Tropical Bryology 3: 37-44

On the anatomy of the costa in Fissidens

M. A. Bruggeman-Nannenga

Institute of Systematic Botany, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands

Abstract. Based on a study of ca. 120 *Fissidens* species covering all sections and subgenera, three types of costae are recognized. One type is characteristic of sect. *Amblyothallia* and of *F. asplenioides, F. fasciculatus* and *F. plumosus* (the fasciculatus-group); the second of subg. *Semidium*, subg. *Fissidens* sect. *Crispidium* and *F. grandifrons* (subg. *Pachyfissidens*) and the third type of subg. *Fissidens* sect. *Fissidens,* sect. *Aloma*, sect. *Crenularia*, sect. *Semilimbidium*, sect. *Pycnothallia*, and sect. *Areofissidens*, subg. *Octodiceras*, and subg. *Sarawakia.*

Introduction

In a previous paper (Bruggeman-Nannenga & Berendsen 1988) it was shown that the peristome in the Fissidentaceae furnishes good additional characters to those traditionally used in the classification of the family into subgenera and sections. Unfortunately, many specimens of *Fissidens* are sterile and some species are known only in the sterile condition. Moreover, there are many species with anomalous peristomes. The structure of the costa appears to be another useful character in the classification of the family.

Material and methods

Stems or leaves were embedded in wax as described by Taylor (1958) and then sliced with a razor blade.

Cell types. In the costae of *Fissidens* there are three types of cells: guide cells, large central cells, and small cells that vary from stereids to substereids to cells with somewhat larger lumina, and slightly incrassate walls. Most authors consider the central large cells as guide cells. Lorentz (1867-1868) studied the development of the costae of many mosses. According to him each costal initial divides into a ventral (= adaxial) and a dorsal cell. The guide cells develop from the ventral cells. The guide cells may divide once more into an abaxial guide cell and an adaxial cell that gives rise to the ventral stereid band. The dorsal cells formed by the first division divide many times more and form the dorsal stereid band. In *Fissidens* the median dorsal cells do not divide as often as the lateral ones; they give rise to large cells with thin walls, the large central cells. Thus there is not one dorsal stereid band, but two lateral stereid bands separated by large central cells. Lorentz called these large cells the conjunctivae or conductivae since they connect the guide cells with the dorsal lamina. In some cases the large central cells are in part of the leaf separated from the guide cells by a uninterrupted dorsal stereid band (Fig. 1a).

The following descriptions of the costal types apply to the duplicate part of the leaf since the

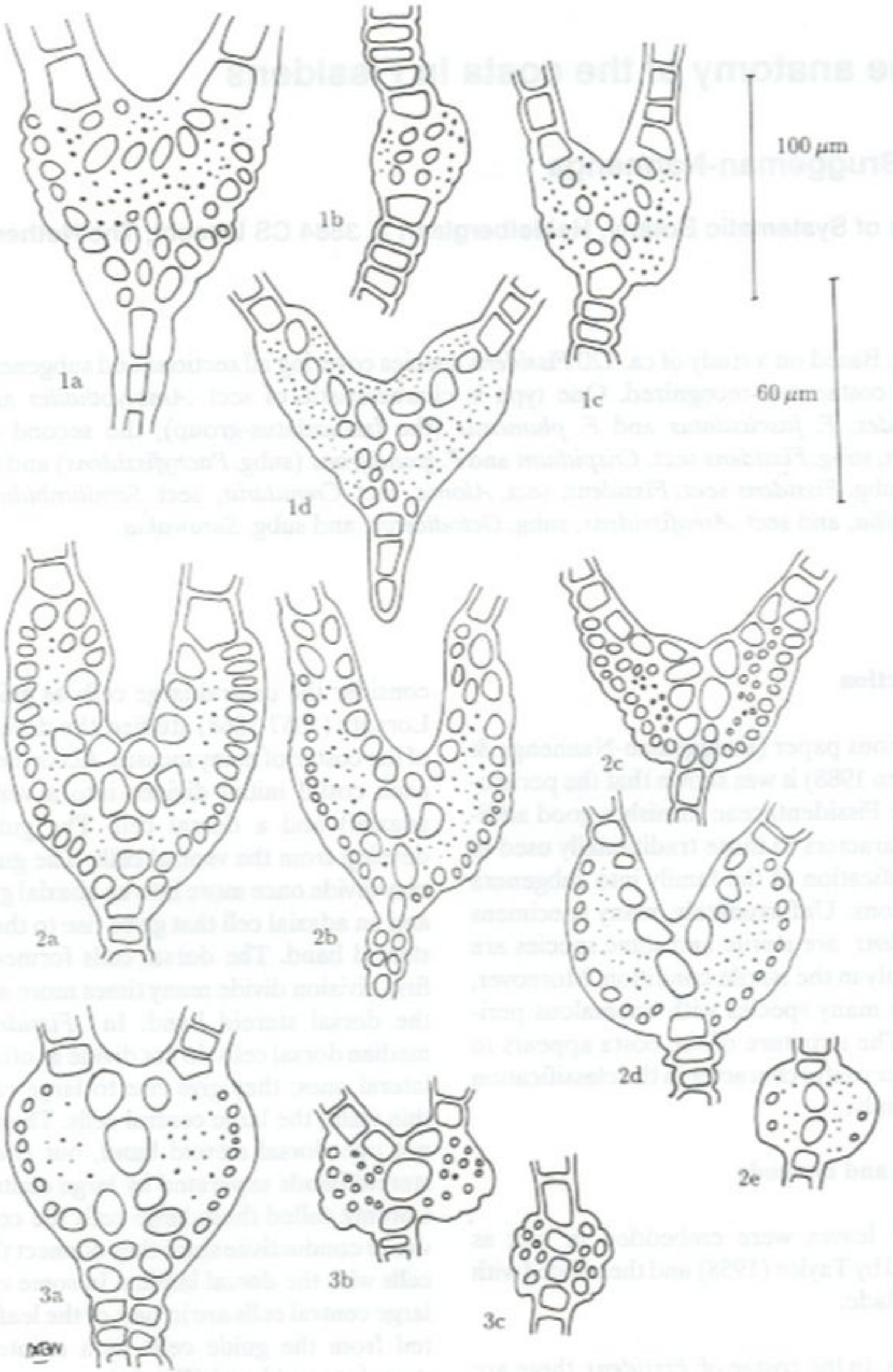
1a
1b
1c
1d
100 μm
60 μm
2a
2b
2c
2d
2e
3a
3b
3c

Table 1: The distribution of peristome types, number of exothecial cells and costa types in the Fissidentaceae (adapted from Bruggeman-Nannenga and Berendsen, 1988).

taxon	peristome	exothecial cells	costa
Group Ia			
Octodiceras	?	b	III
Sarawakia	B,?	b	III
Fissidens	B	b	III
Nanobryum	B	b	III, ?
Group Ib			
Aneuron	S	a	-
Areofissidens	S	a	III
Aloma	S	a	III
Crenularia	S	a	III
Semilimbidium	S	a	III
Pycnothallia	S	a	III
Group II			
Crispidium	Z	b	II
Serridium	T (N)	b	II
F. grandifrons	T	b	II
Group III			
Amblyothallia	Si	b	I
"group fasciculatus"	F	b	I-

Peristome: ? = not belonging to one of the main types and/or reduced, B = bryoides-type, F = fasciculatus-type, N = nobilis-type, S = scariosus-type, Si = similiretis-type, T = taxifolius--type, Z = zippelianus-type. Exothecial cells: a = circa 32 and not more than 40 on the capsule periphery, b = more than 40. Costa: I = oblongifolius-type, II = taxifolius-type and III = bryoides-type, ? = reduced, - = absent.
NB. The fasciculatus-group consists of F. asplenioides, F. fasciculatus and F. plumosus.

Legend for p. 38

Fig. 1: Oblongifolius-type. 1a: *F. maschalanthus* Mont., Chili, *Crosby 12.041* (PAC), 1b and d: *F. fasciculatus* Hornsch., South Africa, *Esterhuysen 25464* (L) and 1c: *F. oblongifolius* Hook. f. & Wils., Society Isl., *De Sloover 20992* (U).

Fig. 2: Showing some of the variations found in the taxifolius-type. 2a: *F. areolatus* Griff., Bhutan, *Long 10577* (E), 2b: *F. dubius* P. Beauv., the Netherlands, *Nannenga-Bremekamp 6* (hb. Bruggeman-Nannenga), 2c: *F. taxifolius* Hedw., France, Le Sauget, *Bruggeman-Nannenga s.n.* (hb. Bruggeman-Nannenga), 2d and 2e: *F. zippelianus* Doz. & Molkenb., Bhutan, *Long 7746* (E).

Fig. 3: Bryoides-type. 3a: *F. rigidulus* Hook. f. & Wils., New Zealand, Wharerata, *Sainsbury* s.n. (BM), 3b: *F. flexinervus* Mitt. Surinam, *Florschütz 2057* (U) and 3c: *F. diversifolius* Broth., India, Waistakhen, *Sedgwick s.n.* (L).

The left scale bar applies to fig. 2a - c and 3b; the right one applies to all other figures.

structure of the costa in the simple, upper part was not systematically studied. The structure of the costa at the base, middle and upper part of the vaginant laminae may not be the same. There may also be differences between the costae of vegetative and perichaetial leaves. Observations cited in this paper, unless otherwise stated, are from the middle part of the vaginant laminae of vegetative leaves.

Important characters appear to be: 1) The number of guide cells, 2) the number of bands of small cells, 3) whether the epidermis cells are differentiated (i.e. have larger lumina than the inner cells) and 4) whether the vaginant laminae at their juncture with the costa are formed by stereids or substereids and guide cells (Fig. 1d, 2a-d) or by laminal cells (Fig. 3a and b).

As a rule only one collection per species is cited in the examined material. Institutional (abbreviated) and personal herbaria are cited in brackets.

Description of the types of costae

I. **Oblongifolius**-type (Fig. 1a - d). This is the most distinct of the three types. It is characterized by:

1) 4 - 7 (-16) guide cells which form a U or V.

2) The 1 - 5 large central cells are usually arranged in 2 (-3) rows (Fig. 1c).

3) Two lateral and one adaxial band of substereids or stereids. In *F. fasciculatus* and *F. plumosus* these bands are larger in the basal part of the leaf (Fig. 1d), more distally they become smaller. In *F. asplenioides* the adaxial band may be stereid or substereid not introduced earlier. In *F. maschalanthus, F. asplenioides* and *F. fasciculatus* the dorsal stereid band (see material and methods) is not always divided into two lateral bands in the basal part of the vaginant laminae (Fig. 1a).

4) Epidermal cells are undifferentiated (Fig. 1c-d), except in *F. asplenioides* and *F. maschalanthus* (Fig. 1a).

5) The vaginant laminae, at their juncture with the costa, are composed of laminal cells (Fig. 1a, c). In the basal part of the leaves of *F. plumosus* and *F. fasciculatus* these areas of the vaginant laminae are composed of stereids and guide cells (Fig. 1d).

In the costa of the simple, upper part of the leaf the large cells are often arranged into 2 rows (Fig. 1b). This arrangement may be characteristic of this type, but is not found in *F. asplenioides* and *F. pallidus*, in which there is a single row. In *F. maschalanthus* there is a row that is double in places. In *F. plumosus* the arrangement varies from a cluster of cells that is wider in the lateral direction than in the dorso-ventral direction to just a single row near the apex of the leaf.

Examined species: F. allenianus Brugg.-Nann. & Pursell, Mexico, Mac-Farland & Sharp 9195 (PAC); F. asplenioides Hedw., Malawi, Long 12567 (E, Bruggeman-Nannenga) and USA, Louisiana, Reese 10678 (U); F. delicatulus Aongstr., Hawaii, Hoe 23030 (U); F. dendrophilus Brugg.-Nann. & Pursell, Brazil, Sehnem 300 (FH-Bartr, type); F. fasciculatus Hornsch., South Africa, Esterhuysen 25404 (L); F. imbricatus Britt. & Bartr., Cuba, La Muleta, Borhidi & Duarte (PC); F. maschalanthus Mont., Chili, Crosby 12.041 (PAC); F. microcarpus Mitt., Banks of Nunn, Mann s.n. (BM); F. oblongifolius Hook. f. & Wils., Society Isl, De Sloover 20992 (U); F. pallidus Hook. f. & Wils., Australia, New South Wales, Streimann 051025 (L); F. plumosus Hornsch., South Africa, Arnell 1968 (PC); F. pseudostipitatus C. Muell., Brazil, Yano 445 (SP, Bruggeman-Nannenga); F. radicans Mont., Surinam, Lanjouw & Lindeman 2288 (U) and French Guyana, Aptroot 15246 (U); F. schusterii Iwats. & Wu, China, Boxi, Chen (HIRO); F. similiretis Sull., Cuba, Schubert Mi54 (PC-Bizot).

The next two types of costae differ from the first type by lacking an adaxial band of stereid cells.

II. **Taxifolius**-type (Fig. 2a - e). This type is characterized by:

1) (2-) 4 - 12 peripheral guide cells.

2) 1 - 8 large, central cells, which are usually

arranged in a single dorso-ventral row (Fig. 2d), but occasionally into two rows (Fig. 2c) or are an irregular mass (Fig. 2a).

3) Two lateral stereid or substereid bands.

4) Epidermal cells which have relatively wide lumina, except in *F. glaucescens* and *F. subangustus* .

5) The juncture of the vaginant laminae and costa is composed of stereids or substereids and guide cells.

As far as has been determined, the costa in the simple, upper part of the leaf has a single row of large cells (Fig. 2e), except in *F. nobilis* , where an irregular mass of large cells is found.
In *F. subbasilaris* this type of costa can only be recognized in that part of the costa which does not have an epidermis of cells similar to those in the lamina.

Examined species: F. adelphinus Besch., Japan, Sasaoka 106 (U); F. adianthoides Hedw., France, St. Ceré, Bruggeman-Nannenga (Bruggeman-Nannenga); F. allionii Broth., Brazil, Reese 13.331 (U); F. anomalus Mont., Bhutan, Long 7868 (E, Bruggeman-Nannenga); F. areolatus Griff., Bhutan, Long 10577 (E, Bruggeman-Nannenga); F. bushii (Card. & Thér.) Card. & Thér., USA, Bruggeman-Nannenga 1119 (Bruggeman-Nannenga); F. cadetii Biz., La Réunion, Cadet 361 (PC-B); F. dubius P. Beauv., The Netherlands, Nannenga-Bremekamp 6 (Bruggeman-Nannenga); F. geminiflorus Doz. & Molkenb. var. nagasakinus (Besch.) Iwats., Iwatsuki, Fiss. As. Exs. 2 (U); F. glaucescens Hornsch., South Africa, Vorster 14962 (L); F. grandifrons Brid., France, Bruggeman-Nannenga 1290 (Bruggeman-Nannenga); F. javanicus Doz. & Molkenb., Bhutan, Long 10576 (E, Bruggeman-Nannenga); F. nigroviridis Salm., Sarawak, Beccari 52 (PC, type); F. nobilis Griff., Iwatsuki, Fiss. As. exs. I: 5 (U); F. nothotaxifolius Pursell & Hoe, Hawaii, Hoe 1500 (PAC); F. obscurus Mitt., Bhutan, Long 8349 (E, Bruggeman-Nannenga); F. osmundoides Hedw., Labrador, Brassard 11707 (Bruggeman-Nannenga); F. pacificus Aongstr., Hawaii, Hoe 65A (PAC); F. perdecurrens Besch., Japan, Nochugi 102 (U) and Sasaoka 215 (U); F. plagiochilus Besch., Smith 8842 Fiji (U); F. planifrons Besch., Mayotte, Marie 160 (PC-B); F. polyphyllus Wils., Bruggeman-Nannenga 1357 (Bruggeman-Nannenga); F. polypodioides Hedw., Jamaica, Jenman (U); F. pulcher C. Muell., Cameroon, Dusén 429 (PC-B, type); F. serrulatus Brid., Allorge, Bryoth. Iber. 19B (L); F. subangustus Fleisch., Iwatsuki, Fiss. As. exsicc. I: 7 (U); F. subbasilaris Hedw., USA, Ohio, Camus (PC-B); F. taxifolius Hedw., France, Hte Savoie, Bruggeman-Nannenga (Bruggeman-Nannenga); F. teysmannianus Doz. & Molk., Fleischer, Musc. Arch. Ind. II, 80 (U); F. zippelianus , Bhutan, Long 7746 (E).

III. **Bryoides**-type (Fig. 3a - c). This type differs from the previous 2 types in having only 3 (rarely more) large cells: two guide cells and one large central cell (Fig. 3b). The type is characterized by:

1) The presence of 2 guide cells.

2) One or more, large, central cells. When there is one it is between the two guide cells (Fig. 3b). When there are more one is between the two guide cells, and the other(s) is/are between this and the dorsal lamina (Fig. 3a).

3) Two lateral bands of small cells, which may have rather large lumina and thin walls, or may be substereids or stereids.

4) An epidermis which may or may not be differentiated.

5) Vaginant laminae which at their juncture with the costa are composed of laminal cells (Fig. 3a-b).

In as far as could be determined, the costa of the simple, upper part of the leaf has a single row of large cells (Fig. 3c).

In some species the costal tissue is so reduced that the structure described above can not be recognized, e.g. in *F. dummerii*. In the closely related *F. gladiolus*, however, it is recognizable in well developed parts of the costae.

Examined species:
Sect. Aloma: F. calabariae C. Muell., Tanzania, Pócs ea. 62571D (EGR); F. celticus Paton, Cornwall, Lostwithiel, Paton (Paton, Bruggeman-Nannenga); F. cryptarum C. Muell., Madagascar, Crosby 6700 (PC-B); F. crassinervis

Lac., Sumatra, Arens 576 (L) and Fleischer, Musci Frond. Arch. Ind. 17 (U); F. flexinervis Mitt., Surinam, Florschütz 2057 (U); F. grandiretis Ren. & Cardot, Madagascar, Sakana, Voeltz-Baur (H); F. holstii Broth. var. perintegrifolius Pot. Varde, Gabon, Lastourville, Le Testu (PC- PV, type); F. kearnbachii Broth., New Guinea, Robbins 2079; F. linderii Pot. Varde, Liberia, Linder 836 (PC-PV); F. nitens Salm. ex Rehm., Umpimilo, leg. Borgen (L); F. pauperculus Howe var. pauperculus, Surinam, Florschütz 2288 (U); F. pellucidus Hornsch., Puerto Rico, Bruggeman-Nannenga 46813 (U); F. porrectus Mitt., Niger-exp., Barter 1425 (NY) [NB. F. porrectus is limbate. It is included in the elimbate sect. Aloma since it has smooth cells and a scariosus type peristome.]; F. rivicola Broth., Gabon, Le Testu 6842 (PC-PV); F. sedgwickii Broth. & Dix., Thailand, Touw 10788 (L); F. splendens Brugg.-Nann., Tanzania, Pócs 6285 (EGR).

Monopapillose species with a scariosus type of peristome: F. brachypus Mitt., Brazil, Buck e.a. 1798 (U); F. donnellii Austin, Guyana, Gradstein 4928 (U); F. ghanae Biz., Ghana, Jones 1314 (PC); F. gymnostomus Brugg.-Nann., Brazil, Vital 5493 (SP, Bruggeman-Nannenga); F. papillosus Lac., Iwatsuki, Fiss. As. exs. II, 16 (U); F. scleromitrius (Besch.) Broth., Madagascar, Borgen (BM); F. tenelliformis Broth. & Watts, Lord Howe Island, Watts 221 (PC-Th).

Pluripapillose species with a scariosus-type of peristome (the peristome of F. pseudoplumosus is reduced, but the number of exothecial cells is that characteristic of taxa with a scariosus-type of peristome): F. aoristoloma Pot. Varde, Central African Republic, nr Mbaki, Tisserant (PC-PV); F. erosulus (C. Muell.) Par., Zimbabwe, Long 12475 (E, Bruggeman-Nannenga); F. desertorum (C. Muell.) Par., Nigeria, Ibadan Distr., Jones & Keay (PC); F. foveolatus Card., Bryoth. Naveau, Flora Congeana 540 (PC-Th); F. glaucissimus Welw. & Dub., Nigeria, MacFarlane 558 (PC); Central African Republic, Assel 722 (PC); F. glaucopteris C. Muell., Sierra Leone, Arnell 2391 (PC-PV) and Liberia, Dusén 99 (PC-PV); F. glauculus C. Muell., Nigeria, Verdoorn, Musc. Sel. Crit. VII, 321 (U); F. humilis Dix. & Watts, New South Wales, Streimann 5944 (L); F. idanreensis Pot. Varde, Mozambique, nr Inhaca, Péntek (EGR); F. marthae Card., Oubangui, nr. Donzo, Tisserant (PC-PV); F. pseudoplumosus Biz. & Onraedt, La Réunion, Onraedt 9378 (PC-B, type); F. subelimbatus Broth. & Pot. Varde, Oubangui, Gamburu, Tisserant (PC-Th); F. sciophylllus Mitt., Tanzania, Pócs 6188AJ (L); F. weirii Mitt., Cuba, Hioram 12842 (PC, type of F. bizotii Thér.); F. wichurae Broth. & Fleisch., Java, Meijer B 5780 (L).

Sect. Areofissidens: F. cellulosus Mitt., Tanzania, Pócs 6777A (Egr); F. grandifolius Broth. & Pot. Varde, Central African Republic, Faurel 10 (PC-B); F. mollis Mitt., Colombia, Griffin 11088 (L); F. zollingerii Mont., Fleischer, Musc. Frond. Arch. Ind. I, 14 (PC, as F. xiphoides Fleisch.).

Sect. Fissidens (Nanobryum included): F. andicola (Herz.) Brugg.-Nann., Bolivia, Herzog 199 (L); F. androgynus Bruch, Malawi, Long 12612 (E, Bruggeman-Nannenga); F. attenuatus Bryhn, Tenerife, Bryhn (PC); F. bryoides Hedw., Ireland, Bruggeman-Nannenga 1351 (Bruggeman-Nannenga); F. crassipes Wils. ex B.S.G., France, Bruggeman-Nannenga 415A (Bruggeman-Nannenga); F. coacervatus Brugg.-Nann., La Gomera, Schwab (Schwab, Bruggeman-Nannenga); F. crenulatus C. Muell., Brazil, Mosén 5 (H-Br); Mosén 128 (H-Br); F. crispopachyloma Dix., Tanzania, leg. Pócs 6208N (EGR); F. curvatus Hornsch., S. Africa, Rehm. 293 (L, type of its synonym F. pycnophyllus C. Muell.); F. dietrichiae C. Muell., Queensland, Bailey 235 (H); F. diversifolius Broth., India, Waistakhen, Sedgwick (L); F. dummerii (Dix.) Pursell & Reese, Uganda, Jones 572 (PC); F. euryloma Pot. Varde, Gabon, Mt Iboundji, Le Testu (PC-PV); F. fluitans (Pot. Varde) Brugg.-Nann., Gabon, Chute de la Lombo, Le Testu (PC); F. gladiolus Mitt. Central African Republic, Assel 416 (PC-B); F. monguillonii Thér., France, Bauer, Musc. Eur. Exs. 1028 (L); F. ovatifolius Ruthe, Italy, Lazio, Schwab (Schwab, Bruggeman-Nannenga); F. pennula Broth., Surinam, Florschütz-De Waard 5796 (U); F. pungens Hamp. & C. Muell., New South Wales, Streimann 7136 (L); F. repandus Wils, Colombia, Cleef 3731 (U) and 7978 (U); F. rigidulus Hook. f. & Wils. subsp. rigidulus, New Zealand, Poverty Bay, Sainsbury (BM) and Peru, Cook & Gilbert 670 (NY); F. r. subsp. masatierrensis Brugg.-Nann., Chili, Juan Fernandez Isl., Svensk. Pac. Exp. 1916-17: 63 (BM); F. rivularis (Spruce) B.S.G., Kreta, Gradstein & Smittenberg 1317 (U); F. robynsianus Pot. Varde, République Congo, Demaret 5257 (BR); F. rochensis Broth., Guadeloupe, Dusén 116 (H-Br); F. rufulus B.S.G., France, Bruggeman-Nannenga 419 (Bruggeman-Nannenga); F. simensis Schimp. ex C. Muell., Abessynia, Schimper 1035 (PC); F. strictulus C. Muell., Japan, Iwatsuki, Fiss. As. exsicc. II, 17 (Bruggeman-Nannenga); F. rufescens Hornsch., South Africa, Schelpe 7529 (PRE); F. steyermarkii Bartr., Guatemala, Steyermark 36576 (FH); F. ventricosus Lesq., Oregon (PC-PV), F. wallisii C. Muell., Colombia, Van der Hammen 2794 (U) and Peru, Bues 1192 (NY).

Subg. Octodiceras: F. fontanus (B.-Pyl.) Steud., USA, Bruggeman-Nannenga 1085 (Bruggeman-Nannenga).

Subg. Sarawakia: F. beccarii (Hamp.) Broth., Sarawak, Beccari 30 (L); F. hydropogon Spruce ex Mitt., Andes Quitensis, Spruce 506 (NY); F. stissotheca (C. Muell.) Mitt. var. stissotheca, Brazil, Puiggari 1175 (H-Br) and Vital 2779-B (SP, Bruggeman-Nannenga); F. s. var. immersus (Mitt.) Pursell e.a., Brazil, Glaziou 2266 (H-BR) and Regnell, Pl. Brasil. Ser. III: 85 (H-BR).

Distribution of the costa types in the Fissidentaceae.

The bryoides-type of costa is found in taxa with a bryoides-type peristome (group Ia) and in taxa with a scariosus-type peristome (group Ib) (see Table I).
The differences in composition between groups Ia and Ib and the traditional supraspecific taxa have been discussed in Bruggeman- Nannenga and Berendsen (1988). A close relationship between the taxa forming group I is not only supported by the peristome, but also by costal structure.

The taxifolius-type of costa is found in sect. *Serridium*, in *F. grandifrons* (subg. *Pachyfissidens)* and in sect. *Crispidium*. It is also found in *F. allionii*, a monopapillose species with a scariosus-type peristome and a very stout costa. One would expect a bryoides-type of costa to be found in this species.

The oblongifolius-type of costa is found in sect. *Amblyothallia* and the fasciculatus group. On the basis of the peristome, the latter would appear to be more closely related to sect. *Serridium* (Group II). The oblongifolius-type is also found in F. *schusteri*, a semilimbate species with smooth cells and more than 40 exothecial cells (sect. *Fissidens*), which has a very strongly developed costa. In this species one would expect a bryoides-type of costa.

Remark. The distribution of the costa types given in table 1 applies to costae in the middle part of the vaginant laminae of vegetative leaves. Deviations from this scheme may occur in the basal part of the vaginant laminae of vegetative leaves and in perichaetial leaves, e.g. *F. wallisii* (sect. *Fissidens*) and *F. glaucissimus* (sect. *Pycnothallia*) have a bryoides-type costa in the middle part of the vaginant laminae, but a taxifolius-type in the basal part of the vaginant laminae. Vegetative leaves of *F. pseudoplumosus* (sect. *Semilimbidium)* have a bryoides-type of costa, but the perichaetial leaves have an oblongifolius-type. Deviations are also found in some, but not all, species with a strongly developed costa, e.g. in *F. allionii* and *F. schusteri* (see above).

It appears also (Table I) that:
1) Sect. *Crispidium* is characterized by a zippelianus-type peristome, more than 40 exothecial cells, and a taxifolius-type costa.
2) Subg. *Serridium* is characterized by a taxifolius- or nobilis-type peristome, more than 40 exothecial cells, and a taxifolius-type costa; the same combination is found in *F. grandifrons* Brid. (*Pachyfissidens*).
3) Sect. *Amblyothallia* is characterized by a similiretis-type peristome, more than 40 exothecial cells and an oblongifolius- type costa, whereas *F. fasciculatus, F. plumosus* and *F. asplenioides* (group fasciculatus) have a fasciculatus-type peristome, more than 40 exothecial cells, and an oblongifolius-type costa.
4) Subg. *Sarawakia*, subg. *Fissidens* sect. *Fissidens* and subg. *Nanobryum* are all characterized by a bryoides-type peristome, more than 40 exothecial cells, and a bryoides-type peristome.
5) Sect. *Areofissidens*, sect. *Aloma*, sect. *Crenularia*, sect. *Semilimbidium* and sect. *Pycnothallia* are all characterized by a scariosus-type of peristome, circa 32 exothecial cells, and a bryoides-type of costa.

It is now possible to distinguish two taxa that in the traditional way can not be separated very well, viz. subg. *Serridium* and sect. *Amblyothallia*. These two taxa are separated easily by their peristomes as well as by their costae. However, *F. pallidus* has an oblongifolius-type of costa and may have similiretis-type of peristome (both typical of sect. *Amblyothallia*), or it may have a peristome that in the undivided part has the characters of the taxifolius-type

peristome (typical of subg. *Semidium*), whereas the filaments are squamose as in the similiretis-type peristome.

Two other sections that are often confused, sect. *Amblyothallia* and sect. *Crispidium*, can be separated also by the type of costa and the type of peristome.

Note. During this study it became clear that, except for subg. *Semidium* the presence of a differentiated epidermis is diagnostic at the species level but not at the sectional level.

Acknowledgements

I am indebted to Prof. Dr. R. A. Pursell and Prof. Dr. Z. Iwatsuki for critically reading this paper.

References

Bruggeman-Nannenga, M. A. & W. Berendsen, 1988. On the peristome types found in the Fissidentaceae and their importance for the classification. In: Bruggeman-Nannenga, M. A., Systematic studies on Fissidens (Musci): 135-171. Thesis. Utrecht. Also to appear in: Journal of the Hattori Botanical Laboratory. (in press).

Lorentz, P. G., 1867-1868. Grundlinien zu einer vergleichenden Anatomie der Laubmoose. Jahrbücher für wissenschaftliche Botanik 6: 363-466, Taf. XXI-XXVIII.

Taylor, E. C., 1958. Freehand sectioning of moss leaves and stems. Bryologist 60: 17-20.