POLISH POLAR RESEARCH
vol. 25, no. 2, pp. 111–122, 2004

Antipodal mosses: XIV. On the taxonomic status of *Grimmia lawiana* (Bryopsida: Grimmiaceae) from the continental Antarctic

Ryszard OCHYRA

Instytut Botaniki, Polska Akademia Nauk, ul. Lubicz 46, 31-512 Kraków, Poland
<e-mail: r.ochyra@ib-pan.krakow.pl>

ABSTRACT: On the basis of the distinctly biplicate and carinate leaves in the distal portion *Grimmia lawiana* J.H. Willis, the only continental Antarctic endemic moss species, is transferred to the genus *Coscinodon* Spreng. and the new combination *C. lawianus* (J.H. Willis) Ochyra is proposed. The species is described and illustrated, its affinities are discussed and its geographical distribution in the Antarctic is mapped. *Grimmia reflexidens* Müll. Hal., a southern South American endemic species from Chile, is briefly assessed and this species is also shifted to *Coscinodon* as *C. reflexidens* (Müll. Hal.) Ochyra, *comb. nov.* A key to all species of the genus *Coscinodon* is presented. *Guembelia longirostris* (Hook.) Ochyra *et* Żarnowiec is reported for the first time from the Antarctic on the basis of a specimen collected from the Nordenskjöld Coast on the eastern coast of the Antarctic Peninsula.

Key words: Antarctica, Bryophyta, Bryopsida, Grimmiaceae, *Coscinodon*, *Grimmia*, taxonomy, distribution.

Introduction

The Grimmiaceae is the largest moss family in the Antarctic biome. It consists of 23 species belonging to three genera, *Schistidium* Bruch *et* Schimp., *Grimmia* Hedw. and *Racomitrium* Brid., although the last two have recently been split, respectively, into five and four segregates (Ochyra *et al*. 2003). *Grimmia* in its traditional circumscription comprises five species in Antarctica, namely *G. lawiana* J.H. Willis, *G. plagiopodia* Hedw., *G. reflexidens* auct. *non* Müll. Hal. [= *Orthogrimmia sessitana* (De Not.) Ochyra *et* Żarnowiec], *G. fuscolutea* Hook. [= *Dryptodon fuscoluteus* (Hook.) Ochyra *et* Żarnowiec] (Ochyra *et al*. 1998) and *G. longirostris* Hook. [= *Guembelia longirostris* (Hook.) Ochyra *et* Żarnowiec]. The latter has not so far been reported from the Antarctic in the literature and the present report is based upon a single specimen collected from Larsen Inlet on the

Nordenskjöld Coast on the eastern coast of the Antarctic Peninsula (*Brading 15*, AAS, KRAM). All these species, except *G. lawiana*, are well-circumscribed and widely known taxa, having wide bipolar geographical distributions, often with intermediate stations in tropical mountains.

In contrast, *Grimmia lawiana* is a poorly known and puzzling species and its taxonomic status is difficult to assess because no plants with sporophytes have so far been discovered. These are critical for discussion of the relationships of mosses and are of special importance in the difficult family Grimmiaceae. It was originally described on the basis of several specimens from Mac.Robertson Land (Filson 1966) and subsequently it was rediscovered in other regions of continental Antarctica, including Dronning Maud Land (Bowra *et al.* 1966, Engelskjøn 1985, Richter 1990, 1995, Thor 1995) and Enderby Land (Nakanishi 1977, Kanda 1981, 1986, 1987a, b, c). Moreover, the Antarctic botanical literature provides information on its occurrence on Wilkes Land (Kanda 1981, Pickard and Seppelt 1984) and Victoria Land (Kappen 1985, Given *et al.* 1991, Linskens *et al.* 1991). Hitherto, the species not been found outside continental Antarctica and it is therefore considered to be one of very few Antarctic endemic moss species.

Grimmia lawiana is primarily characterized by having strongly biplicate leaves in the distal half. It does not fit any known species of *Grimmia* in the world (Muñoz and Pando 2000) and it is especially unlike to any species of this genus from South America (Muñoz 1998a), as well as from the sub-Antarctic and Australasia (Greven 2003). During the course of ongoing revisionary work on Antarctic mosses for the projected "Illustrated Moss Flora of Antarctica" (Ochyra *et al.* 1997, Lewis Smith *et al.* 1998) I studied carefully all available collections of *G. lawiana*, including the type. Althought the species itself does not pose special problems with its identification, establishing its correct generic placement has been one of the most difficult decisions made during the present taxonomic work on the Antarctic mosses owing to the consistent sterility of the plants. On the basis of the overall similarity of the plants of *G. lawiana*, especially its leaves – which are demonstratively similar to those in some species of the genus *Coscinodon* Spreng. from the Andes of Bolivia, namely *C. pseudocribrosus* Hastings and *C. bolivianus* Broth. (Hastings 1996) – the Antarctic species is transferred to this genus.

Description

Coscinodon lawianus (J.H.Willis) Ochyra *comb. nov.*
Fig. 1

BASIONYM: *Grimmia lawiana* J.H.Willis in Filson, ANARE Sci. Rep. Ser. B (II) Bot. 82: 148, pl. 41, f. a–f. 1966. — TYPE: Ring Rocks, Mac.Robertson Land, Antarctica, leg. R. Filson No. 4225, 16 September 1962 [Holotype: "National Herbarium of Victoria (MEL), Australia MEL 1048478 Grimmia lawiana Loc.: Antarctica – Ring Rocks, Mac.Robertson Land. Coll. Rex Filson, no. 4225 Date 16th September 1962 Notes: Abundant in cracks of boulders on the larger rock areas" – MEL!; ISOTYPES: BM!, H!, S!].

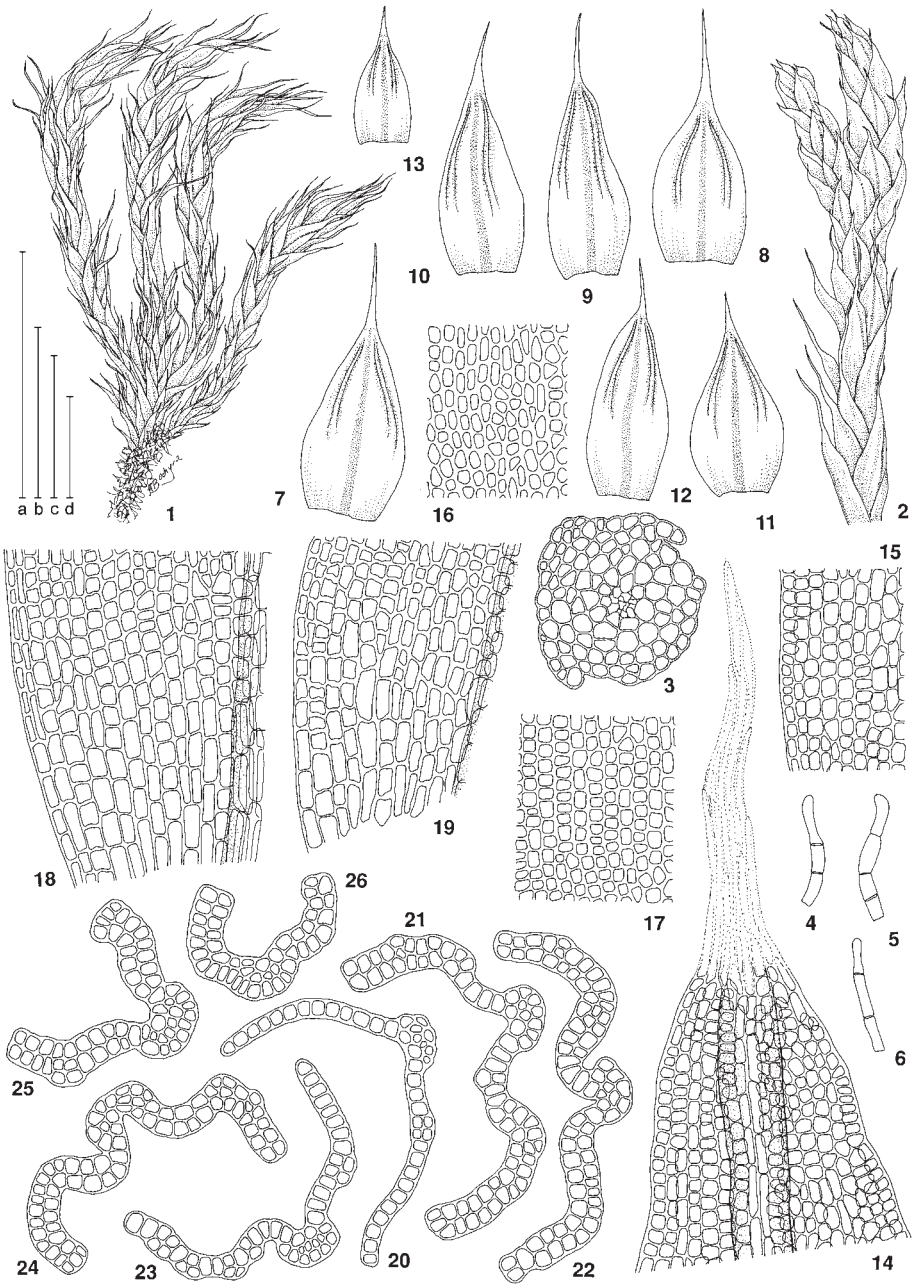

Fig. 1. *Coscinodon lawianus* (J.H. Willis) Ochyra. **1**. Habit. **2**. Portion of branch. **3**. Cross-section of stem. **4–6**. Axillary hairs. **7–13**. Leaves. **14**. Leaf apex. **15**. Upper mid-leaf cells at margin. **16**. Upper mid-leaf cells. **17**. Lower mid-leaf cells. **18–19**. Basal cells. **20–26**. Cross-sections of leaves, a sequence from base to apex [1, 10–12, 17, 21, 25 from *Filson 4225* (holotype of *Grimmia lawiana*); 2, 7–8 from *Filson 4171*; 3–4, 6, 20, 23–24, 26 from *Filson s.n.*, 1.11.1973; 5, 15, 18, 22 from *Filson 4182*; 9, 14, 19 from *Filson 4503*; 13, 16 *from Filson 14930*; all in MEL]. Scale bars: a – 1 mm (7–13); b – 1 mm (2); c – 100 mm (3–6, 14–26); d – 1 mm (1).

Plants small to medium-sized, in dense, fine-textured cushions or forming small mats owing to coalescing cushions, not or hoary, light-, dark- to pale olive-green above, blackish-brown to dark brown below. Stem slender, erect, 0.5–1.5 or, occasionally, to 3.5 cm tall, sparingly branched, radiculose at the base with smooth, light brown, sparingly branched rhizoids, in cross-section rounded, with a small but distinct central strand surrounded by 3–4-stratose medulla of large, hyaline, thin-walled cells and 1–2-layered cortex of somewhat smaller, brownish, thicker-walled cells; axillary hairs sparse, filiform, hyaline, 3–4-celled. Leaves densely set, imbricate, erect-appressed when dry, erecto-patent when moist, ovate to broadly ovate-lanceolate, 0.7–0.9(–1.1) mm long (without the hair-point), 0.25–0.6 mm wide, acute to rounded-acute, biplicate and strongly keeled distally, smooth and deeply and broadly concave below, subepilose or mostly terminated with a stout, flat, not or slightly decurrent, entire to obscurely denticulate, hyaline awn reaching often 1/2–2/3 the lamina length on the uppermost leaves; margins plane and unistratose in the proximal half, erect to manifestly incurved in the distal half, 40–50 μm wide at the base, prominently convex dorsally, semi-terete, internally differentiated in cross-section, with 2 ventral epidermal cells, distinct central stereid band and a dorsal epidermis; laminal cells bistratose throughtout the distal part or occasionally tristratose at plications, unistratose in the middle and below with frequent bistratose streaks; upper cells irregularly quadrate, rounded-quadrate to short-rectangular, becoming often oblate along the margins, 3–10 μm wide, 5–13 μm long, thick-walled, not differentiated over plications; basal juxtacostal cells short- to long-rectangulat, with evenly thickened walls, 8–12 μm wide, 15–35 μm long, becoming quadrate to rectangular, 8–12 μm wide, 15–40 μm long at the margins, with evenly thickened or with transverse walls thicker than the longitudinal walls, sometimes thin-walled and forming 2–3-seriate marginal border. Asexual reproduction occasional by filamentous protonemal gemmae, composed of uniseriate chains of chlorophyllose cells 15–40 μm long, 15–25 μm wide, with somewhat thickened, hyaline walls. Dioecious? Sporophytes unknown.

Discussion

Coscinodon is a small genus of ten species which is best diagnosed and immediately separated from all other genera of the Grimmiaceae by its strongly plicate calyptra which usually covers the whole capsule or extends only to its middle. Other character states, which are considered to be diagnostic to this genus, are widely variable also in *Grimmia*, *Orthogrimmia*, *Dryptodon*, *Guembelia* and *Schistidium*. For example, the strongly biplicate leaves are typical of *Orthogrimmia caespiticia* (Brid.) Ochyra *et* Żarnowiec; the immersed capsules concealed by the enlarged perichaetial leaves occur in most species of *Grimmia*, in

Guembelia involucrata (Cardot) Ochyra *et* Żarnowiec and *G. kidderi* (James) Ochyra *et* Żarnowiec as well as *Dryptodon pseudoanodon* (Deguchi) Ochyra *et* Żarnowiec and the cribrose peristome teeth are found in some species of *Schistidium*, for example in *S. cribrodontium* (Herzog) Ochyra from East Africa. Therefore recognition of the separate subfamily for this genus (Churchill 1981), which is based on a single character state seems to be doubtful and *Coscinodon* certainly show much closer alliance to *Grimmia* than to *Racomitrium* and its allies which constitute the separate subfamily Racomitrioideae (Ochyra *et al*. 2003).

All of the Antarctic populations of *Coscinodon lawianus* are sterile, but female plants have occasionally been observed and they confirm that it is most probably a dioecious species. However, some colonies of this species, especially if infected with algae and/or lichens, copiously produce protonemal gemmae which are easily broken into 1–2-cellular fragments (Imura and Kanda 1986). Due to the sterility of the plants of *C. lawianus*, establishing the correct generic placement for this species has not been an easy task because the structure of the gametophytes may be highly deceptive and misleading as diagnostic features at the generic level owing to convergent evolution of species living in similar environmental conditions.

The leaf plication has developed independently in several lineages of the Grimmiaceae including, apart from *Coscinodon*, also *Orthogrimmia* and *Grimmia*, so it must be considered with caution as a diagnostic generic trait. It is especially so, because in three species of the genus *Coscinodon* itself, namely in *C. yukonensis* Hastings, *C. humilis* Milde and *C. calyptratus* (Drumm.) Kindb., the leaves are not plicate. Therefore the only reliable character supporting the recognition of *Coscinodon* as a genus in its own right is the shape of the calyptra and until fertile plants of *C. lawianus* are found, the placement of this generic species is uncertain and debatable. The present taxonomic decision about the transfer of *Grimmia lawiana* to *Coscinodon* is mostly based on the overall similarity of the plants and leaves of the Antarctic species with two Bolivian species of this genus, namely *C. bolivianus* and *C. pseudocribrosus*. Of these, the latter species shares with *C. lawianus* the size of the plants, the size and shape of the leaves and the restriction of the plication to the upper part of the leaves. However, it is at once distinct in having frequent 3–4-stratose strands beyond the plication, strongly incurved leaf margins in the upper part, as well as in the pale orange-brown coloration of the plants. The present placement of *C. lawianus* was also suggested by Muñoz and Pando (2000), but Greven (2003) retained it in *Grimmia.* However, the latter author studied very limited material of this species and his drawings, especially of transverse sections of the leaf, are somewhat inaccurate and do not show the distinct leaf plications at all.

Coscinodon lawianus is a readily recognized species by its closely imbricate leaves which are distinctly biplicate and carinate in the distal part. The leaf plicae are restricted only to the upper half of the leaves. They are clearly visible in trans-

verse section as bi- or occasionally tristratose spots and are also distinct under the stereomicroscope as low crests on the dorsal surface of the leaves in their upper parts. The leaves are usually strongly pilose with long hyaline hair-points which give the plants a hoary appearance. They are ovate to broadly ovate-lanceolate and very small, rarely longer than 1 mm (without a hair-point), in consequence making *C. lawianus* one of the smallest moss species in the Antarctic moss flora.

In the Antarctic *Coscinodon lawianus* is likely to be mistaken only for *Orthogrimmia sessitana*, especially on the continent where only sterile populations of this species are known to occur. However, this species has strongly keeled but otherwise plane, non-plicate leaves and its leaf lamina is invariably bistratose with frequent unistratose streaks distally. Muñoz (1998a, 1999) and Ochyra (1998) used the name *Grimmia reflexidens* Müll. Hal. as the earliest available name for *G. sessitana*. This species was described by Müller (1849) on the basis of specimens collected by Pöppig in Chile. Maier (2002) carried out a careful investigation of the available type collections of *G. reflexidens* and came to the conclusion that they turned to be a *Coscinodon* species, not *Grimmia*. Although the type specimens of *G. reflexidens* possess sporophytes, they lack the calyptrae which are critical generic character for *Coscinodon.* Nonetheless, the species is recognizable by the distinct bistratose plications of the leaf running down to the leaf insertion as evidenced by excellent drawings provided by Maier (2002). Having examined these specimens I can only confirm the aptness of this conclusion. *G. reflexidens* does not fit the concept of any species of *Coscinodon* from South America and it seems to be closely related to the High Arctic *C. hartzii* in which the leaf margins are plane throughout or inflexed distally and the upper lamina has usually tristratose patches. In contrast, in *Grimmia reflexidens* the proximal leaf margins are narrowly recurved on one side and its upper lamina is mostly bistratose, with only occasional tristratose streaks. *G. reflexidens* is here formally given a name in *Coscinodon* and its transfer to this genus necessitates the following nomenclatural change:

Coscinodon reflexidens (Müll. Hal.) Ochyra *comb. nov*.

BASIONYM: *Grimmia reflexidens* Müll. Hal., Syn. Musc. Frond. **1**: 795. 1849. — TYPE: In Chile australis inter *Gr. consobrinam*: Pöppig. Hb. Kunzeanum [LECTOTYPE (*vide* Muñoz 1998a: p. 394): "Herb. Hampe. 1881. Grimmia reflexidens inter Dryptodon consobrinus Kze. Chile leg. Pöppig" – BM-Hampe!; ISOTYPES: BM!, JE!, NY (not seen), PC!]

The hoary phenotypes of *Grimmia plagiopodia*, a species occasionally found in the continental Antarctic (Ochyra 1993) are also superficially similar to *C. lawianus*. However, this species has broadly concave, non-plicate leaves with entirely unistratose laminal cells, and the fertile plants are distinct at a glance by their asymmetric, ventricose capsules.

Coscinodon lawianus is a saxicole associated with a variety of acidic rocks, growing in crevices, cracks and fissures, on scree, in hollows amongst larger boul-

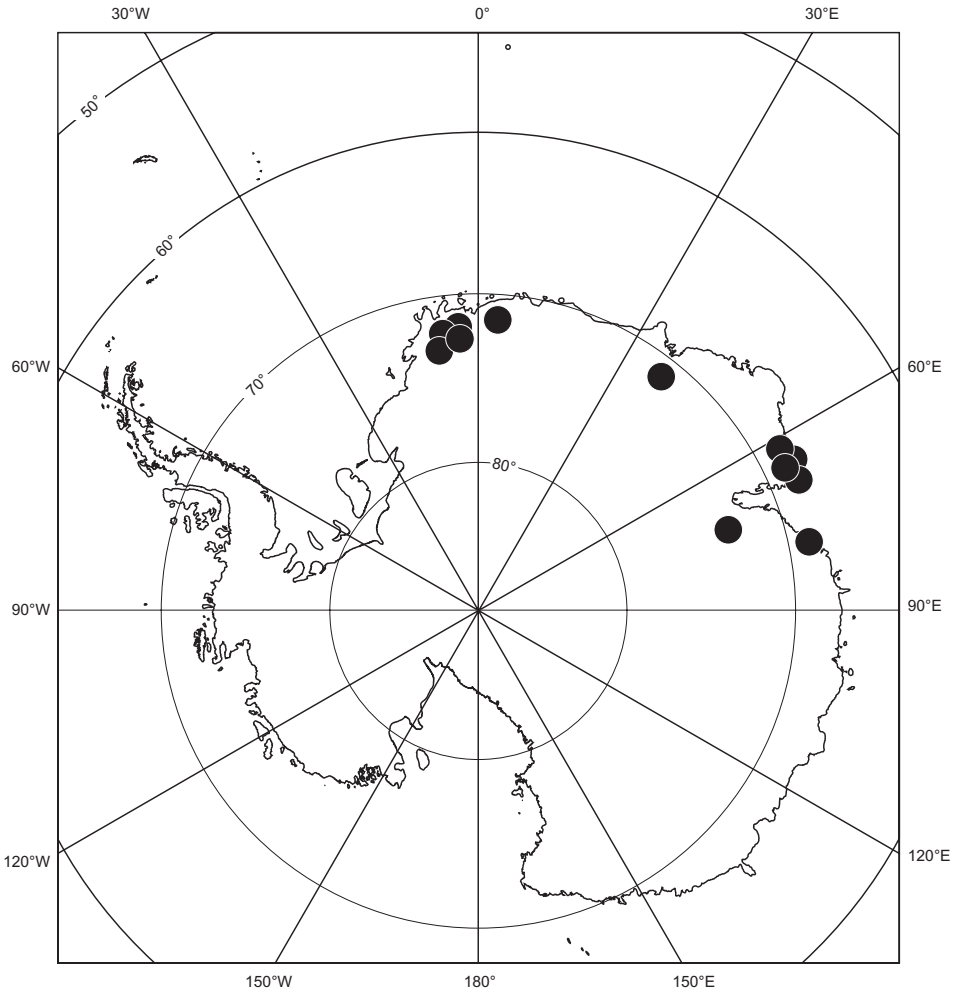

Fig. 2. Global distribution of *Coscinodon lawianus* (J.H. Willis) Ochyra.

ders in moraines and patterned ground. It grows predominantly in dry habitats, but has also been found on wet rocks covered partially with fine mineral soil, beside swift flowing streams running from glaciers (Kanda 1986b, 1987d), on sand and gravel subject to flooding near small melt pools, as well as in seepage areas (Seppelt and Ashton 1978). It avoids areas affected by sea birds or marine salts and appears to prefer nutrient-deficient soils at higher elevations lacking marine and biotic influence. It forms either poor monospecific sociations or is a main component of simple plant communities, with *Ceratodon purpureus* (Kanda 1981, 1986, 1987b, c) or *Bryum pseudotriquetrum* (Seppelt *et* Ashton 1978), belonging to the short moss turf and cushion subformation which are often invaded by imperfect lichens and/or algae.

Coscinodon lawianus is the only endemic species of moss which has hitherto been discovered from the continental Antarctic (Fig. 2) where it is widespread but never abundant. It is frequent in Dronning Maud Land where, in addition to the specimens cited below, it is known from Schirmacher Oasis and nunataks of Gjelsvikfjella and Mühlig-Hofmannfjella, as well as from the Syowa Coast in Enderby Land and Mac.Robertson Land. The records from Wilkes Land and Victoria Land are based on misidentifications of specimens correctly belonging to *Orthogrimmia sessitana*. All known localities of *C. lawianus* are situated south of the Antarctic Circle, and the southernmost are in Tottanfjella in Queen Maud Land at lat. *ca* 75° S (Bowra *et al*. 1966, Thor 1995). In the coastal region of Enderby Land and Mac.Robertson Land it occurs near sea level at 20–30 m, but on the inland nunataks in Tottanfjella it occurs at elevations of 1650–2160 m.

The present distribution of the endemic species on the Antarctic continent contains a number of puzzles and peculiarities and can hardly be explained. As is the case with *Sarconeurum glaciale* (Müll. Hal.) Cardot *et* Bryhn, a widespread subendemic species and genus of Antarctica, *C. lawianus* may be considered as a remnant of the ancient Antarctic flora existing on this continent in the early Tertiary which could have survived the climatic catastroph *in situ* on unglaciated nunataks. Having limited modes of vegetative reproduction, *C. lawianus* is restricted in its present distribution to a few regions on the continent, in contrast to *S. glaciale* which produces vegetative propagulae in masses; these have facilitated the recolonization by this species of much wider expanses of the whole of both East and West Antarctica. It is worth noting that *C. hartzii*, a northern counterpart of *C. lawianus*, is also very rare and widely scattered in the High American Arctic and Greenland (Jensen 1898, Murray 1992, Hastings 1999).

Specimens examined. EAST ANTARCTICA. DRONNING MAUD LAND. **KRONPRINSESSE MÄRTHA KYST.** ***Tottanfjella***: Johnsonhogna, *ca* 1650 m, *Bowra 20A* and *28A* (AAS, KRAM); unnamed nunatak NW of Cottontoppen, 1667 m, *Bowra 7* (AAS, KRAM); Blades Ridge, *ca* 2000 m, *Bowra 2* and *3* (AAS, KRAM). ***Sivorgfjella***: Mathisenskaget, *ca* 2160 m, *Bowra 4* (AAS, KRAM).

ENDERBY LAND. **PRINSESSE ASTRID KYST.** Henriksenskjera, 1200 m, *Lewis Smith 10068* (AAS, KRAM), 1296 m, *Lewis Smith 10108* (AAS, KRAM), *ca* 1300 m, "Wind-Scoop Peak", *Lewis Smith 10077A, 10078* and *10080* (AAS, KRAM) and 1363 m, *Lewis Smith 11138* (AAS, KRAM); Filchnerfjella, Rakenkniven, 1700 m, *Lewis Smith 10061* and *10062A* (AAS, KRAM) and 1800 m, *Lewis Smith 10065B* (AAS, KRAM). **SYOWA COAST**. Langhovde, 20 m, *Kashiwandani 4006* (KRAM, LE).

MAC.ROBERTSON LAND. **MAWSON COAST**. Hayes Peak, *Filson 4378* (MEL); Cape Bruce, *Filson 4335* (MEL); Ufs Is., Melt-Lake Valley, *Filson 14930* (MEL); Ring Rock, *Filson 4378* (MEL) and *Filson 4325* (MEL – type of *Grimmia lawiana*); Mawson Rock, *Filson 4171* (MEL); West Bay, *Filson 4069* (MEL); North Masson Range, *Filson 4092* and *4121* (MEL); Telurometer Peak, *Filson 4417* (MEL); South Masson Range, Peak 1070 S of Trost Peak, 1030 m, *Filson 4503* (MEL); Departure Rocks Group, *Filson 4157* (MEL); Goldsworth Range, Mt. Henderson, *Filson 4185* (MEL); Fisher Nunatak, *Filson 4182* (MEL). **PRINCE CHARLES MOUNTAINS**. Mawson Escarpment, north-west 'J', 1 Nov 1973, *Filson s.n.* (MEL 1012186 and 1012187).

PRINCESS ELIZABETH LAND. **INGRID CHRISTENSEN COAST**. Larsemann Hills, *RILS 10330* and *10339* (AAS, KRAM).

Coscinodon is a small genus of ten species which are predominantly distributed in the Northern Hemisphere where six species and one subspecies are known to occur (Hastings and Deguchi 1997, Hastings 1999). Of these, *C. cribrosus*, has a wide pan-Holarctic, though highly dissected range; *C. calyptratus* (Drumm.) Kindb., *C. arctolimnius* (Steere) Steere and *C. humilis* Milde have bicentric, highly disjunct ranges in the Holarctic and *C. hartzii* C.E.O. Jensen and *C. yukonense* Hastings are narrow Arctic endemics. Two species, *C. bolivianus* and *C. pseudocribrosus*, are known to occur at high elevations in the Andes of Bolivia (Hastings 1996), and *C. calyptratus* has been recorded at the bipolar station in New Zealand (Muñoz 1998*b*) but according to Hastings (1999) this record is based upon misdetermination of the plants which correctly represent *Guembelia longirostris*. Hastings (1996) placed in *Coscinodon* the third Andean species, *C. trinervis*, from Bolivia and Peru, but the small mitrate and non-plicate calyptra covering only the operculum excludes this species from this genus and on account of its sigmoid to coiled setae, eccentrically attached to the ventricose capsule it is best placed in the type subgenus of *Grimmia* (Muñoz 1999). This species is here replaced by *Coscinodon reflexidens* from southern Chile. Hitherto, *Coscinodon* has not been recorded from the austral polar region and here it is reported for the first time from the Antarctic.

All species of *Coscinodon* may be determined using the following key:

1. Stem leaves smooth, not plicate; margins plane or revolute on one side 2
1. Stem leaves plicate, at least in the distal part of the lamina; margin inflexed to inrolled above 4

2. Capsules exserted, leaf margins plane or revolute on one side; autoecious plants . . . . . *Coscinodon calyptratus*
2. Capsules immersed; leaf margins plane; dioecious plants 3

3. Leaves narrowly lanceolate, 1–2 mm long; laminal cells unistratose throughout . . . . . *Coscinodon humilis*
3. Leaves broadly ovate-lanceolate, 0.9–1.2 mm long; laminal cells often in bistratose patches above . . . . . *Coscinodon yukonensis*

4. Plications restricted to the upper part of leaf 5
4. Plications usually extending to the leaf base 6

5. Leaves 1.0–1.4 mm long; leaf margins inrolled above; upper lamina with 3–4-stratose strands outside plications; plants pale orange-brown above . . . *Coscinodon bolivianus*
5. Leaves 0.7–1.1 mm long; leaf margins inflexed above; upper lamina with bistratose strands outside plications; plants pale olive-green above . . . . . *Coscinodon lawianus*

6. Capsules exserted 7
6. Capsules immersed 8

7. Lamina with frequent tristratose regions in the distal part . . . . . *Coscinodon hartzii*
7. Lamina bistratose in the distal part, with very occasional tristratose spots . . . . . *Coscinodon reflexidens*

8. Capsules ochyrostomous 9
8. Capsules gymnostomous 10

9. Leaves oval to ovate with plane margins; median leaf cells quadrate, 3–6 μm long; peristome teeth often truncate at the tips, entire or with only scallops in the distal half . . . . . *Coscinodon pseudocribrosus*
9. Leaves ovate-lanceolate with margins incurved distally; median leaf cells subquadrate to short rectangular, 4–14 μm long; peristome teeth with always developed tips, cribrose with perforations to the base . . . . . *Coscinodon cribrosus*

10. Leaves mostly muticous, rarely with short hair-points; leaf apex cucullate if muticous, otherwise inrolled; leaves 1.5–1.8 mm long; cells of plications short above, elongate only towards the base . . . . *Coscinodon arctolimnius* subsp. *arctolimnius*
10. Leaves commonly with long hair-points; leaf apex mostly cucullate; leaves 0.8–1.4 mm long; cells of plications long and narrow throughout . . . . . *Coscinodon arctolimnius* subsp. *higuchii*

Acknowledgements. — I am grateful to Helen J. Peat, Cambridge (AAS), Rex B. Filson, Melbourne (MEL), Len T. Ellis, London (BM), Catherine Rausch, Paris (PC), Hans-Joachim Zündorf, Jena (JE) and Olga M. Afonina, St. Petersburg (LE) for kindly allowing me to study the herbarium specimens cited in the text. Thanks are also due to my wife, Halina Bednarek-Ochyra, for her drawings, to Katarzyna Biłyk for generating the distribution map and to Robin Stevenson, King's Lynn, UK, for checking the English.

References

BOWRA G.T., HOLDGATE M.W. and TILBROOK P.J. 1966. Biological investigations in Tottanfjella and central Heimefrontfjella. British Antarctic Survey Bulletin 9: 63–70.

CHURCHILL S.P. 1981. A phylogenetic analysis, classification and synopsis of the genera of the Grimmiaceae (Musci). *In*: Funk A.A. and Brooks D.R. (eds), *Advances in cladistics. Proceedings of the First Meeting of the Willi Hennig Society.* The New York Botanical Garden, New York, 127–144.

ENGELSKJØN T. 1985. Botany of Gjelskvikfjella and Mühlig-Hofmanfjella, Dronning Maud Land. Report of the Norwegian Antarctic Research Expedition (NARE) 1984/85. Norsk Polarinstitutt Rapportserie 22: 43–54.

FILSON R.B. 1966. The lichens and mosses of Mac.Robertson Land. ANARE Scientific Reports Series B (II) Botany 82: [i–vii] + 1–169.

GIVEN D.R., MEURK C.D. and FOGGO M. 1991. Checklist of the flora of Terra Nova Bay and Wood Bay, North Victoria Land and southwestern Ross Island, Ross Dependency, Antarctica. DSIR Land Resources and Lower Hutt, Central Institute of Technology, Christchurch, 1–7.

GREVEN H.C. 2003. *Grimmias of the world.* Backhuys Publishers, Leiden, 1–247.

HASTINGS R.I. 1996. The genus *Coscinodon* (Bryopsida, Grimmiaceae) in South America, including a new species. The Bryologist 99: 418–427.

HASTINGS R.I. 1999. Taxonomy and biogeography of the genus *Coscinodon* (Bryopsida, Grimmiaceae) in North America, including a new species. The Bryologist 102: 265–286.

HASTINGS R.I. and DEGUCHI H. 1997. Taxonomy of *Coscinodon arctolimnius* (Bryopsida, Grimmiaceae) including a new subspecies from Asia. The Bryologist 100: 50–55.

IMURA S. and KANDA H. 1986. The gemmae of the mosses collected from the Syowa Station area, Antarctica. Memoirs of National Institute of Polar Research Special Issue 44: 241–246.

JENSEN C. 1898. Mosser fra Øst-Grønland. Meddelelser om Grønland 15: 365–443.

KANDA H. 1981. Flora and vegetation of mosses in ice-free areas of Soya Coast and Prince Olav Coast, East Antarctica. Hikobia Supplement 1: 91–100.

KANDA H. 1986. Moss communities in some ice-free areas along the Soya Coast, East Antarctica. Memoirs of National Institute of Polar Research, Special Issue 44: 229–240.

KANDA H. 1987a. *Handbook of Antarctic mosses.* National Polar Institute, Tokyo, [i–v] + 1–83 (in Japanese).

KANDA H. 1987b. *Catalog of moss specimens from Antarctica and adjacent regions housed mainly in the herbarium of the National Institute of Polar Research*. National Polar Institute, Tokyo, i–iii + 1–186.

KANDA H. 1987c. Ecology of the moss vegetation in the Syowa Station area, Enderby Land, Antarctica. Symposia Biologica Hungarica 35: 259–267.

KAPPEN L. 1985. Vegetation and ecology of ice-free areas of northern Victoria Land, Antarctica. 1. The lichen vegetation of Birthday Ridge and an Inland Mountain. Polar Biology 4: 213–225.

LEWIS SMITH R.I., OCHYRA R., BEDNAREK-OCHYRA H. and ØVSTEDAL D.A. 1998. Moss and lichen floras: aids to understanding biodiversity in Antarctica. *In*: *VII SCAR International Biology Symposium "Antarctic ecosystems: models for wider ecological understanding. 31 August – 4 September 1998, University of Canterbury, Chistchurch, New Zealand". Abstracts handbook*. New Zealand Natural Sciences 23 Supplement: 104.

LINSKENS H.F., BARGAGLI R., FOCARDII S. and CRESTI M. 1991. Antarctic moss turf as pollen traps. Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen 94: 233–241.

MAIER E. 2002. The genus *Grimmia* (Musci, Grimmiaceae) in the Himalaya. Candollea 57: 143–238.

MÜLLER C. 1848–1849. *Synopsis muscorum frondosorum omnium hucusque cognitorum. Pars prima – Musci vegetationis acrocarpicae*. Sumptibus Alb. Foerstner, Berolini, i–viii + 1–812.

MUÑOZ J. 1998. A taxonomic revision of *Grimmia* subgenus *Orthogrimmia* (Musci, Grimmiaceae). Annals of the Missouri Botanical Garden 85: 367–403.

MUÑOZ J. 1998b. Amended description of *Coscinodon calyptratus* (Grimmiaceae) and major range extensions into Eurasia and New Zealand. The Bryologist 101: 89–92.

MUÑOZ J. 1999: A revision of *Grimmia* (Musci, Grimmiaceae) in the Americas. 1: Latin America. – Annals of the Missouri Botanical Garden 86: 118–191.

MUÑOZ J. and PANDO F. 2000. A world synopsis of the genus Grimmia (Musci, Grimmiaceae). Monographs in Systematic Botany from the Missouri Botanical Garden 83: 1–133.

MURRAY B.M. 1992. Bryophyte flora of the Alaskan steppes. Bryobrothera 1: 9–33.

NAKANISHI S. 1977. Ecological studies of the moss and lichen communities in the ice-free areas near Syowa Station, Antarctica. Antarctic Record 59: 68–96.

OCHYRA R. 1993. *Grimmia plagiopodia* (Musci, Grimmiaceae) in the Southern Hemisphere. Fragmenta Floristica et Geobotanica 38: 21–27.

OCHYRA R. 1998. *The moss flora of King George Island, Antarctica*. Polish Academy of Sciences, W. Szafer Institute of Botany, Cracow, i–xxiv + 1–278.

OCHYRA R., BEDNAREK-OCHYRA H. and LEWIS SMITH R.I. 1997. The moss flora of Antarctica. *In*: *IAB Symposium on 2000's Bryology. International Symposium on Bryology, Beijing, China, 26–30 May 1997. Abstracts*. Beijing, 126.

OCHYRA R., BEDNAREK-OCHYRA H. and LEWIS-SMITH R.I. 1998. 170 years of research of the Antarctic moss flora. *In*: Głowacki P. and Bednarek J. (eds), Polish Polar Studies. 25th Polar Symposium. *The 100th anniversary of Prof. Henryk Arctowski's and Prof. Antoni Boles;aw Dobrowolski's participation in the Belgica expedition to the Antarctic in 1887–1889* [sic!]. Institute of Geophysics of the Polish Academy of Sciences, Warszawa, 159–177.

OCHYRA R., ŻARNOWIEC J. and BEDNAREK-OCHYRA H. 2003. *Census catalogue of Polish mosses*. Polish Academy of Sciences, Institute of Botany, Kraków, 1–372.

PICKARD J. and SEPPELT R.D. 1984. Phytogeography of Antarctica. Journal of Biogeography 11, 83–102.

RICHTER W. 1990. The bryoflora of the Schirmacher Oasis (East Antarctica) in relations to hydrosphere and cryosphere. Geodätische und Geophysikalische Veröffentlichungen Reihe I 16: 489–494.

RICHTER W. 1995. Bryophytes in the Schirmacher Oasis. *In*: Bormann P. and Fritzsche D. (eds), *The Schirmacher Oasis, Queen Maud Land, East Antarctica, and its surroundings*. Petermanns Geographische Mitteilungen. 289. Justus Perthes Verlag, Gotha, 341–342 + map 9.

SEPPELT R.D. and ASHTON D.H. 1978. Studies on the ecology of the vegetation at Mawson Station, Antarctica. Australian Journal of Ecology 3: 373–388.

THOR G. 1995. Reassessment of the first lichen and moss collections from Heimefrontfjella, Dronning Maud Land. Antarctic Science 7: 261–264.

Received 15 March 2004
Accepted 22 April 2004