

Taxonomic re-evaluation of the late Cretaceous serial planktonic foraminifer *Gümbelina punctulata* Cushman, 1938 and related species

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Resumen

Se propone un nuevo género, *Braunella*, para una línea de foraminíferos seriales planctónicos de edad Campaniense tardía- Maasrichtiense. El género incluye dos especies: *B. punctulata* (Cushman, 1938) y *B. brauni* nov. sp., que están caracterizadas principalmente por su test de ornamentación que está irregularmente reticulado. Aparentemente, este género evolucionó en el Campaniense tardío a partir de la especie costada *Heterohelix striata* (Ehrenberg, 1840), y se extinguió en el límite Cretácico/Terciario.

Palabras clave: Foraminíferos planctónicos, Cretácico Tardío, Taxonomía, Nuevo género, Nueva especie

Abstract

A new genus, *Braunella*, is proposed for a lineage of serial planktonic Foraminifera of late Campanian-Maastrichtian age. The genus includes two species, *B. punctulata* (Cushman, 1938) and *B. brauni* nov. sp., which are characterized mainly by their irregular reticulated test ornamentation. The genus seemingly evolved in the late Campanian from the costate species *Heterohelix striata* (Ehrenberg, 1840), and became extinct at the Cretaceous/Tertiary boundary.

Keywords: Planktonic Foraminifera, Late Cretaceous, Taxonomy, New genus, New species

1. INTRODUCTION

The taxonomy of the Cretaceous planktonic Foraminifera with serial chamber arrangement had been extensively based on the gross test architecture since the first classification of the group by Cushman (1927). This scheme was adopted subsequently by other taxonomists (Loeblich & Tappan, 1964; Pessagno, 1967; Brown, 1969; Martin, 1972; Masters, 1977; Loeblich & Tappan, 1987) and the practicing micropaleontologists in general. An important breakthrough in understanding was made by Nederbragt

(1991), when she proposed the genus *Laeviheterohelix* for heterohelicid species with smooth tests ornamented with pore mounds. This emphasis on ornamentation was not new in the taxonomy of the Cretaceous planktonic Foraminifera, for test ornamentation had been previously and successfully used to separate a number of genera in a group, such as the globular-chambered, heavily ornamented trochospiral *Rugoglobigerina*, *Plummerita*, and *Trititella* according to Brönnimann (1952) and *Bucherina*, *Kuglerina*, and *Rugotruncana* according to Brönnimann & Brown (1956).

Detailed observations over a number of years convinced the author that the use of test ornamentation in the taxonomy of the serial planktonic Foraminifera of the late Albian-Maastrichtian interval can be extended to the Superfamily Heterohelicacea as a whole. Furthermore, ornamentation patterns and trends were found to be helpful in deciphering ancestor-descendant relationship at genus and species level.

Attention is focused on a newly recognized lineage of two species, one of them new, which initiated its evolution in the late Campanian (upper part of *Radotruncana calcarata* Biozone), and became extinct at the Cretaceous/Tertiary boundary. This lineage is furthermore formalized at generic level, using test ultrastructure and related details such as pore architecture and ornamentation as defining taxonomic criteria. *Braunella* nov. gen. includes *B. punctulata* (Cushman), 1938 and *B. brauni* nov. sp.

2. A HISTORY OF CONCEPTS IN CLASSIFICATION

Detailed SEM photographic examination of test ornamentation, ultrastructure and pore size and distribution patterns of serial planktonic Foraminifera (Family Heterohelicidae) of the late Campanian-Maastrichtian revealed that there are two species (one new) in which the tests are covered by a distinctive, irregularly pattern of reticulation. In the past, the lack of such detailed observations on the test ornamentation using SEM microscopy lead to uncertainty in interpreting test morphology especially when evaluating intraspecific variability of species. As a result, confusion about such species also impaired their biostratigraphic usefulness and impeded the identification of evolutionary lineages helpful in refining stratigraphic schemes and correlations.

The first species of the lineage was described by Cushman (1938) as *Gümbelina punctulata* from the Upper Campanian sediments of the southern United States (Texas), namely from the Upper Taylor Marl. The test ornamentation was described as "... wall in the early portion slightly costate or with fine perforations in vertical lines, in the adult thicker-walled with the surface rather coarsely punctate..." (Cushman, 1938, p. 13).

The species was re-assigned to the genus *Pseudogümbelina* by Brönnimann & Brown (1953), on basis of the argument that "Accessory apertures are not known to be present in the antepenultimate pair of chambers or in preceding chambers. They first appear in the penultimate pair of chambers as small arched openings. In the later stage each chamber exhibits two accessory apertures, one on each side at the junction of the two preceding chambers." (Brönnimann & Brown, 1953, p. 154). In addition, they gave a more detailed description of the test ornamentation: "The walls of the early chambers are marked by fine longitudinal striae, and later by intermittent costae. Still later, in the antepenultimate pair of chambers, the walls are covered by many small pits which produce a somewhat reticular pattern of irregular ridges." (ibid., p. 154).

Montanaro Gallitelli (1957) assigned *Gümbelina punctulata* Cushman, 1938 to *Heterohelix* and retained within the genus *Pseudoguembelina* only species "...with strong modification in the shape of the terminal basal part of the chambers and of the aperture, which give rise to peculiar accessory apertures occasionally found in other species and genera of the Heterohelicidae." (Montanaro Gallitelli, 1957, p. 140).

Pessagno (1967, p. 262) described the chamber surface of *Heterohelix punctulata* (Cushman), 1938 as "... coarsely punctate or cancellate...". When the holotype from the National Museum of Natural History, Smithsonian Institution, Washington, D.C. was refigured the first ESEM figures of this specimen showed no traces of the additional apertures apparent in Pessagno's drawings (Pessagno, 1967, pl. 86, figs 9-10). They confirm, by contrast, that the original figuration by Cushman (1938, pl. 2, fig. 16) was accurate, and therefore reflecting reality.

Observations carried out on samples from eight DSDP/ODP wells, combined with detailed examination of the type specimens and additional material from the Van Morkhoven Collection (National Museum of Natural History, Smithsonian Institution, Washington D.C.) revealed the existence of two species within this lineage. The lineage is formalized at generic level as *Braunella* gen. nov. The group started its history in the late Campanian (upper part of the *Radotruncana calcarata* Biozone) with the first evolutionary occurrence of *B. punctulata* (Cush-

man), the only species of the new genus within this biostratigraphic unit. Another *Braunella* nov. gen. species, namely *B. brauni* nov. gen., nov. sp. makes its first appearance in the succeeding *Globotruncanella havanensis* Biozone, this species presenting additional apertures in the proximity of the zigzag suture, and somehow irregular chamber growth in the adult stage. Both species became extinct at the Cretaceous/Tertiary boundary.

3. MATERIAL EXAMINED AND ITS PROVENANCE

The material analyzed for this study includes both type specimens and new specimens from eight DSDP/ODP sites. The holotype (USNM 307970) and paratypes (USNM 307971) of *Gümbelina punctulata* Cushman, 1938 are deposited in the Cushman Collection at the National Museum of Natural History, Smithsonian Institution, Washington D.C. (Fig. 1). Additional material came from eight DSDP/ODP sites and it is deposited in the Ocean Micropaleontology Collection and Van Morkhoven Collection at the same institution. The specimens investigated came from the upper Campanian-Maastrichtian sediments of the following DSDP/ODP sites: DSDP Leg 12, Site 111A (Orphan Basin, North Atlantic), DSDP Leg 43, Site 384 (Grand Banks, North Atlantic), DSDP Leg 39, Site 356 (Sao Paulo Plateau, South Atlantic), DSDP Leg 39, Site 357 (Rio Grande Rise, South Atlantic), DSDP Leg 62, Site 463 (Shatsky Rise, Central Pacific), and ODP Leg 171B, Sites 1049B, 1050C, and 1052E (Blake Nose Plateau, Central Atlantic). Van Morkhoven Collection includes in addition a number of well preserved specimens from the cores and ditch cuttings from upper Campanian-Maastrichtian sediments of the Gulf of Mexico. Due to rather poor documentation, no precise location can be given for the two wells, which yielded these excellently preserved specimens.

4. TAXONOMY

Suprageneric classification is after Loeblich & Tappan (1987). Species concept follows Georgescu & Huber (2007).

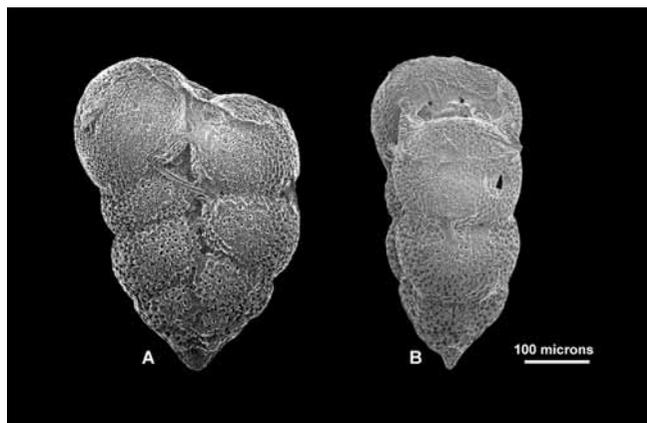


Figure 1. Holotype of *Braunella punctulata* (Cushman, 1938) (USNM 307970). Photographs from the Mesozoic Planktonic Foraminifera Working Group, B.T. Huber-editor (2006). The specimen was figured by Cushman (1938, pl. 2, fig. 16) from the Taylor Marl of the Mustang Creek Valley, Red River County, Texas, USA. It was refigured by Pessagno (1967, pl. 86, figs. 9-10). The paratypes of the species deposited in the Cushman Collection (USNM 307971) were also examined but not figured.

Order FORAMINIFERIDA Eichwald, 1830

Suborder GLOBIGERININA Delage & Hérouard, 1896

Superfamily HETEROHELICACEA Cushman, 1927

Family HETEROHELICIDAE Cushman, 1927

Subfamily HETEROHELICINAE Cushman, 1927

Genus *Braunella* nov. gen.

Type species: *Gümbelina punctulata* Cushman, 1938, p. 13, Pl. 2, Figs 15-16.

Diagnosis.— Test biserial, with subspherical chambers throughout. Chambers increase more or less regularly in size as added. Sutures distinct and depressed. Main aperture in the shape of a low- to medium-high arch, situated at the base of the last-formed chamber. Test ornamentation irregularly reticulate, at least in the earlier portion; chambers sometimes costate.

Description.— Test robust, biserial throughout. Chambers are subspherical, with the younger distinctly overlapping the previously formed ones. Chambers increase more or less regularly in size as added, resulting in highly variable shape of the test in lateral view. Chamber proliferation may occur occasionally in rare specimens. Sutures are distinct, depressed, and straight to slightly oblique to the axis of growth. Main aperture has the shape of a low to medium high arch, situated at the base of the last-formed chamber of the test. It is bordered by two lateral, imperforate

rate, rod-like rims, which are or are not attached to the penultimate chamber, and a wide imperforate band in the central part. Additional apertures can be developed along the zigzag suture if the rod-like rims are suspended. Test ornamentation is irregularly reticulate throughout. Costate ornamentation was observed on the last-formed chambers of some specimens. The test wall is calcareous, hyaline, finely perforate, the pores being situated in the spaces defined by the irregular reticulate network, or between the robust costae.

Remarks.— The distinct, irregular reticulation of the test separates *Braunella* nov. gen. of the coeval *Heterohelix* s.l. species, the latter having dominant costate ornamentation, and from *Pseudotextularia*, which has pronounced, coarse costae. Occasional chamber proliferation in *Braunella* nov. gen. is developed between two rows of diverging chambers, whereas, by contrast, in *Pseudotextularia-Racemiguembelina* lineage the chambers of the proliferating stage are added in two planes resulting in a cone-shaped test. *Pseudoguembelina* Brönnimann & Brown presents secondary apertures along the zigzag suture as a result of chamber prolongation. By contrast, the supplementary apertures in *Braunella* are the result of the development of the periapertural structures. The ornamentation is different in *Pseudoguembelina* and *Braunella*, the former being completely costate and the latter presenting irregular reticulate ornamentation.

Species included. —

Gümbelina punctulata Cushman, 1938, p. 13, Pl. 2,
Figs. 15-16.
Braunella brauni nov. sp.

Etymology.— The genus named after Professor Willi K. Braun (University of Saskatchewan) in appreciation for his dedication to micropaleontological-biostratigraphical studies of the Paleozoic and Mesozoic microfauas of Western and Arctic Canada.

Phylogenetic relationships.— *Braunella* nov. gen. apparently derives from costate *Heterohelix* species of the *H. striata* group (Fig. 2). This assumption is supported by (i) occasional presence of last-formed costate chambers in some specimens of the new genus, (ii) identical periapertural structures at *Heterohelix striata* and *Braunella punctulata*

and (iii) occurrence of transitional test ornamentation between the costate and presumed *H. striata* ancestor and the irregularly reticulate, *Braunella punctulata* descendant.

Stratigraphic range.— Late Campanian-Maastrichtian, from *Radotruncana calcarata* Biozone to and throughout *Pseudoguembelina hariaensis* Biozone.

Geographical distribution.— United States (Texas, Arkansas, southern California), Mexico, Caribbean (Puerto Rico, Cuba, Trinidad, Yucatan Shelf), Atlantic Ocean (Orphan Basin, Grand Banks, Blake Nose Plateau, Rio Grande Rise, Sao Paulo Plateau), Tethyan Realm (Israel), Pacific Ocean (Shatsky Rise), and Europe (Italy, Denmark).

Braunella punctulata (Cushman, 1938) emended
(Pl. 1, Figs. 1-5, Pl. 3, Figs. 1, 3-4)

- 1937 *Gümbelina* sp. Voorwijk, p. 194, Pl. 1, Figs. 11, 13 (Campanian-Maastrichtian, Habana, Cuba).
- 1938 *Gümbelina punctulata* Cushman, p. 13, Pl. 2, Figs. 15-16 (Upper Taylor Marl, Mustang Creek Valley, Red River County, Texas, United States).
- 1946 *Gümbelina punctulata* Cushman – Cushman, p. 108, Pl. 46, Figs. 13-14 (Taylor Marl, Annona Chalk, Wolfe City Sand, and Neylandville Marl, of the Red River, Delta, and Rockwall Counties, Texas, United States; refigured type material).
- 1958 *Pseudotextularia echevarriai* Seiglie, p. 59, Pl. 3, Figs. 2-6, Pl. 5, Fig. 4 (Campanian-Maastrichtian transition layers, Cuba).
- 1960 *Heterohelix punctulata* (Cushman). Pessagno, p. 358 (Maastrichtian, Puerto Rico).
- 1962 *Heterohelix punctulata* (Cushman). Pessagno, p. 358, Pl. 1, Fig. 11 (Maastrichtian, Puerto Rico).
- 1967 *Heterohelix punctulata* (Cushman). Pessagno, p. 262, Pl. 86, Figs. 9-10, only –refigured holotype (San Felipe Formation and Méndez Shale, Mexico; Lower Taylor Marl, Upper Taylor Marl, Neylandville Marl, Corsicana Marl of Texas, and Brownstown Marl of Arkansas, United States).

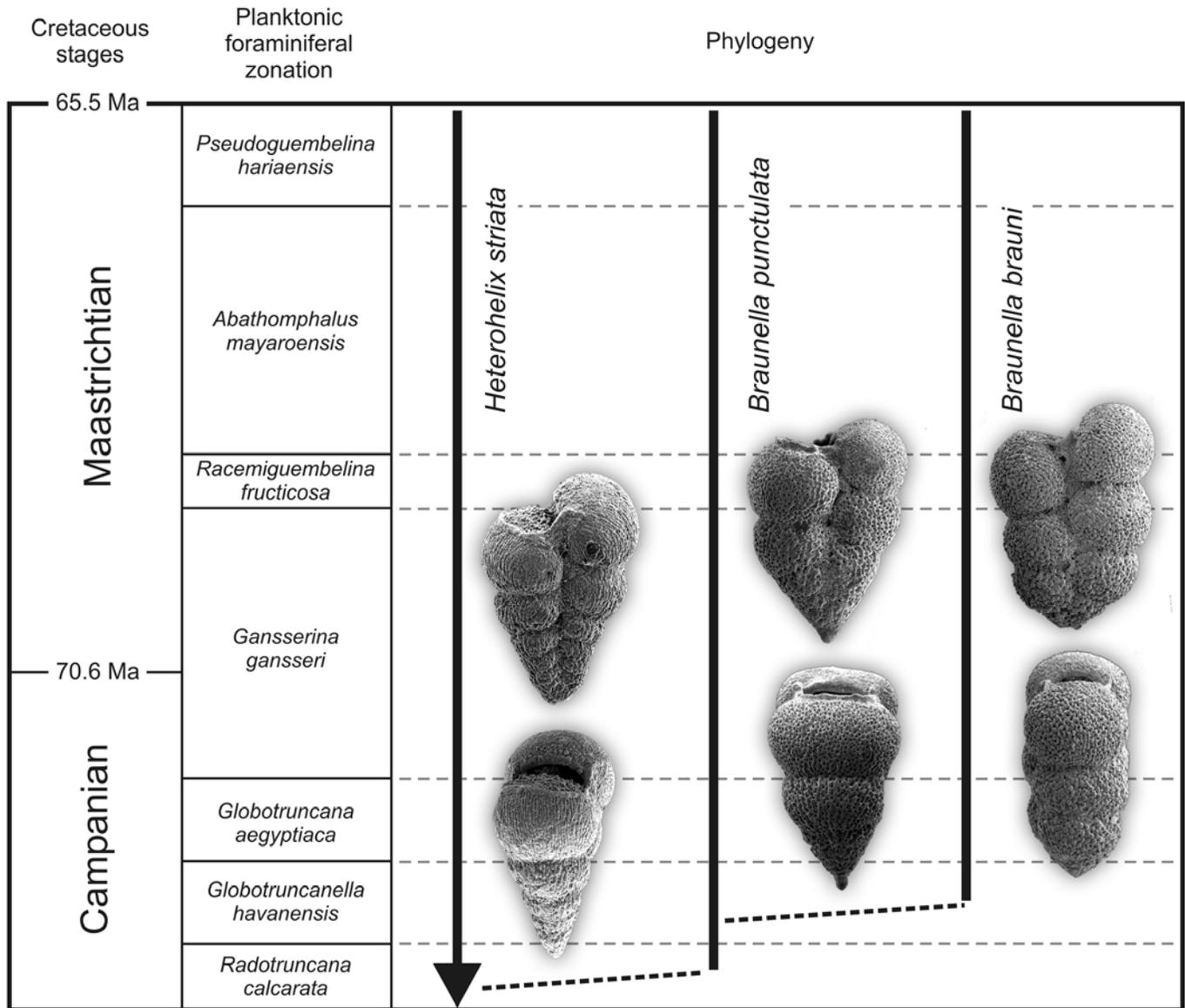


Figure 2. Suggested phylogenetic relationships between *Heterohelix striata* and *Braunella* nov.gen. Ages after Gradstein *et al.* (2004).

- 1968 *Heterohelix punctulata* (Cushman). Sliter, p. 96, Pl. 14, Fig. 7 (late Campanian-Maastrichtian, United States-southern California and Mexico-Baja California).
- 1968 *Heterohelix robusta* Stenestad, p. 68, Pl. 1, Figs. 12-14, Pl. 3, Figs. 1-3 (Campanian-early Maastrichtian, Denmark).
- 1991 *Heterohelix punctulata* (Cushman). Nederbragt, p. 346, Pl. 3, Fig. 6 (late Santonian-Maastrichtian, Tunisia-El Kef section, DSDP Leg 3, Site 21-Rio

Grande Rise, DSDP Leg 39, Site 356-Sao Paolo Plateau, DSDP Leg 39, Site 357-Rio Grande Rise, and late Santonian of DSDP Leg 10, Site 95-Yucatan Outer Platform).

- 1993 *Heterohelix punctulata* (Cushman). Almogi-Labin *et al.*, Fig. 8-1 (Campanian-Maastrichtian, central Israel).
- 1995 *Heterohelix punctulata* (Cushman). Premoli Silva & Sliter, Pl. 24, Fig. 5 (Late Campanian-Maastrichtian, Bottaccione section, northern Italy).

2003 *Heterohelix punctulata* (Cushman). Abramovich *et al.*, Pl. 2, Fig. 5 (Maastrichtian, southern Atlantic DSDP Site 525A, and equatorial Pacific, DSDP Sites 463 and 577A).

Material. – Over two hundred specimens.

Diagnosis.– Test biserial throughout, chamber proliferation occurring occasionally. Test ornamentation is irregularly reticulate, the last-formed chambers occasionally costate.

Emended description.– Test biserial throughout at most specimens, consisting of ten to seventeen chambers. Chamber proliferation may occur between the two rows of diverging chambers. Chambers are subspherical throughout, distinctly overlapping the previous ones these resulting in a slightly lobate test periphery in lateral view. They increase rapidly in size in the earlier part of the test but more slowly in the adult portion. Sutures are distinct, depressed, and straight to slightly oblique to the growth axis. Periphery broadly rounded, without peripheral structures such as rows of pustules, keels, etc. Aperture is situated at the base of the last formed chamber and is bordered by a wide, imperforate band. Test with irregularly reticulate ornamentation throughout; occasionally the last-formed chambers are longitudinally costate. Test wall is calcareous, hyaline, and finely perforate, pore diameter fluctuating between 1.3 and 2.4 microns. The size of the pores is dependent on the irregularly reticulate ornamentation and addition of successive layers of calcite during the ontogenetic growth.

Remarks.– The ESEM photographs of the holotype do not reveal that additional apertures along the zigzag suture as drawn by Pessagno (1967, pl. 86, figs. 9-10). To the contrary, it is the absence of additional apertures along the zigzag suture, together with the more regular increase in chamber size during the ontogeny that separates this species of *Braunella brauni* nov.gen., nov.sp. (Fig. 3).

Phylogenetic relationships.– See ‘Phylogenetic relationships’ section under *Braunella* nov. gen.

Stratigraphic range. –Late Campanian-Maastrichtian (from the *Radotruncana calcarata* Biozone throughout the upper part of the *Pseudoguembelina hariaensis* Biozone).



Figure 3. Two X-ray micrographs of the holotype of *Braunella brauni* nov. gen., nov. sp. (A) and a hypotype of *Braunella punctulata* (B) from the same sample, DSDP Site 463, sample 19-2, 75-76 cm. Notice the two rows of divergent chambers, which are more evident at the specimen of the former species and only in incipient stage at the latter.

Geographical distribution.– United States (Texas, Arkansas, southern California), Mexico, Caribbean (Puerto Rico, Trinidad, Yucatan Shelf), Atlantic Ocean (Orphan Basin, Grand Banks, Blake Nose Plateau, Rio Grande Rise, Sao Paulo Plateau), Tethyan Realm (Israel), Europe (Italy, Denmark), and equatorial Pacific (Shatsky Rise).

Braunella brauni nov. sp.

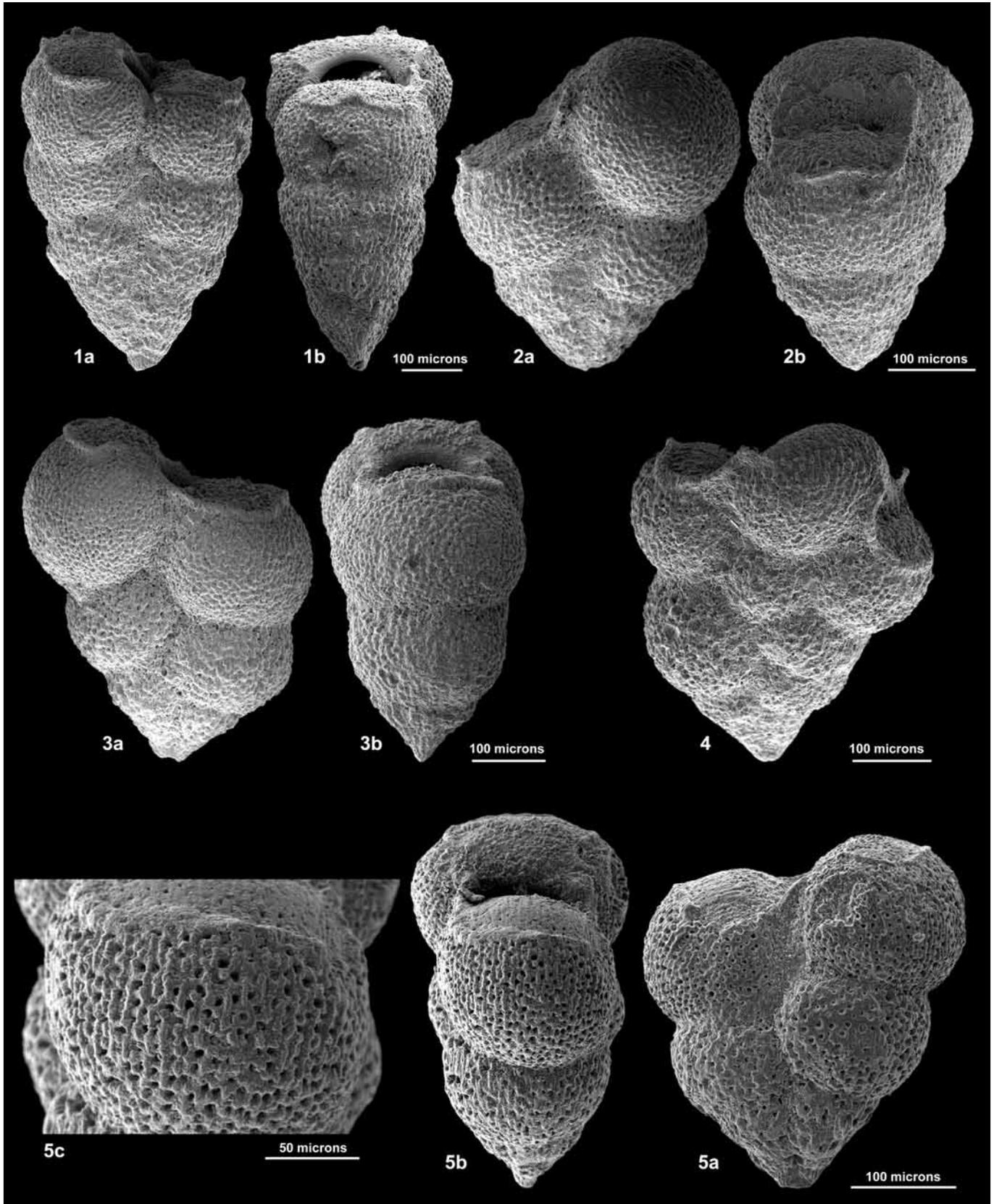
(Pl. 2, Figs. 1-6, Pl. 3, Fig. 2)

1938 *Gümbelina ultimumida* White. Cushman, p.13, Pl. 2, Fig. 18 only (Velasco Shale, Velasco, Mexico).

1946 *Gümbelina ultimumida* White. Cushman, p. 107, Pl. 46, Fig. 7 only (Méndez Shale, Mexico; Upper Cretaceous of Cuba).

1953 *Pseudogümbelina punctulata* (Cushman). Brönnimann & Brown, p. 154, Text-figs. 7-8 (Maastrichtian of Habana, Cuba).

Plate 1. Hypotypes of *Braunella punctulata* (Cushman, 1938). 1–3. Specimens from the late Campanian (*Globotruncana havanensis* Biozone) of the Yucatan Shelf, DSDP Site 152, sample 17-1, 65-79 cm; 4. Specimen with chamber proliferation from the early Maastrichtian (upper part of the *Gansserina gansseri* Biozone) of the Atlantic Ocean (Rio Grande Rise), DSDP Site 356, sample 32-2 60-74 cm; 5. Specimen from the late Campanian (*Radotruncana calcarata* Biozone) from a well drilled in the Gulf of Mexico for which no precise location can be given (Van Morkhoven Collection at the National Museum of Natural History, Smithsonian Institution, Washington, D.C.).



Holotype.— Deposited in the Cushman Collection (USNM 534379).

Holotype dimensions.— Length: L=0.493 mm; width: W=0.359 mm; thickness: T=0.228 mm; W/L=0.728; T/L=0.462; apical angle: A=108°; flaring angle in the adult stage: AA=6°.

Paratypes.— Deposited in the Cushman Collection, (USNM 534380).

Type location.— DSDP Leg 62, Site 463 (Shatsky Rise, equatorial Pacific). Geographical coordinates: 21° 21' N, 174° 40' E.

Type level.— Late Campanian (*Globotruncanella havanensis* Biozone), DSDP Leg 62, Site 463, sample 19-2, 75-76 cm, deposited in the Ocean Micropaleontology Collection at the National Museum of Natural History, Smithsonian Institution, Washington, D.C. The biostratigraphical zonation at the type locality is that of Boersma (1981).

Material.— Over one hundred specimens.

Dimensions.— Length: L=0.424-0.558 mm; width: W=0.327-0.484 mm; thickness: T=0.203-0.251 mm.

Etymology.— As for the genus.

Diagnosis.— Test biserial throughout. Aperture with two free, symmetrically developed, rod-like rims border the aperture on the lateral sides, leaving additional apertures along the zigzag suture as new chambers are added. Test with irregularly reticulate ornamentation, rarely costate on the last-formed chambers.

Description.— Test biserial throughout, chamber proliferation not observed in any of the studied specimens. Chambers are subspherical throughout, those of the earlier part of the test increase rapidly in size. Kummerform last-formed chambers are common. The rate of chamber growth is lower in the adult stage. The two rows of biserially arranged chambers are slightly divergent in some specimens. Sutures are distinct, depressed, and perpendicular to slightly oblique to the growth axis of the test. Periphery is broadly rounded, without any peripheral structures. Main aperture is in the shape of a low to, more rarely, a medium high arch at the base of the last-formed

chambers. It is bordered in the central part by an imperforate band and two detached rod-like rims symmetrically arranged on the two sides of the test. The detached rims define additional apertures along the zigzag suture in the portion of the last-formed one to four chambers. Test ornamentation is irregularly reticulate, costate ornamentation being present on the last-formed one to two chambers of some specimens. Test wall is calcareous, hyaline, and finely perforate, pore diameter being in the range of 1.9-2.5 microns.

Remarks.— *Braunella brauni* nov. gen., nov. sp. differs from any other Cretaceous serial planktonic foraminiferal species by presenting the following combination of features: (i) distinct irregularly ornamented test surface, (ii) additional apertures along the zigzag suture, which are defined by the detached rod-like rims that border laterally the main aperture of the test (Fig. 4), and (iii) fluctuating rate of chamber size increase during the ontogenetic development.

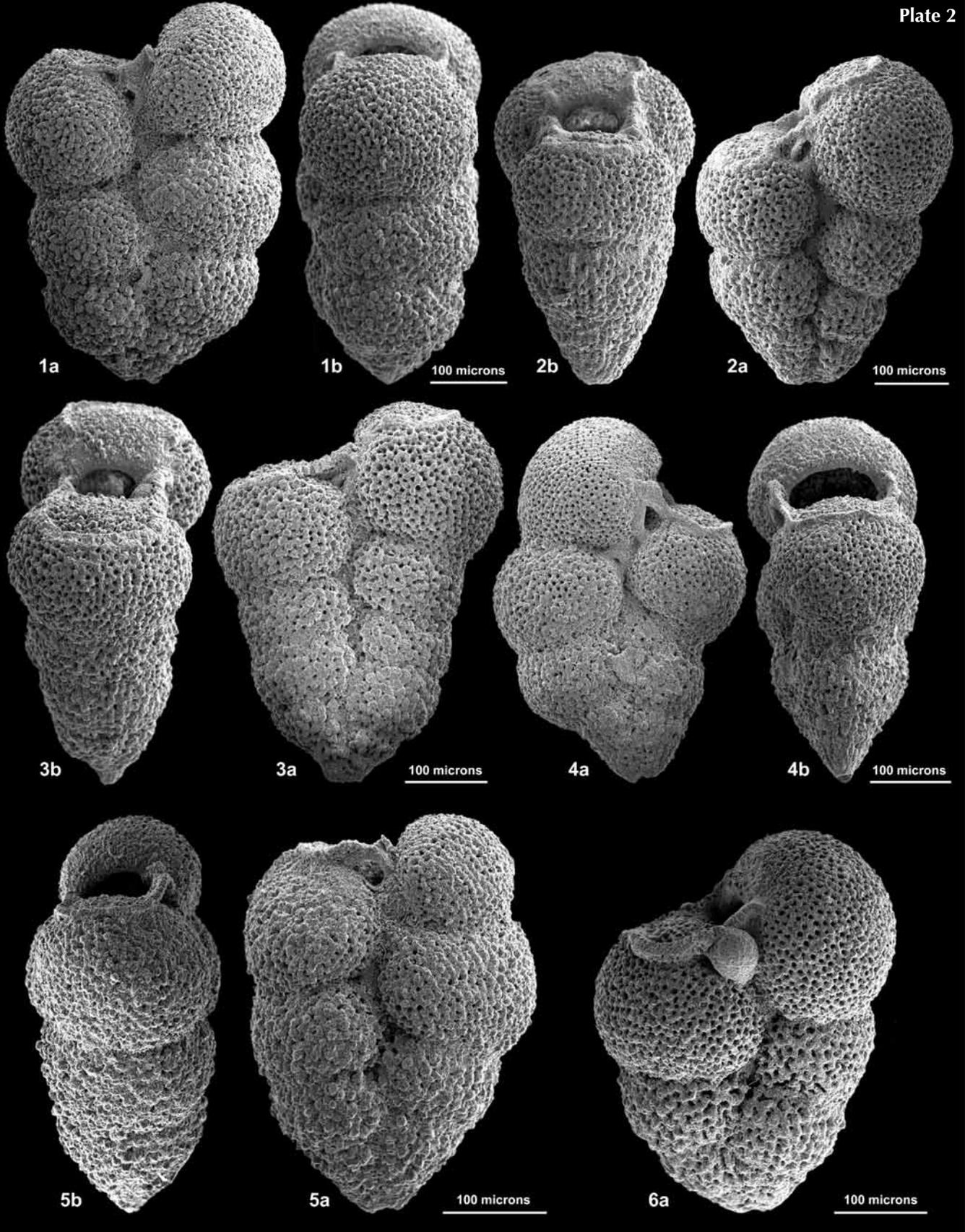
Phylogenetic relationships.— This species most likely evolved from *Braunella punctulata* (Cushman) as a result of development of (i) rather irregular chamber growth in the adult stage, and (ii) free periapertural rod-like rims, which result in the presence of pseudo-apertural openings along the zigzag suture. The stratigraphic ranges of the two species furthermore support this interpretation, with *B. punctulata*'s first evolutionary occurrence being recorded from the late Campanian (*Radotruncana calcarata* Biozone), and that of the descendant species in the younger *Globotruncanella havanensis* Biozone.

Stratigraphic range.— Late Campanian-Maastrichtian (from the *Globotruncanella havanensis* Biozone throughout the upper part of the *Pseudoguembelina hariaensis* Biozone).

Geographical distribution.— Mexico, Caribbean (Puerto Rico, Cuba), Atlantic Ocean (Grand Banks), and Pacific Ocean (Shatsky Rise).

Plate 2. Type specimens of *Braunella brauni* nov. gen., nov. sp. 1. Holotype (USNM 534379). Specimen from the DSDP Site 463, sample 19-2, 75-76 cm (*Globotruncana havanensis* Biozone); 2-3. Paratypes (USNM 534380). Specimens from the DSDP Site 463, sample 19-2, 75-76 cm (*Globotruncana havanensis* Biozone); 4-5. Topotypes from the DSDP Site 463, sample 19-5, 75-76 cm (*Globotruncana havanensis* Biozone).

Plate 2



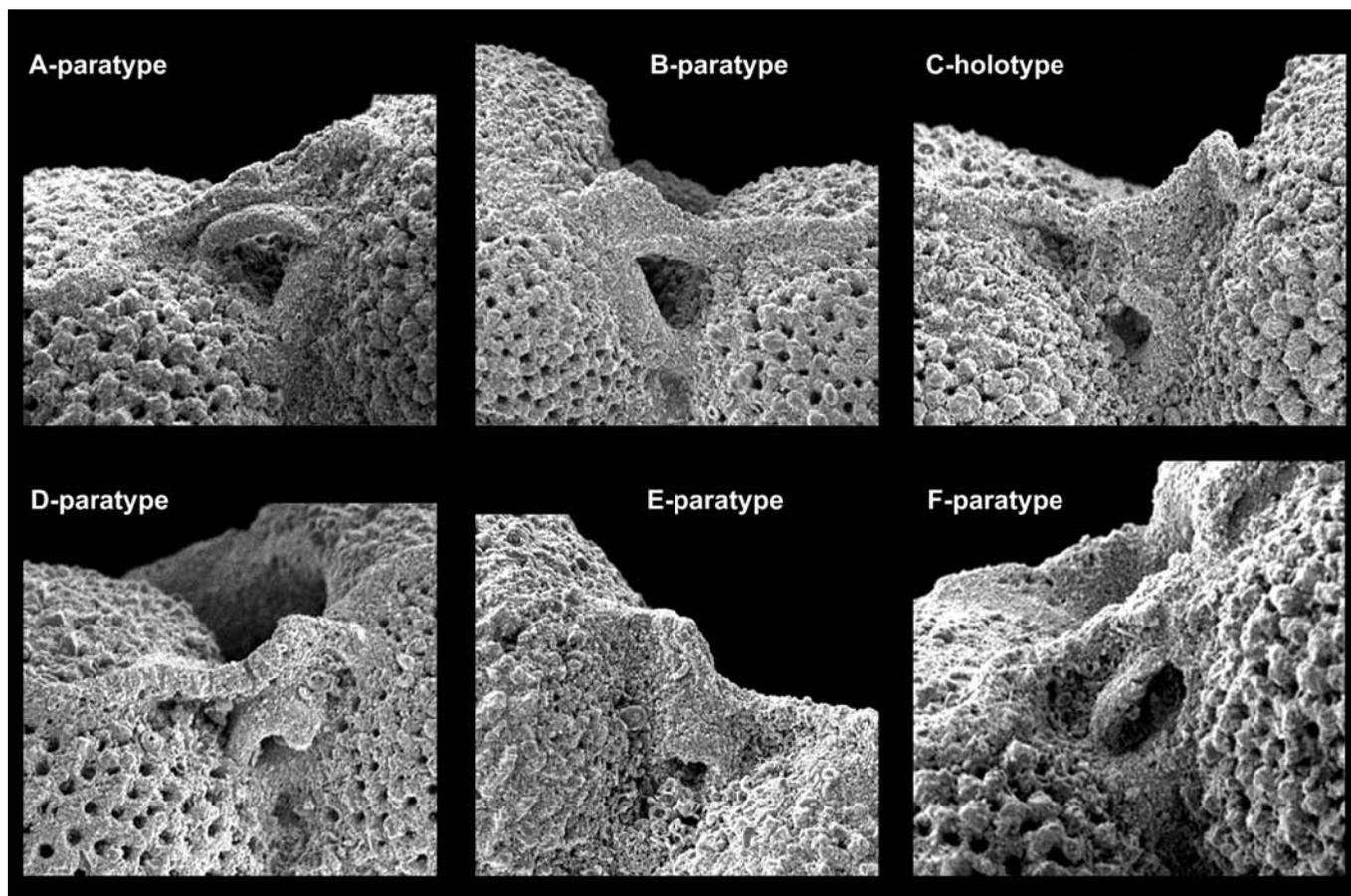


Figure 4. Morphological variability of the lateral periapertural structures of six type specimens of *Braunella brauni* nov. gen., nov. sp. (DSDP Site 463, sample 19-2, 75-76 cm). All the specimens are deposited at the National Museum of Natural History, Smithsonian Institution, Washington D.C. (USNM 534379-holotype, and USNM 534380-paratypes).

5. CONCLUSIONS

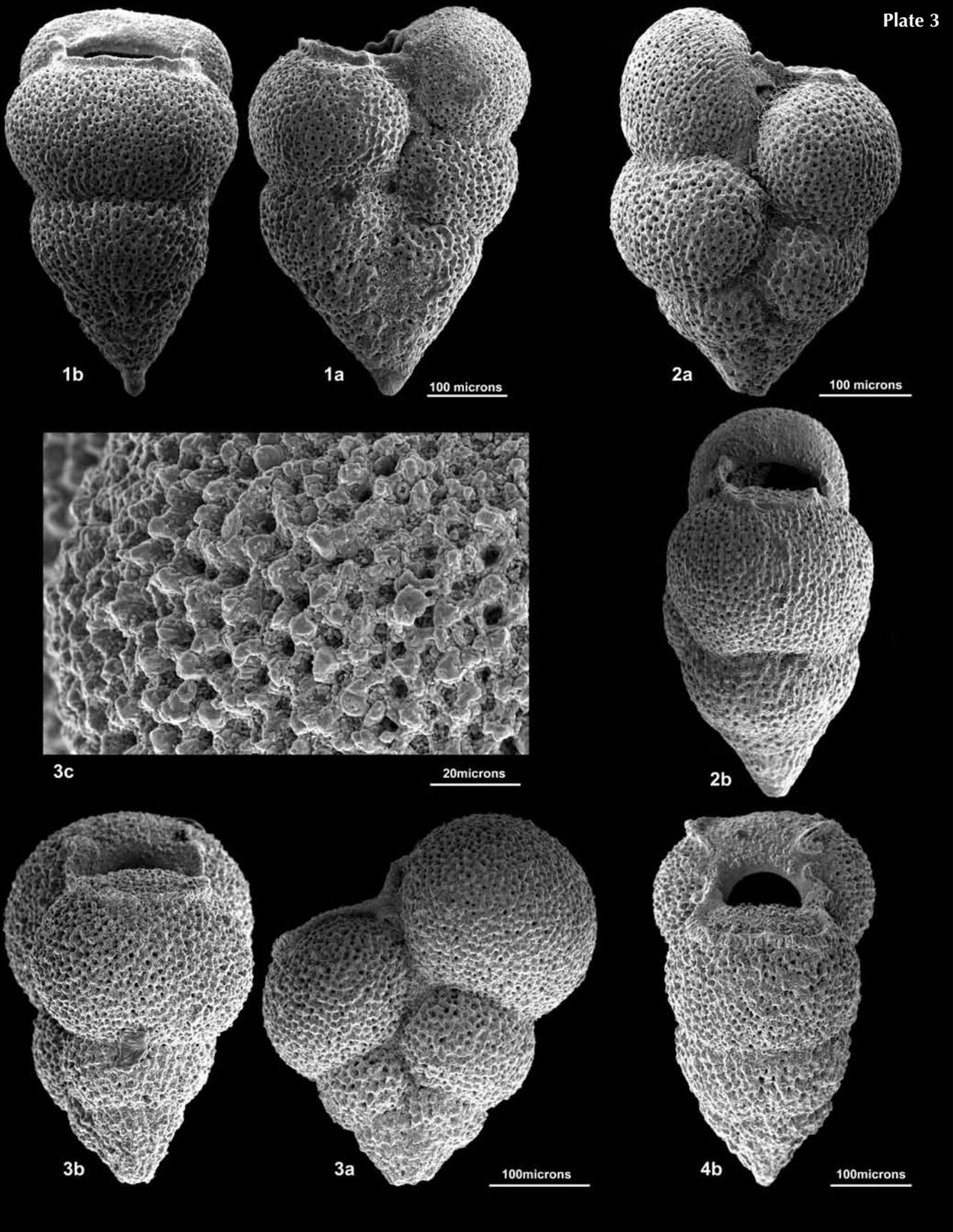
A new lineage of serial planktonic Foraminifera (Superfamily Heterohelicacea) of the late Campanian-Maastrichtian (Late Cretaceous) is formalized at genus level as *Braunella* nov. gen., with *B. punctulata* (Cushman, 1938) as type species. Two species are included in this new genus: *B. punctulata* (Cushman, 1938) and *B. brauni* nov. sp. The new genus is characterized by a distinctive pattern of irregularly reticulate test ornamentation, which contrasts with that of *Heterohelix*, which is mostly costate and without reticulate ornamentation.

The first species of this lineage is *Braunella punctulata* (Cushman, 1938), which first occurs in the late Campanian (upper part of *Radotruncana calcarata* Biozone). The other species included, *B. brauni* nov. sp. starts in the

younger *Globotruncanella havanensis* Biozone (late Campanian). Both species became extinct at the Cretaceous/Tertiary boundary.

Most probably *Braunella* nov. gen. evolved from the globular-chambered, costate *Heterohelix striata* (Ehrenberg, 1840).

Plate 3. Hypotypes of *Braunella punctulata* (Cushman, 1938) (1-3) and *B. brauni* nov. gen., nov. sp. (4). 1. *Braunella punctulata* from DSDP Site 384, sample 15-1, 80-86 cm; 2. *B. brauni* from the *Globotruncana aegyptiaca* Biozone of a well for which no precise location can be given (Gulf of Mexico). Specimen from the Van Morkhoven Collection (National Museum of Natural History, Smithsonian Institution, Washington, D.C.); 3-4. *B. punctulata* from DSDP Site 463, sample 17-1, 75-76 cm.



6. ACKNOWLEDGEMENTS

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