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New Pottiaceae genera to the moss flora of Saudi Arabia and the Arabian Peninsula

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ABSTRACT

Hyophila Brid., *Leptophascum* (Müll.Hal.) J.Guerra & M.J.Cano and *Plaubelia* Brid. are new genera to the bryoflora of Saudi Arabia while the last two genera are new to the Arabian Peninsula. All these genera are represented by one species each namely; *Hyophila baginsensis* Müll.Hal., *Leptophascum leptophyllum* (Müll.Hal.) J.Guerra & M.J.Cano and *Plaubelia involuta* (Magill) R.H.Zander. *Hyophila baginsensis* is a new record to the bryoflora of Asia continent. The new recorded species are described and illustrated. Their sites, habitats, distribution, elements and some floristic remarks are given.

KEY WORDS
Pottiaceae,
moss flora,
Hyophila,
Plaubelia,
Leptophascum,
Saudi Arabia,
Arabian Peninsula.

RÉSUMÉ

Nouveaux genres de Pottiaceae pour la flore d'Arabie Saoudite et la péninsule arabique.

Hyophila Brid., *Leptophascum* (Müll.Hal.) J.Guerra & M.J.Cano et *Plaubelia* Brid. sont des nouveaux genres pour la bryoflore d'Arabie Saoudite alors que les deux derniers sont nouveaux pour la péninsule arabique. Ces genres sont représentés par une espèce chacun ; *Hyophila baginsensis* Müll.Hal., *Leptophascum leptophyllum* (Müll.Hal.) J.Guerra & M.J.Cano et *Plaubelia involuta* (Magill) R.H.Zander. *Hyophila baginsensis* est un nouveau signalement pour la bryoflore du continent asiatique. Les espèces nouvellement signalées sont décrites et illustrées. Leurs sites, leurs habitats, leurs distributions, des éléments et des remarques floristiques sont donnés.

MOTS CLÉS
Pottiaceae,
bryoflore,
Hyophila,
Plaubelia,
Leptophascum,
Arabie Saoudite,
péninsule arabique.

INTRODUCTION

Despite the early beginnings of studies on moss flora of the Arabian Peninsula, when Forsskål recorded two genera of mosses (*Mnium* Hedw. and *Bryum* Hedw.) in 1775 from Yemen, it is still in need for more floristic studies (Forsskål 1775).

After about two centuries, many botanists began to record mosses from different countries of the Arabian Peninsula. Thériot *et al.* (1934) recorded *Splachnobryum arabicum* Dixon from Oman, El-Saadawi (1976) recorded 15 mosses from Kuwait, Hepper (1977) recorded four mosses from the Yemen mainland, Townsend (1978) recorded *Entosthodon pulchellus* (H.Philib.) Brugués from Saudi Arabia, Frey & Kürschner (1988) recorded three mosses from United Arab Emirates; then recently Kürschner *et al.* (2018) recorded three moss species from Qatar.

An intensive floristic work was begun by Frey & Kürschner in 1982 on mosses of the Arabian Peninsula by studying moss flora of Saudi Arabia (Frey & Kürschner 1982) ending by Qatar (Kürschner *et al.* 2018). A long series of papers and two valuable books (Frey & Kürschner 1988; Kürschner 2000) have been published mainly by Kürschner and/or Frey & Ochyra. That in addition to other studies mainly by El-Saadawi and/or Shabbara on moss flora of the Arabian Peninsula e.g. (Shabbara & El-Saadawi 1999, 2001).

Up till now, the various studies from the different countries of the Arabian Peninsula resulted in more than 180 mosses, where no moss record was made from Bahrain, only three mosses were from Qatar (Kürschner *et al.* 2018), 24 mosses from Kuwait (El-Saadawi 1976, 1978, 1979a, b; Kürschner & Ochyra 2014), 44 mosses from the United Arab Emirates (Shabbara & El-Saadawi 1999, 2001; Kürschner & Ochyra 2014), 45 mosses from Oman (Kürschner & Ochyra 2014), 105 mosses from Yemen (excluding the Socotra archipelago) (Kürschner & Ochyra 2014) and 119 mosses from Saudi Arabia (Kürschner & Ochyra 2014; Taha & Shabbara 2019). It is worth mentioning that, in the last decade several taxonomic and nomenclatural changes have been made and many taxa were sunken within synonymy elevated to the specific level, or separated as new genera or new varieties, if compared with the status in Kürschner & Frey (2011).

Saudi Arabia (SA) is the largest country in the Middle East (approximately 2 150 000 km^2) having some regions with very suitable habitats for the growth of mosses especially in the west. In 1982 Frey & Kürschner recorded six mosses and four liverworts, this was followed by about 19 papers by them and by some other bryologists (Refai 2001 ; Al-Shehri 2002 ; Abo Salama *et al.* 2005 ; Taha & Shabbara 2019). All these studies resulted in the recorded of 119 mosses included in 48 genera and 20 families.

Pottiaceae is the largest family in Saudi Arabia and it is well represented in all the 9 phyto-geographical regions of the country (Migahid & Hammouda 1974). It is represented by 56 moss taxa (*c*. 48% of moss taxa in SA) belonging to 16 genera (*c*. 33% of moss genera in SA). Out of these 16 genera eleven are represented by one to three taxa each, while the most common genus is *Tortula* Hedw. being represented by nine taxa.

Asir region is considered the richest region with mosses in Saudi Arabia, where about 95% of moss families, 91% of moss genera and *c*. 77% of moss taxa recorded in the country are found there. Pottiaceae (the largest family there) is represented by 14 genera (87.5% of Pottiaceae genera recorded in SA) and 37 taxa (66% of Pottiaceae taxa recorded in SA).

The great suitability of Asir region for moss growing encouraged more studies, especially in areas which have not been explored yet for mosses, as Muhayil Asir and Bariq governorates. While studying mosses in these governorates, three new moss genera to Saudi Arabia belonging to family Pottiaceae were observed; two of them are new to the Arabian Peninsula.

STUDY AREA AND MATERIAL

Eight field excursions were carried out in October 2011, January 2012, April 2012 and June 2012 by the third author. Twelve moss samples were collected from three sites (Qana, Koran Valley and Athrb Mountain) in two governorates (Muhayil Asir and Bariq) in Asir region.

Muhayil Asir is located in the western part of the Asir region (at 18°32'N and 42°3'E), in the middle of the south-western part of the country (Fig. 1). It is bounded by governorate Bariq in the north, Rijal Alma in south and Abha in the east and Al-Birk in the west (Department of Statistics and Information in Kingdom Saudi Arabia 2017).

Muhayil Asir climate is hot in summer (reaches to 45°C) and mild in winter (*c*. 20°C) ; while the average annual temperature in the province is 28-36°C. Rains are in the summer season with an average of 300 mm and the rate of humidity is up to 18%. It is also exposed to dust storms in some times of the year (Department of Statistics and Information in Kingdom Saudi Arabia 2017).

Muhayil land plain is low and surrounded by volcanic mountains and valleys with permanent flow of water. It has natural vegetation and represent as one of the richest areas of Asir region (Department of Statistics and Information in Kingdom Saudi Arabia 2017).

The studied moss samples (eight samples) were collected from two sites; Qana and Koran Valley in Muhayil Asir governorate. Qana is a rocky low valley, while Koran Valley (north Qana) is an oasis surrounded by palms.

Bariq governorate (Fig. 1) lies at 18°55'N, 41°55'E and an elevation of 412 m above sea level. It is bounded by Tanomah in the east, Almajaridah in the north, Muhayil in the south, and Al Qunfudhah in the west (Al-Shibli 2001).

Bariq climate is tropical with an average high annual temperature of 30.3°C and an average low annual temperature of 19.3°C. Bariq is one of the richest governorates in the Kingdom with rainfall ; annual rates ranging from 600 to 700 mm per year. Rains fall in all seasons, though most fall in spring and winter and the lowest in summer (Al-Shibli 2001).

Bariq land can be divided into two areas: Heights: surrounded by lightning from all sides beyond the north, which

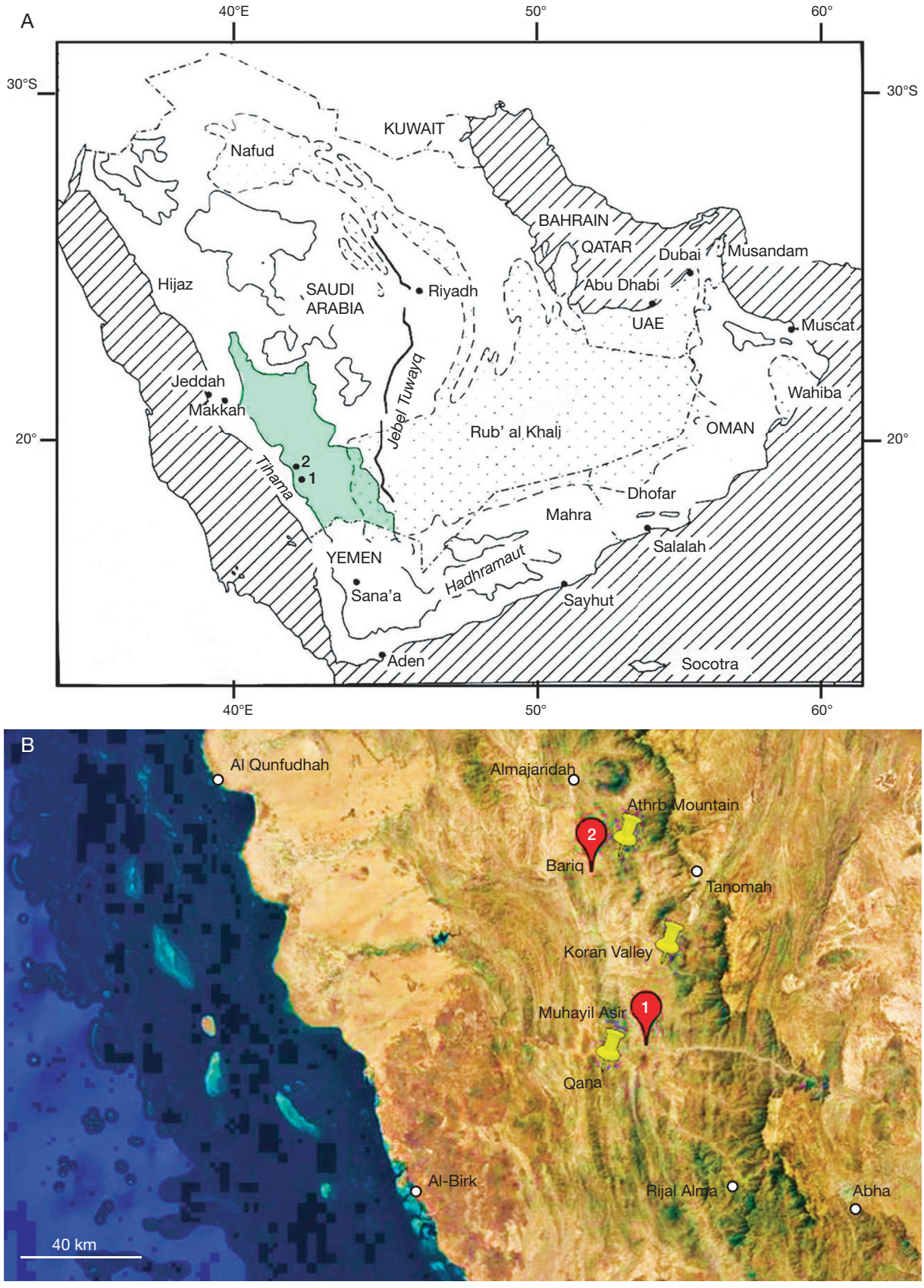

Fig. 1. — **A**, Map showing Asir region, Saudi Arabia in the Arabian Peninsula (after Kürschner 2000); **B**, Map showing: 1, Muhayil Asir; and 2, Bariq governorates includes three sites of collection; Qana, Koran Valley and Athrb mountain (yellow pins) (https://earth.google.com).

are high mountains, some of which rise from the sea to about 2000 meters. Downs: plains and valleys, forming more than half the area of a lightning area. The studied moss samples (four samples) were collected from Athrb Mountain which is located in heights area of Bariq governorate.

RESULTS

Hyophila Brid., *Leptophascum* (Müll.Hal.) J.Guerra & M.J.Cano and *Plaubelia* Brid. are new genera to the bryoflora of Saudi Arabia while the last two genera are new to the Arabian Peninsula. All these genera are represented by one species each namely; *Hyophila baginsensis* Müll.Hal., *Leptophascum leptophyllum* (Müll.Hal.) J.Guerra & M.J.Cano and *Plaubelia involuta* (Magill) R.H.Zander. *Hyophila baginsensis* is a new record to the bryoflora of Asia continent. This increases the number of genera known from SA to 51 moss genera and no. of moss taxa to 122.

The new recorded species are briefly described and illustrated. Their sites (determined precisely by using GPS: GARMIN nuvi 3790), habitats including soil thickness, angle of incidence, date of collection, air humidity (by using Rapidest digital plus moisture), collector and herbarium number are given. Also, distributions, comments, floristic elements (concluded from the distribution maps of bryofloristic elements in Kürschner 2000) and some floristic remarks are mentioned below.

Hyophila baginsensis Müll.Hal.
(Fig. 2)

Specimen examined. — **Saudi Arabia**. Asir region, Muhayil Asir governorate, Koran Valley; 18°43'545"N, 42°05'249"E; 350 m a.s.l.; grow on clay soil in an oasis around palm tree; soil thickness 8 mm; horizontal; 25.X.2011, 23.I.2012, 22.IV.2012, 25.VI.2012; air moisture 54, 41, 40 and 36 respectively; leg. Manal Aseeri; 133Ma-d (CAIA).

Distribution. — In Africa; Central African Republic, Kenya, Mozambique, Namibia, South Africa, Sudan, Swaziland, Transvaal, Uganda, Zambia, Zimbabwe, Zululand (O'Shea 2006; Magill 1981). The distribution of this taxon may indicate its African origin and emphasizes the strong floristic relationships between southern Arabia and Africa (Kürschner 2000).
New to Asia continent.

Floristic element. — Palaeotropical.

Floristic remarks. — The genus *Hyophila* Brid. was recorded previously from south west Asia; as *Hyophila involuta* (Hook.) Jaeg. from Oman, Turkey Yemen and Socotra (Kürschner & Frey 2011), *H. lanceolata* Renauld & Cardot (according to Kürschner & Frey in 2011 as doubtful and may belong to *H. involuta*) from Oman (Radcliffe-Smith 1980) and *H. punctulata* (Mitt.) Kindb. from Socotra (Kürschner 2000; Kürschner & Frey 2011).

Description
Plants
Small, yellowish green, 2.2-2.7 mm high.

Stem
Simple, central strand present, sclerodermis developed.

Leaves
Incurled with involute margins when dry, patent to open spreading with plane margins when moist, oblong lingulate, apiculate, 0.9-1.4 mm long, 0.6-0.7 mm wide; apex sub-acute to obtuse; margins less incurved above, plan below; costa percurrent to short excurrent, one steried band, 2 guides, ventral superficial cells quadrate, mammillose, dorsal superficial cells linear, smooth; upper lamina cells incrassate, adaxial surface cells bulging, nearly flat dorsally, quadrate or sub quadrate, 5-7.5 µm long; basal lamina cells more or less hyaline, sub quadrate to rectangular, (12.5-) 15-20 (-25) µm long, 7.5-15 (-20) µm wide, smooth.

Propagules
Usually present, at axial of apical leaves, reddish, multicellular, branched to un-branched filaments, sometimes with enlarged apical cell.

Comment
The smaller size and generally entire leaf margins of *Hyophila baginsensis* distinguish it from *H. involuta* which was recorded previously from the Arabian Peninsula (Kürschner 2000) and from *H. punctulata* which was recorded in Socotra (Kürschner 2000; Kürschner & Frey 2011).

Axillary gemmae of *H. baginsensis* recorded here are multicellular branched or un-branched filaments, while stellate shaped in Southern Africa (Magill 1981). This may be attributed to drier habitats of the studied area in comparable with that in shrub savanna and forests of Africa. This explanation coincides with that discussed by Dolnik (2006) who dealt with the influence of the environmental conditions on morphology and number of gemmae in leaf axils.

Leptophascum leptophyllum (Müll.Hal.) J.Guerra & M.J.Cano.
(Fig. 3)

In *Journal of Bryology* 22: 92 (2000). — *Chenia leptophylla* (Müll. Hal.) R.H.Zander, *Bulletin of the Buffalo Society of Natural Sciences* 32: 258 (1993).

Phascum leptophyllum Müll.Hal., *Flora* 71: 6 (1888).

Physcomitrium rhizophyllum (Sakurai), *Botanical Magazine, Tokyo* 52: 469 (1938).

Tortula rhizophylla (Sakurai) Z.Iwats. & K.Saito, *Miscellanea Bryologica et Lichenologica* 6: 59 (1972).

Tortula evanescens Broth., *Proceedings of the Linnean Society of New South Wales* 41: 582 (1916).

Specimen examined. — **Saudi Arabia**. Asir region, Bariq governorate, Athrb mountain; 18°57'860"N, 41°59'947"E; 1232 m a.s.l.; grow on soil between the rocks of high mountains around it short shrubs; soil thickness 1.3 cm; slope slop; 29.X.2011, 27.I.2012,

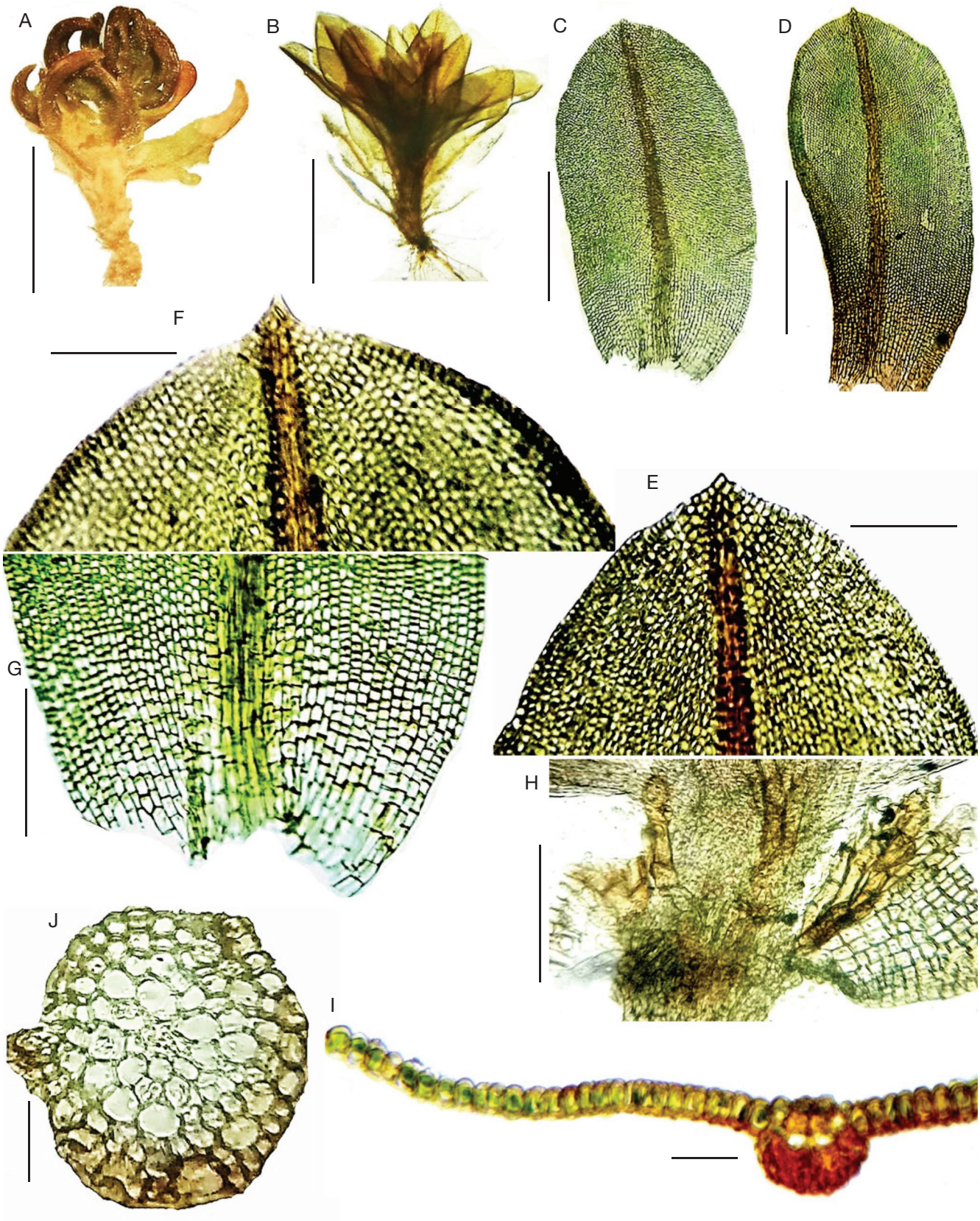

FIG. 2. — *Hyophila baginsensis* Müll.Hal.: **A**, dry plant; **B**, wet plant; **C**, **D**, leaves; **E**, **F**, upper part of leaves; **G**, basal part of leaf; **H**, axillary propagules; **I**, leaf cross section; **J**, stem cross section. Scale bars: A, B, 1 mm; C, D, 0,5 mm; E-H, 200 µm ; I, J, 50 µm.

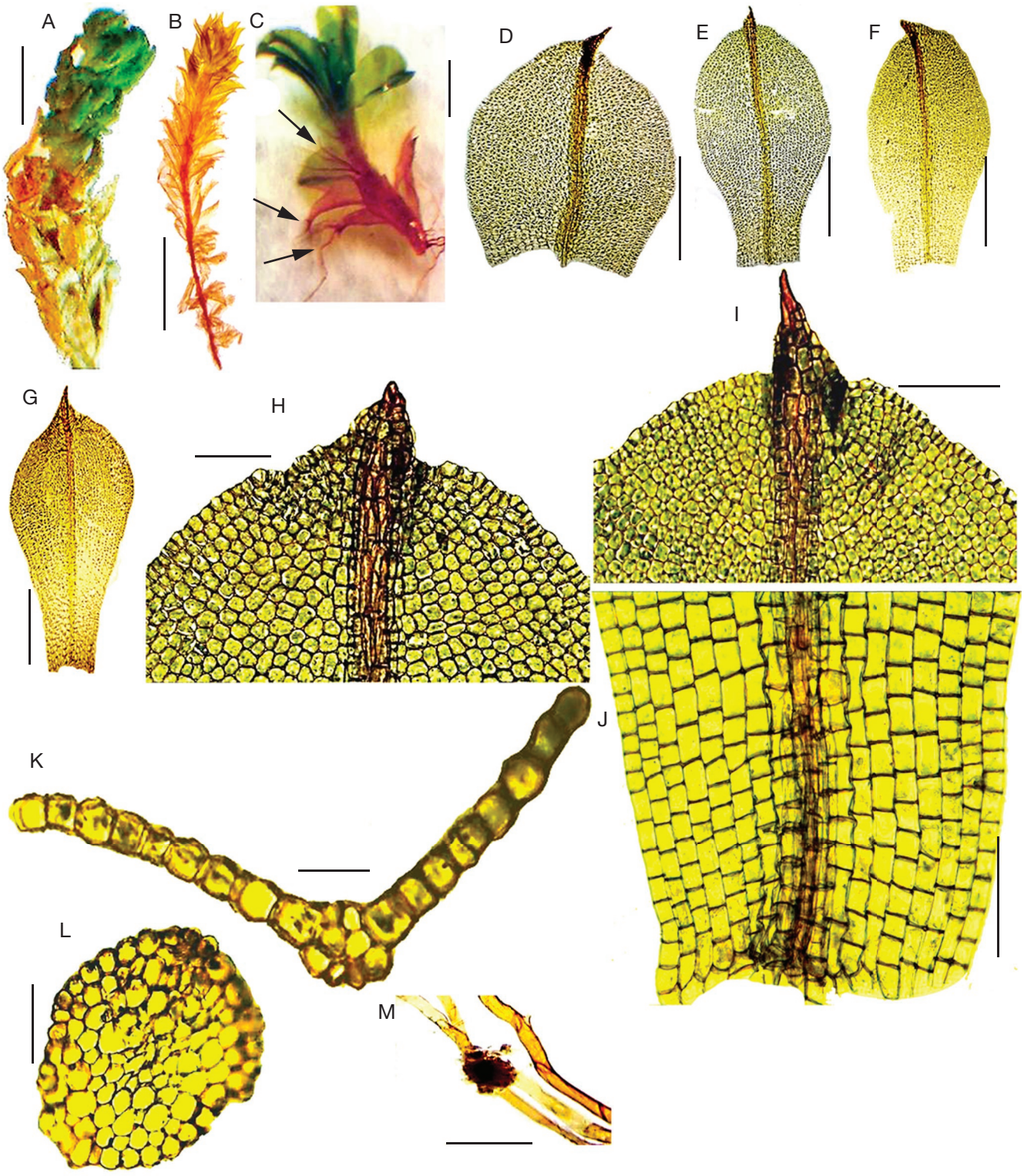

FIG. 3. — *Leptophascum leptophyllum* (Müll.Hal.) J.Guerra & M.J.Cano.: **A**, dry plant; **B**, wet plant; **C**, wet plant with rhizoids from the back of the costa at leaf tips or along the leaf; **D**-**G**, leaves; **H**, **I**, upper part of leaves; **J**, basal part of leaf; **K**, leaf cross section; **L**, stem cross section; **M**, rhizoidal propagule. Scale bars: A, 1 mm; B, 2 mm; C-G, 0.5 mm; H-J, 200 µm; K, 50 µm; L, M, 100 µm.

26.IV.2012, 29.VI.2012; air moisture 57, 56, 30, 35 respectively; leg. Manal Aseeri; 171Ma-d (CAIA).

DISTRIBUTION. — In Africa; Botswana, Canary Islands, Cape Verde, Kenya, Lesotho, Malawi, Mauritania, South Africa, Tanzania, Zimbabwe, in Asia; China: Yuannan, India, Japan, in Australia; New Zealand, in Europe; Azores, France, Germany, Italy, Madeira, Reunion, Portugal, Sardinia, Spain, in North America; Hawaiian Islands, United Kingdom, United States: Alabama; louisiana; New Mexico and in South America; Bolivia, Brazil, Chile, Ecuador, Paraguay (Magill 1981; Arts & Sollman 1991; Crum & Eckel 1994; Lüth 2006; O'Shea 2006; Ros *et al.* 2013; www.tropicos.org 2019).

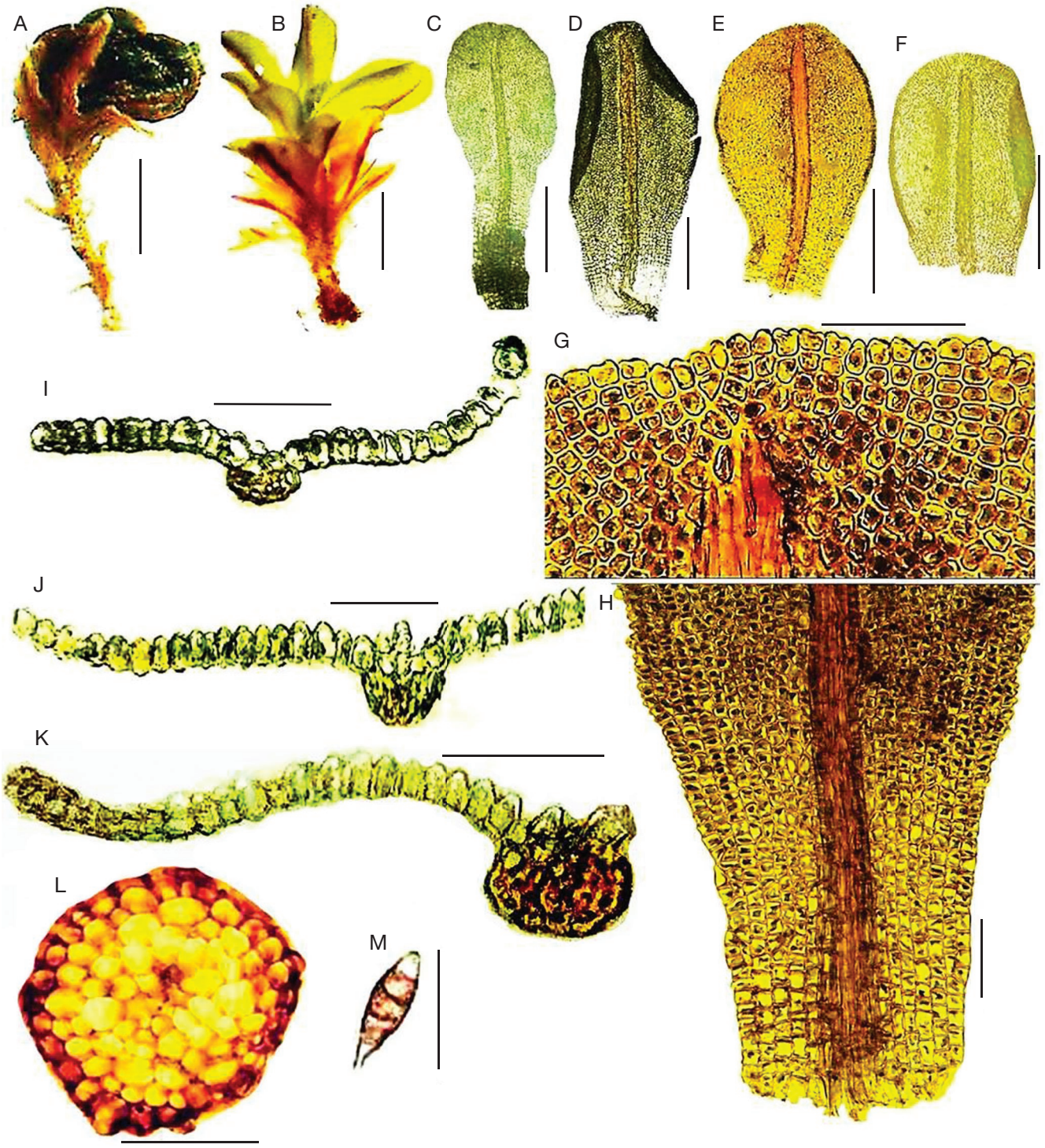

FIG. 4. — *Plaubelia involuta* (Magill) R.H.Zander: **A**, dry plant; **B**, wet plant; **C**-**F**, leaves; **G**, upper part of leaf; **H**, basal part of leaf; **I**-**K**, leaf cross sections; **L**, stem cross section; **M**, axillary propagule. Scale bars: A-F, 0,3 mm; G, I-M, 50 µm; H, 100 µm.

New to the Arabian Peninsula

FLORISTIC ELEMENT. — Sub-cosmopolitan element.

DESCRIPTION

Plants

Green above, yellowish brown below, up to 5-8 (-9) mm long.

Stem

Branched or simple, oval to round in cross section, central strand absent, sclerodermis more or less developed.

Leaves

Appressed when dry, patent to open spreading with reflex apex when moist, obovate to spathulate, 1.3-1.7 mm long,

0.6-1 mm wide; apex acute to acuminate; margins plane usually crenulate, rarely serrate above, entire below; costa excurrent in short reflexed apiculus, stereid bands absent, with two guide cells in one layer; rhizoids shown from the back of the costa at leaf tips or along the leaf; upper lamina cells hexagonal, quadrate to short rectangular, incrassate, usually bulging on both surface, smooth, (15-) 20-25 µm long × 20-25 µm wide, smooth to bulging; basal lamina cells quadrate to short rectangular, 30-45 µm long × 20-25(-30) µm wide, smooth, thinner.

Propagules
Present on rhizoids, varied in shapes, multicellular, 40-80 µm in diameter.

Comment
Although the studied samples *of Leptophascum leptophyllum* have the same range of leaf length, width and cell dimensions of those reported in most floras which described this taxon but the studied samples are taller than others in different areas (see: Crum & Anderson 1981; Magill 1981; Crum & Eckel 1994; Casas *et al.* 2006; Guerra *et al.* 2006). This may be attributed to high soil thickness which indicates more humidity and minerals for nutrition, beside its long duration in the region (Kürschner 1984).

Plaubelia involuta (Magill) R.H.Zander
(Fig. 4)

In *Bulletin of the Buffalo Society of Natural Sciences* 32: 176 (1993). — *Weisiopsis involuta* Magill, *Flora of Southern Africa, Bryophyta* 1: 225 (1981).

Specimen examined. — **Saudi Arabia**. Asir region, Muhayil Asir governorate, Qana; 18°29'676"N, 41°57'000"E; 427 m a.s.l.; grow on the side of the valley; soil thickness 7 mm; slope slop; 25.X.2011, 23.I.2012, 24.IV.2012, 26.VI.2012; air moisture 57, 65, 54, 29 respectively; leg. Manal Aseeri; 131 Ma-d (CAIA).

Distribution. — In Africa; Botswana, Namibia and in Asia; South west China (O'Shea 2006; Cao *et al.* 2010).
New to the Arabian Peninsula

Floristic element. — Palaeotropical element.

Floristic remarks. — *Plaubelia* Bird. was recorded previously by Shabbara (2006) from Isthmic Desert (North Sinai), Egypt as *P. sprengelii* (Schwägr.) R.H.Zander. But this is the first record of *P. involuta* in the Arabian Peninsula.

Description
Plants
Yellowish green 2 mm high.

Stem
Simple, central strand present, sclerodermis well developed.

Leaves
Imbricate crisped when dry, open spreading when wet; broad oblong spathulate, 0.6-1.2 mm long, 0.03-0.5 mm wide; apex rounded; margins more or less incurved above, plane below, adaxial surface cells bulging, mamillose to simple papillose; costa ending up to 8 cells below the apex; single abaxial stereid band; upper lamina cells incrassate, ventrally convex and dorsally nearly flat, rounded or irregularly quadrate (5-) 7-10 µm long and wide; basal lamina cells more or less hyaline, sub quadrate to rectangular, 10-27 µm long, 9-15 µm wide, smooth.

Propagules
Rarely present, axillary, oval shape, multicellular.

Comment
Propagules are very rare in the studied *Plaubelia involuta* samples; although common found by both Magill (1981) and Zander (1993). According to Magill (1981) this species is known only from northern Botswana. The type locality is a near-vertical, soft, crumbly calcrete cliff along the Botei River. Thus, the rarity of gemmae in the studied samples may be attributed to the drier habitats here (Dolnik 2006).

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