Acta Biologica Plantarum Agriensis
ISSN 2061-6716 (Print), 2063-6725 (Online)
https://ojs.uni-eszterhazy.hu/index.php/ABPA
https://doi.org/10.21406/abpa.2023.11.1.211

11(1): 211–224 (2023)
Dedicated issue
Research article

THE GENUS *EPHEMERUM* (POTTIACEAE, BRYOPSIDA) IN CENTRAL AFRICA (GABON, DEMOCRATIC REPUBLIC OF THE CONGO, RWANDA) WITH DESCRIPTION OF TWO NEW SPECIES

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Abstract: Two new species of *Ephemerum* from Rwanda (*E. rwandense*) and Gabon (*E. pocsii*) are described. The identity of *Ephemerum pechuelii* is discussed. As the type is missing, the species can not be defined with high confidence. According to the protologue, the species has rather wide leaves with entire margin that are hardly recurved. A key to all species of *Ephemerum* from Africa is provided.

Keywords: *Ephemerum rwandense*, *E. pocsii*, *E. pechuelii*, identification key, Africa

INTRODUCTION

The genus *Ephemerum* Hampe comprises c. 32 species (worldflora-online.org 2023), 20 species according to Ochyra *et al.* (2020) of minute cleistocarpic bryophytes which belong to the smallest species among mosses. They often resemble a small protonema or green alga and are hardly visible with the naked eye. Recent molecular data have shown that they belong to the family Pottiaceae (Goffinet and Buck 2004) rather than to a family of its own, Ephemeraceae in the order Funariales. In Africa, seven species are presently known, of which three are restricted to Southern Africa. The first species described was *Ephemerum diversifolium* Mitt. (Mitten 1859: 63), only known from the type collection (*Zeyher s.n,* BM000983083, NYBG 944603) in the shrublands of the Southern Cape and not recollected since 1831 (Magill 1987). Two further species described from South Africa are *Ephemerum capense* Müll.Hal. (Müller 1888: 12) and *Ephemerum rehmannii* (Müll.Hal.) Broth. (Brotherus 1924: 219) (= *Ephemerella rehmannii* Müll.Hal., Müller 1888: 12). *Ephemerum capense*, first considered a South African endemic species, was subsequently recorded in Australia,

Queensland (Stone 1996) and Brazil (Yano *et al.* 2010; Lima *et al.* 2020). *Ephemerum aethiopicum* Welw. & Duby (Duby 1872: 443) from Angola and Zimbabwe (O'Shea 2006) turned out to be a member of *Bryoceutherospora* and was subsequently transferred as *B. aethiopica* (Welw. & Duby) Zand. (Zander 1993: 216). *Ephemerum piliferum* Shaw (1878: 314) is an insufficiently known species (Magill 1987; Ochyra *et al.* 2020) that can not be assigned to any accepted taxon. A recently described taxon from South Africa is *E. namaquense* Magill (1987: 307) from the Western Cape. The first species described from tropical Africa is *Ephemerum pechuelii* Müll.Hal (1886: 502) from Stanley Pool in the Democratic Republic of the Congo, discovered as a single plant by Müller in a sample of *Trematodon pechuelii* Müll.Hal. (Müller 1886: 508). Another recently described new tropical African taxon is *Ephemerum perminutum* C.C.Towns. (Townsend 1981: 697) from Southern Tanzania, also discovered accidentally in a sample of *Weisia brachypoma* C.C.Towns. (Townsend 1981: 695). The latest floristic addition to *Ephemerum* in Africa is *E. homomallum* Müll.Hal. (1888: 12). Previously considered endemic to Argentina and Brazil (Lima et al. 2020), it was recently discovered in the Limpopo Province in South Africa (Ochyra *et al.* 2020) as a new record for the African continent.

During bryological research in Gabon and Rwanda, two species of *Ephemerum* were collected that proved to be new to science and are described below. A revision of the African species is in preparation.

MATERIAL AND METHODS

The *Ephemerum* species were collected and photographed during field trips to Rwanda and Gabon. The specimens were studied using a Keyence Digital Microsope VHX-600D. Specimens for comparison were obtained from the Herbarium of the National Botanic Garden Meise (BR, abbreviation after Thiers 2022 continuously updated).

RESULTS AND DISCUSSION

Ephemerum pechuelii Müll.Hal. (Müller 1886: 502)
Type: DEMOCRATIC REPUBLIC OF THE CONGO, at river Congo, Pool Malebo (=Stanley Pool), Sept. 1882, *Pechuel-Loesche s.n.* (B †).

Dioicous. **Stems** very minute, with few leaves. **Leaves** lanceolate-subulate with ovate and rather wide base, hardly recurved, rather robust, margin entire, canaliculate, without costa, with elongate cells and distinct primordial utricle, lacking only at apex and then being transparent. **Capsules** small, brown and sessile. **Spores** brown and small.

Müller (1886) writes in the protologue that he had studied a single plant ("specimen unicum inveni") in a cushion of *Trematodon pechuelii* Müll.Hal. (1886: 509) (=*Trematodon paradoxus* var. *nanus* [Welw. & Duby] Sim). It can be distinguished by the rather wide and large entire leaves without costa and funarioid-reticulate cells ("E foliis latiusculis majusculis integerrimis enerviis funarioideo-reticulatis facile distinguendum" Müller 1886: 502).

The type and only specimen could not be retrieved. Carl (Karl) Johann August Müller (1818–1899) had the majority of his herbarium deposited in Berlin (c. 12000 species in 70000 specimens) where it was destroyed in 1943 (Frahm and Eggers 2001). Thus, the type of *Ephemerum pechuelii* was not available for study, and already Roth (1911) stated that he had not seen it. Also attempts to find the species in an isotype of *Trematodon pechuelii* in PC did not reveal further material. So, we can only rely on the protologue. The above description is entirely based on Müller's description. The species was subsequently recorded in the Central African Republic (Bizot and Dury 1970) and Nigeria (Jones 1985). In Nigeria it was found on vertical banks of moist sandy earth of the Kaduna River, and in the Central African Republic in a gallery forest. Bizot and Dury (1970: 4) state that this minute species resembles the European *Ephemerum serratum* but can be distinguished by the entire leaves and the polygamous inflorescence. As the type of *Ephemerum pechuelii* is missing, it is difficult to define the taxon. At least the specimen from Nigeria is a different species, more resembling the new *E. rwandense*. A specimen from Eastern Rwanda (*Figure 1*) has entire leaf margins and broader leaves and could thus be the real *Ephemerum pechuelii*. However, further studies combined with fieldwork are required to assess the status.

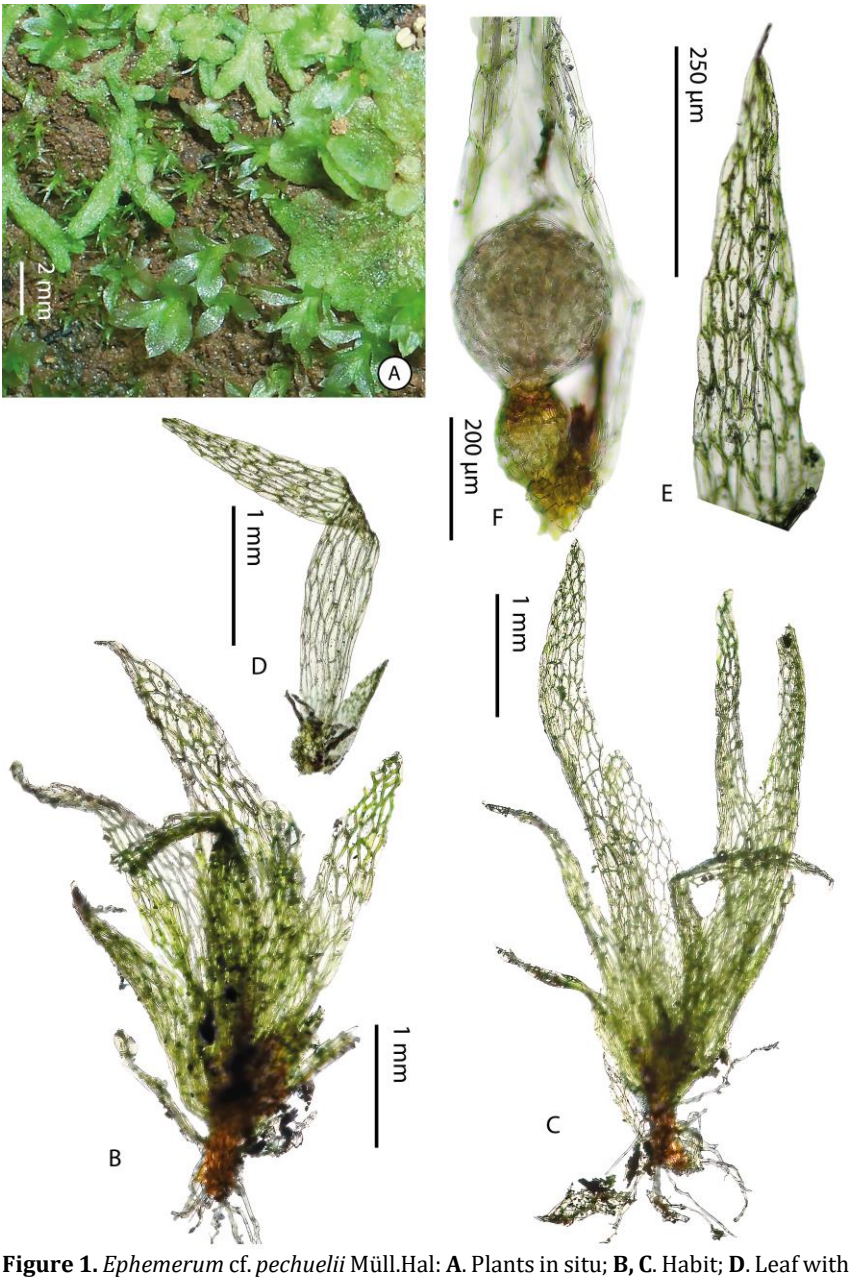

Figure 1. *Ephemerum* cf. *pechuelii* Müll.Hal: **A**. Plants in situ; **B, C**. Habit; **D**. Leaf with young capsule and perichaetial leaves; **E**. Apex of leaf showing entire margin; **F**. Young capsule (All from *Fischer 654/2015*).

Specimen studied: RWANDA, Eastern Province, c. 200 m NE of Rusumo Falls, sandy beach of Akagera River, 2°22'23.86''S 30°47'35.01''E, 1293 m, 19 Sept. 2015, *E.Fischer 654/2015.* (KOBL).

Ephemerum rwandense Eb.Fisch. & Killmann **sp. nov.**
The new species differs from *Ephemerum pechuelii* in the leaves that are lanceolate to linear-lanceolate (lanceolate-subulate with ovate and rather wide base in *E. pechuelii*) and the margin that is serrulate in upper leaf part (entire in *E. pechuelii*). It differs from *E. pocsii* in the erect-spreading leaves (recurved in *E. pocsii*), the margin serrulate at leaf-apex (entire in *E. pocsii*), the larger leaves (2.1–2.13 × 0.12–0.15 mm vs. 0.9–1.05 × 0.09–0.16 mm), the smooth cells at leaf apex (prorate in *E. pocsii*), the larger capsule (238 × 243 µm vs.196 × 195 µm) and the perichaetial leaves that are not different from outer leaves (differ in shape from outer leaves in *E. pocsii*).
Type: RWANDA, Southern Province, Huye, valley below Arboretum Ruhande, vertical banks on clay along ditches and small ponds in agricultural fields, 2°37'11.39''S 29°44'59.91''E, 1650 m, 16 March 2006, *E.Fischer 712/2006* (holotype BR; isotype EGR, KOBL).

Female plants minute, scattered or gregarious, light green to yellow-green, terricolous. **Stems** to 0.3 mm long. **Leaves** erect-spreading, lanceolate to linear-lanceolate, 2.10–2.13 mm × 0.12–0.15 mm, margins plane, serrulate above with obtuse protruding cells. **Costae** absent. **Perichaetial leaves** not different from outer leaves. **Laminal cells** rectangular to rhomboidal, 63–91 × 14.6–24.5 µm, smooth. **Dioicious**. Male plants not seen. **Capsules** globose, 238 × 243 µm, calyptra mitrate, c. 235 µm, apiculi up to 5–9 µm long, setae 40–60 µm long, vaginulae up to 58 µm long, ovoid, swollen, distinctly delimited from base of capsule. **Spores** 60–70 µm in diameter (*Figures 2A, 3, 4*).

Additional specimens studied: RWANDA, Western Province, Mwaga E of Ntendezi, ditch in tea plantation on vertical bank, 2°25'56.26''S 29°03'27.30''E, 1532 m, October 1991, *E.Fischer, J.-P.Frahm & T.Pócs 4652* (KOBL); Southern Province, Mwoga, Nyarusiza, W of Huye, dried pond with *Elatine triandra* along road from Huye to Nyamagabe, 2°30'19.50''S 29°36'09.50''E, 1644 m, 24 September 2015, *E.Fischer, B.Leh & D.Killmann 722/2015.* (KOBL).

Habitat: Vertical banks of ditches in tea plantations and agricultural fields, dried ponds, 1532–1650 m. **Distribution**: Only known from Rwanda. **Etymology**: Named after the country Rwanda.

Figure 2. A. Habitat of *Ephemerum rwandense* at Nyarusiza, Rwanda, 24 September 2015; **B**. Habitat of *E. pocsii* at Ivindo River, Gabon, 9 September 2012 (photo by E. Fischer).

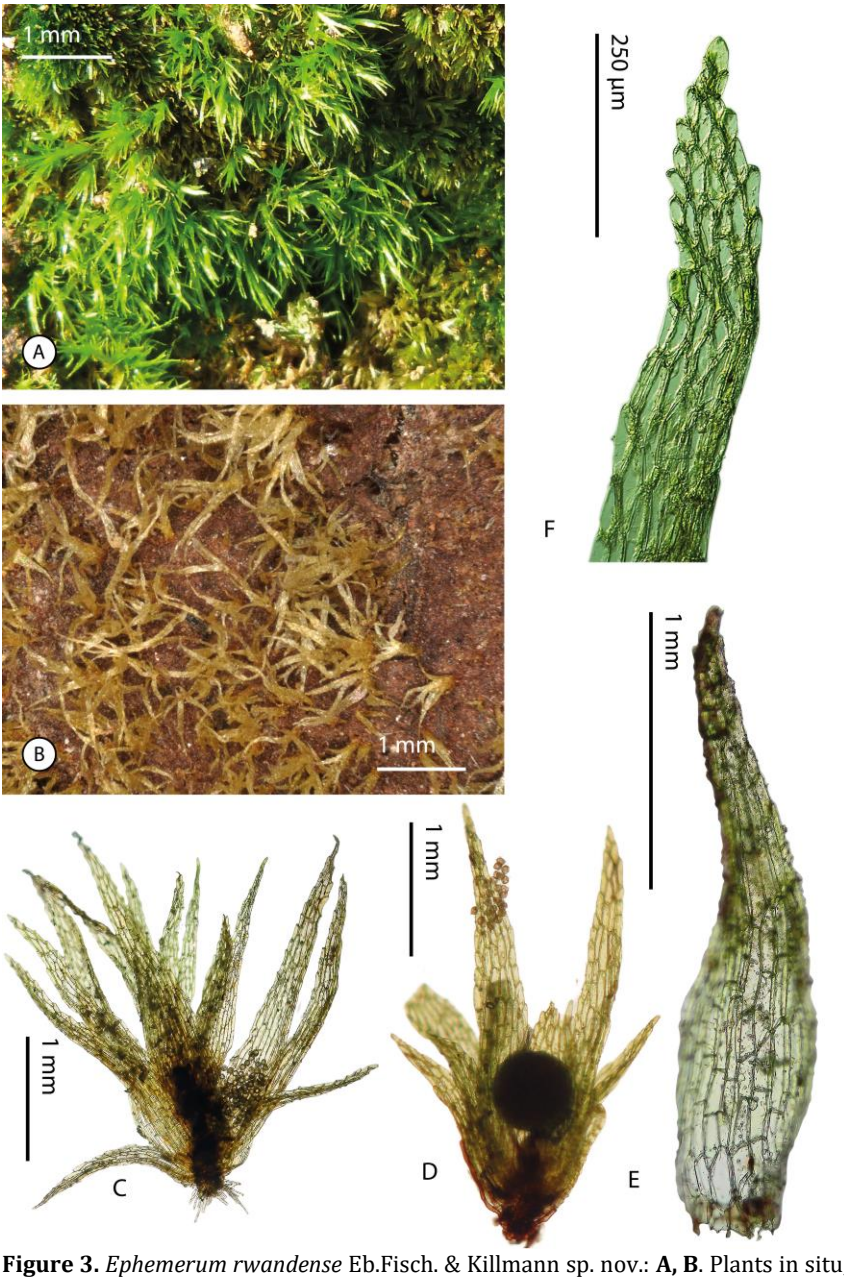

Figure 3. *Ephemerum rwandense* Eb.Fisch. & Killmann sp. nov.: **A, B**. Plants in situ; **C, D**. Habit; **E**. Outer leaf; **F**. Apex of leaf showing serrulate margin (All from holotype *Fischer 712/2006*).

Ephemerum pocsii Eb.Fisch. & Killmann **sp. nov.** (*Figures. 2B, 5, 6*)
The new species resembles *E. rwandense*, but differs in the recurved leaves (erect-spreading in *E. rwandense*), the entire margin (serrulate at leaf-apex in *E. rwandense*), the smaller leaves (0.9–1.05 × 0.09–0.16 mm vs. 2.1–2.13 × 0.12–0.15 mm), the prorate cells at leaf apex, the smaller capsule (196 × 195 µm vs. 238 × 243 µm) and the perichaetial leaves that differ in shape from outer leaves (vs. perichaetial leaves not different from outer leaves). It differs from *Ephemerum pechuelii* in the recurved leaves, the prorate cells at leaf apex and the perichaetial leaves that differ in shape from outer leaves.

Type: GABON, Ogooué-Ivindo, Ivindo River at Loa-Loa near Ipassa Research Station, on sandy river bank, 0°30'51.78''N 12°48'21.44''E, 471 m, 9 Sept. 2012 *E. Fischer 881/2012* (holotype EGR, isotype KOBL).

Female plants minute, scattered or gregarious, light green to dark-green, terricolous. **Stems** to 0.1 mm long. **Leaves** recurved, lanceolate to linear-lanceolate, 0.9–1.05 mm × (0.04–) 0.09–0.16 mm, margins plane, entire. **Costae** absent. **Perichaetial leaves** 0.9 mm long, with broadly ovate bases, 0.235 × 0.2 mm, and linear-lanceolate laminae, 0.6–0.7 × 0.16 mm. **Laminal cells** rectangular to rhomboidal, 90–122 × 0.172–22 µm, upper cells prorate, basal cells rectangular, smooth, 193 × 23 µm. **Dioicious**. Male plants not seen. **Capsules** globose, 196 × 195 µm, calyptra mitrate, up to 190 µm, apiculi up to 4.8 µm long, setae short, 28 µm long, vaginulae 18–20 µm long, ovoid, swollen, distinctly delimited from base of capsule. **Spores** 44 –50 µm in diameter.

Habitat: Sandy beach at river bank, 471 m. **Distribution**: Only known from the type locality in Gabon. **Etymology**: Named after our colleague and friend Tamás Pócs on occasion of his 90th birthday.

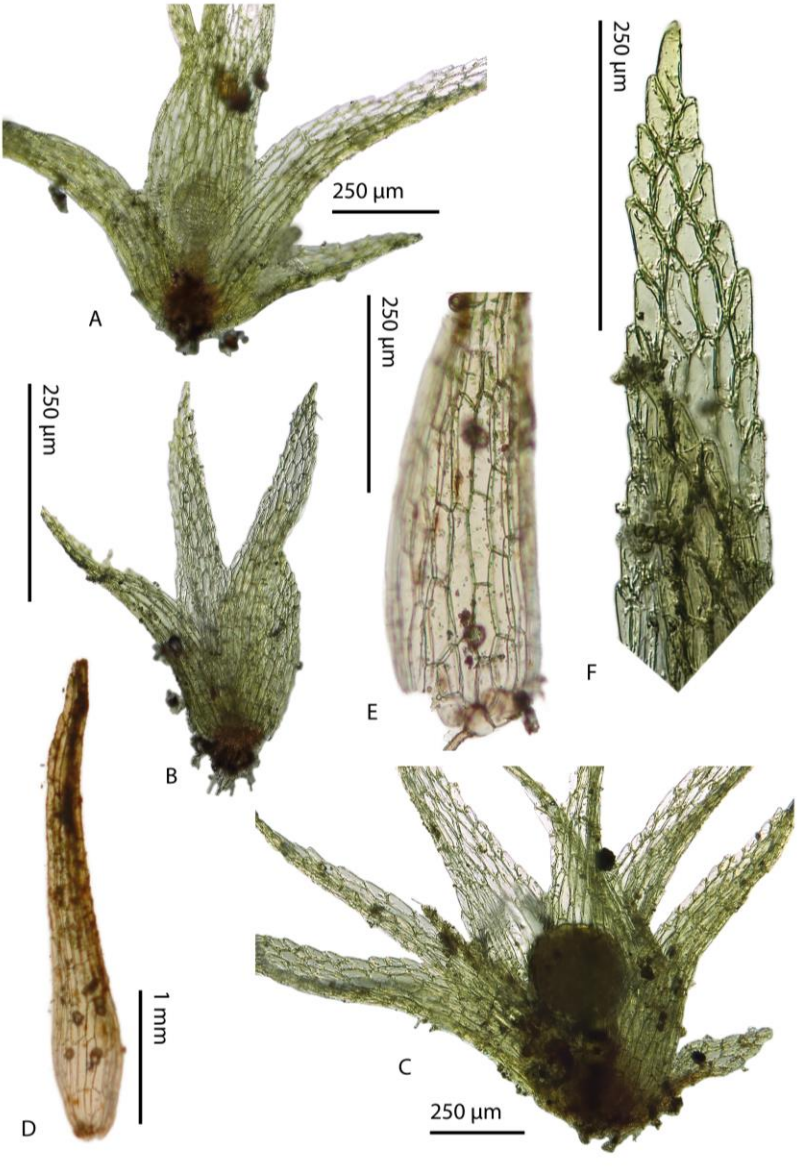

Figure 4. *Ephemerum rwandense* Eb.Fisch. & Killmann sp. nov. **A**–**C**. Habit; **D**. Leaf; **E**. Base of leaf; **F**. Apex of leaf showing serrulate margin (All from holotype *Fischer 712/2006*).

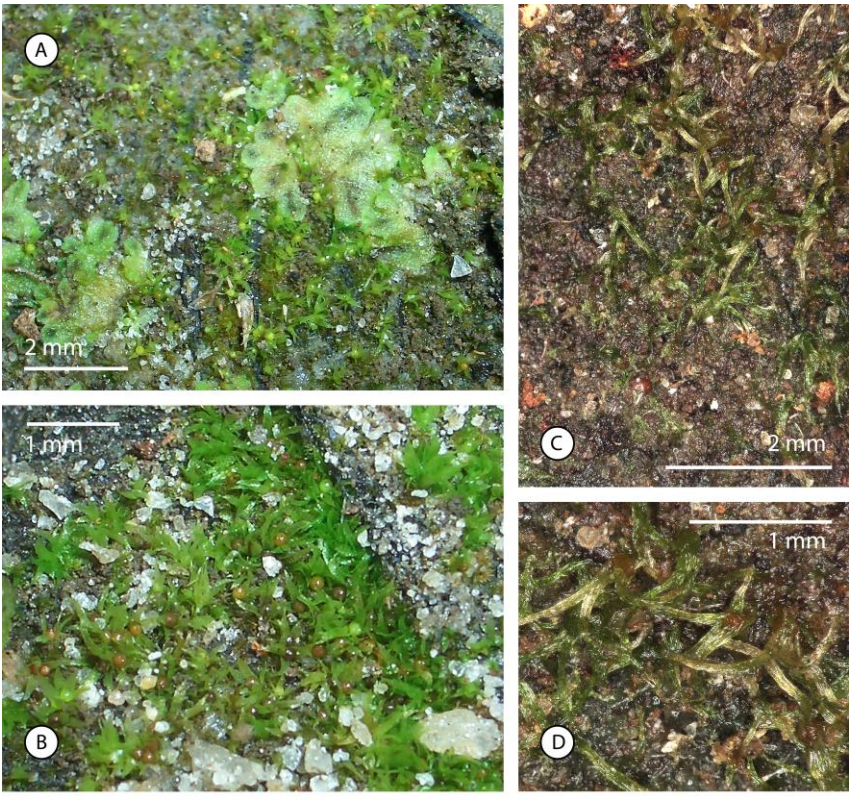

Figure 5. *Ephemerum pocsii* Eb.Fisch. & Killmann sp. nov.: **A**–**D**. Plants in situ (All from holotype *Fischer 881/2012*).

KEY TO THE SPECIES OF *EPHEMERUM* IN TROPICAL AND SOUTHERN AFRICA (PARTLY AFTER MAGILL 1987)

1 Costa absent.....**2**
– Costa present, occasionally absent in perichaetial leaves.....**6**
2 Plants scattered on persistent protonema, leaves almost hidden in protonema, not exceeding 0.4 mm of length, scarcely equaling the capsule, margins spinose.....**3**
– Plants scattered or gregarious, protonema usually disappearing or only vestigial, leaves not hidden in protonema, usually longer, at least 0.6–1 mm long, much longer than the capsule, margins serrulate or entire.....**4**

3 Leaves lanceolate, 5–6, inner leaves 0.3–0.35 mm long, outer leaves 0.21 mm long, southwestern Tanzania ..... ***E. perminutum***

– Leaves linear to elliptical, 1–5, inner leaves 0.2 mm long, outer leaves 0.3–0.4 mm long Lesotho, South Africa ..... ***E. capense***

4 Leaves recurved, 0.9–1.05 × 0.09–0.16 mm, perichaetial leaves different from outer leaves, leaf margin entire, Gabon ..... ***E. pocsii***

– Leaves ± erect, not or hardly recurved, longer, perichaetial leaves not different from outer leaves **5**

5 Leaf margin entire, leaves lanceolate-subulate with ovate and rather wide base, D.R. Congo ..... ***E. pechuelii***

– Leaf margin serrulate, at least near apex, leaves lanceolate to linear-lanceolate, Rwanda ..... ***E. rwandense***

6 Cells in upper leaf prorate, calyptra rough, South Africa (Western Cape) ..... ***E. namaquense***

– Cells of upper-lamina smooth, calyptra smooth **7**

7 Leaf margin entire, perichaetial leaves distinct, without costa, outer leaves with costa distinct at leaf base, weak towards leaf apex, not excurrent, South Africa (southern Cape) ..... ***E. diversifolium***

– Leaf margin distinctly serrate or entire to serrulate, occasionally with a few teeth at apex, perichaetial leaves not distinct, costa excurrent or not **8**

8 Leaf margins entire to serrulate, occasionally with a few teeth at apex, costa well defined but weak in leaf base, excurrent, capsule smooth, South Africa to Zimbabwe ..... ***E. rehmannii***

– Leaf margins distinctly serrate, costa well defined over its total length, not excurrent, capsule rugose, South Africa (Limpopo) ..... ***E. homomallum***

Our observations indicate that *Ephemerum* species occur naturally in temporarily open habitats e.g. river banks. As in Europe, they are pioneer species and tend to be widespread in secondary habitats, e.g. dried ponds or ditches. They seem to be uncompetitive and prefer naked soil with only few other bryophytes.

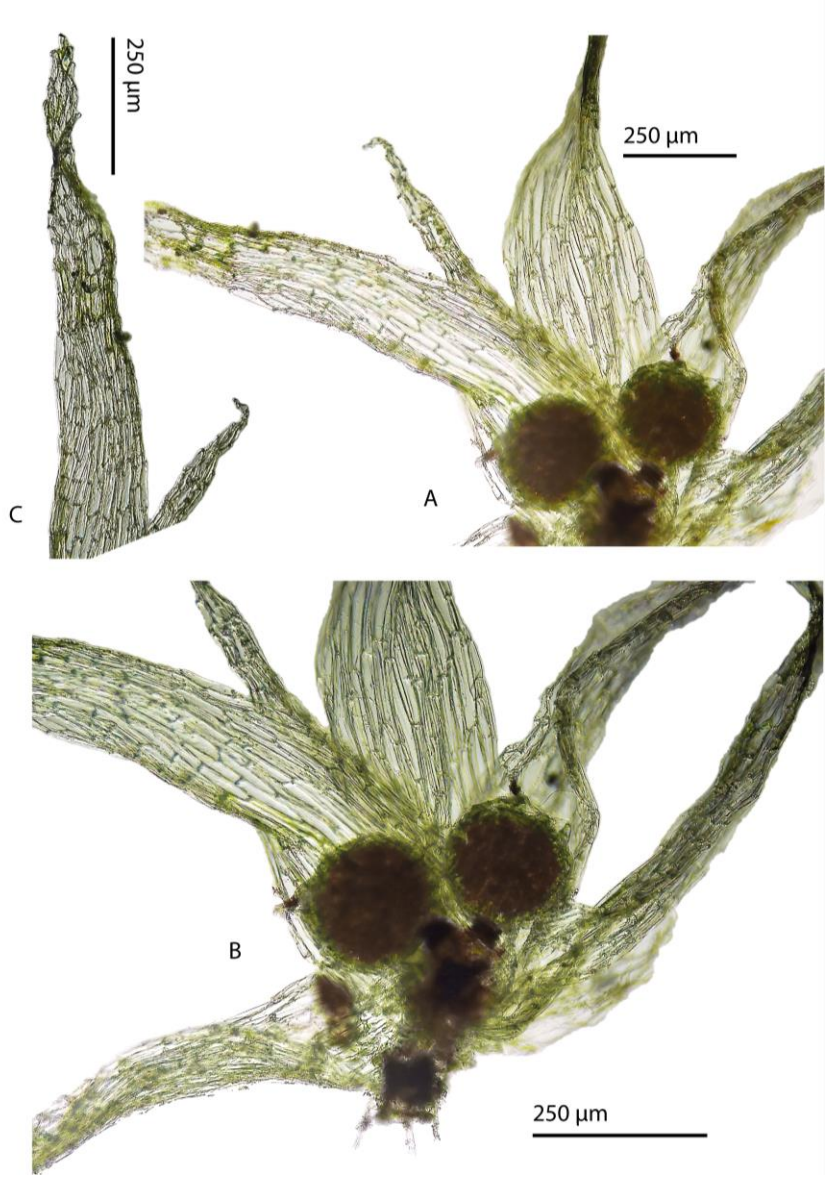

Figure 6. *Ephemerum pocsii* Eb.Fisch. & Killmann sp. nov.: **A**–**B**. Habit; **C**. Apex of leaf showing prorate cells (All from holotype *Fischer 881/2012*).

Acknowledgements – We would particularly like to thank the Rwanda Development Board (RDB) for collection and export permits. We also like to thank the BMUV (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection) for funding the Project ´Conservation of Biodiversity and Natural Resources and Climate Protection by sustainable Agriculture and Forestry at Cyamudongo Forest, Rwanda´ (16_III_083_RWA_A_ Cyamudongo Regenwald) within the International Climate Initiative (IKI) and the ´Akademie der Wissenschaften und Literatur Mainz´ for financial support of field trips to Rwanda. The authors would like to thank the curators of the herbarium BR for making their collections accessible. We are grateful to the Centre National de la Recherche Scientifique et du Dévelopement Téchnologique (CENAREST) in Libreville and to the National Herbarium of Gabon in Libreville (LBV) for research, collection- and export permits. Special thanks go to Dr. Laurent Ndaywel and Dr. Hugues Eyi-Ndong from the CENAREST for the logistic support in the field and the possibility to use the field station Ipassa near Makokou. The field trip in September 2012 was funded by the Zoological Research Museum Alexander Koenig in Bonn, now part of The Leibniz Institute for the Analysis of Biodiversity Change. We thank the former Director Prof. Dr. Wolfgang Wägele and the actual Director General Prof. Dr. Bernhard Misof for their continuous support. We would also like to thank the team of the Museum Koenig and especially Dr. Thomas Gerken and Corinna Seibt for their logistic support in Gabon. We are greatful to Robin Winters and Dr. Markus Ackermann for technical support in the preparation of the plates. Last but not least we would like to thank Bonny Dumbo and Burkhard Leh for their great support during fieldwork in Rwanda.

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(submitted: 18.01.2023, accepted: 28.03.2023)