A new subtribal classification of Arundinariaceae (Poaceae, Bambusoideae) with the description of a new genus

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1. Introduction

Bamboos are important members of forest ecosystems from sea level to alpine mountains (Ohrnberger, 1999; Clark et al., 2015). The bamboo subfamily, Bambusoideae, is one of the 12 subfamilies of the grass family Poaceae, and it is a member of the BOP clade (including Bambusoideae, Oryzoideae and Pooideae) (GPWG, 2001; GPWG II, 2012; Soreng et al., 2015, 2017; Saarela et al., 2018). Nearly 1700 bamboo species in 127 genera are found around the world (GPWG, 2012; Clark et al., 2015; Clark and Oliveira, 2018).

The classification of bamboos at the tribal level has entered a new phase since the first molecular phylogenetic study of bamboos on the basis of broad sampling (Clark et al., 1995) and subsequent phylogenetic and phylogenomic studies (e.g., Bouchenak-Khelladi et al., 2008; Sungkaew et al., 2009; Kelchner and BPG, 2013; Triplett et al., 2014; Ma et al., 2014; Saarela et al., 2018; Guo et al., 2019). The subfamily Bambusoideae is divided into three tribes: the Arundinariaceae (the temperate woody bamboos), the Bambuseae (the tropical woody bamboos), and the Olyreae (the herbaceous bamboos) (BPG, 2012; Kelchner and BPG, 2013). Phylogenetic studies based on plastid regions suggested that the woody bamboos (tribes Arundinariaceae and Bambuseae) were paraphyletic with the herbaceous bamboos sister to the tropical woody bamboos (Bouchenak-Khelladi et al., 2008; Sungkaew et al., 2009; Kelchner and BPG, 2013). However, phylogenies reconstructed from nuclear loci (Triplett et al., 2014), and more recently, nuclear genome sequences, indicated that the woody bamboos were monophyletic, and that during their evolutionary history reticulate evolution and allopolyploidization occurred (Guo et al., 2019).

The subtribal classification of tribes Bambuseae and Olyreae is much clearer than that of Arundinariaceae. Molecular and morphological data support the division of the tribe Bambuseae into 11 subtribes and the division of tribe Olyreae into three subtribes (BPG, 2012; Kelchner and BPG, 2013; Soreng et al., 2017). However, plastid phylogenies indicated that few Arundinariaceae genera were monophyletic and recovered 12 lineages (Triplett and Clark, 2010; Zeng et al., 2010; Yang et al., 2013; Attigala et al., 2014; Zhang et al., 2019).
et al., 2016). Strikingly, none of these lineages corresponded to the subtribes based on morphology (Table 1). In addition, Arundinarieae phylogenies based on several nuclear loci have failed to provide high resolution subtribal delimitation (Peng et al., 2008; Zhang et al., 2012; Yang et al., 2013). The low resolution of the phylogenetic relationships between members of the tribe Arundinarieae has hindered the proposal of subtribal classifications, and consequently, some researchers have instead adopted 12 plastid lineages (Kellogg, 2015). Thus, a formal subtribal classification is needed.

With the development of next generation sequencing technologies, genomic data can be obtained more easily and cheaply, such as with reduced-representation methods. As a pilot study, Wang et al. (2017) exploited the restriction-site associated DNA sequencing (RAD-seq) method to gain tens of thousands of single nucleotide polymorphisms (SNPs) and reconstructed a preliminary phylogeny of the temperate woody bamboos. The results demonstrated that the RAD-seq phylogeny largely agreed with the morphological classification at the generic level with unprecedented resolution. Subsequently, Guo (2019) sampled more than 200 taxa of temperate woody bamboos and used a modified ddRAD-seq (double digest RAD-seq) method to reconstruct the phylogenetic backbone of this tribe. Using a dataset of all 12 plastid clades, five major lineages were recovered, i.e. the leptomorph lineage, the pachymorph lineage, Gaoligongshania megatrythysa (Handel-Mazzetti) D. Z. Li, Hsueh & N. H. Xia, the ADH lineage, and Hsuehochloa calcaria (C. D. Chu & C. S. Chao) D. Z. Li & Y. X. Zhang. The relationships among those lineages and genera were well resolved.

In this paper, we propose a new subtribal classification for the tribe Arundinarieae based on these molecular phylogenies, with an attempt to obtain morphological synapomorphies in support of the classification. In addition, because Indocalamus wilsonii (Rendle) C. S. Chao & C. D. Chu had a unique phylogenetic position in plastid, plastic, and nuclear genomic trees (Zeng et al., 2010; Ma et al., 2014, 2017; Guo, 2019), a new genus, Ravenochloa, is proposed to accommodate this isolated species.

2. Materials and methods

2.1. Specimen examination

We examined specimens of representative clades of Arundinarieae deposited at herbaria from the 1990s to the present (E, HIB, HNNU, ISC, KUN, K, N, NF, P, PE, SIFS, SWFC, SZ, W, WU and US; Table 1. Comparison of four morphology-based classification systems and the 12 plastid lineages of Arundinarieae.

| Clayton and Renvoise (1986) | Soderstrom and Ellis (1987) | Li (1998) | Ohnberger (1999) | The 12 plastid lineagesa |
|----------------------------|----------------------------|-----------|-----------------|------------------------|
| Arundinarieae (20)b | Arundinarieae (12) | Arundinarieae (14) | Arundinarieae (16) | I. Bergbambos (1) |
| Acidosasa | Acidosasa | Acidosasa | Acidosasa | Bergbambos |
| Arundinaria (Bashania, Oligostachyum, Pleioblastus) | Arundinaria (Bashania, Clavinoium, Omeiocalamus, *Aulonemia Goudot) | Arundinaria (Bashania, Clavinoium, Omeiocalamus, Ampeilocalamus) | Arundinaria (Bashania, Clavinoium, Omeiocalamus, Ampeilocalamus) | Arundinaria (Bashania, Clavinoium, Omeiocalamus, Ampeilocalamus) |
| Chimonobambusa | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Chusquea Kunth | *Chusquea Kunth | *Chusquea Kunth | *Chusquea Kunth | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Colanthelia McClure & E. W. Smith | *Colanthelia McClure & E. W. Smith | *Colanthelia McClure & E. W. Smith | *Colanthelia McClure & E. W. Smith | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Glaziophyton Franchet | *Glaziophyton Franchet | *Glaziophyton Franchet | *Glaziophyton Franchet | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Guaduello Franchet | *Guaduello Franchet | *Guaduello Franchet | *Guaduello Franchet | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Hitchcockella A. Camus | *Hitchcockella A. Camus | *Hitchcockella A. Camus | *Hitchcockella A. Camus | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| Indocalamus | Indocalamus | Indocalamus | Indocalamus | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| Indosasa | Indosasa | Indosasa | Indosasa | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Myriocladus Swallen | *Myriocladus Swallen | *Myriocladus Swallen | *Myriocladus Swallen | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Neuropleis Meissner | *Neuropleis Meissner | *Neuropleis Meissner | *Neuropleis Meissner | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Omeia Soderstrom | *Omeia Soderstrom | *Omeia Soderstrom | *Omeia Soderstrom | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| *Perrierbambus | *Perrierbambus | *Perrierbambus | *Perrierbambus | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| Pseudosasa | Pseudosasa | Pseudosasa | Pseudosasa | Chimonobambusa (Oreocalamus, Qionghua, Tetragonocalamus) |
| Sasa | Sasa | Sasa | Sasa | Sasa |
| Sinobambusa | Sinobambusa | Sinobambusa | Sinobambusa | Sinobambusa |
| Sinorundinaria | Sinorundinaria | Sinorundinaria | Sinorundinaria | Sinorundinaria |
| Thamnocalamus | Thamnocalamus | Thamnocalamus | Thamnocalamus | Thamnocalamus |
| *Perrierbambus A. Camus | *Perrierbambus A. Camus | *Perrierbambus A. Camus | *Perrierbambus A. Camus | *Perrierbambus A. Camus |

Genera with # are not members of the tribe Arundinarieae; Guaduello belongs to the subfamily Puelioideae and the others belong to the tribe Bambuseae (Soreng et al., 2015, 2017).

a Refers to Ma et al. (2014); Attigala et al. (2016) and Ma et al. (2017).
b Denotes the number of genera included in the subtribes or lineages.
herbarium acronyms following Thiers, 2019). Our examination emphasized type specimens of some noteworthy genera.

2.2. Molecular phylogenies

To date the most comprehensive molecular phylogenies that have classified subtribal relationships in the tribe Arundinarieae are based on ddRAD-seq data (Guo, 2019). For the species Indocalamus wilsonii, phylogenies reconstructed from plastid regions, plastomes, and ddRAD-seq data were used as references (Zeng et al., 2010; Ma et al., 2014, 2017; Guo, 2019).

2.3. Morphological comparison

Because of the high morphological heterogeneity of the five lineages recovered by Guo (2019), three reproductive characters and two vegetative characters were chosen for comparison. Four reproductive characters and six vegetative characters were selected and compared between I. wilsonii and the morphologically related genera Ferrocalamus Hsueh & P. C. Keng, Indocalamus Nakai and Sasa Makino & Shibata. All the morphological data were gathered based on specimens, field observation, and literature (Keng and Wang, 1996; Li et al., 2006).

3. Results

The phylogenetic relationships within the Arundinarieae based on ddRAD data are discussed in Cen Guo’s PhD dissertation (Guo, 2019). A simplified phylogeny of the tribe Arundinarieae is presented in Fig. 1. Taxa of the leptomorph lineage have the synapomorphy of leptomorph rhizomes, while the other major diagnostic features listed in Table 2 are quite heterogeneous among different genera. Taxa of the pachy morph lineage, Gaoligongshania D. Z. Li, Hsueh & N. H. Xia, the ADH lineage and, Hsuehochloa D. Z. Li & Y. X. Zhang all possess pachymorph rhizomes (except Sarocalamus Stapleton), semelauctant inflorescence, and three stamens. In addition, branch complements and number of stigmas differ among these three lineages.

Indocalamus wilsonii was sister to the rest of the leptomorph lineage (Fig. 1). Morphological comparison between I. wilsonii and related genera is presented in Table 3. I. wilsonii, Indocalamus, and Sasa usually have shorter and thinner culms, while Ferrocalamus has taller and thicker culms. I. wilsonii and Sasa possess a solitary branch at each node, while Indocalamus and Ferrocalamus sometimes have more than one branch apically. Species of Sasa have six stamens, whereas the others possess three stamens. The leaves of I. wilsonii usually become wavy when dry (Fig. 2), and the leaves of Indocalamus (with the exception of a few species), Ferrocalamus and Sasa (except several taxa) are flat. In addition, I. wilsonii is the only species in the leptomorph lineage distributed at higher elevations (1500–3000 m) in Central China, while the other species of Indocalamus, species of Ferrocalamus, and Sasa are distributed usually on lower hills at 500–1000 m, and all below 2000 m.

4. Discussion

The tribe Arundinarieae was established in 1902, making it the most recent tribe in Bambusoideae (BPG, 2012). This is essentially
have leptomorph rhizomes. However, the branch complements and the others belonged to the subtribe Arundinariinae. All these taxa Makino ex Nakai, and *Bataea* Soderstrom and Ellis, 1987; Li, 1998) (Table 1).

Previous subtribal divisions of this tribe have been mainly based on inflorescence type (iterauctant vs semelauctant), number of stamens, rhizome type (leptomorph vs pachymorph), culm leaves, and branch complements. The type of inflorescence and rhizome was treated as the most important diagnostic character at the subtribal level. For example, in the three widely used classification systems proposed by Soderstrom and Ellis (1987), Li (1998), and Ohrnberger (1999) (Table 1), the inflorescence type was the key feature that distinguished the subtribe Arundinariinae (seme-lauctant) from the subtribe Shibataeinae (iterauctant), while the rhizome type discriminated subtribes Arundinariinae and Shibataeinae (leptomorph) from the subtribe Thamnocalaminae (pachymorph) in Ohrnberger’s system. Li (1997) proposed that the subtribe Arundinariinae could be divided into two groups on the differentiation of rhizome type and leaf anatomy, i.e. the Arundinaria group (leptomorph rhizome) and the Thamnocalamus Munro group and allies (pachymorph rhizome). The delimitation of the subtribe Arundinariinae has been the most controversial and complex. Genera with different types of rhizomes and branch complements, and different numbers of stamens have been previously classified into this subtribe (Clayton and Renvoize, 1986; Soderstrom and Ellis, 1987; Li, 1998) (Table 1).

Among the five lineages recovered by Guo (2019), the leptomorph lineage was the most complicated. There were representatives of 20 genera nested in this lineage. Some taxa were members of the subtribe Shibataeinae, such as *Chimonobambusa* Makino, *Hibano-bambusa* Maruyama & Okamura, *Indosasa* McClure, *Phyllostachys* Siebold & Zuccarini, *Semiarundinaria* Makino ex Nakai, *Shibataeae* Makino ex Nakai, and *Sinobambusa* Makino ex Nakai, whereas the others belonged to the subtribe Arundinariinae. All these taxa have leptomorph rhizomes. However, the branch complements and reproductive characters are quite diverse (Table 2). *Acidosasa* C. D. Chu & C. S. Chao ex P. C. Keng, *Chimonobambusa*, *Indosasa*, *Pseudosasa* Makino ex Nakai, and *Sinobambusa* usually have three branches per node, whereas *Indocalamus* and *Sasa* usually have a solitary branch at each node, and *Phyllostachys* possesses two branches at each node. Iterauctant inflorescences can be found in the genera *Chimonobambusa*, *Indosasa*, *Phyllostachys*, and *Sibataeae*. Semelauctant inflorescences can be found in the genera *Arundinaria*, *Acidosasa*, *Indocalamus* and *Pseudosasa*. The stamen number of *Acidosasa*, *Indosasa* and *Sasa* is six, and the other genera have three stamens. Therefore, nearly all the diagnostic character states except the rhizome type in the tribe Arundinarieae can be found in this lineage.

The second large lineage recovered by Guo (2019) was the pachymorph lineage, which included eight genera. *Chimonocalamus* Hsueh & T. P. Yi, *Fargesia* Franchet, *Thamnocalamus* and *Yushania* P. C. Keng were assigned to Arundinariinae or Thamnocalaminae in different classification systems (Table 1). The recently established genera *Bergbambos* Stapleton (2013), *Kuruma* Attigala, *Kathiriarachchi* & L. G. Clark (Attigala et al., 2014), *Oldeania* Stapleton (Stapleton, 2013; Zhang et al., 2017), and *Sarocalamus* (Stapleton et al., 2004) were also members of Arundinariinae or Thamnocalaminae. The third large lineage, the ADH lineage, consisted of *Ampe-localamus* S. L. Chen, *H. W. ten* & G. Y. Shen, *Drepanostachyum* P. C. Keng and *Himalayocalamus* P. C. Keng, which were placed in Thamnocalaminae by Ohrnberger (1999) but in Arundinariinae by Soderstrom and Ellis (1987) and Li (1998). *Gaoligongshania* belonged to the subtribe Arundinariinae and the type species of *Hsuehochloa* was a member of Arundinariinae or Thamnocalaminae (Table 1). These four lineages all have pachymorph rhizomes (except *Sarocalamus*, which has leptomorph rhizomes), semelauctant inflorescences, and three stamens. There are some other fine distinctions among these lineages, such as the branch complements. Taxa of the pachymorph lineage have the most complex branch complements among the four lineages except the leptomorph lineage. The branch number at each node of the pachymorph lineage is one (some species of *Yushania*), three to eight (e.g. *Chimonocalamus* and *Thamnocalamus*), or many (*Fargesia* and *Yushania*) (Table 2).

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**Table 2**

| Comparison of morphological characters of the five major lineages of Arundinarieae based on ddRAD data. |
|--------------------------------------------------|
| **The leptomorph lineage** | **The pachymorph lineage** | **Gaoligongshania** | **The ADH lineage** | **Hsuehochloa** |
| Rhizome | Leptomorph | Pachymorph | Leptomorph | Pachymorph | Pachymorph |
| Branch complement | 1, 3, 5–7, >7 (20) | 1, 3, 5–8, >8 | Leptomorph | Many, subequal or with one prominent branch | 1, 3–7 |
| Inflorescence | Semelauctant, iterauctant | Semelauctant | Leptomorph | Semelauctant | Semelauctant |
| Number of stamens | 3, 6 (occasionally 4 or 5) | 3 | 3 | 3 | 3 |
| Number of stigmas | 2, 3 | 2 | 3 | 2 | 2 |

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**Table 3**

| Morphological comparison of *Indocalamus*, *I. wilsonii*, *Ferrocylamoc*, and *Sasa*. |
|----------------------------------|
| I. wilsonii | Indocalamus | Ferrocylamoc | Sasa |
| Culm height | 0.3–0.9 m | Usually less than 2 m | 2–7 m | <2 m |
| Culm diameter | 0.2–0.4 cm | 0.3–2 cm | 0.8–4 cm | 0.5 cm |
| Internode | Glabrous or white pubescent, 4–12 cm long | Hairy, usually with a brown tomentose ring below nodes, 5–35 cm long, usually 15–25 cm long | Solitary-wall thick, nearly solid at the base, 50–70 cm long | Culm-wall thin, 10–25 cm long |
| Branch complement | Solitary | Solitary, sometimes 2–3 apically | Solitary at the base, 3–5 apically | Solitary |
| Culm sheath | Persistent, pale red-brown or straw-colored | Persistent, longer or shorter than the internode, usually hairy | Tardily deciduous or persistent, yellow-green, 1/2 as long as the internode, densely brown or dark brown setose | Persistent, longer or shorter than the internode, hairy or glabrous |
| Leaf | Wavy when dry Panicles | Wavy or flat when dry Racemes or panicles | Flat when dry Panicles | Flat when dry (occasionally wavy) Panicles |
| Inflorescence | 3–7 | 3–15 | 3–10 | 4–8 |
| Number of florets per spikelet | 3 | 3 | 3 | 6 |
| Stamen | 2 | 3 | 2 | 3 |
| Stigma | 2, occasionally 3 | 2 | 3 | 3 |
Attigala et al. (2016) evaluated the evolution of several key morphological characters in the tribe Arundinarieae, including rhizomes and reproductive structures, based on the plastome phylogenetic tree. Their findings demonstrated that pachymorph rhizomes were possibly the ancestral state, leptomorph rhizomes evolved with reversions to the pachymorph condition once or multiple times, and pseudospikelets evolved at least twice in Arundinarieae. Recently, Guo (2019) estimated the evolution of three key diagnostic characters of Arundinarieae (i.e., rhizome type, inflorescence type, and branch complement) based on comprehensive sampling and well resolved phylogenetic trees retrieved from ddRAD data. It was inferred that inflorescence type and branch complement type experienced multiple transformations among different states, while rhizomes had some phylogenetic signal for distinguishing lineages. Those results suggested that some important diagnostic characters probably experienced convergent evolution in the Arundinarieae, similar to the situation in Arthrostylidiinae of the neotropical bamboo lineage (Bambuseae, Bambusoideae) (Tyrrell et al., 2012).

As Christenhusz et al. (2015) emphasized in their paper recommending that plant classification follow the Angiosperm Phylogeny Group (APG), the more we know about relationships, the...
more difficult it becomes to construct a reasonable classification. Classifications in the bamboos have had the same problem, especially in the tribe Arundinariae. In this paper, we tried to follow the rules of monophyly and exploited the phylogenetic relationships as the main reference for the subtribal division of Arundinariae. The five lineages recovered by Guo (2019) are proposed as five different subtribes. The leptomorph lineage is named subtribe Arundinariae, as it includes the type genus, Arundinaria; the pachymorph lineage is named subtribe Thamnocladamieae; the ADH lineage is named subtribe Ampelocalamieae; and Gaoliangshania and Hseuhochloa are named subtribes Gaoliangshaniae and Hseuhochloa, respectively. These five newly delimited subtribes will have great value for teaching and for in-depth research on this group.

In the leptomorph lineage of Guo (2019), *I. wilsonii* was strongly supported as sister to the rest of the lineage, rather than grouping with species of *Indocalamus* (Fig. 1). The phylogenetic position of this species in the plastid trees was unique as well and it was treated as an independent lineage (Table 1) (Zeng et al., 2010; Ma et al., 2014, 2017; Guo, 2019). Morphologically, the vegetative features of this species are more similar to the species of *Sasa*. They all have short and thin culms and a solitary branch per node, although they have a different number of stamens. Species of *Indocalamus* usually possess a solitary branch at the basal and mid-culm nodes and 2–3 branches at the upper nodes. There is usually a brown tomentose ring below the nodes of most species of *Indocalamus*, but this is absent in *I. wilsonii*. The stigmas number 2 in *I. wilsonii* is usually 2 but occasionally 3, while species of *Indocalamus* have 2 stigmas. The vegetative features of *Feroccalamus* are quite distinct from those of *I. wilsonii*, such as culm height and diameter, and internode length, although they have a solitary branch per node in common. Although the morphological differences between *Indocalamus* and *I. wilsonii* are not prominent, the unique phylogenetic position and geographic distribution of *I. wilsonii* motivated us to establish a new genus to accommodate its peculiarity.

5. Taxonomic treatment

5.1. Description of a new genus

*Ravenochloa* D. Z. Li & Y. X. Zhang, gen. nov.

*Ravenochloa* refers to his family name and *chloa* means grass.

Description. Rhizomes leptomorph. Culms 30–90 cm tall, 0.2–0.4 cm in diameter; internodes 4–12 cm long, glabrous or white pubescent. Culm leaf sheaths pale red-brown or straw-colored, closely embracing the culm, ca. 1/2 as long as the internode, densely deciduously white pubescent, densely pubescent or glabrescent near the outer margins, veins conspicuous, transverse veins sometimes distinct; auricles and oral setae absent; ligule short, ca. 0.6 mm tall; blades erect, deciduous, ovate-lanceolate or narrowly triangular, base contracted, apex acute. Branch sheaths orange-red when dry, glabrous; inner ligule 1.5–4 mm tall; blades lanceolate or narrowly ovate-lanceolate, 2.5–4 cm long. Foliage leaves 3 (–5) per ultimate branch; sheaths yellow-green, tinged with red, glabrous or pubescent; auricles and oral setae absent; ligule 2.5–9 mm tall; blades oblong-lanceolate, 6–17 × 1.5–4.7 cm, wavy when dry, abaxially gray-green and pilose, adaxially yellow-green and glabrous. Panicles 5–10 cm long, base encircled by a leaf sheath; branches ascending, slender, glabrous, pulvinate; spikelets usually purple green; florets 3–7; rachilla internodes ca. 4 mm, densely yellow-villous; glumes usually 2, glabrous; lemma puberulent, 7–9 veined, apex acuminate with a short macro, callus densely white villous; palea puberulent; stamens 3, anthers yellow; styles 2 or 3.

Etymology. *Ravenochloa* is named in honor of Dr. Peter H. Raven, member of the National Academy of Sciences of the USA, and foreign member of the Chinese Academy of Sciences. As the co-editor-in-Chief of the *Flora of China*, Dr. Raven has made great contributions to the study of systematics and biogeography, and conservation of plants in China and the rest of the world in general, and inspired bamboo taxonomy and evolutionary study in particular. *Raven* refers to his family name and *chloa* means grass.

Distribution and habitat. Central China (Chongqing, Hubei and Hunan). Under forests at elevations of (1500–) 2000–3000 m.

Additional specimens examined. CHINA. Chongqing: Fangjia, 1800 m alt., 1 June 1962. H. F. Zhou & H. Y. Su 108411(SZ); Nanchuan, 1800 m, 6 September 1943, Keng & P. C. Keng 3882(N), 1700 m, 24 May 1957, C. F. Li 61519(SZ), 2100 m, 4 October 1957, J. H. Xiong & Z. L. Zhou 93794 (KUN, SZ), 2250 m, 29’02’06”N, 107°11.34’E, 5 July 2010, P. F. Ma MF10146 (KUN), 2243 m, 29’21’0’’N, 107°15.6’’E, 4 September 2015, C. Guo & X. Y. Wang GC122 (KUN). Hunan: Changle, 1530 m, 30°37.00’N, 110°42.94’E, 10 July 2007, Y. X. Zhang & Z. J. Wang 07088 (KUN), Shennongjia, 5 December 1976, T. P. Yi 76342 (HIB). Hunan: Shimen, 1 August 1982, B. Z. Wu s.n. (HNNU), 1818 m, 32°2.83’N, 110°31.50’E, 23 July 2015, Y. X. Ye & J. L. Liu YYX233 (KUN).

5.2. Re-circumscription of subtribes in Arundinarieae

1. Subtribe Arundinarieae Bentham in J. Linn. Soc. Bot. 19: 31. 1881.

Type. *Arundinaria* Michaux, Flora of Boreali-Americana, 1: 73. 1803.

Description. Rhizomes leptomorph. Culms diffuse or pluri-caespitose; internodes terete or quadrate, sulcate or not; sheath scars prominent or inconspicuous. Branch complements various, solitary, 2, 3–7, or many branches per node. Culm leaves deciduous or persistent, longer or shorter than the internodes, sheaths glabrous or hairy, sometimes spotted; auricles conspicuous or absent; blades erect, reflexed or recurved, linear, subulate, lanceolate, or ovate-lanceolate. Folage leaves several or many per ultimate branch; sheaths glabrous, pubescent or setose; blades lanceolate or broadly lanceolate, glabrous or pubescent abaxially, inflorescences iteratant or semelatant, usually subtended by bracts or prophyll when iteratant; stamens 3 or 6, occasionally 4 or 5, anthers yellow or purple; stigmas 2 or 3, plumose.
Included genera. *Acidosasa* (Metasasa W. T. Lin), Arundinaria, *Bashania* P. C. Keng & T. P. Yi, *Brachystachyum* Keng, *Chimonomambusa* (Menstrocalamus T. P. Yi, *Oreocalamus* Keng, *Qiongzhuae* Hsueh & T. P. Yi), *Ferrococalamus*, *Gelidocalamus* T. H. Wen, *Hibano-ambusa*, *Indocalamus*, *Indosasa*, *Oligostachyum* Z. P. Wang & G. H. Ye (Clavinodum T. H. Wen), *Phyllostachys*, *Pleioblastus* Nakai (*Nippono-calamus* Nakai, *Polyanthus* C. H. Hu), *Pseudosasa* Makino ex Nakai, *Ravenochloa*, *Sasa* (*Neosasamorpha* Tatewaki), *Sasaella* Makino, *Sasamorpha* Nakai, *Semiarundinaria*, *Shibataea*, *Sinoambusa* (Neobambus Keng ex P. C. Keng).

**Incertae Sedis.** *Vietnamocalamus* T. Q. Nguyen.

II. **Subtribe Thamnocalaminae** P. C. Keng in J. Bamboo Res. 11: 25. 1992.

**Type.** *Thamnocalamus* Munro, Transactions of the Linnean Society of London, 26: 33. 1868.

**Description.** Rhizomes pachy morph (except *Sarocalamus* with leptomorph), some taxa with elongated necks. Culms unicaespitose, pluricaespitose or diffuse; internodes terete, glabrous, white powdery or hairy; sheath scar prominent or not. Branch complements consisting of solitary to many branches per node. Culm leaves deciduous, tardily deciduous or persistent, sheaths glabrous or hairy; auricles absent or present; blades erect or reflexed, linear to ovate-lanceolate. Foliage leaves a few per ultimate branch; sheath glabrous or hairy; blades lanceolate, glabrous or pubescent abaxially. Inflorescences semelauctant, ebracteate, paniculate or racemose; florets 1–7 per spikelet; stamens 3, anthers yellow or purple; stigmas 2 or 3, anthers yellow; stigmas 2, plumose.

Included genera. *Ampelocalamus* (Petrocalamus Z. P. Wang, N. X. Ma & W. Y. Zhang), *Drepanostachyum*, *Himalayocalamus*.

**V. Subtribe Hsuehochloinae** D. Z. Li & Y. X. Zhang, *subtrib. nov.*

**Diagnosis.** The subtribe Hsuehochloinae resembles the subtribe Ampelocalaminae in scrambling habit, pachy morph rhizomes, semelauctant inflorescences and three stamens, but differs from *Thamnocalaminae* by epiphytic habit, solitary branch per node. Culm leaves deciduous or persistent, longer or shorter than the internode; auricles absent or minute, occasionally prominent; oral setae usually absent; blades linear to ovate-lanceolate, erect or reflexed. Foliage leaves 3–11 per ultimate branch; sheaths glabrous or pubescent; blades papery, lanceolate, glabrous or pubescent abaxially. Inflorescences semelauctant, ebracteate, paniculate or racemose; florets 1–7 per spikelet; stamens 3, anthers yellow; stigmas 2, plumose.

Included genera. *Ampelocalamus* (Petrocalamus Z. P. Wang, N. X. Ma & W. Y. Zhang), *Drepanostachyum*, *Himalayocalamus*.

III. **Subtribe Gaoligongsaninae** D. Z. Li & Y. X. Zhang, *subtrib. nov.*

**Diagnosis.** The subtribe Gaoligongsaninae resembles the subtribe Thamnocalaminae in pachy morph rhizomes, semelauctant inflorescences, and three stamens, but the new subtribe has pendulous or scrambling culms, many branches per node sometimes with one dominant, conspicuous sheath scars, and ebracte ate inflorescences, which distinguish it from *Thamnocalaminae*.

**Type.** *Ampelocalamus* S. L. Chen, T. H. Wen & G. Y. Sheng, Acta Phytotaxonomica Sinica, 19: 332. 1981.

**Description.** Rhizomes pachy morph. Culms caespitose, apically pendulous or scrambling; internodes terete, finely ridged or not; nodal sheath scars prominent. Branch complements consisting of many branches per node, these subequal or the central one dominant. Culm leaves deciduous or persistent, longer or shorter than the internode; auricles absent or minute, occasionally prominent; oral setae usually absent; blades linear to ovate-lanceolate, erect or reflexed. Foliage leaves 3–11 per ultimate branch; sheaths glabrous or pubescent; blades papery, lanceolate, glabrous or pubescent abaxially. Inflorescences semelauctant, ebracteate, paniculate or racemose; florets 1–7 per spikelet; stamens 3, anthers yellow; stigmas 2, plumose.

Included genera. *Ampelocalamus* (Petrocalamus Z. P. Wang, N. X. Ma & W. Y. Zhang), *Drepanostachyum*, *Himalayocalamus*.

**V. Subtribe Hsuehochloinae** D. Z. Li & Y. X. Zhang, *subtrib. nov.*

**Diagnosis.** The subtribe Hsuehochloinae resembles the subtribe Ampelocalaminae in scrambling habit, pachy morph rhizomes, semelauctant inflorescences and three stamens, but differs from it by having 3–7 subequal branches per node, inconspicuous sheath scars and purple stamens.

**Type.** *Hsuehochloa* D. Z. Li & Y. X. Zhang, Phytotaxa, 109: 67. 2018.

**Description.** Rhizomes pachy morph. Culms caespitose, apically drooping, procumbent or scrambling; internodes terete, densely white pubescent initially on the upper part, later subglabrous; nodes and sheath scars inconspicuous. Branch complements with one branch proximally and 3–7 branches apically, branches slender, subequal. Culm leaves persistent, 1/2 as long as internodes, sheaths densely white pubescent abaxially, glabrescent, margins densely white ciliate; auricles falcate, amplexicaul; oral setae many, radiate; ligule short, apex densely white fimbriated; blades reflexed, green, ovate-lanceolate. Foliage leaves 2–5 per ultimate branch; sheaths glabrous, glossy; blades thinly leathery, lanceolate, abaxially slightly glaucous, glabrous on both surfaces. Inflorescences imperfectly known, semelauctant, ebracteate, racemose possibly with 1 or few spikelets; glumes not seen; florets 5; lemma and palea purple green; lodicules not seen; stamens 3, anthers purple; ovary and style not seen; stigmas 2, plumose.

Included genus. *Hsuehochloa*.

**Author contributions.** Yu-Xiao Zhang drafted this paper; Cen Guo conducted the phylogenomic work and revised the draft; De-Zhu Li conceived and wrote this paper.

**Declaration of Competing Interest**

The authors have no conflicts of interest to declare.

**Acknowledgements**

This study was supported by the National Natural Science Foundation of China (Grant 31430011). We are indebted to Dr. Chao–Nan Fu of the Kunming Institute of Botany, Chinese Academy of Sciences for assistance in literature search. Thanks also go to curators of herbaria mentioned in Materials and Methods for their support.
help in specimen examination. We also would like to thank Prof. Lynn G. Clark of Iowa State University, U. S. A. and the anonymous reviewers for their constructive suggestions.

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