MORPHOLOGY AND PHYLOGENY OF
O R B U L I N O I D E S B E C K M A N N I I (S A I T O 1 9 6 2 )

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ABSTRACT. An examination of dissected specimens of the Eocene species Orbulinoides beckmannii (Saito 1962), formerly Porticularaspis mexicana (Cushman 1925), reveals certain morphological features not hitherto described. A study of the ontogeny of O. beckmannii and a comparison with the contemporaneous species Globigerinoides kugleri Bolli, Loeblich and Tappan, and Globigerina acuta bari Bolli, Loeblich and Tappan, indicate that O. beckmannii is unlikely to be related to either of these species. It appears to have developed from some globorotaliid ancestor.

This study is based on specimens obtained from a block of extraneous Eocene in the Miocene Nariva Formation of Trinidad. This same material was used by Bolli (1957b, p. 159) in his monograph on the Eocene faunas of Trinidad. Bolli, Loeblich and Tappan (1957, p. 34) gave a full and accurate description of their new genus Porticularaspis, and Bolli (1957a, p. 116) in placing the Miocene species Globigerinoides glomerosa Blow 1965 in this new Eocene genus commented that detailed comparative studies would probably ... reveal differences between the Eocene and Miocene forms, ...' (op. cit., p. 115). Bolli, Loeblich and Tappan designated Globigerina mexicana Cushman 1925 as the type species of their new genus Porticularaspis. Saito (1962) considered that the Cushman type should be referred to the genus Globigerapsis Bolli, Loeblich and Tappan. Further examination of G. mexicana by Saito, and independently by Blow, has led to the conclusion that G. mexicana Cushman is conspecific with Globigerapsis seminolita (Keijzer 1945). The writer has also examined the holotype of G. mexicana and agrees with their conclusion. Blow and Saito have therefore assigned the specimens which Bolli (1957a) previously referred to as Porticularaspis mexicana (Cushman 1925), and upon which this study is based, to the new genus Orbulinoides as O. beckmannii (Saito 1962).

Olsson (1965) subsequently erected the genus Praeorbulina for the Miocene forms (i.e. Porticularaspis of Bolli 1957a, p. 115) with the type species Globigerinoides glomerosa glomerosa Blow 1956. The object of this paper is to discuss certain morphological features observed in O. beckmannii, and which have not previously been described.

Morphology. Externally O. beckmannii shows numerous apertures at the base of the final chamber. The early trochospiral part of the test shows between one and four supplementary apertures; occasionally no such apertures were present. When present they are usually located at the junction of the spiral and intercaleral sutures. The specimen illustrated by Bolli (1957a, pl. 37, fig. 1a) showing eight such apertures is considered atypical (cf. Bolli, Loeblich and Tappan, 1957, pl. 6, figs. 9a, b).

A removal of the final chamber and part of the walls of the last three chambers of the initial trochospire (text-fig. 1c) reveals the numerous supplementary apertures described by Bolli, Loeblich and Tappan (1957) and Olsson (1965). However, a closer examination

TEXT-FIG. 1. a–d, Orbiculoidea beckmannii (Saito 1962). a, Dissected specimen showing earliest whorl with an umbilical-extra-umbilical aperture, BMNH P46842, ×76. b, c, Dissected specimens, BMNH P46843, 46844, ×105. d, Dissected specimen showing trochospiral supplementary aperture (TS) opening into the vestibule (V), BMNH P46846, ×93.
e–g, Globigerinita knelleri Bolli, Loeblitch and Tappan 1937. Dissected specimens showing globigerinitid primary aperture. e, Specimen with Bulla partly removed, ×120; f, Bulla and two chambers removed, ×120; g, Bulla and five chambers removed; BMNH P46847, ×105.
h–j, Globigerinathela barri Bolli, Loeblitch and Tappan 1957. Dissected specimens showing a globigerinitid primary aperture. h, Bulla partly removed, ×100; i, Bulla and two chambers removed, ×100; j, Bulla and five chambers removed; BMNH P46848, ×73.
All specimens from the O. beckmannii Zone, Navet Formation, Eocene, Point-à-Pierre, Trinidad.
of these apertures shows that in no instance are they directly connected with the outside of the test. They open into a small cavity (here termed vestibule) between the thick outer wall and the delicate wall of the initial trochospirally arranged chambers (text-fig. 1e). This vestibule is usually situated at the junction of the spiral and intercameral sutures, but probably also extends some way along the intercameral suture. It is also seen that the external supplementary apertures on the initial trochospire were never aligned with the internal apertures. Therefore, there is only an indirect connexion, that is via the vestibule, between the inside and outside of the test, as far as the early supplementary apertures are concerned.

Bolli's comparison (op. cit., p. 115) of the supplementary apertures of Orbutiloides and Globigerinoides cannot be upheld. There is a basic difference in that, in the latter genus, these apertures are not covered by the subsequent thickening of the test and are in direct communication with the inside of the test. It would seem that early supplementary apertures became vestigial structures, in the sense that the degree of direct connexion between the inside and outside of the test in this area was much reduced. This appears to be in contrast with species of Globigerinoides (and also Orbula suturealis Bronniann 1951) where a direct connexion is maintained for each of the apertures.

The method of test thickening in Orbutiloides also appears to be in contrast with certain fossil species of Globigerinoides (e.g. G. subquadratae Bronniann 1954 — G. ruber d'Orbigny 1826) of Bolli 1957a). In this genus thickening is progressive rather than occurring only after the adult stage has been reached.

A consideration of the morphology of the initial trochosphere of Orbutiloides (e.g. its large primary aperture, inflated spinose chambers, numerous large supplementary apertures, and thin wall) strongly suggests that during the trochosorial stage the animal inhabited the epipelagic zone (sensu Hedgepeth 1957, p. 18, fig. 1). The subsequent test thickening, and the reduction in the number of supplementary apertures, might be correlated with a migration to deeper levels. The work of Bé and Ericson (1963) and Bé (1965) offers some support for this view, since a correlation between the thickness of the test with depth in the Recent species Globorotalia trunculata and Globigerinoides sacculifer (Brady) was observed. The reduction in the number of 'functional' supplementary apertures may have been one means of increasing its weight in order to occupy lower levels. It is equally possible that the thickening of the test and reduction in supplementary apertures are associated with reproduction. The final inflated chamber may represent a type of brood pouch.

The presence of such an inflated final chamber in Globigerapsis and Globigerinatheka may indicate a similar mode of reproduction in these genera. Le Calvez (1936) showed that in Orbula minima (d'Orbigny) there was a gradual reduction in the globigerine part of the test with depth. Furthermore, in specimens from the deepest levels (about 300 m) the globigerine chambers had completely disappeared, and all that remained was the spheroidal final chamber which was frequently found to be filled with gametes. Therefore, there is some support for the view that the inflated final chambers of these Eocene genera might be connected with reproduction.

Phylogeny, Bolli (1957a, p. 160) stated that '... Globigerapsis, Globigerinatheka and Purticulosphaera obviously represent a related group'. He considered that Globigerapsis index (Finlay) gave rise to G. kugleri Bolli, Loeblich and Tappan, from which O.
beckmanni developed. His further support for this view was the fact that the three genera showed a 90 per cent. tendency to coil dextrally. Bolli is correct in the case of Globigerinoidea and Globigerinatheke, and Eckert's (1963) study of these genera supports this conclusion. However, in the writer's opinion, Orbulininae is unrelated to either of these genera. The gross morphological similarity of these three species is more likely to be a function of convergent evolution than any genetic affinity (at least as far as beckmanni is concerned). This view is based on a comparison of the ontogeny of G. kugleri, G. harrii, and O. beckmanni (text-fig. 1). It is clear that both kugleri and harrii have arisen from a globigerinid ancestral form, while O. beckmanni shows an unmistakable umbilical-extra umbilical primary aperture initially, and therefore is derived from a globorotalid ancestor. The striking differences in the morphology of the initial whorls, particularly the distinctive shape of the later trochospiral chambers of beckmanni, and the large primary aperture, adds further support to this view (text-fig. 1, cf. figs. a, b with f-j). Bolli considered the gross similarity of the adult tests of these three species the most important phylogenetic factors. The writer, however, considers that the evidence of the ontogeny of these species outweighs the adult similarity in gross morphology.

Acknowledgements. The writer is indebted to J. B. Saunders (Texaco Trinidad Inc.) for the material on which this study is based; Dr. R. Lagarj and J. A. Postuma (Bataafse Internationale Petroleum Maatschappij N.V., The Hague) and Dr. J. E. Noorthoorn van der Kruiff (Koninklijke/Shell Explo- ratie en Produktie Laboratorium, Rijswijk) for much helpful discussion and criticism; Dr. W. H. Blow for providing a copy of the Blow and Saito MS.; Dr. R. Cifelli (U.S. National Museum) for permission to examine the types; and Bataafse Internationale Petroleum Maatschappij N.V. for permission to publish this paper.

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CORDEY: **ORBULINOIDES BECKMANNII** (SAITO 1962)


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Typescript received from author 29 June 1967