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OCCURRENCE AND RELIABILITY OF INTERNAL MORPHOLOGIC FEATURES IN SOME GLANDULINIDAE (FORAMINIFERIDA)

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ABSTRACT

Specimens of some glandulinid foraminifers have been critically examined to assess the validity of recently defined genera and their separation from Glandulina. The genus Tappanella, with T. arctica as type species, differs from Glandulina in the prominent biserial stage of the specimens examined. The genus Euglandulina, type species E. inusitata, is here restricted to those species with an asymmetrical entosolenian tube, attached to one wall of the terminal chamber. The formerly invalid genus Barnardina and type species B. thanetana have been validated by provision of a diagnosis and description. Glandulinoides, type species G. yunnanensis, from the Triassic of China, differs from these genera in the short centrally located entosolenian tube and absence of a biserial early stage.

INTRODUCTION

Based on the presence or absence of internally preserved septa and of an internal apertural tube, the former genus *Glandulina* has been variously redefined and subdivided in recent years. When first described as a subgenus by d'Orbigny (1826, p. 251) with two included species, *Nodosaria (Glanduline) laevigata* and *N. (G.) glans* d'Orbigny, it was in the vernacular French, hence the name was not available (International Code of Zoological Nomenclature (ICZN) Art. 11(b)). However, d'Orbigny (1839, p. 12) validated the subgenus when he latinized *Glandulina.* As neither of the originally included species had been designated as type species, Cushman (1927, p. 189) so designated *Nodosaria (Glanduline) laevigata* d'Orbigny.

Gudina and Saidova (1969, p. 1110) described the genus *Tappanella* with *T. arctica* as type species. They report that *Tappanella* resembles *Glandulina* externally but, based on d'Orbigny's original figures, shows two major differences: representatives of *Tappanella* contain an internal apertural tube, whereas *Glandulina* does not. Secondly, *Tappanella* was said to lack the internal structure of *Glandulina,* where walls of previous chambers remain intact as subsequent chambers are formed. We have examined the internal structures of specimens of both *Glandulina* and *Tappanella* from various localities to determine the validity of these characters for generic separation.

McCulloch (1977, p. 13) described the genus *Euglandulina* with *E. inusitata* as type species. The generic definition is revised herein, resulting in reassignment of some of the previously included species.

METHODS

Approximately 290 specimens from five separate localities were studied under a binocular dissecting microscope to determine inner septal structure and arrangement, and the presence or absence of an entosolenian tube. Outer walls were partially removed in a number of specimens with the method described by Plummer (1951). By mixing a thick gum tragacanth solution with a small amount of HCl, small sections of the outer walls of the specimens were dissolved to facilitate study and illustration of the interior. Scanning electron micrographs were taken of selected specimens with an ISI Super-IlIA Scanning Electron Microscope, and Polaroid NP55 film.

MATERIALS

Materials used for this study were from the following localities:

1. Lower Pliocene (Plaisancian): Ponticella di Savena, on right bank of stream below bridge near San Ruffillo, Province of Bologna, Italy. Collected by B. Accordi, H. T. Loeblich, A. R. Loeblich and C. Loriga.
2. Miocene (Badenien stage, Wielician substage: preevaporite): in salt mine, at second mine level, about 95 m below surface, at Wieliczka, west of Cracow, Poland. Collected by S. Geroch, H. T. Loeblich, A. R. Loeblich and B. Olszewska.
3. Miocene: Tortonian (Badener Tegel), in clay pit at Baden, Austria. Collected by W. W. Hay.
4. Pliocene: Deep Sea Drilling Project Leg 36, Site 329, Core4, Section 2, 42-50 cm, at a water depth of 1,519 m from the Falkland Plateau in the southwest Atlantic Ocean, at 50039.31'S.latitude, 46°05.73'W. longitude.
5. Recent: Gullmar Fjord, Sweden, from K. G. Nyholm.

RESULTS

Specimens of the genera *Glandulina* and *Tappanella* were studied from five samples to determine the validity as generic characters of the internal tube and retained internal septa. Pertinent characteristics of individual specimens were quantitatively tabulated (Tables I and 2) to aid in this determination.

Lower Pliocene (Plaisancien), Bologna, Italy. Of the total 22 *Glandulina* specimens observed in this sample, all were megalospheric, with only one individual containing an entosolenian tube.

TABLE 1. Percentages of megalosphcric and microspheric *Glandulina* and *Tappanella* with entosolcnian tube.

	Sample				
	Pliocene, Italy	Miocene, Poland	Miocene, Austria	Recent, Sweden	Pliocene, Atlantic
Number of individuals	22	9	205	57	2
Tappanella	—	—	—	100%	—
Glandulina	100%	100%	100%	—	100%
Megalo/tube	4.5%	—	3.4%	33.3%	100%
Megalo/no tube	95.5%	100%	90.2%	66.7%	—
Micro/tube	—	—	<1%	—	—
Micro/no tube	—	—	5.9%	—	—

TABLE 2. Percentages of megalospheric and microspheric *Glandulina* and *Tappanella* with preserved internal septa.

	Sample				
	Pliocene, Italy	Miocene, Poland	Miocene, Austria	Recent, Sweden	Pliocene, Atlantic
Number of individuals	22	9	205	57	2
Tappanella	—	—	—	100%	—
Glandulina	100%	100%	100%	—	100%
Megalo/septa	—	—	<1%	—	—
Megalo/no septa	100%	100%	92.7%	100%	100%
Micro/septa	—	—	—	—	—
Micro/no septa	—	—	6.3%	—	—

Miocene (Wielician Substage), Wieliczka, Poland. Nine megalospheric specimens of *Glandulina* were examined and none containing entosolenian tubes were observed in this sample.

Miocene (Tortonian), Baden, Austria. Of a total of 205 specimens of *Glandulina* examined, 185 were of the megalospheric generation with no tubes, seven were megalospheric with tubes, while 12 were of the microspheric generation with no entosolenian tube, and one was microspheric with an entosolenian tube. Of the 185 megalospheric individuals, two were found to have complete and non-resorbed internal septa.

Pliocene, Falkland Plateau, Southwest Atlantic Ocean. Two megalospheric *Glandulina* specimens, each with an entosolenian tube, were recovered from this sample.

Recent, Gullmar Fjord, Sweden. Of the 57 individuals of *Tappanella* examined here, 19 contain an entosolenian tube, while 38 do not.

DISCUSSION

The data obtained from various fossil localities provides a firm basis for the subdivision and redefinition of *Glandulina* and related genera.

The genus *Tappanella,* with *T. arctica* as type species, is recognized on an emended basis. Gudina and Saidova (1969) stated that *Tappanella* contained an entosolenian tube whereas *Glandulina* did not. We have shown that both *Glandulina* and *Tappanella* contain entoso1enian tubes. However, due to the delicate nature of the tests, specimens of both genera are quite common without such tubes preserved. These genera are here differentiated on the basis of the relative prominence of the biserial stage in *Tappanella.* In this genus the test commonly is completely biserial, except for the terminal chamber (Pl. **1,** Fig. 5). In *Glandulina* the biserial development is a much less prominent feature.

The size of the proloculus of all *Tappanella* specimens examined for this study was relatively small. Based on this criterion and a strict interpretation of the definition of megalospheric and microspheric foraminifera, these specimens would normally be described as microspheric. However, such a population would be highly unusual. Normally, the megalospheric generation outnumbers the microspheric generation by a significant proportion (Myers, 1943). Schaudinn (1895) observed that the smallest proloculus of the megalospheric form of *Elphidium* was the same size as the largest proloculus of the micro spheric form. In addition, Grell (1958) suggested that the difference in size of the proloculus of sexually as compared to asexually produced individual foraminifera holds true only for species that produce free-swimming gametes, such as *Elphidium* and *Peneroplis.* Both these points make a definite determination of the generation of *Tappanella* very tenuous. It appears then, that the specimens of *Tappanella* observed may be megalospheric, though no representatives of a second generation were found. In our opinion a definitive determination will not be possible until representatives of a second generation of *Tappanella* are observed or the life cycle is better understood.

Gudina and Saidova further differentiated *Glandulina* as containing internally retained septa, and *Tappanella* as lacking such septa. Less than one percent of the *Glandulina* specimens examined in this study contained internal septa, but resorption of septa in specimens of both genera is probably the result of some event in the life cycle of the protozoan, such as gametogenesis. No live culture studies have been carried out on *Glandulina* or *Tappanella.* However, culture studies of reproductive *Glabratella* (Myers, 1940), *Tretomphalus* (Myers, 1943), *Rubratella* (Grell, 1958), and *Orbulina* (Le Calvez, 1936) have shown that in these genera, internal resorption of septa is related to reproductive processes.

Tappanella characterizes high latitude, cold water assemblages, whereas *Glandulina* is more typical of temperate to tropical assemblages.

The genus *Euglandulina* is redefined and restricted to include only those species with entosolenian tubes attached to one wall of the terminal chamber. McCulloch (1977) described the genus as differing from *Glandulina* by the absence of a biserial stage in the microspheric generation and as having slightly depressed sutures. However, the relatively large proloculus of the holotype of the type species *E. inusitata* suggests that this is in reality a megalospheric specimen. The nature of the entosolenian tube appears to be a much more important criterion in differentiating this genus.

Haynes (1981) briefly described a new genus *Barnardina,* citing *B. thanetana* (a nomen nudum) as type species. *Barnardina* differs from *Glandulina* in having a triserial initial stage. The genus was invalid, as Haynes failed to provide a description for the type species, hence it has been validated herein.

Ho [He], and Hu (1977) described the genus *Glandulinoides,* with G. *yunnanensis* as type species, from the Triassic of China. This is the oldest known occurrence of a glandulinid in the fossil record.

SYSTEMATIC DESCRIPTIONS

Family GLANDULINIDAE Reuss, 1860
Subfamily GLANDULININAE Reuss, 1860
Genus Glandulina d'Orbigny, 1839
Pl.1, Figs. 1-4

Nodosaria (Glanduline) D'ORBIGNY, 1826, p. 251.
Nodosaria (Glandulina) D'ORBIGNY *in* DE LA SAGRA, 1839, p. 12.
Giandulina D'ORBIGNY, 1846, p. 28.
Glandilina GALERKINA and LAZUKOV, 1960, p. 120 (err. cit.).
Gladulina P.B. SMITH *in* DURHAM and YERKES, 1964, p. 816 (err. cit.)
Glaudulina MCCULLOCH, 1977, p. 21 (err. cit.).

Type species. Nodosaria (Glanduline) laevigata d'Orbigny, 1826, p. 252, fixed by subsequent designation by Cushman, 1927, p. 189.

Description. Test free, calcareous, elongate-ovate, tapering toward each end, circular in cross section; chambers in early portion biserially arranged and later uniserial in microspheric generation, megalospheric generation uniserial throughout; chambers strongly overlapping and increasing in size; sutures distinct, flush; wall generally opaque except for narrow hyaline band adjacent to aperture, smooth or slightly striated; aperture terminal, central, radiate, with short straight entosolenian tube.

Remarks. Major distinctions of this genus are the initial biserial stage of the microspheric form, and the short, straight entosolenian tube. Internally, the distal wall of earlier chambers undergoes resorption during some stage of growth (Pl.1, Fig. 2, 4) or at the time of reproduction. Both conditions occur in *Glandulina,* as we have found typical specimens of the type species retaining these.

Genus Eugiandulina McCulloch, 1977

Euglandulina McCULLOCH, 1977, p. 13.

Type species. Euglandulina inusitata McCulloch, 1977, fixed by original designation.

Description. Test free, calcareous, oval, circular or somewhat compressed in section; uniserial, chambers strongly embracing, increasing rapidly in diameter; sutures slightly depressed, horizontal; wall generally opaque, surface of type species minutely striated; aperture terminal, central, radiate, with entosolenian tube attached to wall of one side, and extending about half the length of final chamber.

Remarks. McCulloch described this genus as differing from *Glandulina* in the absence of a biserial stage in the microspheric form and in having slightly depressed horizontal sutures. However, the relatively large proloculus of the uniserial holotype suggests that this is megalospheric, and the uniserial or biserial nature ofthe microspheric early stage is unknown. The nature of the entosolenian tube is more important generically, hence, we would restrict the genus to include only those species with entosolenian tubes that are attached to the wall of the terminal chamber, as in *Dainita* and *Siphoglobulina.* The latter two genera differ in being biserial and triserial respectively. On this basis, only the type species is retained herein, *E. colomboensis, E. pilata, E. symmetrica* and *E. translucens* are transferred to *Glandulina,* and *E.* (?) *impolitiformis* is probably referrable to *Globulotuba.*

Genus Barnardina, n. gen.

Barnardina HAYNES,1981, p. 198 (invalid, type species invalid, ICZN Art. 13(a)(i)).

Type species. Barnardina thanetana, n. sp. = *Barnardina thanetana* Haynes, 1981, (invalid, no description), Key fig. 9.7(18/19), non fig. 20; =*Glandulina? laevigata* Haynes, 1958 (non d'Orbigny, 1826), p. 14, pl. 5, figs. 1, la-e.

Diagnosis. A glandulinid with the microspheric generation having a triserial early stage and with an entirely uniserial megalospheric generation.

Description. Test subfusiform, broadest centrally and tapering at both ends, initial part triserial in microspheric form and then uniserial, megalospheric form uniserial throughout; chambers strongly embracing, terminal chamber comprising over one half total length; sutures slightly depressed; aperture terminal, radiate, with short, centrally located entosolenian tube.

Remarks. Barnardina differs from *Glandulina* d'Orbigny in having a triserial early stage in the microspheric generation.

Haynes (1981, p. 198) cites the generic name *Barnardina,* gives a short description, and lists *B. thanelana.* n. sp., without description, as the type species. This is followed by the citation of two additional specific names, *Glandulina? laevigata* and G. ? *ovula* Haynes (non d'Orbigny) 1958, p. 14. No mention is made as to whether these latter citations are conspecific or merely congeneric representatives of the new genus. As the type species, *B. thanetana,* is without description, it is invalid (ICZN, Art. 13(a)(i)), and the genus is invalid as it includes no validly described species. The use of a combined generic-specific description as an indication is only valid prior to 1931 (ICZN Art. 12 and Art. 16(a)(vi)), and after 1930 every new taxon must be accompanied by a statement giving differentiating characters.

Haynes (1981, Key fig. 9.7, nos. 18,20) illustrates two forms as *Barnardina thanetana.* Figure 9.7, no. 18 is taken from *Glandulina? laevigata* Haynes, 1958, pI. 5, no. I, whereas figure 9.7, no. 20 is a copy of G. ? *ovula* Haynes, 1958, pI. 5, fig. 3b. In these illustrations G. *ovula* appears more fusiform, with a terminal chamber that occupies less than one half of the total length, and appears specifically distinct, hence figure 20 (Haynes, 1981) is not here included in *B. thanetana.*

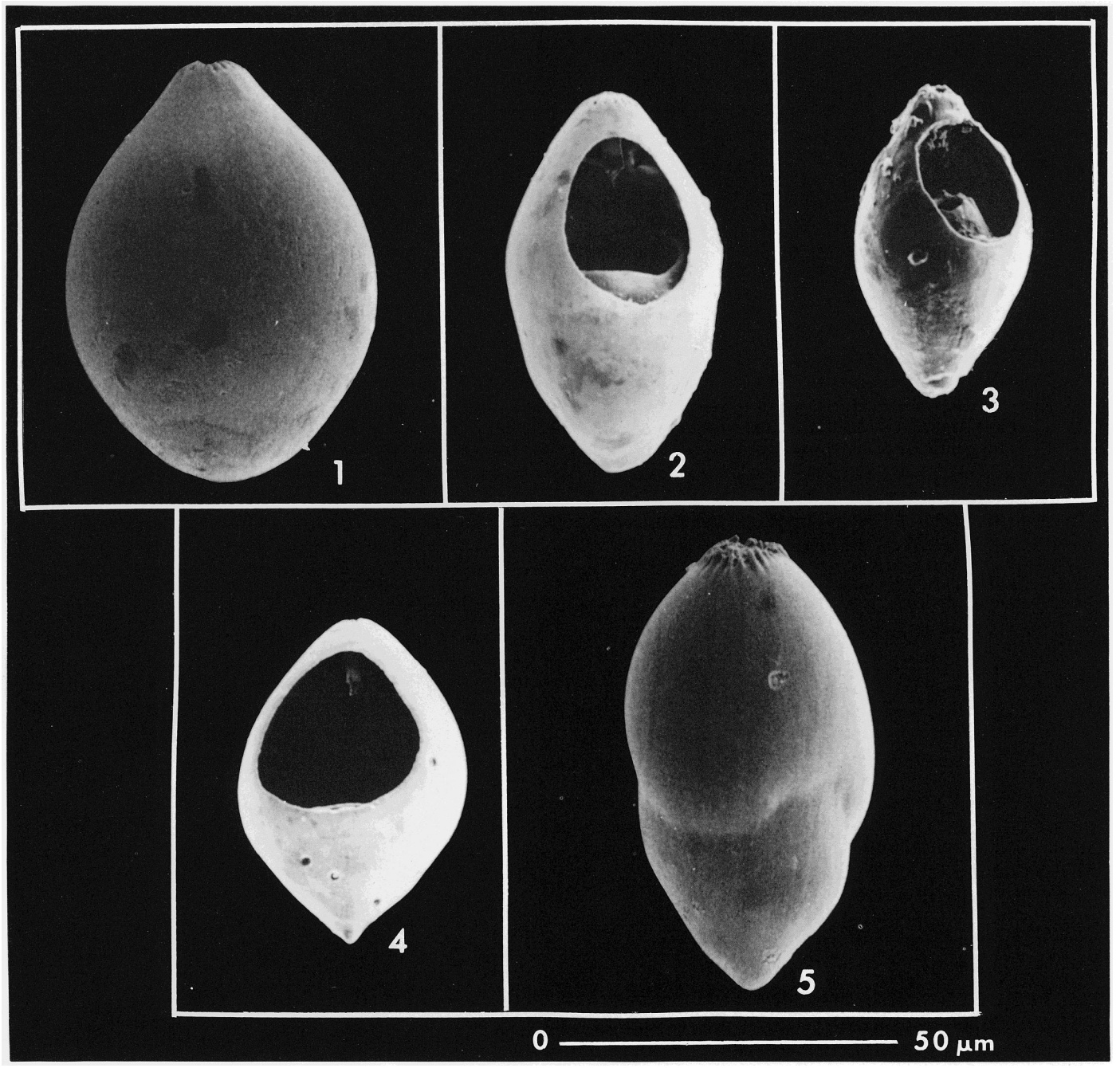

PLATE I

1-4 Glandulina laevigata (d'Orbigny), al1 x 112, Miocene, Baden, Austria. 1. Megalospheric generation; USNM 382265. 2. Megalospheric generation with last chamber dissected to show entosolenian tube and remnant of preceding septum; USNM 382266. 3. Megalospheric generation with last chamber dissected to show nonresorbed septum; USNM 382267. 4. Megalospheric generation with last chamber dissected to show entosolenian tube and almost ful1y resorbed septum; USNM 382268.

5 Tappanella arctica Gudina & Saidova, x 112, Recent, Gul1mar Fjord, Sweden; USNM 382269.

Barnardina thanetana, n. Sp.

Glandulina? laevigata HAYNES, 1958, p. 14, pl. 5, figs.1,1a--e (non *Nodosaria (Glanduline) laevigata* d'Orbigny, 1826).

Barnardina thanetana HAYNES, 1981, p. 198, Key fig. 9.7, figs. 18,19 (non fig. 20) (invalid, no description).

Diagnosis. A species of *Barnardina* with broadly fusiform test and strongly embracing chambers, with final chamber comprising two-thirds to three-fourths the length of the test.

Description. Test free, tapering at both ends, initial end acuminate; triserial in micro spheric form, uniserial in megalospheric form, later stage uniserial in both generations; terminal chamber comprising from two-thirds to three-fourths total length of test; aperture terminal, radiate, with short, central entosolenian tube.

Measurements. Length 0.62 mm, maximum width 0.34 mm.

Types. Holotype, British Museum (Natural History), Catalog number P42554, specimen illustrated as *Glandulina? laevigata* by Haynes, 1958, pl. 5, fig.1, and paratypes, (Haynes, 1958, pl. 5, figs.1 b-e). All from the Paleocene Pegwell marls, at Pegwell, Kent, England, sample P35 of Haynes (1956, p. 81).

Remarks. B. thanetana includes *Glandulina? laevigata* of Haynes, 1958, but not G. ? *ovula* Haynes, 1958, both of which were listed by Haynes (1981) in his initial mention of *Barnardina.*

Genus Tappanella Gudina and Saidova, 1969
Pl. 1, Fig. 5

Tappanel/a GUDINA and SAIDOVA,1969. p. 1110.

Type species. Tappanella arctica Gudina and Saidova, 1969, p. 1111;=*Glandulina laevigata* Gudina, 1966 (non d'Orbigny, 1839), p. 29, pl. 2, figs. 7, 8, pl. 11 , fig. 3;=*G. laevigata* Loeblich and Tappan, 1953 (non d'Orbigny, 1839), p. 81, pl. 16, figs. 2-5; =*G. laevigata* Loeblich and Tappan, 1964 (non d'Orbigny, 1839), p. C537, figs. 421 (1,2); fixed by original designation.

Description. Test free, calcareous, elongate-ovate to subcylindrical, tapering at both ends, white to cream colored; chambers enlarge rapidly and are overlapping, the final chamber comprising one-half to three-fourths of test length; relatively small proloculus; biserial in early part, with nearly central final chamber; distal parts of earlier septa almost completely resorbed internally in most specimens observed; walls polished and smooth, ranging from opaque to semi-transparent, with short translucent subapertural collar below terminal radiate aperture allowing short straight entosolenian tube to be visible within.

Remarks. Tappanella and *Glandulina* are readily differentiated. In *Tappanella* the biserial chambers comprise most of the test, with only the final chamber appearing uniserial. In *Glandulina* the biserial stage of the micro spheric generation is much reduced, to only one or rarely two pair of chambers. All specimens of *Tappanella* observed contained a small proloculus and appear to represent a single generation. Despite the small size of the proloculus, the evidence outlined in the discussion above suggests that they may all be representatives of the megalospheric form.

Gudina and Saidova (1969) differentiated *Tappanella* from *Glandulina* on the basis of internal septa being present in *Glandulina* (basing this on d'Orbigny's 1826 figures), and lacking in *Tappanella,* and an entosolenian tube being present in *Tappanella* and lacking in *Glandulina.* We disagree with both criteria. The degree of septal resorption varies in individuals of both genera and probably results from some event in the life cycle of the protozoan; perhaps gametogenesis. Secondly, we have observed specimens of both *Glandulina* and *Tappanella* with entosolenian tubes, and specimens of *Glandulina laevigata* with preserved internal septa. The tests of *Glandulina* and *Tappanella* are very fragile, and the delicate entosolenian tubes are easily dislodged from specimens of both genera.

Genus Glandulinoides Hu *in* Ho [He] and Hu, 1977

Glandulinoides Hu *in* Ho [HE] and Hu, 1977, p. 15.

Type species. Glandulinoides yunnanensis Hu *in* Ho [He] and Hu, 1977; fixed by original designation.

Description. Test uniserial and rectilinear, with slight degree of chamber overlap; cross section circular or subcircular; sutures distinct, horizontal, flush or slightly depressed; test wall calcareous, finely perforate; aperture terminal, radial, with short, centrally positioned entosolenian tube.

Remarks. This genus is distinguished from *Rectoglandulina* by the presence of an entosolenian tube, from *Glandulina* by the absence ofa biserial stage, and from *Euglandulina* in the entosolenian tube being short and centrally located, rather than attached laterally to the wall of the terminal chamber.

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