

## HEPATICS FROM ROVNO AMBER (UKRAINE)

### ПЕЧЕНОЧНИКИ ИЗ РОВЕНСКОГО ЯНТАРЯ (УКРАИНА)

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Abstract

Two species of the genus *Frullania* are revealed in the Late Eocene amber from Rovno (Ukraine). One is referred to *F. varians*, a widespread species in Baltic amber, whereas the second species with entire underleaves, similar to those in extant *F. davurica* and *F. jackii*, is described as a new species, *F. ucrainica* Konstant. & Ignatov. The latter is known by one short shoot fragment with perianth. A number of specimens are illustrated and briefly described as *Frullania* sp., as the deficit of characters does not allow precise identification.

Резюме

Два вида из рода *Frullania* выявлены в янтаре позднего эоцена из Ровно (Украина). Один из них отнесен к *F. varians*, широко распространенному виду из Балтийских янтарей; второй вид, с цельными амфигастриями, похожими на амфигастрии нынеживущих *F. davurica* и *F. jackii*, описан как новый для науки, *F. ucrainica* Konstant. & Ignatov. Он представлен одним коротким фрагментом побега с периантием. Для нескольких образцов даны иллюстрации и краткие описания, однако они определены только до рода, поскольку в них недостаточно признаков для более точного определения.

KEYWORDS: amber, Eocene, fossil, hepatics, Rovno Province, Tertiary, Ukraine

#### INTRODUCTION

Amber is the main source of information on Tertiary bryophytes, and many of them were found in Baltic and Bitterfeldian amber in Europe and Dominican amber in Central America (Frahm, 2010; Frahm & Newton, 2005). Rovno amber from Ukraine is actively studied now for its insects, and in the course of this study a number of bryophytes were found. An overview of mosses in Rovno amber was published by Ignatov & Perkovsky (2011), and in the present paper we describe liverworts from the same collections of the Institute of Zoology of the National Academy of Sciences of Ukraine, Kiev.

Rovno amber is found predominantly in the lower part of Mezhygorje Formation (Early Oligocene). Amber was also reported from Obukhov Formation (Late Eocene), but it was not confirmed by recent stratigraphic studies (Perkovsky *et al.*, 2010).

However, the insect fauna indicates that the age of the Rovno amber is identical to that of the Baltic amber (Kosmowska-Ceranowicz, 1999; Perkovsky *et al.*, 2003) and corresponds to Late Eocene (see Perkovsky *et al.*, 2007, 2010; Aleksandrova & Zaporozhets, 2008a, b).

Amber specimens from Klesov were excavated from Pugach quarry, where most of Rovno amber material was

obtained, except for KF-21 found in Fedorovka (Maidanovich & Makarenko, 1988, Fig.7); the origin of UA-1966 is Pugach quarry or Dubrovitsa (Vol'noje) quarries (Perkovsky *et al.*, 2010), the origin of UA-5027 is indefinite.

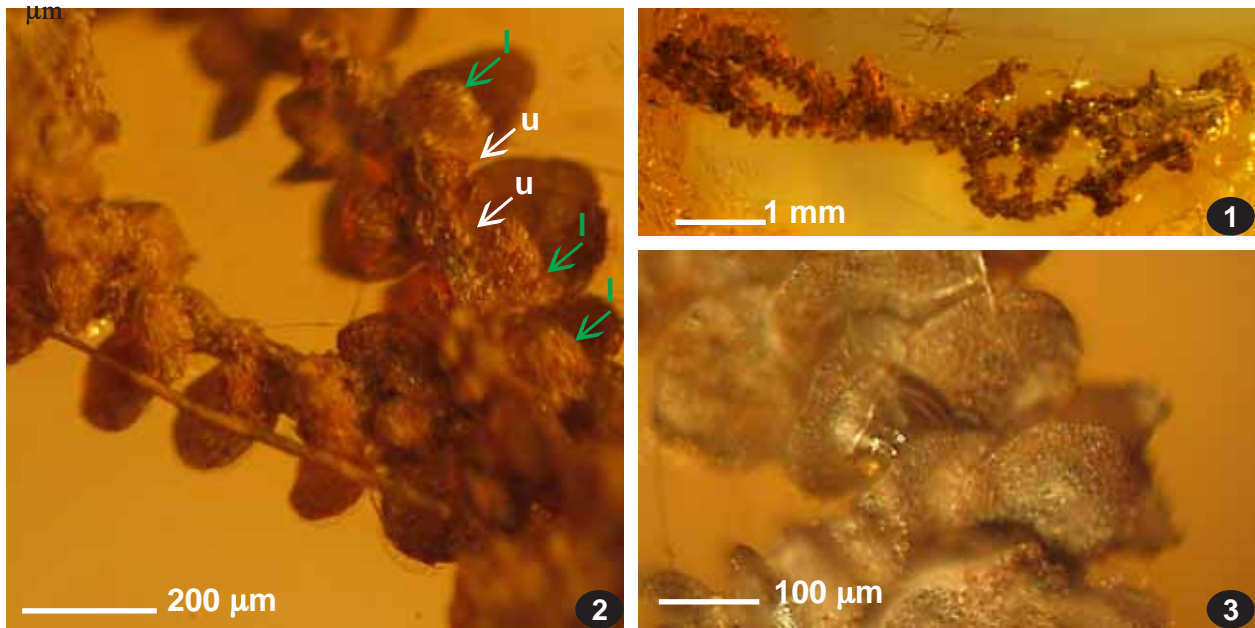
#### GENERAL COMMENTS

Hepatic have been known in the Baltic amber since the mid-XIX century (Berendt, 1845), and their findings in Baltic and Bitterfeldian ambers were described in dozens of publications. Grolle & Meister (2004) provided a comprehensive corollarium of this hepatic flora, supplying it with the key to 16 genera of hepatics and one hornwort, *Nototylas* (the further calculations include this single hornwort together with liverworts). After the revision of all available collections, the list of hepatics included 26 species; all of them were referred to extant genera. Among these collections, only seven specimens with perianths, belonging to six species, were known. Most genera were represented by a single species, while the diversity of the genus *Frullania* was outstanding: it included as much as 9 species. When the number of collections with hepatics was counted, the dominance of *Frullania* became even more sound: 55 out of 129 hepat-

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Figs. 1-3. *Frullania varians* Casp. (from SIZK-K-1248): 1 – habit; 2 – view of shoot from ventral side, showing underleaves (u) and lobules (l); 3 – view of shoot from dorsal side.

ic specimens in the Baltic amber and 45 out of 92 in the Bitterfeldian amber belonged to this genus. In addition, 60 out of 100 *Frullania* specimens belonged to one species, *F. varians*.

Thus it is not surprising that the Rovno amber collections include *Frullania*, and at least some of them fit *F. varians*. No representatives of other genera were observed.

Grolle & Meister (2004) provided the key, descriptions and illustrations for *Frullania* species. However, they used some characters important for identification that are clearly seen only from the ventral side of shoot. Unfortunately, in many amber specimens, plants are laying on opaque material or are situated too deep in the amber piece, and therefore it is impossible to study these charac-

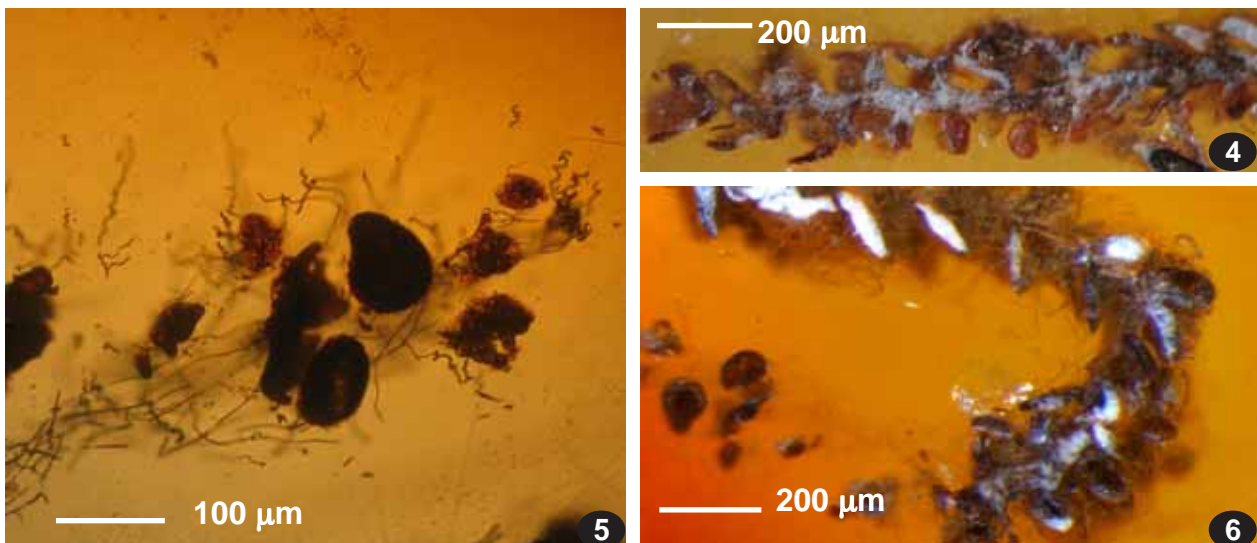
ters. Thus only few specimens have enough characters to be either identified or described as new taxa.

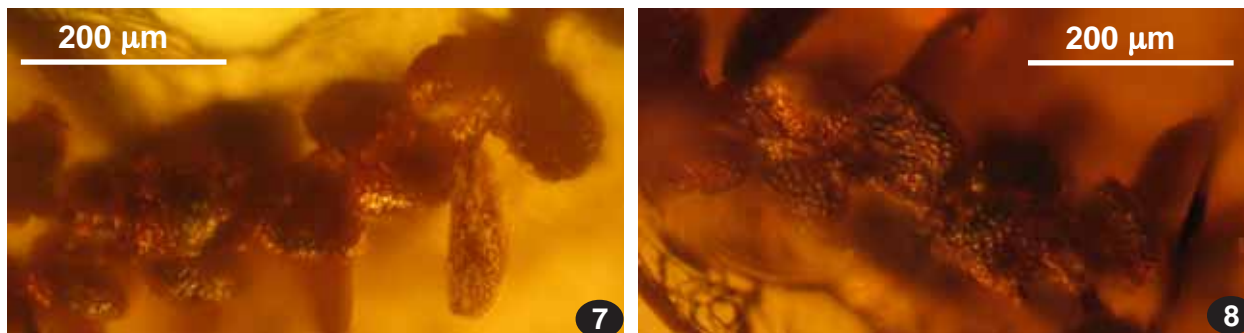
In addition, a remark similar to that made by Ignatov & Perkovsky (2011) for mosses, is necessary. Most, if not all, hepatics from amber collections were epiphytic plants, which were sunk in the resin of *Pseudolarix* (Anderson & LePage, 1996). Epiphytic growth itself makes plants thinner, and, in addition, the probability of being stuck in the resin is higher for small broken parts of plants, especially fragile branches. Therefore it is not especially surprising to see plants with dimensions at the lowest possible limits.

\* \* \*

All specimens are housed in the amber collection of the Schmalhausen Institute of Zoology in Kiev (SIZK).

Figs. 4-6. *Frullania varians* Casp. (from SIZK-K-21), rather slender shoot: 4 – habit; 5 – partly decomposed upper part of shoot with elaters; 6 – shoot with weft of hyphae (rhizoids?) and elaters mixture.





Figs. 7-8. *Frullania varians* Casp. (from SIZK-K-964): one thin shoot photographed at different angles, showing widely spreading leaves with lobules almost equal to lobes.

Ants mentioned as syninclusions for liverwort specimens were determined by G.M. Dlussky, spiders by K.Yu. Eskov, most mites by A.A. Khaustov and E.A. Sidorchuk, other syninclusions by the third author.

#### TAXONOMY

Genus **Frullania** Raddi (extant, family Frullaniaceae)

**Description.** Leafy liverwort. Plants small, medium-sized to robust. Shoots creeping, clearly dorsiventral, sparsely to abundantly branching, branches mostly of *Frullaria*-type, rarer of *Lejeunea*-type. Leaves deeply treefed, distinctly differentiated into large, more or less flat dorsal lobe ('lobe'), smaller, mostly sac-like to evolute ventral lobe ('lobule') and filiform to broad-based stylus. Lobes round to asymmetrically ovate, entire to occasionally denticulate; lamina cells hexagonal, with or without trigones. Lobules elongate to saccate or galeate, sometimes evolute. Underleaves present, relatively large, entire to bilobed, sometimes with lateral teeth. Autoicous or dioicous. Perianth polymorphic, generally trigonous but often with additional keels and ridges; beak usually short.

**Type species:** *Frullania major* Raddi [= *F. dilatata* (L.) Dumort.], widely distributed in Holarctic.

The genus includes ca. 350 species (Frey & Stech, 2009) growing in temperate to tropical areas, although few species occur in arctic and alpine environments as well.

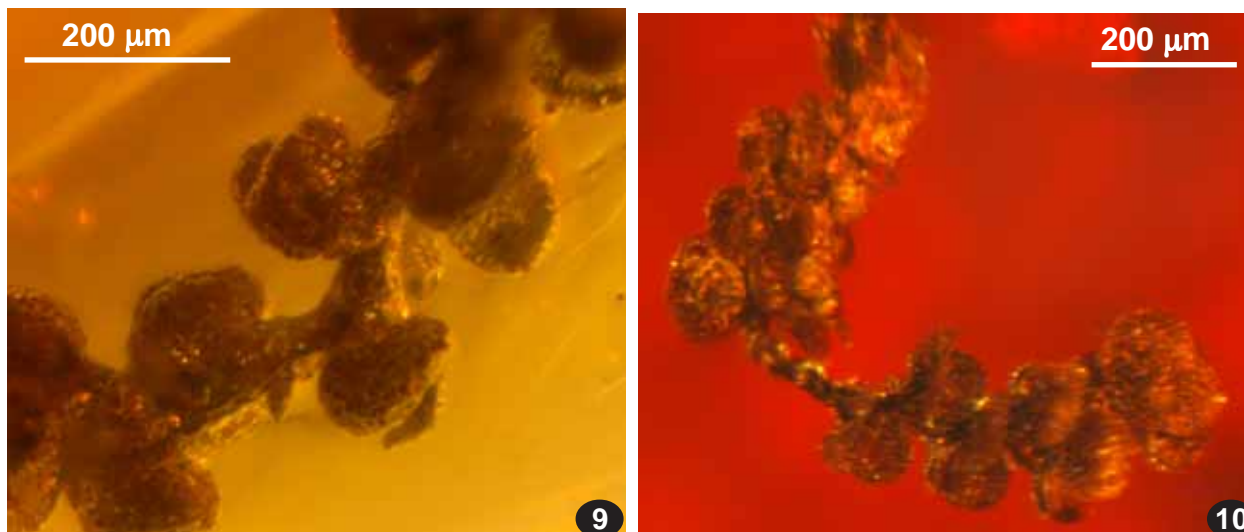
Grolle & Meister (2004) in their revision recognized 9 species of *Frullania* in Baltic and Bitterfeldian amber; in addition, several species were described from Dominican amber (Heinrichs & Schmidt, 2010). The recently found *Frullania* in Early Cretaceous amber in Myanmar is the oldest known one (Hentschel *et al.*, 2009; Heinrichs *et al.*, 2012a).

The present collection of Rovno amber includes 9 specimens in which plant structure is more or less available for study. A few very small ends of shoots apparently of the same genus were also seen, but they are not described here. Unfortunately, many characters significant for the taxonomy of the genus *Frullania*, were unavailable for examination. According to Schuster (1992), "lobule form has been constantly used as a major criterion..." for *Frullania* taxonomy; however, in the present material lobules are seen in only three shoots.

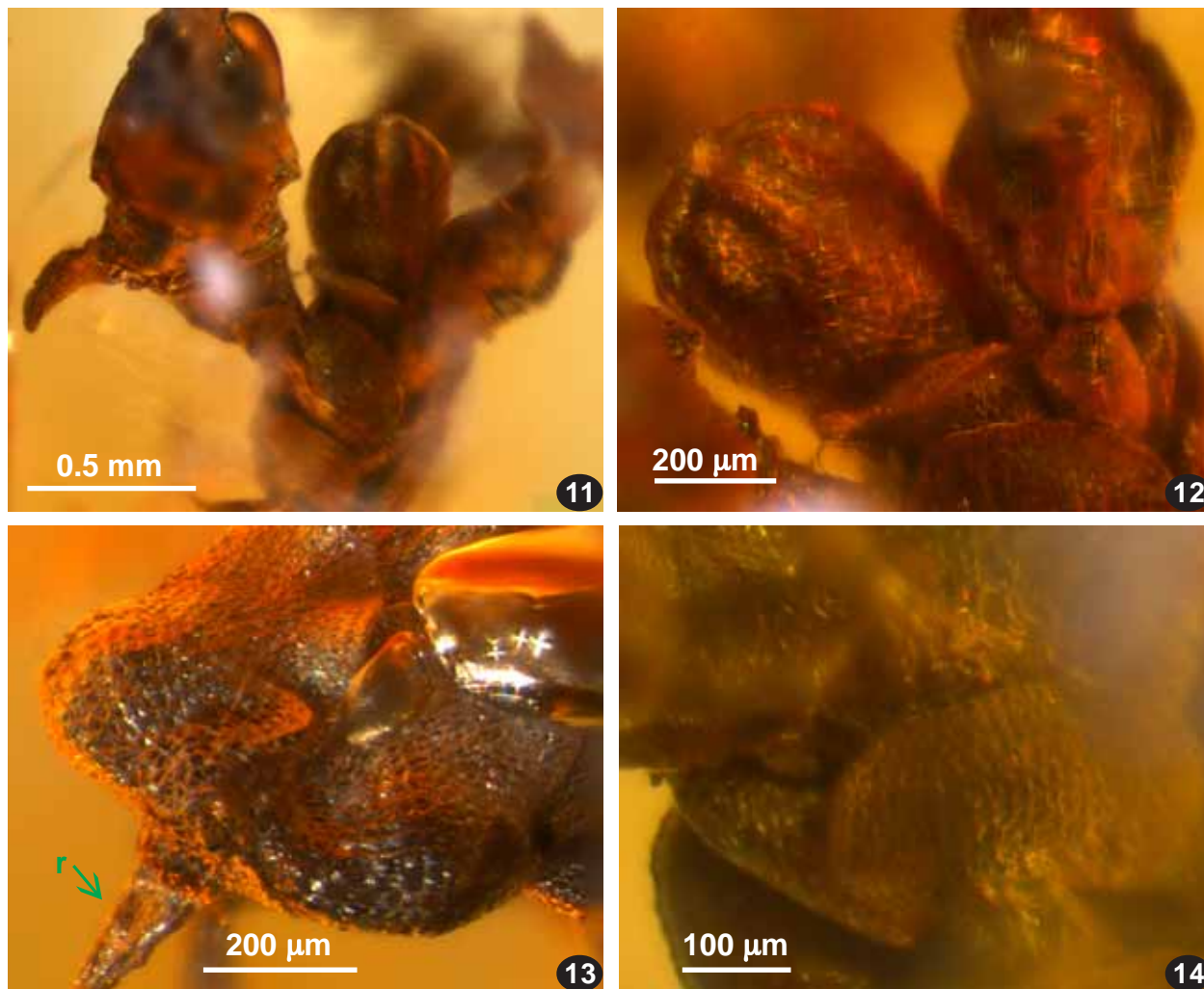
**Frullania varians** Casp. (fossil, described from Baltic amber, Late Eocene) Figs. 1-10.

**Material.** The essential characteristics of this species

Figs. 9-10. *Frullania varians* Casp. (9: from SIZK-UA-1966; 10: from SIZK-K-10023), slender shoots with remotely arranged and (in #10) partly caducous leaves.







Figs. 11-14. *Frullania ucrainica* Konstant. & Ignatov, sp. nov. (from holotype, SIZK-K-6581): 11 – habit, dorsal-apical view; 12 – perianth and subterminal shoot from ventral side, showing underleaves; 13 – base of shoot, view from dorsal side, with, probably, of a bundle of rhizoids (arrowed, r); 14 – shoot, view from ventral side, large underleaf is seen.

are deeply bilobed underleaves and caducous leaves in ultimate branches. In the present collection only one specimen has two underleaves which are apparent enough to describe their shape (Fig. 2).

Four additional specimens have small and partly caducous leaves, thus they should likely be placed in this species (Figs 4-10). One of them has abundant elaters interwoven with rhizoids and/or fungi.

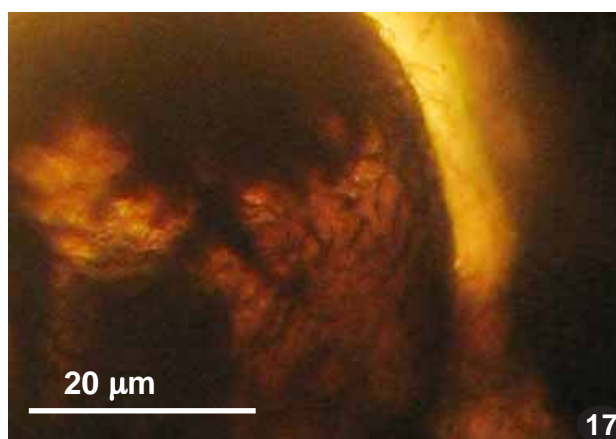
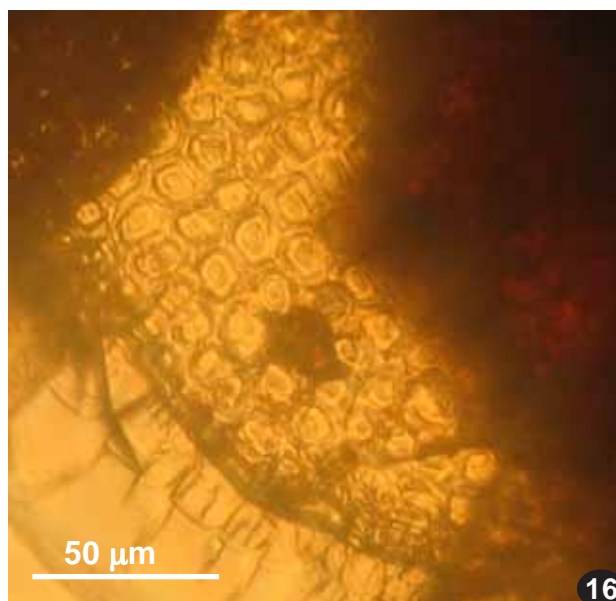
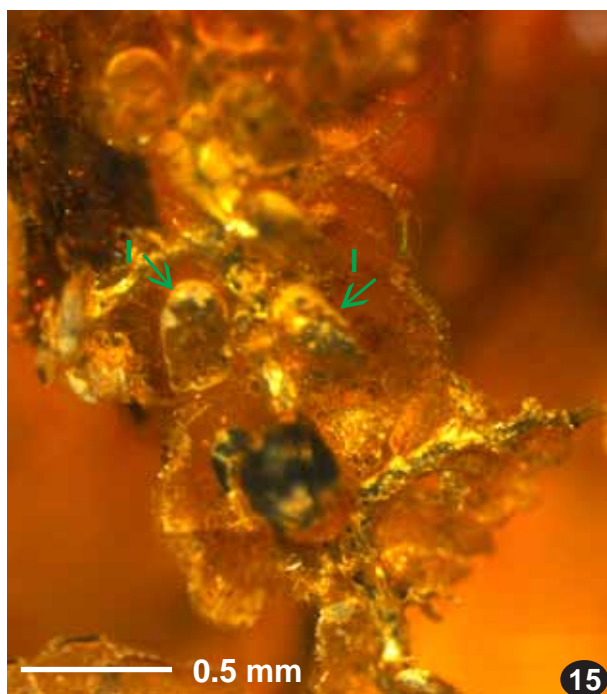
**Description.** Shoots red-brown, up to 5 mm long, irregularly branching, with leaves 200-400 µm wide. Stems 40-65 µm in diameter, cortical cells rectangular, ca. 30×10 µm. Leaves remote to imbricate, 160-220×160-220 µm, narrowly transversely inserted, with very short keel. Lobes as long as wide, slightly convex in dorsal view; dorsal margin evenly rounded, entire throughout; cells rounded-hexagonal, 13-16×12-16 µm, without distinct trigones. Lobules sac-like, 100-160×100-160 µm, elongate to rounded, gradually decreasing to mouth; margin entire; cells smaller than those of lobe, smooth. Underleaves not overlapping, ca. 1.5 times wider than stem, 80×90 µm, bilobed for 2/3 the length, sinus acute, lobes triangular,

somewhat longer than wide. Shoots with smaller caducous leaves present. Elaters ca. 100-150×10 µm.

According to Grolle & Meister (2004), this species is autoicous. These authors provided also perianth description, while capsules with spores and elaters were described by Heinrichs *et al.* (2012b).

**Specimens examined:** (1) Rovno amber. Late Eocene. SIZK-UA-1966; (2) Klesov. Rovno amber. Late Eocene. SIZK-KF-21; (3) Klesov. Rovno amber. Late Eocene. SIZK-K-964 [syninclusions: female of Chironomidae (Orthoclaadiinae) (K-964), Sciaridae (K-965), Acari (Anystidae) (K-966)]; 4) Klesov. Rovno amber. Late Eocene. SIZK-K-1248; [syninclusions: Collembola, Entomobryomorpha (K-1247), Collembola, Entomobryomorpha (K-1248), Chironomidae, 2 Acari (Parasitengona) (K-1249)] 5) Klesov. Rovno amber. Late Eocene. SIZK-K-10023 [syninclusions: stellate hairs, spider web].

**Comparison.** The position of *F. varians* in the section *Microfrullania* (R.M. Schust.) R.M. Schust. was explained by Grolle & Meister (2004) by *Lejeunea*-type of branching, very small size of plants, subquadrate lobe cells without or with very weak trigones, and entire-mar-



Figs. 15-17. *Frullania* sp. 1 (from SIZK-K-2012): 15 – shoot, view from ventral side, lobules arrowed; 16 – lobe cells; 17 – rather unclear view of lobule (left lobule arrowed in Fig. 15), showing smooth cells.

gined gynoecial leaves and underleaf.

***Frullania ucrainica*** Konstant. & Ignatov, sp. nov. Figs. 11-14.

*Frullania* sp. Perkovsky et al., 2010, fig. 10 B.

HOLOTYPE: Klesov. Rovno amber. Late Eocene. SIZK-K-6581 [syninclusions: 4 workers of *Dolichoderus* sp. (Formicidae) (K-6580), Collembola, Entomobryomorpha (K-6581)].

**Material.** There is only one specimen with perianth, which is not surprising, as in numerous and long-accumulated collections of Baltic and Bitterfeldian amber only 7 specimens with perianths were found (Grolle & Meister, 2004). The specimen is represented by the densely foliated shoot ca. 1.5 mm long, terminated with perianth, with two subterminal innovations, on which underleaves are well seen, but it is impossible to say if lobules are hidden under underleaves, or they are absent, and then the specimen does not belong to *Frullania*. However, two broad underleaves are well seen on stem (Fig. 14).

The attribution of this specimen to the genus *Frullania* is based largely on perianth shape. All Lejeuneaceae species known from amber have trigonal perianths, whereas the clearly pentagonal one is presented here.

**Description.** Shoots with leaves 650 μm wide, with subterminal branches. Stems ca. 170 μm in diameter. Leaves closely imbricate, obliquely inserted. Lobes as long as wide, ca. 270×270 μm; dorsal margin evenly rounded, entire throughout; cells rounded-hexagonal to sub-

quadrate, 15-22 μm, without distinct trigones. Underleaves not overlapping, ca. twice wider than stem, broad, entire, 350×150 μm, broader than long, underleaf cells 18-24×11-16(-20) μm.

Perianth 600×450 μm, exerted from involucre, elongate, obovate, in upper 1/5 with 5 low smooth longitudinal folds, otherwise smooth. Beak short.

Involucral leaves broadly rounded, similar to lobes.

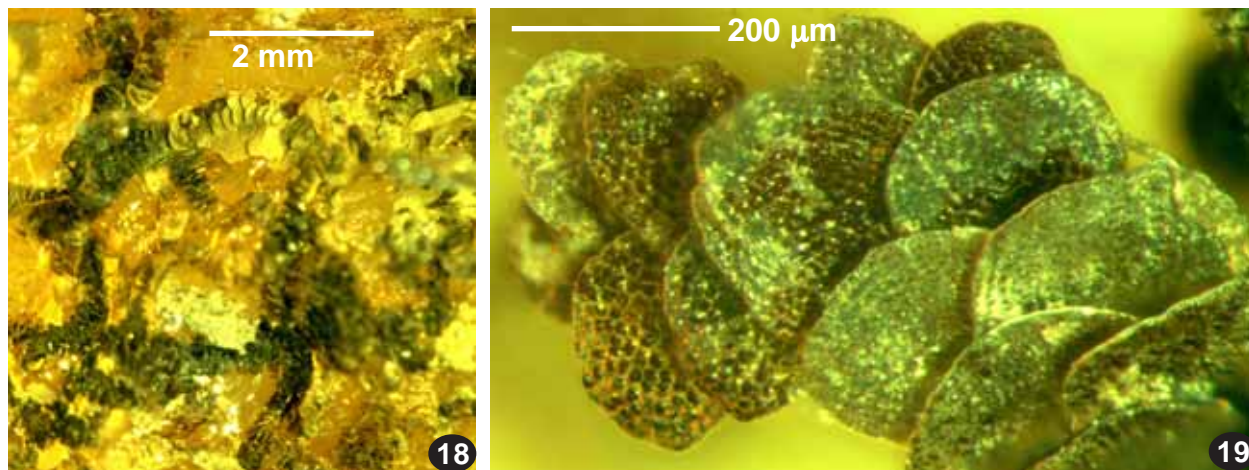
Leaves and underleaves on innovations smaller, underleaves as long as broad.

**Comparison.** All other fossil *Frullania* species have bilobed underleaves. Among modern groups, this specimen relates to *F. davuricum* and *F. jackii*.

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Three fragments of *Frullania* (Figs. 15-22) are left without exact identification. One of them has large plants and lobules, while another one has larger laminal cells, so they cannot be referred to *F. varians*. The first specimen has conspicuous lobules, but underleaves are not clearly seen (Figs. 15-17). Two other specimens (Figs. 18-22) are clearly seen only from the dorsal side, which does not help much with species identification. Thus these specimens are described as sp. 1 and sp. 2.





Figs. 18-19. *Frullania* sp. 2. (from SIZK-K-10049): 18-19 – shoots, dorsal views.

***Frullania* sp. 1** (Figs. 15-17).

**Description.** Shoots red-brown, up to 4 mm long, with leaves ca. 1 mm wide; stem branching, branches deviating at right angle. Stem ca. 100  $\mu\text{m}$  in diameter. Leaves imbricate, obliquely inserted. Lobes as long as wide, ca. 200 $\times$ 200  $\mu\text{m}$ , dorsal margin evenly rounded, entire throughout; cells rounded-hexagonal, 11-15 $\times$ 11-15  $\mu\text{m}$ , without distinct trigones. Lobules sac-like, ca. 350 $\times$ 230  $\mu\text{m}$ , elongate; cell of lobules smooth.

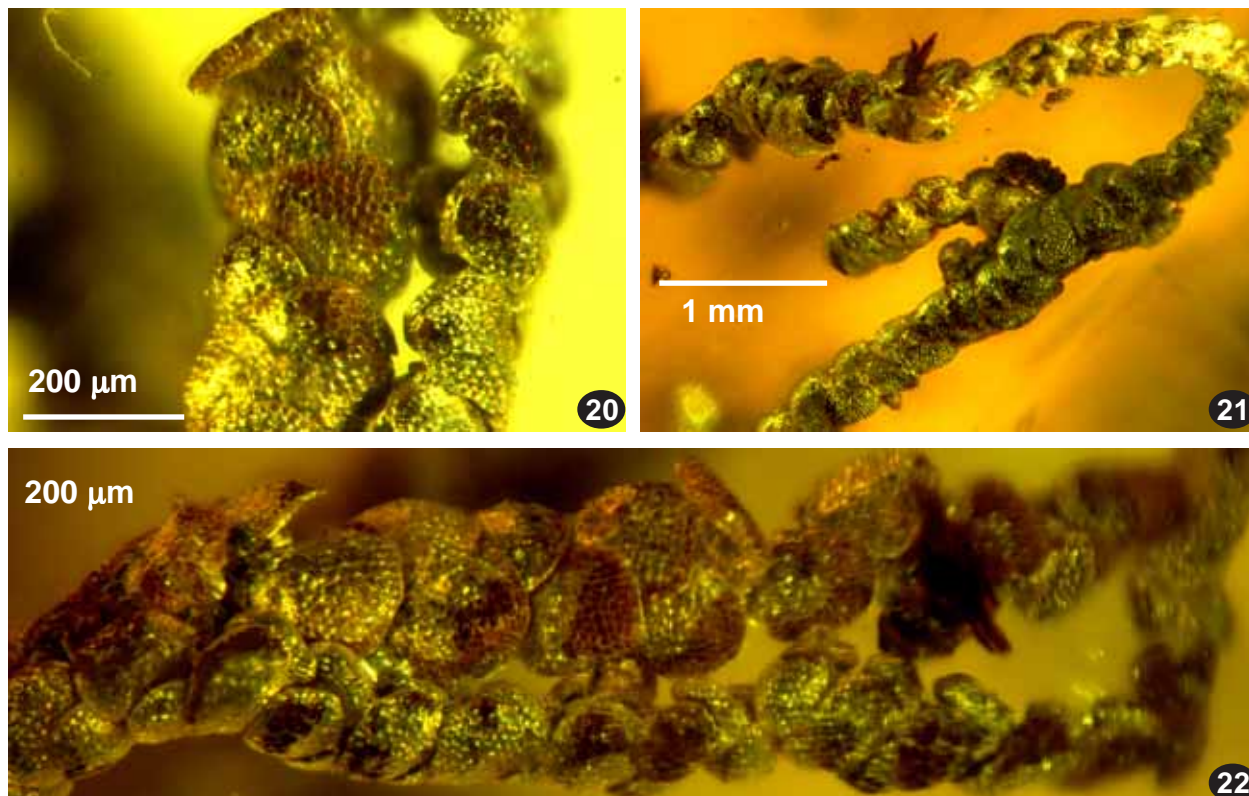
**Specimens examined:** (1) Klesov, Rovno amber, Late Eocene. SIZK-K-2012 [syninclusions: 3 ant workers (1 – *Cam-*

*ponotus mendei* Mayr), 2 Acari (1 – Oribatei, Carabodidae, 1 – Erythraeidae, spider web (K-2012), worker of Formicidae inc. s. (K-2013)];

***Frullania* sp. 2** (Figs. 18-22).

**Description.** Shoots no less than 10 mm long, ca. 400  $\mu\text{m}$  wide with leaves; stem branching, branches deviating at wide angle, but then growing at narrow angle with the stem. Leaves closely imbricate, obliquely inserted. Lobes as long as wide, ca. 200-300 $\times$ 180-300  $\mu\text{m}$ , dorsal margin evenly rounded, entire throughout; cells rounded-hexagonal, 18-22 $\times$ 15-22  $\mu\text{m}$ .

Figs. 20-22. *Frullania* sp. 2. (from SIZK-UA-5027), 20-22 – shoots, dorsal views.



**Specimens examined:** (1) Klesov, Rovno amber, Late Eocene. SIZK-K-10049F; (2) Rovno amber. Late Eocene. SIZK-UA-5027 [syninclusions: 3 Mycetophilidae, Coleoptera, Aranei (UA-5019), Mycetophilidae (UA-5020), Mycetophilidae, Phoridae, Coleoptera, Collembola, Entomobryomorpha, 2 Acari (1 – Oribatei, Carabodidae) (UA-5021), Aranei (UA-5022), Collembola, Entomobryomorpha (UA-5023), worker of Myrmicinae (Formicidae), 2 Aderidae (Coleoptera) (UA-5024), worker of *Tapinoma electrinum* Dlussky (Formicidae) (UA-5025), Mycetophilidae (UA-5026), 4 Mycetophilidae, Coleoptera, Acari (UA-5027).

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