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LOWER TRIASSIC MOSSES FROM YAMAN US (MONGOLIA)

МХИ ИЗ НИЖНЕТРИАСОВЫХ ОТЛОЖЕНИЙ ЯМАН-УСА (МОНГОЛИЯ)

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Abstract

Four moss genera are revealed in the Lower Triassic deposits of Yaman Us (Mongolia). One of them, *Tricostium,* was formerly described from the Upper Jurassic. Three genera, *Yamanusia, Atrichites* and *Palaeosyrrhopodon,* are described as a new for science. All these four genera are represented in collection by leaves with finely preserved laminal cell structure. The strong costa and relatively short lamial cells indicate their position within acrocarpous mosses.

Резюме

Четыре рода мхов выявлены в отложениях Нижнего Триаса из Яман-Уса (Монголия). Один из них, *Tricostium,* был описан ранее из Верхней Юры. Три рода, *Yamanusia, Atrichites* и *Palaeosyrrhopodon* описаны как новые для науки. Все четыре рода представлены в коллекциях листьями с хорошо сохранившейся клеточной структурой пластинки. Сильная жилка и относительно короткие клетки листа указывают на их принадлежность к верхоплодным мхам.

KEYWORDS: mosses, fossil, Lower Triassic, Mongolia, Yaman Us

INTRODUCTION

Mosses are represented by rather numerous records in the Permian and near the border of Jurassic and Cretaceous. No bryophytes are known from the Triassic. The only existing paper of Townrow (1959) on Triassic *Muscites guescilinae* from South Africa was based on a collection whose age was subsequently reconsidered as Permian (Ignatov & Shcherbakov, 2007).

LOCALITY AND AGE

The present collection is from Yaman Us [=Yamaan Us]: Mongolian Republic, Omnogovi Province, 110 km SE of Dalanzadgad, 25 km E of Nomgon sum, 42°53'N – 105°27'E; Yaman Us Formation, upper (sandstone) member, Lower Triassic (?). Coll. D.E. Shcherbakov et al., Borissiak Paleontological Institute, Russian Academy of Sciences, 2003.

The Yaman Us Formation is considered to be entirely Upper Permian (Durante & Luvsantseden, 2002), but its upper stratae has yielded an insect assemblage resembling those of the Triassic (Shcherbakov, 2008), including numerically abundant protorthopterous Chaulioditidae and mayfly nymphal exuvia.

MATERIAL AND METHOD

Plant material is attached to the surface of argillites and is preserved enough to see clearly leaf areolation in most specimens. The cellular structure is essential in this case, as the absence of stomata excludes any vascular group. The placement in mosses is based on the overall similarity in leaf size and shape, cell dimensions, single costa (or rarely with a weaker submarginal costa-like structures) and unistratose lamina (assumed so due to a relatively weak coalification).

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Fig. 1. *Yamanusia crassicostata* sp. n. PIN 5437/1 (holotype). Stem fragment with two almost complete leaves, and two small leaf fragments (one to the left is not shown).

Mosses were photographed mostly using Leica M 165 and Olympus SZX16 stereomicroscopes, in dry condition, and sometimes under ethanol (for contrasting cell structure).

When the surface of rock was not flat enough, the captured images were assembled with Helicon Focus 4.50 software (Kozub et al., 2008).

All specimens are deposited in Borissiak Paleontological Museum of Russian Acad. Sci. in Moscow.

TAXONOMY

Genus **Yamanusia** gen. nov.

Description: Leaves ovate, widest at mid-leaf or shortly below, broadly rounded at apex, rather gradually tapered to base; margin entire. Costa single, stout, reaching ca. 0.8 leaf length and abruptly ending. Laminal cells irregularly polygonal, rather small, thick-walled, in lower leaf to short-rectangular.

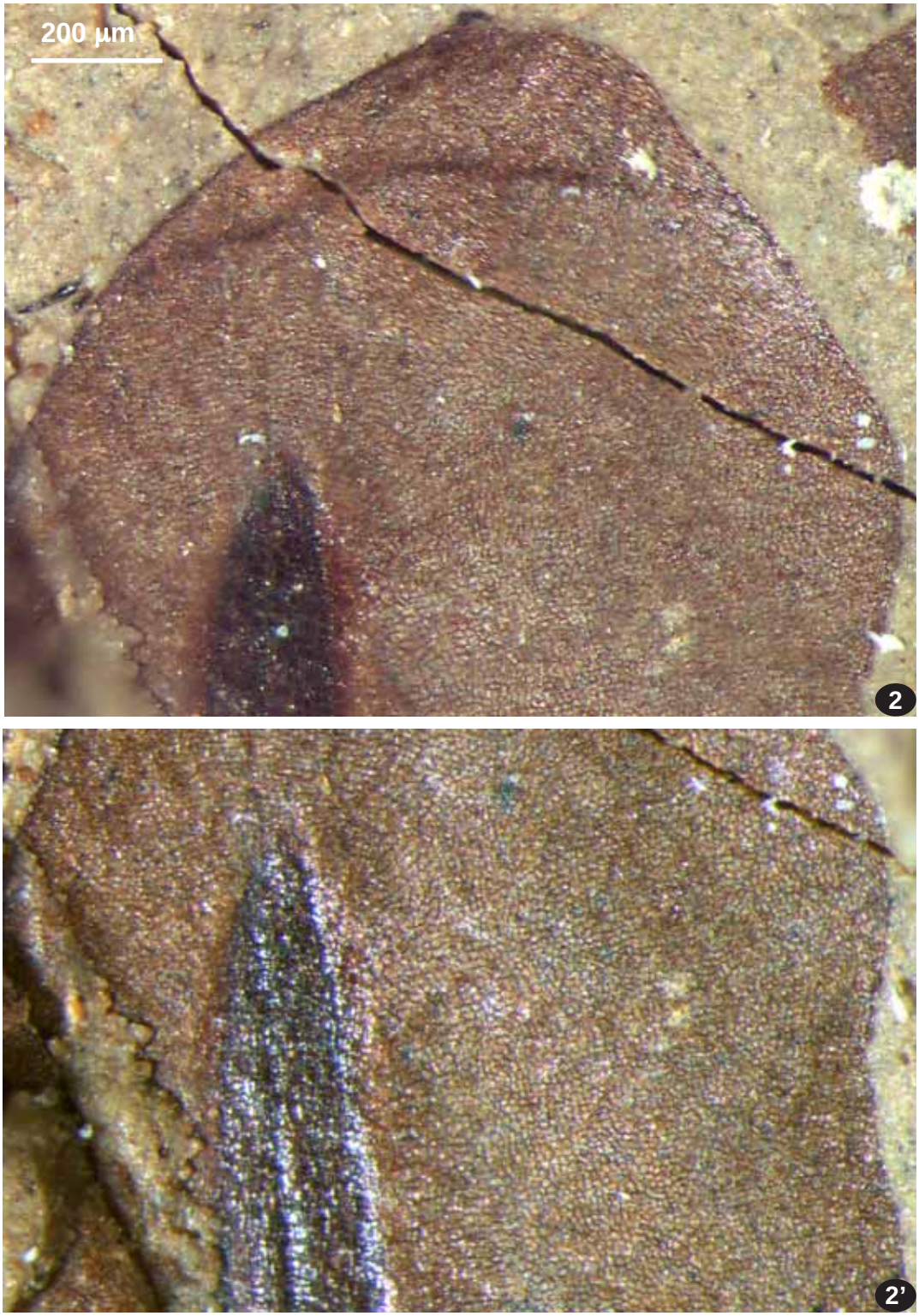


Fig. 2. *Yamanusia crassicostata* sp.n. PIN 5437/1 (holotype). Upper part of leaf–1 (left in Fig. 1), showing abrupt end of keeled costa and its asymmetric position (2 and 2' – same leaf photographed at a sliglthly different angles).

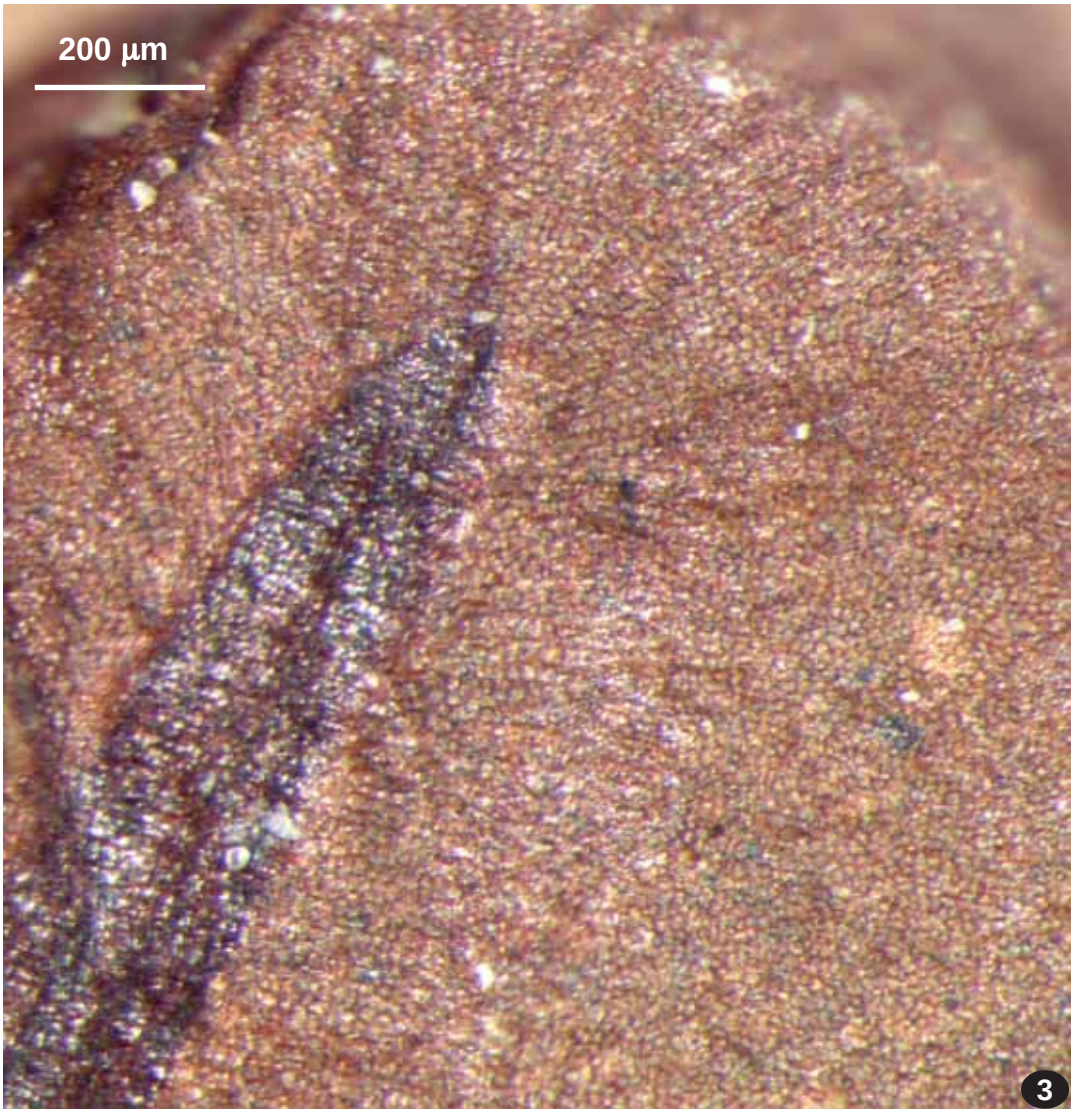


Fig. 3. *Yamanusia crassicostata* sp.n. PIN 5437/1 (holotype). Upper part of leaf–2, showing abrupt end of costa.

Type species: *Yamanusia crassicostata* sp. n., Lower Triassic.

Yamanusia crassicostata sp. n.

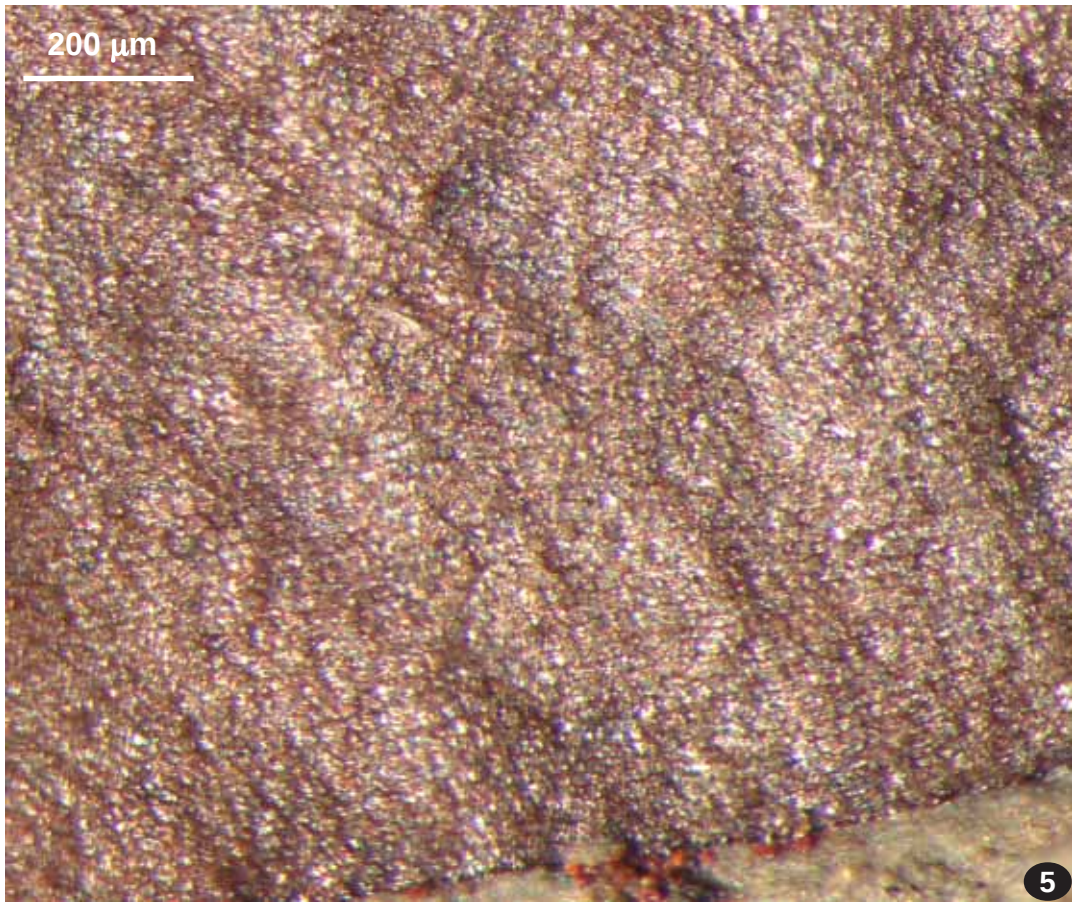
Figs. 1-9.

Holotype: PIN 5437/1 (Figs. 1-4).

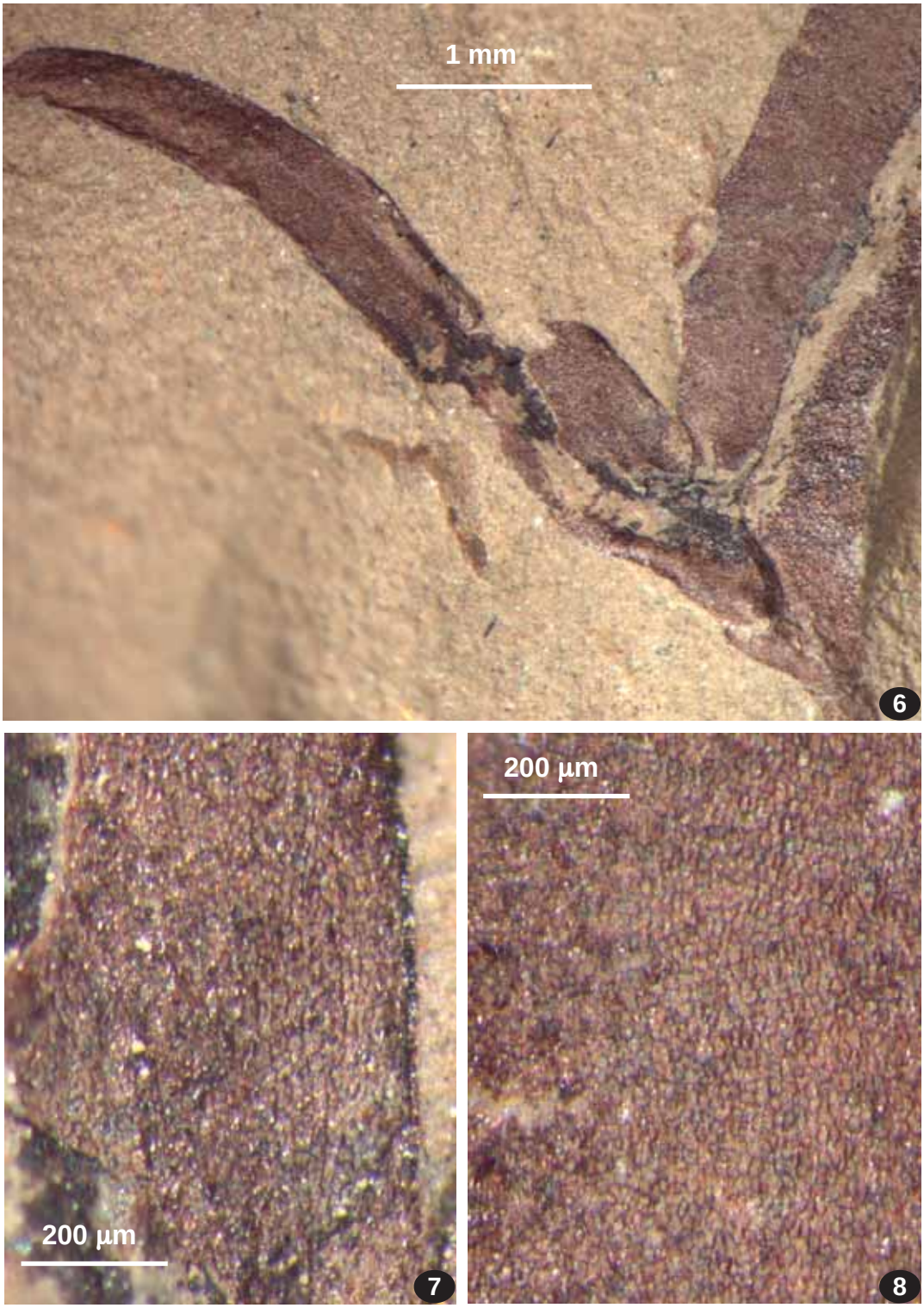
Etymology: generic name refers to the Yaman Us locality; the specific epithet, *crassicostata*, means stout costa.

Description: Leaves to 3.8×1.9 mm, broadly ovate, plane or only weakly concave to undulate; margin more or less plane, narrowly bordered. Costa 400 µm wide below, 250-300 µm wide in mid-leaf, ending ca. 50 cells (0.6 mm) below leaf apex; the end of costa unequally distant from sides of leaf; keeled on abaxial surface and grooved on adaxial one. Laminal cells irregularly polygonal, 12-15 µm and to 20 µm closser to costa, thick-walled, near costa end in apparet radial rows, towards leaf base somewhat larger, short-rectangular, to 40×20 µm long and 15-20 µm wide.

Material: The holotype leaf–1 (Figs. 1-left, 2) is 3.5×1.9 mm; costa 400 µm below, 300 µm in mid-leaf, costa surface keeled; laminal cells ca. 15 µm when measuring individual cells, while the block of 50 cells is 0.6 mm, i.e., cells in aver-



Figs. 4-5. *Yamanusia crassicostata* sp.n.: 4 – PIN 5437/1 (holotype, leaf–2); 5 – PIN 5437/2. Mid-leaf areolation.



Figs. 6-8. *Yamanusia crassicostata* sp.n. PIN 5437/6. 6 – shoot with three leaves;7-8 – mid-leaf areolation.

Fig. 9. *Yamanusia crassicostata* sp.n. PIN 5437/10. Large leaf fragment, showing areolation.

age are 12 μm in this way of measuring. The holotype leaf-2 (Figs. 1 right and 3) is longer, no less than 3.8 mm long, costa 250 μm wide in the middle, ending 0.5 mm (ca. 40 cells) below leaf apex; costa is grooved along its median, thus we interpret leaf–1 as faced by the abaxial surface and leaf–2 by the adaxial side, as in modern mosses the adaxial side is never more convex than the abaxial one. Laminal cells in leaf–2 of the holotype are numerous, ca. 100 on the right from costa, and in this leaf, as well as in other fragments (Figs. 4-5, 9) are irregularly-polygonal, 12-15 μm. More proximal parts of leaves shown in Figs.6 & 9 have a slightly larger short rectangular cells, 15-25 μm long and 15-20 μm wide (Figs. 7-8), with solitary cells up to 40 μm long.

A leaf border is not apparent, but marginal cells probably were somewhat differentiated, especially by more thick walls, as the leaf edge usually has a narrow zone (1-2 cells wide) that is darker. Unfortunately its structure is not clearly seen.

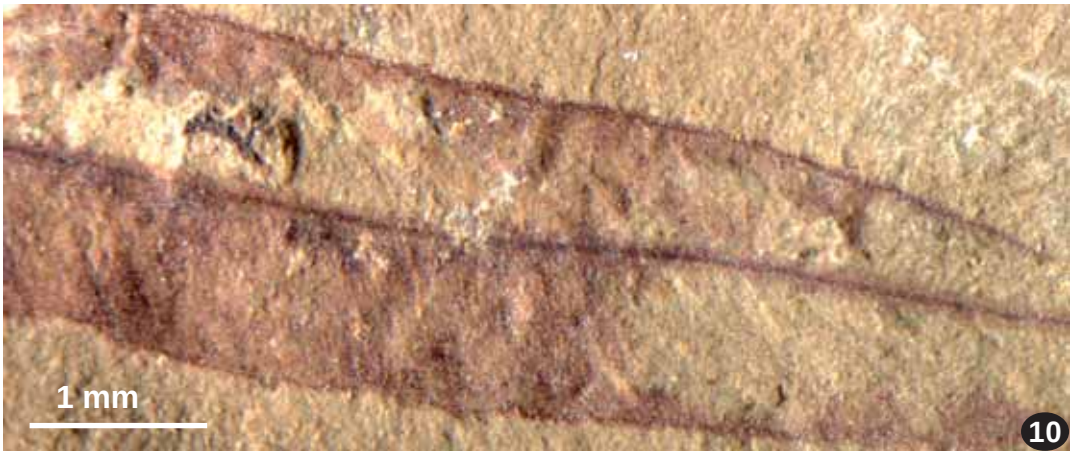
Multiseriate foliage is apparent in specimen in Fig. 6. The basal part of leaf from the same shoot has longer cells: to 40 μm long and ca. 20 μm wide (Fig. 7).

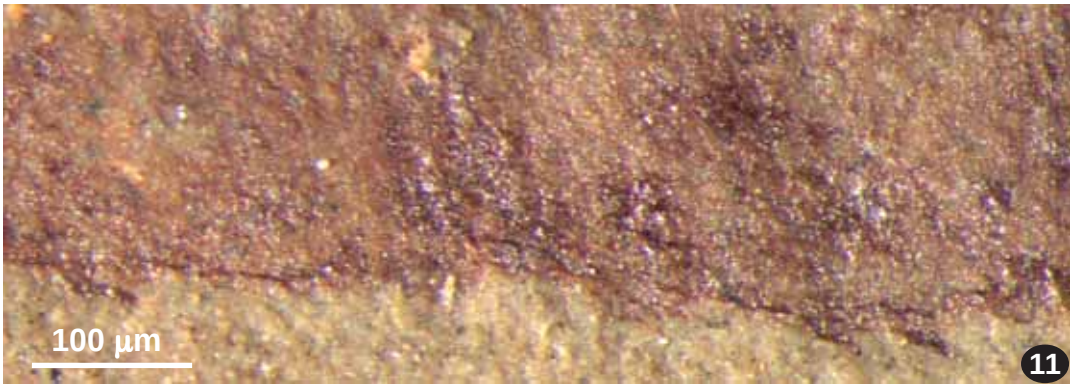
The costa, with its keeled and grooved structure, is not apparent in the leaf in Fig. 9, probably because of its smaller size: its half-width is 0.6 mm only, so it likely represents a less developed leaf from a more proximal part of the shoot or from an underdeveloped plant.

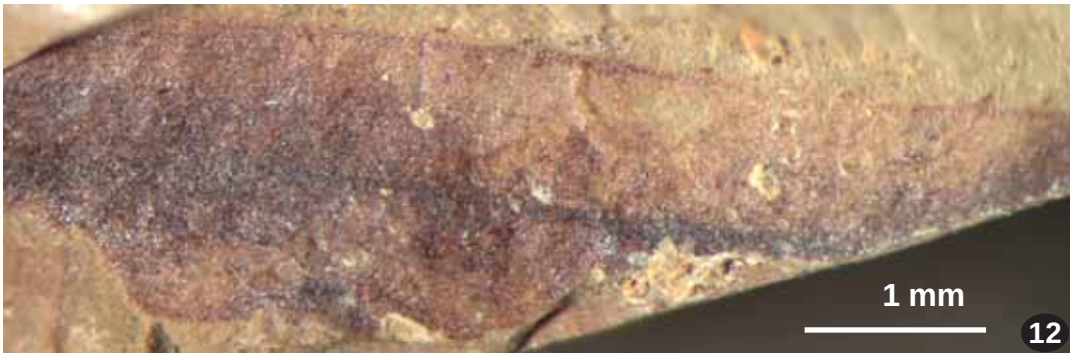
Specimens examined: PIN 5437/1, /2, / 6, /10.

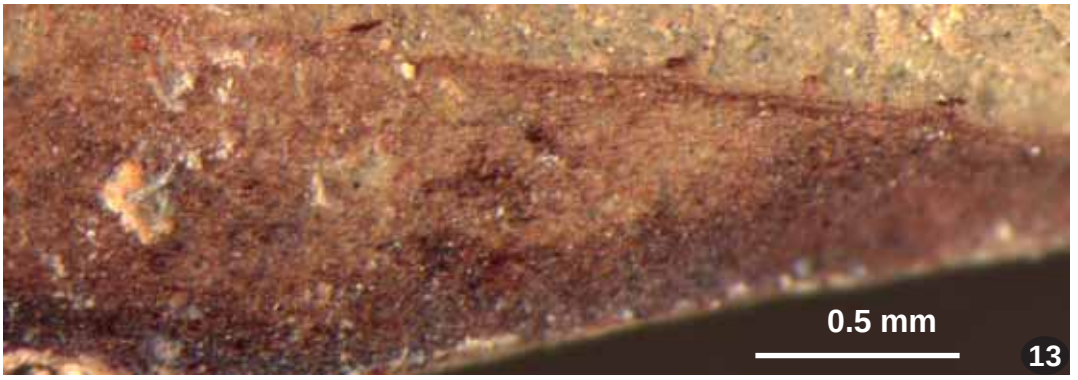
Comparison: One modern and one fossil moss can be mentioned in comparison.

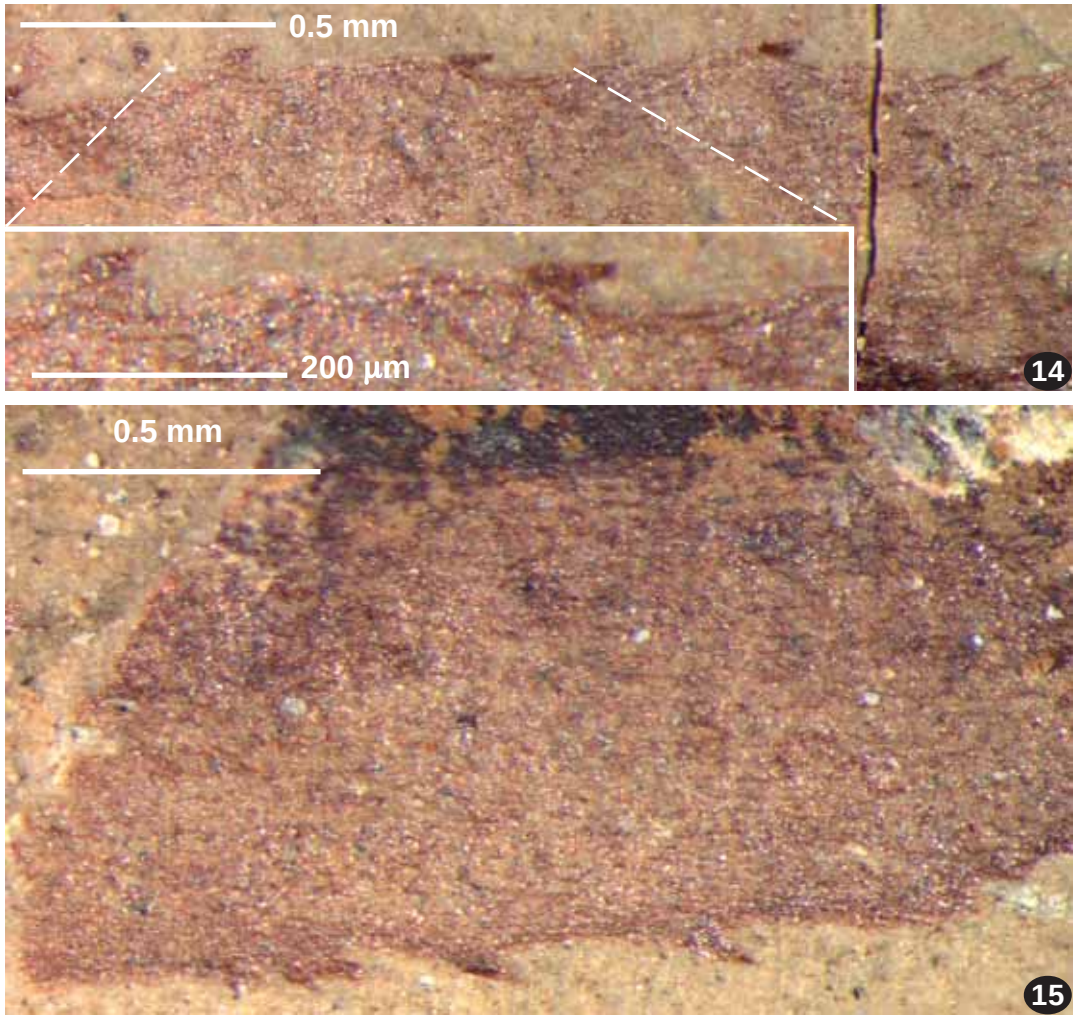
1) The asymmetric position of costa is a very rare character in modern mosses and it is present only in *Fissidens,* where it is possible because of a unique "triradiate" leaf structure. An asymmetric position of the costa end is apparent however only in species where the costa is ended far from apex (e.g., *F. asplenioides* Hedw.*, F. reticulosus* (Müll. Hal.) A. Jaeger). There is nothing similar to the vaginant lamina in *Yamanusia* specimens. However, its partial presence cannot be totally excluded, as no single ideally preserved leaf is available and in the largest one, leaf–1 of holotype (Fig. 1), one side is folded. *Fissidens* species often have rather small cells of shape similar to *Yamanusia*, and also many species have a narrow border.


1 mm
10


100 µm
11


1 mm
12


0.5 mm
13



Figs. 14-15. *Atrichites triassicus* sp.n.: 14 – PIN 5437/5c, 15 – PIN 5437/8. Large leaf fragments, showing marginal serration and laminal areolation.

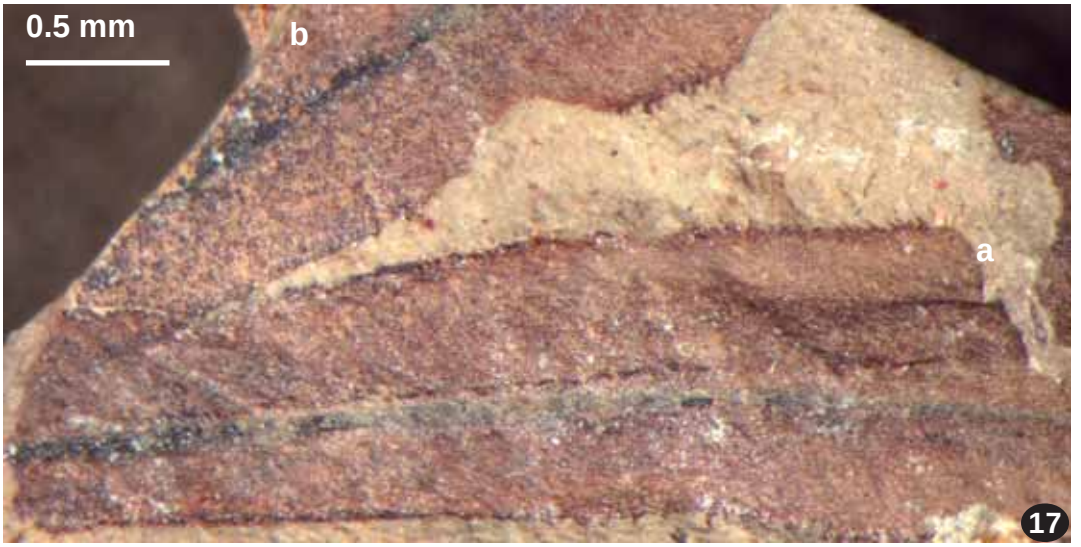
Figs. 10-13 (opposite page) *Atrichites triassicus* sp.n.: 10-11 – PIN 5437/3 (holotype); 12-13 – PIN 5437/4. Large leaf fragments, showing areolation.

2) *Serviktia undulata* Ignatov, described from the Upper Permian (Ignatov, 1990), has a stout, abruptly ending costa, and a similar cell size. Compared with two other species of the genus, whose diagnostic characters include a border of wide cells with oblique transverse walls, *S. undulata* apparently has a border only in places and its structure only moderately corresponds to that of *S. acuta* Ignatov, the type of the genus. The border details cannot be satisfactory understood in *Yamanusia*, so we do not place the present specimens in *Serviktia*, a genus of acrocarpous mosses, although without obvious affinity to any modern family. However the border of *Serviktia*, composed of long cells with oblique partitions, resembles that of some *Fissidens*.

Genus **Atrichites** gen. nov.

Description: Leaves lanceolate, gradually tapered to apex, margin plane, serrate with long sharp teeth, forming acute angles, 30-50° with the margin, formed by large sharp cells; border differentiated by 2-3 rows of elongate cells, but at places inconspicuous; costa single, strong, reaching apical part of leaf; laminal cells closer


b
c
3 mm
e
d
a
16


0.5 mm
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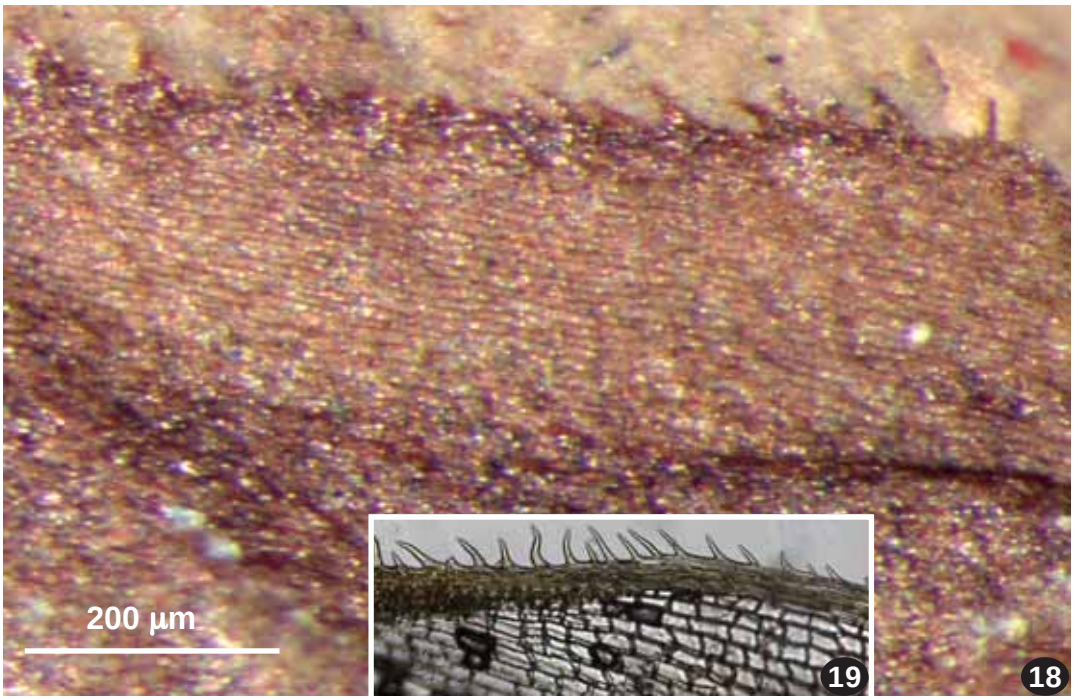
17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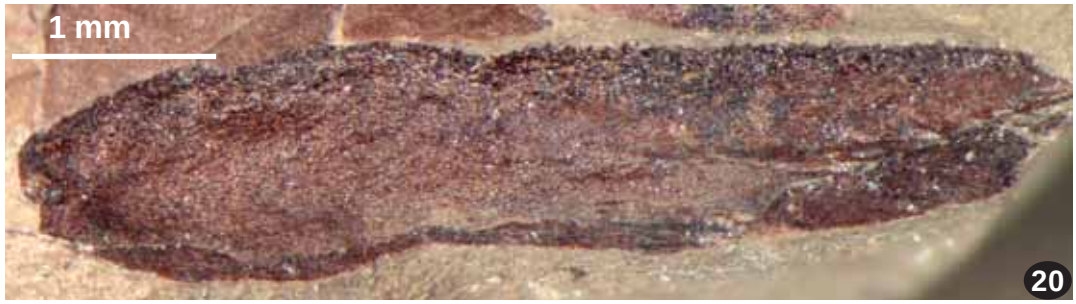
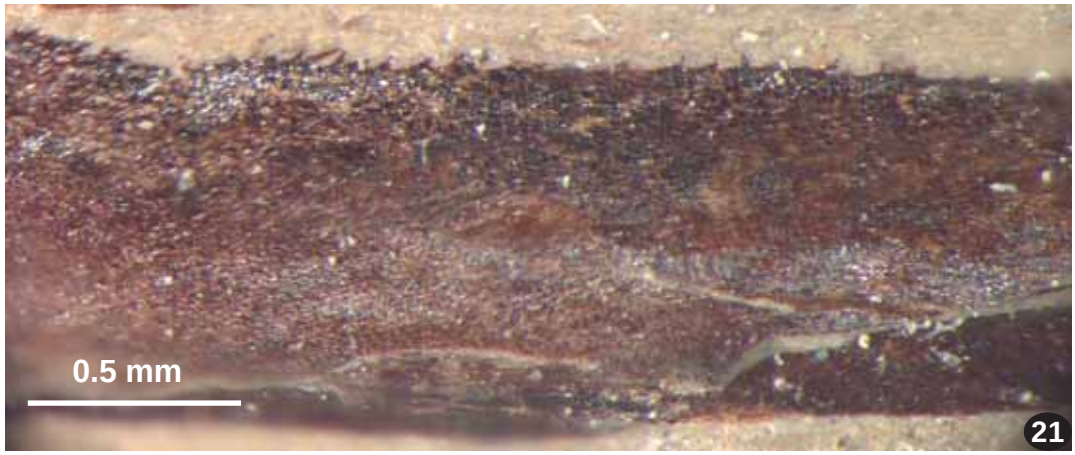
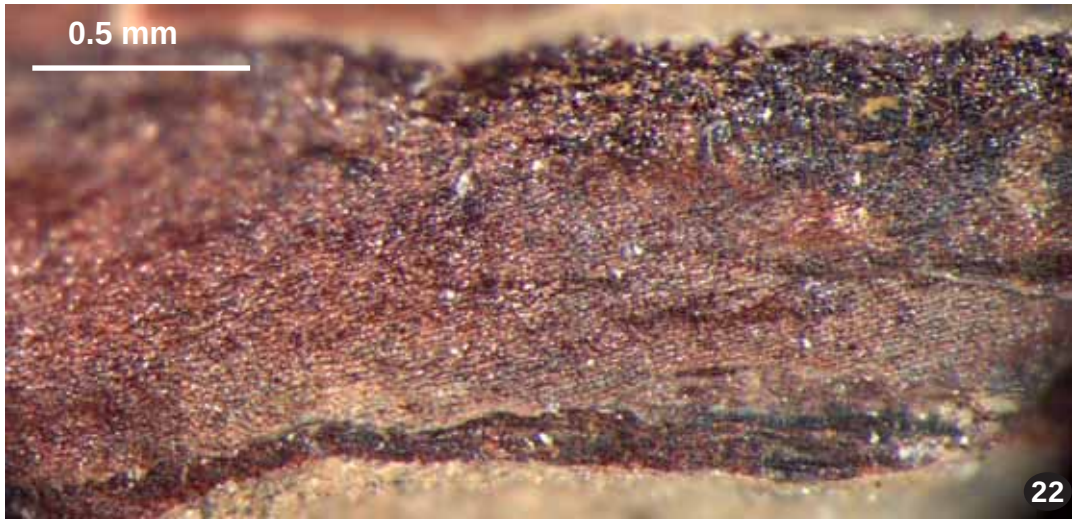






Figs. 20-22. *Palaeosyrrhopodon grossiseratus* sp.n.: PIN 5437/5b. Large leaf fragment and its areolation.

Figs. 16-18 (opposite page). *Palaeosyrrhopodon grossiseratus* sp.n.: PIN 5437/9a (holotype). 16 – leaf fragments; 17-18 – laminal areolation; 19 – leaf margin of extant *Syrrhopodon keniae* Dixon, nom. herbar. (Kenya, Dixon 345, MHA).

to margin isodiametric, moderately thick-walled, closer to costa short-rectangular, to 2:1.

Type species: *Atrichites triassicus* sp. nov.

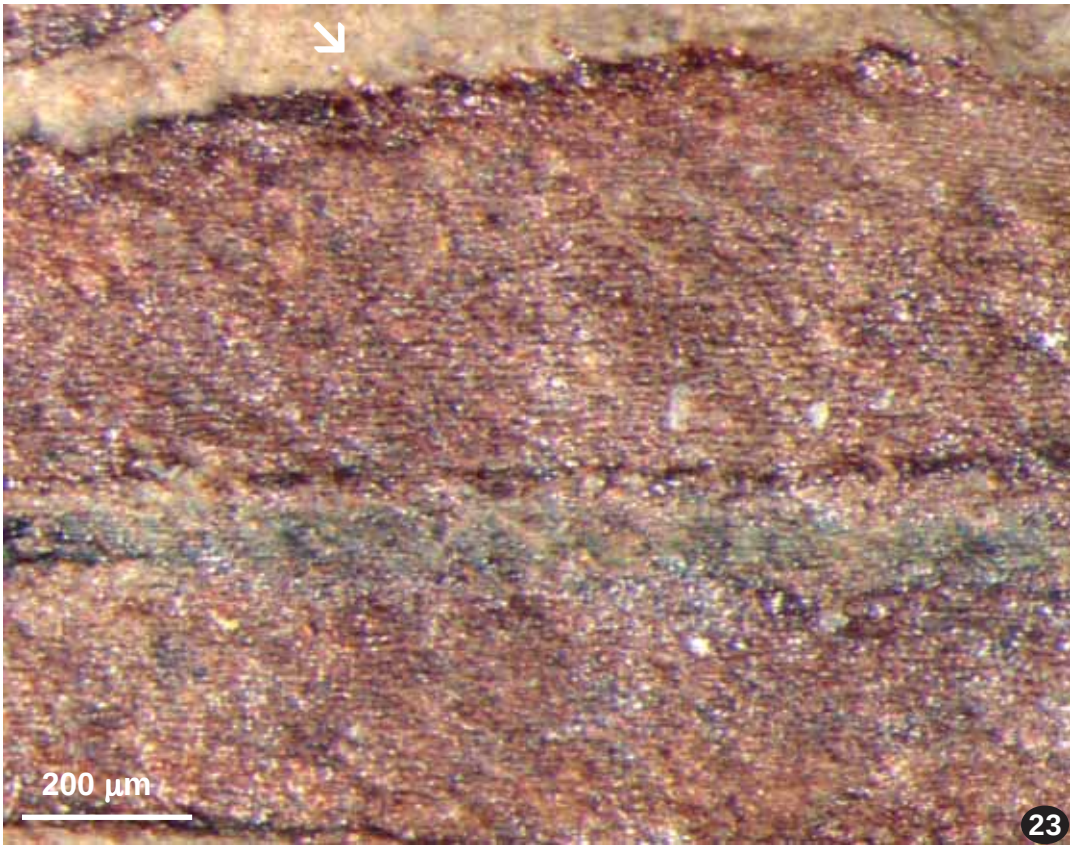
Ethymology: The name refers to the extant genus *Atrichum* (Polytrichaceae).

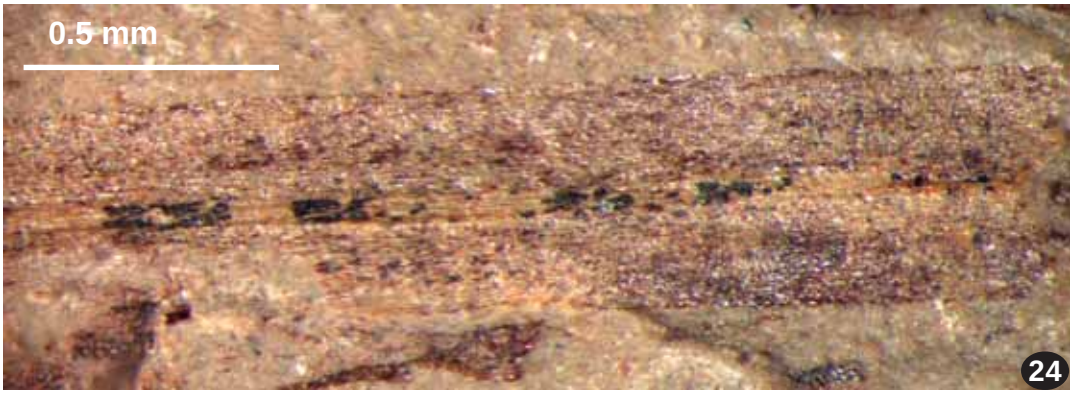
Atrichites triassicus sp. nov.

Figs. 10-15.

Holotype: PIN 5437/3 (Figs. 10-11).

Description: Leaves >6 mm (likely no less than 10 mm) long, to 2 mm wide; marginal teeth

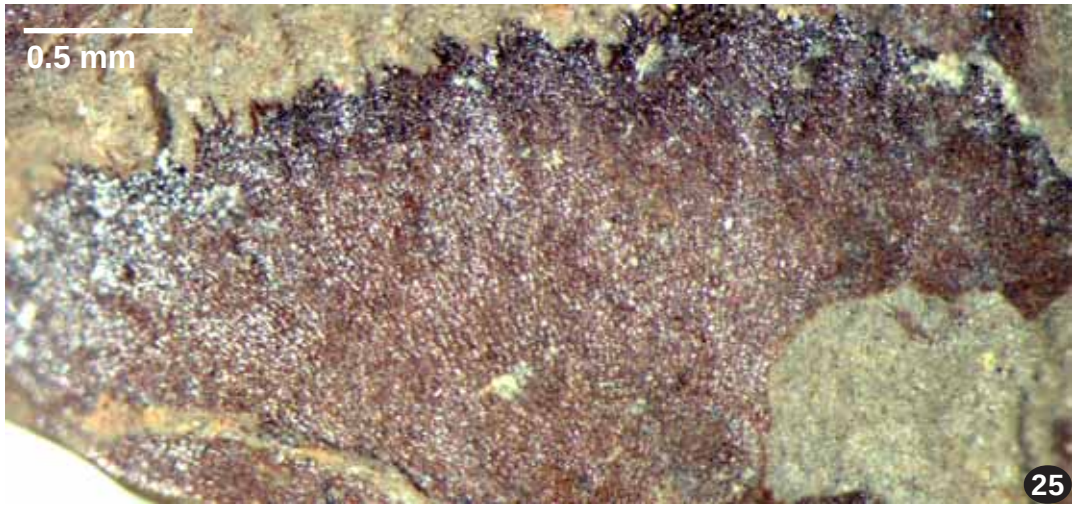


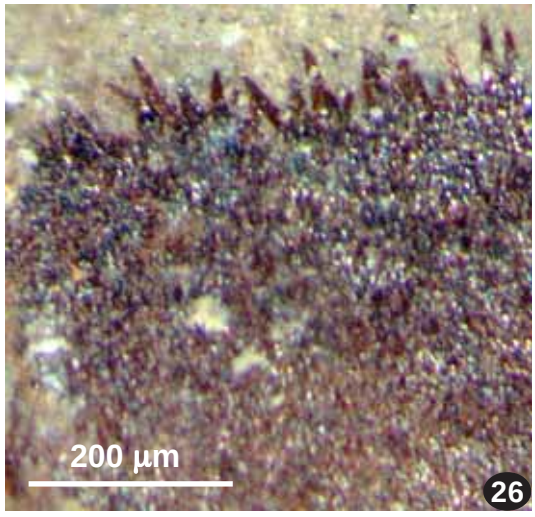


Figs. 23-24. *Palaeosyrrhopodon grossiseratus* sp.n.: PIN 5437/9a (holotype) and PIN 5437/9e: leaf fragments showing laminal areolation.

separated by 200-300 µm from each other, to 50 µm long, formed by large cells, narrowly acute; border differentiated by 2-3 rows of elongate cells, but at places not apparent; costa 150-200 µm wide; laminal cells hexagonal, near margin 25-40 µm, near costa rectangular or elongate-hexagonal, to 50(-60) µm long and 20-30 µm wide, moderately thick-walled.

Material: The species is represented by four leaf fragments, allowing restoration the leaf outline by analogy with modern mosses: the tapering upwards (Fig. 10) corresponds almost always to acute, not acuminate upper part of the leaf. Areolation and marginal serration is well represented in all four fragments and specific serration by long sharp teeth at a distance of ca. 300 µm from each other is the main





Figs. 25-26. *?Palaeosyrrhopodon grossiserratus* sp.n.: PIN 5437/11. Probably an upper leaf very broadly rounded above; 26 – marginal teeth, magnified from 25.

diagnostic character, which is used to refer fragments to the same species.

Teeth are single, but at places can be interpreted as double (Figs. 11, 15), although no one clear view of double teeth is presented in the material.

Specimens examined: PIN 5437/3, /4, /5c (on the same rock slab as holotype of *Tricostium triasscum*, /5a), /8.

Comparison: Large lanceolate leaves with sharp teeth are known in Paleozoic and Mesozoic mosses only in the Cretaceous *Vetiplanaxis pyrrhobryoides* N.E. Bell (Bell & York, 2007) that differs from *Atrichites* in plicate leaves.

Among extant groups, *Atrichites* is similar in leaf shape and pattern of marginal serration with *Dicranum* (Dicranaceae), *Pyrrhobryum* (Rhizogoniaceae), *Timmia* (Timmiaceae), some Bartramiaceae, Calymperaceae, Pottiaceae, Mniaceae, etc. Among these, however, if teeth are sharp and long and associated with a border, then they are usually double. Otherwise, if teeth are single, they are sitting on a non-bordered margin, or, in Mniaceae, leaf shape is very different. *Atrichum* is among the former group of taxa with Rhizogoniaceae and some Calymperaceae. The choice of name does not imply that *Atrichum* has much more in common with *Atrichites*.

Most species of *Atrichum* (as well as nearly all the Polytrichaceae) have lamellae on adaxial side of costa, although not in all species.

Genus: **Palaeosyrrhopodon** gen.nov.

Description: Leaves broadly lanceolate, strongly serrate with densely arranged large teeth; costa single, strong; laminal cells quadrate to short-rectangular, (1.0-)1.5-2:1, thick-walled, below elongate, up to 3:1.

Ethymology: The name refers to the modern moss genus *Syrrhopodon* (Calymperaceae).

Type species: *Palaeosyrrhopodon grossiserratus* sp. nov., Lower Triassic, Mongolia.

Comparison: from other Paleozoic and Mesozoic mosses *Palaeosyrrhopodon* differs in dense large teeth all along the leaf margin.

Palaeosyrrhopodon grossiserratus sp. nov.

Figs. 16-18, 20-24 and (?) 25-26.

Holotype: PIN 5437/9a (Figs.16-18).

Description: Leaves >5 mm (apparently no less than 8 mm) long and 1 mm wide, broadly lanceolate, gradually tapered above, margin plane, serrate with densely arranged teeth (ca.8 teeth per 0.5 mm); costa single, strong, in mid-leaf 60-100 μm wide; laminal cells ca. 15 μm wide, (1.0-) 1.5-2:1, below elongate, up to 3:1, and in a probably young leaf 40×12 μm.

Material: Leaf fragments are found in 3 rock slabs, one of them with 2 rather large leaf fragments (Fig. 16, 9a-b), and some smaller ones. These allow one to understand the whole leaf outline, although the apical part and leaf base are not available. Some leaves are much narrower than holotype, have almost parallel margins, and their compressions look paler (Figs. 16: 9e; 24). We consider them as an upper younger leaves of the same species because of similar shape and size of laminal cells.

Areolation is rather clearly seen in all fragments. Margin serration is the main character that allows attribution of these leaf fragments to one taxon, some being a rather small area from the middle part of leaf.

Teeth are uneven and at places are not seen (Fig. 23, arrow), which probably can be explained by recurved leaf margins – in other parts of the leaf margin, teeth are as numerous as in maximally serrate leaf fragments.

One fragment (Figs. 25-26) has a similar areolation and teeth. Since the areolation has radiate rows, the fragment cannot be interpreted as a one side of leaf from costa to margin, and therefore is considered here as a apical part of a broad leaf, similar to rosette leaves of *Tetraphis* that surround brood bodies or perigonial leaves of, e.g., *Oedipodium*. Marginal serration in this fragment is very strong, teeth somewhat overlaying each other.

Specimens examined: PIN 5437/5b (on the same rock slab as holotype of *Tricostium triasscum*, /5a); /9a-e; /11(?).

Comparison: *Palaeosyrrhopodon* has dense large teeth along the leaf margin, that have no similarity to any fossil mosses. The pattern of serration (cf. Figs. 18, 21, 26) is similar to modern *Syrrhopodon* (Calymperaceae), where teeth are also: (1) very densely arranged; (2) irregular in shape; (3) often somewhat differently oriented; (4) blunt (cf. Fig. 19).

Genus **Tricostium** Krassilov, Palaeontographica, Abt. B, 143: 100, figs. 75-86. 1973.

Description: Leaves oblong-lanceolate, shortly acute; margin plane; middle costa rather thin, ending shortly below apex; two submarginal costae present, reaching above 0.9 leaf length. Laminal cells quadrate-polygonal to short rectangular, towards leaf base longer to short rectangular.

Type species: *T. papillosum* Krassilov, Late Jurassic, Bureya River (Khabarovsk Territory, Russian Far East).

In addition to generitype and the species described here, *Tricostium* definitely includes also Lower Cretaceous *T. longifolium* (see Ignatov & Shcherbakov, 2011, present volume).

Tricostium triassicum sp. nov.

Figs. 27-30.

Holotype: PIN 5437/5a (Figs. 27-30).

Leaves >4 mm long (apparently no less than 5 mm), 0.9 mm wide, narrowly oblong, with margin parallel in its middle part, slightly concave; margin plane and entire in lower and middle part of leaves; median costa reaching apex or almost so, 80 μm wide; two submarginal costae reaching no less than 0.8 leaf length, thin, 30-40 μm wide; laminal cells ca. 13 μm wide, quadrate to short rectangular, thick-walled.

Material: *Tricostium triassicum* is represented in collection by a single leaf that seems to be nearly complete, except the apical part. However, the leaf outline indicates that the missing part is likely not very big and most likely is acute as in other species of the genus (Krassilov, 1973; Ignatov & Shcherbakov, 2011, present volume).

Cells are obviously thick-walled, so their outlines are not clearly seen, but the number of cells on one side of leaf, from costa to margin, can be counted, and by division of 400 μm (width of lamina on one side of costa) to 30 (number of cells, which is easy to count) the mean value can be found. However this method usually provides somewhat lowered values than direct measurements of individual cells, thus we can evaluate the laminal cell size as 13-16 μm.

The median costa is distinct, whereas lateral ones are not that apparent and may be interpreted as plicae. However, they follow along almost the whole margin except the apical part (similar

Figs. 27-30. *Tricostium triassicum* sp.n.: PIN 5437/5a (holotype). Leaf and its counterpart, showing general outline (27-28) and areolation (29-30).

to that in two other species of the genus) and are too regular to be folds considering the shape of leaf and its only moderate (if any) concavity. Note that their distance from margin is the same as in two other species of the genus.

Preservation of the specimen does not allow one to determine if the margin is serrate in the apical part of the leaf and if laminal cells are papillose (as in the type species of the genus, while for another species this character is not possible to say due to insufficient preservation of material).

Comparison: The presence of long lateral costae, similar size of leaf and laminal cells and width of costa, etc., indicate the position of our specimen in the genus *Tricostium*.

The possible relation to a modern group is not apparent: the Scouleriaceae are one modern group with submarginal 'costae' (see comparison in Ignatov & Shcherbakov, 2011, present volume), but a somewhat similar pattern occurs in other groups as well (cf. Ochyra, 1990).

The genus includes two other species, *T. papillosum*, that differs in smaller leaf size (to 2 mm only) and *T. longifolium*, that has more prominent lateral costae (Krassilov, 1973; Ignatov & Shcherbakov, 2011, present volume). These species are known from the Upper Jurassic and Lower Cretaceous, respectively.

Also, *T. triassicum* differs from both of them in laminal cells that are short rectangular, not quadrate.

ACKNOWLEDGEMENTS

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