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## ABERRANT GENERA OF FORAMINIFERA FROM THE MESOZOIC (Sub-family Ramulininae Brady 1884)

The difficult group of ramulinid foraminifera is divided into morphological groups. Six new species are described, and earlier recorded species redescribed where necessary.

Debido a la dificultad del grupo de los Foraminíferos Ramulínidos, se ha dividido en dos grupos morfológicos. Se describen seis nuevas especies; y, donde es necesario, se describen otras especies anteriormente reseñadas.

### INTRODUCTION

Two subfamilies Webbinellinae and Ramulininae of peculiar aberrant foraminifera have been placed by Loeblich and Tappan (1964) in the Family Polymorphinidae d'Orbigny (1839). One of these, the sub-family Webbinellinae Rhumbler (1904) contains many irregular *adherent* foraminifera. Most of the representatives from the Mesozoic have already been considered by Barnard (1958) and Adams (1962).

Some of these genera and species could clearly be considered as the adherent equivalents of free living forms assigned to the other sub-family Ramulininae.

Although Loeblich and Tappan (1964, p. c. 511 - c. 537) have included both these sub-families in the super-family *Nodosariacea* Ehrenberg 1838, there is however doubt whether some, if not all of the genera should be

included in the family Nodosariidae Ehrenberg 1838 and not the Polymorphinidae d'Orbigny 1839.

Most of the genera assigned to these two sub-families *Bullopora* Quenstedt 1856, *Vitriwebbina* Chapman 1892, *Ramulina* Jones 1875 and *Ramulinella* Paalzow 1932 have no polymorphine arrangement of the chambers at all, consisting of arcuate, sigmoidal, or irregular uniserially arranged chambers.

Much confusion has arisen in the past in the taxonomy of the genus *Ramulina* Jones 1875, and two main attempts have been made to clarify the position. Jones R. and Chapman F. (1897) dealt with all the species known at that time, and by making the assumption that a wide range of variation existed in the species, these authors were able to assign most described forms to a few species, even if the specimens were ill preserved or fragmentary.

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Loeblich A. R. and Helen Tappan (1964) included four genera in the subfamily Ramulininae Brady 1884; *Ramulina* Jones 1875, *Ramulinella* Paalzow 1932, *Sporadogenerina* Cushman 1927, and *Washitella* Tappan 1943. The last two genera are Recent and Albian to Cenomanian respectively; the former is beyond the scope of the present paper, whereas the latter has not been found in British rocks of the same stratigraphical age as those in N. America.

Loeblich and Tappan (1964) figure two species under the genus *Ramulina*, *Ramulina aculeata* (d'Orbigny), fig. 420, 8, and *Ramulina laevis* Jones, fig. 420, 9. Both have elongate almost ellipsoidal chambers connected by stoloniferous necks, the former consisting of a single row of individual chambers, the latter clearly showing distinct branching. The distinct differences in morphology, together with the extreme abundance and variety of forms occurring in the Upper Cretaceous (Chalk) of Britain, has led the present author to study these forms in more detail.

## DISCUSSION OF TYPE

Genus *Ramulina* Rupert Jones 1875

Genotype *Ramulina aculeata* (d'Orbigny)

designated Loeblich and Tappan 1964

It soon becomes apparent to students of Upper Cretaceous benthonic foraminifera that considerable confusion exists, in not only, the speciation of the genus *Ramulina*, but also, many forms which clearly belong to the genus *Ramulina* having been assigned to other genera, *Dentalina*, *Bullopورا*, and *Vitriwebbina*.

Wright J. (1875) describes the genus *Ramulina* as follows, «Fragments of tubular forms more or less aculeate near to the so called *Dentalina* (?) *aculeata* of d'Orbigny» and continues, «My friend Professor T. Rupert Jones

proposes to distinguish this simple, calcareous, subsegmented, branching, NODOSARIAN form by the «generic» name *Ramulina* (from «ramules», a little branch); the «species» above mentioned, which is common in the French and British chalk standing as *Ramulina aculeata* (d'Orb.) and our Irish form, which differs from d'Orbigny's in being smooth, as *Ramulina laevis* gen. et sp. nov. Jones. Rather rare.»

Jones species *laevis*, is smooth, consists of three elongate, irregular ellipsoidal chambers, with ill defined tubular connections between the chambers. Possibly the most significant character is the distinct branching on the middle chamber which is also more swollen than the other two chambers.

Dakin W. J. (1906) emended the genus *Ramulina* Jones, taking Brady's (1884) definition of the genus from the Challenger Reports. Brady's description is «Test free, branching; consisting of a calcareous tube, swollen at intervals so as to form more or less definite, often irregular segments, from which lateral stolons or branches are given off. Texture hyaline.»

Dakin (p. 228) states «The definition of the genus given by Brady was quoted above. I suggest that this be now modified so as to read:- Test free, or adherent, branching and anastomosing; consisting of a calcareous tube, swollen at intervals to form more or less definite, often irregular segments (ampullae), opening into another and being contiguous, or separated and connected by tubules. From these segments straight tubes (pipes) are given off. Texture hyaline or opaque.»

This adds little to the description of the genus given by R. Jones except that *adherent* forms are included, and attention is given to the opaque nature of the wall. Loeblich and Tappan (1964 p. C537) do not mention the amendment given by Dakin, possibly because no type was designated.

Adherent specimens must be assigned to the sub-family *Webbinellinae* Rhumbler. The opaque wall may be due to infilling of the pore spaces in hyaline forms or the species could belong to genera with porcellaneous walls and clearly should not be included in the sub-family *Ramulininae* Brady. However, in both the descriptions given by Jones and Dakin, the *branching* nature of the test is emphasised.

The standard works on foraminifera by Cushman (1940), Jones (1956), Glaessner (1944), and Porkony (1958), all consider the typical *Ramulina* to be a branching form.

Loeblich and Tappan (1964), however, have introduced a further complication in their description by stating «Test consisting of globular or irregular chambers loosely connected by stolon-like necks, or by straight or branching tube with local irregular chamber-like swellings». From this, it is not clear whether the test consists of a single series of chambers, or a branching series.

Numerous species of the genus *Ramulina* occur in the Upper Cretaceous (Chalk of Europe). The variation shown in the shapes of the chambers, the connection between the chambers, the ornament, and the preservation, makes the definition of species almost an impossible task. It may be that there are more than the one genus contained in the group to be described below, and in fact, many authors have separated genera out on less character differences than shown by this fauna. In spite of the vast amount of work done on Upper Cretaceous faunas in Europe, very few species of *Ramulina* have been designated. Many broken pieces of *Ramulina* have been confused with other genera such as *Nodosaria*, *Dentalina*, and *Webbina*. It is perhaps unfortunate that two of the earliest described species (including the type) *Ramulina laevis* Jones and *Ramulina brachiata* Jones are from the chalk of Northern Ireland, and preservation is not good. Both these forms fall within one major group of the Ra-

mulinids, namely those having smooth tests, with long connecting prolongations of the chambers, and the chambers usually branching from their central points in one to three directions.

#### MORPHOLOGICAL GROUPS OF RAMULINID SPECIES

Species of Ramulinids can be divided into *five* morphological groups, which may be closely related genetically, and possibly belong to one family, perhaps only two distinct genera being present. The five groups are described below:

Group 1. Forms usually having spherical or ellipsoidal chambers which directly abut against each other, so that the specimens do *not* have connecting tubes.

These closely resemble an irregular *Dentalina*, from which the group could have been derived in Jurassic or early Cretaceous times.

The chambers may be smooth, rugose, pustulose, or spinose.

Group 2. Specimens with spherical or ellipsoidal chambers which are connected by tubular stolons, of varying dimensions.

These two groups are closely similar, and if the specimens are broken and the stolons destroyed, it is extremely difficult to ascertain to which group individual chambers should be assigned.

Group 3. Unilocular forms with a central spherical or sub-spherical chamber extended in conical prolongations. Occasionally specimens may consist of more than one chamber, when these are connected by a modified prolongation.

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Group 4. Elongate stoloniferous chambers often *branching*. This group can be readily distinguished from the above three groups which do not have *branching* tests.

Group 5. Forms with compressed irregularly spatulate chambers of varying outline or varying to sub-spherical, which have been referred to the genus *Ramulinella*, *Sporadogenerina*, and *Washitella*. The extreme irregularity of chamber shape and growth of the test is characteristic of this group.

GROUP 1

*Ramulina aculeata* (d'Orbigny)  
Plate 1, fig. 1

1840 *Nodosaria* (*Dentalina*) *aculeata* d'Orbigny, p. 13, pl. 1, figs. 2, 3.

1964 *Ramulina aculeata* (d'Orbigny); Loeblich & Tappan, C537, fig. 420,8 (d'Orbigny's original material, refigured and designated as lectotype).

*Description*.—The uniserial test may be slightly arcuate or irregular, and consists of three to seven chambers (most specimens however are broken). The wall of the test is thick, calcareous, and laminated.

The chambers are usually ellipsoidal or slightly sub-ellipsoidal; at the base of the proloculum a cylindrical protuberance occurs. Between the chambers the constrictions are broad cylindrical, about the diameter of the broadest part of the chambers.

The ornament consists of numerous short, but robust, conical spines arranged irregularly, but equally distributed over the chambers and constrictions. These spines are translucent and contrast strongly with the dull opaque wall of the test, and also have a central perforation (or canal) which penetrates through the wall of the test. This is well seen

when spines are broken off. Often the interior of the test has small raised protuberances at the base of the spines. On all the specimens studied, the end of the last chamber was broken and the type of aperture was not determined.

Specimen Number: P 48686

Horizon: *mucronata*-Zone.

Locality: Council's pit, Newmarket Road, Norwich.

Dimensions: On figure 1.

*Remarks*.—This species may be regarded as intermediate between Group 1 and 2, but as no long irregular stolons connect the chambers, it is considered to belong to Group 1. D'Orbigny states that the «Loges orale ou pyriformes, tellement séparées par étranglements profonds et prolonges» and figures narrow cylindrical connections between the chambers. All other characters shown, except for the initial end of the test and the aperture, are similar to the author's material. Loeblich and Tappan, refiguring d'Orbigny's specimen, show it to be closely similar to the author's. Fractures in the connections between the chambers are shown in Loeblich and Tappan's fig. 428, 8, which may obscure the exact shape and nature of the constrictions. Unlike d'Orbigny these authors do not figure or describe the nature of the aperture. Apparently, as with the author's material, the apertures are broken away.

The species differs from *Ramulina pseudoaculeata* sp. nov. in having more regular growth and well defined constant ornament. Specimens however are rare compared with the variable species *R. pseudoaculeata*.

GROUP 2

*Ramulina wrightii* sp. nov.  
Plate 1, fig. 2, 3

1886 *Ramulina aculeata* (d'Orbigny).  
Wright, p. 331, pl. 27, fig. 11.

non 1953 *Ramulina novaculeata* Bullard.  
p. 346, pl. 46, fig. 26.

1954 *Ramulina bullardae* Frizzell. 1954,  
no. 22, p. 149.

*Discussion.*—Frizzell cites *Ramulina novaculeata* Bullard 1953, fig. 26, as the type for *Ramulina bullardae* Frizzell, excluding fig. 11, which obviously is a copy by Bullard of Wright's original figure. It is clear from Bullard's figure 26 that this form is not synonymous with *Ramulina aculeata* (d'Orbigny) of Wright. Due to this confusion it is therefore proposed to set up a new species based on Wright's original figure which, however, is not *Dentalina aculeata* d'Orbigny. The name *Ramulina wrightii* is therefore assigned to this species.

*Description.*—Hyaline free test consisting of a series of spherical or sub-spherical chambers, connected by short thick stoloniferous, tubular connections. The test may be straight, slightly arcuate, or occasionally sigmoidal. The chamber wall is thick and consists of radial calcite thickening at the constrictions between the chambers. Chambers and the stoloniferous connections are ornamented by numerous short blunt spines, some of which appear to be hollow and form the pores. The density of the spines is greater on the chambers than on the connecting stolons. Usually the test is broken so that tests with more than three chambers are rare. The last chamber is extended into a thick stolon-like tube which bears a strongly radiate and coarsely ornamented apertural area, a strong character of this species.

Specimen Numbers: P48687. Holotype (fig. 2). Paratype (fig. 3) P48689.

Horizon: *mucronata*-Zone Upper Chalk.

Locality: Council's Pit, Newmarket Road, Norwich., and H. Attock's Pit, New Catton, Norwich, Norfolk.

Dimensions of type specimen: On figure 2.

*Remarks.*—Unfortunately confusion has arisen around Wright's (1886) original species

*Ramulina aculeata*. Loeblich and Tappan (1949) p. 261, 262, have already pointed out that d'Orbigny's *aculeata* (*Nodosaria-Dentalina aculeata*, 1840) is in fact a *Dentalina* and therefore Wright's *Ramulina aculeata* (d'Orbigny), has an invalid name. Bullard (1953) proposed the name *Ramulina novaculeata* for Wright's species, giving both Wright's original figure 11 and his own figure 26. Frizzell (1954) states that Bullard proposed *Ramulina novaculeata* as a «new name» with no cited type other than an hypotype to replace «*Ramulina aculeata* Wright 1886» (*Ramulina aculeata* (d'Orbigny) as identified by Wright, presumably not *Nodosaria (Dentalina) aculeata* (d'Orbigny)). Consequently, the primary type or types of *Ramulina novaculeata* can be the only material upon which Wright based his identification of «*Ramulina aculeata* (d'Orbigny),» and the name must apply to the British species. Frizzell proposes the name *Ramulina bullardae* for *Ramulina novaculeata* to avoid any further confusion. In fact the form originally described by Bullard is from the Upper Cretaceous Cenomanian, whereas that described by Wright was from the *mucronata* zone Upper Chalk of Northern Ireland. A further complication has arisen, Loeblich and Tappan (1964) p. C537 state, «because of confusion concerning the generic status of *R. aculeata* (d'Orbigny), which has been referred to both *Dentalina* and *Ramulina*, even in a single publication..., it was restudied by us in Paris and found to represent a true *Ramulina*.»

This reverses Loeblich and Tappan's (1949) statement that d'Orbigny's specimen was in fact a true *Dentalina*. Loeblich and Tappan (1964) then select *Ramulina aculeata* (d'Orbigny) as the lectotype of the genus and designate and refigure it. However, the specimen (fig. 8) bears only partial resemblance to that figured by Wright (fig. 11) and the two forms are distinct species.

Forms similar to Wright's (fig. 11) have therefore now been called *Ramulina wrightii* by the present author.



*Ramulina pseudoaculeata* sp. nov.

Pl. 1, fig. 4, 5, 6

Numerous single chambers recorded in the literature belong here.

*Description.*—The test is straight, arcuate, or irregular and consists of two or more ellipsoidal to sub-ellipsoidal chambers, connected by thick stoloniferous tubes. The constrictions between the chambers vary considerably depending upon slight variation in the shape of the chambers, usually the stolons are about one half the diameter of the chambers. In some chambers the maximum diameter is near the base, so that instead of being ellipsoidal, the chamber becomes slightly sac-like. In rare specimens the chambers increase regularly in size, but usually the chambers are irregular in shape and size and show no regular growth rate. In most forms however the chambers are almost equidimensional throughout the whole test.

The wall of the test is thick and ornamented by a varying density of short spines occurring on both the chambers and adjoining, necks. The size and number of the small spines varies considerably from specimen to specimen and also from chamber to chamber, so that some forms are almost smooth, others highly spinose.

Tests are usually broken and it is difficult to find a specimen with the aperture preserved, however, occasionally a radiate or broken radiate aperture is found.

Specimen Number: P48690 Holotype (fig. 4). P48691 & P48692 Paratypes (figs. 5, 6).

Horizon: *mucronata*-Zone.

Locality: Council's Pit, Newmarket Road, Norwich.

Dimensions: On figures.

*Remarks.*—The variation in chamber shape, size, growth-rate, and spine density is shown in the figures 4, 5, 6.

This form is extremely common in the *mucronata* zone of Norfolk, Northern Ireland and the Paris Basin.

Unfortunately the nature of the test produces weaknesses at the constrictions between the chambers, and in most cases the tests are broken, only rare whole specimens are found. Individual chambers due to the variation in size, shape and ornament are difficult to assign to definite species.

## GROUP 3

*Ramulina globo-tubulosa* Cushman

Pl. 1, fig. 7

1938 *Ramulina globo-tubulosa* Cushman; p. 42, pl. 7, fig. 1.

*Description.*—An almost spherical thin walled central chamber, with a large number of tapering prolongations arranged at almost regular intervals around the central chamber. These prolongations are long narrow cones, with a thin wall, and a long tapering tube in the centre, opening at the end of the prolongation into a small circular hole. In many cases the prolongations are broken, giving rise to short hollow stumps, but in most specimens one or more of the original lengthy prolongations is preserved. The ornament consists of numerous small spines scattered over the surface of the central spherical chamber, and also occurring in appreciable numbers on the prolongations.

Specimen Number: P48693.

Horizon: *mucronata*-Zone (upper part).

Locality: Thorpe, Norfolk.

Dimensions of Specimen: On figure.

*Remarks.*—Cushman (1938) recorded this species from the upper part of the Taylor Marl and in the Selma Chalk. His figured specimen is almost similar to the specimens described here from the English Chalk, with one slight difference which may be due to Cush-

man's figuring of the specimen, namely, no spines are shown on the prolongations. *Ramulina globotubulosa*, differs from a somewhat similar, but more robust species, *Ramulina ornata* Cushman, in having a more delicate wall, a fine hispid ornament and long tubular prolongations, whereas *Ramulina ornata* Cushman, has numerous rounded pustules ornamenting the surface, and is usually more than double the size of *Ramulina globotubulosa*.

*Ramulina ornata* Cushman

Pl. 1, fig. 8

1938 *Ramulina ornata* Cushman; Vol. 14, part IV, pl. 7, fig. 15.

*Description*.—The test consists of a globular or sub-globular chamber with numerous robust radiating, slightly tapering, tubular processes. The test is ornamented by numerous rounded spines, which occur not only on the globular chamber, but along the tapering prolongations, being more numerous on the globular chamber. The tapering prolongations are of varying length and diameters. Externally the central globular chamber sometimes shows a slight constriction, having the appearance of two chambers abutting directly against each other. In some specimens where part of the chambers are broken, so that the inside of the test is visible, there is no constriction between the two parts of the elongate chamber, no suture is developed between them. The prolongations are of varying length and diameter. Sometimes they are broken, but often finishing in a small, circular hole with a lip secreted around it. In most cases however they are sealed off and have a series of short, irregular spines placed over the extremity of the prolongation, so that the animal has no access through these prolongations. Occasionally one of the prolongations is increased in diameter, but varies in length from extremely short to approximately the same length as the diameter of the chamber, and a second chamber of

almost equal dimensions to the first is attached to this prolongation so that a kind of budding exists. In the author's specimens only two chambered forms occur. This type of budding, or increase in the number of chambers is similar to that shown in the recent form of *Ramulina globulifera* Brady, where a series of almost spherical chambers are united by stoloniferous tubes.

Specimen Number: P48694 Hypotype (figure 8).

Horizons: Throughout the *mucronata* zone.

Locality: Various localities, but most obtained from Tharston, Norfolk.

Dimensions of Hypotype on figure.

*Remarks*.—As stated above, this species differs from the more delicate *Ramulina globotubulosa* Cushman, which has a similar range in the Upper Cretaceous of Britain, with most specimens being obtained from the *mucronata* zone. It is possible that these two species may represent the megalospheric and microspheric generations of one species but this is difficult to prove, therefore the author has assigned these specimens to the Cushman species

#### GROUP 4

This group although readily distinguished from the above mentioned groups, by its branching habit, presents considerable difficulties when assigning specimens to distinct species.

Extreme variation in the size and shape of the chambers, position of the branches, ornament, and the irregularity in the shape of the test almost defy accurate description, for almost every specimen appears different in a number of characters.

Five major species from the Cretaceous may be assigned to this group. Two, *Ramulina abscissa* Loeblich and Tappan (1946) and

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*Ramulina muricatina* Loeblich and Tappan (1949), are smooth and hispid tubular forms. The tubular chambers are of almost equal diameter throughout the test, except showing slight irregularities at the points of branching. These species described from the Albian of N. America are similar to those found throughout the Cretaceous of N. W. Europe. *Ramulina laevis* Jones (1875) is a form in which irregular ellipsoidal or sac-like chambers are connected by irregular stoloniferous tubes, and any branching of the test occurs from the chambers.

Usually the number of branches from each chamber does not exceed one, whereas in species such as *Ramulina brachiata* Jones (1875) and *Ramulina arkadelphiana* Cushman (1938) numerous branches occur from the regularly or irregularly shaped chambers respectively.

### *Ramulina cuspidata* sp. nov.

Plate 1, fig. 9, 10

*Description.*—The test consists of a number of stellate chambers, generally swollen at the centre and having three or more tubular extensions arising from each chamber.

These tubular extensions are usually arranged so that three are in the same plane and a fourth at right angles to it. Variation in the number of tubular extensions and in the placing of these around the central swollen portion of the chamber, together with the fact that all the specimens apparently break easily makes it almost impossible to establish the exact shape of the test.

The tubular extensions are usually arranged symmetrically, are equal in diameter throughout, straight or arcuate, and swollen club-shaped where there are abortive branches. At the end of the extensions, new tubes are formed which in turn expand to form the centre of a new chamber.

The test is ornamented with a few short cylindrical spines (or pustules) arranged haphazardly over the chambers. The spines are

clustered at the end of the club-shaped abortive extensions, which often have within the ring of spines a 'scar', lunate or circular in shape. This 'scar' does not appear to be an aperture, is not a healed broken extension, because the shape of the extension differs from the others around the test, so definitely during the life of the animal had a primary purpose.

At the end of each normal branching extension is a ring of spines, apparently protecting the 'weak' junction between chambers.

Specimen Number: P48695 Holotype (fig. 9). P48696 Paratype (fig. 10).

Horizon: *mucronata*-Zone.

Locality: Thorpe, St. Andrews, Norwich.

Dimensions: On figures.

*Remarks.*—The group of species *R. cuspidata*, *R. anastomosa* and *R. chapmani* all show the abortive club-shaped extensions, and spines in heavy density at the junction points, a character not remarked on by earlier authors.

### *Ramulina anastomosa* sp. nov.

Plate 2; fig. 1, 2

*Description.*—The test consists of a variable number (2-7) of long cylindrical or sub-cylindrical chambers arranged uniserially, but irregular in directions. Some of the chambers branch, giving rise to further similar chambers, arranged in different directions. However whole specimens have not been found so that the overall shape of the test cannot be established. Occasionally short tube-like prolongations originate from the chambers, apparently abortive branches.

The diameter of the chambers may be almost constant throughout their whole length; with sac-like swellings at the points where new branches originate; or irregularly ellipsoidal.

The ornament consists of small tubular pustules sparsely scattered over the surface



of the chambers, but clustered together at the points of abortive junctions, or forming a protective ring at the junction points. Occasionally several of the pustules coalesce to form small flange-like protuberance, usually near chamber junctions.

Specimen Number: P48697 Holotype (fig. 2).  
P48698 Paratype (fig. 1).

Horizon: *mucronata*-Zone.

Locality: Thorpe, St. Andrews, Norwich.

Dimensions: On figure.

*Remarks.*—The test shape, chamber size and shape, and number of branches and abortive branches is extremely variable, it is difficult to give a comprehensive exact description of the species.

*Ramulina chapmani* sp. nov.  
Plate 2; fig. 3

*Description.*—The test consists of a variable number (2-7) of stellate chambers, usually each chamber having four or more tubular extensions, arranged around a central swelling.

The composite volume of the extended tubes is greater than that of the central swelling. The extensions are straight, or equal diameter, or irregularly arcuate of variable diameter. Usually there are four tubes in one plane and a fifth arranged at right angles to the others; however the number and arrangement does vary. Some of the tubular extensions are sealed-off abortive junctions, while others branch and extend to form a network of chambers. As with all related forms complete tests are not found.

The test is ornamented with numerous strongly developed conical or cylindrical spines arranged haphazardly over the chamber, closer and more numerous on the tubular extensions, and forming dense rings at either the ends of abortive branches or at the branch points, where they appear to form protective rings.

At the centre of the rings on abortive branches, small 'scars' occur, which are infilled, not apertures, or healed branches.

Specimen Number: P48699 Holotype (fig. 3).

Horizon: *mucronata*-Zone.

Locality: Council's Pit, Newmarket Road, Norwich.

Dimensions: On figure

*Remarks.*—Broken pieces of the extended tubes are easily confused with fragments of forms resembling *Ramulina muricatina* Loeblich and Tappan.

*Ramulina muricatina* Loeblich and Tappan  
Plate 2; fig. 4, 5, 6

1949 *Ramulina muricatina* Loeblich and Tappan, p. 261, pl. 81, figs. 5-7.

*Description.*—The test consists of elongate, irregular, cylindrical, branching tubular chambers. Usually the tests are broken, so that the final shape of the test and aperture are not established. The test is ornamented with well developed, irregularly spaced spines, clustered at abortive junctions, and ringing branch points.

Specimen Number: P48700 (fig. 4) P 48701 (fig. 5) P48702 (fig. 6).

Horizon: *cor-anguinum*-Zone, *cor-testudinaris*-Zone, *cor-anguinum*-Zone.

Dimensions: On figures.

Locality: Northfleet (Kent), Seaford Head (Sussex), Northfleet (Kent).

*Remarks.*—The specimens are tentatively assigned to Loeblich and Tappan's species from the Albian. The only difference that can be seen is that the Chalk forms have coarser ornament often clustered at both abortive junctions and normal junctions, this however is not considered by the author to be sufficient to differentiate between Loeblich and Tappan's species and the present specimens.

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Loeblich and Tappan state that the aperture is the open end of the tube, this again is not established for all forms figures have broken tubes, the ends not being preserved.

*Ramulina laevis* Jones 1875

Plate 2; fig. 12, 13, 14

1875 *Ramulina laevis*, Jones, p. 88, pl. 3, figure 19

*Description.*—The smooth test consists of two or more irregular sac-like chambers arranged in a meandrine series and branching several times. Usually one branch originates from one chamber, only rarely more than one. The size of the chambers also varies considerably and shows a regular growth rate. No aperture is preserved in the present author's material.

Specimen Numbers: (fig. 12) P48703, (fig. 13) P48704, (fig. 14) P48705.

Horizon: *mucronata*-Zone.

Locality: H. Attock's Pit, New Catton, Norwich.

Dimensions: On figures.

*Remarks.*—As Jones (1875) states, specimens are «rather rare». This form has often been confused with other more common broken species of *Ramulina*. Both in Jones figure 19 and the author's specimens no strengthening of the junctions takes place, hence preserved composite series are not found.

*Ramulina arkadelphiana* Cushman 1939

Plate 2; fig. 7, 8

1938 *Ramulina arkadelphiana* Cushman, p. 43, pl. 7, figs. 12-14.

*Description.*—The test consists of a few irregularly shaped chambers, with several irregularly placed tapering tubes extending from a central swelling. The wall is generally thin and hence specimens are easily broken. The ornament consists of fine hispid spines arranged at random over the surface of the

chambers and connecting tubes. No definite aperture was seen, only broken ends to the tubes.

Specimen Numbers: (fig. 7) P48706, (fig. 8) P48707.

Horizon: *mucronata*-Zone.

Locality: Council's Pit, Newmarket Road, Norwich.

Dimensions: On figures.

*Remarks.*—The tests are extremely irregular and it is almost impossible to find a character that does not show extreme variations. *Ramulina arkadelphiana* Cushman is closely similar, in its extreme irregularity.

## GROUP 5

Three genera, *Ramulinella* Paalzow, 1932; *Sporadogenerina* Cushman 1927; and *Washitella* Tappan 1943, may conveniently be assigned to this group, all having extremely irregular growth, or irregular chambers or both.

*Ramulinella*, with irregular sized sub-spherical chambers, closely appressed, shows irregular growth rate, and specimens similar to those figures by Paalzow; *R. suevica* and *R. ecphyma* Loeblich and Tappan from the Upper Jurassic can be easily matched from the Chalk.

*Washitella*, with extremely irregularly arranged, but well marked chambers, recorded from the Albian by Loeblich and Tappan also has strong similarities to specimens from the Chalk.

*Sporadogenerina*, a genus proposed by Cushman (1927) and further emended by Cushman and Todd (1943) shows perhaps the most remarkable resemblance to the Chalk forms. It is, however, recorded from Recent only. Apparently 'composite' tests were found by Cushman and Todd, one of which, is refigured by Loeblich and Tappan (1964, p. C536, fig. 420, 13) as the side view of the holotype.

This shows end-chambers with an irregular arrangement, but earlier chambers of *Robulus* or even *Neoflabellina* type Cushman and Todd (1943).

If the specimen figured as the holotype is in fact the type of the genus, then in the author's opinion a new specimen should be selected, without a 'composite' test.

Cushman and Todd (1943) draw attention to several abnormal specimens. «One specimen (pl. 16, fig. 12), probably microspheric, shows quite a regular series of five chambers, gradually increasing in size, resembling a *Marginulina* or *Dentalina*, followed by a typical adult chamber which branches off from the fourth one.»

Also, the authors draw attention to «cases of *Robulus* approaching *Sporadogenerina* in their final chambers... There is the possibility that such abnormalities in *Robulus* are pathological conditions resulting from some cause unknown at present.»

Later the authors state, «In the same material from off Porto Rico two specimens of different species of *Robulus* were found which may have some bearing on the relationships of the genus *Sporadogenerina*.» Both specimens have a late irregular growth stage as in *Sporadogenerina*.

Some forms assigned to the genera *Ramulinella* and *Tentifrons*, as already noted in the last genus, by the author (1958) have «composite» tests apparently composed of two genera. In a number of cases the early part of the test is characteristic of one genus; in the case of *Tentifrons*, a *Neoflabellina*; and in some specimens of *Ramulinella* either a *Guttulina*, *Globulina* or *Pyrulina*. The later part of the test has the overall characters, shape and ornament of *Ramulina* or *Ramulinella*

Occasionally some of the characters of the earlier genus are apparently continued into later stages of the test. As remarked on by

Barnard (1949) the genus *Tentifrons* (later designated by Loeblich and Tappan (1957)), changes its living habit from free to fixed in later stages. Barnard (1949 and 1958) considered these specimens as abnormal, and not constituting a new genus.

The discovery of specimens with an early polymorphine growth stage, but later stages similar to those of *Tentifrons* bears out the author's original view that a separate genus was not justified.

In fact, the placing of these forms in a distinct genus has, in the author's opinion, obscured a biological freak, of fundamental importance. Normal changes in growth pattern are well known in many groups of foraminifera, particularly the Lagenidae, where for example, the change from Planularia to Citharina to Citharinella is well seen.

The problem arises, how did one «species» or «genus» take on the characteristics of another possibly from a completely different family? The occupation of the test of one species by that of another may be eliminated by the fact that the later chambers often have characters of the early part of the test developed and even prolonged.

It appears to the author that good evidence exists for hybridization; the resulting mixing of two genera producing pathological monstrosities. It is of interest to note that most examples have so far been observed from closely related families, the Lagenidae and Polymorphinidae. The extreme irregular nature of this group of «species» almost defies description and the author has referred them to *Ramulinella irregularis*.

*Ramulinella irregularis* sp. nov.

Plate 2; fig. 9, 10, 11

*Description.*—The test is composed of a variable number of chambers either somewhat similar in shape, or of differing shapes so that the final shape of the test is extremely variable and irregular. The tests are large

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and although relatively thick shelled, break in preparation or preservation and hence it is difficult to determine the shape of the test, chambers, or connections between the chambers.

The chambers may be almost spherical, ellipsoidal, compressed spatulate to flabelliform; twisted in several planes, or changing direction of growth. The ornament usually consists of numerous well defined cylindrical pustules, or spines, of similar dimensions; or occasionally of two or more distinct sizes; scattered at random over the test. The numerous pustules sometimes coalesce and give rise to a rugose test.

The aperture is seldom preserved, but in forms with poorly developed chevron-shaped chambers a radiate aperture rarely occurs, these chambers, however, are often parts of «mixed species» and are characteristic of forms with neoflabelline early stages.

Specimen Numbers: P48708 Holotype (fig. 9). P48709, P48710 Paratypes (fig. 10, 11).

Horizon: *mucronata*-Zone.

Locality: H. Attock's pit, New Catton, Norwich: Burgh (Norfolk) (Paratypes).

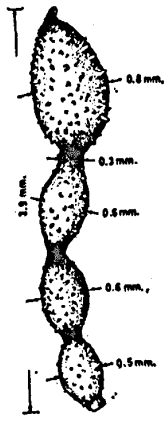
Dimensions: On figures.

Remarks.—Specimens occur which are close-

## PLATE 1

- Figure 1. *Ramulina aculeata* (d'Orbigny), x20.  
Showing meandrine nature of the dentaline-like test.
- Figure 2. *Ramulina wrightii* Barnard, x20.  
Two chambers, connected by a narrow stoloniferous tube.  
Aperture surrounded by spines.
- Figure 3. *Ramulina wrightii* Barnard, x18.  
Two chambers, sparsely spinose, part of a series of at least four chambers.
- Figure 4. *Ramulina pseudo aculeata* Barnard, x20.  
Two chambers densely ornamented with short spines.
- Figure 5. *Ramulina pseudo aculeata* Barnard, x15.  
Specimen shows rugose chambers not spinose ornament.
- Figure 6. *Ramulina pseudo aculeata* Barnard, x15.  
Arcuate specimen composed of two pustulose ornamented chambers.
- Figure 7. *Ramulina globo-tubulosa* Cushman, x40.  
Single chambered form, showing large spinose tubular projections as well as fine hispid ornament.
- Figure 8. *Ramulina ornata* Cushman, x30.  
Central chamber with fine spinose cylindrical tubes, the two unbroken showing rings of concentrated spines at their ends.
- Figure 9. *Ramulina cuspidata* Barnard, x20.  
Shows branching test with abortive chambers terminating in dense concentrations of spines.
- Figure 10. *Ramulina cuspidata* Barnard.  
Show the extension of the tubular connection to a second chamber (broken away), rings of spines at the branch point.

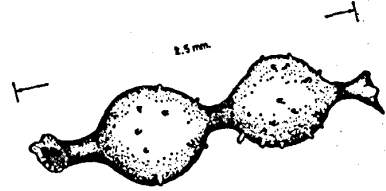




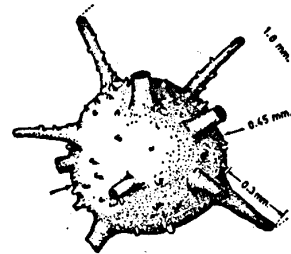
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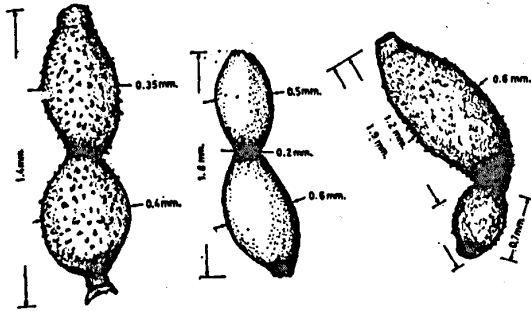
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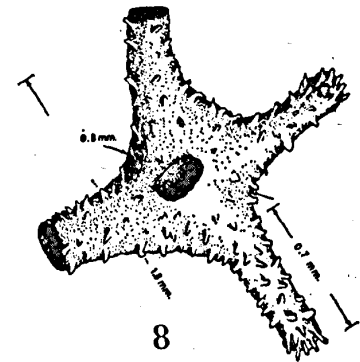
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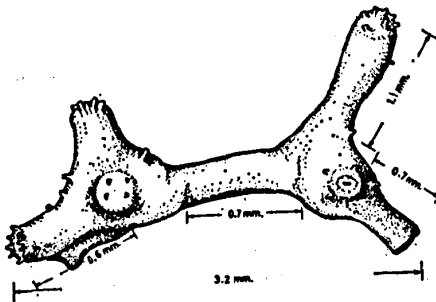
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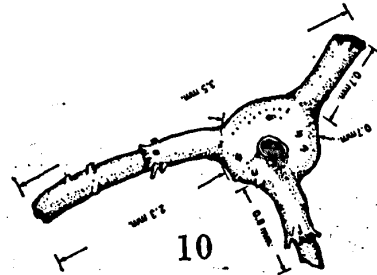
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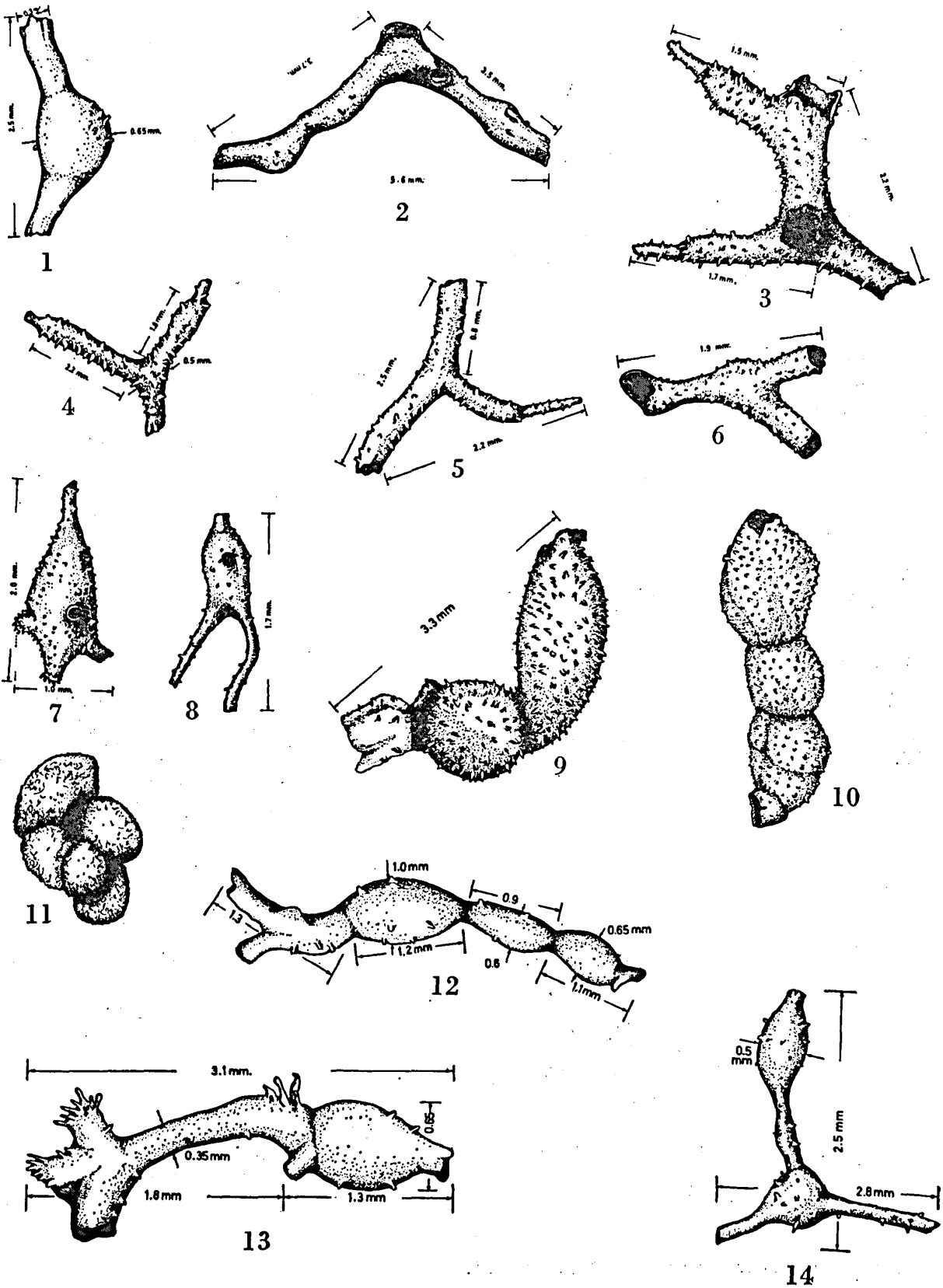
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9



10



## PLATE 2

- Figure 1. *Ramulina anastomosa* Barnard, x15.  
Showing bulbous chamber and two tubes developed from it, a third abortive branch is densely ornamented with short spines.
- Figure 2. *Ramulina anastomosa* Barnard, x10.  
Long tubular extensions swollen at times into sac-like chamber, sparse pustulose ornament.
- Figure 3. *Ramulina chapmani* Barnard, x15.  
Five branches, three broken, the remainder showing constrictions growing, giving rise abruptly to narrow tubes, at the point of constrictions denser ornament occurs in the form of ring of spines. The whole test is spinose, the spines arranged haphazardly.
- Figure 4. *Ramulina muricatina* Loeblich and Tappan, x10.  
Three branched test, constricted tubular branches.
- Figure 5. *Ramulina muricatina* Loeblich and Tappan, x15.  
The unbroken branch shows abrupt constriction, followed by a long thin tubular extension.
- Figure 6. *Ramulina muricatina* Loeblich and Tappan, x15.  
Three branches at differing angles to those of Figs. 4,5.
- Figure 7. *Ramulina arkadelphiana* Cushman, x20.  
Sac-like central chamber, with five tubular extensions, two of which are abortive and densely ornamented with spines, the others broken.
- Figure 8. *Ramulina arkadelphiana* Cushman, x40.  
Sac-like chamber, with two narrow long tubular extensions (although these are broken they are as long as the chamber).
- Figure 9. *Ramulinella irregularis* Barnard, 15.  
Showing irregular sized, and shaped chambers, meandrine tests
- Figure 10. *Ramulinella irregularis* Barnard, x15.  
Showing five coarsely ornamented chambers, meandrine test.
- Figure 11. *Ramulinella irregularis* Barnard, x15.  
Showing irregular chamber shape, size, and arrangement, so that test almost coils. The aperture is at the end of the chamber not umbical as the figure suggests, there is a space between the chambers.
- Figure 12. *Ramulina laevis* Jones, x20.  
Irregular chambers, sporadic pustulose ornament, one branch.
- Figure 13. *Ramulina laevis* Jones, x25.  
Irregular almost tubular chambers, with abortive ends covered with spines.
- Figure 14. *Ramulina laevis* Jones, x20.  
Long stoloniferous connections between chambers, branching test.

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ly similar to *Ramulinella ephyma* Loeblich and Tappan, a species with irregularly arranged spherical chambers.

Loeblich and Tappan (1964) state when describing *Tentifrons* (C524) «aperture as in *Citharinella* in early stages, later stage with numerous apertures at ends of fistulose extensions.» In the original description, Barnard (1949) pointed out that small outgrowths from the chambers held the specimens to the granules on *Micraster*. During the preparation of the plates for Loeblich and Tappan's (1964) paper the outline of *Tentifrons* has been cut round so eliminating the surface to which the specimen adhered, and Loeblich and Tappan have then misinterpreted these outgrowths as apertures. Only adherent specimens have these outgrowths; in both free and fixed forms the apertures are radiate.

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