

Ultrastructure of the sporoderm in megaspores of some Indian Selaginellas

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ABSTRACT

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Megaspores of six species of the genus *Selaginella* were studied under light microscope and Scanning Electron Microscope. In general, the sporoderm of all the species investigated shows a tuberculate sculpture, intervening areas have a fine reticulum. The sporopollenin units could also be examined in some megaspores by fracturing the spore wall.

Key-words—Palynology, Pteridophytes, *Selaginella*, Megaspores, India.

कुछ भारतीय सेलाजिनेलाओं के गुरुबीजाणुओं में उपस्थित बीजाणुचर्म की परासंरचना

ऊषा बाजपेई

सारांश

सेलाजिनेला वंश की 6 प्रजातियों के गुरुबीजाणुओं का प्रकाश सूक्ष्मदर्शी तथा क्रमवीक्षण इलेक्ट्रॉन सूक्ष्मदर्शी की सहायता से अध्ययन किया गया. सामान्यतः इन सभी प्रजातियों के बीजाणुचर्म गुलिकीय लक्षण प्रदर्शित करते हैं तथा मध्यवर्ती क्षेत्रों में उत्कृष्ट कोटि की जालिकाएँ हैं. कुछ गुरुबीजाणुओं की बीजाणुभित्तियों को तोड़कर स्पोरोपोलेनिन इकाइयों का भी परीक्षण किया गया.

संकेत शब्द—परागाणुविज्ञान, टेरिडोफाइट्स, सेलाजिनेला, गुरुबीजाणु, भारत.

INTRODUCTION

THE importance of the structure of the megaspore sporoderm in systematics of extinct and extant heterosporous lycophytopsids has been emphasised in recent years. The megaspore wall-structure has been investigated in several species under the Scanning Electron and Transmission Electron Microscopes (Kempf, 1970; Bajpai & Maheshwari, 1986; Taylor & Taylor, 1987; Kovach, 1989; Sen *et al.*, 1989; Taylor, 1989, 1993; Hemsley *et al.*, 1992; Morbelli, 1995).

Selaginella is an important genus of the lycopods because all species of this taxon possess a ligule and show heterospory. Heterospory of course was not uncommon in extinct Lycophytopsida. The genus *Selaginella* is widely distributed, and though the vast majority is confined to the tropical and sub-tropical regions, some are markedly xerophytic; and some species are also known from the temperate regions.

Micromorphological details of wall-structure are known only for a few species of *Selaginella* (Kempf, 1970; Tryon & Lugardon, 1979; Bajpai & Maheshwari, 1986; Taylor, 1989; Morbelli, 1995); many Indian species of the genus are yet to

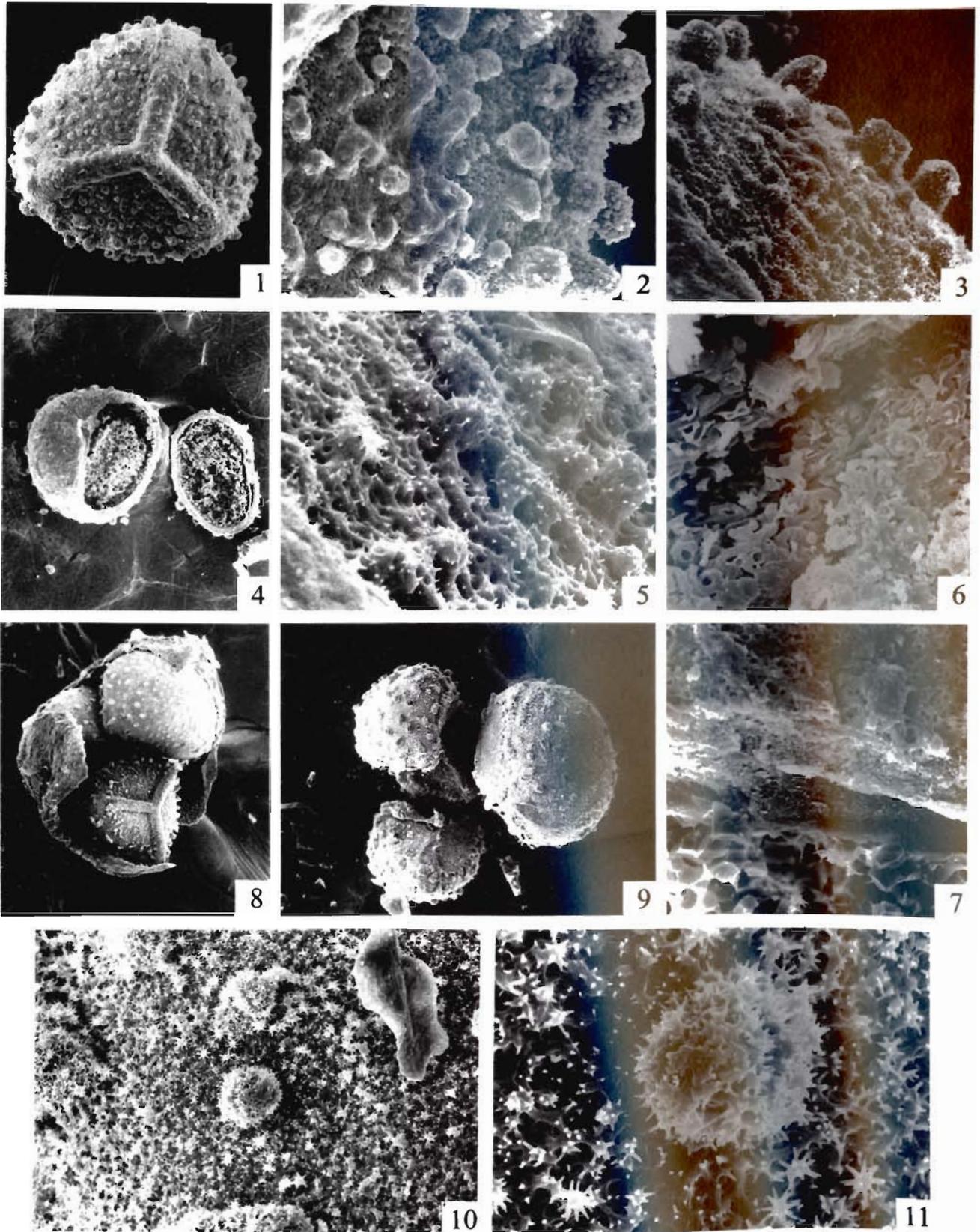


PLATE 1

be investigated in detail. Therefore, megaspores were collected from well-identified herbarium specimens present at Lucknow University for SEM studies in order to elucidate structural details of the megaspore wall and to understand the arrangement of sporopollenin units.

MATERIAL AND METHODS

Mature megaspores of six species of *Selaginella*, including two species studied earlier, were selected for investigation. The megaspores were measured under the light microscope. For detailed resolution of the surface features under Scanning Electron Microscope, selected megaspores, some with vertically fractured sporoderm, were mounted on silver tape and coated with gold as described in an earlier publication (Bajpai & Maheshwari, 1983). Photomicrographs were prepared in the Scanning Electron Microscope facility of Birbal Sahni Institute of Palaeobotany, Lucknow.

OBSERVATIONS

S. repanda (Desv.) Spring

Pl. 1·1-3

Megaspores sub-triangular to sub-circular in proximo-distal orientation, 247-279 μm in diameter; trilete, triradiate ridges broad, raised, uniformly wide, about 11-13 μm at the base, four-fifths of megaspore radius in length. Sporoderm surface is sculptured by tubercles both on proximal and distal surfaces. Tubercles vary in size and shape, and are 6-16 μm high. Each tubercle is covered with small granules, which give it an appearance resembling a 'mulberry' fruit (Pl. 1·2). The granules spill over the exine in between the tubercles.

S. decipiens Warb.

Pl. 1·4-7

The megaspores are rounded-triangular in proximo-distal view, 187-189 μm in diameter; trilete, triradiate ridges not very prominent, about four-fifths of spore radius long.

Sporoderm ornamentation is tuberculate, tubercles being sparsely distributed. The whole of the exoderm including the tubercles is covered with minute spines. The sporoderm as seen in fractured megaspores (Pl. 1·4) shows a spongy exine comprising irregularly arranged tubular sporopollenin units (Pl. 1·6, 7). The nexine occupies almost the entire cavity (Pl. 1·4).

S. exigua Spring

Pl. 1·8-11

Megaspores roundly triangular in polar view, 267-289 μm in diameter; trilete, triradiate ridges stout and raised and do not reach up to spore equator; arcuate ridges not seen. Exine sculpture comprises sparsely distributed tuberculae and minute spines that are often grouped in the form of 'sparkling stars'. The latter are uniformly present all over the exine, including over the tuberculae. Exine structure is reticulate; the meshes are in the form of a dense web, which probably comprises intertwined sporopollenin units. The megaspore exhibits two layers, an outer 15 μm thick, spongy sexine, and an inner 2 μm thick nexine showing a wrinkled appearance.

S. pennata (Don) Spring

Pl. 2·1-4

Megaspores are circular to sub-circular in proximo-distal view, 368-425 μm in diameter; trilete, triradiate ridges about 12-14 μm wide at base, reach almost up to the equator, no arcuate ridge seen. Megaspore sporoderm is ornamented with tubercles, the tubercles are comparatively small and relatively densely arranged on the proximal inter-ray areas than on the distal surface (Pl. 2·1). There is no other sculpture. The exine is apparently reticulately structured; the meshes transgress over even the tubercles (Pl. 2·3). This network gives a spongy appearance to the sporoderm surface at high magnifications. At some places the tubercles seem to be joined by the reticulate network. In a fracture-section of the sporoderm, the sporopollenin units are very clearly seen. These are coiled, curved tubular rods, making loops of different sizes and in various orientations at short distances (Pl. 2·4). The nexine



PLATE 1

(All SEM photomicrographs)

1-3. *Selaginella repanda*;

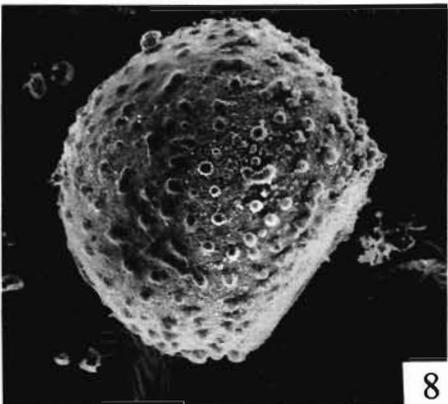
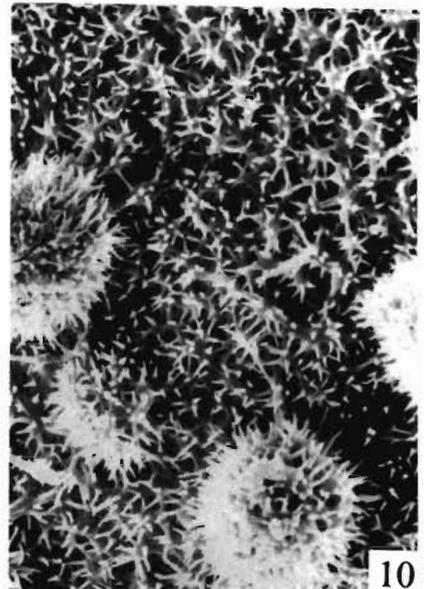
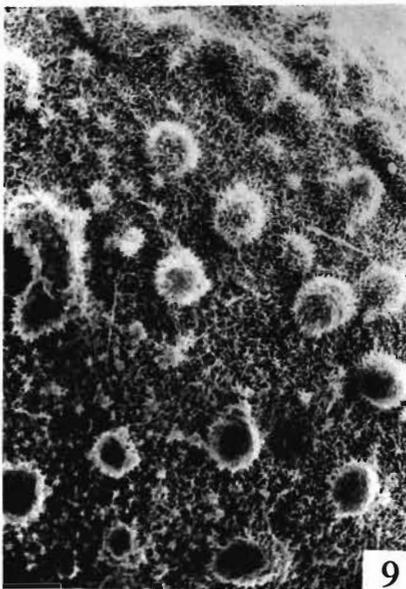
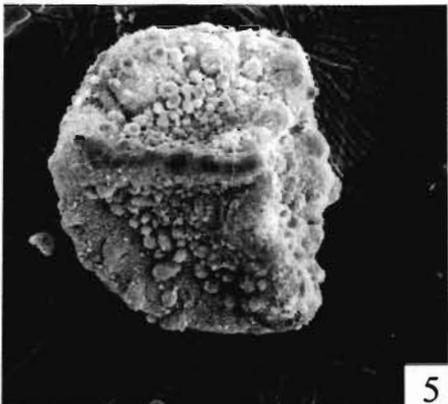
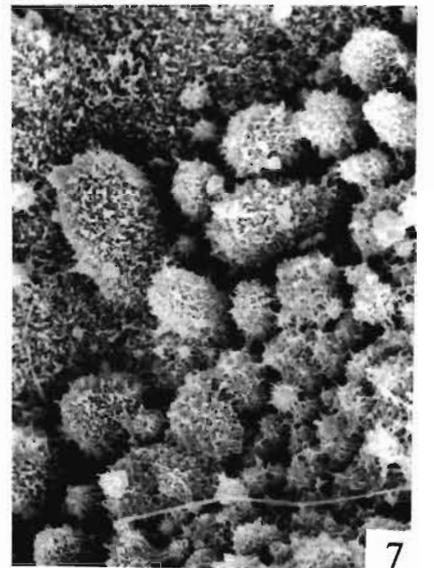
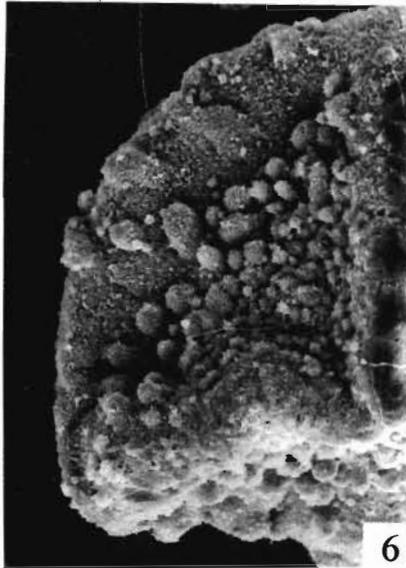
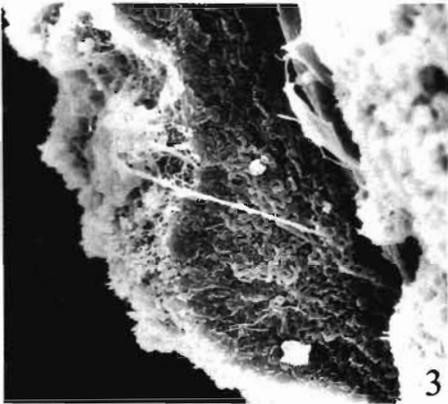
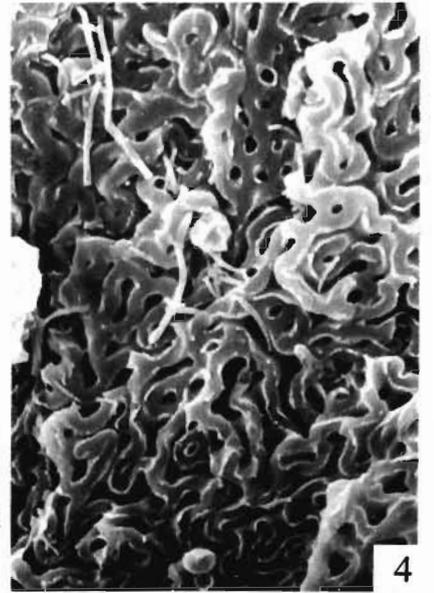
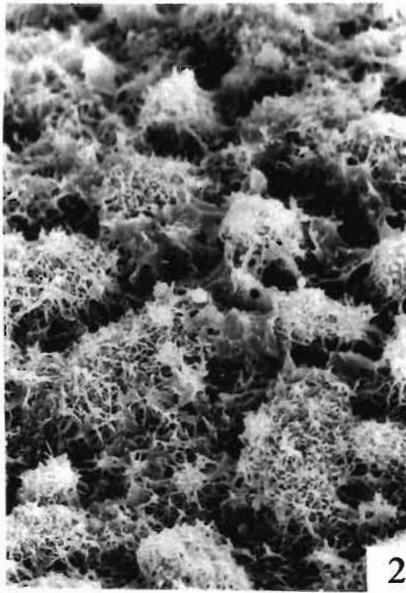
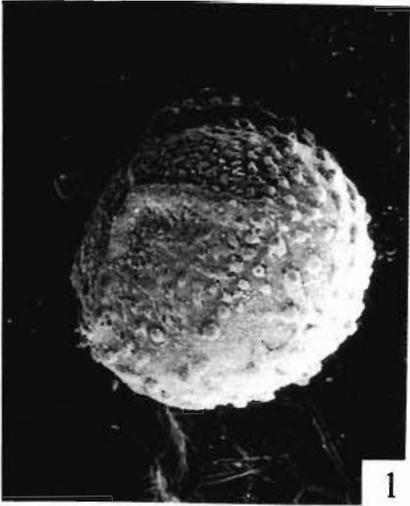
- 1 a megaspore in proximo-distal orientation. x 160.
- 2-3. tuberculate sporoderm, note the 'mulberry'-like appearance of the tuberculae, especially on the equator. 2 x 3,000; 3 x 2,600.

4-7 *Selaginella decipiens*;

4. a megaspore fractured in two unequal halves. x 115.
5. surface ornamentation of the sporoderm. x 6,000.
6. rod-shaped, coiled, looped and inter-twined sporopollenin units in the fracture-section of the sporoderm. x 18,000.
7. the sexine and nexine as seen in the fracture-section. x 115.

8-11. *Selaginella exigua*;

8. a megaspore tetrad with one large ("functional") megaspore in lateral view and three comparatively small ("non-functional") megaspores. x 110.
9. a megaspore tetrad, with one viable and three non-functional megaspores. x 110.
- 10-11. surface ornamentation of the sporoderm, note the star-like arrangement of the spines. 10 x 3,000; 11 x 9,000.



completely fills the inner cavity of megaspores.

S. plumosa Baker

Pl. 2·5-7

Megaspores are roundly triangular in polar view, 275-294 µm in diameter in proximo-distal view; trilete, triradiate ridges robust, 13-18 µm wide and reach almost up to the spore equator. The exine ornamentation is tuberculate; tubercles vary in size and shape. The tubercles in the inter-ray areas are densely arranged but near the equator and on the distal surface the tubercles are scanty. The sporoderm in between the tubercles is sculptured with minute spines which are so closely intertwined as to give a superficial resemblance with the surface of *S. pennata*.

S. delicatula (Desv.) Alston

Pl. 2·8-10

Megaspores are spherical in shape, circular to sub-circular in polar view, 280-295 µm in diameter in proximo-distal view; trilete, triradiate ridges 7-9 µm wide and extend to about three-fourths of the spore radius. Exine ornamentation is tuberculate, tubercles are scanty on the proximal surface but distally the tubercles are uniformly distributed; small spines cover the sporoderm all over, including the tubercles. In general appearance of the sporoderm, the megaspores of *S. delicatula* resemble to some extent those of *S. exigua*.

DISCUSSION

The scanning electron microscopy of the sporoderm in six species of the genus *Selaginella* collected from Northeast Himalaya has provided data which apparently is species-specific. The surface ornamentation of the megaspore sporoderm in all the species of the genus *Selaginella* investigated here is mainly tuberculate; but the distribution of the tubercles varies with species. In between the tubercles, the sporoderm is often covered with minute, sparsely or densely distributed spines. In some species the spines occur separately while in others, the spines are grouped in star-shaped entities and form a 'flowery' pattern on the surface. Sporopollenin units as seen in fracture-sections of the sporoderm are rod-shaped bodies, which are variously curved and inter-twined as a three-dimensional

system but show no orderly arrangement. Two ultrastructural patterns are suggested for the sporoderm of *Selaginella*, and the arrangement of sporopollenin units in super-units (Morbelli, 1995), are, however, not decipherable in photomicrographs of fracture-sections.

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PLATE 2

(All SEM Photomicrographs)

1-4 *Selaginella pennata*;

1 a megaspore in an oblique view. x 100.

2 surface ornamentation of the sporoderm. x 6,500.

3 fractured surface of megaspore. x 3,200.

4 rod-shaped sporopollenin units that are inter-twined and looped in a three-dimensional system. x 21,000.

5-7 *Selaginella plumosa*;

5 a megaspore in a lateral view. x 150.

6 surface ornamentation of the sporoderm in the equatorial regions. x 1,600.

7 tuberculae in an inter-ray area. x 4,600.

8-10 *Selaginella delicatula*;

8 a megaspore in lateral view. x 160.

9-10 surface sculpture of the sporoderm. 9 x 2,000; 10 x 6,000.