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Contribution to the knowledge of epiphyllous bryophytes of Bioko Island (Equatorial Guinea), including additional remarks on non-epiphyllous species

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SUMMARY

A collection of epiphyllous bryophytes from Bioko Island was investigated. It contained 57 epiphyllous bryophytes, comprising 55 hepatics and two mosses. Three taxa, *Cololejeunea eustacei* Pócs, *Colura calderae* Pócs and *Lejeunea halei* Robinson subsp. *africana* Pócs, are new to science. *Cololejeunea papilliloba* Steph. is new to Africa, five species of hepatics are new to West Africa, and an additional 31 species of hepatics are newly reported from Bioko Island. The second part of the paper deals with records of non-epiphyllous collections. Fourteen species are reported for the first time for Bioko Island. *Actinodontium dusenii* Broth. is made a synonym of *Actinodontium streptopogoneum* Broth. The following new combination is proposed: *Wijkia rigidicaule* (Müll.Hal. ex Broth.) Frank Müll., comb. nov. (Basionym: *Acanthocladium rigidicaule* Müll.Hal. ex Broth.).

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A contribution to the knowledge of epiphyllous bryophytes of Bioko Island (Equatorial Guinea), including additional remarks on non-epiphyllous species

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SUMMARY

A collection of epiphyllous bryophytes from Bioko Island was investigated. It contained 57 epiphyllous bryophytes, comprising 55 hepatics and two mosses. Three taxa, *Cololejeunea eustacei* Pócs, *Colura calderae* Pócs and *Lejeunea halei* Robinson subsp. *africana* Pócs, are new to science. *Cololejeunea papilliloba* Steph. is new to Africa, five species of hepatics are new to West Africa, and an additional 31 species of hepatics are newly reported from Bioko Island. The second part of the paper deals with records of non-epiphyllous collections. Fourteen species are reported for the first time for Bioko Island. *Actinodontium dusenii* Broth. is made a synonym of *Actinodontium streptopogoneum* Broth. The following new combination is proposed: *Wijkia rigidicaule* (Müll.Hal. ex Broth.) Frank Müll., comb. nov. (Basionym: *Acanthocladium rigidicaule* Müll.Hal. ex Broth.).

KEYWORDS: Equatorial Guinea, Bioko, epiphyllous bryophytes, ecology, rainforests.

INTRODUCTION

In August 1994 and February 2002 the first author visited Bioko Island to investigate its bryophyte flora, and made collections in a wide range of habitats. Most of the non-epiphyllous collections were described in earlier papers (Müller, 1996; Váňa & Müller, 2003; Müller, 2006). This paper deals mainly with the epiphyllous collections, 25 of which were made at different sites on the island, most collections (packets) containing many leaves. The material was forwarded to the second author for determination.

Hitherto, very little has been known about the epiphyllous bryoflora of Bioko Island (Thorold, 1955; Heras & Infante, 1996, 2001), and this is also the case for most of West Africa (e.g. Gradstein & Lücking, 1997). The data presented in this paper is a first step to fill this gap in our knowledge.

In the second part of this paper, additional information is given on new and interesting non-epiphyllous species of Bioko Island.

GENERAL CHARACTERIZATION OF BIOKO ISLAND

Bioko Island, formerly Fernando Poó, is located in the Gulf of Guinea 32 km west of the coast of Cameroon (03°12' to 03°47'N, 08°25' to 08°56'E). It is a part of Equatorial Guinea,

known as Spanish Guinea before its independence from Spain in 1968. Bioko Island is roughly rectangular in shape, is 69 km from north to south and 32 km from east to west, and 2017 km² in area. Bioko is a very mountainous island. Three volcanic peaks dominate the island's topography: Pico Basile (3011 m), formerly Pico de Malabo, Clarence Peak, or Pico de Santa Isabel, in the northeast central part; Biao (2009 m) in the southeast, with its picturesque Caldera lake; and the Caldera (2261 m) in the southwest with its steep walls and almost inaccessible interior. There are no great rivers in Bioko, but some lakes occur in the interior of old volcanic craters, e.g. Lago Loreto and Lago de Biao near Moca. Bioko Island is part of a volcanic chain formed in the middle and late Tertiary that extends diagonally across the Gulf of Guinea from St Helena in the South Atlantic, northeast toward Lake Chad, to the northern tip of Cameroon (Kingdon, 1989). Bioko Island is thought to have been part of continental Africa during the last glaciation, becoming isolated <12 000 years ago by rising sea levels which created the channel between Bioko and Mt Cameroon (Moreau, 1966). This channel is only 32 km across at its narrowest point, and only 60 m deep at its greatest depth.

The island belongs to the climate zone of the ever-wet tropics, which is characterized by uniform temperatures, high rainfall, and the absence of a cold season. Bioko's high

mountains lead to great variations in rainfall and temperature on the island. The mean annual temperatures at lower elevations are about 24–25°C. The annual rainfall varies from 1900 mm in the lower parts of the north, to 10900 mm in the southern end of the island. The area around the Caldera is one of the wettest places on earth. The rainy season runs from March to mid-November, with maxima in July and August.

The flora of Bioko is not of an insular character, and there are close relationships with the flora of Mt Cameroon on the African mainland. The degree of endemism is low: for example, of the 1105 vascular plant species recorded on Bioko, 5–9% are endemic (Davis *et al.*, 1986).

The natural vegetation on the island varies with altitude and, to a lesser extent, with precipitation. The marked relief of Bioko creates a clear altitudinal zonation, and four main vegetation zones can be recognized. (1) A belt of lowland rainforest, with trees of *Ficus* spp., Sapotaceae, Euphorbiaceae, etc., occupies ground up to an altitude of about 600–900 m. This vegetation belt is subject to the strongest human influence, and large areas of forest have been replaced by extensive cocoa, coffee and banana plantations, and other cultivations. However, on the south and southwest coast, where the rainforest reaches the coast, human influence has been only minor. (2) Between 600–900 and 2300 m is the zone of montane rainforest (cloud forest), with trees of Araliaceae (*Polyscias fulva*, *Schefflera mannii*, *S. ledermannii*), *Prunus africana*, *Nuxia congesta* and tree ferns (*Cyathea* spp.). These montane rainforests have an open canopy and are characterized by a great abundance of epiphytes. In the highland of Moca this type of forest was cleared to create grassland. Because the terrain at higher altitudes is difficult of access and because there are relatively few large trees, logging has not been a serious threat to these forests. (3) On the Pico Basile from ca 2300 to 2800 m, heath vegetation with *Hypericum lanceolatum*, *Agauria salicifolia*, *Philippia mannii*, *Blaeria mannii*, *Adenocarpus manii* is characteristic. (4) Above 2800 m on the upper parts of the Pico Basile, grassland predominates mixed with a few shrubs.

Bioko Island is part of the Guinea Forests of West Africa, one of the world's 34 biodiversity hotspots (Mittermeier *et al.*, 2004). The government of Equatorial Guinea has designated two protected areas on Bioko Island, namely the Pico Basile National Park and the Gran Caldera Southern Highlands Scientific Reserve. Together they make up >40% of the island's area. Rugged topography combined with low human population afford additional protection for the natural vegetation of Bioko Island, and the island has become an important refuge for many plant and animal species that are approaching extinction on the mainland.

THE COLLECTING LOCALITIES AND REMARKS TO THE ENUMERATION OF SPECIES

The locations of the collecting sites are shown in Fig. 1.

1. Pico Basile: summit and crater N.E. of the summit, 2840–3010 m, 03°35'N, 08°46'E, grassland with

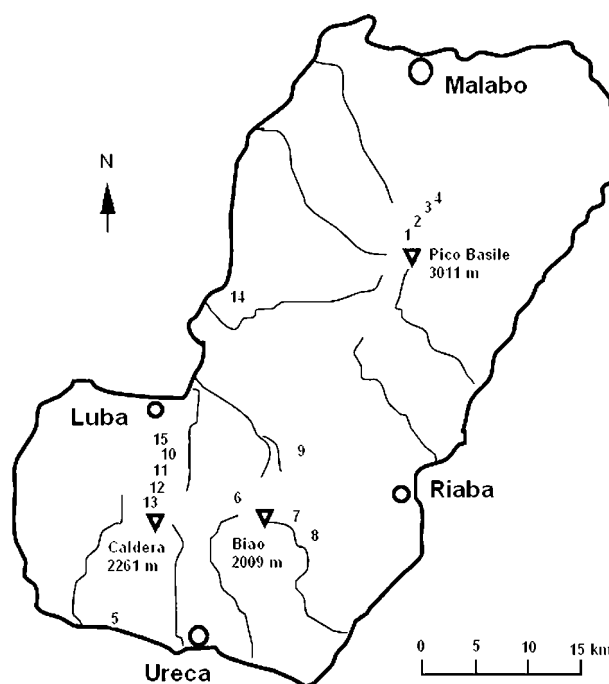


Figure 1. Bioko Island with the locations of the collecting sites (numbers 1–15).

Poaceae and Cyperaceae and heath with *Philippia mannii*, *Hypericum lanceolatum* and *Agauria salicifolia*, 6 and 7 February 2002.

2. Pico Basile: N.E. slope of the mountain along the road to the summit, 2600–2870 m, 03°36'N, 08°46'E, heath with *Philippia mannii*, *Hypericum lanceolatum* and *Agauria salicifolia*, 8 February 2002.
3. Pico Basile: N.E. slope of the mountain along the road to the summit, 2400–2600 m, 03°36'N, 08°46'E, mixture of heath and *Schefflera* forest ('Bosque de araliaceas') with *Polyscias fulva*, *Schefflera mannii*, *S. hierniana*, *Mimulopsis solmsii* and *Crassocephalum mannii*, 9 February 2002.
4. Pico Basile: N.E. slope of the mountain along the road to the summit, ca 2000 m, 03°36'N, 08°46'E, *Schefflera* forest ('Bosque de araliaceas') with *Polyscias fulva*, *Schefflera mannii*, *S. hierniana* mixed with *Hypericum lanceolatum*, *Mimulopsis solmsii* and *Crassocephalum mannii*, 10 February 2002.
5. Ureca W: coast between the mouth of the Rio Ole and Punta Sagre (= Playa de Moraca), 0–100 m, 03°16'N, 08°29'E, lowland rainforest with many montane elements ('Bosque monzónica') and coastal cliffs, 14 and 15 February 2002.
6. Highland of Moca: around the Lago de Biao, ca 1750 m, 03°21'N, 08°42'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., lakeshore and bog vegetation, 19 February 2002 (Fig. 2).
7. Highland of Moca: along the path from Moca to the Lago de Biao, 1500–1900 m, 03°21'N, 08°41'E, cultivated area with forest remnants, 19 February 2002.



Figure 2. The Lago de Biao in the highland of Moca, a picturesque Caldera lake. In the montane rainforest at the edge of the lake there is situated the type locality of *Lejeunea halei* subsp. *africana* Pócs, subsp. nov.

8. Highland of Moca: along the path from Moca to the Cascades de Iladyi, 1100–1300 m, 03°20'N, 08°40'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., 20 and 22 February 2002 (Fig. 3).
 9. Highland of Moca: around the Lago Loreto, ca 1050 m, 03°25'N, 08°40'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., 21 February 2002.
 10. Caldera 10 km S. Luba, N.N.E. slopes along the path from Ruiche to the summit, 800–1200 m, 03°24'N, 08°33'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., partly cleared. 16 August 1994.
 11. Caldera 10 km S. Luba, N.N.E. slopes along the path from Ruiche to the summit, 1200–1600 m, 03°23'N, 08°32'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., 18 August 1994.
 12. Caldera 10 km S. Luba, N.N.E. slopes along the path from Ruiche to the summit, 1600–2000 m, 03°22'N, 08°32'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., 15 August 1994.
 13. Caldera 10 km S. Luba, N.N.E. slopes along the path from Ruiche to the summit, summit region, ca 2000–2260 m, 03°22'N, 08°32'E, montane rainforest ('Bosque de montaña') with *Cyathea* spp., 15 August 1994.
 14. Village Transformador 10 km N.E. Luba, ca 50 m, 03°33'N, 8°36'E, cacao plantation, 22 August 1994.
 15. Village of Ruiche ca 10 km S. Luba, 750 m, 03°5'N, 08°33'E, small village surrounded by cacao, banana and palm plantations, 21 August 1994.
- Species marked with an asterisk (*) are new for Bioko Island, species with two asterisks (**) are new for West Africa, and species with three asterisks (***) are new for science. The nomenclature of the species follows O'Shea (2003) for the mosses and Wigginton (2004a) for the hornworts and liverworts. Voucher specimens are in the herbarium of the University of Dresden (DR), with duplicates of some specimens in the herbarium of the Eszterházy College, Eger (EGR). The numbers in bold type refer to the collection sites (Fig. 1). The world-wide distribution of each taxon is compiled from the literature.
- The epiphyllous collections were determined by the second author, unless otherwise indicated, and the non-epiphyllous collections by the first author.

THE EPIPHYLLOUS COLLECTION: DESCRIPTION OF NEW TAXA

Cololejeunea eustacei Pócs, sp. nov. (Fig. 4)

Similis *Cololejeunea peraffinis* Schiffn. et *Cololejeunea platyneurae* (Spruce) A.Evans sed differt a *Cololejeunea peraffinis* cum vitta fere semper uniserialis et denti primi lobuli unicellulari denti secundi longiore, a *Cololejeunea*



Figure 3. Montane rainforest near the Cascades de Iladyi in the highland of Moca. Type locality of *Cololejeunea eustacei* Pócs, sp. nov.

platyneura cum vitta bene distincta et dentibus lobuli saepe superpositi vel cruciati.

Type: EQUATORIAL GUINEA, BOKO ISLAND, Hochland von Moca, an den Cascades de Iladyi südlich Moca, 1100–1200 m, 03°19'N, 08°40'E, Bergregenwald, epiphyll, *F. Müller B1004/d*, 15.2.2002 (holotype DR, isotype EGR). Paratypes: Idem, *F. Müller B1002/B*, 20.2.2002 (DR, EGR), *F. Müller B1003/f* (DR), *F. Müller B1005/d* (DR, microslide in EGR), *F. Müller B1006/b & B1007/d*, 20.2.2002 (DR); Hochland von Moca, am Lago Loreto nördl. Moca, 1000–1100 m, 03°24'N, 08°40'E, *F. Müller B1008/b, B1009/O*, 21.2.2002 (DR); Ureca 11 km W., Küstenwälder zwischen Punta Sagre und der Mündung des Rio Ole, 10–50 m, 03°16'N, 08°29'E, *F. Müller B998/B*, 15.2.2002 (DR, EGR).

Epiphyllous, forming round patches on the leaf surface 5–8 mm across, pale green, readily turning rusty brown in the herbarium. Shoots 2–6 mm long and up to 0.85 mm wide. Stem about 50 μ m wide, with 5 cortical cells, ventral merophyte 1 cell row wide. Lobe asymmetrically ovate, falcate, 400–500 \times 200–250 μ m, cells unipapillose, quadrate to polygonal, 12–20 μ m in diameter with medium size trigones and intermediate thickenings, at the border much smaller. Vitta uniseriate, 4–5 cells long, seldom with 1–2

parallel cells in a second row, vitta cells 18–20 \times 30–40 μ m, translucent, with fading traces of a papilla. (The sharply delimited vitta can be seen even with a dissecting microscope, as a shining line on the lobe surface). Lobule ovate, about 2/5 lobe length, with two 1-celled teeth, the first tooth longer than the second tooth, often overlapping or crossing it. Hyaline papilla in the narrow sinus between the two lobule teeth. The distal end of lobule keel often denticulate with protruding cells. Autoicous. Androecia on short lateral branches, of 3–5 pairs of bracts, antheridia 1 per bract. Gynoeceia on short branches. Perianth cordate, slightly applanate with two narrow carinae.

This taxon had already been observed by E. W. Jones, from collections made by S. Lisowski near Macenta, Guinea, and later by A. J. Harrington from Lake Sonafon, Sierra Leone and by himself from the Okomu Forest Reserve, Nigeria. On the basis of the very scanty material at his disposal, he placed the taxon under *Cololejeunea peraffinis* var. *elegans* Benedix, accompanying the description with precise illustrations (Jones, 1968, figs 4b, 5c; Jones, 1985). Bizot & Pócs (1974) also reported *C. peraffinis* var. *elegans* from Tanzania, but this collection was later re-determined as *C. usambarica* E.W.Jones (= *C. platyneura* (Spruce) A.Evans). Subsequently, E. W. Jones became uncertain of the taxonomic position of the West African plant, and in his later manuscript for a West African Liverwort flora, noted differences between it and both *C. peraffinis* var. *elegans* and *C. platyneura* (Wigginton, 2004b). Detailed descriptions of *C. peraffinis* var. *elegans* by Benedix (1953) and by Tixier (1969) also show that the West African taxon is different.

Now, after the careful examination of the very rich material from Bioko and comparison with the above-mentioned taxa, we can establish that the West African plant belongs to an undescribed species related to both *C. peraffinis* and *C. platyneura*. From *C. peraffinis*, it differs basically in the almost always uniseriate vitta consisting of 4–5 cells and in the unicellular first tooth of the lobule exceeding the second in length. From *C. platyneura*, it differs in the sharply delimited, 4–5 celled vitta and that the first lobule tooth in many cases is superposed and crosses the second (as in *C. peraffinis*, and this was the reason why Jones originally placed it there), and by the single antheridium within each male bract (two in *C. platyneura* according to Pócs, 1976). The species seems to be widespread in West Africa. On the basis of our present knowledge, *Cololejeunea peraffinis* must therefore, as Jones suggested, be removed from the African flora.

The taxon is named in the honour of the late Eustace W. Jones, renowned hepaticologist, who first dealt with this taxon, among many other African *Cololejeunea* species.

Colura calderae Pócs, sp. nov. (Figs 5, 6, 7a–d)

Similis *Colurae digitalis* (Mitt.) Steph. et *Colurae hattorianae* Pócs sed differt cellulibus basalibus saepe duabus

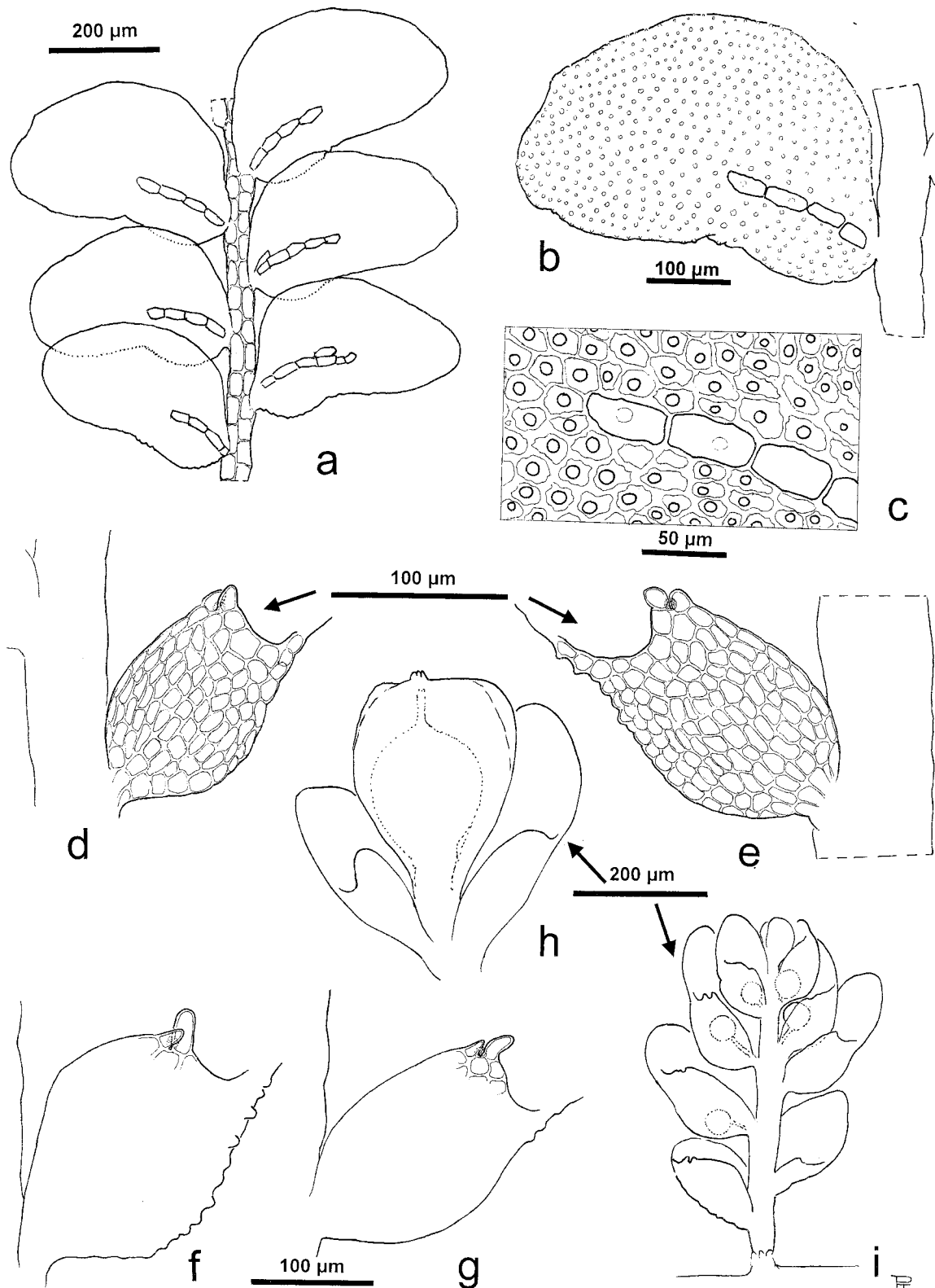


Figure 4. *Cololejeunea eustacei* Pöcs: (a) shoot, dorsal view; (b) leaf, dorsal view; (c) vitta; (d–g) lobules; (h) perianth; (i) male branch, ventral view. a–c drawn from Müller B1005/D, d and e drawn from the type.

et cellulibus clypei (valvae) numerosis; a *Colura digitalis* lobis latioribus et apicibus lobuli acutissimis, a *Colura hattoriana* lobuli foliae et amphigastriorum multo angustioribus.

Type: EQUATORIAL GUINEA, BIOKO ISLAND, Berg Caldera 10 km südlich Luba, am NON-Hang am Weg von Ruiche zum Gipfel, ca 1200–1500 m, 03° 23'N, 08°32'E, Bergregenwald, epiphyll, F. Müller B312/a,

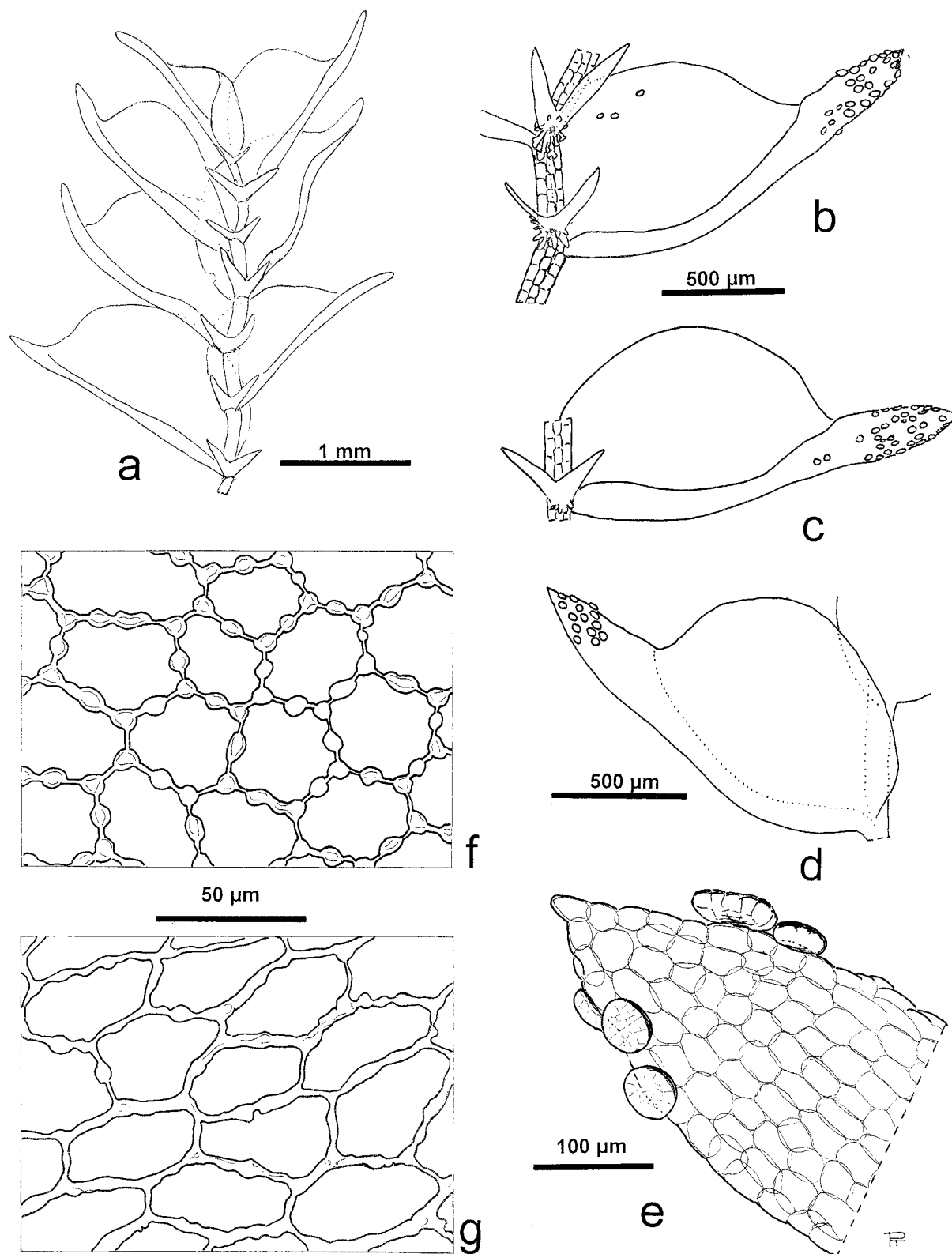


Figure 5. *Colura calderae* Pócs: (a) shoot, ventral view; (b, c) leaves, ventral view; (d) leaf, dorsal view; (e) acute leaf (lobule) apex with gemmae; (f) mid-lobe cells; (g) basal-lobe cells. All drawn from the type.

18.8.1994 (holotype DR, isotype EGR). Paratype: idem, *F. Müller B317/b*, 18.8.1994 (DR, microslide in EGR).

Epiphyllous, relatively large, forming large, irregular patches on the leaf surface, 6–18 mm across, yellowish

green. Leafy shoots 3–10 mm long and up to 3.8 mm wide. Stems about 100 µm in diameter, with 7 rows of cortical cells, ventral merophyte 2 cell rows wide. Leaves 1500–1850 µm long. Lobe up to 780 µm wide and

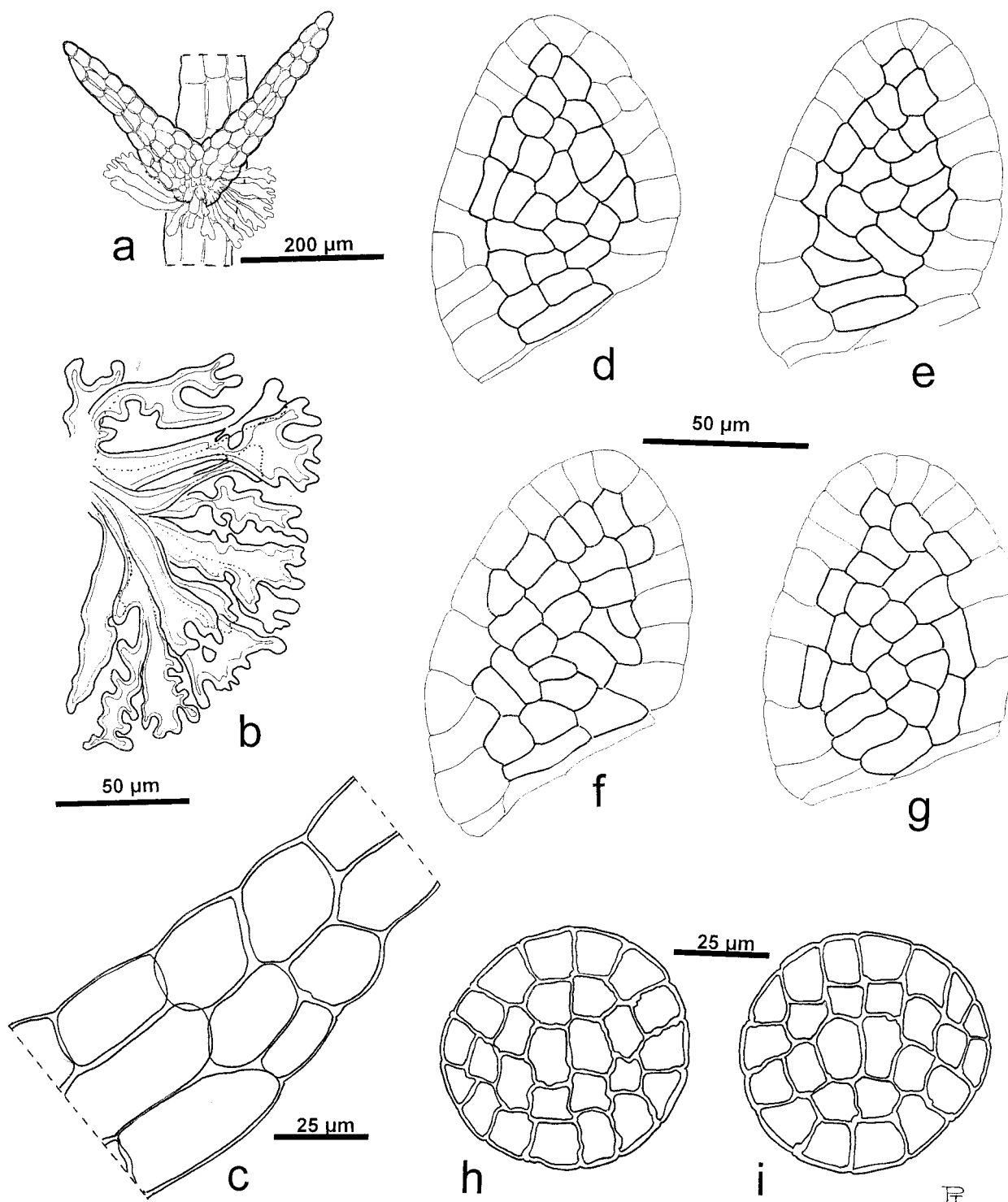


Figure 6. *Colura calderae* Pócs: (a) underleaf; (b) rhizoids; (c) segment of underleaf lobe; (d–g) valves; (h, i) discoid gemmae. All drawn from the type.

1000–1300 µm long, semicircular, *lobule* narrow, ending in a narrow cylindrical sac about 12 cells wide, very acutely tipped by one cell and covered by many discoid *gemmae*, each formed of 24–30 cells. *Mid-lobe cells* 30–40 × 36–48 µm, with bulging trigones and large intermediate thickenings. *Basal cells* 20–30 × 40–50 µm, with walls irregularly incrassate. *Valve* 65–70 × 90–100 µm, of

36–44 cells (16–19 hyaline marginal cells, and 20–25 thicker walled median cells). The median tissue is 3–5 cells wide with 1 or 2 basal median cells. *Underleaves* V-shaped, the lobes elongate, acute, 3–4 cells wide at base. *Rhizoids* hyaline, adhering to the substrate by flattened, irregularly widened and branching tips. Probably dioicous, gynoecia seen very rarely. *Androecium* either at the

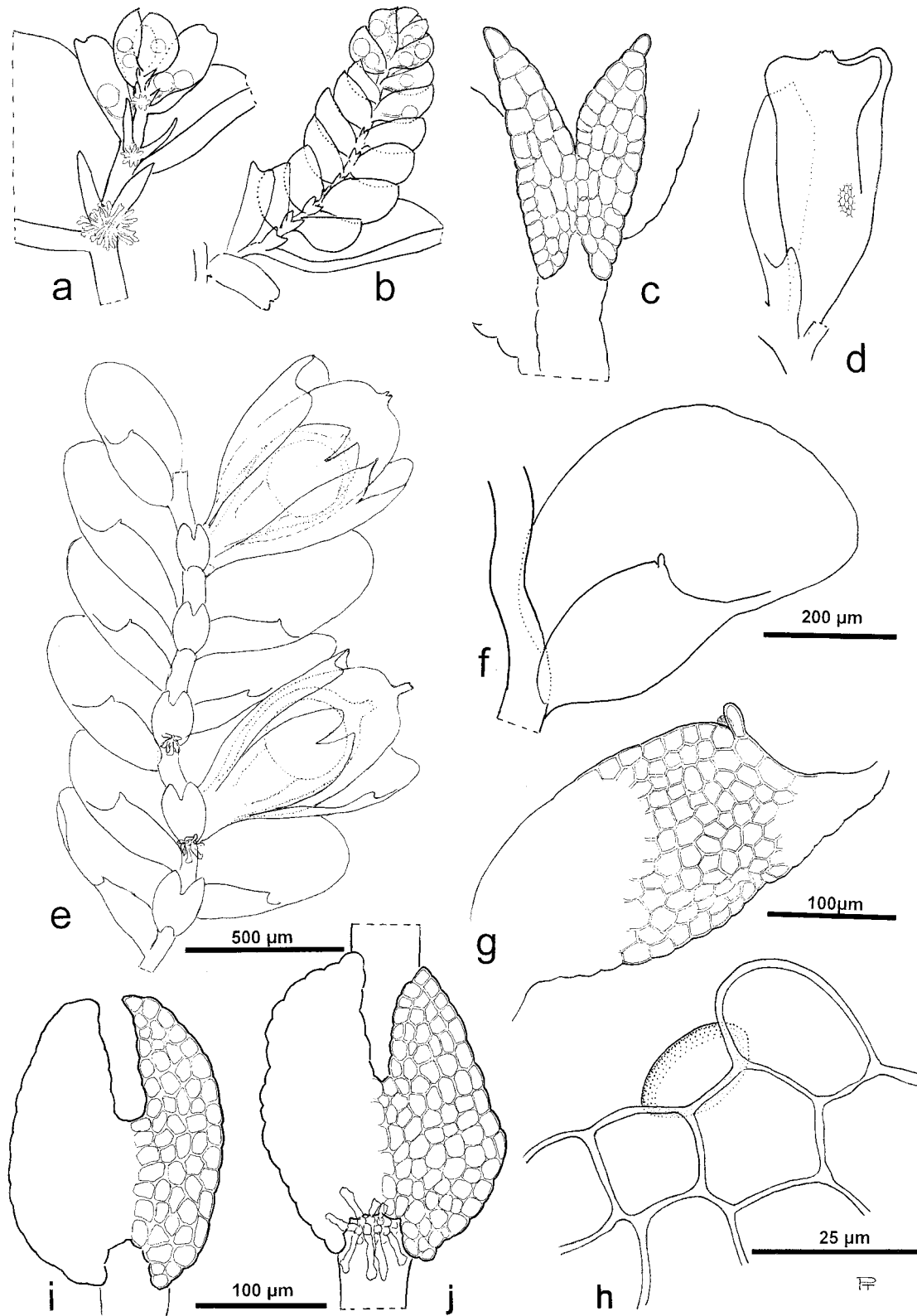


Figure 7. (a–d) *Colura calderae* Pócs: (a, b) male branches, ventral view; (c) male bracteole; (d) perianth. a–c drawn from Müller B317/b, d from the type. (e–j) *Lejeunea halei* Robinson subsp. *africana* Pócs: (e) habit, ventral view; (f) leaf, ventral view; (g) lobule, ventral view; (h) lobule tooth with the proximal hyaline papilla, ventral view; (i, j) underleaves. e–j drawn from the type of subsp. *africana*.

shoot tip or more often on short lateral branches. Male branch of 2–12 pairs of bracts, each bract with 2 antheridia. Bracteoles incised with a V-shaped incision

to half their length in about 2/3 number of bract pairs. Perianth obpyriform with 3 auriculate wings. Perianth cells without thickenings.

This new species is superficially similar to *Colura digitalis* (Mitt.) Steph. and *Colura hattoriana* Pócs, both of which were collected recently at two different localities on Bioko Island. However, *C. calderae* has several distinguishing properties. Neither of the two related species has a valve composed by so many cells. The valve of *Colura digitalis* has 14–18 hyaline marginal cells (usually fewer than 16), and 10–18 thicker-walled median cells (Jovet-Ast, 1953 and our own observations), while *Colura hattoriana* has only 10–12 marginal cells and 15–16 median cells (Pócs, 1993). The acute lobule apex occurs in *C. hattoriana* on a much wider, conical sac, and the semicircular lobe is wider in *C. calderae* than in any related species. In this respect, and in the characters of the valve (numerous cells and double median basal cells), *C. calderae* seems to be related to the Indomalesian *Colura herzogii* Ast. However, the latter has dentate lobe margins and perianth wings (Jovet-Ast, 1953).

Lejeunea halei Robinson (1964) *Bryologist* 67: 454, figs 37–42. **subsp. *africana*** Pócs, **subsp. nov.** (Fig. 7e–j)

Differt a typo statuta multo maiora, ad 1.2 mm lata foliis ad 770 μ m longa et 550 μ m lata, lobulis elongatioribus, amphigastrium lobi latioribus, perianthiis ad 800 μ m longis.

Type of subsp.: EQUATORIAL GUINEA, BIOKO ISLAND, Hochland von Moca, Wälder am Südufer des Lago Biao, 1750–1800 m, 03°21'N, 08°37'E, *F. Müller* B999/f, 19.2.2002 (holotype: DR, isotypes: EGR, GOET).

Lejeunea halei was quite recently described from Mexico (Robinson, 1964), and was unknown in Africa. Since its publication, a number of new localities became known in the tropical parts of Mexico, from the states of Chiapas, Mexico, Michoacán, Oaxaca, Puebla and Tamaulipas (Fulford & Sharp, 1990). The flat, elongate lobule about half the length of the lobe distinguishes this species from other members of subgenus *Inflatolejeunea* Robinson (1964), (Arnell, 1963, as a genus).

Subgenus *Inflatolejeunea* is distinguished by the terete perianth without any keels. There are three or four members of the subgenus occurring in Africa and in America. *Lejeunea capensis* Gottsche was already known from both continents (Vanden Berghen, 1965; Giancotti & Vital, 1989), and now *L. halei* has also been found in Africa. We were able to compare our plant with the original description and illustration made by Robinson (l.c.) and with the drawings of its type (coll. *Hale & Söderström* 199292, US) made by Dr Elena Reiner-Drehwald, who kindly placed it at our disposal. The African subspecies differs from subsp. *halei* only in its size and by its more elongated lobule.

ANNOTATED LIST OF SPECIES

Marchantiopsida

****Aphanolejeunea microscopica* var. *microscopica*** (Tayl.) A.Evans 5 B997/k, B1000/f. 8 B1006/j. 9 B1001/f. 11 B314/i.

13 B265/lb. Circumatlantic species occurring in the Neotropics, W. Europe and in Africa, where it is widespread. In West Africa hitherto only known from Ivory Coast.

Aphanolejeunea truncatifolia Horik. 8 B1006/c. 13 B265/c. Pantropical species, rare in Africa and hitherto known from Bioko, Malawi, and Uganda. From Bioko already reported by Infante, Heras & Buck (1997).

***Aphanolejeunea* sp.** 9 B1009/n.

****Archilejeunea abbreviata*** (Mitt.) Vanden Berghen 14 B308/a. Fairly widely distributed in tropical Africa.

****Caudalejeunea hanningtonii*** (Mitt.) Schiffn. 5 B998/m. Widely distributed in tropical Africa.

****Caudalejeunea lehmanniana*** (Gottsche) Evans 5 B998/d. An Afro-American species, in Africa restricted to the West African lowland rainforest area.

Ceratolejeunea* cf. *calabariensis Steph. 8 B1005/j, sterile. Widely distributed in tropical Africa, widely distributed and often frequent in the rainforests of West Africa. Many non-epiphyllous fertile collections were made of this species and positively identified.

****Ceratolejeunea* cf. *diversicornua*** Steph. 5 B997/c, B1000/k. 9 B1009/c. All sterile. A rare species, in Africa hitherto known from Cameroon, Ghana and the Democratic Republic of Congo. Sterile.

****Cheilolejeunea intertexta*** (Lindenb.) Steph. 9 B1009/a. A palaeotropical species. Widely distributed in tropical Africa.

*****Cheilolejeunea krakakammae*** (Lindenb.) R.M.Schust. 9 B1009/b. In Africa hitherto known from the eastern and southern part, and from the East African islands. First record for West Africa.

Cheilolejeunea serpentina (Mitt.) Mizut. 5 B997/e, B1000/j. 8 B1002/e, B1005/h, B1006/k, B1007/b. 9 B1003/h. A palaeotropical species, widely distributed in tropical Africa.

*****Cololejeunea adhaesiva*** (Mitt.) R.M.Schust. 9 B1009/g. A rare species, in Africa hitherto only known from Tanzania.

****Cololejeunea appressa*** (A.Evans) Benedix 9 B1009/f. A pantropical species, widely distributed in tropical Africa.

****Cololejeunea cuneifolia*** Steph. 4 B1011. 5 B998/l. 9 B1008/b. Widely distributed in tropical Africa.

****Cololejeunea duvignaudii*** E.W.Jones 5 B997/f. 11 B313/a, B317/b. A predominantly East African species, rarely recorded from West Africa.

****Cololejeunea elegans*** Steph. 6 B999/h. Widely distributed in tropical Africa. Montane.

******Cololejeunea eustacei*** Pócs, **sp. nov.** 5 B998/b (Paratype). 8 B1001/e (Paratype), B1002/b (Paratype, DR & EGR), B1004/d (Holotype DR, Isotype EGR), B1005/d (Paratype DR & EGR), B1006/b (Paratype DR), B1007/g (Paratype DR). 9 B1003/f (Paratype). An element of the West African bryoflora (see more detailed information above).

****Cololejeunea* cf. *lanceolata*** E.W.Jones 8 B1002/a. A species of the West African lowland rainforest area. Poorly represented.

**Cololejeunea obliqua* Nees et Mont. 5 B997/l, B998/j, B1000/g. 8 B1001/d, B1002/h, B1006/d, B1007/d. 9 B1009/e. A pantropical species, widely distributed in tropical Africa.

***Cololejeunea papilliloba* Steph. 8 B1004/c. 9 B1008/e, B1009/m. A South American taxon, new to Africa.

**Cololejeunea pusilla* Steph. var. *obtusifolia* E.W.Jones 5 B998/g p.p. 9 B1009/h. Widely distributed in tropical Africa.

**Cololejeunea pusilla* Steph. var. *pusilla* 5 B998/g p.p, B1000/b. 8 B1002/j, B1005/g, B1006/h, B1007/k. 9 B1008/c. Widely distributed in West Africa and also known from Rwanda and Tanzania.

***Cololejeunea tenella* Benedix 5 B997/j, B998/a. 8 B1001/a, B1002/d (DR & EGR), B1005/e, B1007/m. A rare species, in Africa otherwise known only from Rwanda. First record for West Africa.

**Cololejeunea tonkinensis* Steph. 9 B1008/d. A pantropical species, widely distributed in tropical Africa.

**Cololejeunea zenkeri* (Steph.) E.W.Jones 5 B998/c. 6 B999/a. 8 B1004/a, B1006/a, B1007/c. 9 B1003/c, B1008/b, B1009/o. 11 B312/c, B314/e. Widely distributed in tropical Africa.

****Colura calderae* Pócs, sp. nov. 11 B312/a (Holotype DR, Isotype EGR), B317/b (Paratype DR) (see more detailed information above).

**Colura digitalis* (Mitt.) Steph. 5 B997/n, B998/k. An African species, widely distributed in tropical Africa. According to Gradstein & da Costa (2003) the American record is erroneous.

***Colura hattoriana* Pócs 5 B997/p, B1000/a. A rare species, hitherto known from the Comoro Islands and Malawi. First record for West Africa.

**Drepanolejeunea capulata* (Tayl.) Steph. 13 B265/e. A rare species, hitherto only known from the type collection in Nigeria.

Drepanolejeunea cultrella (Mitt.) Steph. 5 B997/m, B1000/e. 6 B999/b. 8 B1001/b, B1002/k, B1004/e, B1005/f, B1006/l, B1007/a. 9 B1003/d, B1008/j, B1009/p. Widely distributed in tropical Africa. Already reported from Bioko by Infante *et al.* (1997).

***Drepanolejeunea pentadactyla* (Mont.) Steph. 5 B997/o. Primarily an Asian-Oceanic species. In Africa hitherto only known from Madagascar. First record for West Africa.

**Heteroscyphus dubius* (Gottsche) Schiffn. 5 B810/c. Widely distributed in tropical Africa.

Lejeunea acuta Mitt. 6 B999/e. 8 B1002/c, B1004/b, B1005/b, B1007/l. More or less widely distributed in montane areas of tropical Africa.

Lejeunea caespitosa Lindenb. 9 B1009/l. 14 B308/b. An Afro-American species, widely distributed in tropical Africa.

**Lejeunea confusa* E.W.Jones 5 B810/a. Non-epiphyllous collections: 2 epiphytic, B616. 5 epiphytic, B605. 15 epiphytic, B185. 10 epiphytic, B171. Widely distributed in tropical Africa.

**Lejeunea dipterocarpa* E.W.Jones 5 B998/h. 9 B1008/h. 11 B312/b, B314/d, B315/c, B316/a (DR & EGR), B317/c. A

species of the West African rainforest area, hitherto only known from Cameroon and Nigeria.

Lejeunea flava (Sw.) Nees agg. 6 B999/g. 9 B1003/e, sterile. 13 B265/h. Widely distributed in tropical Africa, the infraspecific segregation is unclear.

****Lejeunea halei* Robinson subsp. *africana* Pócs, subsp. nov. 6 B999/f (Holotype DR, Isotypes EGR, GOET) (see more detailed information above).

**Lejeunea obtusistipula* (Steph.) E.W.Jones 8 B1006/f, sterile, cf. *obtusistipula*. Non-epiphyllous collections: 2 epiphytic, B616, det. T. Pócs. 13 epiphytic on tree fern, B178, conf. T. Pócs. A rare species of the West African lowland rainforest area, hitherto only known from Guinea, and Sierra Leone.

Lejeunea cf. ramosissima Steph. 13 B265/f, sterile. Widely distributed in tropical Africa, montane.

Lejeunea sp. 11 B317/c, sterile.

Lepidozia succida Mitt. 5 B810/b. Widely distributed in the lowland rainforest areas of tropical Africa.

**Leptolejeunea maculata* (Mitt.) Schiffn. 5 B997/g, B1000/d. 9 B1003/a. A pantropical species, widely distributed in tropical Africa, Asia and America.

**Metzgeria consanguinea* Schiffn. 6 B999/i. A pantropical species, widely distributed in tropical and southern Africa, especially in montane areas. In West Africa hitherto only known from Cameroon.

**Metzgeria furcata* (L.) Dum. 5 B997/h. 11 B314/f. 13 B265/g. Cosmopolitan species with montane character in Africa.

**Metzgeria madagassa* Steph. 3 B545. 8 B1007/f. Widely distributed in tropical Africa, montane.

Microlejeunea africana Steph. 4 B1011/b. 5 B997/b, B998/f, 1000/h. 6 B999/c. 9 B1009/k. 13 B265/a. 14 B308/c. Widely distributed in tropical Africa.

**Microlejeunea kamerunensis* Steph. 4 B1010 (det. F. Müller, confirmed T. Pócs). 5 B997/d, B998/e. 6 B999/d. 8 B1001/c, B1002/e, B1005/c, B1007/h. 9 B1003/g, B1008/a, B1009/k. 11 B314/k. Widely distributed in tropical Africa, montane.

Odontolejeunea lunulata (F.Weber) Schiffn. 6 B999/l. 8 B1007/e. 9 B1003/b, B1008/f. 11 B313/c. An Afro-American species, widely distributed in tropical Africa.

Plagiochila sp. 11 B314/h, B315/a. Sterile fragments only.

Prionolejeunea grata (Gottsche) Schiffn. 11 B313/d, B314/c. 13 B265/d. Widely distributed in tropical Africa. Already reported from Bioko by Infante *et al.* (1997).

**Prionolejeunea cf. principensis* Vanden Berghen 8 B1006/g, sterile. A rare species, hitherto only known from the type locality in Príncipe.

**Radula flaccida* Lindenb. & Gottsche 5 B997/a, B1000/c. 8 B1006/e. 9 B1009/j. An Afro-American species, widely distributed in tropical Africa.

**Radula stenocalyx* Mont. 8 B1002/g, B1004/f, B1005/a, B1007/j. 11 B313/b, B314/g. An Afro-American species, widely distributed in tropical Africa.

**Taxilejeunea conformis* (Nees & Mont.) Steph. 11 B314/b. Widely distributed in tropical Africa.

Bryopsida

***Daltonia* sp. 11 B314/a.**

***Floribundaria* sp. 11 B315/b.**

INTERESTING RECORDS OF NON-EPIPHYLLOUS SPECIES

Anthocerotophyta

****Anthoceros punctatus* L. 1** on soil on a path, B548. **2** wet soil along a path, B968. In sub-Saharan Africa hitherto known from Cape Verde, Rwanda, Socotra and the Democratic Republic of Congo.

****Dendroceros africanus* Steph. 8** epiphytic on trees in pastures, B812. A very rare species, reported from only two occasions. The type locality is situated in Cameroon, the other report is from the East Usambara Mts in Tanzania. In Africa very rare, as is the whole genus.

****Folioceros incurvus* (Steph.) D.C.Bharadwaj 5** rocky slopes along the Rio Ole, B490. Hitherto only known from four confirmed records from Cameroon (Jones, 1981).

****Phaeoceros carolinianus* (Michx.) Prosk. 1** earthy slopes along a path, B661, B663. Widespread in sub-Saharan Africa.

Marchantiopsida

****Cheilelejeunea montagnei* (Gottsche) R.M.Schust. 13** epiphytic, B192, B194. A montane species of eastern Africa and the East African islands. In West Africa the species was hitherto only known from São Tomé.

****Herbertus mollis* (Steph.) Dusén 1** rockface, B913, B934. **3** epiphytic, B938. Only known from Cameroon and São Tomé, but very close to, and probably conspecific with, *H. dicranus* (Taylor ex Gottsche *et al.*) Trevis. (Wigginton, 2004b).

****Lejeunea eckloniana* Lindenb. 11** on wet rocks, B176. **10** epiphytic, B172. Widely distributed in tropical Africa.

*****Lepidozia cupressina* (Sw.) Lindenb. 3** epiphytic, B459, det. T. Pócs. Pantropical. In Africa restricted to the montaneous regions in East and South Africa. First record for West Africa.

***Plagiochila punctata* (Taylor) Taylor 3** epiphytic, B489, det. T. Pócs, conf. J. Heinrichs. The marginal teeth are rather long and narrow, the marginal cells hardly wider than 20 µm. This is an important record confirming the record of Arnell (1956) 'Bioko: Moka, Byström 837 p.p.'. Jones (1962) doubted the occurrence of this predominantly European species in sub-Saharan Africa thinking that the record was probably based on a misidentification. The presence of this Atlantic European species was confirmed in tropical East Africa by Heinrichs *et al.* (2005), who also recorded its presence from Central and South America.

*****Targionia lorbeeriana* Müll.Frib. 1** rocky slopes along a path, B974. In Wigginton (2002) *T. lorbeeriana* was placed in synonymy with *T. hypophylla* L., therefore both records

for Bioko Island were treated under this name in Müller (2006). In the newest version of the checklist of the liverworts of sub-Saharan Africa (Wigginton, 2004a) the two species are treated separately, because Grolle (1995) and Grolle & Long (2000) considered the complex far from clarified. One of the two *Targionia* samples from Bioko Island cited by Müller (2006) belongs to *T. hypophylla* s. str. (3 rocks along a wet rivulet, B600), but the other one (see above) shares the features of *T. lorbeeriana*. This species is known in sub-Saharan Africa from Madagascar, Kenya, Reunion and Tanzania.

Bryopsida

****Actinodontium streptopogoneum* Broth.,** *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 24: 260. 1897. HOLOTYPUS: *Lepidopilum streptopogoneum* C.Müll. Africa occ., Camerunia prope Ekundu pagum in truncis arborum. Oct. 1890. P. Dusén. Typus! P. Dusén's moss herbarium. Handwritten by Brotherus: 'Typus Äv en *Actinodontium A. streptopogoneum* Broth.' (S B2285). ISOTYPUS: *Lepidopilum streptopogoneum* C.M. n.sp. W.Afrika. Kamerun, Ekundu, rotten trunks, 28.10.1890, P. Dusén, Herbarium bryologicum Hjalmar Möller (S B2286).

Syn. nov.: *Actinodontium dusenii* Broth., *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 24: 260. 1897. HOLOTYPUS: *Lepidopilum dusenii* C.Müll. Africa occ., Camerunia supra Bomanam pagum in ramulis arborum, c. 900 m., julius 1890, P. Dusén. Typus! P. Dusén's moss herbarium. Handwritten by Brotherus 'Äv en *Actinodontium A. dusenii* Broth.' (S B2284).

8, epiphytic on solitary trees in pasture, B436, B508, B724.

In Africa there are two known species of the genus *Actinodontium*, *A. streptopogoneum* and *A. dusenii*, both described by Brotherus (1897) based on material collected by P. Dusén in Cameroon. Brotherus described the two taxa as very closely related. *Actinodontium streptopogoneum* is described as differing from *A. dusenii* only by the colour of the plants (*A. streptopogoneum*, dirty green, non-glossy; *A. dusenii*, bright green, glossy), the foliation of the stems (*A. streptopogoneum*, stems densely foliate; *A. dusenii*, stems loosely foliate), and length and width of the nerve (*A. streptopogoneum*, leaf nerve extending well beyond mid-leaf, nerve strong; *A. dusenii*, nerve seldom reaching beyond mid-leaf, nerve thin).

However, examination of type material of the two taxa and the newly collected material of Bioko has shown that the features mentioned above intergrade. The length and width of the nerve is very variable, even between leaves of the same sample. In addition, the foliation of the stems and the colour and glossiness of the plant are not good differentiating characters. For example, in the holotype of *A. streptopogoneum*, only the plants with sporophytes have

a compact habit, whereas the sterile stems are loosely foliate and non-glossy. Therefore both taxa are treated here as identical and *A. dusenii* is made to a synonym of *A. streptopogoneum*.

The relationship of the African species of the genus to the American and Asian species needs further investigation.

**Anoetangium aestivum* (Hedw.) Mitt. 1 rocky slopes along a path, B727, det. P. Sollman.

Fairly widespread in montane areas of Africa, the nearest records are from Cameroon.

**Bartramia brachypus* Müll.Hal. 1 rocks in a crater, B870, B937; rocky slopes along a path, B879. For the identification the revision of Fransén (2004) was used. The species occurs in the East African Mountains and on Mt Cameroon.

***Didymodon tectorum* (Müll.Hal.) K.Saito 1 slopes along a path, B909, det. P. Sollman.

Didymodon rigidulus var. *acutus* Bizot should be a synonym of this species (Sollman, *in litt.*). The African range consists of Tanzania and Bioko.

***Pohlia baronii* Wijk & Margad. 1 slopes along a path, B634, B991. 2 rocky slopes along a path, B981. With many long, thread-like axillary bulbils similar to the Holarctic *P. prolifera*, but differing from the latter by the longly decurrent leaves without a metallic sheen. In Africa hitherto known from the southern part and the East African Mountains. First record from West Africa.

**Wijkia rigidicaule* (Müll.Hal. ex Broth.) Frank Müll., comb. nov. Basionym: *Acanthocladium rigidicaule* Müll.Hal. ex Broth., *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 24: 278. 1897. 8 on boulders, B813.

The specimen was compared with the following type material in S:

1. Musci Africani in Camerunia a P. Dusén collecti. 794. *Heterophyllum rigidicaule* C.M. In montibus Camerunensibus prope Bomanam pagum c. 600 metra supra mare in truncis arborum die 19 m. Julii a. 1892, B54175 (intern number of S).
2. Musci Africani in Camerunia a P. Dusén collecti. 794. *Acanthocladium rigidicaule* Broth. (note: handwritten added to the printed label). In montibus Camerunensibus prope Bomanam pagum c. 600 metra supra mare in truncis arborum die 19 m. Julii a. 1892, B54176 (intern number of S). ex Herb. Forstrat Dr Georg Roth (handwritten comment of Roth: 'Astbll. oft bis über die Mitte herab gesägt! Über den großen gelben Blattflügelzellen bis zu 6 Reihen locker ..., die übrigen linear').
3. Musci Africani in Camerunia a P. Dusén collecti. 794. *Heterophyllum rigidicaule* C.M. In montibus Camerunensibus prope Bomanam pagum c. 600 metra supra mare in truncis arborum die 19 m. Julii a. 1892, B54178 (intern number of S).

The species is characterized by a robust habit (stem leaves to 2 mm long), \pm regularly pinnate stems, distinctly dentate margins of stem and branch leaves (regularly in

the upper half of the leaves, sometimes to the base), often twisted leaf tips; inflated, hyaline, decurrent auricles of rectangular-rhomboidal cells inserted in several rows, the neighbouring basal cells to the central part of the basal leaf often reddish; the costa indistinct and double or lacking; the basal leaf cells with strongly porose walls.

The species was first described by Brotherus (1897) as *Acanthocladium rigidicaule* Müll.Hal. ex Broth. Later, Müller (in Paris, 1898) mentioned the taxon as *Heterophyllum rigidicaule* Müll.Hal. Paris (1898) transferred it to the genus *Rhaphidostegium* as *Rhaphidostegium rigidicaule* (Broth.) Paris, and Brotherus (1925) later transferred it to *Trismegistia*, as *Trismegistia rigidicaulis* (Broth.) Broth.

Following the recent genus concept of the Sematophyllaceae (e.g. Hedenäs & Buck, 1999; O'Shea, 1999), the species belongs to the genus *Wijkia*. Therefore the above-mentioned new combination is made. Because of its enlarged and inflated, oval to oblong, differently sized alar cells, it cannot be assigned to *Heterophyllum* (in *Heterophyllum* the alar cells are subquadrate, thick-walled and all about the same size). The genus *Rhaphidostegium* is integrated in *Sematophyllum*, a genus characterized by uniseriate, enlarged alar cells. The genus *Trismegistia* is characterized by Akiyama (2004) as follows: 'The genus *Trismegistia* (Sematophyllaceae; Musci) can be distinguished from allied genera (*Wijkia*, *Brotherella*, *Mastopoma* and *Pseudotrismegistia*) by the procumbent or upright stems with more or less developed stipes from prostrate primary shoots, differentiation of shapes among stipe, stem and branch leaves, well-bordered and deeply serrate or dentate (rarely only serrulate) leaf margins, and segmented alar cells at least in the outer one or two tiers'. 'The only species previously reported from Africa, *Trismegistia monodii* (P. de la Varde) Ando is not recognized as a member of *Trismegistia*' (Akiyama, 2004). *Trismegistia rigidicaule* was overlooked by Akiyama (2004) in his revision as an additional African species, but since the latter species does not belong to *Trismegistia*, this genus can be excluded from the African bryoflora.

DISCUSSION

A total of 57 epiphyllous species were found on Bioko Island. *Daltonia* sp. and *Floribundaria* sp. were the only mosses found on living leaves. All other species belonged to the liverworts, with 15 genera and 47 species of the family Lejeuneaceae, three species of *Metzgeria* (Metzgeriaceae), two species of *Radula* (Radulaceae) and one species each of *Plagiochila* (Plagiochilaceae), *Heteroscyphus* (Geocalycaceae) and *Lepidozia* (Lepidoziaceae). Fifty-two of the 57 epiphyllous bryophytes found on Bioko Island could be identified to species level. Of these, 29 species can be classified as typically epiphyllous, 12 species as regularly epiphyllous but also known from other substrates, and 11 species only rarely grow as epiphylls and occur mainly on other substrates.

Table 1. Distribution types of epiphyllous bryophytes found on Bioko Island

Distribution type	Species number	Percentage
Widely distributed (at least on two continents) and frequent in sub-Saharan Africa	13	25.0
Widely distributed (at least on two continents), but scattered in sub-Saharan Africa	4	7.7
African element, and widely distributed and frequent	21	40.44
African element, and only scattered records	6	11.5
African element, restricted to West Africa	6	11.5
endemic to Bioko	2	3.8

The epiphyllous bryoflora of Africa is considered to be poorer than that of Southeast Asia or the Neotropics (Pócs, 1978). Pócs (1997) lists 91 true epiphyllous liverwort species for the Indian Ocean Islands, 62 for West Africa, 105 for Oceania, 106 for lowland South America, 115 for the Andes, 125 for Meso-America with Mexico, and 167 for Melanesia with New Guinea. For some smaller African regions, Pócs (1997) gives more detailed information on the species number of true epiphylls (Seychelles: 23 species; Comores: 39 species; Madagascar: 65 species; Reunion: 24 species; Mauritius: 23 species; Usambara Mountains in Tanzania: 32 species). With 29 true epiphylls, Bioko Islands is comparable in species diversity of the epiphyllous bryophytes with the smaller ones of the Indian Ocean Islands and the Usambara Mountains. Wigginton (2004b) lists 48 true epiphyllous species for West Africa. More than 60% of the epiphyllous bryophytes of West Africa are therefore known from Bioko Island.

Table 1 shows the share of the epiphyllous bryophytes of Bioko Island in order of their distribution type. According to their known distribution, six types were distinguished: (1) widely distributed (at least on two continents) and frequent in sub-Saharan Africa; (2) widely distributed (at least on two continents), but scattered in sub-Saharan Africa; (3) widely distributed and frequent in Africa; (4) scattered in Africa; (5) restricted to West Africa; (6) endemic to Bioko.

Most of the bryophytes recorded are widely distributed in sub-Saharan Africa and restricted in their global range to Africa (40.4%) or are known at least from two continents (25.0%). A smaller percentage of species is scattered in Africa and restricted to Africa (11.5%) or known from at least two continents (7.7%). Among these groups are some rare species reported as new for Africa (*Cololejeunea papilliloba*) or West Africa (*Cheilejeunea krakakammae*, *Cololejeunea adhaesiva*, *Cololejeunea tenella*, *Colura hattoriana*, *Drepanolejeunea pentadactyla*). Of special phyto-geographic interest are the species limited in their known distribution to West Africa (*Ceratolejeunea diversicornua*, *Cololejeunea eustacei*, *Cololejeunea lanceolata*, *Drepanolejeunea capulata*, *Lejeunea dipterocarpa*, *Lejeunea obtusistipula*, *Prionolejeunea principensis*) or Bioko Island (*Cohura calderae*, *Lejeunea halei* subsp. *africana*).

Normally with increasing elevation above sea level, the epiphyll diversity decreases, or increases with elevation only to a certain altitude. This limit depends very much on the latitude and on the oceanicity of the climate. For example, Tixier (1975) has found maximum epiphyll diversity in Southeast Asia (and later also in Madagascar) between

800 m and 1200 m a.s.l. On Bioko Island we have found on the Caldera a high diversity of epiphylls right up to the summit region (2000–2261 m). On the highest peak of the island, the Pico Basile, the highest record of an epiphyllous liverwort was *Metzgeria madagassa* at an altitude of ca 2400 m. At altitudes of around 2000 m on Pico Basile only poor fragments of epiphylls were found at protected sites. The main reason for the well-developed epiphyllous bryoflora at high altitude at the Caldera is the very high precipitation and humidity.

The recent collection contains 56 species, 49 liverworts and hornworts and seven mosses, as new for the island. In total, 370 species (170 liverworts and hornworts and 200 mosses) are now known from Bioko Island. Bioko Island belongs therefore to a centre of bryophyte biodiversity in West Africa with a larger bryophyte flora than any West African country, apart from the very much larger Cameroon. Bioko Island shows a high concentration of species in a limited area.

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TAXONOMIC ADDITIONS AND CHANGES: *Cololejeunea eustacei* Pócs, sp. nov.; *Colura calderae* Pócs, sp. nov.; *Lejeunea halei* Robinson subsp. *africana* Pócs, subsp. nov.; *Actinodontium streptopogoneum* Broth. (*Actinodontium dusenii* Broth., syn. nov.); *Wijkia rigidicaule* (Müll. Hal. ex Broth.) Frank Müll., comb. nov. (*Acanthocladium rigidicaule* Müll. Hal. ex Broth.).

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