscope, possibly owing to crystal orientation of the thin wall. It differs from Globoturborotalita, to which a number of species discussed here have been previously assigned, by the distinctive reticulate nature of the wall and on average ½ to 1 more chamber in the final whorl.

DISCUSSION.— Ciperoella is a common form in the Oligocene that has been regarded by workers as a species of Globigerina. However, it does not have the wall texture of Globigerina. Hence, the naming of a new genus.

STRATIGRAPHIC RANGE.— Upper Eocene to lower Miocene.

Ciperoella anguliofficinalis (Blow, 1969)

PLATE 7.1. FIGURES 1-18

Globigerina anguliofficinalis Blow, 1969:379, pl. 11, figs. 1, 2, holotype, figs. 3-5 paratype [lower Oligocene Zone P19 (= Zone O1, this study), Cipero Fm., Trinidad].— Hooyberghs and De Meuter, 1972:17, pl. 4, figs. 1a-c ['upper Oligocene', Edgem Sands, Belgium].— Poore, 1979: pl. 15, fig. 6 [Oligocene Zone P21, DSDP Site 407, North Atlantic Ocean].— Molina, 1979:144, pl. 10, figs. 2a-c [lower Oligocene 'G. (G.) gortanii' Zone (= E16), Serie del Gobernador-Sur de Torre Cárdena, Cordilleras Béticas, Spain].— Charollais and others, 1980:64, pl. 6, figs. 12, 13 [lower Oligocene, Marnes à Foraminifères French Alps].— Rögl, 1994:137, pl. 1, figs. 7-10 [lower Oligocene Zone O2, Egerian, Austria].— Cicha and others, 1998:99, pl. 31, figs. 24-26 [lower Oligocene, Central Paratethys].— Székely and Filipescu, 2016:490, pl. 2, figs. 7a-c [lower Oligocene, Rupelian, Transylvanian Basin, Romania].

Globigerina officinalis anguliofficinalis (Blow).— Chaproniere, 1981:109, figs. 4Ba-c [upper Oligocene, Ashmore Reef No. 1 Well, northwest Australia].

Globigerina ciperoensis anguliofficinalis (Blow).— Bolli and Saunders, 1985:182, fig. 13 (10,11) [holotype re-illustrated].

"Globigerina” anguliofficinalis” (Blow).— Spezzaferri and Premoli Silva, 1991:237, pl. IV, figs. 5a-d [upper Oligocene, Ashmore Reef No. 1 Well, northwest Australia].

Globoturborotalita anguliofficinalis (Blow).— Olsson and others, 2006:116, pl. 6.2, figs. 1-7 [Zone E15/16, Shubuta Clay, Mississippi].— Baldassini and others, 2013:111, text-fig. 4.31-4.32 [upper Oligocene Zone P22, Sliema Point section, Malta].

Globigerina angustiumbilicata Bolli.— Blow and Banner, 1962:85, pl. 9, figs. x-z [lower Oligocene Globigerina oligocaenica Zone, Lindi area, Tanzania].— Hooyberghs and De Meuter, 1972:17, pl. 4, figs. 4a-c ['upper Oligocene’, Houthalen Sands, Belgium].— Hooyberghs and others, 1992:9, pl. 2, figs. 9-12 [lower Oligocene Zones P19/P20, Boom Fm., Kruibeke Section, Belgium]. [Not Bolli, 1957.]

‘Globoturborotalita angustiumbilicata’ Bolli.— Rincón and others, 2007:284, pl. 1, figs. 3a,b [upper Oligocene to lowest lower Miocene, Globigerina ciperoensis zone, Bolívar, Colombia]. [Not Bolli, 1957.]

Globigerina ottnangiensis Rögl, 1969:221, pl. 4, fig. 3 [nannoplankton Zone NN2, lower Miocene, Ottnangien, ‘Phosphorite sand’, Plesching near Linz, Austria].— Rögl,
DESCRIPTION.

Type of wall: Normal perforate, spinose, Neogloboquadrina-type wall texture. Pore concentrations range from around 25-60 pores/50 μm² test surface area and pore diameters from around 0.9-2.5 μm

Test morphology: Moderately low trochospiral, globular, lobulate in outline, chambers globular; in spiral view 5 slightly embracing chambers in final whorl, increasing moderately in size, sutures depressed, straight; in umbilical view 5 slightly embracing chambers, increasing moderately in size, sutures depressed, straight, umbilicus large, open, enclosed by surrounding chambers, aperture umbilical, a rounded arch, bordered by a thin rim; in edge view chambers globular, slightly embracing, initial whorl slightly elevated.

Size: Maximum diameter 0.21-0.30 mm, minimum diameter 0.18-0.21 mm, maximum width 0.17 mm.

DISTINGUISHING FEATURES.—The species is distinguished by its small lobulate test, globular chambers, large umbilical aperture, and Neogloboquadrina-type wall texture. It differs from C. ciperoensis by the less lobulate peripheral outline, more compact form and a greater rate of chamber size increase. Its sutures may be incised but not over-widened and U-shaped as in C. angulisuturalis, although intermediates occur.

DISCUSSION.—Ciperoella anguliofficinalis is a common species in the Oligocene, evolving in the upper Eocene. It was described as a species of Globigerina. Olsson and others (2006) placed it in the genus Globoturbo. SEM study of the wall texture of this species shows a Neogloboquadrina-type wall characteristic of the new genus Ciperoella. The angular appearance of anguliofficinalis chambers in the holotype (Pl. 7.1, Figs. 1-2) is likely due to gametogenetic build-up. In spiral view the outline of rounded chambers is more clearly visible. Ciperoella anguliofficinalis becomes more common in the Oligocene. In fact Pearson and Chaisson (1997:48) remark that “the base of “G.” anguliofficinalis-like morphologies coincides with the base of “G.” angulisuturalis and they co-occur for much of the stratigraphic range of that form”.

Rögl’s (1969) Paratethys species Globigerina ciperoensis ottngangensis, described from the lower Miocene of Austria where it is a common and important stratigraphic marker, appears to be a junior synonym of C. anguliofficinalis (holotype Pl. 7.1, Fig. 13). Both anguliofficinalis and ottngangensis were published in 1969, however, Blow presented his work at the 1967 foraminifera conference in Geneva giving anguliofficinalis priority.

The upper part of the stratigraphic range of both C. anguliofficinalis, as well as the other ciperoensis-group taxa is complicated by Rögl’s ottngangensis. Based on comparisons of the holotype (reproduced here on Pl. 7.1, Fig. 13) and paratype images (Rögl, 1969), we cannot consistently distinguish ottngangensis from C. anguliofficinalis. In fact, Rögl (1969, 1994) describes and illustrates a high degree of variability among forms assigned to ottngangensis that includes features of anguliofficinalis, ciperoensis and angulisuturalis.

Ciperoella anguliofficinalis is present in the late Rupelian and early Chattian in the southern North Sea.

Plate 7.1 Ciperoella anguliofficinalis (Blow, 1969)

1-2 (holotype), 3 (paratype), Zone P19 (= Zone O1, this study), Cipero Fm., Trinidad (reproduced from Blow, 1969, pl. 11, figs. 1, 2, and 4); 4-12, 17, Zone O6, Atlantic Slope Project corehole 5B/10F/6, 12', western North Atlantic slope; 13, holotype, Globigerina ottngangensis Rögl, 1969; 14, Zone O6, Atlantic Slope Project corehole 5B/19D/29, 35', western North Atlantic slope; 15, 16, 18, Zone O1, AGS 66, 9A-1A, Shubuta Fm., Alabama. Scale bar: 1-7, 9-11, 13-17 = 50 μm; 8 = 25×50 μm surface area, 12 = 25 μm² surface area, 18 = 10 μm.
PLATE 7.1 Ciperoella anguliofficinalis (Blow, 1969)
Basin (Hooyberghs and De Meuter, 1972; Hooyberghs
and others, 1992). Among the examples described from
the Belgian Boom Clay, several specimens described as
‘G. angustiambilicata Bolli’, but lacking a microperfo-
rate wall (that we now know this taxon to possess), can
be assigned to Ciperoella anguliofficinalis (e.g., Hooy-
record “G.” anguliofficinalis occurring throughout the
range of ciperoensis and angulusatulalis.

Spezzaferri (1994) records a common highest
occurrence for ciperoensis and anguliofficinalis in the
Indian Ocean, Gulf of Mexico and Caribbean, equa-
torial and North Atlantic Ocean that correlates to the
uppermost part of lower Miocene Zone N4b/N5 (= end
M1). In its type region, Rögl (1994) and Cicha and
others (1998) show ottnangiensis to range above the
highest occurrence of C. ciperoensis s.s. up to the low-
er/middle Miocene boundary (= Zone M5 = end of the
Burdigalian stage = Eggenburgian-Karpathian central
Paratethys stages). Spezzaferri (1994) records a similar
stratigraphic range for forms she records and illustrates
in the upper Eocene (Zone E15).

PHYLOGENETIC RELATIONSHIPS.— Evolved from
Ciperoella gnaucki in the upper Eocene (Zone E15).
Gave rise to C. angulusatulalis and C. ciperoensis.

TYPE LEVEL.— Sample Cb. 1964, lower Oligocene
Zone P19 (= Zone O1), Bamboo silt member, Cipero
Fm., Trinidad.

STRATIGRAPHIC RANGE.— Zone E15? (Olsson and
others, 2006) to lower middle Miocene Zone M5 (Rögl,
1994; Spezzaferri, 1994). The upper stratigraphic limit
includes the range of Globigerina ottnangiensis and
“Globigerina” aff. ottnangiensis described from the
Paratethys region (Rögl, 1969) and elsewhere (Spez-
zaferri, 1994) and here synonymized under Ciperoella
anguliofficinalis.

GEOGRAPHIC DISTRIBUTION.— Cosmopolitan
from high to low latitudes, including the North Sea and
Paratethys regions.

STABLE ISOTOPE PALEOBIOLOGY.— Douglas and
Savin (1978) recorded moderately negative δ18O for this
species indicating a mixed-layer habitat.

REPOSITORY.— Holotype (P49582) deposited at the
Natural History Museum, London.

_Ciperoella angulusatulalis_ (Bolli, 1957)

_PLATE 7.2. FIGURES 1-17
(Pl. 7.2, Figs. 1-3: new SEMs of holotype of
_Globigerina angulusatulalis_ Bolli)_

_Globigerina ciperoensis anguliofficinalis_ Bolli, 1957:109, pl.
22, figs. 11a-c, holotype [Oligocene Globorotalia opima
opima Zone, Cipero Fm., Trinidad].—Toumarkine, 1978,
pl. 8, figs. 12-16 [upper Oligocene Globigerina cipero-
ensis ciperoensis Zone, DSDP Site 363, eastern South
Atlantic Ocean].—Bolli and Saunders, 1985:182, fig. 13
(4-7), holotype re-illustrated [Oligocene Globorotalia
opima opima Zone, Cipero Fm., Trinidad].

_Globigerina angulusatulalis_ Bolli.— Blow, 1969:118, pl. 11,
fig. 8 (topotype) [Oligocene Zone N2 = P21, Trinidad], pl.
11, fig. 9, pl. 12, figs. 1, 2 [upper Oligocene Zone “N3 =
P22”, Lr. Ragusa Limestone Fm., Sicily].—Stainforth and
others, 1975:250, fig. 104 (1-6) [Oligocene Globorotalia
opima opima Zone, Cipero Fm., Trinidad].—Krashenin-
nikov and Pflaumann, 1978:591, pl. 1, figs. 1, 2 [Oligo-
cene, DSDP Site 369, eastern North Atlantic Ocean].—
Molina, 1979:146, pl. 10, figs. 1A-C [upper Oligocene
Zone O5, Fuente Caldera Section, Cordilleras Béticas,
Spain].—Leckie and others, 1993:123, pl. 9, figs. 1-6
[upper Oligocene Zone P22, ODP Hole 628A, Little Ba-
hama Bank, western Atlantic Ocean].—Rögl, 1994:136,
pl. 1, figs. 5, 6 [Zone NP 23, Ottenthal, Austria].—Cicha
and others, 1998:99, pl. 31, figs. 22, 23 [lower Oligocene,
Plate 7.2 Ciperoella angulusatulalis (Bolli, 1957)

1-3 (holotype, USNM 5608), Globorotalia opima opima Zone, Cipero Fm., Trinidad; 4-7, 11, 12, Zone P21/P22, ODP Site 872C/16H/1, 20-22 cm, Lo-En Guyot, Marshall Islands, western equatorial North Pacific Ocean; 8-10, 13-17, Zone O5, Paragloborotalia opima type locality; RDL sample 1033, Cipero Fm., Trinidad. Scale bar: 4-14, 17 = 100 µm; 1-3 = 50 µm; 15, 16 = 10 µm.
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Plate 7.2 Ciperoella angulisuturalis (Bolli, 1957)
DESCRIPTION.

Type of wall: Normal perforate, spinose, Neogloboquadrina-type wall. Pore concentrations range from around 25-60 pores/50 μm² test surface area and pore diameters from around 0.9-2.5 μm.

Test morphology: Moderately low trochospiral, globular, lobulate in outline, chambers globular; in spiral view 5 globular, slightly embracing chambers in ultimate whorl, increasing moderately in size, chambers squared off at sutures, sutures distinctly depressed, straight; in umbilical view 5 globular, slightly embracing chambers, increasing moderately in size, chambers squared off at sutures, sutures distinctly depressed forming steep U-shaped walls between chambers, straight, umbilicus large, open, enclosed by surrounding chambers, aperture umbilical, a rounded arch, bordered by a thin rim; in edge view chambers globular, slightly embracing, initial whorl of chambers slightly elevated.

Size: Maximum diameter of holotype 0.18 mm, minimum diameter 0.16 mm, thickness 0.11 mm.

DISTINGUISHING FEATURES.— The species is distinguished from C. ciperoensis and C. anguliofficinalis by its smaller lobulate test, squared off / wedge shaped chambers, distinctly depressed sutures forming steep U-shaped walls between chambers and large umbilical aperture.

DISCUSSION.— This is an easily identified species and its first occurrence is a marker for the lower Oligocene Zone O4 (Wade and others, 2011). We note that C. anguliofficinalis is missing from published species lists for the boreal North Sea (Hooybergh and De Meuter, 1972; Hooyberghs and others, 1992), whereas the ancestor C. anguliofficinalis and descendant C. ciperoensis respectively are recorded and illustrated (Rögl, 1969). This suggests that C. anguliofficinalis has a more tropical affinity than other members of the genus and may explain the observed diachroneity of the last occurrence (see below). Blow (1969) regarded extreme versions with overly deepened sutures (Blow, 1969; pl. 11, fig. 9; pl. 12, figs. 1 and 2) from Zone N3/P22 (= O6/O7) Sicily as “phylogenetically advanced”.

PHYLOGENETIC RELATIONSHIPS.— Evolved from Ciperoella anguliofficinalis in the lower Oligocene. See the Ciperoella genus introduction for a summary on previous views on the evolutionary pathway. It did not leave any descendants.

TYPE LEVEL.— Globorotalia opima opima Zone, Cipero Fm., Trinidad.

STRATIGRAPHIC RANGE.— Zone O4 to M2. The FAD of C. anguliofficinalis defines the base of Zone O4 (29.4 Ma), and the LAD is within Zone M2 (21.6 Ma) (Berggren and others, 1995; Wade and others, 2011). An earlier LAD in Subzone M1b is recorded in the Indian Ocean and Caribbean by Spezzaferri (1994). Pearson and Chaisson (1997:40) remarked that the datum is difficult to place in the equatorial Atlantic Ocean because of “a combination of abundance fluctuations of “G.” anguliofficinalis in the higher part of its range and its
susceptibility to dissolution”.

**GEOGRAPHIC DISTRIBUTION.**—Widespread in low to mid-latitudes. Rare or absent in high productivity areas.


**REPOSITORY.**—Holotype (USNM P5608) deposited at the Smithsonian Museum of Natural History, Washington, D.C.

**Ciperoella ciperoensis** (Bolli, 1954)

**PLATE 7.3, FIGURES 1-17**

(Pl. 7.3, Figs. 1-3: new SEMs of holotype of *Globigerina ciperoensis* Bolli)

*Globigerina concinna* Reuss, 1850:373, pl. 47, fig. 8a, b [Tertiary, Grinzin, Austria].—Nuttall, 1932:29, pl. 6, figs. 9-11 [Alazán shales, Mexico].—Franklin, 1944:317, pl. 48, fig. 5 [Oligocene, Carapita Fm., Venezuela]. [Not Reuss, 1850.]

*Globigerina cf. concinna* Reuss.—Cushman and Stainforth, 1945:67, pl. 13, fig. 1a, b [Cipero Fm., Trinidad]. [Not Reuss, 1850.]

*Globigerina ciperoensis* Bolli, 1954:1, figs. 3-3a (holotype drawing of *Globigerina cf. concinna* Reuss from Cushman and Stainforth, 1945), figs. 4-4b [Oligocene, *Globigerina ciperoensis* Zone, Cipero Fm., Trinidad], figs. 5-5b (drawing of *Globigerina concinna* Reuss from Nuttall, 1932), fig. 6 (drawing of *Globigerina concinna* Reuss from Franklin, 1944).—Jenkins and Orr, 1972:1087, pl. 7, figs. 7, 8 [lower Miocene *G. kugleri* Zone, DSDP Hole 77B, eastern equatorial Pacific Ocean].—Stainforth and others, 1975:263, fig. 111.1-8 [Oligocene, Trinidad and Tanzania].—Krasheninnikov and Pflaumann, 1978:591, pl. 1, figs. 5-7 [Oligocene, DSDP Site 369, eastern North Atlantic Ocean].—Leckie and others, 1993:123, pl. 9, figs. 7-10 [upper Oligocene, Zone P22, DSDP Hole 628A, Little Bahama Bank, western Atlantic Ocean].—Rögl, 1994:135, pl. 1, figs. 1, 2 [Oligocene Zone P21/P22, Cipero Fm., Trinidad], figs. 3, 4, [Zone NP 23, Otenthal, Austria].—Cich and others, 1998:99, pl. 31, figs. 27, 28 [lower Oligocene, Central Paratethys].—Pearson and Wade, 2009:206, pl. 5, figs. 1a-3c [upper Oligocene Zone O6 (= O7), Cipero Fm., Trinidad].—Baldassini and others, 2013:111, text-fig. 4.27 and 4.28 [upper Oligocene Zone P22, Sliema Point section, Malta].

*Globigerina ciperoensis ciperoensis* Bolli.—Bolli, 1957:109, pl. 22, figs. 10a, b [Oligocene *Globorotalia opima* opima Zone, Cipero Fm., Trinidad].—Jenkins, 1977:303, pl. 1, fig. 6 [lower Miocene *G. trilobus* trilobus zone, Seabla Trial Borehole, eastern North Atlantic Ocean].—Toumarkine, 1978, pl. 8, figs. 10, 11 [upper Oligocene *Globigerina ciperoensis ciperoensis* Zone, DSDP Site 363, eastern South Atlantic Ocean].—Bolli and Saunders, 1985:182, fig. 13.1a-b [mid-Oligocene, Cipero Fm., Trinidad], fig. 13.2 and 13.3 [upper Oligocene *G. ciperoensis ciperoensis* Zone, DSDP Site 363, Walvis Ridge, eastern South Atlantic Ocean (reproduced from Toumarkine, 1978)].

*Globigerina ouachitaensis ciperoensis* Bolli.—Blow and Banner, 1962:90, pl. IX, figs. e-g [lower Oligocene Zone O3, Lindi Area, Tanzania].—Hooyberghs and De Meuter, 1972:22, pl. 6, figs. 1a-c [‘upper Oligocene’, Houthalen Sands, Belgium].—Molina, 1979:151, pl. 11, figs. 1A-C [lower Miocene, *Globigerinoides primordius* Zone, Navazuelo section, Guadahortuna, Spain].—Chaproniere, 1981:109, figs. 4Ga-d, 1a-d [upper Oligocene, Ashmore Reef No. 1 Well, northwest Australia].

*Globigerina* (Globigerina) *ciperoensis* Bolli.—Kennett and Srinivasan, 1983:29, pl. 4, figs. 6-8 [upper Oligocene Subzone N4a, DSDP Site 289, Ontong Java Plateau, equatorial Pacific Ocean].

*Globigerina* (Globigerina) *ciperoensis* Bolli.—Spezzaferri and Premoli Silva, 1991:237, pl. IV, figs. 7a-b, pl. V, figs. 3a-d, 4a-d [upper Oligocene Zone P22, DSDP Hole 538A, Gulf of Mexico].—Spezzaferri, 1994:28, pl. 3, figs. 2a-c [upper Oligocene Subzone P21b, DSDP Hole 516F, South Atlantic Ocean].

*Globigerina* (Globigerina) *ciperoensis* Bolli.—Pearson, 1995:46, pl. 1, figs. 13, 14 [upper Oligocene Zone P21/P22, DSDP Hole 872A, Lo-En Guoyt, western Pacific Ocean].

*Globoturbo rotalilata ciperoensis* (Bolli).—Rincón and others, 2007:294 (partim), pl. 5, figs. 6, 7 [upper Oligocene *Globorotalia ciperoensis* zone, Carmen Fm., Colombia].

*Globorotalia opima* subsp. *opima* (Bolli).—Jenkins, 1960:366, pl. 5, fig. 3a-c [upper Oligocene pre-*Globorotalia dehiscens dehiscens* Zone, Lakes Entrance Oil Shaft, Victoria, Australia]. [Not Bolli, 1957.]

*Globigerinastuberculata* (Bolli).—Stainforth and others, 1975:253, pl. 105, figs. 1, 2, 4 [upper Oligocene *Globigerina ciperoensis* Zone, Cipero Fm., Trinidad]. [Not Bolli, 1957.]

*Globigerina ciperoensis angulisuturalis* (Blow).—Jenkins, 1977:302, pl. 1, fig. 4 [lower Miocene *G. trilobus trilobus* zone, Seabla Trial Borehole, eastern North Atlantic Ocean]. [Not Bolli, 1957.]

Not ‘Giant’ *Globigerina ciperoensis* Bolli.—Ujetz and Wernli, 1994:200-201 (partim), pl. 1, figs. 2a-b [lower Oligocene Zone P20, Haute Savoie, France] (= *Globigerinella wagneri*).
Not Globoturborotalita ciperoensis (Bolli).—Rincón and others, 2007:294, pl. 1, figs. 4a-c [upper Oligocene Zone O5, Bolívar, Colombia] (= C. angulisuturalis).

DESCRIPTION.

Type of wall: Normal perforate, spinose, Neogloboquadrina-type wall structure. Pore concentrations average 32 pores/50 μm² test surface area and pore diameters from around 0.9-2.5 μm.

Test morphology: Moderately low trochospiral, globular, lobulate in outline, chambers globular; in spiral view 5 globular, slightly embracing chambers in ultimate whorl, increasing slowly in size, ultimate chamber may be smaller than the penultimate chamber, sutures depressed, straight; in umbilical view 5 globular, slightly embracing chambers, increasing slowly in size, ultimate chamber often smaller than the penultimate chamber, sutures depressed, straight, umbilicus large, open, enclosed by surrounding chambers, aperture umbilical, a rounded arch, bordered by a thin thickened rim; in edge view chambers globular, slightly embracing, initial whorl slightly to moderately elevated.

Size: Maximum diameter of holotype 0.29 mm, minimum diameter 0.26 mm, thickness 0.18 mm.

DISTINGUISHING FEATURES.— The species is distinguished from C. anguliofficinalis and C. angulisuturalis by the typically larger size, and open umbilicus. Its sutures are usually narrow and shallow but can be somewhat incised as in the holotype specimen, this can lead to confusion with C. angulisuturalis. Ciperoella fariasi Bermúdez is morphologically similar but is larger, more globular and has a more elevated initial spire than C. ciperoensis.

DISCUSSION.— This is a well known species in the Oligocene and is the type species for the new genus Ciperoella. ‘Giant’ “Globigerina ciperoensis” recorded by Ujetz and Wernli (1994) from Zone P20 (= O2) of the Haute-Savoie in France appear to be conspecific with Globigerinella wagneri (Chapter 6, this volume) described from an equivalent level in the Central Paratethys region (Rögl, 1994).

Reuss (1850) described Globigerina concinna from the Tertiary (probably Tortonian) of Austria, for large forms possessing 5 globular chambers, with a wide umbilical aperture. This form was recognized by Nuttall (1932) from the Alazan shales of Mexico, and Franklin (1944) from the Oligocene, Carapita Formation, of Venezuela. Cushman and Stainforth (1945) recognized cf. concinna from the Oligocene, Cipero Formation of Trinidad and considered it to be a useful stratigraphic marker. Bolli (1954) investigated the species concept but found that the type material was lost. He concluded that the lower Oligocene specimens recognized by Nuttall (1932), Franklin (1944) and Cushman and Stainforth (1945) were smaller and not directly related to G. concinna and thus described Globigerina ciperoensis to incorporate these forms. The type specimen is that of Cushman and Stainforth (1945), pl. 13, figs. 1a-1b. Note, Bolli and Saunders (1985) indicate that the holotype is from the Globorotalia opima opima Zone, but this is not consistent with Bolli (1954) which indicates the Globigerina ciperoensis Zone.

PHYLOGENETIC RELATIONSHIPS.— Evolved from C. anguliofficinalis in the mid-Oligocene and gave rise to C. fariasi.

TYPE LEVEL.— Globigerina ciperoensis Zone, Cipero Fm., Trinidad.

STRATIGRAPHIC RANGE.— Zone O3 to Subzone M1a. The lowest occurrence is not well constrained. Most records are from the upper Oligocene, but Blow and Banner (1962) record C. ciperoensis in Zone O3 in Tanzania. The top of C. ciperoensis is used as a secondary marker within Subzone M1a (23.68 Ma, Pearson and Chaisson, 1997; Wade and others, 2011).

GEOGRAPHIC DISTRIBUTION.— Occurs in low to mid-latitudes including the North Sea (Hooyberghs and De Meuter, 1972, Hooyberghs and others, 1992) and Paratethys region (Rögl, 1994).

STABLE ISOTOPE PALEOBIOLOGY.— Poore and Others 2007:294, pl. 1, figs. 4a-c [upper Oligocene Zone O5, Bolivar, Colombia] (holotype, USNM 43947), Globigerina ciperoensis Zone, Cipero Fm., Trinidad; 6-8, Zone O6, RDL sample 409, C. ciperoensis type locality, Trinidad; 4, 9, Zone O7, Atlantic Slope Project corehole 5B/5A/0, 6", western North Atlantic slope; 5, 10-12, Zone O6, Atlantic Slope Project corehole 5B/10F/6, 12", western North Atlantic slope; 13, Zone O6, RDL sample 1017, Cipero Fm., Trinidad; 14-17, Zone O6, Cipero Fm., Trinidad. Scale bar: 1-3, 6-16 = 100 μm; 17 = 20 μm; 4, 5 = 50 μm² surface area.
Plate 7.3 Ciperoella ciperoensis (Bolli, 1954)
Matthews (1984) consistently record low δ¹⁸O and high δ¹³C in C. ciperoensis indicative of a symbiotic ecology within the surface mixed-layer.

REPOSITORY.— Holotype (USNM 43947) deposited at the Smithsonian Museum of Natural History, Washington, D.C.

**Ciperoella fariasi** (Bermúdez, 1961)

**Plate 7.4. Figures 1-18**

(Pl. 7.4, Figs. 1-3: new SEMs of holotype of *Globigerina fariasi* Bermúdez)

*Globigerina fariasi* Bermúdez, 1961:1181, pl. 3, figs. 5a-c [mid-Oligocene, Tingnaro Fm., Matanzas Province, Cuba].—Molina, 1979:154, pl. 11, figs. 2A-B [upper Oligocene Zone P22, DSDP Site 538A, Gulf of Mexico].—Bolli and Saunders, 1985:182, fig. 13.9a-c (re-illustration of holotype) [mid-Oligocene, Tingnaro Fm., Matanzas Province, Cuba].

“*Globigerina*” *ciperoensis fariasi* Bermúdez.—Spezzaferri and Premoli Silva, 1991:237, pl. IV, figs. 6a-d [upper Oligocene Zone P22, DSDP Hole 538A, Gulf of Mexico].


Not *Globigerina ouachitaensis fariasi* Bermúdez.—Blow, 1979:778, pl. 2, figs. 1-3 (Blow and Banner holotype of *G. gnaucki* reproduced) [Zone P19, Lindi area, Tanzania] = *Globoturborotalita gnaucki*.

**DESCRIPTION.**

Type of wall: Normal perforate, spinose, *Neogloboquadrina*-type wall structure. Pore concentrations range from around 25-60 pores/50 μm² test surface area and pore diameters from around 0.9-2.5 μm.

Test morphology: High trochospiral, globular, lobulate in outline, chambers globular; in spiral view 5 globular, slightly embracing chambers in ultimate whorl, increasing slowly in size, ultimate chamber may be smaller than the penultimate chamber, sutures depressed, straight; in umbilical view 5 globular, slightly embracing chambers, increasing slowly in size, ultimate chamber often smaller than the penultimate chamber, sutures depressed, straight, umbilicus large, open, enclosed by surrounding chambers, aperture umbilical, a rounded arch, bordered by a thin rim; in edge view chambers globular, slightly embracing, initial whorl of chambers highly elevated.

Size: Maximum diameter of holotype 0.36 mm, minimum diameter 0.30 mm, thickness 0.30 mm.

**DISTINGUISHING FEATURES.**— The species is distinguished from *C. ciperoensis* by the larger more globular test, larger umbilicus and higher trochospire. It bears some resemblance to *Globigerinella wagneri* (Chapter 6, this volume) but has a *Neogloboquadrina*-type wall texture, compared to the *bulloides*-type wall in the former.

**DISCUSSION.**— A relatively less common species. Blow (1979) considered this species to be a prior synonym of *Globigerina ouachitaensis gnaucki* Blow and Banner. However in this work *gnaucki* is regarded as a distinct species within *Globoturborotalita* (see Chapter 8, this volume) and the ancestor of the *Ciperoella* group.

**PHYLOGENETIC RELATIONSHIPS.**— Closely related to *C. ciperoensis* which gave rise to *C. fariasi* in the mid-Oligocene.

**TYPE LEVEL.**—Mid-Oligocene, Tingnaro Formation, Matanzas Province, Cuba.

**STRATIGRAPHIC RANGE.**— Zone O3 to M1 (?) (Spezzaferri, 1994). Pearson and Chaisson (1997) identified this species from Zone O3 at Ceara Rise, equatorial Atlantic Ocean.

**GEOGRAPHIC DISTRIBUTION.**— Occurs in low to middle latitudes.

**STABLE ISOTOPE PALEOBIOLOGY.**— No data available.

**REPOSITORY.**— Holotype (USNM MO 638935) deposited at the Smithsonian Museum of Natural History, Washington, D.C.

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Plate 7.4 Ciperoella fariasi (Bermúdez, 1961)

1-3 (holotype, USNM 638935), upper Oligocene, Cuba; 4, Zone O5, ODP Hole 925A, Ceara Rise, western equatorial Atlantic Ocean; 5-7, 14-17, Zone M1, ODP Site 904/34/5, 144 cm, New Jersey slope; 8-13, 18, Zone M1, ODP Site 904/34/4, 139 cm, New Jersey slope. Scale bar: 1-11, 13-15, 17, 18 = 100 μm; 12, 16 = 50 μm² surface area.
Plate 7.4 Ciperoella fariasi (Bermúdez, 1961)
REFERENCES


HOOYBERGHS, H.J.F., and DE MEUTER, F., 1972, Biostratigraphy and inter-regional correlation of the Miocene deposits of Northern Belgium based on planktonic foraminifera; the Oligocene-Miocene boundary on the southern edge of the North Sea basin, Brussels: Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België.


LECKIE, R.M., FARHAN, C., and SCHMIDT, M.G., 1993, Oligocene planktonic foraminifer biostratigraphy of Hole 803D (Ontong Java Plateau) and Hole 628A (Little Bahama Bank), and comparison with the southern high latitudes, in BERGER, W.H., KROENKE, L.W., MAYER, L.A., and others (eds.): Proceedings of the Ocean Drilling Program, Scientific Results, College Station, TX, v. 130, p. 113-136.


NUTTALL, W.F., 1932, Lower Oligocene Foraminifera from Mexico:
Journal of Paleontology, v. 6, p. 3-35.


Roetzel, R., Ćorić, S., Galović, I., and Rögl, F., 2006, Early Miocene (Ottangian) coastal upwelling conditions along the southeastern scarp of the Bohemian Massif (Parisdorf, Lower Austria, Central Paratethys): Beiträge zur Paläontologie, (Wien), v. 30, p. 387-413.


Subbotina, N.N., 1960, in Subbotina, N.N., Pishvanova, L.S. and Ivanova, L. V., Vsesoyuznogo nauchoissledovat' skogo geologorazvedochnogo instituta (VNIGRI), vyp. 153, Mikrofauna SSSR, Cb. XI: Foraminifery i Radiolariy gretichnikh otlozhenii predkarpat’ya i o va sakhalina, 127 p. [In Russian].


Citation