

## Genus *Pterygoneurum* (Pottiaceae, Musci) in China

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Three species of *Pterygoneurum* are present in China: *P. ovatum* (Hedw.) Dix., *P. subsessile* (Brid.) Jur. and *P. kozlovii* Laz. *Pterygoneurum ovatum* has exserted, stegocarpous capsules, while those of *P. subsessile* are immersed, although also stegocarpous. *Pterygoneurum kozlovii* is reported for the first time from Inner Mongolia Province of China. It is distinguished from the other species by the cleistocarpous capsules. Detailed descriptions, illustrations and distribution maps are given for the species and a key to the Chinese species is provided. The spore morphology of the three species was examined by SEM.

Key words: Pottiaceae, *Pterygoneurum*, SEM, taxonomy

### Introduction

The Pottiaceae are a large and diverse family of mosses with many of its species restricted to seasonally dry environments. It is taxonomically difficult and has undergone an extensive review in recent years. *Pterygoneurum* is a small genus of Pottiaceae, established by Juratzka (1882) on the basis of *P. carifolium* (*P. ovatum*). The genus consists of about nine to thirteen species in the world, depending on different taxonomic interpretations (Cano *et al.* 1994, Crosby *et al.* 1999). Following the genus concept of Zander (1993), the species are characterized and easily identified by the short, often bulbiform habit, with concave, ovate to spatulate leaves that have lamellae on the ventral surface of the costa. Specialized asexual reproduction is absent, and the sexual condition is autoicous or parocous. The capsules are stegocarpous, rarely cleistocarpous;

the theca is short-cylindric, often macrostomous, the operculum is rostrate to conic-rostrate, and peristome teeth are absent or rudimentary. The calyptrae are cucullate or mitrate, with 3–4 large lobes.

*Pterygoneurum* is closely related to *Aloina*, *Aloinella* and *Crossidium*. These are mosses that have outgrowths on the ventral surface of leaves (Delgadillo 1973). The outgrowths of *Pterygoneurum* appear as wing-like flaps or lamellae, but in the other three genera they are filaments. Because of the presence of the flap-like lamellae, it is easy to distinguish *Pterygoneurum* from the other genera in the subfamily Pottioideae. However, except for the lamellae on the leaves, according to Zander (1993), *Pterygoneurum* is quite similar to species of *Tortula* sect. *Pottia* and is approached in many characters by *Tortula californica*, *T. cuneifolia*, and *T. grandiretis*. Zander (1993) supports the hypotheses that the

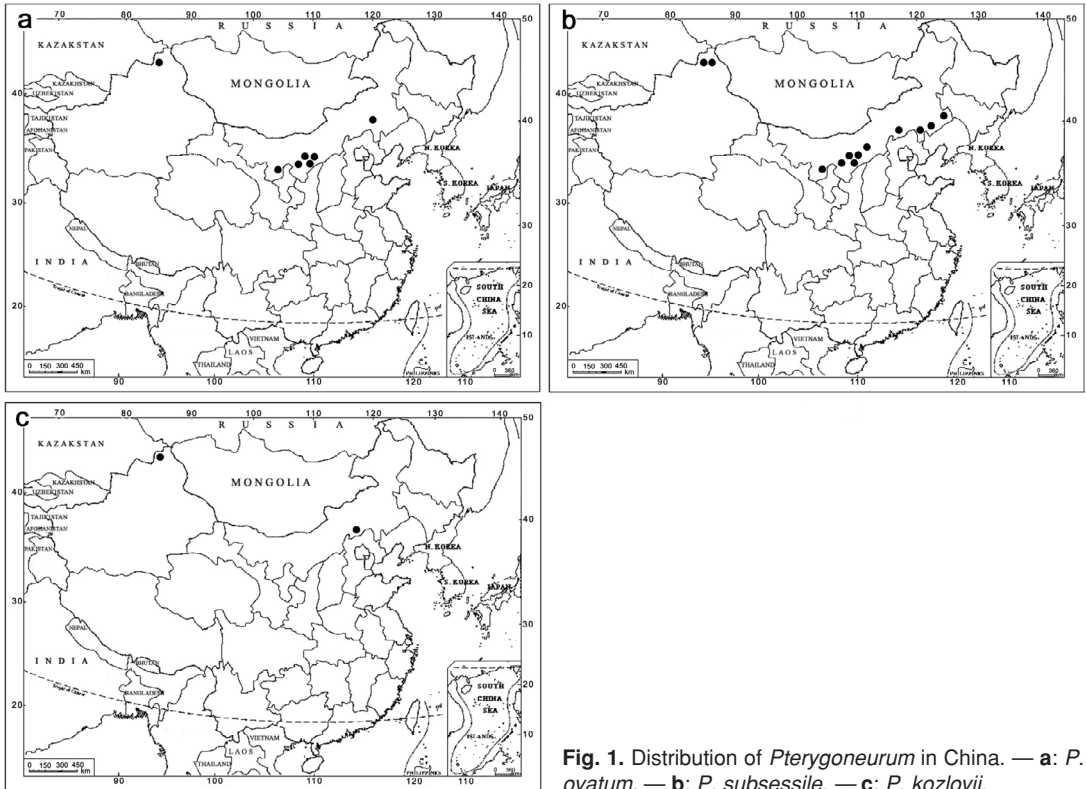


Fig. 1. Distribution of *Pterygoneurum* in China. — a: *P. ovatum*. — b: *P. sessile*. — c: *P. kozlovii*.

genus was derived from *Hyophila*-like ancestors.

During a bryological exploration in Xilin Gol Meng of Inner Mongolia in China on August 2005, a distinctive species of *Pterygoneurum* caught our attention. The plants did not look like any previously known species of *Pterygoneurum* in China. After studying the description in Abramova *et al.* (1973), we concluded that the interesting specimen was *P. kozlovii*. The Chinese specimens of *P. kozlovii* typically grow on soil among *Artemisia intramongolica* on alkaline swale between fixed dunes. It often grows mixed with *Pterygoneurum sessile*, which has a similar general appearance, but is easily separated by the usually cleistocarpous capsules.

Tan *et al.* (1995) reported a Xinjiang collection with long apical awns and several capsules with aborted spores as *P. kozlovii*. Thus, the genus *Pterygoneurum* is now represented in China by three confirmed species: *P. ovatum*, *P.*

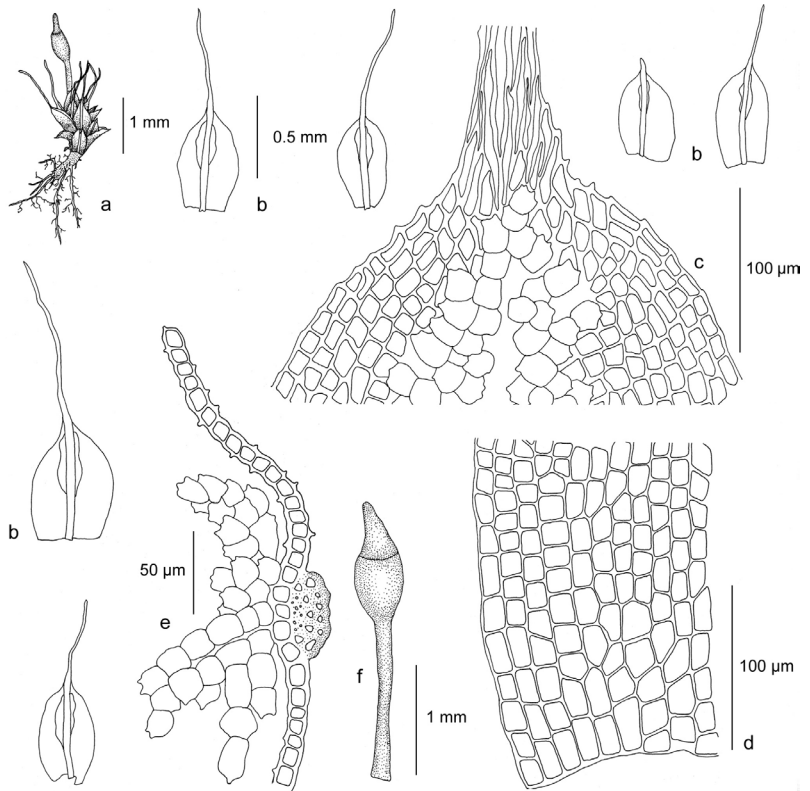
*sessile* and *P. kozlovii*. The Chinese distribution of *Pterygoneurum* is in Fig. 1.

## Material and methods

This revision is based on collections preserved at the herbarium HIMC. Microscopic examinations were undertaken and exact measurements made. Descriptions and illustrations were made from the examined Inner Mongolian plants. Cross-sections of vegetative leaves were all made at mid-leaf. Scanning electron micrographs were taken with H-7000 SEM. Before scanning, the spores were washed in a drop of distilled water on a microscope slide and allowed to air dry for two days, and then they were coated with gold.

The Chinese specimens studied for spore morphology are as follows:

*P. ovatum*: Inner Mongolia Prov., Ordos, Dongsheng, VII.2005 X. L. Bai 057013.



**Fig. 2.** *Pterygoneurum ovatum* (from X. L. Bai 05715, HIMC). — **a:** Plant with sporophyte. — **b:** Leaves. — **c:** Apical leaf cells. — **d:** Basal marginal leaf cells. — **e:** Cross section of costa and portion of leaf. — **f:** Capsules and operculum.

*P. subsessile*: Inner Mongolia Prov., Xilin Gol Meng, Sanggin Dalai, VIII.2005 X. L. Bai 058125.

*P. kozlovii*: Inner Mongolia Prov., Xilin Gol Meng, Sanggin Dalai, VIII.2005 X. L. Bai 0582118.

2. Capsules immersed, cleistocarpous. Operculum absent. Costa awn excurrent in a relatively long, hyaline hair-point, denticulate or nearly so ..... *P. kozlovii*

## Taxonomic treatment

### Key to Chinese species of *Pterygoneurum*

The following key is based partially on keys published in Li *et al.* (2001), Oesau (2003), and also on the material collected by the author.

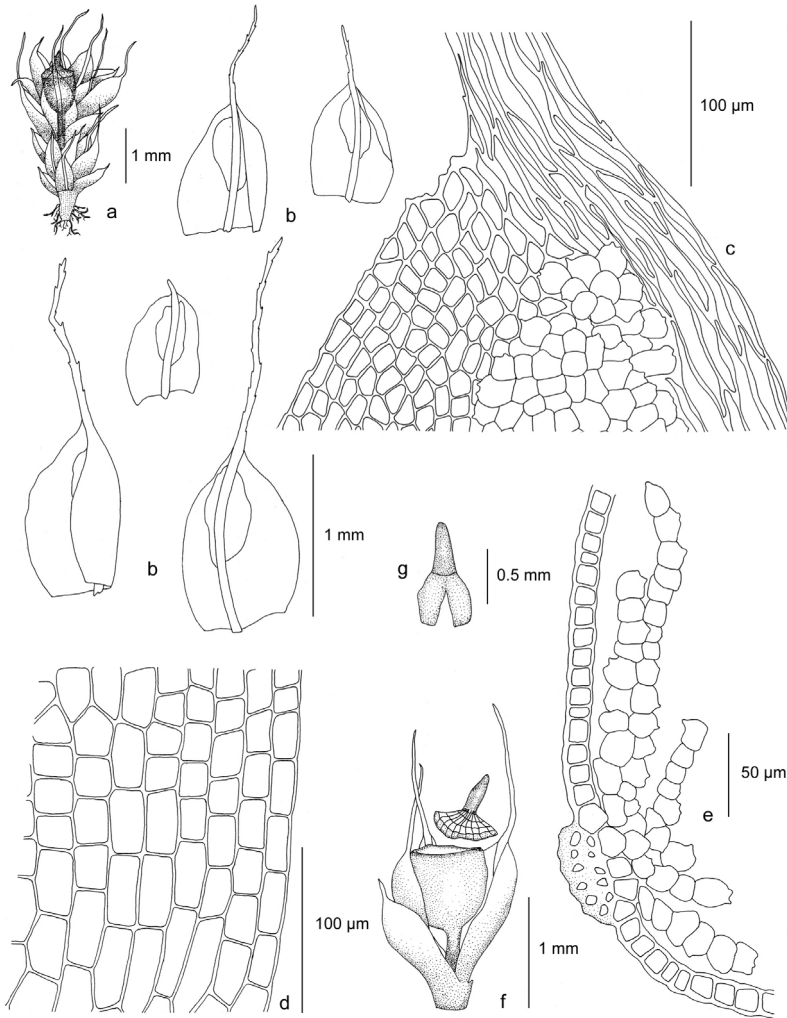
1. Capsules shortly exserted with elongate setae, calyptrae cucullate, smooth ..... *P. ovatum*
1. Capsules immersed or partly exserted, calyptrae mitrate, smooth ..... 2
2. Capsules immersed, stegocarpous, peristome lacking, operculum conic-rostrate. Costa excurrent in a long hyaline hair-point twice as long as lamina, serrate ..... *P. subsessile*

## Taxonomy

### *Pterygoneurum ovatum* (Hedw.) Dix. (Fig. 2)

Rev. Bryol. Lichénol. 6: 96. 1934. — *Gymnostomum ovatum* Hedw., Sp. Musc. Frond. 31. 1801.

Plants small, 1–2 mm high, yellowish green, in thin tufts. Stems very short, erect. Leaves weakly spreading when moist, appressed when dry, ovate to triangularly ovate, broadly concave, 1.0–1.5 mm long with awn; margins plane or weakly incurved; costa ending in a smooth long awn, shorter than or nearly as long as leaf base; with 2–4 rows of green lamellae on ventral side of costa; upper leaf cells rounded quadrate to irregularly hexagonal, 10–14 µm in diameter,



**Fig. 3.** *Pterygoneurum subsessile* (from X. L. Bai 04823, HIMC). — **a:** Plant with sporophyte. — **b:** Leaves. — **c:** Apical leaf cells. — **d:** Basal marginal leaf cells. — **e:** Cross section of costa and portion of leaf. — **f:** Capsules and operculum. — **g:** Calyptra.

smooth or occasionally with minute C-shaped papillae; basal cells rectangular,  $23\text{--}56\ \mu\text{m} \times 13\text{--}20\ \mu\text{m}$ , thin-walled, smooth. Setae  $1.5\text{--}3.0\ \text{mm}$  long; capsules shortly exserted, shortly cylindrical,  $1.0\text{--}1.5\ \text{mm}$  long, dark brown; annuli none; opercula conic-rostrate, with a short, oblique beak; peristome lacking. Calyptrae cucullate, smooth. Spores  $23\text{--}39\ \mu\text{m}$  in diameter, brownish.

**SPECIMENS EXAMINED:** **China.** Inner Mongolia Prov.: Bairin You Qi, Daban,  $43^{\circ}30'\ \text{N}$ ,  $118^{\circ}42'\ \text{E}$ , on soil on dry rock faces, 1991 X. L. Bai 208 (HIMC); He-lan Shan (Mt.), Halawu,  $38^{\circ}48'\ \text{N}$ ,  $105^{\circ}48'\ \text{E}$ , on soil on shady slopes, 23.VII.1963 Z. G. Tong 1844 (HIMC); Ordos, Ejn Horo Qi,  $39^{\circ}36'\ \text{N}$ ,  $109^{\circ}42'\ \text{E}$ , on arenaceous soil, VII.2000 J. Xu 2009 (HIMC); Ordos, Dongsheng,  $39^{\circ}48'\ \text{N}$ ,  $110^{\circ}\ \text{E}$ , on soil under the canopy of shrubs, VIII.2005 X. L. Bai 057013 (HIMC); Ordos, Ejn Horo Qi,  $39^{\circ}36'\ \text{N}$ ,  $109^{\circ}42'\ \text{E}$ , on arenaceous soil,

VII.2000 J. Xu 2009 (HIMC); Ordos, Hanggin Qi,  $39^{\circ}48'\ \text{N}$ ,  $108^{\circ}42'\ \text{E}$ , on calcareous soil, 2002 J. Xu 02046 (HIMC); Ordos, Otog Qi,  $39^{\circ}\ \text{N}$ ,  $108^{\circ}\ \text{E}$ , on soil on old walls, 2002 J. Xu 02027 (HIMC); Ordos, Jungar Qi,  $39^{\circ}36'\ \text{N}$ ,  $110^{\circ}48'\ \text{E}$ , on arenaceous soil, 15.VII.2005 X. L. Bai 05715 (HIMC). — Ningxia Prov.: He-lan Shan (Mt.),  $38^{\circ}35'\ \text{N}$ ,  $105^{\circ}54'\ \text{E}$ , on soil on shady slopes, 12.VIII.2003 X. D. Wang 192 (HIMC).

There are only two previous reports from China (Li 2001): Tong 1844 (see above) and Xinjiang Prov.: Altai Mt., Burgin Co., Whittemore & R. L. Zhu 4651 (MO).

***Pterygoneurum subsessile* (Brid.) Jur. (Fig. 3)**

Laubm.-F1. Oesterr.-Ung. 96. 1882. — *Gymnostomum subsessile* Brid., Muscol. Recent. Suppl. 1: 35. 1806.

Plants 2–4 mm high, grayish green to yellowish green, gregarious or in low tufts. Stems erect, simple or occasionally branched at base. Leaves appressed when dry, weakly erect-spreading when moist, oblong ovate to ligulate or elliptic, strongly concave, 2–3 mm long with awn; margins entire or serrulate at or near base of awn, plane or weakly incurved; costa rather stout, excurrent, ending in a long awn, nearly twice as long as leaf length, denticulate; with 2–4 rows of green lamellae on ventral side of costa; upper leaf cells quadrate to rounded hexagonal, 10–14  $\mu\text{m}$  in diameter, moderately thin-walled, smooth or with simple or blunt C-shaped papillae; basal cells rectangular, 23–40  $\mu\text{m}$   $\times$  13–16  $\mu\text{m}$ , thin-walled, smooth. Setae 0.3–0.5 mm long; capsules immersed, stegocarpous, subhemispheric to ovoid; annuli none; opercula conic-rostrate, with a short, straight beak; peristome teeth absent. Calyptrae mitrate, smooth. Spores 29–39  $\mu\text{m}$  in diameter, brownish.

**SPECIMENS EXAMINED:** **China.** Inner Mongolia Prov.: Chifeng City, Aohan Qi, 42°18'N, 119°54'E, on soil in mixed forests, VII.2004 *G. Q. Tian 04439* (HIMC); Chifeng City, Songshan Qu, 42°12'N, 118°54'E, on calcareous soil, VII.2004 *G. Q. Tian 04506* (HIMC); He-lan Shan (Mt.), Halawu, 38°48'N, 105°48'E, on soil on shady slopes, 1963 *Z. G. Tong 2124, 2189, 2023* (HIMC); Hohhot City, 40°48'N, 111°42'E, on soil on rocks, 29.VIII.1964 *Z. G. Tong 2532* (HIMC); Ordos, Dalad Qi, 40°24'N, 111°E, on soil, 2002 *J. Xu 02058* (HIMC); Ordos, Dongsheng, 39°48'N, 110°E, on soil, VII. 2000 *X. L. Bai 2043, 2031* (HIMC); Ordos, Ejin Horo Qi, 39°36'N, 109°42'E, on arenaceous soil, VII.2000 *J. Xu 2009* (HIMC); Ordos, Hanggin Qi, 39°48'N, 108°42'E, on arenaceous soil, VII.2003 *J. Xu 03070003* (HIMC); Ordos, Jungar Qi, 39°36'N, 110°48'E, on soil in mixed forest, VII.2003 *J. Xu 0307015, 0308006, 031012006* (HIMC); Ordos, Otog Qi, 39°N, 108°E, on soil under the shrubs, 2002 *J. Xu 02020, 23.VIII.2004 X. L. Bai 04823* (HIMC); Ordos, Uxin Qi, 38°36'N, 108°54'E, on arenaceous soil, VII.2000 *J. Xu 2016* (HIMC); Tongliao City, Horqin Zuoyi Houqi, 42°54'N, 122°18'E, on arenaceous soil, VII.2004 *G. Q. Tian 04329* (HIMC); Tongliao City, Naiman Qi, 42°48'N, 120°54'E, on arenaceous soil, VII.2004 *G. Q. Tian 04336* (HIMC); Xilin Gol Meng, Zhenglan Qi Sanggin Dalai, 42°43'N, 115°52'E, on soil among *Artemisia ordosica* VIII.2005 *X. L. Bai 058125* (HIMC). — Ningxia Prov.: He-lan Shan (Mt.), 38°42'N, 105°54'E, on damp soil in *Pinus tabulaeformis* forest and *Picea crassifolia* forest, 13.VIII.2003 *X. D. Wang 008, 111, 112* (HIMC).

There are only three previous localities in China (Li 2001): Inner Mongolia Prov.: Hohhot City, *Tong 2525* (PE), and Xinjiang Prov.: Altai

Mt., Burgin Co., *Whittemore et al. 4753* (MO), Altai Mt., Qing he River valley, *Whittemore et al. 4605c, 4630* (MO).

### *Pterygoneurum kozlovii* Laz. (Fig. 4)

Bot. Zhurn. Ak. Nauk Uk. RSS 3: 61. 1946.

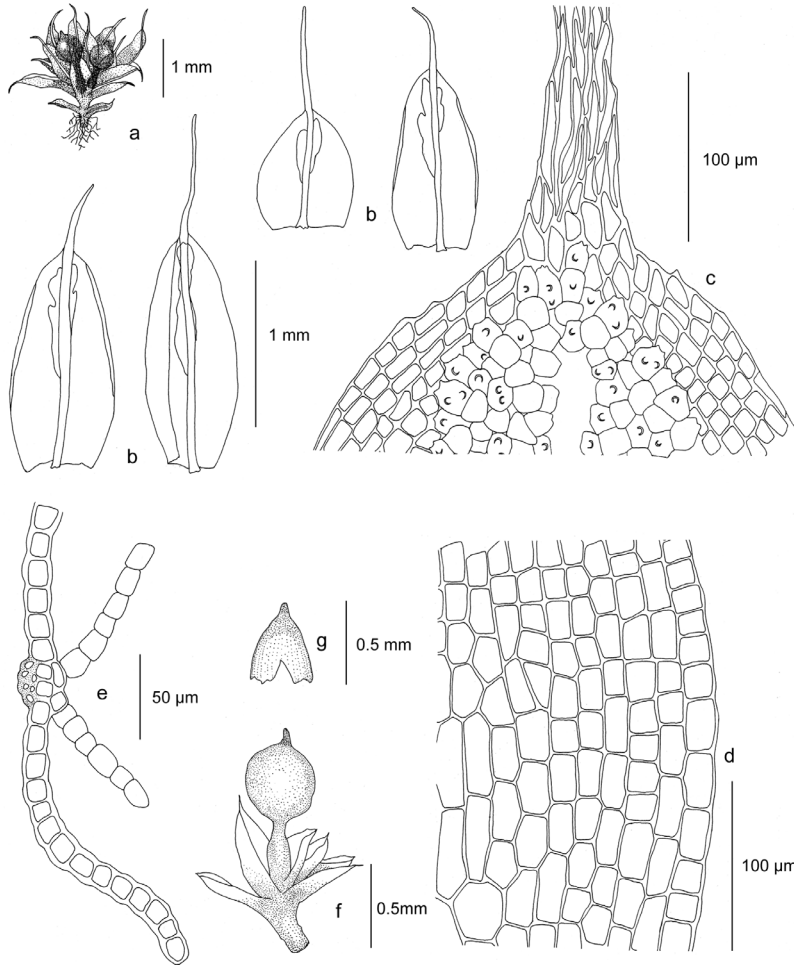
Plants 1.8–2.6 mm high, yellowish green, in thin tufts. Stems erect. Leaves appressed when dry, weakly erect-spreading when moist, ovate-lanceolate to ovate, concave, 1.6–2.4 mm long with awn; margins entire, incurved in middle leaves; costa is usually short-excurrent, smooth to weakly denticulate, with 2–4 rows of green lamellae on upper surface; upper leaf cells quadrate to rounded quadrate, 8–15  $\mu\text{m}$  wide  $\times$  13–23  $\mu\text{m}$  long, smooth or weakly C-shaped papillae; basal cells rectangular, thin-walled, smooth. Setae 0.26–0.47 mm long; capsules immersed, short-ovoid, cleistocarpous. Calyptrae cucullate or rarely mitrate. Spores large, 34–47  $\mu\text{m}$  in diameter, brownish.

**SPECIMEN EXAMINED:** **China.** Inner Mongolia Prov.: Xilin Gol Meng Zhenglan Qi Sanggin Dalai, 42°43'N, 115°52'E, on soil among *Artemisia ordosica* VIII.2005 *X. L. Bai 0582118* (HIMC).

There is only one previous record from China: Xinjiang Prov.: Habahe Co., *Tan 93-1032* (XJU).

## Discussion and SEM study of spores

Among the species of *Pterygoneurum* there are a few differences in gametophyte characters. For example, the costal awns of *P. kozlovii* tend to be short and smooth, and its leaf margins are weakly incurved in the middle; in addition, the lamellae cells possess sparsely C-shaped papillae. *Pterygoneurum subsessile* and *P. ovatum* usually have longer and denticulate costal awns, the leaf margins are plane and the lamellae cells are smooth or nearly so. However, *P. kozlovii* differs from *P. ovatum* and *P. subsessile* principally in that its capsules are immersed in the leaves at maturity and lacking an operculum. Among the



**Fig. 4.** *Pterygoneurum kozlovii* (from X. L. Bai 0582118, HIMC). — **a**: Plant with sporophyte. — **b**: Leaves. — **c**: Apical leaf cells. — **d**: Basal marginal leaf cells. — **e**: Cross section of costa and portion of leaf. — **f**: Capsules. — **g**: Calyptra.

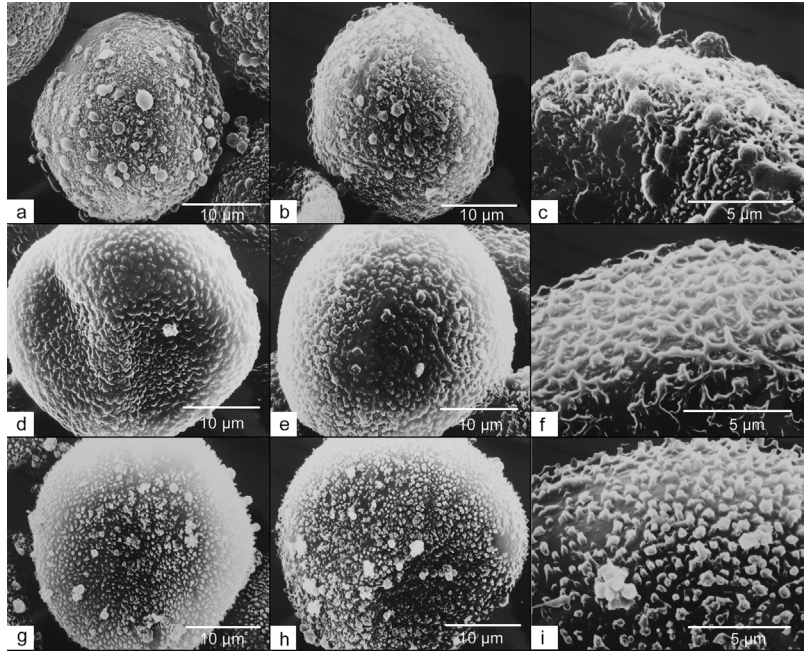
other species, only *P. subsessile* has immersed capsules, but they are operculate. Because of these distinct gametophytic and sporophytic differences between *P. kozlovii* and other members of the genus *Pterygoneurum*, it may warrant a change in its taxonomy at both the species and genus level (McIntosh 1986).

Globally, *P. ovatum* is distributed in China, Mongolia, Russia, North America and northern Africa, and it is found on open calcareous soil, frost soil, and low desert scrub areas. *Pterygoneurum subsessile* occurs in Central Asia, Europe, North America, north Africa and northwestern China, and it grows on decomposed limestone, loess and calcareous soil. *Pterygoneurum kozlovii*, occurring in North America in western Canada, and in Siberia, is a globally threatened and rare species.

Some xeric mosses have the ability to remain viable after years of intermittent or prolonged desiccation, and direct exposure to intense sunlight. Because of the high air pressure zone over Siberia with prevailing winds which could disseminate fragments of some xeric mosses to everywhere, the presence of *P. kozlovii* in northern China probably is due to dispersal from Siberia.

Although we can easily distinguish *P. subsessile*, *P. ovatum* and *P. kozlovii* from each other, a SEM study on the spore ornamentation may supply a diversity of potential diagnostic characters. We wanted therefore to estimate the taxonomic significance of spore morphology in this genus based on Chinese specimens by using SEM.

The spores of *P. ovatum* (Fig. 5a–c) are 23–39 µm in diameter, yellow, and the surface is



**Fig. 5.** Spores of Chinese species of *Pterygoneurum* (SEM). — **a–c:** *P. ovatum*. — **d–f:** *P. subsessile*. — **g–i:** *P. kozlovii*.

roughened and sparsely papillose.

The spores of *P. subsessile* (Fig. 5d–f) are yellow-brown, 29–39  $\mu\text{m}$  in diameter, and the ornamentation is irregularly reticulate, formed of smooth contorted walls.

*Pterygoneurum kozlovii* (Fig. 5g–i) has big spores, 34–47  $\mu\text{m}$ , yellow in colour, and relatively densely papillose.

The spore ornamentation appears to slightly differ among the Chinese species. Occasionally, spores from plants referred to the same species may exhibit considerable variation. For example, Steere and Iwatsuki (1974) described the spores of Alaskan material of *P. subsessile*: “with fairly conspicuous papillae, 31–39  $\mu\text{m}$ ”, which is very similar to our material of *P. kozlovii*. Therefore, we think that environmental conditions may have an effect on variation in the spore ornamentation.

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## References

- Abramova, A. L., Blagodatskich, L. S. & Czerepanova, L. A. [Абрамова, А. Л., Благодатский, Л. С. & Черепанова, Л. А.] 1973: [Conspectus generis *Pterygoneurum* Jur. (MUSCI) in URSS]. — *Nov. Syst. Nizsh. Rast.* 10: 305–316. [In Russian].
- Bai, X. L. & Gao, C. 1993: Newly records genus and species of Pottiaceae in China. — *Acta Scient. Nat. Univ. Intramongolicae* 24: 421–426.
- Cano, M. J., Guerra, J. & Ros, R. M. 1994: *Pterygoneurum compactum* sp. nov. (Musci: Pottiaceae) from Spain. — *Bryologist* 97: 412–415.
- Crosby, M. R., Magill, R. E., Allen, B. & He, S. 1999: *A checklist of the mosses*. — Missouri Bot. Garden, St. Louis.
- Delgadillo, M. C. 1973: A new species, nomenclatural changes, and generic limits in *Aloina*, *Aloniella*, and *Crossidium* (Musci). — *Bryologist* 76: 271–277.
- Juratka, J. 1882: *Die Laubmossflora von Österreich-Ungarns*. — W. Baumüller, Wien.
- Li, X. J., He, S. & Iwatsuki, Z. 2001: Pottiaceae. — In: Li, X. J. & Crosby, M. R. (eds.), *Moss flora of China*, vol. 2, Fissidentaceae–Ptychomitriaceae: 114–249. Sci. Press, Beijing & Missouri Bot. Garden Press, St. Louis.
- McIntosh, T. T. 1986: *The bryophytes of the semi-arid steppe of south-central British Columbia*. — Ph.D. thesis, Univ. British Columbia, Vancouver.
- Oesau, A. 2003: *Pterygoneurum papillosum* (Bryopsida: Pottiaceae), a new moss species from Germany. — *J. Bryol.* 25: 247–252.
- Steere, W. C. & Iwatsuki, Z. 1974: The discovery of *Pterygoneurum subsessile* (Brid.) Jur. in Arctic Alaska. — *J.*

*Hattori Bot. Lab.* 38: 463–473.

Tan, B. C., Zhao, J. C. & Hu, R. L. 1995: An updated checklist of mosses of Xinjiang, China. — *Arctoa* 4: 1–14.

Zander, R. H. 1993: Genera of the Pottiaceae: mosses of harsh environments. — *Bull. Buffalo Soc. Nat. Sci.* 32:

199–202.

Zhao, J. C. 1993: [*Pterygoneurum*, a new generic record of Chinese mosses]. — In: *Proceedings of First Academic Meeting of Young People Sponsored by Xinjiang Association of Sciences*: 194–195. [In Chinese].