

New cleistocarpous species of the genus *Pterygoneurum* (Pottiaceae, Bryophyta) from the steppe slopes of Siberia (Russia)

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Abstract. On the steppe slopes in the Yenisey River Basin in the vicinity of the City of Krasnoyarsk a new cleistocarpous species of the genus *Pterygoneurum* was found. The new species *Pterygoneurum sibiricum* is characterized by sessile cleistocarpous capsule, short triangular-cucullate calyptrae, and leaves loosely appressed and somewhat slightly twisted when dry, as well as papillose leaves and lamellae. It differs from all stegocarpous species of *Pterygoneurum* in a cleistocarpous capsule. It also differs from the cleistocarpous *Pterygoneurum kozlovii* in having high lamellae of 4–10(15) rows of cells in height (vs. low lamellae of 1–4 rows of cells in height in *P. kozlovii*); papillae of lamellae located on both sides of the lamellae, branched or sometimes simple (vs. simple to hardly branched or absent in *P. kozlovii*); papillae of the leaf lamina located on the dorsal side of the lamina, branched or sometimes simple (vs. mostly simple to hardly branched or absent in *P. kozlovii*). It is known from the steppe slopes in Siberia (Republic Sakha (Yakutia), Indigirka River Basin; Trans-Baikal Territory; Republic of Buryatia; Krasnoyarsk Territory, near the City of Krasnoyarsk).

Keywords: *Pterygoneurum arcticum*, *Pterygoneurum kozlovii*, *Pterygoneurum lamellatum*, *Pterygoneurum ovatum*, *Pterygoneurum sibiricum*, *Pterygoneurum subsessile*, morphology, moss flora, taxonomy, Asia, Russia.

Новый клейстокарпный вид из рода *Pterygoneurum* (Pottiaceae, Bryophyta) с остепненных склонов Сибири (Россия)

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Резюме. В окрестностях Красноярска на остепненных склонах обнаружен новый клейстокарпный вид из рода *Pterygoneurum*. Новый вид *Pterygoneurum sibiricum* характеризуется сидячей коробочкой, треугольным клубоковидным колпачком, рыхло прижатыми и слегка изогнутыми в сухом состоянии листьями, а также папиллами на листовых пластинках и брюшных пластинках (ламеллах). Отличается от всех стегакарпных видов рода клейстокарпной коробочкой. От клейстокарпного *Pterygoneurum kozlovii* отличается высокими брюшными пластинками из 4–10(15) рядов клеток в высоту, 1–4 ряда клеток в высоту у *P. kozlovii*, разветвленными или иногда простыми папиллами, расположенными на обеих сторонах ламелл (простые до неотчетливо разветвленных или отсутствуют у *P. kozlovii*), а также разветвленными, иногда простыми папиллами на спинной стороне листа (простые до неотчетливо разветвленных или отсутствуют у *P. kozlovii*). Вид выявлен на остепненных склонах в Сибири (Республика Саха (Якутия), бассейн реки Индигирки; Забайкальский край; Республика Бурятия; Красноярский край, окрестности г. Красноярска).

Ключевые слова: *Pterygoneurum arcticum*, *Pterygoneurum kozlovii*, *Pterygoneurum lamellatum*, *Pterygoneurum ovatum*, *Pterygoneurum sibiricum*, *Pterygoneurum subsessile*, морфология, таксономия, флора мхов, Азия, Россия.

In the genus *Pterygoneurum* Jur. about 15 species are known. They occur in the Northern Hemisphere mostly in areas with dry climate. Among them six species were reported from the territory of the former USSR, *P. arcticum* Steere, *P. kozlovii* Laz., *P. lamellatum* (Lindb.) Jur., *P. medium* (Salm.) Broth., *P. ovatum* (Hedw.) Dix. and *P. sessile* (Brid.) Jur. (Savicz-Ljubitskaja, Smirnova, 1970) and four species from the Middle European Russia (Ignatov, Ignatova, 2003).

On the steppe slopes in the Yenisey River Basin in the vicinity of the City of Krasnoyarsk three species of the genus *Pterygoneurum* were found. Among them two species are well known, these are *P. sessile* and *P. ovatum*, the third species found does not fit to the morphological characters of any known species. It is characterized by sessile cleistocarpous capsule, oblong, triangular-cucullate calyptra, papillose leaf lamina and lamella cells. This species combines the characters of four species. It has a cleistocarpous capsule as in *P. kozlovii*, sessile capsule as in *P. sessile* and *P. kozlovii*; papillose leaf lamina and lamella cells with branched papillae as in *P. arcticum* and *P. lamellatum*.

Thus, the Siberian specimens are morphologically distinct and deserve to be considered as a separate species. To clarify its distinctions from *P. kozlovii* and *P. sessile*, all specimens of *P. kozlovii* and selected specimens of *P. sessile* kept in LE and MHA were studied.

Pterygoneurum sibiricum Otnyukova, sp. nov.

(Plates I, II)

Diagnosis. It differs from all stegocarpous species of *Pterygoneurum* in its cleistocarpous capsule, from cleistocarpous *P. kozlovii* in high leaf lamellae of 4–10(15) rows of cells in height (vs. low of 1–4 rows of cells in height); it is characterized by short elliptic or globose capsule with small, short, straight operculum; spores 37–45 µm; papillae of lamellae located on both sides of the lamellae, papillae of leaf lamina mainly located on the dorsal side of the lamina, 1–3(4) per cell, variously branched, C-shaped with auricles, C-, horseshoe- and ring-shaped or sometimes simple.

Type. **Russia**, Krasnoyarsk Territory, north-western spurs of the East Sayan Mts., vicinity of the City of Krasnoyarsk, right bank of Yenisey River, Laletino stream, Zmeiny Log, 55°57'43"N, 92°45'27"E, ~ 250 m a. s. l., steep southern steppe slope, on dry mineralized soil among grasses, 23 IX 2019, *Otnyukova 19-27* (holotype LE, isotypes MHA, MW).

Plate I. *Pterygoneurum sibiricum* Otnyukova, sp. nov.

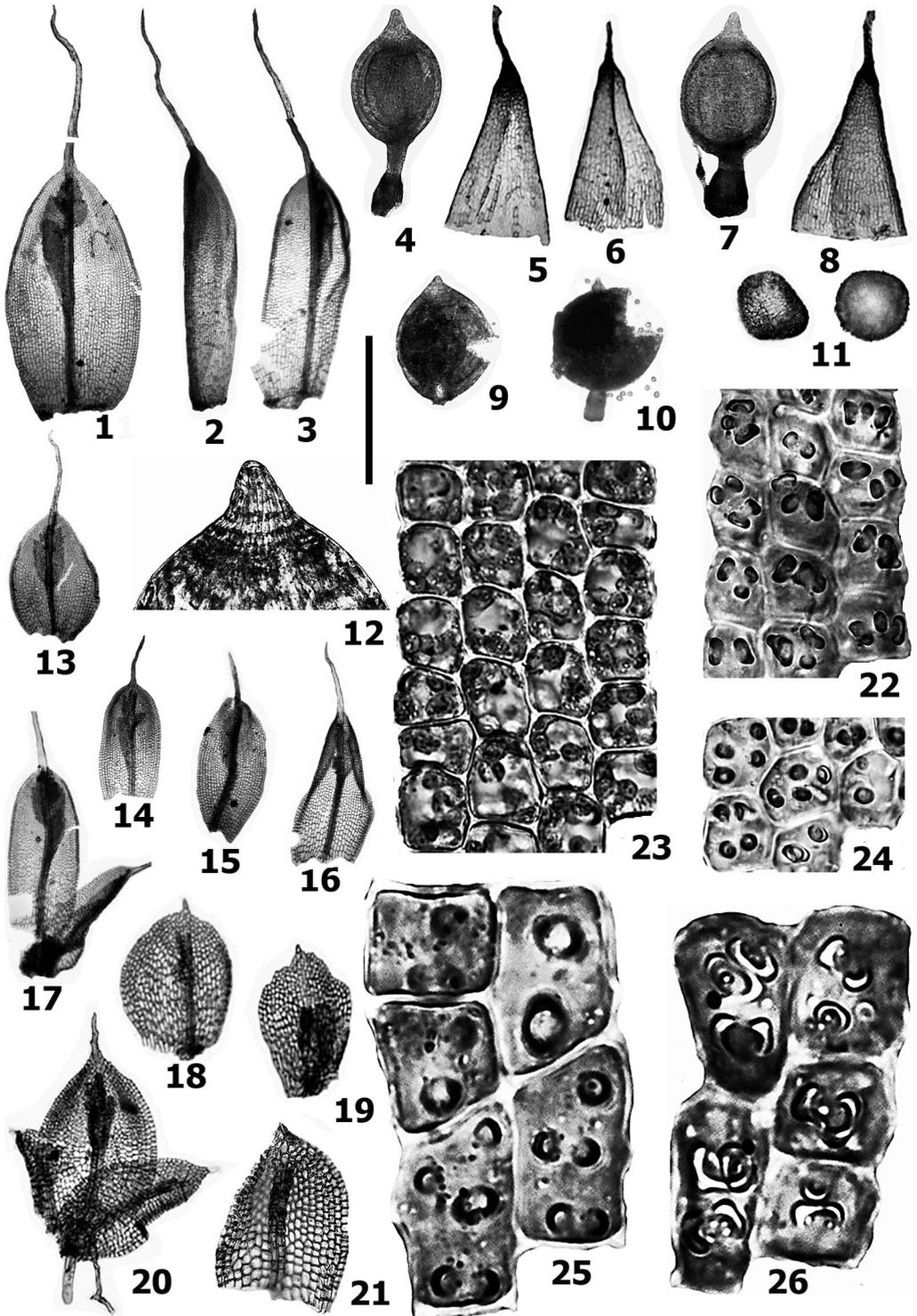
1–3 – perichaetial leaves; 4, 7, 9, 10 – capsules; 4, 6, 8 – calyptrae; 11 – spores; 12 – upper part of capsula with short operculum; 13–17 – leaves in the middle part of stem; 18, 19 – inner perigonal bracts; 20 – juvenile plants; 21 – outer perigonal bract; 22–26 – leaf lamina cells from the dorsal side of lamina: epapillose and with few simple papillae (23), with C-shaped and ring-shaped papillae (24, 25), C-shaped with auricles, horseshoe- and ring-shaped papillae (22, 26).

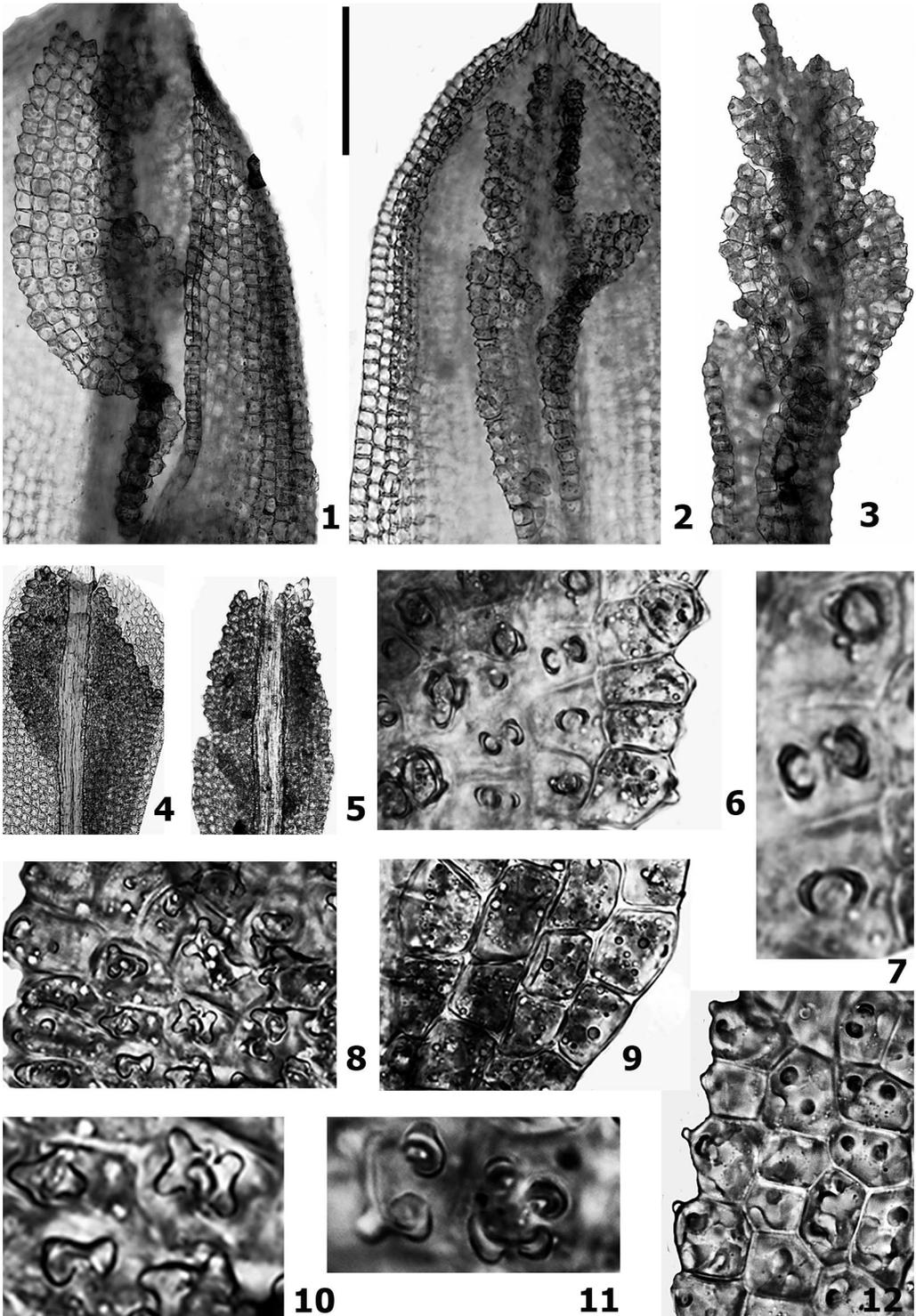
Scale bars: 1–4, 7, 9, 10, 13–17 – 1 mm; 5, 6, 8, 12, 18–21 – 0.5 mm;

11 – 80 µm; 22–24 – 40 µm; 25, 26 – 20 µm.

1–5, 7, 8, 13–26 – from holotype; 6, 9, 12 – from paratype (16 VI 1976, *Afonina*, LE);

10, 11 – from paratype (18 VI 1976, *Afonina*, LE).





Paratypes from the type locality. **Russia**, Krasnoyarsk Territory, north-western spurs of the East Sayan Mts., vicinity of the City of Krasnoyarsk, right bank of Yenisey River, Laletino stream, the rock Chyortov Paletz, 55°57'45"N, 92°44'60"E, ~250 m a. s. l., steep southern steppe slope, on dry mineralized soil among grasses, 27 VIII 2018, *Otnyukova*, LE; *ibidem*, 30 VIII 2019, *Otnyukova*, LE.

Paratypes from the other territories. **Russia**: Trans-Baikal Territory, 14 km from Dauria Town, 49°55'N, 116°42'E, grass-herb steppe, 27 VII 2005, *Afonina* (*Афонина*) 5805 (as *P. subsessile*), LE; Daursky Ridge, Aratsa River, tributary of Ingoda River, 51°54'50"N, 114°25'06"E, 900 m a. s. l., roadside, on bare soil, 14 VII 2012, *Czernjadjeva* (*Чернядьева*) 4-12/1 (as *P. kozlovii*), LE; Republic of Buryatia, Mukhorshibirsky District, valley of Altacheika Creek, 50°57'05"N, 107°13'33"E, 700 m a. s. l., south-west facing steppe slope, 22 VIII 2018, *Afonina* (*Афонина*) 0118 (as *P. kozlovii*), LE; Republic of Sakha (Yakutia), right bank of Indigirka River, near mouth of Ystan-Yuryakh (oppo site village of Tyubelyakh), grass steppe with *Koeleria* and epigeous lichens, 27 VI 1976, *Afonina* (*Афонина*) (as *P. subsessile*), LE; *ibidem*, grass meadow steppe with *Poa*, 1 VII 1976, *Afonina* (*Афонина*) (as *P. kozlovii*, with numerous brown capsules), LE; left bank of Indigirka River, above mouth of Inyali River, on flat top, dry steppe with *Artemisia*, *Koeleria*, *Helictotrichon* and lichens, 18 VI 1976, *Afonina* (*Афонина*) (as *Pterygoneurum kozlovii*, with capsules; in admixture to *Bryum argenteum*), LE; *ibidem*, on steep slope, steppe with *Artemisia*, *Koeleria* and *Carex*, 16 VI 1976, *Afonina* (*Афонина*) (as *Pterygoneurum kozlovii*, with capsules; with *Ceratodon purpureus* and in admixture to *Bryum argenteum*), LE; Oimyakon District, surroundings of Ust'-Nera Settlement, 64°32'27.8"N, 142°58'10"E, 585 m a. s. l., left bank of Indigirka River, 957 km along Magadan Road, dry steppe slope, on bare soil among grasses, 31 VII 2015, *Ignatov*, *Ignatova* (*Игнатов*, *Игнатова*) 15-1022 (as *P. kozlovii*), МНА 9046874.

Description. *Plants* numerous in thin, flat, ± loose turfs, up to 3 square decimeters, or few in admixture to mosses, green to gray-green or yellowish with age. *Stems* 0.5–3 mm long, simple or 2(3)-branched. *Leaves* loosely appressed, somewhat erect and slightly twisted when dry, erect-spreading when moist; ± concave, obovate to obovate-lanceolate, upper 1.2–1.5 × 0.9–1.1 mm (without awn), lower 0.5–0.7 mm (without awn); margins plane below, ± incurved above, shortly acuminate. *Costa* long-excurrent as a ± denticulate hyaline awn, (0.3–0.5)0.8–1.1 mm; ventral outgrowths of 2–4 lamellae longitudinally inserted on ventral side of costa of 4–10(15) rows of cells

Plate II. *Pterygoneurum sibiricum* Otnyukova, sp. nov.

1, 2, 4 – ventral part of leaves with lamellae (view from the inner side of the leaf-shaped lamellae); 3, 5 – lamellae (view from the inner side of the leaf-shaped lamellae); 6–8, 10–12 – lamella cells in the upper half of lamellae from their inner side: with C-shaped and ring-shaped papillae (6, 7), C-shaped with auricles, horseshoe- and ring-shaped papillae (8, 10, 11), simple papillae (12); 9 – lamella cells in the lower half of lamellae from its inner side, epapillose or with few simple papillae.

Scale bars: 1–3 – 150 μm; 4–5 – 300 μm; 6, 8, 9, 12 – 40 μm; 7, 10, 11 – 20 μm.

1–3, 11, 12 – from holotype; 4–10 – from paratype (16 VI 1976, *Afonina*, LE).

in height, low-papillose; papillae of lamella cells located on both sides in the upper half of lamella, 1–3(4) per cell, mainly variously branched, C-shaped with auricles, C-, horseshoe- and ring-shaped or sometimes simple. *Cells* in the upper part of the leaf lamina rhomboidal, in the middle part of the lamina quadrate to shortly rectangular, (10)15–18(22) × 13–15 μm, low-papillose, basal cells rectangular, thin-walled, epapillose; papillae of leaf lamina cells located mainly on dorsal side of lamina, 1–3(4) per cell, mainly variously branched, C-shaped with auricles, C-, horseshoe- and ring-shaped or sometimes simple. Paroicous. Inner perigonal bracts with costa ending near apex, scarcely dentate above. *Perichaetial* leaves little differentiated, obovate, up to 1.5 mm, hyaline awn 0.8–1.1 mm. *Seta* straight, thickened, 0.3–0.4 mm. *Capsule* cleistocarpous, short-elliptic to globose 0.6–0.7 mm long. *Operculum* small, short, straight, 0.15–0.2 mm long. *Calyptra* small, triangular-cucullate, 0.5–0.6 mm long. Spores brown, papillose, (32)37–45(47) μm.

Ethymology. The species name is given for its occurrence in Siberia.

Distribution. *Pterygoneurum sibiricum* is widespread in the Asian part of Russia, including Indigirka River Basin in the Republic Sakha (Yakutia), the Trans-Baikal Territory and southern part of the Krasnoyarsk Territory, while *P. kozlovii*, described from the Ukraine, occurs only in the South East European Russia, where it grows in dry conditions of the Republic of Kalmykia and the Saratov Region.

Based on the differences in the geographical distribution of both species in Russia, it can be supposed that species of the genus *Pterygoneurum* recorded as *P. kozlovii* for Mongolia (Tsegmed, 2001) represents *P. sibiricum*. Also, it is logical to assume that species of the genus *Pterygoneurum* with high lamellae [2–6(10) rows of cells] recorded as *P. kozlovii* for North America (Zander, 2007) represents another species.

Ecology. *Pterygoneurum sibiricum* grows in Siberia on the steppe slopes on soil among grasses. Detailed observations of ecology were made on the steppe slopes in the Yenisey River Basin in the vicinity of Krasnoyarsk. *Pterygoneurum sibiricum* dominates there on south-facing slopes, on dry mineralized soil, found at the end of August only with perichaetia and at the end of September with perichaetia and juvenile green capsules with calyptrae.

In the study area there are three species, *P. sibiricum*, *P. subsessile* and *P. ovatum*. Although two species *P. sibiricum* and *P. subsessile* dominate on soil on steppe slopes among grass, they occupy different niches. *Pterygoneurum subsessile* dominates on the slopes of the south-western exposure and grows on less mineralized soil with dead plant debris, found at the end of September with green and near mature capsules, both with calyptrae. The third species, *P. ovatum*, is very rare under the same conditions as *P. subsessile* (on south-western slopes), grows in small turfs on gravelly substrate among crushed stones, found at the end of September with juvenile green capsules with calyptrae.

Distinctive characters and variation. Comparison of materials of *Pterygoneurum* species kept in LE and MHA has distinguished the constant and variable features of *P. sibiricum*. All the studied specimens are characterized by distinctive short

elliptic or globose capsules and small, triangular-cucullate calyptrae; leaves somewhat erect and slightly twisted when dry; papillae located on dorsal side of leaf lamina and on both sides of lamellae; high lamellae mainly of 4–10(15) rows of cells in height. In *P. sibiricum* papillae of leaf lamina and of lamella cells mainly branched, C-shaped with auricles, C-, horseshoe- and ring-shaped or sometimes simple. In all studied specimens of *P. sibiricum* the number of papillae varies from one cell to another and from one leaf to another. Because of that it is recommended to study several plants to find typical branched papillae of leaf lamina and lamella cells.

Differentiation. Specimens of *P. sibiricum* studied in the field superficially resemble small green *Syntrichia* Brid. species due to the somewhat erect and slightly twisted leaves when dry, while in the stegocarpous species of *Pterygoneurum* the leaves are mainly appressed, giving plants a bulbiform appearance. Because of the specific characteristic of turfs, *P. sibiricum* is easily distinguished in the field from the other species of the genus.

Pterygoneurum sibiricum is the second cleistocarpous species after *P. kozlovii* (Plate III: 1–5, 9–21) and therefore it can be easily confused with the latter. Comparison of materials of *Pterygoneurum* species kept in LE and MHA has shown common features and distinctions of *P. sibiricum* and *P. kozlovii*. Both species are similar in cleistocarpous capsule but differ in all other characters.

In the diagnosis of *P. kozlovii* there are no descriptions of sexual condition, sporophyte structures and spores. A comparison of *P. sibiricum* and *P. kozlovii* showed that capsules of *P. sibiricum* short-elliptic to globose, 0.6–0.7 mm long vs. in *P. kozlovii* elliptic, 1.0–1.2 mm long; operculum small, triangular, straight, 0.15–0.20 mm long in *P. sibiricum* vs. in *P. kozlovii* large, conical, \pm inclined, 0.4–0.5 mm long; calyptra short, triangular-cucullate, 0.5–0.6 mm long in *P. sibiricum* vs. long, oblong-cucullate, 1.0–1.1 mm in *P. kozlovii*. Both species also differ in the sexual condition. In paroicous *P. sibiricum* perigonia are often situated near the archegonia and inner perigonial bracts oval and dentate at apex, with slender costa, while in autoicous *P. kozlovii* perigonia are situated on the same plant but far from the perichaetia and inner perigonial bracts are similar to the stem leaves, oval to widely-obovate with costa shortly excurrent. Besides characters mentioned above both species differ in high lamellae of 4–10(15) rows of cells in height, obovate, i. e., leaf-shaped in outline vs. low lamellae of 1–3(4) rows of cells in height, narrowly oblong, i. e., ribbon-like in outline in *P. kozlovii*; papillae located on both sides of the lamellae, branched, C-shaped with auricles, C-, horseshoe- and ring-shaped or sometimes simple vs. simple or hardly branched in *P. kozlovii*; papillae of leaf lamina located on the dorsal side of the lamina, branched or sometimes simple vs. mostly simple or absent in *P. kozlovii*.

Pterygoneurum sibiricum has papillose leaf and lamella cells as in *P. arcticum* and *P. lamellatum* (Savicz-Ljubiskaja, Smirnova, 1970) but differ in cleistocarpous and sessile capsule (vs. stegocarpous capsule with long seta). *Pterygoneurum sibiricum* is also similar to *P. subsessile* because of sessile capsule, but differs in triangular-cucullate calyptra, which is mitrate in *P. subsessile* (Plate III: 6–8).

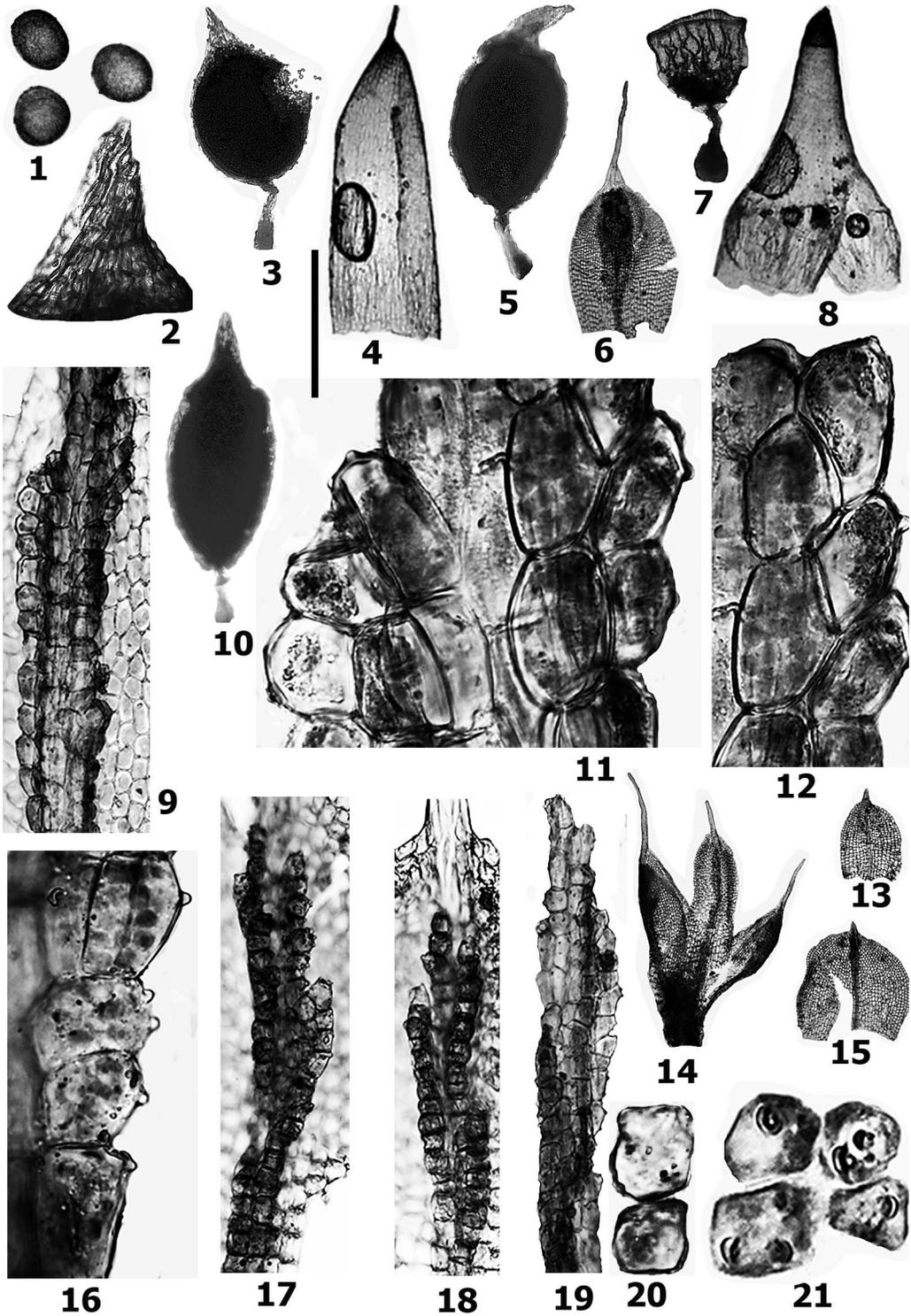


Plate III. *Pterygoneurum kozlovii* Laz. (1–5, 9–21) and *Pterygoneurum subsessile* (Brid.) Jur. (6–8).

1 – spores; 2 – operculum; 3, 5, 7, 10 – capsules; 4, 8 – calyptrae; 6 – stem leaf; 9, 17–19 – ribbon-like, narrow lamellae (view from the inner side of the lamellae); 11, 12 – upper part of lamellae with few simple papillae: bilateral location of lamellae along the costa (11), unilateral location of lamella along costa (12); 13, 15 – inner perigonial bracts; 14 – part of stem with leaves; 16 – low part of lamella with few simple papillae; 20 – lamella cells from the inner side of lamella with rare, simple papillae at margin and on the surface of cell; 20, 21 – cells of leaf lamina from the dorsal side of leaf: epapillose (20), with hardly branched papillae,

C-shaped and ring-shaped (21).

Scale bars: 1 – 80 μm ; 2, 4, 8 – 0.5 mm; 3, 5, 7, 10 – 1.0 mm; 6, 13–15 – 1 mm;

9, 17–19 – 150 μm ; 11, 12, 16, 20, 21 – 20 μm .

1–3, 19, 21 – from 12 VI 1970, L. Cherepanova, LE; 4, 5, 9–18, 20 – from 24 V 2010, G. Ukrainskaya 138-кл, LE; 6, 7, 8 – from 29 VI 1976, Afonina, LE.

Selected specimens examined: *Pterygoneurum kozlovii* – **Russia**, Republic of Kalmykia, Priyutninsky District, Priyutnoe Village, 46°05'N, 43°30'E, steppe, on soil among grass, 12 V 2010, G. Ukrainskaya (Г. Украинская) 163-кл; Komsomolsky District, Achinery Village, 45°24'N, 44°20'E, on sand among grass, 24 V 2010, G. Ukrainskaya (Г. Украинская) 138-кл, LE; Saratov Region, Novouzensky District, Varfolomeevka Village, abandoned vegetable plantation (pasture), wall of former canal, on soil, 12 VI 1970, L. Cherepanova (Л. Черепанова) (marked by E. Ignatova as *Phascum cuspidatum?*).

Pterygoneurum subsessile – **Russia**, Krasnoyarsk Territory, north-western spurs of the East Sayan Mts., vicinity of the City of Krasnoyarsk, right bank of Yenisey River, Laletino stream, 55°59'N, 92°44'E, ~ 250 m a. s. l., Zmeiny Log, steep south-western steppe slope, 23 IX 2019, Otnyukova, LE; Trans-Baikal Territory, 30 km east-south-east of Zabaikalsk Town, Argun Ridge, 49°51'N, 117°00'E, stony feather-grass-forb steppe on slope, 27 VII 2005, Afonina (Афонина) 5705, LE; Republic of Sakha (Yakutia), right bank of Indigirka River, near mouth of Ystan-Yuryakh (opposite village of Tyubelyakh), high river terrace, grassy steppe with *Poa* and *Artemisia*, 29 VI 1976, Afonina (Афонина), LE; left bank of Indigirka River, above mouth of Inyali River, at base of slope, grass meadow, 17 VI 1976, Afonina (Афонина), LE; *ibidem*, mountain steppe on steep slope of south-east exposure, 16 VI 1976, Afonina (Афонина), LE; *ibidem*, shrub-birch forest, 23 VI 1976, Afonina (Афонина), LE; Astrakhan Region (Astrakhan Guberniya), semi desert near Baskunchak Lake, 1926, V. P. Savich (В. П. Савич), LE; Republic of Kalmykia, Caspian lowland steppe, 1954, A. T. Andreev (А. Т. Андреев), LE. — **Kazakhstan**, near City of Kzyl-Orda (Karaganda), at foot of Coxinger Mt., 3 VI 1958, I. Borisova (И. Борисова), LE; near City of Atyrau (Guryev), Atyrau Region (Novobogatinsky District), Shaubten Tract, hilly plain, 12 X 1952, unclear handwritten name, LE.

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