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The bryophytes of Sabah (North Borneo) with special reference to the BRYOTROP transect of Mount Kinabalu. VI. *Polytrichaceae* and *Buxbaumiaceae (Bryopsida)*

Abstract

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The *Polytrichaceae* are represented in Borneo by the genera *Dawsonia* (2 species) and *Pogonatum* (11 species), the family *Buxbaumiaceae* by the genus *Diphyscium* (5 species). Keys are presented as well as descriptions, illustrations and distributional data. Comments on the total range of the species, nomenclatural notes and taxonomic remarks are also included. Four names are reduced to synonymy, i.e. *Diphyscium rhynchophorum, Pogonatum euryphyllum, P. spurio-cirratum* and *P. submacrophyllum*.

Introduction

According to the studies by Smith (1971) and more recently by Touw (1986) the family *Polytrichaceae* is represented in E Asia by eleven genera. It is thus slightly surprising that only two of them are reported for the island of Borneo. The number of species known from Borneo (so far 14) is low as well, when compared with the Philippines with 15 species (Iwatsuki & Tan 1979, Tan 1983) and New Guinea with 22 species belonging to seven genera (Hyvönen 1986). However, in the latter area the percentage of species attributable to the southern Gondwana-element is more pronounced being one reason for the high figure.

The *Polytrichaceae* species of Borneo mostly belong to the Malesian and SE Asian element (Hyvönen 1988) with *Pogonatum iwatsukii* Touw being endemic to Borneo. *Dawsonia longifolia* (Bruch & Schimp.) Zant. represents a southern Gondwana-element with a range extending from New Zealand to Malesia. *Pogonatum urnigerum* (Hedw.) P. Beauv. is a plant with wide distribution both in the N and S hemispheres.

The *Buxbaumiaceae* are represented in Borneo by the genus *Diphyscium* Mohr with five species. The occurrance of *Buxbaumia javanica* C. Muell. is anticipated as it has been reported from all surrounding areas (Hyvönen 1986).

Touw (1982) presented some figures on the number of taxa known to occur in Borneo thereby clearly showing the poor knowledge of the Indonesian parts of the island. Like in many other tropical regions places of easy access have been visited by several bryologists and thus we are faced with an extremely uneven knowledge of any larger area.

The distribution data presented here are based on the recent literature as well as on an unpublished manuscript by Cadée-Coenen (1965); consequently specimens from all areas listed have not been consulted.

Polytrichaceae Schwaegr. in Willd., Sp. Pl. 5(2): 1 (1830).

Two genera of the *Polytrichaceae*, i.e. *Dawsonia* R. Br. and *Pogonatum* P. Beauv., are present in Borneo. I follow Smith (1971) in including the genus *Dawsonia* in this family rather than separating it as a family of its own.

As noted by Touw (1978) in his checklist of mosses from Borneo earlier records are rather scattered. On the other hand the two genera have recently been revised: *Dawsonia* by Zanten (1973) and *Pogonatum* sect. *Racelopus* Touw by Touw (1986). A synopsis of the genus *Pogonatum* is under preparation by the present author.

I prefer to avoid the use of subspecific taxa following the general practice in the series of papers on the bryophytes of the Huon Peninsula in Papua New Guinea (cf. Koponen & Norris 1985). The Roman numerals refer to collecting sites as listed by Menzel (1988).

Key to Bornean species of *Polytrichaceae*

1. Ventral side of lamina covered by lamellae 2
– Leaves without lamellae 12
2. Stems with dawsonioid central strand consisting of hydroids and sclerenchyma (Fig. 1b), large or robust plants, leaves essentially straight when dry 3
– Stems with polytrichoid central strand (solid hydromcylinder, Fig. 1a) or with poorly differentiated central strand 4
3. Apical cells of lamellae straight or very slightly crenate in side view ..... *Dawsonia longifolia*
– Apical cells of lamellae distinctly crenate in side view ..... *D. beccarii*
4. Apical cells of lamellae papillose 5
– Apical cells of lamellae smooth 6
5. Apical cells of lamellae very finely papillose, cells mostly retuse in cross-section, small to medium-sized plants with leaves contorted in dry condition ..... *Pogonatum neesii*
– Apical cells of lamellae coarsely papillose, distinctly convex in cross-section, leaves appressed or erect spreading and only slightly curved in dry condition ..... *P. urnigerum*
6. Lamellae absent or very reduced and restricted to the costal area, lamina unistratose ..... *P. proliferum*
– Lamellae present practically on the whole lamina or when absent lamina multistratose 7
7. Apical cells of lamellae crenate in side view 8
– Apical cells of lamellae essentially straight in side view 9
8. Lamellae 5–7 cells high, apical cells of lamellae very irregularly and distinctly crenate in side view, leaves incurved when dry ..... *P. microphyllum*
– Lamellae 3(–4) cells high, regularly crenate, leaves contorted when dry ..... *P. subtortile*
9. Robust plants, ventral lamellae reduced and restricted to leaf apex or practically absent ..... *P. macrophyllum*
– Small to robust plants, ventral lamellae present on at least half of the leaf length 10
10. Robust plants, lamellae reduced and often geminate, present on whole leaf or restricted to upper half ..... *P. macrophyllum*
– Small to robust plants, lamellae 1–4 cells high, present on whole leaf 11
11. Lamellae 1, rarely 2 cells high, upper part of sheath margins dentate, laminar cells fairly wide (fig. 3e) ..... *P. cirratum*
– Lamellae 1–4 cells high, sheath margins entire, laminar cells fairly narrow and lamellae tightly set (fig. 3d) ..... *P. fuscatum*
12. Plants with distinct stem with many leaves 13

– Plants with reduced stems with only few leaves 15
13. Some reduced lamellae present on ventral side of lamina ..... *P. proliferum*
– Lamellae totally absent 14
14. Stems up to 7 cm high, leaf apex acute with sharp marginal teeth ..... *P. rutteri*
– Stems up to 3 cm high, leaf apices broadly acute to obtuse, marginal teeth rounded .....
..... *P. philippinense*
15. Leaf-cells nearly homogenous, elongated throughout ..... *P. piliferum*
– Leaf-cells elongated at base, polygonal in upper part 16
16. Leaf apex obtuse or broadly acute, lamina with many polygonal cells ..... *P. philippinense*
– Leaf apex narrowly acute with only few polygonal cells in upper part 17
17. Lower leaves broadly ovate to circular, leaves without stereid bands ..... *P. camusii*
– Lower leaves triangular, leaves with stereid bands ..... *P. iwatsukii*

Dawsonia R. Br. in Trans. Linn. Soc. London 10: 316 (1811).

Two species of this Austro-Malesian genus are present in Borneo, *D. beccarii* Broth. & Geh. and *D. longifolia* (Bruch & Schimp.) Zant. Both of them belong to *Dawsonia* sect. *Superba* Schlieph. & Geh. emend. G. L. Sm. and thus possess the typical "dawsonioid" central strand (see Fig. 1B), a good and easily observed diagnostic character. Both species are also characterized by their large size. Some species of the genus *Pogonatum* are also fairly robust but all of them have leaves distinctly contorted in dry condition thus deviating clearly from the two species of *Dawsonia* with straight or only slightly and spirally twisted leaves.

When fertile, specimens of the genus *Dawsonia* are immediately identified by the unique, asymmetrical capsule with brush-like peristome.

Dawsonia beccarii Broth. & Geh., in Broth. in Rev. Bryol. Lichénol. 23: 78 (1896) – Fig. 2B.
= *Dawsonia brevifolia* Gepp. in Gibbs in J. Linn. Soc. Bot. 42: 209 (1914). – Typus: Malaysia, Sabah, Kinabalu, 9000 ft., on exposed serpentine, 2. 1910, *Gibbs 3117* (Holo-BM, iso-GRO; not seen) – cf. Wijk 1957.
= *Dawsonia kinabaluensis* Broth. in Herz., Geogr. Moose 183 (1926), nom. nud. – Original collection: Malaysia, Borneo, Sabah, Mt Kinabalu, Kemberanga, 11.–15. 11. 1915, *Clemens 10549* (H-BR!) – cf. Burges 1949.

Ic.: Geheeb 1898: tab. 12; Dixon 1922: pl. 28, fig. 3 (as *D. crispifolia* Dix.), fig. 4 (as *D. limbata* Dix.); Noguchi 1953: 21, fig. 10, 14–17; Zanten 1973: pl. 6g–k, 8c, 10h (as var. *beccarii*), pl. 6a–f, 8e, 11c, photo 2 (as var. *limbata*), pl. 7a, 8d, 10g (as var. *longivaginata* Zant. & P. Heuk); Hébant 1976: 234, pl. 1, fig. 4 (as var. *limbata*); Hyvönen 1986: 113, fig. 2d, 114, fig. 3g, 115, fig. 4c; Eddy 1988: 53, fig. 41.

Plants erect, robust, stems up to 39 cm high. Leaves linear-lanceolate, sheathing, closely appressed when dry, appressed to erect spreading when moist, 9–14 mm long and lamina 0.6–1.1 mm wide. Lamellae 5–6 cells high, apical row distinctly crenate as seen in side view, cells finely papillose with incrassate walls. Dioicous. Seta 2–3 cm and capsule 5–8 mm long.

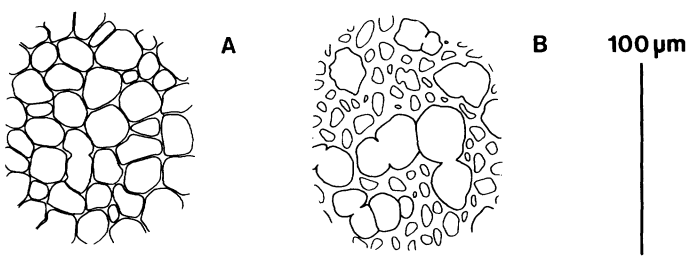
D. beccarii is distinguished from *D. longifolia* by the typical terete habit with short leaves closely appressed to the stem. In addition, the apical cells are distinctly crenate in side view in *D. beccarii* while in *D. longifolia* they are essentially smooth or very slightly crenulate.

D. beccarii is variable species with three varieties distinguished by Zanten (1973). Two of them, var. *beccarii* and var. *limbata* (Dix.) Zant. & P. Heuk., have been recorded from Borneo, the latter, however, only

once by Iwatsuki & Noguchi (1975). Specimens of var. *limbata* with speading, fairly long leaves and short stems might be difficult to identify.

On Borneo *D. beccarii* has been recorded at an altitude of 1425–3800 m from montane rainforests to upper montane (mossy) forests and areas above the timberline. It is a plant of fairly open habitats growing on ground.

Geographical range: Borneo (SAB, KIN), Sulawesi, West Irian, Papua New Guinea, Philippines.
Altitudinal range (Borneo): 1425–3800 m.
Specimens examined:
BRYOTROP: XXIII: *3346, 3384.* - XXV: *3642, 3708.*
Additional collections: KIN: Anstieg zum Mt Kinabalu zwischen Park Headquarter und Power Station, Regenwald, um 1700 m, *Albertshofer 60* (H).



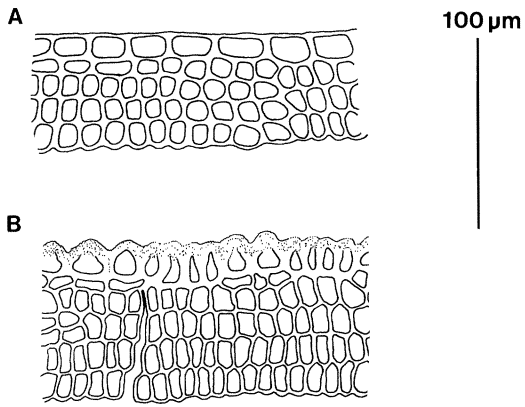
Figs. 1A–B. – Stem cross-sections. – A. *Pogonatum macrophyllum* Dozy & Molk. (*Menzel et al. 4632*, H). – B. *Dawsonia longifolia* (Bruch & Schimp.) Zant. (*Menzel et al. 3360*, H).

Dawsonia longifolia (Bruch & Schimp.) Zant. in Lindbergia 4: 133 (1977) – Fig. 1B, 2A.
≡ *Polytrichum longifolium* Bruch & Schimp. in B. S. G., Bryol. Eur. 4: 256 (1844).
= *Dawsonia superba* Grev. in Ann. Mag. Nat. Hist. 19: 226 (1847) – cf. Zanten 1973.
= *Dawsonia altissima* Geh. ex Gepp. in Gibbs in J. Linn. Soc. Bot. 42: 209 (1914). – Typus: Malaysia, Sabah, Kinabalu, Kamburangau and above, 8000 ft., in mossy forest, male plant, 2. 1910, *Gibbs 3118*; Gurulau spur, above Kiau, 5000 ft., in high forest, male plant, 2. 1910, *Gibbs 3992*; Kinabalu, *Burbidge s.n.* (Syn-BM, not seen) – cf. Wijk 1957.

Ic.: Greville 1847: pl. 12 (as *D. superba*); Brotherus 1925: 521, fig. 796 (as *D. superba*); Sainsbury 1955: 42, fig. 1 (as *D. superba*); Wijk 1957: 12, fig. 3, 2, 13, fig. 4, 2 (as *D. superba*); 10, fig. 2, 12, fig. 3, 1, 13, fig. 4, 1 (as *D. pulchra* (Wijk) Zant.); Zanten 1973: pl. 4b, e, f, 9a, 10b (as var. *longifolia*), pl. 4c, d, 9b, 10c (as var. *superba* (Grev.) Zant.); Scott & Stone 1976: 77, pl. 6; Hyvönen 1986: 111, fig. 1c, 114, fig. 3c; Eddy 1988: 56, fig. 45 (as *D. superba*).

Plants erect, robust, stems up to 52 cm high. Leaves linear-lanceolate, sheathing, slightly spirally twisted, appressed to erect-spreading when dry, widely spreading when moist, 14–32 mm long, lamina 0.7–1.0 mm wide. Lamellae 4–6 cells high, apical row essentially straight or finely crenulate as seen in side view, cells finely papillose or smooth with incrassate walls. Dioicous. Seta 1.6–2.0 cm, capsule 9–11 mm long.

D. longifolia is recognized at once by the large size of the plants and easily distinguished from large specimens of the genus *Pogonatum* by the leaves straight or slightly spirally twisted in dry condition. For distinction from *D. beccarii* see the discussion under the latter species.



Figs. 2A–B. – Lamellae in side view. – A. *Dawsonia longifolia* (Bruch & Schimp.) Zant. (*Menzel et al. 3360*, H). – B. *D. beccarii* Broth. & Geh. in Geh. (*Menzel et al. 3642*, H).

D. longifolia is a plant of lower montane forests, which has been collected at altitudes of 1300–2750 m growing on ground. Apparently it is confined to more shaded and moister habitats than *D. beccarii* and has not been recorded at extremely high elevations like the latter species.

Geographical range: Borneo (SAB, KIN, SAR, KTI), Sulawesi, West Irian, Papua New Guinea, Philippines, Australia, New Zealand.
Altitudinal range (Borneo): 1300–2750 m.
Specimens examined:
BRYOTROP: XIII: *3003, 3033, 3047.* – XV: *3524.* – XVII: *3460.* – XVIIa: *4610.* – XIX: *3103, 3164.* – XIXb: *4738.* – XXI: *3295.* – XXIII: *3360.*
Additional collections: Malaysia, Sabah, Kota Belud district, Kinabalu Park, S slopes of Gunong Kinabalu, Summit Trail near Power Station, lower montane forest on sedimentary rocks, 1800–1900 m, 3. 8. 1986, *Frey M-36* (B, BSB, DUIS, H, NICH, SAN).

Pogonatum P. Beauv. in Mag. Encycl. 5: 329 (1804).

This genus is represented in Borneo by fourteen species. Four of them belong to *Pogonatum* sect. *Racelopus* sensu Touw (1986). Formerly the species were mostly assigned to the genera *Pseudoracelopus* Broth. and *Racelopus* Dozy & Molk.

The *Pogonatum* species growing in Borneo are mostly confined to tropical and subtropical regions of Asia.

Pogonatum camusii (Thér.) Touw in J. Hattori Bot. Lab. 60: 26 (1986) – Fig. 3D.
≡ *Racelopodopsis camusii* Thér. in Monde Pl., sér. 2, 9: 22 (1907).

Ic.: Brotherus 1901–1909: 1212, fig. 849; Brotherus 1925: 497, fig. 775 (as *Racelopodopsis camusii*); Horikawa 1934: 718, fig. 4 (as *Pogonatum papillosum* Hor.); Bartram 1939: tab. 29, fig. 496 (as *Pseudoracelopus*

mindanensis Bartr.); Smith 1971: 12, fig. 13, 125, fig. 125 (as *Racelopodopsis mindanensis* (Bartr.) G. L. Sm.); Iwatsuki & Mizutani 1972: 47, fig. 35 (as *Racelopodopsis camusii*); Chen 1978: 306, fig. 393 (as *Racelopodopsis camusii*); Rosario 1979: 127, fig. 98 (as *Racelopus pilifer*); Tan & Alvarez 1981: 172, fig. 14–16 (as *Racelopodopsis mindanensis*); Touw 1986: 27, fig. 12.

Plants erect, minute, stems 1–2 mm high. Leaves ovate to lanceolate, appressed when dry, appressed to erect spreading when moist, 2.2–4.3 mm long and 0.8–1.1 mm wide, stereid bands and lamellae absent, apex with obtuse irregular teeth. Laminar cells basally elongated, apically isodiametric. Dioicous. Seta scabrous, 10–15 mm long, capsule 1.7–2.1 mm long, plicate.

P. camusii belongs to a group of three minute *Pogonatum* species which can be found growing in similar habitats, i.e. on shady sandstone, loamy rocks or on ground at fairly low elevations. *P. camusii* is easily distinguished from *P. piliferum* by its apically dentate leaves. For distinction from *P. iwatsukii* see the discussion under the latter species.

This is the first report of *P. camusii* in Borneo. Formerly this species has been collected in the surrounding areas in Indonesia.

Geographical range: China, Japan, Thailand, Vietnam, Borneo (KIN), Flores, Sumatra, Philippines.
Altitudinal range (Borneo): 1500–1700 m.
Specimen examined:
BRYOTROP: XVI: *4266.*

Pogonatum cirratum (Sw.) Brid., Bryol. Univ. 2: 110 (1827) – Fig. 4E.
≡ *Polytrichum cirratum* Sw. in J. Bot. (Schrader) 1800(2): 175, 176 (1801).

Ic.: Swartz 1801: tab. 4; Dozy & Molkenboer 1854–1870: tab. 34; Horikawa 1935b: 594, fig. 25 (as *P. hetero-contortum* Hor.); Hyvönen 1986: 132, fig. 14; Eddy 1988: 37, fig. 24.

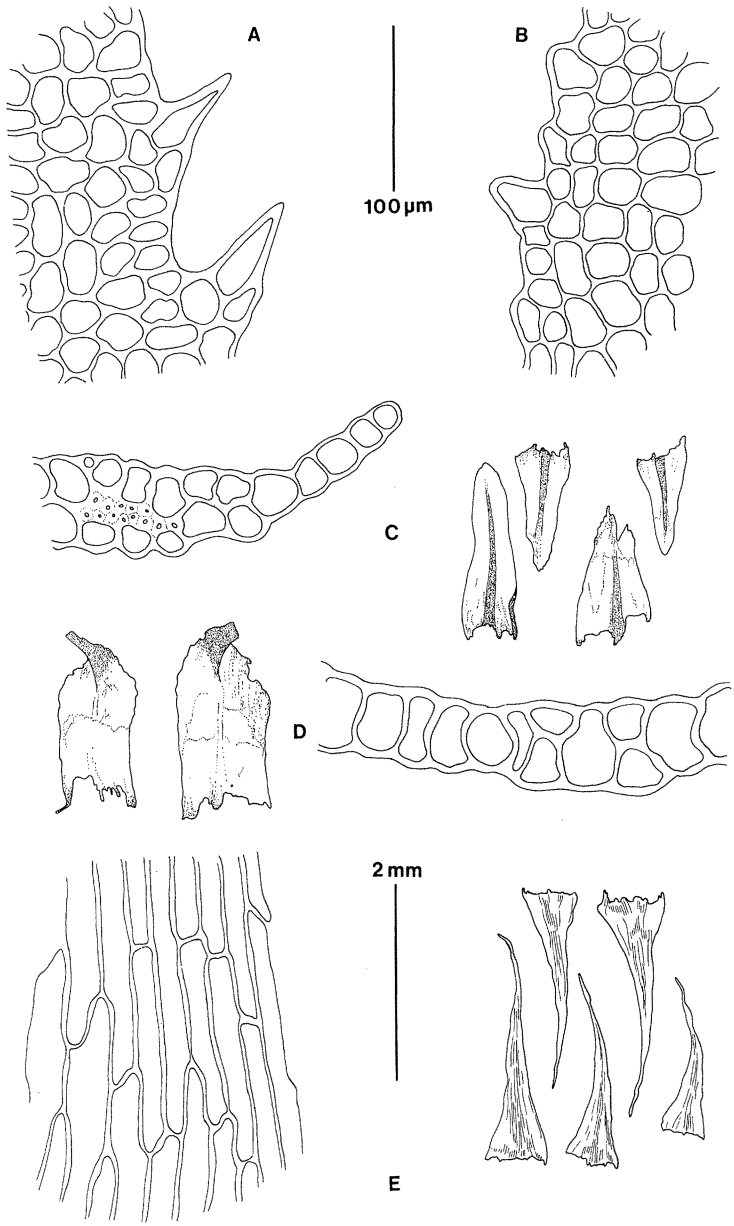
Plants erect, medium-sized to large, stems up to 11 cm high. Leaves linear-lanceolate, sheathing, contorted when dry, erect-spreading to squarrose when moist, 5–8 mm long and 0.6–1.1 mm wide. Margins mostly bistratose. Lamellae 1–3(–4) cells high, apical row straight or slightly crenate as seen in side view, cells smooth. Dioicous. Seta 30–35 mm long, smooth, capsule 2.2–3.2 mm long, plicate.

P. cirratum belongs to a group of closely related and in some areas hardly separable taxa. The largest species of the group, *P. macrophyllum* Dozy & Molk., has leaves with lamellae restricted to the upper part of the lamina; in addition, the lamellae possess also much more geminations. The dentation of the sheath present in type material of *P. cirratum* collected in Java is to some degree found also in Bornean plants, thus deviating from the material collected in the Philippines and Taiwan otherwise identical with the type.

P. cirratum grows on ground in fairly shaded habitats from lowland forests to upper montane forests.

Geographical range: China, India, Nepal, Sri Lanka, Thailand, Borneo (KIN, SAR), Java, Moluccas, Sulawesi, Sumatra, West Irian, Malaysia, Philippines, Papua New Guinea, Solomon Islands.
Altitudinal range (Borneo): 800–3400 m.
Specimens examined: .
BRYOTROP: XVI: *4265.* – XIX: *3393.* – XIXb: *4705.* – XXIII: *3345.*
Additional collections: Borneo, s. loc., *Korthals 79* (H-BR).

Pogonatum fuscatum Mitt. in J. Proc. Linn. Soc. Bot. Suppl. 1: 154 (1859) – Fig. 4D.
= *Pogonatum spurio-cirratum* Broth. in Philipp. J. Sc. 5: 150 (1910). – Typus: Philippines, Lepanto, Mt Data,



Figs. 3A–E. – A. *Pogonatum rutteri* (Thér. & Dix.) Dix. (*Brooks 42*, BM) Apical margin of leaf. – B. *P. philippinense* (Broth.) Touw (Solomon Islands, *Norris 49901*, H) Apical margin of leaf. – C. *P. iwatsukii* Touw (*Iwatsuki 1715*, NICH) Leaves and cross-section of leaf. – D. *P. camusii* (Thér.) Touw (*Menzel et al. 4266*, H) Leaves and cross-section of leaf. – E. *P. piliferum* (Dozy & Molk.) Touw (*Touw 20706*, H) Leaves and laminar cells of leaf. – Use the 100 µm scale for all figures with cellular details and 2 mm scale for the leaves.

on trees, ca. 7000 ft., 11. 1905, *Merrill 4908*; Luzon, Benguet, Heights in the Oaks, 7000 ft., *Mearns 4557*; Pauai, ca. 2100 m, 6. 1901, *McGregor 8688*; Mt Tonglon, 12. 1908, *Ramos 5505*; Mt Pulog, 5. 1909, *Merrill 6396*; ibid., 1. 1909, *Curran, Merritt & Zschokke 16393, 16412*; Laguna, Mt Banajao, terrestrial, 2000 m, 1. 1909, *Robinson 6562*; ibid., *Curran & Merritt 7992* (H-BR!, syntypes).

Ic.: Bartram 1939: pl. 29, fig. 507 (as *P. spurio-cirratum*); Gangulee 1969: 110, fig. 44; Smith 1971: 66, fig. 105 (as *P. flexicaule* Mitt.); Li & al. 1985: 446, fig. 21–26 (as *P. spurio-cirratum*); Eddy 1988: 37, fig. 25 (as *P. flexicaule*).

Plants erect, medium-sized, stems up to 5 cm high. Leaves linear-lanceolate, sheathing, contorted when dry, erect-spreading to squarrose when moist, lamina 3–7 mm long and 0.6–0.9 mm wide. Margins uni- to bistratose. Lamellae 34–50, 1–4 cells high, apical row essentially straight as seen in side view, cells smooth. Dioicous. Seta ca. 20 mm long, smooth, capsule 3 mm long, plicate.

P. fuscatum is very closely related to *P. cirratum* (Sw.) Brid. and distinction of the two species is in many cases difficult. A study of this species-group widely distributed in SE Asia may prove the two species to be conspecific but they are tentatively treated as separate taxa here. Leaves of *P. fuscatum* are generally narrower than those of *P. cirratum* and consequently with less and higher lamellae and with narrower laminar cells as seen in cross-section. The sheath of the leaves is always without serration unlike in *P. cirratum*.

P. fuscatum is a plant of medium to high altitudes which has been collected on soil and cliffs and generally grows in drier habitats than *P. cirratum*.

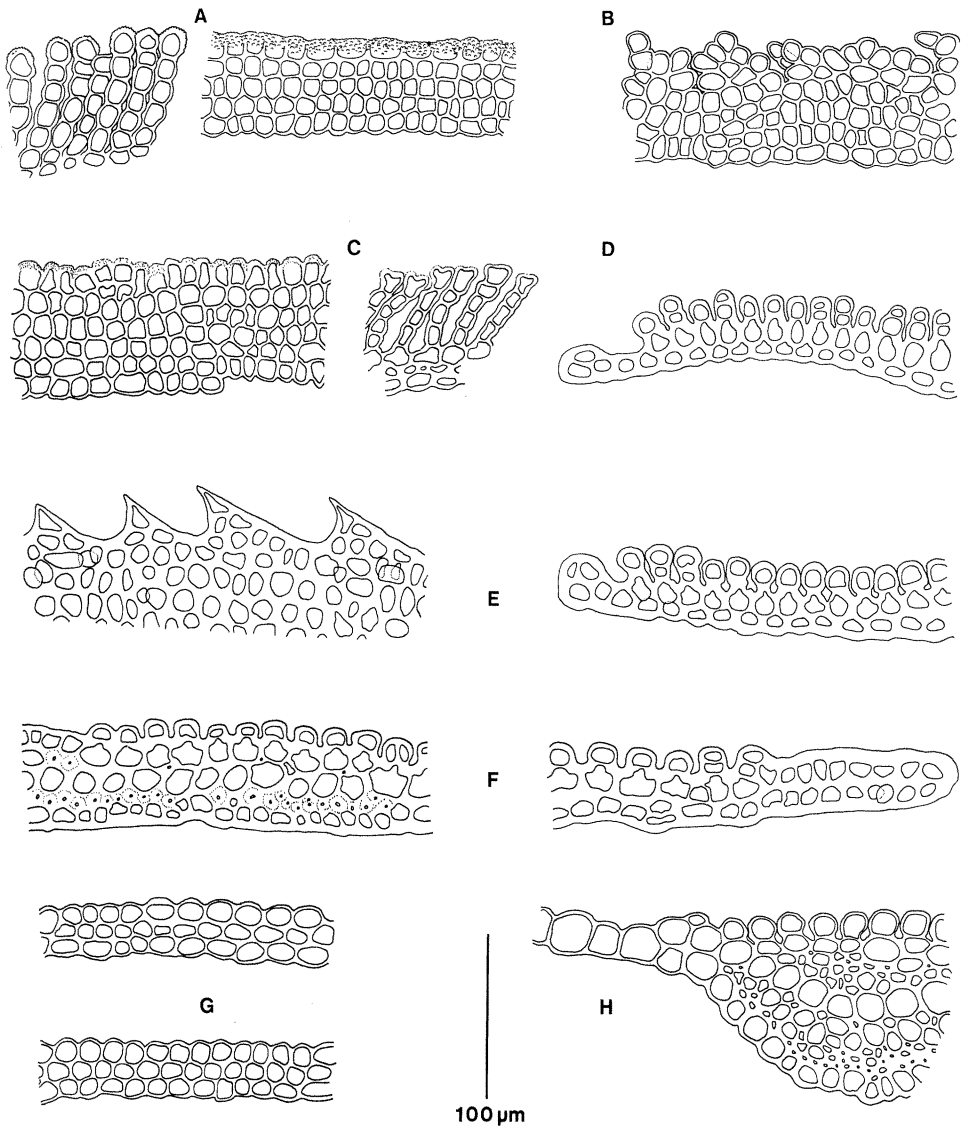
Geographical range: China, Bhutan, India, Nepal, Borneo (KIN), Philippines.
Altitudinal range (Borneo): 2000–3350 m.
Specimens examined:
KIN: Granodiorite slope above Paca Cave, 2984–3350 m, on crevice of rock cliff, 19. 5. 1963, *Iwatsuki 499* (NICH); ibid., on soil, 2984–3200 m, 21. 5. 1963, *Iwatsuki 1017a, 1022* (NICH); between Kambaranga Radio Station and Water Falls, 2000–2146 m, on cliff, 17. 5. 1963, *Iwatsuki 544* (NICH).

Pogonatum iwatsukii Touw in J. Hattori Bot. Lab. 60: 22 (1986) – Fig. 3C.
≡ *Racelopus acaulis* Mitt. in Mitt. & Wright in Stapf in Trans. Linn. Soc. London Bot. 4: 258 (1894) ≡ *Pseudoracelopus acaulis* (Mitt.) Iwats. in J. Hattori Bot. Lab. 32: 285 (1969). – Typus: Malaysia, Borneo, Sabah, Mt Kinabalu, *Burbidge s.n.* (Holo- NY, not seen) – cf. Touw 1986.
= *Pseudoracelopus borneensis* Dix. in J. Linn. Soc. Bot. 50: 137 (1935). – Typus: Malaysia, Borneo, Sabah, Bettotan near Sandakan, *Boden Kloss 19171* (Holo- BM, iso- GRO, not seen); Malaysia, Borneo, Sarawak, G. Dulit, boulder in shade in stream-bed, under 300 m, 15. 8. 1932, *P. W. Richards 1287* (Para- BM, GRO, L, not seen) – cf. Iwatsuki 1969.

Ic.: Dixon 1935: tab. 4, fig. 51 (as *Pseudoracelopus borneensis*); Iwatsuki 1969: 286, fig. 10 (as *Pseudoracelopus acaulis*); Smith 1971: 68, fig. 123 (as *Racelopus acaulis*); Touw 1986: 23, fig. 10; Eddy 1988: 46, fig. 35 (as *Pseudoracelopus acaulis*).

Plants erect, minute, stems 1–2 mm high. Leaves appressed when dry, slightly spreading when moist, triangular to lingulate lanceolate, up to 4 mm long, apices acute with few rounded, indistinct teeth. Lamellae absent, upper laminar cells subquadrate, lower cells elongated and rectangular, cell walls not incrassate. Dioicous. Seta up to 25 mm long, scabrous, capsule 2–3 mm long, essentially terete.

By its extremely small size *P. iwatsukii* is distinguished from all other species of the genus except *P. camusii* (Thér.) Touw and *P. piliferum*. A closer study of the leaves, however, reveals clear distinctive charac-



Figs. 4A–H. – A. *Pogonatum urnigerum* (Hedw.) P. Beauv. (*Menzel et al. 4149*, H) Lamellae in side view and cross-section. – B. *P. microphyllum* (Dozy & Molk.) Dozy & Molk. (Papua New Guinea, *Streimann & Tamba 12165*, H) Lamellae in side view. – C. *P. neesii* (C. Muell.) Dozy (*Menzel et al. 3688*, H) Lamellae in side view and cross-section. – D. *P. fuscatum* Mitt. (*Iwatsuki 1017a*, NICH) Cross-section of leaf. – E. *P. cirratum* (Sw.) Brid. (*Menzel et al. 4265*, H) Cross-section of leaf and upper margin of sheath. – F. *P. macrophyllum* Dozy & Molk. (*Menzel et al. 4632*, H) Cross-section of leaf. – G. *P. subtortile* (C. Muell.) Jaeg. (Papua New Guinea, *Koponen 31107*, H) Lamellae in side view. – H. *P. proliferum* (Griff.) Mitt. (*Menzel et al. 3173*, H) Cross-section of leaf.

ters; the apices of leaves are irregularly dentate in *P. iwatsukii* whereas they are entire in *P. piliferum*. The distinction from *P. camusii* may be difficult as both have irregularly dentate apices. The lower leaves of the latter, however, are broadly ovate to almost circular whereas they are triangular in *P. iwatsukii*. In addition, the total lack of stereids in *P. camusii* is another good and reliable distinctive character.

Geographical range: Endemic to Borneo (KIN, SAR).
Altitudinal range (Borneo): 300–1700 m.
Specimens examined:
KIN: E slope of Mt Kinabalu, in forest between Hot Spring, Poring and Royal Soc. Bungalow, 600–11001 m, on rock, 28. 5. 1963, *Iwatsuki 1715, Mizutani 3033* (NICH).

Pogonatum macrophyllum Dozy & Molk., Bryol. Jav. 1: 45 (1856) – Fig. 1A, 4F.
= *Pogonatum submacrophyllum* Herz. in Hedwigia 57: 236 (1916). – Typus: Indonesia, Seram, Mittel-Ceram, Urwald am Gunung Pinaia, ca. 1760 m, dichte feuchte Teppiche am Boden bildend, 8. 1911, *Stresemann 225* (JE!, holotype).
= *Pogonatum macrophylloides* Broth. in Mitt. Inst. Allg. Bot. Hamburg 7: 140 (1928). – Typus: Malaysia, North Borneo, Sabah, Mt Kinabalu, Marai Parai spur, 4. 12. 1915, *Clemens 11125* (Lecto-H–BR!, selected by Iwatsuki 1975); Paka cave to Lobang, 15. 11. 1915, *Clemens 10745*; Gurulau spur, 11. 1915, *Clemens 10868* (Syn- H–BR!) – cf. Eddy 1988.
= *Pogonatum euryphyllum* Dix. in J. Linn. Soc. Bot. 50: 138 (1935). – Typus: Malaysia, Sabah, near Kamborangah, 2200 m, 13. 2. 1931, *Holttum 25644* (Holo- BM!); Malaysia, Sabah, Tenompok, 1300 m, 11. 11. 1931, *Holttum 25344* (Para- BM!).

Ic.: Dozy & Molkenboer 1854–1870: tab. 35; Bartram 1939: pl. 29, fig. 505; Smith 1971: 66, fig. 103; Iwatsuki & Noguchi 1975: 318, fig. 3 (as *P. macrophylloides*); Eddy 1988: 35, fig. 22, 23 (as *P. macrophylloides*).

Plants erect, large to robust, stems up to 21 cm high. Leaves contorted or curved to one side when dry, erect to widely spreading when moist, 7–17 mm long and 1.1–1.7 mm wide, margins bistratose. Lamellae 1–2 cells high, mostly restricted to upper part of leaf, apical row straight or slightly crenate as seen in side view. Dioicous. Seta 2.5–4.0 cm long, smooth, capsule 4–6 mm long, plicate.

As noted also by Eddy (1988) the large size of the plants is in many cases a sufficient character to distinguish *P. macrophyllum* from all other species of the genus in the area. Two species of the genus *Dawsonia* are large as well. The leaves of the latter are, however, never contorted in dry condition as in *P. macrophyllum*. In addition, the leaves of *P. macrophyllum* are in many cases typically turned to one side. The lamellae are poorly differentiated and restricted to the upper half of the lamina.

Traditionally two or three closely related, large species of *Pogonatum* have been distinguished in SE Asia. This separation is, however, not warranted by the present material as it includes many specimens with intermediate characters between the types. It has been even proposed by Huffelen & Vries (1980) that *P. macrophyllum* is only a subspecies of *P. cirratum*. This might well be the correct solution but *P. macrophyllum* is still tentatively accepted here as the two taxa are quite easily distinguished in Bornean material.

P. macrophyllum is a plant of lower and upper montane (mossy) forests which has been collected at altitudes of 1350–2850 m. It grows on ground in fairly shaded habitats.

Geographical range: Borneo (KBA, KIN, KTI), Java, Moluccas, Seram, Sumatra, Malaysia, Philippines.
Altitudinal range (Borneo): 1300–2850 m.
Specimens examined:

BRYOTROP: XV: *3533.* – XVII: *3475.* – XVIIa: *4632.* – XIX: *3127, 3393* (with *P. cirratum*). – XIXb: *4720.* – XXI: *3277, 3310.* – XXIII: *3358.* – XXV: *3646.*
Additional collections: KIN: Columbon river, 5–6000 ft., 10. 8. 1933, *Clemens 3500* (H); between Tenompock Pass and Kambaranga Radio Station, 1400–1900 m, on soil, 16. 5. 1963, *Iwatsuki 332* (NICH); ibid., on clay, 16. 5. 1963, *Iwatsuki 363* (NICH); between Kambaranga Radio Station and Water Falls, on clay, 2000–2146 m, 17. 5. 1963, *Iwatsuki 526* (NICH); ibid., on bush, 17. 5. 1963, *Iwatsuki 535* (NICH); SE slope of Mt Kinabalu, ultrabasic (serpentine) area between Paca Cave and Ulu Liwagu, on humus, 2500–2850 m, 22. 5. 1963, *Iwatsuki 1117* (NICH); SE slope of Mt Kinabalu, Ulu Liwagu, by a stream near camp, on soil, ca. 2500 m, 22. 5. 1963, *Iwatsuki 1120* (NICH); forests above confluence of S Liwagu and S Kelinggen, SE slope of Mt Kinabalu, on soil, 1700–2150 m, 23. 5. 1963, *Iwatsuki 1244* (NICH); between Sosopodon and S Kelinggen, foot of Mt Kinabalu, on soil, 1350–1400 m, 26. 5. 1963, *Iwatsuki 1418* (NICH); S slope of Mt Kinabalu, around Kambaranga Radio Station, on soil, 2146 m, 17. 5. 1963, *Iwatsuki 2576* (NICH); Borneo, Exp. Nieuvenhuis, 1898 m, *Amdjah s.n.* (B, H).

Pogonatum microphyllum (Dozy & Molk.) Dozy & Molk., Bryol. Jav. 1: 39 (1856) – Fig. 4B.
≡ *Polytrichum microphyllum* Dozy & Molk. in Miq., Pl. Jungh. 3: 326 (1854).

Ic.: Dozy & Molkenboer 1854–1870: tab. 29; Bartram 1939: pl. 29, fig. 501; Hyvönen 1986: 124, fig. 10; Eddy 1988: 31, fig. 18.

According to Touw (1978) the species was erroneously reported from Borneo. However, as the species is recorded from surrounding areas it is tentatively included here.

By its habit it resembles *P. urnigerum*. The irregularly crenate lamellae in side view are, however, easily seen diagnostic characters. *P. microphyllum* seems to thrive generally on lower altitudes than *P. urnigerum*.

Geographical range: Java, Papua New Guinea, Philippines.

Pogonatum neesii (C. Muell.) Dozy in Ned. Kruidk. Arch. 4: 75 (1856) – Fig. 4C.
≡ *Polytrichum neesii* C. Muell., Syn. Musc. Frond. 2: 563 (1851).

Ic.: Dozy & Molkenboer 1854–1870: tab. 31, tab. 36; Fleischer 1923: 1589, fig. 251; Bartram 1939: pl. 29, fig. 502 (as *P. junghuhnianum* (Dozy & Molk.) Dozy & Molk.); Osada & Noguchi 1962: 364, fig. 9–15 (as *P. akitense* Besch.); Osada 1965: 193, fig. 8,2, 199, fig. 11 (as *P. akitense*); Gangulee 1969: 104, fig. 41 (as *P. junghuhnianum*), 106, fig. 42 (as *P. akitense*); Smith 1971: 18, fig. 29; Chen 1978: 303, fig. 392 (as *P. inflexum* (Lindb.) Par.); Li & al. 1985: 446, fig. 192, 1–6 (as *P. inflexum*); Hyvönen 1986: 128, fig. 12; Noguchi 1987: 41, fig. 13b (as *P. akitense*); Eddy 1988: 31, fig. 19.

Plants erect, small to medium-sized, stems up to 4 cm high. Leaves linear lanceolate, sheathing, appressed and incurved or contorted when dry, erect-spreading to squarrose when moist, 4–7 mm long, lamina 0.5–0.9 mm wide. Margins unistratose. Lamellae (3–)5–7 cells high, apical row crenate in side view, mostly retuse in cross-section, cells predominantly finely papillose. Dioicous. Seta smooth, 25–37 mm, capsule 2.4–4.0 mm long, plicate.

P. neesii is a widespread and variable species, which is, however, quite easily distinguished from all other species of *Polytrichaceae* in Borneo by its small size and numerous, high lamellae (5–7) with finely papillose and retuse apical cells.

Another species with high lamellae is *P. microphyllum*, but the apicals of lamellae of the latter are distinctly irregularly crenate in side view and always smooth. Other species of the genus have much lower lamellae except *P. urnigerum*. The apicals of this species are, however, coarsely papillose and thus the species is easily identified.

P. neesii is here treated in a wide sense; further study is still needed to reveal if the complex can clearly be divided into a group of closely related taxa. The latter is, however, not warranted by the present material from Borneo. The distinction of independant taxa would be based on arbitrary limits and of no value in practical work.

P. neesii is a typical plant of fairly open habitats growing on ground and on rocks. It is more common at lower elevations but has been reported even from 3700 m (Iwatsuki & Noguchi 1975).

Geographical range: China, Japan, Korea, Bangla Desh, Bhutan, Burma, India, Nepal, Sikkim, Sri Lanka, Thailand, Vietnam, Borneo (KIN, KTI), Java, Sulawesi, Sumatra, Philippines, Papua New Guinea, Oceania, Australia.
Altitudinal range (Borneo): 900–3700 m.
Specimens examined:
BRYOTROP: XVII: *4609*. – XIX: *3172*. – XXIII: *3378*. – XXV: *3682, 3688*.
Additional collections: KIN, Kiau, 1.–8. 12. 1915, *Clemens 10315* (H); Sosopodon, Kundsang, S foot of Mt Kinabalu, around Forest Dept. Bungalow, on soil, ca. 1350 m, 16. 5. 1963, *Iwatsuki 102* (NICH); ibid., on rock, 15. 5. 1963, *Iwatsuki 251* (NICH); ibid., in crevices of rock, ca. 1350 m, 31. 5. 1963, *Iwatsuki 4516* (NICH); ibid., on soil, 31. 5. 1963, *Iwatsuki 4516a* (NICH); near the rest house, 15. 5. 1963, *Iwatsuki 255* (NICH); granodiorite slope below Sayat Sayat, on soil, 3350–3700 m, 20. 5. 1963, *Iwatsuki 933* (NICH); S slope of Mt Kinabalu, around Kambaranga Radio Station, on soil, 2146 m, 17. 5. 1963, *Iwatsuki 2571, 2572* (NICH).

Pogonatum philippinense (Broth.) Touw in J. Hattori Bot. Lab. 60: 16 (1986) – Fig. 3B.
≡ *Pseudoracelopus philippinensis* Broth. in Öfvers. Förh. Finska Vetensk.-Soc. 52A(7): 2 (1910).
= *Pogonatum bornense* Dix. in J. Linn. Soc. Bot. 43: 311 (1916). – Typus: Malaysia, Borneo, Sabah, Sandakan, 25. 4. 1913, *Binstead 47* (Holo- BM, not seen) – cf. Touw 1986.

Ic.: Brotherus 1910: tab. 2, figs. 1–18 (as *Pseudoracelopus philippinense*); Dixon 1916: tab. 27, fig. 13 (as *Pogonatum bornense*); Bartram 1939: tab. 29, fig. 495 (as *Pseudoracelopus philippinensis*); Sakurai 1943: 91, fig. 14 (as *Racelopus ponapensis* Sak.); Smith 1971: 12, fig. 10, 68, fig. 119; Chen 1978: 307, fig. 394; Rosario 1979: 126, fig. 97; Tan & Alvarez 1981: 172, figs. 17–19; Hyvönen 1986: 136, fig. 16 (all as *Pseudoracelopus philippinensis*); Touw 1986: 17, fig. 7; Eddy 1988: 44, fig. 34 (as *Pseudoracelopus philippinensis*).

Plants erect, minute to small, stems 4–10 mm high. Leaves lingulate, 2.0–3.7 mm long and 0.8–1.4 mm wide, margins plane, dentate apically, apices obtuse to apiculate. Laminar cells collenchymatous, polygonal, ca. 12–30 μm in diameter. Dioicous. Seta 12–20 mm long, scabrous, capsule plicate, 2.3–3.5 mm long.

P. philippinense has been recorded for Borneo only once (type collection of *Pogonatum bornense*). Unfortunately I was unable to study this specimen and consequently the description given above and the illustrations are based on material from surrounding regions, i.e. the Philippines, New Guinea and the Solomon Islands.

P. philippinense is a minute plant but still possesses a distinct stem and well developed leaves unlike the two smaller species of the same section, *P. iwatsukii* Touw and *P. piliferum* (Dozy & Molk.) Touw. The leaves of the latter are without well defined lamina and the stems are inconspicuous. For distinction of *P. philippinense* from *P. rutteri* see discussion under the latter.

Geographical range: Borneo (SAB), Papua New Guinea, Philippines, Oceania.
Altitudinal range (after Touw 1986): from sealevel up to 1200 m.
Specimens examined: none from Borneo.

Pogonatum piliferum (Dozy & Molk.) Touw in J. Hattori Bot. Lab. 60: 29 (1986) - Fig. 3E.
≡ *Racelopus pilifer* Dozy & Molk., Bryol. Jav. 1: 37 (1856).
= *Racelopus enervis* Mitt. in Salm. in Rev. Bryol. Lichénol. 27: 81 (1900), nom. nud. in synon. - Original collection: Malaysia, Borneo, North Borneo, *Burbidge s.n.* (BM, not seen).

Ic.: Dozy & Molkenboer 1854-1870: tab. 27; Brotherus 1901-1909: 684, fig. 518; Fleischer 1923: 1578, fig. 249; Brotherus 1925: 496, fig. 774; Bartram 1939: tab. 29, fig. 497; Smith 1971: 12, fig. 12, 68, fig. 124; Tan & Alvarez 1981: 172, fig. 11-13; Hyvönen 1986: 135, fig. 15 (all above as *Racelopus pilifer*); Touw 1986: 31, fig. 13; Eddy 1988: 44, fig. 32 (as *Racelopus pilifer*).

Plants erect, minute, stems ca. 1 mm high. Leaves elongated triangular, appressed when dry, appressed to slightly spreading when moist, 3.0-6.0 mm long and 0.8-1.2 mm wide, margins entire. Laminar cells elongated. Dioicous. Seta scabrous, 20-30 mm long, capsule 2.1-2.9 mm long, plicate.

A reduction of the laminar part of the leaves is a typical feature of all species of *Pogonatum* sect. *Racelopus*. This feature is most pronounced in *P. pilifer*, where the whole leaf is practically without lamina and composed of elongated sheath cells only. For distinction from *P. iwatsukii* see the discussion under the latter species.

P. piliferum is a plant of low altitudes growing in fairly shaded habitats on ground and especially on loamy rocks and sandstone.

Geographical range: Thailand, Vietnam, Malaysia, Borneo (Kalimantan, KIN, SAB, SAR), Moluccas, West Irian, Papua New Guinea, Philippines, Oceania.
Altitudinal range (Borneo): 300-1100 m.
Specimens examined:
BRYOTROP: V: *4485.*
Additional collections: Malaysia, Borneo, Sarawak, 4th division, Gunong Mulu National Park, G. Mulu, 114°55'E 4°05'N, mixed forest, on rock, 23. 5. 1978, *Touw 20706* (H).

Pogonatum proliferum (Griff.) Mitt. in J. Proc. Linn. Soc. Bot. Suppl. 1: 152 (1859) - Fig. 4H.
≡ *Polytrichum proliferum* Griff. in Calcutta J. Nat. Hist. 2: 475 (1842).

Ic.: Horikawa 1935a: 506, fig. 7 (as *P. takao-montanum* Hor.); Bartram 1939: pl. 29, fig. 504 (as *P. gymnophyllum* Mitt.); Gangulee 1969: 136, fig. 61, 138, fig. 62 (as *P. fastigiatum* Mitt.), 140, fig. 63 (as *P. fastigiatum* var. *darjeelingense* Gangulee), 141, fig. 64 (as *P. gymnophyllum*); Smith 1971: 65, fig. 100; Eddy 1988: 40, fig. 28 (as *P. gymnophyllum*).

Plants erect, medium-sized, stems up to 7 cm high. Leaves linear lanceolate, contorted when dry, erect to widely spreading when moist, 5-8 mm long and 0.7-1.5 mm wide, margins and lamina unistratose. Lamellae restricted to costa, 1-2 cells high, apical row straight or slightly crenate as seen in side view. Only sterile material from Borneo has been examined.

By its habit in dry condition this species resembles other medium-sized species, like *P. neesii*, *P. cirratum* and *P. subtortile*. The few and poorly developed lamellae in the costal area are a unique character for *P. proliferum* and thus identification is easy even in the field.

P. proliferum was collected growing on ground in lower and upper montane forests at altitudes of 1400–2500 m.

Geographical range: China, Bhutan, Burma, India, Nepal, Sikkim, Thailand, Vietnam, Borneo (KIN), Java, Sulawesi, Philippines.
Altitudinal range (Borneo): 1400–3500 m.
Specimens examined:
BRYOTROP: XIX: *3173.* – XXIII: *3377.* – XXXV: *3869.*
Additional collections: KIN: Between Tenompock Pass and Kambaranga Radio Station, 1400–1900 m, on soil, 16. 5. 1963, *Iwatsuki 366* (NICH); SE slope of Mt Kinabalu, Ulu Liwagu, by a stream near camp, ca. 2500 m, on rock, 22. 5. 1963, *Iwatsuki 1125* (NICH); S slope o Mt Kinabalu, around Kambaranga Radio Station, 2146 m, on soil, 17. 5. 1963, *Iwatsuki 2592* (NICH).

Pogonatum rutteri (Thér. & Dix.) Dix. in J. Bot. 79: 76 (1941) – Fig. 3A.
≡ *Atrichum rutteri* Thér. & Dix. in Dix. in J. Linn. Soc. Bot. 43: 310 (1916).
Typus: Malaysia, Borneo, Sabah, Rundum, 7. 5. 1913, *Rutter 227* (Holo- M!).

Ic.: Dixon 1916: table 27, fig. 12 (as *Atrichum rutteri*); Smith 1971: 68, fig. 121 (as *Pseudoracelopus armatus* Bartr.); Touw 1986: 15, fig. 6; Eddy 1988: 48, fig. 38 (as *Pseudoracelopus rutteri* (Thér. & Dix.) A. Eddy).

Plants erect, small to medium-sized, stems up to 70 mm high. Anisophyllous. Leaves contorted when dry, erect spreading when moist, lingulate lanceolate, up to 7.5 mm (smaller leaves 4.5 mm) long and 1.4 mm wide, margins sharply dentate. Lamellae absent. Upper laminar cells polygonal to rectangular with large corner thickenings, lower cells elongated. Dioicous. Seta scabrous, ca. 30 mm long.

Pogonatum rutteri is distinguished from other species of the section by its large size. Another species with well defined stem and leaves with distinct lamina, *P. philippinense* (Broth.) Touw, is normally smaller and the leaf-apices and marginal teeth are obtuse. The total absence of ventral lamellae is a character distinguishing *P. rutteri* from other, larger species of the genus, in the first place *P. proliferum*.

When fertile, all species of *Pogonatum* sect. *Racelopus* are easily distinguished from other species of *Pogonatum* by their papillose seta.

Geographical range (after Touw 1986): Borneo (SAB), Java, Mentawei Islands, Sumatra, Philippines.
Altitudinal range (after Touw 1986): 470–1200 m.
Specimen examined:
SAR: 1910, *Brooks 42* (BM).

Pogonatum subtortile (C. Muell.) Jaeg. in Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1873–1874: 256 (1875) – Fig. 4G.
≡ *Polytrichum subtortile* C. Muell., Syn. Musc. Frond. 1: 216 (1849).

Ic.: Smith 1971: 67, fig. 107; Hyvönen 1986: 130, fig. 13; Eddy 1988: 33, fig. 21.

Plants olivaceous, erect,. medium-sized, stems 20–25 mm high. Leaves contorted when dry, erect-spreading when moist, linear-lanceolate, 2.7–4.2 mm long and ca. 0.8 mm wide, margins unistratose. Lamellae ca. 50, 2–3 cells high, apical row regularly crenate as seen in side view. Dioicous. Seta 17–22 mm long, smooth, capsule ca. 2 mm long.

In the field *P. subtortile* may easily be mistaken as *P. neesii* or *P. cirratum* – all are medium-sized species with contorted leaves in dry condition. Low lamellae with unistratose, wide margins are, however, good, reliable and distinctive characters of *P. subtortile*. When a cross-section of the leaves is studied the weaker ventral stereid band of *P. subtortile* as compared to the *P. cirratum*-group becomes also evident.

Geographical range: China, India, Sri Lanka, Borneo (KIN, KBA), Java, Moluccas, Sumatra, Malaysia, Papua New Guinea, Philippines, Oceania.
Altitudinal range (Borneo): up to 2150 m.
Specimen examined:
KBA: Sebalamo, *Teysmann 10867* (H-BR).

Pogonatum urnigerum (Hedw.) P. Beauv. in Prodr. Aethéogam. 84 (1805) – Fig. 4A.
≡ *Polytrichum urnigerum* [L. ex] Hedw., Sp. Musc. Frond. 100 (1801).
= *Polytrichum wallisii* C. Muell. in Linnaea 37: 171 (1872) ≡ *Pogonatum wallisii* (C. Muell.) Jaeg. in Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1873–1874: 260 (1875) – cf. Smith (1971).

Ic.: Bartram 1939: pl. 29, fig. 509 (as *P. wallisii*); Zanten 1964: pl. 33, fig. 5a–d (as *Dawsonia papillata* Zant.); Osada 1965: 180, fig. 3m–u; Gangulee 1969: 46, fig. 66; Hyvönen 1986: 123, fig. 9; Noguchi 1987: 31, fig. 11d; Eddy 1988: 38, fig. 26.

Plants erect, medium-sized to large, stems up to 9 cm high. Leaves linear-lanceolate, sheathing, appressed when dry, erect-spreading when moist, 4–8 mm long and 0.7–0.9 mm wide. Margins unistratose. Lamellae 5–8 cells high, apical cells distinctly coarsely papillose. Dioicous. Seta smooth, 17–20 mm, capsule ca. 3 mm long, terete.

P. urnigerum is a plant confined to high altitudes at tropical latitudes and accordingly it has been found in Borneo only on Mt Kinabalu. It is easily distinguished from all other species of *Polytrichaceae* by distinctly coarsely papillose apical cells of the lamellae.

P. urnigerum is a typical plant of fairly open habitats growing on ground and on rocks.

Geographical range: Europe, China, Japan, Korea, Soviet Union, India, Nepal, Borneo (KIN), West Irian, Papua New Guinea, Philippines, N Africa, N America.
Altitudinal range (Borneo): 1830–4100 m.
Specimens examined:
BRYOTROP: XIXa: *4149.* – XXXI: *3918.* – XL: *3890.*
Additional collections: KIN: Granodiorite slope above Paca Cave, 2984–3350 m, on soil, 19. 5. 1963, *Iwatsuki 891, 1524* (NICH); ibid., on rock crevice, 19. 5. 1963, *Iwatsuki 1522* (NICH); granodiorite slope above Paca Cave, 2984–3200 m, on soil-covered rock, 21. 5. 1963, *Iwatsuki 1044* (NICH).

Buxbaumiaceae Schwaegr. in Willd., Sp. Pl. 5: 23 (1830).

Buxbaumiaceae Schwaegr. is a small family including only four genera. Only the largest of them, the genus *Diphyscium* Mohr, is represented in the flora of Borneo.

For this taxon 19 species and two varieties are currently accepted for East Asia but the number is probably too high as the genus has not been revised as a whole. The most recent works on the genus in Asia are those by Iwatsuki (1976), Manuel (1980) and Hyvönen (1986). Five species are reported by Touw (1978) to occur in Borneo.

Diphyscium Mohr, Obs. Bot. 34 (1803).

Key to Bornean species of *Diphyscium*

1. Laminar cells distinctly mamillose, plants minute ..... *D. granulosum*
– Laminar cells smooth, plants small to medium-sized 2
2. Margins of leaves entire 3
– Margins of leaves dentate or denticulate at least apically 4
3. Leaves distinctly constricted below the middle ..... *D. involutum*
– Leaves not constricted below the middle ..... *D. mucronifolium*
4. Leaf margins coarsely dentate ..... *D. loriae*
– Leaf margins very slightly denticulate apically ..... *D. rupestre*

Diphyscium granulosum Chen in Feddes Repert. Spec. Nov. Regni Veg. 58: 34 (1955) – Fig. 5A.

Ic.: Chen 1955: fig. 7; Wang & Lin 1974: fig. 1–25 (as *D. macrophyllum* Wang & Lin); Iwatsuki 1976: 147, fig. 5.

Plants brown to olivaceous, minute, stems up to 2 mm high. Leaves lingulate with acute apices and entire margins, 1.9–2.7 mm long and 0.3–0.5 mm wide. Upper laminar cells polygonal to transversely ovate, distinctly mamillose with cuticular papillosity, 11–20 µm in diameter, basal cells elongated, rectangular, smooth. Lamina bistratose, costa percurrent.

The species greatly resembles the widespread *D. foliosum* (Hedw.) Mohr and revisional study of large material may reduce *D. granulosum* to a synonym of *D. foliosum*.

There is only one record of this species for Borneo (Iwatsuki 1976) based on two specimens. *D. granulosum* is easily distinguished from other Bornean species of the genus by its distinctly mamillose laminar cells and minute size.

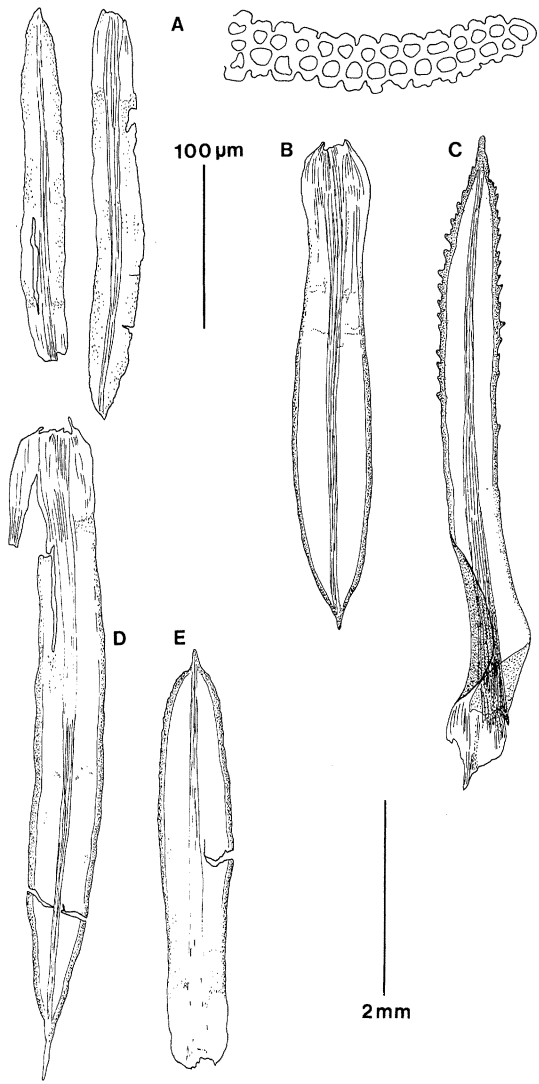
Both specimens have been collected at fairly high altitude on cliffs and on soil.

Geographical range (Iwatsuki 1976): China, Borneo (KIN).
Altitudinal range (Borneo): 2984–3700 m.
Specimens examined:
KIN: Granodiorite slope above Paca Cave, 2984–3350 m, on soil, 19. 5. 1963, *Iwatsuki 485* (NICH); Mt Kinabalu, granodiorite slope below Sayat Sayat, 3350–3700 m, on cliff, 20. 5. 1963, *Iwatsuki 962* (NICH).

Diphyscium involutum Mitt. in J. Proc. Linn. Soc. Bot. Suppl. 1: 149 (1859) – Fig. 5B.

Ic.: Bartram 1939: pl. 28, fig. 491; Gangulee 1969: 63, fig. 27; Hyvönen 1986: 146, fig. 22; Noguchi 1987: 15, fig. 6.

Plants olivaceous to brown, medium-sized, stems 1.3–1.6 mm high. Leaves lingulate, distinctly constricted below the middle, 2.5–4.7 mm long and 0.6–1.0 mm wide, apices acute to apiculate, perichaetial leaves with gradually longer apiculus towards inner leaves, costa excurrent, margins entire, thickened. Lamina bistratose. Cells polygonal to transversely ovate, 9–11 x 11–17 µm, basal cells rectangular and elongated. Capsule immersed, 2.6–3.6 mm long.



Figs. 5A–E. A. *Diphyscium granulosum* Chen (*Iwatsuki 962*, NICH) Leaves and cross-section of leaf. – B. *D. involutum* Mitt. (*Iwatsuki 1939*, NICH) Leaf. – C. *D. loriae* C. Muell. (*Mizutani 2124*, NICH) Leaf. – D. *D. mucronifolium* Mitt. in Dozy & Molk. (*Mizutani 3288*, NICH) Leaf. – E. *D. rupestre* Dozy & Molk. (*Winkler 3207*, H-BR) Leaf. – Use the 100 µm scale for the figure with cellular details and 2 mm scale for the leaves.

D. involutum differs from *D. mucronifolium* Mitt. by its leaves distinctly constricted below the middle and from the other two species of same size by its entire leaf-margins.

D. involutum has also been recorded only once for the island of Borneo (Iwatsuki & Noguchi 1975). It is an epilithic plant of low and mid-altitudes.

Geographical range (Iwatsuki & Noguchi 1975): China, Japan, India, Sri Lanka, Borneo (KIN), Malaysia, Papua New Guinea, Philippines.
Altitudinal range (Borneo): 600–1400 m.
Specimens examined:
KIN: Foot of Mt Kinabalu, between Sosopodon and S. Kelinggen, on rock, 1350–1400 m, 26. 5. 1963, *Iwatsuki 1416* (NICH); E slope of Mt Kinabalu, in forest between Hot Spring, Poring and Royal Soc. Bungalow, on rock, 600–1100 m, 28. 5. 1963, *Iwatsuki 1702, Mizutani 3051* (NICH); S foot of Mt Kinabalu, in a forest along S. Liwagu (river) near Kundusang, on boulders, 1350–1400 m, 31. 5. 1963, *Iwatsuki 1939* (NICH).

Diphyscium loriae C. Muell. in Hedwigia 36: 334 (1897) – Fig. 5C.
= *Diphyscium rhynchophorum* Dix. in J. Linn. Soc. Bot. 50: 136 (1935). – Typus: Malaysia, Borneo, Sarawak, Ulu Koyan, on submerged sandstone rocks in bed of small blackwater stream, ca. 950 m, 15. 9. 1932, *P. W. Richards 1868* (Holo- BM!).

Ic.: Dixon 1935: pl. 4, fig. 53 (as *D. rhynchophorum*); Hyvönen 1986: 144, fig. 21.

Plants brownish olivaceous, medium-sized, stems 6.5–25 mm high. Leaves lingulate, 5.5–7.0 mm long and 0.4–0.8 mm wide, apices acute to apiculate, costa excurrent, perichaetial leaves with gradually longer apiculus, margins thickened to multistratose. Lamina bistratose. Cells polygonal, ca. 9–12 µm in diameter.

I have not studied the type specimen of *D. loriae* collected in Papua New Guinea but judging from recent collections (Hyvönen 1986) and the original description it is evident that *D. rhynchophorum* can be reduced to a synonym of *D. loriae*.

D. loriae is easily distinguished from all other species of the genus in Borneo by its coarsely dentate margins. The stems of *D. loriae* can also be much longer (up to 25 mm) than those of other species.

D. loriae has been collected at low to medium altitudes growing on rocks.

Geographical range: Borneo (KIN, SAR), Papua New Guinea.
Altitudinal range (Borneo): 950–1900 m.
Specimen examined:
KIN: Between Tenompock Pass and Kambaranga Radio Station, on rock, 1400–1900 m, 16. 5. 1963, *Mizutani 2124* (NICH).

Diphyscium mucronifolium Mitt. in Dozy & Molk., Bryol. Jav. 1: 35 (1855) – Fig. 5D.

Ic.: Dozy & Molkenboer 1854–1870: tab. 26.

Plants light-brown to olivaceous, medium-sized, stems 1.0–2.1 mm high. Leaves lingulate, 4.0–6.3 mm long and 0.5–1.0 mm wide, apices acute to apiculate, perichaetial leaves with gradually longer apiculus toward inner leaves, costa excurrent, margins entire, multistratose. Lamina bistratose. Cells polygonal to transversely ovate, smooth, 6–15 µm in diameter.

The entire leaf-margin is a good character to separate *D. mucronifolium* from *D. granulosum*, *D. loriae* and *D. rupestre*. In *D. involutum* the leaf-margin is entire as well, but the leaves are typically constricted below the middle whereas in *D. mucronifolium* no constriction can be observed. There is also a difference in the form of the apices of the perichaetial leaves but the character is not constant enough to be reliable in identification.

D. mucronifolium has been collected on rocks at low and mid-altitudes.

Geographical range (Iwatsuki & Noguchi 1975): Borneo (KIN, SAB), Moluccas.
Altitudinal range (Borneo): from sealevel to 1500 m.
Specimens examined:
KIN: S slope of Mt Kinabalu, mossy forest between Tenompock Pass and Ulu Damaian, on rock, 1463–1500 m, 1. 6. 1963, *Mizutani 3288* (NICH). – SAB: Kebun China Forest near Sandakan, East Coast, on wet rock side of a stream, 7. 6. 1963, *Iwatsuki 5814* (NICH).

Diphyscium rupestre Dozy & Molk. in Miq., Pl. Jungh. 3: 340 (1854) – Fig. 5E.

Ic.: Dozy & Molkenboer 1854-1870: tab. 25; Bartram 1939: pl. 28, fig. 492.

Plants brownish, medium-sized, stems ca. 1.0 mm high. Leaves lingulate, constricted below the middle, apices acute to apiculate, costa excurrent, margins thickened, slightly denticulate apically, ca. 4.0 mm long and 0.6–0.8 mm wide. Lamina bistratose. Cells polygonal, ca. 9–11 µm in diameter.

The leaves of *D. rupestre* are constricted below the middle like in *D. involutum* but have at least slightly denticulate apices providing a good distinctive character. In *D. loriae* the dentation of leaves is more pronounced with multicellular teeth and thus identification is easy.

Geographical range: Borneo (KBA), Java, Philippines.
Specimen examined:
KBA: Bukit, Mehipit, um 500 m, 28. 12. 1924, *Winkler 3207* (H-BR).

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