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The position of Indian Bamboos in Bamboo Systematics

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Abstract

The bamboo genera occurring in the Indian phytogeographic regions have been arranged according to the current system of classification. However, with necessary modifications based on the recent studies on Southeast Asian and African species of *Arundinaria*, which, former authors have not recognized in their classification. An artificial key for native bamboos of South India is provided based on easily observable vegetative and floral characters.

INTRODUCTION

Bamboos form a significant component of the natural vegetation in India, particularly in the dry and moist deciduous forests in montane subtropical, temperate and alpine forests. It occurs as an important associate in southern hilltop forests, tropical evergreen forests, west coast tropical evergreen forests, wet bamboo breaks, west coast semi-evergreen forests, moist teak bearing forests, dry bamboo and reed breaks.

They are arborescent grasses belonging to the family Poaceae and are placed under the subfamily Bambusoideae. This subfamily is differentiated from other members of the Poaceae by the tree like habit, hollow culms, rhizome, branch system, sheathing organs and petiolate leaf blades with tessellate venation. There are three major growth forms of bamboos in India; Tree forms which are the most abundant in deciduous forests which constitute 45 percent, shrubs found in restricted habitats such as, stream banks of the evergreen forests come to about 36 percent and the rest are climbers which occur under closed canopy of evergreen forests (Prasad & Gadgil, 1981).

CLASSIFICATION

It was Rumphius in 1743, who described and named some bamboos in his publication *Herbarium Ambionense*. Linnaeus (1753) in his *Species Plantarum* mentioned a single species

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Arundo bambos that is the present *Bambusa bambos*. Munro (1868) was the first to classify bamboos based on flower and fruit characters such as, number of stamens and lodicules. In his monographic work 170 species were described under 21 genera and grouped under three divisions. The first division included the plants having culms without thorns eg. *Arundinaria*. The second division consisted of true bamboos such as *Bambusa* and *Gigantochloa* and a third division included the bamboos with fruit having thick pericarp eg. *Melocanna*. Later, Bentham (1883) used Munro's system largely based on the fruit structure and recognised four subtribes namely, Arundinariinae, Eubambuseae, Dendrocalameae and Melocanneae. Gamble (1896) in his *Bambuseae of British India* adopted Bentham's system without any modification. Later, Stapf (1897) recognized bamboos under five sub tribes Bambusineae, Dendrocalamiae, Arundinariiae, Melocanneae and Puellineae based on the characters of the fruit, nature of spikelets, palias and the number of stamens and treated them under the subfamily Poideae of the family Poaceae. Hooker (1897) slightly modified Stapf's system and reduced some of the tribes and subtribes. Subsequently, Camus (1913) in his *Les Bambusees* adopted Munro's system of classification and treated bamboos as a subfamily Poaceae and divided them into five tribes and four subtribes. Holttum (1946,1956) proposed a system based on the ovary structure and divided all the genera under four groups namely, *Schizostachyum* type, *Oxytenanthera* type, *Bambusa-Dendrocalamus* type and *Arundinaria* type. Subsequent workers (Ghosh & Negi, 1960; Raizada & Chatterjee, 1963; Pattanath & Rao,1969; Grosser & Leise,1971; Bahadur, 1979; Hiroshi,1985; Wen & Chou,1985; Zhang & Chen, 1985) tried to arrange and identify bamboos based on various characters like culm buds, prophylls, anatomical and cytological evidences. Even though, these studies are significant contributions to bamboo taxonomy, it has merits as well as demerits and is mostly meant for the purpose of identification rather than classification.

Recently, Clayton and Renvoize (1986) recognized the tribe Bambuseae with three subtribes, viz., Arundinariinae Benth., Bambusinae Presl. and Melocanninae Reichenb. mostly relied on Holttum's (1956) primary criterion of ovary appendage and included 49 genera. Further, Soderstrom and Ellis (1987) included 54 genera in the tribe Bambuseae and 5 genera under 'uncertain placement'. This tribe has further been divided into 9 subtribes namely, Arthrotylidinae, Arundinariinae, Bambusinae, Chusqueinae, Guaduininae, Nastinae, Neurolepidinae, Shibatinae and Schizostachyidinae. The subtribe Schizostachyidinae is presently treated under the subtribe Melocanneae. Stapleton (1991,1994a, 1994b, 1994c) modified the system of Soderstrom and Ellis (1987) and erected a new subtribe Racemobambusinae and included the genus *Racemobambos* under this subtribe. However, Dransfield and Widjaja (1995) merged the subtribe Neurolepidinae having only one genus *Neurolepis* under the subtribe Chusqueinae and proposed a classification mostly adopted from Soderstrom and Ellis (1987).

Bamboos are taxonomically one of the most difficult group of grasses and have been highly problematic for field studies, collection and classification. Most herbarium specimens are too poor consisting of bits of either only vegetative or reproductive materials and consequently generic and specific delimitations have often been based on scanty material (Kumar, 1990, 1993, 1995).

Position of Indian Bamboos

In the present paper, the bamboo genera occurring in the Indian phytogeographic regions have been arranged as per the classification of Dransfield and Widjaja (1995). However, with necessary modifications based on the studies on South-East Asian and African species of *Arundinaria* made by Chao and Reinvioze (1989), which, former authors have not recognized in their classification. Only two species of *Arundinaria* have been recognized here, while, all the other species of *Arundinaria* have been transferred under *Sinarundinaria*, *Thamnocalamus*, *Racemobambos*, *Chimonobambusa*, *Indosassa*, *Sinobambusa* and *Acidosasa* respectively. The new combinations proposed have been included under the respective tribes.

Family Poaceae

This family includes annual and perennial herbs or trees, rarely climbing plants. Stem mostly cylindrical, hollow or rarely solid. Ligules membranaceous or hairy, rarely absent. Leaf-blade linear or lanceolate or rarely fan shaped or folded. Inflorescence is composed of panicle, racemose, simple or compound spikelet or capitate spikelet of false racemes in heads of congested spikes.

There are five subfamilies recognized under Poaceae and the bamboos are included in the subfamily Bambusoideae. This subfamily includes both woody and herbaceous bamboos with altogether 1575 species distributed world over (Ohrnberger, 1999).

Subfamily: Bambusoideae Ascher & Graeb.

This subfamily includes perennial herbaceous or woody rhizomatous plants. Leaves flat, petiolate, mostly with tessellate venation. Inflorescence of various types, spikelets or pseudospikelets one to many flowered; lodicules 3-6, rarely absent, usually the base with different types of hairs. Flowers bisexual, perianth armed or unarmed. Palea glabrous or hairy; stamens 3-6 or many, styles usually 3, stigmas mostly plumose. Fruit usually a caryopsis or glans or bacca.

There are five tribes recognised under this subfamily. The tribe Anomochloae is monotypic containing the monotypic genus *Anomochloa* that is so far known only from Brazil. The tribe Buergerisiochloae is also monotypic with *Buergerisiochloa* known from New Guinea. Most of the other herbaceous genera are included under the tribe Olyreae. This tribe contains many genera distributed throughout tropical America, from Mexico to Argentina. This tribe is confined to the New World Tropics except one species *Olyra latifolia* which has been introduced into the Old World and occurs in tropical Africa and Madagascar. The tribe Steptochaeteae is again a monotypic tribe containing the herbaceous genus *Steptochaeta* so far known only from tropical America. All the major woody bamboos are included under the tribe Bambuseae.

In India only the tribe Bambuseae is represented with 128 species under 18 genera so far known including native, cultivated and introduced species. Among these, 105 species under 15 genera are native to India (Seethalakshmi & Kumar, 1998).

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Tribe Bambuseae Nees

Bambuseae is the largest and most widespread tribe of the subfamily Bambusoideae. It is represented by woody bamboos occurring from sea level to above 4000m altitude. They are characterized by having woody culms, leaves with an outer ligule and deciduous blade and a complex system of rhizomes and branches. Inflorescence produce pseudospikelets as well as grass type spikelets. Lodicules are ciliate and the number of stamens varies from 3-many.

Under this tribe 10 subtribes namely, Arthrostylidinae, Arundinariinae, Bambusinae, Chusqueinae, Guaduinae, Melocanninae, Nastinae, Racemobambusinae, Shibatinae and Thamnocalaminae are recognized. In the Indian phytogeographic regions there are only 5 subtribes, namely, Arundinariinae, Bambusinae, Melocanninae, Racemobambusinae and Thamnocalaminae are represented. In South India, only 3 subtribes, Arundinariinae, Bambusinae and Melocanninae are represented.

Subtribe 1. Arthrostylidinae Soderstrom & Ellis

The genera included under this subtribe is confined to New World and found in the habitats from the wet low land tropical forests to cool montane forests at an elevation of 3000 m. They are characterized by the sympodial rhizomes, dense to loose clumps and erect to arching or vine like culms. In most of the genera the spikelets are grass type with 2 to many florets. Stamens are generally 3 in number.

Under this subtribe Soderstrom and Ellis (1987) recognised 11 taxa (*Actinocladum*, *Arthrostachys*, *Arthrostylidium*, *Atractantha*, *Aulonemia*, *Colantheia*, *Elytrostachys*, *Merostachys*, *Myriocladus* and *Rhipidocladum*) and considered *Matuda calamus* to be congeneric with *Aulonemia*. Dransfield and Widjaja (1995) recognized 14 genera with the inclusion of *Alvinia*, *Apoclada* and *Glaziophyton* in their system.

This tribe does not have representative taxa in the Indian phytogeographic region.

Subtribe 2. Arundinariinae Benth.

This is an Old World subtribe with the extension of one genus *Arundinaria* into the New World. The members of this subtribe are temperate in habitat and distributed on the mountains in the tropics and lower elevations with increasing latitude. All types of rhizomes are found in this subtribe. The inflorescences are racemes or panicles. Spikelets 2 to many flowered, stamens 3 to 6.

Soderstrom and Ellis (1987) included *Acidosasa*, *Ampelocalamus*, *Arundinaria*, *Chimonobambusa*, *Chimonocalamus*, *Drepanostacyum*, *Fargesia*, *Gelidocalamus*, *Indocalamus*, *Perrierbambus*, *Sasa* and *Thamnocalamus*, with some allied genera in this subtribe. In their classification the genera *Pleioblastus* and *Pseudosasa* are treated as a synonym of *Arundinaria*. Similarly, *Himalayacalamus* under *Drepanostacyum* and

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Sinarundinaria and *Yushania* treated under the genus *Fargesia*. They also opined that it is very complex subtribe in which the generic limits are not well known. However, Dransfield and Widjaja (1995) included 14 genera that are mostly confined to the temperate regions and in the mountains in the tropics of the Old World. They included the genera *Borinda* and *Indocalamus* to this subtribe and treated *Himalayacalamus*, *Pseudosasa* and *Yushania* as separate independent genera. The genera *Chimonobambusa* and *Parrierbambus* have been transferred to the subtribes *Shibatinae* and *Nastinae* respectively. Chao and Reinvolve (1989) in the revisionary studies on the genus *Arundinaria* of Southeast Asia and Africa considered only two species to be of true *Arundinaria* and rest of the species are transferred under seven other genera namely, *Sinarundinaria*, *Thamnocalamus*, *Racemobambos*, *Chimonobambusa*, *Indosasa*, *Sinobambusa* and *Acidosasa*. It is estimated that there about 380 binomials under the name *Arundinaria* including American, Asian and African species, thus representing a taxonomically heterogeneous group. McClure (1973) excluded many genera of bamboos formerly included under the genus *Arundinaria* and made several new combinations and erected new genera as well. Based on the culm node with root thorns, the genus *Chimonocalamus* is reduced to one of the sections of the genus *Sinarundinaria*, originally described by Nakai in 1935. According to Chao and Reinvolve (1989), the genera *Drepanostachyum* and *Yushania* are treated as synonyms of *Sinarundinaria*. Some of the species described under the genera *Arundinaria*, *Chimonobambusa*, *Drepanostachyum* and *Indocalamus* are transferred to the genus *Sinarundinaria*. In the present paper the genus *Pleoblastus* is treated as a separate genus under this subtribe.

In the Indian phytogeographic regions this subtribe is represented by the 5 genera, *Arundinaria* (2 spp.), *Pseudosasa* (1 sp.), *Pleoblastus* (1 sp.), *Sinarundinaria* (21 spp.) and *Thamnocalamus* (3 spp.). In south India only one genus *Sinarundinaria* with 5 species is known to occur.

Subtribe 3. *Bambusinae* Agardh

Members of this subtribe occur in the Old World tropics from Africa to India, Southeast Asia and China to Northern Australia. They have sympodial rhizomes, indeterminate inflorescence, spikelets 2 to many flowered with the upper most floret reduced. Stamens are generally 6 in number.

Soderstrom and Ellis (1987) included 6 genera namely, *Bambusa*, *Dendrocalamus*, *Dinochloa*, *Klemachloa*, *Melocalamus* and *Thyrsostachys* in this subtribe and considered the genera *Gigantochloa*, *Oreobambos* and *Oxytenanthera* to be congeneric with *Dendrocalamus*. Dransfield and Widjaja (1995) included 13 genera, *Bambusa*, *Dendrocalamus*, *Dinochloa*, *Gigantochloa*, *Holttumochloa*, *Kinabaluchloa*, *Maclurochloa*, *Melocalamus*, *Oreobambos*, *Oxytenanthera*, *Soejatmia*, *Sphaerobambos* and *Thyrsostachys* mostly distributed in tropical Asia.

In the earlier classification many more genera were included under this subtribe which later were treated as congeneric with *Bambusa* and some with *Dendrocalamus* or

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Gigantochloa. The genus *Oxytenanthera* Munro, was considered to be monotypic with a single species *Oxytenanthera abyssinica* (A. Rich.) Munro, native of Africa and the rest of the species of the genus was placed under either *Gigantochloa* or *Dendrocalamus* (Holtum, 1956). Widjaja (1987) supported this. Soderstrom and Ellis (1988) found that *Oxytenanthera* belong to new taxa and they described it as a new genus *Pseudoxytenanthera* and transferred *O. monadelphica* under a new generic name. Majumdar (1989) described it as yet another new genus *Pseudotenanthera*, which later, Naithani (1990) treated as a synonym of *Pseudoxytenanthera* Soderstrom & Ellis. The genus *Melocalamus* is considered as related to the genus *Dinochloa* and therefore, presently, all the species of this genus is merged with it.

In the Indian phytogeographic regions, 7 genera of Bambusinae are known to occur, namely, *Bambusa* (26 spp.), *Dendrocalamus* (15 spp.), *Dinochloa* (6 spp.), *Gigantochloa* (7 spp.), *Oxytenanthera* (2 spp.) *Pseudoxytenanthera* (4 spp.) and *Thyrsostachys* (2 spp.).

The following 6 genera of this tribe are represented in South India viz., *Bambusa* (6 spp. and 1 variety among which only one species is native to South India and all the other species are either introduced or cultivated.), *Dendrocalamus* (5 spp. among which only one species is native and the others are being cultivated), *Gigantochloa* (1 sp.), *Pseudoxytenanthera* (4 spp. all the species are found to be endemic to South India) and *Thyrsostachys* (1 sp.) are known to occur among which the genera, *Gigantochloa* and *Thyrsostachys* are known under cultivation.

Subtribe 4. Chusquinae Soderstrom & Ellis

Members of this subtribe are found distributed in the New World tropics from Mexico to Argentina and Chile. They have sympodial or amphipodial rhizomes. Inflorescences are determinate with racemes or spikelets, stamens 2 or 3.

The subtribe includes two genera, which is not represented in the Indian phytogeographic region.

Subtribe 5. Guaduinae Soderstrom & Ellis

Members of this subtribe are confined to the New World tropics. They have sympodial or monopodial rhizomes, inflorescence determinate or indeterminate, spikelets iterant or semi laucant, stamens 3 to 6.

Five genera are included in this tribe, but none of them occur in India.

Subtribe 6. Melocanninae Reichb.

Members of this subtribe are found only in the Old World tropics mostly in tropical Asia at lower elevations. They are often clump forming or sometimes scandent or vine-like, inflorescence iterant, ovary glabrous, stamens 6 to many.

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Soderstrom and Ellis (1987) included genera such as *Cephalostachyum*, *Leptocanna*, *Melocanna*, *Ochlandra*, *Pseudostachyum* and *Teinostachyum* under the subtribe Schizostachydinae, which has now become a synonym for Melocanninae Reichb. Later Dransfield and Widjaja (1995) included 8 genera viz. *Cephalostachyum*, *Davidsea*, *Melocanna*, *Neohouzeana*, *Ochlandra*, *Pseudostachyum*, *Schizostachyum* and *Teinostachyum* under this subtribe Melocanninae.

Presently only 3 genera *Melocanna*, *Ochlandra* and *Schizostachyum* are included under this subtribe. Holttum (1946,1956) suggested a close relationship between these two genera and opined that *Cephalostachyum*, *Pseudostachyum* and *Teinostachyum* should be united with *Schizostachyum*. As a result of the merger, the genus *Schizostachyum* is the largest, comprising of 45 species, distributed in Laos, Philippines, Malaysia, Singapore, Thailand, Africa and India.

In the Indian phytogeographic regions this subtribe is represented by 3 genera *Melocanna* (2 spp.), *Ochlandra* (11 spp. and 1 variety), and *Schizostachyum* (18 spp.). In South India the genera *Melocanna* (1 sp.), *Ochlandra* (11 spp. and 1 variety) and *Schizostachyum* with a single species is known to occur.

Subtribe 7. Nastinae Soderstrom & Ellis

Members of this subtribe are distributed mostly in the Southern Hemisphere of the Old World tropics. Sympodial rhizomes characterize them, determinate inflorescence with spikelets or capitate panicles, spikelets 2 to many flowered, stamens 3 to 6.

This subtribe includes 6 genera, *Decaryochloa*, *Greslania*, *Hickelia*, *Hitchcockella*, *Nastus* and *Perrierbambus*. In the Indian phytogeographic regions there are no representative taxa under this subtribe.

Subtribe 8. Racemobambos Stapleton

Members of this subtribe are distributed in Himalaya and tropical Asia. They are characterized by sympodial rhizome, indeterminate inflorescence with sessile spikelets and 6 stamens.

There are 3 genera included in this subtribe, *Neomicrocalamus*, *Racemobambos* and *Vietnamosasa*.

Holttum (1956) erected the genus *Racemobambos*. Chao and Reinvoize (1989) included 18 species under this genus in South Asia. They treated the genera *Microcalamus* and *Neomicrocalamus* as congeneric. The genus is reported as confined to Malaysia (Dransfield & Widjaja, 1995). However, *Racemobambos* is quite different from *Arundinaria* and matches well with *Neomicrocalamus*. Chao and Renvoize (1989) have included only one Indian species under *Racemobambos*. Therefore, two new combinations i.e., *Racemobambos clarkei* (Gamble

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ex Brandis) Muktesh Kumar and *Racemobambos manii* (Gamble) Muktesh Kumar have been proposed (Seethalakshmi & Kumar, 1998). In the Indian phytogeographic region only one genus *Racemobambos* with 2 species are known to occur. This subtribe does not have any representative taxa in South India.

Subtribe 9. Shibateinae (Nakai) Soderstrom & Ellis

Members of this subtribe are found in temperate Asia. They are characterized by sympodial or amphipodial or monopodial rhizomes, inflorescence are iterant and produces spikelets with bracts, stamens 3 to 6.

There are 5 genera *Chimonobambusa*, *Phyllostachys*, *Semiarundinaria*, *Shibatia* and *Sinobambusa* included in this subtribe.

Tewari (1992) reported 4 species of *Chimonobambusa* from North Eastern India and one from Peninsular India. Recently, Chao and Renvoize (1989) transferred 3 species to the genus *Sinarundinaria*.

In the Indian phytogeographic regions only 2 genera *Chimonobambusa* with a single species and *Phyllostachys* (5 spp.) are known to occur. This subtribe does not have any representative taxa in South India.

SOUTH INDIAN BAMBOOS

There are 32 species and 2 varieties of bamboos under 9 genera in South India. Among these, 23 species and 2 varieties under 6 genera are native to South India. The genera, *Melocanna*, *Thyrsostachys*, and *Gigantochloa* are found under cultivation. 15 species and 2 varieties of bamboos, (*Bambusa bambos* var. *gigantea*, *Ochlandra beddomei*, *O. ebracteata*, *O. scriptoria*, *O. spirostylis*, *O. soderstromiana*, *O. setigera*, *O. sivagiriana*, *O. talbotii*, *O. travancorica*, *O. travancorica* var. *hirsuta*, *O. wightii*, *Pseudoxytenanthera bourdillonii*, *P. ritcheyi*, *P. stocksii*, *Schizostachyum beddomei* and *Sinarundinaria wightiana*) are endemic to South India. Within South India, Kerala is perhaps the richest habitat of natural bamboo species. Evergreen forests of Western Ghats are the largest natural home for bamboos. Based on the extensive survey and field observations throughout the Western Ghats the authors have constructed an artificial key for the identification of south Indian bamboos both at generic and specific levels mainly depending on fresh specimens. The floral and vegetative characters have been taken for the preparation of this key.

Key to the subtribes of the Bambuseae in South India

- 1a. Bamboos shrubby upto 2.5 m tall; spikelets not clustered or fascicled, borne in raceme or panicle-like inflorescence, stamens 3 **Arundinariinae**
- 1b. Bamboos not shrubby; spikelets clustered, borne in fascicles or capitate heads; stamens 6 or more 2

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- 2a. Bamboos tall arborescent; culms large, hollow to semi solid, wall of the culm up to 3.5 cm thick, summit of the ovary pubescent **Bambusinae**
 2b. Bamboos medium sized; culms comparatively small, strictly hollow, thin walled, wall of the culm up to 0.5 cm thick; summit of ovary glabrous **Melocanninae**

Key to the genera based on vegetative characters

- 1a. Bamboos up to 20 m tall, tree-like 2
 1b. Bamboos up to 3 m tall, shrubby in appearance **Sinarundinaria**
- 2a. Culms erect; leaves narrow, up to 30 x 1.2 cm 3
 2b. Culms not erect; leaves broad up to 55 x .6 cm 4
- 3a. Culms large, hollow, basal node with fibrous roots **Bambusa**
 3b. Culms medium sized, not hollow (semisolid) basal node with short and stout thorn like roots **Dendrocalamus**
- 4a. Culms thin walled and reed-like; leaves broad up to 6 cm 5
 4b. Culms not thin walled and reed-like; leaves comparatively narrow up to 3.5 cm **Pseudoxytenanthera**
- 5a. Bamboos occurs in large patches; culms self supporting **Ochlandra**
 5b. Bamboos occurs in small patches; culms straggling or climbing **Schizostachyum**

Native bamboos of South India represented by 23 species and 2 varieties under 6 genera. *Dendrocalamus strictus* and *Schizostachyum beddomei* in South India represent the genera *Dendrocalamus* and *Schizostachyum*.

Key to the species based on vegetative characters

Bambusa Schreber

- 1a. Culms 15-25 cm in diameter, branches developing from the fifth node onwards **B. bambos** var. **gigantea**
 1b. Culms 15-18 cm in diameter, branches developing from all nodes **B. bambos** var. **bambos**

Sinarundinaria Nakai

- 1a. Leaves thick with thickened cartilaginous margins, base nearly truncate 2
 1b. Leaves thin margin neither thickened nor conspicuously cartilaginous 3
- 2a. Culms up to 1 m tall, leaves small up to 5.2 x 0.8 cm, tip spiny **S. microphylla**
 2b. Culms up to 2.5 m tall, leaves large up to 15 x 5 cm tip not spiny **S. walkeriana**

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- 3a. Branch compliment appressed to the culm, crowded 4
 3b. Branch compliments continue length wise, not crowded **S. floribunda**
- 4a. Root with air canals **S. densifolia**
 4b. Root without air canals **S. wightiana**

Pseudoxytenanthera Soderstrom & Ellis

- 1a. Bamboos erect 2
 1b. Bamboos not erect, straggling or climbing **P. monadelpha**
- 2a. Bamboos with large culms, culms up to 10-15 m high, culm covered with white powdery mass **P. bourdilloni**
 2b. Bamboos with medium sized culms, culms up to 8 m tall, culms without a powdery mass 3
- 3a. Culm surface glabrous, smooth, dark green **P. stocksii**
 3b. Culm surface pubescent, covered with golden yellow velvety tomentum **P. ritcheyii**

Ochlandra Thwaites

- 1a. Leaves large, up to 60 x 12 cm 2
 1b. Leaves comparatively small, up to 34 x 4 cm 5
- 2a. Leaf sheath and culm sheath with long ligule, ligule up to 4 cm long **O. wightii**
 2b. Leaf sheath and culm sheath with short ligule, ligule up to 2 mm long 3
- 3a. Culms with shiny green nodes, culm sheath blade with conspicuous auricles **O. ebracteata**
 3b. Culms with pale green nodes, culm sheath with inconspicuous auricles 4
- 4a. Culms and branches with bulbous based golden brown hairs **O. travancorica** var. **hirsuta**
 4b. Culms and branches lacking bulbous based golden brown hairs **O. travancorica** var. **travancorica**
- 5a. Culms up to 3.5 cm diameter; leaves up to 34 x 5.8 cm 6
 5b. Culms up to 2.5 cm diameter; leaves up to 26 x 2.5 cm 9
- 6a. Culms smooth; internode 17-25 cm long, nodes sparsely pubescent **O. beddomei**
 6b. Culms rough; internodes 47-65 cm long, nodes glabrous 7
- 7a. Culms with a greyish band on the node, nodes with a prominent brown hairs towards the shoot apex **O. spirostylis**

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- 7b. Culms without greyish band on the node, nodes without brown hairs towards the shoot apex **O. soderstromiana**
- 8a. Culms shiny dark green, upper part of the culms, with a powdery mass on the nodal line 9
- 8b. Culms yellowish green, without powdery mass on the nodal line 10
- 9a. Culm-sheath caducous; blade reflexed with a lateral extension **O. stridula**
- 9b. Culm-sheath persistent; blade not reflexed, subulate, hair-like, without a lateral extension **O. setigera**
- 10a. Culms up to 6 m tall; internode up to 40 cm long, culm sheath ciliate on the margin, blade subulate **O. talboti**
- 10b. Culms less than 5 m tall; internode up to 30 cm long, culm sheath not ciliate in the margin; blade not subulate 11
- 11a. Leaves up to 25 x 3 cm; culm sheath with two falcate long ciliate auricles **O. scriptoria**
- 11b. Leaves up to 22 x 2.5 cm; culm sheath with inconspicuous auricle **O. sivagiriana**

Key to the genera based on floral characters

- 1a. Flowers with 3 stamens **Sinarundinaria**
- 1b. Flowers with 6 stamens or more 2
- 2a. Lodicules present 3
- 2b. Lodicules absent 4
- 3a. Spikelets with 6 stamens; caryopsis not fleshy 5
- 3b. Spikelets with more than 6 stamens; caryopsis fleshy **Ochlandra**
- 4a. Caryopsis elliptic with a pubescent nipple at the summit **Bambusa**
- 4b. Caryopsis not elliptic, without a pubescent nipple at the summit **Schizostachyum**
- 5a. Spikelets stout; filaments free **Dendrocalamus**
- 5b. Spikelets thin; filaments united **Pseudoxytenanthera**

Key to the species based on floral characters

Bambusa Schreber

- 1a. Spikelets up to 1.3 cm long **B. bambos** var. **gigantea**
- 1b. Spikelets up to 0.8 cm long **B. bambos**

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- 1a. Ovary with 3 plumose stigmas **S. walkeriana**
 1b. Ovary with 2 plumose stigmas 2
- 2a. Spikelets with fertile floret and palea with a sulcus **S. densifolia**
 2b. Spikelets with more than one fertile floret, palea without a sulcus 3
- 3a. Spikelets 3 to 5-flowered; ovary elliptic, stigma divided into two towards the apex 4
 3b. Spikelets 6-7-flowered; ovary-ovoid, stigmas divided into two from the basal portion
 onwards **S. microphylla**
- 4a. Spikelets silky pubescent; flowers acuminate at apex **S. floribunda**
 4b. Spikelets not silky pubescent; flowers blunt at apex **S. wightiana**

Pseudoxytenanthera Soderstrom & Ellis

- 1a. Stigma undivided 2
 1b. Stigma divided into 3 3
- 2a. Spikelets slender, long and single flowered **P. ritcheyii**
 2b. Spikelets stout, short and two-flowered **P. stocksii**
- 3a. Spikelets small; anthers apiculate at apex **P. monadelphica**
 3b. Spikelets robust; anthers not apiculate at apex **P. bourdillonii**

Ochlandra Thwaites

- 1a. Staminal filaments fused 2
 1b. Staminal filaments free 4
- 2a. Spikelets up to 6 cm long; palea acute at apex; stigma less than 3 3
 2b. Spikelets up to 4 cm long; palea not acute at apex; stigma up to 9 **O. ebracteata**
- 3a. Spikelets pubescent **O. travancorica** var. **hirsuta**
 3b. Spikelets glabrous **O. travancorica** var. **travancorica**
- 4a. Lodicule one **O. wightii**
 4b. Lodicule more than one 5
- 5a. Lodicules three 6
 5b. Lodicules more than three 7

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- 6a. Palea notched at apex; style spirally twisted **O. spirostylis**
 6b. Palea not notched at apex; style not spirally twisted **O. soderstromiana**
- 7a. Ovary suborbicular; style flattened **O. beddomei**
 7b. Ovary not suborbicular; style not flattened 8
- 8a. Lodicules 5, 3 of them bifid at apex **O. setigera**
 8b. Lodicules 6 or more, all entire 9
- 9a. Lodicules six 10
 9b. Lodicules more than six 11
- 10a. Lodicules equal, margin entire; stigmas unequal **O. sivagiriana**
 10b. Lodicules unequal, margin not entire; stigmas equal **O. talboti**
- 11a. Palea with a sulcus at the middle, a rudimentary rachilla at the base **O. stridula**
 11b. Palea without a sulcus and a rudimentary rachilla **O. scriptoria**

CONCLUSION

One of the major problems in bamboo systematics is to find reliable characters for the delimitation of genera. The emphasis placed upon floral and vegetative characters for bamboo taxonomy has been considered differently by different taxonomists. It has been well accepted that to evolve a natural taxonomic system, both floral and vegetative morphology has to be relied upon. For identification of the sterile specimens vegetative characters are often given more emphasis at the generic level, and the culm-sheath morphology, especially of the new shoots at the specific level. Since the flowering in bamboos are erratic and at very long intervals the vegetative characters are often given more emphasis to identify the specimens. Due to the vast morphological variations found within species and between closely related species the generic and specific delimitations are still not clearly defined. Holttum (1956) suggested that the three genera *Cephalostachyum*, *Teinostachyum* and *Pseudostachyum* should be merged with Malaysian genus *Schizostachyum*. Clayton and Renvoize (1986) and Majumdar (1989) followed Holttum's suggestions and treated all four genera as conspecific. However, Dransfield (1980) kept these three genera separate from *Schizostachyum*. Most of the Asian botanists include the genera *Fargesia*, *Sinarundinaria* and *Yushania* under *Arundinaria*.

Some Asian genera *Drepanostachyum*, *Chimonocalamus* and *Butania* have been assigned to another subtribe Chuqueae based on bud morphology. Recently three genera with 6 stamens *Racemobambos*, *Neomicrocalamus* and *Monocladus* have been placed into the *Thamnocalamus* group. The genus, *Himalayacalamus* is treated congeneric to the genus *Thamnocalamus*. Recently, a large number of new species have been reported by Chinese botanists and have been assigned under the *Thamnocalamus* group and the whole group has become more complex. Most of the new species are so far merely known by their vegetative parts, only very few species are known by flowers. The diversity of spikelets and inflorescence

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structure remains unknown and many species described could therefore be merely tentatively assigned to a genus. The generic status given with regard to certain genera by earlier workers did not give any justification for the merger and no comparative studies are available to investigate generic limitation of the respective subtribes. Therefore, unless a thorough revisionary studies of at least some of the complex group under the subfamily Bambusoideae is undertaken, the treatment of genera under the respective subtribes and its systematic position cannot be understood.

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