Riccia (Hepaticae: Ricciaceae) of West Bengal

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(Manuscript received 17 November 2009; accepted 9 February 2010)

ABSTRACT: Twelve species of the genus *Riccia* L. from State of West Bengal have been studied critically under SEM. Three rare species, viz. *R. melanospora, R. perssonii* and *R. stricta* have been recorded for the first time from the State. The sporoderm of *R. crispatula, R. cruciata, R. discolor, R. huebeneriana, R. melanospora, R. perssonii* and *R. plana* from Indian materials have been studied for the first time under SEM. Brief taxonomic descriptions of each species based on observation under Light Microscope as well as Scanning Electron Microscope have been provided along with SEM micrographs.

KEY WORDS: Hepaticae, *Riccia*, West Bengal.

INTRODUCTION

West Bengal - a State of India, lies between 21°45′ and 27°16′ N latitude to 85°55′ and 89°56′ E longitude. It is bordered in the East by Bangladesh, in northeast by Assam, Sikkim and Bhutan, West by Jharkhand and Bihar, southwest by Orissa and extreme northwest by Nepal and South by Bay of Bengal. It has an area about 88,676 Sq km. The Darjeeling Himalaya in the northern extreme of the State belongs to the eastern Himalaya with an elevation up to 3636 m above mean sea level, while the remaining areas lies in the Gangetic plains including a small coastal area of Sundarbans. The climate varies from tropical savannah in the southern part to humid subtropical in the North. The main seasons are summer, rainy and winter. The summer is very hot, temperature reaches up to 38-45°C. Monsoons (June-September) in State receive a heavy rainfall and humidity reaches optimum. Winter (especially in December-January) is mild over the plains areas with average minimum temperatures of 15°C. However, the hilly areas experience a harsh winter, with occasional snowfall at some places. The overall geography and climate of the State especially the hilly region supports the luxurious growth of bryophyte in general and the genus *Riccia* in particular.

The genus *Riccia* L. is represented by 11 species viz., *R. billardieri* Mont. & Nees, *R. crispatula* Mitt., *R. cruciata* Kashyap, *R. crystallina* auct non L. (= *R. cavernosa* Hoffm. emend. Raddi), *R. ciliata* Hoffm., *R. discolor* Lehm. & Lindenb., *R. frostii* Austin, *R. gangetica* Ahmad, *R. huebeneriana* Lindenb., *R. plana* Taylor and *R. sorocarpa* Bisch. in the State of West Bengal (Kachroo, 1959; Pande and Udar, 1959; Kachroo and Bapna, 1963; Srivastava, 1964; Bhattacharya, 2005; Bag et al., 2007). Present study adding three rare species viz. *R. melanospora* Kashyap [earlier reported from Ootacamund, Coimbatore, Hoshiarpur, Mt. Abu, Jodhpur, Lucknow, Bhopal, Konsa Nag (Kashyap, 1929; Pande and Udar, 1958; Sivastava, 1964), *R. perssonii* Sultan Khan [Gorakhpur, Bangladesh and S. Africa (Sinha and Sahai, 1972; Arnell, 1963; Perold, 1989)] and *R. stricta* (Lindenb.) Perold [earlier reported from Pachmarhi, Kodiakanal, Devicolam, Munnar and Silent Valley, South Africa (Udar and Agarwal, 1985; Wigginton et al., 1996)] to the State of West Bengal.

SEM studies on the genus from India are scanty and very few (Kumar et al, 1987; Udar and Agarwal, 1985; Singh and Singh, 2008). The present study provides micromorphological details of all the species of *Riccia* studied under SEM collected from the State of West Bengal (except *R. ciliata* Hoffm. and *R. frostii* Austin which could not be collected by the authors). A brief taxonomic description of each species studied under optical microscope and SEM have been given. It is interesting to note that the sporoderm of *R. crispatula, R. cruciata, R. discolor, R. huebeneriana, R. melanospora, R. perssonii* and *R. plana* from Indian materials have been studied for the first time, while the studies of epidermal cells of thalli of all species under SEM have been attempted for the first time.

MATERIALS AND METHODS

The materials for present study were collected in different seasons in between 2003 – 2009, from different localities of West Bengal. The collected materials were fixed in FAA overnight and preserved in 70% alcohol for further anatomical studies. For SEM studies, the spores and thalli dehydrated in alcohol series, dried in a Critical Point Dryer, then placed over the adhesive surface of double-sided tape affixed on the aluminum stubs and

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gold coating done. The materials were stereo-scanned for microstructures under suitable magnification at an accelerating potential of 10-15 K.V. using Scanning Electron Microscopes viz. JSM 5200 Jeol, installed at Jadavpur University; Leica S440 at GSI, Kolkata; FEI Quanta 200 installed at Bose Institute, Kolkata.

All the materials studied unless otherwise mentioned are deposited at Cryptogamic Section of the Botanical Survey of India, Eastern Regional Centre, Shillong (ASSAM).

TAXONOMIC TREATMENTS

There are 14 species of *Riccia* occurring in West Bengal (incl. three new records).

Keys for distinguishing these fourteen species are as below:

1a. Thallus with large air chambers, spongy ……..……..…….... 2
1b. Thallus without large air chambers, compact ……..…….. 8
2a. Spores permanently in isobilateral tetrads ……..… *R. perssonii*
2b. Spores free not as above ……..…… 3
3a. Spores lamellate, male thalli usually pink …….. *R. frostii*
3b. Spores usually reticulate, male thalli green not as above ……..…… 4
4a. Thalli cruciate, obovate, 6-8 mm long, 5-6 mm wide; spores with complete reticulations on outer surface ……..…….. *R. cruciata*
4b. Thalli not cruciate, 3-10 mm long, up to 3 mm wide; spores with complete or incomplete reticulations on outer surface ……..…….. 5
5a. Thalli forming compact rosettes; spores with incomplete reticulation …….. *R. cavernosa*
5b. Thalli in patches or semi rosettes; spores with complete reticulation ……..…… 6
6a. Dioecious; sulcus prominent towards apex; spores 51-78 µm with 4-6 reticulations across on distal surface ……..…….. *R. stricta*
6b. Monoecious; sulcus not very prominent towards apex; spores comparatively larger with more than six reticulation across on distal surface ……..…….. 7
7a. Thalli 2-3 furcately branched; spores 61.6 - 82.9 x 54.5 - 75.8 µm with 6 - 8 reticulations across diameter, wing margin entire ……..... ……. *R. huebeneriana*
7b. Thalli 3-4 furcately branched; spores 85.3-90.1 x 68.7-85.3 µm with 10-13 reticulations across on distal surface ...…….. *R. plana*
8a. Spores isopolar ……..…. 9
8b. Spores anisopolar ……..…… 11
9a. Monoeciuos; spores comparatively larger, 99.5-125.6 x 97.2-120.9 µm, with highly attenuated margin ……..… *R. billardieri*
9b. Dioecios; spores comparatively smaller, without highly attenuated margin …….... 10
10a. Spores 82.9- 92.4 x 73.5-85.3 µm, reticulations 4-5 across on distal surface, with slightly attenuated margin ...…….. *R. crispatula*
10b. Spores 88-100 µm, reticulations 7-9 across on distal surface, with undulated margin ……..... *R. discolor*
11a. Thallus margin ciliate ……..……... 12
11b. Thallus margin non-ciliate ……..…… 13
12a. Thallus lobes linear cuneate with very prominent cilia; spores 70-90 µm, with 9-11 reticulation across on distal surface ... *R. ciliata*
12b. Thallus lobes oblong obovate with inconspicuous cilia; spores 82-95 µm, with 10-14 reticulation across on distal surface ……..... …….. *R. melanospora*
13a. Thalli 1-2 furcate, oblong to oblong-obovate, 8-11 mm long, 2-3 mm broad; sulcus prominent almost up to the base; spores 85.3-97.2 x 75.8-87.7 µm with 7- 10 reticulations across on distal surface ……..… *R. gangetica*
13b. Thalli 2-3 furcate, oblong-ovate, narrowed towards the subacute apex, 5-7 mm long, 1-1.5mm wide; sulcus very prominent up to the middle; spores 62-85 x 56-82 µm, with 8-11 reticulation across on distal surface ……..…..... *R. Sorocarpa*

1. *Riccia billardieri* Mont. & Nees, Syn. Hepat.: 602. 1846. Fig. 1: 1-3

Monoecious. Plants deep green, dichotomously branched, 1-2 furcate; thalli oblong-obovate, 10-11mm long, about 2 mm broad, apex sometimes with stalked bulb-like structures; sulcus prominent towards apex, margin undulate; ventral surface with purple, semilunate scales along the margin; epidermal cells globose or oval 40-50 x 20-30 µm (when globose 20-30 µm); in cross section thallus differentiated into upper compact photosynthetic zone with slit like pores and lower compact parenchymatous, multilayered storage zone (Euriccia-type).

Capsules prominent on the ventral surface, 2-4 per thallus, arranged in 1-2 rows; spores golden brown to blackish, globose-subglobose, 99.5-125.6 x 97.2-120.9 µm, isopolar with 7-9 reticulations across diam., partition wall of reticulum smooth, thin and low, sometimes with prominent projections present at corners of reticulations, triradiate mark indistinct; wing inconspicuous, margin attenuated.

Specimen examined: *Terrestrial, growing on exposed moist soil, in overlapping large patches, 24-Paraganas, Titagarh, 01.9.2004,* A.K. Bag *05 (CAL).*

Distribution: INDIA (Western Himalaya: Uttarakhand; Eastern Himalaya: West Bengal-hills, Assam; Punjab & West Rajasthan: Rajasthan; Central India: Madhya Pradesh; Gangetic Plains: Uttar Pradesh, Bihar, West Bengal-plains; Western Ghats: Maharashtra, Karnataka; Andaman & Nicobar: Andaman Island), PAKISTAN, SRI LANKA, INDONESIA, (Udar, 1957, 1959; Meijer, 1958; Srivastava, 1964; Kachroo and Bapna, 1963; Parihar et al., 1994; Bapna and Kachroo, 2000; Bag et al., 2007; Singh et al., 2009).

2. *Riccia cavernosa* Hoffm., Deutschl. Fl. 2 (Cryptog.): 95. "1795" 1796. emend. Raddi, Opusc. Sci. (Bologna) 2: 351. 1818. Fig. 1: 4-6

Monoecious. Plants green, spongy, dichotomously branched, broad, 3-9 mm long, 1.5-3 mm broad; sulcus inconspicuous except near apex; ventral surface without scales; epidermal cells globose, 42-54 µm in diam., sometimes ovate 42-54 x 36-45 µm; in cross section thallus differentiated into upper photosynthetic zone with large air chambers and pores and lower compact, parenchymatous storage zone (Ricciella-type).

Capsules numerous in 1-3 rows, slightly projecting ventrally; spores brown, globose to subglobose, 68-85 µm, anisopolar, distal surface with prominent lamellae incrusted by granules and puncti forming incomplete

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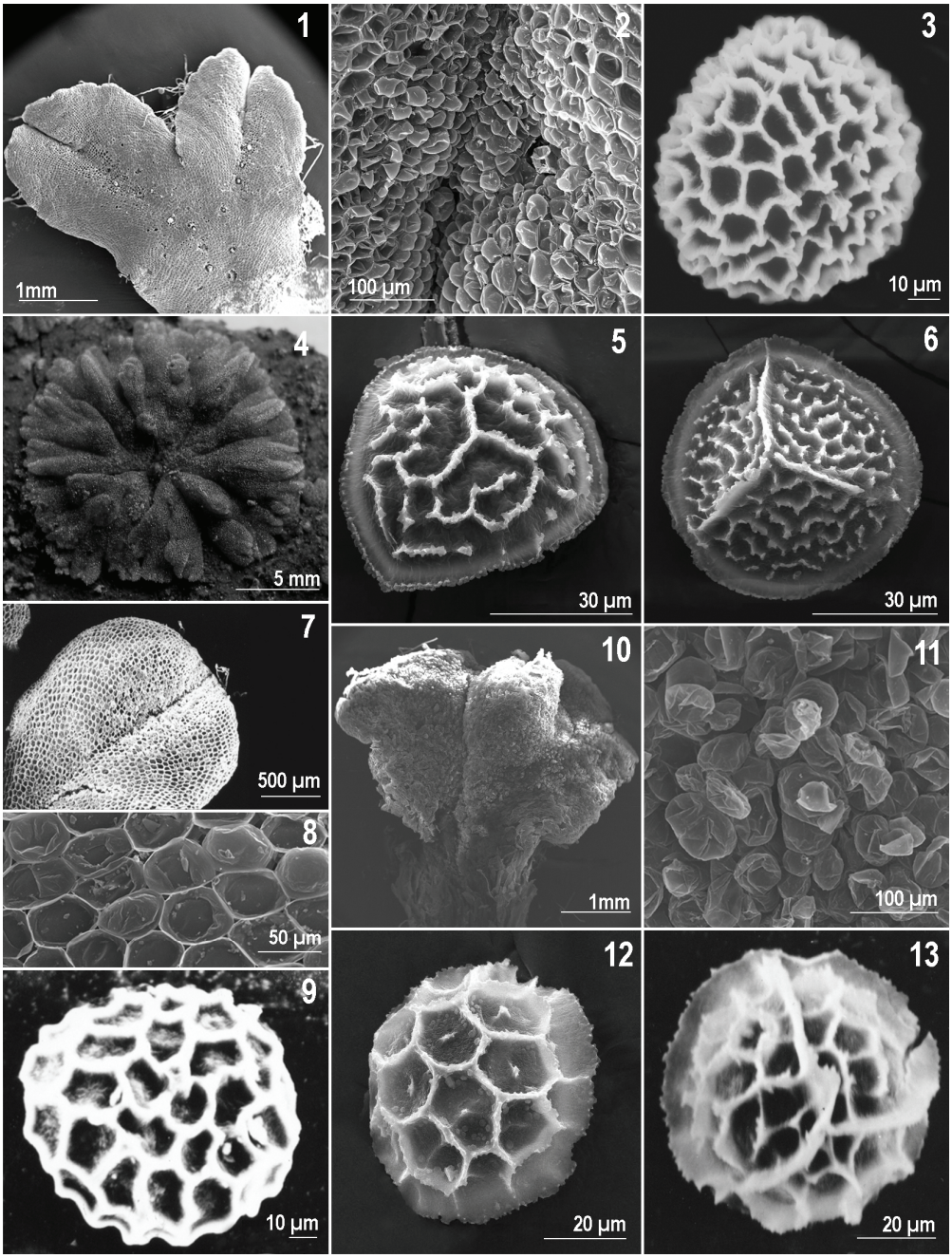


Fig. 1. *Riccia billardieri* Mont. & Nees (1-3): 1: A portion of thallus. 2: Same enlarged showing epidermal cells and sulcus. 3: A spore. *R. cavernosa* Hoffm. emend. Raddi (4-6): 4: Thalli in rosette (under optical microscope). 5: A spore in distal surface. 6: Same in proximal surface. *R. crispatula* Mitt. (7-9): 7: A portion of thalli. 8: A portion of the same enlarged showing epidermal cells. 9: A spore. *R. cruciata* Kashyap (10-13): 10: Thalli. 11: A portion of the same enlarged showing epidermal cells. 12: A spore in distal surface. 13: Same in proximal surface.

reticulations, sometimes free standing or anastomosing, widely spaced or crowded and occasionally with a nearly continuous ridge along periphery at inner side of wing, proximal surface with conspicuous tri-radiate mark, often with granules on each faces, simple or branching and anastomosing ridges which occasionally form complete reticulum; wing broad, up to 6 µm, margin crenate.

Specimen examined: *Terrestrial, growing in moist and exposed places in rosettes, 24 Parganas, Amtala, 07.01.2008,* A.K.Bag *20 (ASSAM).*

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Distribution: INDIA (Western Himalaya: Himachal Pradesh; Eastern Himalaya: West Bengal Hills; Gangetic plains: Uttar Pradesh; Central India: Madhya Pradesh; Punjab & West Rajasthan: Rajasthan), PAKISTAN, RUSSIA, NORTH AMERICA, EUROPE, AUSTRALIA (Udar and Agarwal, 1985; Schuster, 1992; Wigginton et al., 1996; Paton, 1999; MacCarthy, 2003; Bapna, 1958; Udar, 1961 and Srivastava, 1964 as *R. crystallina*; Kashyap, 1916, 1929 as *R. robusta* Kashyap).

Udar and Agarwal (1985) remarked that Jovet-Ast (1964-65) has shown that many previous records of *R. crystallina* (Casares-Gil, 1919; Macvicar, 1926; Zodda, 1934; Frye and Clark, 1937-47; Müller, 1951-54; Schuster, 1953; Hässel de Menéndez, 1958) do not belong to this species but to *R. cavernosa* Hoffm. emend. Raddi. He (Udar and Agarwal *l.c.*) rightly suggested that the Indian plants, earlier described as *R. robusta* Kashyap. (Kashyap, 1916, 1929) and *R. crystallina* L. (Udar, 1961) should also be treated under *R. cavernosa.* The report of *R. crystallina* from other parts of the country (Bapna, 1958; Srivastava 1964) may also belong to *R. cavernosa*. Udar and Agarwal (1985 see also Jovet-Ast, 1964-65) had remarked that the spores in *R. crystallina* and *R. cavernosa* are quite distinctive. In the former the spores have 6-10 complete reticulations across the diameter, the wall of the reticulations at the angles have either bifid or smooth tubercles and wing with pore while spores of the latter have lamellate pattern with tendency to form incomplete reticulations in the centre on distal surface, and wing is devoid of pores. The SEM details of spores of the materials collected from West Bengal (Fig. 1: 5 & 6) also show the irregular arrangement of lamellae and the distinct wing with conspicuous banded structure and crenate margin. The SEM of the spores of *R. crystallina* (Perold, 1989) show distinctly reticulate pattern. This study once again confirms the view of Udar and Agarwal (1985) that the earlier reports of *R. crystallina* from India do not belong to *R. crystallina* in true sense, but resemble to *R. cavernosa.* A comprehensive study of the materials of *R. crystallina* and *R. cavernosa* from different part of the country may lead to interesting conclusions.

3. *Riccia ciliata* Hoffm., Deutschl. Fl. 2 (Cryptog.): 95. "1795" 1796.

Distribution: INDIA (Western Himalaya: Himachal Pradesh; Eastern Himalaya: West Bengal-hills/ plains, Sikkim), EUROPE (Kachroo et al., 1977).

4. *Riccia crispatula* Mitt. in J. Proc. Linn. Soc., Bot. 5: 127. 1861. Fig. 1: 7-9

Dioecious. Plants dark green with brownish margin, dichotomously branched, 1-2 furcate; thalli oblong-obovate, 12-15 mm long, 2-3 mm broad; sulcus prominent to the base of the thallus, margin entire-slightly undulate; ventral surface with deep purple, semilunate scales along the margin; epidermal cells globose or oval 41-58 x 34-47 μm (when globose 34-45 μm); in cross section thallus differentiated into upper compact photosynthetic zone with slit-like pores and lower compact, parenchymatous, multilayered storage zone (Euriccia-type).

Capsules prominent on the ventral surface, arranged in 1-2 rows; spores dark brown, globose to subglobose, 82.9-92.4 x 73.5-85.3 μm, isopolar, with 4-5 rounded pentagonal to hexagonal reticulations across diam., partition walls of reticulum smooth, sometimes with sinuate protuberances at the corners; wing inconspicuous, margin slightly attenuated.

Specimen examined: Terrestrial, growing on rock soil, in large patches, caespitose Darjeeling, Bejanbari, 20.10.2005, *A.K.Bag* 13 (CAL).

Distribution: INDIA (Eastern Himalaya: West Bengal-hills; Gangetic plains: Orissa), SRI LANKA (Mitten, 1861; Pande and Udar, 1957; Srivastava, 1964; Parihar et al., 1994, Bag et al., 2007).

5. *Riccia cruciata* Kashyap in J. Bombay Nat. Hist. Soc. 24: 349. 1916. Fig. 1: 10-12

Monoecious. Plants yellowish green, dichotomously branched, 1-2 furcate; thalli spongy, obovate, cruciate, 6-8 mm long, 5-6 mm broad; sulcus prominent towards apex; ventral surface with inconspicuous scales; epidermal cells globose, 48-56 μm in diam.; in cross section thallus differentiated into upper photosynthetic zone with large air chambers and pores and lower compact, parenchymatous storage zone (Ricciella-type).

Capsules prominent on the ventral surface in 1-2 row; spores golden brown, globose-triangular, 59.3-71.1 x 54.5-63.9 μm, anisopolar, ornamentation reticulate on both spore surfaces but somewhat different, distal surface with 4-5 reticulations across diam., some with low papilla in middle, partition wall of the reticulum crenulate or with minute puncti, proximal surface with thin armed triradiate mark, each face with 7-12 angular reticuations; wing 7.1-9.5 μm wide, margin slightly undulated-crenate.

Specimen examined: Terrestrial, growing on exposed moist soil, in rosettes, Darjeeling, Bhutia basti, 25.10.2005, *A.K.Bag* 14 (CAL).

Distribution: INDIA (Western Himalaya: Uttarakhand; Eastern Himalaya: West Bengal-Hills; Gangetic plains: Uttar Pradesh; Punjab & West Rajasthan: Punjab, Rajasthan; Western Ghats: Maharashtra, Kerala), PAKISTAN (Kashyap, 1916, 1929; Kachroo and Bapna, 1963; Srivastava, 1964; Kachroo et al., 1977; Bapna and Kachroo, 2000; Bag et al., 2007; Singh and Singh, 2007).

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6. *Riccia discolor* Lehm. & Lindenb. in Lehm., Nov. Stirp. Pug. 4: 1. 1832. Fig. 2: 1-3

Dioecious. Plants bluish green, dichotomously branched, 1-3 furcate; thalli 5 – 9 mm long, 1.5-2 mm broad, linear-obovate or oblong; sulcus narrow prominent at apex, margin undulate; ventral surface purple with semilunate scales bent over the margins; epidermal cells globose 28-35 µm in diam.; in cross section thallus differentiated into upper compact photosynthetic zone with slit like pores and lower compact parenchymatous, multilayered storage zone (Euriccia-type).

Capsules prominent on the ventral surface, arranged in 1 row; spores golden brown to blackish, globose, 88-100 µm, isopolar, with 7-9 reticulations across the diam., partition wall low sometimes reticulum depressed in the centre and swollen at the point of joining, surface of partition wall and reticulum smooth to somewhat vermiculate; wing inconspicuous, margin smooth undulated.

Specimen examined: *Terrestrial, growing on exposed moist soil,* overlapping in large patches, *Darjeeling, 08.11.2006, A.K.Bag 17.*

Distribution: INDIA (Western Himalaya: Uttarakhand; Eastern Himalaya: West Bengal-hills, Assam, Meghalaya; Punjab & West Rajasthan: Rajasthan; Central India: Madhya Pradesh; Gangetic Plains: Uttar Pradesh; Western Ghats: Karnataka), PAKISTAN, NEPAL, SRI LANKA, MYANMAR, AFRICA. (Pande and Udar, 1957; Srivastava, 1964; Kachroo et al., 1977; Wigginton, 2004).

7. *Riccia frostii* Austin in Bull. Torrey Bot. Club 6: 17. 1875.

Distribution: INDIA (Western Himalaya: Jammu & Kashmir, Uttarakhand; Eastern Himalaya: Assam, Sikkim, Manipur; Gangetic plains: U.P., West Bengal; Punjab & West Rajasthan: Rajasthan; Western Ghats: Tamil Nadu, Kerala), BANGLADESH, PAKISTAN, CHINA, AFRICA, EUROPE, N. & S. AMERICA. (Srivastava, 1964; Kachroo et al., 1977; Piippo, 1990; Schuster, 1992; Singh and Singh 2007).

8. *Riccia gangetica* Ahmad in Curr. Sci. 11: 433. 1942. Fig. 2: 4-8

Monoecious. Plants deep green, dichotomously branched, 1-2 furcate; thalli oblong to oblong-obovate, 8-11 mm long, 2-3 mm broad; sulcus prominent almost up to the base; ventral surface with small, purple, semilunate scales along the margin; epidermal cells globose to subglobse, 44-68 x 39-56 µm; in cross section thallus differentiated into upper compact photosynthetic zone with slit like pores and lower compact parenchymatous, multilayered storage zone (Euriccia-type).

Capsules prominent on the ventral surface, in 1-2 rows; spores light brown – blackish brown, globose to subglobose, 85.3-97.2 x 75.8-87.7 µm, anisopolar, distal surface with 7-10 reticulations across the diam., partition walls with prominent granules scattered throughout, proximal surface with similar ornamentations and triradiate mark; wing 7.1-10.5 µm wide, margin entire or slightly undulate to crenate.

Specimen examined: Terrestrial, growing on moist garden bed, Howrah, 20.10.2003, *A.K.Bag* 01 (CAL).

Distribution: INDIA (Western Himalaya: Himachal Pradesh, Uttarakhand; Eastern Himalaya: Meghalaya; Punjab & West Rajasthan: Rajasthan; Gangetic plains: Uttar Pradesh, West Bengal-plains; Central India: Madhya Pradesh; Western Ghats: Maharashtra, Tamil Nadu), INDONESIA (Ahmad, 1942; Udar, 1957; Kachroo et al., 1977; Srivastava, 1964; Bapna and Kachroo, 2000; Bag et al., 2007).

9. *Riccia huebeneriana* Lindenb. in Nova Acta Phys.-Med. Acad. Caes. Leop. -Carol. Nat. Cur. 18: 504. 1836. Fig. 2: 9-12

Monoecious. Plants light green, forming semi rosettes, dichotomously branched, 2-3 furcate; thalli narrow, linear, ribbon-shaped, 8-10 mm long, about 1mm broad; sulcus shallow towards apex; ventral surface with inconspicuous scales; epidermal cells elongated pentagonal to hexagonal, 52-116 x 25-41 µm; in cross section thallus differentiated into upper photosynthetic zone with large air chambers and pores and lower compact, parenchymatous, highly reduced storage zone (Ricciella-type).

Capsules prominent on the ventral surface, arranged in single row; spores golden yellow, subglobose to triangular, 61.6-82.9 x 54.5-75.8 µm, anisopolar, distal surface with 6-8 reticulations across diam., partition wall of reticulum crenate to granulated, few of them with tendency to form sub reticulation within the reticulum, proximal surface with incomplete reticulations and prominent triradiate mark; wing 4.7-9.5 µm, margin entire-crenate.

Specimen examined: Terrestrial, growing on cultivated land, Darjeeling, Rimbik, 17.10.2005, *A.K.Bag* 11 (CAL).

Distribution: INDIA (Eastern Himalaya: Sikkim, West Bengal-hills, Assam; Central India: Madhya Pradesh; Western Ghats: Karnataka), CHINA, JAPAN, KOREA, EUROPE, AFRICA, NORTH AMERICA (Udar, 1956; Kachroo and Bapna, 1963; Srivastava, 1964; Piippo, 1990; Schuster, 1992; Yamada and Choe, 1997; Bapna and Kachroo, 2000; Grolle and Long, 2000; Yamada and Iwatsuki, 2006; Bag et al., 2007).

10. *Riccia melanospora* Kashyap, Lierw. W. Himal. 1: 94. 1929. Fig. 3: 1-4

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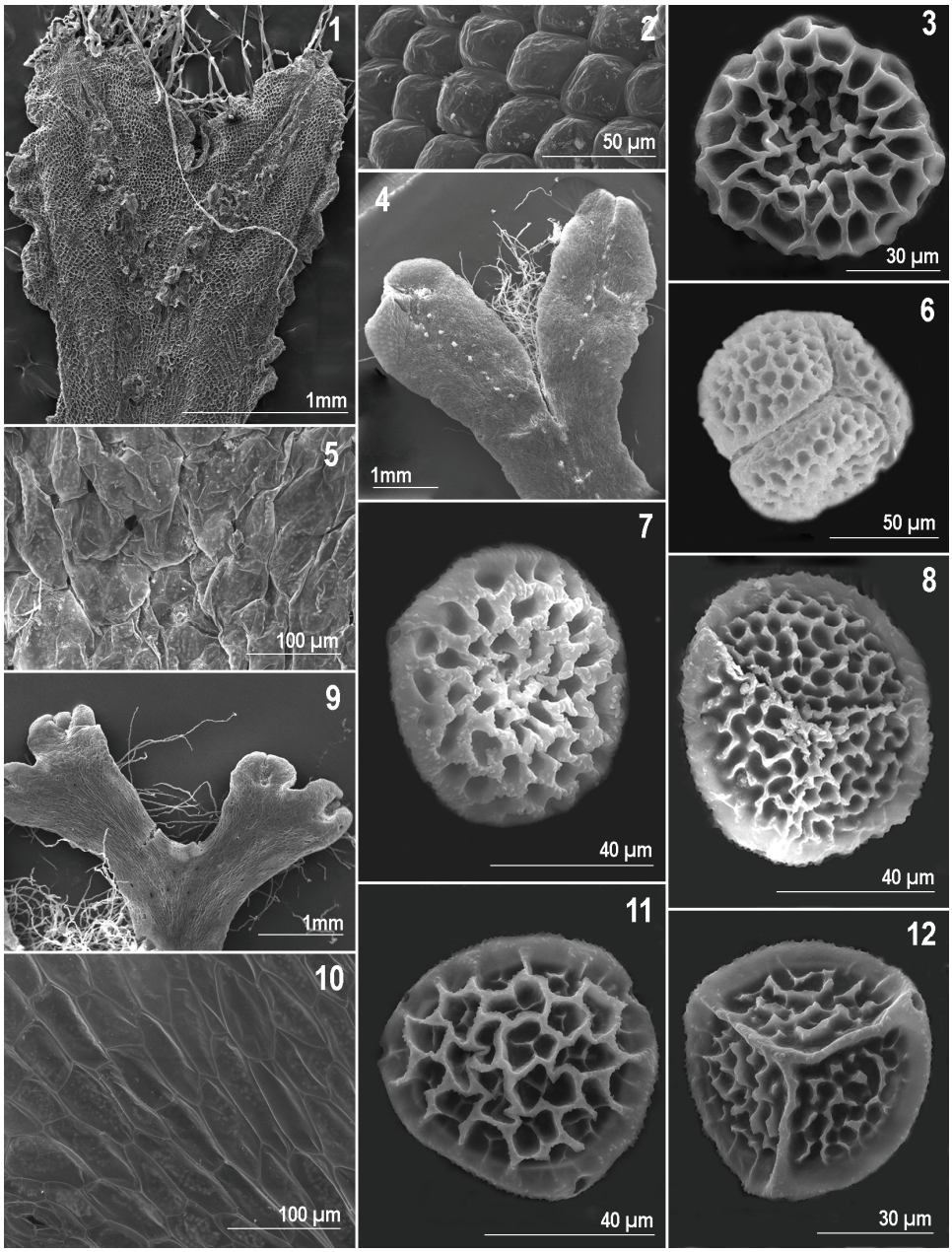


Fig. 2. *Riccia discolor* Lehm. & Lindenb. (1-3): 1: A portion of thallus. 2: A portion of same enlarged showing epidermal cells. 3: A spore. *R. gangetica* Ahmad (4-8): 4: A portion of thallus. 5: A portion of the same enlarged showing epidermal cells. 6: Spore tetrad. 7: A spore in distal surface. 8: Same in proximal surface. *R. huebeneriana* Lindenb. (9-12): 9: A portion of thallus. 10: A portion of same enlarged showing epidermal cells. 11: A spore in distal surface. 12: Same in proximal surface.

Monoecious. Plants bluish green, simple or dichotomously branched; thalli oblong-obovate, up to 4 mm long, 1.5-2 mm. broad; sulcus prominent towards apex, broad shallow or slightly concave towards base; ventral surface projecting prominently with large, deep purple scales; margin entire to slightly undulate with inconspicuous cilia; epidermal cells globose-subglobose or oval, 28-35 x 18-26 µm; in cross section thallus differentiated into upper compact photosynthetic zone with slit like pores and lower compact parenchymatous, multilayered storage zone (Euriccia-type).

Capsules embedded in thalli, slightly bulging; spores dark brown, globose to subglobse, 82-95 µm in diam., anisopolar, distal surface with 10-14 reticulations across diam., partition wall with prominent granules and reticulum depressed in the centre, sometime with

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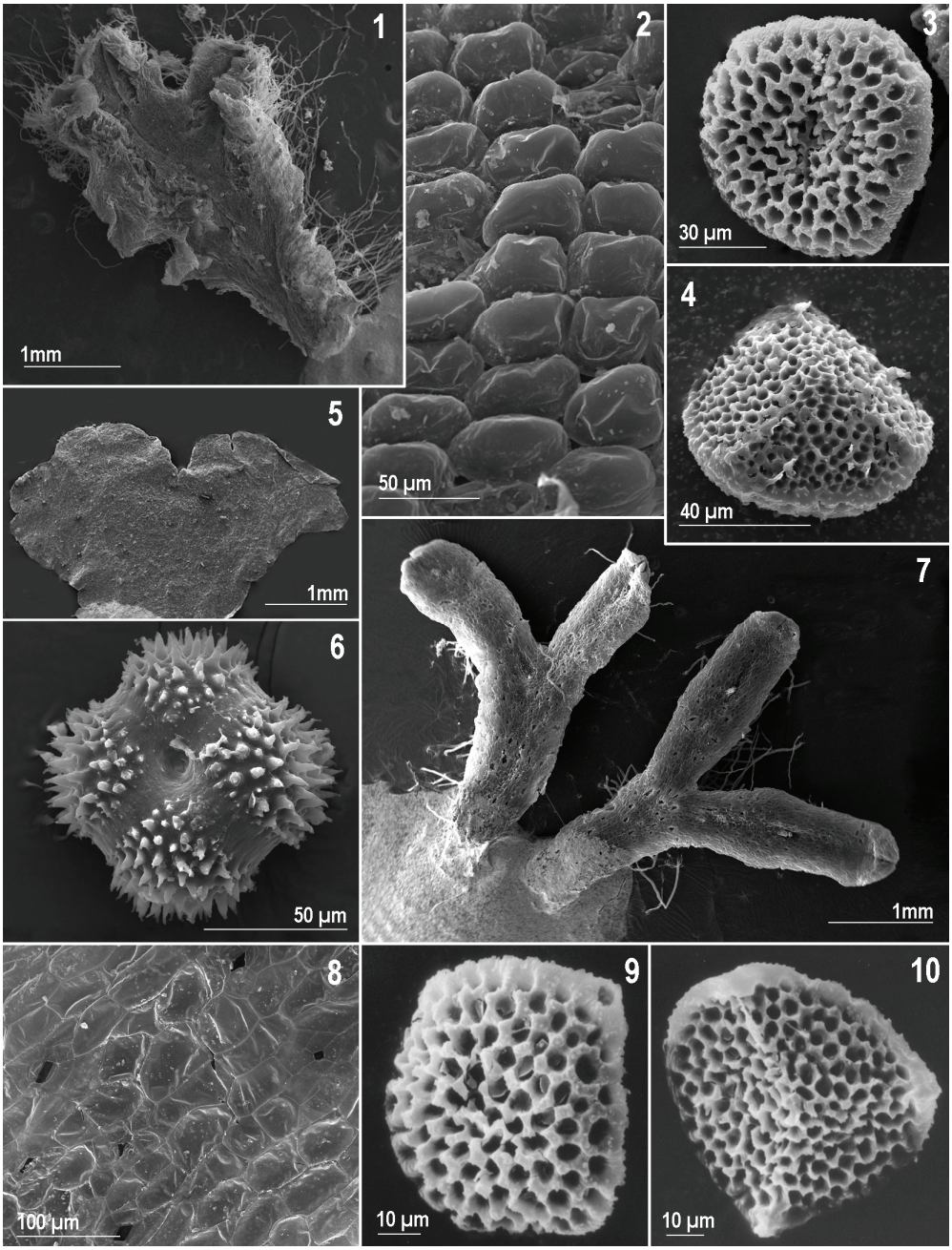


Fig. 3. *Riccia melanospora* Kashyap (1-4): 1: A thallus. 2: A portion of same enlarged showing epidermal cells. 3: A spore in distal surface. 4: Same in proximal surface. *R. perssonii* Sultan Khan (5-6): 5: A portion of thallus. 6: An isobilateral spore tetrad. *R. plana* Taylor (7-10): 7: Thalli. 8: A portion of thalli enlarged showing epidermal cells and pore. 9: A spore in distal surface. 10: Same in proximal surface.

swollen at joining point, proximal surface with tri-radiate mark; wing inconspicuous, margin crenate.

Specimen examined: Terrestrial, growing on exposed places, Birbhum, Santineketan, 06.1.2009, *A.K.Bag* 16 (ASSAM).

Distribution: INDIA (Western Himalaya: Jammu & Kashmir, Uttarakhand; Central India: Madhya Pradesh; Gangetic Plains: U.P.; Punjab & West Rajasthan: Punjab, Rajasthan; Western Ghats: Tamil Nadu) (Kashyap, 1929; Pande and Udar, 1958; Kachroo and Bapna 1963; Srivastava, 1964).

R. melanospora resembles *R. gangetica* in coloration of thalli, size of spores, thallus anatomy and shape of epidermal cells but the latter differ by being non-ciliate, distinctly longer thalli having very prominent sulcus

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extended up to base. *R. melanospora* was earlier reported from Ootacamund, Coimbatore Hoshiarpur, Mt. Abu, Jodhpur, Lucknow, Bhopal, Konsa Nag (Kashyap, 1929; Pande and Udar, 1958; Sivastava, 1964). Kachroo and Bapna (1963) in a review of Indian species of *Riccia* wrongly reported it from Pakistan but this species is probably endemic to our country.

11. *Riccia perssonii* Sultan Khan in Svensk. Bot. Tidskr. 49: 433. 1955. Fig. 3: 5-6

Dioecious. Plants light green, dichotomously branched, small; thalli oblong-obovate, 3-5 mm long, 1-2 mm broad; sulcus visible only at apex; ventral surface without any scales; epidermal cells globose or oval, 61-101 x 61-91 µm; in cross section thallus differentiated into upper photosynthetic zone with large air chambers and pores and lower compact, parenchymatous storage zone (Ricciella-type).

Capsules embedded in thalli, sometimes confluent, arranged in 1-2 rows; spores golden brown, permanently adhered in tetrads, about 88-99 µm in diameter, four spores of tetrad lying in the same plane (isobilateral tetrads), joined together by a broad, usually smooth, sometime granulated band, band which generally with small depression in the centre where four spores join, each surface densely spinous, spines 6-9 µm, broader at base and tapering to narrow tip, straight or bent, sometimes truncate and crowned with granules.

Specimen examined: Terrestrial, in moist sandy places in patches or semirossettes, Hooghly, Nalikul, 22.12.2008, *A.K.Bag* 19 (ASSAM).

Distribution: INDIA (Gangetic Plains: U.P), BANGLADESH, AFRICA (Khan, 1955; Arnell, 1963; Jovet-Ast, 1967, 1975, Perold 1989).

This species was instituted by Khan (1955) from Dhaka, Bangladesh (the then Dakka, East Pakistan). Thereafter it was reported from Africa (Arnell, 1963; Jovet-Ast 1967, 1975; Perold, 1989). In India, it was reported from Gorakhpur U.P. only (Sahai and Sinha, 1972). Occurrence of this species in West Bengal constitutes its second authentic record from India. This rare species shows interesting and unique spores which are permanently adhered in isobilateral type of tetrads and with long spines. This uniqueness easily separates it from other species of the genus known from the country.

12. *Riccia plana* Taylor in London J. Bot. 5: 414. 1846. Fig. 3: 7-10

Monoecious. Plants bright green, dichotomously branched, 3-4 furcate; thalli narrow, linear, ribbon-shaped, 7-10 mm long, about 1 mm wide; sulcus shallow towards apex; ventral surface with inconspicuous scales at margin; epidermal cells globose 27-35 µm or quadrangular or pentagonal to hexagonal, 32-62 x 21-40 µm; in cross section thallus differentiated into upper photosynthetic zone with large air chambers and pores and lower compact, multilayered, parenchymatous storage zone (Ricciella-type).

Capsules prominent on the ventral surface, in 1 row; spores golden brown to black at maturity, subglobose to triangular, 85.3-90.1 x 68.7-85.3 µm anisopolar, distal surface with 10-13 reticulations across diam., wall of reticulum swollen at joining point, often with small granules, proximal surface with similar ornamentation and weakly developed triradiate mark; wing 4.7-9.5 µm wide, margin entire to undulate.

Specimen examined: Terrestrial, growing on moist shady garden bed, in semi rosettes, 24 Parganas, Jaynagar, 31.8.2005, *A.K.Bag* 09 (CAL).

Distribution: INDIA (Punjab & West Rajasthan; Rajasthan; Central India: Madhya Pradesh; Gangetic Plains: West Bengal Plains; Western Ghats: Karnataka), MACRONESIA, AFRICA, AUSTRALIA (Ahmad, 1942 and Udar, 1957 as *Riccia manglorica*; Pande and Udar, 1958; Kachroo and Bapna, 1963; Srivastava, 1964; Bapna and Kachroo, 2000; Bag et al., 2007).

13. *Riccia sorocarpa* Bisch., Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 17: 1053. 1835. Fig. 4: 1-4

Monoecious. Plants glaucous green, dichotomously branched, 2-3 furcate, thalli oblong-ovate, narrowed towards the subacute apex, 5-7 mm long, 1-1.5 mm wide; sulcus very prominent up to the middle; ventral surface with small, colourless scales along margins; epidermal cells oval, 36-52 x 23-38 µm, soon vanishing, subepidermal cells persisting; in cross section thallus differentiated into upper compact photosynthetic zone with slit like pores and lower compact parenchymatous, multilayered storage zone (Euriccia-type).

Capsules prominent on the ventral surface, in 2-3 rows; spores dark brown, sometimes almost black, globose to subglobose, 62-85 x 56-82 µm, anisopolar, distal surface with 8-11 reticulation across diam., walls of reticulum with granules, tubercles, at joining with low wart-like papillae or verrucae, proximal surface with less prominent triradiate mark, each faces with small, shallow depressions incomplete to complete reticulations; wing 4.7-9.5 µm wide, margin crenulate to serrulate.

Specimen examined: Terrestrial, growing on moist places in semi rosettes, Howrah, Ramkrishnapur, 22.03.2007, *A.K.Bag* 18.

Distribution: INDIA (Western Himalaya: Himachal Pradesh, Uttarakhand; Eastern Himalaya: West Bengal-hills), JAPAN, CHINA, AFRICA, EUROPE, NORTH AMERICA. (Srivastava, 1964; Kachroo et al., 1977; Piippo, 1990; Schuster, 1992; Paton, 1999; Singh and Singh, 2007).

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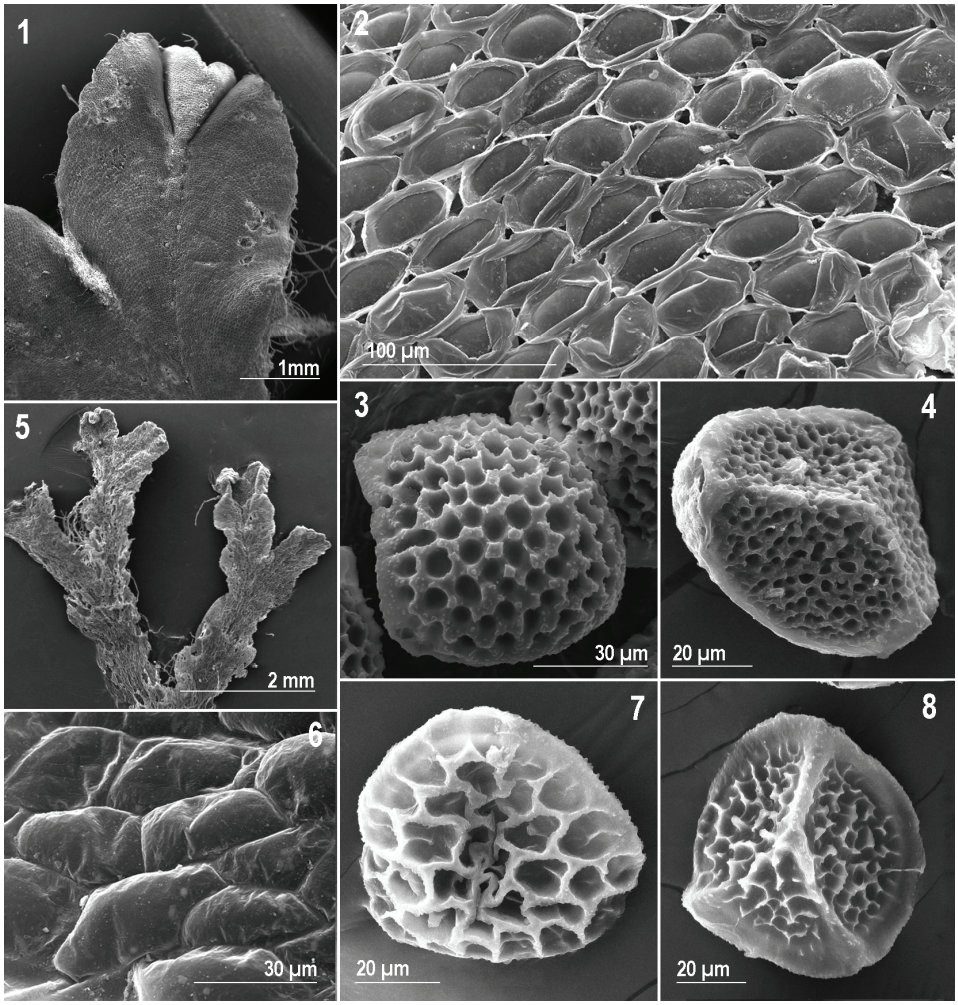


Fig. 4. *Riccia sorocarpa* Bisch. (1-4): 1: A portion of thallus. 2: A portion of same enlarged showing epidermal cells. 3: A spore in distal surface. 4: Same in proximal surface. *R. stricta* (Lindenb.) Perold (5-8): 5: A portion of thallus. 6: A portion of thallus enlarged showing epidermal cells. 7: A spore in distal surface. 8: Same in proximal surface.

14. *Riccia stricta* (Lindenb.) Perold in Bothalia 20: 197. 1990. Fig. 4: 5-8

R. stricta Duthie ex S.Arnell, Hepaticae of South Africa: 37. 1963, *nom. inval.*

Dioecious. Plants light green, spongy, usually 1-4 times branched, thalli narrow, elongated, 5-15 mm long, 1 mm broad; sulcus prominent towards apex only; ventral surface without conspicuous scales; epidermal cells oblong-ovate, pentagonal- hexagonal, 31-46 x 14-25 µm; in cross section thallus differentiated into upper photosynthetic zone with large air chambers and pores and lower compact, highly reduced storage zone (Ricciella-type).

Capsules in 1-2 rows, prominent ventrally; spores brown, globose to subglobose, 51-78 µm, anisopolar, distal surface with 4-6 reticulations across diam., reticulum with secondary finer lamellae radiating either from a central elevated area or extending from the lateral wall of reticulations, proximal surface with prominent tri-radiate mark, each faces with complete or incomplete reticulations; wing up to 7 µm broad, margin crenate.

Specimen examined: Terrestrial, growing on moist exposed places in patches, Darjeeling, Rimbick, 10.10.2005, *A.K.Bag 15*; (ASSAM)

Distribution: INDIA (Central India: Madhya Pradesh; Gangetic Plains: West Bengal- plains; Western Ghats: Tamil Nadu, Kerala), SOUTH AFRICA (Udar and Agarwal, 1985; Arnell, 1963).

Riccia stricta is a very rare species of the genus in India known from Pachmarhi in Central India and Tamil Nadu, Kerala in Western Ghats only (Udar and Agarwal, 1985). Since then, no one reported this species from any other localities of the country. Present report extended its range of distribution within the country from Western Ghats and Central India to Gangetic Plains.

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ACKNOWLEDGEMENTS

The authors are grateful to Dr M. Sanjappa, Director and Dr D.K. Singh, Addl. Director, Botanical Survey of India, Kolkata and Director, Bose Institute, Kolkata for facilities and encouragements. The authors are thankful to Director, GSI, Kolkata, Sri S.C. Maikap, Head, SEM Division, Bose Institute, Kolkata and Head, USIC Dept. Jadavpur University, Kolkata for SEM Facilities. One of us (AKB) is also thankful to Prof. K.K. Mukherjee, Bose Institute, Kolkata for their help in one or other ways.

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印度西孟加省之錢蘚屬 (錢蘚科) 植物

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(收稿日期：2009 年 11 月 17 日；接受日期：2010 年 2 月 9 日)

摘要：印度西孟加省之12種錢蘚屬植物經由掃描電子顯微鏡詳細研究，其中三稀有種為本省新紀錄種包括：*R. melanospora* 、*R. perssonii* 及 *R. stricta*。另外七種孢子之掃描電子顯微鏡圖包括：*R. crispatula* 、*R. cruciata* 、*R. discolor* 、*R. huebeneriana* 、*R. melanospora* 、*R. perssonii* 及 *R. plana* 乃首次由印度之標本呈現。本文藉由光學顯微鏡及掃描電子顯微鏡觀察後，每種都有簡短敘述，並附有掃描電子顯微鏡圖。

關鍵詞：蘚類、錢蘚屬 、西孟加省、印度。

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