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Geocalyx heinrichsii sp. nov., the first representative of Geocalycaceae (Jungermanniales, Marchantiophyta) in Baltic amber

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Abstract

Geocalyx heinrichsii T.Katag. is described as a new leafy liverwort species from Eocene Baltic amber. It is characterized by (1) small sized shoots less than 1 mm wide including leaves, (2) bifid underleaves, not connate with leaf bases, (3) presence of gemmiferous ascending microphyllous shoot, and (4) 1–2-celled spherical to ellipsoidal gemmae. This is the first fossil record for the genus *Geocalyx* and for the family Geocalycaceae (Jungermanniales, Marchantiophyta) from Baltic amber, and constitutes an important addition to our knowledge of the Eocene Baltic liverwort flora.

Key words: Baltic amber, Eocene, fossil, Geocalycaceae, *Geocalyx,* liverworts

Introduction

Baltic amber is the richest source of bryophyte fossils from the Palaeogene (Frahm 2008, Grolle & Meister 2004, Heinrichs *et al*. 2018, Tomescu *et al.* 2018). The well-preserved inclusions in amber allow detailed examination of morphological characters which enable species level identification, and a total of 27 liverwort species have so far been recognized from Eocene Baltic amber (Heinrichs *et al.* 2018).

I recently had an opportunity to examine the private Baltic amber collection of Mr. Jürgen Velten (Idstein, Germany) and among his collection I discovered a piece that includes gametophyte fragments of a leafy liverwort with *Lophocolea*-like appearance. Detailed microscopic observations revealed that the plant does belong to the genus *Geocalyx* (Nees 1833: 97) of the Geocalycaceae Klinggräff (1858: 34), and the plant is here described as a new species of the genus. The plant is significant because it constitutes the first fossil record for the genus and family known not only in Eocene Baltic amber but also worldwide.

Material & Methods

A single piece of Baltic amber, 35 × 25 mm and 6 mm thick, containing two liverwort sterile shoots was studied. The embedded plants are therefore visible from both dorsal and ventral sides. The most precise radiometric ages for marine strata containing Baltic amber are 44.1 ± 1.1 and 47.0 ± 1.5 Ma, based on $^{40}Ar/^{40}K$ analyses of glauconite (Ritzkowski 1997). The inclusion containing the plant was examined using a Leica M205C stereomicroscope equipped with a Nikon DS-Fi3 digital camera. In order to enhance contrast and avoid casting shadows, a Leica LED5000 RL ringlight was used.

Taxonomy

Geocalyx heinrichsii T.Katag., ***sp. nov.*** Figure 1A–E

Holotype: Two sterile liverwort shoots (Fig. 1A–C & Fig.1 1D–E) in Baltic amber piece (NICH-492966).

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Type locality: Baltic region.

Age: Eocene, 44.1 ± 1.1 to 47.0 ± 1.5 Ma (Ritzkowski 1997).

Etymology: Named in honour of Dr. Jochen Heinrichs (1969–2018) in recognition of his significant contributions to our knowledge of fossil and extant bryophyte diversity and systematics.

Systematic position: Marchantiophyta Stotler & Crand.-Stotl., Jungermanniopsida Stotler & Crand.-Stotl., Jungermanniales H.Klinggr., Geocalycaceae H.Klinggr., *Geocalyx* Nees

Diagnosis: Species of *Geocalyx* distinctive in its possession of (1) small sized shoots less than 1 mm wide including leaves, (2) bifid underleaves, not connate with leaf bases, (3) presence of gemmiferous ascending microphyllous shoot, and (4) 1–2-celled spherical to ellipsoidal gemmae.

Description: Plant prostrate, 8–10 mm long and 0.4–0.6 mm wide including leaves (Fig.1A) or 1.5 mm long in gemmiferous ascending shoot (Fig.1D); branching not seen. Leaves alternate, succubous, remote to contiguous, patent to divergent, very obliquely inserted, decurrent dorsally, undecurrent ventrally, longer than wide, subrectangular to oval, 0.2–0.5 mm long and 0.2–0.3 mm wide, bilobed 0.25–0.35 of the length, with entire margin; lobes usually triangular, acute or with acuminate apex of 1–2 cells long; sinus triangular to lunate; cells of leaves verrucose; underleaves, bilobed 0.5 of the length, 0.2–0.3 mm long and 0.2–0.3 mm wide, as wide as the stem, not connate with leaf bases. Rhizoids scarce, in fascicles at the base of underleaves. Gemmae spherical to ellipsoidal, 1–2-celled, frequent on apex of ascending microphyllous shoot. Oil bodies not seen. Reproductive structures and sporophytes not seen.

Discussion

Geocalyx heinrichsii preserved in Baltic amber is the first evidence which proves that the genus *Geocalyx* and that the family Geocalycaceae already was present in the Eocene Baltic amber forest, supporting the Cretaceous origin for Geocalycaceae recently estimated by Heinrichs *et al*. (2007) and Laenen *et al.* (2014). Although, the lack of reproductive characters prevents us from comparing *G. heinrichsii* to extant species more extensively, the morphological characters seen in the sterile plant fully match the generic concept of the extant genus *Geocalyx*, to which the amber inclusion is assigned. The genus *Geocalyx* includes four extant species (Söderström *et al.* 2016), and important vegetative characters of taxonomic value which segregate the genus from the other leafy liverworts are: (1) prostrate, irregularly branched shoot, (2) alternate, succubous, bifid leaves with its very oblique insertion line, (3) large bifid underleaves with the bases not connate with leaves, (4) ascending gemmiferous microphyllous shoots, and (5) ellipsoidal gemmae. The genus *Lophocolea* (Dumortier 1831: 59) Dumortier (1835: 17) of Lophocoleaceae Vanden Berghen (1956: 208) shares some of these characters, but the ascending gemmiferous microphyllous shoots has never been reported from *Lophocolea* species. Among the species of Jungermanniales Klinggräff (1858: 10), the presence of ascending gemmiferous microphyllous shoots are rare and known in genera of *Geocalyx* [*G. lancistipulus* (Stephani 1922: 281) (Hattori 1953: 234)] (Inoue 1974), *Harpanthus* (Nees 1836: 351) [*H. drummondii* (Taylor 1846: 283) Grolle (1965: 274) of Harpanthaceae Arnell (1928: 147)], *Mesoptychia* (Lindberg & Arnell 1889: 39) Evans (1903: 15) [*M. heterocolpo*s (Thed. in Hartman 1838: 328) L.Söderstr. & Váňa (Váňa *et al.* 2012: 53)] and *Liochlaena* Nees (Gottsche *et al.* 1845: 150) [*L. subulata* (Evans 1892: 258) Schljakov (1981: 71) of Jungermanniaceae Reichenbach (1828: 256)]. I consider *G. heinrichsii* is morphologically most closely related to *G. lancistipulus*, an Asian species known from Japan, China, Nepal, and India (Asthana & Murti 2009, Inoue 1974, Long 2005). Both species share above-mentioned characters, but *G. lancistipulus* is distinguished from *G. heinrichsii* by its larger size of shoots more than 1 mm wide including leaves (Asthana & Murti 2009, Inoue 1974).

In spite of the comprehensive survey conducted by Grolle & Meister (2004) and recent additions shown in Heinrichs *et al.* (2018) who listed 27 species of liverworts from Baltic amber, the liverwort flora of the Eocene Baltic amber forest has not been fully uncovered and does not seem to reflect the actual liverwort flora in Baltic amber forests due to limited number of non-bark inhabiting genera (e.g., *Calypogeia*, *Cephalozia*, *Lophozia*, *Metacalypogeia*, *Plagiochila*, *Scapania*, *Solenostoma*, *Tetralophozia*). More multiple and taxonomically non-biased fossil records are also needed in the study of historical biogeography for establishing more reliable chronograms as constraints on a molecular phylogeny (Feldberg *et al*. 2013).

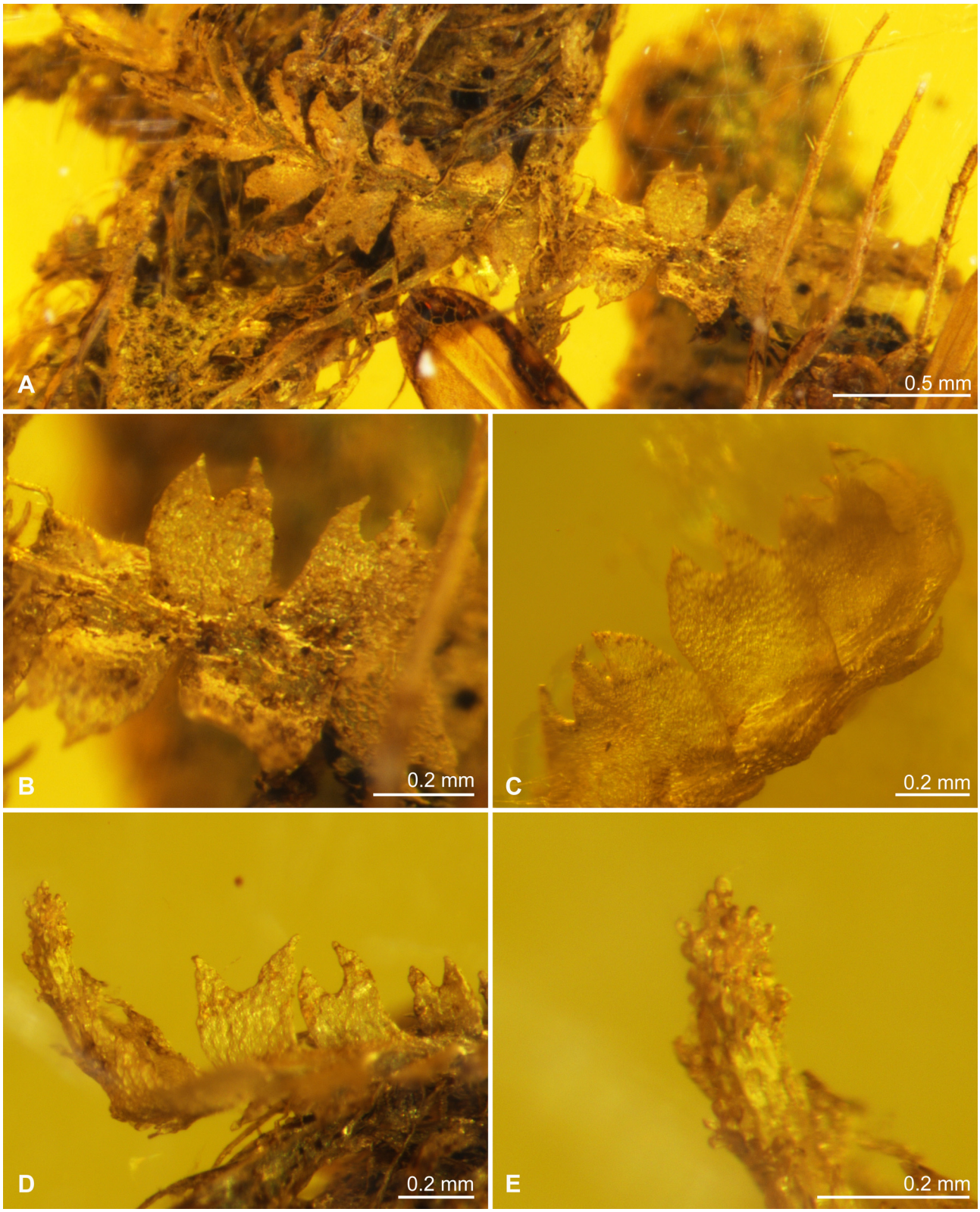

FIGURE 1. *Geocalyx heinrichsii* T.Katag. (holotype, NICH-492966). A: Plant from dorsal view. B: Close-up of leaves. C: Plant from lateral-ventral view showing underleaves. D: Gemmiferous ascending shoot. E: Close-up of the apex of gemmiferous shoot bearing gemmae.

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