Cushman Foundation Special Publication No. 46 p. 215-230, 2018

Chapter 7

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

Richard K. Olsson[1], Christoph Hemleben[2], Helen K. Coxall[3], and Bridget S. Wade[4]

[1]Department of Earth and Planetary Sciences, Busch Campus, Rutgers University, Piscataway, NJ 08854, U.S.A.
Email: olsson@rci.rutgers.edu

[2]Department of Geoscience, Sand 6/7 Kernlabor und –Lager, D-72076 Tübingen, FR Germany.
Email: christoph.hemleben@uni-tuebingen.de

[3]Department of Geological Sciences, Stockholm University, SE-106 91, Stockholm, Sweden.
Email: helen.coxall@geo.su.se

[4]Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, U.K.
Email: b.wade@ucl.ac.uk

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-*

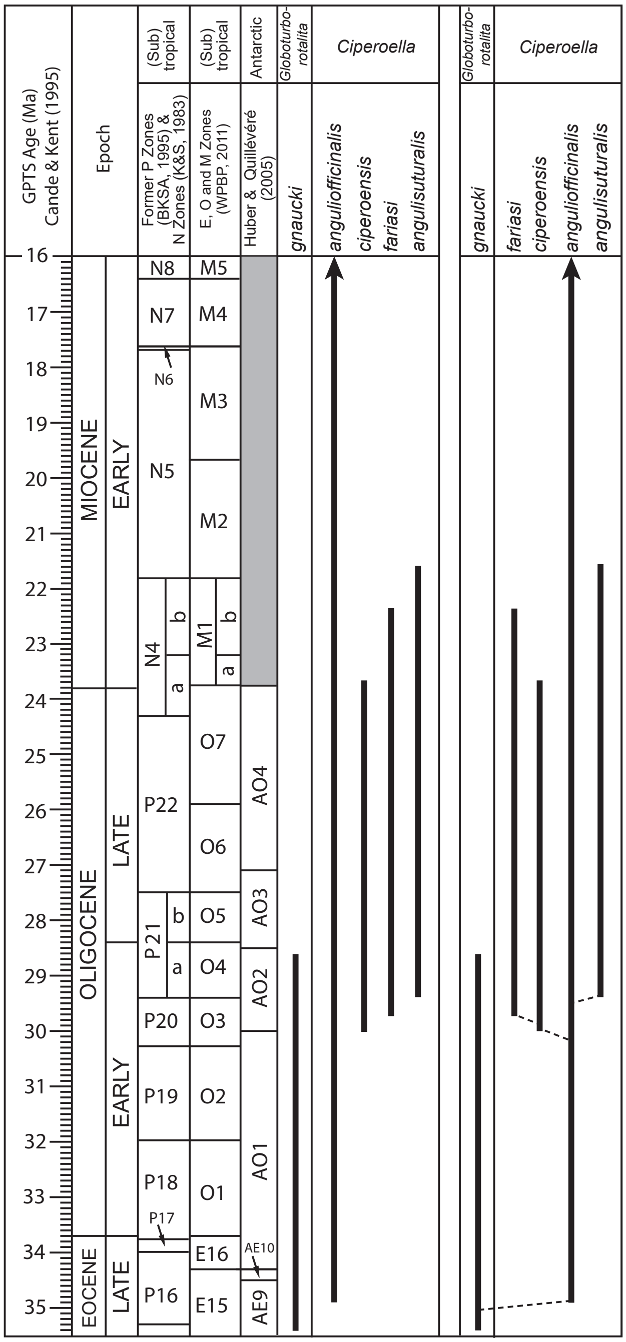

FIGURE 7.1. Stratigraphic ranges and inferred phylogenetic relationships of Oligo-Miocene species of *Ciperoella* discussed in this chapter. BKSA, 1995 = Berggren and others, 1995; K&S, 1983 = Kennett and Srinivasan, 1983; WPBP, 2011 = Wade and others, 2011.

cata (Bolli) is now regarded as a species of *Tenuitella* because it has a microperforate wall (Chapter 16, this volume). Forms previously assigned to '*angustiumbilicata*' can be variably placed in *C. anguliofficinalis* or *Tenuitella angustiumbilicata* 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 decendants from *angustiumbilicata - ciperoensis - angulisuturalis*. This can now be ruled out due to the microperforate affinity of *angustiumbilicata* 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.

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.

TYPE SPECIES.— *Globigerina ciperoensis* Bolli, 1954.

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 µm^2 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 µm^2 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', Edegem 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 Cárdela, 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 Zone P22 (= O7 this study), DSDP Site 538A, Gulf of Mexico].—Spezzaferri, 1994:29, pl. 3, figs. 4a-c [upper Oligocene Subzone P21b, DSDP Site 516F, South Atlantic Ocean].

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, 1994:pl. 1, figs. 11, 12 [lower Miocene, Ottnangien, Kletzenmarkt, Austria], pl. 1, fig. 13 [lower Miocene, Ottnangien, Zwickledt, "Blättermergel", Austria], pl. 1, figs. 14-16 [lower Miocene, upper Ottnangien, Parisdorf, diatomite quarry, Austria].—Cicha and others, 1998:99, pl. 31, figs. 9-14 [lower Oligocene, Central Paratethys].

Globorotalia (?) *brevispira* (*Subbotina*).—Krasheninnikov and Pflaumann, 1978:593, pl. 5, figs. 4, 5 [Oligocene, DSDP Hole 369A, eastern North Atlantic Ocean]. [Not Subbotina, 1960.]

Globigerina (*Globigerina*) *angulisuturalis* (Blow).—Kennett and Srinivasan, 1983:32, pl. 5, figs. 1-3 [upper Oligocene Zone P22, DSDP Site 209, Queensland Plateau, South Pacific Ocean]. [Not Bolli, 1957.]

Globigerina ciperoensis Bolli.—Hooyberghs and others, 1992:9, pl. 2, figs. 13-15 [lower Oligocene Zones P19/P20, Boom Fm., Kruibeke Section, Belgium]. [Not Bolli, 1954.]

Not *Globigerina anguliofficinalis* Blow.—Krasheninnikov and Pflaumann, 1978:592, pl. 5, figs. 1-3 [Oligocene, DSDP Site 369, eastern North Atlantic Ocean] (= *C. fariasi*).

DESCRIPTION.

Type of wall: Normal perforate, spinose, *Neogloboquadrina*-type wall texture. Pore concentrations range from around 25-60 pores/50 µm^2 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 *Globoturborotalita*. 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 ottnangiensis*, 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 *ottnangiensis* 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 *ottnangiensis*. Based on comparisons of the holotype (reproduced here on Pl. 7.1, Fig. 13) and paratype images (Rögl, 1969), we cannot consistently distinguish *ottnangiensis* from *C. anguliofficinalis.* In fact, Rögl (1969, 1994) describes and illustrates a high degree of variability among forms assigned to *ottnangiensis* 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 ottnangiensis* 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** = 25x50 µm surface area, **12** = 25 µm^2 surface area, **18** = 10 µm.

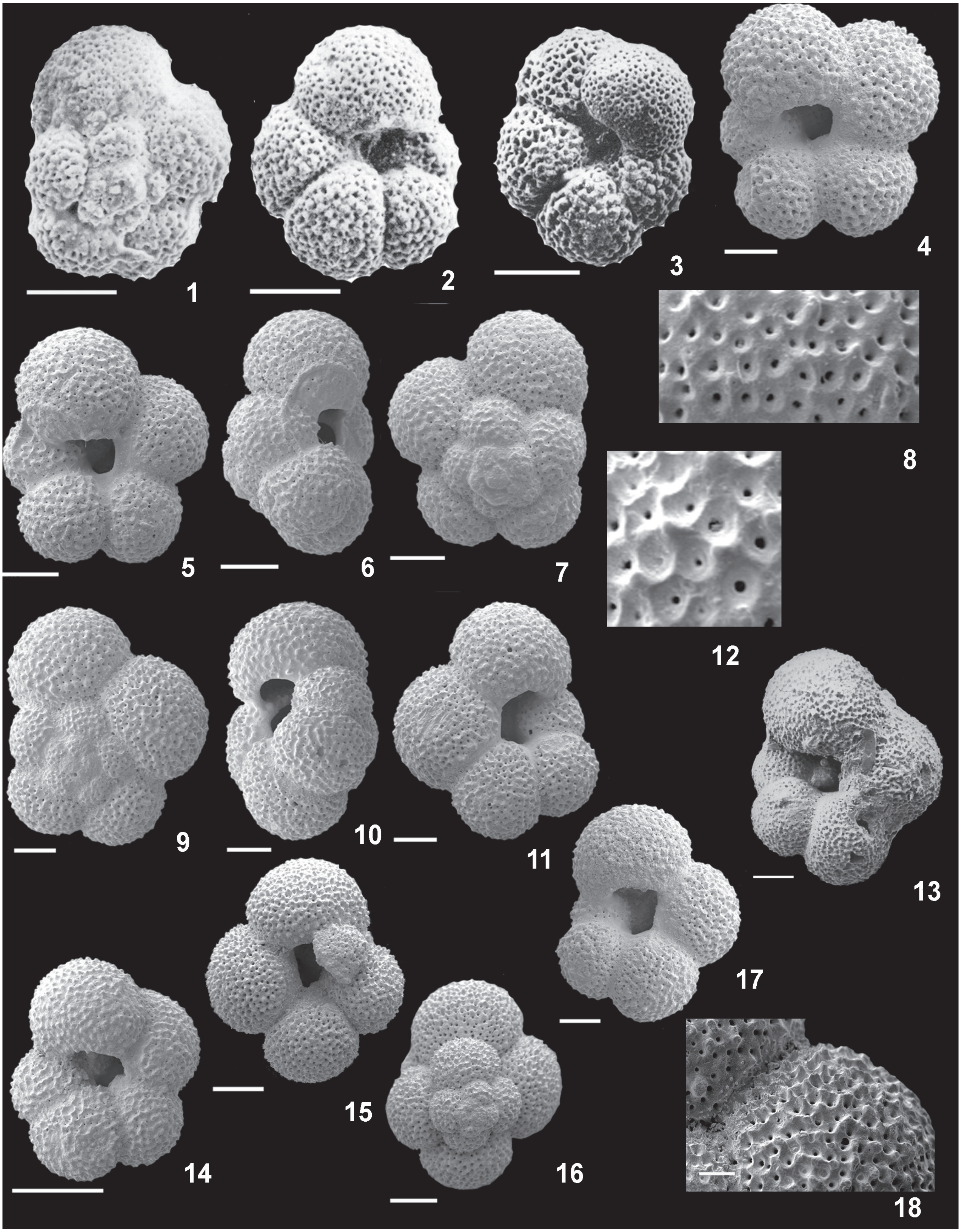

Plate 7.1 *Ciperoella anguliofficinalis* (Blow, 1969)

Basin (Hooyberghs and De Meuter, 1972; Hooyberghs and others, 1992). Among the examples described from the Belgian Boom Clay, several specimens described as '*G. angustiumbilicata* Bolli', but lacking a microperforate wall (that we now know this taxon to possess), can be assigned to *Ciperoella anguliofficinalis* (e.g., Hooyberghs and others, 1992). Pearson and Chaisson (1997) record "*G*." *anguliofficinalis* occurring throughout the range of *ciperoensis* and *angulisuturalis*.

Spezzaferri (1994) records a common highest occurrence for *ciperoensis* and *anguliofficinalis* in the Indian Ocean, Gulf of Mexico and Caribbean, equatorial 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 lower/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 as "*G*." *ottnangiensis* and "*G*." aff. *ottnangiensis* in a number of Atlantic, Indian, and Pacific Ocean deep sea drill sites. Having here synonymized *ottnangiensis* under *anguliofficinalis* we extend the range of *anguliofficinalis* to Zone M5. Further investigation of Miocene sequences (which is beyond the scope of this study) is necessary to further test the morphological and stratigraphic limits of the *ciperoensis*-group in the Paratethys compared to open ocean.

PHYLOGENETIC RELATIONSHIPS.— Evolved from *Ciperoella gnaucki* in the upper Eocene (Zone E15). Gave rise to *C. angulisuturalis* 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 (Spezzaferri, 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 $\delta^{18}O$ for this species indicating a mixed-layer habitat.

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

Ciperoella angulisuturalis (Bolli, 1957)

Plate 7.2. Figures 1-17
(Pl. 7.2, Figs. 1-3: new SEMs of holotype of *Globigerina angulisuturalis* Bolli)

Globigerina ciperoensis angulisuturalis 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 ciperoensis 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 angulisuturalis 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].—Krasheninnikov and Pflaumann, 1978:591, pl. 1, figs. 1, 2 [Oligocene, 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 Bahama 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 angulisuturalis* (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.

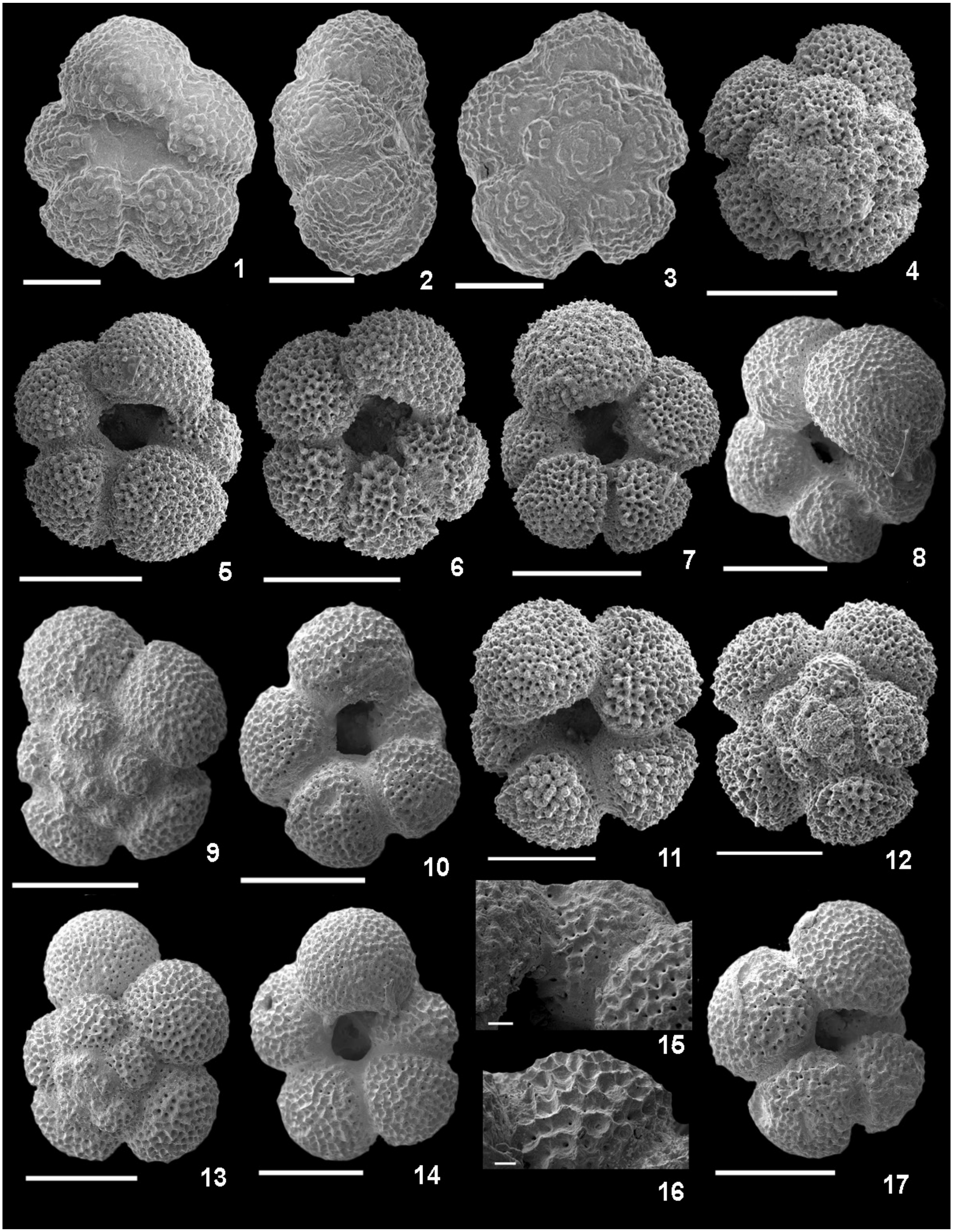

Plate 7.2 *Ciperoella angulisuturalis* (Bolli, 1957)

Central Paratethys].—Pearson and Wade, 2009:203, pl. 5, figs. 4a-c [Zone O6 (= O7), Cipero Fm., Trinidad].

Globigerina officinalis angulisuturalis Bolli.—Chaproniere, 1981:109, figs. 4Ca-Dc [upper Oligocene, Ashmore Reef No. 1 Well, northwest Australia].

Paragloborotalia angulisuturalis (Bolli).—Cifelli, 1982:109, pl. 1, figs. 5, 5a [Oligocene *Globorotalia opima opima* zone, Cipero Fm., Trinidad].

"*Globigerina*" *angulisuturalis* Bolli.—Spezzaferri and Premoli Silva, 1991:237, pl. IV, figs. 1a, 2a-c, 4a-b [mid Oligocene Subzone P21a/b, DSDP Site 538A, Gulf of Mexico].—Spezzaferri, 1994:29, pl. 3, figs. 3a-c [upper Oligocene Subzone P21b, DSDP Site 516F, South Atlantic Ocean].—Pearson, 1995:46, pl. 1, figs. 13, 14 [mid-upper Oligocene Zone P21/P22, ODP Hole 872A, Lo-En Guyot, western Pacific Ocean].

Globoturborotalita angulisuturalis (Bolli).—Baldassini and others, 2013:111, fig. 4, 29, 30 [upper Oligocene, Zone P22, Reqqa Point section and Dingli section, Malta].—Rincón and others, 2007:292, pl. 5, figs. 1, 3 [upper Oligocene *Globoturborotalita ciperoensis* zone, Carmen Fm., Colombia].

Globigerina ottnangiensis Rögl.—Roetzel and others, 2006:394, pl. 5, figs. 1-3 [lower Miocene, Ottnangian stage (=M1b) Bohemian Massif, Parisdorf, Austria, Central Paratethys]. [Not Rögl, 1969.]

Globoturborotalita ciperoensis (Bolli).—Rincón and others, 2007:294 (partim), pl. 1, figs. 4a-c [upper Oligocene Zone O5, Bolívar, Colombia]. [Not Bolli, 1954.]

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

Not *Globigerina* (*Globigerina*) *angulisuturalis* Blow.—Kennett and Srinivasan, 1983:32, pl. 5, figs. 1-3 [upper Oligocene Zone P22, DSDP Site 209, Queensland Plateau, South Pacific Ocean] (= *C. anguliofficinalis*).

DESCRIPTION.

Type of wall: Normal perforate, spinose, *Neogloboquadrina*-type wall. Pore concentrations range from around 25-60 pores/50 μm^2 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. angulisuturalis* 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. angulisuturalis* 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. angulisuturalis* 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.*" *angulisuturalis* 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.

STABLE ISOTOPE PALEOBIOLOGY.— Poore and Matthews (1984) and Shackleton and others (1984) record *C. angulisuturalis* as having isotopic ratios indicative of shallow, mixed-layer habitat.

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, Grinzing, Austria].—Nuttall, 1932:29, pl. 6, figs. 9-11 [Alazan 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, ODP 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, Ottenthal, Austria].—Cicha 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, Sealba 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, Ia-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*" *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*" cf. *ciperoensis* Bolli.—Pearson, 1995:46, pl. 1, figs. 13, 14 [upper Oligocene Zone P21/P22, ODP Hole 872A, Lo-En Guyot, western Pacific Ocean].

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

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

Globigerina angustiumbilicata 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, Sealba 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 µm^2 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

Plate 7.3 *Ciperoella ciperoensis* (Bolli, 1954)

1-3 (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 µm^2 surface area.

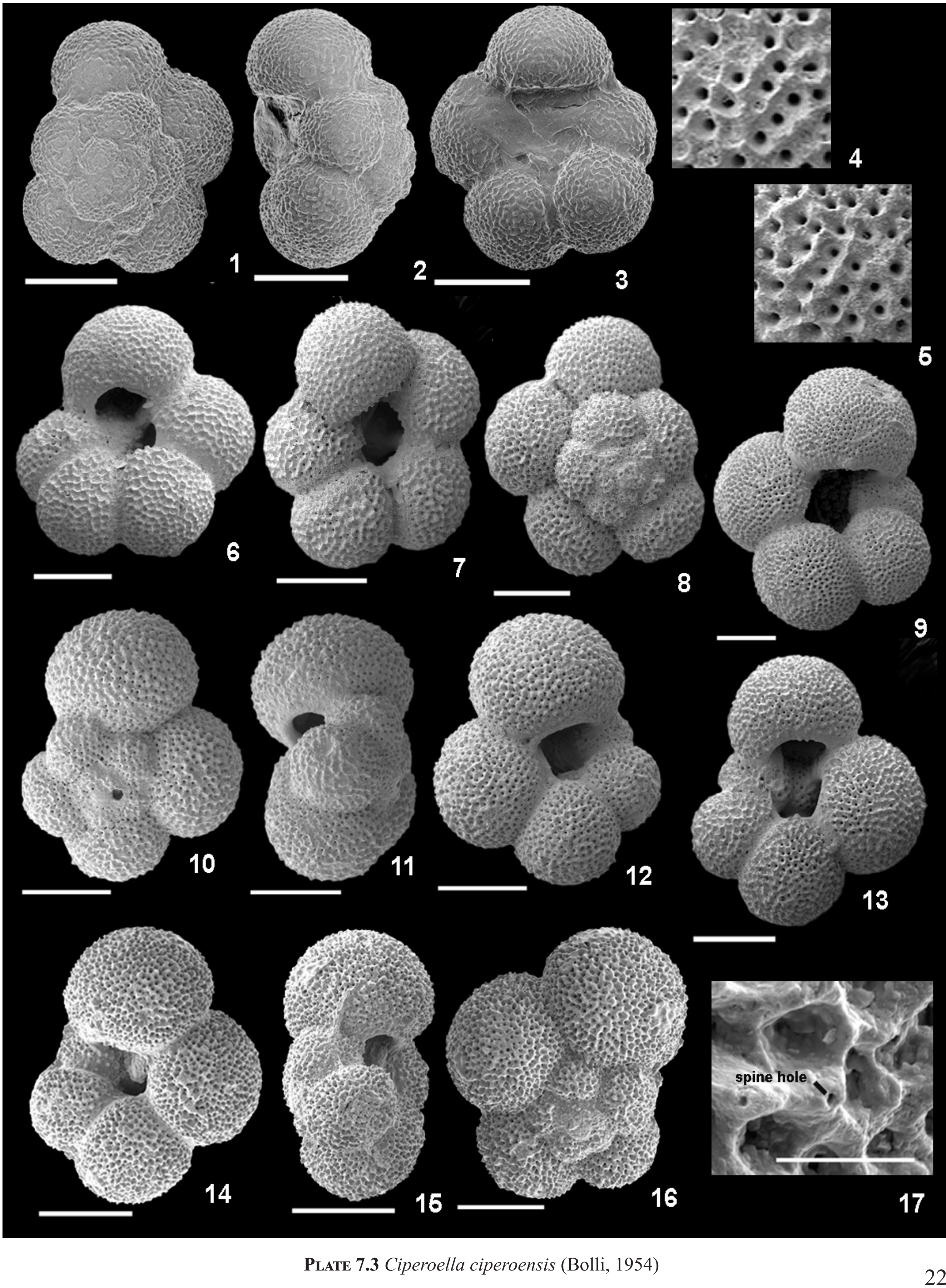

PLATE 7.3 *Ciperoella ciperoensis* (Bolli, 1954)

Matthews (1984) consistently record low $\delta^{18}O$ and high $\delta^{13}C$ 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].

Globigerina anguliofficinalis Blow.—Krasheninnikov and Pflaumann, 1978:592, pl. 5, figs. 1-3 [Oligocene, DSDP Site 369, eastern North Atlantic Ocean]. [Not Blow, 1969.]

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 μm^2 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.

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 μm^2 surface area.

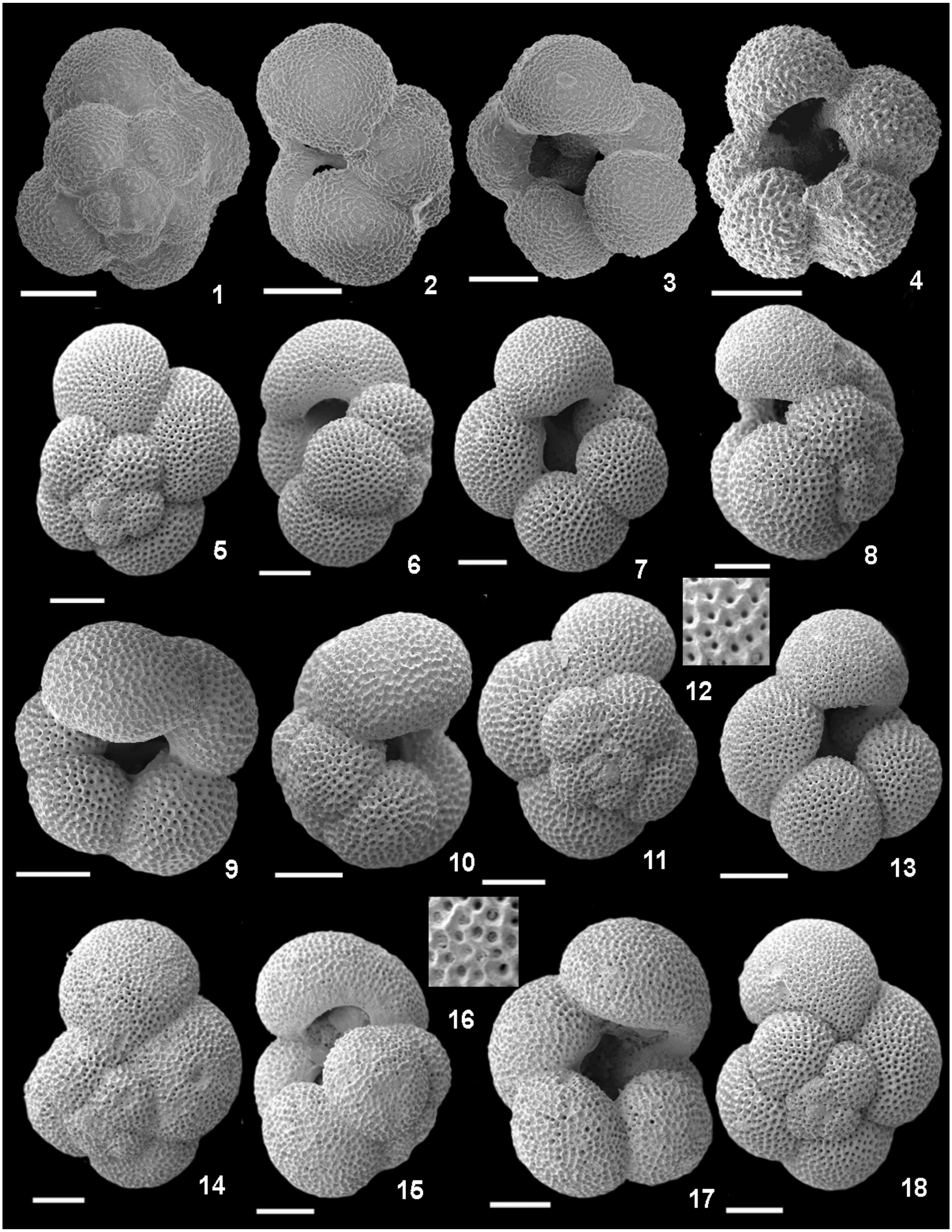

Plate 7.4 *Ciperoella fariasi* (Bermúdez, 1961)

REFERENCES

Aze, T., Ezard, T.H.G., Purvis, A., Coxall, H,K., Stewart, D.H. M., Wade, B.S., and Pearson, P.N., 2011, A phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data: Biological Reviews, v. 86, p. 900-927.

Baldassini, N., Mazzei, R., Foresi, L. M., Riforgiato, F., and Salvatorini, G., 2013, Calcareous plankton bio-chronostratigraphy of the Maltese Lower Globigerina Limestone member: Acta Geologica Polonica, v. 63, p. 105-135.

Berggren, W.A., Kent, D.V., Swisher, III, C.C., and Aubry, M.-P., 1995, A revised Cenozoic geochronology and chronostratigraphy, *in* Berggren W.A., Kent D.V., Aubry M.-P., and Hardenbol, J. (eds.), Geochronology, Time Scales and Global Stratigraphic Correlation: A Unified Temporal Framework for an Historical Geology: SEPM Special Publication, v. 54, p. 129-212.

Bermúdez, P.J., 1961, Contribucion al estudio de las Globigerindea de la region Caribe-Antillana (Paleocene-Reciente): Boletino Geologia (Venezuela), Special Publicacion, v. 3 (Congres Geologia Venezolano, 3d, Caracas, 1959, Mem. 3): p. 1119-1393.

Blow, W.H., 1969, Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy, *in* Brönnimann, P. and Renz, H.H. (eds.): Proceedings of the First International Conference on Planktonic Microfossils, Leiden: E.J. Brill, v. 1, p. 199-422.

———, 1979, The Cainozoic globigerinida. A study of the morphology, taxonomy, evolutionary relationships and the stratigraphical distribution of some of the Globigerinida (mainly Globigerinacea). Leiden, E. J. Brill, v. 3, 1413 pp.

——— and Banner, F.T., 1962, The Mid-Tertiary (Upper Eocene to Aquitanian) Globigerinacea, *in* Eames, F.T., and others (eds.), Fundamentals of Mid-Tertiary Stratigraphical Correlations: Cambridge, Cambridge University Press, p. 61-151.

Bolli, H.M., 1954, Note on *Globigerina concinna* Reuss 1850 (Point-a-Pierre, Trinidad): Contributions from the Cushman Foundation for Foraminiferal Research, v. 5, p. 1-3.

———, 1957, Planktonic foraminifera from the Oligocene-Miocene Cipero and Lengua Formations of Trinidad, B.W.I. United States National Museum Bulletin 215, p. 97-131.

———, and Saunders, J.B., 1985, Oligocene to Holocene low latitude planktic foraminifera, *in* Bolli, H.M., Saunders, J.B., and Perch-Nielsen, K. (eds.), Plankton Stratigraphy: Cambridge: Cambridge University Press, p. 155-262.

Carpenter, W.B., Parker, W.K., and Jones, T.R., 1862, Introduction to the study of the Foraminifera: Ray Society publications, London, 139 p.

Chaproniere, G.C.H., 1981, Late Oligocene to Early Miocene planktic Foraminiferida from Ashmore Reef No. 1 Well, northwest Australia: Alcheringa, v. 5, p. 103-131.

Charollais, J., Hochuli, P., Oektlt, H., Perch-Nielsen, K., Toumarkine, M., Rögl, F., and Pajris, J., 1980, Les Marnes Foraminiféres et les Schistes a Meletta des Chaines Subalpines septentrionales (Haute-Savoie, France): Eclogae Geologicae Helvetiae, v. 73, p. 9-69.

Cicha, I., Rögl, F., Rupp, C. and Ctyroka, I., 1998, Oligocene-Miocene Foraminifera of the Central Paratethys: Abhandlugen Senckenberg. Naturforschung Gesellshaft, v. 549: 325 pp.

Cifelli, R., 1982, Early occurrence of some phylogenetic implications of spiny, honeycomb textured planktonic foraminifera: Journal of Foraminiferal Research, v. 12, p. 105-115.

Cushman, J.A. and Stainforth, R.M., 1945, The foraminifera of the Cipero Marl Formation of Trinidad, British West Indies: Cushman Laboratory for Foraminiferal Research, v. 14, p. 1-75.

D'Orbigny, A., 1826, Tableau méthodique de la classe des Céphalopodes: Annales des Sciences Naturelles, v. 7, p. 245-314.

Douglas, R.G., and Savin, S.M., 1978, Oxygen isotopic evidence for the depth stratification of Tertiary and Cretaceous planktic foraminifera: Marine Micropaleontology, v. 3, p. 175-196.

Franklin, E.S., 1944, Microfauna from the Carapita Formation of Venezuela: Journal of Paleontology, v. 18, p. 301-319.

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.

———,Vercauteren, T., de Meuter, F., and Symons, F., 1992, Foraminiferal studies in the Boom Formation, Ministerie van Economische Zaken, Belgische Geologische Dienst Professional Paper 8, 26 pp.

Howe, H.V., and Wallace, W.E., 1932, Foraminifera of the Jackson Eocene at Danville Landing on the Ouachita, Catahoula Parish, Louisiana: Louisiana Department of Conservation, Geologic Survey, Geologic Bulletin, v. 2, p. 7-118.

Jenkins, D. G., 1960, Planktonic foraminifers from the Lakes Entrance oil shaft, Victoria, Australia: Micropaleontology, v. 6, p. 345-371.

———, 1977, Lower Miocene planktonic foraminifera from a borehole in the English Channel: Micropaleontology, v. 23, p. 297-318.

———, and Orr, W.N., 1972, Planktonic foraminiferal biostratigraphy of the eastern equatorial Pacific—DSDP Leg 9, *in* Hays, J.D., and others (eds.): Initial Reports of the Deep Sea Drilling Project, Washington, D.C. (U.S. Government Printing Office), v. 9, p. 1060-1193.

Kennett, J.P. and Srinivasan, M.S., 1983, Neogene Planktonic Foraminifera, Hutchinson Ross Publishing Co., Stroudsburg, Pennsylvania, 265 pp.

Krasheninnikov, V.A., and Pflaumann, U. 1978, Cretaceous agglutinated foraminifera of the Atlantic Ocean off west Africa (Leg 41, Deep Sea Drilling Project), *in* Lancelot, Y., Seibold, E. and others (eds.): Initial Reports of the Deep Sea Drilling Project, U.S. Government. Printing Office, Washington, D.C., v. 41, p. 565-580.

Leckie, R.M., Farnham, 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.

McGowran, B., and Li, Q., 1993, Miocene planktonic planktonic foraminifera from Lakes Entrance in Gippsland: mid-latitude neritic signal from a transforming ocean: Memoir of the Association of Australian Palaeontologists, v. 15, p. 395-405.

Molina, E., 1979, Oligoceno-Mioceno inferior por media de foraminiferos planctonicos en el sector central de las Cordilleraa Beticas Espana, (Tesis doctoral): Publicacion Universidades de Granada y Zaragoza, 342p.

Nuttall, W.L.F., 1932, Lower Oligocene Foraminifera from Mexico:

Journal of Paleontology, v. 6, p. 3-35.

Olsson, R.K., Hemleben, Ch., Huber, B.T., and Berggren, W.A., 2006, Taxonomy, biostratigraphy, and phylogeny of Eocene *Globigerina*, *Globoturborotalita*, *Subbotina*, and *Turborotalita*, *in* Atlas of Eocene Planktonic Foraminifera, Pearson, P.N., Olsson, R.K., Huber, B.T., Hemleben, Ch., and Berggren, W.A. (eds.), Cushman Foundation for Foraminiferal Research, Special Publication, No. 41, p. 111-168.

Pearson, P.N., 1995, Planktonic foraminifer biostratigraphy and the development of pelagic caps on guyots in the Marshall Islands Group, *in* Haggerty, J., Premoli Silva, I., Rack, F., McNutt, M.K. (eds.): Proceedings of the Ocean Drilling Program, Scientific Results, v. 144: College Station, Texas (Ocean Drilling Program), p. 21-59.

———, and Chaisson, P., 1997, Late Paleocene to middle Miocene planktonic foraminifer biostratigraphy of the Ceara Rise, *in* Shackleton, N.J., Curry, W.B., Richter, C., and Bralower, T.J. (eds.): Proceedings of the Ocean Drilling Program Scientific Results, v. 154: College Station, Texas (Ocean Drilling Program), p. 33-68.

———, and Wade, B.S., 2009, Taxonomy and stable isotope paleoecology of well-preserved planktonic foraminifera from the uppermost Oligocene of Trinidad: Journal of Foraminiferal Research, v. 39, p. 191-217.

Poore, R.Z., 1979, Oligocene through Quaternary planktonic foraminiferal biostratigraphy of the North Atlantic: DSDP Leg 49, *in* Luyendyk, B.P., Cann, J.R., and others (eds.): Initial Reports of the Deep Sea Drilling Project, U.S. Government Printing Office, Washington, D.C., v. 49, p. 447-581.

———, and Matthews, R.K., 1984, Oxygen isotope ranking of Late Eocene and Oligocene planktonic foraminifers: implications for Oligocene sea-surface temperature and global ice volume: Marine Micropaleontology, v. 9, p. 111-134.

Reuss, A.E., 1850, Neue Foraminiferen aus den Schichten des Österreichischen Tertiärbeckens: K. Akad. Wiss Wien, Math.-naturw. Kl. v. 1, p. 365-390.

Rincón, D., Arenas, J.E., Cuartas, C.H., Cárdenas, A.L., Molinares, C.E., Caicedo, C., and Jaramillo, C., 2007, Eocene–Pliocene planktonic foraminifera biostratigraphy from the continental margin of the southwest Caribbean: Stratigraphy, v. 4, p. 261-311.

Roetzel, R., Ćorić, S., Galović, I., and Rögl, F., 2006, Early Miocene (Ottnangian) 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.

Rögl, F., 1969, Die Foraminiferenfauna aus den Phosphoritsanden von Plesching bei Linz (Oberösterreigh).-Ottnangien (Untermiozän): Naturkundliches Jahrbuch der Stadt Linz, p. 213-234.

———, 1994, *Globigerina ciperoensis* (Foraminiferida) in the Oligocene and Miocene of the Central Parathethys: Annuales Naturhistorisches Museum, Wien, v. 96A, p.133-159.

Shackleton, N. J., Hall, M. A., and Boersma, A., 1984, Oxygen and carbon isotope data from Leg 74 foraminifers, *in* Moore, T.C. and Rabinowitz, P.D., and others (eds.): Initial Reports of the Deep Sea Drilling Project, U.S. Government Printing Office, Washington, D.C., v. 74, p. 599-612.

Spezzaferri, S., 1994, Planktonic foraminiferal biostratigraphy and taxonomy of the Oligocene and lower Miocene in the oceanic record. An overview. Palaeontographia Italica, v. 81, 187p.

———, and Premoli Silva, I., 1991, Oligocene planktonic foraminiferal biostratigraphy and paleoclimatic interpretation from Hole 538A, DSDP Leg 77, Gulf of Mexico: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 83, p. 217-263.

Stainforth, R.M., Lamb, J.L., Luterbacher, H. Beard J.H., and Jeffords R.M., 1975, Cenozoic planktonic foraminiferal zonation and characteristics of index forms, University Kansas Paleontological Contributions., Art. 62, p. 1-425.

Subbotina, N.N., 1960, *in* Subbotina, N.N., Pishvanova, L.S. and Ivanova, L. V., Vsesoyuzhnogo Neftyanogo nauchnoissledovatel'skogo geologorazvedochnogo instituta (VNIGRI), vyp. 153, Mikrofauna SSSR, Cb. XI: Foraminifery i Radiolyarii tretichnikh otlozhenii predkarpat'ya I o va sakhalina, 127 p. [In Russian].

Székely, S.-F., and Filipescu, S., 2016, Biostratigraphy and paleoenvironments of the Late Oligocene in the north-western Transylvanian Basin revealed by the foraminifera assemblages: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 449, p. 484-509.

Toumarkine, M., 1978, Planktonic foraminiferal biostratigraphy of the Paleogene of Sites 360 to 364 and the Neogene of Sites 362A, 363, and 364 Leg 40, *in* Bolli, H.M., Ryan, W.B.F. and others (eds.): Initial Reports of the Deep Sea Drilling Project: U.S. Government Printing Office, Washington, D.C., v. 40, p. 679-721.

Ujetz, B., and Wernli, R., 1994, "*Globigerina ciperoensis*", atypically giant planktonic foraminifers from the Oligocene of the Haute-Savoie, France: Annuales Naturhistorisches Museum, Wien, v. 96A, p. 199-207.

Wade, B.S., Pearson, P.N., Berggren, W. A., and Pälike, H., 2011, Review and revision of Cenozoic tropical planktonic foraminiferal biostratigraphy and calibration to the geomagnetic polarity and astronomical time scale: Earth-Science Reviews, v. 104, p. 111-142.

Citation

Olsson, R.K., Hemleben, Ch., Coxall, H.K. and Wade, B.S., 2018, Taxonomy, biostratigraphy, and phylogeny of Oligocene *Ciperoella* n. gen., *in* Wade, B.S., Olsson, R.K., Pearson, P.N., Huber, B.T. and Berggren, W.A. (eds.), Atlas of Oligocene Planktonic Foraminifera, Cushman Foundation of Foraminiferal Research, Special Publication, No. 46, p. 215-230.