



## *Poa liuliangii* and *P. kengii* (Poaceae), two new species from the Hengduan Mountains of southwest China

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**ABSTRACT:** Two new species, *Poa liuliangii* and *P. kengii*, from the Hengduan Mountains (Sichuan province of southwest China) are described and illustrated. Detailed description and comparison tables are also provided. *Poa liuliangii* is similar to *P. incerta* and *P. orinosa* of the *Poa versicolor* aggregate (in accordance with a monotypic species concept), but differs from them in its more mesomorphic appearance (broader panicles, broader leaf blades, flag leaf blades longer than sheathes or equal) and pubescent rachillas. *Poa kengii* is similar to *P. sphondylodes* and *P. faberi*, but differs from them in its shorter ligules and glabrous lemma calluses.

**KEY WORDS:** Alpine flora, Hengduanshan, Pooideae, Sichuan province, taxonomy.

### INTRODUCTION

The Hengduan Mountains (Hengduanshan) of southwestern China are naturally gifted with a diverse flora. It is one of the most significant centers of biodiversity in extratropical Asia (Wu, 1988; Boufford, 2014). According to Boufford (2014), as many as a third of China's 31,500 species of vascular plant grow just in the regions encompassing the Hengduan Mountains. Landscapes of high-elevation mountains with steep slopes, separated by isolated valleys, has favored the isolation of plant populations resulting in accelerated diversification giving rise to this global biodiversity hotspot (Hughes and Atchinson, 2015). Within these landscapes, grass taxa of *Poa* subg. *Stenopoa* sect. *Stenopoa* Dumort. are a common to dominating component but are also some of the most taxonomically complex. Both new species described herein belong to this section.

Sect. *Stenopoa* is one of the largest infrageneric groups within the bluegrass genus *Poa* L., which itself is one of the largest grass genera (Clayton and Renvoize, 1999). According to various regional estimates (Keng, 1959; Tzvelev, 1976; Liu, 2003; Tzvelev and Probatova, 2019), this section comprises up to 100 species and is present mainly in Eurasia, reaching its highest morphological diversity in mountainous areas of Central Asia and the Pan-Himalayas (Olonova *et al.*, 2014). Because of the prevalence of hybridization (Tzvelev, 1976) and apomixis (Stebbins, 1941), the systematic treatment of this section and subgenus is especially complicated. This is compounded by the extraordinary floristic richness and scarcity of specimens from the hard-to-reach mountainous areas where taxa of sect. *Stenopoa* are commonly found.

The first targeted and detailed taxonomic studies of

*Poa* in China were initiated by Keng (1959) and were continued by Liu (2003), wherein the existing knowledge on this difficult genus was organized and many new species were described. The last circumstantial revision of Chinese *Poa* was carried out as part of the "Flora of China" project by American graminologist Dr. R. J. Soreng (Zhu *et al.*, 2006), who made a considerable contribution to the study of this genus and also described several new species from the most taxonomically difficult sections. Nevertheless, there are still many gaps in our knowledge of the diversity of *Poa* from China, in particular that of the Hengduan Mountains.

The Flora of Pan-Himalaya (FLPH) project (<http://www.flph.org/>; Chen, 2019) was developed to help document this diversity and, as part of this, an expedition to the Sichuan province of southwest China was undertaken in 2015. Taking part in this expedition provided an opportunity to observe the character variability of species in natural populations across their ranges so that more informed taxonomic conclusions could be drawn. During the course of this expedition, some interesting samples of *Poa* sect. *Stenopoa* bluegrasses were encountered. Within these, two morphologically distinct taxa were observed that did not match the protologues, types and other specimens of all currently described species. On critical examination, these were confirmed to be new species. Both new species are represented by several populations that deviate from the already known species by several morphological characters that remain stable within these populations and are distributed in a restricted area. We adopt a narrower monotypic species concept as compared to that of Zhu *et al.* (2006). Groups of poorly-isolated monotypic species, which are supposed to be of the same origin, and that have been treated as polytypic species in the Flora of China (Zhu *et al.*, 2006), we treat here as species aggregates (aggr.).

**Table 1.** Morphological comparison between *Poa liuliangii* sp.nov., *P. orinosa* and *P. incerta*.

Characters	<i>Poa liuliangii</i> sp.nov.	<i>P. orinosa</i>	<i>P. incerta</i>
Height (cm)	45–70	45	60–70
Uppermost node	at lower 1/6	at lower 1/4	at lower 1/4
Ligule length (mm)	2–3(4)	2–4	1–3
The ratio between sheath length and blade length of the flag leaf	slightly shorter than blade or equal	sheath longer than blade length	sheath longer than blade length
Leaf blade length of (cm)	10–15	8–10	5–11
Leaf blade width of (mm)	1.5–2(3)	1–1.5	1.5–2
Panicle length (cm)	10–15	8–10	7–11
Panicle width (cm)	3–4	0.5	ca 1
Spikelets length	4–5(6)	3–4	4–5
Rachilla	pubescent	glabrous	scabrous

Using this informal designation, we avoid the necessity of making new nomenclatural combinations to reflect new interpretations of the affinities of taxa until more information is available, with a comprehensive morphometric and phylogenetic study currently in preparation. At the same time, this allows us to highlight distinct and novel diversity from the Hengduan Mountains in a timely manner, before it is lost through continued anthropogenic impact (Xu and Wilkes, 2004).

This study is based on specimens collected during the FLPH Expedition to the Hengduan mountains (Sichuan, China) and examination of specimens from BM, CDBI, E, K, KUN, LE, M, MSB, PE, SZ, XJA, XJBI, and material kindly provided by Prof. G. Mische and Dr. B. Dicoré. Nomenclatural information developed from our work has been shared with Dr. R. J. Soreng who has made it available via TROPICOS (2020).

***Poa liuliangii* Olonova & Sylvester, sp. nov.**

**Figs. 1 & 2A**

**Type:** CHINA. Sichuan Province: Ganzi prefecture, Kanding, 30.6534°N, 102.4286°E, 3875 m alt., gravelly slope, 12 Sep. 2015, *Y.-Sh. Chen & M.V. Olonova TK-002704* (holotype: TK!, isotype: PE!)

**Diagnosis:** *Poa liuliangii* is similar to *P. orinosa* Keng and *P. incerta* Keng ex Liu, but differs from them in its more mesomorphic appearance (broader panicles, broader leaf blades, at least, the flag ones, which are slightly longer than sheathes or equal) and pubescent rachillas (Table 1).

Plants perennial, tufted, not stoloniferous, not rhizomatous. **Tillers** extravaginally branched. **Culms** 45–70 cm tall, erect, scabrous, nodes 3–4, uppermost to 1/5–1/3 way up culm. **Leaves** - **Upper leaf sheath** terete, closed for 1/6 of length, scabrid, usually slightly shorter than blade or equal in fully mature specimens; **throats and collars** surface same as sheathes and adaxial part of blades; **ligules** of flag leaves 2–3(4) mm long, pointed, sometimes splitting; **blades** 10–15 cm long, 1.5–2(3) mm wide, narrowly linear, flat or folded, scabrid, apex pointed, never naviculate. **Panicles** 10–15 × 1–3(–5) cm; more or less spreading to spiciform, branches up to 4 cm

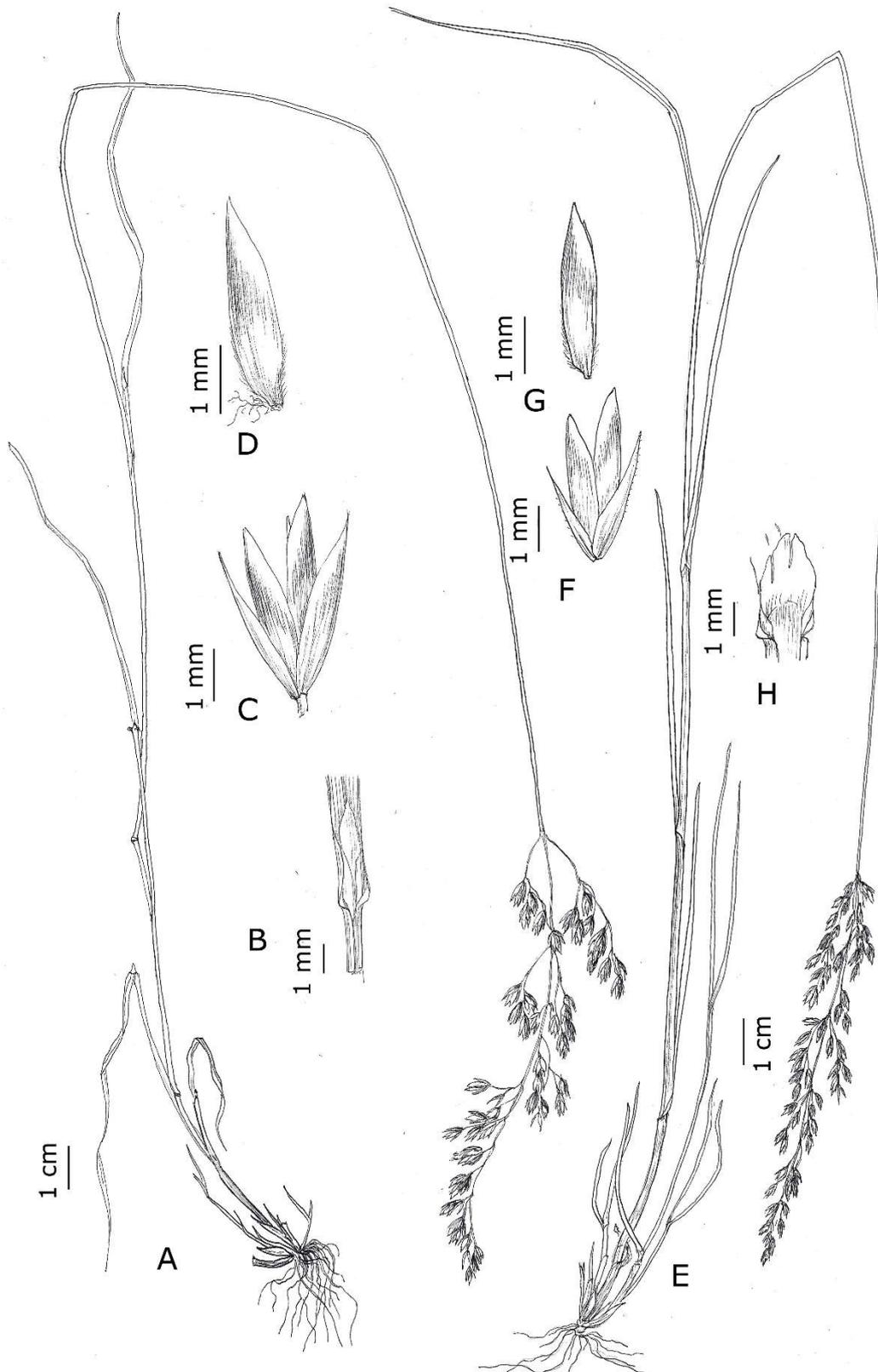
long, 2–4 in the lower node, densely scabrous, without spikelets in the basal part. **Spikelets** (3)4–5(6) mm long, lanceolate; **florets** 2(3); **rachillas** pilose, with soft hairs to 0.5 mm long, smooth; **glumes** 2.3–4 mm long, unequal or, rarely, subequal, lanceolate, 3-veined, slightly scabrous along keels and on the surfaces distally; **lemmas** 3–4 mm long, keel shortly villous for 1/2 of length, marginal veins for 1/3, area between veins glabrous, smooth; **calluses** webbed, sometimes sparsely; **paleas** slightly shorter than lemma, smooth between keels, with short prickles along almost the whole length of keels; **anthers** 1.4–1.6 mm long. **Caryopses** light brown.

**Distribution and Habitat:** *Poa liuliangii* is distributed western Hengduan Mountains. It is found growing on rocks, gravelly slopes and alluvial deposits along streams, 3500–4300 m above sea level.

**Etymology:** This new species has been named in honor of Prof. Liu, Liang, an outstanding researcher of Chinese grasses.

**Notes:** In accordance with its morphological characteristics, *P. liuliangii* belongs to a huge species complex, which followers of the polytypical species concept interpret as a single polytypical species, *P. versicolor* Bess, represented by numerous subspecies (Tsvelev, 1976). This polytypical species concept was used by Zhu *et al.* (2006), i.e. groups of morphologically similar but ecologically or geographically isolated populations were treated as subspecies. Groups which were not geographically or ecologically isolated, but which exhibited morphological deviation within populations were treated as varieties and forms. This approach created a problem for the proper treatment of taxa of hybrid origin. Moreover, the lack of reliable and comprehensive information about possible relationships between, and origin of, many populations does not allow the attribution of specimens to one or another polytypical species with certainty.

The *P. versicolor* aggr. was named as such according to the rule of priority, although *P. versicolor* s.str. has a rather limited Central European distribution. According to the monotypic species concept adopted here, the *P. versicolor* aggr. is represented by more than 20 closely



**Fig 1.** *Poa liuliangii* (A-D). A: Habit. B: Ligule, adaxial view. C: Spikelet, lateral view. D: Lemma, lateral view. *Poa kengii* (E-H). E: Habit. F: Spikelet, lateral view. G: Floret, lateral view. H: Ligule of flag leaf, adaxial view. A-D drawn from the paratype Chen & Olonova TK-002711 (TK), E-H drawn from paratype Chen & Olonova TK-002709 (TK). Illustrations by M.V. Olonova.

**Table 2.** Morphological comparison between *Poa kengii* sp. nov., *P. sphondylodes* and *P. faberi*.

Characters	<i>P. kengii</i> sp. nov.	<i>P. sphondylodes</i>	<i>P. faberi</i>
Height (cm)	40–70	30 – 60	30 – 60
Ligule length (mm)	1.2–2	ca 4–5.5(6)	3 –6(9.5)
The ratio between sheath length and blade length of the flag leaf	sheath shorter than blade length	sheath longer than blade length	sheath longer than blade length
Panicle length (cm)	8–14	3 – 10	10 – 12
Panicle branches	2–3 at the lower node	4 – 6 at the lower node	(2)3 – 5 at the lower node
Spikelets	3.2–4(5) mm, 2–3(4)florets	5–7(8) mm, 4 – 6(8) florets	4–5.5 mm, 4 florets
Lemma callus	glabrous	webbed	webbed

related species, the ranges of which extend latitudinally from central Europe to the Pacific coast and longitudinally from Taimyr to the Himalayas. This *P. versicolor* aggr. achieves its greatest species richness and diversity in the mountain systems of Asia. The aggregate unites moderately xeromorphic species, with an uppermost node located from 1/6 to 1/3 from the base of the stem. The species attributed to the aggregate represent a wide range of ecotypes, from the most mesomorphic *P. stepposa*, adjacent to the much more mesomorphic *P. urssulensis* Trin., to the xeromorphic *P. botryoides* Trin., which is almost indistinguishable from the alpine dwarf species *P. attenuata* Trin. in the upper mountain belts. The taxa belonging to the *P. versicolor* aggr. differ not only in their degree of xeromorphism, but also in the indumentum and scabrousness of the lemmas, glumes, and rachillas, ligule length, and in the size of all floral and vegetative organs.

It is assumed (Tsvelev, 1976) that the *P. versicolor* aggr. is represented by xeromorphic derivatives of the ancient mesomorphic species *P. palustris* L., which differs from another mesomorphic species, *P. nemoralis* L., with a pubescent rachilla and a ligule of the flag leaf 2–2.5 mm long. In the process of evolution, which proceeded mainly as xerophilization (Serebryakova, 1965; Tsvelev, 1976) and as a result of hybridization with other species of sect. *Stenopoa*, populations with pubescent spikelets appeared within the aggregate, the lemma pubescence varying from completely glabrous to densely pubescent not only along the keel and marginal veins, but also between the veins. The callus of the lower florets also varies in pubescence from glabrous to well webbed. Within some populations, the frequency of these character states varies randomly and independently, without showing geographic confinement, while in others the same character states demonstrate stability and are correlated with other character states.

All three populations of *P. liuliangii* differ from closely related species in their more mesomorphic appearance, as well as a relatively low position of the uppermost culm node, which indicates its preference for low temperatures. *Poa liuliangii* differs from *P. orinosa* in its longer stems and spikelets, and shorter ligules. The species also differs from both *P. orinosa* and *P. incerta* in its uppermost culm node situated in the lower 1/6 of the

culm, sheathes which are shorter (or sometimes equal) than the flag leaf blade, longer leaf blades and panicles, and pubescent rachillas. The last character state is quite rare among the *P. versicolor* aggr. and may have been derived from *P. nemoralis*. Height of the uppermost culm node can only be reliably measured from mature specimens towards the end of the flowering season, approx. August to October.

**Additional specimens examined (paratypes):** CHINA. Sichuan: Ganzi prefecture, Kanding, 30.4472°N 101.6685°E, 4200 m alt., alluvial deposit along the stream, 11 Sep. 2015, *Y.-Sh. Chen & M.V. Olonova* TK-002710 (TK!, PE pending export); Ganzi prefecture, Kanding, 30.6162°N 102.3962°E, 3582 m alt., cliffs along the road, 12 Sep. 2015, *Y.-Sh. Chen & M.V. Olonova* TK-002711 (TK!, PE pending export).

*Poa kengii* Olonova & Sylvester, *sp. nov.*

**Figs. 1 & 2B**

**Type:** CHINA. Sichuan Province: Ngava-Tibetan and Qiang autonom. prefecture, Zen Lha county, 31.309°N, 102.489°E, 3144 m alt., cliffs along the road, 13 Sep. 2015, *Y.-Sh. Chen & M.V. Olonova* TK-002705 (holotype: TK!, isotype: PE!).

**Diagnosis:** *Poa kengii* is similar to *P. sphondylodes* Trin. and *P. faberi* Rendle, but differs from them in its shorter ligules and glabrous lemma calluses (Table 2).

Plants perennial, tufted, glaucous plants, not rhizomatous. **Tillers** extravaginally branched. **Culms** 40–75 cm tall, terete, erect, almost smooth under panicle, nodes 3–4(5), uppermost to 1/5–1/3 way up culm. **Leaves** - **Upper leaf sheath** closed for 1/10–1/6 of length, scabrid, usually equal or a bit shorter than blade in fully mature specimens; **throats and collars** surface same as sheathes and adaxial side of the blades; **ligules** of flag leaves 1.3–2 mm long, triangular, usually splitting; **blades** 7–10(12) cm long, 1–1.5 mm wide, narrowly linear, folded, scabrid, apex pointed. **Panicles** 8–14 × 1–2 cm, elongated to spiciform, branches densely scabrous, up to 3 cm long, erect, 2–4 in the lower node, with spikelets in the basal part. **Spikelets** 3.2–4(5) mm long, lanceolate; **florets** 2–3(4); **rachillas** smooth or scabrous; **glumes** 2–3.5 mm long, unequal or subequal, lanceolate, 3-veined, slightly scabrous on the keels and sometimes surfaces distally; **lemmas** 2.8–3.2 mm long, keel and marginal veins scantily villous at least in the lower 1/3 of their length, between veins glabrous, smooth; **calluses** glabrous; **paleas** smooth between keels, with short prickles along



keels; **anthers** 1.2–1.6(1.8) mm long. **Caryopses** light brown.

**Distribution and Habitat:** *Poa kengii* is distributed in the western Hengduan Mountains. It is found growing on rocks and gravelly slopes, 3000–4000 m above sea level.

**Etymology:** This new species has been named in honor of Prof. Keng, Yi Li, an outstanding researcher of Chinese grasses.

**Notes:** *Poa kengii* is found naturally occurring in at least three populations, with the main characters which differentiate it from other species being constant within the populations studied and seem to be accompanied by differences at the genetic level. In accordance with its morphological characteristics, *P. kengii* may be attributed to the *P. sphondylodes* aggr., known as one of the most common polytypic species of sect. *Stenopoa* in Eastern China (Zhu *et al.*, 2006). Specimens of the *P. sphondyloides* aggr. are commonly quite robust, with an elongated uppermost internode, especially at the end of the flowering season, 4- to 8-flowered spikelets, abundant pubescence along the keel and marginal veins of the lemmas, and a well pronounced web on the calluses. The special shape of the panicles, with spikelets found at the base of lower branches, and usually long (>3.5 mm) pointed ligules differentiate it from other species of sect. *Stenopoa*. Being broadly distributed in China, the *P. sphondylodes* aggr. seems to have hybridized with some other species aggregates (or polytypic species) and has formed populations of obscure taxonomic rank, which exhibit combinations in different proportions of the character states of two or three species (e.g., glabrous calluses, or atypical panicles, with the spikelets crowded on the upper parts of the branches). However, these hybrids can be easily identified by their character states not being constant within populations, with their frequency usually very low even among different individual plants placed on the same herbarium sheet. The *P. sphondylodes* aggr. also exhibits a broad ecological amplitude, being found both in dry continental steppe grasslands and humid oceanic coast and islands. In the Chinese continental area, its populations look quite like xeromorphic species, but in humid regions of North and South Korea and Japan it has a more mesomorphic appearance.

This has all resulted in the description of numerous similar and poorly morphologically-isolated species. Specimens which exhibited the most deviation from typical samples were treated by Zhu *et al.* (2006) as varieties, while many names were placed in synonymy. Besides the typical var. *sphondylodes*, *P. sphondylodes* was represented by three other varieties in the Flora of China (Zhu *et al.*, 2006): a) var. *macerrima* Keng, with spikelets crowded in the upper 2/3 of the branches. Such a panicle arrangement is more characteristic of the *P. versicolor* aggr. and may have arisen from hybridization between *P. sphondylodes* s.str. and another species of sect.

*Stenopoa*; populations that exhibit intermediate character states between the *P. sphondylodes* aggr. and the *P. versicolor* aggr. are generally attributed to this variety although studies on its true origin are lacking; b) var. *subtrivialis* Ohwi, which appears much more robust, and is possibly a polyploid derivative of *P. sphondylodes* s.str.; c) var. *erikssonii* Melderis, described from Inner Mongolia and seems to be the least deviated from the type of *P. sphondylodes* s.str.

Certain perceived overlap in morphological characters between *P. kengii*, and *P. sphondyloides* based on descriptions in the Flora of China (Zhu *et al.*, 2006) are also in need of reappraisal. Although Zhu *et al.* (2006) mention *P. sphondylodes* var. *erikssonii* to have ligules 2–3 mm long, in the original paper of Melderis (1949) this characteristic concerns another taxon, *P. sphondylodes* var. *dahurica* (Trin.) Melderis, which was considered a variety of *P. attenuata* by Zhu *et al.* (2006) and Tzvelev (2001) or a distinct species (Kitagawa, 1979; Liu, 2003). This taxon can be easily distinguished from *P. kengii* by, among others, a) its short stature, 7–15(–25) cm tall (vs. 40–75 cm tall in *P. kengii*); b) tillers intravaginally branched (vs. extravaginally branched); c) culm nodes 2, held near base (vs. 3–4(5), uppermost to 1/5–1/3 way up culm); d) shorter, densely-contracted spiciform panicles, 1.5–4 × 0.4–1 cm (vs. elongated to spiciform panicles, 8–14 × 1–2 cm). The other main distinguishing character of *P. kengii*, its glabrous calluses, is also mentioned by Zhu *et al.* (2006) for *P. sphondyloides* which was noted to have either a webbed or glabrous callus. However, this was presumably recorded from hybrid populations. Glabrous calluses are atypical for the *P. sphondyloides* aggr., being found very rarely within populations and being generally correlated randomly with other character states. Thus, this character being found constantly throughout populations and being correlated with other character states clearly differentiates *P. kengii* from other taxa within the *P. sphondyloides* aggr.

In morphological characters, *P. kengii* is also similar to another very polymorphic complex of similar species, the *P. faberi* aggr., which may belong to the same lineage as the *P. sphondyloides* aggr. Both species aggregates are similar in their panicle shape and arrangement, and extremely long ligule (3.5–5, up to 9.5 mm long). The *P. faberi* aggr. differs from common samples of *P. sphondylodes* in being much softer and more slender, with its distribution in the mountains of SW China, whereas the main range of the *P. sphondylodes* aggr. lies in the plains and hills of E China. Nevertheless, like the *P. sphondylodes* aggr., the *P. faberi* aggr. is represented by numerous morphological types. Besides the typical one, five of them have been described as species, but Zhu *et al.* (2006), in accordance with a polytypic species concept, represented these by three varieties which differ from one another mainly in ligule length and rachilla surface scabrocity and indumentum.



Fig 2. Digitized images of holotype. **A.** *Poa liuliangii*. Chen & Oloнова TK-002704 (TK). **B.** *Poa kengii*. Chen & Oloнова TK-002705 (TK).

There is also a need for reappraisal of descriptions of taxa of the *P. faberi* aggr. in the Flora of China (Zhu *et al.*, 2006). According to Zhu *et al.* (2006), *P. faberi* var. *faberi* has ligules (2–)3–6(–8) mm long which does slightly overlap with that of *P. kengii*. However, this is due to Zhu *et al.* (2006) including two closely-related species, *P. paucifolia* Keng ex Shan Chen and *P. prolixior* Rendle, as synonyms of *P. faberi* var. *faberi*. The ligules of *P. paucifolia* and *P. prolixior* vary from 2 to 4 mm long, with continued observation revealing that the longer ligule occurs more frequently. Both these species can also be differentiated from *P. kengii* by their webbed lemma calluses. In addition, *P. paucifolia* does not reach past 30 cm tall, while the spikelets of *P. prolixior* are usually not longer than 3 mm. Certain overlap between *P. kengii* and taxa of the *P. faberi* aggr. is also seen by how *P. faberi* var. *faberi* and *P. faberi* var. *ligulata* Rendle are described by Zhu *et al.* (2006) as having lemma calluses that are sometimes glabrous. Indeed, var. *faberi* sometimes has glabrous calluses, but this occurs in deviated populations, probably of hybrid origin, which, in accordance with the majority of morphological characters, should be attributed to *P. faberi* var. *faberi*. As for var. *ligulata*,

instances where a glabrous callus is exhibited are also most likely a result of hybridization, but the taxon can still be easily differentiated from *P. kengii* by its abnormally elongated ligule. Thus, while certain taxa of the *P. faberi* aggr. occasionally exhibit a glabrous callus, this is correlated with other character states which are absent from *P. kengii*. As for the type specimens of *P. faberi*, the callus is reported as being webbed (Forbes and Hemsly, 1904).

*Poa kengii* also shares similarities with the *P. versicolor* aggr., which may be a result of hybridization. A more exhaustive study that utilizes morphometric and phylogenetic analyses is currently in preparation that will shed further light on species delimitation within these species aggregates and help resolve taxonomic problems of sect. *Stenopoa*.

**Additional specimens examined (paratypes): CHINA.**  
**Sichuan:** Ngava-Tibetan and Qiang autonom. Prefecture, Zen Lha county, 31.645°N 102.343°E, 3852 m alt., cliffs along the road, 13 Sep. 2015, Y.-Sh. Chen & M.V. Oloнова TK-002709 (TK!, PE pending export); Ganzi-Tibetan Autonom. Prefecture, Zen Lha county, 31.214°N 102.448°E, 3083 m alt., gravelly slope, 11 Sep. 2015, Y.-Sh. Chen & M.V. Oloнова TK-002708 (TK!, PE pending export).



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