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Chapter 13

TAXONOMY, BIOSTRATIGRAPHY, AND PHYLOGENY OF OLIGOCENE *ACARININA*

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ABSTRACT

The taxonomy, phylogeny and biostratigraphic ranges of three Oligocene species of *Acarinina* are discussed together with their synonymies. Acarinina diversified in the Paleocene and Eocene and only a few species remain in the OligoceneThe following taxa are recognized as valid species: *Acarinina collactea* (Finlay), *Acarinina echinata* (Bolli), and *Acarinina medizzai* (Toumarkine and Bolli).

INTRODUCTION

The muricate wall texture which is characterized by multiple pustules on the test surface is present in many early Paleogene planktonic foraminifera (e.g., *Morozovelloides, Acarinina, Morozovella, Igorina, Pearsonites*). All these genera were abundant in tropical / subtropical oceans of the early Paleogene. Stable isotope data suggest that muricate forms dominated in the upper part of the water column and have been inferred as mixed-layer dwellers (e.g., Boersma and others, 1987; Pearson and others, 1993; Wade and Kroon, 2002; Wade, 2004; Luciani and others, 2017a). Size fraction carbon isotope analysis also suggests that the muricate forms had a symbiotic relationship with algae (e.g., Pearson and others, 1993; Norris, 1996; Kelly and others, 1998; Wade and others, 2008; Luciani and others, 2017b).

The taxonomy and phylogeny of Paleocene and Eocene *Acarinina* has been addressed in Olsson and others (1999) and Berggren and others (2006), respectively. The diversity of the acarininids decreased through the Eocene, with 16 species recognized in the latest early Eocene (~50 Ma), diminishing to 6 in the latest middle Eocene (~40 Ma; Berggren and others, 2006). The turnover of planktonic foraminifera at the end of the Bartonian saw the demise of many of the muricate forms with the extinction of *Morozovelloides* and the large (>250 μm) acarininids (Wade, 2004; Wade and others, 2012). Small acarininids continued in the <125 μm size fractions through the latest Eocene (Wade, 2004; Berggren and others, 2006; Agnini and others, 2011) but it has generally been accepted that all muricate forms were extinct prior to the Eocene / Oligocene boundary (Berggren and others, 2006). However, our studies of Oligocene sediments from multiple locations indicate that the acarininid lineage continued through the Oligocene and perhaps into the Miocene. These documented occurrences of muricate forms in the Oligocene are significant and suggest that this ancient and now extinct group continued for >10 myr later than previously documented. All these forms are distinctive, small in size (<125 μm), and thought to be *in situ* because they occur in the absence of other small reworked species. Here we report and illustrate Oligocene muricate planktonic foraminifera assigned to *Acarinina* from the Pacific, Indian and Atlantic Oceans.

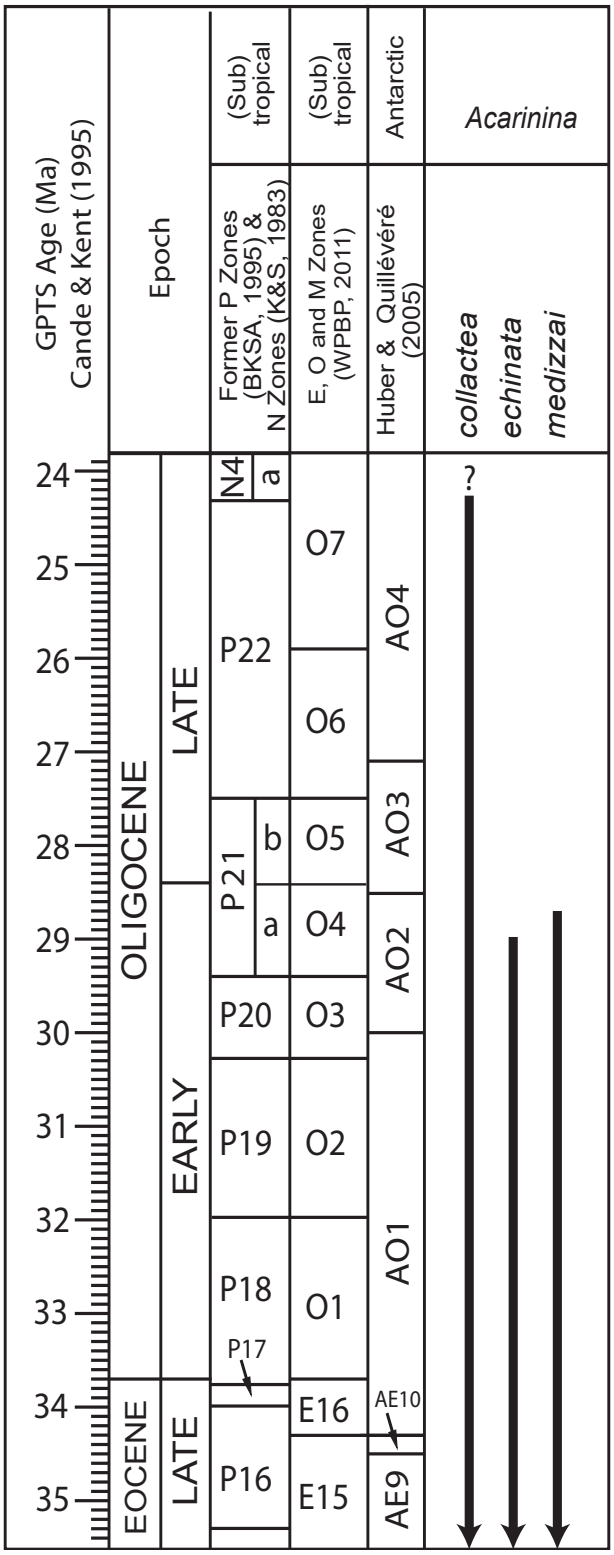

FIGURE 13.1. Stratigraphic ranges of Oligocene species of *Acarinina* discussed in this chapter. BKSA, 1995 = Berggren and others, 1995; K&S, 1983 = Kennett and Srinivasan, 1983; WPBP, 2011 = Wade and others, 2011.

We suggest that these taxa are not reworked but true descendants of Eocene *Acarinina* and an extension of the ancient muricate phylogeny.

The Oligocene acarininids are generally rare and never dominate the assemblages like their Eocene ancestors. It has therefore been difficult to constrain their ranges and phylogeny. The Oligocene acarininids differ from early Paleogene forms in that they are characterized by muricae which are blunter, shorter, and more widely dispersed. They differ from dipsidripellids by their normal perforate wall and more evenly distributed muricae (rather than short hispid pustules). While the large Eocene acarininids are well documented as having been mixed-layer dwellers with photosymbionts, it is not clear whether these small Oligocene forms shared that ecological preference. The species level range-chart is presented in Figure 13.1.

In addition to the species discussed, *Acarinina inaequiconica* Subbotina, 1960 was described from Oligocene sediments in the Ciscarpathian region of Ukraine (Subbotina and others, 1960). Our new SEMs of the holotype reveal a small, low trochospiral specimen, but the poor preservation has inhibited the determination of the taxonomic affinity of this form (see Chapter 20, this volume).

SYSTEMATIC TAXONOMY

Order FORAMINIFERIDA d'Orbigny, 1826
Superfamily GLOBIGERINOIDEA Carpenter, Parker, and Jones, 1862
Family TRUNCOROTALOIDIDAE Loeblich and Tappan, 1961

DISCUSSION.—See Olsson and others (1999:45).

Genus *Acarinina* Subbotina, 1953

Truncorotaloides Brönnimann and Bermúdez, 1953.
Pseudogloboquadrina Jenkins, 1965b:1122.
Muricoglobigerina Blow, 1979:1118.

TYPE SPECIES.—*Acarinina acarinata* Subbotina, 1953 (= junior subjective synonym of *Globigerina nitida* Martin, 1943; see Olsson and others, 1999).

DISCUSSION.—See Olsson and others (1999:46) and Berggren and others (2006:261) for general comments.

Acarinina collactea (Finlay, 1939)

Plate 13.1, Figures 1-16

(Pl. 13.1, Figs. 1-3: re-illustration of holotype of *Globorotalia collactea* Finlay)

See Berggren and others (2006:276) for full synonymy list.

Globorotalia collactea Finlay, 1939:327, pl. 29, figs. 164, 165 [middle Eocene, Hampden Beach, North Otago, New Zealand].

Truncorotaloides collactea (Finlay).—Jenkins, 1965a:843-848, figs. 1-27 [middle Eocene, Hampden Beach, North Otago, New Zealand].

Acarinina collactea (Finlay).—Pearson and Wade, 2015: 25, fig. 30.1 [lower Oligocene Zone O1, TDP Site 11, Tanzania].

DESCRIPTION.

Type of wall: Moderately to coarsely muricate, normal perforate, nonspinose.

Test morphology: Chambers arranged in a low to moderate trochospiral, test compact, typically 4½ -5 chambers in the final whorl, slowly increasing in size; peripheral outline weakly lobate; chambers on the umbilical side wedge-shaped or triangular with blunt and blocky muricae; sutures distinct, straight, radial and wide; umbilicus narrow, deep; umbilical-extraumbilical aperture; weakly convex to flat; on spiral side 10-12 sub-circular chambers in three whorls; sutures weakly incised, curved; rounded to subangular peripheral margin in edge view (modified after Berggren and others, 2006).

Size: Maximum diameter of holotype 0.18 mm, thickness 0.13 mm.

DISTINGUISHING FEATURES.— *Acarinina collactea* is characterized by its compact test, subangular chambers that increase slowly in size, and wide, incised sutures. It differs from *Acarinina medizzai* and *A. echinata* by its lower trochospire, wedge shaped and more angular chambers.

DISCUSSION.— Berggren and others (2006) noted that this taxon is a particularly common form in mid-high latitude assemblages, but the extension of the range of *Acarinina collactea* into the upper Eocene was controversial. *Acarinina collactea* is the most common Oligocene acarininid. Here we extend the range of this taxon further to the upper Oligocene (Zone O7). Berggren and others (2006) restricted *Acarinina collactea* to exclusively dextrally coiled specimens (see their plate 9.8). We illustrate specimens with angular chambers and wide sutures that are consistent with *Acarinina collactea* although they are sinistrally coiled (Plate 13.1, Figs. 11-16). Jenkins (1965a) found 95% of specimens from the type locality to be dextrally coiled.

PHYLOGENETIC RELATIONSHIPS.— Berggren and others (2006) tentatively suggested that *Acarinina collactea* evolved from *Acarinina pentacamerata*. *Acarinina collactea* probably gave rise to *A. medizzai*.

STRATIGRAPHIC RANGE.— Zone E7 (Berggren and others, 2006) to Zone O7 (this study), possibly ranges into the Miocene.

TYPE LEVEL.— Middle Eocene, Hampden Beach, North Otago, New Zealand.

GEOGRAPHIC DISTRIBUTION.— Cosmopolitan distribution in the Eocene. Our Oligocene records are from the Adriatic Sea and western Indian Ocean.

STABLE ISOTOPE PALEOBIOLOGY.— No data available.

REPOSITORY.— Holotype (TF 1150/1) and paratypes deposited in collections of the New Zealand Geological Survey Survey Collection, Lower Hutt, New Zealand.

Acarinina echinata (Bolli, 1957)

Plate 13.2, Figures 1-16

(Pl. 13.2, Figs. 1-3: re-illustration of holotype of *Catapsydrax echinatus* Bolli)

See Berggren and others (2006:284) for full synonymy list and taxonomic discussion.

Catapsydrax echinatus Bolli, 1957:165, pl. 37, figs. 2-5 [middle Eocene *Porticulasphaera mexicana* Zone, Navet Fm., Trinidad].—Huber, 1991:439, pl. 5, figs. 17, 20 [lower Oligocene Zone AP13, ODP Hole 744A, Kerguelen Plateau].

Acarinina sp. (Bolli).—Grimm and others, 2005:246, pl. 1, fig. 11 [lower Oligocene, Bodenheim Fm., Mainz Basin, Germany].

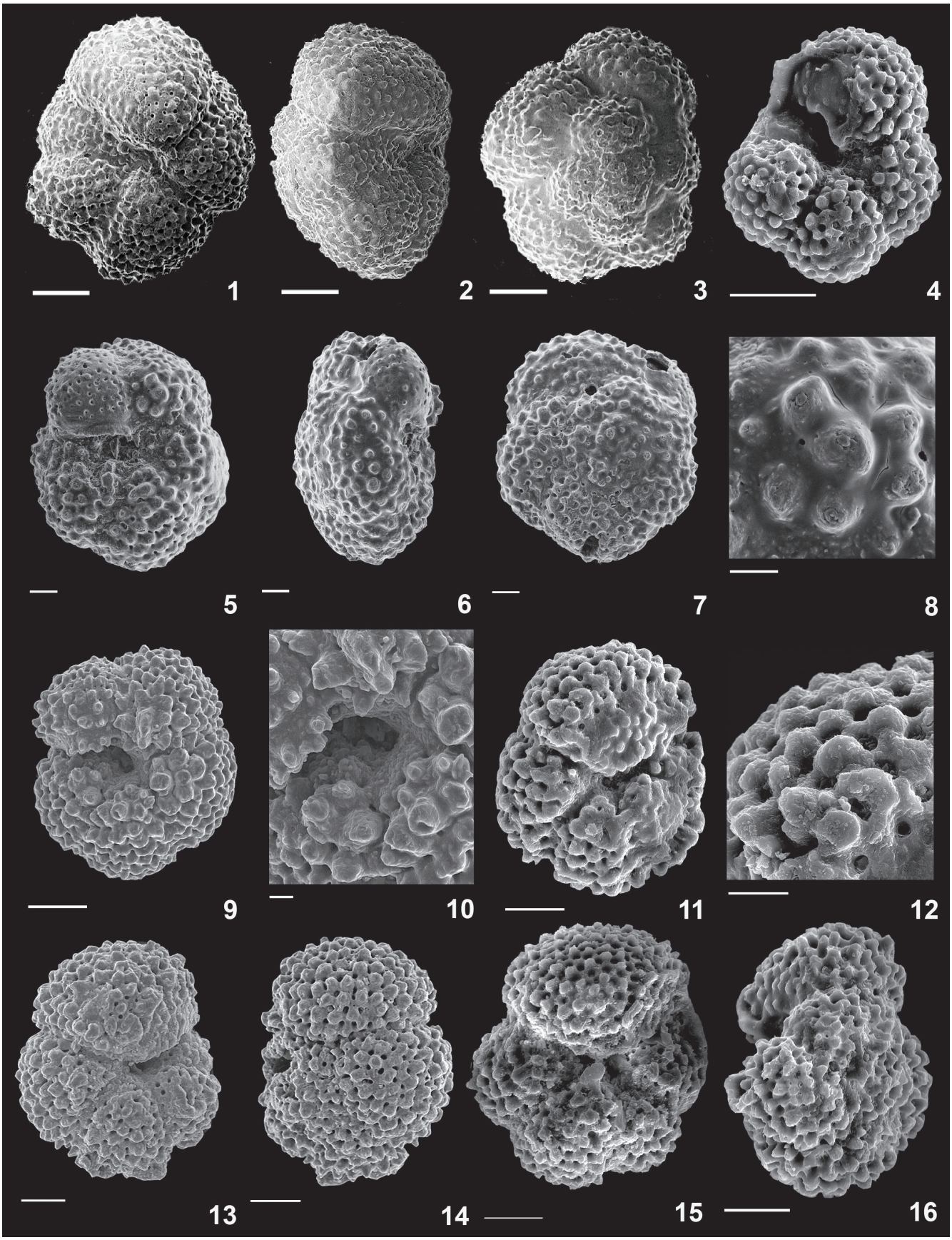

Plate 13.1 *Acarinina collactea* (Finlay, 1939)

DESCRIPTION.

Type of wall: Moderately to coarsely muricate, normal perforate, nonspinose.

Test morphology: Overall outline circular to subcircular. "Test compact, biconvex, peripheral outline weakly to moderately lobate, axial periphery rounded, more rarely becoming slightly subangular; chambers globular, 11-13 in adult tests increasing rapidly in size until ultimate chamber, which is usually kummerform and often connected to a variably shaped bulla that often covers the umbilicus and part or most of the umbilical sutures, 3½-4 chambers in the final whorl; umbilical sutures radial, weakly to moderately depressed, spiral sutures radial, weakly depressed to indistinct; aperture variable in size, shape, position and number depending on the characteristics of the bullate final chamber, usually a single low arched opening directed towards the umbilicus and surrounded by a narrow lip, more rarely two or three small, low arched openings directed along umbilical sutures" (Berggren and others, 2006:284).

Size: Maximum diameter of holotype 0.30 mm, thickness 0.25 mm.

DISTINGUISHING FEATURES.— "Characterized by its compact coiling, muricate surface texture, and presence of a kummerform or bullate final chamber and/or sutural bullae. Differs from *Acarinina medizzai* by lacking a visible umbilicus and presence of kummerform or bullate final chamber" (Berggren and others, 2006:284).

DISCUSSION.— Among the Oligocene acarininids *Acarinina echinata* is not very common.

PHYLOGENETIC RELATIONSHIPS.— Berggren and others (2006) suggested that *Acarinina echinata* may have evolved from *Acarinina pseudosubsphaerica* during the middle Eocene. There are no known descendants.

STRATIGRAPHIC RANGE.— The range of *Acarinina echinata* is poorly constrained. It was described from Zone E10 (Bolli, 1957), our highest recorded specimens are from Zone O3/O4.

TYPE LEVEL.— Middle Eocene *Porticulasphaera mexicana* Zone, Navet Fm., Trinidad.

GEOGRAPHIC DISTRIBUTION.— Rare, but globally distributed in high and low latitudes. We have recorded Oligocene occurrences from the Indian Ocean, Pacific Ocean, Paratethys, and Kerguelen Plateau.

STABLE ISOTOPE PALEOBIOLOGY.— No data available.

REPOSITORY.— Holotype (USNM P5729) deposited at the Smithsonian Museum of Natural History, Washington, D.C.

Acarinina medizzai (Toumarkine and Bolli, 1975)

Plate 13.3, Figures 1-16

(Pl. 13.3, Figs. 1-4: re-illustration of holotype and paratype of *Globigerina medizzai* Toumarkine and Bolli)

See Berggren and others (2006:294) for full synonymy list and taxonomic discussion (and also discussion, below).

Globigerina medizzai Toumarkine and Bolli, 1975:77, pl. 6, figs. 1-8, pl. 5, figs. 8, 10, 13-15, 17, 19-22 [upper Eocene, Scaglia Cinerea, *Globigerinatheka semi-involuta* Zone, Possagno, Treviso, Northern Italy].

DESCRIPTION.

Type of wall: Moderately to coarsely muricate, normal perforate, nonspinose.

Test morphology: Test relatively small, biconvex, quadrate to subcircular in outline, weakly to moderately lobate with a rounded periphery; chambers globular, 8-12 arranged in a low trochospire of 3-4 whorls, increasing moderately in size, 4-6 in the final whorl, rarely kummerform; umbilicus narrow in more compact specimens, shallow and broad in more evolute

Plate 13.1 *Acarinina collactea* (Finlay, 1939)

1-3, holotype (Berggren and others, 2006, pl. 9.8, figs. 1-3), middle Eocene, Hampden Beach, New Zealand; **4**, Zone O4/O5, Istra More-3 well, 1045 m, Adriatic Sea; **5-8**, (5, Pearson and Wade, 2015, pl. 30, fig. 1a, b) Zone O1, TDP Site 11/19/1, 60-75 cm, Stakishari, Tanzania; **9-10**, **13-14**, Zone O1, DSDP Site 242, 10/5, 100-103 cm, western Indian Ocean; **11-12**, Zone E16, Istra More-3 well, 1295 m, Adriatic Sea; **15-16**, Zone O5, Istra More-3 well, 968-974 m, Adriatic Sea. Scale bar: **4**, **9**, **11**, **13-16** = 50 μm; **1-3** = 40 μm; **5-7**, **12** = 20 μm; **8**, **10** = 10 μm.

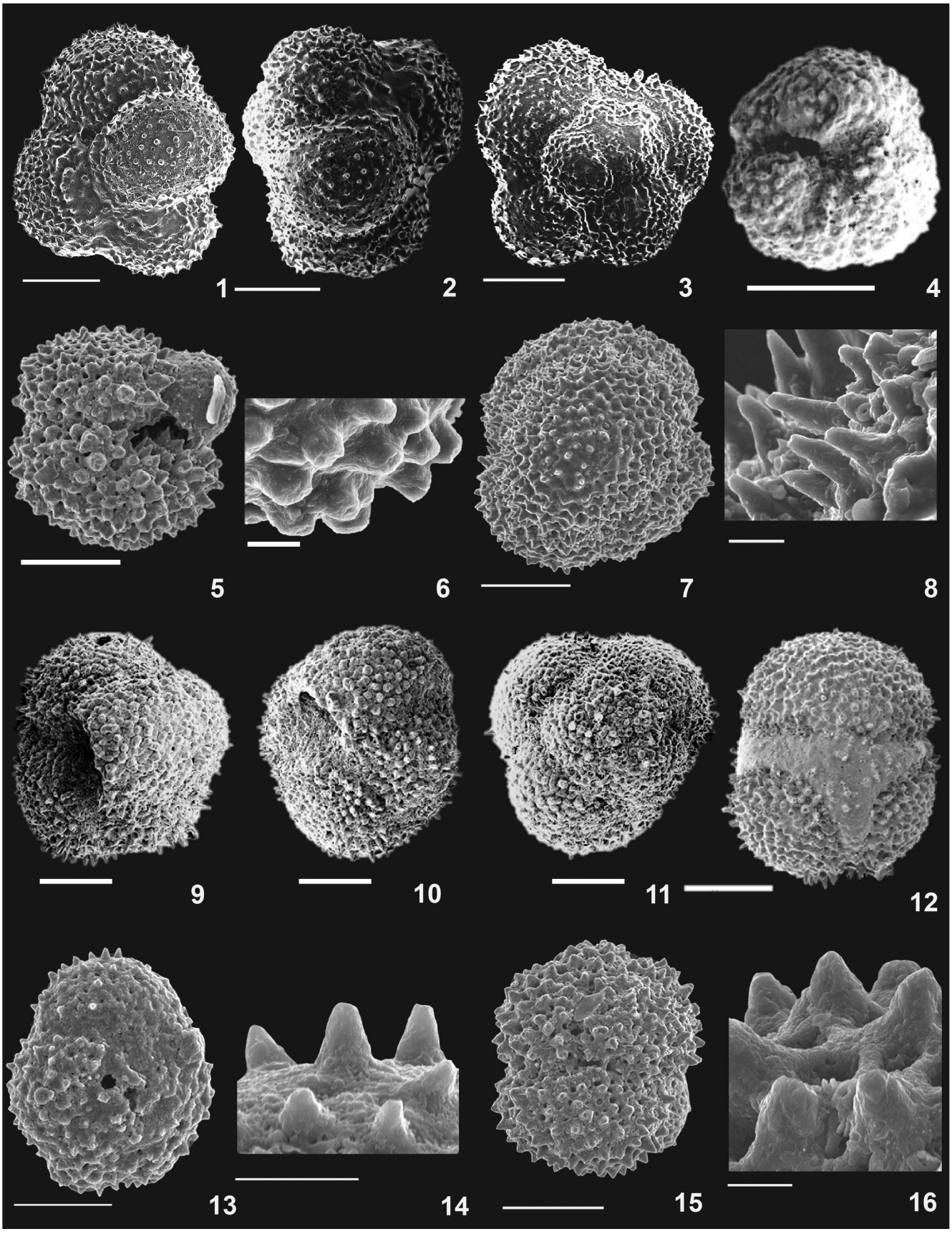

Plate 13.2 *Acarinina echinata* (Bolli, 1957)

forms; sutures weakly depressed, radial on both sides; aperture a small and often indistinct low umbilical to slightly extraumbilical arch (modified from Berggren and others, 2006).

Size: Maximum diameter of holotype 0.19 mm; test sizes range from 0.16 to 0.20 mm.

DISTINGUISHING FEATURES.— *Acarinina medizzai* differs from *A. collactea* in its more rounded chambers, lobate outline and more open umbilicus. It "differs from *A. echinata* in the absence of a bulla and in the presence of an umbilicus" (Berggren and others, 2006:294). It is distinguished from *Dipsidripella danvillensis* (Howe and Wallace) by its muricate wall texture and lower arched aperture.

DISCUSSION.— *Acarinina medizzai* is not common in the Oligocene. See discussion in Berggren and others (2006).

PHYLOGENETIC RELATIONSHIPS.— Probably descended from *Acarinina collactea*.

STRATIGRAPHIC RANGE.— The range is poorly constrained. *Acarinina medizzai* evolved in middle Eocene Zone E10 (Berggren and others, 2006). Our youngest recorded occurrences are from Zone O4.

TYPE LEVEL.— Upper Eocene, Scaglia Cinerea, *Globigerinatheka semi-involuta* Zone, Possagno, Treviso, Northern Italy.

GEOGRAPHIC DISTRIBUTION.— In the Oligocene we have recorded this species from the Adriatic Sea and western Indian Ocean.

STABLE ISOTOPIC PALEOBIOLOGY.— No data available.

REPOSITORY.— Holotype (C 24315) and paratypes (C 27327-27329) deposited at the Basel Museum of Natural History.

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Plate 13.2 *Acarinina echinata* (Bolli, 1957)

1-3 (holotype, USNM 5729), Zone E12, Navet Fm., Trinidad; **4** (Grimm and others, 2005, pl. 1, fig. 11), lower Oligocene, Bodenheim Fm., Mainz Basin, Germany; **5-6**, **15-16**, Zone O1, DSDP Site 242, 10/4, 100-103 cm, western Indian Ocean; **7-8**, Zone O2, DSDP Hole 516F, 30/6 125-126 cm, Rio Grande Rise, South Atlantic Ocean; **9-11**, **12** (9-11, same specimen), (Berggren and others, 2006, pl. 9.10, figs. 6-8, 22), Zone AO1, ODP Hole 744A/15H/CC, Kerguelen Plateau, South Indian Ocean; **13-14**, Zone O1, DSDP Site 242, 10/6, 106-109 cm, western Indian Ocean. Scale bar: **1-5**, **7**, **9-12**, **15** = 100 μm; **13** = 50 μm; **6**, **8**, **14**, **16** = 10 μm.

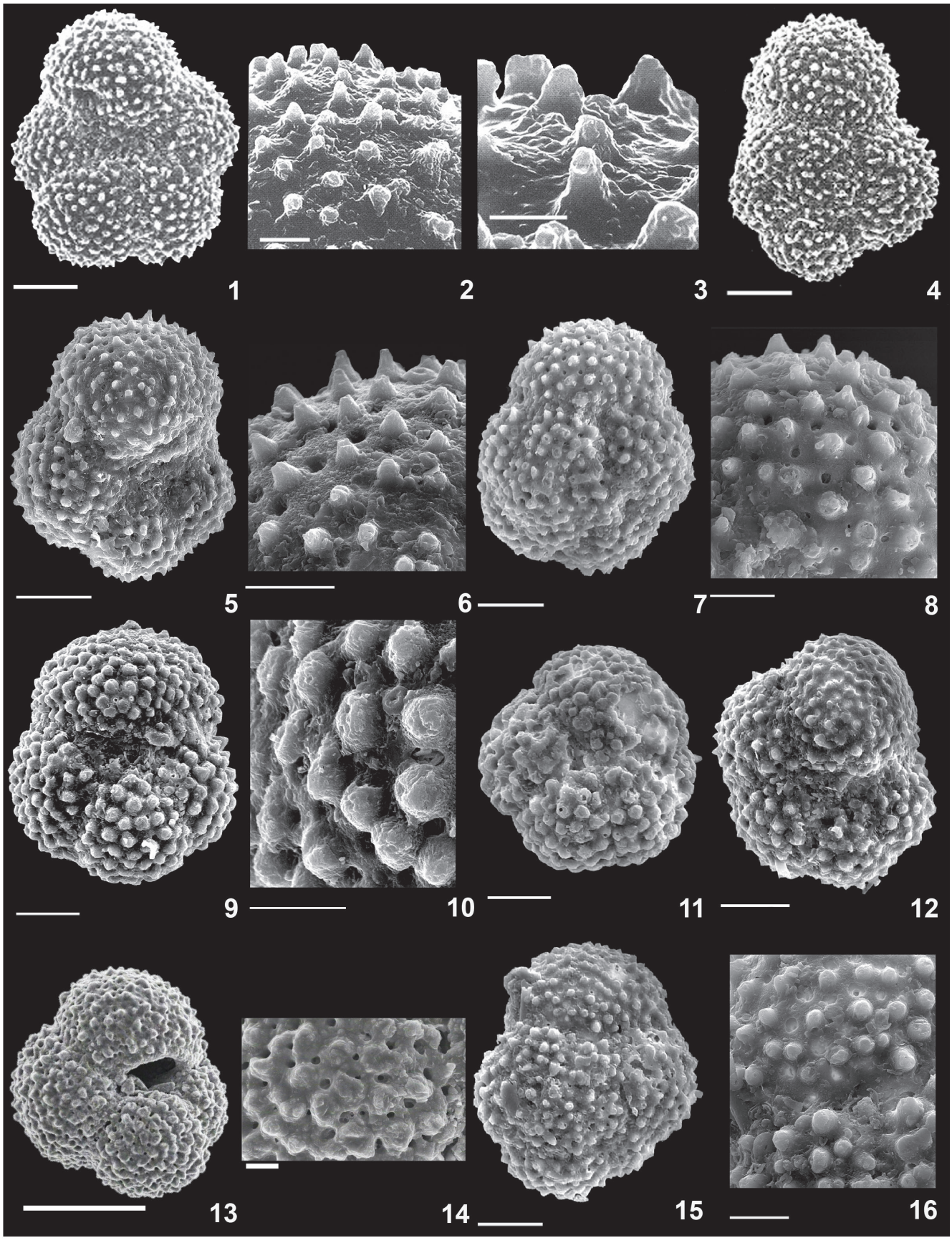

Plate 13.3 *Acarinina medizzai* (Toumarkine and Bolli, 1975)

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Plate 13.3 *Acarinina medizzai* (Toumarkine and Bolli, 1975)

1-4 (1-3, holotype, Toumarkine and Bolli, 1975, pl. 6, figs. 1, 7, 8; 4, paratype, Toumarkine and Bolli, 1975, pl. 6, fig. 3), Zone E14, sample 68/60, Italy; **5-6**, Zone O2, Istra More-3 well, 1175 m, Adriatic Sea; **7-11**, Zone O4, Istra More-4 well, 1225-1231 m, Adriatic Sea; **12**, Zone O1, Istra More-3 well, 1270 m, Adriatic Sea; **13-14**, Zone O1, TDP Site 17/22/1, 0-15 cm, Stakishari, Tanzania; **15-16**, Zone O4, Istra More-4 well, 1225-1231 m, Adriatic Sea. Scale bar: **13** = 100 μm; **1**, **4-5**, **7**, **9**, **11-12**, **15** = 50 μm; **6**, **8**, **10**, **16** = 20 μm; **2**, **14** = 10 μm; **3** = 5 μm.