# FURTHER OBSERVATIONS ON *MORELLETPORA NAMMALENSIS* VARMA FROM THE KHAIRABAD LIMESTONE ( RANIKOT ) BEDS OF THE NAMMAL GORGE, PUNJAB SALT RANGE

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## ABSTRACT

Recently the author ( 1950 ) reported the occurrence of a new genus of calcareous alga *Morelletpora* ( Dasycladaceae ) from the Ranikot beds ( Paleocene ) of the Punjab Salt Range. A diagnosis of the genus and a very brief description of *M. nammalensis* was given. The Ranikot alga has been studied further and the genus and its only known species have been redefined. *M. nammalensis* has been described and compared in detail. The alga has been classified under a new tribe Morelletporeae and sub-tribe Morelletporinae created by the author. *Gyroporella* Gümb and *Uragiella* Pia have been suggested to be classified under Gyroporellinae, another sub-tribe of Morelletporeae.

## INTRODUCTION

THE beds exposed at Nammal Gorge were first studied by Wynne ( 1878 ) and later by Gee ( 1946 ). A palaeontological study of the beds exposed here was made by Waagen ( 1881 ) and later by Cowper Reed ( 1931, 1944 ). Gee has given the following sequence of the beds exposed at Nammal Gorge which shows an almost continuous record of the Tethys from Permian to Lower Eocene.

| | |
|---|---|
| Pleistocene conglomerates | |
| — unconformity — | |
| Lower Nimadrics ( Miocene-Pliocene ) | |
| — Time interval: Regional unconformity — | |
| Sakesar limestone ( Laki ) | Eocene |
| Nammal limestone and shales | Eocene |
| Patala shales ( Ranikot ) | Eocene |
| Khairabad limestones ( Ranikot ) | Eocene |
| Dhok-pass beds ( Ranikot ) | Eocene |
| — Time interval, Regional unconformity — | |
| Baroch limestones | Jurassic[1] |
| Variegated stage | Jurassic[1] |
| — Regional unconformity | |
| Kingriali dolomites | ( Trias ? ) |
| Kingriali sandstones | ( Trias ? ) |
| — Conformable, transitional junction — | |
| Ceratite beds | Trias |
| Upper Productus beds | Permian |
| Middle Productus limestones[2] | Permian |

Recently Professor Rao and the author undertook a palaeobotanical study of these beds. Marine calcareous algae have been found to occur in the Middle[2] Productus limestones ( RAO & VARMA, 1953 ) and in two of the Eocene beds ( Khairabad and Sakesar limestones ). The algal flora represented in Sakesar limestone belongs exclusively to Rhodophyceae, represented by members belonging to Melobesieae, a sub-family of Corallinaceae ( cf. VARMA, 1952, 1953, 1953a; RAO & VARMA 1953a ), whereas the algae represented in the Khairabad limestone belong exclusively to Chlorophyceae ( family Dasycladaceae and Codiaceae ).

*Fossil Records of the Ranikot Algae in India* — The occurrence of calcareous algae, both Chlorophyceae ( Dasycladaceae ) and Rhodophyceae ( Melobesieae ), has already been recorded by several authors from the Ranikot beds of India. From the Ranikot series of Tibet, Morellet ( 1916, pp. 47-49 ) described ( Dasycladaceae ) two species of *Cymopolia* and one of *Larvaria*. The former was later referred by Pia ( 1927, p. 83 ) to *Karreria tibetica*. Walton ( 1925 ) described an alga as *Triploporella ranikotensis* ( Dasycladaceae ) which was later referred by Pia ( 1927, p. 76 ) to be a species of *Broeckella* Morellet and Morellet. Some genera belonging to *Corallinaceae* ( Melobesieae ), viz. *Archaeolithothamnium*, *Lithophyllum*, *Mesophyllum* and *Melobesia*, have been described by Rao ( 1941 ) from the Lockhart limestones ( Ranikot ) of the Samana Range ( North-west India ). He has also recorded a single Neomerearum ring, the occurrence of which indicates the presence of Dasyclada-

1. Rao and Tripathi (1950) reported an Upper Cretaceous limestone with *Globotruncana* at the upper part of the Baroch limestone and below the Ranikot ( Paleocene ) beds.

2. Rao and Varma ( 1953 ) reported the occurrence of an alga *Gymnocodium bellerophontis* and some aberrant types of fusulinids, *Leëla*, *Codonofusiela* and *Nipponitella*, which have elsewhere been found in the Upper Permian beds. The authors, therefore, regard this bed as Upper Permian.

ceae also in those rocks. Rao and Rao ( 1939 ) published a short note, after a general examination of some Khairabad limestone ( Punjab Salt Range ) sent to them by the authorities of the Burmah Oil Company, announcing the discovery in these rocks of some genera, viz. *Dissocladella, Neomeris, Acicularia, Oligoporella* and *Diploporella*. The genera *Oligoporella* and *Diploporella* are known in rocks much older than Tertiary. If their presence in these rocks could be established beyond doubt, the discovery of these genera would be of much importance because this would show the presence of endosporic forms right up to the Lower Eocene period. The material on which my observations are based was collected at short intervals by Professor S. R. N. Rao, Department of Geology, Lucknow University, in 1946 from the Khairabad limestones ( Ranikot ) exposed at Nammal Gorge ( 32°40′: 71°48′ ) in the Punjab Salt Range. An examination of more than 150 slides shows the occurrence of forms belonging to Dasycladaceae and Codiaceae. The most dominant alga is *Morelletpora nammalensis* Varma with which occur forms ( almost equally numerous ) belonging to the tribe Thyrsoporelleae ( Dasycladaceae ). Several specimens belonging to the family Codiaceae have also been observed by the author. Forms belonging to Thyrsoporelleae occurring in these rocks could easily be mistaken to be a species of *Dissocladella* due to bad or no preservation of the tertiary branches, although at least one species of *Dissocladella* seems to be present. It is interesting to note that with the exception of *Dissocladella* the author has not been able to observe the occurrence of other genera of algae reported by Rao and Rao ( 1939 ) in the Khairabad limestones which he has investigated.

In this paper are presented the results of a detailed study of *M. nammalensis*, which the author named after the late Lucin and Jean Morellet in appreciation of their classical works on fossil Dasycladaceae. The other algae belonging to Codiaceae and Thyrsoporelleae occurring with *M. nammalensis* will be described in a subsequent paper.

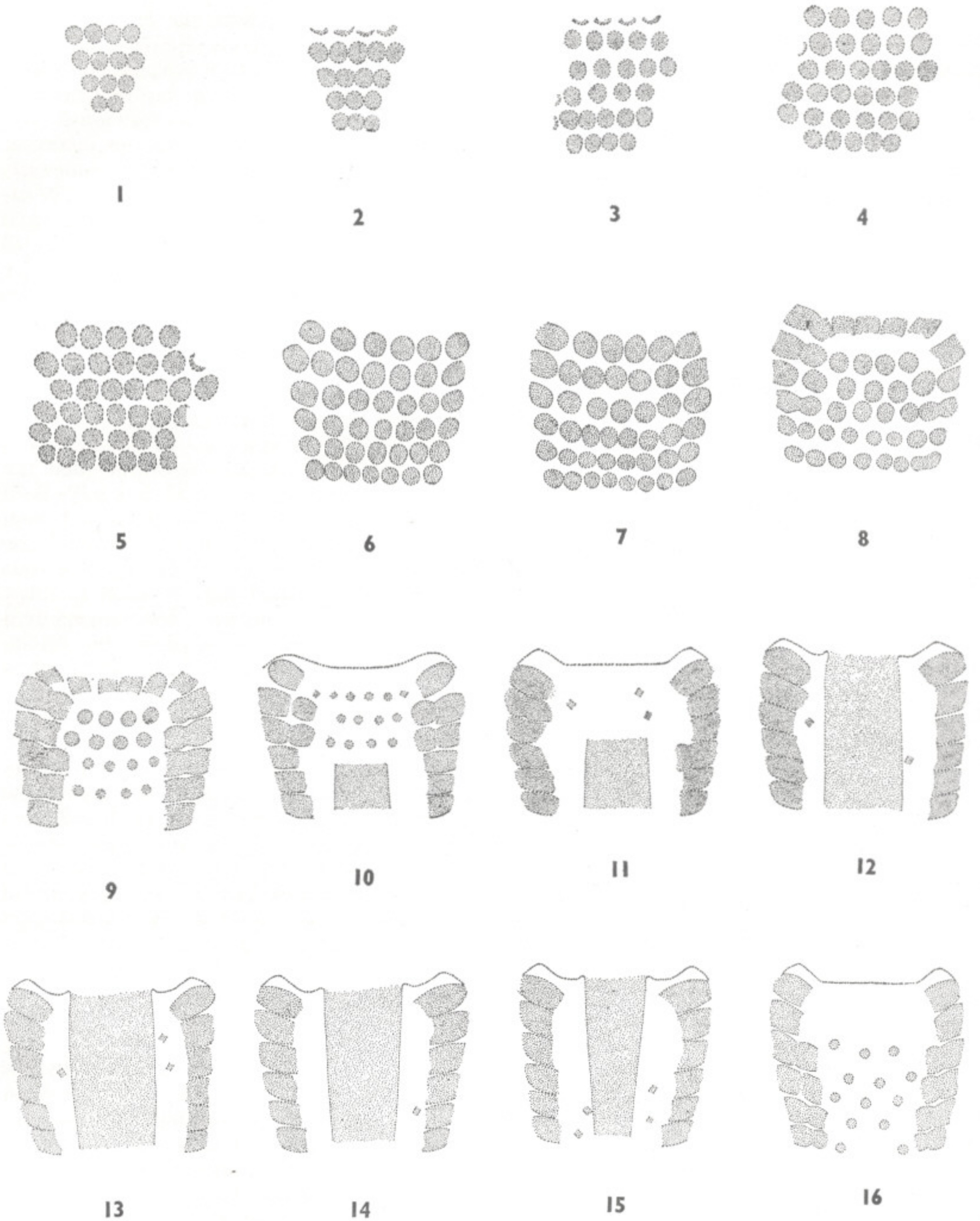
## MATERIAL AND METHODS

Khairabad limestones are mottled grey in colour and of friable nature. An examination of some mechanically broken material of the limestone under a binocular microscope did not reveal any loose specimen or fragment of the alga. Some limestone was also boiled with sodium carbonate with a view to separate the algae but with no success.

In the absence of any loose material the most common technique of sectioning the rocks in random palnes was adopted. An examination of a large number of thin sections indicated the presence of a well-preserved alga along with numerous Ranikot foraminifera among which *Miscellanea miscella*, a characteristic fossil of the Lower Eocene, is very common. Though an examination of these slides had given a good deal of information about the structure of the alga, yet the habit remained obscure. With a view to ascertain whether the suspicion of a jointed habit could be substantiated, the following technique was adopted.

A number of slices were made out of which a piece of limestone was chosen which happened to contain ( luckily ) a sufficiently big, though broken, piece of the alga. The two sides of the limestone were levelled to give it the appearance of a thick slice ( which was sufficiently compact so there was no need of impregnating it with macro resin or balsam ). One of the sides was stuck to the slide and the other side was further ground and then slightly etched ( by pouring over the surface a little of very dilute HCl ), the surface washed with water and, after smearing a drop of dilute glycerine, was examined under a microscope with strong reflected light ( various well-known devices may be applied to minimize strain on the eyes ). The whole surface was examined after every repetition of the above process of grinding and etching. When the structures began to appear, camera lucida sketches were made and the magnification noted. A series of such sketches resulting from the grinding of the limestone gives an idea regarding the various structures and their course of distribution quite satisfactorily.

Although this piece did not give the desired information, it incidently did reveal much about the shape of the upper part of the alga and established the open nature of the axial cell at the upper end. The shape of the lower part of the alga could not be known from the serial drawings shown in Text-figs. 1-16 because the fragment of the alga seems to have represented a part of the upper end only. A few more pieces of the limestones were subsequently studied in



TEXT-FIGS. 1-16 — Serial sections of *Morelletpora nammalensis* Varma. 1-8, tangentially longitudinal sections through the sporangial zone. × 17. 9, tangentially longitudinal section passing through the sporangia and the zone of the stalk-like parts of the branches. × 17. 10-11, obliquely longitudinal sections, the lower central part passing through the axial siphon and the upper part through the stalks while on sides the sporangia of more than one whorl are cut lengthwise. × 17. 12-15, obliquely longitudinal sections passing through the open upper end of the axial siphon. × 17. 16, an obliquely longitudinal section passing away from the central opening ( of the axial siphon ) through the depressed upper end. × 17.

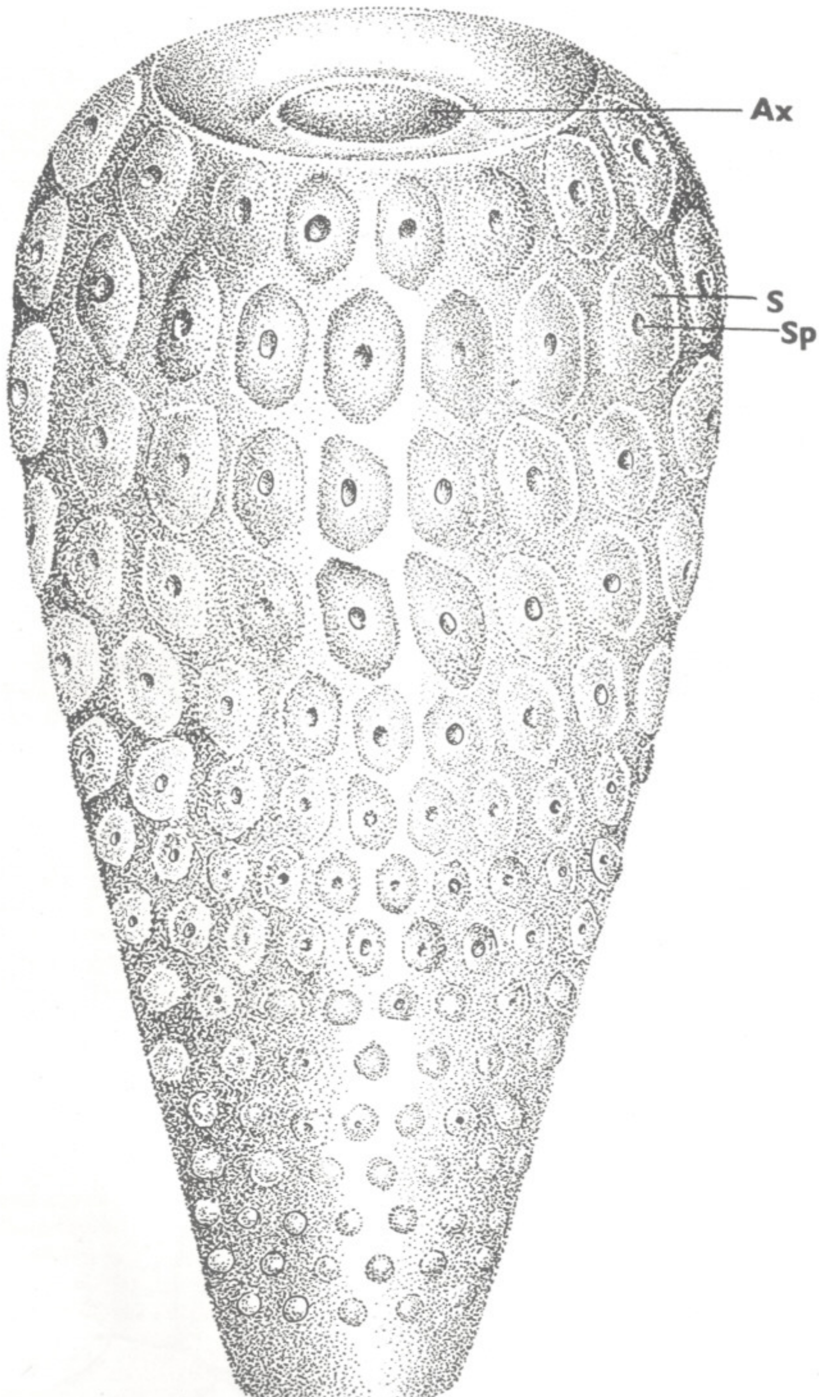
this way which gave some additional information about the alga or confirmed the earlier conclusions.

## DESCRIPTION

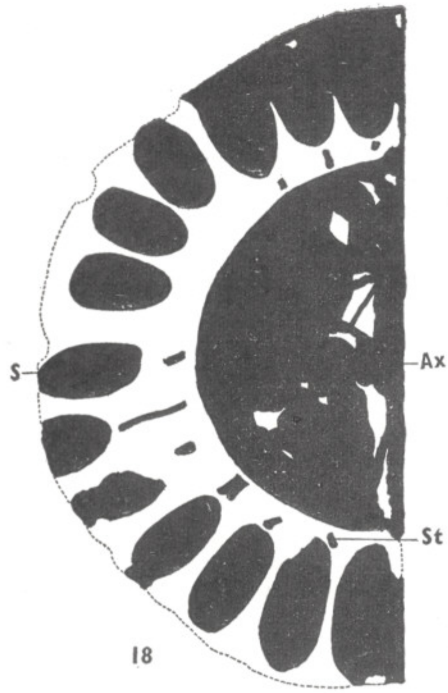
### *Morelletpora nammalensis* Varma

*Generic Diagnosis* — From what is gathered through the single species representing this genus, the overall shape of the thallus, as in other members of the Dasycladaceae, may have been jointed, cylindrical or club-shaped. Axial cell hollow, circular in section, open at both ends ( in species showing a jointed habit ) bearing a number of branches of the first-order only, arranged in regular verticils forming the cortex. Branches arising as thin, upwardly inclined tubes enlarging almost abruptly to form long oval to barrel-shaped sporangia, the thinner parts presenting a stalk-like appearance. Each sporangium opens externally through a pore which may occupy the whole width of the sporangium ( probably due to mechanical breaking of the external wall during fossilization ) or less.

*Description of the Khairabad Species* — So far the genus is known only through a single species *M. nammalensis* Varma. This species most probably represents a jointed alga composed of a number of segments. Externally each segment is club-shaped. The external width of the upper end, in most of the cases, increases gradually to about 2-2·5 mm. In one specimen, however ( PL. 1, FIG. 1), it is seen to increase rather suddenly. This specimen may be the topmost member of the alga. The lower end tapers down gradually. Segments are up to 4·5 mm. ( or more ? ) in length and circular in cross-section. The exterior of the uppermost part of each member ( or segment ) tends to become rounded, about 1-1·4 mm. wide, with a depression towards inside which is centrally perforated through the whole width of the axial siphon. The Text-figs. 12-15 show a little projection in the depressed roof of the upper end round the opening of the axial siphon which was at first interpreted to be a part of a rind-like structure around the upper opening of the axial siphon but subsequent studies of the serial sections reveal that in others nothing comparable to a rind-like structure could be seen. This rind-like appearance in Text-figs. 12-15 may probably be due to a deposit of lime on the axial cell from where the upper member broke away. The axial siphon is uniformly broad for the greater part of its length except for a slight incurving at the top and a narrowing down at the lower end from where it is seen to enlarge again at the basal part attaining a width somewhat equal to that of the upper end ( TEXT-FIGS. 19, 20; PL. 1, FIGS. 1-3 ). The axial siphon is open at both the ends. Width of the axial siphon in different thalli may vary between 0·2 and 0·8 mm. Branches arising in whorls, about 0·1-0·2 mm. apart, each ending in a single sporangium. Each whorl with about 14-26 ( or more ? ) sporangia ( PL. 2, FIG. 11; TEXT-FIG. 18 ). Some sporangial whorls may show a mixing of the sterile and fertile branches ( PL. 2, FIG. 6 ). In the lower sterile region of the alga the number of branches per whorl may have been even less and laterally more separated from each other than in the fertile region. The lateral branches seem to have come out right from the basal part of each member ( PL. 1, FIG. 2 ), but in some longitudinal sections this space is occupied by calcite which probably indicates that the branches may have fallen off at an early stage of its life. These branches seem to have come out from the axial siphon at no definite angles ( they diverge from the axial siphon at an angle very near 90° or more ). Their course also does not appear to have been fixed ( PL. 1, FIGS. 2, 3 ). In the lower sterile part the branches go out as narrow tubes with or without a gradual enlargement of their distal ends. In the transitional part upwardly directed branches with distal swellings oval to barrel-shaped, are most common but some branches of this region are also seen to have a varied route before opening out ( PL. 1, FIGS. 1-3 ). The sporangia appear to have opened outwards with a single opening small or big. Most of the openings in the fertile region of the fossil specimens, with sporangia predominantly barrel-shaped, appear to be as big as the whole width of the sporangium. But one oblique transverse section ( PL. 2, FIG. 5 ) shows a sporangium cut in an obliquely longitudinal manner through its distal opening. The author's idea of a small opening in each sporangium is based upon this section passing through the distal pore of a sporangium. Such lucky transverse or tangential sections passing through the distal pore are evidently to be found very very rarely.




TEXT-FIG. 17 — *Morelletpora nammalensis* Varma. Reconstruction of a single member ( or segment ) as seen from outside with a perfect calcareous coating. $\times$ 40. Ax, axial siphon; S, sporangium; Sp, sporangial pore.

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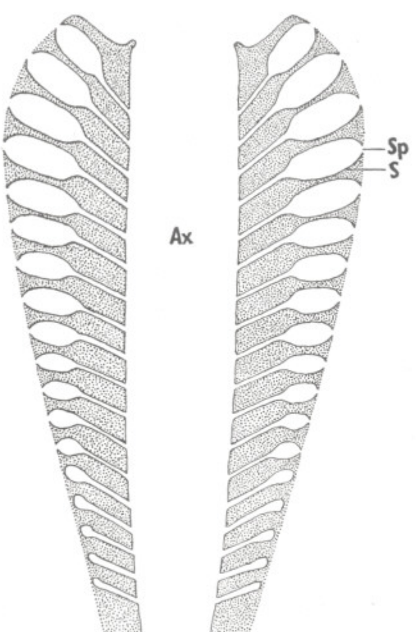


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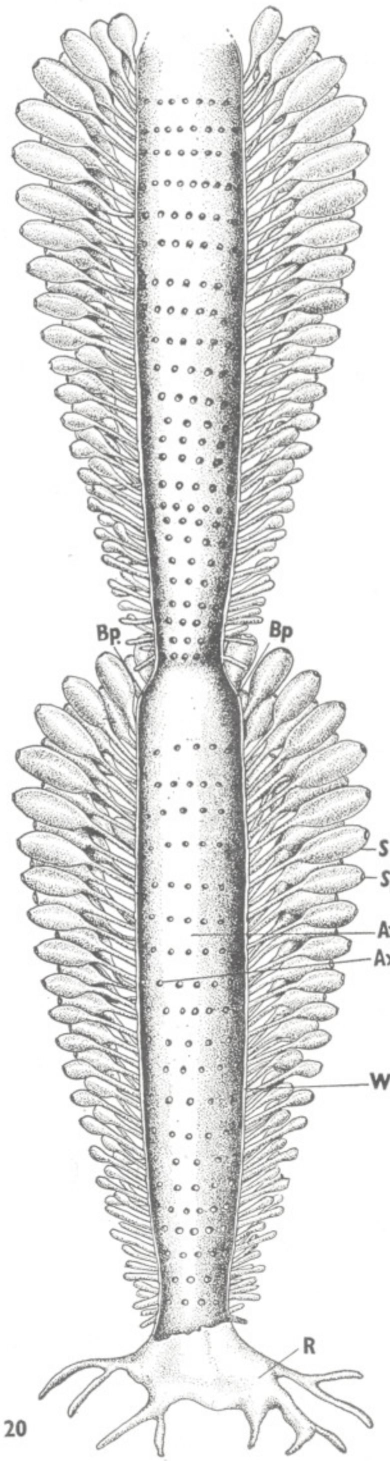


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TEXT-FIGS. 18-20.

Moreover, during fossilization also it would have been these distal parts of the sporangia which must have been subjected most to mechanical and chemical breaking and during this process, it is very probable, the outer walls along with the pores must have given way leaving behind a shape commonly observed in most of the sections showing the sporangia opening to the exterior with their whole width.

*Details about the Stalks and the Sporangia* — In the fertile region the axial siphon gives out a number of upwardly directed branches which enlarge rather abruptly into barrel-shaped parts ( sporangia ). A clear continuity is observed between the stalk-like parts and the sporangia ( which are both filled with the same matrix ); also these branches being undivided provide a clear-cut reason to call these lateral extensions ( including stalk and sporangium as the first-order branches only ). Moreover, in no case more than one sporangium at the end of a stalk could be observed. The stalks ( sporangial or sterile ) are almost uniformly broad, about 0·02 mm. wide, the distance between adjoining stalks in each whorl ranges between 0·1 and 0·2 mm. As already indicated the course of the stalks in the sterile region is most irregular, that in the transitional region it is more regular ( arising at an angle between 50° and 70° ). Stalks in the fertile region show a most regular course arising upwardly at an angle of about 45° ( rarely between 35° and 50°) with the axial siphon, each ending in a single sporangium. Stalks of the adjacent whorls in the fertile part of the alga show a strictly alternate arrangement ( PL. 2, FIG. 10 ) but a section passing deeply through the sporangia forming, so to say, the cortical region of a segment does not show this fact so well ( PL. 1, FIG. 4 ). But the sporangia of the adjacent whorls do show a strictly alternate arrangement in some ground serial sections ( PL. 2, FIGS. 7-9 ). These sections also show incidentally the hexagonal outline of the closely packed sporangia. These sections are, of course, passing through a region slightly behind the sporangial openings. From these sections ( PL. 1, FIG. 4; PL. 2, FIGS. 7-9 ) it becomes evident that the sporangia actually have circular walls but due to the lateral pressure created by a dense packing of the sporangia in each whorl they show a somewhat hexagonal outline. Thus from outside when alive, at least in the fertile and partially in the transitory regions, it would have shown hexagonal facets perforated by a pore ( TEXT-FIG. 17 ). The walls of the axial siphon, the stalks and the sporangia must have been completely encrusted with the lime ( TEXT-FIG. 19 ).

## COMPARISONS

Among Siphonales the family Dasycladaceae is characterized by a central axial cell with a whorled arrangement of branches which may be undivided or divided once or a number of times, the development of specially differentiated reproductive organs and the tendency to get more or less completely encrusted with lime. From the description of *Morelletpora nammalensis* given above, it becomes clear that the alga is essentially a member of the Dasycladaceae having features characteristic of this family.

Among the Dasycladaceae, *Morelletpora* is readily distinguished from members possessing secondary and tertiary branches by the fact that it is diagnosed by the first-order branches only. Thus it is compared best with those members of the family which possess only first-order branches.

There are a large number of genera belonging to various tribes of the fossil Dasycladaceae which have undivided branches but the author intends to confine his comparisons only to those genera with which *M. nammalensis* shows a reasonable similarity.

*Gyroporella* Gümb, represented by three species known from the middle and upper Trias, and *Uragiella* Pia known from the

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TEXT-FIGS. 18-20. *Morelletpora nammalensis* Varma. 18, a transverse section of a part of the whorl where the matrix is shown by black and calcite by white. The number of sporangia estimated in this whorl is 26. ×52. 19, a semi-diagrammatic radially longitudinal section of a segment passing through the axial siphon, its openings and through the stalks, sporangia and the sporangial openings. × 20. 20, reconstruction of a decalcified alga with two members ( or segments ) connected. The section is in a longitudinal plane through the distal end of the axial siphon. The rhizoidal part has not been cut. × 20. Bp, place from where the upper member would ordinarily break; S, sporangium; Sp, sporangial pore; St, stalk-like part of the branch; Ax, axial siphon; Axp, pore through which the stalk-like part communicates with the axial siphon; W, wall of the axial siphon; R, rhizoid.

Upper Jurassic, both belonging to the tribe Diploporeae (sub-tribe Macroporellinae), show an approach to this genus in exhibiting a tendency to form swellings on the distal ends of their branches which are comparable to sporangia. The various genera classified under the tribe Diploporeae are supposed to have built reproductive cells ( gametes ? or spores ? ) partially in the main axial cell and partially in the branches. The comparable forms *Gyroporella vesiculifera* Gümb ( *see* PIA, 1927, p. 69 ) and *Uragiella suprajurassica* Gümb ( *see* PIA, 1927, p. 71 ) differ from *Morelletpora nammalensis* mainly in having cylindrical thalli. *G. vesiculifera* differs in having spherical sporangia borne on short stalks which are not arranged in whorls and arise at right angles to the axial siphon ( a condition similar to this in *M. nammalensis* is sometimes found in the sterile region ), while *U. suprajurassica* differs in possessing somewhat club-shaped lateral branches. These branches, though arranged in regular whorls and obliquely directed, begin to enlarge gradually. They are inclined upwards at an angle different from that of *Morelletpora*. Moreover, in *U. suprajurassica* the branches are somewhat club-shaped and do not have a prominent stalk-like part. In *M. nammalensis*, on the other hand, the distal parts of the branches become suddenly dilated into oval to barrel-shaped sporangia giving the proximal parts a stalk-like appearance.

Among the Ranikot Dasycladaceae, *Broeckella ranikotensis* ( Walton ) Pia shows a great resemblance with *M. nammalensis* in its overall shape and size. Walton ( 1925, p. 214 ) noted in his alga the " Occurrence at both ends of the segments of depressions " and he further writes, " Mr. Gupta pointed out that there are two depressions at the larger end of one of the segments ( PL. 16, FIG. 5 ) ". From these observations he concludes that the alga must have had an axial siphon open at both ends and that the alga had a jointed habit which also showed a dichotomous type of branching. Thus Walton's alga besides showing similarity in shape and size also resembles in having apical and basal openings of the axial siphon and in putting up a hexagonal external appearance but with many small holes whereas in *M. nammalensis* there is only one. Walton's alga differs from *M. nammalensis* mainly in having primary branches arising almost at right angles, opening through 3-7 pores representing branches of the second order. Also, the primary branch of *B. ranikotensis* does not show anything similar to sporangial stalks found in *M. nammalensis*. But if Walton's alga is regarded to be a species of *Broeckella* as done by Pia ( 1927, 76 ), the points of attachment of the second-order branches are to be interpreted as simple holes opening outside, and the first-order branches are to be regarded as radiating compartments of a chamber, separated from those above and below by horizontal walls, which communicate with the axial cell through a single pore and the outer wall through a number of pores arranged irregularly. Moreover, in the case of *Broeckella* hexagonal outlines separated by so much of lime is not expected on weathering of the specimens, because in this genus " — celles du tube axial, diviseé par des planchers horizontaux en un certain nombre de compartements superposés, chacun de ces compartements étant lui-même divisé par des septes radiaires en plusieurs chambres — " (cf. MORELLET & MORELLET, 1922, p. 22 ). Walton ( 1925, p. 217 ) giving the diagnosis of his alga clearly mentions, " There are depressions on the outside which represent the bases of the second-order branches which arose, 3-7 in number, from the end of each first-order branch ". In the opinion of the author these depressions, though may not essentially be the bases of second-order branches, Pia has certainly given nothing to disprove it. On the other hand, Walton ( 1925, PL. 16, FIG. 11 ) has given a figure of a radial longitudinal section of his alga showing second-order branches. On the whole, as this alga shows some very striking similarities with *M. nammalensis* and comes from rocks of the same age and from the same country, its re-study will probably reveal some more points regarding its structures and affinities.

*Indopolia satyavanti* Pia ( 1936, pp 20-23 ), described from the Cretaceous rocks of Trichinopoly, South India, shows a closer resemblance with regard to its stalk-like primary branches which run obliquely upwards ( at an angle of 30°-40° ) but differs in having a practically cylindrical form ( and it is not known whether its axial tube is also open at both ends ). Moreover, the distal part of each stalk-like primary branch bears two cortical cells and two sporangia, the latter have been interpreted as modified secondary branches. *Indopolia satyavanti* Pia, therefore, has to be put under the tribe Neomereae. Thus it is clear that the Khairabad alga represents a new genus as already reported by the author (1950).

## RECONSTRUCTION

From the structures exhibited by the alga it is evident that it must have been attached to the substratum standing erect and that it did not possess any additional organs for the manufacture of food, comparable to the assimilatory hairs found in many members of the family Dasycladaceae. The manufacture of food in this alga seems to have been the primary duty of the sterile and transitory parts while that of reproduction must have been the lookout mainly of the fertile and partially of the transitory regions.

So far no two segments have been found in organic connection and hence the jointed habit cannot be stressed beyond a mere probability. *Morelletpora nammalensis* seems to have been a jointed alga because all the sections showing the lower end of the segments show a complete absence of anything like rhizoids and that the lower end is almost pointed which could not be expected to have provided a very firm stronghold to the alga, though the possibility of its attachment with the substratum could not be refuted altogether.

Secondly, the central part of the upper end occupied by the axial siphon is seen open in all cases where the longitudinal sections are very nearly radial or are oblique but pass through the upper opening. In no case more than one opening could be seen and hence there is reason to suppose it to be an unbranched alga. From such a structure the upper member may have been regenerated and the axial cell may have continued up into a similar member above with all the three sterile, transitory and fertile regions. This process may have been repeated several times thus forming a jointed alga or an alga showing joints or segments. The part nearer to the axial tip of the lower member may have been either feebly calcified or even uncalcified (this condition of the joints is somewhat comparable to *Mizzia* classified under Dasycladaceae and to members of the Corallineae). The presence of one of the above conditions would have made an easy detachment of the upper member quite possible.

Thirdly, the lowermost part of the axial cavity of each member is nearly as big as that of its upper end providing a strong suggestion that at the time of regeneration or growth the axial siphon of the lower member continued to converge for a certain distance and then enlarged again to regain its normal size in the upper member with all the three sterile, transitional and fertile zones (TEXT-FIG. 20).

*Affinities and Classification* — An overall shape of *Morelletpora nammalensis* must have resembled some of the jointed algae like *Ovulites margaritula* Lamk. (Codiaceae), *Mizzia velebitana* Schubert, and species of *Cymopolia* Lamouroux and *Karreria* Mun.-Chalm. (Dasycladaceae). So far there is no reason to believe *M. nammalensis* to be a branched form. The genus *Mizzia* belongs to tribe Cyclocrineae while *Cymopolia* and *Karreria* belong to the tribe Neomereae and sub-tribe Cymopolinae. In spite of the resemblance in shape *M. nammalensis* shows internal characters, which, although of the Dasycladaceae type, do not stand a detailed comparison with any genus described so far under any tribe or sub-tribe of this family. Hence it becomes essential to classify the genus *Morelletpora* under a new tribe of Dasycladaceae which the author proposes to call *Morelletporeae*. This tribe is defined to have members which show the following characters — thallus cylindrical, jointed or club-shaped. Axial siphon producing regular or irregular whorls of stalk-like primary branches each ending in a single sporangium enclosed or open distally. The tribe is further divided into two sub-tribes — Morelletporinae and Gyroporellinae. The sub-tribe Morelletporinae is created to include forms having a jointed thallus, axial siphon bearing whorls of long stalk-like, upwardly directed primary branches ending in a single sporangium open distally. The sub-tribe Gyroporellinae is created to include forms having a cylindrical thallus, fertile whorls of the axial cell bearing stalk-like primary branches running more or less horizontally and ending gradually or abruptly into a single sporangium, distally open or enclosed. Sporangia never on sides as found in fossil genera belonging to Dactyloporeae and in the recent genera *Bornetella* and *Batophora* (cf. FRITSCH, 1948, pp. 389, 392) where they behave as gametangia. It is further proposed to classify *Gyroporella* and *Uragiella* under the sub-tribe Gyroporellinae instead of retaining them under Macroporellinae, a sub-tribe of Diploporeae, because they have horizontally extending primary branches which swell distally to form sporangia-like organs. Moreover, in these genera the occurrence of reproductive parts in the main stem is not definitely known and it is more apt that their distal parts alone behaved as sporangia.

It is proposed to classify the genus *Morelletpora* Varma as under:

*Class* — Chlorophyceae
*Order* — Siphonales
*Family* — Dasycladaceae
*Tribe* — Morelletporeae
*Sub-tribe* — Morelletporinae
*Genus* — Morelletpora

### *M. nammalensis* Varma

*Diagnosis*—Thallus most probably jointed, each segment club-shaped, upper end rounded, with a depression open centrally. Axial siphon open at both ends, circular in section, bearing a number of superposed whorls made up of first-order branches only. Branches arising as thin upwardly inclined tubes, enlarging rather abruptly to form oval to barrel-shaped sporangia, giving the thinner part a stalk-like appearance. Average length of each segment about 4·5 mm. and width about 2 mm. External surface forming rounded to hexagonal facts each pierced by a hole. Axial siphon 0·2-0·8 mm. wide, longitudinally extending from base to tip. Each whorl with about 14-26 stalked sporangia, separated vertically from each other by about 0·1-0·2 mm. Stalks of adjacent whorls alternately arranged. Sporangial stalks 0·02 mm. wide and separated from the next in its whorl by about 0·1-0·2 mm. Each stalk enlarging in a sporangium, oval or barrel-shaped, 0·1-0·2 mm. wide and 0·2-0·5 mm. long. Stalks in the lower whorls mostly arising at angles between 50° and 70°, those in the fertile whorls arising at about 45° ( range 35°-50° ).

## ACKNOWLEDGEMENT

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## EXPLANATION OF PLATES

### PLATE 1

1. Part of a thin section of the Khairabad limestone showing fragments of algae and the associated foraminifera. × 9.

2. *Morelletpora nammalensis*. An oblique longitudinal section passing through the whole length of a single member. The section appears to be passing slightly away from the axial opening at the top, but passes obliquely through the opening at the bottom. Branches could be seen even in the lowermost sterile part. × 21.

3. *M. nammalensis*. An oblique longitudinal section passing through the lower opening of the axial siphon but passing away from the axial opening at the top. On the right hand side in the transitional region is seen a sporangial stalk exhibiting an unusual course. × 21.

4. *M. nammalensis*. An oblique tangential section passing through the sporangia of the fertile and transitory regions at a deeper level. × 21.

### PLATE 2

5. *M. nammalensis*. An oblique transverse section passing through the transitory region. In the lower half are seen two sporangia, one on either side of the axial cavity, exhibiting their outer openings. At this level the section appears to be passing through the sporangial pores. × 42.

6. *M. nammalensis*. An oblique transverse section passing through the upper part of the transitory region showing both sterile and fertile branches. The estimated number of sporangia in this whorl is twenty-four. × 42.

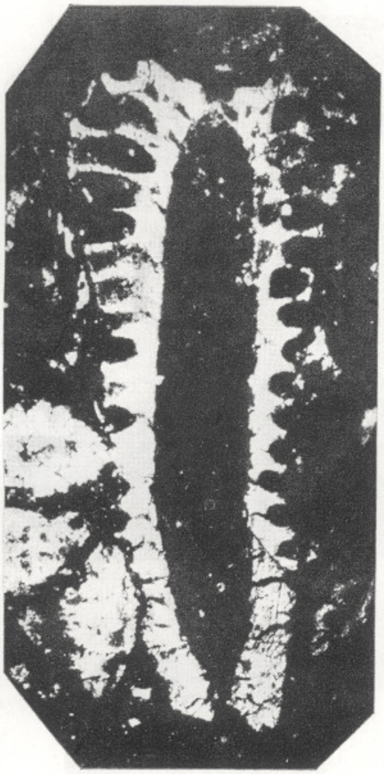
7. *M. nammalensis*. A ground tangential section passing distally ( obviously through a level below the sporangial pore ) showing a crowded packing of the sporangia resulting in hexagonal outlines. × 15.

8. *M. nammalensis*. The same slice of limestone on being ground a little more shows the hexagonal outlines more clearly. × 15.

9. *M. nammalensis*. The same slice of limestone on being ground further shows the hexagonal boundaries of the sporangia getting transformed into oval to oblong outlines. × 15.

10. *M. nammalensis*. An oblique vertical section passing a little away from the axial opening at the top. The alternate arrangement of the sporangial stalks in the neighbouring whorls can be observed very well. × 42.

11. *M. nammalensis*. An oblique transverse section passing through the lower transitory region showing sporangia. The estimated number of sporangia in this whorl is 14. × 42.



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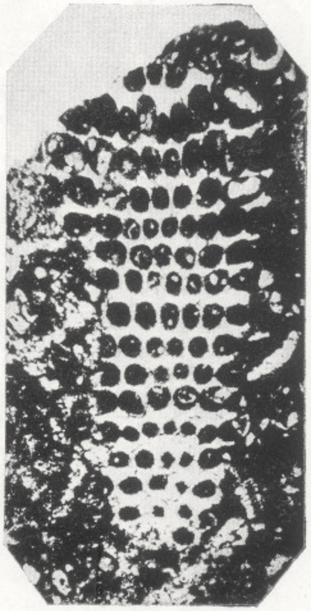

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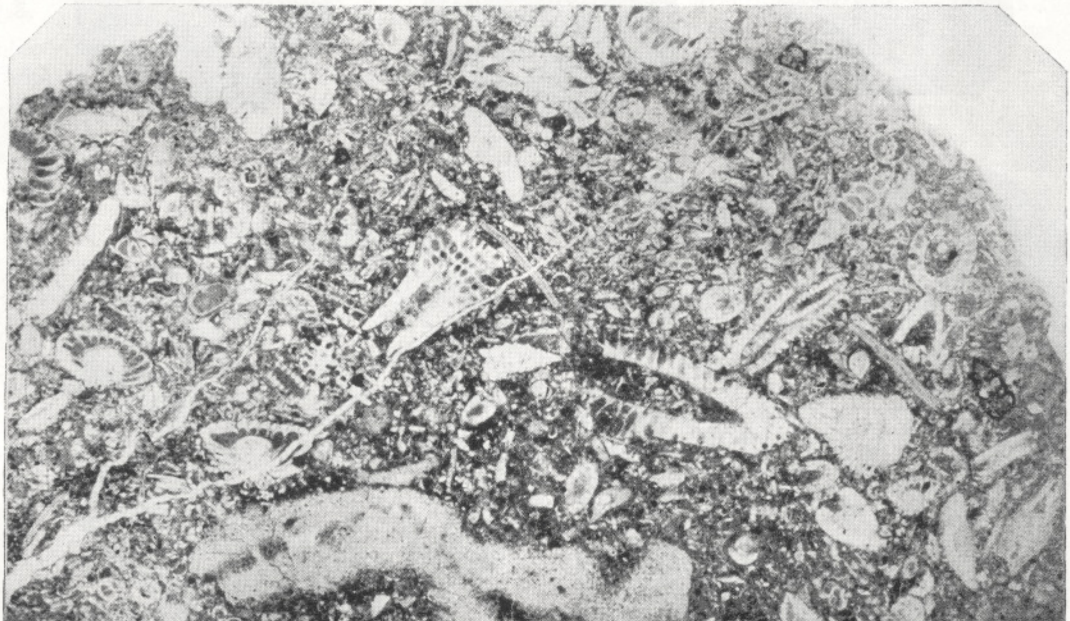

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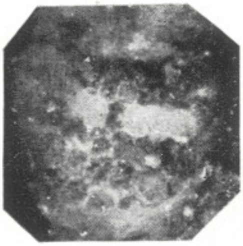
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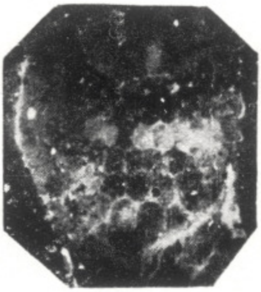
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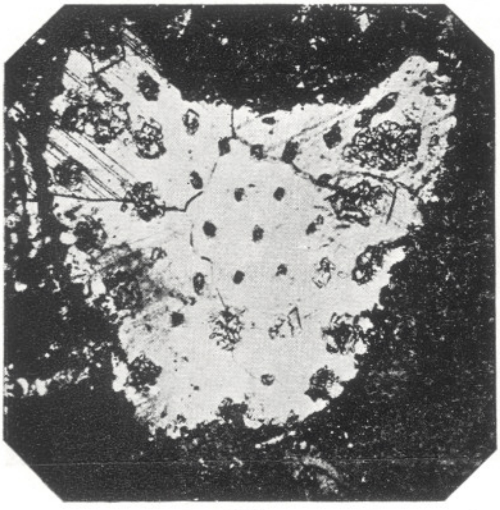
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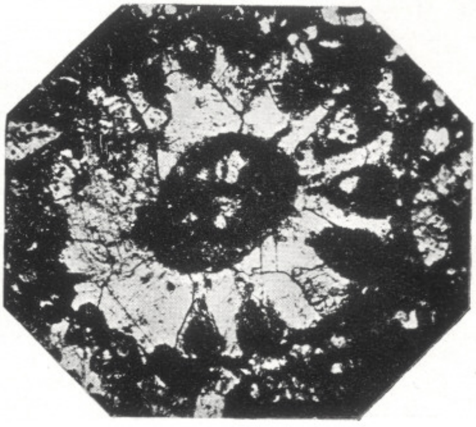
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