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Taxonomic Studies on the Midrib in Musci

(1) Significance of the Midrib in Systematic Botany

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Introduction

The taxonomical study of Musci has to be made from many points of view. I place my primary emphasis upon the characteristics of the gametophyte. As it is not always easy to find sporophytes in Musci species, the features of the gametophyte are actually more useful than those of the sporophyte in the taxonomical study of this class. In a taxonomic study of the inner structure of the leaf, the midrib seems to be the most important, because the characteristics of the midrib seem to be the most peculiar to the species.

Once I studied the midribs by way of tracing the mode of ontogeny in *Grimmia* (Kawai 1965). The first midrib tissue to appear was the part which connects with the cells of the lamina, that is, adaxial part, and this I named a-part. Next I named c-part the layer of cells which is formed on the abaxial side of the a-part through its cell divisions. Lastly I named b-part the cell group which is formed inside the c-part through its cell divisions. The study showed that the mode of ontogeny of the midrib is characteristic to the species. Next in the structure of the completed midrib, I found that the number of the cells of the a-part is definitely specific, and the three parts, a-, b- and c-part looked quite indistinguishable morphologically (cf. *Grimmia alpicola*, *Gr. incurva*, *Gr. decalvata*): in others, however, those were quite distinct in the cross section (cf. *Gr. arizonae*, *Gr. decipiens*, *Gr. ovalis*, *Gr. patens*): further some (cf. *Gr. maritima*) of the latter even had guide cells in the b-part. Thus several characteristics of the inner structure of the midrib were specific to the species in *Grimmia*. In *Rhacomitrium*, the number of the cells of the a-part and the inner structure of the completed midrib in the cross section were definitely specific as in *Grimmia* (Kawai 1963).

Thus I will start the observation of the midrib and tracing of the mode of ontog-

eny and study the inner structure of the completed midrib in all the species of Musci and consider whether these characteristics of the midrib are definitely specific to the species or not.

In this paper, I group many observations on the inner structure of the midrib tissue which many scholars have previously made and I make a summary of these facts. Then I consider whether it is significant for systematic botany.

Discussion

Morphological differentiation of tissue also showed some differences from species to species in *Grimmia*, and on the basis of affinity shown in morphological differentiation I was able to classify the inner structures of the midrib into four groups: A group (the distinction between a-, c-part and b-part is not clear), B group (the distinction between a-, c-part and b-part is slightly clear), C group (the distinction between a-, c-part and b-part is clear, without guide cells) and D group (the distinction between a-, c-part and b-part is clear, with guide cells). In the whole Musci, however, now I classify the inner structures of the midrib into six new types: A-type (the dist inction among a-part, b-part and c-part is quite obscure), B-type (the distinction between a-part and b-, c-part is clear), C-type (the distinction among a-part, b-part and c-part is clear), D-type (the distinction among a-part, b-part and c-part is clear, and b part is differentiated into b and G), E-type (the distinction among a-part, b-part and c-part is clear, and b-part is differentiated into b-1, b-2 and G), F-type (the distinction among a-part, b-part and c-part is clear, and b-part is differentiated into b-1, b-2, b-3 and G-1, G-2).

The type of the midrib named A-type has almost uniform cells in the three parts as shown in Fig. I, II. Putting together the number of cells of each part (a-, b-, c-part), I arrived at the fomula a+b+c=T (a, b, c, the number of the cells of the a-, b-, c-part; T, the total number of the cells). When T is a large number, the midrib is also large. When a/b is smaller than 1/2, the midrib form is semicircular (cf. *Pleurorthotrichum chilense*). When a/b is larger than 1/2, the midrib form is ovoid (cf. *Sciaromnium fryer*). When a/b is nearly 1, the midrib form is fusiform (cf. *Drepanocladus aduncus*, *Bryoandersonia illecibra*).

In B-type, the distinction between b-part and c-part is not clear, but distinctions between a- and b-part, and between a- and c-part are somewhat clearer. As shown in Fig. III, *Grimmia incurva*, *Rhacomitrium anomodontoides*, *Leptobarbula berica* etc. belong to the B-type. Of the B-type, *Grimmia incurva*, *Grimmia brunnescens* f. *humilior*, *Grimmia pilifera*, *Grimmia torquata*, *Luisierella barbula* etc. have semicircular midribs. In *Grimmia apocarpa* var. *rivularis*, *Ephemerum recurvifolium*, *Brachythecium cirrosum*, the midrib form is ovoid, and in *Rhacomitrium anomodontoides*, *Brachythecium plumosum*, the midribs are fusiform.

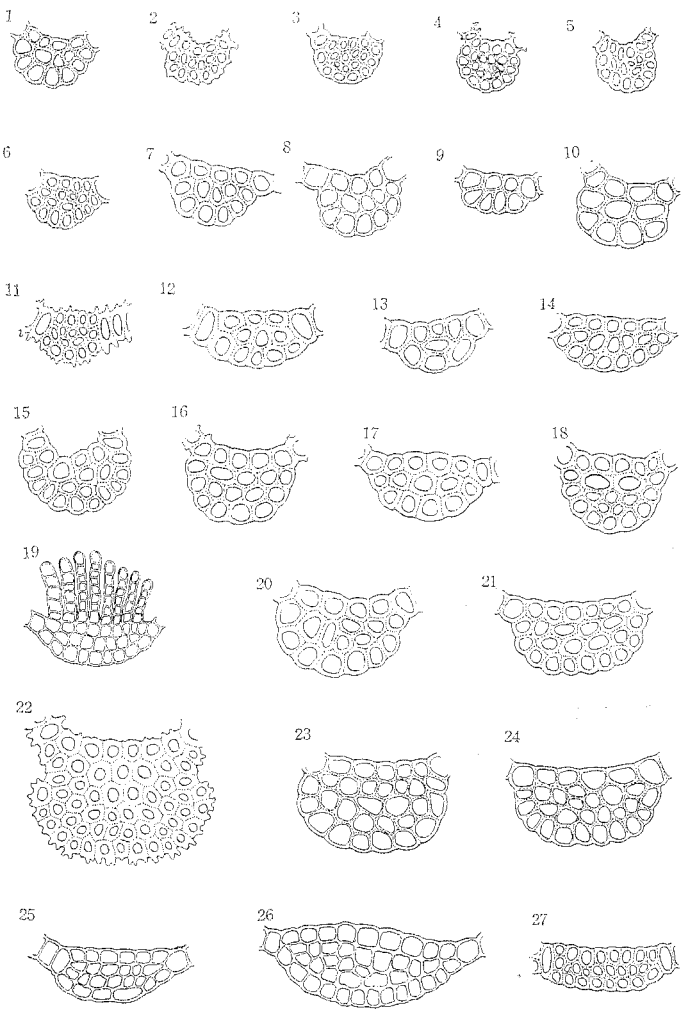

Fig. I Cross sections of the A-type midrib. The distinction among the a-part, b-part and c-part is quite obscure.

1) *Pleurorthotrichum chilense* BROTH. 2) *Anomodon longifolius* (BRID.)HARTM. 3) *Paludella squarrosa* (L.)EHRH. 4) *Orthotrichum anomalum* HEDW. 5) *Anomodon giraldii* MÜLL. 6) *Anomodon rugelii* var. *ferrugineus* (BESCH.) IWATS. 7) *Chamberlainia erythrorrhiza* (B. S. G.) ROBINS. 8) *Chamberlainia albicans* (HEDW.)ROBINS. 9) *Anomobryum fuji-alpinum* TAK. 10) *Amblystegium montanae* BRYH. 11) *Anomodon abbreviatus* MITT. 12) *Anomodon rugelii* (MÜLL.) KEISSL. 13) *Gyroweisia tenuis* (SCHRAD.) SCHIMP. 14) *Brachythecium rutabulum* (HEDW.)B. S. G. 15) *Camptodontium brotheri* DUS. 16) *Orthotrichum affine* SCHRAD. 17) *Homalothecium leskeoides* (HOOK.)ROBINS. 18) *Plagiopus oederi* (SCHWAEGR.)LIMPR. 19) *Aligrimmia peruviana* WILL. 20) *Chamberlainia axyclada* (BRID.) ROBINS. 21) *Chamberlainia rotaeana* (D. NOT.) ROBINS. 22) *Leratia neocaledonica* BROTH. 23) *Chamberlainia acuminata* ROBINS. 24) *Chamberlainia salebrosa* (WEB. et MOHR.)ROBINS. 25) *Drepanocladus fluitans* (HEDW.)WARNST. 26) *Drepanocladus aduncus* (HEDW.)WARNST. 27) *Anomodon thraustus* MÜLL.

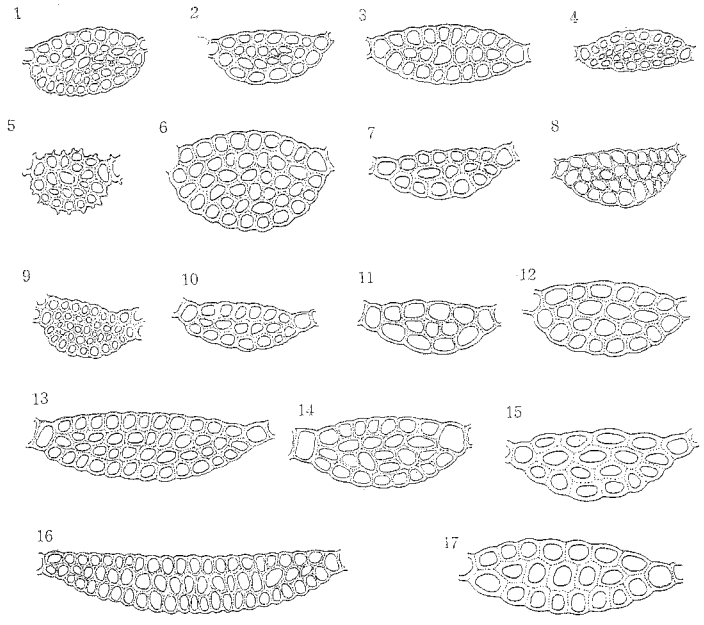

Fig. II Cross sections of the A-type midrib. The distinction among the a-part, b-part and c-part is quite obscure.

1) *Sciaromium fryer* WILL. 2) *Drepanocladus aduncus* (HEDW.) WARNST. 3) *Drepanocladus revolvens* (TURN.) WARNST. 4) *Drepanocladus vernicosus* (LINDB.) WARNST. 5) *Gyroweissia tenuis* (SCHRAD.) SCHIMP. 6) *Hygroamblystegium tenax* (HEDW.) JENN. 7) *Brachythecium latifolium* KINDB. 8) *Entodon concinnus* (D. NOT.) PAR. ssp. *caliginosus* (MITT.)MIZUSHIMA 9) *Anomodon viticulosus* (HEDW.) HOOK. et TAYL. 10) *Brachythecium serrulatum* (HEDW.) ROBINS. 11) *Anomodon acutifolius* MITT. 12) *Bryhnia novae-angliae* (SULL. et LESQ.) GROUT 13) *Cratoneurella uncinifolia* (BROTH. et PAR.)ROBINS. 14) *Brachythecium rivulare* (BRUCH.)B. S. G. 15) *Kiaeria starkei* (W. et M.)HAG. 16) *Paraleucobryum longifolium* (HEDW.) LOESK. 17) *Bryoandersonia illecibra* (HEDW) ROBINS.

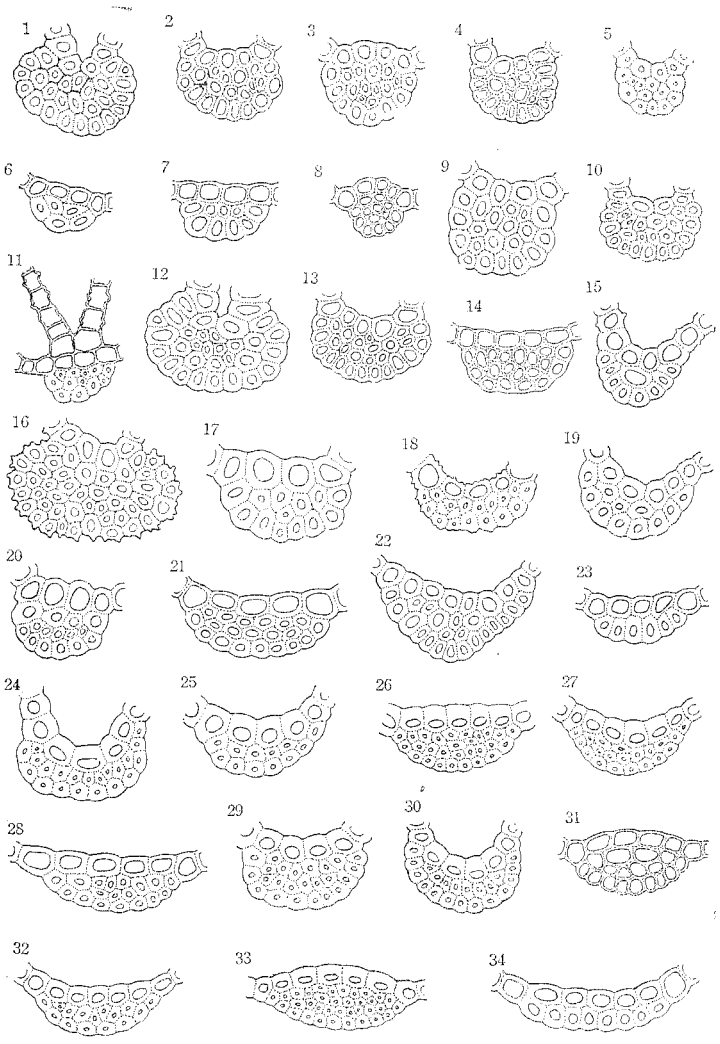

Fig. III Cross sections of the B-type midrib. The distinction between the a-part and b-, c-part is clear.

1) *Grimmia incurva* SCHWAEGR. 2) *Grimmia brunnescens* f. *lutnilior* VILHL. 3) *Grimmia apocarpa* var. *rivularis* (BRID.) NEE. et HORNS. 4) *Grimmia pilifera* P. BEAUV. 5) *Grimmia torquata* GREV. 6) *Grimmia cratericola* SAK. et TAK. 7) *Splachnobryum kieneri* WILL. 8) *Ephemerum recurvifolium* (DICKS.) BOUL. 9) *Grimmia apocarpa* var. *atrofusca* (SCHIMP.) HUSN. 10) *Grimmia apocarpa* var. *conferta* (FUNCK.) SPRENG. 11) *Pterygoneurum arcticum* STEE. 12) *Grimmia decalvata* CARD. 13) *Grimmia brunnescens* f. *epilosa* (SCHIFFN.) PAR. 14) *Rhachitheciopsis tisserantii* IWATS. 15) *Macromitrium trinitense* WILL. 16) *Grimmia anomala* HAMP. 17) *Grimmia gracilis* SCHWAEGR. 18) *Hypnodontopsis apiculata* IWATS. et NOG. 19) *Rhacomitrium microcarpum* BRID. 20) *Luisierella barbula* (SCHWAEGR.) STEE. 21) *Brachythecium plumosum* B. et S. 22) *Grimmia cratericola* SAK. et TAK. 23) *Glyphomitrium minutissimum* (OKAM.) BROTH. 24) *Rhacomitrium lanuginosum* (HEDW.)BRID. 25) *Rhacomitrium canescens* var. *ericoides* (WEB.)SCHIMP. 26) *Rhacomitrium carinatum* CARD. 27) *Rhacomitrium lanuginosum* (HEDW.)BRID. 28) *Leptobarbula berica* (D. NOT.)SCHIMP. 29) *Grimmia apocarpa* HEDW. 30) *Rhacomitrium heterostichum* (HEDW.) BRID. 31) *Brachythecium cirrosum* SCHP. 32) *Rhacomitrium fasciculare* (HEDW.) BRID. 33) *Rhacomitrium anomodontoides* CARD. 34) *Hypnodontopsis apiculata* IWATS. et NOG.

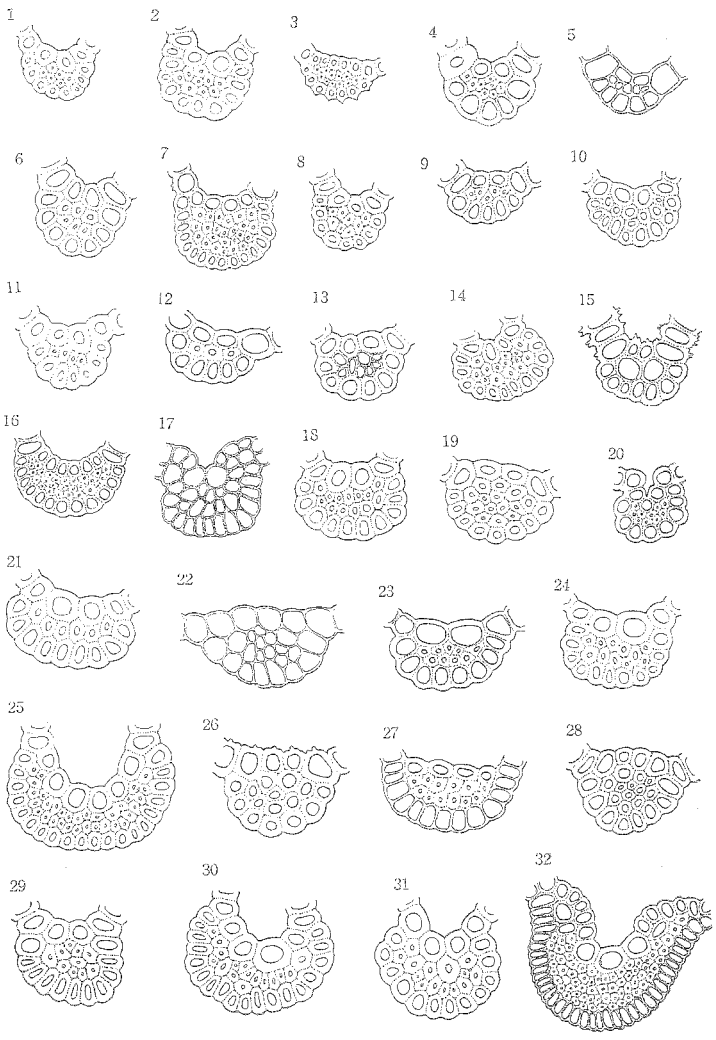

Fig IV Cross sections of the C-type midrib. The distinction among the a-part, b-part and c-part is clear.

1) *Grimmia funalis* f. *longipila* BOUL. 2) *Grimmia funalis* (SCHWAEGR.) B. S. G. 3) *Catoscopium nigrelum* (HEDW.) BRID. 4) *Grimmia orbicularis* var. *persica* SCHIFFN. 5) *Tortula propagulosa* SCHARP. 6) *Grimmia pulvinata* (HEDW.) SM. 7) *Anoectangium compactum* SCHWAEGR. 8) *Grimmia trichophylla* ssp. *lisae* (D. NOT.) BOUL. 9) *Pohlia defecta* (SANIO) L. R. ANDR. 10) *Grimmia gracilis* f. *subepilosa* PIL. 11) *Grimmia funalis* var. *calvescens* (KINDB.) MÖLL. 12) *Rhacomitrium perpusillum* (THW. et MITT.) BROTH. 13) *Grimmia plagiopodia* HEDW. 14) *Grimmia gracilis* f. *tenuis* VILHL. 15) *Amphidium lapponicum* (HEDW.) SCHIMP. 16) *Amblyodon dealbatus* (DICKS.) P. BEAUV. 17) *Grimmia apocarpa* var. *tenerrima* NEE. et HORNS. 18) *Grimmia apocarpa* var. *microtheca* CARD. 19) *Grimmia agassizii* (SULL. et LESQ.) JAEG. 20) *Coscinodon cribrosus* (HEDW.) SPRUC. 21) *Grimmia alpicola* HEDW. 22) *Grimmia mollis* B. S. G. 23) *Rhacomitrium tisserantii* (P. VAR.) ROBINS. 24) *Grimmia donniana* SM. 25) *Grimmia trichophylla* f. *robusta* PODP. 26) *Tortula caroliniana* ANDR. 27) *Distichum capillaceum* (SW.) B. S. G. 28) *Grimmia teretinervis* LIMPR. 29) *Grimmia pulvinata* var. *africana* (HEDW.) HOOK. et WILS. 30) *Grimmia hartmanii* SCHIMP. 31) *Grimmia elatior* BRUCH. 32) *Grimmia arizonae* REN. et CARD.

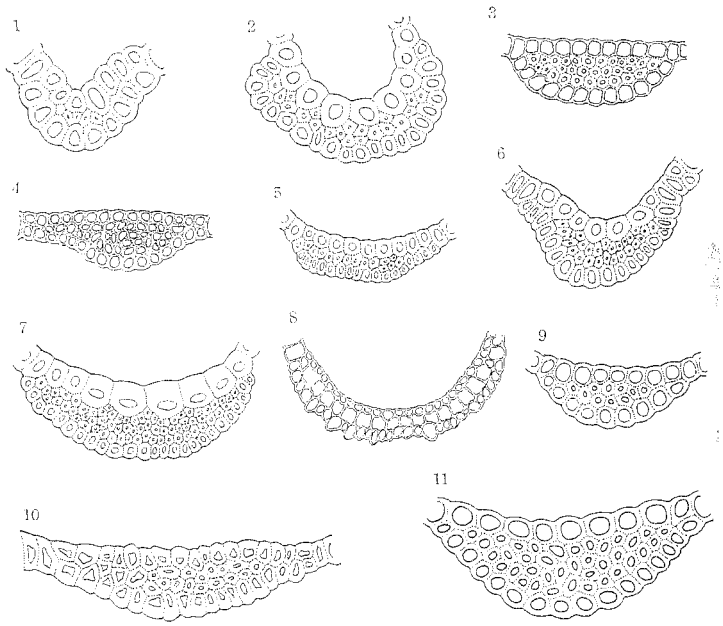

Fig. V Cross sections of the C-type midrib. The distinction among the a-part, b-part and c-part is clear.

1) *Grimmia anodon* B. S. G. 2) *Grimmia decipiens* (SCHULTZ.) LINDB. 3) *Indusiella thianscharica* C. MÜLL. et BROTH. 4) *Diphyscium cumberlandianum* HARV. 5) *Grimmia laevigata* (BRID.) BRID. 6) *Grimmia ovalis* (HEDW.) LINDB. 7) *Grimmia patens* (HEDW.) B. S. G. 8) *Brachythecium reflexum* (STARK.) B. S. G. 9) *Dicranella huchinsonii* KRAJI. 10) *Pogonatum spinulosum* MITT. 11) *Meesia triquetra* (HOOK. et TAYL.) ÅONGST.

The midribs which belong to C-type, have clear distinctions between a- and c-part, and between b- and c-part, and between b- and a-part, but do not possess the guide cells in the b-part. This is shown in Fig. IV and Fig. V. In *Grimmia funalis, Amblyodon dealbatus* etc. in Fig. IV, the midrib form is semicircular, and *Grimmia ovalis, Grimmia patens, Meisia triquetra, Pogonatum spinulosum* in Fig. V have midribs of fusiform. In D-type, the distinction among a-part, b-part and c-part is clear, and guide cells become differentiated from the tissue of the b-part and consequently the distinction between b (sclerenchyma) and G (guide cells) is clear in the b-part. In *Bryum cirrhatum, Calymperes rufum, Encalypta vulgaris* etc. of Fig. VI, the guide cells draw a line or two parallel to the a-part, but those of *Leptobryum piriforme* (Fig. VII) and *Rhodobryum giganteum* (Fig. XIV) get together in the center. In Fig. VI, the midribs are almost semicircular, but the whole midribs of Fig. VII are fusiform. Only Fig. XIV (*Rhodobryum roseum, Mnium undulatum Mnium medium, Mnium punctatum, Rhodobryum giganteum, Mnium speciosum*) are roundish triangle or ovoid.

The type of the midrib named E-type (Fig. VIII, Fig. IX, Fig. X, Fig. XI, Fig. XII, Fig. XIII) has cells of each part different from those in the other parts, and

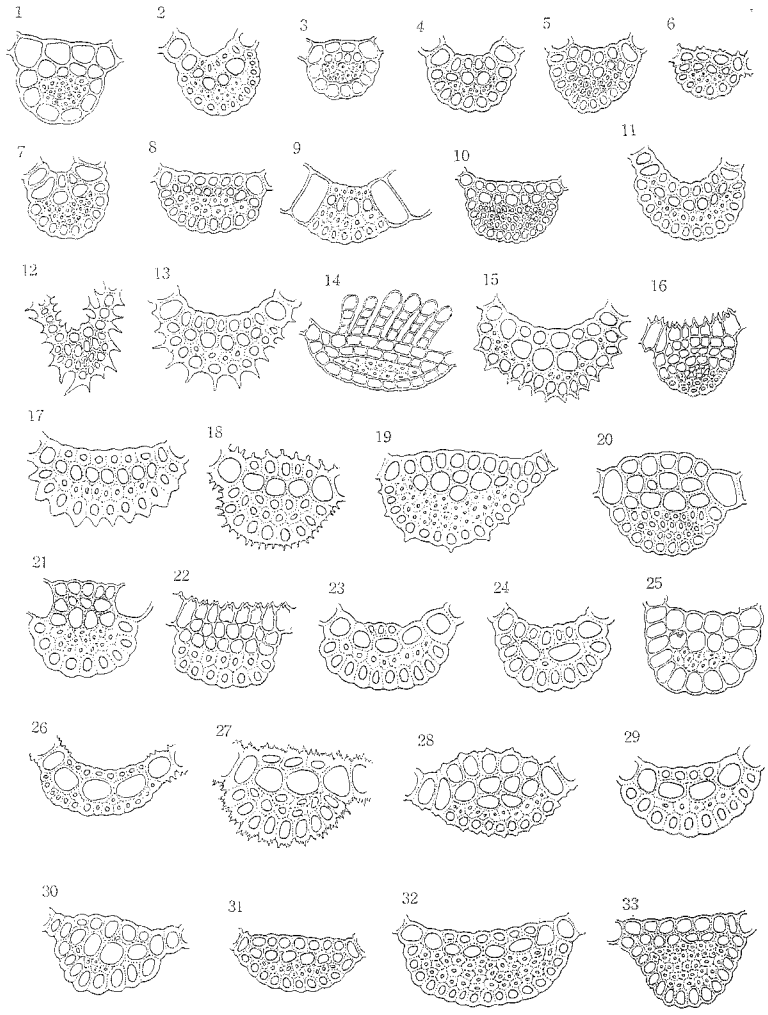

Fig. VI Cross sections of the D-type midrib. The distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b and G (guide cells).

1) *Bryum cirrhatum* HOPP. et HORNSCH. 2) *Calymperes rufum* HERZ. 3) *Plagiobryum demissum* (HOP. et HORNSCH.) LINDB. 4) *Rhabdoweisia denticulata* (BRID.) B. S. G. 5) *Plagiopus javanicus* (D. et M.) FLEISCH. 6) *Pottia davalliana* (SM.) JENS. 7) *Tortula williamsii* BARTR. 8) *Tortula stanfordensis* STEE. 9) *Syrrhopodon yakushimensis* TAK. et IWATS. 10) *Leptostomum splachnoides* HOOK. 11) *Rhabdoweisia fugax* (HEDW.) B. S. G. 12) *Leptodontium spinosum* WILL. 13) *Syrrhopodon tsushimae* CARD. 14) *Oligotrichum rigidum* (GORENTZ.) BROTH. 15) *Oreoweissia serulata* (FUNCK.) D. NOT. 16) *Encalypta vulgaris* var. *lunata* BARTR. et CHAMB. 17) *Campylopus arctocarpus* (HORNSCH.) MITT. 18) *Gymnostomum calcareum* NEE. et HORNSCH. 19) *Leiomela javanica* (REN. et CARD.) BROTH. 20) *Bryum formosum* MITT. 21) *Orthomniopsis elimbata* NOG. 22) *Encalypta vulgaris* (HEDW.) HOFFM. 23) *Hypnodontopsis apiculata* IWATS. et NOG. 24) *Dicranoweissia cirrhata* (L.) LINDB. 25) *Trichodon tenuifolius* (SCHRAD.) LINDB. 26) *Leptodontium bassii* WILL. 27) *Sarconeurum glaciale* (HOOK. et WILS.) CARD. et BRYH. 28) *Trichostomopsis brevifolia* BARTR. 29) *Hypnodontopsis mexicana* (THÉR.) ROBINS. 30) *Breutelia anomala* WILL. 31) *Rhacopilum tomentosum* (HEDW.)BRID. 32) *Glyphomitrium humillimum* (MITT.) BRID. 33) *Neobryum costatum* WILL.

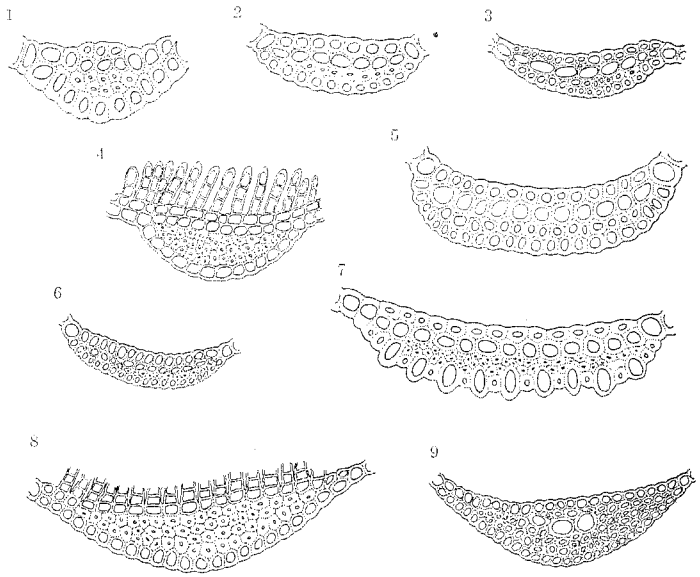

Fig. VII Cross sections of the D-type midrib. The distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b and G (guide cells).
1) *Atractylocarpus panus* WILL. 2) *Didymodon fuscoviridis* CARD. 3) *Leiomela peruviana* WILL. 4) *Aloina stellata* (SCHREB.) KINDB. 5) *Hymenoloma nordenskjoldii* DUS. 6) *Campylopus piriformis* (SCHULTZ.) BRID. 7) *Sphaerothecium phascoideum* WILL. 8) *Aloina ambigua* (B. S. G.) LEYSS. 9) *Leptobryum piriforme* (HEDW.) SCHIMP.

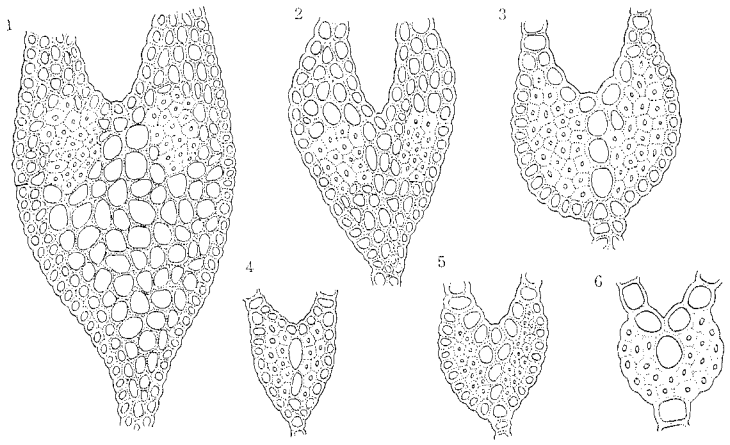

Fig. VIII Cross sections of the E-type midrib. The distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b-1, b-2 and G (guide cells).
1) *Fissidens grandifrons* var. *planicaulis* (BESCH.) NOG. 2) *Fissidens grandifrons* BRID. 3) *Fissidens cristatus* WILS. 4) *Fissidens rufulus* B. S. G. 5) *Fissidens serrulatus* BRID. 6) *Fissidens flavosetus* PURS.

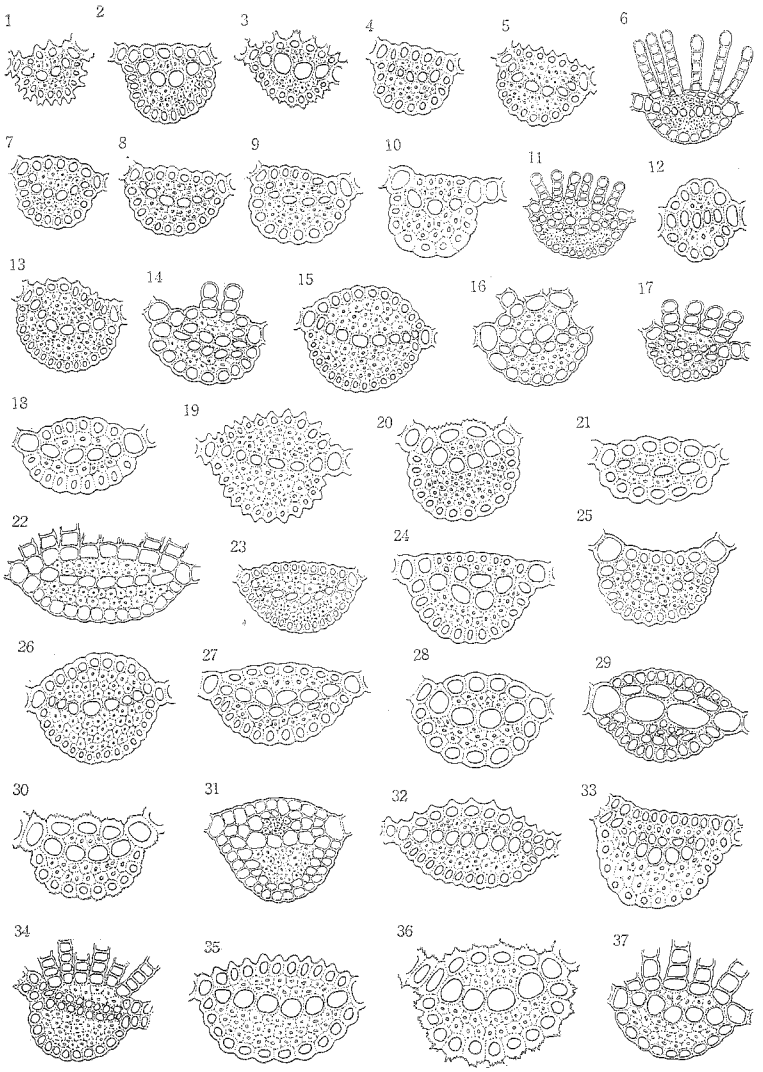

Fig. IX Cross sections of the E-type midrib. The distinction among the a-part, b-part and c-part is clear and the b-part is differentiated into b-1, b-2 and G(guide cells).

1) *Syrrhopodon simmondsii* STEE. 2) *Hydrogonium subpellucidum* var. *hyaloloma* HERZ. 3) *Syrrhopodon gaudichaudii* MONT. 4) *Calymperes smithii* BARTR. 5) *Calymperes erosum* C. M. 6) *Atrichum xanthopelma* (MÜLL.) JAEG. 7) *Calymperes meyeri* REE. 8) *Calymperes nicaraguense* CARD. et REN. 9) *Calymperes guildingii* HOOK. et GREV. 10) *Pilotrichum leoni* WILL. 11) *Atrichum undulatum* (HEDW.) P. BEAUV. 12) *Ephemerum mexicanum* BARTR. 13) *Calymperes donnellii* AUST. 14) *Atrichum crispum* (JAM.) SULL. 15) *Calymperes lanceolatum* HAMP. 16) *Atrichum paraphyllum* WARE. 17) *Atrichum polycarpum* (SCHIMP.) MITT. 18) *Spiridens mülleri* HAMP. 19) *Syrrhopodon croceus* MITT. 20) *Weissia andrewsii* BARTR. 21) *Didymodon fuscoviridis* CARD. 22) *Oligotrichum erosum* (HAMP.) LINDB. 23) *Aulacomnium palustre* (HEDW.) SCHWAEGR. 24) *Dicranum majus* TURN. 25) *Syrrhopodon kiiensis* IWATS. 26) *Calymperes lanceolatum* HAMP. 27) *Dicranum majus* TURN. 28) *Hyophila subcucullata* WIL. 29) *Mnium carolinianum* ANDER. 30) *Hymenostomum ligulaefolium* BARTR. 31) *Mnium hornum* HEDW. 32) *Calymperes petiolatum* BARTR. 33) *Tortula bistratosa* FLOW. 34) *Bartramiopsis lescurii* (JAM.) CARD. et THÉR. 35) *Calymperes nashii* WILL. 36) *Hymenostomum flavescens* BRITT. 37) *Atrichum ligulatum* MITT.

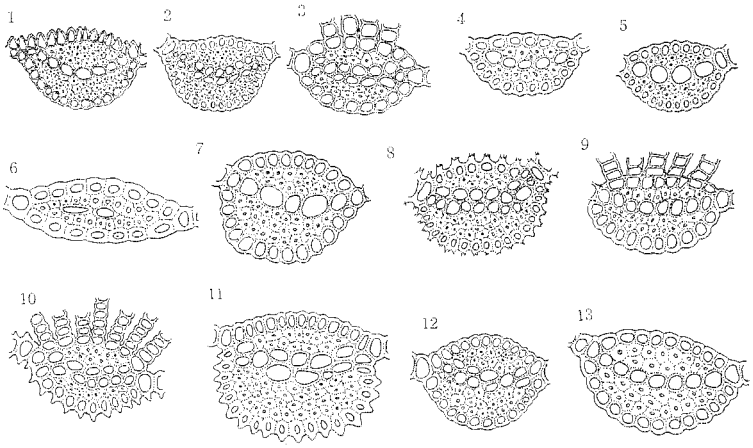

Fig. X Cross sections of the E-type midrib. The distinction among the a-part, b-part and c-part is clear and the b-part is differentiated into b-1, b-2 and G (guide cells).

1) *Timmiella anomala* (B. S. G.) LIMPR. 2) *Calymperes serratum* BR. 3) *Atrichum oerstedianum* (MÜLL.) MITT. 4) *Cyrtopus setosus* (HEDW.) HOOK. 5) *Syrrhopodon ligulatus* MONT. 6) *Pterobryella vagapensis* MÜLL. 7) *Barbula pachyloma* BROTH. 8) *Encalypta streptocarpa* HEDW. 9) *Atrichum selwyni* AUST. 10) *Atrichum angustatum* (BRID.) B. S. G. 11) *Calymperes nashii* WILL. 12) *Mnium hornum* HEDW. 13) *Cinclidotus aquaticus* (JAEG.) B. S. G.

guide cells become differentiated from the tissue of b-part, and are drawn up in one line as in D-type. But what differs from the D-type is the fact that the guide cell row draws a line between the adaxial part (b-1) and abaxial part (b-2) with a few marked exceptions (cf. Fig. VIII), so that in the b-part the distinction among b-1, b-2, and G is well-defined. In Fig. VIII, *Fissidens grandifrons*, *Fissidens cristatus*, *Fissidens rufulus* and *Fissidens serrulatus* have midribs inwhich the guide cells are longitudinally drawn up in one line from adaxial side to abaxial side, so that b-1 and b-2 are not arranged in adaxial and abaxial order, but in right and left of the guide cell row. In Fig. IX, the midribs have a form of the b-part so that, from adaxial side to abaxial side, the tissue is arranged in b-1, G, b-2, order, and are of semicircular or ovoid form as in Fig. IX and Fig. XI. In Fig. X, the whole midrbs are ovoid and the midribs in Fig. XII are almost fusiform.

The midribs which belong to F-type as shown in Fig. XIV-7 (*Calymperes venezuelanum*), have clear distinctions among the a-, b- and c-part and among b-1, b-2, b-3, G-1, G-2, and the tissues of the midrib are arranged in order of b-1, G-1, b-2, G-2, b-3 from the adaxial side; namely, the structure of F-type is the same form as that of E-type, the guide cell row bifurcates and the sclerenchyma (b-2) is differentiated between the two guide cell rows. Thus I classify the inner structures of the

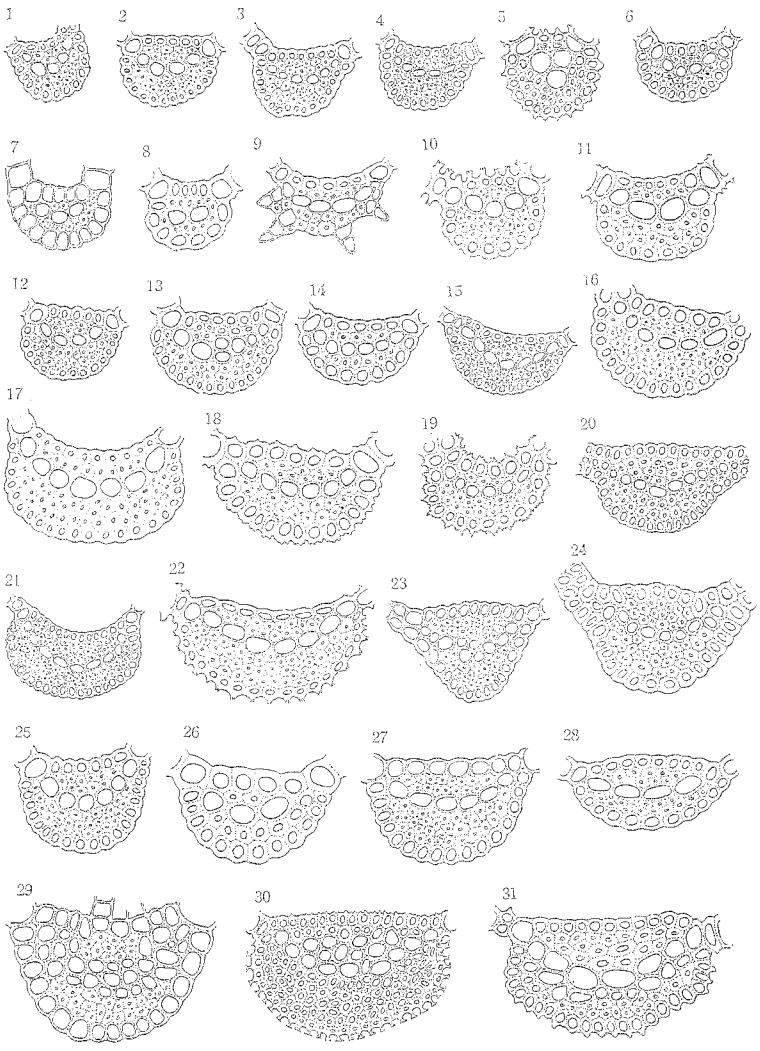

Fig. XI Cross sections of the E-type midrib. The distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b-1, b-2 and G (guide cells).

1) *Onchophorus virens* (SW.) BRID. 2) *Dialytrichia mucronata* (BRID.) SCHIMP. 3) *Calymperes platyloma* MITT. 4) *Calymperes platyloma* MITT. 5) *Tortula ruralis* EHRH. 6) *Rhabdoweisia africana* DIX. et NAV. 7) *Rhabdoweisia crenulata* (MITT.) JAM. 8) *Barbula crassicuspis* ROBINS. 9) *Dicranum scoparium* HEDW. 10) *Weissia glauca* BARTR. 11) *Dialytrichia mucronata* (BRID.) SCHIMP. 12) *Dialytrichia mucronata* (BRID.) SCHIMP. 13) *Barbula unguiculata* (HUDS.) HEDW. 14) *Dicranum rugosum* (HOFFM.) BRID. 15) *Dicranum bergeri* BLAND. 16) *Ptychomitrium godfreyi* ROBINS. 17) *Ptychomitrium formosicum* BROTH. 18) *Molendoa sendtneriana* (B. S. G.) LIMPR. 19) *Dicranoweissia crispula* (HEDW.) LINDB. 20) *Alophosia azorica* CARD. 21) *Ptychomitrium polyphyllum* (SW.) FURNR. 22) *Didymondon killipii* WILL. 23) *Calymperes lonchophyllum* SCHWAEGR. 24) *Grimmia maritima* TURN. 25) *Ptychomitrium longisetum* REIM. et SAK. 26) *Oreas maritima* (HOP. et HORNSCH.) BRID. 27) *Ptychomitrium linearifolium* REIM. 28) *Didymodon giganteus* (FUNCK.) JUR. 29) *Atrichum crispum* (JAM.) SULL. 30) *Encalypta contortao* (WULF.) LINDB. 31) *Calymperes uleanum* BROTH.

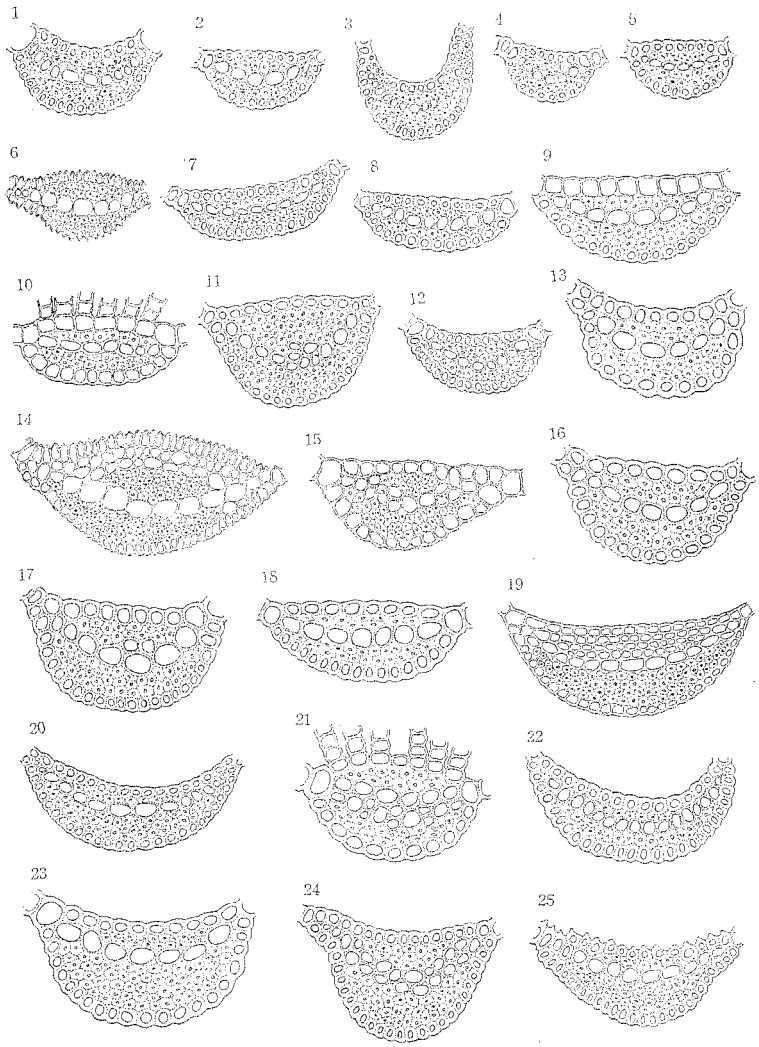

Fig. XII Cross sections of the E-type midrib. The distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b-1, b-2 and G(guide cells).

1) *Syrrhopodon hasegawae* TAK. et IWATS. 2) *Didymodon mexicanus* var. *subulatus* THÉR. et BARTR. 3) *Dicranum fulvum* MITT. 4) *Dicranum hamulosum* MITT. 5) *Calymperes bartramii* REE. 6) *Timmia megapolitana* HEDW. 7) *Dicranum mayrii* BROTH. 8) *Campylopus brevipilus* B. S. G. 9) *Ptychomitrium sinense* (MITT.) JAEG. 10) *Oligotrichum riedelianum* (MONT.) MITT. 11) *Rhizogonium dozyanum* LAC. 12) *Molendoa hornschuchiana* (FUNCK.) LINDB. 13) *Leptotheca gaudichaudii* SCHWAEGR. 14) *Timmia bavarica* HESSL. 15) *Pogonatum gymnophyllum* MITT. 16) *Ptychomitrium wilsoni* SULL. et LESQ. 17) *Calymperes richardii* C. M. 18) *Ptychomitrium fauriei* BESCH. 19) *Timmia megapolitana* HEDW. 20) *Trematodon ambiguus* (HEDW.) HORNSCH. 21) *Atrichum undulatum* (HEDW.) P. BEAUV. 22) *Syrrhopodon parasiticus* (SW.) BESCH. 23) *Ptychomitrium dentatum* JAEG. 24) *Calymperes levyanum* BESCH. 25) *Chrysoblastella boliviana* WILL.

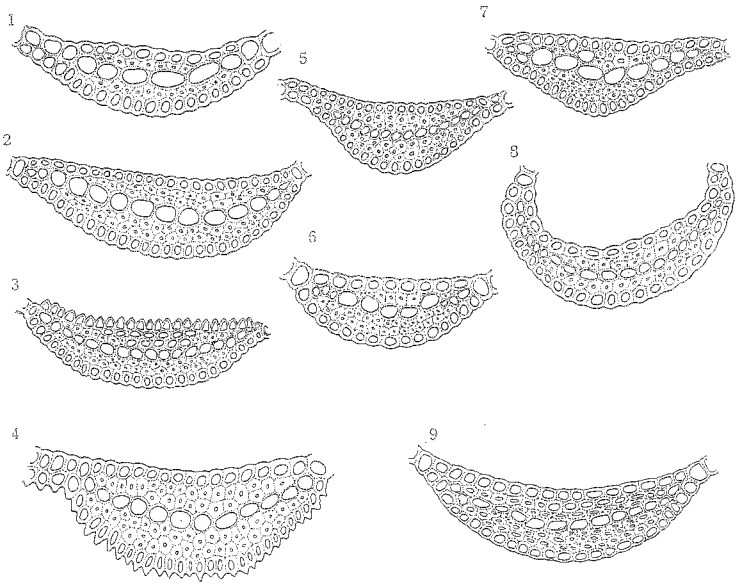

Fig. XIII Cross sections of the E-type midrib. The distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b-1, b-2 and G (guide cells).

1) *Hygrodicranum herrerai* WILL. 2) *Dicranum caesium* MITT. 3) *Timmiella barbuloides* (BRID.) MÖNK. 4) *Symblepharis tenuis* WILL. 5) *Diphyscium sessile* (SCHMID.) LINDB. 6) *Hymenoloma turpe* CARD. 7) *Dicranum fulvum* HOOK. 8) *Dicranodontium denudatum* (BRID.) HAG. 9) *Theriotia lorifolia* CARD.

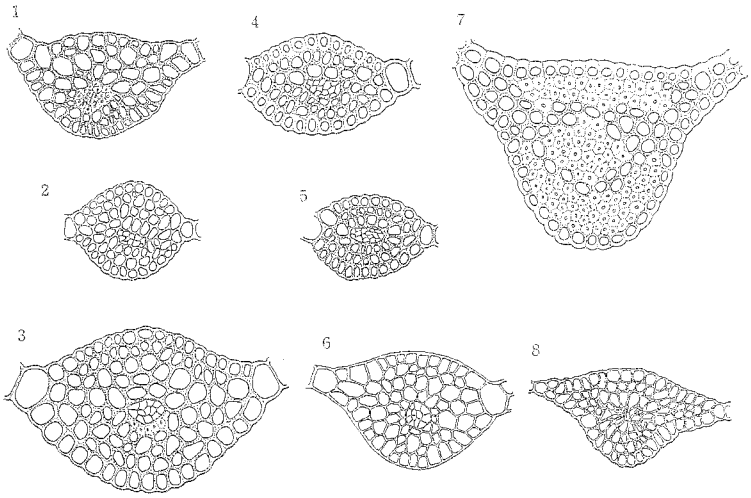

Fig. XIV Cross sections of the D-type (No. 1–6, 8) and F-type (No. 7) midribs. D-type : the distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b and G (guide cells). F-type : the distinction among the a-part, b-part and c-part is clear, and the b-part is differentiated into b-1, b-2, b-3 and G-1, G-2.

1) *Rhodobryum roseum* (HEDW.) LIMPR. 2) *Mnium undulatum* (L.) HEDW. 3) *Mnium medium* B. S. G. 4) *Mnium punctatum* HEDW. 5) *Mnium punctatum* HEDW. 6) *Rhodobryum giganteum* (HOOK.) PAR. 7) *Calymperes venezuelanum* (MITT.) REE. 8) *Mnium speciosum* MITT.

midrib, which many scholars have observed, into six types (A-, B-, C-, D-, E-, F-type).

Next, I consider the relationship between the classification system and the types of the midrib-structure, as shown in Tab. I. The species of which I make an object of consideration, are 276 species, 109 genera, 33 families. In some genera, the whole species or almost all the species, which belong to the same genus, have the identical

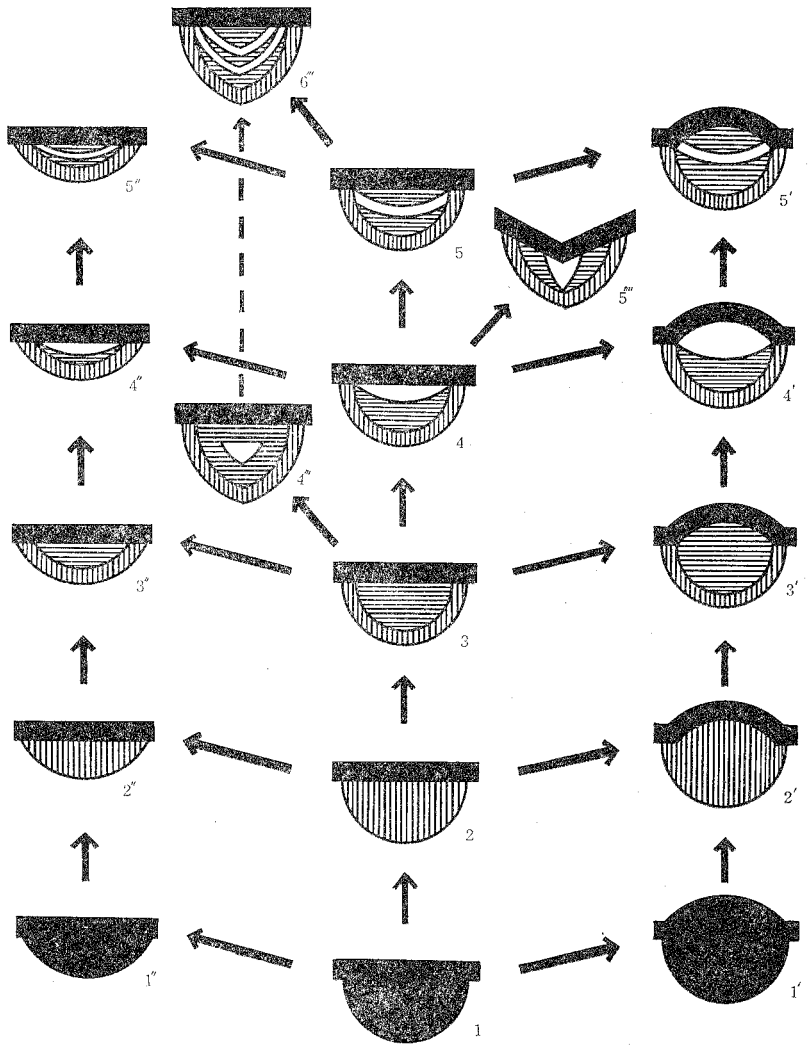

Fig. XV A imaginary picture shown the relationship of typical 18 figures of midrib.

1 : A-type (1 : semicircular, 1′ : ovoid, 1″ : fusiform)
2 : B-type (2 : semicircular, 2′ : ovoid, 2″ : fusiform)
3 : C-type (3 : semicircular, 3′ : ovoid, 3″ : fusiform)
4 : D-type (4 : semicircular, 4′ : ovoid, 4″ : fusiform, 4‴ : triangle)
5 : E-type (5 : semicircular, 5′ : ovoid, 5″ : fusiform, 5⁗ : obvolutus)
6 : F-type (6‴ : triangle)

Tab. I Relationship between the classification system and types of the midrib-structure

Families	Species names	Authors	Types of midribs	Numbers of Fig.
Fissidentaceae	*Fissidens cristatus* WILS.	AUGIER	E	VIII-3
Fissidentaceae	*Fissidens flavosetus* PURS.	PURSELL	E	VIII-6
Fissidentaceae	*Fissidens grandifrons* BRID.	NOGUCHI	E	VIII-2
Fissidentaceae	*Fissidens grandifrons* var. *planicaulis* (BESCH.) NOG.	NOGUCHI	E	VIII-1
Fissidentaceae	*Fissidens rufulus* B. S. G.	CONGIER	E	VIII-4
Fissidentaceae	*Fissidens serrulatus* BRID.	AUGIER	E	VIII-5
Ditrichaceae	*Distichum capillaceum* (SW.) B. S. G.	LINDERG	C	IV-27
Ditrichaceae	*Trichodon tenuifolius* (CHRAD.) LINDB.	LINDERG	D	VI-25
Seligeraceae	*Hymenoloma nordenskjoldii* DUS.	DUSEN	D	VII-5
Seligeraceae	*Hymenoloma turpe* CARD.	CARDOT	E	XIII-6
Dicranaceae	*Camptodontium brotherii* DUS.	DUSEN	A	I-15
Dicranaceae	*Kiaeria starkei* (W. et M.) HAG.	AUGIER	A	II-15
Dicranaceae	*Paraleucobryum longifolium* (HEDW.) LOESK.	AUGIER	A	II-16
Dicranaceae	*Amphidium lapponicum* (HEDW.) SCHIMP.	LIMPICHT	C	IV-15
Dicranaceae	*Dicranella huchinsonii* KRAJI.	KRAJINA	C	V-9
Dicranaceae	*Atractylocarpus panus* WILL.	WILLIAMS	D	VII-1
Dicranaceae	*Oreoweissia serrulata* (FUNCK.) D. NOT.	LIMPRICHT	D	VI-15
Dicranaceae	*Sphaerothecium phascoideum* WILL.	WILLIAMS	D	VII-7
Dicranaceae	*Campylopus arctocarpus* (HORNS.) MITT.	BREEN	D	VI-17
Dicranaceae	*Campylopus piriformis* (SCHULTZ.) BRID.	LIMPRICHT	D	VII-6
Dicranaceae	*Campylopus brevipilus* B. S. G.	LIMPRICHT	E	XII-8
Dicranaceae	*Dicranoweissia cirrhata* (L.) LINDB.	FLOWERS	D	VI-24
Dicranaceae	*Dicranoweissia crispula* (HEDW.) LINDB.	FLOWERS	E	XI-19
Dicranaceae	*Dicranodontium denudatum* (BRID.) HAG.	AUGIER	E	XIII-8
Dicranaceae	*Dicranum dergeri* BLAND.	TAKAKI	E	XI-15
Dicranaceae	*Dicranum caesium* MITT.	KAWAI	E	XIII-2
Dicranaceae	*Dicranum fulvum* HOOK.	AUGIER	E	XII-3
Dicranaceae	*Dicranum fulvum* HOOK.	TAKAKI	E	XIII-7
Dicranaceae	*Dicranum hamulosum* MITT.	TAKAKI	E	XII-4
Dicranaceae	*Dicranum majus* TURN.	AUGIER	E	IX-24
Dicranaceae	*Dicranum majus* TURN.	LIMPRICHT	E	IX-27
Dicranaceae	*Dicranum mayrii* BROTH.	TAKAKI	E	XII-7
Dicranaceae	*Dicranum rugosum* (HOFFM.) BRID.	AUGIER	E	XI-14
Dicranaceae	*Dicranum scoparium* HEDW.	AUGIER	E	XI-9
Dicranaceae	*Hygrodicranum herrerai* WIILL.	WILLIAMS	E	XIII-1
Dicranaceae	*Onchophorus virens* (SW.) BRID.	AUGIER	E	XI-1
Dicranaceae	*Oreas maritima* (HOP. et HORNS.) BRID.	STEERE	E	XI-26
Dicranaceae	*Symblepharis tenuis* WILL.	WILLIAMS	E	XIII-4
Dicranaceae	*Trematodon ambiguus* (HEDW.) HORNSCH.	TAKAKI	E	XII-20

Calymperaceae	*Calymperes rufum* HERZ.	REESE	D	VI-2
Calymperaceae	*Calymperes bartramii* REE.	REESE	E	XII-5
Calymperaceae	*Calymperes donnellii* AUST.	REESE	E	IX-13
Calymperaceae	*Calymperes erosum* C. M.	REESE	E	IX-5
Calymperaceae	*Calymperes guildingii* HOOK. et GREV.	REESE	E	IX-9
Calymperaceae	*Calymperes lanceolatum* HAMP.	KAWAI	E	IX-15
Calymperaceae	*Calymperes lanceolatum* HAMP.	REESE	E	IX-26
Calymperaceae	*Calymperes levyanum* BESCH.	REESE	E	XII-24
Calymperaceae	*Calymperes lonchophyllum* SCHWAEGR.	REESE	E	XI-23
Calymperaceae	*Calymperes meyeri* REE.	REESE	E	IX-7
Calymperaceae	*Calymperes nashii* WILL.	BREEN	E	IX-35
Calymperaceae	*Calymperes nashii* WILL.	REESE	E	X-11
Calymperaceae	*Calymperes nicaraguense* REN. et CARD.	REESE	E	IX-8
Calymperaceae	*Calymperes petiolatum* BARTR.	BARTRAM	E	IX-32
Calymperaceae	*Calymperes platyloma* MITT.	BREEN	E	XI-4
Calymperaceae	*Calymperes platyloma* MITT.	REESE	E	XI-3
Calymperaceae	*Calymperes richardii* C. M.	REESE	E	XII-17
Calymperaceae	*Calymperes serratum* BR.	MORIN	E	X-2
Calymperaceae	*Calymperes smithii* BARTR.	REESE	E	IX-4
Calymperaceae	*Calymperes uleanum* BROTH.	REESE	E	XI-31
Calymperaceae	*Calymperes venezuelanum* (MITT.) REE.	REESE	D	XIV-7
Calymperaceae	*Syrrhopodon tsushimae* CARD.	IWATSUKI	D	VI-13
Calymperaceae	*Syrrhopodon yakushimensis* TAK. et IWATS	IWATSUKI	D	VI-9
Calymperaceae	*Syrrhopodon croceus* MITT.	MORIN	E	IX-19
Calymperaceae	*Syrrhopodon gaudichaudii* MONT.	BREEN	E	IX-3
Calymperaceae	*Syrrhopodon hasegawae* TAK. et IWATS.	IWATSUKI	E	XII-1
Calymperaceae	*Syrrhopodon kiiensis* IWATS.	IWATSUKI	E	IX-25
Calymperaceae	*Syrrhopodon ligulatus* MONT.	BREEN	E	X-5
Calymperaceae	*Syrrhopodon parasiticus* (SW.) BESCH.	BREEN	E	XII-22
Calymperaceae	*Syrrhopodon simmondsii* STEE.	STEERE	E	IX-1
Encalyptaceae	*Encalypta vulgaris* (HEDW.) HOFFM.	CHAMBERLAIN	D	VI-22
Encalyptaceae	*Encalypta vulgaris* var. *lunata* BARTR. et CHAMB.	CHAMBERLAIN	D	VI-16
Encalyptaceae	*Encalypta contorta* (WULF.) LINDB.	IWATSUKI	E	XI-30
Encalyptaceae	*Encalypta streptocarpa* HEDW.	AUGIER	E	X-8
Pottiaceae	*Gyroweisia tenuis* (SCHRAD.) SCHIMP.	AUGIER	A	II-5
Pottiaceae	*Gyroweisia tenuis* (SCHRAD.) SCHIMP.	STEERE	A	I-13
Pottiaceae	*Leptobarbula berica* (D. NOT.) SCHIMP.	SCHIMPER	B	III-28
Pottiaceae	*Luisierella barbula* (SCHWAEGR.) STEE.	CRUM et ANDERSON	B	III-20
Pottiaceae	*Pterygoneurum arcticum* STEE.	STEERE	B	III-11
Pottiaceae	*Tortula caroliniana* ANDR.	ANDREWS	C	IV-26
Pottiaceae	*Tortula propagulosa* SCHARP	SCHARP	C	IV-5
Pottiaceae	*Tortula stanfordensis* STEE.	STEERE	D	VI-8
Pottiaceae	*Tortula williamsii* BARTR.	BARTRAM	D	VI-7
Pottiaceae	*Tortula bistratosa* FLOW.	STEERE	E	IX-33
Pottiaceae	*Tortula ruralis* EHRH.	AUGIER	E	XI-5

Pottiaceae	*Anoectangium compactum* SCHWAEGR.	LIMPRICHT	C	IV-7
Pottiaceae	*Aloina stellata* (SCHREB.) KINDB.	NOGUCHI	D	VII-4
Pottiaceae	*Gymnostomum calcareum* NEE. et HORNS.	STEERE	D	VI-18
Pottiaceae	*Leptodontium bassii* WILL.	WILLIAMS	D	VI-26
Pottiaceae	*Leptodontium spinosum* WILLL.	WILLIAMS	D	VI-12
Pottiaceae	*Pottia davalliana* (SM.) JENS.	WILLIAMS	D	VI-6
Pottiaceae	*Rhabdoweisia denticulata* (BRID.) B. S. G.	LAWTON	D	VI-4
Pottiaceae	*Rhabdoweisia fugax* (HEDW.) B. S. G.	LAWTON	D	VI-11
Pottiaceae	*Sarconeurum glaciale* (H. et W.) CARD. et BRYH.	BRYHN	D	VI-27
Pottiaceae	*Trichostomopsis brevifolia* BARTR.	BARTRAM	D	VI-28
Pottiaceae	*Didymodon fuscoviridis* CARD.	FRYE	D	IX-21
Pottiaceae	*Didymodon fuscoviridis* CARD.	REESE	E	VII-2
Pottiaceae	*Didymodon giganteus* (FUNCK.) JUR.	TAKAKI	E	XI-28
Pottiaceae	*Didymodon killipii* WILL.	WILLIAMS	E	XI-22
Pottiaceae	*Didymodon mexicanus* var. *subulatus* THER. et BARTR.	BARTRAM	E	XII-2
Pottiaceae	*Barbula crassicuspis* ROBINS.	ROBINSON	E	XI-8
Pottiaceae	*Barbula pachyloma* BROTH.	BROTHERUS	E	X-7
Pottiaceae	*Barbula unguiculata* (HUDS.) HEDW.	AUGIER	E	XI-13
Pottiaceae	*Chrysoblastella boliviana* WILL.	SPINDLER	E	XII-25
Pottiaceae	*Cinclidotus aquaticus* (JAEG.) B. S. G.	AUGIER	E	X-13
Pottiaceae	*Dialytrichia mucronata* (BRID.) SCHIMP.	AUGIER	E	XI-2
Pottiaceae	*Dialytrichia mucronata* (BRID.) SCHIMP.	KAWAI	E	XI-11
Pottiaceae	*Dialytrichia mucronata* (BRID.) SCHIMP.	LIMPRICHT	E	XI-12
Pottiaceae	*Hydrogonium subpellucidium* Var. *hyalolomа* HERZ.	NOGUCHI	E	IX-2
Pottiaceae	*Hymenostomum flavescens* BRITT.	BRITTON	E	IX-36
Pottiaceae	*Hymenostomum liglaefolium* BARTR.	BARTRAM	E	IX-30
Pottiaceae	*Hyophila subcucullata* WILL.	WILLIAMS	E	IX-28
Pottiaceae	*Molendoa hornschuchiana* (FUNCK.) LINDB.	LIMPRICHT	E	XII-12
Pottiaceae	*Molendoa sendtneriana* (B. S. G.) LIMPR.	LIMPRICHT	E	XI-18
Pottiaceae	*Rhabdoweisia africana* DIX. et NAV.	LAWTON	E	XI-6
Pottiaceae	*Rhabdoweisia crenulata* (MITT.) JAM.	LAWTON	E	XI-7
Pottiaceae	*Timmiella anomala* (B. S. G.) LIMPR.	LIMPRICHT	E	X-1
Pottiaceae	*Timmiella barbuloides* (BRID.) MÖNK.	AUGIER	E	XIII-3
Pottiaceae	*Weissia andrewsii* BARTR.	BARTRAM	E	IX-20
Pottiaceae	*Weissia glauca* BARTR.	BARTRAM	E	XI-10
Grimmiaceae	*Aligrimmia peruviana* WILL.	ROTH	A	I-19
Grimmiaceae	*Grimmia anomala* HAMP.	KAWAI	B	III-16
Grimmiaceae	*Grimmia apocarpa* HEDW.	KAWAI	B	III-29
Grimmiaceae	*Grimmia apocarpa* var. *atrofusca* (SCHIMP.) HUSN.	KAWAI	B	III-9
Grimmiaceae	*Grimmia apocarpa* var. *conferta* (FUNCK.) SPRENG.	KAWAI	B	III-10
Grimmiaceae	*Grimmia apocarpa* var. *rivularis* (BRID.) NEE. et HORNSCH.	KAWAI	B	III-3
Grimmiaceae	*Grimmia brunnescens* f. *epilosa* (SCHIFFN.)	KAWAI	B	III-13

Grimmiaceae	*Grimmia brunnescens* f. *humilior* VILHL.	KAWAI	B	III-2
Grimmiaceae	*Grimmia cratericola* SAK. et TAK.	KAWAI	B	III-22
Grimmiaceae	*Grimmia cratericola* SAK. et TAK.	TAKAKI	B	III-6
Grimmiaceae	*Grimmia decalvata* CARD.	KAWAI	B	III-12
Grimmiaceae	*Grimmia incurva* SCHWAEGR.	KAWAI	B	III-1
Grimmiaceae	*Grimmia pilifera* P. BEAUV.	KAWAI	B	III-4
Grimmiaceae	*Grimmia torquata* GREV.	KAWAI	B	III-5
Grimmiaceae	*Grimmia gracilis* SCHWAEGR.	KAWAI	B	III-17
Grimmiaceae	*Grimmia gracilis* f. *subepilosa* PIL.	KAWAI	C	IV-10
Grimmiaceae	*Grimmia gracilis* f. *tenuis* VILHL.	KAWAI	C	IV-14
Grimmiaceae	*Grimmia agassizii* (SULL. e. LESQ.) JAEG.	KAWAI	C	IV-19
Grimmiaceae	*Grimmia alpicola* HEDW.	KAWAI	C	IV-21
Grimmiaceae	*Grimmia anodon* B. S. G.	KAWAI	C	V-1
Grimmiaceae	*Grimmia apocarpa* var. *microtheca* CARD.	KAWAI	C	IV-18
Grimmiaceae	*Grimmia apocarpa* var. *tenerrima* NEE. et HORNSCH.	KAWAI	C	IV-17
Grimmiaceae	*Grimmia arizonae* REN. et CARD.	KAWAI	C	IV-32
Grimmiaceae	*Grimmia decipiens* (SCHULTZ.) LINDB.	KAWAI	C	V-2
Grimmiaceae	*Grimmia donniana* SM.	KAWAI	C	IV-24
Grimmiaceae	*Grimmia elatior* BRUCH.	KAWAI	C	IV-31
Grimmiaceae	*Grimmia funalis* (SCHWAEGR.) B. S. G.	KAWAI	C	IV-2
Grimmiaceae	*Grimmia funalis* var. *calvescens* (KINDB.) MÖLL.	KAWAI	C	IV-11
Grimmiaceae	*Grimmia funalis* f. *longipila* BOUL.	KAWAI	C	IV-1
Grimmiaceae	*Grimmia hartmanii* SCHIMP.	KAWAI	C	IV-30
Grimmiaceae	*Grimmia laevigata* (BRID.) BRID.	KAWAI	C	V-5
Grimmiaceae	*Grimmia mollis* B. S. G.	KAWAI	C	IV-22
Grimmiaceae	*Grimmia orbicularis* var. *persica* SCHIFFN.	KAWAI	C	IV-4
Grimmiaceae	*Grimmia ovalis* (HEDW.) LINDB.	KAWAI	C	V-6
Grimmiaceae	*Grimmia patens* (HEDW.) B. S. G.	KAWAI	C	V-7
Grimmiaceae	*Grimmia plagiopodia* HEDW.	KAWAI	C	IV-13
Grimmiaceae	*Grimmia pulvinata* (HEDW.) SM.	KAWAI	C	IV-6
Grimmiaceae	*Grimmia pulvinata* var. *africana* (HEDW.) HOOK. et WILS.	KAWAI	C	IV-29
Grimmiaceae	*Grimmia teretinervis* LIMPR.	KAWAI	C	IV-28
Grimmiaceae	*Grimmia trichophylla* ssp. *lisae* (D. NOT.) BOUL.	KAWAI	C	IV-8
Grimmiaceae	*Grimmia trichophylla* f. *robusta* PODP.	KAWAI	C	IV-25
Grimmiaceae	*Grimmia maritima* Turn.	KAWAI	E	XI-24
Grimmiaceae	*Rhacomitrium anomodontoides* CARD.	KAWAI	B	III-33
Grimmiaceae	*Rhacomitrium canescens* var. *ericoides* (WEB.) SCHIMP.	KAWAI	B	III-25
Grimmiaceae	*Rhacomitrium carinatum* CARD.	KAWAI	B	III-26
Grimmiaceae	*Rhacomitrium fasciculare* (HEDW.) BRID.	KAWAI	B	III-32
Grimmiaceae	*Rhacomitrium heterostichum* (HEDW.) BRID.	KAWAI	B	III-30
Grimmiaceae	*Rhacomitrium lanuginosum* (HEDW.) BRID.	KAWAI	B	III-24
Grimmiaceae	*Rhacomitrium lanuginosum* (HEDW.) BRID.	KAWAI	B	III-27
Grimmiaceae	*Rhacomitrium microcarpum* BRID.	KAWAI	B	III-19

Grimmiaceae	*Coscinodon cribrosus* (HEDW.) SPRUC.	BROTHERUS	C	IV-20
Grimmiaceae	*Indusiella thianschanica* MÜLL. et BROTH.	BROTHERUS	C	V-3
Ephemeraceae	*Ephemerum mexicanum* BARTR.	BARTRAM	E	IX-12
Ephemeraceae	*Ephemerum recurvifolium* (DICKS.) BOUL.	LIMPRICHT	B	III-8
Splachnaceae	*Splachnobryum kieneri* WILL.	WILLIAMS	B	III-7
Bryaceae	*Anomobryum fuji-alpinum* TAK.	TAKAKI	A	I-9
Bryaceae	*Pohlia defecta* (SANIO.) L. R. ANDR.	LIMPRICHT	C	IV-9
Bryaceae	*Bryum cirrhatum* HOPP. et HORNSCH.	LORENTZ	D	VI-1
Bryaceae	*Bryum formosum* MITT.	SALMON	D	VI-20
Bryaceae	*Lepiobryum piriforme* (HEDW.) SCHIMP.	LIMPRICHT	D	VII-9
Bryaceae	*Neobryum costatum* WILL.	WILLIAMS	D	VI-33
Bryaceae	*Plagiobryum demissum* (HOP. et HORNS.) LINDB.	WILLIAMS	D	VI-3
Bryaceae	*Rhodobryum giganteum* (HOOK.) PAR.	SALMON	D	XIV-6
Bryaceae	*Rhodobryum roseum* (HEDW.) LIMPR.	SALMON	D	XIV-1
Leptostomaceae	*Leptostomum splachnoides* HOOK.	BROTHERUS	D	VI--10
Mniaceae	*Orthomniopsis elimbata* NOG.	NOGUCHI	D	VI-21
Mniaceae	*Mnium medium* B. S. G.	LIMPRICHT	D	XIV-3
Mniaceae	*Mnium punctatum* HEDW.	LIMPRICHT	D	XIV-4
Mniaceae	*Mnium punctatum* HEDW.	HORIKAWA	D	XIV-5
Mniaceae	*Mnium speciosum* MITT.	HORIKAWA	D	XIV-8
Mniaceae	*Mnium undulatum* (L.) HEDW.	AUGIER	D	XIV-2
Mniaceae	*Mnium carolinianum* ANDER.	ANDERSON	E	IX-29
Mniaceae	*Mnium hornum* HEDW.	AUGIER	E	IX-31
Mniaceae	*Mnium hornum* HEDW.	KAWAI	E	X-12
Rhizogoniaceae	*Rhizogonium dozyanum* LAC.	LORENTZ	E	XII-11
Aulacomniaceae	*Aulacomnium palustre* (HEDW.) SCHWAEGR.	LIMPRICHT	E	IX-23
Aulacomniaceae	*Leptotheca gaudichaudii* SCHWAEGR.	ROTH	E	XII-13
Meesiaceae	*Paludella squarrosa* (L.) EHRH.	MORIN	A	I-3
Meesiaceae	*Amblyodon dealbatus* (DICKS.) P. BEAUV.	LIMPRICHT	C	IV-16
Meesiaceae	*Meesia triquetra* (HOOK. et TAYL.) ÅONGST.	AUGIER	C	V-11
Catoscopiaceae	*Catoscopium nigritum* (HEDW.) BRID.	MORIN	C	IV-3
Bartramiaceae	*Plagiopus oederi* (SCHWAEGR.) LIMPR.	AUGIER	A	I-18
Bartramiaceae	*Plagiopus javanicus* (D. et M.) FLEISCH.	FLEISCHER	D	VI-5
Bartramiaceae	*Bartramia anomala* WILL.	WILLIAMS	D	VI-30
Bartramiaceae	*Leiomela javanica* (REN. et CARD.) BROTH.	FLEISCHER	D	VI-19
Bartramiaceae	*Leiomela peruviana* WILL.	WILLIAMS	D	VII-3
Spiridentaceae	*Spiridens Mülleri* HAMP.	LORENTZ	E	IX-18
Timmiaceae	*Timmia bavarica* HESSL.	LIMPRICHT	E	XII-14
Timmiaceae	*Timma megapolitana* HEDW.	TAKAKI	E	XII-6
Timmiaceae	*Timma megapolitana* HEDW.	LIMPRICHT	E	XII-19
Erpodiaceae	*Glyphomitrium minutissimum* (OKAM.) BROTH.	NOGUCHI	B	III-23
Erpodiaceae	*Glyphomitrium humillimum* (MITT.) CARD.	NOGUCHI	D	VI-32

Ptychomitiaceae	*Ptchomitrium dentatum* JAEG.	NOGUCHI	E	XII-23
Ptychomitiaceae	*Ptchomitrium fauriei* BESCH.	NOGUCHI	E	XII-18
Ptychomitiaceae	*Ptchomitrium formosicum* BROTH.	KAKAI	E	XI-17
Ptychomitiaceae	*Ptchomitrium godfreyi* ROBINS.	ROBINSON	E	XI-16
Ptychomitiaceae	*Ptchomitrium linearifolium* REIM.	NOGUCHI	E	XI-27
Ptychomitiaceae	*Ptchomitrium longisetum* REIM. et SAK.	NOGUCHI	E	XI-25
Ptychomitiaceae	*Ptchomitrium polyphyllum* (SW.) FURNR.	LIMPRICHT	E	XI-21
Ptychomitiaceae	*Ptchomitrium sinense* (MITT.) JAEG.	NOGUCHI	E	XII-9
Ptychomitiaceae	*Ptchomitrium wilsoni* SULL. et LESQ.	NOGUCHI	E	XII-16
Orthotrichaceae	*Leratia neocaledonica* BROTH.	SPINDLER	A	I-22
Orthotrichaceae	*Orthotrichum affine* SCHRAD.	AUGIER	A	I-16
Orthotrichaceae	*Orthotrichum anomalum* HEDW.	LIMPRICHT	A	I-4
Orthotrichaceae	*Pleurorthotrichum chilense* BROTH.	TÉRIOT	A	I-1
Orthotrichaceae	*Macromitrium trinitense* WILL.	WILLIAMS	B	III-15
Orthotrichaceae	*Rhachitheciopsis tisserantii* IWATS.	IWATSUKI	B	III-14
Orthotrichaceae	*Hypnodontopsis apiculata* IWATS. et NOG.	IWATSUKI	B	III-18
Orthotrichaceae	*Hypnodontopsis apiculata* IWATS. et NOG.	KAWAI	B	III-34
Orthotrichaceae	*Hypnodontopsis apiculata* IWATS. et NOG.	ROBINSON	D	VI-23
Orthotrichaceae	*Hypnodontopsis mexicana* (THÉR.) ROBINS.	ROBINSON	D	VI-29
Orthotrichaceae	*Rhachithecium perpusillum* (THWA. et MITT.) BROTH.	ROBINSON	C	IV-12
Orthotrichaceae	*Rhachithecium tisserantii* (P. VAR.) ROB.	ROBINSON	C	IV-23
Rhacpiaceae	*Rhacopilum tomentosum* (HEDW.) BRID.	KAWAI	D	VI-31
Cyrtopodaceae	*Cyrtopus setosus* (HEDW.) HOOK.	ROTH	E	X-4
Pterobryaceae	*Pterobryella vagapensis* MÜLL.	BROTHERUS	E	X-6
Pilotrichaceae	*Pilotrichum leoni* WILL.	WILLIAMS	E	IX-10
Thuidiaceae	*Anomodon abbreviatus* MITT.	IWATSUKI	A	I-11
Thuidiaceae	*Anomodon acutifolius* MITT.	IWATSUKI	A	II-11
Thuidiaceae	*Anomodon giraldii* MÜLL.	IWATSUKI	A	I-5
Thuidiaceae	*Anomodon longifolius* (BRID.) HARTM.	IWATSUKI	A	I-2
Thuidiaceae	*Anomodon rugelii* (MÜLL.) KEISSL.	IWATSUKI	A	I-12
Thuidiaceae	*Anomodon rugelii* var. *ferrugineus* (BESCH.) IWATS.	IWATSUKI	A	I-6
Thuidiaceae	*Anomodon thraustus* MÜLL.	IWATSUKI	A	I-27
Thuidiaceae	*Anomodon viticulosus* (HEDW.) HOOK. et TAYL.	IWATSUKI	A	II-9
Amblystegiaceae	*Amblystegium montanae* BRYH.	WYNNE	A	I-10
Amblystegiaceae	*Drepanocladus aduncus* (HEDW.) WARNST.	WYNNE	A	I-26
Amblystegiaceae	*Drepanocladus exannulatus* (B. S. G.) WARNST.	WYNNE	A	II-2
Amblystegiaceae	*Drepanocladus fluitans* (HEDW.) WARNST.	WYNNE	A	I-25
Amblystegiaceae	*Drepanocladus revolvens* (TURN.) WARNST.	WYNNE	A	II-3
Amblystegiaceae	*Drepanocladus vernicosus* (LINDB.) WARNST.	WYNNE	A	II-4
Amblystegiaceae	*Hygroamblystegium tenax* (HEDW.) JENN.	AUGIER	A	II-6
Amblystegiaceae	*Sciaromium freyer* WILL.	WILLIAMS	A	II-1

Brachytheciaceae	*Bryhnia novae-angliae* (SULL. et LESQ.) GROUT.	ROBINSON	A	II-12
Brachytheciaceae	*Bryoandersonia illecebra* (HEDW.) ROBINS.	ROBINSON	A	II-17
Brachytheciaceae	*Cratoneurella uncinifolia* (BROTH. et PAR.) ROBINS.	ROBINSON	A	II-13
Brachytheciaceae	*Chamberlainia acuminata* ROBINS.	ROBINSON	A	I-28
Brachytheciaceae	*Chamberlainia albicans* (HEDW.) ROBINS.	ROBINSON	A	I-8
Brachytheciaceae	*Chamberlainia axyclada* (BRID.) ROBINS.	ROBINSON	A	I-20
Brachytheciaceae	*Chamberlainia erythrorrhiza* (B. S. G.) ROBINS.	ROBINSON	A	I-7
Brachytheciaceae	*Chamberlainia rotaeana* (D. NOT.) ROBINS.	ROBINSON	A	I-21
Brachytheciaceae	*Chamberlainia salebrosa* (WED. et MOHR.) ROBINS.	ROBINSON	A	I-24
Brachytheciaceae	*Homalothecium leskeoides* (HOOK.) ROBINS.	ROBINSON	A	I-17
Brachytheciaceae	*Brachythecium latifolium* KINDB.	ROBINSON	A	II-7
Brachytheciaceae	*Brachythecium rivulare* (BRUCH.) B. S. G.	ROBINSON	A	II-14
Brachytheciaceae	*Brachythecium rutabulum* (HEDW.) B. S. G.	ROBINSON	A	I-14
Brachytheciaceae	*Brachythecium semilatum* (HEDW.) Robins.	ROBINSON	A	II-10
Brachytheciaceae	*Brachythecium cirrosum* SCHRF.	ROBINSON	B	III-31
Brachytheciaceae	*Brachythecium plumosum* B. et S.	ROBINSON	B	III-21
Brachytheciaceae	*Brachythecium reflexum* (STARK.) B. S. G.	B. S. G.	C	V-8
Entodontaceae	*Entodon concinnus* (D. NOT.) ssp. *caliginosus* (MITT.) MIZU.	MIZUSHIMA	A	II-8
Dipsciaceae	*Diphyscium cumberlandianum* HARV.	HARVILL	C	V-4
Dipsciaceae	*Diphyscium sessile* (SCHMID.) LINDB.	MORIN	E	XIII-5
Dipsciaceae	*Theriotia lonifolia* CARD.	CARDOT	E	XIII-9
Polytrichaceae	*Pogonatum spinulosum* MITT.	KAWAI	C	V-10
Polytrichaceae	*Pogonatum gymnophyllum* MITT.	SALMON	E	XII-15
Polytrichaceae	*Oligotrichum rigidum* (GORENTH.) BROTH.	FRYE	D	VI-14
Polytrichaceae	*Oligotrichum erosum* (HAMP.) LINDB.	FRYE	E	IX-22
Polytrichaceae	*Oligotrichum riedlianum* (MONT.) MITT.	FRYE	E	XII-10
Polytrichaceae	*Alophosia azorica* CARD.	CARDOT	E	XI-20
Polytrichaceae	*Atrichum angustatum* (BRID.) B. S. G.	KAWAI	E	X-10
Polytrichaceae	*Atrichum crispum* (JAM.) SULL.	OSADA	E	IX-14
Polytrichaceae	*Atrichum crispum* (JAM.) SULL.	KAWAI	E	XI-29
Polytrichaceae	*Atrichum ligulatum* MITT.	FRYE	E	IX-37
Polytrichaceae	*Atrichum oerstedianum* (MÜLL.) MITT.	ANDERSON	E	X-3
Polytrichaceae	*Atrichum paraphyllum* WAREH.	WAREHAM	E	IX-16
Polytrichaceae	*Atrichum polycarpum* (SCHIMP.) MITT.	ANDERSON	E	IX-17
Polytrichaceae	*Atrichum selwynii* AUST.	FRYE	E	X-9
Polytrichaceae	*Atrichum sendulatum* (HEDW.) P. BEAUV.	HABERLANDT	E	IX-11
Polytrichaceae	*Atrichum undulatum* (HEDW.) P. BEAUV.	KAWAI	E	XII-21
Polytrichaceae	*Atrichum xanthopelma* (MÜLL.) JAEG.	FRYE	E	IX-6
Polytrichaceae	*Bartramiopsis lescurii* (JAM.) CARD.	SALMON	E	IX-34

Tab. II Relationship between the characteristics of the midrib structure and the classification system of the genera

(1) Types of the midrib structure	(2) Genus names	(3) Numbers of species having identical type of midrib structure	(4) The rate of (3) to the total number of species belonging to each genus
A	Gyroweisia	2	1.0
	Orthotrichum	4	1.0
	Anomodon	9	1.0
	Drepanocladus	8	1.0
	Chamberlainia	6	1.0
	Brachythecium	4	0.7
B	Grimmia	14	0.4
	Rhacomitrium	8	0.8
C	Aloina	26	0.6
	Rhacomitrium	2	0.2
D	Aloina	2	1.0
	Leptodontium	2	1.0
	Bryum	2	1.0
	Rhodobryum	2	1.0
	Mnium	5	0.8
E	Fissidens	6	1.0
	Dicranum	20	1.0
	Calymperes	20	0.9
	Syrrhopodon	7	0.8
	Barbula	3	1.0
	Didymodon	5	0.8
	Dialytrichia	3	1.0
	Hymenostomum	2	1.0
	Molendoa	2	1.0
	Timmiella	2	1.0
	Weissia	2	1.0
	Timmia	3	1.0
	Ptychomitrium	9	1.0
	Atrichum	11	1.0

type of midrib. In *Gyroweisia*, all of the two species, all species of *Orthotrichum* (4 species), all species of *Anomodon* (9 species), all species of *Drepanocladus* (8 species), all species of *Chamberlainia* (6 species) and almost all of *Brachythecium* (4 species) have an A-type midrib. Some species of *Grimmia* (14 species), all species of *Rhacomitrium* (8 species) have a B-type midrib. The midribs of some *Grimmia* (26 species) and all species of *Rhachithecium* (2 species) are C-type. All species of *Aloina* (2 species), *Leptodontium* (2 species), *Bryum* (2 species), *Rhodobryum* (2 species) and almost all species of *Mnium* (5 species) have a D-type midrib. The midribs which belong to E-type are found on all species of *Fissidens* (6 species), *Dicranum* (10 species), *Barbula* (3 species), *Pialytrichia* (3 species), *Hymenostomum* (2 species), *Molendoa* (2 species), *Timmiella* (2 species), *Weissia* (2 species), *Timmia* (3 species), *Ptychomitrium* (9 species), *Atrichum* (11 species) and on almost all species of *Calymperes* (20 species), *Syrrhopodon* (7 species) and *Didymodon* (5 species), as seen in Tab. II. In view of these facts, I conclude that the characteristics of the midrib-structure are fairly peculiar to the genus, so that the characteristics of the midrib-

structure are vitally important in the classification system of the genus. Moreover all midribs of Thuidiaceae (8 species), of Amblystegiaceae (8 species) and almost all midribs of Brachytheciaceae (14 species) are A-type. Some midribs of Grimmiaceae (22 species) are B-type and other midribs of Grimmiaceae (26 species) are C-type. Almost all midribs of Bryaceae (7 species), of Mniaceae (5 species), of Bartramiaceae (4 species) and some midrbs of Pottiaceae (12 species) are D-type. Some midribs of Pottiaceae (26 species), almost all midribs of Polytrichaceae (16 species), Calymperaceae (26 species) and all midribs of Timmiaceae (3 species), Ptychomitriaceae (9 species) and Fissidentaceae (6 species) are E-type (as seen in Tab. III).

Tab. III Relationship between the characteristics of the midrib structure and the classification system of families

(1) Types of the midrib structure	(2) Family names	(3) Numbers of species having the identical type of the midrib strucrute	(4) The rate of (3) to the total number of species belonging to each family
A	Thuidiaceae	8	1.0
	Amblystegiaceae	8	1.0
	Brachytheciaceae	14	0.9
B	Grimmiaceae	22	0.4
C	Grimmiaceae	26	0.6
D	Bryaceae	7	0.8
	Mniaceae	5	0.6
	Bartramiaceae	4	0.8
	Pottiaceae	12	0.3
E	Pottiaceae	26	0.5
	Polytrichaceae	16	0.9
	Timmiaceae	3	1.0
	Ptychomitriaceae	9	1.0
	Fissidentaceae	6	1.0
	Calymperaceae	26	0.9

As stated above, not only in some genera but in some families, the whole species or almost all species which belong to the same family, have the identical type of the midrib.

In Thuidiaceae, Amblystegiaceae, Timmiaceae, Ptychomitriaceae, Fissidentaceae, Aulacomniaceae, the whole species should give the identical type of the midrib. However, the rate of the number of species which I here consider, to the total number of species belonging to each family, is very small and consequently I can not be quite conclusive through these facts alone. Again in Brachytheciaceae, Bryaceae, Mniaceae, Bartramiaceae, Polytrichaceae, Calymperaceae, almost all species have the identical type of midrib, and only a few species give a different type of midrib. If we make a more detailed observation, it may possibly be known whether the whole species belonging to each family give the identical type of midrib or several different types of midrib.

On the other hand, *Ditrichum capillaceum* and *Trichodon tenuifolius* in Ditrichaceae, *Hymenoloma nordenskjoldii* and *Hymenoloma turpe* in Seligeraceae, *Ephemerum mexicanum* and *Ephemerum recurvifolium* in Ephemeraceae, *Paludella squarrosa*, *Amblyodon dealbatus* and *Meesia triquetra* in Meesiaceae, *Glyphomitrium minutissimum* and *Glyphomitrium humillium* in Erpodiaceae and *Diphyscium cumberlandianum* and *Diphyscium sessile* in Diphysciaceae give a different type of midrib in each family; however, these species closely resemble each other.

As compared with these, in *Aloina*, *Anoectangium*, *Barbula*, *Chrysoblastella*, *Cinclidotus*, *Gyroweisia*, *Leptobarbula*, *Luisierella*, *Pterygoneurum*, *Gymnostomum*, *Leptodontium*, *Pottia*, *Didymodon*, *Dialytrichia*, *Hydrogonium*, *Hymenostomum*, *Hyophila*, *Molendoa*, *Tortula*, *Trichostomopsis*, *Rhabdoweisia*, *Timmiella*, *Weissia*, *Sarconeurum* (in Pottiaceae), *Grimmia*, *Rhacomitrium*, *Coscinodon*, *Aligrimmia*, *Indusiella* (in Grimmiaceae), *Camptodontium*, *Kiaeria*, *Paraleucobryum*, *Amphidium*, *Dicranel-*

Tab. IV Relationship between Dixon's system of the classification and the characteristics of the midrib structure

Dixon's system of the classification			The characteristics of the midrid			
			Lack	Short	Weak	Strong
I. Nematodonteae		Polytrichaceae			●	●
		Buxbaumiaceae	●	●	●	●
II. Arthrodonteae 1. Aplolepideae		Dicranaceae			●	●
		Fissidentaceae			●	●
		Grimmiaceae		●	●	●
		Tortulaceae			●	●
2. Diplolepideae	(1) Acrocarpae	Encalyptaceae				●
		Orthotrichaceae		●	●	
		Funariaceae		●	●	
		Timmiaceae			●	●
		Bartramiaceae		●	●	
		Bryaceae		●	●	●
	(2) Pleurocarpae	Fontinalaceae	●			
		Cryphaeaceae		●		
		Neckeraceae	●			
		Hookeriaceae	●	●		
		Leucobryaceae	●			
		Leskeaceae	●	●		
		Hypnaceae	●			

la, Atractylocarpus, Campylopus, Dicranoweissia, Oreoweisia, Sphaerothecium, Dicranodontium, Dicranum, Hygrodicranum, Onchopholus, Oreas, Symblepharis, Trematodon (in Dicranaceae), *Encalypta* (in Encalyptaceae), *Glyphomitrium* (in Erpodiaceae), *Leratia, Orthotrichum, Pleurorthotrichum, Macromitrium, Rhachitheciopsis, Hypnodontopsis, Rhachithecium* (in Orthotrichaceae), the species belonging to each family give several distinctly different types of midrib structure.

As for the rest of the families: Splachnaceae, Leptostomaceae, Rhizogoniaceae, Catoscopiaceae, Spiridentaceae, Rhacopilaceae, Cyrtopodaceae, Pterobryaceae, Piloyrichaceae, Entodontaceae, only one species in each family is placed under consideration in this paper, so that here I can not discuss them adequately.

Tab. IV shows the relationship between Dixon's system of classification and the characteristics of the midrib (presence, length, strength). There is much to be desired in Dixon's system, which is old. Moreover, the characteristics of the midrib are expressed in terms of obscure sense. However, the system is good in that, consistently based on the characteristics of the sporophyte, the groups are divided and that this shows some correlation between the order based on the characteristics of the sporophyte and the order based on the characteristics of the gametophyte (midrib). This fact may indicate that the characteristics of the midrib structure have to be given due emphasis in taxonomical studies.

Summary

Since about ten years ago, I have studied the midrib in Musci, the characteristics of the inner structure of Musci-midrib have been observed by many bryologists, too. However, the significance and relevancy of the midrib for systematic studies have so far been little investigated. I have always studied placing my primary emphasis upon the characteristics of the inner structure of the midrib in Grimmia. And I came to know that such characteristics of the midrib as the cell number in the a-part, morphological differentiation of the midrib, ontogeny of the midrib, are less variable, distinctly specific and peculiar to the species. Since then I have studied and taken a great in whether I can place my emphasis upon the characteristics of the inner structure of the midrib in Musci too. To begin with, in this paper I consider only one point of significance of the midrib for systematic study. That is, I examine whether these characteristics are peculiar to the species and whether there is something in common among the characteristics of the inner structure of the midrib in the species belonging to the identical genus.

The species which I have considered here, are thirty-three families, 109 genera, 276 species. The number of the genera which have something in common among the characteristics of the inner structure of the midrib in the species belonging to one genus, are 29 genera and the total number of the species which belong to these genera, are 183 species. In the families: Thuidiaceae, Amblystegiaceae and Brachytheciaceae,

the whole species have the midrib of the A-type. In Grimmiaceae some midribs are B-type and others are C-type. The species in Bryaceae, Mniaceae, Bartramiaceae, give all the D-type of the midrib structure. In Pottiaceae some species have the D-type of the midrib structure and others give the E-type. The species belonging to the families, Polytrichaceae, Timmiaceae, Ptychomitriaceae, Fissidentaceae, Calymperaceae give all the E-type of the midrib structure. As stated above, of thirty-three families, thirteen families have something in common among the characteristics of the inner structure of the midrib, and the next five families: Ditrichaceae, Seligeraceae, Ephemeraceae, Meesiaceae, Erpodiaceae may give the identical type of the midrib if we will more minutely observe them.

In all of the 276 species which I have here considered, the characteristics of the inner structure of the midrib are found to show some differences from species to species and to be peculiar to the species. Next, 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 specific character of the inner structure of the midrib to the species and something in common among the characteristics of them in the species belonging to the identical genus and family, I think that these characteristics have to be given due emphasis in taxonomical studies.

Problems for further study——some of the characteristics observed in the midrib are considered to be peculiar to the species and hence taxonomically significant, so that, the midrib structure will be of the most important of all the parts of the gametophyte for the taxonomical study of Musci. I will, therefore, continue observation of the following subjects;

1) Ontogenetic development of the midrib.
2) Peculiarity of the midrib structure.
3) Uniformity of the midrib structure in a genus and family.
4) Relationship among these.

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