

FORAMINIFERAL GENUS HANTKENINA AND ITS SUBGENERA.

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ABSTRACT. Based on distinct morphologic features of the tests of sixteen species of the genus *Hantkenina* and of the geologic ranges, this stratigraphically important fossil is subdivided into the following subgenera: *Hantkenina* (subgenotype: *H. alabamensis* Cushman); *Aragonella* (subgenotype: *H. mexicana* Cushman var. *aragonensis* Nuttall); *Applinella* (subgenotype: *H. dumblei* Weinzierl and Applin), and *Cribrohantkenina* (subgenotype; *H. bermudezi* Thalmann nom. nov.). The genus *Hantkenina*, *sensu lato*, is regarded as a typical Eocene fossil. Occurrences reported from Lower Oligocene beds are believed to be questionable.

INTRODUCTION.

THE morphologic features of the tests of the different species of the genus *Hantkenina* Cushman, 1924, and their stratigraphic ranges justify a subdivision of the genus into several subgenera. The arrangement proposed below adds value to the use of these smaller *Foraminifera* for the correlation of Eocene formations throughout the world.

Although there are so far no records of *Hantkenina* in beds of Paleocene (Montian and Thanetian) age, the genus probably was derived from the Cretaceous genus *Schackoina* Thalmann, 1932. The earlier stages of the test of *Schackoina* are slightly trochiform, while the adult stages become planispiral and involute. The tests of *Hantkenina* are usually planispiral throughout, though thin sections reveal a slight trochiform initial stage, especially in microspheric forms.

The results of this investigation are based upon a study of hundreds of specimens from widely separated localities. Topotypes from Mexico and Alabama, and Eocene specimens from Cuba are in the micropaleontological collections at Stanford University. W. J. Parr kindly supplied a specimen from New Zealand. Dorothy K. Palmer graciously sent a sample from her station 1640 in Camaguey province, Cuba. Numerous specimens from Louisiana, Texas, and other localities were donated by Helen Jeanne Plummer. Topotypes of *Hantkenina inflata* Howe, and specimens of *H. danvillensis* Howe and Wallace from a new locality of uppermost Jackson beds in Clarke County, Alabama, collected by R. Hendee

Smith, were kindly submitted for examination by Henry V. Howe. Material from the Tampico and Coatzacoalcos embayments of Mexico, collected by W. Staub, were studied in 1934 at the Geological Department, University of Berne (Switzerland), and specimens from East Borneo have been examined during the course of the writer's professional routine work in Palembang (Sumatra). Lastly, opportunity is taken here to express sincere appreciation of the many suggestions by Hubert G. Schenck and Henry V. Howe.

SYNOPSIS OF ARRANGEMENT.

The arrangement of the *Hantkeninae* here adopted is summarized below. Rey's (1938) recognition of the constellation of species independently coincides in a general way with that one presented in this paper.

Genus *Hantkenina* Cushman, 1924.

Plate I, Figs. 1-7.

Hantkenina Cushman, 1924, U. S. Nat. Mus. Proc., Vol 66, Art. 30, p. 1. Genotype by original designation: *Hantkenina alabamensis* Cushman, 1924, p. 3, *ibid.*, Pl. 1, Figs. 1-6, Text Fig. 1. Upper Eocene "Zeuglodon beds", Alabama.

Description of genus: Test free, early stages slightly trochiform or planispiral, later stages planispiral, involute, biumbilicate; chambers arranged in 2-3 close-coiled whorls, of which only the last-formed is visible on both sides of the test; whorls embracing nearly to the small umbilicus; number of chambers 4 to 6, rarely 7, flattened or laterally compressed or inflated, gradually or rapidly increasing in size and distinctly separated; each chamber with either a short, stout or a long, slender, hollow spine, which is apparently of pure calcite; the last-formed chambers are usually the largest, either triangular or globiform in shape; spines situated at the periphery of the chambers, either in the prolongation of the chamber-axis, or in the prolongation of the chamber-sutures; often broken, or rudimentary, especially on highly inflated end-chambers; wall finely perforate, calcareous, smooth; inflated end-chambers often slightly granulated; sutures distinct, deep or depressed, clearly separating adjacent chambers; aperture a small arched slit at the base of the chamber, or clover-like tripartite with one lobe on each side of the apertural face

and the other extending peripherally at the base of the chamber; in upper Eocene forms the aperture is either a relatively large, irregularly shaped hollow, or consists of a series of one to several tubular openings, cribrate or trematophore-like, either in the wall of the end-chamber or as a shield or apertural plate.

Diameter: 0.3 - 0.75 mm. without spines; 0.45 - 1.2 mm. with spines.

Habitat: fairly deep neritic and perhaps bathyal waters, associated with specimens of *Globigerina*; also shallow waters, often associated with *Orbitoididae*.

Abundance: frequent in argillaceous or sandy marls and shales; rare in poorly calcareous sediments; so far not proved beyond doubt to be autochthonous in limestones or indurated rocks.

Geologic range: Ypresian to Wemmelian (lower to upper Eocene); questionably Lattorfian (lower Oligocene).

Subgenus *Hantkenina* Thalmann subgen. nov.

Plate 1, Figs. 3 a - f.

Synonym: *Sporohantkenina* Bermudez, 1937, Soc. Cubana Hist. Nat., Mem., Vol. 11, p. 151, where *Hantkenina brevispina* Cushman, 1924, was designated as subgenotype. (See Thalmann, 1942.)

Subgenotype: *Hantkenina alabamensis* Cushman, 1924, U. S. Nat. Mus., Proc., Vol. 66, Art. 30, p. 3, Pl. 1, Figs. 1-6, Text Fig. 1. Upper Eocene, "Zeuglodon beds", Cocoa post office, Alabama, U. S. A.

The following published species are allocated to this subgenus: *Hantkenina alabamensis* Cushman, 1924; *H. alabamensis* var. *primitiva* Cushman and Jarvis, 1929, herewith elevated to specific rank; *H. kochi* (Hantken, 1875); *H. brevispina* Cushman, 1925, (Pl. 1, Fig. 4); *H. hamata* (Brotzen, 1934), and *H. australis* Finlay, 1939.

Geologic range: Middle to upper Eocene (Lutetian to Wemmelian).

Subgenus *Aragonella* Thalmann subgen. nov.

Plate 1, Fig. 1.

Subgenotype: *Hantkenina mexicana* Cushman, 1924, var. *aragonensis* Nuttall, 1930, (herewith elevated to specific rank),

Jour. Paleont., Vol. 4, p. 284, Pl. 24, Fig. 1, Lower Eocene, Aragon Formation, Eastern Mexico.

Included in this subgenus are *Hantkenina mexicana* Cushman, 1924; *H. lehneri* Cushman and Jarvis, 1929, and *H. longispina* Cushman, 1924.

Geologic range: Lower to middle Eocene (Ypresian to Lutetian), questionably also in upper Eocene (Ledian).

Subgenus *Applinella* Thalmann subgen. nov.

Plate 1, Figs. 2 a, b.

Subgenotype: *Hantkenina dumblei* Weinzierl and Applin, 1929, Jour. Paleont., Vol. 3, p. 402, Pl. 43, Figs. 5 a, b. Eocene, Yegua formation, East Texas, U. S. A.

Another species of this subgenus is *Hantkenina liebusi* Shokhina, 1937.

Geologic range: Middle Eocene (Lutetian).

Subgenus *Cribrohantkenina* Thalmann subgen. nov.

Plate 1, Figs. 6 a - c.

Subgenotype: *Hantkenina* (*Sporohantkenina*) *brevispina* Bermudez, 1937, (*non Hantkenina brevispina* Cushman, 1924), Soc. Cubana Hist. Nat., Mem., Vol. 11, p. 151, Pl. 19, Figs. 7, 8 - 10, for which *Hantkenina* (*Cribrohantkenina*) *bermudezi* Thalmann *nom. nov.* is herewith proposed. Eocene, Camaguey province, Cuba. Bermudez' specimen on his Pl. 19, Figs. 8 - 10 (*non* Fig. 7) are here designated as subgenotype. The specimens figured by Bermudez from the upper Eocene Chapapote formation of Mexico and from the Eocene of the Camaguey province in Cuba are entirely different from Cushman's protograph of *Hantkenina brevispina* (compare Pl. 1, Fig. 4 with Fig. 6) from the Eocene of eastern Mexico.

To this subgenus belong also: *Hantkenina danvillensis* Howe and Wallace, 1934, *H. inflata* Howe, 1928, (Pl. 1, Fig. 7), and *H. mccordi* Howe and Wallace, 1932.

Geologic range: Upper Eocene (Ledian and Wemmelian); questionably also in lower Oligocene (Lattorfian).

In a personal communication (letter, dated April 2, 1942), Henry V. Howe stated, that by washing topotype material of *Hantkenina inflata* with his soap method details of the aperture were brought out which are not evident from the description of the holotype. He found that what he had taken to be a tripartite aperture in his holotype (Pl. 1, Fig. 7), is in

fact an aperture with three distinct holes, one median, and two lateral. Topotype specimens sent to the writer confirmed Howe's discovery, and, therefore, *H. inflata* is placed into the subgenus *Cribrohantkenina*. With regard to the alleged Oligocene age of the holotype, Howe further states, that, when collecting the sample in 1924, he landed on the contact between the Vicksburg and the Jackson formation at the type locality. The basal Vicksburg beds apparently contain reworked Jackson fossils, a condition that "certainly prevails for at least ten feet above the base of the Red Bluff at its type locality," where the Foraminifera are distinctly of Vicksburg, the Bryozoa, however, clearly of reworked Jackson age.

With respect to *Hantkenina mccordi* Howe and Wallace, Henry V. Howe, in his letter cited above, remarks that the edge of the aperture does not appear to be broken (see Howe and Wallace, 1932), "but I suspect that the animal was about to begin the secretion of the supplementary apertural plate similar to that possessed by *H. danvillensis*, and from the number of lobes it shows, I suspect that if it had been complete it should have had as many as seven or eight holes in it." *H. mccordi* Howe and Wallace, is, therefore, placed by the writer into the subgenus *Cribrohantkenina*.

MORPHOLOGIC CRITERIA.

The shapes of the chambers, the place of the insertion of the spines, the position of the axis of the spines, and the nature of the sutures are the morphologic criteria employed for the subdivision of the genus *Hantkenina* into its component subgenera.

The most primitive representatives of this genus are allocated to the subgenus *Aragonella*, typified by *Hantkenina aragonensis* Nuttall, 1930. The species placed in this subgenus have 5-6 bilaterally compressed, distinctly separated and stellate arranged chambers; each chamber is elongated distally and terminates in a spine. The chambers are longer than broad; the spines are situated in the prolongation of the chamber-axis; the sutures are straight or only slightly curved. The size of the specimens of this subgenus varies between 0.45 and 1.00 mm. Unbroken spines measure about one-half the length of the chambers. The aperture is not visible, usually filled and indistinct.

Somewhat more advanced are the species of the subgenus

Applinella, typified by *Hantkenina dumblei* Weinzierl and Applin, 1929. The 5-6 chambers are less distinctly separated, only slightly bilaterally compressed or but slightly inflated, and radiately arranged. The spines are short or stout and measure less than one-half the length of the chambers; they are placed at the anterior angle of the chambers. The sutures are radiate, slightly depressed, and are either straight or sigmoidally curved. Aperture unknown. The size varies between 0.5 and 0.9 mm.

Species placed in the subgenus *Hantkenina*, typified by *Hantkenina alabamensis* Cushman, 1924, are characterized by

EXPLANATION OF PLATE I.

Fig. 1. *Hantkenina (Aragonella) aragonensis* Nuttall, 1930. Subgenotype: *Hantkenina mexicana* Cushman var. *aragonensis* Nuttall, 1930, Jour. Paleont., Vol. 4, p. 284, Pl. 24, Fig. 1. Eocene, Aragon formation, Arroyo Puentillo, 2600 meters N 73°E of El Tula, State of Veracruz, Mexico. (After Nuttall).

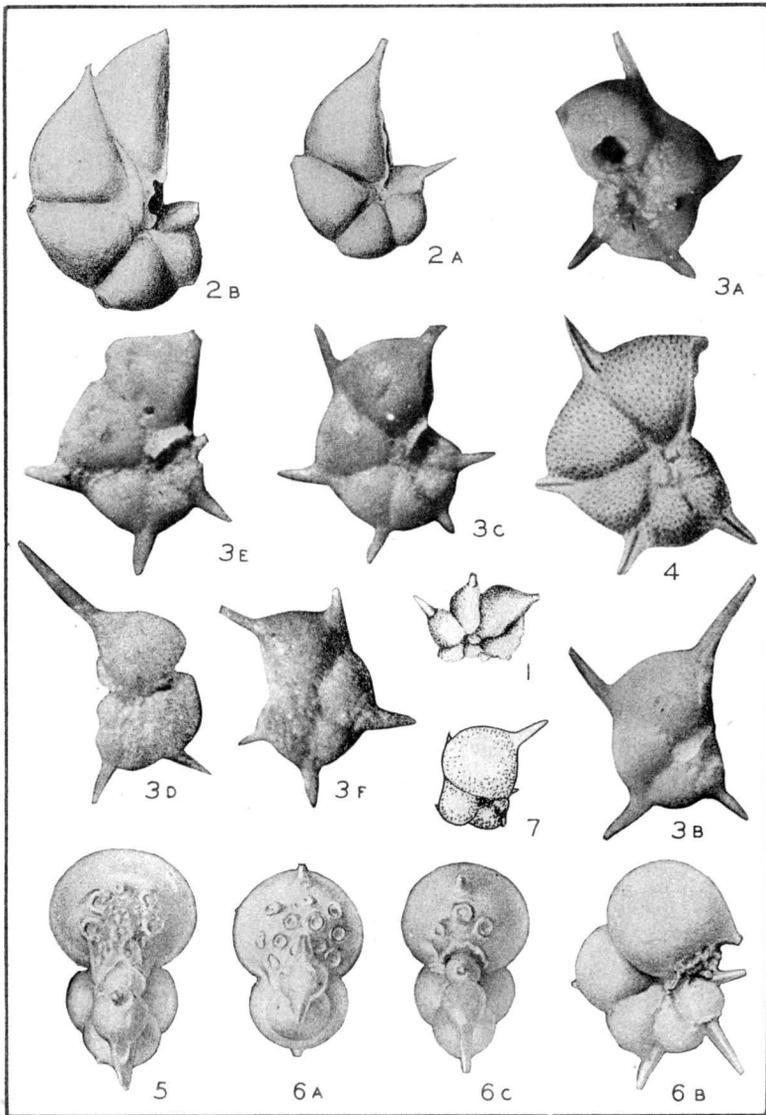
Figs. 2 a, b. *Hantkenina (Applinella) dumblei* Weinzierl and Applin, 1929. Subgenotype: *Hantkenina dumblei* Weinzierl and Applin, 1929, Jour. Paleont., Vol. 3, p. 402, Pl. 43, Figs. 5 a, b. Cushman Coll. no. 12204. Eocene, Yegua formation, Rio Bravo Oil Company's Deussen Well B-1, depth 4010 feet, South Liberty dome, Liberty County, Texas. (After Weinzierl and Applin).

Figs. 3 a-f. *Hantkenina (Hantkenina) alabamensis* Cushman, 1924. Subgenotype: *Hantkenina alabamensis* Cushman, 1924, U. S. Nat. Mus., Proc., Vol. 66, Art. 30, p. 3, Pl. 1, Figs. 1-6, Text Fig. 1. U. S. Nat. Mus. Cat. no. 353082. Eocene, Zeuglodon beds, Cocoa post office, Alabama. (After Cushman).

Fig. 4. *Hantkenina (Hantkenina) brevispina* Cushman, 1924. Type species, to be compared with Figs. 5, and 6 a-c. Cushman, 1924, U. S. Nat. Mus., Proc., Vol. 66, Art. 30, p. 2, Pl. 2, Fig. 3. U. S. Nat. Mus. Cat. no. 353079. Eocene, Mexico, Rio Pantepec, 2.2 kilometers S 20°W from Buena Vista, State of Veracruz. (After Cushman).

Fig. 5. *Hantkenina (Cribrohantkenina) bermudezi* Thalmann *nom. nov.* Subgenotype: *Hantkenina brevispina* Bermudez, 1937, (*non* Cushman, 1924), Soc. Cubana Hist. Nat., Mem., Vol. 11, p. 151, Pl. 19, Figs. 7, 8-10. Fig. 5 is Bermudez' Fig. 7, from the upper Eocene Chapapote formation on Rio Tuxpam, Veracruz, Mexico. Figs. 6 a-c are Bermudez' Figs. 8-10, which are herewith designated as the subgenotype of *Cribrohantkenina*, from Eocene beds, just north of Grua 9, Ramal Juan Criollo, Central Jatibonico, Camaguey province, Cuba. (After Bermudez).

Fig. 7. *Hantkenina (Cribrohantkenina) inflata* Howe, 1928, Jour. Paleont., Vol. 2, p. 14, Text Fig. 2. Louisiana State University Museum no. H. 16, from "the limestones at the base of the Oligocene section, Old St. Stephen Bluff, Alabama." (After Howe). According to personal communication (letter of April 2, 1942), the original sample is labelled "immediately below base of lime section," St. Stephen Bluff, and in Howe's opinion this locality corresponds with Bed 3 of Cooke's section (see Alabama Geol. Surv., Spec. Rept. 14, p. 283, 1926).



having chambers which increase rapidly in size, are generally broader than long, inflated, definite in outline, and clearly separated. The test is closely coiled, although in some species one notes a tendency towards slight uncoiling in the last-formed whorl. The spines are of variable length; they are situated near or at the end of the suture; usually the spines are radially oriented but sometimes they may be inclined backwards or forwards, tangentially to the contour of the test. The sutures are radiate, generally straight, and deeply furrowed. Aperture slitlike, arched, or tripartite (clover-like). Specimens of this subgenus attain a size varying between 0.4 and 0.8 mm.

The subgenus *Cribrohantkenina*, typified by *Hantkenina* (C.) *bermudezi* Thalmann, comprises species with 4 - 5 chambers which increase rapidly in size so that they become inflated, globular, or even bulbous, especially the last-formed chamber,—a development suggesting phylogerontism. The sutures are deep, distinct, radiate. Short, stout spines are present on some chambers, but they may be absent or only rudimentarily developed on the last-formed one. When spines are present they are differently situated during the ontogeny of the individual: in early stages they are located on the sutures, but later in life the tests bear spines, (or their rudiments), either at or near the middle of the end-chamber. Aperture trematophore-like, cribrate, number of perforations ("holes") variable (3 to 7, or more), either situated on outer wall of last-formed chamber, or on an apertural plate, which may break-off during burial. The representatives of the subgenus *Cribrohantkenina* are the most specialized species of the genus, and may attain a diameter up to 1,2 mm. The last-formed inflated chamber alone may have sometimes a diameter of 0,6 mm.

Although there is a fair variation of the morphological features of the tests in all species of the genus, the criteria used for the subdivision into subgenera are amazingly constant even in specimens from widely separated areas.

GEOLOGIC RANGE.

A summary of the geologic ranges of sixteen species belonging to the genus *Hantkenina*, *sensu lato*, is presented in Table 1. In Table 2 the stratigraphic range of the five subgenera is given.

Inspection of the two tables shows that these *Foraminifera* are excellent guide fossils for the Eocene. As far as known, specimens of the genus have not been recorded from Paleocene (Montian and Thanetian) strata. This is noteworthy because the Cretaceous genus *Schackoina* Thalmann probably is related to *Hantkenina* Cushman.

TABLE I
GEOLOGIC RANGE OF THE SPECIES OF THE GENUS HANTKENINA (s.l.)

Species of HANTKENINA (s.l.)	Lower	Middle	Upper Eocene		Lower
	Eocene	Eocene	Bartonian		Oligocene
	Ypresian	Lutetian	Ledian	Wemmelian	Lattorfian
aragonensis Nuttall	—————				
lehneri Cushm. & Jarv.	—————				
dumblei Weinz. & Appl.	---	—————	---		
liebusi Shokhina	---	—————			
australis Finlay	---	—————	---		
mexicana Cushman		—————	—————	---	
longispina Cushman		—————	—————	---	
alabamensis Cushman		-----	—————	—————	—————
brevispina Cushman		-----	—————	—————	—————
kochi (Hantken)		—————	—————		
bermudezi nom. nov.			—————	—————	—————
mccordi Howe & Wall.			—————	—————	—————
primitiva Cushm. & Jarv.			—————	—————	—————
hamata (Brotzen)			-?-?-	-?-?-	
danvillensis Howe & Wall.			---	—————	
inflata Howe				—————	= ?

The ranges given in Table 1 have been tested in widely separated localities and verified in such cases where type material was available for personal inspection. They are believed to be essentially correct. It would be audacious, however, to assert that they are not subject to alteration, as many problems remain to be solved. Some of these problems may be mentioned:

Hantkenina (*Hantkenina*) *hamata* (Brotzen), included in Table I, was originally described erroneously under the generic name *Siderolina*. Brotzen (1934) affirmed that the species is from Senonian (Upper Cretaceous) strata of Palestine. Because of its similarity to *Hantkenina* (*Hantkenina*) *longispina* Cushman, the question is raised whether the Senonian age is correct, the more so, since the presence of repre-

Table II

Geologic Range of Subgenera of *Hantkenina*(s.l.)

Geologic Range of the SUBGENERA of HANTKENINA	Aragonella	Applinella	Hantkenina	Hantkeninella	Cribrohantkenina
Lattorfian				•	
Wemmelian			●	●	●
Ledian	•		●	●	●
Lutetian	●	●	●		
Ypresian	●				
Paleocene					

sentatives of *Hantkenina* in middle and upper Eocene strata of Palestine, Syria and Iraq' is well established.

Only with reservation can one accept the records of *Hantkenina* in beds of Oligocene age. Howe (1928) described *Hantkenina* (*Cribrohantkenina*) *inflata* from limestones at the base of the Oligocene section at Old Fort St. Stephen Bluff in Alabama, and also from the type locality of the Red Bluff (Oligocene) at Hiwannee, Mississippi. More recent detailed

investigations, (Mornhinveg, 1941), seemingly have failed to disclose the presence of other representatives of *Hantkenina* in Oligocene beds in the Gulf States of North America. Moreover, Howe's locality would be one of the few rare occurrences of this genus in limestones. Consequently, might not one suspect that specimens in the Oligocene strata, especially at the very base of a section, are allochthonous?

The same argument applies to the occurrence of *Hantkenina* (*Hantkenina*) *australis* Finlay in the basal Kaiatan (Oligocene) stage of New Zealand, as reported by Finlay and Marwick (1940). The beds of the Kaiatan stage are unconformable upon subjacent strata.

As a final example of the kind of questions to be answered before the time range of *Hantkenina* is settled, consider the reports by Rey (1938) of *Hantkenina inflata*, *H. alabamensis*, *H. dumblei*, and *H. brevispina* occurring in mutual association in the Mzoufroun marls of Morocco. These marls are dated as early Oligocene (Lattorfian). Curiously enough, the accompanying *Foraminifera* in this marl, as listed by Rey, are strikingly upper Eocene in aspect. The geologic structure of the district around Mzoufroun in Morocco is perhaps more complex than anticipated, so that one may harbor the suspicion that the *Hantkenina*-bearing marls may form part of an overturned fold and were thus incorrectly considered to be of Oligocene age.

GEOGRAPHIC DISTRIBUTION.

The world-wide geographic distribution of the species of the genus *Hantkenina*, *sensu lato*, has already been brought out by Thalmann (1932, 1942). It may be added, that according to Galloway (1933) *Hantkenina* occurs also in the Eocene of Ecuador (Santa Elena peninsula), but no species are mentioned.

The primitive members of *Hantkenina*, that is to say *Aragonella*, occur in the lower Eocene of Mexico, Cuba, Trinidad, and probably also of Peru (cited as "*Hastigerinella*" by Hugues, 1934); in the middle Eocene of Louisiana, Mexico, Trinidad, Venezuela, Morocco and the North Caucasus region. The records from basal upper Eocene in Morocco, Bonaire, Mississippi, Cuba and North Caucasus need verification as to correct determination of species.

Applinella has been found in the middle Eocene of California, Texas, Morocco and Borneo.

Hantkenina, *sensu stricto*, is reported from the uppermost middle Eocene and from the upper Eocene of Morocco, France, Dalmatia, Hungary, Crimea, Caucasus, Transcaspia, Transcaucasus, Palestine, Syria, Iraq', Sinai region, Borneo, New Zealand, Venezuela, Trinidad, Bonaire, Barbados, Panama, Mexico, Cuba, Alabama, Texas, Louisiana, Mississippi, and Georges Bank off the eastern coast of the U. S. A. Questionable records are from lower Oligocene of Alabama, Mississippi, Morocco, and New Zealand.

Cribrohantkenina is so far known from the upper Eocene of the Gulf Coast States (Mississippi, Alabama, Louisiana, etc.), Mexico, Cuba, and Morocco, and questionably from lower Oligocene of Alabama and Morocco.

The distribution is sometimes described as Tethian, if by extension one can include the Californian province, East Borneo and New Zealand in the ancient Tethys region. Further investigations of microfaunal assemblages undoubtedly will bring to light new occurrences of this interesting and geologically important genus.

LITERATURE AND REFERENCES.

Besides the literature cited in the preceding text, all papers in which the species mentioned have been described, are given here:

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