SPORELING DEVELOPMENT IN *FOSSOMBRONIA KASHYAPII* SRIVASTAVA & UDAR

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ABSTRACT

Spore morphology as well as stages of sporeling development in *Fossombronia kashyapii* have been described. Two types of sporeling patterns have been observed, (i) with germ tube, later forming an intermediate filamentous stage, (ii) without germ tube, generally forming a globose cell-mass. A distinctive feature is the predominance of the former over the latter. Affinities of Fossombroniaceae with Marchantiaceae, Sauteriaceae, Calobryaceae and Anthocerotaceae have been suggested in sporeling development.

INTRODUCTION

The genus *Fossombronia* belongs to Metzgeriales, a group of liverworts under which seven types of sporelings have been recognized (NEHIRA, 1966). These are : 1. '*Fossombronia* type' (includes *Fossombronia pusilla*: LEITGEB, 1877; CHALAUD, 1929; *F. longiseta* : HUMPHREY, 1906; *F. japonica*: INOUE, 1959; NEHIRA, 1966 and *F. cristula*: UDAR & SRIVASTAVA, 1972); 2. '*Pallavicinia* type' (includes *Pallavicinia lyellii*: HAUPT, 1918; WOLCOTT, 1942; KACHROO, 1956 and NEHIRA, 1966; *P. ambigua*: KACHROO, 1956; *P. longispina*: NEHIRA, 1966; *Moerckia flotowiana:* MADER, 1929; *Aneura pinguis:* CLAPP, 1912 and NEHIRA, 1966; *A. pellioides*: NEHIRA, 1966; *Riccardia palmata*: LEITGEB, 1877 and NEHIRA, 1966 and *R. nana*: NEHIRA, 1966); 3. '*Riccardia* type' (includes *Riccardia multifida, R. sinuata, R. nagasakiensis*: NEHIRA, 1962 and *R. miyakeana*: NEHIRA, 1966); 4. '*Metzgeria* type' (includes *Metzgeria conjugata*: NEHIRA, 1966); 5. '*Makinoa* type' (includes *Makinoa crispata*: INOUE, 1958 and NEHIRA, 1966); 6. '*Cavicularia* type' (includes *Cavicularia densa* : NEHIRA, 1966) and 7. '*Pellia* type' (includes *Pellia epiphylla*: HEDWIG, 1784; BISCHOFF, 1853; GRÖNLAND, 1854; GREENWOOD, 1911; *P. fabroniana*: SHOWALTER, 1925; NEHIRA, 1966 and *P. neesiana* : WOLFSON, 1928 and NEHIRA, 1966). NEHIRA (1966) remarked, that within Metzgeriales the sporeling pattern is constant in all the families except Riccardiaceae where the sporeling development differs even in the two closely related genera *Riccardia* and *Aneura*.

The Indian species of this genus (*Fossombronia*) have been grouped under the following categories exclusively based on spore morphology and elater characteristics (SRIVASTAVA & UDAR, 1973).

1. '*Fossombronia cristula* type': it includes *F. cristula* and *F. foreaui*. The latter has recently been described as a new species from Kodaikanal, India (UDAR & SRIVASTAVA, 1972a).

2. '*Fossombronia wondraczekii* type': it includes *F. wondraczekii, F. himalayensis, F. pusilla* and *F. kashyapii*.

3. '*Fossombronia indica* type': it includes only one species *F. indica*.

In an earlier paper the sporeling development in a species of the first category has been described (UDAR & SRIVASTAVA, 1972). The present paper gives an illustrated account of sporeling development in *F. kashyapii*—a species belonging to the second category recently described from Rahla (Western Himalayas), India (SRIVASTAVA & UDAR, 1973). An

attempt is being made to investigate the species of the third category to trace the relationship, if any, between the spore morphology and sporeling morphology.

MATERIAL AND METHOD

Plants of *Fossombronia kashyapii* with fully matured (black) sporogonia were collected by us from Rahla, on way to Rohtang pass (ca 9000 ft.)—about 25 miles from Manali in Kulu valley during October, 1967 in a plant collection trip of Botany students of this University.

These plants grow fairly exposed on rocks under natural conditions. Mature sporogonia were dissected out and thoroughly washed by distilled water. Spores were sown in covered pyrex glass petridishes containing liquid as well as semi-solid agar medium. The following constituents (as formulated by INOUE, 1960) were used and the medium was prepared in 1000 ml distilled water: KNO_3 (0.25 gm), KH_2PO_4 (0.25 gm), $Ca(NO_3)_2$ (1.00 gm), $MgSO_4$ (0.25 gm), $Fe_3(PO_4)_2$ (0.20 gm) and $FeCl_3$ (1 drop). Difco Agar was used for preparing the semi-solid medium. All the petridishes containing spores were subjected to receive diffuse sunlight through North glass window panes of the laboratory at room temperature.

The glass wares and the medium used in the present investigation were autoclaved before use.

The sowing of the spores was done two times i.e. on 19th November, 1967 as well as on 14th December, 1968 to repeat the observations.

SPORE MORPHOLOGY OF *F. KASHYAPII*

Mature spores are ca 48.0—57.6 μ in diameter, dark-brown, perinous and polar with distinct proximal and distal faces. The proximal face has more or less conspicuous triradiate mark and is devoid of any ornamentation (Text-fig. 4). Distal face has, however, characteristic ornamentation consisting of thick and high lamellae usually forming reticulations (1-8) in the middle (Text-figs. 1-3). The lamellae continue at the periphery and project out in the form of spines. Spines are numerous.

OBSERVATIONS

The spores after a few days of sowing showed a marked increase in size by absorption of moisture. Due to this the inner contents of the spore exerted pressure on the wall and eventually the rupture of the spore-coat took place. The spore-coat ruptured on the proximal face through tri-radiate mark.

Initial stages of spore germination in ca 75-80% of the spores were observed only after two weeks in both liquid as well as on semi-solid medium. However, about 3-5% of the spores (sown on 19th November, 1967) started sprouting on 10th day (i.e. on 29th November, 1967) and some of the spores (sown on 14th December, 1968) germinated in about two weeks time (i.e. on 26th and 27th December, 1968). A number of spores were observed forming the germ-tube (Text-figs. 5-7), although the globose cell-masses have also been noticed in quite a sufficient number of germinated spores (Text-figs. 9, 12, 17-19).

In the sporelings where the germ-tube is prominently formed, the first two divisions are usually transverse (Text-fig. 8) forming a 3-celled filament. The sporeling drawn in Fig. 12 seems to have undergone two vertical divisions (at right angle to each other) while the

germ-tube is still very short, resulting in the formation of 4-celled disc. This condition may also be considered as an early stage of cell-mass formation.

Sometimes when the sporeling is very young, having no division of the germ-tube, it develops a rhizoid more or less at right angle to the germ-tube (Text-fig. 7) comparable to those of the germ rhizoid of *Stephensoniella* and *Exormotheca*. This rhizoid contains chloroplasts towards the tip. It is remarkable that it shows a germ-rhizoid formation which is rather rare not only in the genus *Fossombronia* but also in the Metzgeriales where the rhizoids are generally formed in the later stages of sporeling development.

The terminal cell of the 3-celled filament (Text-fig. 8) undergoes a vertical division to form a 2-celled terminal disc (Text-fig. 10). Subsequent vertical division occurs in the middle cell of the filament and a four celled germ disc is thus formed (Text-fig. 13). Occasionally, however, there occur two more or less parallel vertical divisions in the terminal cell resulting into a 3-celled terminal disc (Text-fig. 11). Thereafter further walls are laid down to form many-celled germ-disc (Text-figs. 14-17) and ultimately an apical cell with two cutting faces is organized (Text-fig. 18). Further growth of the sporeling takes place by the activity of the apical cell and well organized sporelings are formed (Text-figs. 19-72). These, in later stages of development, develop rhizoids on the morphological ventral surface of the sporelings. The juvenile gametophyte with stem (axis) and leaves is subsequently formed.

The stages illustrated in the present work (Text-figs. 5-27) have been drawn from the cultures maintained up to 45 days under laboratory conditions.

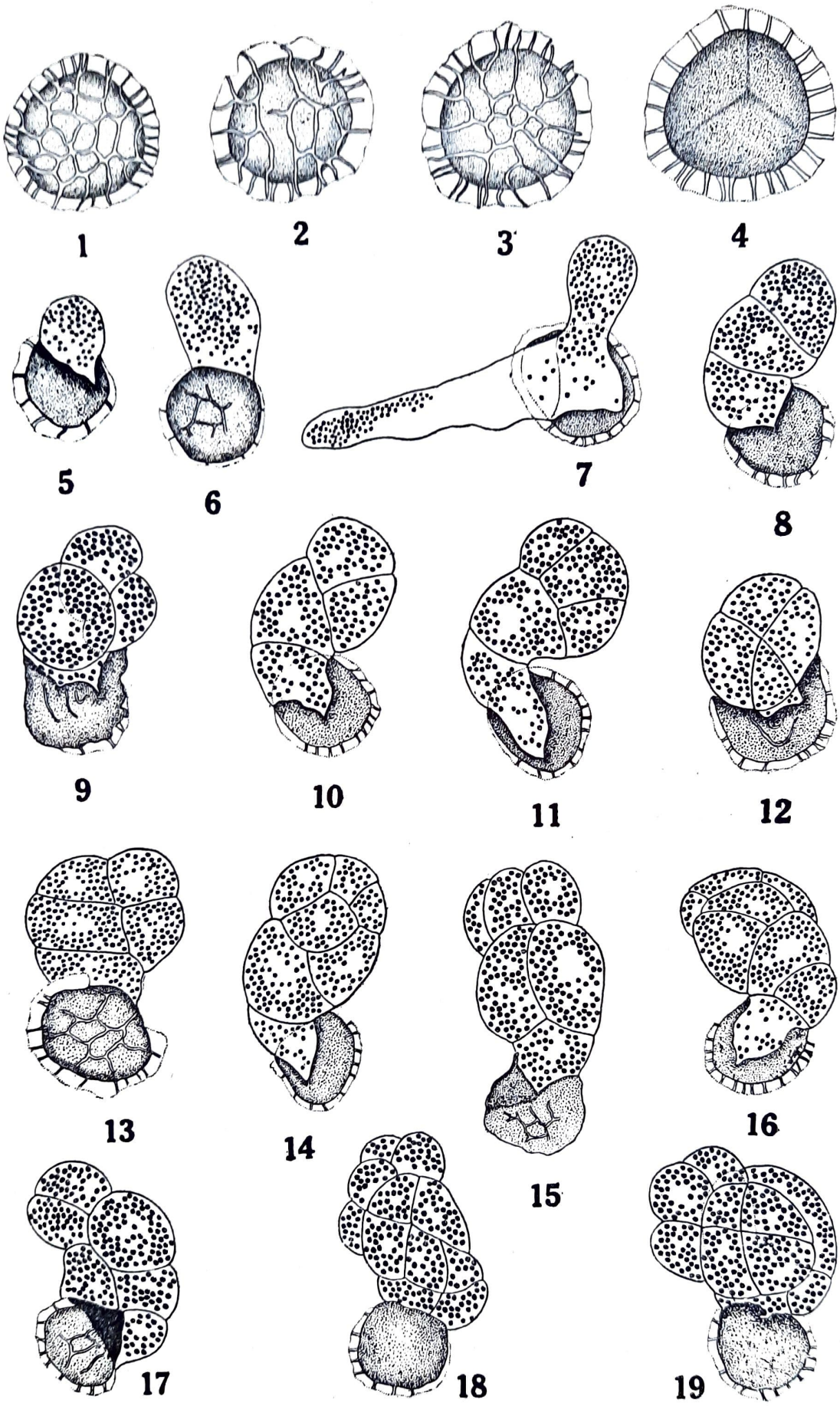
CONCLUSION

The present investigation shows that the sporeling development in *Fossombronia kashyapii* follows two patterns: (i) where a germ-tube is initially formed (Text-figs. 5-7), (ii) where normally a globose cell-mass (Text-figs. 9, 12, 17-19) is formed.

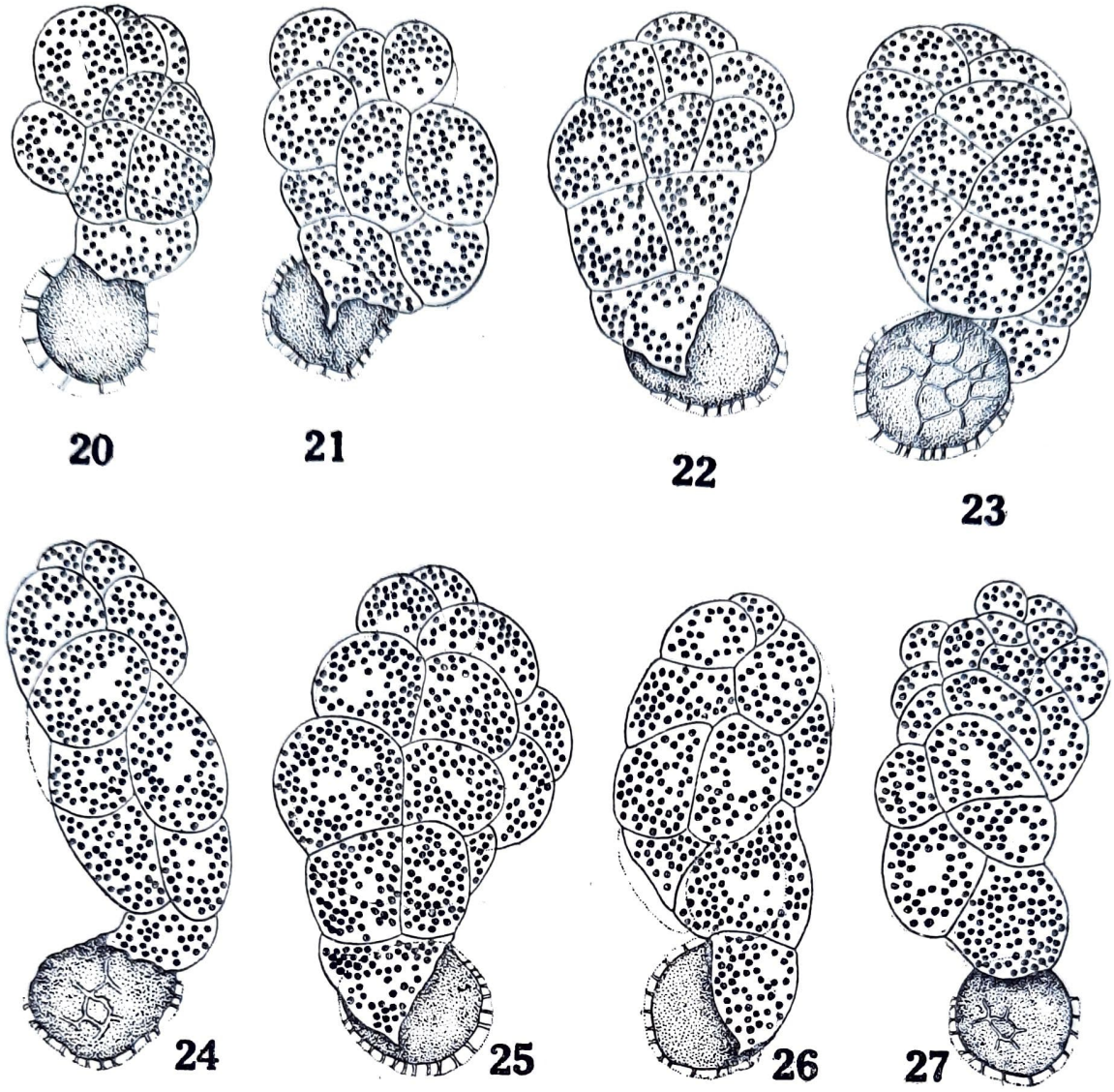
The first type of sporeling development corresponds with those in the Marchantiales, while the latter type is characteristic of Calobryales and of some Anthocerotae (*Megaceros*). However, the pattern in early stages of sporeling development in *Calobryum* and *Megaceros* differ from *Fossombronia* type in many other details. The occurrence of globose cell-mass in Fossombroniaceae, some Marchantiales (Sauteriaceae and Marchantiaceae), Calobryales and some Anthocerotae (*Megaceros*) indicates a close relationship between them and may also provide a favourable answer to a common ancestry of these plants.

The overall pattern of sporeling development in this species (*F. kashyapii* nearly corresponds to those already described in *F. pusilla* (Leitgeb, 1877 and Chalaud, 1929), *F. longiseta* (Humphrey, 1906), *F. japonica* (Inoue, 1959; Nehira, 1966) and *F. cristula* (Udar & Srivastava, 1972). All the above species usually show a cell-mass formation with stray occurrences of filamentous stages which are considered to have developed because of the environmental effect (Inoue, 1959). In *F. kashyapii*, however, the germ-tube formation is predominant (Text-figs. 5-8, 10, 11, 13-16 and 20-27) and only a few sporelings show the cell-mass formation (Text-figs. 9, 12 and 17-19).

The Marchantialean taxa have a tendency to form germ-tube in early stages of spore germination (Mehra & Kachroo, 1951, 1952; Inoue, 1960; Udar, 1957, 1957a, 1957b 1958; Udar & Chandra, 1965; Udar & Kumar, 1972 and Udar & Srivastava, 1968). But in *Athalamia pinguis* (Udar, 1958a) and *Preissia quadrata* (Udar & Sriavstava, 1970) there is germ-tube as well as the cell-mass formation, similar to *Fossombronia kashyapii*, thus indicating affinities of Fossombroniaceae with Sauteriaceae and Marchantiaceae in the



Text-figs. 1—19: 1-3, Mature spores (distal view); 4, Spore (proximal view); 5-6, Early stages of germ-tube formation; 7, Early sporeling with a germ-tube and germ-rhizoid; 8, Three-celled filamentous stage; 9, Early stage of cell-mass formation; 10-11, Vertical divisions in the terminal cell of the filament; 12, Two vertical divisions intersecting each other; 13-16, Subsequent stages of sporeling development; 17-19, Cell-mass formation.



Text-figs. 20-27. Later stages of sporeling development. (Text-figs. 1-4 magnified 420 × and Text-figs. 5—27 magnified 285 × approximately).

sporeling development. In addition, Text-fig. 7 shows a germ-rhizoid formation which is also a feature of Marchantialean sporeling and may be compared with those of the germ-rhizoid formation in *Stephensoniella* and *Exormotheca* [i.e. the '*Stephensoniella* type' of germ-rhizoid formation (Mehra & Kachroo, 1952; see also Udar & Srivastava, 1968]. The predominant occurrence of germ-tube formation in *F. kashyapii* further suggests that this species of *Fossombronia* approaches more towards Marchantiales than those with the usual feature of cell-mass formation. Investigations on the third category would only provide a complete picture of the sporeling development and their stability or otherwise in the genus *Fossombronia*.

REFERENCES

+Bischoff, G. W. (1853). Bemerkung zur Entwicklungsgeschichte der Lebermoose. *Bot. Zeit.* **11**: 113—123.

Chalaud, G. (1929). Le cycle evolutif de *Fossombronia pusilla* Dum. La phase protonomique et la phase de premiere jeunesse. *Rev. Gen. Bot.* **41**: 95—105.

Clapp, G. L. (1912). The life history of *Aneura pinguis*. *Bot. Gaz.* **54**: 177—193.

Greenwood, H. (1911). Development of *Pellia epiphylla*. *Bryologist.* **14**: 59—70, 77—83, 93—100.

+Grönland, J. (1854). Memoir sur la germination de quelques Hepatiques. *Ann. Sci. Nat.* **4** Ser., Bot. **1**: 5—29.

Haupt, A. W. (1918). A morphological study of *Pallavicinia lyelli*. *Bot. Gaz.* **66**: 524—531.

+Hedwig, J. (1784). *Theoria Generationis et Fructificationis Plantarum Cryptogamicarum*, Petropoli.
Humphrey, H. B. (1906). The development of *Fossombronia longiseta* Aust. *Ann. Bot.* **20:** 83—108.
Inoue, H. (1958). Studies on spore germination of Hepaticae, 4. *Makinoa crispata* (Steph.) Miyake. *Bot. Mag. Tokyo.* **70:** 214—217.
Inoue, H. (1959). Studies on spore germination of Hepaticae, 5. *Fossombronia japonica* Schiffn. *Bot. Mag. Tokyo.* **72:** 131—136.
Inoue, H. (1960). Studies in spore germination and the earlier stages of gametophyte development in the Marchantiales. *Jour. Hattori Bot. Lab.* **23:** 148—191.
Kachroo, P. (1956). Morphology of *Pallavicinia. Proc. nat. Inst. Sci. India.* **22:** 6—21.
+Leitgeb, H. (1877). *Untersuchungen über die Lebermoose III. Die Frondosen Jungerm—annien.* Jene.
+Mader, A. (1929). Untersuchungen über die Gattung *Moerckia* Gott. *Planta.* **8:** 742—790.
Mehra, P. N. & Kachroo, P. (1951). Sporeling germination studies in Marchantiales. I. Rebouliaceae. *Bryologist.* **54:** 1—16.
Mehra, P. N. & Kachroo, P. (1952). Sporeling germination studies in Marchantiales. II. *Stephensoniella brevipedunculata* Kash. *Bryologist.* **55:** 59—64.
Nehira, K. (1962). The germination of spores in Hepaticae. 4. Two types of sporeling pattern in the *Riccardia. Hikobia.* **3:** 96—101.
Nehira, K. (1966). Sporelings in the Jungermanniales. *Jour. Hiroshima Univ. Ser B, Div.* 2 (*Botany*). **11** (1) : 1—49.
Showalter, A. M. (1925). Germination of the spores of *Riccardia pinguis* and of *Pellia fabbroniana. Bull. Torrey Bot. Club.* **52:** 157—166.
Srivastava, S. C. & Udar, R. (MS.). The genus *Fossombronia* Raddi in India with a note on the Indian taxa of the family Fossombroniaceae. *Nova Hedwigia.*
Udar, R. (1957). Culture studies in the genus *Riccia* (Mich.) L. I. Sporeling germination in *Riccia billardieri* Mont *et* N. *J. Indian bot. Soc.* **36:** 46—50.
Udar, R. (1957a). Culture studies in the genus *Riccia* (Mich.) L. II. Sporeling germination and regeneration in *R. crystallina* L. *J. Indian bot. soc.* **36:** 580—586.
Udar, R. (1957b). Culture studies in the genus *Riccia* (Mich.) L. III. Sporeling germination in *R. trichocarpa* Howe—A reinvestigation. *J. Indian bot. soc.* **37:** 70—74.
Udar, R. & Chandra, V. (1965). Morphology and life history of *Plagiochasma intermedium* L. *et* G. *Jour. Hattori Bot. Lab.* **28:** 75—93.
Udar, R. & Kumar, D. (1972). Sporeling development in *Athalamia pusilla. Phyton.* **14:** 229—237.
Udar, R. & Srivastava, S. C. (1968). Sporeling development in the genus *Exormotheca* 1. *E. ceylonensis. Canadian J. Bot.* **46:** 1009—1012.
Udar, R. & Srivastava, S. C. (1970). Sporeling development in *Preissia quadrata. Phyton* **14:** 165—173.
Udar, R. & Srivastava, S. C. (1972). Sporeling development in the genus *Fossombronia* Raddi. I. *F. cristula* Aust. *Jour. Palynology.* **8:** 1—7.
Udar, R. & Srivastava, S. C. (1972a). A new species of *Fossombronia* Raddi, *F. foreaui* Udar *et* Srivastava from Kodaikanal (Palni Hills), South India. *Nova Hedwigia: Lower plants of the Indian sub-continent. A collection of papers by Indian Scientists.* **47:** 463-468.
Wolcott, G. B. (1942). Spore germination and polarity in *Pallavicinia lyellii. Bryologist.* **45** : 29—34.
Wolfson, A. M. (1928). Germination of the spores of *Pellia epiphylla* and *P. neesiana. Amer. Jour. Bot.* **15:** 179—184.
+Not seen in original.