DIFFERENTIATION OF THE GENUS *TARGIONIA* L. IN INDIA—1. THE WEST HIMALAYAN COMPLEX*

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ABSTRACT

In western Himalayas the genus *Targionia* exhibits two morphoforms : one referable to *T. hypophylla* L. *sensu stricto* and the other described in the paper as *T.* sp. Plants of both these species differ from each other in almost all significant taxonomic characters, viz., thallus size, colour, scale, pore, male shoot, capsule wall, lid, elaters and spores. The spore germination patterns also show sufficient diversity because in *T. hypophylla* it is endosporic and a cell mass is nearly always formed inside the spore coat while in *T.* sp. it is usually exosporic as germ tube is formed outside the spore coat. It is interesting that there is a gradual disappearance of thickening bands in the cells of capsule wall from apex to base, presence of a well-defined lid and the presence of faint, elongated line in the middle of free elaters in *T. hypophylla* recalling the condition in *Cyathodium*—a genus closely related to *Targionia*.

INTRODUCTION

Targionia is a genus widely distributed in various parts of the world. In India it grows luxuriantly in many places including western and eastern Himalayas, hills of south India, Assam and Madhya Pradesh. The morphological and taxonomic significance of the plant has attracted the attention of several workers : Cavers (1904), Deutsch (1912), O'keffe (1915), Macvicar (1926), Kashyap (1914, 1929), Müller (1951-1958), Mahabale and Mahajan (1955), Arnell (1963), Zigliara (1970), Proskauer (1971) and Vital (1974). The spores of these plants present a complicated sporoderm pattern and have been investigated by Erdtman (1957, 1965), Miyoshi (1966), Jovet-Ast *et al.*, (1966), Mehra and Sood (1969), Zigliara (1971-1972), Taylor, Kaufman and Bigelow (1971), Taylor *et al.*, (1974), Denizot (1974) and Boros and Komlódi (1975) and the sporeling pattern described by Kachroo (1955) and Inoue (1960).

It would appear that apart from Kashyap (1929) the complete plant has never been investigated for critical taxonomic details in Indian bryology for about five decades now. In western Himalayas, *Targionia* occurs in two clearly defined populations, and particularly at Nainital these two morphoforms tend to show distinct specific categories. It is difficult to reconcile that both these should belong to *Targionia hypophylla* L. This species by Kashyap (1929) was reported to be common throughout the western Himalayas at altitudes of 5000—7000 ft. but he remarked : "In moist and shady places the plants form masses of deep green overlapping individuals which are fixed to the soil only at their base. The scales and involucres in such cases are purple. In exposed places the plants are closely creeping, almost always dichotomously divided, light green or yellowish above, with hyaline or light purple scales and involucres. The spores in these cases are smaller, 25 to 30 μ, and elaters longer, 180 to 200 μ". These two distinct populations were unfor-

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tunately not critically investigated by him and significant spore characteristics were completely ignored in the entire description of the species as only the size of spores and elaters have been given : "Spores 30 to 40 μ. Elaters 140 to 188 μ." The present paper gives a detailed taxonomic account of the west Himalayan plants recognizing the taxon *T. hypophylla* L. *sensu stricto* and treating the second form as *T.* sp. The problem of assigning clearly defined status to *T.* sp. plants is postponed for a later date when the east Himalayan and south Indian plants have been fully investigated. In the latter territory in particular, the differentiation of the genus has occurred along very different lines.

MATERIAL AND METHODS

Plants of both species were collected by one of us (Asha Gupta) from Nainital, western Himalayas : *Targionia hypophylla* from Snow View on October 14, 1978 and *Targionia* sp. from Tiffin Top and Dhobi Ghat on October 15 & 17, 1978 respectively. At this period of the year both forms had mature sporophytes. *Targionia* sp. was abundantly available growing in pure populations as well as in association of *Plagiochasma* sp. *Targionia hypophylla* was found only in few pure patches. Plants of *T.* sp. were also studied from a collection from Mussoorie made by Mr. D. K. Singh in September-October, 1978. Spores of the above plants were cultured for germination on November 25, 1978 in separate sterilized petridishes containing sterilized half-strength Knop's solution. The cultures received diffused sunlight from the north window panes of the laboratory at room temperature.

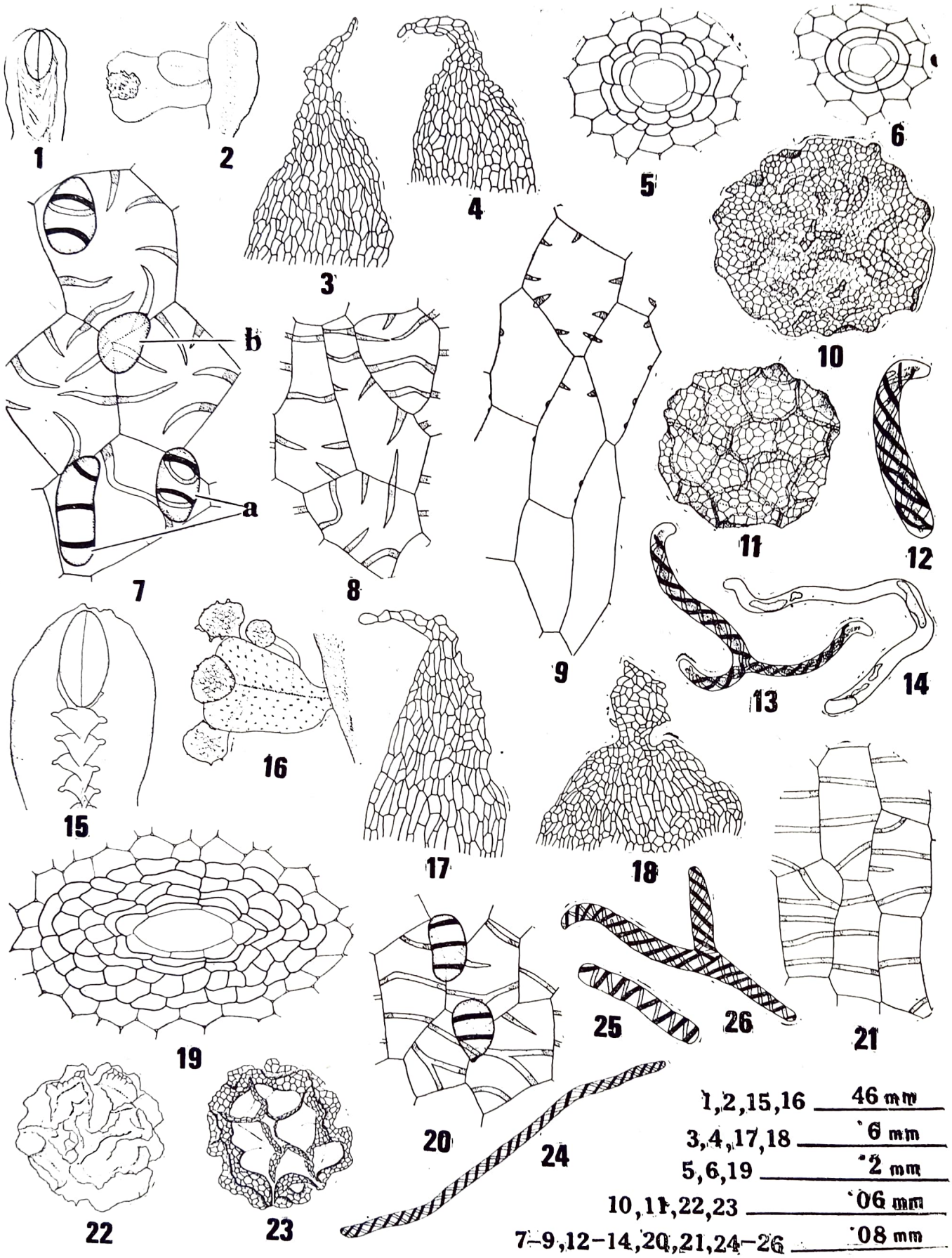
OBSERVATIONS

Targionia hypophylla L. *sensu stricto* (Text-figs. 1-14)

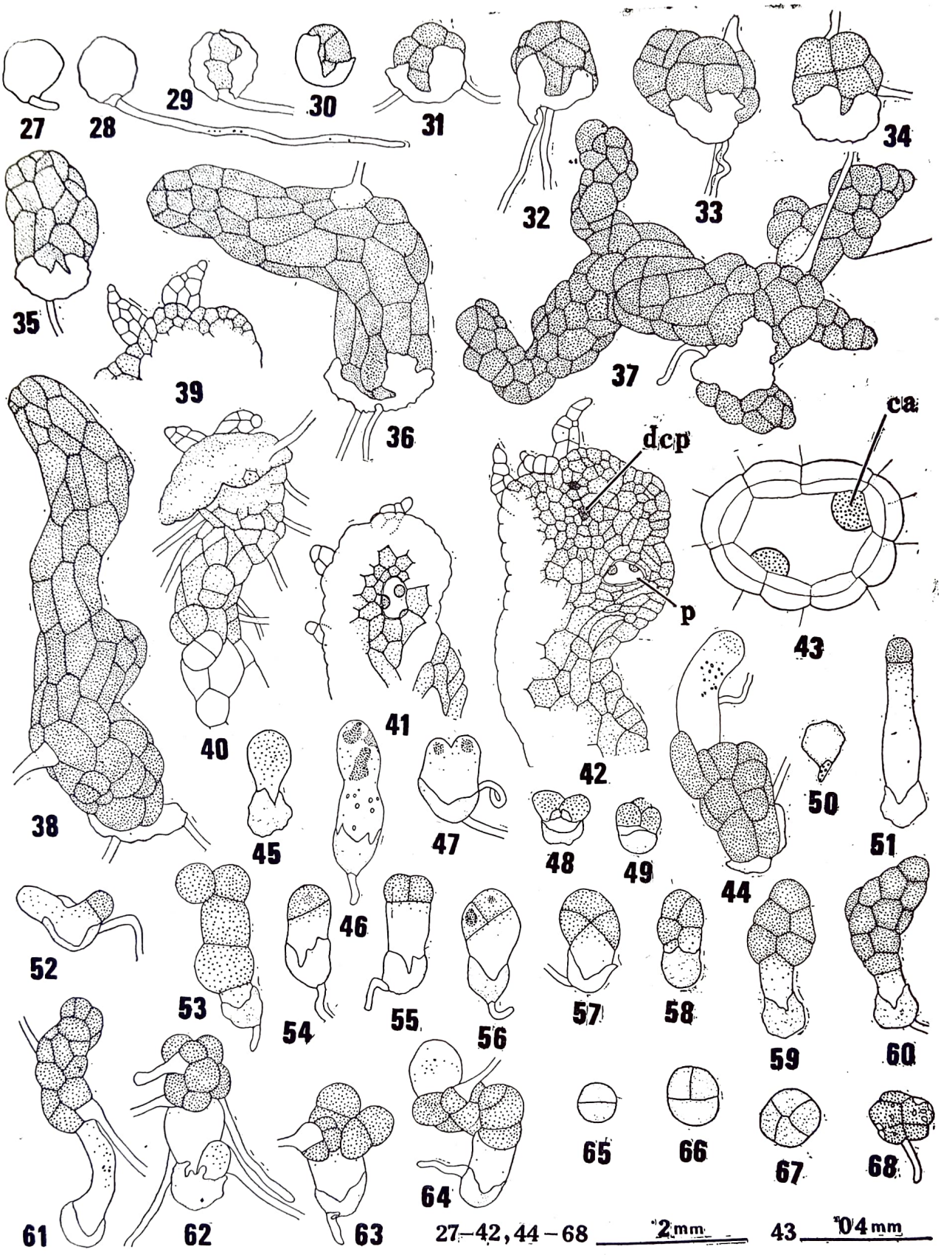
Plants dioecious, thalli 3.25-11 mm long, 0.75-3 mm broad, ventral innovations less frequent, dorsal surface yellow green ; scales purplish, delicate, unappendaged with straight to slightly curved-subulate apex, some appendaged ; pores nearly rounded, enclosed by superimposed 2-4 rings, upper two rings with 5-8 cells, rest with 9-15 cells ; antheridial group situated on ventral shoot, usually devoid of secondary lateral shoots ; capsule wall with thickening bands semi-annular, few annular, generally reduced towards basal half being confined to radial walls only when nodular to indistinct, disappearing completely towards base ; lid clearly defined from wall cells, thickening bands mostly semi-annular, some annular also ; elaters with or without thickening bands, surface-fixed elaters 27-70 μm long, 16-27 μm broad, mostly at apex of capsule, rarely also at base, one-end-fixed elaters lacking, free elaters 70-370 μm long, 6-21 μm broad, spirals 2-4, usually disappearing at tips ; spores 25-65 μm, occasionally 87-99 μm in diameter, deep brown-blackish, minutely reticulate all over, just below the latter the distal surface with much larger 4-8 reticulations, proximal surface with irregular folds (no definite pattern).

Targionia sp. (Text-figs. 15-26)

Plants dioecious or monoecious, thalli 6-17 mm long, 2-5mm broad, ventral innovations frequent, dorsal surface green; scales stiff, appendaged with ovate-subovate appendage, only rarely also unappendaged with attenuate straight to curved apex, pores mostly elliptical, some roundish, enclosed by superimposed 4-6 rings of cells, antheridial group on main thallus or ventral shoots often with several lateral shoots having narrow long stalk and subspherical disc ; capsule wall with annular to semiannular thickening bands throughout, bands becoming fainter towards base but never disappearing completely ; lid not



Text-figs. 1-26. (1-14. of *Targionia hypophylla*, 15-26. of *Targionia* sp.). 1, 15. Portion of female thallus. 2, 16. Male shoots. 3, 4, 17, 18. Scales. 5, 6, 19. Air pores. 7, 20. Cells of lid with fixed elaters. 8, 9, 21. Cells of capsule wall. 10, 22. Proximal surface of spores. 11,23. Distal surface of spores. 12-14, 24-26. Elaters.



Text-figs. 27-68. (27-44. of *Targionia hypophylla*, 45-68. of *Targionia* sp). 27-29. Development of germ rhizoid. 30-32. Early stages of cell mass formation. 33. Formation of apical cell. 34, 35. Subsequent stages of sporelings. 36-38. Various forms of sporelings. 39, 40. Portion of a sporelings with juvenile scales. 41-42. Part of sporeling with initial stages of pore and assimilatory zone formation ; dcp, dedifferentiated cell of pore ; p, pore. 43. Magnified area of pore; ca, cell of assimilatory zone. 44. Sporeling showing regeneration. 45-49. Various forms of germ tubes. 50. Emergence of germ rhizoid. 51-55. Earlier stages of germ plate formation. 56. Formation of apical cell. 57-60. Further stages of sporeling. 61-64. Sporelings with secondary germ rhizoids. 65-68. Endosporic development of sporeling.

clearly demarcated from capsule wall cells, with complete few incomplete pointed thickening bands ; elaters always with thickening bands, surface-fixed elaters 21-54 μm long, 13-40 μm broad, at apex and several at base, one-end-fixed elaters present at base, free elaters 106-272 μm long, 2-19 μm broad, spirals 1-3 throughout ; spores 35-68 μm in diameter, yellow brown, distal surface with large reticulations of much raised folds, minor reticulations confined mainly at partition walls of major reticulations, lumina granulated, some with 1-few secondary minor lamellae, proximal surface totally different from distal face, surface thrown in irregular folds, the latter generally minutely granulate with irregularly scattered secondary lamellae to reticulations.

Differentiation—The main characters delimiting the above two plants into distinct specific levels include the following : the thalli of *Targionia hypophylla* are smaller in size (Text-figs. 1, 2) and usually have yellow green colour, while those of *Targionia* sp. are larger in size (Text-figs. 15, 16) and have dark green colour. The scales in the former are hyaline and unappendaged (Text-figs. 3, 4), some appendaged, while in the latter are normally stiff and appendaged (Text-fig. 18) and only rarely unappendaged (Text-fig. 17). In *T. hypophylla* the pores are surrounded by lesser number of superimposed rings with each ring containing smaller number of cells (Text-figs. 5, 6) but in *Targionia* sp. they are surrounded by larger number of superimposed rings and each ring has relatively more cells (Text-fig. 19). The lid is clearly demarcated in the former, as in *Cyathodium*, while it is less distinctly defined in the latter. The cells of the capsule wall of *T. hypophylla* show gradual reduction in thickening bands from apex to base leading to their complete disappearance towards the base (Text-figs. 8, 9) whereas in *T.* sp. thickening bands are present throughout (Text-fig. 21). The elaters exhibit two types of conditions in *T. hypophylla* (Text-figs. 7, 12-14) viz. they show thickening bands which is the usual case (Text-figs. 7a, 12, 13) or the thickening bands may be lacking (Text-figs. 7b, 14). It is interesting that like *Cyathodium* they may contain an additional, less clear line of thickening running along the length of the elater in the middle and show disappearance of thickening (both the bands as well as the central line) at the extremities (Text-figs. 12, 13). The fixed-elaters are scarce at the base of the capsule. In contrast to the above, the elaters of the latter species are of one type only, i.e. always contain thickening-bands which are normally extended up to extremities (Text-figs. 20, 24-26). Several fixed-elaters (both surface and one-end-fixed) adhere at the base of capsule. The spores in *Targionia* basically show distinctive pattern in distal and proximal faces. In *T. hypophylla* the spores are dark in colour and contain minor reticulations all over (Text-figs. 10, 11), thus masking the distinction of the two surfaces (ie. distal and proximal), whereas in *T.* sp. the spores are lighter in colour with minor reticulation mainly confined on partition walls of larger reticulations and thus the two surfaces (i.e. distal and proximal) are absolutely distinct (Text- figs. 22, 23). The size of the spores is variable in *T. hypophylla* ranging usually between 25-65 μm but occasionally reaching 87-99 μm, whereas the spores in *Targionia* sp. range between 35-68 μm, never attaining higher dimensions.

Spore Germination—The above two taxa show clearly defined sporeling patterns. The spores of *Targionia hypophylla* show nearly hundred per cent viability. In initial stages of germination the size increases by absorption of water. Within a week the spore coat cracks in irregular pieces and usually the germ rhizoid emerges first (Text-figs. 27, 28) as in *Athalamia pinguis* (Udar, 1958), *Preissia quadrata* (Udar & Srivastava, 1970), *Sauteria yatsuensis* and *Targionia hypophylla* (Inoue, 1960). Occasionally two germ rhizoids may emerge from the same sporeling (Text-figs. 31-34). These show the presence of few

chloroplasts and oil drops. Mostly these have continuity from the basal cell, i.e. *Targionia* type but in few sporelings they are separated by a partition wall, i.e. *Marchantia* type (Text-fig. 29). Both the types are found in *Cyathodium aureonitens* (Udar & Srivastava, 1978), *Preissia quadrata* (Udar & Srivastava, 1970), *Athalamia pinguis* (Udar, 1958) and *Targionia hypophylla* (Kachroo, 1955). Rarely, a cell mass appears first (Text-fig. 30). In either case the cell mass is developed within the spore coat (endosporic formation) which then exerts pressure resulting in the formation of cracks on the spore coat. These cracks widen exposing the cell mass as in *Athalamia pinguis* (Udar, 1958). The development of cell mass and germ rhizoid exhibits polarity developing at opposite ends (Text-figs. 32, 33, 35, 36) but it is not a constant feature (Text-fig. 34) as in *Cyathodium aureonitens* (Udar & Srivastava, 1978). Apical cell with two cutting faces subsequently appears (Text-fig. 33) giving rise to a germ disc which later becomes variously curved showing *Asterella*-type of column (Text-fig. 36), or may remain nearly straight (Text-fig. 38). The column may freely branch in certain cases (Text-fig. 37). In advanced stages of growth, scales are formed towards the apex on the ventral side (Text-figs. 39-42). The cells of scale develop a purplish pigmentation rather early. There is a gradual widening of the base of the scale. These scales show partial curvature of the narrowed apex as in most scales of the mature plant. The youngest scales cover the growing point of the thallus (Text-fig. 42). Secondary rhizoids develop in large numbers from the ventral side (Text-fig. 40). Subsequent to or simultaneous with the formation of scales the pores and assimilatory zone develop on the dorsal surface. The cell destined to form the pore acquires a darker tint (Text-fig. 42, dcp) in cultures maintained for over a month. It is meristematic (Text-fig. 41) and undergoes divisions to form rings of cells (Text-figs. 42, p; 43). This development takes about two weeks for the formation of a completely organised pore with the associated rings of cells. The cells at the floor of the pore area start becoming papillate and divide to form assimilatory filaments. The top cells of the filament are seen across the pore area in optical section (Text-fig. 43, ca). Regeneration of sporeling is rather rare (Text-fig. 44). It is interesting to note that under the conditions of culture the spores behaved almost uniformly in developing a cell mass.

Spores of *Targionia* sp. show lesser viability in contrast to *T. hypophylla* spores. Instead of a cell mass getting uniformly formed as in *T. hypophylla* a germ tube is formed first (Text-figs. 45-47) and some spores may develop more than one germ tubes (Text-figs. 48, 49). The germ tubes may show various degrees of elongation and shapes. In majority of the cases the germ rhizoid develops late or may even be absent (Text-figs. 58, 59, 61) as also noted in *Cyathodium aureonitens* (Udar & Srivastava, 1978).

Rarely the germ rhizoid may appear rather early (Text-fig. 50). More than one germ rhizoid may also be formed. In general the polarity between the germ tube and germ rhizoid is sufficiently evident. The germ tube undergoes transverse divisions (Text-figs. 51-53) forming 2-4-celled filament. Occasionally such divisions may be by oblique walls (Text-figs. 54, 56, 57). A vertical wall (Text-fig. 55) may be formed or cells may develop in irregular planes. An apical cell with two cutting faces may develop rather early (Text-fig. 56) and its activity results in the formation of a multicelled germ disc (Text-figs. 56-64) which may remain straight or gets curved (*Asterella* type). The formation of germ tube is not a perfectly stabilized pattern of development. Rarely a cell mass develops as in *Targionia hypophylla*. Since the spore coat is much lighter in colour, the sequence of divisions could be clearly seen. A cross wall forms a two-celled stage (Text-fig. 65) followed by a vertical wall (Text-fig. 66). A quadrant (Text-fig. 67) is subsequently organized. Then the spore coat ruptures exposing the cell mass (Text-fig. 68).

Some sporelings possess regeneration capacity which is more pronounced as compared to the condition in *Targionia hypophylla*. The cultures did not survive for the same period as in *T. hypophylla* and therefore advanced stages of development could not be followed.

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