TULANE STUDIES IN GEOLOGY

Volume 3, Number 3 May 25, 1965

TAXONOMIC REVISION OF CERTAIN DISCORBACEA AND ORBITOIDACEA (FORAMINIFERIDA)

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CONTENTS

I. Abstract

Taxonomic revision of genera of two superfamilies of Foraminiferida, the Discorbacea and Orbitoidacea, is presented. The classification adopted in this paper is based on wall structures, life cycles, and morphology of the test. Descriptions are based on type material or living specimens grown under laboratory conditions.

Discorbis vesicularis Lamarck is shown to be monolamellar. The genus *Rotorbinella* Bandy is reinstated and placed in the Discorbinae and includes *Gavelinopsis* Hofker, and *Biapertorbis* Pokorný as synonyms. *Rotorbinella campanulata* (Galloway and Wissler) includes the following as specific synonyms: *Globorotalia campanulata* Galloway and Wissler, *Rotalia turbinata* Cushman and Valentine, *R. vesiformis* Bandy, *R.* spp. Walton, *R. avalonensis* Natland, and *Rosalina campanulata* Uchio.

[1] Names arranged alphabetically, no seniority implied.

Trochulina d'Orbigny is bilamellar, removed from the Discorbinae and reinstated in the family Eponididae, superfamily Orbitoidacea.

Tretomphalus Möbius is a junior synonym of *Rosalina* d'Orbigny. *R. globularis* d'Orbigny is bilamellar and placed in the family Rosalinidae, of the Orbitoidacea. Synonyms of *R. globularis* include: *Discorbis columbiensis* Cushman, *D. monicana* Zalesny, *Tretomphalus myersi* Cushman, *T. bulloides* (d'Orbigny), *Rosalina bulloides* d'Orbigny, and *Discorbis isabelleana* (d'Orbigny) (?) Cushman and Valentine. *Rosalina mira* (Cushman) and *R. subbertheloti* (Cushman) are regarded as distinct species. *Discorbis floridana* Cushman is considered to be a glabratellid.

II. Introduction

Two excellent taxonomic studies of the Foraminiferida have recently appeared in the literature (Reiss, 1963; Loeblich and Tappan, 1964a). The classifications presented in these studies have been based primarily upon test morphology, emphasizing in particular the wall structure and methods of reproduction. While these revisions add to our knowledge of these protozoans, they, at the same time, point out the current limited state of knowledge of life cycles and genetic studies as well as the lack of definitive information on the wall structure of many genera. In 1962 the present writers began a study of living West Coast foraminifers with the hope of obtaining a better understanding of the organisms and of perhaps gaining information applicable to the investigation of their fossil representatives. This paper summarizes one aspect of the work now in progress and is an attempt at a more complete paleontologic-biologic approach to the foraminiferal taxonomy of a group of species.

Shortly after laboratory cultures of foraminifers were initiated, *Rosalina globularis* was selected for life cycle and ecologic studies, and at that time a routine identification was attempted. It soon became apparent that this species and another, *Rotorbinella campanulata,* previously had been assigned to several genera and species, thus obscuring the geographic distribution, the known range of morphologic variation, and the systematic affinities. Different stages in the life cycle of *Rosalina globularis* were also referred to separate genera, along with conflicting data on the mode of reproduction. Utilizing information gained from life studies, wall structure, and comparison with type specimens, certain revisions of systematic placement are proposed.

III. Methods and Materials

This study is based on specimens from many different localities and type material from various organizations. The holotypes of *Tretomphalus myersi* Cushman, *T. clarus* Cushman, *T. pacificus* Cushman, *T. atlanticus* Cushman, *Rotalia turbinata* Cushman and Valentine, *R. avalonensis* Natland, *Discorbis columbiensis* Cushman, *D. mira* Cushman, *D. floridana* Cushman, and *D. subbertheloti* Cushman and plesiotypes of *Rosalina globosa* Todd and Low, and *Discorbis isabelleana* (d'Orbigny) (?) Cushman and Valentine were loaned for study by the U. S. National Museum. Holotypes of *Discorbis monicana* Zalesny, *Rotalia lomaensis* Bandy, and *R. versiformis* Bandy were loaned from the type collection by the University of Southern California, Los Angeles. Specimens of *Discorbis vesicularis* and *Trochulina turbo* were picked from samples collected at Méc-rings, near Montmirant (Locality UCLA 4448), France. Hypotypes of *Rosalina globularis* from the Ross Sea, Antarctica, *Gavelinopsis praegeri* (Heron-Allen and Earland) from the Sahul Shelf, N. W. Australia, topotypes of *Rotorbinella colliculus* Bandy, and samples of the Calcaire grossier (Zone IV of Abrard), Grignon, France, were obtained from the Loeblich Collection. Recent examples of *Rosalina globularis* d'Orbigny and *Rotorbinella campanulata* (Galloway and Wissler) were collected from along the southern California coast and from the living cultures maintained by the writers at the University of California, Los Angeles, Department of Geology.

Laboratory cultures of *Rosalina globularis* and *Rotorbinella campanulata* were grown in 30 gallon circulating aquaria, at about 18°C, upon fronds of *Corallina officinalis* (Harvey), and in 100 ml agnotobiotic cultures. Agnotobiotic cultures with one species of diatom and foraminifer, and limited bacteria were maintained at various temperatures from 15°-23°C. Salinity in the cultures were adjusted to 34-35 ‰ using distilled water and seawater from Oceanarium, Inc., Marineland of the Pacific. PH was maintained at 7.5-8.5. Illumination was provided by cool-white, 15-watt fluorescent lamps supplying about 250 foot-candles on a 24 hour cycle.

Oriented thin-sections of specimens were made by arranging individuals on a glass slide with gum tragacanth glue and covering the specimen with Selectron 5003. The plastic was allowed to cure and then cut to standard thin-section thickness or slightly less.

The photomicrographs used in this paper were taken with a Zeiss Photomicroscope using Agfa 35 mm Isopan Iff black and white film and Polaroid black and white film. Specimens were originally photographed at magnifications, of 40X, 64X and 126X.

Cultures were routinely examined with a Leitz binocular stereoscopic microscope at magnifications of 25X, 50X, 100X and 150X. Cytology and thin sections were examined with an American Optical Co. Microstar binocular microscope at magnifications of 35X, 100X, 430X and 970X.

Shaded pencil drawings were made with the use of a Leitz camera lucida mounted on a Leitz binocular stereoscopic microscope.

All thin-sections used in this paper and the illustrated specimens of *Rosalina globularis* and *Rotorbinella campanulata* are on deposit in the Department of Geology, University of California, Los Angeles.

IV. Acknowledgments

The present studies were undertaken while both the writers were American Chemical Society Petroleum Research Fund Fellows, under the ACS PRF grant 979A2, awarded to Dr. Helen Tappan Loeblich, Department of Geology, University of California, Los Angeles.

The writers gratefully acknowledge the generous assistance of the following persons and organizations: Dr. Richard Cifelli, U. S. National Museum, for loan of type specimens; Dr. Orville Bandy, Department of Geology, University of Southern California, for loan of holotypes; Dr. John Lee, American Museum of Natural History, Living Foraminifera Laboratory, for loan of specimens; Dr. A. R. Loeblich, California Research Company, for use of photomicrographic equipment and use of personal specimens and samples; Dr. Helen Tappan Loeblich, Department of Geology, University of California, Los Angeles, for loan of type materials and for reading and criticism of the manuscript; Mr. John De Grosse, Department of Geology, University of California, Los Angeles, for preparation of the oriented thin-sections; and Mrs. Martha Matthews, scientific illustrator, for preparation of shaded camera-lucida drawings.

V. Systematic Descriptions

Superfamily DISCORBACEA Ehrenberg, 1838

Family DISCORBIDAE Ehrenberg, 1838

Subfamily DISCORBINAE Ehrenberg, 1838

A. Genus DISCORBIS Lamarck, 1804

Discorbis LAMARCK, 1804, Suite des mémoires sur les fossiles des environs de Paris: Muséum Natl. Histoire Nat. Paris, Ann., v. 5, p. 182, pl. 62.

Type species: *Discorbis vesicularis* Lamarck, 1804

Test free, trochospiral, plano-convex, all chambers visible on the spiral side, only chambers of final whorl visible on flattened umbilical side, with sutural openings extending from umbilicus towards margin, partly covered by flaps radiating from umbilical region; sutural openings connecting to interior of chamber cavity beneath flaps; primary aperture interiomarginal-extraumbilical; secondary sutural openings positioned on chamber flap opposite from primary aperture, remaining as relict openings in later chambers; biflagellate gametes, wall calcareous, perforate, radial in structure, septa monolamellid.

Remarks: Considerable uncertainty has surrounded the generic concept of *Discorbis* in the published literature because of poor illustration and description of the type species. This is vividly shown by the widely differing morphologic types which have been placed in this genus by different workers at various times. Lamarck's original figure of *D. vesicularis* did not clearly illustrate the diagnostic characters, particularly the features of the umbilical side. Later illustrations (Cushman, 1927) gave good spiral and side views but also failed to portray clearly the umbilical openings extending along the basal portion of the chambers and the flaps which radiate along the edge of these openings. This situation was resolved by Le Calvez (1949) and Loeblich and Tappan (1964a) who described and illustrated topotype material. Despite these attempts to clarify the genus, disagreement about its basic morphology persists. Reiss (1963) states that based on examined topotypes of *D. vesicularis* the genus is bilamellar, and so placed the family Discorbidae within his Superfamily Bilamellidea. Glaessner (1963) concurred with the bilamellar structure stated by Reiss for the discorbids.

Based on the description and illustrations given by Le Calvez (1949) and Loeblich and Tappan (1964a) topotypes of *D. vesicularis* were isolated from samples of the Paris Basin Lutetian and sectioned by the writers to determine the lamellar structure. In contrast to the reports mentioned above the genus is monolamellar (plate 1, fig. 1a). This observation is in agreement with Hofker (1963) and Loeblich and Tappan (1964b).

It appears that the confusion as to the lamellar nature of the septa is a result of misidentification of *Trochulina turbo* and *D. vesicularis,* which frequently occur in the same samples. The adults of these species attain large size (up to 2 mm in diameter) and superficially resemble each other. Parker and Jones (1862), for example, in their discussion of the genus *Discorbis* illustrate d'Orbigny's model 73 of *Trochulina turbo* but describe features which characterize *D. vesicularis.* The two species are morphologically similar but are readily distinguished on the basis of their wall structure. *T. turbo* is clearly bilamellar (plate 2, figs. 1a, 1b).

B. Genus ROTORBINELLA Bandy, 1944

Rotorbinella BANDY, 1944, Jour. Paleontology, v. 18, p. 372, pl. 61, fig. 6.
Gavelinopsis HOFKER, 1951, Siboga Exped., pt. III, v. 8, p. 485.
Biapertorbis POKORNY, 1956, Univ. Carolina Geologica, v. 2, no. 3, p. 265, figs. 4-6.

Type Species: *Rotorbinella colliculus* Bandy, 1944

Test free, small, rotaloid, only last whorl visible ventrally, with definite umbilical plug; spire visible dorsally, this side usually much more convex than ventral side; chambers numerous, moderately or closely appressed; dorsal sutures flush, usually limbate, ventral sutures depressed, sometimes channeled, at times with reentrants; wall smooth, very coarsely perforate; aperture a slit at base of septal face, not extending onto periphery. (Original description, Bandy, 1944)

Remarks: To the above the writers add that the genus has a radial wall structure and monolamellar septa based on examination of topotypes.

The close similarity of this genus with other discorbid genera has been recognized by several authors (Hornibrook and Vella, 1954; Reiss, 1963). Most recently (Loeblich and Tappan, 1964a) *Rotorbinella, Biapertorbis,* and *Trochulina* (=*Discorbina*) were all placed in synonymy with the genus *Discorbis.* This reallocation was largely based on their general discorbid-like apertures, *i.e.,* an umbilical flap separating the primary aperture from secondary sutural openings. We agree with the previous workers as to the great degree of similarity between *Trochulina, Rotorbinella* and *Biapertorbis* but do not believe them all to be junior synonyms of *Discorbis.*

On the basis of wall characters and the basically similar apertural development, *Rotorbinella* is retained within the subfamily Discorbinae Lamarck. However, *Rotorbinella* is a high domed form, with a thickening at the apex of the spiral side and a solid central "column" which commonly projects as a knob or boss on the umbilical side. Discorbis in X-section is low, umbrella-shaped, without extensive secondary thickening on the spiral side and has no comparable central structure. Therefore, we recognize *Rotorbinella* as a distinct genus, and not a synonym of *Discorbis* Lamarck.

Pokorný (1956) described *Biapertorbis* from the Eocene of Czechoslovakia, placing great emphasis on the development of two apertures, one near the umbilical plug, the other half way between the periphery and the plug along the base of the frontal suture. The umbilical plug was indicated as either present or absent, although it is present in the type species. Pokorný remarked that *Rotorbinella* is comparable and that the "reentrant" apertural features of *Rotorbinella* should be re-examined as they suggested a more specialized aperture than was described in the original diagnosis. Restudy of topotypes of *Rotorbinella* shows the congeneric relationship of the two genera. The development of the umbilical plug was disregarded as an important character by Pokorný, who stated that closely similar species may or may not possess this feature. We disagree, and believe the presence or absence of the umbilical plug cannot be determined merely by an external examination of the shell. We believe the distinguishing features indicated by Pokorný are included in the generic description of *Rotorbinella* and for these reasons regard *Biapertorbis* as a junior synonym.

Gavelinopsis (Hofker) 1951 was first published as a *nomen nudum,* mentioning "*G. pacifica*" (then undescribed) as type species. Later the same year Hofker validated the genus, designating *Discorbina praegeri* Heron-Allen & Earland as type species. This genus is regarded as a synonym of *Rotorbinella* as no clear cut characters can be found to distinguish it from the latter (see also Reiss, 1963, p. 72). This conclusion is supported by thin-sections of hypotypes of *D. praegeri* from the Sahul Shelf which show the monolamellar nature of the septa. It should be noted that the specimens figured as *D. praegeri* by Hofker (figs. 332, 333, & 334, pp. 487, 488, and 489) differ from the illustrations of the original authors. Hofker's specimens are biconvex, with umbilical reentrants. The original type is convex-plano, with a prominent umbilical plug and a small slit aperture at the base of the final chamber. No mention was made of the special umbilical reentrants demonstrated by Hofker. The specimens examined and sectioned by the writers match the type of Heron-Allen and Earland.

ROTORBINELLA CAMPANULATA (Galloway and Wissler), 1927

Pl. 1, fig. 1; pl. 6, fig. 6

Globorotalia campanulata GALLOWAY and WISSLER, 1927, Jour. Paleontology, v. 1, p. 58, pl. 9, fig. 4.
Rotalia turbinata CUSHMAN and VALENTINE, 1930, Stanford Univ., Geology Contr., v. 1, no. 1, p. 25, pl. 7, figs. 1, 3.
Rotalia avalonensis NATLAND, 1950, Geol. Soc. America, Mem., 43, pt. 4, p. 30.
Rotalia lomaensis BANDY, 1953, Jour. Paleontology, v. 27, p. 179, pl. 22, fig. 6.
Rotalia versiformis BANDY, 1953, Jour. Paleontology, v. 27, p. 179, pl. 22, fig. 5.
Rotalia spp. WALTON, 1955, Jour. Paleontology, v. 29, p. 1014, pl. 103, figs. 18, 19, 24.
Rosalina campanulata (Galloway & Wissler) UCHIO, 1960, Cushman Found. Foram. Research, Spec. Publ. 5, p. 66, pl. 7, fig. 26.

Test trochoid or bell-shaped, composed of numerous whorls, dorsal side highly convex, ventral slightly concave or flat except for the last formed chamber which projects; peripheral margin rounded and limbate; chambers numerous, about six in the last volution; sutures nearly straight and tangent to the periphery of the previous coil dorsally, depressed ventrally and slightly irregular; umbilicus depressed or sometimes provided with a rounded knob of clear shell material; wall finely perforate; aperture an elongate slit extending into the umbilicus. Diameter of the type specimen, 0.23 mm; thickness 0.14 mm. (Original description, Galloway and Wissler, 1927).

Remarks: This species should be placed in *Rotorbinella* because of its plano-convex shape, definitive umbilical plug, limbate sutures and apertural characters. *R. campanulata* also has a radial, monolamellar wall structure. The quoted description above does not mention the secondary relict sutural openings which are present on most of the topotypes examined by the writers. Numerous specimens from the Lomita Quarry were oriented and thin-sectioned to examine the axial fillings. This structure is initiated at an early stage in the life of the individual and in extreme cases may occupy the major part of the test interior (see text-fig. 1d). In contrast to the plug developed by rotalids, which consists of many vertical pillars bound together, the filling is a single unit. All the specimens examined, both Recent and Pleistocene, contain this axial structure whether or not an external projection was developed. Described from the Pleistocene Lomita Marl, *R. campanulata* occurs in other Pleistocene deposits in California. Older occurrences are not known. The attached benthonic mode of life of this species produces individuals with a wide range of phenotypic variation in convexity of the test, the "keel" on the final whorl and the umbilical knob. Culturing this species in the laboratory has helped to demonstrate the conspecific nature of these variations although several names have been given to the different morphovariates. For example, the holotype of *Rotalia turbinata* closely matches one end member of the variation (see fig. 1d) while the holotype of *R. lomaensis* and *R. versiformis* fall within the range of variation shown by fig. 1b and 1c. Most Recent and Pleistocene examples of *Rotorbinella campanulata* compare closely to the forms illustrated by fig. 1b and 1c, but complete gradations from concavo-convex (fig. 1a) to unequally biconvex (fig. 1d) can be found whenever a large number of individuals are examined. The holotype and paratypes of *Discorbis monicana,* belong to different genera and species. The paratypes include specimens of

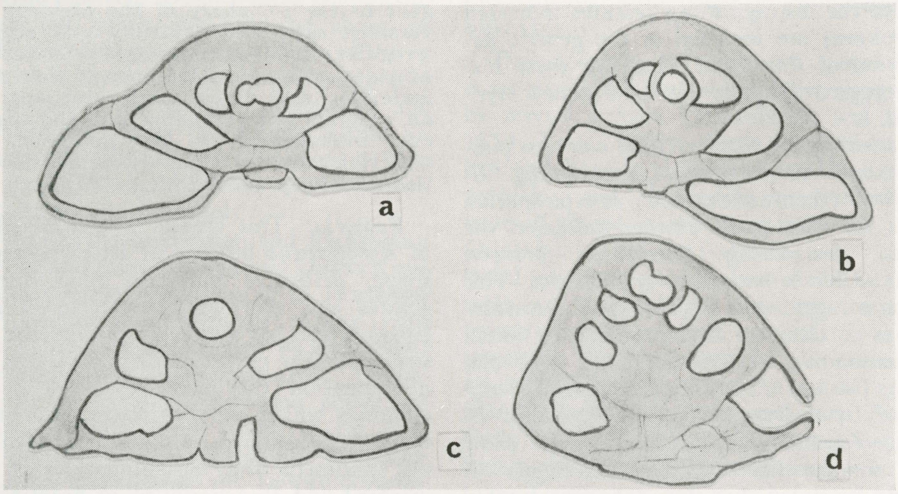

Figure 1. Axial sections of topotype specimens of *Rotorbinella campanulata* showing phenotypic variation in convexity of test. All X146.

both *Rotorbinella campanulata*, and *Rosalina globularis*. On the basis of many collections from localities along the California and Baja California coastline, we believe that several other species mentioned in papers on Recent Foraminifera from this area are also conspecific. However, few of these papers contain illustrations of their faunas and we have not examined all such types.

Range: The geographic range of this species is from Oregon, south to at least Punta Banda, Baja California, Mexico. It is a common intertidal form extending to about 10 fathoms. Within this zone it is most abundant on fronds of coralline algae, particularly *Corallina gracilis*. The distribution in deeper water is not as well documented. Uchio (1960) reports it living to 300 feet, with its greatest frequency at about 120 feet in the area off San Diego, California. Walton (1955) cites the range from 3 to 43 fathoms. Although it has been reported in much deeper water (Zalesny, 1959), information is not given to indicate if it was living at the time of collection at these depths.

Superfamily ORBITOIDACEA Schwager, 1876
Family EPONIDAE Hofker, 1951

C. Genus TROCHULINA d'Orbigny, 1839

Trochulina D'ORBIGNY, *in* EHRENBERG, 1839, K. Preuss. Akad. Wiss. Berlin, Physik. Abh., Jahrg. 1838, table 1, p. 120.

Discorbina PARKER and JONES, *in* CARPENTER, PARKER and JONES, 1862, Ray Soc. Publs., p. 200, 203.

Type Species: *Rotalia (Trochuline) turbo* d'Orbigny, 1826, Tableau méthodique de la classe des Céphalopodes: Ann. Sci. Nat. Paris ser. 1, v. 7, p. 274.

Test free, trochospiral, plano-convex to unequally biconvex, all chambers visible on the spiral side, only chambers of final whorl visible on umbilical side, with narrow slit opening along the chamber suture extending from the umbilicus to the margin, opening into the chamber cavity; initial chambers of spiral side covered by heavy layer of clear shell material; aperture a slit at the base of the final chamber extending from the margin to the umbilical area, frequently bordered by a thin apertural lip; peripheral margin imperforate with slight thickening or keel; umbilical plug or thickening commonly present; wall radial hyaline, coarsely perforate with bilamellar septa.

Remarks: D'Orbigny (1826) named three species under the French vernacular subgeneric term "Les Trochulines" of which only *Rotalia turbo* was valid. This species name was used in combination with the Latin subgeneric name *Trochulina* d'Orbigny, 1839, by Basset (1885) and therefore becomes the type species of *Trochulina* by subsequent monotypy. *Discorbina* Parker and Jones (1862) also based on *Rotalia turbo* d'Orbigny, 1826, is a junior synonym. In the original description of *Discorbina*, Parker and Jones may have confused *R. turbo* with the type species of *Discorbis*, as both the description and the figure are interlaced with references to the latter. For example, the authors note "astral flaps" on the preceding chambers in the umbilical region.

Hofker (1951) erected the genus *Discopulvinulina,* within which he included *Rotalia turbo.* The same author later (1954) placed *turbo* in *Rotorbinella* and stated that the species did not occur in the Paris Basin Eocene. Loeblich and Tappan (1964a) noted that several labeled specimens of this species from the Lutetian of the Paris Basin were present in d'Orbigny's collection at the Muséum National d'Histoire Naturelle, Paris, and designated one of them as lectotype. Nevertheless, this species can be readily separated from *Discopulvinulina* by shape and apertural characters and from *Rotorbinella* by wall structure.

Since the citation of the combination *Trochulina turbo* by Basset, apparently no other species have been described under this generic name. Specimens of *turbo* from Méc-ring and Grignon, France, were sectioned and found to have a bilamellar wall structure (plate 2, fig. 1). For this reason the genus cannot be included with the discorbids, which are monolamellar. On the basis of the information at hand it appears to be a separate and distinct taxon and is herein recognized as such. Examination of numerous species during the preparation of this paper suggests that many of the Tertiary to Recent forms which have previously been referred to *Discorbina, Discorbis* and *Rotalia* are more properly placed in *Trochulina.* However, thin-section analysis of wall structure is necessary for accurate assignment.

Family ROSALINIDAE Reiss, 1963

D. Genus ROSALINA d'Orbigny, 1826

Rosalina D'ORBIGNY, 1826, Tableau méthodique de la classe des céphalopodes: Ann. Sci. Nat. Paris, ser. 1, v. 7, p. 271.

Tretomphalus MÖBIUS, 1880, Beitr. zur Meeresfauna der Insel Mauritius und der Seychellen, p. 67, 99.

Type Species: *Rosalina globularis* d'Orbigny, 1826

Test free or attached, plano- or concavo-convex, trochospiral; aperture interiomarginal and elongate, extending under broad umbilical flap; wall perforate, radial, septa bilamellid; reproductive float chamber developed in some species producing temporary planktonic stage.

Occurrence: Eocene to Recent.

ROSALINA GLOBULARIS d'Orbigny, 1826

Pl. 3, figs. 1-5

Rosalina globularis D'ORBIGNY, 1826, Tableau méthodique de la classe des céphalopodes: Ann. Sci. Nat. Paris, ser. 1, v. 7, p. 271, pl. 13, figs. 1-4.

Rosalina bulloides D'ORBIGNY, 1839, Foraminifères, in Ramon de la Sagra, Histoire physique, politique et naturelle de l'Ile de Cuba, p. 98, pl. III, figs. 2-5.

Discorbis columbiensis CUSHMAN, 1925, Cushman Lab. Foram. Research, Contr., v. 1, p. 43, pl. 6, fig. 13 (a-c).

Discorbis isabelleana (d'Orbigny) (?) CUSHMAN and VALENTINE, 1930, Stanford Univ. Contr. Geology, v. 1, no. 1, p. 23, pl. 6, figs. 6, 7 a-c, 8 a-c.

Tretomphalus bulloides (d'Orbigny) MYERS, 1943, Stanford Univ. ser. Biology, v. 9, no. 1, pl. III, pl. IV, figs. 4-5.

Tretomphalus myersi CUSHMAN, 1943, Cushman Lab. Foram. Research, Contr., v. 19, p. 26-27, pl. 6, fig. 6a-c.

Test free or attached, trochospiral; agamontic individuals benthonic, with plano-convex test, all chambers visible from convex spiral side, only those of final whorl visible on flattened umbilical side; chambers are distinct and range from 18-21 in number, with 5-6 in the final whorl, later chambers commonly irregular, periphery moderately lobate to angled; sutures radial, curved, slightly depressed; wall thin, calcareous, bilamellid, perforate, with few large pores in early chambers replaced by smaller and more numerous ones in later chambers, central periphery and umbilical flaps commonly imperforate; aperture interiomarginal, umbilical and elongate, extending from near the periphery to the umbilicus, where its posterior extension continues under the broad umbilical flap for about one-third the distance along the previous suture; gamontic individuals benthonic in early stages, planktonic in later stages with a more high spired test, plano- or concavo-convex, umbilical side flat to concave (pl. 3, fig. 1a-c); chambers more inflated, ranging from 10-16, with 5-6 in the final whorl; sutures radial, curved; during gamogony a nearly hemispherical float chamber develops over umbilical region (pl. 3, fig. 4a-b) enclosing a spherical, thin walled gas float with internal tube (pl. 3, fig. 2), allowing test to assume a temporary planktonic habit, biflagellate gametes develop within the chambers and the area between the float and float chamber, escape through the areal float chamber pores to fuse and produce agamontic generation; aperture as in agamont but commonly depressed in concave umbilical surface.

Remarks: The genus *Rosalina* was described by d'Orbigny (1826) but without designation of a type species. Galloway and

Wissler (1927) redescribed the genus and fixed *R. globularis* as the type. D'Orbigny regarded the species as widespread, as he gave the occurrence merely as "all the seashores of the ocean", adding that it is attached to algae and polyps. These remarks appear well founded as the writers have examined specimens from Queen Charlotte Sound, British Columbia, Santa Monica Bay, California, and Punta Baja, Mexico, and from Florida, Cuba and the Antarctic. Such a world wide geographic distribution suggests that the numerous presently recorded "species" of *Rosalina* and related genera should be carefully restudied. Furthermore, additional occurrences should be carefully compared to existing species before proposal of additional names.

Laboratory studies by Sliter (Jour. Protozool., in press) on the life cycle of *R. globularis* disclosed the development of the float-chambered planktonic stage that is identical to the holotype of *Tretomphalus myersi* Cushman. Specimens of this float-chambered stage were also compared to a topotype of *T. bulloides* (d'Orbigny) (=*R. bulloides* d'Orbigny) and again found to be identical. Thus *T. myersi* is a junior synonym of *T. bulloides,* and because *R. bulloides* d'Orbigny is the type species of *Tretomphalus* Möbius, the latter becomes a junior isotypic synonym of *Rosalina.*

The rejection of the genus *Tretomphalus* leaves certain other species without generic assignment until life cycle studies can make it possible definitely to place them in their correct taxonomic position. It has been noted (Cushman, 1934) that the initial chambers of the various species referred to *Tretomphalus* are decidedly different, with only the final float chamber common to all. On the basis of morphologic characters the following recommendations are presently proposed for the placement of species previously referred to *Tretomphalus.*

The species characterized by a rosalinid early stage are here referred to *Rosalina* and probably represent only the reproductive stage of other rosalinid species. These include the species *R. clarus* (Cushman), and *R. concinnus* (Brady). The remaining species possess the morphologic features of *Cymbaloporetta.* Here included are those with 1) early chambers trochospiral, later chambers added in an alternating annular series, 2) sutures deeply depressed and radial on umbilical side with small, central umbilicus and, 3) apertures consisting of umbilical, sutural openings bordering chambers. The final chamber is again a globular, float chamber. The following species are here referred to *Cymbaloporetta: C. atlanticus* (Cushman), *C. pacificus* (Cushman), *C. milletti* (Heron-Allen and Earland), *C. grandis* (Cushman), and *C. planus* (Cushman).

The variable morphologic characters of rosalinids, due to their attachment during various stages of growth (fig. 2, a-f) has been noted by several authors (Myers, 1943; Cushman and Todd, 1947; Cooper, 1961; Reiss, 1963; Uchio, 1960). *Rosalina globularis* is no exception, and varies considerably in test height and shape, chamber shape, suture curvature and thickness, number of pores in the initial chambers, float-chamber shape and float pore size and arrangement. Examination of the holotype of *Discorbis columbiensis* Cushman, (pl. 3, fig. 3a-c) to which most of the American West Coast examples of *Rosalina* have been assigned, demonstrates that it falls within the range of variation of *R. globularis* (see fig. 2). Also conspecific with this species is *Discorbis monicana* Zalesny, including the paratypes in part. The plesiotype of *D. isabelleana* (d'Orbigny) (?) Cushman and Valentine was examined and adjudged to be a phenotypic variant of *Rosalina globularis,* closely resembling a specimen taken from coralline algae (fig. 2d). The holotypes of *D. mira* Cushman, *D. floridana* Cushman and *D. subbertheloti* Cushman were found to differ from *R. globularis* although their original illustrations closely resemble this species. *D. subbertheloti* is considered to be a rosalinid based on the open umbilicus and lack of pronounced chamber flaps characteristic of *Discorbis.* But it differs from *R. globularis* in being finely perforate and moderately keeled. *D. mira* possesses the same rosalinid feature with the umbilicus nearly obscured by umbilical flaps. This species also differs from *R. globularis,* in the hyaline wall, sharply angled periphery and scarcity of pores. On the basis of test morphology and mode of reproduction *D. floridana* is neither a discorbid nor rosalinid. Without additional material to section for wall character determination, its present taxonomic placement must remain tentative. The species certainly bears a more than superfical

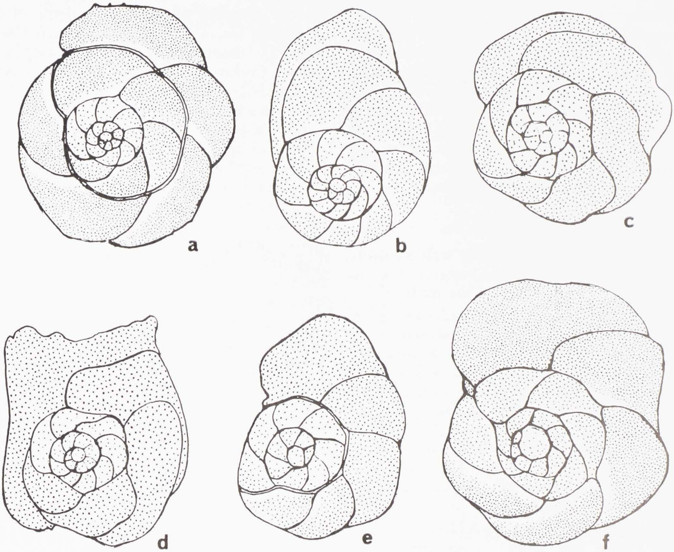

Figure 2. Spiral view of agamontic specimens of *Rosalina globularis* illustrating possible degree of phenotypic variation. a, X72; b and d, X134; c, e, and f, X99. (All figures camera lucida drawings, prepared by Mrs. Martha Matthews).

morphologic resemblance to *Glabratella,* in the lobate periphery and open, pustulose umbilicus. However, this species has an interiomarginal aperture rather than the umbilical aperture of *Glabratella* and it lacks the characteristic umbilical radial ornamentation. The degree of such ornamentation may vary considerably, being absent or nearly so in some specimens (Helen Tappan Loeblich, personal comm.). Species showing the interiomarginal aperture have been noted previously (Bermudéz, 1952) and are now placed in *Angulodiscorbis* (Loeblich and Tappan, 1964a). Such assignment is not applicable for *D. floridana* as this species does not have the high spired test required by the generic definition. Life cycle studies of *D. floridana* (Lee, *et al.,* 1963) indicate that the foraminifer undergoes a plastogamic mode of reproduction. This evidence further suggests a placement with the glabratellids, although Lee *et al.* placed it in *Rosalina.* An additional reference has been made to plastogamy in *Rosalina* (Todd and Low, 1961) but their pleisotypes of *R. globosa* (Sidebottom) were examined and found to belong to *Glabratella.* On the basis of morphology and the reported plastogamic type of reproduction *D. floridana* is here tentatively placed in *Glabratella.*

A plastogamic mode of reproduction has never been observed during laboratory experiments with cultures of *Rosalina globularis* (Myers, 1943; Sliter, in press). In this species reproduction is limited to 1) the pelagic stage modification of the alteration of generations, and 2) the common apogamic reproduction (asexual production of successive agamontic stages). Presently plastogamy is known only in the Glabratellidae, Spirillinacea and Ceratobulimindae (Loeblich and Tappan, 1964a). Other species that are found to undergo plastogamy should be carefully examined before inclusion in genera of other families.

In wall character both generations of *R.*

globularis are calcareous, perforate, radial in structure and bilamellid as noted by Reiss (1963) (see pl. 2, fig. 2). For the latter reason, the genus *Rosalina* can no longer be included in the Discorbidae Ehrenberg (Loeblich and Tappan, 1964a). The writers therefore agree with Reiss (1963) and Loeblich and Tappan, (1964b) in the recognition of the family Rosalinidae for this common and widespread group of organisms.

VI. Conclusions

Based on life cycle studies, wall structure, and comparison with type material, the following taxonomic revisions are made.

Topotype material of *Discorbis vesicularis* Lamarck was sectioned and shown to be monolamellar. The genus *Rotorbinella* Bandy (synonyms *Biapertorbis* Pokorný and *Gavelinopsis* Hofker) is also monolamellar, and retained within the subfamily Discorbinae, but its distinct morphologic characters (*i.e.,* apical thickening, solid central column, and higher spire, etc.) are of generic value, hence it is regarded as distinct and not a synonym of *Discorbis.*

Trochulina d'Orbigny (synonym, *Discorbina* Parker and Jones) is recognized as a distinct bilamellar genus, removed from the subfamily Discorbinae, and placed in the family Eponididae, superfamily Orbitoidacea. The following taxa are regarded as conspecific and referred to *Rotorbinella campanulata* (Galloway and Wissler): *Globorotalia campanulata* Galloway and Wissler, *Rotalia turbinata* Cushman and Valentine, *Rotalia lomaensis* Bandy, and *R. versiformis* Bandy, *Rosalina campanulata* (Galloway and Wissler) Uchio, *Rotalia* spp. Walton and *R. avalonensis* Natland.

Tretomphalus Möbius is a junior synonym of *Rosalina* d'Orbigny as the type species of the former is conspecific with the type species of *Rosalina.* Specific synonyms of *R. globularis* are: *Discorbis columbiensis* Cushman, *D. monicana* Zalesny, *Tretomphalus myersi* Cushman and *D. isabelleana* (d'Orbigny) (?) Cushman and Valentine. *Discorbis mira* Cushman and *D. subbertheloti* Cushman belong to the genus *Rosalina* but appear to be distinct species. Because of its morphology and mode of reproduction *D floridana* is considered to be a glabratellid. Reproduction of *R. globularis* involves a sexual pelagic stage and an asexual benthonic phase; plastogamy is unknown in the family Rosalinidae Reiss. *R. globularis* is shown to be bilamellar and the family Rosalinidae is therefore placed in Orbitoidacea Schwager.

Glaessner (1963) criticized the primary use of septal layering as a satisfactory basis for major classification. Laboratory experiments on living foraminifers undertaken to date, however, suggests that wall structure is a genetic character unaffected by ecologic-environmental controls. The writers have collected and cultured species from lagoonal, intertidal, nearshore, and continental shelf environments up to 300 feet deep. Species from each of these ecologic realms have been cultured in the laboratory for as long as two years, under approximate natural conditions to extreme conditions far exceeding those of the natural habitat. Effects on different species of Foraminiferida produced by varying such factors as food, light, salinity, temperature, and pressure have been and are presently being studied. During these studies examples have never been found to change the basic test structure, such as type of wall septa lamellae, wall structure, and others. The ecologic factors enumerated above may produce a certain amount of phenotypic variation. This morphologic variation is minor, and the fundamental test characteristics are easily recognized. Morphologic variation brought about by the

Plate 1

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1. *Discorbis vesicularis* Lamarck 151

   Lutetian, Grignon, Paris Basin, France. 1a, horizontal section of topotype showing monolamellar septa; 1b, axial section of topotype, both X 100.

2. *Rotorbinella campanulata* (Galloway and Wissler) 153

   Recent. 2a, axial section showing central axial column, X 130; 2b, horizontal section showing monolamellar septa, X 125.

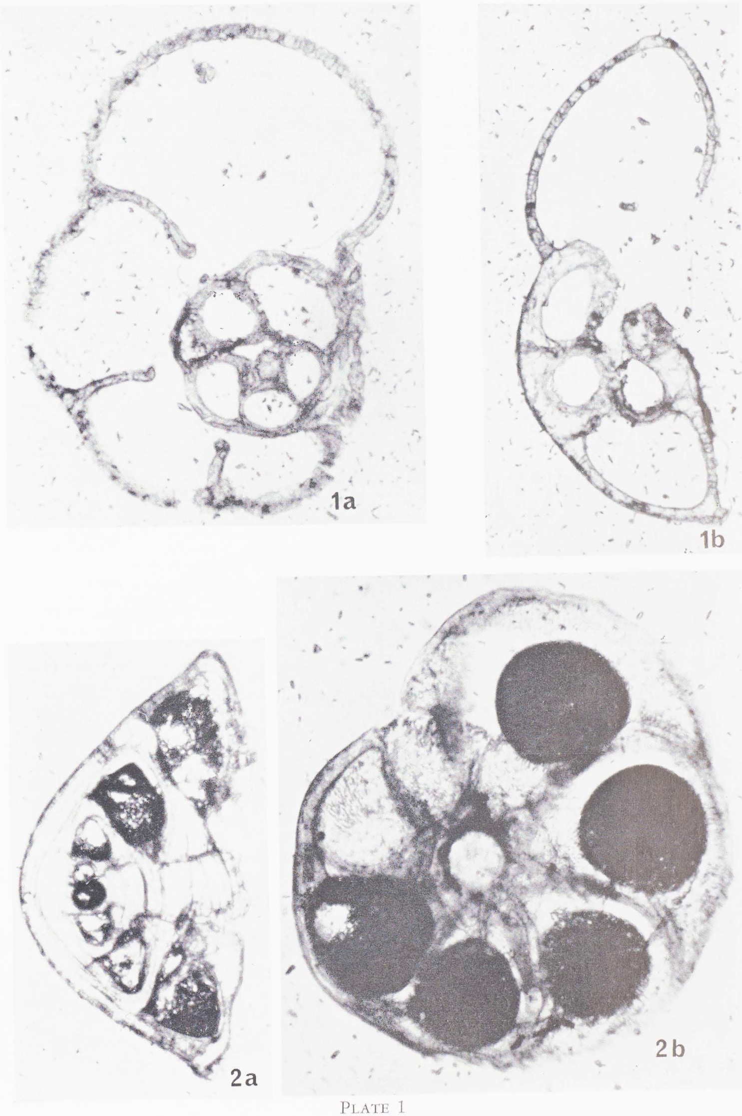

Plate 1

different reproductive methods in the life cycle of a species may appear to approach generic level (Sliter, in press). In all cases examined by us, however, the characteristic test structure has remained unchanged regardless of reproductive generation. If a single morphologic character can provide a basis for foraminiferal classification, then wall structure would appear to provide the best criterion.

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Plate 2

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1. *Trochulina turbo* d'Orbigny 154

   Lutetian, Grignon, Paris Basin, France. 1a, enlarged view of portion of section in 1c, showing bilamellid septa, X 180; 1b, axial section of topotype, X 62; 1c, horizontal section of topotype showing bilamellid septa, X 62.

2. *Rosalina globularis* d'Orbigny 155

   Recent. Horizontal section showing bilamellar septa, X 130.

3. *Rotorbinella praegeri* (Heron-Allen and Earland) 153

   Recent, Sahul Shelf, N. W. Australia. Horizontal section of hypotype, showing monolamellar septa, X 130.

(All figures are unretouched photographs.)

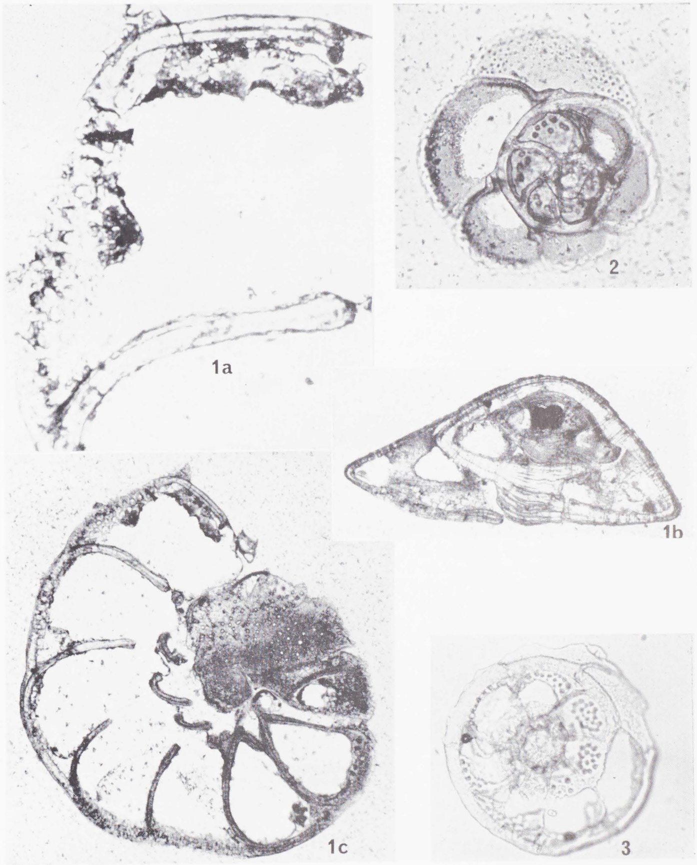

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PLATE 3

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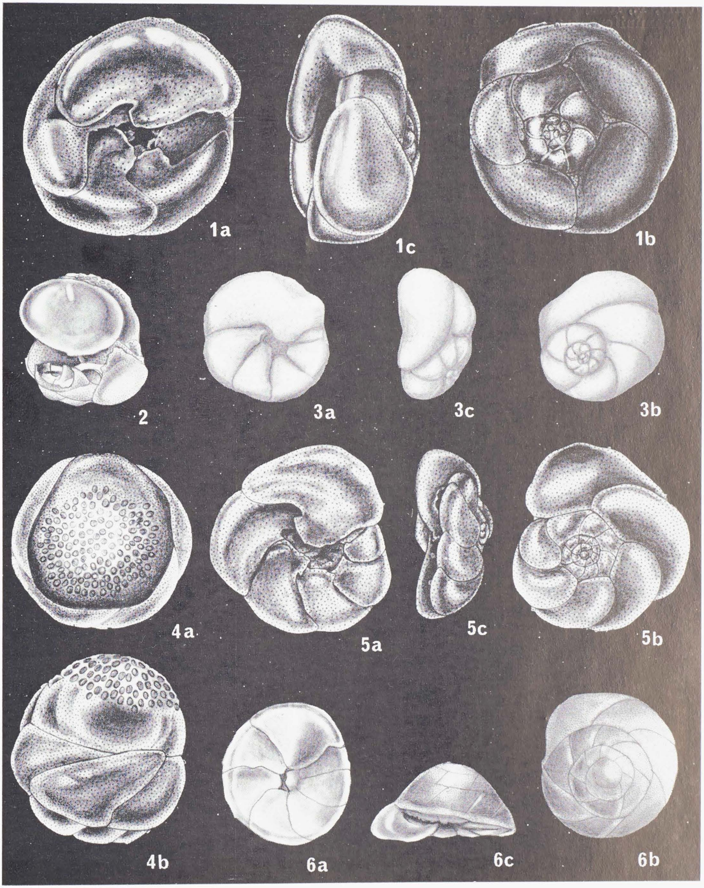
1-5. *Rosalina globularis* d'Orbigny	155

Recent. 1a-c, umbilical, spiral and peripheral views respectively of gamont without float chamber, X 130; 2, peripheral view of etched gamont with float chamber wall removed to show interior gas float and tube, X 66; 3a-c, umbilical, spiral and edge views of holotype of *Discorbis columbiensis* Cushman, redrawn X 88; 4a-b, areal and peripheral views of *R. globularis* with float chamber, X 88; 5a-c, umbilical, peripheral and spiral views of agamont, X 88.

6. *Rotorbinella campanulata* (Galloway and Wissler) 153

Pleistocene. 6a-c, umbilical, peripheral, and spiral views of topotype, Lomita Marl, X 66.

(All figures are shaded camera lucida drawings: Figs. 1a-c, 2, 4a, b, 5a-c, 6a-c, by Mrs. Martha Matthews, Fig. 3a-c by Helen Tappan Loeblich.)



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