

Fossil aquatic fungi from the Miocene sediments of Mizoram, Northeast India

Two kinds of fossil aquatic fungi of the Ingoldian type are reported from the Miocene sediments of Mizoram, Northeast India, revealing that though living ones were known barely 60 odd years ago, they were in existence on earth at least for the last 20 million years!

Terrestrial fungi were known to man from time immemorial; man might have appreciated the delicacies of mushrooms since the hunting and gathering stage. However, the presence of aquatic fungi came to light only in 1942, when Ingold reported them from UK^{1,2}. This opened new vista of knowledge and mycologists were motivated to describe them from the different countries³⁻⁵.

Aquatic fungi are placed under hyphomycetes as their conidia remain segregated within the conidiomata, and are divided into Ingoldian and aeroaquatic or helicosporeous types. The former is characterized by translucent, branched conidia which are often tetra- or multiradiate and grow generally in running water on submerged plants⁶. The branches help fix the conidium on the substrate. This is a heterogeneous group and occurs in *Nectria* of pyrenomycetes, *Hymenoscyphus* of discomycetes and *Massarina* of loculoascomycetes, etc.^{7,8}.

Aeroaquatic fungi are generally found in stagnant water; the conidia are often dark-coloured, spiral or many-celled cage-like structures. The conidia are found at the air-water interface and trapped air provides them the necessary buoyancy.

The Ingoldian type of conidia was recovered from a 12 m thick section exposed adjacent to Tlangsam village (lat. 23°28' and long. 93°25') on the India - Myanmar border, roughly 50 km east of Champhai (Figure 1). The section belongs to the Bhuban Formation (Miocene)⁹. At the base of the exposure, there is a gravel bed (0.2 m) and the rest exhibits an alternation of claystones and sandstones; occasionally some minor shale bands are also found between them. Samples were collected from all the lithological units, but only shales yielded the palynomorphs. The position of the yielding samples and the lithology are shown in Figure 1.

The samples are rich in palynofossils and consist of pteridophytic spores, gymnospermic and angiospermic pollen and fungal elements. The palynology of Mizoram has been worked out by a number of researchers and they assigned a Miocene age¹⁰⁻¹² for palynological assemblages due to the presence of *Striatriletes susannae*, *Pinuspollenites crestus*, *Abiespollenites cognatus*, *Hibisceapollenites splendidus* and *Palaeomalvaceapollis mammilatus*. Besides, some pollen of *Potamogeton*, an aquatic angiosperm, is also found in the assemblage. Fungal spores and other bodies are common in the assemblage and spores are represented by amerspores, didymospores, phragmothyrites, dictyospores, solespores, helicospores and staurospores¹³. Endomycorrhizal fungi form a major part of the assemblage¹⁴. The common fungal genera are *Inapertisporites*, *Dicellaesporites*, *Fusiformisporites*, *Multicellaesporites*, *Diporicellaesporites*, *Phragmothyrites*, *Notothyrites*, *Parmathyrites*, *Kutchiathyrites*, *Cucurbitariaceites*, etc.¹⁰⁻¹².

Two types of Ingoldian aquatic fungi are found in the assemblage. One is needle-shaped and belongs to the scolespores, the other is globular and placed under the staurospores¹⁵. In the first type, the conidia are blastic in development - they arise from a narrow part of the conidiogenous

cell with elongation, before the development of the septa. The conidia are straight at the nascent stage but are curved at the ripe stage, to produce two lateral arms at the same time; the arms are 15-30 × 2-4 μm, roughly 8 to 10 times longer than broad, and equal or unequal in length with pointed tips. Arms are generally four to five in number and may again branch laterally; spore wall is about 1 μm thick, translucent, psilate and generally not septate (Figure 2 a-c).

Fossil forms are not assignable to any extant Ingoldian species. The closely comparable genus is the *Tetrachaetum*, which also shows the blastic development of the conidia; but the present specimens are distinguished from this genus in having unequal arms that are again divided to produce more than four arms¹. In *Varicospora*, conidia are globular and branched haphazardly from one side of the main axis¹⁵. *Articulospora* is characterized by the development of arms successively¹. *Digitatispora* is tetra- or multiradiate, but is distinguished in having a cylindrical basal cell and three radiating apical cells¹⁶.

The Ingoldian aquatic fungi play an important part in disintegration of the submerged plant parts. Preliminary decomposition of the plant materials by the fungi is instrumental in producing palatable enzymes for others^{17,18}.

The other type of aquatic fungi recovered have subtriangular - circular, irregularly folded conidia; they are light brown in colour, size range 13-20 × 10-15 μm, generally they have four to five arms of unequal length, 10-20 × 3-4 μm, straight or curved, slightly swollen at the base and uniformly broad in the remaining part; the wall is about 1 μm thick and laevigate. Conidiophores are mostly straight, sometimes are slightly bent and septate (Figure 2 d).

The fossil form comes close to *Ceratosporella* in possessing star-shaped conidia, but is distinct by its prominent stalk cell of the septate conidium and repeated division of the conidiophore¹⁹. *Clavatospora* is distinguished by the three-armed swollen conidia¹. *Actinospora* has globular conidia with four septate arms¹, whereas the genus *Nia* is hyaline and has non-septate radiating arms.

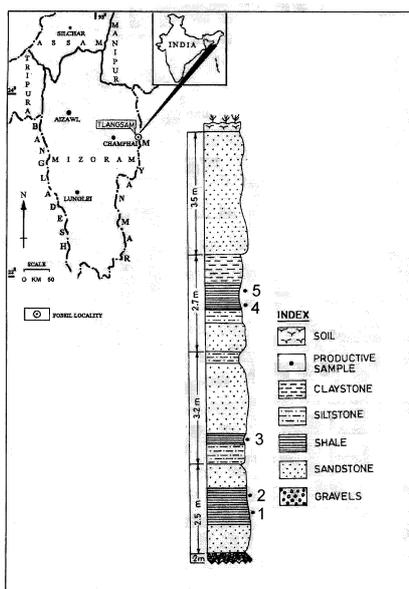


Figure 1. Locality from where samples were collected and litholog indicating position of productive samples.

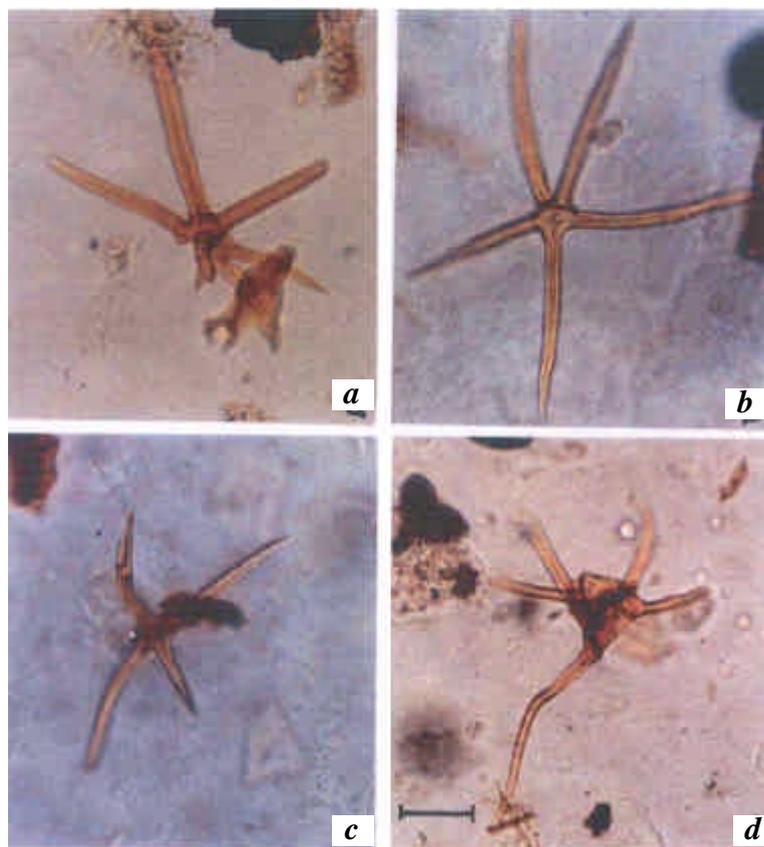


Figure 2. *a-c*, Aquatic fungi belonging to Ingoldian type with 4–5 needle-shaped arms of conidia. *d*, Five-armed globular conidia also of Ingoldian type. Bar – 10 μ m.

Extant aquatic fungi generally occur in temperate climate and so their presence in the assemblage generally reflects a cooler climate. Besides, the gymnospermous pollen represented by *Pinuspollenites crestus* and *Abiespollenites cognatus* also corroborates this assumption. These forms are, however, meagrely represented and the major assemblage constitutes the tropical–subtropical elements, viz. the epiphyllous forms (*Phragmothyrites*, *Parmathyrites*, *Kutchiathyrites*), the endomycorrhizal VAM elements (*Archaeoglosum*), the Meliolales, *Colletotrichum*, etc. Therefore, it seems that the aquatic fungi in the assemblage were not growing at the site of deposition, but came from nearby higher hills in the sediments. It may be mentioned that the aerial distance of the Shillong Plateau from the site is roughly 200 km and this was a considerably high land (more than 2000 m) during the Miocene²⁰. The fungi were probably growing in the running streams and creeks, and came to the depositional

sites along with the water; the gymnospermous pollen, viz. *Pinuspollenites* and *Abiespollenites* could have negotiated the distance by air. It may be mentioned here that during the time of deposition of the studied sediments, the Shillong Plateau was the only elevated land and there was sea all around, including the present day Mizoram State, during the Miocene²⁰.

The present investigation on aquatic fungi reveals that though the extant forms were reported only in 1942, they were in existence on earth at least for the last 20 million years!

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