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Studies on the Affinity Regarding the Conducting Tissue of the Sporophyte in the Musci

(2) On the Seta in Some Species of the Family Polytrichaceae

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Introduction

The bryological anatomist has first to remind himself that in the study of the stems and leaves of mosses, and that of the tissues which they display, he is dealing with structures that have no direct counterpart in vascular plants. He is, in a word, examining gametophyte structures, whereas the whole organized anatomical studies of the structure of pteridophytes aud seed plants, including vascular bundles, xylem and the rest, are concerned with the sporophyte. If we are to look among bryophytes for the strict counterpart of these features, then we must look in the capsule, seta and foot. Anything found in the gametophyte will be at most a parallel development. We do indeed find, among the larger gametophytes of mosses and liverworts, quite a complex tissue differentiation. In the best-developed sporophytes we find epidermis, stomata, water-storage tissue, chlorophyllous tissue and some kind of conducting parenchyma; but of genuine vascular strands, as understood among higher plants, we find no trace whatever. Spiral thickenings in columella cells of *Dendroceros crispus* have, however, been noted by PROSKAUER. LORCH, in his very full account of the anatomy of mosses, alludes to the central strand that is sometimes, but not always, present in the foot. He also shows that the seta can at times display marked tissue differentiation. This is so, for example, in the Australian moss, *Dawsonia polytrichoides*, the seta of which LORCH figures in transverse section. Around well-developed central strand this seta has a sheath of cells strongly suggestive of endodermis. The seta is often notable for a number of thick-walled cells in its composition, especially near the surface, where for mechanical reasons they are most needed. Thick walls are found too in the epidermal cells of the capsule(exothecial cells); but according to LORCH these are not always lignified. If woodiness is absent, however, cutinization is apparently widespread on the surfaces of these organs. LORCH quotes the earlier work of STRUNK's on the widespread occurrence of cuticle in mosses, and some kind of cuticular covering is probably

responsible for the high gloss normally seen on seta and capsule. Without it the green capsule would be very vulnearable to desiccation (E.V.WATSON 1964).

The mature sporogonium consists of a foot, a long seta and a capsule. The foot is embedded in the tissue of the apex of the archegonial branch and consists of thin-walled parenchymatous cells. Just above the foot and continuous with it is the long slender seta, which supports the capsule at its apex. A transverse section of the seta shows the following tissues. On the outside there is a superficial layer of cells with thick walls. Inside the superficial layer(epidermis)is a band of brown sclerenchymatous cells, which merges internally into thin-walled green parenchymatous cells with intercellular spaces. The axial tissue of the seta forms a central strand, without intercellular spaces, and consists of cells essentially similar to those in the gametophore axis, but usually of much simpler structure.

Taxonomic considerations of the conducting tissue T. KOPONEN (1968) described as follows: "The stem of the species of the family Mniaceae consists of an epidermis which is one or several cell layers thick, the parenchymatous cortex and the central conductive strand. In the cortex there are smaller strands of conductive tissue called false leaf traces. They are downward continuations of the conductive strands of leaves which end blindly without reaching the central conductive strand. The stem epidermis shows characters which may have taxonomic significance. In the tribes Mnieae and Cinclidieae the epidermis consists mainly of one cell layer with strongly thickened cell walls. In the mature stem parts the cell wall is thickened by an inner, often clearly defined, secondary layer, which nearly fills the lumen of the cell. In *Rhizomnium*, *Cinclidium* and *Cyrtomnium* the secondary layer usually turns bright yellow when treated with KOH solution; in *Mnium*, *Leucolepis* and *Trachycystis* it often assumes a brownish or reddish colour. In *Cinclidium stygium* the radial walls are seen to be more strongly thickened than the tangential ones and the lumen has a characteristically narrow shape. In other *Cinclidium* species and in other genera all the walls thicken equally, or the outermost wall is the thinnest. This is especially characteristic in *Trachycystis*, in which the outermost cell wall may disappear in old stem parts producing a distinctive structure. According to LORCH the yellow secondary wall layer of *Cinclidium stygium* consists of almost pure cellulose. In *Plagiomnium*, *Orthomnium* and *Orthomniopsis* the epidermis is composed of two or more layers of cells. In typical cases the cell walls show no or only slight secondary thickening. Such thickening was seen in some mature stem parts, e.g. in *Plagiomnium cuspidatum*, but in no case did it reach the degree observed, for instance, in *Mnium*. The same type of thickening was found to be present in *Bryum*, *Rhodobryum* and *Roellia*. In the stems of *Pseudobryum cinclidioides* and P. *speciosum* the main thickening takes place in the tangential walls between the first and the second cell layers. In addition, the outermost wall of the epidermis is extremely thin, especially in P. *cinclidioides*. In old stems the thin wall disappears in the same way as in *Trachycystis*. Similar thickening of the tangential walls is present in *Bryomnium*. In the following, the three different types

of epidermis are called the *Bryum*, *Mnium* and *Pseudobryum* types. Each type seems to occur throughout a given genus and they can therefore be included among the generic characters. The *Mnium* type is most striking and seems to separate the tribes Mnieae and Cinclidieae from the other groups. As regards the structure of the stem epidermis, the *Bryum* type is most probably the original one. The *Mnium* type is more complicated, and although slight secondary thickening was found in some *Bryum* and *Plagiomnium* species it has not advanced so far in them as in the tribes Mnieae and Cinclidieae. The *Mnium* type was also present in all the *Rhizomnium* species studied. The *Pseudobryum* type differs less distinctly from the *Bryum* type, but is, however, characteristic, and, being more complicated than the *Bryum* type, is probably derived. The three types described are also present in other groups of mosses. A large number of stereids in the costa is probably a more primitive character than a small number or their absence. In several genera of Bryaceae they are numerous, practically filling the costa. Thus *Leucolepis* is the most primitive genus within Mniaceae in this respect. The two main phylogenetic branches, Mnieae-Cinclidieae and Plagiomnieae, include species with both bands of stereids which suggests that this situation is the original one. Otherweise this rather complicated structure must have originated on two separate occasions. *Mnium stellare* and *Rhizomnium* sect, *Micromnium* offer evidence of the reduction of stereids".

As described above, T. Koponen (1968) has pointed out that these characters shown in the conducting tissue of the gametophyte, the midrib of leaf and the stem, can be taken into consideration in the taxonomic discussion. I have also considered the characteristics of the midrib of 276 species in Musci and they are found to show some differences from species to species and to be peculiar to the species. Moreover, in the species belonging to the identical genus and family, it is proven that there is something in common among the characteristics of the inner structure of the midrib. Seeing that there is a peculiar character to the species in the inner structure of the midrib and something in common among the characteristics of the midribs in the species belonging to the identical genus and family, I think that these characteristics have to be given due emphasis in taxonomical studies (Kawai 1968). Studies on the conducting tissue and the stem of gametophyte have been made by many other bryologists, too; in Musci (Takaki 1953, 1955, 1964, 1966, 1967 ; Ando 1957 ; Augier 1966 ; Reese 1956, 1961 ; Robinson 1959, 1964 ; Iwatsuki 1956, 1957, 1958, 1959, 1963, 1965 ; Williams 1911, 1920, 1921, 1924, 1925, 1926, 1928, 1930, 1932 ; Crum 1957, 1959) and in Hepaticae (Bischler 1962 ; Kitagawa 1964, 1965, 1966, 1967).

Anatomy of the seta and foot I have made observations of the conducting tissue of the seta and foot (sporophyte) in *Pogonatum spinulosum* Mitt. and *Atrichum undulatum* (Hedw.) P.Beauv. (Kawai 1969). The conducting tissue of the sporophyte differentiates most in the seta in both of the species, that is, into an epidermis of thick-walled cells, cortical sclerenchyma, cortical parenchyma with intercellular spaces, an endodermal layer and a central strand consisting of rather thick-walled

cells and a central mass. The epidermis is one cell layer of the smaller fulvescent cells with thick walls. The epidermal cells are stained orange with fuchsin. Inside the superficial layer is a band of brown sclerenchymatous cells, external cortex, which, containing a few chloroplasts, merges internally into sparsely spaced, thin-walled green parenchymatous cells, internal cortex, containing a great number of chloroplasts. This layer of chloroplast-containing parenchymatous cells with intercellular spaces may be a part of the assimilation tissue in the sporophyte. At the inner limit of these cortical layers, which are a band of brown sclerenchymatous cells and a layer of thin-walled green parenchymatous cells, is a layer, one cell thick. This layer resembles the endodermis of the stem. The cells of the endodermal layer and the thin-walled green parenchyma are much alike in characters such as shape, size and cell wall. The axial cylinder consists of an inner compact mass of tissue. The central mass consists mainly of extremely thin-walled, smaller living cells. Between an endodermis-like layer and the central mass are two to three layers of thin-walled polygonal living cells. The foot within the gametophytic shoot differentiates into an epidermis, cortex and central strand, of which the latter is surrounded by cortical tissue containing chloroplasts. In the foot such a tendency is in evidence as the lower the part of the foot is, the less differentiation is shown in the inner structure, and all the part embedded in the gametophytic tissue is not a foot. The lower part of the seta is also embedded in the tissue of the apex of an archegonial branch. Thus I perceive some striking differences between the inner structures of the seta and the foot.

Material and methods

The main source of material used for this research comprises specimens of mosses collected from Japan and Germany. All the samples studied are deposited in the Moss Herbarium of Kanazawa University.

Bartramiopsis lescurii (JAM.) KINDB. : Mt. Hakusan Ishikawa Pref. (33259) ; Mt. Oodaigahara Nara Pref. (34965). *Atrichum undulatum* (HEDW.) P.BEAUV. : Mittfeld Kreis Harburg Germany (30063) ; Mt. Rokumanzan Ishikawa Pref. (33240) ; Mt. Hakusan Ishikawa Pref. (33244) ; Bettodeai Ishikawa Pref. (36323) ; Mt. Kenzan Tokushima Pref. (30503) ; Ishikiri Shizuoka Pref. (30508) ; Hittfeld Kreis Harburg Germany (30571) ; Jesteburg Kreis Harburg Germany (30693) ; Omata Shizuoka Pref. (30890). *Atrichum undulatum* (HEDW.) P. BEAUV. var. *minus* (L. et D.C.) WEB. et MOHR. : Agata Miyazaki Pref. (35186) ; Mt. Hakusan Ishikawa Pref. (34813). *Pogonatum spinulosum* MITT. : Mt. Hakusan Ishikawa Pref. (32218) ; Keta Shizuoka Pref. (30934). *Pogonatum grandifolium* (LINDB.) JAEG. : Mt. Ontake Gifu Pref. (34960) ; Kami-ina Nagano Pref. (35161) ; Mt. Kenzan Tokushima pref. (30371) ; Mt. Hakusan Ishikawa Pref. (35330) ; Mt. Rokumanzan Ishikawa Pref. (32026) ; Mt Hakusan Ishikawa Pref. (35328) ; Mt. Kenzan Tokushima Pref. (30373) ; Ooshirakawa Gifu Pref. (30911) ; Mt. Huji Shizuoka Pref. (30459). *Pogonatum contortum* (SCHWAEGR.) SULL. ;

Mt. Hakusan Ishikawa Pref. (35332) ; Mt. Rokumanzan Ishikawa Pref. (32177) ; Miyoshi Tokushima Pref. (30451) ; Nagoro Tokushima Pref. (30448) ; Mt. Huji Shizuoka Pref. (30452). *Pogonatum inflexum* (Lindb.) Par. : Keta-shrine Ishikawa Pref. (30822) ; Nishihiba Nagasaki Pref. (34641) ; Mt. Rokumanzan Ishikawa Pref. (31941) ; Ishikiri Shizuoka Pref. (30465) ; Omata Shizuoka Pref. (10131) ; Unoya Ishikawa Pref. (11395) ; Iyadani Tokushima Pref. (30477) ; Kankakei Kagawa Pref. (15478) ; Ichiu Tokushima Pref. (30462). *Pogonatum nipponicum* Noguchi et Osada : Yana Aichi Pref. (35197) ; Mt Jinkakuji Ooita Pref. (35183) ; Ishikiri Shizuoka Pref. (30471). *Polytrichum piliferum* Hedw. : Wiedenthal Kreis Harburg Germany (30163) ; Evendorf Kreis Harburg Germany (33413) ; Wiedenthal Kreis Harburg Germany (30158) ; Reinfeld Holstein Bezirk Germany (30164). *Polytrichum juniperinum* Hedw.: Mt. Gaki Nagano Pref. (35088) ; Chugu Ishikawa Pref. (35369) ; Jesteburg Kreis Harburg Germany (34012) ; Metzendorf Kreis Harburg Germany (30166) ; Wiedenthal Kreis Harburg Germany (30945) ; Mt. Hakusan Ishikawa Pref. (35317) ; Mt. Huji Shizuoka Pref. (30356) ; Hujimiyaguchi Shizuoka Pref. (30484) ; Harburg Kreis Harburg Germany (30167). *Polytrichum commune* Hedw. : Mt. Chausu Aichi Pref. (35028) ; Mt. Rokumanzan Ishikawa Pref. (33303) ; Hamstedter Berge Kreis Harburg Germany (30171) ; Mt. Hakusan Ishikawa Pref. (33245) ; Reinfeld Holstein Bezirk Germany (30172). *Polytrichum formosum* Hedw. : Ooshirakawa Gifu Pref. (11989) ; Inuyama Aichi Pref. (35200) ; Sendai Miyagi Pref. (34894) ; Mt. Rokumanzan Ishikawa Pref. (31122) ; Harburg Kreis Harburg Germany (30084) ; Mt. Hakusan Ishikawa Pref. (35361) ; Mt. Sanpogan Gifu Pref. (33268) ; Iwama Ishikawa Pref. (34829).

For anatomical studies, microtome sections of the fresh moss are prepared by the ethylalcohol-buthylalcohol-paraffin method, following Bouin's fluid fixation. Before examination the dry moss is boiled in water for about half an hour. The transverse sections are mounted in gum arabic and sealed immediately with varnish.

Observation

As stated before, on the outside of the seta there is a brown superficial layer of the smaller cells with strongly thickened walls (epidermis). The epidermis usually turns orange when treated with fuchsin solution. Inside the epidermis is a band of brown sclerenchymatous cells, which, containing a few chloroplasts, merges internally into sparsely spaced, thin-walled green parenchymatous cells containing a great number of chloroplasts. I name external cortex the band of brown sclerenchymatous cells containing a few chloroplasts. The external cortex has several cell layers with strongly thickened cell walls and is considered to be a mechanical tissue. I name internal cortex the thin-walled green parenchyma with intercellular spaces which consists of globe- or ovoid-shaped cells. The internal cortex containing a great number of chloroplasts may be a part of the assimilation tissue in the sporophyte. At the inner limit of these cortical

layers, which are a band of brown sclerenchymatous cells and a band of green parenchymatous cells, is a layer, one cell thick. This layer, of which the cells are also green thin-walled parenchymatous cells containing a great number of chloroplasts and bear a striking resemblance to the cells of the internal cortex, has many points of likeness to the endodermis of the stem. The central strand, in which two tissues are distinct one from the other, consists in an inner compact mass. The central mass, of which the walls hardly turn violet when treated with gentian violet solution, consists mainly of extremely thin-walled, smaller living cells. Between an endodermal layer and the central mass are one or several layers of thin-walled polygonal living cells. The cell walls of these layers which are thicker than those of the central mass, usually turn violet when treated with gentian violet solution. All the species of the family Polytrichaceae used for the present study have the seta consisting of tissues as stated above, except for the species of *Bartramiopsis lescurii* (JAM.) KINDB.

In *Bartramiopsis lescurii* (JAM.) KINDB., the seta differentiates into an epidermis of very thick-walled cells, an external cortex consisting of three layers of sclerenchymatous cells, an internal cortex of a parenchymatous layer with intercellular spaces, an endodermal layer and a central strand consisting of uniform cells. It is only in the species of *Bartramiopsis lescurii* (JAM.) KINDB. that the central strand doesn't differentiate into two tissues (Fig. 2)

In *Atrichum undulatum* (HEDW.) P. BEAUV., the seta differentiates into an epidermis of very thick-walled cells, an external cortex consisting of two layers of sclerenchymatous cells, an internal cortex consisting of two layers of parenchymatous cells with intercellular spaces, an endodermal layer and a central strand consisting of two kinds of tissues, that is, one is a band of two cell layers of slightly thick-walled cells and the other is a central mass with a cross section consisting of about fifteen extremely thin-walled cells. (Fig. 12)

The seta of *Atrichum undulatum* (HEDW.) P.BEAUV. var. *minus* (L.et D.C.) WEB. et MOHR. has an epidermis of thick-walled cells, an external cortex of three to four sclerenchymatous layers, an internal cortex consisting of two chlorophyllous cell layers with intercellular spaces, an endodermal layer, an outer slightly thick-walled cell layer of the central strand, and a central mass consisting of about ten cells with extremely thin walls. (Fig. 7)

The seta of *Pogonatum nipponicum* NOGUCHI et OSADA consists of an epidermis, the sclerenchymatous cortex, the parenchymatous cortex and the central conductive strand. The epidermis is one cell layer thick with brown sclerenchymatous cells. The sclerenchymatous cortex consists of about five-brown cell layers containing a few chloroplasts. The distinction between the sclerenchymatous cortex and the epidermis is not clear in size and shape of cells. Inside the sclerenchymatous cortex there are thin-walled green parenchymatous cells with intercellular spaces. The parenchymatous cortex named an internal cortex, of which the cells are globe- or ovoid-shaped, contains a great number of chloroplasts. At the inner limit of these cortical layers,

there is an endodermal layer which consists of cells similar to those of the internal cortex. There is a central conductive strand in the central part of the seta. The central strand differentiates into outer three cell layers and central cells with extremely thin walls (Fig. 8).

In *Pogonatum spinulosum* MITT., the epidermis, which is made up of one cell layer, has more thickened cell-walls than any other parts. The cortical layers which generally exist between the epidermis and the endodermal layer, differentiate into an external cortex consisting of three to four sclerenchymatous cell layers with a few chloroplasts and an internal cortex consisting of about two parenchymatous cell layers with intercellular spaces. The internal cortex contains a great many chloroplasts and is thought to be an assimilation tissue. The endodermal layer inside the internal cortex also contains many chloroplasts. The cell-wall of outer layers in the central strand are slightly thickened and turn usually violet when treated with gentian violet solution. The central mass , however, which consists of about fifteen extremely thin-walled cells, doesn't turn violet with gentian violet (Fig. 10).

The seta of *Pogonatum inflexum* (LINDB.) PAR. has one layer of the epidermis like that of *Pogonatum spinulosum* MITT. and *Pogonatum nipponicum* NOGUCHI et OSADA. The external cortex consists of four sclerenchymatous layers and the internal cortex consists of two parenchymatous layers. The internal cortex, of which the cells contain a great number of chloroplasts, consists of two parenchymatous layers with intercellular spaces. Inside the endodermal layer there are an outer band, which consists of two to three cell layers with slightly thick cell walls, and a central mass, which doesn't turn violet with gentian violet solution (Fig. 6).

The epidermis and the external cortex of *Pogonatum grandifolium* (LINDB.) JAEG. are much the same as those of *Pogonatum inflexum* (LINDB.) PAR. But the features that the internal cortex consists of one layer and that the outer band of the central strand consists of three to four cell layers, mark *Pogonatum grandifolium* (LINDB.) JAEG. off from *Pogonatum inflexum* (LINDB.) PAR. The central mass shows about eighteen cells in its section (Fig. 3).

The seta of *Pogonatum contortum* (SCHWAEGR.) SULL. is almost the same as that of *Pogonatum inflexum* (LINDB.) PAR., namely, differentiates into an epidermal layer, about four external cortical layers, two to three parenchymatous layers of the internal cortex, one endodermal layer, two to three outer layers of the central strand with slightly thick-walled cells, but the central mass of *Pogonatum contortum* (SCHWAEGR.) SULL. is slightly larger than that of *Pogonatum inflexum* (LINDB.) PAR. (Fig. 5).

In *Polytrichum piliferum* HEDW., the epidermis, which is made up of one cell layer, has much more thickened cell walls than other parts, as in the other species of Polytrichaceae. The cortical layers which generally exist between the epidermis and the endodermal layer, differentiate into an external cortex consisting of about five sclerenchymatous cell layers with a few chloroplasts and an internal cortex consisting

of a parenchymatous layer with intercellular spaces. The internal cortex contains a great number of chloroplasts and is thought to be an assimilation tissue. The endodermal layer inside the internal cortex also contains many chloroplasts. The cell-walls of outer layers in the central strand are slightly thickened and usually turn violet when treated with gentian violet solution. The central mass consists of about ten parenchymatous cells (Fig. 4).

The seta of *Polytrichum formosum* HEDW. differentiates into an epidermis, an external cortex of eight cell layers, an internal cortex of two cell layers, an endodermal layer, two outer layers of the central strand and a central mass consisting of about ten cells (Fig. 11).

The seta of *Polytrichum juniperinum* HEDW. differentiates into an epidermis, an external cortex of six cell layers, an internal cortex of two to three cell layers, an endodermal layer, four to five outer layers of the central strand and a central mass consisting of about forty cells (Fig. 9).

The seta of *Polytrichum commune* HEDW. differentiates into an epidermis, an external cortex of eight cell layers, an internal cortex of two to three cell layers, an endodermal layer, five to six outer layers of the central strand and a central mass consisting of about forty cells (Fig. 1).

The feature that the central mass is absent, marks *Bartramiopsis lescurii* (JAM.) KINDB. off from the other species of Polytrichaceae. And the features that the external cortex consists of six to eight cell layers, that the cortical layers (external and internal) consists of eight to eleven cell layers and that the diameters of the seta, the central strand, the central mass are each 0.5 to 1 mm, 0.15 to 0.28 mm, 50 to 70μ, mark off the species of *Polytrichum* (*P. commune* HEDW., *P. juniperinum* HEDW., *P. formosum* HEDW.), from the species of *Pogonatum*, *Atrichum*, *Bartramiopsis* (Tab. I).

Summary

In twelve species of the family Polytrichaceae, the anatomy of the seta is observed and comparatively studied. However, dry mosses as well as fresh materials are used for this study ; some of them are mature while others are too young for me to observe the complete pattern of the transverse section of the seta. Therefore, all of the twelve species are not studied sufficiently to obtain the complete anatomy of the seta. Besides variation in the same species is known to exist. These facts make it very difficult to determine the representative structure of the seta of a species. However, the degree of variation is not so great as to obscure the specificity of a species. Only in the species of *Bartramiopsis lescurii* (JAM.) KINDB., the central mass of parenchymatous cells is missing. The characteristics that the external cortex consists of six to eight cell layers, that the cortical layers consist of eight to eleven cell layers and that the diameters of the seta, the central strand, the central mass are respectively 0.5 to 1 mm, 0.15 to 0.28 mm, 50 to 70μ, mark off the species of *Polytrichum* (*P. commune* HEDW., *P.*

Tab. I The relationship of twelve species of the family Polytrichaceae as classified on the basis of affinity in characteristics of the inner structure of the seta.

	Epidermal layer (one cell in thickness : A)	External cortex (3, 4, 5 cells in thickness : A; 6, 7, 8 cells in thickness : B)	Internal cortex (1 cell in thickness : A; 2, 3 cells in thickness : B)	Number of cell layers of the cortex	Endodermal layer (one cell in thickness : A)	Outer layers of the central strand (1, 2, 3 cells in thickness : A; 4, 5, 6 cells in thickness : B)	Central mass of the central strand (10–20 cells : A; 21–40 cells : B)	Diameter of seta (0.25–0.5mm : A; 0.525–0.75mm : B ; 0.775–1mm : C)	Diameter of central strand (75–150μ : A ; 175–275μ : B)	Diameter of central mass (25–50μ : A; 52.5–75μ : B)	
Polytrichum commune Hedw.	B	B	B	B	B	A	11	B	B	A
Polytrichum juniperinum Hedw.	B	B	B	B	B	A	9	B	B	A
Polytrichum formosum Hedw.	B	B	B	A	A	A	10	A	B	A
Polytrichum piliferum Hedw.	A	A	A	A	A	A	6	A	B	A
Pogonatum contortum (Schwaegr.) Sull.	A	A	A	A	A	A	7	B	A	A
Pogonatum grandifolium (Lindb.) Jaeg.	A	A	A	A	A	A	5	A	A	A
Pogonatum inflexum (Lindb.) Par.	A	A	A	A	A	A	7	B	A	A
Pogonatum spinulosum Mitt.	A	A	A	A	A	A	5	A	A	A
Pogonatum nipponicum Noguchi *et* Osada	A	A	A	A	A	A	7	A	A	A
Bartramiopsis lescurii (Jam.) Kindb.	A	A	A	—	A	A	4	A	A	A
Atrichum undulatum (Hedw.) *P.* Beauv.	A	A	A	A	A	A	4	A	A	A
Atrichum undulatum var. *minus* (L. et D. C.) Wed. et Mohr.	A	A	A	A	A	A	6	A	A	A

juniperinum HEDW., *P. formosum* HEDW.) from the species of *Pogonatum*, *Atrichum*, *Bartramiopsis*. Also all the *Pogonatum* species agree with each other in the number of outer layers of the central strand. Thus several characteristics of the inner structure of the seta are to a certain degree specific to the genus and the degree of differentiation is different from species to species. Seeing that affinity in terms of such structural characteristics is definitely present, I conclude that these characteristics have to be given due emphasis in taxonomical studies.

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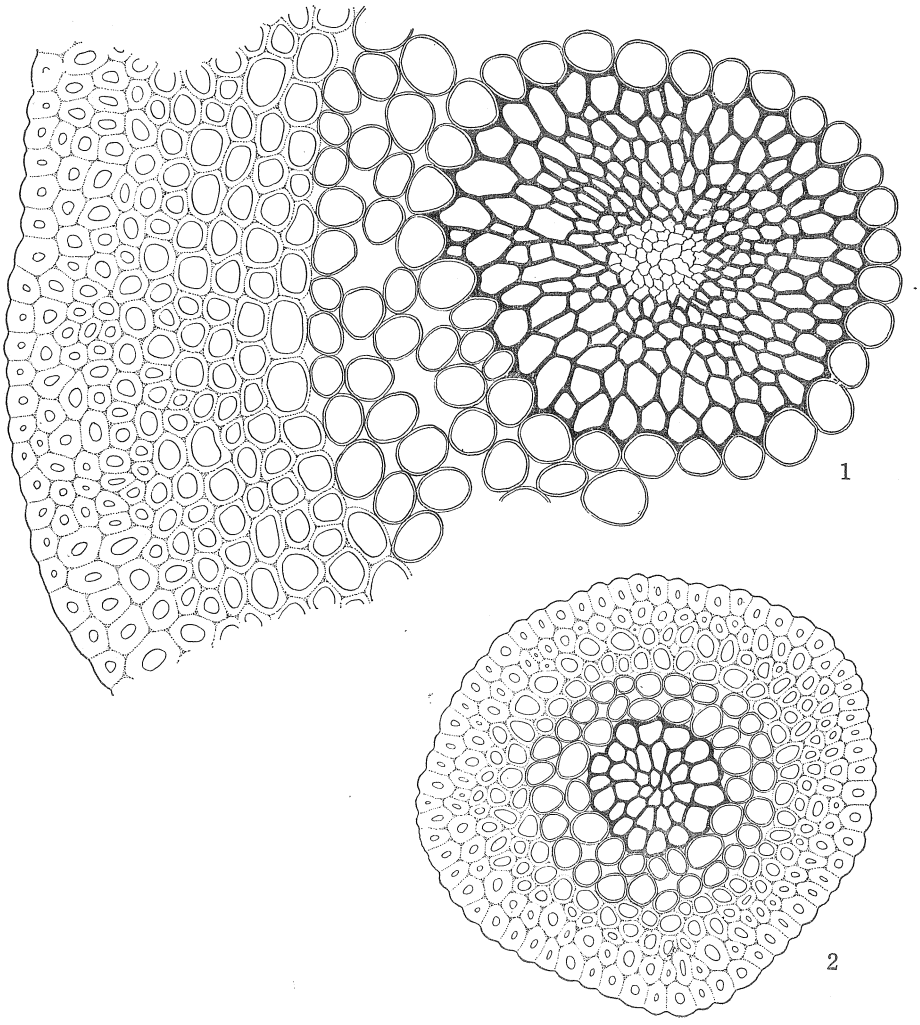
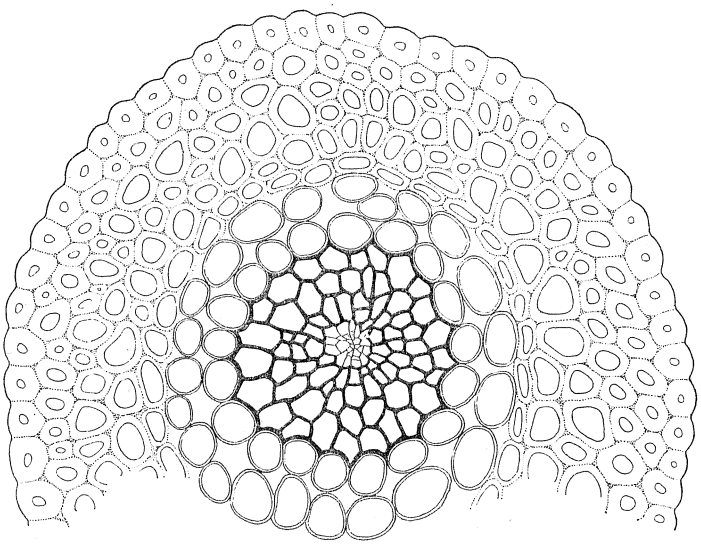


Plate I. Cross section of seta.

Fig. 1 : *Polytrichum commune* HEDW. ×200
Fig. 2 ; *Bartramiopsis lescurii* (JAM.) KINDB. ×200



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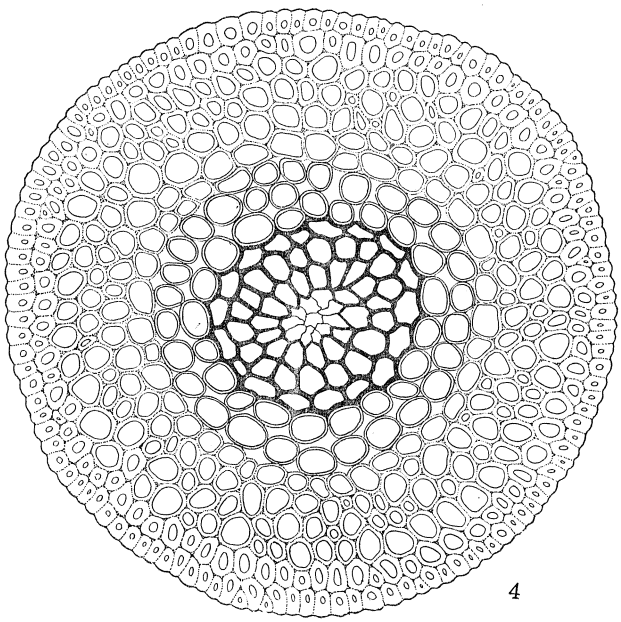

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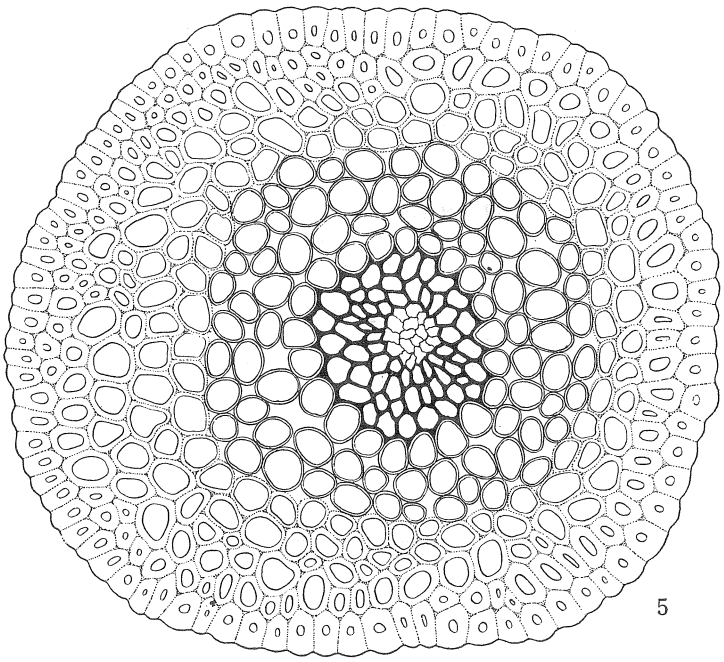
Plate II. Cross section of seta.

Fig. 3 : *Pogonatum grandifolium* (LINDB.) JAEG. ×200

Fig. 4 : *Polytrichum piliferum* HEDW. ×200



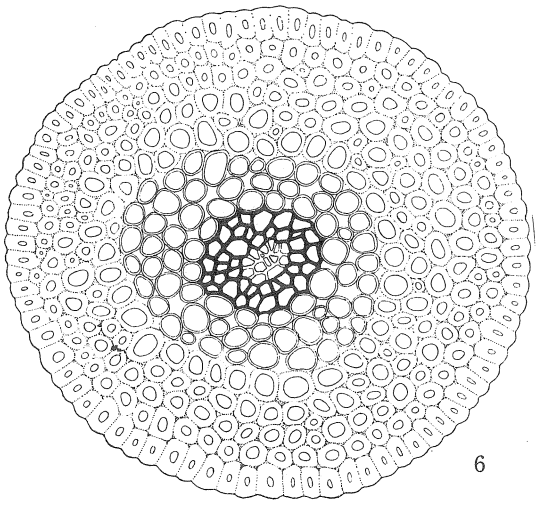
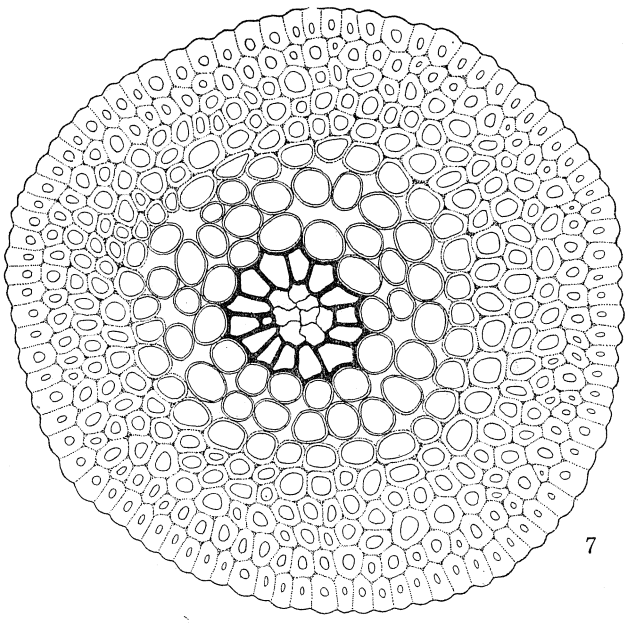


Plate III. Cross section of seta.

Fig. 5 : *Pogonatum contortum* (SCHWAEGR.) SULL. ×200

Fig. 6 : *Pogonatum inflexum* (LINDB.) PAR. ×200



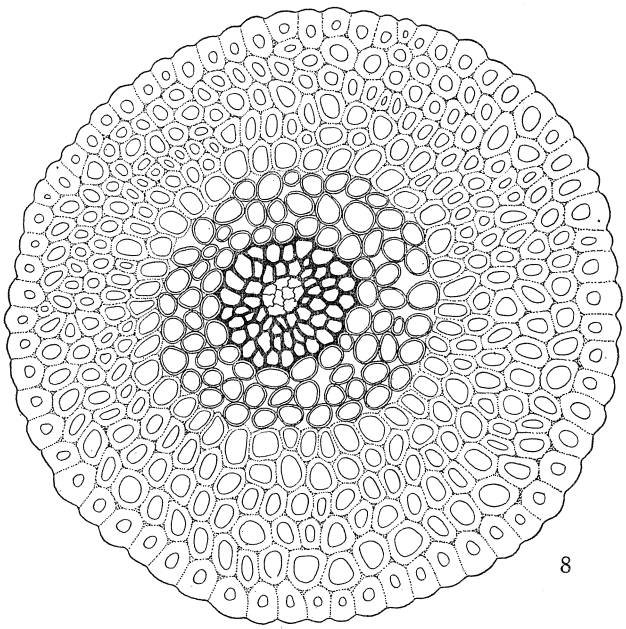
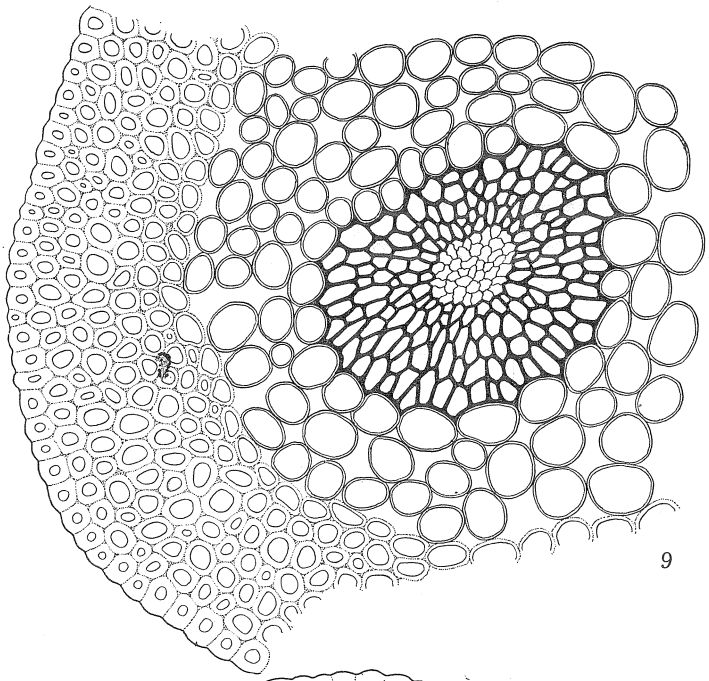


Plate IV. Cross section of seta.

Fig. 7 : *Atrichum undulatum* (HEDW.) P. BEAUV. var. *minus* (L. et D. C.) WEB. et MOHR. ×200
Fig. 8 : *Pogonatum nipponicum* NOGUCHI et OSADA ×200



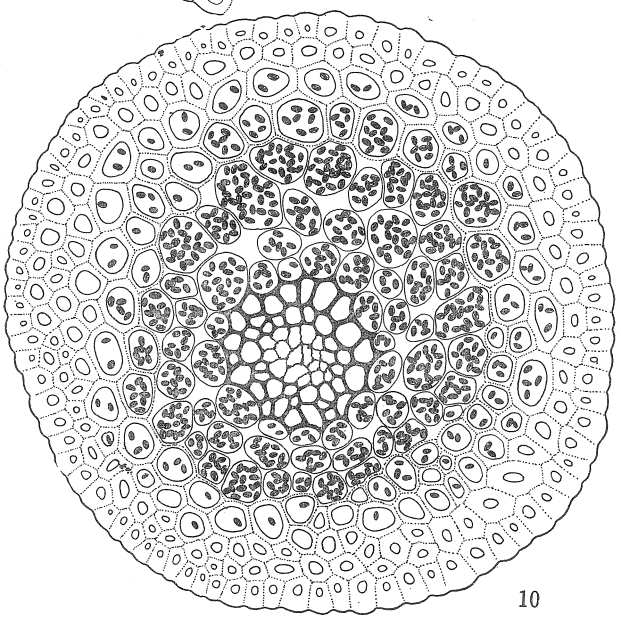
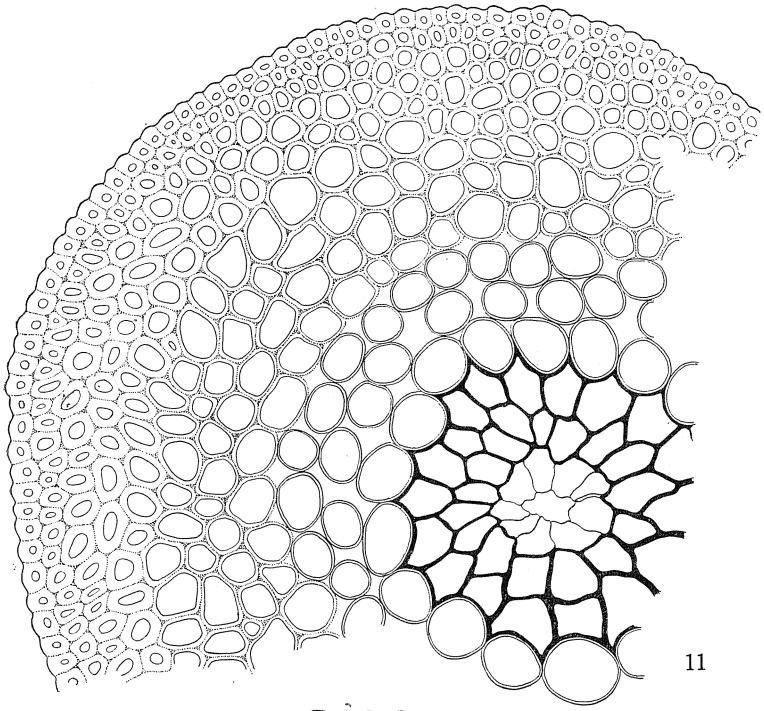


Plate V. Cross section of seta.

Fig. 9 : *Polytrichum juniperinum* HEDW. ×200
Fig. 10 : *Pogonatum spinulosum* Mitt. ×200



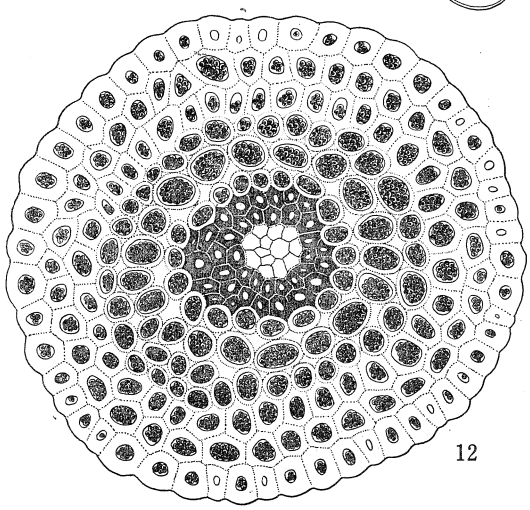


Plate VI. Cross section of seta.

Fig. 11 : *Polytrichum formosum* HEDW. ×200

Fig. 12 : *Atrichum undulatum* (HEDW.) P. BEAUV. ×200