

MORPHOTAXONOMY OF *RADULA COMPLANATA* (L.) DUMORT. FROM INDIA*

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ABSTRACT

Morphotaxonomic details of *Radula complanata* from India have been described. The plant grows luxuriantly in the alpine zone of Kashmir Himalayas. The occurrence of this taxon in the Indian territory is being firmly established for the first time. The complete details of the gametophyte, gametangial organization as well as the sporophyte and LM and SEM details of the spores and elaters have been provided.

INTRODUCTION

Radula complanata is a widely distributed taxon, although its occurrence in the Indian territory has been time and again refuted by several workers (HATTORI, 1952; CASTLE, 1967; YAMADA, 1979). Recently, SCHUSTER (1980) suggested that the Indian materials of *R. complanata* from the western Himalayas need reinvestigation. We have, however, studied a population of the above taxon collected from Khilanmarg in the alpine zone of Kashmir valley which, after careful detailed study, establishes the occurrence of *R. complanata* in the Indian territory and the contention of earlier workers is thus not tenable.

R. complanata is one of the most frequently quoted taxa in Indian bryology since KASHYAP AND CHOPRA (1932) provided details of the vegetative plant; but this and other records of the plant from south India and eastern Himalayas (UDAR, SRIVASTAVA & KUMAR, 1970; UDAR & NATH, 1976, 1977) may or may not represent it correctly. This conclusion is based on the concept that unless this species is studied in fertile conditions, it may always lead to confusion with *R. lindbergiana* Gott. ex Hartm., both of which are closely related and primarily differ in sexuality, *R. complanata* being paroecious and the latter dioecious. Influenced by broad similarities in the two species, SCHUSTER (1980) treated *R. complanata* under two subspecies, viz. *R. complanata* subsp. *complanata* (L.) Dumort., and *R. complanata* subsp. *lindbergiana* (Gott. ex Hartm.) Schust. In the absence of suitable fertile specimens of *R. lindbergiana* it is difficult to express an opinion on its status at the species or a subspecies rank, but complete details of *R. complanata*, not earlier described in Indian bryology, have been provided in this paper. The details of the spores under SEM have been given for the first time for this taxon.

MATERIAL AND METHODS

The plants of *R. complanata*, growing luxuriantly on the bark of conifers, were collected from Khilanmarg by one of us (R. Udar) in October-November, 1976. A solution of 1 per cent Methylene Blue was used to facilitate the study of pattern of thickening of the capsule wall. The spores and elaters, preserved in ethanol and coated with

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gold, were scanned under suitable magnifications at an accelerating potential of 10 Kv using SEM S4-10 model Cambridge Scientific Instruments Ltd., England, installed at the Textile Technology Division at IIT, New Delhi.

OBSERVATIONS

VEGETATIVE SHOOT

The plants of *R. complanata* are 1-2 cm long, light-green or yellow-green and show profuse pinnate branches which are mostly obliquely spreading. Most of these branches in Indian populations tend to bear perianths and are richly fertile (Text-fig. 1; Pl. 1, Fig. 1). The branching is typically of the *Radula*-type wherein, the branch arise from a cell adjacent to the base of leaf and is infra-axillary in position. The rhizoids arise in cluster from a convex rhizoid initial area on lobule surface. They are colourless but later become brown to deep brown.

The stem is oval, 0.14×0.11 mm and with more or less similar cells in cortical and medullary zones. All the cells are thickened at corners (Text-fig. 4).

The leaves are alternate, imbricate and complicate-bilobed. They are widely spreading or may be rarely falcate. The leaf lobes in *R. complanata* are broadly ovate, nearly flat or slightly concave, 0.89-0.97 mm in length and 0.91-0.97 mm in width. The apex of the leaf lobe is broadly rounded (Text-figs. 5-9) with the dorsal base arched and free, extending across the stem, leaving no leaf-free strip (Text-fig. 3). The cells of the leaf lobe are thin-walled, $15-25 \times 20-31$ μm in the middle with or without small trigones (Text-figs. 10-12). The leaf lobule is sub-quadrangle, appressed to the lobe but for the inflated convex area bearing rhizoids. The apex of lobule is obtuse (Text-figs. 5-9). Occasionally on the same plant it may be subacute to extended mamillate or even notched (Text-fig. 13). It ranges in size from 0.34-0.43 mm in length and 0.32-0.42 mm in width. The front margin is straight, slightly ampliate and extending $1/4$ over the stem width, with the line of attachment to stem straight. The abaxial region is straight or curved. The keel extends at an angle of $50-60^\circ$ from the stem.

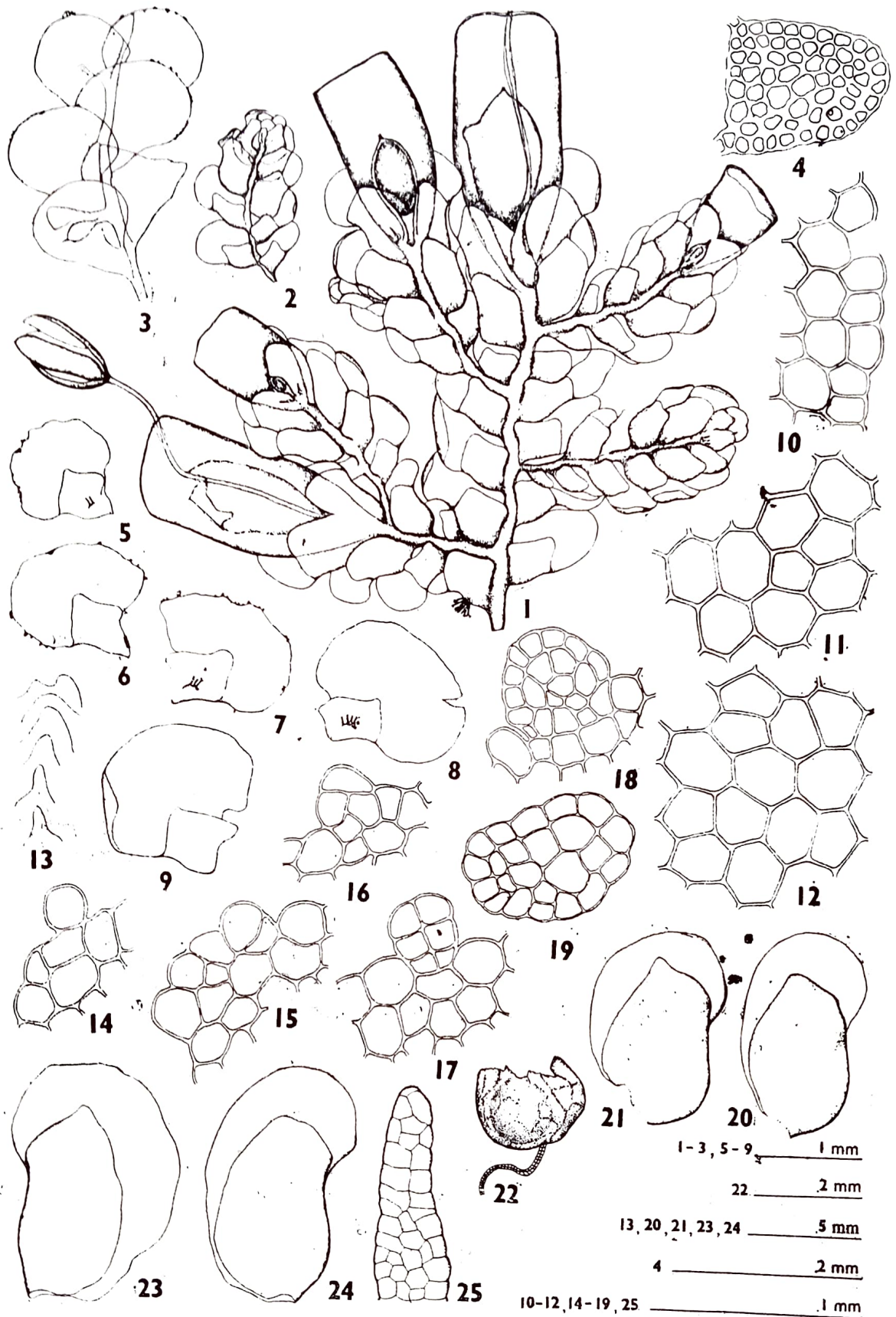
The shape of the leaf lobule is highly variable in *Radula*. In this connection, JONES (1977) rightly remarked: "The exact shape, the degree of development and extent of the imbrication of the lobules, though undoubtedly important as specific characters, are subject to great variation, sometimes even on a single frond, and weak forms of allied species are difficult to separate."

ASEXUAL REPRODUCTION

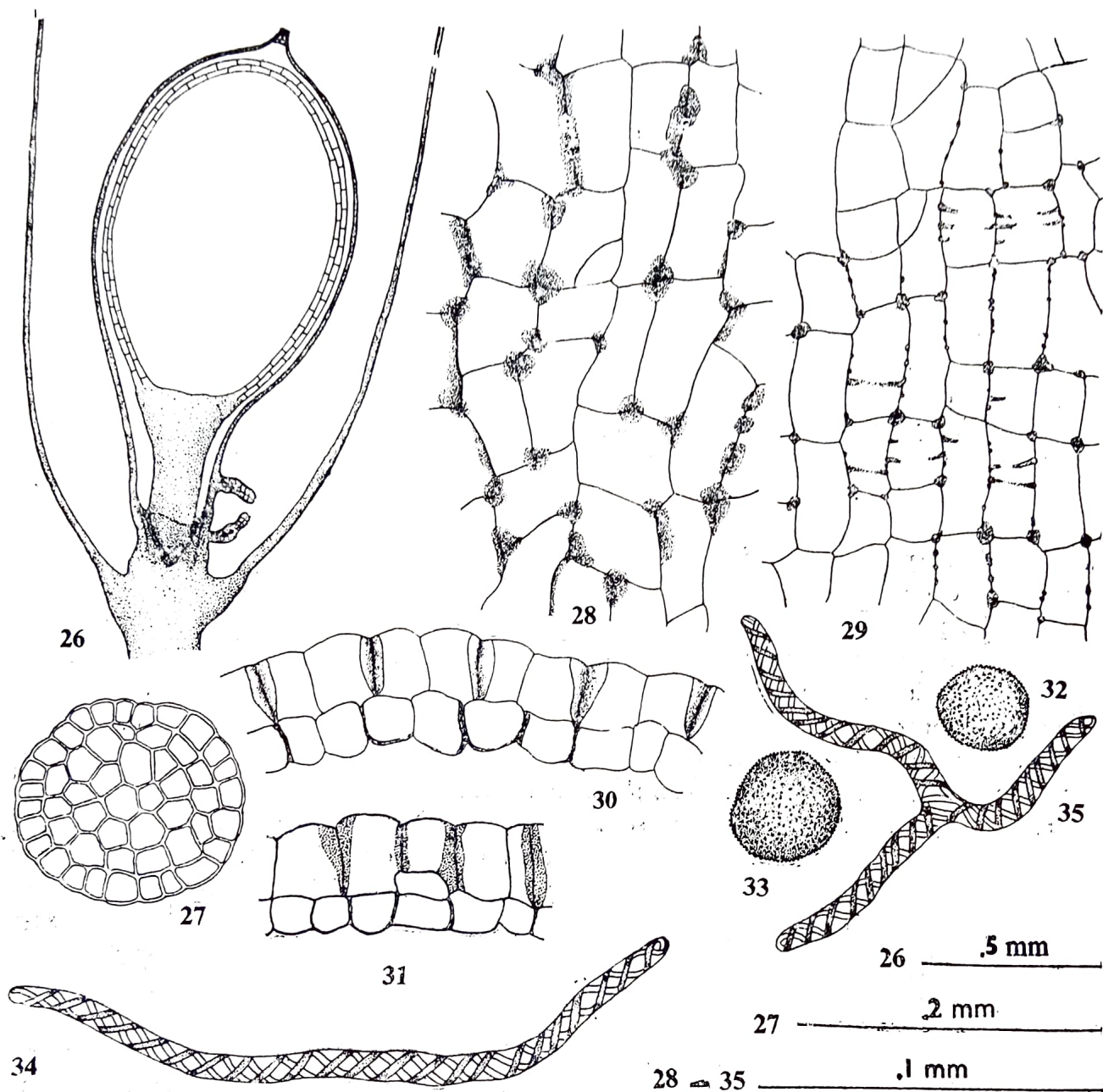
Radula complanata reproduces asexually by means of gemmae (Text-fig. 3) formed haphazardly at leaf margin. They occur in all stages of development. Each gemma is developed when a marginal cell of the leaf lobe bulges out, undergoes repeated divisions till the formation of multicelled discoid gemma (Text-figs. 14-19). Gemmae are easily detached and on germination give rise to young plants.

SEXUAL SHOOT

R. complanata is richly fertile with paroecious shoots in contrast to many other species collected by us which are not so richly fertile and are dioecious. The dioecious condition is believed to be primitive (see SCHUSTER, 1980a). With the exception of *R. complanata*, all other species so far gathered in India have male shoots with very stereotypic organisation in either being terminal or intercalary in position on the main axis



Text-figs. 1-25. *Radula complanata* (L.) Dumort. 1. Paroecious plant (ventral view); 2. Young paroecious plant to show the position of male bracts, antheridium and archegonia (ventral view). 3. Dorsal view of a vegetative gemmiferous twig. 4. Cross section of stem. 5-9. Dissected leaves. 10. Marginal cells of lobe. 11. Median cells of lobe. 12. Basal cells of lobe. 13. Variations in lobule apices. 14-19. Stages in the development of marginal gemmae. 20-21. Male bracts. 22. A dehiscing antheridium. 23-24. Female bracts 25. An archegonium.



Text-figs. 26-35. *Radula complanata* (L.) Dumort. 26. Median longi-section of perianth with sporophyte (semi-diagrammatic); 27. Cross section of seta; 28. Epidermal layer of capsule wall; 29. Inner layer of capsule wall; 30-31. Cross section of capsule wall; 32-33. Spores; 34-35. Elaters.

or its branches. There is also variation in the number of male bracts. In *R. complanata* just below the perianth and succeeding pair of female bract there are saccate male bracts in 2-4 pairs (Text-figs. 1-2). The saccate male bracts (Text-figs. 20, 21) mostly possess a solitary stalked antheridium which may occasionally occur in pairs. The stalk is either uni- or biseriate. In *R. complanata* (Text-fig. 22) the antheridium appears to dehisce by means of an apical cap which separates to liberate the mass of antherozoids.

Gynoecia are terminal either on main or on lateral branches of stem with either none or 1 to 2 subfloral innovations, often eventually becoming fertile. The female bracts are somewhat erect, narrowly obovoid with broadly rounded apex, 1.02-1.03 mm long, 0.54-0.64 mm wide being widest at the middle. The bract lobules are obovate

with rounded to obtuse apex and a strongly arched keel. They are 0.81-0.86 mm long and 0.45-0.54 mm wide. There are 5-7 archegonia in a group, each with a fairly long neck (Text-fig. 25). In a cluster only one archegonium is fertilized to form the sporophyte but occasionally two developing sporophytes may also be noticed. However, normally only one attains full maturity.

The perianths, developing subsequent to fertilization, though rare in many taxa are taxonomically significant, when present (JONES, 1977). The shape and size of perianth vary in different species. In *R. complanata* and other allied species, like *R. constricta* Steph. and *R. nilgiriensis* Udar & Kumar, they are dorsi-ventrally flattened with parallel sides, slightly broadened distally with a cuncate basal portion and normally not subtended by a conspicuous, terete and fleshy stem perigynium as noticed in the epiphyllous taxa, like *R. acuminata* Steph. and *R. protensa* Lindenb. In the latter, the sporophyte is sunken into stem tissue to about the level of capsule base (SCHUSTER, 1980a). In the Indian population of *R. complanata*, however, a stem perigynium, reaching half the length of seta, was noticed (Text-fig. 26).

THE SPOROPHYTE

The sporophyte is distinguishable into a multi-celled foot, massive seta (Text-fig. 27) and oval capsule which splits in 4 valves—mostly after the elongation of seta outside the perianth.

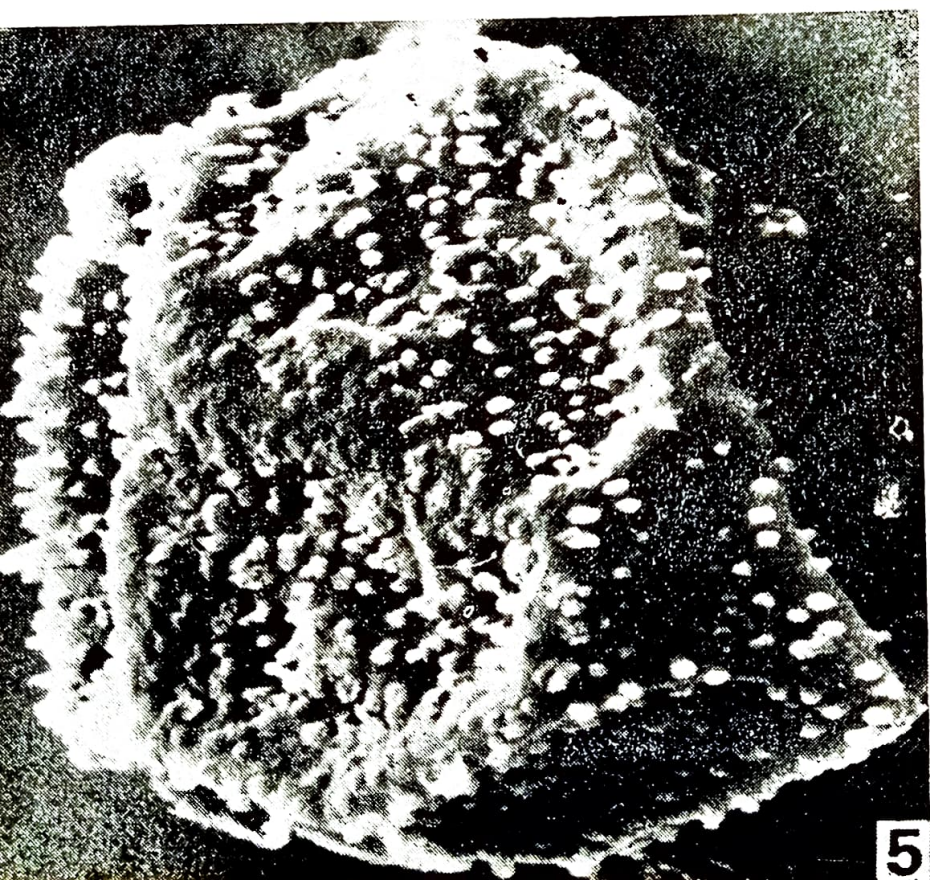
The pattern of thickenings on the capsule wall has considerable significance as noticed by us in the Indian taxa. While the outer epidermal layer of capsule wall has a nearly stabilized pattern of nodular to confluent nodular thickening, the inner wall layer shows great diversity (UDAR & KUMAR, 1982).

The capsule wall in *R. complanata* is bistratose. The epidermal layer consists of quadrate to subquadrate cells and shows biphasic development. Nodular to confluent nodular thickenings are formed on the radial walls (Text-fig. 28). The cells of the inner layer are narrow, elongated, thin-walled with feeble nodular thickenings often extending from radial to tangential walls forming incomplete, rarely complete, bands (Text-fig. 29).

SPORES AND ELATERS

The spore tetrads in *R. complanata* are tetrahedral (Pl. 1, fig. 2) but at least in *R. tabularis* (UDAR & KUMAR, 1982) they are both tetragonal and tetrahedral. In the latter in particular, the tetragonal tetrads prevail over the tetrahedral ones providing an interesting feature (see also UDAR *et al.*, 1974). In several fertile Indian taxa of *Radula* investigated by us, features of considerable significance have been revealed in spore morphology, both under LM and SEM. The spores of *R. complanata* are 26-31 μm in diameter, globose to sub-globose and with minutely papillose to granulate surface (Pl. 2, fig. 3). The pattern of thickening of sporoderm, as revealed by the scanning electron micrographs, presents closely to widely spaced tuberculate outgrowths (Pl. 1, Figs. 4, 5). This species, however, differs markedly from *R. tabularis* in the shape, size and ornamentation of spores. The spores of *R. tabularis* (see UDAR & KUMAR, 1982, 1983) are 46-57 μm in diameter and the surface is studded with spinous outgrowths but sporoderm, as revealed by the SEM, shows a double pattern of the exine. The prominent ornamentation is of widely spaced spinules with toad-stool like appearance. The intervening portions of exine surface have finely granulose pattern.

The elaters in *R. complanata* are mostly bispirate, rarely trispirate, simple or



branched, 7-8 μm in diameter and 200-270 μm long. The elateroderm pattern in scanning electron micrographs does not reveal any tangible significant character except that the margin of the helical bands may be normally entire but closely crenate in *R. tabularis* (UDAR & KUMAR, 1983).

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REFERENCES

- CASTLE, H. (1967). A revision of the genus *Radula*. Part II Subgenus *Acroradula*. Section 11. *Complanatae*. *Rev. Bryol. Lichenol.*, **35** : 1-94.
- HATTORI, S. (1952). Hepaticae of Shikoku and Kyushu, Southern Japan, 1. *Jour. Hattori bot. Lab.*, **7** : 38-61.
- JONES, E. W. (1977). African Hepatics XXX. The genus *Radula* Dumortier. *J. Bryol.*, **9** : 461-504.
- KASHYAP, S. R. & CHOPRA, R. S. (1932). *Liverworts of the Western Himalayas and the Panjab Plain* (Part II). Lahore.
- SCHUSTER, R. M. (1980). *The Hepaticae and Anthocerotae of North America, East of the Hundredth Meridian*. (Vol. IV). Columbia Univ. Press, New York.
- SCHUSTER, R. M. (1980a). Phylogenetic studies on Jungermanniidae II. Radulinae (Part I). *Nova Hedwigia*, **32** : 637-693.
- UDAR, R. & KUMAR, D. (1982). The genus *Radula* Dumort. in India-I. *J. Indian bot. Soc.*, **61** : 177-182.
- UDAR, R. & KUMAR, D. (1982). *Radula pandee*, a new Hepatic from South India *Lindbergia*, **9** : 133-136.
- UDAR, R. & NATH, V. (1976). Oil bodies in west Himalayan Liverworts. *J. Indian bot. Soc.*, **55** : 80-83.
- UDAR, R. & NATH, V. (1977). Oil bodies in South Indian Liverworts. *Geophytology*, **7**(1) : 50-53.
- UDAR, R., SRIVASTAVA, S. C. & KUMAR, D. (1970). Oil bodies in Indian liverworts. *Curr. Sci.*, **20** : 458-459.
- UDAR, R., SRIVASTAVA, S. C. & MEHROTRA, L. (1974). Observations on cytokinesis in *Riccia cruciata* Kash. and its spore morphology. *New Botanist*, **1** : 1-7.
- YAMADA, K. (1979). A revision of Asian taxa of *Radula*, Hepaticae. *Jour. Hattori bot. Lab.*, **45** : 201-322.

EXPLANATION OF PLATE 1

- Figs. 1-5. *Radula complanata* (L.) Dumort. 1. Paroecious plant (ventral view), $\times 17$; 2. Spore tetrad, $\times 725$. 3. Spore, $\times 725$; 4. Scanning electron micrograph of spores and elaters, $\times 1800$; 5. Scanning electron micrograph of spore, $\times 2850$.