

Multimorphic spores in *Equisetum* L. (Equisetaceae, Pteridophyta) from Rajasthan, India

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ABSTRACT

Sharma B. D., Bohra D. R., Suthar O. P., Harsh R. & Purohit S. N. 2015. Multimorphic spores in *Equisetum* L. (Equisetaceae, Pteridophyta) from Rajasthan, India. *Geophytology* 45(1): 71-75.

Equisetum L. is the only extant genus of class Sphenopsida. Serial sections of the *Equisetum* cones, collected from wet places in the Aravalli Hills and Chambal ravines in Rajasthan, have been studied. Size and other morphological variations in the spores have been observed. The spores are alete, monolete or trilete and minute, spherical, empty, etc. The present investigation challenges the earlier concept that *Equisetum* spores are homosporous and only alete. The 'abnormal' spores are rare but their presence creates anxiety about the relationship of *Equisetum* with other fern allies. The multimorphic spores are described here for the first time in genus *Equisetum*.

Key-words: *Equisetum* L. Sphenopsida, multimorphic spores, spore morphology, Rajasthan, India.

INTRODUCTION

The sphenopsids flourished well during the Late Palaeozoic Era (Andrews 1961, Taylor et al. 2009), but their extant representative is only *Equisetum*. It is a green, herbaceous, leafless plant with differentiation of nodes and internodes; the latter have ridges and furrows, which alternate at the adjoining internode. *Equisetum* grows almost throughout the world, except Australia and New Zealand (Sharma et al. 2009). *Equisetum* flourishes in marshy places and along the banks of rivers, streams and waterfalls. The plants range in size from 3 cm, e.g. *E. scirpoides*, to 8-10 m, e.g. *E. elongatum* and *E. myriochaetum* (Willd 1810,

Schlecht & Chambers 1830, Sharma et al. 2009). Milde (1867) divided the genus into two subgenera, viz. *Equisetum* and *Hippochaete*. Majority of researchers accept this division. The fertile structures, i.e. cones, are lodged terminally on stems and branches. A cone has several whorls of umbrella shaped stalked sporangiophores. Each has 8-10 bag shaped sessile sporangia on the inner face of the peltate head. In a young sporangium, the wall is 3-4 cells thick but in a mature one, it reduces to only one cell thick. It is believed that a sporangium stores large number of spherical alete spores (and no monolete or trilete spores) with thread shaped enveloping non-cellular

elaters (Bierhorst 1971, Bold et al. 1987, Gifford & Foster 1988). But Vangani (1989), in her unpublished Ph.D. thesis, described alete, monolete and trilete spores in *E. ramosissimum* collected from Rajasthan. McLean and Ivimey-Cook (1960) described variations in size of spores, i.e. both smaller and larger spores, and called it incipient heterospory. However, Duckett (1973) rejected the view and suggested homospority with equal sized spores. Kashyap (1914) observed sex expression, i.e. male, female and bisexual gametophytes in nature, in *E. debile*. Mohan Ram and Chatterji (1970) and Hauke (1971, 1977) studied further the behaviour of spores regarding sex expression in the laboratory and found that it depends on the physical, chemical and genetic factors like intensity and colour of light, temperature, PGRs in medium, etc. *Equisetum* spores are peculiar in having elaters, a character that existed in some of the extinct taxa like *Elaterites* (Good & Taylor 1975), presence of chlorophyll and low viability. There are four wall layers on a spore, i.e. perispore, middle layer, exine and intine (Bierhorst 1971, Bold et al. 1987). The present investigation is based on the study of microtome cut serial sections of *Equisetum* cones and presence of multimorphic spores has been noticed for the first time.

MATERIAL AND METHOD

The material of *Equisetum ramosissimum* was collected from several places in Rajasthan, e.g. Jamuva Ramgarh (Jaipur), Nasirabad Valley (Ajmer), Mt. Abu, etc. The cones were fixed in F.A.A. (Formaldehyde+Acetic Acid+Alcohol) and then preserved in 70% alcohol. The material was processed for microtomy as suggested by Johansen (1940). Staining was done by using safranin and haemotoxylin and mounted in dilute canada balsam.

DESCRIPTION

Both longi- and cross-sections of the cones have been examined. Early stages of sporangium development are not known with certainty, i.e. whether it originates from a single cell or a group of cells (Hawkins 1907, Fagerlind 1961, Bierhorst 1971). In a young sporangium, there is a distinct 2-3 cells thick tapetum surrounding the central sporogenous tissue. The tapetal cells disintegrate and form tapetal plasmodium (Bold et al. 1987) which provides nutrition to the developing sporogenous cells. The spores are produced from spore mother cells by meiosis which are multimorphic, i.e. in addition to the normal spherical, alete, thick walled spores (Text-figures C-F) measuring 35-50 μm (Plate 1, figures A-D), a few abnormal spores are also produced, e.g. smaller, thin walled spores with 10-15 μm diameter (Plate 1, figure A) and spherical, empty, thin walled spores (probably sterile) measuring 20-25 μm (Plate 1, figures B, L). Monolete, spindle shaped, sterile spores measuring 20-35 μm (Plate 1, figures B, D-E, G, Text-figure D) and triangular or spherical trilete spores (Plate 1, figure N, Text-figures A, F) with distinct triradiate straight ridges (Text-figure F) are also visible. Such spores measure 30-45 μm and are probably fertile. A large circular spore (70 μm in diameter) is shown in Plate 1, figure P. In *Equisetum*, viability of spores is quite low, i.e. 1-6 days (Bold et al. 1987) and some of the spores start germination in situ (Plate 1, figure O) before liberation. The 'minute' spores (in groups) are visible in many sporangia (Text-figures B-E). These spores originate either by fission of spore content of a normal spore (Plate 1, figures E-F, H-J, P) or in a regular sequence (Plate 1, figure K). The size of minute spores is variable from 4 to 8 μm . The behaviour or fate of 'minute' spores remains unknown. The term 'minute' spore is not related here to the

Plate 1

A-P. Variations in spores of *Equisetum*. A. L.S. of sporangium with two smaller sized spores (arrow). B. L.S. of sporangium with minute spores, monolete spores and a spherical thin walled spore (all arrows). C. C.S. of sporangium with an isobilateral tetrad (arrow). D. L.S. of sporangium with a monolete spore (arrow). E-F, H-K. Minute spores (arrow) and other types of spores. G. A monolete spindle shaped spore. L. A thin walled spherical spore (arrow) and a tetrad of large sized empty spores (arrow). M. A tetrad of thin walled empty spores (arrow). N. Trilete spores with distinct ridges (arrow). O. Two germinating (arrow) circular spores (in situ). P. A large spherical spore (arrow) and a bunch of minute spores (arrow). (Bar 1-4 = 80 μm , 5-16 = 30 μm).

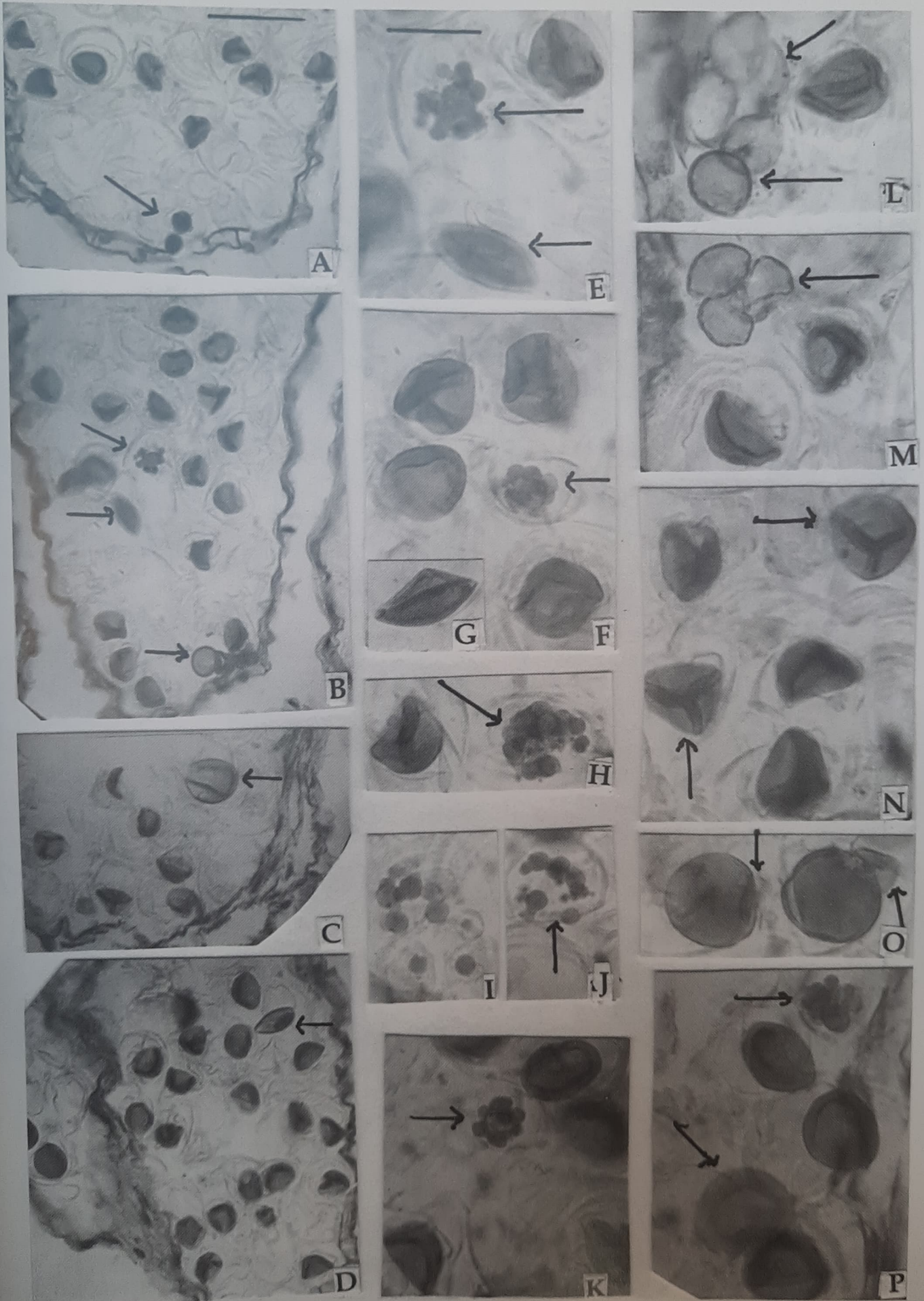
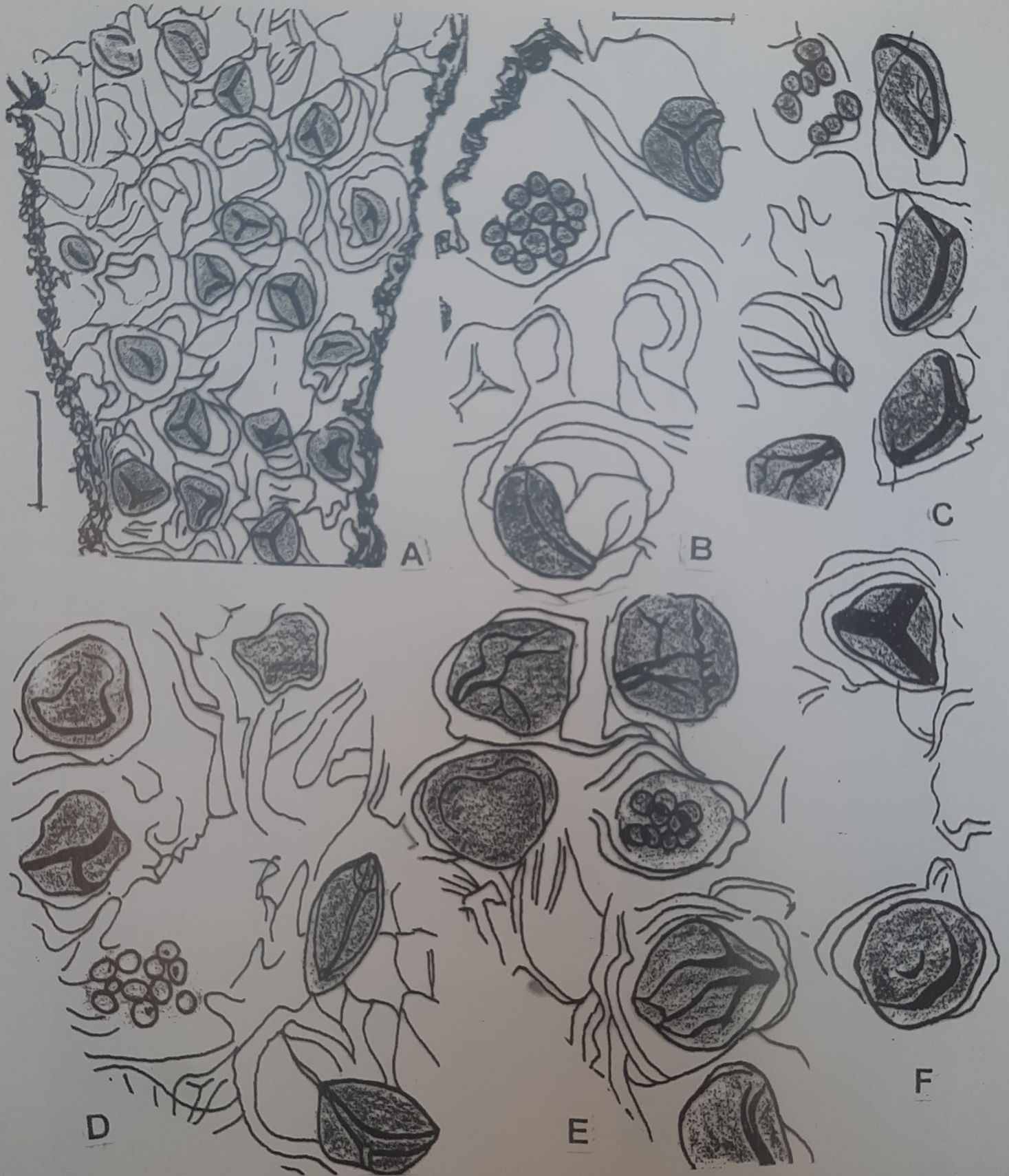


Plate 1



Text-figures A-F. Various types of spores of *Equisetum*. A. L.S. of sporangium with alete and trilete spores and intermingled thread like elaters. B. A bunch of minute spores and two bigger spores. C. A bunch of 8 minute spores and four bigger spores. D. A bunch of 10 minute spores, one spindle shaped monoalete spore and 4 bigger spores. E. A spore sac with a bunch of 9 minute spores and four alete spores. F. One trilete spore and an alete spore (Bar A = 50 μ m, B-F = 20 μ m, drawn from photographs).

'microspore', because the latter term is generally means the male spore. In some of the sporangia, large, isobilateral, empty tetrads (60-80 μm) are visible (Plate 1, figure C). Empty, large, thin walled, spore tetrads are also seen in some of the sporangia (Plate 1, figures L, M). These are sterile spores.

From the above description it is clear that multimorphic spores occur in *Equisetum* and the earlier concept of homosporous and alete spores is not correct. The present investigation is the first report of multimorphic spores in *Equisetum* and it needs studies on more material and further research work.

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