Morphotaxonomical studies on bryophytes with special reference to the water pollution of Sai river at Raebareli U.P., India

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In the Gangetic plains of India, the bryophytes commonly grow on the river banks specially in their catchment areas. Two bryophytes: *Riccia frostii* Aust. (Liverwort) and *Physcomitrium japonicum* (Hedw.) Mitt. (Moss) collected from bank of Sai river at four selected sites (Lohanipur, Dariyapur, Jagdishpur and Behta Picnic Spot) at Raebareli district have been undertaken for morphotaxonomical and pollution studies. The present work has been carried out to find the effect of polluted water on some selected bryophytes as well as their distribution pattern, morphological and anatomical characteristics.

Key-words – Bryophytes, Raebareli, Sai River, Water Pollution.

INTRODUCTION

BRYOPHYTES are highly suited for the studies of pollution because they are simplest, green land plants. The bryophytes growing on river banks (catchment area) are directly affected by the water quality. Burton and Peterson (1979) collected *Pellia endivifolia,* from the polluted sites of river Ystuagh. Sinha *et al.* (1990) reported five moss species, viz., *Trematodon capillifolius* C. Muell. Ex. Roth, *Physcomitrium indicum* (Dix. Gangulee, *Physcomitrium japonicum*) (Hedw.) Mitt., *Hydrogonium consomguineum* (Thw. et Mitt.) Hilp., and *Fissidens curvato-involutus* Dix from banks of Ganga river between Unnao and Pratapgarh. Chopra and Vashistha (1993) collected *R. frostii* from the banks of Yamuna at Delhi for their experimental studies. Pandey *et al.* (1995), who initiated a survey of bryophytes along the Ganga river between Shuklaganj and Kalakankar, reported two liverworts (*Riccia frostii* and *Riccia gangetica*) and six moss species affected by the water quality.

A perusal of the literature reveals that the banks of Sai river have not been studied with regard to the bryoflora growing on its banks. The pollutants ultimately settle down and disturb the normal concentration of riverbeds and its catchment areas. Activity naturally affects the bryoflora harbouring in these habitats. Hence, the present studies on two bryophytes: *Riccia frostii* and *Physcomitrium japonicum* growing on bank (River bed) of Sai river at Raebareli city between Lohanipur to Behta Picnic Spot with special reference to their distribution pattern, morphology, anatomy and the effect of water quality on these plants are studied for the first time.

MATERIAL AND METHOD

The bryophytes (*R. frostii* and *P. japonicum*) were collected from catchment area and upland region of Sai river (The upland region of the Sai river is considered as non-polluted area and act as control) at Lohanipur, Dariyapur, Jagdishpur and Behta Picnic Spot, scrapped and brought to the laboratory in bags, washed carefully, dried in air and kept in brown paper envelope. For morpho-anatomical studies, material was dissected and observed under binocular microscope. Camera lucida drawings were made under compound microscope. Plants were identified with the help of literature. The specimens have been deposited in Environmental Research Centre (ERC), Feroze Gandhi College, Raebareli.

Specimens examined

ERC-14/2000; Loc.-Lohanipur (non-polluted habitat) Date-July 2000. ERC-22/2000; Loc.-Dariyapur (non-polluted habitat) Date-July 2000. ERC-23/2000; Loc.-Jagdishpur (Non polluted habitate), Date-July 2000. ERC-25/2000; Loc-Behta Picnic spot (non-polluted habitat), Date-July 2000. ERC-73/200; Loc.-Lohanipur (polluted habitat) Date-Feb. 2001. ERC-74/2001. Loc.-Dariyapur (polluted habitate) Date-Feb. 2001. ERC. 75/2001; Loc.-Jagdishpur (polluted habitat), Date-Feb. 2001 ERC-76/2001; Loc.-Behta Picnic spot (polluted habitat), Date Feb. 2001. Leg. Meenakshi Singh. Det. Adarsh Kumar and Meenakshi Singh.

OBSERVATION

Distribution pattern

The distribution of *R. frostii* and *P. japonicum* at selected sites of Sai river during July, 2000 to Jun, 2001 have been recorded in Table 1 which clearly indicates that both the species were absent in rainy season (July to September, 2000). In the month of December the bryophytes begin to appear at all selected sites. Both the species abundantly grow at Lohanipur and Behta Picnic Spot and frequently to rarely at Dariyapur and Jagdishpur in the month of January and February 2001. In the month of March, both bryophytes were frequently growing at Lohanipur, Dariyapur and Behta Picnic Spot but rarely at Jagdishpur. Only *P. japonicum* was rarely present at all selected sites in the month of April whereas *R. frostii* was found absent in this month. In the month of October, November, May and June both plants were found absent but in the last week of June when monsoon begins they appear again. It was also observed that the winter season was best for the growth of *R. frostii* and *P. japonicum* and it was also noticed that *Riccia frostii* (live wort) was most sensitive to polluted water than *Physcomitrium japonicum* (moss).

Morphotaxonomical Studies

Morphotaxonomic description of *Riccia frostii* and *Physcomitrium japonicum* collected from different habitat (Non-polluted and polluted) of Sai river, have been described below:

Liverwort

Riccia frostii Aust. Bull. Torrey Bot. Cl. **6**; Cl. 6; 17(1875).

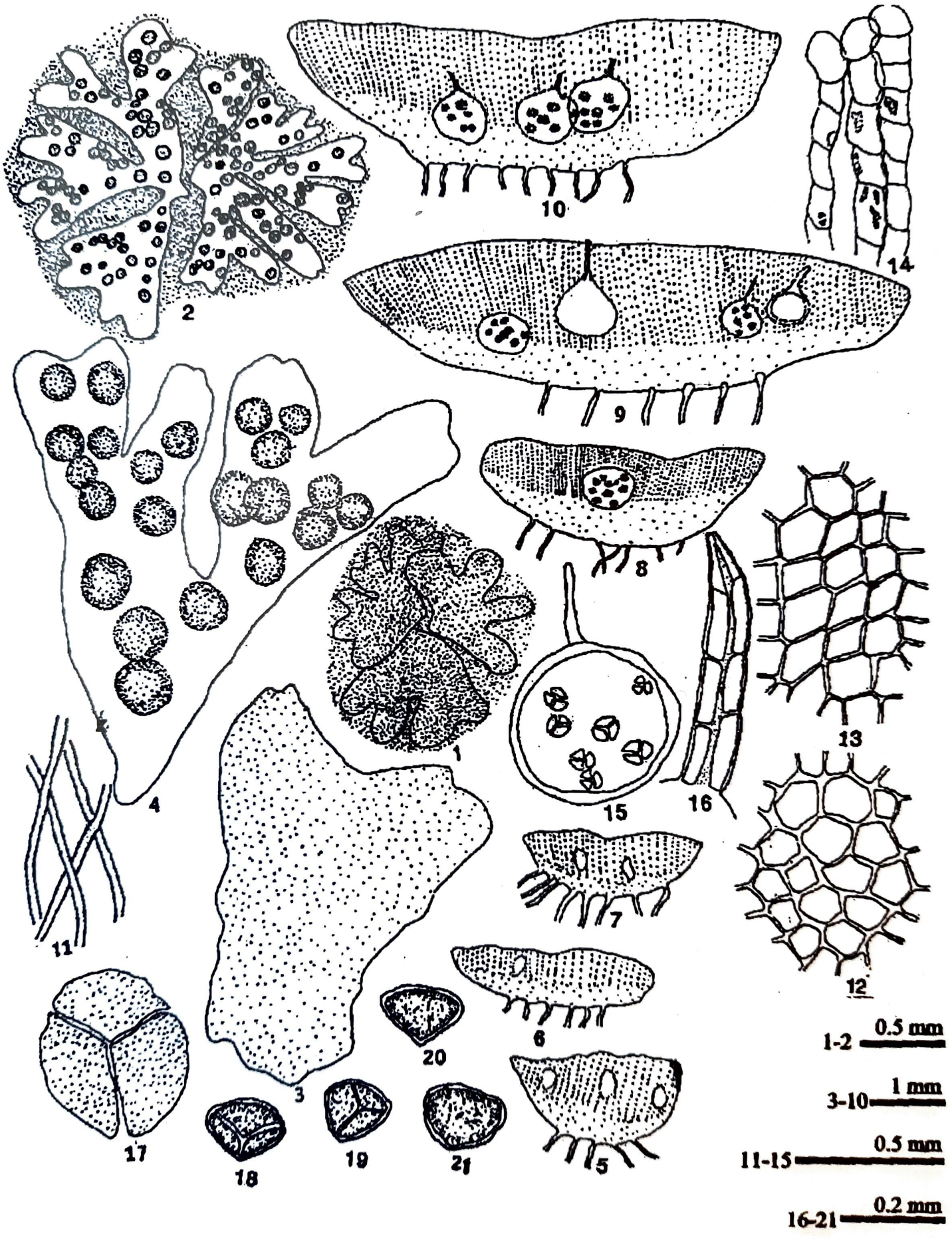
Riccia sanguinea Kash. Jour. Born, Nat. Hist. Soc. Vol. XXIV p. 32. **19** (1916)

Dioecious, growing in perfect rosettes, rarely overlapped, male rosettes pinkish sometimes only centre portion was pink (polluted habitat) (Pl. 2, Fig. 1). The male rosettes up to 7 to 10 mm in diameter (non polluted habitat) (Pl. 1, Fig. 1), 4 to 6 mm in diameter (polluted habitat) (Pl. 2, Fig.1). Female rosettes 21 to 25mm in diameter, (non-polluted habitat) (Pl. 2, Fig. 2) and 7 to 11 mm in diameter (polluted habitat) (Pl. 2, Fig. 2) . The thalli dark green and larger up to 6.65 to 7.2 mm long and 2-2.25 mm broad (non-polluted habitat) (Pl. 1, Fig. 4) and 3.9-4.25 mm long and 1.5-2.75 mm broad (polluted habitat) (Pl. 2, Fig. 4). The thalli are simple, forked, farming 2-3 lobes, spongy, without scales, without dorsal grooves, rhizoids only smooth walled (Pl. 1, Fig. 11), tuberculate rhizoids absent in all collected specimens. The male thalli up to 4.25-4.50 mm long and 2.5-2.6 mm broad (non-polluted habitat) (Pl. 1, Fig. 3) and 2.5-3.0 mm long and 1.4-1.5 mm broad, (polluted habitat) (Pl. 2, Fig. 3) of Sai river. Male thallus at Jagdishpur (a highly polluted site, WQI =

PLATE 1 →

Riccia frostii Aust. 1. A mature male rosette*. 2. Female rosette with sporophyte*. 3-4. Male and female thallus.* 5-7. Cross-section of male thallus: at base, in middle and at the apex*. 8-10. Cross-section of female thallus through base, middle and at apex showing young capsule. 11. Rhizoids. 12. Cells of storage zone (Male thallus)*. 13. Cells of storage zone (Femlae thallus)*. 14. Cross-section of thallus showing assimilatory filaments and epidermis*. 15. A young sporophyte*. 16. The archegonial neck*. 17. Spore tetrads*. 18-21. Spores inner and outer faces*. 19-20. Spores inner and outer faces#.

Note: *Non-polluted habitat, #Polluted habitat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20
21
1-2 0.5 mm
3-10 1 mm
11-15 0.5 mm
16-21 0.2 mm

Table 1. Distribution pattern of *R. frostii and P. japonicum* at selected sites of River Sai at Raebareli district.

Months	Lohanipur		Dariyapur		Jagdishpur		Behta Picnic spot	
	R. frostii	*P. japonicum*	*R. frostii*	*P. japonicum*	*R. frostii*	*P. japonicum*	*R. frostii*	*P. japonicum*
Jul.	-	-	-	-	-	-	-	-
Aug.	-	-	-	-	-	-	-	-
Sep.	-	-	-	-	-	-	-	-
Oct.	-	-	-	-	-	-	-	-
Nov.	-	-	-	-	-	-	-	-
Dec.	++	++	+	++	+	+	+	++
Jan.	+++	+++	++	++	+	++	+++	++
Feb.	+++	+++	++	++	+	+		
Mar.	++	++	++	++	+	+	++	++
Apr.	-	+	-	+	-	+	-	+
May	-	-	-	-	-	-	-	-
Jun.	-	-	-	-	-	-	-	-

Note : (+++) Abundant, (++) Frequent, (+) Rare, (-) Absent

216.56-1582.46) with ruptured epidermis (Pl. 2, Fig. 7). Cross-section of male thalli 2.5-2.6 mm broad at apex (non-polluted habitat) and 2.2-2.3 mm (polluted-habitat), in he middle 2.75-2.85 mm broad 2.35-2.40 mm (non-polluted habitat) and 2.1-2.2 mm in broad (polluted habitat) respectively. Thallus in cross-section usually 4-5 times broader than the length.

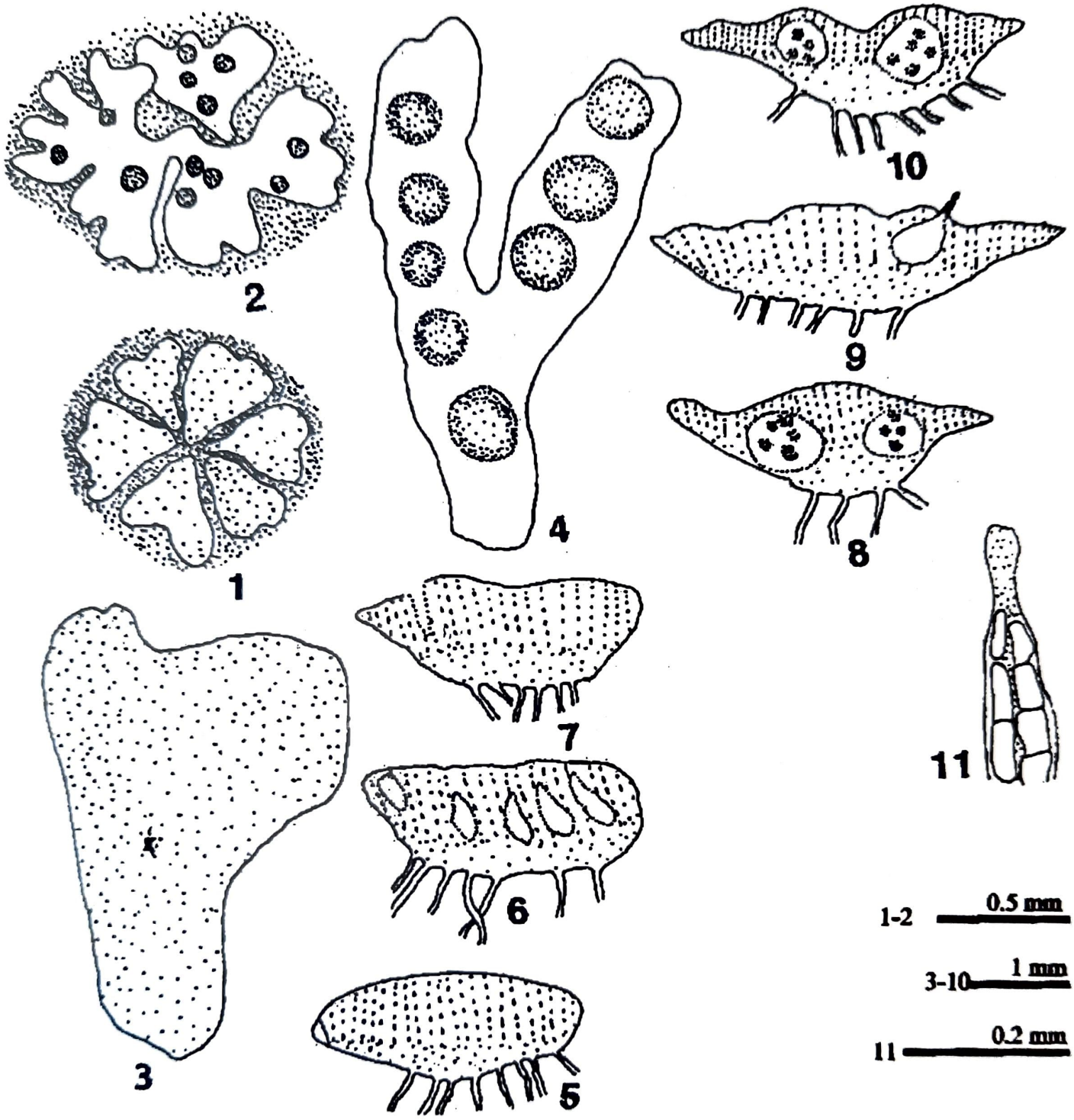
The cross-section of female thalli through apex 6.3-6.5 mm broad (non-polluted habitat) (Pl. 1, Fig. 10) and 2.5-2.7 mm broad (polluted habitat) (Pl. 2, Fig. 10), in the middle 12.5-13.6 mm broad (non-polluted habitat) (Pl. 1, Fig. 9) and 3.0-3.3 mm broad (poluted habitat) (Pl. 1, Fig. 8) and 2.5-2.5 mm broad (polluted habitat) (Pl. 2, Fig. 2) and at the base 3.54-3.75 mm broad (non-polluted habitat) (Pl. 1, Fig. 8). In male thallus cells of storage region were quadrate to pentagonal, whereas in female thallus were hexagonal (Pl. 1, Figs. 12 - 13). Assimilatory zone compact, epidermal cells rounded to oval and hyaline (Pl. 1, Fig. 14).

The archegonia neck long, 0.32-0.34 mm (non polluted habitat) (Pl. 1, Fig. 16) and 0.2-0.25 mm (polluted habitat) (Pl. 2, Fig. 11). Saprophyte prominent, dorsal, numerous in several 12 to 23 in non polluted samples (Pl. 1, Fig. 2) and 3 to 9 in polluted samples in each thallus (Pl. 2, Fig. 2), the sporophyte 0.58 to 0.6 mm in diameter (Pl. 1, Fig. 15). Spore adherent 0.21-0.22 mm in diameter (Pl. 1, Fig. 17). Spores were brown and 90-104 μm at polluted habitat and 100-110 μm in diameter at non-polluted habitat. Outer face with irregular and in complete reticulation and inner faces similarly reticulate with prominent tri-radiate mark (Pl. 1, Figs. 18-21.).

PLATE 2 →

Riccia frostii Aust : 1. Male rosette#. 2. Mature female rosette#. 3-4. Male and female thallus#. 5-7. Cross-section of male thallus at the base, in the middle and at the apex respectively#. 7. Thallus showing ruptured epidermis. 8-10. Cross-section of female thallus at the base, in middle and at apex#. 11. Archegonial nek#.

Note# Polluted habitat.


2
4
10
9
1
8
7
11
6
3
5
1-2 0.5 mm
3-10 1 mm
11 0.2 mm

Moss

Physcomitrium japonicum (Hedw.) Mitt., Trans, Linn. Soc. Bot. London. Ser. 2,3 : 164 (1981). *Gymnostomum,* 1801.

Plant dioecious, green, about 8.75-9.25 mm long (non-polluted habitat) (Pl. 3, Fig. 1) and 5.5-5.6 mm (Polluted habitat) (Pl. 3, Fig. 2-3), gametophyte up to 1.0-1.25 mm (non-polluted habitat) and 0.75-0.8 mm (polluted habitat), rhizoids branched, dense, separate, orange brown in colour up to 0.04-0.06 mm in diameter, stem very short, covered with leaves, 69-70 mm in diameter usually 9 cells across (Pl. 3, Fig, 4, 5).

Leaves arising from base of stem in whorl of 7-9 (non-polluted habitat) and 4-6 (polluted habitat). Apical leaves much longer, 3.66 to 3.70 mm (non-polluted habitat) (Pl. 2, Fig. 8) and 2.0 to 2.3 mm (polluted habitat) (Pl. 3, Fig. 9), basal leaves 2.2-2.3 (non-polluted habitat) (Pl. 3, Fig. 6) and 1.15-1.17 mm (polluted habitat) (Pl. 3, Fig. 7). The leaves lanceolate, acute to acuminate, margin serrulate above, laminal cells elongated, irregularly pentagonal to rectangular, some times hexagonal. Marginal cells up to 0.12-0.20 x 0.03 mm (Pl. 3, Fig. 13), apical 0.06-0.09 x 0.03-0.04 mm (Pl. 3, Fig. 12), middle 0.07-0.12 x 0.03-0.05 mm (Pl. 3, Fig. 11) and basal 0.08-0.12 x 0.03-0.036 mm (Pl. 3, Fig. 10).

Archegonia red brown, about 2-3 in number, 0.64 to 0.68 mm long. Venter 0.10 mm in diameter, above portion of neck slightly curvd (Pl. 4, Fig. 1). Sporophyte 7.6-8.25 (non-polluted habitat) (Pl. 3, Fig. 1) and 4.0-4.25 mm (polluted habitat) (Pl. 3, Fig. 2-3) long. Seta erect, slender and up to 0.60 mm (non -polluted habitat) (Pl. 3, Fig. 15) and 0.45 mm (polluted habitat) (Pl. 3, Fig. 15) in diameter. Seta usually 10 to 11 cells across, capsule 2.0-2.1 mm (non-polluted habitat) and 1.4-1.44 mm (polluted habitat) long and 1.8-1.86 mm (non-polluted habitat) and 1.2-1.3 mm (polluted habitat) in diameter. The cells of capsule were quadrate to pentagonal (Pl. 4, Fig. 8). Calyptra mitreform, up to 2.2-2.3 mm (non-polluted habitat) and 1.64-1.66 mm (polluted habitat) (Pl. 4, Figs. 2 & 3) long, operculum conical up to 1.16-1.18mm (non-polluted habitat) and 1.0-1.2 mm (polluted habitat) in diameter (Pl. 4, Figs. 6-7). Peristome teeth absent, spores 80-90 μm (non-polluted habitat) and 30-50 μm (polluted habitat) in diameter, round, red brown (non-polluted habitat) and orange brown (polluted habitat), spinose-papillose (Pl. 4, Figs. 9-13).

DISCUSSION

The distribution of selected bryophytes varied with degree of pollution of Sai river. The maximum growth of *R. frostii* and *P. japonicum* was recorded from Lohanipur, Dariyapur and Behta Picnic Spot as compared to Jagdishpur (Table 1). It is mainly due to the water quality of river Sai. At Jagdishpur site the water quality index was recorded 216.59-582.46 whereas at Lohanipur 144.05-343.95, Dariyapur 159.67-429.79 and Behta Picnic Spot 166.77-311.25 respectively (Kumar & Shukla 2002). Similar observations were made by Pandey (1992), who reported maximum number of bryophytes on river bank of Ganga at least polluted site-Arkha while minimum bryophytes from Jajmau and Jajmau Pumping station (Kanpur) most polluted sites.

R. frostii and P. japonicum were absent in months of July to September because in these months, the bryophytes swept away along with the upper layer of soil due to heavy rains. In the months of October-November, 2000 and May-June, 2001, plants were also absent mainly due to high temperature (32-48^{0}C), lack of soil water and environmental humidity.

PLATE 3 →

Physcomitrium japonicum (Hedw.) Mitt.: 1. Plant with sporophyte*. 2-3 Plant with sporophyte#. 4. Rhizoids*, 5. T.S. of Stem*. 6. A basal leaf*. 7. A basal leaf#. 8. A apical leaf*. 9. A apical leaf#. 10-13. The cells of leaf, basal. middle, apex and marginal*. 14. T.S. of Seta*. 15. T.S. of Seta#. 16. A mature capsule*. 17. Calyptra*.

Note : * Non-polluted habitat, # Polluted habitat

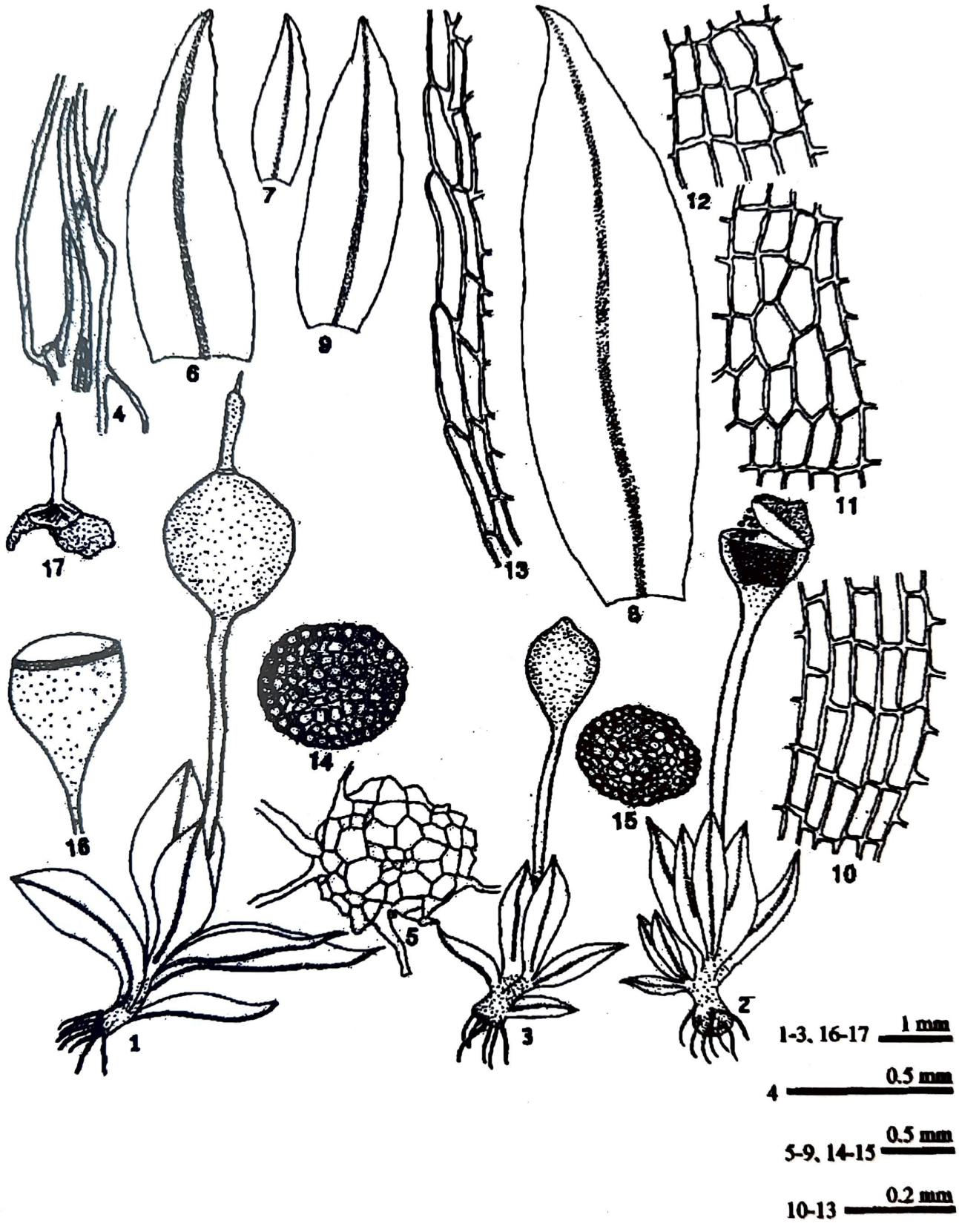
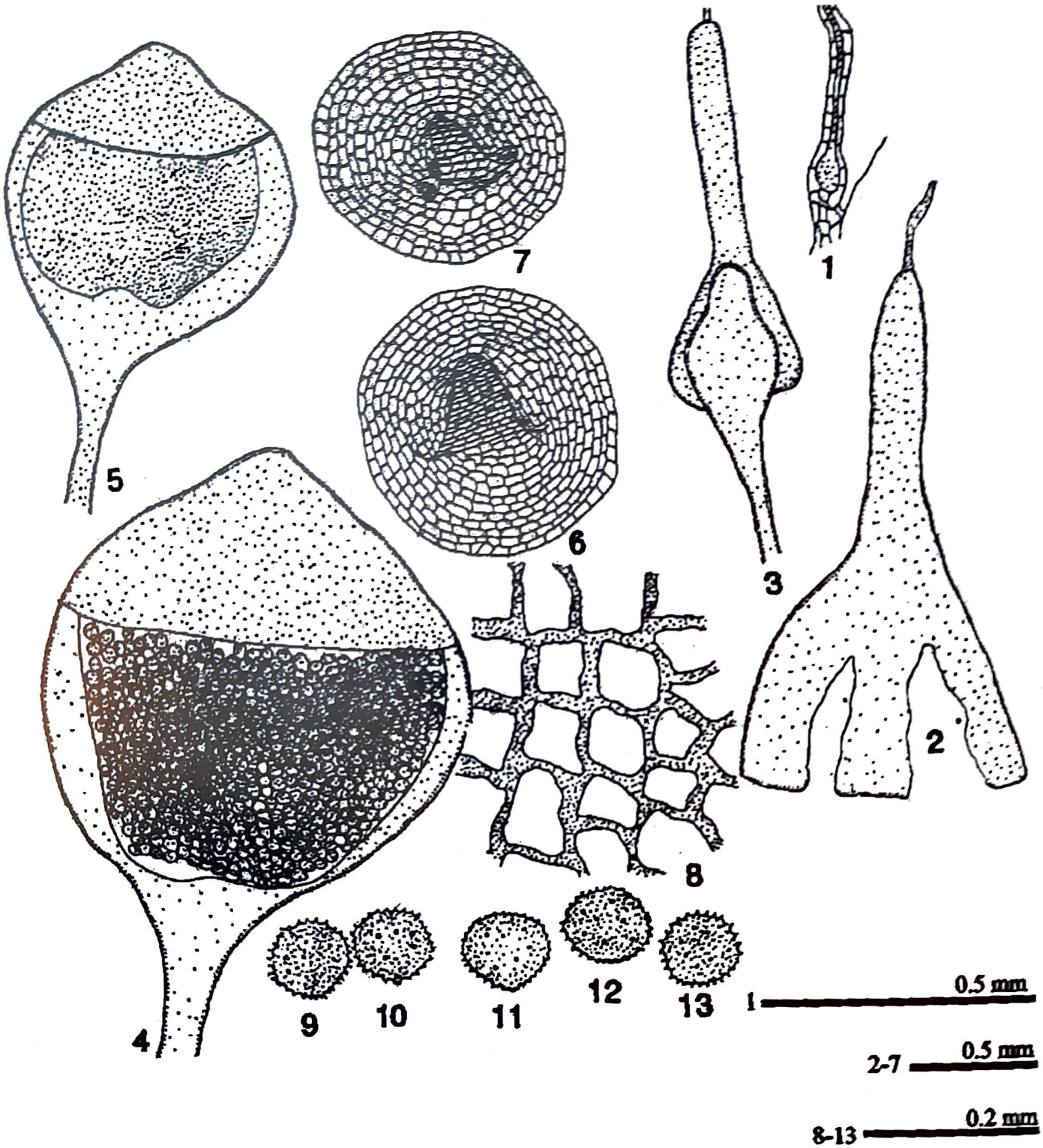


PLATE 4

P. japonicum: 1. Archegonia*. 2. Calyptra*. 3. A young capsule with calyptra#. 4. Mature capsule*. 5. Mature capsule#. 6. Operculum*. 7. Operculum#. 8. The cells of capsule wall*. 9-13. Spores#.

Note: *Non-polluted habitat, # Polluted habitat



The morphology and anatomy of *R. frostii* and *P. japonicum* were closely related with the quality of Sai river water as well as habitat contamination. Shukla (1971) reported that the higher concentration of nutrients might cause decrease in the thallus diameter of *Marchantia polymorpha* and *Plagiochasma appendiculatum*. In the light of the observation of the present studies, the higher concentration of mineral nutrients were also reported in habitat soil and river Sai water (Shukla 2003), which might be responsible for the reduced thallus size (*R. frostii*) and height of plant (*P. japonicum*) as well as other changes. In case of *R. frostii* the male plant appeared to be more susceptible than those of the female plants. Our observations thus support the contention of Richardson (1981), who reported that the pollutants adversely affect the nutrient availability and morphology of bryophytes.

The present investigation reveals huge variation in distribution pattern of selected two bryophytes, which were growing in polluted (catchments area) habitats and were affected by degree of pollution, environmental condition as well as human interference. This view supports the observation of Mirza and Shimwell (1977) that community structure of moss species was affected by their habitat characters. Denise and Touffet (1987) observed that the distribution of bryophyte growing on the banks of river depends upon water quality and can serve as bio-indicator.

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