MORPHOLOGICAL AND BIOLOGICAL NOTES ON NEW AND LITTLE KNOWN WEST-HIMALAYAN LIVERWORTS. I.

By Shiv Ram Kashyap, B.A., M.Sc.,

Professor of Botany, Government College, Lahore.

[With Four Figures in the Text.]

Introduction.

THE liverworts here described were collected by the writer during the months of August, 1912, and July, August and September, 1913, at Mussoorie.[1] A few visits were paid to the place at other times in order to get an idea of the vegetation throughout the year. Mussoorie is a hill station in the north-western Himalayas, its exact position being 78° 71′ E., 30° 26′ W. Its height above sea-level is about 6,000 feet.

A few words about the climate of the district will not be out of place, as the various adaptations in the plants described will be better understood in the light of the climatic conditions. The most important fact in connection with the climate is that there is a short rainy season, roughly from June to August, while the rest of the year is comparatively dry. The following table shows the rainfall and the number of rainy days for the last five years. I am indebted to Col. C. Milne, Civil Surgeon of Mussoorie, for allowing me the use of the figures which were obtained at the Civil Dispensary.

Rainfall.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total of Year.	Total of June to Sept.
1909	2·33	3·18	·03	3·11	·68	17·65	32·75	37·45	5·65	·03	·00	2·39	105·35	93·50
1910	1·45	1·10	·00	·88	2·21	9·89	41·00	31·76	9·68	5·80	·27	·32	104·36	92·33
1911	9·94	·55	11·11	·82	·70	4·84	5·14	17·23	8·30	1·70	6·50	·00	66·83	35·51
1912	2·48	1·16	1·98	2·60	1·86	6·78	29·20	43·40	14·59	·00	2·40	1·08	107·53	93·97
1913	·20	6·82	3·22	·09	3·90	25·12	30·70	16·92	—	—	—	—	—	—

[1] Many of these species along with some others not mentioned here have been recently found by the writer in another part of the western Himalayas, *i.e.*, the Chamba state.

RAINY DAYS.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1909	7	9	1	12	2	22	23	26	7	1	0	5
1910	4	5	0	4	6	19	30	28	19	3	2	1
1911	13	2	13	4	2	16	13	16	17	2	3	0
1912	3	4	2	4	4	11	26	30	11	0	1	2
1913	1	9	4	3	10	16	23	19	—	—	—	—

It will be seen from the above that the plants have to pass through a dry period representing the greater part of the year. In addition to the small amount of precipitation, insolation is very strong and evaporation very great, as in all mountain districts. In September, for instance, at the end of the rainy season, a fortnight of uninterrupted sunshine is sufficient to kill a large number of herbs growing as epiphytes or in exposed places.

Connected with the long dry period, we find that many herbaceous plants have developed organs of perennation in the form of tubers, bulbs, rhizomes, etc. As examples may be cited many orchids, aroids, crassulaceous and many other flowering plants, epiphytic ferns, also two species of *Selaginella*[1] and *Gymnogramme leptophylla* with its tuberous prothallus. The liverworts possessing such perennating organs are mentioned below and it will be seen that their number is pretty large. During the rainy season four or five inches of rain in twenty-four hours is not unusual and occasionally the rainfall may reach eight to ten inches. The force of the water on the slopes is naturally very strong and the plants have to be firmly fixed in order to escape being washed away.

The thallose liverworts, including the Anacrogynous Jungermanniales, will be taken first. The latter series, although possessing some foliose forms, is here included in the thallose group as all these plants taken together form essentially one ecological class. Most of the plants described below can be found, with a little careful search, within half a furlong on many more or less exposed eastern slopes. This does not, however, apply to the species of the genera *Cyathodium* and *Cryptomitrium* which are adapted to light of a very low intensity, the hygrophilous genus *Dumortiera*, the genera *Aneura* and *Metzgeria*, and a species of *Marchantia*. The

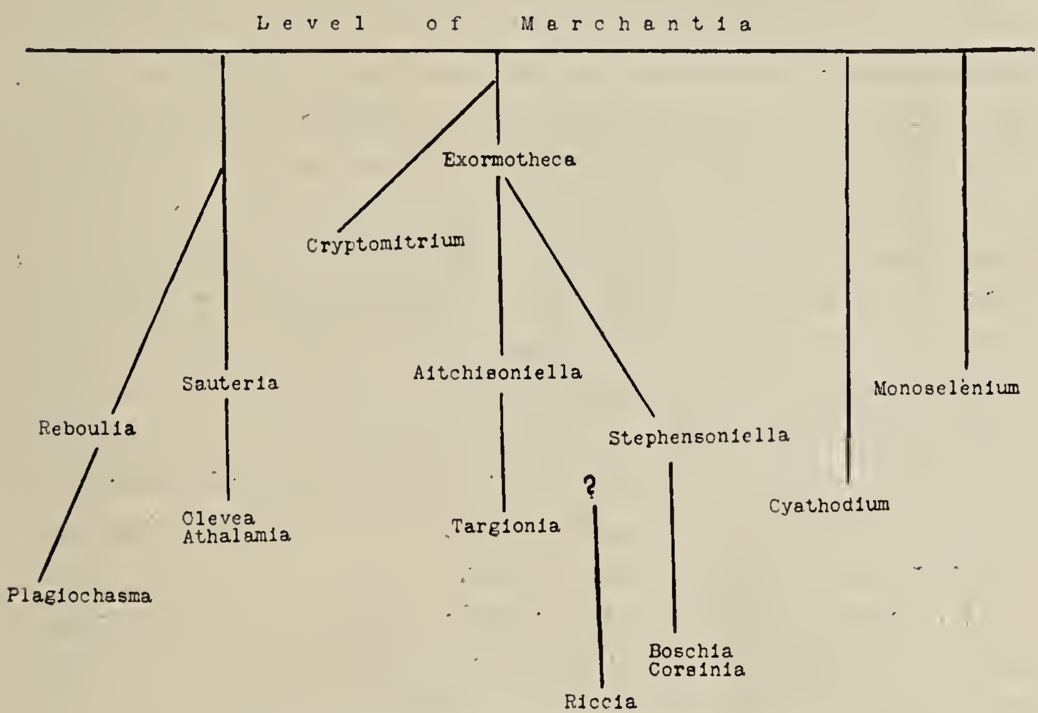
[1] *S. chryrorhizos* with underground tubers, and *S. chrysocaulos* with resting buds. My thanks are due to Professor Seward who had these species identified for me.

last three are found at a level of about 5,000 feet, *Metzgeria* being an epiphyte.

The following is a list of the thallose forms met with at Mussoorie at a level of 6,000 feet (with the exception of the three species mentioned above). The position of the new genera and species is briefly indicated, as full descriptions are given later. The methods by which these plants pass through the dry period are indicated by letters: A indicates the ability of the plant to revive as a whole after desiccation; B indicates that the apical part only survives, but is not much modified; C that the apex is modified to form a definite tuber; D that ventral or lateral shoots are modified to form tubers. The rest are hygrophilous or annuals. It must be also mentioned that reproduction by spores plays a very unimportant part in this region.

(1) *Riccia discolor* (B). (2) *Targionia hypophylla* (A). (3) *Cyathodium tuberosum*, sp. nov. (C). Male receptacle of composite type. (4) *Aitchisoniella himalayensis*, gen. et sp. nov. (B). Near *Targionia* but female shoot reduced to receptacle. (5) *Athalamia pinguis* Falc. (Trans. Linn. Soc., vol. 20, 1851) (B). Near *Clevea*. (6) *Gollaniella pusilla* St. (Hedwigia, vol. 44, 1905) (B). (7) *Plagiochasma appendiculatum* (A). (8) *P. articulatum*, sp. nov. (A). Receptacles terminal, growth continued by an adventitious shoot. (9) *Reboulia hemispherica* (A). (10, 11, 12) *Fimbriaria*, three species (B). (13) *Grimaldia californica* (A). (14) *Exormotheca tuberifera*, sp. nov. (D). Ventral shoots form tubers. (15) *Stephensoniella brevipedunculata*, gen. et sp. nov. (C). Near *Exormotheca* but growth continued by an adventitious apical shoot after formation of female receptacle. (16) *Cryptomitrium himalayensis*, sp. nov. (C). (17) *Dumortiera hirsuta*, hygrophilous. (18, 19) *Marchantia*, two species, in shady moist places. (20) *Aneura pinguis*, in shady moist places. (21) *Metzgeria hirsuta*, sp. nov. (A). (22) *Pellia calycina*, in moist places. (23) *Fossombronia himalayensis*, sp. nov. (C). (24) *Sewardiella tuberosa*, gen. and sp. nov. (C). Very near *Fossombronia* but thallose. (25) *Notothylas* sp. Annual. (26) *Anthoceros himalayensis*, sp. nov. (D). Ventral and lateral shoots form long-stalked tubers. (27) *Anthoceros erectus*, sp. nov. Annual, with large mucilage cavities. (28) *Massalongoa tenera*, described by Stephani (Hedwigia, Bd. 44, 1905), but not found by the writer.

The general conclusions arrived at by the writer with regard to the evolution of the Marchantiales in the light of the new species may be set forth in a few lines. The detailed discussion will be taken up in connection with individual species. The view expressed by Goebel after his study of *Monoselenium tenerum* (Flora, Bd. 101, 1910) that simpler forms of the Marchantiales are reduced has been strongly confirmed in a general way. It has been possible to work out the relationships in some cases in detail. The following scheme indicates the probable evolution of the Marchantiales by reduction as judged particularly by the position and structure of the carpocephalum and sporophyte.



Suggested Phylogeny of Marchantiales (see Text).

CYATHODIUM, TARGIONIA, AND AITCHISONIELLA.

The genera *Cyathodium* and *Targionia* have been placed together by most authors—as Schiffner,[1] Campbell,[2] Lang,[3] Lotsy,[4] Goebel[5] and Cavers[6]—on account of the similarity of the male and female receptacles. Deutsch,[7] however, has recently called attention to the great difference between the two genera, but he has ignored Lang's important contribution to the morphology of *Cyathodium* and has not added any new fact in connection with that genus. The study of *Cyathodium tuberosum* shows that the distance between the two genera is greater than has been supposed up to this time.

[1] Engler and Prantl. "Natürliche Pflanzenfamilien."

[2] "Mosses and Ferns," 1905.

[3] "The morphology of *Cyathodium*." Annals of Botany, 1905.

[4] "Vorträge über Botanische Stammesgeschichte," Band 2, 1909.

[5] "Archegoniatenstudien, XIII. *Monoselenium tenerum*." Flora, Bd. 101, 1910.

[6] "Inter-relationships of the Bryophyta." NEW PHYTOLOGIST, 1910, 1911; New Phytologist Reprint No. 4.

[7] "A study of *Targionia hypophylla*." Bot. Gazette, vol. 53, 1912.

CYATHODIUM TUBEROSUM KASHYAP.

In shape and structure the thallus is like that of *C. cavernarum* as described by Lang. The species under consideration, however, is diœcious and forms tubers. Thus the plants are met with in three forms—sterile, male, and female. The sterile plants are once or twice dichotomously divided and the lobes are linear or linear-oblong. The appearance of the male plants is variable, the lobes being linear or oblong obcordate. The female plants may be linear or linear-oblong, but more often they are fan-shaped with many growing points on the anterior margin due to rapid dichotomy. The narrow plants are usually less than 2 mm. broad, while the large female plants may be as much as 1 cm. long and 2 cm. broad in favourable localities. The plants are usually found in dark and moist places forming dense masses of overlapping individuals. In some cases the only other plant inhabitant of the cave was *Cryptomitrium himalayensis* Kashyap, and under these circumstances both these species have a yellowish phosphorescence. *Cyathodium tuberosum* may, however, occur in only slightly shady places along with *Riccia*, *Targionia*, *Plagiochasma*, *Anthoceros* and other more or less xerophilous forms and even in almost exposed situations, where it develops a deep green colour.

In some sterile and smaller male plants no pores are ever formed. In a large number of them, however, pores are present but on the *ventral* surface. In the larger female plants pores are present on the dorsal surface. Pores on both surfaces were not met with in any plant. The dorsal pores (Fig. 1, *a*) are scattered on the dorsal surface, one being found in one but not in every areole; they are circular just behind the anterior margin but become elongated and elliptic further back. Each pore is surrounded by two or three series of four or five cells each; these cells are narrow and hyaline and peculiar in that the outer walls of the innermost cells are also concave outwards like the inner walls. The transition to the ordinary cells of the thallus is gradual. The ventral pores are much simpler and much larger and elongated in the direction of the longitudinal axis of the thallus (Fig. 1, *b*). They are bounded by ordinary cells of the thallus. All the cells of both the upper and lower layers of the thallus contain chloroplasts but they are more numerous on the dorsal side.

There are two rows of scales on the ventral surface. They may be simple cell rows or small plates (Fig. 1, *c*, *d*). Usually there are no mucilage cells but occasionally a small cell differing from the rest is met with at or near the apex. All cells of the scales contain chloroplasts, as is the case with the scales of *Monoselenium*[1] and the young scales of *Aitchisoniella*.

Both the thick-walled narrow and thin-walled wide rhizoids are present, but the former do not possess the pegs and are much more numerous than the latter. There is no distinct midrib in the thallus.

The ventral pores, apart from their absence in other Marchantiales, are interesting in another respect also. Filaments of *Oscillatoria* and small colonies of *Nostoc* which grow near the plants often find their way into the thallus-chambers through them. In one case even small eggs of some animal were found inside the chambers. This connection between *Cyathodium* and the blue-green algæ mentioned above seems to be quite accidental, but it suggests the method by which a permanent connection may have been established between *Anthoceros* and *Nostoc*.[2]

The ventral pores seem to have been produced in order not to reduce the area of the upper surface available for the absorption of the small amount of available light and at the same time to provide for adequate gaseous exchange.

The apical parts of the sterile plants and the sterile branches of male plants become transformed into tubers about the end of the rainy season, *i.e.*, about the end of August. Short pointed thick-walled hairs begin to appear on the margins and the ventral and dorsal surface of the thallus, a short distance behind the apex. The thallus itself becomes very much denser than it was before near the apex. On the anterior margin there is one growing point which in many cases forks into two before tuber formation. The air chambers are small and numerous and divided by horizontal septa so that there is more than one layer of them (Fig. 1, *e*). There are no pores. The mature tuber (Fig. 1, *f*) is about 1 mm. long and a little broader, firmly fixed to the substratum and covered dorsally and laterally by numerous forwardly directed spike-like hairs, and ventrally by similar hairs and rhizoids. These hairs are obviously modified rhizoids. On the ventral surface there are a few scales. The cells of the tuber contain numerous chloroplasts and some starch. There are one or two growing points on the anterior margin. The margins of the tuber are directed obliquely upwards, so that there is a groove in the mid-dorsal line.

[1] Goebel, loc. cit.

[2] Cavers (Ann. Bot., vol. 18, 1904, p. 91) describes the occurrence of *Nostoc* chains in the ventral tissue of *Fegatella* and several other Marchantiales. It would be interesting to know whether these forms also possess ventral pores.

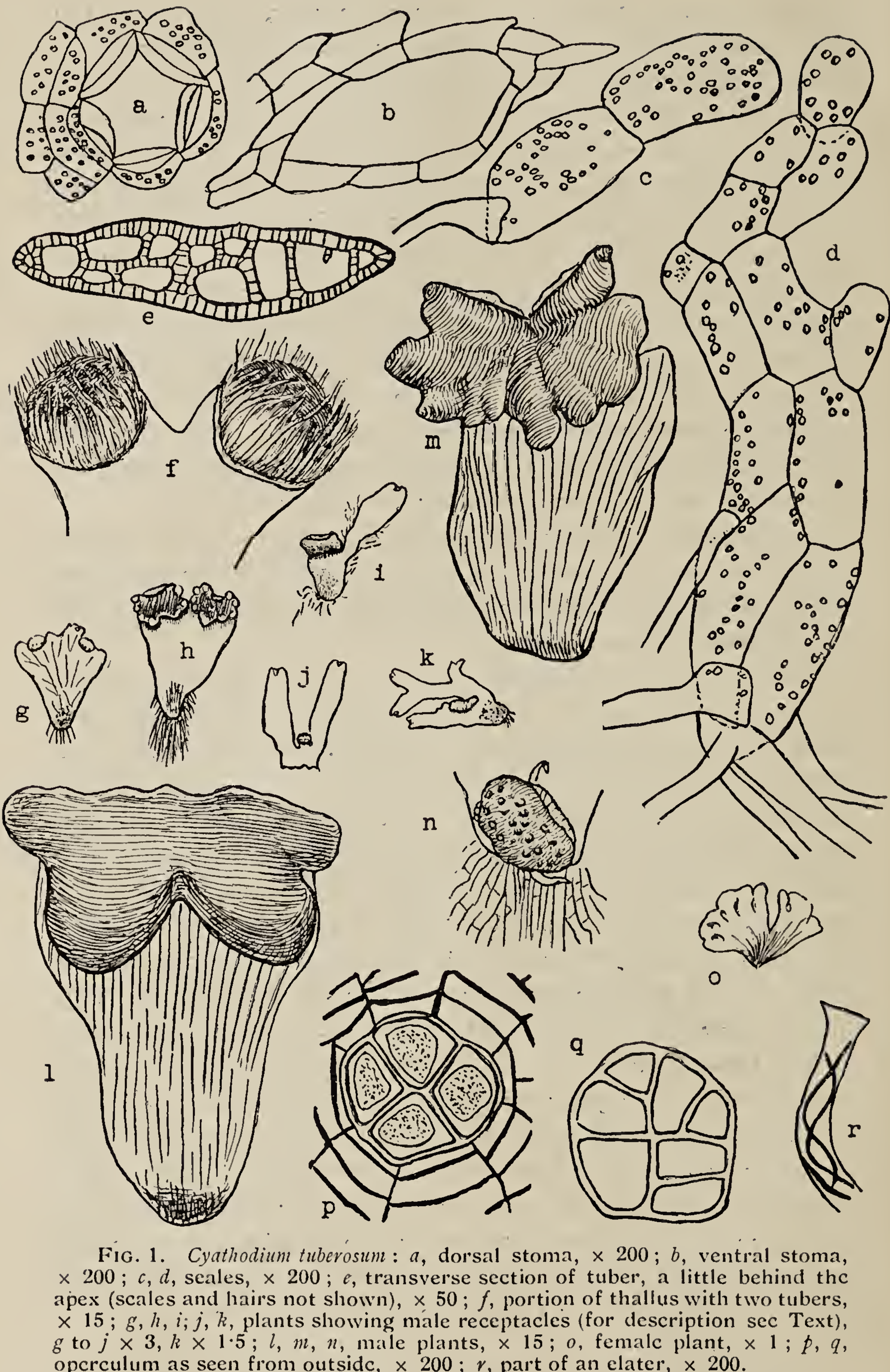


FIG. 1. *Cyathodium tuberosum*: *a*, dorsal stoma, × 200; *b*, ventral stoma, × 200; *c*, *d*, scales, × 200; *e*, transverse section of tuber, a little behind the apex (scales and hairs not shown), × 50; *f*, portion of thallus with two tubers, × 15; *g*, *h*, *i*; *j*, *k*, plants showing male receptacles (for description see Text), *g* to *j* × 3, *k* × 1·5; *l*, *m*, *n*, male plants, × 15; *o*, female plant, × 1; *p*, *q*, operculum as seen from outside, × 200; *r*, part of an elater, × 200.

The growing-point was studied in these tubers and it was found to be occupied by a single initial cell. This cell has a triangular outline in vertical longitudinal sections, and it is oblong in horizontal sections. It cuts off segments dorsally, ventrally and laterally. Goebel[1] concludes from the figures of Leitgeb that a similar apical cell is present in the species investigated by the latter. *C. cavernarum* differs from the present species in having an apical cell cutting three segments (Lang). Vertical transverse sections showed that the tuber was two to four cells thick immediately behind the apical cell, without any spaces between the cells. A little further back spaces appear owing to the more numerous vertical walls in the upper and lower layers and horizontal walls in the middle layers.

C. tuberosum seems to have lost all distinction between its upper and lower surfaces as shown by the position of the pores and the rhizoids. The biological significance of the pores has already been alluded to. The hairs on the upper surface of the tuber protect this region from drought. The part behind the tuber dies in a short time, and often the tuber is separated from the thallus by a constriction before maturity.

The position of the male receptacle is variable, and is similar to the position of the female receptacles of *Exormotheca* and *Aitchisoniella.* It may be terminal, lateral or in the angle between two sterile branches (Fig. 1, *g* to *m*), In the case where it is lateral the main shoot has divided into two branches, one of which grows on as an ordinary branch while the other forms the receptacle. In the case where the receptacle is in the fork the main shoot has divided into two, one of which again forks producing a sterile branch and a receptacle (Fig. 1, *k*). In both cases the receptacle has the form of a cushion separated from the thallus and a little raised by a stalk-like constriction. It is either circular in outline or elongated laterally and has a few scales on the ventral (anterior) side. Where the receptacle is terminal it is much more highly developed. It is raised upon a short stalk-like constriction which has a distinct groove on the anterior surface and is a branch-system. This last form of the receptacle is met with in plants which occur along with large female plants and are often concealed below the latter. In the case of the receptacle being lateral or in the fork branching has occurred, some branches being reproductive, others vegetative. In other plants all branches are reproductive and we have a composite

[1] "Organography of Plants." Eng. Trans., vol. 2, 1905, p. 21.

receptacle consisting of many branches. The same explanation holds good for the female receptacle of *Exormotheca*, but the number of reproductive branches there (two) has become permanently fixed. In *Griffithia*, as described below, the number of female reproductive shoots in an involucre varies between one and two. Finally, in *Targionia* the number is again fixed at one.

Laterally elongated receptacles have also been mentioned by Lang in *Cyathodium cavernarum* and these no doubt indicate a single dichotomy. The terminal receptacles of *C. tuberosum* may have four to nine or more branches (Fig. 1, *h*, *l*, *m*), each being represented by a lobe of the disc and each having a few scales in two rows on the ventral surface. The receptacle is obviously similar to the receptacle of *Marchantia*, but reduced as regards assimilating tissue. Goebel[1] has pointed out that the disc of the receptacle of the composite type like *Marchantia* is not radial but symmetrically divisible only by one plane. This condition is very well seen in the receptacle under consideration (Fig. 1, *h*, *l*, *m*). Antheridia are developed in centrifugal order so that the youngest antheridia are found near the tips of the lobes. The upper surface is studded with the papillæ containing the openings of the chambers in which the antheridia are situated. The mouth of the papilla is usually bounded by six cells. The structure and development resemble what has been described by Lang for *C. cavernarum*. A row of six cells was observed without any vertical walls at one stage of development. The mature antheridium has a short stalk and a wall of large hyaline cells. Ripe spermatozoids were observed in many sections, though the cilia were not visible. The spermatozoids are long narrow thread-like coiled bodies about 10μ long without the cilia. They resemble the spermatozoids of *Targionia hypophylla* and *Riccia crystallina* as observed by the writer, and other Marchantiales in general.

As already stated the female plants (Fig. 1, *o*) are either long and narrow or more often they are fan-shaped, due to rapid dichotomy of the growing-point. Their large size under favourable conditions is remarkable as already mentioned. The number of involucres and sporogonia is very large. In one specimen twenty-one involucres were counted and this is by no means unusual. The number of ripe sporogonia is one to four in each involucre. The archegonia differ in position from those of *C. cavernarum* as the growing-point is displaced downwards and backwards and they

[1] "Organography of Plants." Eng. Trans., vol. 2, p. 85.

come to lie on the lower surface. The involucre is ovoid, opening by a circular or elliptic mouth. An interesting feature in connection with the female receptacle is that after fertilisation stiff short hairs similar to those of the tubers begin to grow from the base, apex and margins of the scales near the involucre, the ventral surface of the involucre and the margins and even the dorsal surface of the thallus for a short distance behind the apex. The number of these hairs is, however, not very large on the dorsal surface.

The structure of the sporogonium presents some interesting features. The foot and seta are like those of *C. cavernarum.* The former consists of two branched cells and the latter of a row of cells. As usual there is an operculum, a thick-walled region and a thin-walled region in the wall of the capsule. The cells of the latter are full of starch before maturity of the capsule but later on are quite empty. The operculum may consist of four cells in the outermost tier but very often some of these cells divide so that the number is increased to six or seven(Fig. 1, *p*, *q*). One of Griffiths' figures[1] showing a part of the operculum of *C. aureo-nitens* shows clearly that this division also occurs in the latter species. The cells of the innermost tier are not eight as in *C. cavernarum* but sixteen to twenty. They can be easily counted by removing the operculum and examining it upside down. The diameter of the operculum as seen from the outside is about 80μ and the diameter of the whole capsule is 0·5 to 0·75 mm.

The spores have long spinous projections as in *C. cavernarum* with a diameter of 40μ. The spore-mother-cells do not become lobed while undergoing division as is the case in *Targionia hypophylla* mentioned by Cavers[2] and also observed by the writer. The elaters are interesting on account of their shape and position. They are long slender structures, 500 to 550μ long, closely trispiral and have one end expanded and they are fixed to the capsule wall by this broad end (Fig. 1, *r*). Lang[3] describes the elaters of *C. fœtidissimum* as free. Goebel[4] has described similar fixed elaters in species of *Jungermannia.* Griffith[5] figures a part of the capsule wall with one elater partly inside. It may be a mere accident but it is, perhaps, an indication that the elaters are fixed in that species. The number of the elaters is very small. The largest number counted was thirty

[1] "Icones plantarum Asiaticarum," Part 2, 1849, Plate 69, D. ii.

[2] "Inter-relationships of the Bryophyta," 1911, p. 24 of Reprint.

[3] "Annals of Botany," 1905, p. 420.

[4] "Organography of Plants," vol. 2, p. 99.

[5] "Icones plantarum Asiaticarum," Part 2, 1849, Plate 69, D. ii.

and the smallest seventeen. They are, however, very regularly placed. The capsule opens by eight valves, and eight elaters are attached near the eight lines of dehiscence at the junction of the thick-walled and thin-walled parts of the capsule wall. The rest are arranged below these towards the base of the capsule at short distances forming eight rows. All the elaters are directed to the centre of the capsule. As the length of an elater is rather more than the diameter of the capsule in its apical and basal part it is probable that they help in the dehiscence of the capsule in addition to the dispersal of the spores by their hygroscopic movements. The small number of the elaters can also be explained by their adhesion to the capsule wall. It would not be easy for a small form like *Cyathodium* to spare material to form numerous elaters, but if the elaters were fixed at one end they would be as efficient as if they were numerous and free.

Two abnormalities which are met with in this species may also be described here. (1) In the capsule here and there small clumps of a sticky substance were found in which some abortive spores were imbedded. These masses were often found adhering to the wall of the capsule and appeared as white patches from the outside in spirit material. (2) In one specimen a curious condition was observed. On the ventral surface behind the apex (but not at the apex) of a large fan-shaped thallus some twenty groups of archegonia were found, each group consisting of about six archegonia and seated, it appeared, at the base of a small concave adventitious shoot of the thallus and surrounded by several scales whose cells contained chloroplasts.[1]

It appears from the above that *Cyathodium tuberosum* stands near *C. cavernarum* as regards the structure of the thallus and sporogonium, but it has some peculiarities of its own as for instance, ventral pores, tubers, dioecious habit and fixed elaters among other things. It differs markedly from *C. cavernarum* as regards the male receptacle and the position of the archegonia. The significance of the male receptacle and the position of *Cyathodium* will be discussed at the end of the paper.

TARGIONIA HYPOPHYLLA L. VAR. *INTEGERRIMA*.

The species described there under the above name differs from the type as described by Stephani[2] and others in a few respects, but

[1] Stephani ("Species Hepaticarum," vol. 1, p. 63) has described a similar abnormality in *C. aureo-nitens* where the involucre is replaced by a flat shoot bearing the capsule directly.

[2] "Species hepaticarum," vol. 1, 1900, p. 61.

on the whole it appears that it need not be separated (see footnote below). The chief difference lies in the form of the male receptacle but there are minor differences in the vegetative region as well.

The plant is very variable as regards its form. In shady moist places where it attains greatest luxuriance it forms masses of deep green overlapping individuals which are fixed only by their bases to the substratum. They are 20 mm. or more long and often dichotomously divided. The scales and the involucre are dark purple. In exposed and moist places the plants grow similarly but have a light-green and even yellowish colour, and are almost always once or twice dichotomously branched. They are, however, smaller, often less than 10 mm. in length. The involucre and the scales are hyaline, or only pink. Often only the appendage of the scale is pink, while the rest of the scale is hyaline. This diminution of colour in the exposed places is surprising. One might have thought that the colour would be deeper. Mucilage cells are usually found projecting from the margins of the scales. In dry and exposed places the plants are firmly fixed to the substratum by the whole of the ventral surface and give off a few straggling branches. In all cases the scales may sometimes be slightly overlapping. There is another difference between the plants in shady and exposed places which concerns the relative size of the spores and elaters. The spores and elaters, in plants growing in shady places are respectively, 30 to 40μ, and 140 to 180μ; whereas in plants found in exposed places they are 25 to 30μ and 180 to 200μ.

The number of archegonia is up to seven in each involucre which may develop one or two ripe sporogonia. The apex of the capsule has short elater-like cells attached to it, but the involucre has no tooth-like interlocking processes as described by Cavers.[1] A few elaters slightly shorter than the normal ones are usually found fixed at the base of the capsule. The seta is very short and the capsule does not come out of the involucre.

The antheridia are found usually on the well known ventral shoots in plants growing in shady places. Each shoot has a cylindrical stalk and a terminal disc studded with antheridial chambers separated by assimilation tissue and possessing numerous scales ventrally. Sometimes, however, these discs develop wings on both sides so that they become terminal and are surrounded by scales on all sides (Fig. 2, *a*, *b*). The scales surrounding these male

[1] "Contributions to the Biology of the Hepaticæ," Leeds and London, 1904, p. 8. (Following a suggestion made by Dr. Cavers, I have given my form the varietal name *integerrima* on account of the entire margin of the involucre).

receptacles are similar to those of the ventral surface, purple in colour, but simpler. The appendage usually is either small or absent. Even more interesting are the variations met with in the male receptacle of plants growing in exposed places. Here the male shoot, though arising from the ventral surface has the appearance of the ordinary shoot, and the antheridia form a cushion along the midrib, but this cushion is not at all separated from the wings of the shoot. In addition to these ventral male shoots in the species under discussion the main shoot itself often forms the antheridial cushion on the midrib (Fig. 2, *c*, *d*). The appearance of these main male shoots is very much like that of the male shoots of some species of *Fimbriaria*. It is interesting to note that in such cases the ventral surface has, at a little distance behind the apex, two rows of scales, but immediately behind the anterior margin the

FIG. 2. *Targionia hypophylla*: *a*, *b*, *c*, male shoots, × 4; *d*, transverse section of male shoot, × 20.

scales sometimes appear to be scattered as in the modified ventral male shoots. The reason of this is that rapid dichotomy occurs and the two or more growing points can often be easily distinguished. But if these growing points were still further obscured, we shall have no indication of the cause of scattered scales. This is what happens in the modified ventral male shoots.

It appears, therefore, that the disc of the male shoot of *Targionia* has been formed from a receptacle of a composite type by reduction as described above and as explained by Goebel (Flora, Bd. 101, 1910, Fig. 41). The scales on the ventral surface of each lobe in the ancestral condition would, on the disappearance of the lobes, appear to be scattered on the under surface. The same holds good for the scales surrounding the receptacles of genera like *Plagiochasma* which will be discussed later, especially in view of the species *P. articulatum* in which the receptacles arise terminally but become dorsal by adventitious apical shoots, like those of *Pressia commutata* (Goebel in Flora, Bd. 101, Figs. 19 and 20).

The appearance of the dorsal male receptacle of *Targionia* in exposed places is to be considered a still further reduction. The shoot begins to form vegetative tissue in place of antheridia, so that the latter instead of occupying the whole of the dorsal surface as they do in the modified ventral shoots, occupy only about one half of this. That the disc of the male shoots of *Targionia* is a reduced branch system is further proved by the occurrence of both the composite and the so-called simple receptacle in *Cyathodium tuberosum* where we can actually trace the transformation of the one into the other. In *Targionia* itself there is no trace left of the composite condition except the scattered scales.[1]

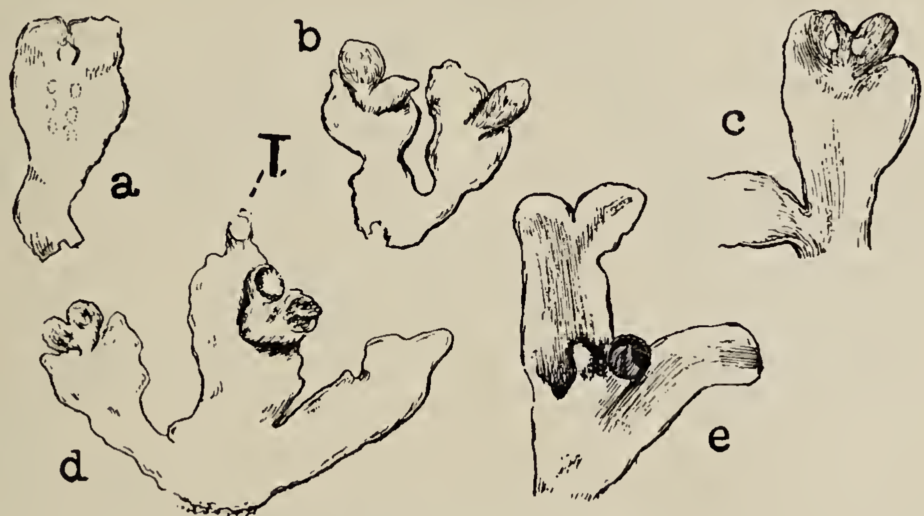


FIG. 3. *Aitchisoniella himalayensis*: *a*, plant with antheridia in two rows behind the female receptacle, × 5; *b*, *c*, *d*, plants showing various positions of female receptacle (*T*, thickened apex), *b* and *d* × 5, *c* × 6; *e*, plant with mature sporogonium, × 5.

AITCHISONIELLA HIMALAYENSIS KASHYAP.

The plants of this species were found growing on an exposed eastern slope only in one locality. They were discovered accidentally near the end of the vegetative season (the end of August). Although a diligent search was made they were not found anywhere else. The number of the plants was, therefore, rather small and almost all of them bore ripe capsules. Fortunately a few young specimens were found among some other liverworts, but it was not known at what particular place in Mussoorie the latter were collected. It is not probable that the species is rare, and the reasons why only a few plants were found are two. First, the search was made at the

[1] In this connexion it may be noted that Cavers ("Contributions to the Biology of the Hepaticæ," p. 8) states that the male branches "may give rise to secondary shoots, which may either develop new antheridial receptacles or even grow out as sterile shoots." This observation certainly appears to confirm the view here advanced that the male receptacle of *Targionia* is to be regarded as a reduced branch system.

end of the season when only a few plants would be alive. Secondly, this plant resembles a *Riccia* with which it was found growing and is very small so that it can be easily overlooked or mistaken for the *Riccia*, especially in the sterile state.

The thallus is dichotomously divided but sometimes the branches are so placed that the branching appears to be pinnate. The lobes are about 4 mm. long and at most 2 mm. broad, and are oblong-ovate with a small depression at the apex (Fig. 3, *a* to *d*). The plants have a light-green, rather greyish colour. The dorsal surface is perfectly smooth, no raised pores or areoles being visible. The pores, however, are present, being very minute, very little raised, simple and of the type found in the Astroporeæ. Each pore is surrounded by a single ring of six cells which have slightly thickened radial walls (Fig. 4, *a*). The cell walls of the rest of the uppermost layer are quite thin. A thin membrane projects far towards the centre of the pore from the margin (Fig. 4, *a*). The pores are pretty numerous and each leads to an air-chamber below. The chambers have no assimilating filaments and are in one or two layers especially well seen near the margins where the part of the wing forming the floor of the lowermost chamber is reduced to a single layer of cells. The chambers are quite small. They are directed forwards and for this reason a transverse section of the thallus shows several layers of these chambers but a longitudinal section shows mostly a single layer (Fig. 4, *b*, *c*). The ventral surface is hyaline or bluish. The thick midrib projects strongly below and the thallus is continued into the thin wings abruptly as seen at some distance behind the apex; near the apex the midrib gradually passes into the thin margins (Fig. 4, *a*, *e*). The rhizoids are attached to the midrib and are of both smooth and tuberculate kinds. The scales are arranged in two rows on the sides of the midrib so that the latter is not covered by them. They are small, distant, hyaline or bluish and do not project beyond the margins. Each scale is triangular or lunate and has an apical filamentous appendage of three to five cells. The cells of the young scales contain some chloroplasts. The terminal cell of the appendage contains mucilage and similar mucilage cells are also found projecting from the margins, and a few such cells are even found in the body of the scale (Fig. 4, *d*, *e*). Such mucilage cells in the body of the scale have also been observed by the writer in the scales of *Plagiochasma appendiculatum* and *P. articulatum*. The appendage of the scales bends over the growing point and protects it. The cells of the compact part of the thallus contain numerous starch grains. In the older parts of the thallus these cells are either empty or contain some minute grains stained brown with iodine.

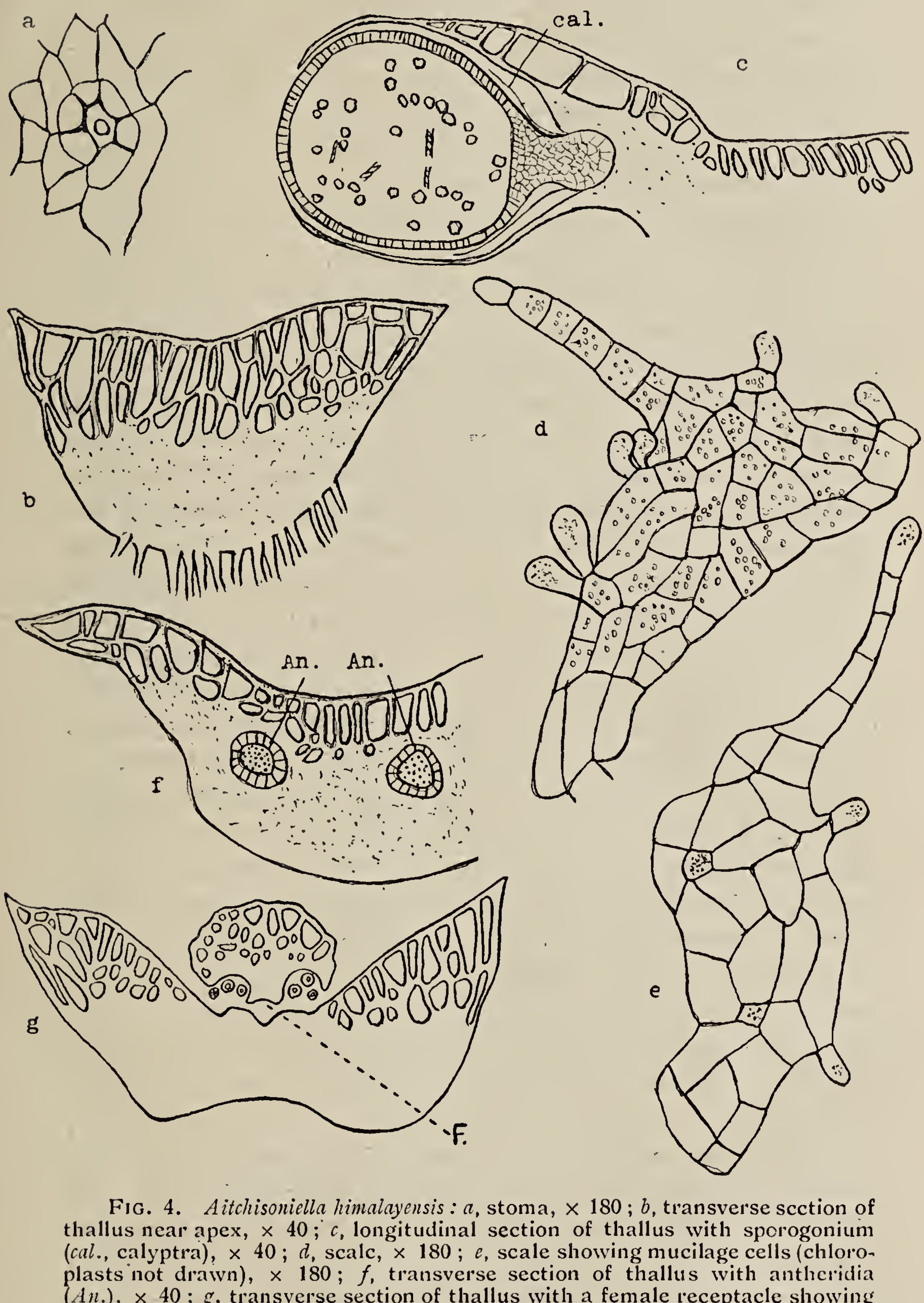


FIG. 4. *Aitchisoniella himalayensis* : *a*, stoma, × 180 ; *b*, transverse section of thallus near apex, × 40 ; *c*, longitudinal section of thallus with sporogonium (*cal.*, calyptra), × 40 ; *d*, scale, × 180 ; *e*, scale showing mucilage cells (chloroplasts not drawn), × 180 ; *f*, transverse section of thallus with antheridia (*An.*), × 40 ; *g*, transverse section of thallus with a female receptacle showing two grooves with archegonia (*F.*, furrow of receptacle), × 40.

We see, on the whole, that the structure of the thallus is like that of a *Clevea*, but the scales are not scattered on the ventral surface. They are in two rows.

The plant is monoecious. The antheridia are produced in two rows embedded in the thallus behind the female receptacle (Fig. 3, *a*). There is absolutely no indication of the presence of the antheridia in the fresh thallus from the outside. There are no projecting papillæ of the antheridial chambers as are found in most other Marchantiales. In spirit specimens the antheridia can be seen by means of a powerful magnifying lens under suitable conditions of light as round white bodies inside the thallus. On account of the small amount of material their development could not be traced. The ripe or almost ripe antheridium lies in close contact with the cells of the thallus and the separation of the thallus cells from the walls of the antheridium can be made out only with difficulty. Even in the microtome sections of the few specimens showing antheridia no trace of a papilla could be made out. Efforts will be made to obtain more material next year in order to work out the development and the dehiscence of the antheridium. The antheridium in the later stages of its development (Fig. 4, *f*) resembles that of *Cyathodium* or *Targionia*. It is, however, not elongated, but spherical and no stalk could be made out. The wall consists of a layer of hyaline cells which were very large and radially elongated in the specimens examined, so that they were very conspicuous. The spermatozoid mother cells did not present any peculiarity.

The female receptacle is very remarkable and variable in position. It may be terminal, lateral or in the fork between two branches (Fig. 3). The position is to be explained in the same way as the position of the male receptacle of *Cyathodium tuberosum*, i.e., some branches of the forking thallus develop as sterile shoots and others become female. The female shoot, however, is reduced to the receptacle. The receptacle may have a single involucre or the shoot may have branched forming two involucres side by side (Fig. 3, *b*). The mature receptacle is attached to the thallus by a small stalk-like constriction which has a distinct groove (Fig. 4, *g*) and a few scales on the anterior (ventral) side. The involucre in the mature state is an ovate body opening by a narrow circular mouth directed upwards and forwards. The dorsal tissue of the receptacle is the same as the dorsal tissue of the thallus and is *continuous* with it. The margins of the involucre are very thin and hyaline and the ventral part is only a single layer of cells in thickness and quite hyaline. The dorsal tissue has the usual pores found in the thallus and similar chambers in one layer directed obliquely forwards.

The receptacle arises as a small hemispherical body at the end of a shoot, but the main shoot, as pointed out before, often forks once or twice before this. The one or two small shoots were seen in several cases near the receptacles about the same level. In this receptacle, if it remains undivided, a vertical groove is present on the anterior surface in which five or six archegonia are produced one after another in one row by the apical cell which can be seen in vertical longitudinal sections below the youngest archegonium. This apical cell in such sections has the usual triangular outline and below it a thin ridge appears a little later which joins the growing margins of the groove. In the meantime the dorsal tissue grows forwards and transforms the groove into a large tubular structure. The archegonial neck consists of six rows of cells. If the receptacle forks and forms two involucres the grooves containing the archegonia are more or less lateral (Fig. 4, *g*).

The resemblance to *Targionia* and *Cyathodium* is obvious. If the shoot which is to form a receptacle, instead of forming the receptacle at once, were to grow a little before producing archegonia we would have a fertile shoot and a receptacle of the type of *Cyathodium* or *Targionia*.

The involucre contained only one ripe capsule in all the specimens examined, but in several cases two or three sporogonia were found in the very early stages. The calyptra is only a single layer of cells. The sporogonium resembles that of *Targionia* (Fig. 4, *c*). The foot is pretty well developed; its cells are densely granular and stain deeply. The seta is short, being a mere constriction between the capsule and the foot. The capsule is wholly like that of *Targionia*. The wall consists of a single layer of cells all of which are strengthened by annular and spiral thick bands. The apex of the capsule has some short elater-like cells with annular bands only attached to it, projecting below into the cavity of the capsule. Three or four short elaters are found fixed at the base of the capsule. Similar cells occur also in the capsule of *Targionia*. The elaters are simple or branched, trispiral and on the average 120μ long. They are fusiform as a rule, but in one case an elater was observed with one end expanded. The spores are 36μ in diameter, tetrahedral, and densely covered with round papillæ on the convex side. The spore-mother-cells do not become lobed at the time of division. The capsule does not come out of the involucre at maturity. It opens by the separation of a part of the apex irregularly.

The chief characters of the genus *Aitchisoniella* may be briefly summarized thus. Thallus of the type of the Astroporeæ, *i.e.*, with narrow chambers in one or two layers and pores with one ring of cells having slightly thickened radial walls; scales in two rows with terminal filamentous appendages; antheridia in two rows along midrib, imbedded in the thallus, behind the female receptacle; female receptacle terminal, lateral or in the fork between two branches, sessile, consisting of one or two involucres joined to the thallus by a stalk-like constriction; dorsal tissue of receptacle continuous with dorsal tissue of thallus; capsule included with a well developed foot; cells of the capsule-wall with thick annular and spiral bands.

It is obvious that the genus *Aitchisoniella* must be placed near *Targionia.* Although the structure of the thallus has some resemblance to that of the thallus in the Astroporeæ, the involucre, the group of archegonia in each involucre, the capsule-wall and to a less extent the ventral scales at once suggest its affinities with *Targionia.* The receptacle in *Aitchisoniella* may bear one involucre or two. In this respect it is midway between *Targionia* and *Exormotheca.* If we suppose the female receptance of *Exormotheca* to become sessile we should have a structure like the female receptacle of *Aitchisoniella* with the difference that the involucres in the latter are not directed so distinctly laterally as those of the former. But this difference can be easily understood by the absence of the peduncle, the small amount of the receptacle-tissue and the stoppage of growth soon after dichotomy. This resemblance between *Aitchisoniella* and *Exormotheca* is further increased if we take into account the position of the female receptacle in the two. We can thus arrange the three genera in a descending series taking into consideration the structure and position of the female receptacle which is admittedly the most important character for classification: (1) *Exormotheca*, (2) *Aitchisoniella*, (3) *Targionia.*

But it might be asked, why should we not arrange them in an ascending series? This, however, cannot be maintained. Apart from the arguments advanced by Goebel after his study of *Monoselenium*, the writer has strong evidence in the structure of *Stephensoniella* and *Plagiochasma articulatum*, which will be described later, that there has been a wholesale reduction in the Marchantiales. At present it is sufficient to call attention to the facts in connection with the male receptacle of *Cyathodium tuberosum.* This genus is undoubtedly reduced and is admitted as such by all. We can see in the species of *Cyathodium* described above the actual reduction of a composite receptacle into a simple disc by the transformation of some of the branches into vegetative shoots and the slight development of the rest so that the margin of the male receptacle does not show any lobes. Indeed, according to this view of wholesale reduction the guiding principle in the evolution of the living Marchantiales has been to increase the amount of vegetative tissue at the expense of the sexual organs and the sporophyte. The writer has already pointed out that in Mussoorie at least reproduction by spores hardly plays any part in the multiplication of the species. The great power of reproducing themselves by vegetative means possessed by all Hepaticæ everywhere indicates that the reproduction by spores in these plants is only of a secondary importance in these days. For this reason the complex receptacles and the complex sporophytes are disappearing and have disappeared in all probability in ancient times.

If a male receptacle can be transformed from a composite type to a simple type as in *Cyathodium tuberosum*, and even such a type again to a mere cushion on the vegetative shoot which is the case in *Targionia*, surely the female receptacle may undergo the same changes, particularly when we find intermediate stages, like the receptacle of *Aitchisoniella*, between *Targionia* and *Exormotheca*. If in *Aitchisoniella* the shoot which is going to form a female receptacle produced at first for some time vegetative tissue, we would have a female branch of *Targionia* type, in which the shoot does not fork and there is therefore only one receptacle. But if the shoot forks, or two or more shoots close to each other behave similarly, we would have a female plant of the type of *Cyathodium tuberosum*. Just as the male receptacle of this species is derived from a composite receptacle by reduction, similarly the female shoot of this plant must have been derived from a composite receptacle possessing many involucres. This view would also explain the fan-shaped appearance of the female plants. We know two involucres are often found in the genus *Aitchisoniella*. Thus *Targionia* and *Cyathodium* may be compared as simple and compound types, while *Aitchisoniella* is intermediate. It is probable, in view of the numerous differences between the two former genera, particularly as regards the sporogonium, that they have arrived at the same structure as regards the female receptacle by parallel evolution. The presence of a composite male receptacle in *Cyathodium tuberosum* along with the facts of the structure of the