

HEPATICS FROM ROVNO AMBER (UKRAINE),
2. ACROLEJEUNEA UCRAINICA SP. NOV.

ПЕЧЁНОЧНИКИ ИЗ РОВЕНСКОГО ЯНТАРЯ (УКРАИНА),
2. ACROLEJEUNEA UCRAINICA SP. NOV.

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Abstract

A fossil of Lejeuneaceae subfam. Ptychanthoideae is described based on an inclusion in Late Eocene Rovno amber. The unbranched sterile shoot has obliquely spreading, squarrose, complicate-bilobed leaves with rounded lobes and some dorsal lobe margins curved backwards as well as suberect upper shoot sectors with small leaves possibly serving for vegetative distribution. Based on morphological similarities the fossil is assigned to the extant genus *Acrolejeunea*, as *A. ucrainica* Mamontov, Heinrichs et Schäf.-Verw. sp. nov., being the first fossil of this genus and the third liverwort from Rovno amber.

Резюме

Ископаемый вид печёночников семейства Lejeuneaceae (подсемейство Ptychanthoideae) описан из ровенского янтаря, относящегося к позднему эоцену. Неветвящийся стерильный побег характеризуется косо отстоящими, растопыренными листьями с частично завернутыми внутрь верхушками дорсальных лопастей, а также наличием отогнутой верхней части побега с более мелкими листьями, вероятно, служившими для вегетативного размножения. На основании морфологического сходства растение отнесено к современному роду *Acrolejeunea* и описано как новый для науки вид *A. ucrainica* Mamontov, Heinrichs et Schäf.-Verw. sp. nov. Таким образом, впервые описан ископаемый вид рода *Acrolejeunea*. Данная находка – третий вид печёночников для эоценовой флоры Ровно.

KEYWORDS: fossil, hepatics, Ptychanthoideae, Lejeuneaceae, amber, Rovno, Ukraine, Tertiary, Eocene

INTRODUCTION

Baltic amber is the best-known source for Late Eocene bryophyte inclusions. As yet, some 23 liverworts (Grolle & Meister, 2004) and 60 mosses (Frahm, 2010) have been described, allowing for a comparison with the extant diversity and insights into European palaeoecosystems.

In contrast, little attention has been given to bryophyte inclusions in contemporaneous amber from Rovno region, Ukraine. Only recently, two liverworts (*Frullania varians* Casp. and *F. ucrainica* Konstant. & Ignatov, Konstantinova et al., 2012) and ten mosses (Ignatov & Perkovsky, 2011) were recognized, indicating that this amber could be a rich source of bryophytes of the Paleogene of Eastern Europe. Indeed, subsequent study of Rovno amber revealed new inclusions, of which one is described in the present paper. This inclusion belongs to Lejeuneaceae rather than

Frullaniaceae due to the presence of a leaf lobule with a long keel. The reniform underleaves and broad ventral merophytes point to Lejeuneaceae subfam. Ptychanthoideae (Gradstein, 2013). This subfamily has been recognized in various Cenozoic ambers. Eocene Baltic amber includes the Ptychanthoideae genera *Spruceanthus* Verd. and *Mastigolejeunea* (Spruce) Schiffn.; the latter is also present in Late Eocene Bitterfeld amber (Grolle & Meister, 2004). The Ptychanthoideae genera *Archilejeunea* (Spruce) Schiffn., *Bryopteris* (Nees) Lindenb., *Lopholejeunea* (Spruce) Schiffn., *Marchesinia* Gray, and *Mastigolejeunea* have been reported from Middle Miocene Dominican amber (Grolle, 1984a, 1993; Gradstein, 1993).

The new inclusion has obliquely spreading, squarrose, complicate-bilobed leaves with rounded lobes and some dorsal lobe margins curved backwards as well as

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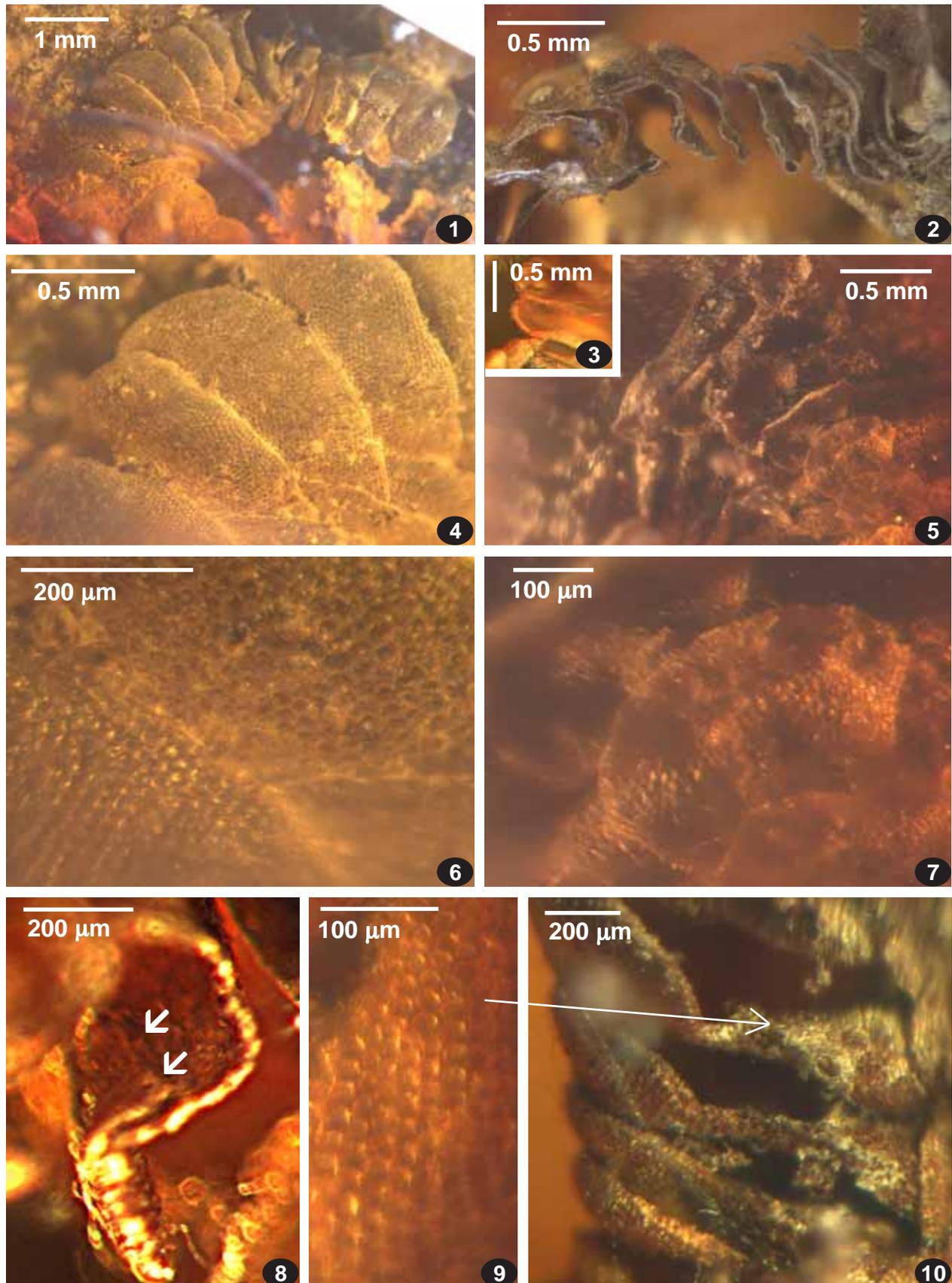
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Figs. 1-10. *Acrolejeunea ucrainica* sp. nov. (from SIZK-K-10052F): 1 – habit, dorsal view; 2 – habit, lateral view; 3 – leaves from distal part of shoot (ventral view), showing involute margin; 4 & 6 – lobe areolation of leaves from middle part of shoot, dorsal view; 5 & 7 – amphigastria, ventral view; 8 – damaged leaf (lateral view), showing dentate margin of lobule (arrowheads point to teeth); 9 – cells from proximal part of lobule close to keel, ventral view; 10 – leaf in ventral view, showing keel areas.

suberect upper shoot sectors with small leaves serving possibly for vegetative distribution. These characters do not correspond to any of the above genera but point to *Acrolejeunea* (Spruce) Schiffn.

Here, we describe the new Rovno amber inclusion as *Acrolejeunea ucrainica*, sp. nov.

MATERIALS AND METHODS

The amber piece is part of the Rovno amber collection of the Schmalhausen Institute of Zoology in Kiev (SIZK-K-10052F). According to recent studies (Kosmowska-Ceranowicz, 1999; Perkovsky *et al.*, 2003, 2007, 2010; Aleksandrova & Zaporozhets, 2008a, b), it shares its age with Baltic amber, hence being Late Eocene in age.

The fossil liverwort was photographed using a stereomicroscope Olympus SZX16 with a 1.6× objective lens, equipped with an Infinity 4 digital camera. To better illustrate the three-dimensional inclusion, a number of images were combined from 5-15 optical sections using the software package HeliconFocus 4.50 (Kozub *et al.*, 2008). Additional measurements were conducted using a compound microscope Carl Zeiss Axiolab with ocular ruler and with 4× and 10× objective magnification.

TAXONOMY

Genus *Acrolejeunea* (extant, subfamily Ptychanthoidae of family Lejeuneaceae)

Description. Leafy liverwort. Plants medium-sized to robust (up to 2.4 mm broad and to 5 cm long). Shoots prostrate to ascending, very sparsely irregularly branched; branching of *Lejeunea*-type, rarely of *Frullaria*-type; subfloral innovations absent. Leaves incubously inserted, imbricate, when moist often squarrose, when dry becoming convolute and suberect. Lobes oblong-ovate, entire-margined, rounded to obtuse, base cordate to auriculate. Lobules ovate, 0.4-0.65 the lobe length, the portion adjacent to keel inflated; free lobule margin flat, appressed to lobe, bearing (1-)3-8(-9) small teeth. Keel moderately to strongly arched. Cells elongate-hexagonal, thin-walled, with usually large sinuous trigones; intermediate thickenings present; the cell lumen usually clearly sinuate-undulate. Cells regularly oriented in curving rows; ocelli absent. Underleaves contiguous to imbricate, entire, reniform to broadly obdeltoid, usually clearly wider than long; the line of insertion weakly to moderately acropically arched. Asexual reproduction often present, via caducous leaves of abbreviated, specialised erect shoot apices. Plants di-, aut-, or paroecious. Female inflorescences terminal, on elongated branches, without true subfloral innovations. Perianths normally somewhat dorsiventrally compressed and plicate with 4-10 smooth keels, contracted at apex into a short beak; the keels never sharp or dentate. Male bracts not sharply differentiated from leaves, in 6-18 (to 50) pairs, becoming intercalary on main shoots.

Type species: *Acrolejeunea aulacophora* (Mont.) Schiffn. [= *Ptychocoleus aulacophorus* (Mont.) Trevis.]

The pantropical genus includes 15 extant species (Gradstein, 1975).

Fossil record: Hitherto no fossils known.

Acrolejeunea ucrainica Mamontov, Heinrichs et Schaf.-Verw., sp. nov.

HOLOTYPE: Klesov. Rovno amber. Late Eocene. SIZK-K-10052F (Figs 1-10). Specimen found in transparent, partly contaminated amber piece (#2-748, 18.5 g, 48×33×16 mm), syninclusion K-9651: male Theridiidae (Aranei).

Description: Sterile, unbranched, creeping shoot, ca. 6 mm long and up to 2 mm wide. Stem robust, visible only between some underleaves which are bent downwards (Fig. 5), with incubous foliation. Leaves alternating, imbricate, with U-shaped insertion, dorsally deeply interlocking and covering the whole stem (Figs. 1, 4). Lobes concave in ventral view, 0.70-1.35 mm long and 0.5-0.9 mm wide, asymmetrical-ly ovate-oblong, margins entire, reflexed to ventral side; dorsal margin curved outwards, apex rounded, broadly incurved towards the ventral side of the stem; ventral margin sinuate, free ventral margin taking ca. 0.50-0.66 of lobe with widely curved transition to keel (Fig. 10). Cells of lobes regularly arranged in curving rows (Figs. 4, 6), hexagonal; cell walls thin, not sinuate, trigones large, cordate, not sinuate; intermediate thickenings present. Median lobe cells 15-18 μm wide, 20-27 μm long, marginal cells subsodiametric, 18-23 μm in diam., similar to median leaf cells in shape and size but overall slightly less elongate. Cuticle smooth throughout. Larger leaf cells indicating ocelli not observed. Keel at an angle of 15-45°, 0.3(-0.5) the leaf lobe length, moderately arched, at base convex; the rear narrowly rounded distally, towards base becoming broadly rounded. Lobule large, widest near apex, 0.35-0.44 mm long and 0.25-0.37 mm wide; the portion adjacent to keel inflated; free margin flat, appressed to lobe, not clearly visible throughout but at least with two indistinct teeth (Fig. 10). Underleaves with somewhat inverted U-shaped insertion, weakly imbricate to slightly distant, suborbicular to reniform, entire-margined, 377-485 μm wide, 250-320 μm long, ca. 1.5-1.6× wider than long, about 3.2-5.4 times wider than stem, not decurrent, with rounded to almost cordate base, touching the stem or strongly reflexed to ventral side (Figs. 5, 7). Lamina concave or convex, without distinct area of rhizoid initials. Upper part of shoot (ca. 1/3 of the whole length) abruptly bent upwards, suberect, with smaller leaves, some of them detached and possibly serving for vegetative distribution.

The classification of amber inclusions is often hampered by their incomplete preservation and the way they are embedded in the fossil resin. This holds especially true for the hitherto known liverworts from Rovno amber, representing Lejeuneaceae and Frullaniaceae. Members of these families often grow attached to bark. If they are embedded together with parts of the substratum, their ventral sides are at best indistinctly visible. However, the ventral structures, *i.e.* lobuli, styli and underleaves, are often essential for a reliable identification; lack of information on these structures usually allows a classification only to the level of family or order.

Fortunately both the dorsal and the ventral sides of the new inclusion could be investigated, indicating the pres-

ence of a representative of Lejeuneaceae subfam. Ptychanthoideae. Although fertile structures are lacking and not all details of the sterile gametophyte were clearly visible, the morphology of the fossil allowed for rejecting an affiliation to other Ptychanthoideae species known from Eocene ambers, namely *Mastigolejeunea contorta* (Göpp. & Berendt) Gradst. & Grolle and *Spruceanthus polonicus* Grolle (Grolle & Meister, 2004). The subvertically positioned, squarrose leaves resemble extant representatives of *Acrolejeunea*, as do the dorsal leaf margins which are curved backwards (Figs. 2, 8). The suberect upper shoot sector with small leaves is also typical for *Acrolejeunea*. Further support comes from the arrangement of the lobe cells in curved rows which parallel the dorsal lobe margin (Figs. 4, 6), and the presence of cordate trigones as well as intermediate thickenings.

Molecular data indicate a Cretaceous age of *Acrolejeunea* (Wilson *et al.*, 2007) and hence do not contradict our interpretation. Currently only a few accessions of *Acrolejeunea* have been included in molecular analyses, hampering a detailed reconstruction of the evolutionary history of this genus. According to available data, the crown group of *Acrolejeunea* started to diversify in the Paleogene. Hence, the Eocene amber inclusion could represent either a member of the genus' stem lineage or of its crown group.

The Eocene age of the fossil renders the presence of an extant species unlikely, and the morphology of the species likewise differs from the extant diversity (Gradstein, 1975; Gradstein *et al.*, 2002; Renner, 2013). A detailed comparison with the extant species is hampered by the lack of knowledge on the exact constitution of the lobule, especially the number of its teeth. According to available evidence, the amber inclusion resembles the Paleotropical *A. pycnoclada* (Tayl.) Schiffn. but is more robust than this species, and has squarrose leaves. More fossils of *Acrolejeunea ucrainica* are necessary to scrutinize its present classification, and to amend the diagnosis.

Acrolejeunea ucrainica is the first representative of Lejeuneaceae described from Late Eocene Rovno amber, which already yielded *Frullania ucrainica* Konstant. & Ignatov and *F. varians* Casp. Only the latter species has so far been recognized in contemporaneous Baltic amber. According to current evidence, both Eocene amber deposits are dominated by inclusions of *Frullania* and Lejeuneaceae but differ with regard to species composition. A similar situation is seen in the amber liverwort floras of the Middle Miocene of the Dominican Republic (Reiner-Drehwald *et al.*, 2010) and Mexico (Grolle, 1984b), however, these amber floras were dominated by Lejeuneaceae rather than by *Frullania*, which hitherto has only rarely been observed in Dominican amber (Heinrichs & Schmidt, 2010).

It remains to be seen if these trends are confirmed by future studies on Cenozoic ambers, which hopefully will lead to further finds of liverwort inclusions. These inclusions will allow for a reconstruction of palaeocommunities of bryophytes colonizing either bark or the floor of past amber forests, and provide new insights into biogeographical patterns.

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