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MOSSES FROM SAKHALINIAN AMBER (RUSSIAN FAR EAST)

МХИ ИЗ САХАЛИНСКОГО ЯНТАРЯ (РОССИЙСКИЙ ДАЛЬНИЙ ВОСТОК)

MICHAEL S. IGNATOV[1] & EVGENY E. PERKOVSKY[2]

МИХАИЛ С. ИГНАТОВ[1], ЕВГЕНИЙ Э. ПЕРКОВСКИЙ[2]

Abstract

Mosses are found in Middle Eocene amber from Sakhalin in the Russian Far East for the first time. They are referred to form-genera of Hypnalean mosses and described as *Brachytheciites sachalinensis* sp. nov. and *Pseudoleskeellites obscurus* gen. et sp. nov. Both species are known by gametophytes with partly observable leaf cell structure.

Резюме

Приводится первая находка мхов из Сахалинского янтаря среднеэоценового возраста. Выявлены два вида, которые описываются в форм-родах бокоплодных мхов, *Brachytheciites sachalinensis* sp. nov. и *Pseudoleskeellites obscurus* gen. et sp. nov. Оба вида представлены гаметофитами с отчасти различимым клеточным строением листьев.

KEYWORDS: fossil, mosses, amber, Sakhalin, Middle Eocene, *Brachytheciites, Pseudoleskeellites*

INTRODUCTION

Amber is probably the main medium for preservation of mosses of Tertiary and Late Mesozoic time. The richest source for them remains the Late Eocene Baltic amber in Europe, whose moss inclusions were recently summarized by Frahm (2010).

Middle Miocene Dominican amber is probably even richer (cf. Frahm & Newton, 2005), but it still attracts less attention and data on its bryophyte findings are not fully summarized yet. Recent additions were made from the Ukrainian Rovno amber (Ignatov & Perkovsky, 2011, 2013), whose species composition appeared to be rather similar to that of the Baltic amber moss flora.

In Asia, only a few recent reports are known, both referred to Late Cretaceous. Bell & York (2007) described *Vetiplanaxis* N.E. Bell with one species *V. pyrrhobryoides* N.E. Bell from birmite (Myanmar) amber, the species compared with modern *Hypnodendron*. Katagiri *et al*. (2013) described *Muscites kujiensis* from Japan, which did not have enough characteristics for definite placement among modern genera or families.

No mosses have been reported from the Sakhalin amber from the Russian Far East. This amber attracted attention of palaeontologists after the expedition of the Palaeontological Institute, Academy of Sciences of the USSR, in 1972. Numerous insects were collected in it by V.V. Zherikhin and I.D. Sukacheva and listed and described by Zherikhin (1978). The amber was found on the beach of the Okhotsk Sea near the village Starodubskoye, Dolinsky District, close to the mouth of the Naiba River. In *situ,* fossil resin of the same composition was found later at the Naiba River embedded in coal of the Naibuchi Formation (Kodrul, 1999). The age of the amber thus has been dated by Kodrul as Middle Eocene

Baranov *et al*. (2014) summarized Sakhalinian paleontological and geological records in the locality of amber accumulation. Species composition of vascular plants and insects indicates clearly an extensive swampy environments of the coniferous 'amber forest'.

The Sakhalinian amber belongs to the rumanite-type. Common for such fossil resins (rumanite, simetite, delatynite, schraufite, burmite, *etc*.) is a high degree of polymerization of the resin itself and deformation caused by thermal metamorphosis during the diagenesis. Insects in Sakhalinian rumanite are often deformed (Rasnitsyn & Quicke, 2002), and mosses also are less clearly seen comparatively with the european Baltic and Rovno succinite-type ambers.

MATERIAL AND METHODS

The collection discussed in the present paper was gathered on the beach of the Okhotsk Sea near Starodubskoye in 1972. Specimens are kept in A.A. Borissiak Paleontological Institute, RAS, Moscow (PIN).

Mosses were found in five pieces of amber. They obviously represent two species. The first one is represented by numerous shoots in four pieces (Figs. 1-10), while another is known by only poorly discernible inclusions in one piece (Figs. 11-12) , although the cell structure is visible (Figs. 13-14).

The material referred to the former species is variable. Leaves in some shoots are long acuminate to filiform distally, while others have gradually tapered short acuminate leaves. Their attribution to the same species is based on co-occurrence, transitions in leaf shape seen within some individual shoots, and consideration the variation in modern mosses of similar habit.

[1] – Main Botanical Garden, Russian Academy of Sciences, Botanicheskaya 4, Moscow 127276 Russia, e-mail: misha_ignatov@list.ru
[2] – Schmalhausen Institute of Zoology of the Ukrainian National Academy of Sciences, B. Khmelnitsky str., 15, Kiev 01-106, Ukraine; e-mail: perkovsk@gmail.com

Genus **Brachytheciites** J.-P. Frahm (form-genus, family Brachytheciaceae)

Description: Plants medium-sized, in loose tufts or growing by solitary shoots. Stem moderately dense terete foliate. Leaves erect to spreading, ovate-lanceolate to lanceolate, short to long acuminate, ±concave; costa disappearing above mid-leaf or in narrow part of acumen; margin entire or subentire, plane. Laminal cells elongate to linear, smooth.

Type species: *Brachytheciites veltenii* J.-P. Frahm, Late Eocene, Baltic amber.

Even in the modern moss flora, the species of the Brachytheciaceae are often misidentified and/or referred to other families, especially the Amblystegiaceae and the Meteoriaceae. Lanceolate leaves with costa and long cells are a combination occurring in all of them, and as this combination is about all that can be seen in the fossil collection under question, any linkage to modern families will be far from well based. The hygrophilous Amblystegiaceae taxa, *e.g. Campyliadelphus* are similar in many respects to the present collection (spreading entire leaves are characteristic for them), although stolons with much smaller leaves are not known in this family. The wetland entomofauna represented in Sakhalinian amber, however, has to be kept in mind, and additional material may provide more evidence of the position of this moss in Amblystegiaceae. Species of the Meteoriaceae are similar to *B. sachalinensis* in long attenuate leaves, but lamina cells in almost all species of this family are papillose, which would likely be seen in images as in Figs. 8 and 10. Species of the Brachytheciaceae, especially *Brachythecium* itself, have the least number of dissimilarities. The only species so far referred to the form-genus *Brachytheciites*, *B. veltenii,* is also characterized by lanceolate leaves with costa to 2/3 up-leaf and prosenchimatous cells (Frahm, 2010).

Brachytheciites sachalinensis sp. nov. Figs. 1-10

Holotype: PIN 3387/165, Sakhalinian amber, Middle Eocene. Figs. 5, 7, 9, 10.

Description: Stems >5 mm long, 50-85 μm wide, without paraphyllia and apparent branching, densely to loosely terete foliate. Rhizoids abundant on small-leaved stolon shoots. Leaves erect to spreading, 0.9-1.5 mm long, 0.3 mm wide, in stolons 0.4×0.1 mm, from ovate or ovate-lanceolate base gradually of moderately abruptly tapered to acumen, lanceolate in shorter leaves to filiform in larger leaves, slightly concave, channeled above being semilunar on cross section; not plicate; margin plane, not bordered, entire to indistinctly serrulate distally, costa distinct up to acumen in short acuminate leaves, disappearing in narrow part of acumen in long acuminate subpiliferous leaves; ca. 40 μm wide below. Laminal cells linear elongate, 4-10:1, 25-50×5-8 μm.

Material: The species is found in four pieces of amber. PIN 3387/165 inlcudes holotype (3387/165), another shoot, poorly seen as situated in dark area (3387/164), and several cut off leaf apices lying near holotype shoot and likely originated from it (unnumbered). Similar dispersed apices are seen in #3387/163 (Figs. 1, 3, 8).

Holotype is represented by several shoots (Figs. 5, 7), likely in a compact group, and judging from similarity and arrangements, belonging to one plant. Leaves are spreading below, at 40-80°, to 1.5 mm long, 0.3 mm wide, more long acuminate, with filiform acumens (Figs. 7, 9), the latter constituting about half of leaf; costa reaching at least the lower part of acumen.

PIN 3387/163 includes six shoots, some with longer leaves similar to holotype. Other shoots have short and more gradually acuminate leaves ca. 1 mm long, somewhat more rigid, forming an angle of 15-50°(-65°) with the stem (Figs 1-3). Costa is reaching apex in such leaves (Fig. 2).

PIN 3387/162 includes six shoots, leaves vary from widely spreading to erect near shoot apices (Fig. 6).

PIN 3387/161 is a stoloniform shoot, with smaller leaves ca. 0.5 mm long, 0.1 mm wide and numerous rhizoids.

The referring of all these plants to *Brachytheciites sachalinensis* is based on leaf shape, whose variation is generally similar to what is seen in the extant species of pleurocarps. Cells are seen in few places (Figs. 2, 5, 8, 10), their width is commonly 5-7 μm, while the length is not as clearly seen and can be only roughly estimated as 25-50 μm.

Comparison: The type species of *Brachytheciites* is a smaller plant, with costa reaching 2/3 of leaf length, whereas in the new species it is disappearing within the very narrow part of acumen, while in a less long acuminate leaves it is percurrent.

Among Rovno amber mosses, the most similar is *Palamocladium fossile* Ignatov & Perkovsky, as it also has long acuminate leaves and costa almost to the apex. However, this plant differs from *B. sachalinensis* in more rigid leaves arranged at the angle ca. 30° along all their length (never spreading or reflexed), somewhat plicate (which is not the case in *B. sachalinensis*) and serrulate at margin (as far as one can see in *B. sachalinensis*, they are entire).

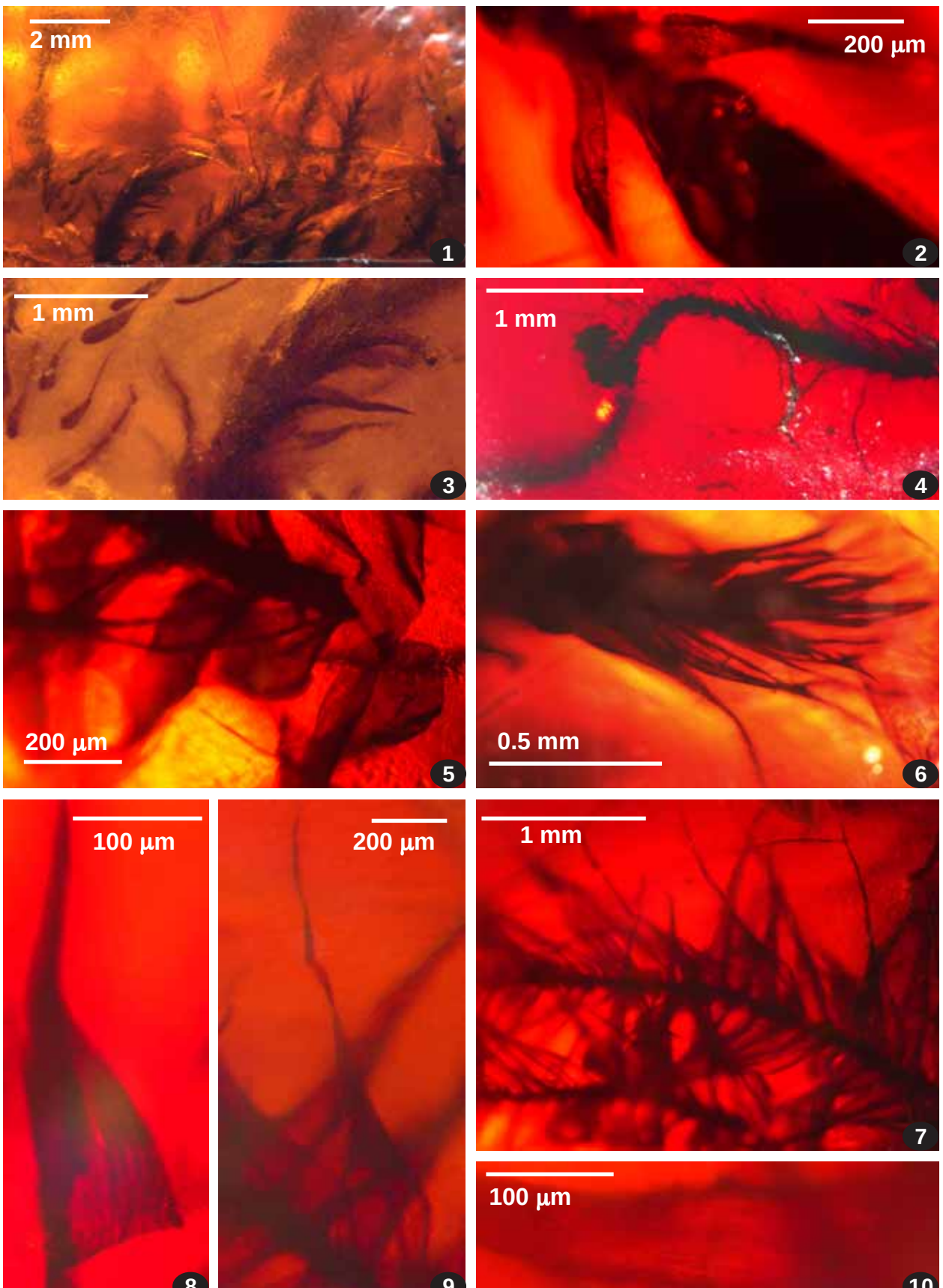
Specimens examined: PIN 3387/165, 1966, 168, 169. Sakhalinian amber, Middle Eocene.

Genus **Pseudoleskeellites**, gen. nov. (form-genus, order Hypnales, family indefinite)

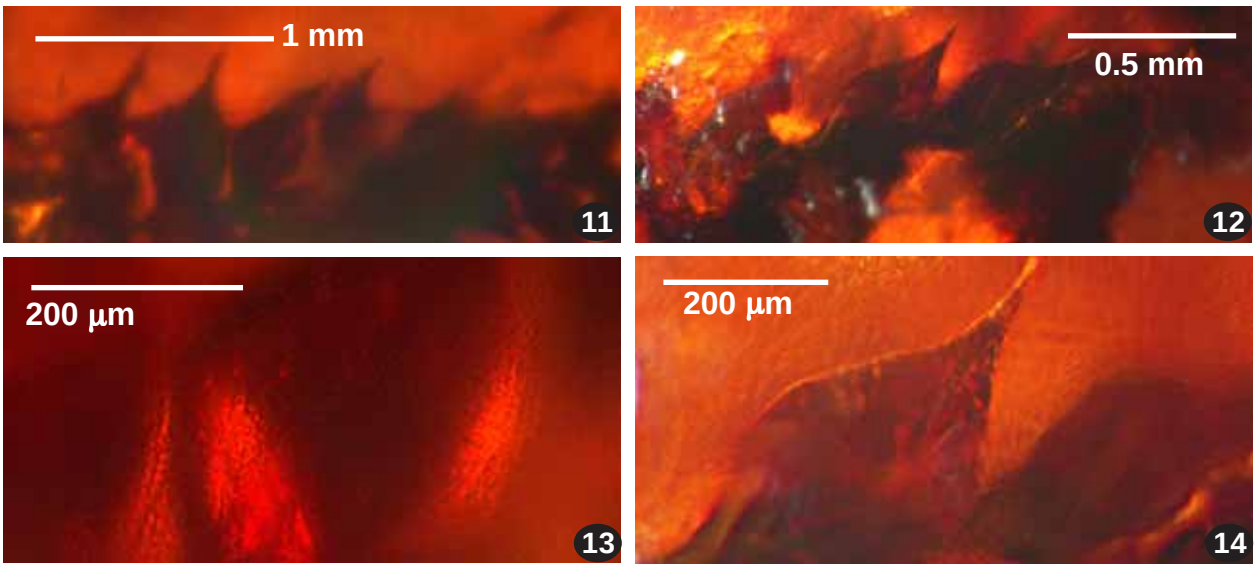
Description: Shoot with 3 leaves per 1 mm. Leaves erect-spreading to spreading, from broadly ovate base gradually tapered to short acumen, concave, margin entire; costa not apparent in upper half of leaf; laminal cells quadrate to short rectangular.

Type species: *Pseudoleskeellites obscurus* sp. nov. [Sakhalinian amber, Middle Eocene].

Due to imperfect preservation the number of characters of this moss is limited and only leaf shape, margin and cell shape can be seen. The absence of strong costa indicates more probable position of this species in Hypnales (most of pleurocarpous mosses), and overall leaf shape supports this placement. However, within this order, short leaf cells are characteristic for epiphytic habitats and parallely evolved



Figs. 1-10. *Brachytheciites sachalinensis* sp. nov. (Sakhalinian amber, Middle Eocene – **1-3, 8**: PIN 3387/163; **4**: PIN 3387/161; **5, 7, 9-10**: PIN 3387/165 (holotype); **6**: PIN 3387/162). 1, 3, 5, 6, 7 – habit; 2 – leaves with some cells visible; 4 – stoloniform shoot; 6 – shoot tip; 8 – broken leaf; 9 – leaf with long filiform acumen; 10 – areolation in middle part of leaf.



Figs. 11-14. *Pseudoleskeellites sachalinensis* sp. nov. (Sakhalinian amber, Middle Eocene – **11, 13**: PIN-3387/167; **12, 14**: PIN-3387/166, holotype). 1-2 – habit; 3 – mid-leaf cells, as seen from leaf dorsal side; 4 – leaf, showing areolation in its distal part.

in most of large families (Ignatov *et al*., 2007). Thus, the familial placement is not certain: the specimen can be referred to the Leskeaceae (*Pseudoleskeopsis*), Regmatodontaceae (*Regmatodon*), Pseudoleskeellaceae (*Pseudoleskeella*), Pseudoleskeaceae (*Lescuraea*), Amblystegiaceae (*Cratoneuron*), Brachytheciaceae (*Clasmatodon*), Taxiphyllaceae (*Leptopterigynandrum*).

Pseudoleskeellites obscurus sp. nov. Figs. 11-14

Holotype: PIN 3387/166 Sakhalinian amber, Middle Eocene (Figs. 12, 14); paratype PIN3387/167 (Figs. 11, 13).

Description: Shoots moderately densely terete foliate, with ca. 10 leaves per 1 mm. Leaves forming an angle 50-70° with the stem, 0.4-0.5 mm long and 0.2-0.3 mm wide, from broadly ovate base gradually tapered to short acumen, concave, margin entire; costa not apparent in upper half of leaf; laminal cells quadrate to short rectangular, ca. 15 µm.

Material: The species is found in one piece of amber, and represented by two shoots. One with sparser leaves with better seen cells (Fig. 14) is selected as the holotype, it is less than 1.5 mm long. Another one is 3 mm long, more densely foliate, with 4 leaves on one of its side, thus with ca. 10 leaves from all sides, with poorly seen but still discernible laminal areolation (Figs. 13). Indistinct darker area in the middle of some leaves may indicate costa in lower half of leaf, but what can be stated definitely is that in upper half of leaf it is absent.

Comparison: There are not many mosses in Eocene amber without long costa and short laminal cells at the same time. *Neckerites* from Rovno amber is one of them, but it has coarsely serrate leaves and its cells albeit short are somewhat elongate. Among extant mosses, *Pseudoleskeella* is one of the most similar, *e.g.* in the pattern of constriction to apex. However, species of *Leptopterigynandrum, Lindbergia*, *etc*. may have a similar appearance.

We refer the genus to Hypnales because ecostate acrocarpous mosses, *e.g.* the Hedwigiaceae, are larger plants.

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