THE TAXONOMIC STUDIES ON THE BAMBOOS OF SOUTH INDIA

Thesis
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for the degree of
Doctor of Philosophy

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Dedicated to my beloved students who have been the greatest source of inspiration in my career

DECLARATION

I, Unnikrishnan N, do hereby declare that the work presented in this thesis entitled **"The Taxonomic Studies on the Bamboos of South India"** submitted by me in partial fulfilment for the Ph. D. degree in Botany of the University of Calicut under the supervision of Dr. M.S. Muktesh Kumar, Scientist, Kerala Forest Research Institute, Peechi and Dr. Philip Mathew, Professor of Botany, University of Calicut, incorporates the results of the work done by me. I have not submitted this thesis to any other University for the award of any other degree, diploma or any other titles and it represents the original work done by me.

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CERTIFICATE

This is to certify that the thesis entitled **"The Taxonomic Studies on the Bamboos of South India"** submitted to the University of Calicut by **Unnikrishnan N.** for the ***Degree of Doctor of Philosophy in Botany*** embodies the results of bona fide research work carried out by him under our supervision and guidance, and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title or recognition.

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Introduction

I. INTRODUCTION

Man is the roof and crown of all the flora and fauna on this troubled planet. Bamboo is the roof and crown of all plants, having close association with man's existence from primeval times. It was used by Gods and humans, the haves and have-notes, the sophisticated and the rustic, the artistes and the artisans. Man's inhumanity to men was made clear when he made weapons out of bamboo; man's aesthetic sense was roused when he made flute out of it, spreading divine music to change a heart of stone into a heart of gold. A petite bamboo piece was transformed into a mesmerizing flute for Lord Krishna; a squeezed bamboo became the world-famous walking stick of Charlie Chaplin. From the time immemorial to the time of information technology, the bamboo has been man's closest friend. The leaves proclaim this message when a zephyr fondles them. When all is said and done, it is easier to fathom this sky than fathom the various aspects of the elegant and graceful bamboo.

Bamboos are the members of the natural group Poaceae, the grasses, under the subfamily Bambusoideae. They are mainly distributed in the tropical and subtropical regions of the world. Bamboos are generally tall, erect and woody arborescent grasses. Although, bamboos are considered as giant members of the grass family, certain bambusoid characters set them off from other grasses (McClure, 1966). A well developed rhizome system which supports the aerial portions, woody culms bearing the branch complements, petioles of the leafblade, the culm sheaths covering the new shoots and buds and the peculiar flowering and seeding behaviour are some of the important morphological characters of bamboos. The lodicules of bamboos are well developed. Single columned style with one, two, three or more stigmas, the presence of fusoid cells surrounded by strongly lobed, armed cells in the mesophyll are important features which separate bamboos from other grasses.

Taxonomically, bamboos are considered as one of the most difficult group of plants. They are highly problematic for field studies, collection and classification owing to the non-availability of flowers and fruits, since most bamboo species flower only at irregular intervals and often die soon after. Most of the bamboos flower only once in their lifetime and the life span varies from 7-120 years (Janzen, 1976; Dransfield & Widjaja, 1995). The flowering is at

fixed intervals and all culms die after flowering. The flowering is unpredictable. It is also observed that some species of bamboos remain sterile

Though, the flowers are not available in bamboos for taxonomic studies as and when required, there are several taxonomically useful vegetative characters such as the culm sheath, bud and well-developed branch complements that help for identifying the species. These characters vary from species to species and can be used for generic and specific delimitations. Many workers also emphasized the importance of vegetative structures in bamboo taxonomy (Gamble, 1896; Brandis, 1899; Raizada & Chatterjee, 1963; McClure, 1966).

I.1.GENERAL MORPHOLOGY

I.1.a. Habit

Bamboos exhibit basically three types of habits. Culms caespitose or closely packed, culms loosely arranged and culms scattered. The caespitose habit develops from short necked pachymorph rhizomes and loosely arranged habit from pachymorph long necked rhizomes. Culms with scattered habit arise from a leptomorph rhizome. The culms may be erect, erect with pendulous tips, arching or scandent.

Most of the south Indian bamboos are with closely packed culms and with erect or erect with pendulous tips. Culms are arching in *Pseudoxytenanthera monadelpha* and *Schizostachyum beddomei*. *Pseudoxytenanthera ritchiei* and *P. bourdillonii* have loose culms arising from long-necked pachymorph rhizomes. All species of *Ochlandra* possess closely packed caespitose culms. The species of *Sinarundinaria* are shrubby bamboos with closely packed culms. The species like *Bambusa bambos* and *Dendrocalamus strictus* form closely arranged culms.

Morphologically bamboos differ from other members of the grass family and are characterised by tree-like habit, well-developed rhizome system, woody and hollow culms, branching, petiolate leaves and specialised sheathing organs. The morphological structures are taxonomically very important. They can be used as diagnostic characters at the generic and species level.

Plate 1. Rhizome, culm and flowering. **A.** flowering; **B. 1.** flower. *Ochlandra* - Scriptoria group, **2.** flower. *Ochlandra* - Travancorica group; **C. 1.** fruit *Ochlandra* - Scriptoria group; **2.** fruit *Ochlandra* - Travancorica group; **D. & F.** pachymorph rhizome; **E.** culms

I.1.b. Rhizome

The rhizome system in bamboo is well developed and it supports the aerial parts (Figure 1). It is subterranean, highly branched and forms the structural foundation of the plant. They store food and also function in vegetative reproduction.

The individual axes of the rhizome system are referred as rhizome segments. Each individual branch or axis of the rhizome system is known as a rhizome. The rhizome consists of two parts, the rhizome neck and the rhizome proper. The rhizome neck may be short or sometimes elongated.

Basically there are two types of rhizomes. They are determinate and indeterminate or sympodial and monipodial. The determinate rhizome is called Pachymorph rhizome and indeterminate rhizome is known as Leptomorph rhizome.

I.1.b.i. Pachymorph or sympodial rhizome

These are short, thick, curved and subfusiform structures. The internodes are broader than long, lateral buds solitary and solid (Figure 2; Plate 1). Roots arise from the lower side. The apical portion of a pachymorph rhizome always ends in a culm. The lateral buds produced develop only as rhizomes.

Based on the length of the rhizome neck, pachymorph rhizomes are categorised under two types, short-necked and long-necked. The bamboos having short-necked pachymorph rhizomes show a caespitose clump habit. In bamboos with long-necked pachymorph rhizomes the culms grow in a diffuse manner.

I.1.b.ii. Leptomorph or monopodial rhizome

This type of rhizome exhibits a basically monopodial branching. The rhizome is long and slender and has a diameter usually less than the culms originating from it (Figure 2). It is also characterised by cylindrical or subcylindrical form, the internodes are longer than broad, relatively uniform in length, typically hollow, rarely solid, the central lumen is separated into compartments by a cross wall at each node and the lateral buds are boat shaped.

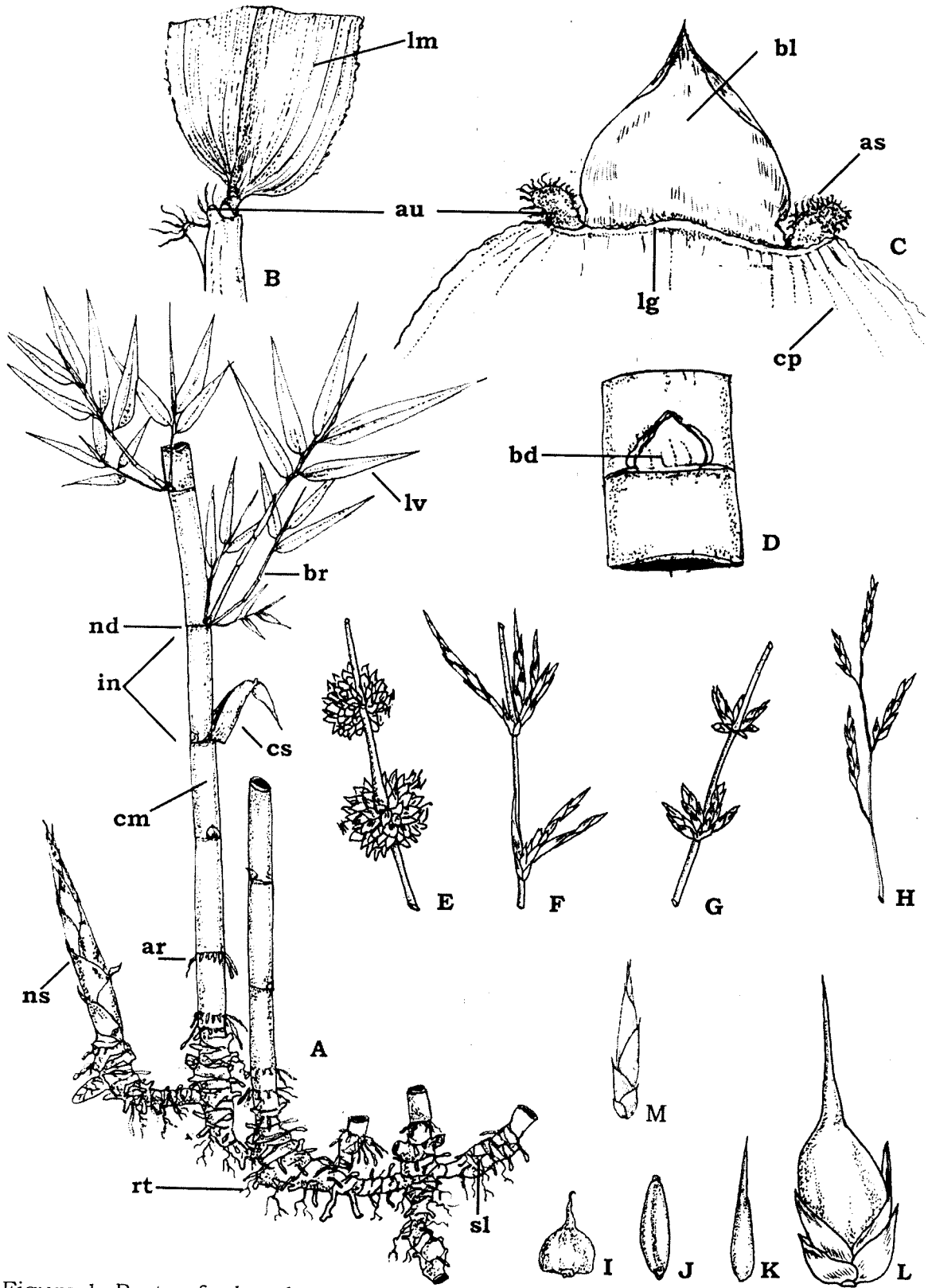


Figure 1. Parts of a bamboo plant. **A.** plant with rhizome; **B.** leaf sheath; **C.** culm sheath; **D.** node with prophyllate bud; **E., F., G. & H.** inflorescences; **I., J., K. & L.** fruits; **M.** spikelet; **sl.** scale leaf; **rt.** root; **ns.** new shoot; **ar.** aerial root **cm.** culm; **cs.** culm sheath; **nd.** node; **in.** internode; **br.** branch; **lv.** leaves; **lm.** lamina; **au.** auricle; **bl.** blade; **as.** auricular setae; **lg.** ligule; **cp.** culm sheath proper; **bd.** bud

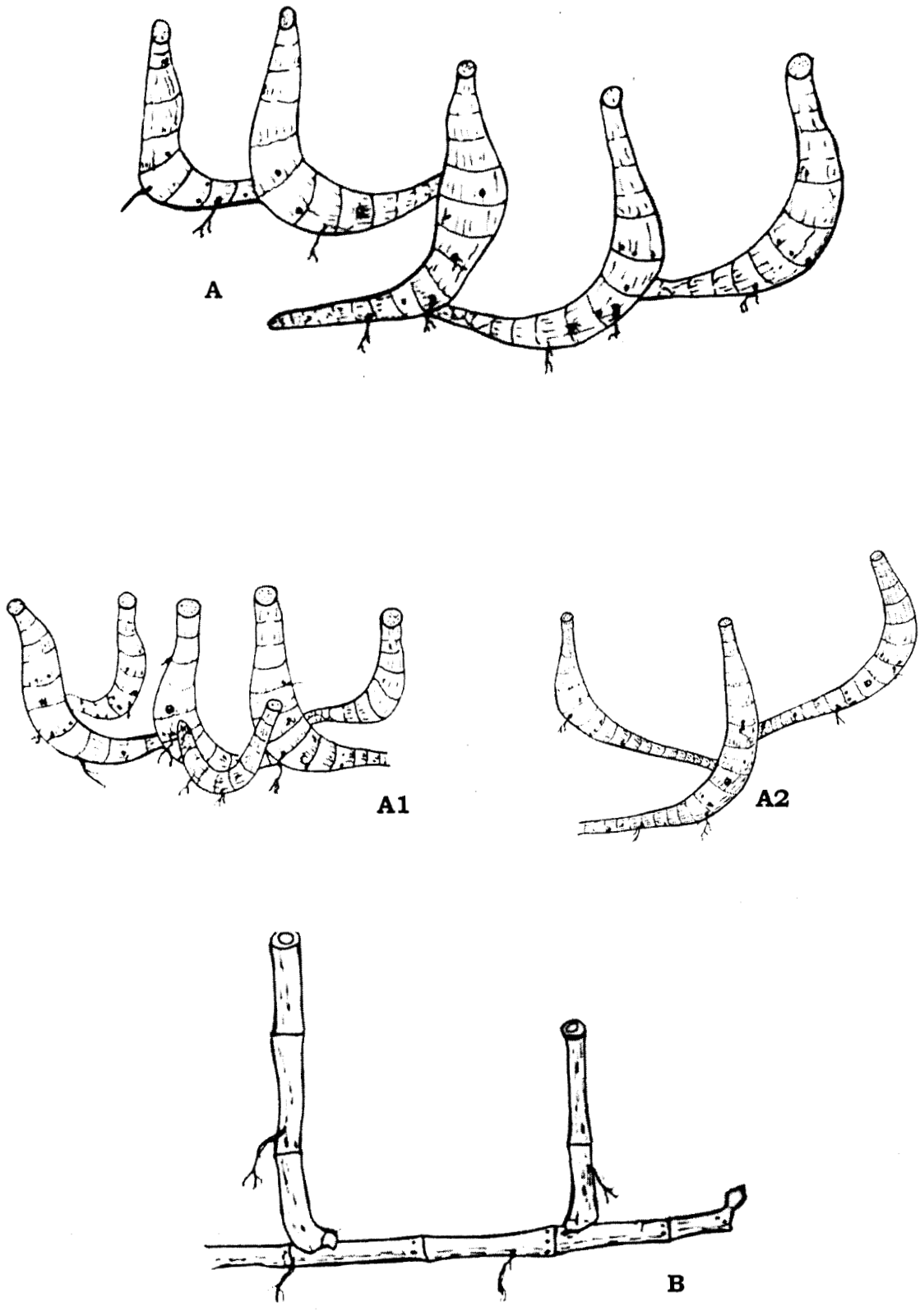


Figure 2. Rhizome. **A.** pachymorph (sympodial) rhizome; **A1**. pachymorph - short necked; **A2.** pachymorph - long necked; **B.** leptomorph (monopodial) rhizome

The culms develop from the lateral buds. Some of the lateral buds give rise to rhizomes. A single ring of roots arise at the nodal region. The leptomorph rhizomes show different pattern of branching.

Majority of tropical bamboos have pachymorph rhizomes. In all South Indian genera such as *Bambusa, Dendrocalamus,* all species of *Ochlandra, Pseudoxytenanthera* and *Sinarundinaria* have pachymorph rhizome. In temperate bamboos such as *Phyllostachys pubescence* and *Arundinaria gigantea* the rhizome is leptomorph.

The culms developed from long-necked pachymorph rhizomes resemble the culms produced from leptomorph rhizomes. They show an open diffuse clump habit as in *Melocanna baccifera.*

I.1.c.Young shoot

Young shoot or culm shoot is the new aerial stem arising from the apical bud of a pachymorph rhizome or from the lateral bud of a leptomorph rhizome (Figure 1). The young shoot consists of short, soft internodes protected by numerous overlapping rigid culm sheaths attached to the alternate sides of successive nodes. It consists of a short massive little differentiated stem packed with nutrients and protected by numerous rigid sheaths. Each shoot is a highly condensed series of internodes and nodes. These shoots elongate rapidly to become a mature culm.

The young shoots are used as an important criterion for species identification. During the elongation of the internodes of the culm shoots, the culm sheath and their parts become visible and clear.

I.1.d. Culm sheath

The culm sheaths are modified leaves that clothe the developing internodes of young shoots and young culms (Figure 1). They fall off when the culms mature or sometimes they are persistent. They closely cover the young culms and developing internodes and protect them from mechanical or pest damage.

A culm sheath consists of an expanded sheath, a narrow blade and a ligule. Auricles and oral setae may present. The auricles when developed are typically lobe-like or rim-like structures occurring on each side of the base of the blade at the top of the sheath. They are sometimes considered as lateral extension of the base of blade. Ligule is present on the inner side of the sheath, where the blade joins. In some species, outer ligule is also present.

The culm leaf blade is highly variable with respect to its size, position and morphology. They can be erect spreading or reflexed. They also vary in their shapes. In some species the blade is triangular or dome shaped as in *Bambusa* sps. In some others they are inflated, lanceolate or narrowly linear. They may be persistent or deciduous.

Morphologically the culm sheaths vary from species to species and therefore are used in the identification of bamboos at species level. The culm sheaths of the same plant may vary somewhat from the base to its tip. The culm sheath at the middle of the culm is considered as the one, which has the fully developed characters, typical of the species.

I.1.e. Culms

Culms are the aerial vegetative axes arising from the rhizomes. The culms are produced apical in pachymorph rhizome and as lateral branches in leptomorph rhizomes (Figure 1). The habits of culms vary from erect, erect with drooping or pendulous tips, broadly arched, scrambling, climbing and to strongly zigzag.

Culms are segmented and the nodes and internodes are distinct. Most of the culms are cylindrical and hollow. They are separated by horizontal partitions at nodes. In some bamboos the culms are almost solid or completely solid. In *Dendrocalamus strictus* the culms are solid or with a very narrow lumen. The culms are solid in *Pseudoxytenanthera ritchiei.*

The nodal region is very distinct in bamboos. It is a very important region on the culm where an intercalary meristem is present. It helps in the elongation of internodal region. The culm sheaths arise from the nodal region. It encloses a branch bud. The lowest boundary of the node in bamboo is the nodal line or

sheath scar which is the scar left after the culm leaf falls off. The mark just above the nodal region is known as the supra nodal ridge.

The bud is usually inserted just above the nodal line. In some bamboos down curved root-thorns develop at their lower and basal nodes. *Eg. Sinarundinaria longispiculata, Chimonobambusa quadrangularis.* In *Bambusa vulgaris Dendrocalamus asper, D. giganteus* and *D. strictus* and develop verticels of normal roots at the lower culm nodes.

Generally, the internodes are cylindrical. In *Chimonobambusa quadrangularis* the internodes are quadrangular. In *Bambusa vulgaris* var. *wamin* the internodes are short and swollen. In *B. vulgaris* var. *striata,* the culms are yellow-streaked, green or occasionally pale yellow. In species such as *Bambusa bambos* and *Pseudoxytenanthera bourdillonii* the internodal region is covered with a white powder or wax. In *P. ritchiei* the internodes are thickly covered with golden yellow tomentum.

I.1.e.i. Prophyll

A sheath, which occurs at the base of the node of each vegetative branch, it represents the first leaf of that branch (Figure 1). It is a one or two-keeled structure, which encloses and protects the branch primordia. The back of the prophyll closely adheres to the axis from which the branch that bears it emerges. The margins of the prophyll clasp the branch primordia to form a bud. The morphology of the prophyll varies in different species of bamboos and therefore considered taxonomically very important.

I.1.f. Branches

When the culm has reached its full height; the lateral buds begin to grow and to form branches (Figure 1). The buds at the lower nodes usually remain dormant. But, in *Bambusa bambos* and *Dendrocalamus strictus* the branches develop from the basal culm nodes as well. In *Bambusa bambos* these form a thicket around the base of the culm and are spiny. In *Dendrocalamus strictus* the branches are not spiny. In many bamboo genera the primary branch emerges and remains strongly dominant. Other branches develop from its

basal buds but do not attain the size of the primary branch as found in *Bambusa bambos* and in different species of *Ochlandra*. In *Sinarundinaria* species there is a central branch with two secondary branches arising almost simultaneously. All these three branches together produce a cluster of many sub equal branches, as in *Sinarundinaria densifolia* and *S. floribunda*. In *Pseudoxytenanthera monadelpha* the secondary axes originate earlier to the primary one and produce clusters of short branches. The primary axis remains dormant in bud stage and later produces a new culm or long whip-like branch. In *Schizostachyum,* a dense cluster of subequal branches arises at each node which develops from a single primary branch axes at the node. In *Phyllostachys* there is just one primary branch bud at a node, which produces a single secondary branch at its base. Sometimes a third small branch also develops form the base of secondary branch.

I.1.g. Leaves

Leaves consist of basically two parts, the leaf sheath and the blade. The leaves have a relatively small sheath and an expanded, well-developed leaf blade (Figure 1) .

The sheaths are attached at the nodal region and wrapped around the branch. They support the leaf blade. On the outer surface of the sheath, veins are distinct which represent the vascular supply. The inner surface is smooth and shining. They may be persistent or deciduous. The sheaths also bear outer and inner ligules. They are present at the region of attachment of the petiole and sheath. The outer ligule is usually inconspicuous. The inner ligule is a short extension of the adaxial surface in the central part of the sheath summit. The ligules vary in size from small, thin structure to a part of substantial size and shape as in *Ochlandra wightii.*

The sheaths bear auricles and bristles. The auricles and bristles are clear and prominent in young leaves.

Leaf blade is petiolate. They are dorsiventral. The size of the leaf varies from species to species. Venation of the leaves is parallel and veins of three orders namely the midrib, secondary veins and tertiary veins are present. This division is based on the size of the veins. In some bamboos, the adjacent veins

are connected by transverse veinlets, which are very distinct. This pattern is called tessellate venation as in the leaves of *Sinarundinaria.* In most of the tropical bamboos the leaf blades are deciduous as in *Bambusa bambos and Dendrocalamus strictus.* The margins of the leaf are scabrous. In some species the leaf lamina is hirsute on one side or on both sides.

I.1.h. Inflorescence

Bamboos have a compound inflorescence, which consists of numerous flowers. The bamboo inflorescence is an aggregation of spikelets (Figure 1). They may appear on leafy branches or as gigantic panicles covering the whole culm. There are four basic types. They are the spicate, racemose, paniculate and capitate. In spicate inflorescence the stalk of the spikelet is highly reduced or absent. Racemose inflorescence has spikelets with stalks. In paniculate inflorescence the spikelet is stalked and shows more than one order of branching. The capitate inflorescence is similar to paniculate, but the inter nodes are very short, forming a dense, globose appearance.

In the South Indian genus *Ochlandra* the inflorescence is a large compound, spicate panicle with semiverticillate clusters of spikelets. In *Bambusa bambos* the inflorescence is a very large panicle. The spikelets arise on spicate branchlets forming loose clusters. *Dendrocalamus strictus* has large paniculate inflorescence with dense globular heads of spikelets. In *Sinarundinaria* the inflorescence arise as a small panicle at the tip of leafy branches. In the genus *Pseudoxytenanthera* the inflorescence is a large panicle with spicate heads. In some of the species of *Schizostachyum* the inflorescence is a large drooping panicle.

I.1.h.i. Determinate inflorescence

The inflorescence composed of ordinary spikelets is also known as determinate inflorescence. In this, the spikelets arise in a raceme or in a simple panicle, emerging and dying almost simultaneously (Dransfield & Widjaja, 1995). All spikelets are formed and reach maturity almost at the same time as in the genus *Arundinaria.*

I.1.h.ii. Indeterminate inflorescence

An indeterminate inflorescence is composed of pseudospikelets. The formation of pseudospikelets from prophyllated buds continues almost indefinitely until the culm's reserves are exhausted. The inflorescence of *Bambusa bambos* and all species of *Ochlandra* are examples for this type of inflorescence.

In pseudospikelets the short rachilla also bears below the spikelets proper, one to several small bracts, each subtends a tiny branch bud with a prophyllum (Figure 3). It is difficult to distinguish these bud-bearing bracts externally. A pseudospikelet, from the base to the apex, typically subtend by a bract, consists of a prophyll, a series of one to a few germmiparous bracts and a spikelet proper (Judziewicz *et al.*, 1999).

I.1.i. Spikelet

The spikelet is the basic unit of a bamboo inflorescence (Figures 1 and 3). The spikelets are arranged on the rachilla. The number of spikelets vary from one to many. They may be short stalked or sessile. Single flower of the spikelet is the floret. In most of the South Indian bamboos the spikelets are many flowered. In the genus *Ochlandra* it is single flowered. Spikelets are subtended by one or more scaley bracts. All flowers contain two or more empty or sterile glumes. Sometimes empty glumes are absent. The fertile glumes are composed of lemma and palea. Palea is keeled in some of the bamboos. The palea encloses the lodicules, stamens and the ovary.

The lodicules are very thin filmy, hyaline structures, 3-7 in number. They are absent in some species. Lodicules are now generally considered to be true perianth appendages. Intermediate stages between stamens and lodicules were observed in *Ochlandra scriptoria* during this study. At anthesis the lodicules swell up and force up the lemma and palea enclosing the flower so that the stamens and stigma can be exerted.

The number of stamens varies from species to species. In *Sinarundinaria* species it is three and in the genus *Ochlandra* the number of stamens vary from 17-130. Usually the stamens are free, but in some species, the filaments

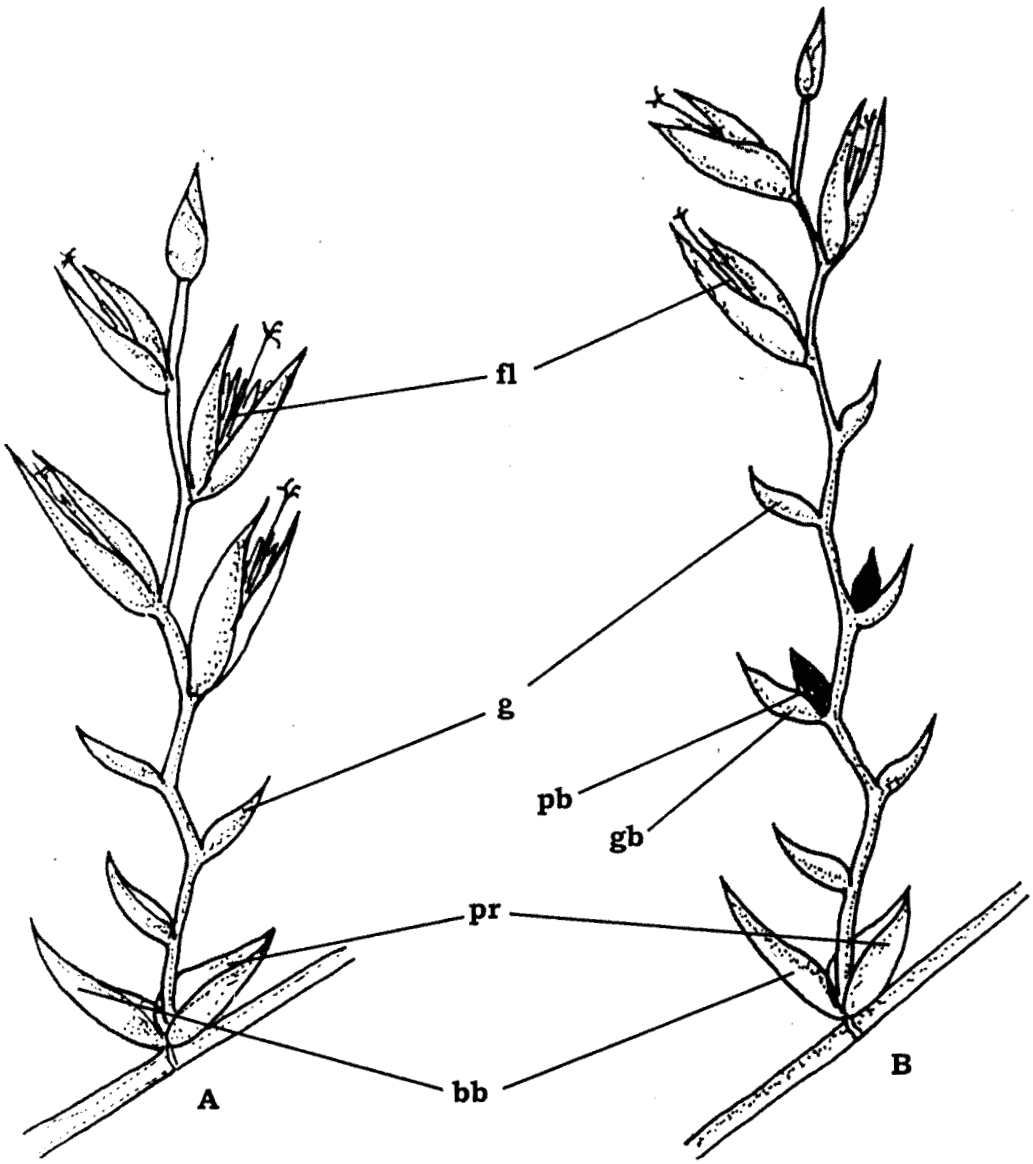


Figure 3. Comparison of spikelet and pseudospikelet. **A.** spikelet; **B.** pseudospikelet; **bb**. bracts; **pr.** prophyllated bracts; **fl.** florets; **g.** glumes; **pb.** prophyllated bud; **gb.** gemmiparous bract

are fused to form monadelphous condition as in *Pseudoxytenanthera monadelpha*. Stamens are apiculate or bifid at the tip.

The ovary is surmounted by the style and stigmas. The stigma may be single or divided into 2-7 branches. It is highly plumose and helping in wind pollination.

I.1.j. Fruit

In bamboos the fruit is a caryopsis, an indehiscent one-seeded structure (Figure 1). It consists of a pericarp enclosing the seed. In some genera like *Ochlandra* and *Melocanna* the pericarp of the fruit is thick and fleshy. In *Ochlandra* the fruit is long-beaked and supported by the persistent lemma and palea.

I.2. FLOWERING

The flowering behaviour in bamboos is very unique when compared to other plant groups because of the mechanism of flowering. Most of the Indian bamboos flower synchronously at regular and long intervals. The majority of the known bamboos fall between two physiological extremes (constant sterility and constant flowering) by manifesting a cyclic recurrence of the flowering state at intervals of few to many years. After a definite period or many years of vegetative growth all of the members of a given generation of bamboo plants (from seeds of a common origin) flower, produce seeds and die. This phenomenon is called gregarious flowering or mast flowering (Plate 1). Most of the bamboo species have a characteristic and more or less sharply defined flowering cycles of 3, 7, 11, 15, 30, 48, 60 or 120 years, at the end of which, all plants of a given seedling generation flowers gregariously (Janzen, 1976; Chaturvedi, 1988).

Another type of flowering is sporadic flowering. In this type only a single culm of a plant produces flowers. This is common in many species such as *Bambusa bambos, Dendrocalamus strictus* and different species of *Ochlandra*. In sporadic flowering only the culms that flower die and not the entire clump.

On the basis of flowering behaviour Blatter (1929) divided bamboos in to three groups. They are i) annually flowering, ii) gregariously and periodically flowering and iii) irregularly flowering.

Bamboos generally die within one or two years after flowering. Example is *Bambusa bambos*. Some other species do not die, but their vegetative growth slows down during the flowering period. All species of the genus *Phyllostachys* and several species of *Arundinaria* belong to this category. Flowering in bamboos is like setting an alarm clock which is set to go off at a particular time when all populations of a given species raised from the same seed source would start flowering simultaneously. Climate is a factor which influences flowering since very dry years are said to coincide with the flowering of bamboo and bamboo in exposed situations flowers earlier than in sheltered or cooler places.

The exact reason for the death of bamboos subsequent to flowering and fruiting is still a mystery. Ramesh *et al.* (1998) conducted studies on the biochemical changes during flowering of bamboos that lead to death of the plants. They studied the total carbohydrates, α-cellulose, hemi cellulose, and lignin, reducing sugars, ash and moisture content before, during and after flowering. It is reported that death of bamboos after flowering can be due to the excessive deprivation of reducing sugars and moisture content, leading to loss in vitality and osmotic shock along with toxicity generated due to enormous increase in lignin content.

Bamboo flowering can be predicted one year before flowering by certain indications, such as the decline in growth rate, decrease in amount of bamboo sprouts, early formation of bamboo shoots and brittleness of bamboo wood. Bamboo flowers usually in different stages and the floral buds develop together with in one batch. The formation of floral buds may continue for one to one and a half years.

The gregarious flowering of *Ochlandra travancorica, Pseudoxytenanthera ritchiei* and *Sinarundinaria wightiana* was observed during the present study. Sporadic flowering was found in many species of *Ochlandra, Sinarundinaria, Pseudoxytenanthera, Bambusa bambos* and *Dendrocalamus strictus*. According to Gamble (1896), *Ochlandra scriptoria* produces flowers annually. During the

study, it was observed that *O. scriptoria* flowers gregariously and sporadically. But, the flowered plants die after fruit production. Based on the information from the local people the flowering cycle of *Ochlandra* is 6-7 years. Bamboos could flower in all seasons, but it was observed during the present study that in South Indian bamboos flowering starts during the summer months, March-April. For almost one and a half to two years the plants produce spikelets and fruits continuously and gradually become dry and the clump dies.

According to Janzen (1976) the long flowering cycle and enormous seed production is an adaptive response to seed predators. The bamboos store reserves over a period of many years and use those reserves for the production of large quantities of seed. Predators that might otherwise consume the seeds and thwart reproduction are satiated, thus, leaving plenty of seeds to germinate and grow.

I.3. PHYLOGENY

Bamboos are considered as the most primitive members of the grass family (Holttum, 1958). The floral characters of bamboos are relatively primitive.

The origin of grasses is obscure, for whatever link existed with the rest of the monocotyledons is now extinct. Their close living relatives are found in the group of small families like Joinvillaceae, Flagellariaceae and Restionaceae. These families are broadly distributed in the tropics, so hints at a tropical origin for the grasses (Clayton and Renvoize, 1986).

Based on taxonomic evidences the grasses can be divided into three evolutionary lines. Bambusoideae, Arundinoideae-Chloridoideae-Panicoideae and Pooideae. These lines were originated from a common ancestor but the base of each line is now extinct. The most likely indications come from Bambusoideae whose diversity and fragmentations speak of age, whose spikelets especially that of Bambuseae retain traces of a primitive trimerous symmetry and whose origin seems to lie in the relatively benign forest margin environment. However, in proposing Bambusoideae as the most primitive of the subfamilies it is necessary to add the caveat that subsequent adaptation to specialised habitats has carried it a long way from the original prototype (Clayton and Renvoize, 1986).

According to Soderstrom (1981a) bamboos have developed from herbaceous stock and have a close and common ancestry. Bamboos, which have woody culms and several genera with herbaceous culms, share a similar type of leaf anatomy and epidermis. Various other morphological features, including a distinctive type of seedling also indicate a close relationship that supports the grouping of these genera together into a single family, the Bambusoideae. The herbaceous members are mostly diploid and the woody bamboos are polyploid with a basic number n=12. Such evidence corroborates the hypothesis that bamboos have been derived from herbaceous ancestors. The Bamboos have less opportunity for floral evolution because of their infrequent flowering nature. So they retain a primitive type of inflorescence. The herbaceous members flower continuously or at least seasonally so they develop highly specialised type of inflorescences. Soderstrom (1981a) studied a herbaceous member *Streptochaecta* in detail for comparison. Based on his studies he came to the conclusion that bamboos have developed from herbaceous ancestor.

Tzvelev (1989) in his work discussed the evolution of grasses. He compared bamboos and true grasses. There are many differences between true grasses and bamboos. In the embryo structure also they differ. In true grasses there is a meristematic layer formed under the plumule. Therefore, during germination the base of the plumule can lengthen considerably beneath the coleoptile and adventitious roots can develop beneath the coleoptilar node. In bamboos, such a meristem is absent. The presence of such a meristem beneath the plumule is an advanced feature. The bamboo subfamily may be considered on the basis of this character to be on the lower evolutionary level than the true grasses.

The Grass Phylogeny Working Group (GPWG, 2001) identified 12 sub-families under Poaceae. The studies were conducted using six molecular sequence data sets, Chloroplast restriction site data and morphological data. They included *Bambusoideae* under BEP clade, that is *Bambusoideae, Ehrhartoideae* and *Pooideae.* The subfamilies *Anomochloideae, Pharoideae* and *Puelioideae* are considered primitive than *Bambusoideae.* Their phylogenetic studies based on morphological and molecular characters confirm that the grasses are most closely related *to Joinvilleaceae, Restionaceae, Anarthriaceae* and *Ecdeiocoleaceae.* The traditional subfamily *Bambusoideae* is polyphyletic and the true bamboos are monophyletic in origin (Clark *et al.*, 1995).

When compared with other grasses bamboos are characterised by some primitive characters. The monocarpic and multinial nature, woody habit, presence of culm sheath, complex inflorescence, pesudospikelets, spikelets with a large and indefinite number of flowers, presence of large and many lodicules, numerous stamens, connate filaments in some bamboos, many stigmas and fleshy fruits in some bamboos are distinct and primitive characters of bamboos.

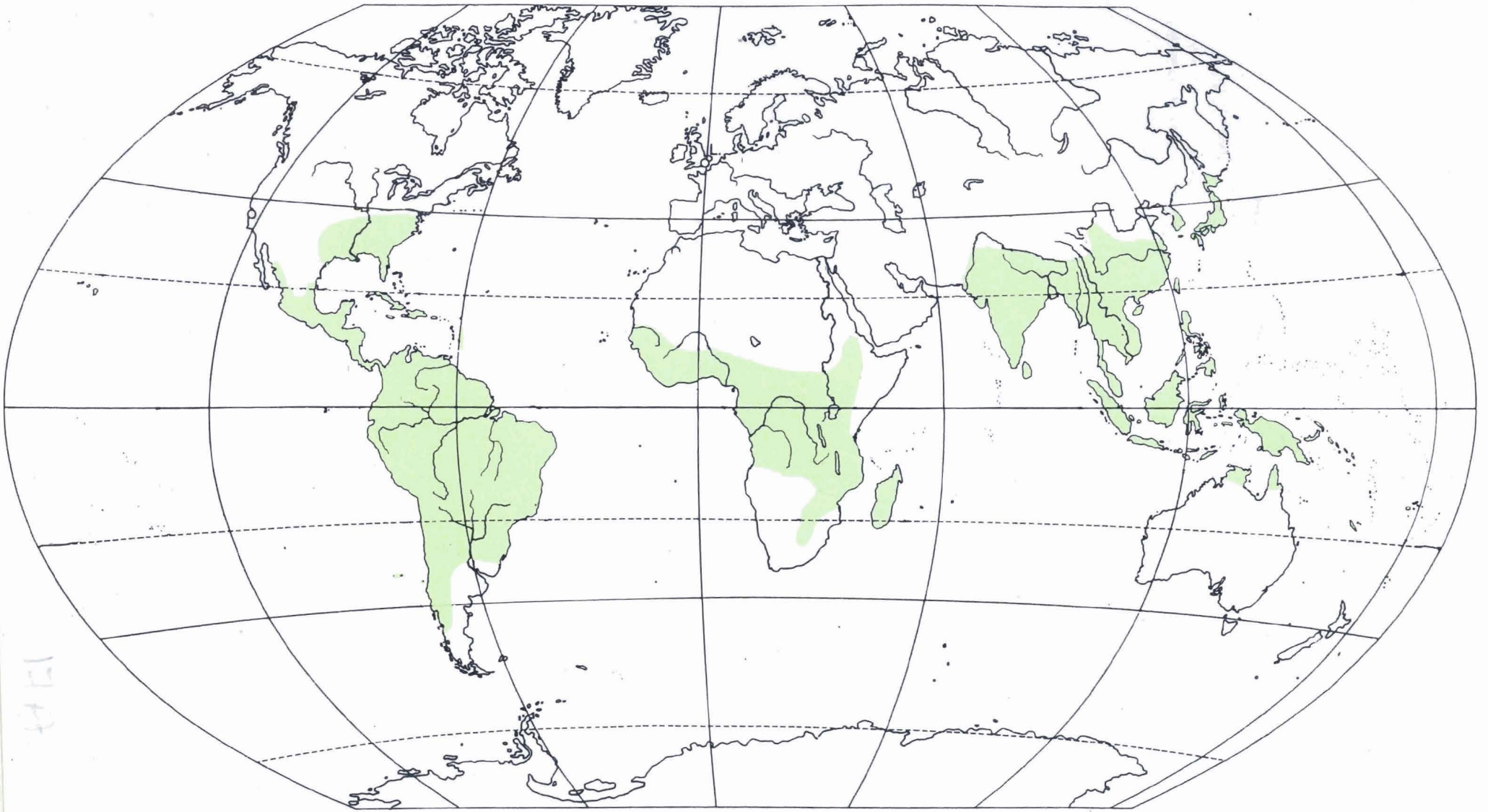
Among the South Indian bamboos the genus *Arundinaria* (*Sinarundinaria*) is considered as the most advanced group. They are with shrubby habit, simple flowers with small lodicules and 3 stamens. This genus connects bamboos to the main mass of true grasses (Holttum, 1958). The genus *Ochlandra* is considered as more primitive with complex inflorescence, spikelets with numerous glumes, large and many lodicules, numerous stamens and fleshy fruits.

I.4. DISTRIBUTION AND ECOLOGY

The *Bambusoideae* appears to be one of the most successful and diverse subfamilies of grasses. They have strong adaptability and are distributed widely from near the equator zone to boreal zone. They occupy habitats from sea level to high mountains, up to an altitude of 3300-4000 m. Most of the bamboo species need warm and humid climate and are distributed over plain and hilly area in tropical and subtropical monsoon zone between the Tropic of Capricorn and the Tropic of Cancer (Zhu Shilin *et al.*, 1994).

I.4.a. World distribution

According to Ohrnberger (1999), there are 1575 species of bamboos under 111 genera all over the world. They appear in the natural vegetation of many parts of the tropical, subtropical and mild temperate regions of the world, from sea level to the snow. They are abundant in the southern and southeastern boundaries of Asia, from India through China and Japan to Korea. Bamboos are also growing in Africa, Australia and in Madagascar (Map 1). In the Western hemisphere bamboos extend from eastern United States to Chile and



Map 1. World distribution of bamboos

Argentina. South America is rich in bamboos (Soderstrom and Calderon, 1979b).

The distribution of bamboos in the world can be divided in to 3 large geographical regions.

1. Asia-Pacific bamboo region (42°S-51°N): Major bamboo growing countries in these regions are China, India, Myanmar, Thailand, Cambodia, Japan, etc.
2. American bamboo region (47°S-40°N): It extends across south and north Americas, Mexico, Guatemala, Honduras, Columbia, Venezuela, the Amazon valley in Brazil are the main centres of bamboo distribution in this region.
3. African bamboo region (22°s -16°n): The southern Mozambique and eastern Sudan from south to north. The main places in this regions are Senegal, Guinea, Liberia, Ivory coast, Nigeria, Congo, Zaire and Madagascar Island (Zhu Shilin *et al.*, 1994).

Sasa kurilensis occurs on the island of Sakhalin at 46°N latitude further north than any other bamboo. The southern most limit of bamboos has been recorded as 47°S latitude for *Chusquea culeou* (Soderstrom and Calderon, 1979b).

Bamboo forests cover about 14 million hectares of the earth's surface, 80 per cent of which is present in Asia (Tewari, 1992a). The tropical climate of this region is congenial to bamboos and also the limiting factor for their distribution. Tropical Asia can be referred as the centre of bamboo germplasm (Biswas, 1988). Among the bamboo growing countries China stands first in species diversity in position with *ca.* 33 genera and 450 species (Li, 1998).

I.4.b. Distribution of bamboos in India

From India, 128 species of bamboos under 18 genera were reported (Seethalakshmi and Kumar, 1998). According to a recent statistics, there are 84 species under 18 genera of bamboos in India (personal communication: Kumar and Remesh). Bamboos are found growing in all States except Jammu and Kashmir. The tropical moist deciduous forests of the north and the south,

the deciduous and semi-evergreen regions of the northeastern part show maximum diversity of bamboos. They are most abundant in the northeastern states, western and also in Eastern Ghats (Rawat *et al.*, 2002). Northeastern hill regions possess largest species diversity (Hore, 1998). They are represented in the five major bioclimatic regions, alpine region, temperate region, subtropical region, dry tropical regions and moist region (Varmah and Bahadur, 1980). They are usually found in moist valleys, sheltered depressions, along stream sides and the lower hill slopes. They also grow on higher slopes and hilltops, and grow as a component of moist deciduous and semi-evergreen forests. Bamboos also form secondary breaks and they also occur as pure patches. *Bambusa bambos, Ochlandra* travancorica and *Melocanna baccifera* are some species, which form bamboo breaks. Bamboos are also growing under cultivation in homesteads.

They thrive best and form rich belts of vegetation in the well-drained parts of monsoon forests at the foot of the Himalayas and in the peninsular region. The main bamboo-growing regions in India are the northeastern region and the Western Ghats. Andaman and Nicobar Islands also have a promising diversity (Mauria and Arora, 1988; Kumar, 2003). In India the diversity of bamboos is mainly confined to the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal in the north east; some regions of Madhya Pradesh, Utter Pradesh, Bihar, Orissa in central region; Andhra Pradesh, Kerala, Karnataka and Tamil Nadu in the Peninsular region.

I.4.c. Distribution of bamboos in South India

In South India, bamboos are found growing in plains and also as a major component of moist deciduous and semi-evergreen forests. In some places, they occupy large areas forming bamboo breaks. From South India, 22 species and two varieties of bamboos under six genera were reported (Seethalakshmi & Kumar, 1998). The maximum species diversity is in Kerala part of Western Ghats. The dominant genus is the reed bamboo *Ochlandra.* Other genera are *Bambusa, Dendrocalamus, Pseudoxytenanthera, Sinarundinaria and Schizostachyum.* Ten species and one variety of *Ochlandra* were reported from

Kerala part of Western Ghats. One species and one variety of *Bambusa* and one species of *Dendrocalamus,* four species of Pseudo*xytenanthera,* four species of *Sinarundinaria,* one species of *Schizostachyum* were found growing in Kerala part of Western Ghats. The major bamboo-growing areas in Kerala are the forests areas of Trivandrum, Kollam, Pathanamthitta, Idukki, Ernakulam, Malappuram and Palakkad districts.

In Karnataka, 50 per cent of the bamboo population belongs to *Bambusa bamboos. Dendrocalamus strictus* contributes 40 per cent (Bennet, 1993). One species of *Bambusa,* one species of *Dendrocalamus,* three species of *Ochlandra,* two species of *Pseudoxytenanthera,* one species of *Schizostachyum* are found growing in Karnataka. The major bamboo growing areas in Karnataka are Mysore, Coorg, South Kanara, Shimoga, Chickmangalore, Bharavati, Begur, Bababudan hill range, and Agumbe.

In Tamil Nadu, bamboos are distributed in the hills and mountains of Kannyakumari, Thirunelvelly, Courttalum, Madurai, Coimbatore, Niligiris, Salem and North Arcot districts. Here *Bambusa bambos* and *Dendrocalamus* strictus are very common. Three species of *Ochlandra,* one species of *Pseudoxytenanthera,* two species of *Sinarundinaria* and one species of *Schyzostachyum* are also reported from Tamil Nadu.

Bambusa bambos and *Dendrocalamus strictus* are found growing in many places in Andhra Pradesh. *Dendrocalamus strictus* is the dominant species in the dry areas. Adilabad, Khammam, Vishakapatnam, West and East Godaveri, Karnool and Prakasam districts are the major bamboo growing areas in Andhra Pradesh.

The geographical distribution of bamboos is governed largely by the conditions of rainfall, temperature, altitude and soil. Most of the bamboos require a temperature from 8°C to 36°C, and a minimum annual rainfall of 1000 mm and high atmospheric humidity for good growth.

Major parts of the Western Ghats receive both southwest and northeast monsoons. Tropical moist evergreen, semi-evergreen and moist deciduous forests are the important forest types of the Western Ghats region. Bamboos are most abundant in the semi-evergreen and moist deciduous forests. They are also rich as part of riparian flora, found along the river and streamside.

Bamboos perform best on well-drained, fine textured rich soils. The factors like soil depth, texture, bulk density and nutrient content influence their growth. (Thomas and Sujatha, 1993). Some of the bamboos like *Bambusa bambos, B. vulgaris and Dendrocalamus strictus* grow on a wide range of soils.

I.5. ENDEMISM OF BAMBOOS IN PENINSULAR INDIA

Endemism compasses taxonomic units of any rank or taxa, which occur in a bio-geographical area usually isolated by geographical, ecological or temporal barriers (Nayar, 1996). Endemics are categories that occur in a restricted area, a phytogeographical region, and mountain range or in an island. Endemic area is defined as an area of a taxonomic unit, especially species that has a restricted distribution or habitat isolated from its surrounding region through geographical, ecological or temporal barriers. Islands, mountain ranges, and geographical regions with ecological boundaries usually form endemic areas.

Based on endemism and high species diversity, 24 *hotspot* areas are identified in the world, which support about 46% of the global endemics (Russellet *et al.*, 1988). Among the 24 *hotspot* areas of the world, three are in India. They are Eastern Himalayas, Western Ghats and Indo-Burma border.

Endemic plants in India occur in the three major geo-morphological divisions. They are the Himalayan endemics, Peninsular Indian endemics and Andaman and Nicobar endemics (Nayar, 1996). Next to islands peninsular region provides ideal conditions for endemism (Turrill, 1964). The Peninsular Indian region provides very suitable environment for endemism. Oceans border the three sides of this region, the east, south and west. At the north the peninsular region is separated from other parts of India by the Aravallys, Malva, the Vindhyas, the Satpura and Chotanagpur hills. These geographic boundaries made this region an ideal endemic area.

The Western Ghats in the peninsular Indian region is one of the three India's mega centres of endemism. This region harbours about 2065 endemic species (Nayar, 1996) and rich in biodiversity. The Western Ghats constitute the hill ranges traversing the states of Kerala, Tamil Nadu, Karnataka, Goa and Maharastra running parallel to the Arabian Sea. The Western Ghats hilltops

resemble islands so far as the distribution of endemic species is concerned (Subramanyan & Nayar, 1974). In most montane environments the isolation of populations could have promoted speciation and accumulation of unique localized species, endemism (Clark, 2001).

In the Peninsular Indian region, especially in Western Ghats bamboos show a high degree of endemism. Among the 24 natural species, 17 were reported endemic to Southern Western Ghats.

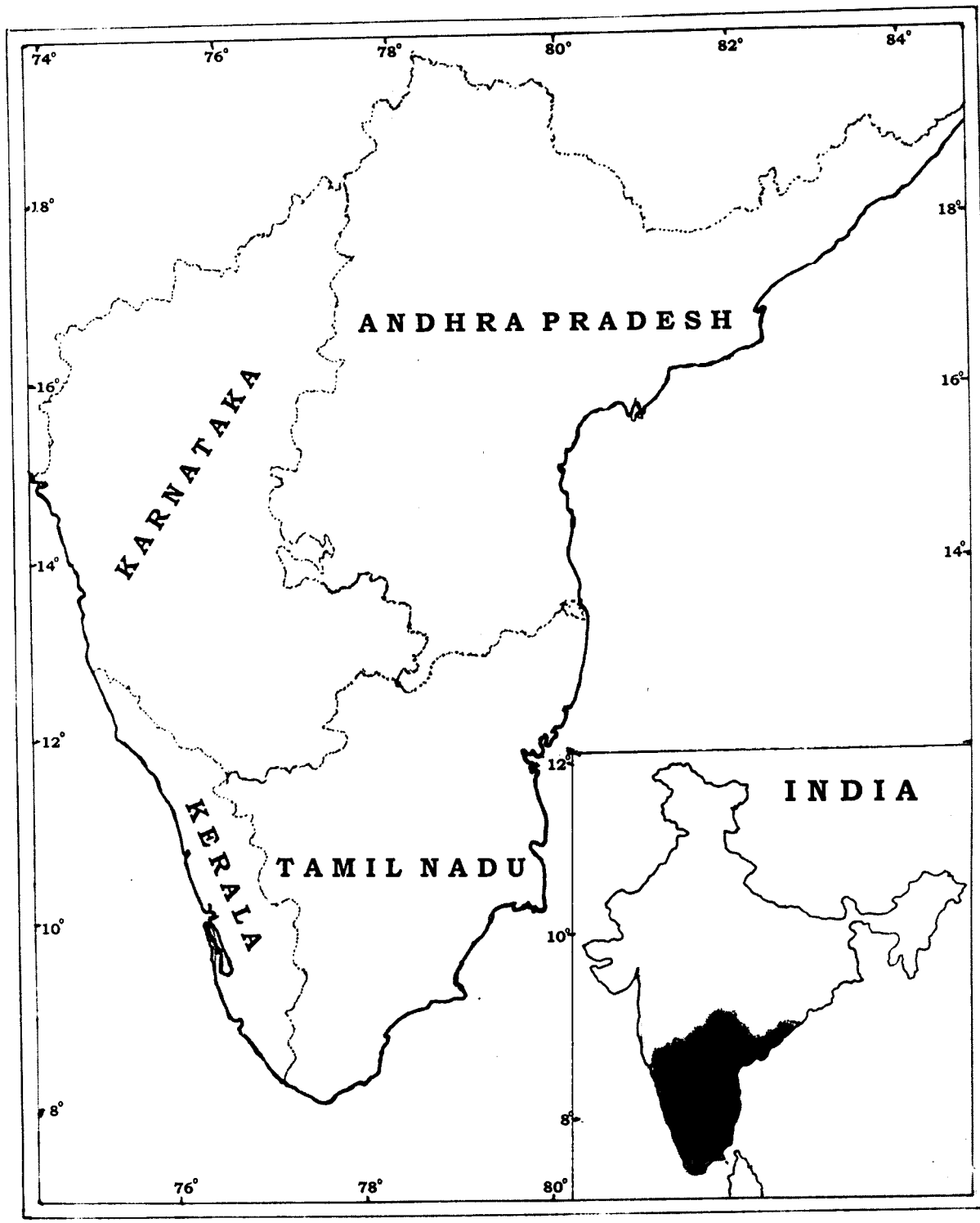
Eleven species and one variety of *Ochlandra* were reported from the Western Ghats and all these species are endemic to southern part of peninsular India. Among these, five species and one variety were reported only from Kerala part of Western Ghats. *Ochlandra talboti* is endemic to Karnataka and Goa. *Ochlandra setigera* is distributed only in North Kerala and Tamil Nadu. *Ochlandra wightii* is endemic to Southern Kerala, Tirunelveli and Courtallum areas.

Pseudoxytenanthera bourdillonii is endemic to Kerala part of Western Ghats. It has a very restricted distribution. *Pseudoxytenanthera ritchiei* is found growing in Northern Kerala and Karnataka. *Pseudoxytenanthera stocksii* is endemic to Western Ghats up to Maharastra. *Schizostachyum beddomei* is endemic to Kerala, Karnataka and Tamil Nadu. *Sinarundinaria wightiana* is endemic to some areas in Kerala and Tamil Nadu.

Some of the species such as *Pseudoxytenanthera monadelpha, Sinarundinaria floribunda, S. densifolia* and *S. walkeriana* are distributed both in Western Ghats and Sri Lanka and share the endemic status.

I.6. STUDY AREA

The area of study, South India consists of the States of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh (Map 2). South India stretching north south between 8^0 and 18^0 north latitudes and east west between 74^0 and 85^0 E longitude. The total area is 4,67,186 km^2. South India is surrounded by the States of Madhya Pradesh, Maharastra and Orissa in the north, Bay of Bengal in the east, Indian Ocean in the south and Arabian sea in the west.



Map 2. Area of study

The study area can be subdivided in to two floristic regions, Malabar and Deccan. Malabar or Malabar Coast is the strip of land lying west of Western Ghats, running parallel to the coast of Arabian Sea. This area is floristically very rich and includes coastal plains and series of hill ranges of the Western Ghats traversing the States of Tamil Nadu, Kerala, and Karnataka up to Gujarat. The Western Ghats is more or less continuous except at Palakkad gap, which separates the Nilgiri ranges from Anamalais. It runs along the western border of the Deccan plateau. The western side of the Ghat facing the Arabian sea and eastern side merges gradually through a series of hills with the Deccan plateau. The average altitude of Western Ghats is 1,550 m. The highest peak is Anamudi with a height of 2,695 m. It is the highest peak in the south of Himalayas. Some of the important centers of diversity in Western Ghats are Agasthyamala, Kalakkad Mundanthurai and Kothayar, Courttalum, Periyar Tiger Reserve, Anamudi and surroundings and Nilgiri Biosphere Reserve. It supports about eight major forest types. Moist evergreen and moist deciduous forests are dominating in the western slopes. The Eastern Ghats running along the eastern border of the Deccan plateau. When compared to Western Ghats it is not a continuous stretch and also less prominent. Scrub jungles and dry deciduous forests are dominating in the Eastern Ghats. Moist deciduous and semi-evergreen forests are also there in some areas.

The major land area east to Western Ghats is the Deccan plateau. It extends up to the Aravallies, the Malva, the Vindhyas, and the Satpura and Chotanagpur hills in the north. Towards the south it narrows almost right down to Kannyakumari. Western and eastern sides are bordered by Western Ghats and Eastern Ghats. The northern part of the plateau slopes westwards while the southern part slopes towards the southeast. The annual rainfall is less in this region and the vegetation is tropical deciduous type. In the open plains the climatic condition is dry and replaced by drought resistant species and thorny shrubs. The eastern sides of the plateau consist of fertile coastal plains running parallel to the Coromandel coasts. These plains are mainly formed from the deltas of Cauvery in Tamil Nadu, Godaveri and Krishna in Andhra Pradesh and a number of small rivulets and streams.

The four major phytogeographic divisions of South India are the mountain regions in the east and west, the undulating midland with hillocks, the

northern plains and the sloping coastal strips. It provides a wide variety of habitat, lateritic hills and valleys, swamps, marshy low lands, sandy seacoasts, fresh water rivers, ponds and backwaters on the sea front and harbors diverse type of vegetations.

South India is fed by two rain bearing winds, the southwest monsoon (June-September) and northeast monsoon (October-December). Kerala and coastal Karnataka receive heavy rainfall from the south-west monsoon. North-east monsoon is less active in these States. It is more active in Tamil Nadu and Andhra Pradesh. During the monsoon season the west coast region receives the heaviest rainfall, more than 2,200 mm annually. Tamil Nadu and Andhra Pradesh get 1,000-2,000 mm rainfall annually. The climate of the southern parts of Andhra Pradesh is dry and getting only an annual rainfall of 500 mm.

South India is divided in to four climatic types (Chowdhury and Sarwade, 1982). Based on these, the coastal districts of Andhra Pradesh, some parts of Karnataka and Tamil Nadu fall under semi-aried climate. Northern coastal Andhra Pradesh, southern districts of Karnataka and northern Tamil Nadu have dry sub-humid climate. Coastal Karnataka and northern Kerala experience moist sub-humid type of climate. The higher elevation around Coonor, Ootty and Kodaikanal is considered as a super humid area.

South India is gifted with lot of large and small rivers. Most of the rivers are originating from the Western Ghats and pour in to Arabian sea and bay of Bengal. The major rivers are Godaveri, Krishna and Cauveri. These rivers flow through the Deccan and empties in to bay of Bengal. Nethravathy, Bharatapuzha, Periyar and Pampa are some of the minor rivers that originates from Western Ghats and pour in to Arabian sea.

I.7. ECONOMIC IMPORTANCE

Bamboo is considered to be a versatile natural material and has been used by man from earliest times. Bamboo is deeply rooted in Asia's culture and civilisation. China is one of the most important bamboo producers in the world and bamboo is closely bound with the life of Chinese people throughout history. Ancient Chinese started to use bamboos 7000 years ago. Direct

evidence for its use can be traced as far back as 5000 years ago in the Indus Valley civilisation. The archaeological excavations at Harappa have yielded considerable quantity of this material (Ghosh and Negi, 1960). In the Indian context, bamboo reached dizzy heights when it found itself on the lips of Sri Krishna in the form of a *venu*, flute.

From the utilization point of view there is no other plant with as much importance to the rural as well as urban people as that of bamboos. The uses of bamboos vary from place to place depending upon the need and taste of the people as well as availability of particular species in their locality.

One of the important uses of bamboo is for the construction of houses. Bamboo has wide acceptance for construction of houses due to its desired structural properties of size, shape, flexibility and strength. Bamboo houses are strong and generally suffer very little damage due to earthquake. Bamboos are used for construction of bridges. The tradition of crossing Himalayan mountain valleys on bamboo bridges is over two thousand years old. Even today there are hundreds of locations in northeast India where bamboo bridges are the only means to reach them (Vinookaley, 2000). Bamboos are extensively used for making fences, scaffolding, ladders, supports, etc.

Just as certain trees, animals, birds, insects are woven into the tribal religion bamboo too features as a tribal *devak* (religious totem). Bamboo is an important material for their religious functions and rituals. Bamboo is mentioned in their stories, songs and proverbs. From providing a cradle for the new born baby to a bier for the dead, bamboo takes care of shelter, articles of daily use and tools.

Tribes and rural people depend on bamboo products for house construction (Plate 3). The tribes of northeast India use different species of bamboos for making their shelter. Some of the species commonly used are *Melocanna baccifera, Bambusa polymorpha, B. balcova, B. nutans, Cephalostachyum pergracile, Dendrocalamus hamiltonii* and *D. strictus* (Ramachandra Laha, 2000). Tribes and rural folk of other parts of India also use bamboos for the construction purpose. In South India *Dendrocalamus strictus, Bambusa bambos* and different species of *Ochlandra* are used for building huts and

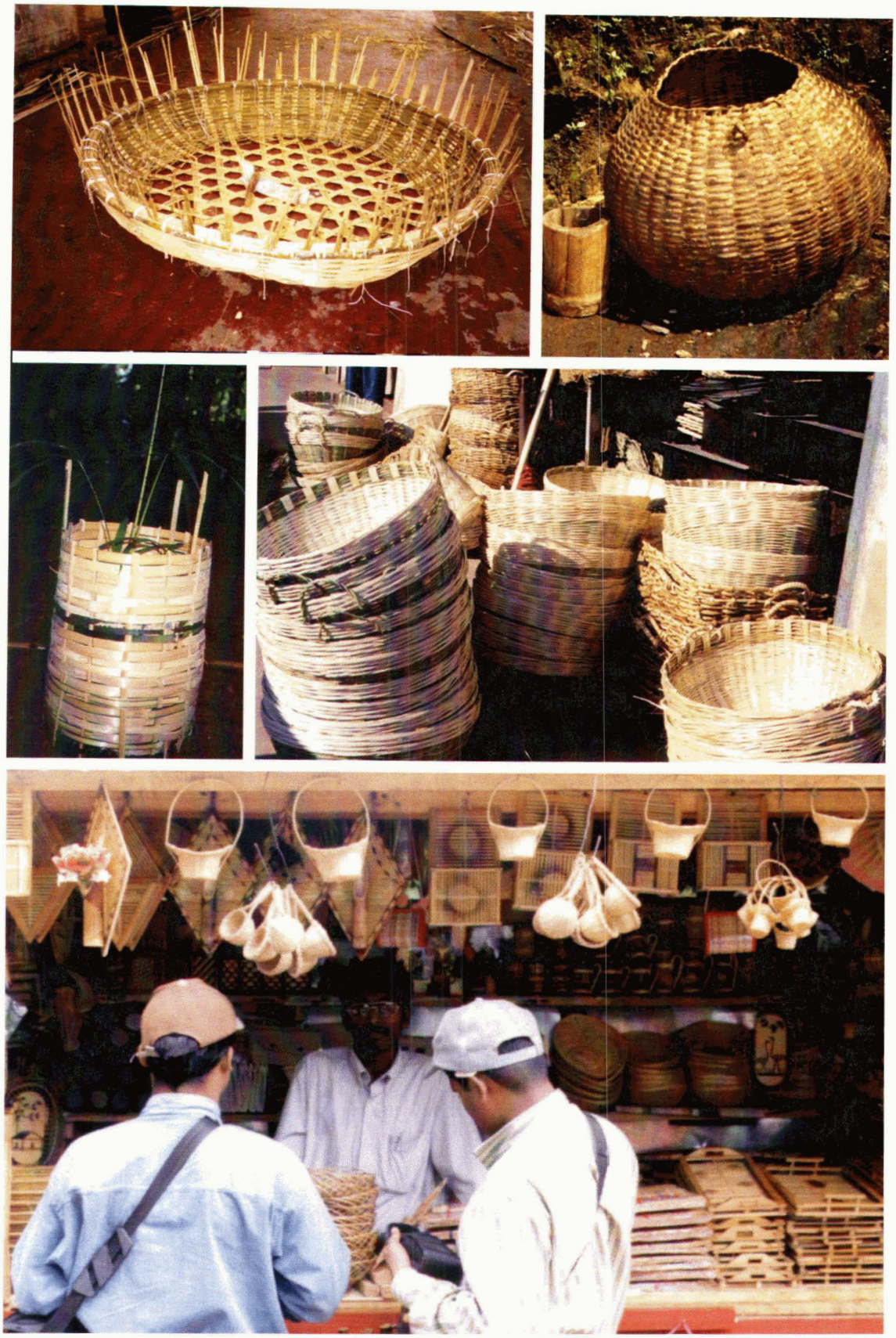


Plate 2. Bamboo - uses

temporary houses. The outer walls and inner partitions of the houses are made of split and flattened culms interwoven as mats. The frame is made of bamboo culms and thatching by bamboo leaves.

Tribal people use bamboo culm for lighting fire. The Kurichiya tribes of Wayanad, Kerala, use dry culm of *Bambusa bambos* for making fire. A piece of dry bamboo culm is split into two halves, a groove is made on it and the groove is filled with culm dust, when rubbed against the culm forcefully using a piece of bamboo will produce fire. (Kumaran,1996). They also use *Bambusa bambos* to make bows and *Ochlandra beddomei* for making arrows and fish trap (Plate 4).

Another important use of bamboos is in basketry (Plate 2). Different types of baskets and trays for various uses can be made out of bamboos. Bamboo baskets for storage of grain and fish are very common in northeast, western and central India. Winnowers of different sizes and shapes to fan or toss grain are also made out of bamboos. Bamboo is also used for making furniture, walking sticks, cooking utensils, mats, water containers, agricultural implements, tool handles, fishing rods and hookah pipes. Bamboos have been used for making hundreds of handicrafts.

The hollowness of the bamboo stem can produce melodious music. The culms can be used for making musical instruments.

In hilly areas open bamboo channels are used for carrying down water in the slopes. Bamboo channel serves as a substitute for pipeline to supply water. The farmers of the hill tracts of Sampage in the Dakshinakannada district of Karnataka use bamboos for irrigation. Here the farmers tap perennial streams in the higher reaches at the hills and use them to irrigate their terraced cultivation. (Prasad and Gadgil, 1985).

Some of the bamboos are medicinally important. The stems and leaves of *Bambusa bambos* are used as a blood purifier and to treat leucoderma and inflammatory conditions. The juice prepared from the warmed tender stems of *Dendrocalamus strictus* is used to relieve earache by the tribes. (Parrotta, 2001). 'Tabasheer' or 'Banslochan' is a siliceous material found in the hollow culms of some species of bamboos. It had great demand and was exported as

Plate 3. Bamboo - uses. **A.** thatching; **B.** construction of hut; **C.** fencing; **D.** place of worship; **E.** handicrafts

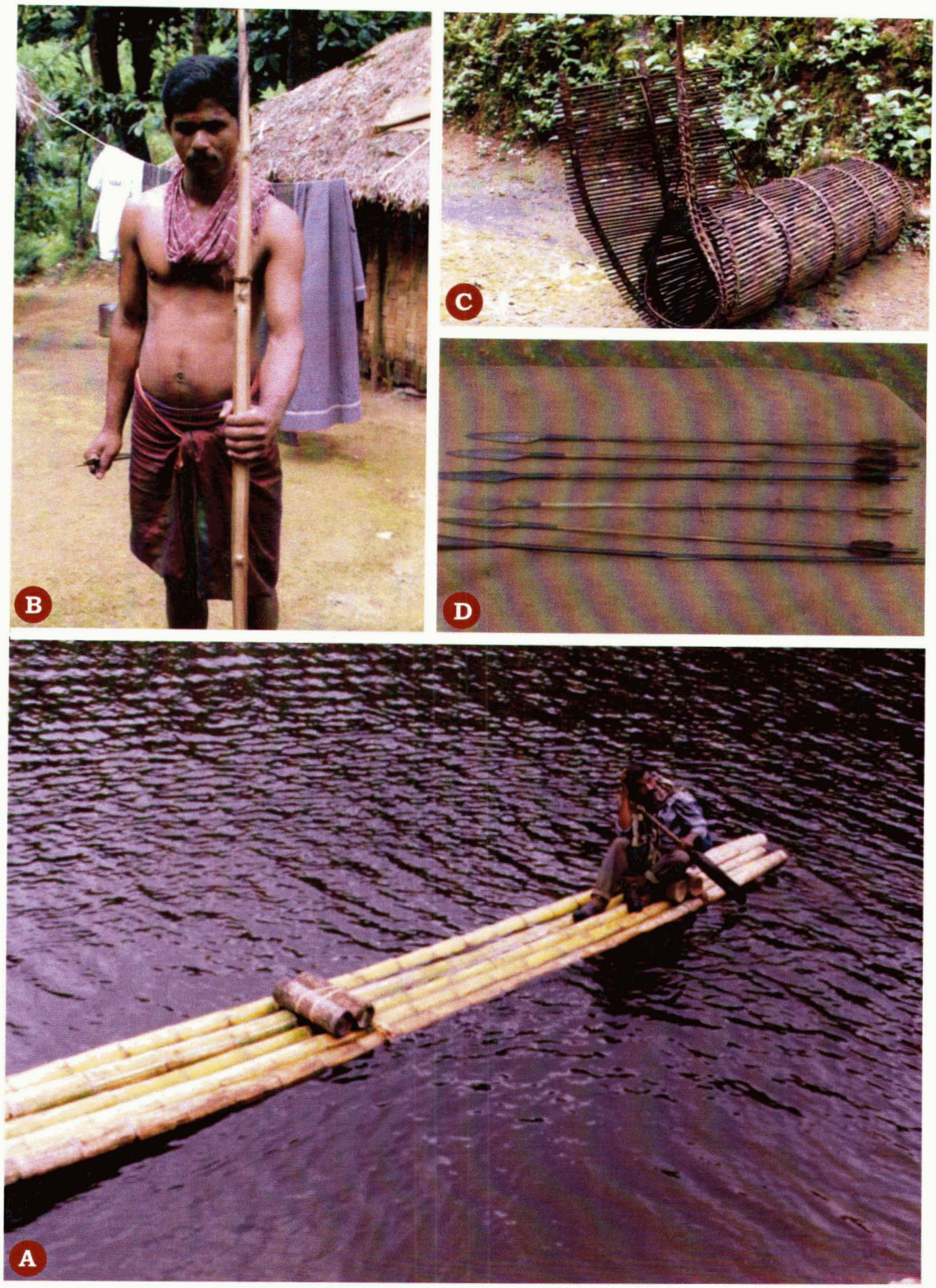


Plate 4. Bamboo - uses. **A.** ferry; **B.** tribal man with bow and arrow; **C.** fish trap; **D.** arrows

medicine from India. It is used as a cooling tonic and aphrodisiac and for the treatment of asthma, cough and other debilitating diseases. The medicinal use of bamboo is also mentioned in Van Rheed's (1685) Hortus Malabaricus. A decoction of the leaf of *Bambusa bambos* is good for blood purification and also for healing of wounds. Consuming this decoction just after delivery will help to clean the uterus. The decoction made by boiling the leaves of *Ochlandra scriptoria* is good for menstrual problems. It is also used for treating tooth and gum diseases.

As a food item or as a vegetable the young bamboo shoots are of great demand in countries like China, Japan, Thailand, Malaysia, etc. In India, people of northeast use new sprouts as food material. In China and Japan, they are used for making pickles and different types of dishes. The new shoots of *Bambusa tulda, B. multiplex, B. polymorpha, B. blumeana, Dendrocalamus hamiltonii, D. longispathus, Phyllostachys edulis, P. pubescens, P. nuda, P. viridis* are edible and in use in different countries like China, Japan, Thailand and also in India. Majority of the tribal people in South India use the young shoots of *Bambusa bambos* and *Dendrocalamus strictus* for the preparation of delicious dishes. Bamboo seeds are nutritious and eaten by tribes and rural people. The seeds produced were widely consumed by the local population. The seeds were found to be comparable to wheat in their protein content and to rice in their protein quality (Mitra and Nayak, 1972). In Sikkim, the seed of *Bambusa hookeriana* is used for making a highly popular traditional beer (Vinookaley, 2000). In Tanzania growing shoots of *Oxytenanthera braunii* are decapitated and the extruding sap can be collected for many weeks. The fermented sap is a tasty alcoholic drink of the locals (Liese, 1987).

Bamboos are important components of many planned landscapes. Bamboos with attractive features and striking appearance can be used for landscaping. Some of the ornamental bamboos are *Bambusa glaucescens, B. ventricosa, B. vulgaris, B. multiplex, Phyllostachys aurea, Chimonobambusa quadrangularis, Lingnaria chungii, Thyrsostachys siamensis, Dendrocalamus giganteus,* etc. (Bahadur, 1979).

Other than traditional and conventional uses modern technological advances and applied research find out new uses for bamboos. Bamboos are the most

Plate 5. Bamboo extraction. **A.** reed break; **B., C., D. & E.** bamboo extraction

important raw material in the pulp and paper industry. In India, *Dendrocalamus strictus, Bambusa bambos* and *Melocanna baccifera* are used for making different types of papers. In South India, *Bambusa bambos,* the reed bamboo *Ochlandra travancorica, O. ebracteata* and *O. scriptoria* are used as raw material for pulp and paper production. Another modern use of bamboo is the bamboo reinforced cement concrete construction. In this process bamboos have been used as reinforcing material replacing steel in the construction of concrete slabs, beams, electric post, etc. (Bahadur, 1979). In Kerala, the reed bamboo *Ochlandra travancorica* is used for making plywood. It is commercially known as bamboo ply and is very strong and used for making furniture, partition boards, etc.

I.8. CONSERVATION

The use of Bamboos other than its conventional one leads to large-scale exploitation. Bamboo is an industrial raw material for the production of paper and rayon. The demand for bamboo the world over and in India has been increasing at a very rapid rate. In India, the annual production of bamboo is estimated to be 9.5 million tonnes, of which 5 million tonnes are being utilised by the paper and pulp industries alone (Varmah & Bahadur, 1980). Bamboos with good fibre quality are identified and they are in great demand as an industrial raw material (Plate 5). Some of the important species used in paper and rayon industry in South India are *Ochlandra travancorica, O. ebracteata* and *Bambusa bambos.* There is large scale cutting of *Pseudoxytenanthera ritchiei* and *P. bourdillonii* for various uses. In countries such as India almost all the requirements of bamboo is met from natural populations. The indiscriminate extraction of bamboos coupled with the large-scale habitat loss has seriously depleted the natural resource of bamboos.

The extraction of bamboo over the years has led to a severe reduction in the yield from natural population. Gregarious flowering, which leads to death of the plants, accelerates the process of destruction. The reed population of Western Ghats region of Kerala is facing extinction owing to large-scale exploitation and unscientific management (Aravindakshan & Jayasree, 1991).

Therefore steps should be taken for *ex situ* and *in situ* conservation of bamboo population in South India. The large-scale exploitation of bamboos from their natural habitats should be controlled. Measures should be taken for the protection of their natural habitats. Establishment of bambusetum and germplasm is another method of conservation. Tropical Botanic Garden, Palode, Trivandrum and Kerala Forest Research Institute, Thrissur, established bamboosetum of important bamboo species. These institutes are also doing large-scale vegetative multiplication of bamboos using micro and macro propagation methods.

I.9. RELEVANCE OF STUDY

The available information on the taxonomy and classification of Indian bamboos are far from satisfactory. In many cases generic and specific delimitations are not clearly defined. As the orthodox system of classification was based on reproductive parts, the early workers depended on herbarium specimens for their studies. Most of the 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 materials. More over because descriptions of bamboos so far has been based on a very limited number of specimens which are insufficient to elucidate their variations, population structure and distribution, many species have been placed under the wrong group. (Bedell, 1997). In certain cases different workers treated the same genera differently. For example, Holttum (1956a) treated the three genera *Cephalostachyum, Teinostachyum* and *Pseudostachyum* under the Malayan genus *Schizostachyum.* Other workers like Clayton & Renvoize (1986) and Majumdar (1989) followed these suggestions and treated all genera as congeneric. However, Dransfield (1980) kept these three genera separate from *Schizostachyum.* Extensive field studies and thorough revisionary studies are required to solve these problems.

The generic and specific delimitations of some of the south Indian bamboos are doubtful. The dominant genus in South India is the reed bamboo *Ochlandra.* From south India 11 species and one variety were reported so far. Among these, the specific delimitations and affinities of *O. soderstromiana, O.*

sivagiriana and the varietal status of *O. travancorica* var. *hirsuta* are doubtful. The other important genera in South India are *Pseudoxytenanthera, Sinarundinaria, Schizostachyum, Bambusa* and *Dendrocalamus*. The generic status of *Pseudoxytenanthera, Sinarundinaria* and *Schizostachyum* are also dubious. The genus *Bambusa* has one species and one variety in South India. The variety status of *Bambusa bambos* var. *gigantea* is also doubtful. Therefore a detailed taxonomic study is needed to analyse all these problems.

Most of the herbarium specimens of South Indian bamboos kept in various herbaria are incomplete. The type materials of some of the south Indian bamboos are not known and some of the species are not typified. Extensive fieldwork for collection of specimens and preparation of herbarium materials are essential. A detailed taxonomic work is very relevant in this context. The objectives of the present study are: -

- Extensive fieldwork, collection of all south Indian bamboos and preparation of herbarium specimens of all south Indian bamboo species.
- Solving the generic and specific delimitation problems.
- Correction of nomenclature problems.
- Preparation of detailed descriptions, illustrations and keys for all south Indian bamboos.
- Typification of untypified south Indian bamboos.

Review of literature

II. REVIEW OF LITERATURE

II.1. HISTORICAL BACKGROUND

In Indian taxonomic literature the first direct reference to bamboo is as old as Rig-Veda (Circa 5000 BC) and it is written as *bestow upon as a hundred bamboo culms* (Vinookaley, 2000). Theophrastus, Greek philosopher, mentioned the bamboos in his work *Enquiry in to plants* (Kumar & Stephen, 1999). Another early record of bamboo in Western literature was in a letter from Alexander the Great to Aristotle and referred to by Pliny in his Encyclopaedic natural history (Soderstrom, 1987).

In Arthashastra written by Chanakya (300 BC) mentioned the trade of bamboo craft as an important source of state revenue. He also described the names of different species of bamboos growing in his country. They are *Utaja, Cimaya, Chapa, Venu, Sathina, Kantaka* and *Bhalluka.* This classification was based on different characters like hollowness and solid nature of culms, presence and absence of thorns and internodal length of the culms (Vinookaley, 2000; Sensarma, 1993).

The Persian scholar and physician of 11th century Avicenna (Iben-Sina, 980-1037), in his work *Qanun of medicine* referred about Tabaxir (Soderstrom, 1987). In the same book he also referred to *Mambu* which later subsequent authors took to be a reference to bamboos.

In India, the modern floristic studies were started during the colonial period. In the 16th century, Garcia da Orta, a physician, wrote an important treatise called *Coloquios dos Simples e Drogas da India.* This work was about the native plants and their uses, and it was published in 1653. This was the first publication on Indian plants. In this book he mentioned about *Tabaxir,* which was exported during that period to Arabia, Persia and Turkey as a medicine. Merchants called it *Tabaxir Mambu.*

The famous physician and botanist Casper Bauhin published his book *Pinax* in 1623 (Soderstrom, 1987). In this book several pages were utilised for discussing reed grasses. He used the name *Arundo* for the reed and first name he used was *Arundoarbour,* which is a woody or tree like reed. It was the

source of Tabaxir and the Indians named it as *Mambu*. He also referred to Avicenna and Garcia da Orta. Later in his list of reference to this plant, Bauhin give the following *Cana Tabaxir* and *Arundo*, which the Indians call *Bambus*. According to him, they are reeds of very pleasing aspect, are very tall, black, round, thick and grows spontaneously all over the Malabar coast and especially near Coromandel. The word *Bambus* later used by Linnaeus in 1753 on the basis of his *Arundo bamboos* from which the genus name *Bambusa* was later adopted (Soderstrom, 1987).

In the 17th century, the Malabar Coast came under the Dutch rule. The Dutch commander Hendrik Adrian Van Rheede tot Draakestein realised the importance of the medicinal plants of Malabar with the help of local physicians. He described and illustrated these medicinal plants. The work that eventually consisted of 12 volumes and the first volumes was published in the year 1678 from Amsterdam. It was the great classic the *Hortus Indus Malabaricus* that later became the basis for many floristic works. Three species of bamboos were described and illustrated in the 5th volume (1685). They were Illy, *Bambusa bambos;* Beesha, *Ochlandra scriptoria* and Nolla Illy, which is *Ochlandra travancorica* (Nicolson *et al.,* 1988).

In 1737, Linnaeus's *Hortus Cliffortianus* was published. In this work he listed an Arundoarbour. Rumphius (1743) published a book *Herbarium Amboinense* in which some bamboos were mentioned. He divided the then bamboos under eight classes and these classes were again classified into various subdivisions. In 1753, the masterpiece of Linnaeus, the *Species Plantarum* was published. He mentioned a bamboo, the *Arundo bambos*. This is the first validly published name of a bamboo in scientific literature. Schreber (1789) published the generic name *Bambusa*. Another botanist Retzius (1789) published *Bambus arundinacea*. Schreber cited the generic name *Bambos* published by Retzius (1789) as a synonym under *Bambusa*. Retzius is the man who first described scientifically *Bambusa bambos*.

In 1790, Joaode Loureiro described another bamboo species *Arundo multiplex* now recognised as *Bambusa multiplex*. In 1791, Gmelin from the island of Reunion described *Nastus borbonicus*. Walter (1788) described *Arundo gigantea* and was elevated to the genus *Arundinaria* by Michaux (1803).

Therefore, the first described bamboo genera are *Bambusa, Nastus and Arundinaria.* Wendland (1808) described *Bambusa vulgaris.* William Roxburgh (1814) was the Director of East India Company's Calcutta Garden described *Dendrocalamus strictus* and *Bambusa bambos* in Plants of the Coast of Coromandel (1778) and 7 species of bamboos in his *Hortus Bengalensis* (1814). Kunth (1815) recognised bamboos as one of his ten natural groups of genera and referred to the group as *Gramina Bambusacea.*

Nees (1834) for the first time recognised the relation between woody and herbaceous species. In *Bambusacea Brasiliensis,* he included *Streptochaeta* as one of the bamboo groups. Nees (1834) classified the bamboos into three groups, *Bambuseae, Arundinariae and Streptochaete.* The first monograph on bamboo taxonomy was Ruprecht's (1839) *Bambuseas Monographice exponit.* He included 67 taxa under 9 genera among which 55 species were described with flowers. Munro (1868) published a world *Monograph of the Bambusaceae.* It is one of the most useful original references on bamboos. In this treatise, 170 species of bamboos were described under 20 genera. All the groups and subgroups that Munro had recognised are accepted even now, though under different names or included under different ranks with recent concepts.

Kurz (1876) published a paper on *Bamboo and its Uses.* He was the first man who studied special type of proliferation in bamboo spikelets. Another important work of Kurz was the *Forest Flora of British Burma* (1877) in which 30 species of Burmese bamboos were included.

Colonel Beddome (1873) included 18 South Indian bamboo species in *Flora Sylvatica for Southern India.* Subsequently, in *Genera Plantarum* of Bentham (1883) 18 genera of South Indian bamboos were described.

In 1887, Franchet described some herbaceous bamboos from French Congo. Later, Gamble the Director of the imperial Forest School, Dehra Dun during 1890-1899, wrote several books on the forests of India and Burma. In 1896, *The Bambuseae of British India,* his monumental work on Indian bamboos was published. He included 15 genera under 115 species with 119 illustrations. This work still remains as the foundation for the subsequent studies on Indian bamboos. He also studied the taxonomy of the genus *Arundinaria* and Burmese bamboos (Gamble, 1888, 1894). In his book, *A Manual of Indian*

Timbers (1902) he described the species of *Arundinaria, Bambusa, Dendrocalamus, Oxytenanthera* and *Ochlandra.*

Brandis (1899) in *Biological Notes on Indian Bamboos,* described bamboos from both south India and northeastern part of India. In 1906, Brandis published a book, *Indian Trees.* In this book the general characteristics of the tribe Bambuseae are given along with descriptions of the genera *Arundinaria, Bambusa, Oxytenanthera, Dendrocalamus* and *Ochlandra.* His remarkable work appeared in 1907 on the structure of bamboo leaves.

In Forest Flora of the Bombay Presidency and Sind, Talbot (1912) described *Bambusa bambos, Dendrocalamus strictus, Oxytenanthera stocksii, O. monostigma* and *Ochlandra talbolti.*

II.2. INTERNATIONAL STATUS

In the beginning of 20th century Camus (1913) published a monograph of bamboos, *Les Bambusees.*

The British Botanist, Agnes Arber (1926, 1927, 1928, 1929, 1934) conducted studies on the flower structure and organisation of different species of bamboos such as *Dendrocalamus strictus, Bambusa bambos, Cephalostachyum* sps., *Oxytenanthera* sps., *Schizostachyum* sps. and *Ochlandra* sps.

South America is rich in bamboos and considerable work on bamboo taxonomy has been carried out. One of the earlier descriptions of American bamboos was in *Flora Brasiliensis* by Doell (1880). Parodi (1936, 1941, 1961) studied the bamboos of Argentina and Chile. McClure and Smith (1967) revised the Brazilian bamboos. McClure (1973) also published another work on new world bamboos. Among the studies of South American bamboos the work of Soderstrom is estimable. Soderstrom (1981a) described a new genus *Olmeca* from Mexico. It has with fleshy fruits similar to that of *Ochlandra.* Some of the important publications on American bamboos are Calderon and Soderstrom (1973), Soderstrom (1981b, 1987, 1988), Soderstrom and Ellis (1982, 1987, 1988), Soderstrom and Calderon (1974, 1978, 1979), Soderstrom and Young (1983, 1989), Soderstrom and Londono (1987, 1988) and

Soderstrom and Zuloaga (1985). The taxonomy, systematics and diversity of South American bamboos were studied by Clark (1985, 1987a, 1987b, 1993, 1996), Clark and Londono (1990, 1991), Londono and Clark (1998), Londono and Davidse (1991), Sendulsky (1992, 1995), Tucker (1988), Young and Judd (1992) and Zuloaga *et al.* (1993). Judziewicz (1992) revised the South American bamboo genus *Atracantha* with keys, descriptions, illustrations and maps of all five recognised taxa. Recently, Judziewicz *et al.* (1999) published a detailed treatise on American bamboos.

There are a lot of valuable taxonomic publications from China by different workers. Accounts of bamboos of China appear in many works of McClure between 1919 and 1940. Other important taxonomic work on Chinese bamboos are of Chao and Chu (1981), Chao and Renvoize (1987), Keng (1982a, 1982b, 1983a, 1983b, 1984a, 1984b, 1986, 1987, 1991), Keng and Wen (1991), Li (1998), Stapleton and Xia (1997), Wang and Ye (1991), Wen and Chou (1985), Xia (1996), Xia and Jia (1996), Yi (1993a, 1993b, 1996, 2000), Yi and Yang (1998) and Zhang and Chen (1991).

South East Asia has rich genetic diversity of bamboos. Recently lot of explorations was done in this area and lot of scientific data on bamboos came out. The contributions of Holttum, Dransfield and Widjaja on the taxonomic studies of south east Asian bamboos are of great significance (Holttum, 1946, 1954, 1956a, 1956b, 1956c, 1956d, 1958, 1967; Dransfield, 1980, 1981, 1983a, 1983b, 1989a, 1989b, 1994, 1996, 1998a, 1998b; Widjaja, 1990, 1994, 1998). Chao and Renvoize (1989) revised *Arundinaria* in South East Asia and Africa. Widjaja (1987) revised the genus *Gigantochloa* of Malaysia. Dransfield and Widjaja (1995) done a notable work with complete descriptions, illustrations of south east Asian bamboos. Wong (1995a) published a book on Malaysian bamboos. His other important contributions are Wong (1981, 1982, 1986, 1991, 1992, 1993a, 1993b, 1995b). Other workers also done important taxonomic works on south east Asian bamboos (Chialiang-Chi *et al.*, 1983; Susiarti & Soedjito, 1996; Sumantera, 1996; Rudall and Dransfield, 1989). Chua *et al.* (1996) wrote a detailed taxonomic account of bamboos of Singapore.

In Japan the bamboos are very important both economically and culturally. Makino, Nakai and Koidzumi, Usui and Aoki made significant contributions to Japanese bamboo taxonomy (Makino, 1900, 1923, 1932a, 1932b; Makino and Shibata, 1901; Nakai, 1925; Koidzumi, 1936, 1937, 1940a, 1940b; Usui, 1985, 1987; Aoki, 1987).

McClure in the field of world bamboo taxonomy made exceptional contributions. He published a number of papers on Chinese and American bamboos. In 1966, he published an excellent book on the morphology, taxonomy and cultivation of bamboos. He reported lot of new species, made new combinations and typified a number of genera and species (McClure, 1936a, 1936b, 1936c, 1946, 1956, 1957, 1959, 1960, 1961, 1962, 1963a, 1963b, 1973).

Ohrnberger and Gorrings (1983) published the bamboos of the world. This treatise is with the nomenclature and distribution of the herbaceous and woody bamboos. Ohrnberger (1999) released a detailed annotated nomenclature and taxonomic literature on the bamboos of the world.

Bangladesh has a very good natural resource of bamboos. Alam (1982, 1994), Alam *et al.* (1997) and Banik (1998) studied the taxonomy, distribution and genetic resources of bamboos in Bangladesh. Parker (1928, 1931, 1932) worked on the taxonomy of Burmese bamboos.

Sri Lankan flora has a lot of affinities with south Indian flora. Six species of bamboos are common in South India and Sri Lanka. De Zoysa studied various aspects of bamboos of Sri Lanka (De Zoysa, 1994; De Zoysa *et al.*, 1990). Soderstrom and Ellis (1988) published detailed taxonomic and anatomical studies on Sri Lankan bamboos.

Chao and Renvoize (1988a, 1988b) conducted studies on bamboos of the Himalayan region and southern Burma. They revised the genus Arundinaria of South East Asia and Africa and made some new combinations (1989a, 1989b). In the field of modern bamboo taxonomy Stapleton has made significant contributions (Stapleton, 1994a, 1994b, 1994c). Besides these, he published several papers on bamboo taxonomy (Stapleton, 1998; Stapleton *et al.*, 1996, 1997; Xia and Stapleton, 1997a, 1997b).

II.3. NATIONAL STATUS

The studies on Indian bamboos were geared up subsequent to the publication of Gamble's monumental work *Bambuseae of British India* (1896). Parker (1929) wrote additional notes on the taxonomy of Indian bamboos. In the famous publication *Wealth of India* (1948, 1952, 1966) the importance and uses of the genera *Arundinaria, Dendrocalamus, Ochlandra* and *Oxytenanthera* were mentioned. Kedharnath and Chatterjee (1966) reported an important species of bamboo *Phyllostachys bambosoides* from Himachal Pradesh. Qureshi and Deshmukh (1965) studied the distribution and importance of Indian bamboos. Raizada and Chatterjee (1956, 1963) studied the world distribution of bamboos with special reference to India, and also reported a new species from South India. Many workers reported new species and also studied the taxonomy and distribution of Indian bamboos (Bahadur, 1974, 1979; Bahadur and Naithani, 1976, 1983; Bahadur and Jain, 1981; Varmah and Bahadur, 1980; Bor, 1982; Majumdar, 1983; Suri and Chauhan, 1984; Gaur, 1987; Sulhan, 1991; Thangam, 1992; Vinayak Kelkar, 1994; Jainendra Kumar and Sinha, 1994; Das, 1994; Subramanian, 1995, 1998; Moulic, 1997; Hore, 1998; Rai and Chauhan, 1998; Adakoli, 1999).

Significant contributions were made by Biswas (1988, 1993, 1995, 2002a, 2002b) and Biswas *et al.* (1991) on the taxonomy of northeastern bamboos. Tewari (1992a, 1992b) published a monograph and a handbook on Indian bamboos. Bedell (1997) wrote an excellent book on the taxonomy of Indian bamboos. Naithani worked on bamboos of northeastern States and reported a number of new species (Naithani, 1990a, 1990b, 1992, 1993, 1994a, 1994b; Naithani and Bahadur, 1982; Naithani and Bennet, 1986, 1991; Naithani and Sumer Chandra, 1998). Bennet worked on the taxonomy and nomenclature problems of some Indian bamboos (Bennet, 1988, 1989, 1993; Bennet and Gaur, 1990a, 1990b).

Apart from classical taxonomy many workers emphasised the importance of anatomy of leaf, culm, etc. in bamboo systematics. These characters can be considered as supporting evidence for generic and specific delimitations. Epidermal anatomy of culm, leaves and nodal anatomy can also be used for the purpose of bamboo classification.

Brandis (1907) had done an excellent work on the structure of bamboo leaves. He studied the similarity in features of leaf anatomy and epidermis of different bamboos. Metcalf (1960) published a remarkable book on the anatomy of monocots. In this work he discussed the anatomy of grasses including bamboos. Grosser and Liese (1971) studied the vascular bundles of Asian bamboos. Calderon & Soderstrom (1973) studied the detailed leaf anatomy of the genus *Maclurolyra* from Panama. Alam and Dransfield (1981) did the anatomical studies of the species *Melocalamus compactiflorus*. Renvoize (1985, 1987) studied the leaf blade anatomy of bamboos. Wen and Chou (1984, 1985) conducted a detailed study of the vascular bundle arrangement of 100 species of 28 genera of Chinese bamboos. Based on vascular bundle anatomy they provided a generic key. Usui (1987) studied the phylogeny of 20 Japanese bamboo species based on nodal anatomy. Soderstrom and Londono (1988) published a paper on the morphological studies on the Brazilian bamboo genus *Alvimia*. Raechal and Curtis (1990) published a paper, which deals with the root anatomy of bamboos. Yao and Xu (1992) published the anatomical analysis of native bamboo culms of China.

Another important work is that of Ghosh and Negi (1960) on the anatomy of Indian bamboos. They studied the culm epidermis of some important species of Indian bamboos. Pattanath & Rao (1969) did an outstanding work on the epidermal and internodal anatomy of bamboos. According to them the anatomical features can be used as an aid to identification and classification of bamboos. Bisen *et al.* (1988) studied the culm and leaf epidermis of 36 species belonging to 22 genera of Indian bamboos. Agarwal and Luxmi Chauhan (1995, 1990, 1991. 1992) conducted detailed study on the leaf epidermal anatomy of Indian bamboos. Holttum (1946) proposed a classification based on the structure of ovary.

Some of the morphological characters are also useful in generic and specific delimitations. Chatterjee and Raizada (1963) reported the importance of culm sheath as an aid to the identification of bamboos. Based on the culm sheath characters they made a key for the identification of 22 species of bamboos. Guedes and Dupuy (1976) studied the morphology of lodicules. Prophylls are taxonomically important vegetative structures (Usui, 1985).

Modern molecular techniques have been applied in the field of taxonomy to study the phylogeny and affinities of bamboos. These techniques are not widely used in India to study the affinities of Indian bamboos. Some workers did some basic studies. Lalitakumari *et al.* (1985) applied the electrophorotic pattern of peroxydase isozyme of 13 species of *Bambusa* for species identification. Seethalakshmi and Preethy (1999) studied the details on the identity of some tropical bamboos using molecular techniques.

Wantanabe *et al.* (1994) applied chloroplast DNA restriction site mapping to study the phylogeny of Asian bamboos. Clark *et al.* (1995) used ndhF sequence data to analyse the phylogeny of grass family. Alam *et al.* (1997) conducted chemotaxonomic studies in peroxydase isozyme of 15 species of Bamboos of Bangladesh. Kobayashi (1997) used RFLP of chloroplast DNA to analyse the phylogeny of world bamboos. Kiew *et al.* (2000) studied the genetic variation and relationship within the subtribe *Bambusinae* using AFLP technique. Hong and Man (2002) done the enzyme electrophorosis of *Pseudosasa japonica* in Korea to estimate the genetic diversity.

II.4. SOUTH INDIAN STATUS

The first authentic reference of South Indian bamboos is in Hortus Malabaricus (Rheede, 1685). Munro (1868) and Beddome (1873) described some of the South Indian bamboos. Gamble (1896) described and illustrated all South Indian bamboos known at that time. Gamble (1902) in his publication a manual of Indian timbers described 15 species of South Indian bamboos. Bourdillon (1908) described 10 species of South Indian bamboos in *The Forest Trees of Travancore.* Rama Rao (1914) in his book, *Flowering Plants of Travancore,* included 15 species of South Indian bamboos.

The taxonomy of bamboos distributed in the South Indian States were studied by later workers (Kadambi, 1949; Andiappan and Wilson, 1963; Hussain, 1980; Nair, 1980). Nair and Ansari (1982) discussed the nomenclature problem of *Oxytenanthera monostigma.*

Matthew (1999) in the Flora of Palani Hills, South India described six South Indian bamboos. Pullaiah and his co-workers described *Dendrocalamus*

strictus and *Bambusa bambos* in the district floras of Andhra Pradesh (Pullaiah *et al.*, 1992, 1998, 2000; Pullaiah and Mohammad, 2000; Venkata Raju and Pullaiah, 1995).

Koshy and Pushpangadan (1997), Koshy and Harikumar (2001) and Koshy *et al.* (2001) studied the pollination biology of some South Indian bamboos. Seethalakshmi conducted studies on various aspects like seed storage, flowering and fruiting behaviour of some South Indian bamboos (Seethalakshmi, 1991, 1993, 2001; Seethalakshmi and Preethi, 1999; Seethalakshmi *et al.*, 1983, 1990; Seethalakshmi and Gnanaharan, 1998). Seethalakshmi and Kumar (1998) published a compendium on Indian bamboos and included all the published details of 128 species of Indian bamboos. Some of the recent publications on bamboos of this phytogeographic region are that of Kumar (Kumar, 1990, 1991, 1993, 1995; 2002; Kumar & Stephen, 1995, 1996, 1999; Kumar & Remesh, 1999, 2000, 2001, 2003; Manilal & Kumar, 1998; Kumar *et al.*, 1999, 2000, 2001a, 2001b).

Materials and methods

III. MATERIALS AND METHODS

Extensive fieldwork was done in four states of South India. Fresh specimens were collected from the field. The habit of the plant, morphology of rhizome, new shoots, culms, culm sheaths, branches, leaves and inflorescence were studied and recorded. The important parts were photographed. Collected specimens were killed using Formalin. Flowers and fruits were fixed in FAA. The collected specimens were taken to the lab, pressed and kept in the dryer for few days. Herbarium sheets were prepared as per the techniques in Diane Bridson and Leonard Forman (1992) and Soderstrom and Young (1983) and the herbarium sheets are deposited at Calicut University Herbarium (CALI).

The herbarium specimens of bamboos deposited at Central National Herbarium, (CAL) Calcutta; FRI Herbarium, (DD) Dehra Dun; Blatter Herbarium, (BLAT) Bombay; Madras Herbarium, (MH) Coimbatore; BSI Central Circle Herbarium, (BSI) Pune; Herbarium of Botany Department, Sri Krishna Devaraya University, (SKU) Anantapur; Andhra University Department of Botany Herbarium, Vishakpatanam; Kerala Forest Research Institute Herbarium, (KFRI) Peechi; Calicut University Herbarium, (CALI); were consulted and comparative studies were done. Protologue and early literature were also verified and studied.

The cibachromes of type specimens kept at the herbarium, Royal Botanic Gardens, Kew, (K) and Museum National *d histoire Naturelle, Laboratoire de Phanerogamie,* Paris (P) were also consulted.

Comparative morphological study was done using all available specimens of a species. Fresh and pickled flowers were dissected and the floral characters are studied in detail. The details of sterile glumes, lemma, palea, lodicules, stamens, ovary, style and stigma were studied under the STMI-SV8 binocular microscope. Morphology of the fruit was also studied. All the floral parts were illustrated and descriptions were made. Brummitt and Powell (1992) was referred for abbreviation of author names. Abbreviations used to represent the names of herbaria are given below.

Abbreviations

BLAT : Blatter Herbarium, Bombay
BSI : BSI Central Circle Herbarium, Pune
CAL : Central National Herbarium, Calcutta
CALI : Calicut University Herbarium, Calicut
DD : FRI Herbarium, Dehra Dun
K : Royal Botanic Gardens, Kew
KFRI : Kerala Forest Research Institute Herbarium, Peechi
MH : Madras Herbarium, Coimbatore;
P : *Museum National d histoire Naturelle, Laboratoire de Phanerogamie*, Paris
SKU : Herbarium of Botany Department, Sri Krishna Devaraya University, Ananthapur

Systematic treatment

IV. SYSTEMATIC TREATMENT

POACEAE Barnh.

POACEAE Barnh., Bull. Torr. Bot. Cl. 22: 7. 1895.

Type: genus *Poa* L.

Gramineae Juss., Gen. Pl. 28. 1789; Benth. & Hook.f., Gen. Pl. 3: 1074-1215. 1883; Hack. in Engl. & Prantl, Nat. Pfl.-Fam. ed. 2, 14e. 1940; Pilger, Bot. Jahrb. 76: 271-409. 1954 (nom. alt. ICBN 1994 Art. 18.5-18.6).

Anomochloaceae Nakai, Ord. Fam. etc. App. 222. 1943.

Bambusaceae Nakai, Fl. Sylv. Koreana 20, 1-55. 1933.

The Poaceae is one of the largest of the families of flowering plants represented by over 10000 species under 650 genera (Clayton & Renvoize, 1986). The grasses are distributed worldwide and they grow in all types of climatic and soil conditions. It is economically the most important family and includes cereals, millets, sugarcane, forage grasses and bamboos, which have multiple uses.

The family Poaceae was described based on the genus *Poa.* The alternate and the most popularly used name is Gramineae. Lot of workers have made valuable contributions to the systematics of this family. The family Poaceae is divided in to subfamilies, tribes and subtribes. The first scientific work was that of Robert Brown (1814) and he divided the grass family into Pooideae and Panicoideae. In almost all classifications bamboos were considered as a separate group. Pilger (1956) recognised 9 subfamilies in Gramineae. Bentham (1883) divided Gramineae into two groups, series A. Panicaceae and series B. Poaceae. In this classification, he treated bamboos as a separate tribe Bambuseae. Bor (1960) classified the family into two subfamilies, Panicoideae and Pooideae. He excluded bamboos.

In all the important system of recent classification Poaceae is divided into 2-6 subfamilies. Among them bamboos are treated under subfamily Bambusoideae. Tateoka (1957) classified Poaceae into five subfamilies. Clayton

and Renvoize (1986) classified Poaceae into six subfamilies, he treated Bambusoideae as the first subfamily. Tzvelev (1989) divided Poaceae into 2 subfamilies, Bambusoideae and Pooideae. The grass phylogeny-working group classified Poaceae based on all available data including molecular evidences. They recognized 12 subfamilies and one incertae sedis. In this classification bamboos are treated as a subfamily. The classification of Poaceae by Clayton and Renvoize (1986) is important and has universal acceptance. In this treatise, this classification is accepted up to the level of subfamily. They recognized 6 subfamilies in Poaceae. They are:

1. subfamily Bambusoideae.
2. " Centothecoideae
3. " Pooideae
4. " Arundinoideae
5. " Chloridoideae
6. " Panicoideae

Each subfamily is again divided into tribes and subtribes.

Annual or perennial, often rhizomatous or stoloniferous herbs, sometimes shrubs or trees with woody tall stems (culms). Root system fibrous, well developed in perennials arise from rhizomes or stolons, adventitious roots arise from the nodes of prostrate culms. Culms jointed, erect or prostrate and creeping at the base and then usually rooting at the nodes, cylindrical, rarely flattened or quadrangular, branched or unbranched, nodes solid, internodes hollow, sometimes solid. Leaves alternate, distichous with long narrow or linear-lanceolate, flat or narrow blades and closed or open sheaths; ligule membranous or ciliated or fimbriate, often present, sometimes absent, proper petiole absent, pseudopetiole present in bamboos. Inflorescence in spikes, few or many spikate panicles or racemes; composed of pseudospikelets in some bamboos; flowers or spikelets often bisexual, sometimes unisexual, the spikelets have a short or long stalk, the rachilla, 1-many flowered; florets with subtending glumes, fertile glumes composed of lemma and palea; perianth

leaves are represented by 2 or 3 or more growths known as lodicules, sometimes absent; stamens 3 or sometimes 6 in two whorls, many in some bamboos, normally free, united in some bamboos; anthers versatile. Ovary glabrous or hirsute, one-celled, one-ovuled, the point of attachment of ovule inside the ovary is visible on the grain as the hilum; style usually 2, one in bamboos, stigmas 2-6, plumose. Fruit 1-seeded, indehiscent caryopsis, pericarp dry, sometimes fleshy in bamboos.

Distribution and ecology: Cosmopolitan in distribution except in some forest types and polar region. It forms grasses dominated ecosystems like prairies of America, savannah of Africa and steppies of Central Asia.

Key to the subfamilies

1a. Spikelets usually 1-flowered (except in unisexual and neutral spikelets), more or less dorsally compressed; mature spikelets fall entire from their pedicels ..... **Panicoideae**

1b. Spikelets usually 2-many flowered or reduced from above downwards to a one flowered condition, more or less laterally compressed, sometimes terete; mature spikelets fall from the pedicels leaving the glumes behind.. 2

2a. Culms woody, lodicules 3-7, number of stamens 3-many .... **Bambusoideae**

2b. Culms herbaceous, lodicules 2 (rarely 3), number of stamens usually 2-3 .. 3

3a. Styles fused at base, leaves usually pseudopetiolate..... **Centothecoideae**

3b. Styles not fused at base, leaves not petiolate 4

4a. Awn of the lemma usually attached from the sinus, silica bodies mostly saddle shaped ..... **Chloridoideae**

4b. Awn of the lemma attached dorsally or terminally, silica bodies usually dumbbell shaped or absent..... 5

5a. Culm internodes usually hollow, silica bodies present..... **Arundinoideae**

5b. Culm internodes solid, silica bodies absent..... **Pooideae**

A comparative table of grasses and bamboos

Character	Grasses	Bamboos
Habit	annuals or perennials, tufted, stoloniferous, sometimes rhizomatous	perennials, multinials, gregarious or form open clumps
Rhizome	not well developed	well developed, monopodial or sympodial, woody
Culms	slender to erect or prostrate, not woody, with rather small number of well spaced nodes; branched near the base; culm sheath absent	erect woody, with well spaced nodes; culm branched above; culm sheath present
Leaves	without a petiole, rarely pseudopetiolate, blade linear, seldom lanceolate or lance ovate, persistent	always pseudopetiolate, persistent or deciduous, blade usually form lanceolate to lance ovate, very rarely linear
Anatomy	not bambusoid; C_3 or C_4 plants	bambusoid; C_3 plants
Inflorescence	usually determinate	determinate or indeterminate
Spikelets	with definite or indefinite number of flowers; pseudospikelets absent; provided with 2 glumes at the base, seldom without glumes or with only one	spikelets often with indefinite number of flowers, rarely definite, often with more than two glumes at the base; pseudospikelets present
Fertile glume	lemmas usually with less number of veins; palea with 2 veins forming keels	lemmas and paleas usually with indefinite number of nerves; palea keeled or not keeled
Lodicules	2, seldom 3	usually 3, sometimes up to 7 or absent
Stamens	usually 3, rarely 2, 4, 6; filaments free, dorsifixed	stamens usually 6, rarely 3, sometimes up to 130; filaments free, sometimes connate, basifixed
Ovary	usually glabrous	glabrous or hirsute
Style	short, 2; stigmas 2	long, single; stigma 1-7
Fruit	a caryopsis	caryopsis or sometimes drupaceous, fleshy
Seedling	a meristematic layer present under the coleoptile as a result of which the base of the plumule can elongate during germination and produce adventitious roots	a meristematic layer under the base of the plume absent

Subfamily **Bambusoideae** Asch & Graebn.

Bambusoideae Asch & Graebn., Syn. Mitteleurop. Fl. 2(1): 769. 1902; Rehd.J. Arn. Arb. 26: 78. 1945; Clayton & Renvoize, Kew Bull. Addl. Ser. 13, 34-57. 1989; McClure, Kew Bull. 15: 321-324. 1961; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Grass Syst. Evol. 225-237. 1987; Tzvelve, Bot. Rev. 55(3): 141-203. 1989; S. Dransf. & Widjaja (eds.), Plant Reso. S. E. Asia 7: 34. 1995; Ohrnberger, Bamb. World 7.1999.

Type: *Bambusa* Schreb.

Gramineae, Tribe - Bambuseae Nees, Linnaea 9: 461-494. 1834; Rupr., Bamb. Monogr. Exp. 1-71. 1839; Benth. & Hook. f., Gen. Pl. 3: 1094. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7:1. 1896; E. G. Camus, Les Bamb. 15. 1913.

Class X - Bambusacea Kunth, Mem. Mus. Hist. Nat. 2: 75. 1815.

Bambusaceae Link, Hort. Reg. Bot. Berol. 2: 308. 1883; Trin., Mem. Acad. St. Petersburg, Ser. 6, Sci. Nat. 1: 613. 1835; Munro, Trans. Lin. Soc. London 26: 10. 1868; Nakai, Fl. Sylv. Koreana 20: 12. 1933.

Perennial herbs, shrubs, woody and arborescent or climbers, rhizomatous, the aerial and subterranean axes segmented, rhizomes and culms bear buds and sheathing foliar organs. Culms with many well-spaced nodes, branched above, culms usually hollow, semi-solid, rarely solid, erect, scandent or climbing and vine-like, branched throughout or above, sometimes unbranched, the node of the segmented axis is marked either by a sheath scar or also by a supranodal ridge; the culm sheaths ligulate, persistent, abscissile or incompletely abscissile. Leaves petiolate, abscissile, blades usually flat, broad, lanceolate or linear-lanceolate, rarely linear, midrib more prominent on the abaxial surface, veins parallel with tessellate venations, strongly or weakly manifest superficially, glabrous to sparsely pubescent, leaf sheath persistent. Flowering usually gregarious, sometimes erratic or only a portion of the plant flower. Inflorescence terminal or lateral, determinate or indeterminate; determinate, paniculate, racemose or spicate racemose; indeterminate consists of pseudospikelets forming semi-verticillate clusters; spikelets often sessile or pedicellate, one to many-flowered, bisexual, often with 2 or more sterile glumes at the base; lemma mucronate or cuspidate, many-nerved; palea enclosed by lemma, many nerved, with a longitudinal dorsal sulcus; lodicules

two, three or many, sometimes absent; stamens usually 3 or six and sometimes up to 130, free, rarely connate in to a tube; ovary solitary, normally one-celled with one ovule; style short or long, stigmas commonly two or three, sometimes up to seven. Fruit a caryopsis, sometimes nut-like or drupaceous, one seeded, indehiscent, sessile.

In South India, there are 22 species and two varieties of bamboos under six genera are known to occur. The dominant genus is *Ochlandra* with eleven species and one variety and all are endemic to this region. Another important genus is *Pseudoxytenanthera,* is represented by four species. Among these, three species are endemic to South India and one species is found in Sir Lanka. The genus *Sinarundinaria* is distributed in high altitudes of Southern Western Ghats. This genus has a very restricted distribution. Three species of *Sinarundinaria* are also distributed in Sri Lanka. One species is endemic to Nilgiri Biosphere Reserve. The genus *Schizostachyum* is represented by one species and is endemic to South India. One species and one variety of *Bambusa* and one species of *Dendrocalamus* are distributed in South India.

CLASSIFICATION OF THE SUBFAMILY BAMBUSOIDEAE

Bamboos are diverse group of plants under the family Poaceae and posses some distinct bambusoid characters, which separates them from other grasses. In all classifications bamboos were treated under a separate group or treated as a subfamily of Poaceae.

The first description of Bamboos with illustration was published in Rheede's Hortus Malabaricus (1685). Subsequently, more bamboo species were reported and therefore, the number gradually increased. Later workers treated Bamboos as a separate group under the family Poaceae.

Rumphius (1750) in his work Herbarium Amboinense mentioned some bamboos. He divided the bamboos into eight classes under a single name *Arundo.* Roxburgh (1814) described seven species with same generic name, *Bambusa.*

Kunth (1815) considered Bambusaceae as one of his ten natural groups of genera and referred the groups as *Gramina Bambusaceae.*

Nees (1834) was the first man who was able to differentiate the woody and herbaceous groups of bamboos. He treated Bambusaea as a tribe under Gramineae. He divided bamboos into three groups as Bambuseae, Arundinariae and Streptochaeta. Streptochaeta included the herbaceous bambocs. He also recognised two subgroups under Bambuseae, *Bambusa* and *Guadua*.

Another earlier work was that of the Russian botanist, Franz Ruprecht (1839). He published a monograph on bamboos. He placed 67 species of woody bamboos in two groups and followed the system of Nees (1834).

Hooker (1854) treated Bambuseae as a tribe of the order Gramineae and divided into 4 subtribes.

Order: Gramineae

Tribe: Bambuseae

Subtribe : Arundinarieae

" : Eubanbuseae

" : Dendrocalameae

" : Melocanneae

In 1868 Colonel William Munro's world monograph of bamboos came to light. He treated bamboos under Bambusaceae, a division under the family Gramineae. He followed the basic system of Nees (1834) but expanded to include many new taxa. He described 21 genera and about 158 species completely and more than 50 species incompletely. He divided Bambusaceae again in to 3 divisions.

1. Triglossae or Arundinariae - Plants with three stamens and three squamulae. There are 8 genera under this division.
2. Bambuseae – According to Munro this is the division of true bamboos. There are 5 genera under this division.
3. Bacciferae – In this group he included berry bearing bamboos like *Ochlandra, Melocanna* and also *Schizostachyum, Dendrocalamus,* etc. There are 8 genera under this division.

Bentham in 1883 followed the system of Munro and divided Bambuseae in to four sub-tribes.

Tribes: Bambuseae

Subtribes : Arundinarieae
" : Eubambuseae
" : Dendrocalameae
" : Melocanneae

Gamble (1896) published Bambuseae of British India. He described 151 species under 14 genera. He considered Bambuseae as a tribe and divided it into 4 subtribes.

Subtribe : Arundinareae
" : Eubambuseae
" : Dendrocalameae
" : Melocalameae.

Stapf (1897) considered bamboos as a tribe of the subfamily Pooideae of Gramineae and divided into five subtribes. His classification is based on the nature of spikelets, paleas, number of stamens and fruit characters.

Subtribe : Dendrocalameae
" : Melocanneae
" : Bambusineae
" : Arundinareae
" : Puellineae

Holttum (1956) proposed a new system of classification of bamboos based on the structure of the ovary. He divided bamboos under four major divisions.

A. *Schizostachyum* type of ovary
B. *Oxytenanthera* type of ovary
C. *Bambusa-Dendrocalamus* type of ovary
D. *Arundinaria* type of ovary

Parodi (1961) in his system of classification included all woody bamboos in a single tribe Bambuseae. The herbaceous members were allocated in three tribes: Olyreae, Phareae and Streptochaeteae.

According to Grosser and Liese (1971) in addition to morphological characters anatomical characters can also be used for the classification of bamboos. Based on their studies conducted in 52 species belonging to 14 genera and

proposed a classification. They described four basic type of vascular bundles in bamboos. Based on the presence of these four basic types, as well as combinations of them, an anatomical system of classification was formulated.

Four basic types of vascular bundles are:

vascular bundle type I
vascular bundle type II
vascular bundle type III
vascular bundle type IV

Based on the occurrence of these, there are six groups viz. Group A, Group B, Group B1, Group B2, Group C and Group D.

Clayton and Renvoize (1986) in their classification of grasses treated bamboos under the subfamily Bambusoideae. It is divided in to five tribes. On of the tribes is Bambuseae in which all the bamboos were included. It was divided in to three subtribes, Arundinariinae, Bambusinae and Melocanninae.

Under Arundinariinae there were 20 genera, the subtribe Bambusinae included 25 genera and the third subtribe Melocanninae with 4 genera.

Another important classification is that of Soderstrom and Ellis (1987). They treated Bambusoideae as subfamily of Gramineae. In this classification leaf anatomy characters along with those from the spikelets, flower and fruits are included. He divided the subfamily into five tribes. Bambuseae was one among them, in which all bamboos were included. The tribe Bambuseae was again split into nine subtribes:

Subtribe	:	Arthrostylidiinae
"	:	Arundinariinae
"	:	Bambusinae
"	:	Chusqueinae
"	:	Gauaduinae
"	:	Nastinae
"	:	Neurolepidinae
"	:	Schizostachydinae
"	:	Shibataeinae

They recognized 54 genera and 5 genera of uncertain placement.

The Russian agrostologist Tzvelev (1989), in his classification of grasses divided Gramineae (Poaceae) into two subfamilies: Bambusoideae and Pooideae. The subfamily Bambusoideae was divided in to 14 tribes and a group of genera of uncertain position.

Subfamily Bambusoideae

Tribe : Arundinarieae
" : Shibataceae
" : Bambuseae
" : Dendrocalameae
" : Melocanneae
" : Oxytenanthereae
" : Atractocarpeae
" : Streptogyneae
" : Streptochaeteae
" : Buergersiochloeae
" : Olyreae
" : Parianeae
" : Leptaspideae
" : Anomochloeae
" : Bambusoid genera of uncertain position.

Dransfield and Widjaja (1995) followed the classification of Soderstrom and Ellis (1987) with some modifications. They proposed a new sub tribe, Racemobambosinae to accommodate a new genus *Racemobambos* and abolished the subtribe Neurolipidinae. Schizostachydinae of Soderstrom and Ellis became a synonym for Melocanninae.

Subtribes : Arthrostylidiinae
" : Arundinariinae
" : Bambusinae
" : Chusqueinae
" : Guaduinae
" : Melocanninae
" : Nastinae
" : Racemobambosinae
" : Shibateinae.

Li (1998) also followed the classification of Soderstrom and Ellis (1987) modified by Dransfield and Widjaja (1995) for Chinese bamboos. He treated total 67 genera of bamboos under different subtribes of the tribe Bambuseae.

In the present study, the classification of Soderstrom and Ellis (1987) modified by Dransfield and Widjaja (1995) is followed. All the south Indian subtribes are included in this classification. This classification is accepted worldwide and is found most suitable for the south Indian bamboos.

According to the classification of Soderstrom & Ellis (1987) Bambusoideae is divided in to five Tribes i) Anomochloeae, ii) Buergersiochloeae, iii) Olyreae, iv) Streptochaeteae and v) Bambuseae.

Key to the tribes

1a. Plants with woody, strong rhizomes and culms; rhizomes monopodial or sympodial; vegetative branching complex ..... **Bambuseae**

1b. Plants with short weak rhizomes and herbaceous culms; rhizomes .strictly sympodial; vegetative branching absent or simple 2

2a. Inflorescence a spike; flowers bisexual, lodicules absent; stigma non plumose 3

2b. Inflorescence mixed panicles; flowers unisexual, lodicules present; stigma plumose 4

3a. Leaves with prominent elongate pseudopetioles; stamens 4..**Anomochloeae**

3b. Leaves with short pseudo petioles; stamens 6 ..... **Streptochaeteae**

4a. Inflorescence on specialized non leafy culms; filaments united .... **Buergersiochloeae**

4b. Inflorescence on leafy culms; filaments free..... **Olyreae**

Tribe: **Bambuseae** Nees

Bambuseae Nees, Agrost. Brass. 520. 1829; Munro, Trans. Linn. Soc. London 73. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 1. 1896; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Proc. Int. Symp. Grass Syst. Evol. 232. 1987;

Clayton & Renvoize, Kew Bull. Addl. ser. 13, 35. 1989; S. Dransf. & Widjaja (eds.), Plant Reso. S. E. Asia 7: 34. 1995; Ohrnberger, Bamb. World 17. 1999.

Type: *Bambusa* Schreb.

Arthrostylideae E. G. Camus, Les Bambusees 16. 1913.

Shibataeeae Nakai, J. Jap. Bot. 9: 83. 1993.

Phyllostachideae Keng, Fl. Ill. Pl. Prim. Sin. Gram. 87. 1959.

Perennial shrubs, semiarborescent or arborescent plants with closely tufted or loosely arranged culms. Rhizomes complex, well developed, monopodial or sympodial, solid or hollow. Culms woody, semi-erect or erect or sometimes climbing, usually hollow, sometimes solid, divided into cylindrical segments by the nodes, young shoots and culms are covered with sheaths; branches well developed, grouped at each node; leaf blades linear-oblong, usually with cross-nerves and a short pseudopetiole, persistent or deciduous. Inflorescence small or large compound panicle or raceme, sometimes composed of pseudospikelets, spikelets form compact heads, semiverticillate clusters or loosely arranged on nodes; spikelets 1-many flowered, fertile and sterile florets mixed, usually laterally compressed; sterile glumes 2-many, coriaceous, many-nerved, sometimes mucronate; fertile glumes, lemma herbaceous to coriaceous, many nerved, awnless or sometimes mucronate, palea membranous, exposed or enfolded by lemma, many nerved, keeled or not keeled; lodicules 3-7, sometimes absent, 2-5 nerved; stamens 3-6, sometimes up to 130, filaments free or sometimes united; stigmas 1-3, sometimes 5-7; ovary glabrous or hairy. Fruit a caryopsis with a linear hylum, sometimes drupaceous and long beaked.

It is the largest tribe with wide distribution. The members are found growing in the temperate and tropical regions up to an elevation of 4000 m from sea level.

The Tribe Bambuseae is divided into nine sub-tribes.

1. Arthrostylidiinae
2. Arundinariinae
3. Bambusinae
4. Chusqueinae
5. Guaduinae

6. Melocanninae
7. Nastinae
8. Racemobambosinae
9. Shibateinae

The South Indian bamboos are coming under three sub-tribes, Arundinariinae, Bambusinae and Melocanninae. The other sub-tribes are not naturally represented in South India. A key to the South Indian sub-tribes is given.

Key to the subtribes of ***Bambuseae***

1a. Inflorescence determinate, racemes or panicles; spikelets not clustered or fascicled; stamens 3; stigma 2, rarely 3 ..... **Arundinariinae**

1b. Inflorescence indeterminate; spikelets clustered, arise in fascicles or capitate heads; stamens six or more; stigma 3 2

2a. The primary branch at each node is dominant; branches few, unequal; ovary appendage short, broadly conical and hirsute..... **Bambusinae**

2b. The primary branch at each node is not dominant; many subequal branches arise at each node; ovary appendage long, narrow, glabrous ..... **Melocanninae**

Subtribe 1. **Arundinariinae** Benth.

Arundinariinae Benth., J. Linn. Soc. Bot. 19: 31. 1881; Clayton & Renvoize, Kew Bull. Addl. ser. 13, 41. 1989; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Proc. Int. Symp. Grass Syst. Evol. 234. 1987; S. Dransf. & Widjaja (eds.), Plant Reso. S. E. Asia 7: 34. 1995; Ohrnberger, Bamb. World 19. 1999.

Type*: Arundinaria* Michx.

Arundinarieae, Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 1. 1896.

Perrierbambusinaea A. Camus, Arch. Mus. Hist. Nat. Paris Ser. 6, 12: 603. 1935.

Pleioblastinae Keng, Fl. Ill. Pl. Prim. Sin. Gram. 29. 1959.

Thamnocalaminoae Keng f., J. Bamb. Res. 1: 15-18. 1982.

Shrubby, medium sized, semi-arborescent bamboos. Rhizome sympodial to monopodial. Culms erect or scandent, usually hollow, rarely solid. Inflorescence determinate, racemes or panicles; spikelets 2-many flowered; palea always keeled; lodicules 3; stamens 3, free; ovary glabrous with 2-3 stigmas. Caryopsis with thin pericarp, adnate to the seed.

This subtribe includes taxonomically heterogenous group of bamboos. All types of rhizomes are found in this subtribe, from sympodial to monopodial. The plants are shrubby or medium sized up to 8 m tall. This is a large and complex subtribe in which the generic limits are far from adequately resolved (Soderstrom and Ellis, 1987). The numerous genera were described by different authors under this subtribe. *Arundinaria, Thamnocalamus, Fargesia, Chimonobambusa, Sinarundinaria, Pleoblastus, Nipponocalamus, Yushania, Drepanostachyum, Himalayocalamus, Ampelocalamus* and *Borinda* are some of the important genera described by various workers under this subtribe. This subtribe has a wide recognition by World bamboo taxonomists.

Almost all the members of this subtribe are distributed in the Old World except one species *Arundinaria gigantea* which is native of United States. Most of the genera are high altitude plants growing under temperate climatic conditions. In South India, the subtribe *Arundinariinae* is represented by the genus *Arundinaria* formerly known as *Sinarundinaria.*

Arundinaria Michx.

The genus was first described by Michaux in 1803. The type species *Arundinaria gigantea* is native to the United States of America. Later different species have been placed under this genus. They include American, African and Asian species. The type genus *Arundinaria gigantea* is a monopodial bamboo. But, later sympodial bamboos having similar characters like several branches, racemose or open paniculate inflorescence, three stamens with free filaments and 2-3 stigmas, were placed under the genus *Arundinaria.* This group represents a taxonomically heterogeneous group of bamboos (Chao & Renvoize, 1989). The genus *Arundinaria* is considered as the most advanced group among bamboos. They are shrubby and with two glumes and three stamens.

The root of the generic name means *cane* or *reed.* There were about 380 binomials under the name *Arundinaria.* It is one of the earliest names in the group of bamboos. Once this genera was the biggest one in Bambusoideae. Different authors made 11 genera out of this large group.

Arundinaria Michx., Fl. Bor. Amer. 1: 73. 1803; Munro, Trans. Linn. Soc. London 26: 13. 1868; Bedd., Fl. Sylv. S. India (3): 230. 1873; Benth. & Hook. f., Gen. Pl. 3: 1207. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 1. 1896; Brandis, Indian Trees 664. 1906; Bourd., For. Trees Travancore 397. 1908; E. G. Camus, Les Bamb. 26. 1913; Blatt. Indian For. 55(10): 542. 1929; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1857. 1934; McClure, Smith. Contr. Bot. 9: 21. 1973; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Proc. Int. Symp. Grass Syst. Evol. 234. 1987; Soderstr. & R.P. Ellis, Smith. Contr. Bot. 72: 2. 1988; Tzvelve, Bot. Rev. 55(3): 151. 1989; C.S. Chao & Renvoize, Kew Bull. 44: 2. 1989; Clayton & Renvoize, Kew Bull. Addl. ser. 13, 45. 1989; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 34. 1995; Judziewicz *et al.*, Amer. Bamb. 195. 1999; Ohrnberger, Bamb. World 35. 1999.

***Type**: Arundinaria gigantea* (Walter) Muehlenb.

Pleioblastus Nakai, J. Arn. Arb. 6: 145. 1925.

Nippocalamus Nakai, J. Jap. Bot. 18: 350. 1942.

Oligostachyum Wong & Ye, Nanj. Univ. J. Nat. Sci. 95. 1982.

Bashania Keng. f. & Yi, J. Bamboo Res. 1(2): 37. 1982.

Sinarundinaria Nakai, J. Jap. Bot. 11: 1. 1935; Seethalakshmi & M. Kumar, Bamb. India Comp.261. 1998.

Yushania Keng. f., Acta. Phytotax. Sin. 6: 355. 1957; R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 282. 1989.

Ludolfia Willd., Mag. Nevest. Entdeck. Naturk. 2: 320. 1808.

Macronax Raf., Med. Repos. 11: 503. 1808.

Shrubby, perennial woody bamboos with sympodial rhizomes, the rhizome neck short. Culms erect, hollow, branch compliments many, subequal; culm sheaths persistent or deciduous; branching is intravaginal and above the nodal line; leaf blades are tessellate. Inflorescence, racemes or open panicles;

spikelets semelauctant, 2-several flowered, the terminal aborted or reduced to a rachilla segment; glumes 2, palea keeled; stamens 3, filaments free; stigmas 2-3, plumose. Caryopsis with a hilum extending throughout its length.

Distribution and ecology: The genus *Arundinaria* is distributed in eastern United States, Brazil, Mexico, Argentina, Africa, China, Sri Lanka, India, Myanmar, Nepal, Bhutan and Vietnam. In India, this species occurs in north eastern states and South India. In South India, the genus *Arundinaria* is represented by four species. All are high altitude plants, growing in grasslands, sholas or as a component of semi-evergreen forests.

Note: The genus *Arundinaria* was originally described by Michaux (1803). Munro (1868) accepted this generic concept and described two species of bamboos from South India, *Arundinaria densifolia* and *A. walkeriana.* Nees (1834) based on the specimen of Wight from Nilgiris described another species *A. wightiana.* Thwaites (1864) described *A. floribunda* based on a Sri Lankan specimen. Rama Rao (1913) reported this species from South India. Gamble (1896) followed Munro's concept and treated all these species under the genus *Arundinaria.* Later workers like Beddome (1873), Bentham & Hooker (1883), Brandis (1906), Bourdillon (1908), E.G. Camus (1913) and Blatter (1929) followed this generic concept, *Arundinaria.*

Chao and Renvoize (1989) revised all the species described under *Arundinaria* in south east Asia and Africa. They transferred all the species of South India previously treated as *Arundinaria,* under the genus *Sinarundinaria.* Seethalakshmi and Kumar (1998) accepted the generic concept of Chao and Renvoize (1989) and transferred all the south Indian species previously described under *Arundinaria* to the genus *Sinarundinaria.*

The genus *Sinarundinaria* was first described by Nakai (1935) based on *Sinarundinaria nitida* and *S. murielae.* His description was based on the vegetative structures only. *Sinarundinaria murielae* flowered in 1970's and *S. nitida* flowered in 1993 (Stapleton, 1994). It was found that both these species were *Fargesia spathacea.* Thus, the genus name *Sinarundinaria* became invalid.

Soderstrom (1988) while studying the bamboos of Sri Lanka followed the generic concept *Arundinaria*. Majumdar (1989) accepted Keng's (1957) generic concept *Yushania* and transferred all the South Indian species which were previously treated under the genus *Arundinaria* to the genus *Yushania*.

Nakai (1925) treated three species of *Arundinaria, A. floribunda, A. wightiana* and *A. walkeriana* under the genus *Indocalamus*. Tewari also (1992) followed this concept.

In the present study, the generic concept *Arundinaria* of Munro (1868) and Gamble (1896) is followed. Soderstrom and Ellis (1988) also followed this generic concept to describe the species in Sri Lanka. All the species in South India previously described under *Sinarundinaria* are treated under the genus *Arundinaria*. Renvoize in a personal communication also suggested to treat the *Sinarundinaria* species under the genus *Arundinaria*.

Key to the species of ***Arundinaria***

1a. Plants small, erect, up to 1.5 m tall with small narrow leaves, 2.5-3.5 cm long, 0.5-0.7 cm broad ..... **A. densifolia**

1b. Plants large, scandent, up to 3.5 m tall with large broad leaves, 4-17 cm long, 0.8-3 cm broad 2

2a. Leaf blades thick and leathery up to 3.5 cm wide; stigmas 3 . **A. walkeriana**

2b. Leaf blades not thick and not leathery up to 2 cm wide; stigmas 2..... 3

3a. Culm dark green when young; internode flattened on one side near the node; leaf sheath hispid with bulbous based hairs; spikelets usually 3-flowered, pedicel 1.5-2 cm long..... **A. wightiana**

3b. Culms having purple-black speckles when young; internode not flattened; leaf sheath sparsely hirsute; spikelets 5-7 flowered, pedicel 0.7-0.8 cm long..... **A. floribunda**

Arundinaria densifolia Munro, Trans. Linn. Soc. London 26: 32. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 8, t.7. 1896 & in Hook. f., Fl. Brit. India 7: 379.1897; Brandis, Indian Trees 664. 1906; Bourd., For. Trees Travancore 398. 1908; E. G. Camus, Les Bamb. 31. 1913; Rama Rao, For. Pl. Travancore 446. 1914; Blatt. & McCann, J. Bombay Nat. Hist. Soc. 33: 900. 1929; Soderstr. & R.P. Ellis, Smith. Contr. Bot. 72: 8, t.5,6. 1988 [Figures 4 and 5; Plate 6].

Type: Sri Lanka, *Watson 25* (lectotype K. selected by Soderstrom & Ellis, 1988)

Chimonobambusa densifolia (Munro) Nakai, J. Arnold Arbor. 6: 151. 1925; Bahadur, Indian J. For. 2: 240. 1979; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980; Varmah & Pant, Indian For. 107: 672. 1982; Tewari, Monogr. Bamb. 55. 1992.

Sinarundinaria densifolia (Munro) Chao & Renvoize, Kew Bull. 44: 354. 1989; Seethalakshmi & M. Kumar, Bamb. India Comp.264. 1998.

Yushania densifolia (Munro) R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 282. 1989; Ohrnberger, Bamb. World 158. 1999.

A small dense, shrubby bamboo with gregarious, closely packed culms and bushy habit. Rhizome sympodial, pachymorph, short necked, covered with scales; culms erect, 20-50 cm tall, slender, hollow; node not prominent, marked by sheath scar, supranodal ridge absent, small triangular nodal bud present, enclosed inside prophyllum; internodes 1.5-9 cm long, 0.5-0.9 cm diameter, wall thick, glabrous; culm sheath 2.5-4 cm long, 1-2 cm broad at base, striate, coriaceous, hirsute below, tip attenuate, persistent; blade erect, small, triangular, narrow, glabrous, 0.5-1.4 cm long, 0.2-0.4 cm broad at base; auricle inconspicuous, oral setae delicate; inner ligule highly reduced, a membranous rim; branches arise from the lower nodes, produced just above the nodal line, intravaginal, short, the primary axes develop first followed the formation of numerous laterals from its base, form a cluster of small subequal branches, 20-30 numbers, nodes become close towards the tip and the branches form a dense cluster giving the plant a bushy appearance; leaves arise from the base of branches, 2.5-3.5 cm long, 0.5-0.8 cm broad, triangular

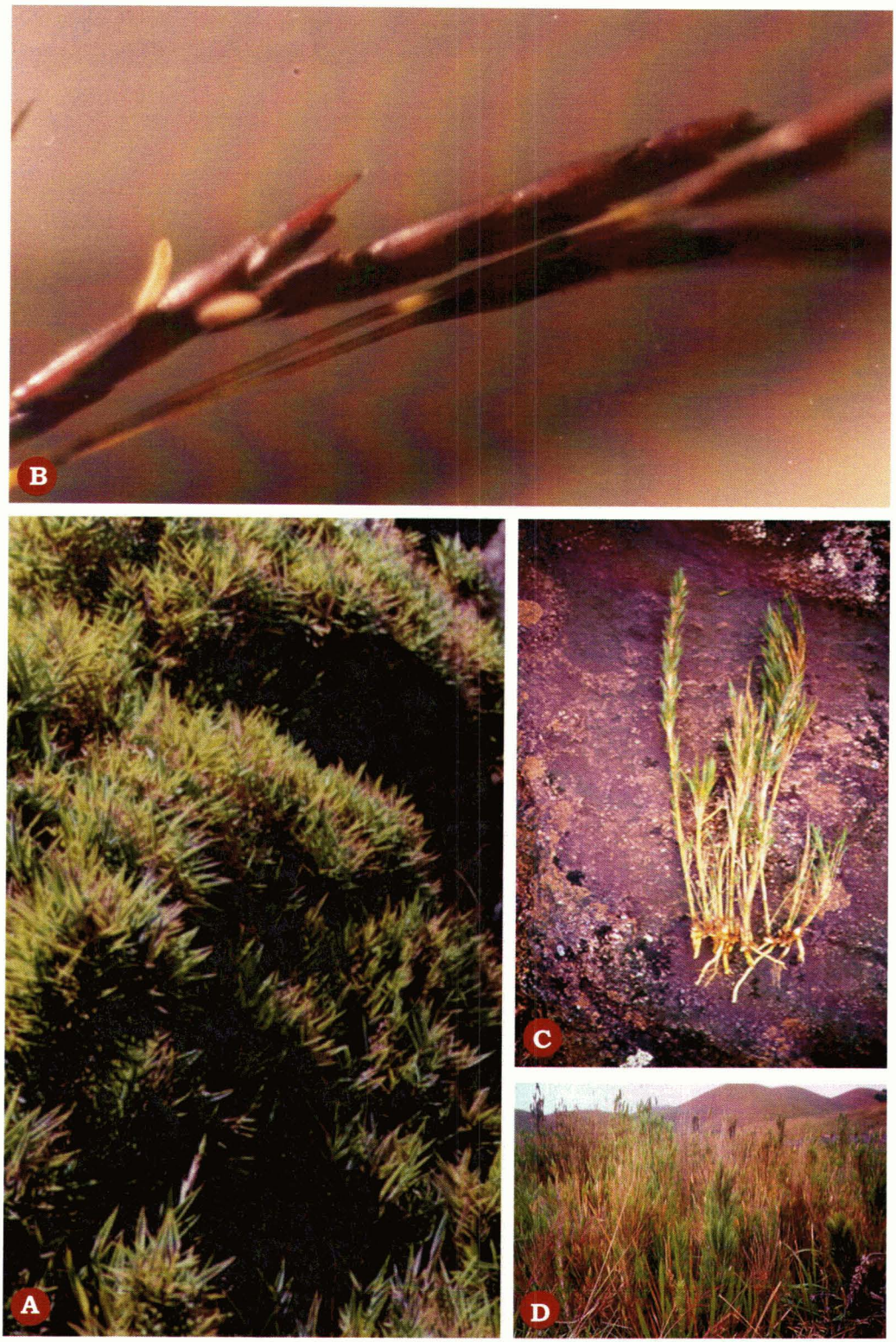


Plate 6. ***Arundinaria densifolia*** Munro **A.** habit; **B.** inflorescence; **C.** culms; **D.** flowering

Figure 4. *Arundinaria densifolia* Munro **A.** habit; **B.** culm sheath; **C.** flowering branch

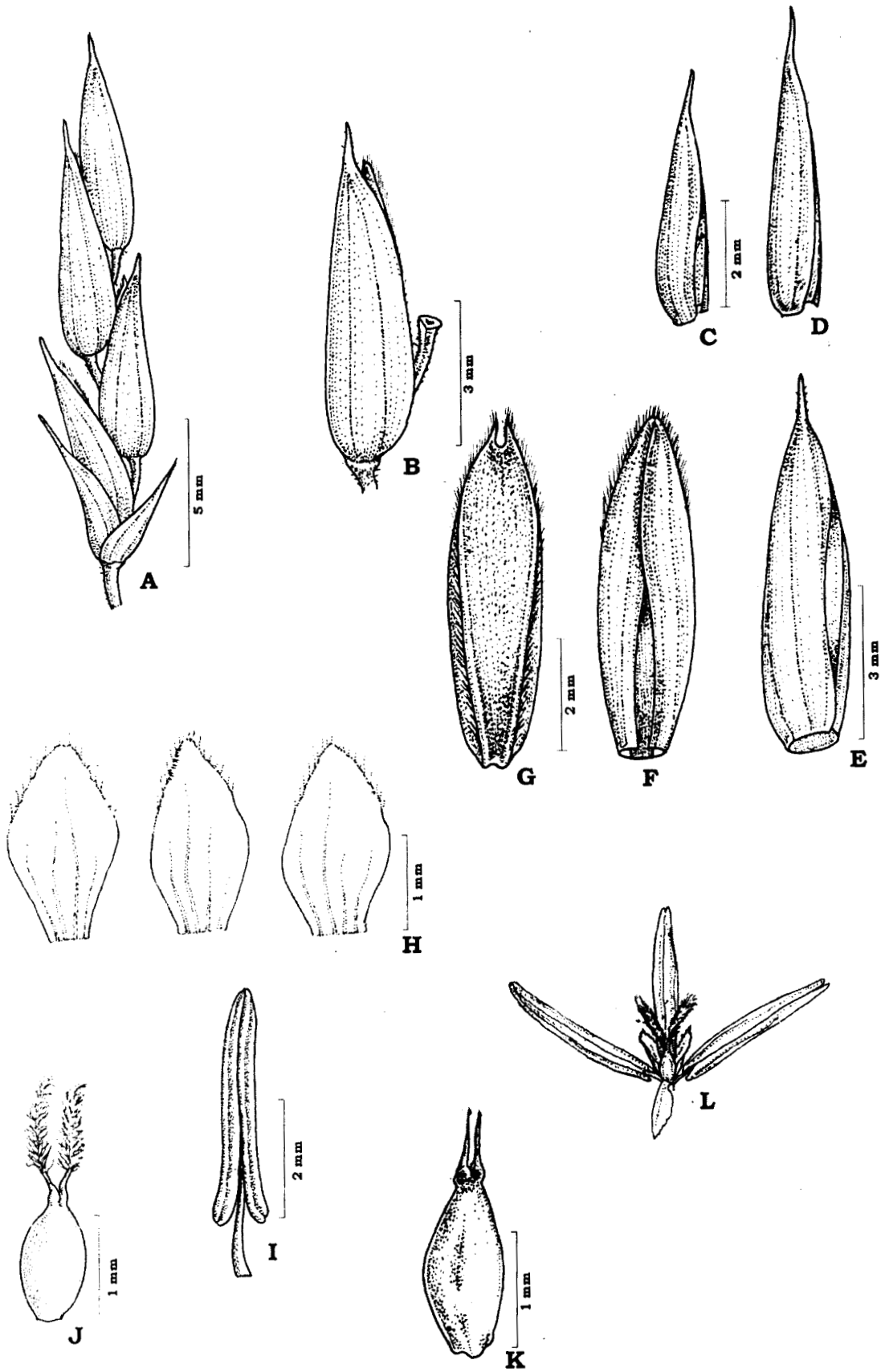


Figure 5. *Arundinaria densifolia* Munro **A.** spikelet; **B.** floret; **C. & D.** sterile glumes; **E.** lemma; **F.** palea-inner side; **G.** palea-surface view; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

to lanceolate, stiff, glabrous on both sides, tessellate venation, margins cartalagenous, serrulate, midrib clear on the lower side, tip pungent, hard, spinous, scabrous, base truncate, leaves subsessile; leaf sheath imbricate, glabrous, auricle inconspicuous, oral setae present, deciduous; inner ligule a hairy rim, outer not clear. Inflorescence arise on leafy branches, a dense panicle, with racemes of 3-5 spikelets, terminal; spikelets 1.5-2.1 cm long, up to 3-flowered, with a terminal free rachilla or a rudimentary floret, purple coloured; sterile glumes 2, stiff coriaceous, 0.4-0.5 cm long, ovate-triangular, lanceolate, the lower short, acuminate, midnerve scabrous, tip ends in a scabrous stiff awn; fertile glumes, lemma ovoid-lanceolate, mucronate, mucron scabrous, 5-7 nerved, 0.6-0.7 cm long; palea membranous, lanceolate, with two prominent keels, keels scabrous, form a sulcus in between, the tip is bifid, glabrous except the keel, 0.5-0.6 cm long, lodicules 3, hyaline, thin, flat, obtuse, 2-3 nerved, margins fimbriate, 0.1-0.2 cm long; stamens 3, yellowish, free, 0.4-0.5 cm long; ovary elliptic, glabrous with a short style, stigma 2, plumose. Fruit a caryopsis with persistent style.

Distribution and ecology: This species is distributed in high altitude grasslands of South India and Sri Lanka. In Southern Western Ghats, it is found growing in Eravikulam and Anamudi from 2000-2695 m. Sporadic flowering is common in summer months.

Specimens examined: KERALA: Idukki Dist. Anamalai, *M Remesh & Stephen Sequiera 20732* (KFRI); Eravikulam, *Manju C Nair 20649* (KFRI).

Uses: It is a favourite food of Nilgiri Tar.

Note: Kishore Kumar and Kumar (1997) reported *A. microphylla* from southern Western Ghats. A critical study of this specimen proved that it is *A. densifolia.*

Arundinaria floribunda Thwaites, Enum. Pl. Zeyl. 475. 1864; Munro in Trans. Linn. Soc. London 26: 20. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 5, t.3.1896 & in Hook. f., Fl. Brit. India 7: 377.1897; E. G. Camus, Les Bamb. 28. 1913; Rama Rao, For. Pl. Travancore 446. 1914; Soderstr. & R.P. Ellis, Smith. Contr. Bot. 72: 14. 1988 [Figures 6 and 7; Plate 7].

Type: Sri Lanka, Matturatte district, 5000 ft. *Thwaites* s.n. (holotype PDA. Isotype K., MH !).

Indocalamus floribundus (Thwaites) Nakai, J. Arn. Arb. 6: 148. 1925; Tewari, Monogr. Bamb. 101. 1992; Ohrnberger, Bamb. World 46. 1999.

Sinarundinaria floribunda (Thwaites) Chao & Renvoize, Kew Bull. 44: 356. 1989; Seethalakshmi & M. Kumar, Bamb. India Comp.270. 1998.

A gregarious shrubby bamboo with erect, loose culms. Rhizome sympodial, pachymorph, solid, short necked, covered with scales. Culms erect, self supporting, hollow, 1.5-2.5 m tall, tip straight; node slightly swollen, sheath scar and supranodal ridge, prominent, sheath scar clothed with ring of golden brown hairs, single branch bud present, enclosed by prophyllum; internodes 15-20 cm long, 1-1.3 cm diameter, light-green, young culms with purplish black spots, glabrous; culm sheath 8-12 cm long, 2.5-5 cm broad at base, thin, papery and clothed with bulbous based maroon hairs when young, striate, sparsely hirsute, deciduous when old; blade erect or reflexed, glabrous, linear-lanceolate, margins ciliate, narrow towards the tip acuminate, deciduous, 1.5-3.5 cm long, 0.2-0.4 cm at base; auricle short with short ciliate bristles; inner ligule very short, outer not prominent; branches arise from the mid culm nodes, numerous, subequal, the central branch develops first, numerous laterals arise from its basal buds, 15-20 numbers; leaves arise on branches, lanceolate, 4-12 cm long, 0.5-1.8 cm wide, glabrous, transverse veinlets present, tessellate venation, margins scabrous, midrib narrow, prominent on the lower side, tip acuminate, base attenuate, petiole very short, leaf sheaths imbricate, smooth, coriaceous, striate, auricle inconspicuous, bristles numerous, deciduous; ligule inner short, outer ligule not prominent. Inflorescence a large panicle, with appressed branches which later become spreading, terminal branches glabrous, base pulvinous on top, pedicels short; spikelets 5-8 flowered, 1.8-2.1 cm long, purple, hirsute, covered with minute silky pubescence, usually the uppermost smallest, sterile, each spikelet separated by a rachilla segment, rachilla flat, glabrous at the base, pubescent upwards; sterile glumes 2, outer 0.2-0.3 cm long, ovate, glabrous, ciliate at apex, acute, inner 0.4-0.5 cm long, ovate-lanceolate, glabrous, many nerved,

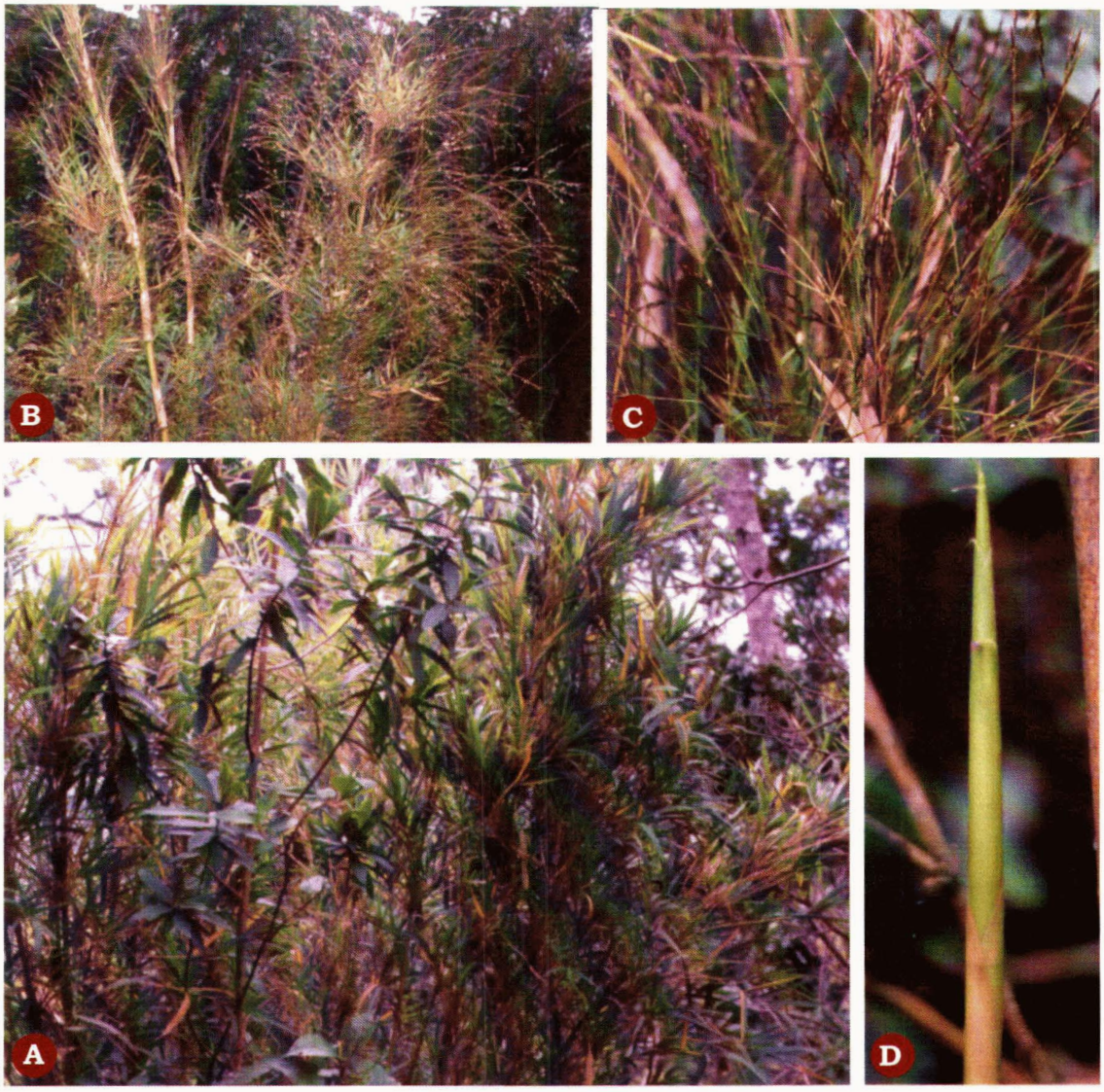


Plate 7. ***Arundinaria floribunda*** Thwaites **A.** habit; **B.** flowering; **C.** inflorescence; **D.** new shoot

Figure 6. *Arundinaria floribunda* Thwaites **A.** leafy branch; **B.** culm sheath; **C.** flowering branch

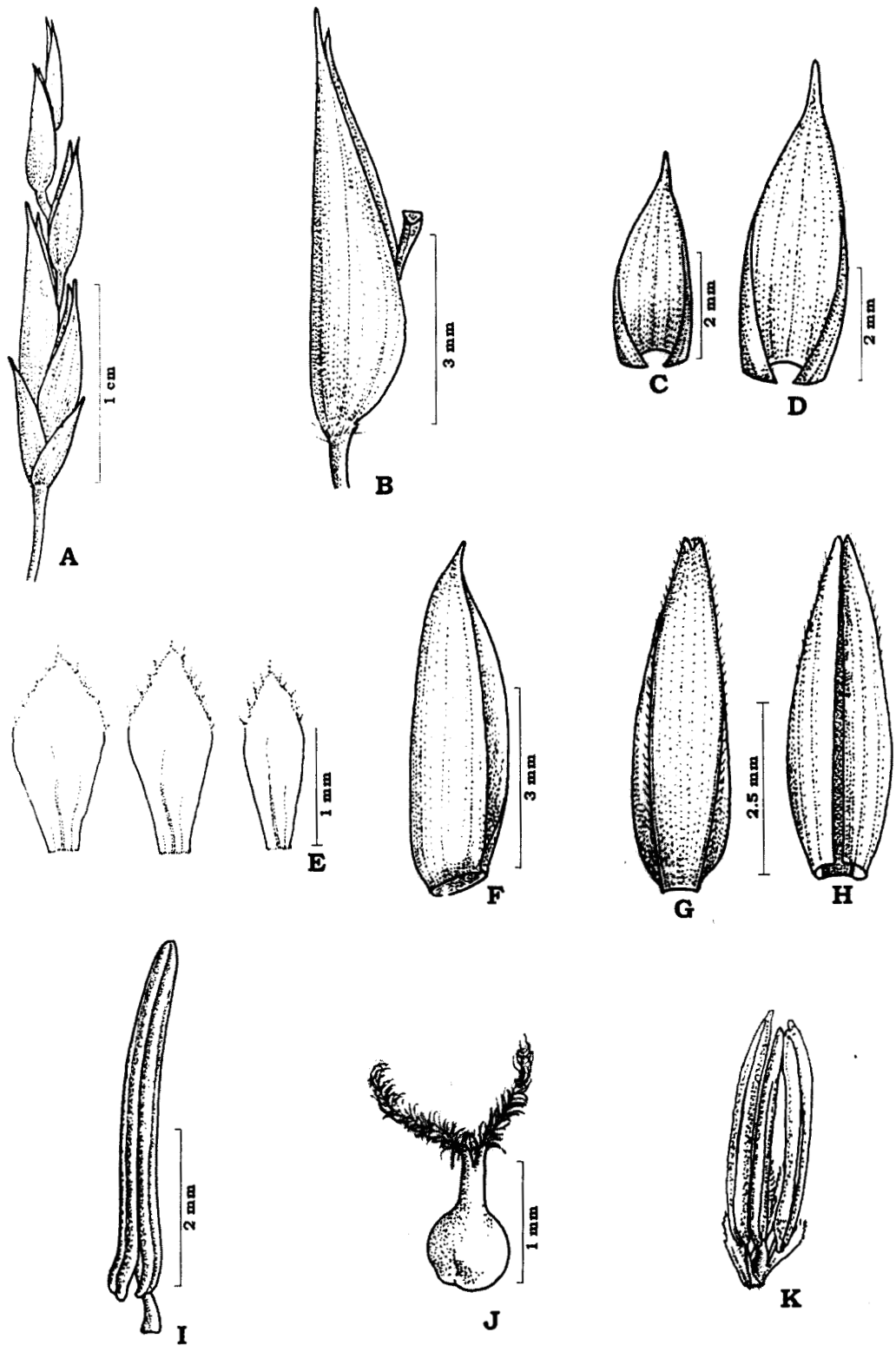


Figure 7. *Arundinaria floribunda* Thwaites **A.** spikelet; **B.** floret; **C. & D.** sterile glumes; **E.** lodicules; **F.** lemma; **G.** palea-surface view; **H.** palea-inner view; **I.** stamen; **J.** ovary with style; **K.** open floret (diagrammatic)

upper edge ciliated, tip mucronate; fertile glumes, lemma lanceolate, membranous, many nerved, mucronate, scabrous, ciliate at apex, 0.5-0.7 cm long; palea membranous, almost same size of the lemma, glabrous, 2 keeled and with 2 broad wings, sulcate between keels, keels ciliate, ovate-lanceolate, apex bicuspidate, scabrid, 4.8-6.4 cm long; lodicules 3, up to 0.2 cm long, hyaline, ovate, 2-3 nerved, fimbriate, ciliate; stamens 3, filaments free, short, anthers yellow, 0.4-0.5 cm long; ovary glabrous, globose; style short with 2 plumose stigma. Fruit a caryopsis.

Distribution and ecology: It is distributed in South India and Sri Lanka at high altitudes. In South India, it is growing in Munnar on the way to Anamudi and Berijam from 1600-2200 m. It is a component of semi-evergreen forests and sholas. It flowers sporadically in summer months.

Specimens examined: KERALA: Idukki Dist. Mannavan Shola, *K Kishore Kumar 16401* (KFRI); Mannavan Shola, *M Remesh & N Unnikrishnan 20617* (KFRI); Mannavan Shola, *M Kumar & Stepher 7890* (KFRI); Munnar, *M Remesh & Stephen Sequiera 20639* (KFRI); Munnar, Top Station, *M Remesh & N Unnikrishnan 20738* (KFRI); Munnar, Top Station, *N Unnikrishnan 74023* (CALI); Way to Anamudi, *N Unnikrishnan 74026* (CALI). TAMIL NADU: Madurai Dist. Kodaikanal, Tiger Shola, *M Remesh & N Unnikrishnan 20616* (KFRI).

Note: During the study, it was collected from Anamudi hills. Specimens that are very similar to this species were collected from Palani hills, Tamil Nadu. The habit, leaves and culm sheaths of this specimen resembles with *A. floribunda.*

Arundinaria walkeriana Munro, Trans. Linn. Soc. London 26: 21. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 3.1896 & in Hook. f., Fl. Brit. India 7: 377, t.1. 1897; Brandis, Indian Trees 664. 1906; E. G. Camus, Les Bamb. 27. 1913; Rama Rao, For. Pl. Travancore 446. 1914; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1857.1934; Blatt., Indian For. 55(10): 542. 1929; Soderstr. & R.P. Ellis, Smith. Contr. Bot. 72: 24. 1988 [Figures 8 and 9; Plate 8].

Type: Sri Lanka, *Walker 96* (lectotype, K. selected by Soderstrom & Ellis, 1988).

Sinarundinaria walkeriana (Munro) Chao & Renvoize, Kew Bull. 44.354.1989; Seethalakshmi & M. Kumar, Bamb. India Comp.287. 1998.

Indocalamus walkerianus (Munro) Nakai, J. Arn. Arb. 6: 148. 1925; Tewari, Monogr. Bamb. 101. 1992.

Yushania walkeriana (Munro) R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 282. 1989; Ohrnberger, Bamb. World 165. 1999.

A small dense, shrubby bamboo with caespitose, gregarious, densely placed culms. Rhizomes sympodial, pachymorph, short necked. Culms erect, self supporting hollow, 1.5-3 m tall; node slightly swollen, sheath scar and supranodal ridge prominent, a single nodal bud on each node, enclosed by prophyllum; internodes smooth, 0.5-1.2 cm long, 1-1.2 cm diameter, pale green; culm sheath 4-6 cm long, 1-2.6 cm broad at base, papery, coriaceous, densely covered with golden brown, bulbous based hairs when young, striate, sparsely hirsute, deciduous when old, mature sheaths almost smooth towards the tip; blade erect, 1-2 cm long, 0.2-0.4 cm broad at base, narrow towards the apex, margin ciliate, tip acute, spiny; auricles not prominent, oral setae delicate, silky; inner ligule prominent 0.1-0.2 cm high, outer ligule not prominent; branches arise from the lower nodes, the central axis and two laterals develop first, later lateral buds develop to form 25-30, subequal branches; leaves 6-10 cm long, 1.5-3.5 cm wide, ovate-lanceolate, glabrous on both side, transverse veinlets, prominent, tessellate venation, margins cartalagenous, scabrous, tip strongly spinose, scabrous, midrib prominent on the lower sides, base attenuate, leaf almost sessile; leaf sheath imbricate, striate, glabrous; auricles inconspicuous, with delicate bristles, deciduous; inner ligule 0.1-0.2 cm high, membranous, plicate. Inflorescence a spreading, terminal, compound panicle, terminal on leafy branches, branches glabrous, filiform and wavy with pulvini at the axils towards the upper surface, pressed together when young and later become spreading; spikelets 3-4 flowered, purplish, 2-2.5 cm long, upper most sterile, smallest, rachilla segment narrow, flat and glabrous below, expanded, faintly swollen and densely pubescent where the spikelets are attached; sterile glumes 2, 0.3-0.4 cm long, ovate or ovate-lanceolate, the first glume shorter than the second, mucronate; fertile glumes, lemma lanceolate, mucronate, ciliate long the margins, glabrous, many nerved, 0.6-0.7 cm long; palea almost equal to lemma, thin, 2-keeled

Plate 8. ***Arundinaria walkeriana*** Munro **A.** habit; **B.** culm with branches; **C. & D.** young shoot with sheath; **E.** inflorescence

Figure 8. *Arundinaria walkeriana* Munro **A.** leafy branch; **B.** culm sheath; **C.** flowering branch

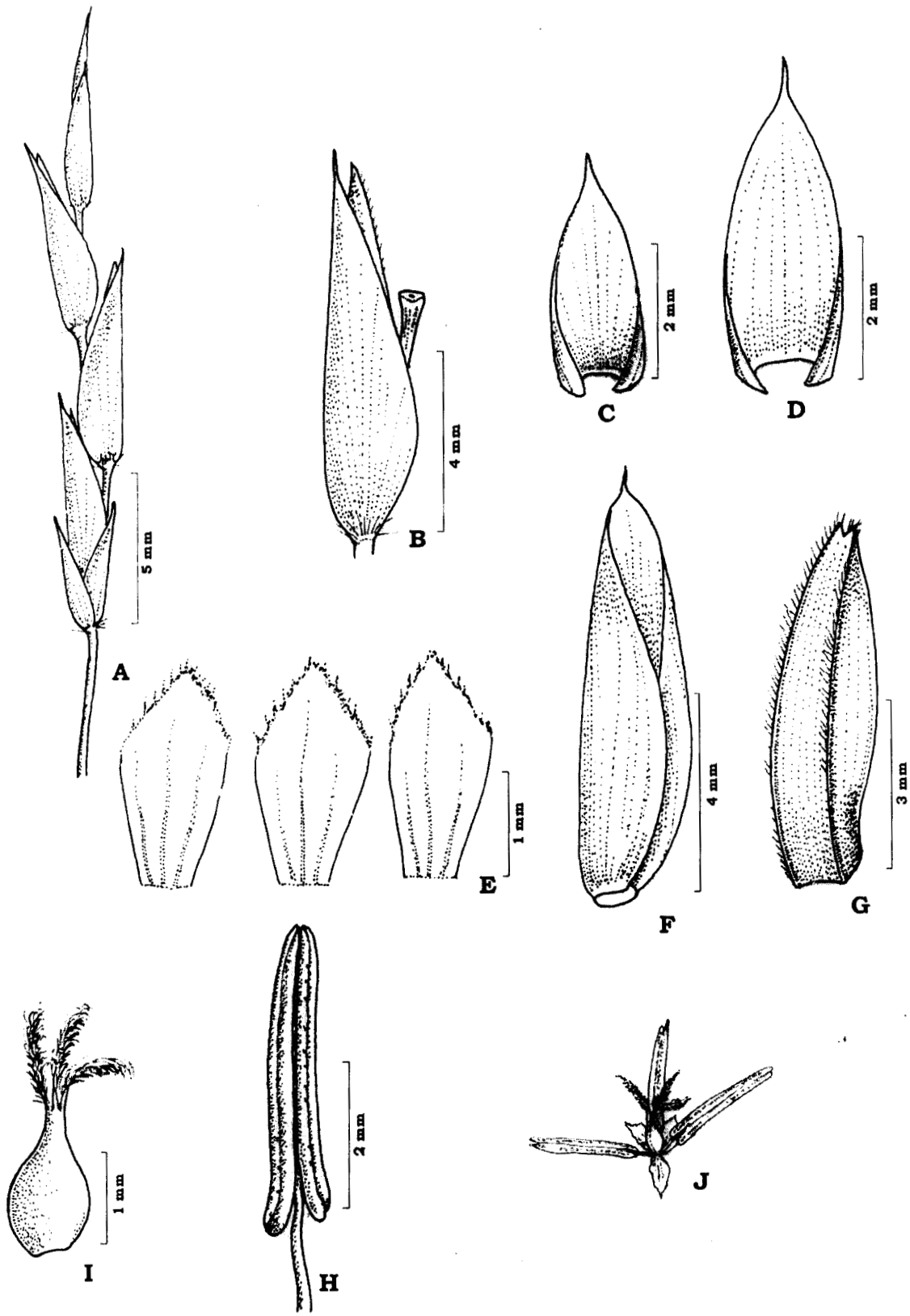


Figure 9. *Arundinaria walkeriana* Munro **A.** spikelet; **B.** floret; **C. & D.** sterile glumes; **E.** lodicules; **F.** lemma; **G.** palea; **H.** stamen; **I.** ovary with style; **J.** open floret (diagrammatic)

and with 2 wings, keels ciliate, the apex part between the keels, minutely pubescent, bifid at the tip, ciliate, 0.4-0.6 cm long; lodicules 3, almost of equal size, hyaline, up to 0.2 cm long, 2-3 nerved, margins fimbriate, ciliate; stamens 3, filaments free, short, yellowish, 0.3-0.4 cm, obtuse; ovary glabrous, swollen, style short, stigma 3, feathery. Fruit a caryopsis with a short beak, slightly sulcate on one side.

Distribution and ecology: *A. walkeriana* is distributed in South India and Sri Lanka. It is found growing from an elevation of 1800-2200. In South India, it is found growing in Agasthyamala and Eravikulam. Flowers sporadically in summer months. It grows in grasslands and also as undergrowth in semi-evergreen forests.

Specimens examined: KERALA: Idukki Dist. Eravikulam, *Manju C Nair 20648* (KFRI); Kottamala, *Jomy Augustine 17779* (CALI). Trivandrum Dist. Agasthyamala, *N Mohanan 4283* (CALI); Agasthyamala, *N Unnikrishnan 74044* (CALI).

Arundinaria wightiana Nees, Linnaea 9: 182. 1834; Munro, Trans. Linn. Soc. London 26: 19. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 4, t. 2. 1896 & in Hook. f., Fl. Brit. India 7: 377. 1897; Brandis, Indian Trees 664. 1906; Bourd., For. Trees Travancore 397. 1908; E. G. Camus, Les Bamb. 28. 1913; Rama Rao, For. Pl. Travancore 446. 1914; Blatt., Indian For. 55(10): 542. 1929 [Figures 10 and 11; Plate 9].

Type: India, Nilgiri, *Wight* 1797 (lectotype CAL !. Isolectotype K. designated here).

Arundinaria wightiana var. *hispida* (Steud.) Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 5.1896.

Indocalamus wightianus (Nees) Nakai, J. Arnold Arbor. 6: 149. 1925; Bahadur, Ind. J. For. 2: 240. 1979; Tewari, Monogr. Bamb. 103. 1992.

Yushania wightiana (Nees) R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 283. 1989; Ohrnberger, Bamb. World 166. 1999.

Sinarundinaria wightiana (Nees) Chao & Renvoize, Kew Bull. 44: 356. 1989; Seethalakshmi & M. Kumar, Bamb. India Comp.289. 1998.

Typification: This species was first collected by Wight from Nilgiris. This specimen was deposited at CAL. A duplicate of this specimen was deposited at K and typified by Chao and Renvoize (1989) as isotype. The specimen at CAL with the number 1797 is designated here lectotype and the specimen deposited at K with the same number is designated isolectotype [Plate 10].

A gregarious shrubby bamboo with erect slender culms. Rhizome sympodial, pachymorph, solid, short necked. Culms erect, self supporting, hollow, 2.5-4 m tall; node swollen, sheath scar and supranodal ridge prominent, sheath scar clothed by hairs to form a ring at the nodal region, a branch bud is present on each node enclosed inside prophylllum; internodes 20-35 cm long, 0.8-1.7 cm diameter, slightly flattened on one side, yellowish-brown, smooth below, rough towards the summit; culm sheaths thin, papery, 11-15 cm long, golden yellow coloured, hirsute with bulbous based golden brown hairs when young, base with a ring of golden brown hairs, sparsely hirsute, deciduous when old; blade erect or reflexed, 2.5-3 cm long, 0.3-0.6 cm broad at base, narrow, deciduous, scabrid; auricle inconspicuous with delicate bristles, bristles deciduous; inner ligule short, often fimbriate, outer ligule not prominent; branches arise from the lower nodes, numerous, sometimes up to 50, subequal, semiverticillate on the nodes; leaf arise on branches, linear-lanceolate, glabrous on both sides, scabrous along the veins on the lower side, 6-17 cm long, 0.8-2 cm broad, midrib prominent on the lower side, margins scabrous, tessellate venation, tip acute, base attenuate, petiole short; leaf sheaths imbricate, striate, hirsute, keeled, margins ciliate, tip with a short auricle and stiff bristles; inner ligule very short, dentate, outer not prominent. Inflorescence a dense open panicle borne at leafy branches, terminal, rachis hairy, axils of branchlets glandular; spikelets 2-3 flowered, rarely 4, purple coloured, hirsute, 1.5-1.8 cm long, the terminal flower sterile; rachilla flat, ciliate and thick at the summit; sterile glumes 2, 0.4-0.5 cm long, 4-5 nerved, almost of the same size, ovate-acute; fertile glumes, lemma ovate-acuminate, mucronate, hispid towards the apex, 0.5-0.7 cm long; palea ovate, bifid at apex, two keeled, hirsute along the keels, slightly sulcate between the keels with transverse nerves, 0.4-0.5 cm long; lodicules 3, 0.1-0.2 cm long, ovate-obtuse, almost of the same size, 2-3 nerved, hyaline, margins fimbriate, ciliate; stamens 3; filaments free, short; anthers yellowish-brown, 0.4-0.5 cm long;

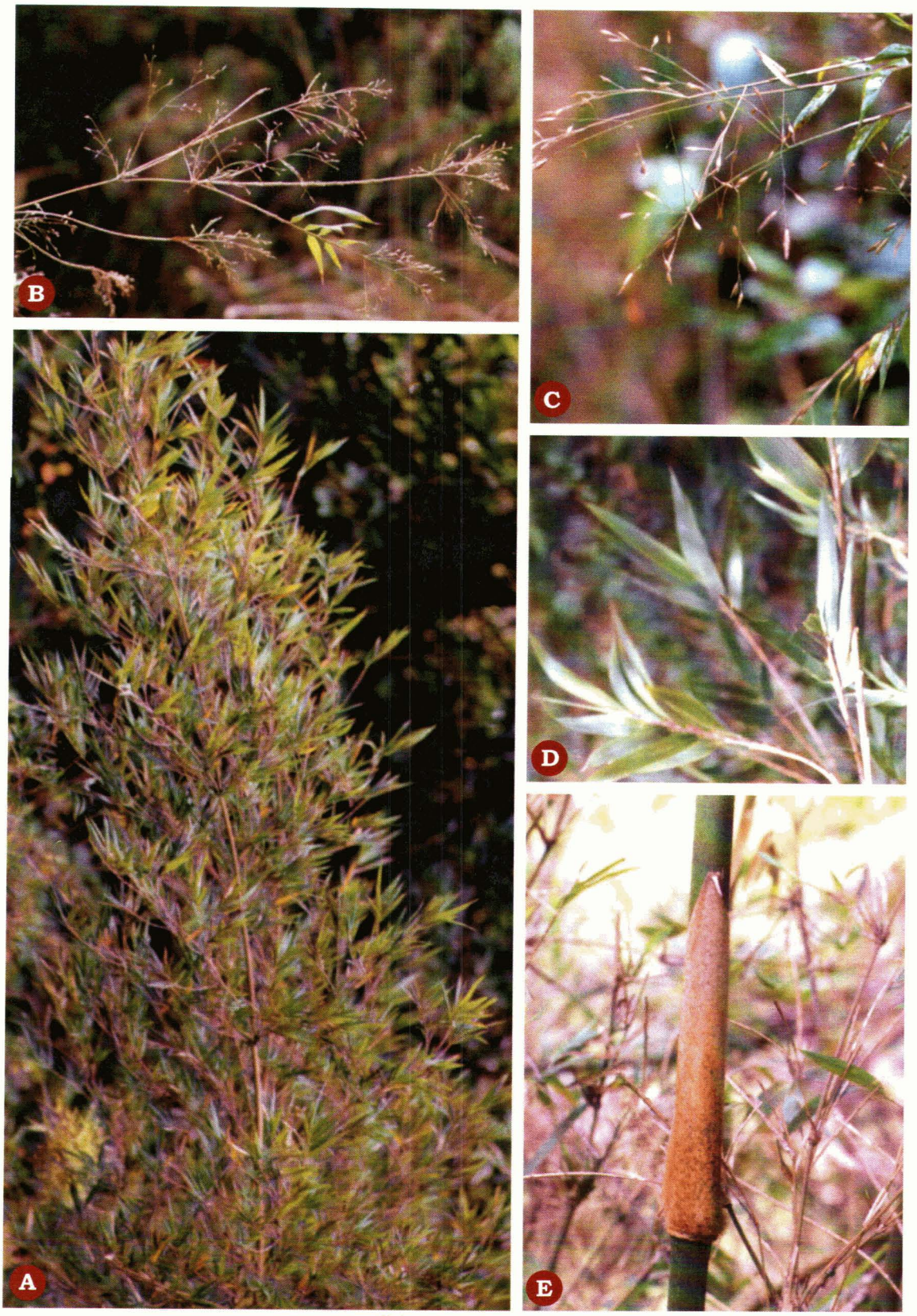


Plate 9. ***Arundinaria wightiana*** Nees **A.** habit; **B. & C.** flowering; **D.** branches; **E.** sheath

Plate 10. ***Arundinaria wightiana*** Nees - lectotype (CAL)

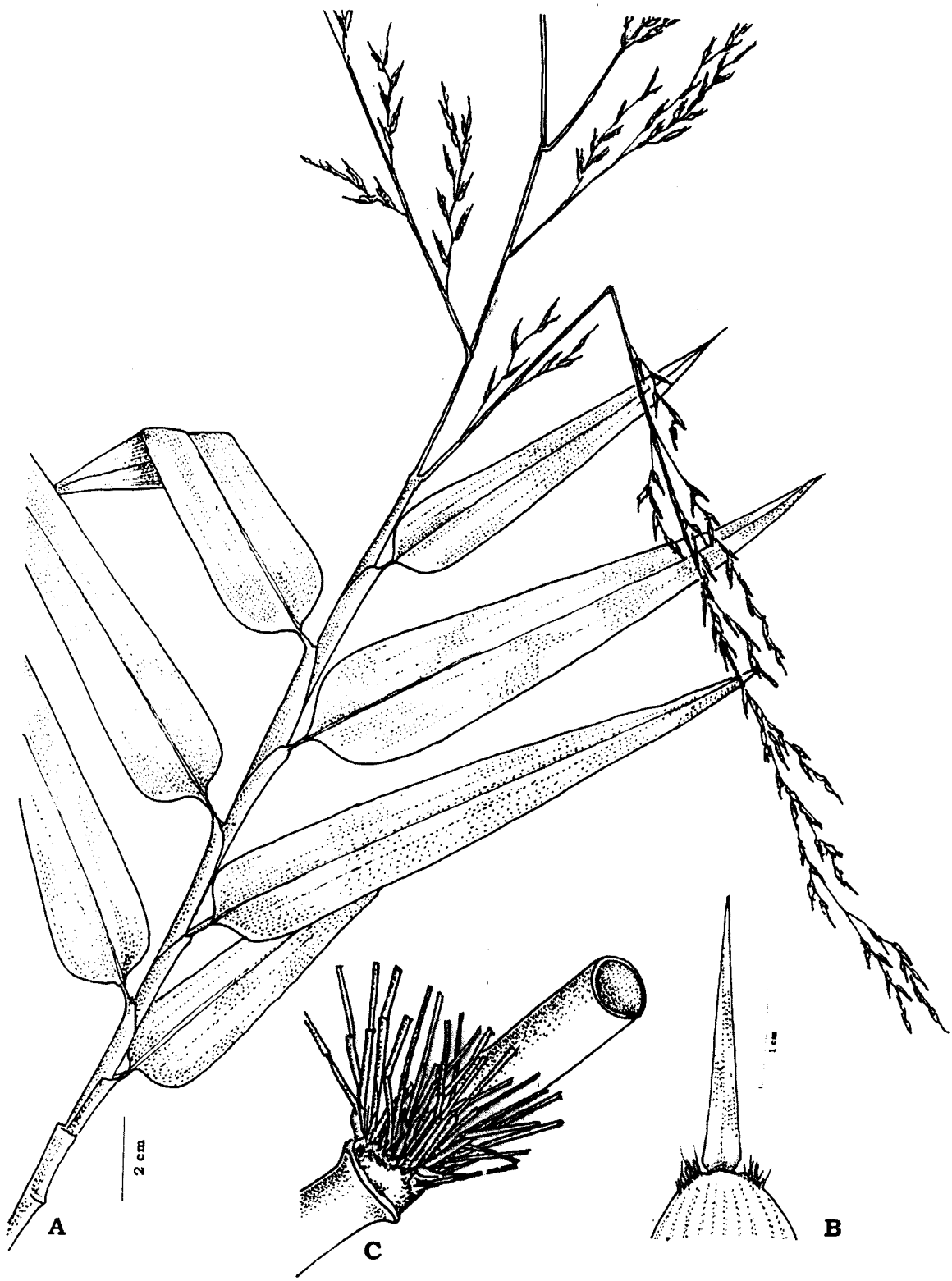


Figure 10. *Arundinaria wightiana* Nees **A.** flowering branch; **B.** culm sheath; **C.** branching

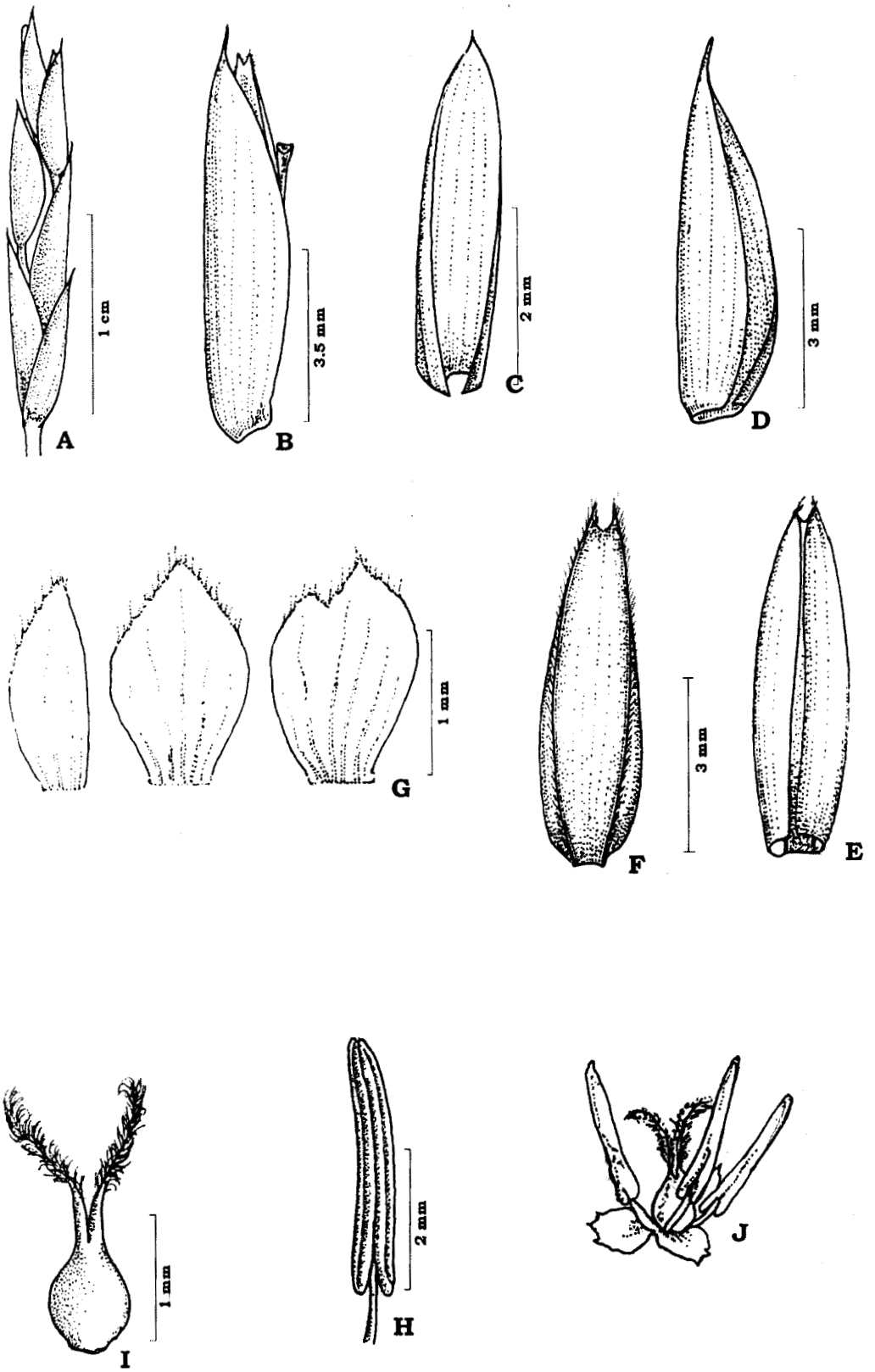


Figure 11. *Arundinaria wightiana* Nees **A.** spikelet; **B.** floret; **C.** sterile glumes; **D.** lemma; **E.** palea-inner side; **F.** palea-surface view; **G.** lodicules; **H.** stamen; **I.** ovary with style; **L.** open floret (diagrammatic)

ovary glabrous, globose; style short, entire at the base, forming two plumose stigmas. Fruit a caryopsis, elliptic, acute, sulcate on one side.

Distribution and ecology: This is a high altitude bamboo distributed in South India and endemic to this phytogeographical area. It grows in open mountaintops and also a component of semi-evergreen forests and sholas. In South India, it is common in the Nilgiri Biosphere Reserve, from 1800-2400 m. Flowering starts in summer and sporadic flowering is common, gregarious flowering was observed in 2000 at Nilgiris.

Specimens examined: KERALA: Palakkad Dist. Sispara, *JS Gamble 13359* (DD); Sispara, *M Remesh & TR Viswakumar 20647* (KFRI); Mutthikulam, *M Remesh & Stephen Sequiera 20713* (KFRI). TAMIL NADU: Nilgiri Dist. Dodapetta, *JS Gamble 20724* (DD); Dodapetta, *JS Gamble 20733* (MH); Dodapetta, *JS Gamble 20733* (CAL); Dodapetta, *JS Gamble 17453* (CAL); Dodapetta, *M Remesh & N Unnikrishnan 20618* (KFRI); Dodapetta, *N Unnikrishnan 74010* (CALI); Coonoor, *JS Gamble 11997* (DD); Coonoor, *JS Gamble 11797* (MH); Nilgiris, *RH Beddome 88778* (CAL); Nilgiris, *RH Beddome* (s.n.) (MH); Mukkuruthi, *M Remesh & Stephen Sequiera 20623* (KFRI).

Uses: Local people use it for making huts, for fencing and leaves for thatching.

Subtribe: **Bambusinae** J. Presl

Bambusinae J. Presl, Rel. Haenk. 1: 256. 1830; Clayton & Renvoize, Kew Bull. Addl. ser. 13, 48. 1989; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Proc. Int. Symp. Grass Syst. Evol. 234. 1987; S. Dransf. & Widjaja (eds.), Plant Reso. S. E. Asia 7: 34. 1995; Ohrnberger, Bamb. World 19. 1999.

Type: *Bambusa* Schreb.

Bambusoidea Munro, Trans. Linn. Soc. London 26: 131. 1868.

Dendrocalaminae Benth., J. Linn. Soc. Bot. 19: 31. 1881.

Eubambuseae Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 28. 1896.

Hickeliinae E. G. Camus, Compt. Rend. Acad. Sci. 179: 480. 1924.

Perennial, medium sized or arborescent plants with caespitose, gregarious habit. Rhizomes sympodial, pachymorph, woody. Culms woody, erect sometimes climbing, hollow or sometimes solid, armed or unarmed; culm

sheath usually deciduous; branching intravaginal at midculm nodes, primary branch buds solitary; leaves linear-lanceolate, pseuodpetiolate, sometimes deciduous. Inflorescence rarely simple, usually compound panicle, indeterminate, composed of pseudospikelets; spikelets form heads, semiverticillate clusters or loosely packed, 2-many-flowered, upper most floret usually reduced; sterile glumes usually 2, palea sometimes 2-keeled; lodicules 3, rarely two or lacking; stamens 6, sometimes 3; filaments free or united; ovary broadly conical, glabrous or hairy; stigma three, plumose, style short; sometimes long. Fruit a caryopsis.

This subtribe includes many genera. The members of this large subtribe occur in the Old World tropics from Africa to India, South East Asia and China to northern Australia. They usually grow at low elevations. The members are with sympodial rhizomes and loose to dense clumps with hollow to solid culms. The major genera are *Bambusa* and *Dendrocalamus*. Some of the genera distributed under this subtribe may be congeneric with *Bambusa* and *Dendrocalamus*. In South India, this subtribe is represented by three genera, *Bambusa, Dendrocalamus* and *Oxytenanthera.*

Bambusa Schreber

The origin of the generic name *Bambusa* is from Bambu or Bamboe, which has an Indo-Malayan origin. It may be also a modified version of the word Mambu or Tabashir-mambu which is a Silicaceous Substance present in the hollow internodes of some bamboos. It is considered as medicinal and was exported to Europe and Persian countries.

It was originally described by Schreber (1789). When this name was proposed Schreber gave generic description only and cited no species. Later, he referred to *Bambos* Retzius as a synonym, without mentioning a species. The names *Bambusa* and *Bambos* were published in the same year and *Bambusa* was accepted as the correct name (Holttum, 1958).

In India, this genus is naturally represented by seven species. In South India, it was known to represent by one species and one variety, *Bambusa bambos* and *B. bambos* var. *gigantea.* In the present study, the variety *Bambusa bambos* var. *gigantea* is synonymised and one species is treated under this genus.

Bambusa Schreb., Caro. Linn. Gen. Pl. 1: 236. 1789; Munro, Trans. Linn. Soc. London 26: 87. 1868; Bedd., Fl. Sylv. S. India 3: 231. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 28. 1896 & in Hook. f., Fl. Brit. India 7: 395. 1897; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1858. 1934; Holttum, Bamb. Malay. Penin. Gar. Bull. 16: 27. 1958; Clayton & Renvoize, Kew Bull. Addl. ser. 13, 53. 1989; Wong, Bamb. Penin. Malaysia 41: 84. 1995; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 17, 34. 1995; Zhu Shilin *et al.* (eds.), Comp. Chinese Bamb. 25-53. 1994; Seethalakshmi & M. Kumar, Bamb. India Comp.31. 1998; Ohrnberger, Bamb. World 250. 1999.

Type: *Bambusa bambos* (L.) Voss.

Arundoarbor Rumph., Herb. Amboin. 4: 2-18. 1743.

Bambos Retz., Obs. Bot. 5 : 24. 1788.

Bambusa sect. Leleba Kurz, J. Asiat. Soc. Bengal n.s. 39(2): 87. 1870.

Trees, shrubs or sometimes climbing. Rhizomes sympodial. Culms erect, stout or slender, closely or fairly close, tufted; branches several to many, one dominant, sometimes with recurved branch-thorns at the node. Inflorescence iterauctant, composed of pseudospikelets, usually glumaceous, sometimes spathaceous; spikelets 2-many flowered, upper most 1 or 2, usually imperfect, rachilla jointed at the base of each fertile lemma, lemmas broad and many veined; palea 2-keeled; lodicules 2 or 3; stamens 6, filaments usually free, anthers sometimes apiculate with a tuft of hairs at the top; ovary hairy at the apex, with a long or short style and 1-3 slender, hairy stigmas; fruit a caryopsis, almost cylindric, hairy at top, slightly sulcate along the hilum.

Distribution and ecology: It is an Old World genus, distributed in the tropics and subtropics. *Bambusa* is distributed in India, Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, Vietnam, China, Thailand, Japan, Malaysia, Singapore, Indonesia, Philippines, Papua New Guinea, Australia and Madagascar. In Australia, Madagascar and Africa, it is introduced under cultivation.

This genus can grow in a wide range of climatic and soil conditions. Some of the species are drought resistant and grow under dry climatic conditions. It is found growing from sea level to an altitude of 1300 m.

Bambusa bambos (L.) Voss. in Vilm., Blumeng. ed. 3, 1: 1189. 1896; Soderstr. & R.P. Ellis, Smith. Contr. Bot. 72: 19, t.30. 1988; Bennet & Gaur, Thirty Seven Bamb. India 19. 1990; Tewari, Monogr. Bamb. 33. 1992; Wong, Bamb. Penin. Malaysia 86. 1995; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 56. 1995; Xia & Stapleton, Kew. Bull. 52(3): 693. 1997; Seethalakshmi & M. Kumar, Bamb. India Comp.40. 1998 [Figures 12 and 13; Plate 11].

Type: Sri Lanka, Hermann fol.15, s.loc. Arundo indica maxime cortice spinoso Tabaxir fundens. Mambu & Bambu dicta Arundo arbor B.Pin. Unaghas. (lectotype L. selected by Xia and Stapleton, 1997)

Arundo bambos L., Sp. Pl. 81. 1753.

Bambusa bambos (L.) Voss. var. *gigantea* (Bahadur & Jain) Bennet & Gaur, Thirty seven bamboos India 21. 1990. **syn. nov.**

Bambos arundinacea Retz., Obs. Bot. 5: 24. 1788; Roxb., Pl. Corom. Coast 1: 56. 1798.

Bambusa arundinacea (Retz.) Willd., Sp. Pl. 2, 1: 245. 1799; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 51, t.48. 1896; Holttum, Gard. Bull. Singapore 26: 59. 1958; Bedd., Fl. Sylv. S. India 231. 1873; Gamble in Hook. f., Fl. Brit. India 7: 395. 1897; Talbot, For. Fl. Bombay Pres. Sind. 2: 566. 1912; Blatt., Indian For. 55(10): 556. 1929; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1859. 1934; Brandis, Indian Trees 671. 1906.

Bambusa arundinacea (Retz.) Willd. var. *gigantea* Bahadur & Jain, Indian J. For. 4: 283. 1981.

Vernacular names: Mula, Mullumula, Illy, Eanimula, Paruva (Malayalam); Mungil (Tamil), Bongu veduru, Mulla veduru (Telugu)

A tall arborescent, densely tufted, caespitose, gregarious, thorny bamboo. Rhizome sympodial, pachymorph, solid with short neck. Culm erect, strong, hollow, 25-35 m tall, branches arise from the base, lower nodes with aerial roots; nodes slightly swollen, sheath scar prominent, bearing a single nodal bud, enclosed by prophyllum; internodes 20-47 cm long, 6-18 cm diameter, wall thick, sometimes solid under dry conditions, smaller culms flattened on one side when young, sparsely covered with white powdery mass, bright green; culm sheath 12-45 cm long, 10-36 cm broad at base, coriaceous, dark maroon

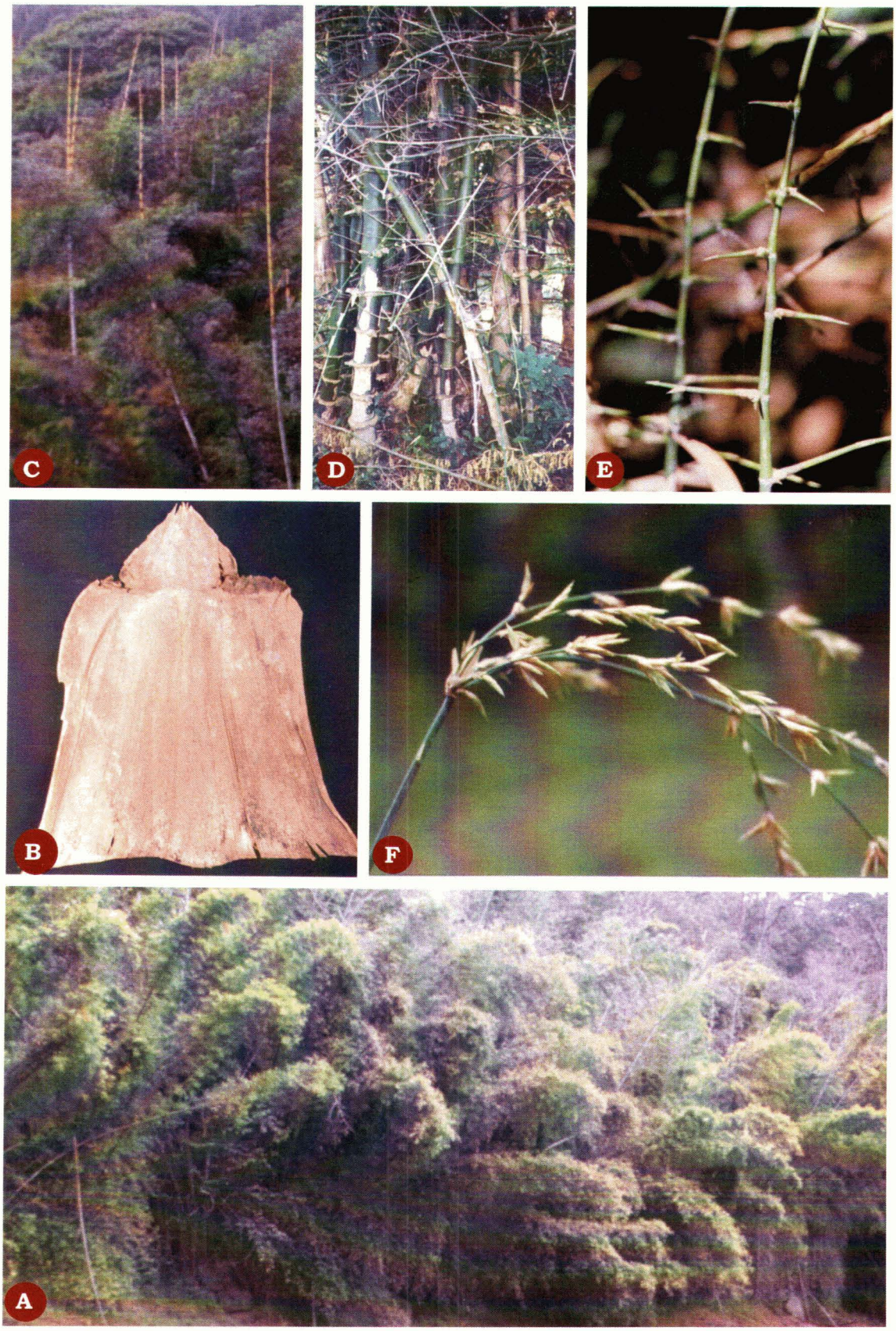


Plate 11. ***Bambusa bambos*** (L.) Voss. **A.** habit; **B.** culm sheath; **C.** young shoot; **D.** culms; **E.** thorns; **F.** inflorescence

Figure 12. *Bambusa bambos* (L.) Voss. **A.** leafy twig; **B.** culm sheath; **C.** inflorescence

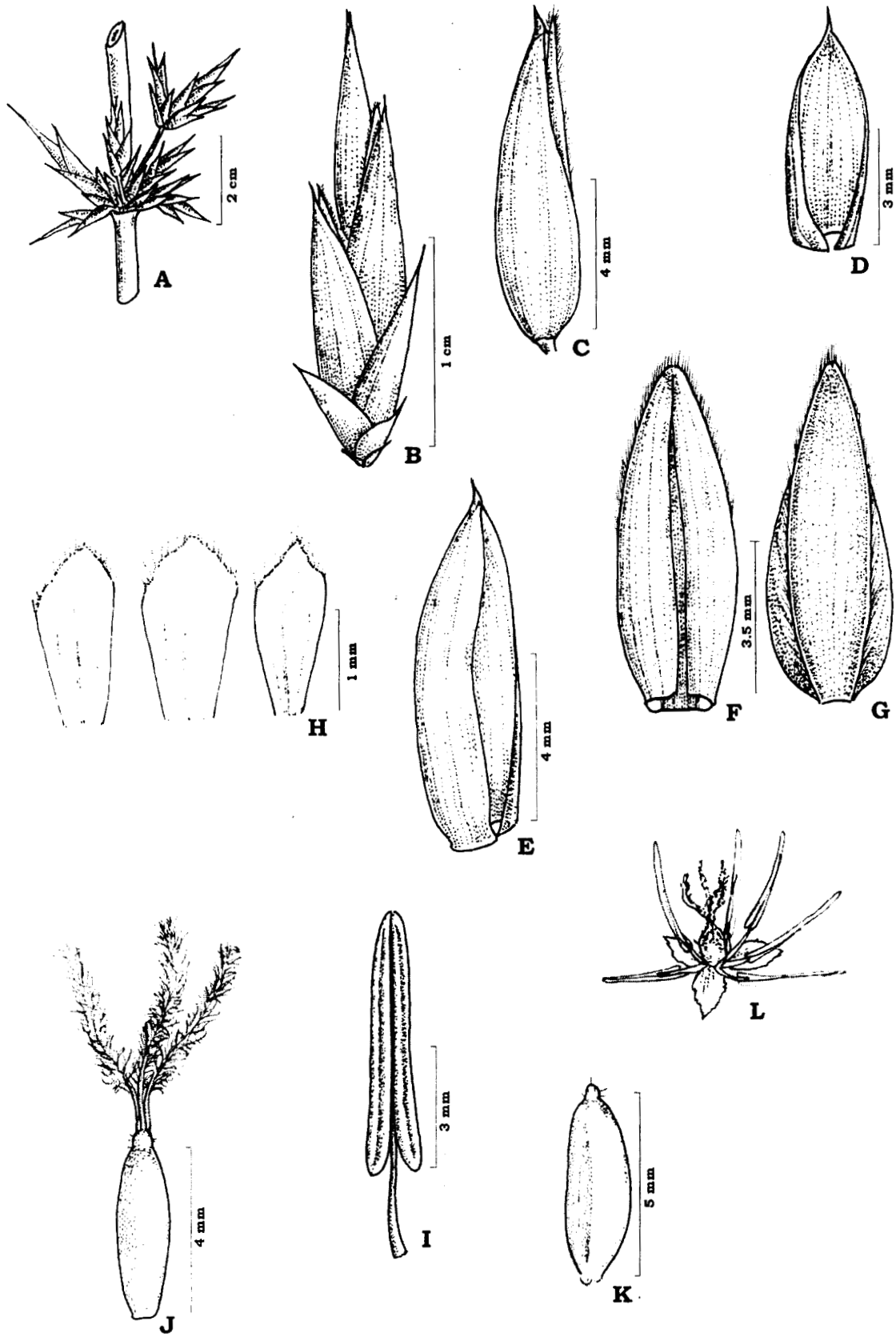


Figure 13. *Bambusa bambos* (L.) Voss. **A.** portion of inflorescence; **B.** spikelet; **C.** floret; **D.** sterile glume; **E.** lemma; **F.** palea-inner side; **G.** palea-surface view; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

or yellowish, thickly covered with bulbous based brown hairs when young, become glabrous when old, striate, broad, sides almost parallel, tip truncate, wrinkled at the summit, this portion thickly covered with brown tomentum, sometime bear thick marginal bristles, deciduous when the branches develop; blade erect, triangular, the base decurrent on the margins of the sheath, outer surface glabrous, except at the wrinkled portion, inner side covered by velvety dark brown, appressed hairs, 5-10 cm long, 6-12 cm broad at base, margins involute, sharply pointed, persistent, much shorter than the sheath; auricle absent; inner ligule a short brown ciliate membrane, outer ligule not prominent; branches develop from the lower nodes, the central dominant branch develop first, 2-3 laterals produced from its lower nodes, some of the braches recurved and bend downward, become spine like, spines also develop from the nodes of branches, sometimes on leafless branches, the spiny branches become long, whip-like drooping and form a dense cluster or tuft of branches around the plant; leaves 6-20 cm long, 0.6-1.8 cm wide, linear-lanceolate, glabrous on both sides, scabrous along the margins, midrib clear on the lower surface, tip pointed, acuminate, base attenuate, narrows to a short flat petiole; leaf sheath overlapping, striate, glabrous, auricle very short, oral setae soft, deciduous. Inflorescence a very large panicle, at first on terminating leafy branches, then spread all over the plant, in small clusters at the nodes of leafless branches, composed of pseudospikelets; spikelets sessile, 1.8-2 cm long, supported by 2-3 bracts, cauducous, glabrous, lanceolate, acute, consisting of 3-4 fertile flowers and 1-2 sterile flowers, rachilla internodes very short, often not visible, stiff, glabrous, angular, sterile glume 0.4-0.5 cm long, ovate, mucronate, glabrous on back, short hairy near the apex, many nerved; fertile glume, lemma 0.6-0.8 cm long, ovate-lanceolate, many nerved, glabrous, ciliate on the margins, mucronate; palea 0.6-0.7 cm long, almost equal in length to lemma, 2-keeled, keels ciliate, broadly winged, tip obtuse, ciliate; lodicules 3, 1-1.3 cm long, almost equal, obovate, hyaline, 3-4 nerved, apex acute, margin fimbriate, ciliate; stamens 6, free; filaments long, anthers 0.5-0.6 cm long, basifixed, yellow, exserted. Ovary elliptic, glabrous below, hairy at the tip, style very short, ciliate, tip divides to 3, long, plumose stigma. Fruit a caryopsis, elliptic, 0.5-0.6 cm long, glabrous, grooved on one side, short beaked, beak ciliate.

Distribution and ecology: This species is distributed in India, Southern China, Thailand, Burma, Java, Singapore, Peninsular Malaysia, Philippines and Sri Lanka. In South India, it is widely distributed in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Under dry conditions the culms become solid and stunted in growth, leaves become small and sometimes deciduous. At places where water is available it shows a luxuriant growth, becomes 30-35 m tall and 60-80 or sometimes more than 100 culms per clump. The drooping spiny branches make an impenetrable thicket. It is a major component of moist deciduous forests and occupies large areas and also form bamboo breaks. In Tamil Nadu and Andhra Pradesh, it grows in vast areas under dry climatic conditions. It is a highly resistant species having a wide distribution under different climatic as well as soil conditions. It is found growing from sea level to an elevation of 1200 m. It has a long flowering cycle. Sporadic flowering was observed at many places. Gregarious flowering was observed at Marayur, Idukki district; Parambikulam, Palakkad district and Nilambur, Malappuram district.

Specimens examined: ANDHRA PRADESH: Ananthapur Dist. Ananthapur, *N Unnikrishnan 74105* (CALI). Chittoor Dist. Mamandur, *D Rangacharyulu 1291* (MH). Cuddapah Dist. Siglabyle, *JS Gamble 20860* (DD); Lankamalai RF, *SRS Reddy 13176* (SKU). East Godavari Dist. Bhupatipalam, *T Pullaiah & MN Gayathri* 12249 (SKU). Krishna Dist. Enamadala, *P Venkanna 5510* (MH). Visakhapatnam Dist. Arkavalley, *N Unnikrishnan 74103* (CALI). KARNATAKA: Kodagu Dist. Sonwarpet, *AS Rao 85506* (BSI); Vir Rajapetta, *N Unnikrishnan 74201* (CALI). Mysore Dist. Bandipur RF, *BD Naithani 23139* (MH). KERALA: Idukki Dist. Mullakkudy, *BD Sharma 43848* (MH). Kannur Dist. Pariyaram, *R Ansari 67868* (MH); Panathur, *VJ Nair 59951* (MH). Kollam Dist. Punalur, *CN Mohanan 5579* (MH). Malappuram Dist. Nilambur, *SK Jain 22748* (DD); Malaparamba, *VV Sivarajan 144* (CALI). Palakkad Dist. Panthanthode, *E Vajravelu 33125* (MH). Kottayam Dist. Changanassery, *VJ Antony 1150* (MH). Thrissur Dist. Shornur, *EK Janakiammal* (s.n.) (DD); Athirapally, *BV Shetty 33496* (MH). Wayanad Dist. Sulthan Bathery, *JL Ellis 18680* (MH); Thirunelli, *M Remesh & SKM Basheer 20702* (KFRI); Kottiyur, *N Unnikrishnan 74211* (CALI). TAMIL NADU: Chennai Dist. Adayar, *JS Gamble 207603* (DD). Coimbatore Dist. Bennai RF, *KN Subramanian 135* (DD); Siruvani, *AN Henry 693* (MH). South Arcot Dist. South Arcot, *CA Barber 1000* (MH). Thirunelveli Dist. Courtallam, *KKN Nair 1192* (CALI).

Uses: It is a multipurpose bamboo with wide range of uses. The culms are used for construction, for making scaffoldings, ladders, supports and other household articles. The ladders made of its culms are extensively used for climbing coconut palms in Kerala. Young shoots are edible and seeds can be used as food. Tribes use the culms for making bow. Leaves are medicinal and used for blood purification, for the treatment of leucoderma, bronchitis and fever. Leaves are also used as fodder. It is an industrial raw material for making pulp, paper and plywood.

Note: *Bambusa arundinacea* var. *gigantea* was first described as *B. arundinacea* var. *gigantea* by Bahadur and Jain (1981). Later, the nomenclature was changed to *B. bambos* var. *gigantea*. According to the protologue this is a giant bamboo having a very restricted distribution. It was reported from Palakkad district of Kerala. This species was published without an illustration. No type material was cited.

In 2001, this species flowered at Chittoor Dam site, Palakkad district, Kerala. The detailed study of the flowers showed that it has no difference from *Bambusa bambos* in floral characters. The only difference, is in the size of the plants. *Bambusa bambos* of large size was found distributed in some undisturbed areas of Wayanad district, Kerala. The plants in the FRI campus, Dehra Dun, under cultivation were also studied. These plants were mentioned by Bennet and Gaur (1990). It was not able to find any difference between *Bambusa bambos* and the variety *B. bambos* var. *gigantea*. The size difference may be due to the edaphic and climatic conditions and a varietal status cannot be assigned.

Because of the above reasons, in this work *Bambusa bambos* var. *gigantea* is considered as a synonym of *Bambusa bambos*.

Subtribe **Bambusinae** J. Presl

Dendrocalamus Nees

The term *Dendrocalamus* was derived from Greek, *'Dendro'* means tree and *'kaliimos'* mean reed.

This genus was first described by Nees (1834). This generic concept was followed by Munro (1868), Bentham (1883) and Gamble (1896). This genus is closely related to *Bambusa* but can be distinguished by the presence of single-keeled prophylls throughout the inflorescence (Stapleton, 1994a). The inflorescence is highly branched and forms compact capitulum. The spikelets are short with long styles and no lodicules.

Dendrocalamus Nees, Linnaea 9(4): 476. 1834; Munro, Trans. Linn. Soc. London 26: 146. 1868; Bedd., Fl. Sylv. S. India 3: 235. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 77. 1896 & in Hook. f., Fl. Brit. India 7: 403. 1897; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1857. 1934; Holttum, Bamb. Malay. Penin. Gar. Bull. 16: 29. 1958; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Proc. Int. Symp. Grass Syst. Evol. 235. 1987; Clayton & Renvoize, Kew Bull. Addl. ser. 13, 54. 1989; Stapleton, Edinb. J. Bot. 51(1): 20. 1994; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 17. 1995; Seethalakshmi & M. Kumar, Bamb. India Comp. 99. 1998; Ohrnberger, Bamb. World 282. 1999.

Type: *Dendrocalamus strictus* (Roxb.) Nees

Klemachloa Parker Indian For. 58: 7. 1932.

Sinocalamus McClure, Lignan Univ. Sci. Bull. 9: 66. 1940.

Neosinocalamus Keng. f., J. Bamb. Res. 2: 148. 1983.

Medium sized to arborescent forms. Rhizome woody, sympodial, pachymorph. Culms strong, erect, usually thick walled, sometimes solid, unarmed; culm sheath blades usually reflexed, narrowly triangular, deciduous; branch compliments several, the primary branch dominates. The inflorescence is iterauctant, densely capitate, spiky globose mass on bare branches, composed of pseudospikelets; spikelets 1-6-flowered, with or without rachilla extension and rudiment; glumes 2-3; palea 2 keeled or imperfectly keeled; lodicules 0; stamens six; the filaments usually free. Caryopsis ovoid to sub-globose.

Distribution and ecology: The members of this genus are distributed in the tropics and subtropics. They are found growing in tropical Asia, different parts of China, throughout India, Myanmar, Malaysia, Philippensis and Papua New Guinea. In India, six native species are distributed.

In South India, this genus was known to represent by one species. In the present study, a new combination is needed under the genus *Dendrocalamus* and is included here.

Key to the species of ***Dendrocalamus***

1a. Culms tomentose, without powdery mass when young, culm sheath with prominent auricle and persistent bristles, blade narrow, lanceolate, spikelet glabrous, thin, lanceolate.....**D. stocksii**

1b. Culms glabrous with white powdery mass on the surface when young, culm sheath with inconspicuous auricle and bristles, blade short, triangular, spikelets hirsute, stout, ovate.....**D. strictus**

Dendrocalamus stocksii (Munro) M. Kumar, Remesh & Unnikrishnan, **comb. nov.** [Figures 14 and 15; Plate 12].

Type: India, Concan, *Stocks* s.n. (lectotype K. designated here, Cibachrome seen).

Oxytenanthera stocksii Munro, Trans. Linn. Soc. London 26: 130. 1868; Bedd., Fl. Sylv. S. India 3: 233. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 75 t. 66. 1896; Brandis, Indian Trees 674. 1906; Talbot, For. Fl. Bombay Pres. Sind. 2: 570. 1912; Rama Rao, For. Pl. Travancore 446, 447. 1914; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1861. 1934; Gamble in Hook. f., Brit. India 7: 403. 1897; E. G. Camus, Les Bamb. 149. 1913; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.

Pseudotenanthera stocksii (Munro) R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 280. 1989.

Pseudoxytenanthera stocksii (Munro) Naithani, J. Nat. Hist. Soc. 87: 440. 1990; Tewari, Monogr. Bamb. 129. 1992.

Typification: This species was first collected by Stocks from Concan (Gamble, 1896). Two sheets of these specimens were deposited at K. Munro (1868) in his description of this species referred these specimens. Munro labelled both these specimens as *Dendrocalamus stocksii*. But, he described it as *Oxytenanthera stocksii*. Both these specimens are without number and year. On one of the sheets, the locality is written as Concan, Stocks. This specimen is selected for typification and designated here as lectotype [Plate 13].

Vernacular names: Uyi, Mula (Malayalam), Konda (Karnataka)

An erect, tall, arborescent, gregarious bamboo with closely placed culms. Rhizomes sympodial, pachymorph, with short necks, solid. Culms erect, self supporting, lumen, narrow or rarely solid, 12-16 m tall, tip straight; node slightly swollen; sheath scar prominent, nodal ridge clear, each node bear a single nodal bud enclosed inside a prophyllum, lower nodes have aerial roots; internodes 20-38 cm long, 2.5-4 cm diameter, yellowish-green, covered with soft greyish-white pubescens when young, glabrous when old; culm sheath 12-25 cm long, 10-15 cm broad at base, striate, coriaceous, hirsute, covered with bulbous based brownish hairs, tip concavely truncate, persistent; blade erect, subulate, 5-8 cm long, 0.8-1.4 cm broad at base, striate, involute, glabrous, persistent, acuminate; auricle 0.2-0.3 cm long, clothed with numerous, erect, stiff, bristles, bristle persistent; inner ligule prominent, conspicuous, 0.8-1 cm high, deeply fimbriate; branches, branching starts from the lower nodes, the central dominant branch arise first, 2-4 laterals produced from its basal nodes, the primary and secondary branches rebranch at their nodes, intravaginal emergence; leaves arise on branches, linear-lanceolate, 6-25 cm long, 0.8-2.5 cm broad, dorsal side glabrous, ventral side faintly hirsute, one of the margins and midrib regions scabrous, tip acute, ending in a setaceous point, midrib narrow, prominent on the lower side, base attenuate, petiole short; leaf sheath overlapping, glabrous, striate; auricle short, bristles not found; inner ligule short, 0.1-0.2 cm high, outer ligule inconspicuous. Inflorescence a large panicle, terminal and axillary as verticillate clusters or large globose heads on the nodes, composed of closely packed spinous spikelets; spikelets 2-flowered, lanceolate, glabrous, mucronate, 1.2-1.5 cm long, 0.1-0.2 cm broad, fertile and sterile spikelets mixed, sterile glumes 2, 0.4-0.7 cm long, ovate-lanceolate, glabrous, mucronate, many-nerved; fertile glumes, lemma 1-1.2 cm long, ovate-lanceolate, mucronate, strongly spinose, many nerved; palea slightly shorter than lemma, 2 keeled, ciliate on the keels, 3-4 nerved between, tip obtuse, convolute; lodicules 0; stamens 6, free, filaments short, exserted, anthers 0.4-0.5 cm long, basifixed, apiculate, tip ciliate; ovary ovate, sparsely hirsute, style 0.8-1 cm long, ciliate, stigma single plumose. Fruit a caryopsis, oblong, pericarp dry.

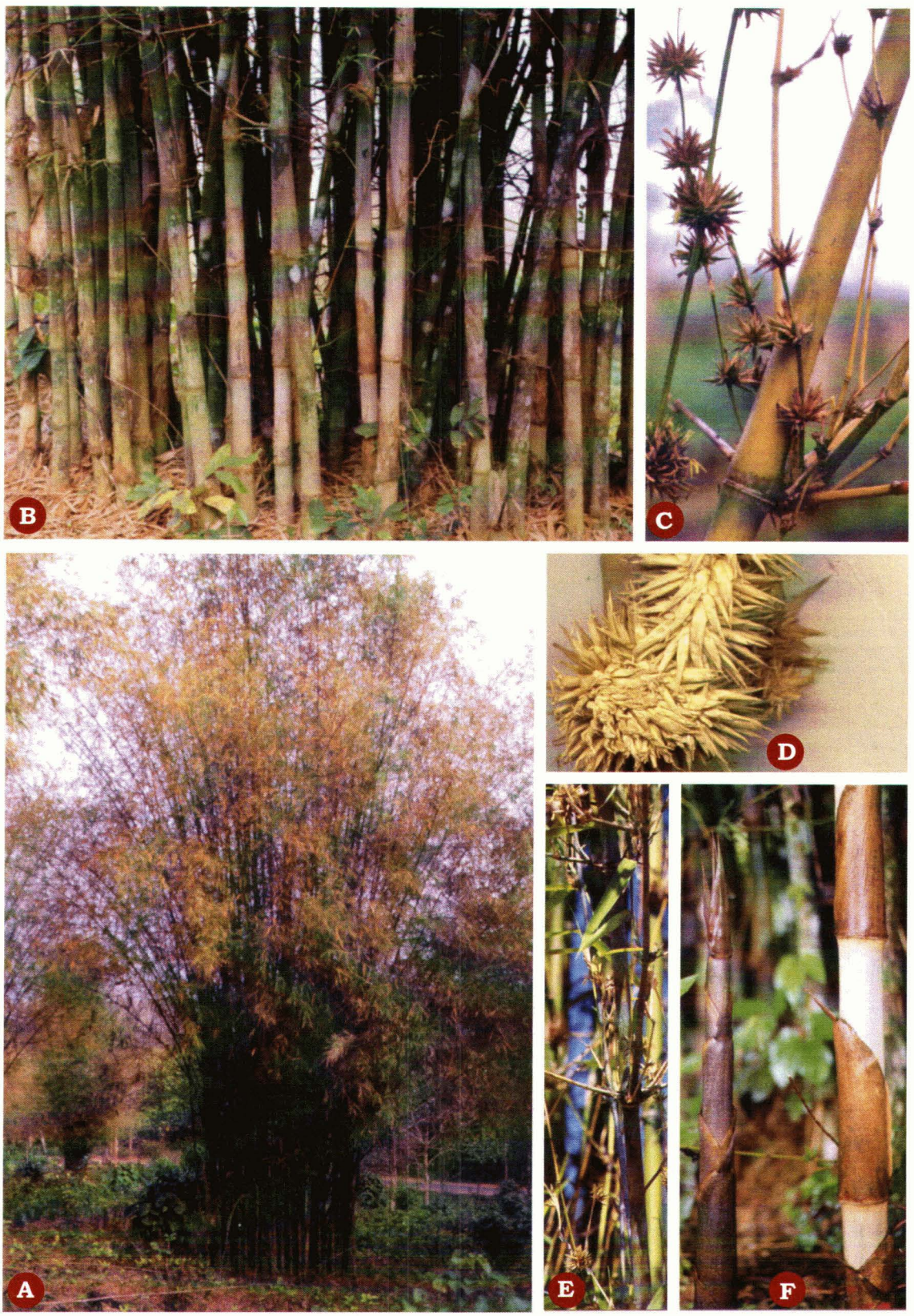


Plate 12. ***Dendrocalamus stocksii*** (Munro) M. Kumar, Remesh & Unnikrishnan **comb. nov. A.** habit; **B.** culms; **C.** & **D.** inflorescence; **E.** flowering; **F.** young culm with sheath

Plate 13. ***Dendrocalamus stocksii*** (Munro) M. Kumar, Remesh & Unnikrishnan -lectotype (K)

Figure 14. *Dendrocalamus stocksii* (Munro) M. Kumar, Remesh & Unnikrishnan **comb. nov.** **A.** leafy branch; **B.** culm sheath; **C.** inflorescence

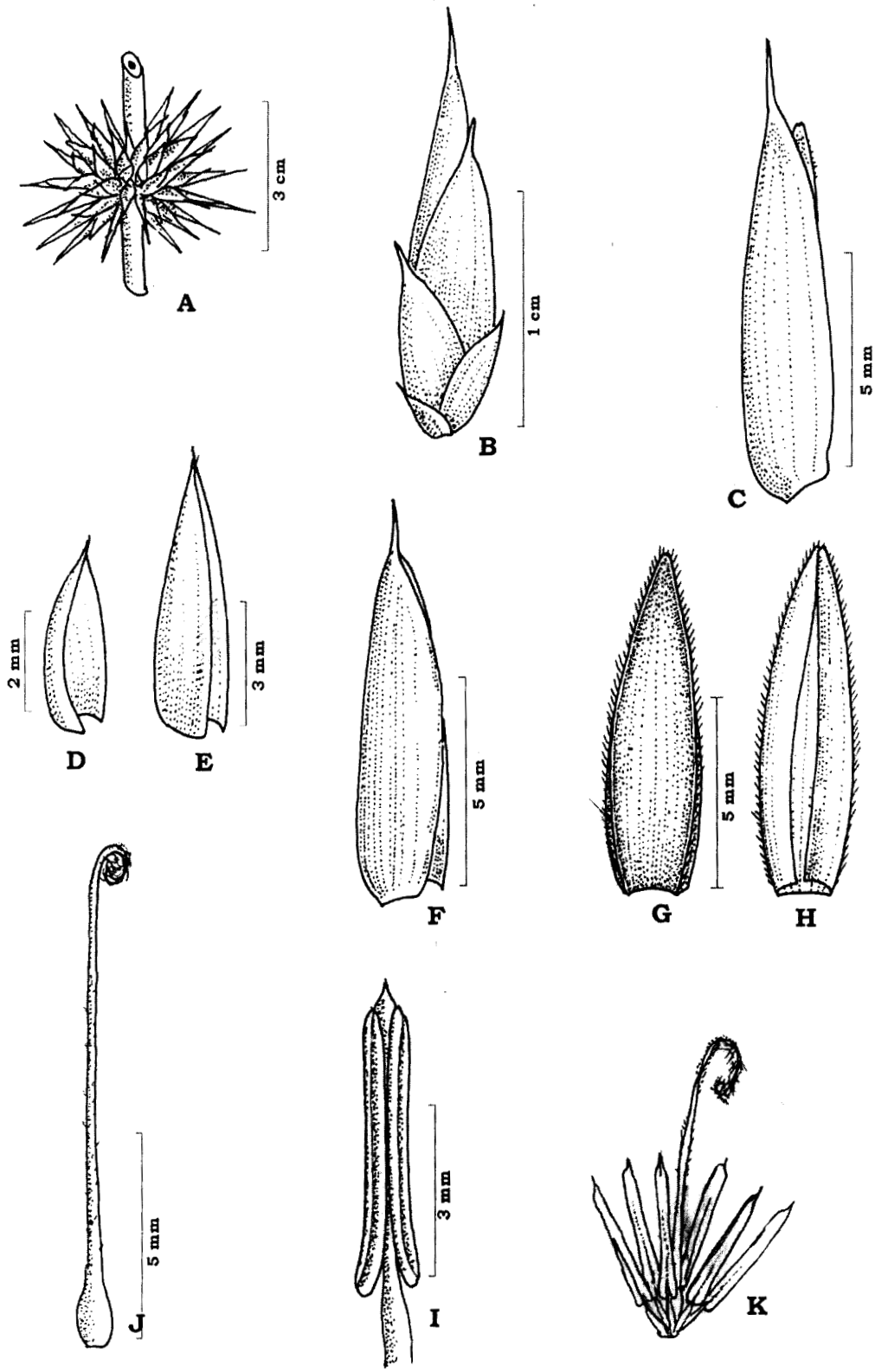


Figure 15. *Dendrocalamus stocksii* (Munro) M. Kumar, Remesh & Unnikrishnan **comb. nov.**
A. portion of inflorescence; **B.** spikelet; **C.** floret; **D. & E.** sterile glumes;
F. lemma; **G.** palea-surface view; **H.** palea-inner view; **I.** stamen;
J. ovary with style; **K.** open floret (diagrammatic)

Distribution and ecology: It is endemic to southern peninsular India and distributed in northern Kerala and Karnataka along Concan coast up to Karwar. It is also distributed in Goa and Mahabaleshwar in Maharastra. It is found growing from sea level to an altitude of 800 m. Sporadic flowering is common in this species. It flowered at Palapilly, Thrissur district under cultivation in 2000. It is widely cultivated in Karnataka and northern Kerala.

Specimens examined: KARNATAKA: North Kanara Dist. Coompta, *WA Talbot 269* (BSI); Flora of North Kanara *WA Talbot 549974* (CAL). KERALA: Kasaragod Dist. North Kasargod, *Bamboo Products Exports 140317* (DD); Kanjangad, *VP Raveendran 20637* (KFRI). Thrissur Dist. Palapilly, *N Unnikrishnan 74039* (CALI); Palapilluy, *M Remesh & M Kumar 20646* (KFRI).

Uses: It is a very strong bamboo with tall culms. It is ideal for construction purpose. Also used for making furniture, ladders and supports.

Note: *Oxytenanthera stocksii* was first described by Munro (1868). It was first collected by Stocks from Concan, Karnataka. Munro labelled the herbarium sheet of Stocks as *Dendrocalamus stocksii,* but he described *Oxytenanthera stocksii.* The resemblance of this species with *Dendrocalamus* was first mentioned by Gamble (1896). He pointed out the similarity of the narrow leaves, long petiole and the culm sheath with that of *Dendrocalamus strictus.* The culms and branching of *Oxytenanthera stocksii* also resembles with that of *Dendrocalamus* group. The culms are erect, the internodes are short, the lumen of the culm is narrow and sometimes solid and the lower nodes bear aerial roots. The inflorescences of *D. stocksii* is a large panicle of spikate heads. It resemblans with the inflorescence of the genus *Dendrocalamus.* In *Dendrocalamus,* the inflorescence is composed of round congested globose heads. In both, this species the spikelets are few flowered and lodicules are absent. The character of the palea is very important. In *O. stocksii* and in *Dendrocalamus* group the palea is keeled, and ciliate on the keels. The palea of the upper flower in both these is not keeled. The stamens are shortly apiculate. Another important character of resemblance is the style and stigma. In *O. stocksii* the style is sparsely ciliate and ends in a single feathery stigma. The style of *Dendrocalamus*

group is also ciliate and ends in a single feathery stigma. In *Oxytenanthera stocksii* and *Dendrocalamus* the basal nodes bear aerial roots.

Oxytenanthera stocksii differs from the other two species *O. bourdillonii* and *O. ritchiei* in growth habit and culm characters. *Oxytenanthera bourdillonii* is a large arborescent bamboo with long internodes. The culm wall is thin and culm sheath is very specific. Stamens are monadelphous and strongly apiculate. The stigma is divided in to three. In *Oxytenanthera ritchiei* the culms are covered with thick golden brown tomentum when young. The palea of this species is not keeled.

The type genus of *Oxytenanthera* is *O. abyssinica* of Africa. *Oxytenanthera stocksii* differs from the type in two important characters. In the type the stamens are monadelphous and the style is divided in to three stigmas. In *O. stocksii* the stamens are free and it is monostigmatic.

The above observations strongly support the separation of the species *Oxytenanthera stocksii* from the genus *Oxytenanthera* and supports its placement under the genus *Dendrocalamus*. A new combination *Dendrocalamus stocksii* M. Kumar, Remesh & Unnikrishnan is proposed here.

Dendrocalamus strictus (Roxb.) Nees, Linnaea 9(4): 476. 1834; Munro, Trans. Linn. Soc. London 26: 147. 1868; Bedd., Fl. Sylv. S. India 3: 235. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 78, t. 68, 69. 1896 & in Hook. f., Fl. Brit. India 7: 404. 1897; Brandis, Indian Trees 675. 1906; Bourd., For. Trees Travancore 401. 1908; Talbot, For. Fl. Bombay Pres. Sind. 2: 567. 1912; Rama Rao, For. Pl. Travancore 446, 448. 1914; E. G. Camus, Les Bamb. 152. 1913; Blatt., Indian For. 55(11): 593. 1929; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1858. 1934; Holttum, Bamb. Malay. Penin. Gar. Bull. 16: 98. 1958; Bennet & Gaur, Thirty Seven Bamb. India 61. 1990; Tewari, Monogr. Bamb. 77. 1992; Stapleton, Edinb. J. Bot. 51(1): 26. 1994; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 93. 1995; Seethalakshmi & M. Kumar, Bamb. India Comp.129. 1998; Ohrnberger, Bamb. World 291. 1999 [Figures 16 and 17; Plate 14].

Type: India, Andhra Pradesh, East Godaveri district, Devipatanam *CA Barber 4929* (neotype MH!. designated here).

Bambos stricta Roxb., Plants Coromandel Coast 1, 58. 1798.

Bambusa stricta (Roxb.) Roxb., Hort. Beng. 25. 1814.

Typification: *Dendrocalamus strictus* was first described by Roxburgh (1798) as *Bambos stricta* based on the specimen collected from the Coromandel coast. Roxburgh's collections were destroyed in an inundation (King, 1895). Roxburgh's original illustration is rather stylized and not adequate for typification (Stapleton, 1994a). Therefore, neotypification is essential for *D. strictus*. Barber in 1902 collected *D. strictus* from Devipatanam, Godaveri district, Andhra Pradesh. These specimens were deposited at MH. Roxburgh's description of *D. strictus* was based on the collections from the Coromandel coast. During this study, the specimens deposited at MH were critically verified and found that they are most suitable for neotypification.

The specimens of *Dendrocalamus strictus* collected by Barber and deposited at MH are selected here as *neotype*.

Vernacular names: Kallanmula, Kurathimula, Korna (Malayalam); Kanka kara, Sandapa veduru (Telungu)

A medium sized, caespitose, gregarious, densely tufted, deciduous bamboo with erect strong culms. Rhizome sympodial, pachymorph, solid and with short necks. Culms erect, strong self supporting, height varies under different climatic conditions, 8-15 m tall, slightly arched at the top; node faintly swollen, sheath scar prominent, nodal ridge clear, aerial roots arise from the basal nodes, lower nodes often bear branches; internodes 20-35 cm long, 4-7 cm diameter, short, yellowish green, long, sparsely covered with white powdery mass when young smooth and yellowish when old, wall very thick, sometimes solid; culm sheath 12-22 cm long, 4-6 cm broad at base, coriaceous, covered with golden brown hairs when young, striate papery, glabrous, deciduous when old, tip truncate, auricle, very short, aural setae represented by short hairs, deciduous; blade erect, almost triangular, 5-8 cm long, 2-3.5 cm broad at base, smooth, persistent; inner ligule 0.1-0.2 cm long, outer ligule inconspicuous; branches arise from the lower nodes, the central primary branch become dominant, strong, 3-4 laterals develop from it's base,

Plate 14. ***Dendrocalamus strictus*** (Roxb.) Nees **A.** habit; **B.** inflorescence; **C.** culms; **D. & E.** young shoot with sheath

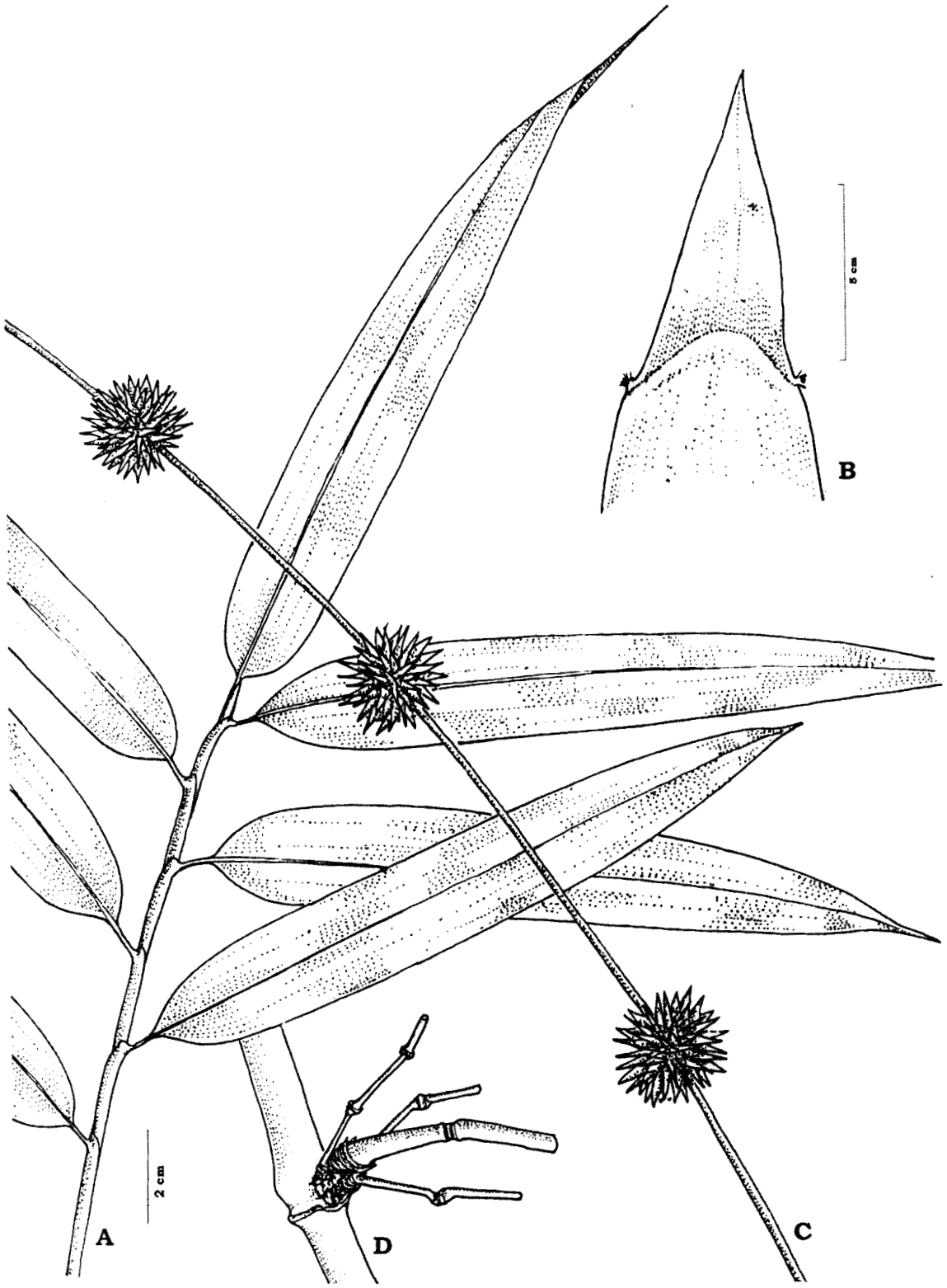


Figure 16. *Dendrocalamus strictus* (Roxb.) Nees **A.** leafy branch; **B.** culm sheath; **C.** inflorescence; **D.** branching

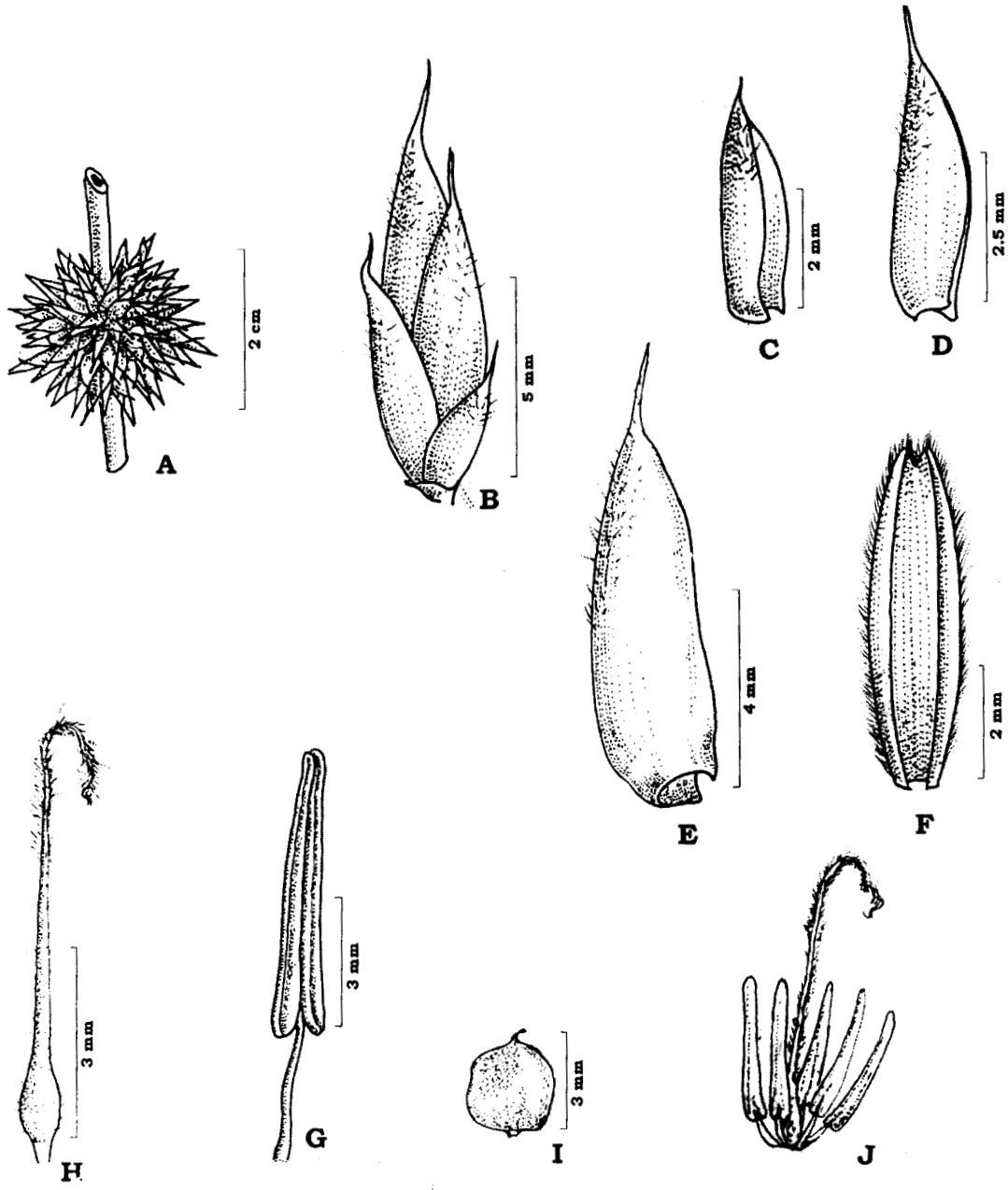


Figure 17. *Dendrocalamus strictus* (Roxb.) Nees **A.** portion of inflorescence; **B.** spikelet; **C. & D.** sterile glumes; **E.** lemma; **F.** palea; **G.** stamen; **H.** ovary with style; **I.** fruit; **J.** open floret (diagrammatic)

rebranch, branches of the upper nodes are long, drooping, extravaginal; leaves arise on branches, linear-lanceolate, 7-24 cm long, 1-2.4 cm broad, dorsal surface rough and hirsute, lower side softly hirsute, scabrous along the margins, midrib prominent on the lower side, pellucid dots present on the lamina, tip acuminate, base attenuate to a short petiole, leaf sheath overlapping, hirsute when young, striate, lateral sides at the tip projecting to a prominent callus, ligule inconspicuous; auricle short, ciliate. Inflorescence a large, leafless branching panicle with dense globular heads, rachis rounded, smooth, heads supported by striate, ovate-lanceolate, deciduous bracts; spikelets 0.8-0.1 cm long, ovate, 2-3-flowered, hirsute, sharply spinous, fertile and sterile ones intermixed; sterile glumes 2, hirsute, ovate, spiny, 0.4-0.5 cm long, many nerved, fertile glumes, lemma 0.7-0.8 cm, ovate-lanceolate, strongly spinescent, hirsute; palea 0.6-0.7 cm long, ovate, 2-keeled, ciliate on the keels, emarginate, convolute, palea of the uppermost flower not keeled; lodicules absent; stamens 6, free, filaments long, anthers short, 0.6-0.7 cm long, exserted, slightly apiculate; ovary turbinate, short stalked, hirsute, narrowed upward in to a style; style 0.5-0.6 cm long, ciliate, stigma single, feathery. Fruit a caryopsis, reddish-brown, obovate to subglobose, beaked with persistent style.

Distribution and ecology: It is distributed in India, Nepal, Bangladesh, Myanmar and Thailand. It is one of the most common bamboos in India. In South India, it is distributed in Andhra Pradesh, Karnataka, northern Kerala and Tamil Nadu. It is a drought resistant species and can grow under extreme dry climatic conditions. It is also growing as a component of dry and moist deciduous forests. This species is distributed from sea level to an altitude of 800 m. It flowers in summer months, sporadic flowering is frequent. Sporadic flowering was observed in Arkavalley, Andhra Pradesh; Tamil Nadu and Kerala.

Specimens examined: ANDHRA PRADESH: Adilabad Dist. Debumallaloddhi, *T Ravisankar 85227* (MH); Sadarmott, *T Pullaiah & PV Prasanna 4104* (SKU). Anantapur Dist. Kalasamudram RF, *N Yesoda 398* (MH). East Godawari Dist. Devipatanam, *CA Barber 4929* (MH); Bhupatipalam, *T Pullaiah & MS Gayathri 12251* (SKU). Kurnool Dist. *JS Gamble 18698* (MH); way to Nallamalis, *JL Ellis 32572* (MH); Velugode, *SK Wagh 4937* (BLAT). Visakapatnam Dist. Arkavalley,

N Unnikrishnan 74102 (CALI). KARNATAKA: Uttara Kanara Dist.: s.loc. *WA Talbot 1788* (BSI); Dandeli, *J Fernandez 1061* (BLAT). Carvar, *WA Talbot 1824* (BSI). KERALA: Malappuram Dist. Nilambur, *N Unnikrishnan 74106* (CALI). Palakkad Dist. Nelliyampathy, way to Kaikatty, *Stephen Sequiera 7593* (KFRI); Mukkali, *M Kumar & Stephen Sequiera 7896* (KFRI); Parambikulam, *SKM Basheer 20722* (KFRI). TAMIL NADU: Coimbatore Dist. Varadimalai, *CEC Fischer 2753* (DD). Chennai Dist. Adayar, *JS Gamble 20810* (DD). Nilgiri Dist. Coonoor, *JS Gamble 11536* (DD).

Uses: Culms are used as a building material, also for making furniture, handicrafts, baskets, mats, agricultural implements, etc. It is an important raw material in the pulp and paper industry.

Note: *Dendrocalamus strictus* has a very wide distribution in India, especially in areas under dry climatic conditions. It is a drought resistant species. In South India, it is common in the States of Andhra Pradesh, Tamil Nadu and Karnataka. In Kerala, it has only a restricted distribution in the northern part. It is commonly known as male bamboo. The culms are very strong with a narrow lumen or sometimes solid.

The gregarious flowering cycle various from 25-45 years. But, sporadic flowering is common in this species. During this study, flowering was observed at Arkavalley, Andhra; Nelliampathy and Marayoor, Kerala.

Subtribe: **Bambusinae** J.Presl

Oxytenanthera Munro

The origin of the generic name was from Greek, *'Oxyten'* or *'Oxytenes'* means pointed and *'Anthera'* means anther referring to the pointed anthers of this genus.

This genus was originally described by Munro (1868). It is closely related to the genus *Dendrocalamus* The loosely arranged culms, strongly apiculate anthers and presence of three stigmas separate this genus from *Dendrocalamus*.

Oxytenanthera Munro, Trans. Linn. Soc. London 26: 126. 1868; Benth. & Hook. f., Gen. Pl. 3: 1211. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 68. 1896 & in Hook. f., Fl. Brit. India 7: 400. 1897; Brandis, Indian Trees 673. 1906; Bourd., For. Trees Travancore 400. 1908; Talbot, For. Fl. Bombay Pres. Sind. 2: 567. 1912; E. G. Camus, Les Bamb. 143. 1913; Blatt., Indian For. 55(11): 591. 1929; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1860. 1934; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Grass Syst. Evol. 235. 1987; Clayton & Renvoize, Kew Bull. Addl. Ser. 13, 56. 1989; Seethalakshmi & M. Kumar, Bamb. India Comp.203. 1998; Ohrnberger, Bamb. World 309. 1999.

***Type**: Oxytenanthera abyssinica* (A. Rich.) Munro

Pseudoxytenanthera Soderstr. & R.P. Ellis, Smith. Contr. Bot. 72: 52.1988; Naithani, J. Bombay Nat. Hist. Soc. 87: 450. 1990; Seethalakshmi & M. Kumar, Bamb. India Comp.221. 1998; Ohrnberger, Bamb. World 311. 1999.

Pseudotenanthera R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 280. 1989.

Medium or small sized bamboos. Rhizome sympodial sometimes with long necks. Culms erect, hollow, thick walled or sometimes solid; culm sheath various types; branching, the primary axis is prominent with few secondary braches. Inflorescence indeterminate with pseudospikelets, form spicate, globose clusters, sometimes the spikelet condensed in to a capitulum at the branch tip; spikelets long, narrow, 1-2-flowered, usually rachilla extension not present; lodicules absent; stamens 6, monadelphous; ovary ovoid, stigmas 1 or 3, plumose. Fruit a caryopsis.

Distribution and ecology: *Oxytenanthera* is distributed in Africa, Sri Lanka and India. The type genus *O. abyssinica* is found in tropical Africa. It is tapped for wine in Tanzania. From India, four species were reported and all are distributed in South India. In the present treatise, one species is transferred under the genus *Dendrocalamus*, so three species are included under the genus *Oxytenanthera*. Two are endemic to southern peninsular India and one species is distributed in south India and Sri Lanka. They are found growing from sea level to an altitude of 1500 m.

Note: Holttum (1956a) conducted studies on the ovary structure of this genus and considered it as a monotypic species. He also suggested that all other Asiatic species under the genus *Oxytenanthera* either belong to *Dendrocalamus* or *Gigantochloa*. But, later Pattanath & Rao (1969) and Grosser and Liese (1973) conducted anatomical studies of different species of *Oxytenanthera* including *O. abyssinica*. According to them, the anatomical structure of vascular bundles of different Asiatic species of *Oxytenanthera* is similar to the structure of vascular bundles of *O. abyssinica*. Holttum, 1972 (cf, Grosser & Liese, 1973) later pointed out that his assessment of the distinctiveness of the ovary character of *Oxytenanthera abyssinica* was possibly wrong and these observations need a reanalysis.

Soderstrom and Ellis (1988) transferred *Oxytenanthera monadelpha* to a new genus *Pseudoxytenanthera*. This species is found in South India and Sri Lanka.

Majumdar (1989) included the *Oxytenanthera* under a new genus *Pseudotenanthera*. According to Naithani (1990b) the name *Pseudotenanthera* is superfluous and treated it as a synonym of *Pseudoxytenanthera*. Therefore, all the South Indian species were included under the genus *Pseudoxytenanthera*.

Soderstrom and Ellis (1988) justified their new combination, *Pseudoxytenanthera* referring to Holttum (1956a). But their justification is not relevant now because of the reasons mentioned previously. Their species *Pseudoxytenanthera monadelpha* resembles with the type genus *Oxytenanthera abyssinica* in key characters such as, loosely arranged culms, monadelphous stamens, keeled palea, strongly apiculate anthers and hairy style with three stigmas.

Soderstrom's new combination *Pseudoxytenanthera* closely resembles the genus *Oxytenanthera*. The morphological characters, branching and whip-like culm tip are not sufficient to separate this species from *Oxytenanthera* (Sharma, 1996).

In the present study, the generic name *Oxytenanthera* is retained Soderstrom's new combination *Pseudoxytenanthera monadelpha* is treated under *Oxytenanthera monadelpha*.

Key to the species of ***Oxytenanthera***

1a. Culms solid; flowers monostigmatic ..... **O. ritchiei**

1b. Culms hollow; flowers with 3 stigmas..... 2

2a. Culms erect, tip straight, culm sheath without auricle and auricular setae ..... **O. bourdillonii**

2b. Culms semi-erect, tip whiplike, drooping, culm sheath with auricle and auricular setae ..... **O. monadelpha**

Oxytenanthera bourdillonii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 76, t. 67. 1896 'bourdilloni' & in Hook. f., Fl. Brit. India 7:403.1897; Brandis, Indian Trees 675. 1906; Bourd., For. Trees Travancore 401. 1908; E. G. Camus, Les Bamb. 149. 1913; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1861.1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980 [Figures 18 and 19; Plate 15].

Type: India, Kerala, Travancore, *JF Bourdillon* s.n. (lectotype K. designated here. Cibachrome seen, isotype CAL !).

Pseudoxytenanthera bourdillonii (Gamble) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990; Tewari, Monogr. Bamb. 124. 1992; Seethalakshmi & M. Kumar, Bamb. India Comp.222. 1998.

Pseudoxytenanthera bourdillonii (Gamble) Ohrnberger, Bamb. World 311. 1999.

Pseudotenanthera bourdillonii R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 280. 1989.

Typification: Bourdillon collected this species first from Travancore hills in 1889, based on which Gamble (1896) described this species. This specimen was deposited at K. A duplicate specimen was deposited at CAL. The specimen collected by Bourdillon at K is designated here as lectotype and the specimen at CAL is designated as letotype [Plate 16].

Vernacular names: Arayampu, Vellimula, Kaman (Malayalam); Ponmungil (Tamil)

Arborescent, tall, straggling bamboo forming loose, open culms. Rhizome sympodial, pachymorph, very thick, solid, neck slightly long; culms erect, self supporting, hollow, 15-20 m tall; node not swollen, marked by a nodal ring and a single nodal bud enclosed by prophyllum; internodes 40-60 cm long, 6-30 cm diameter, pale green, smooth, densely covered with white powdery mass when young; culm sheath 15-36 cm long, 13-32 cm broad at base, striate, coriaceous, golden yellow, hirsute at base, covered with white powdery mass when young, provided with curious calluses, tip round; blade foliose in young shoots, almost vertical to the main axis, triangular with sharp mucronate tip, glabrous, 6-12 cm long, 12-18 cm broad at base, stiff, coriaceous in mature culms, base broad, ear-shaped or winged, the wing rounded, entire, recurved, decurrent and run the entire, upper edge of the sheath; auricle absent; inner ligule 0.4-0.6 cm high, membranous, faintly serrate, outer ligule not prominent; branches arise from the upper nodes, just above the nodal line, extravaginal, the central primary axis develops first and become dominant, numerous secondary branches, develop from its basal buds, the mature branches rebranch form their lower nodes; leaves arise on branches and branchlets, 10-25 cm long, and 1.5-3.8 cm broad, lanceolate, dorsal and ventral side glabrous, one of the margins and midrib region, scabrous, midrib prominent in the lower side, tip acute-acuminate, setaceous, base attenuate, narrowed to a short petiole, secondary veins not clear, leaf sheath imbricate, thin, papery, sparsely hirsute, striate, keeled, the tip on each side of the petiole form raised callus; auricle not prominent, oral setae absent; inner ligule 0.1-0.2 cm high, serrate, outer very short. Inflorescence a large panicle bearing semiverticillate heads of spikelets on leafy branches, composed of pseudospikelets, arise on the nodes of branches; spikelets 3-flowered, ovate-lanceolate, glabrous, shining, 1.2-2 cm long, 0.2-0.3 cm broad, almost sessile, supported by 2 bracts at the base; sterile glumes 3, ovate to ovate-lanceolate, mucronate, glabrous, many nerved, first one ovate, 0.3-0.4 cm long, second ovate, 0.4-0.6 cm long, third ovate-lanceolate, 0.6-0.9 cm long; fertile glumes lemma, ovate-lanceolate, membranous, 1.2-1.4 cm long, 0.2-0.3 cm broad, glabrous, mucronate, many nerved; palea thin, membranous, oblong, tip almost retuse, 2 keeled, 3 nerves between the keels, keels strongly ciliate, 1-1.2 cm long, palea of the terminal flower is not keeled, grooved, ciliate along the groove; lodicules absent; stamens 6, monadelphous, exerted,

Plate 15. ***Oxytenanthera bourdillonii*** Gamble **A.** habit; **B. & E.** culm sheaths; **C.** culms; **D.** inflorescence

Plate 16. ***Oxytenanthera bourdillonii*** Gamble -lectotype (K)

Figure 18. *Oxytenanthera bourdillonii* Gamble **A.** leafy branch; **B.** culm sheath; **C.** inflorescence

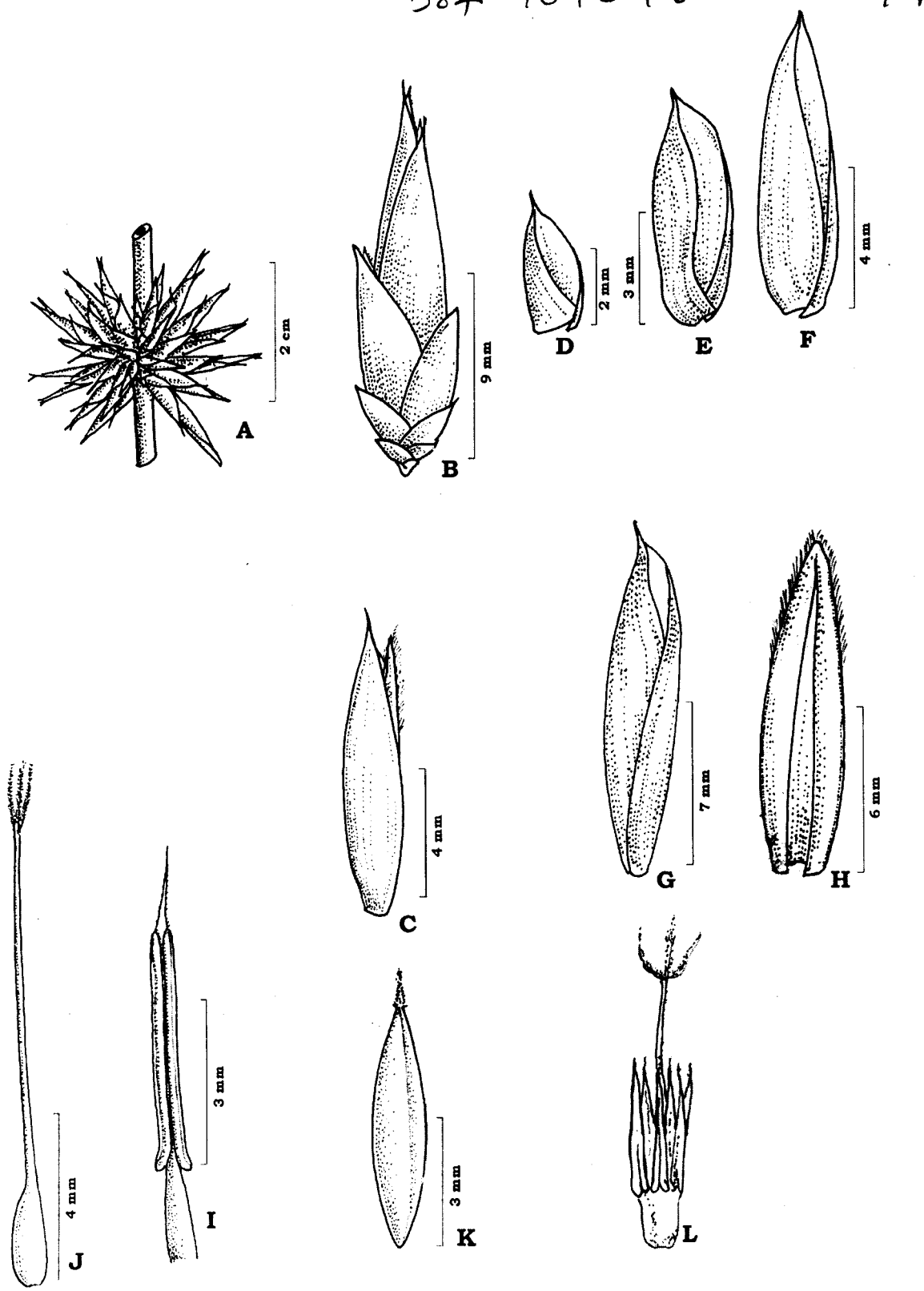


Figure 19. *Oxytenanthera bourdillonii* Gamble **A.** portion of inflorescence; **B.** spikelet; **C.** floret; **D., E. & F.** sterile glumes; **G.** lemma; **H.** palea; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

anthers 0.6-0.7 cm long, apiculate, tip ciliate; ovary ciliate, ovate, surmounted by a style; style 1-1.2 cm long, ciliate, tip divide to form 3 plumose stigma. Fruit a caryopsis, elliptic, one side sulcate, shortly beaked by the persistent base of the style.

Distribution and ecology: *Oxytenanthera bourdillonii* has a restricted distribution in Southern Western Ghats. It is endemic to Kerala part of Western Ghats. It grows only on steep precipitous places from an elevation of 800-1300 m. Flowering is rare, it flowers at long intervals. Flowering was reported in 1983 in Vazhachal, Thrissur district, Kerala and in Kurusumala, Idukki district in 1997.

Specimens examined: KERALA: Travancore, *JF Bourdillon* (s.n.) (CAL). Idukki Dist. Kurisumala, *Jomy Augustine 13050* (CALI); Peerumed, *N Unnikrishnan 74207* (CALI). Malappuram Dist. New Amarambalam, *R Jayakumar 22212* (KFRI). Palakkad Dist. Nelliyampathy, Ranimedu, *M Kumar & TR Viswakumar 8869* (KFRI). Thrissur Dist. Sholayar, *Seethalakshmi* s.n. (KFRI).

Uses: The internodes are used by the tribes for storing honey and millets. It is also used for making combs and tooth picks. The mature culms are used for construction of huts by the tribes and also for basketry.

Note: This genus was originally described by Gamble (1896). The spelling of the specific epithet in the protologue was '*bourdilloni*'. Many workers later treated the specific epithet as '*bourdillonii*'. The correct spelling of the specific epithet accepted here is '*bourdillonii*'. It was confirmed with Dr JF Veldkamp in a personal communication. The pertinent articles are 32.5, 60.11, Rec. 60.C.2 ICBN.

Oxytenanthera monadelpha (Thwaites) Alston in Trim., Fl. Ceylon 6 (Suppl.) 342.1931; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 1861.1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; Tewari, Monogr. Bamb. 124. 1992 [Figures 20 and 21; Plate 17].

Type: Sri Lanka, Ambagamuwa, *Thwaites* s.n. (lectotype PDA. selected by Soderstrom & Ellis, 1988; isotype MH !).

Dendrocalamus monadelphus Thwaites, Enum. Pl. Zeyl. 376.1864.

Pseudoxytenanthera monadelpha (Thwaites) Soderstr. & R.P. Ellis, Smith.Contr. Bot. 72: 52.1988; Seethalakshmi & M. Kumar, Bamb. India Comp.224. 1998.

Pseudotenanthera monadelpha (Thwaites) R.B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 280. 1989.

Oxytenanthera thwaitesii Munro, Trans. Linn. Soc. London 26: 129. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 72, t. 63.1896 & in Hook. f., Fl. Brit. India 7: 402. 1897; Brandis, Indian Trees 673. 1906; Bourd., For. Trees Travancore 400. 1908; E. G. Camus, Les Bamb. 147. 1913; Rama Rao, For. Pl. Travancore 447. 1914.

Vernacular names: Valli eetta (Malayalam)

Medium sized, caespitose, gregarious bamboo, forming loose clumps. Rhizome sympodial, pachymorph, solid, neck slightly long, covered with scale leaves. Culms erect, self supporting, hollow, 7-10 m tall, tip gradually become curved and whip like; node slightly swollen; sheath scar is very prominent forming a girdle, supranodal ridge not clear, a single dormant branch bud is present at each node enclosed inside a prophyllum; internodes 30-35 cm long, 1.5-2.5 cm diameter, dull green, hirsute, scabrous; culms sheath 15-25 cm long, 7-11 cm broad at base, purplish-green, coriaceous, margins ciliate, covered with bulbous based brown hairs, yellowish orange when young, striate, brittle, abscissle, straw coloured, hirsute towards the base when old, tip truncate; blade reflexed, foliose, upper surface glabrous, lower side slightly hirsute, broad, acuminate, 7-12 cm long, 1.2-3 cm broad at base, base truncate, spreading and decurrent along the top of the sheath, deciduous when old; auricles very prominent, ear-shaped, falcate, with stiff bristles, oral setae numerous, persistent; inner ligule large, prominent in large sheaths, 0.5-1 cm high, short in smaller sheaths, erose, outer ligule not clear; branches starts form the lower nodes, arise just above the sheath scar, extravaginal, branches numerous, forming semiverticillate clusters on the nodes, the primary bud remain dormant and numerous laterals, develop from its sides, sometimes the central axis become prominent, whip like similar to the main culm; leaves arise on branches, size highly variable, 4-32 cm long, 0.5-3.2 cm broad, linear-lanceolate, glabrous on both sides, margins rough and scabrous, tip acuminate, midrib prominent, base attenuate, narrows in to a short petiole, leaf sheaths closely attached, overlapping, smooth, striate, straminous, keeled, tip ends in a callus; auricle prominent, falcate with stiff bristles, bristles deciduous; inner ligule prominent in mature branches, 0.4-0.5 cm high, erose,

Plate 17. ***Oxytenanthera monadelpha*** (Thwaites) Alston **A.** habit; **B. C. D. & E.** young shoot with sheaths; **F.** inflorescence

Figure 20. *Oxytenanthera monadelpha* (Thwaites) Alston **A.** leafy branch; **B.** culm sheath; **C.** inflorescence; **D**. branching

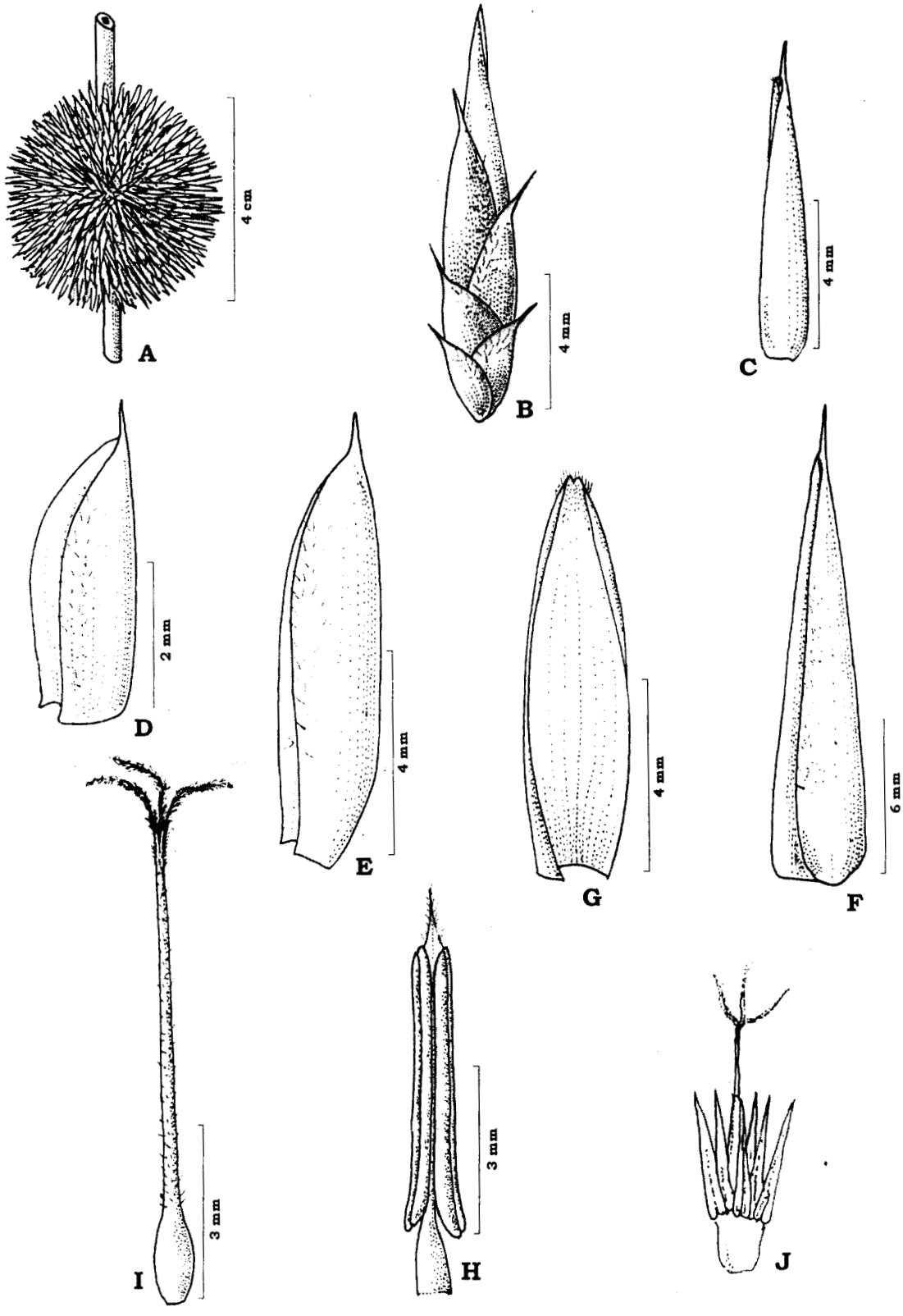


Figure 21. *Oxytenanthera monadelpha* (Thwaites) Alston **A.** portion of inflorescence; **B.** spikelet; **C.** floret; **D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** stamen; **I.** ovary with style; **J.** open floret (diagrammatic)

membranous, outer ligule short. Inflorescence a large compound spicate panicle on leafy branches, later shed all leaves and the whole plant is converted to a huge inflorescence, spikelets arise on the nodes of all branches, composed of pseudospikelets form semiverticillate clusters or as very large globose heads, those at the ends of the branchlets are small; spikelets 1-3-flowered, ovate-lanceolate, acute, 1-1.4 cm long, 0.2-0.3 cm across, supported by two bracts, hirsute along the margins of glumes, the lower most develop first and dominate with reduction upwards; sterile glumes 2, stiff, coriaceous, many nerved, mucronate, hirsute along the sides, first glume 0.4-0.5 cm, ovate, second glume 0.6-0.8 cm long, ovate-lanceolate; fertile glumes, lemma ovate-lanceolate, thin, 1-1.2 cm, many nerved, strongly mucronate, ciliate along the sides and also the tip; palea thin, membranous, concave, 0.8-1 cm long, two keeled, ciliate on the keels, convolute, slightly bifid, tip ciliate; lodicules absent; stamens 6, monadelphous, yellowish, exserted; anthers 0.5-0.6 cm long, short, apiculate, ciliate at the tip. Ovary glabrous, fusiform, style long, 0.8-1 cm long, hairy; stigma 3, plumose. Fruit a caryopsis, 0.4-0.5 cm long, thin, fusiform, scabrous, sulcate along one side, tip mucronate, hairy, pericarp dry.

Distribution and ecology: This species is distributed in southern Peninsular India and Sri Lanka. It is a component of moist deciduous and semi-evergreen forests and found growing from 600-2000 m altitude. Sporadic flowering is common in summer months. In South India, it is distributed in Kerala, Karnataka and some parts of Tamil Nadu.

Specimens examined: ANDHRA PRADESH: Kurnool Dist. Kurnool Forest, *RH Beddome* s.n. (MH). KARNATAKA: Chickmangalore Dist. Bababudan, *NS Adakoli* 156635 (DD). KERALA: Idukki Dist. Vellimala, *Jomy Augustine 13334* (CALI); Munnar, *N Unnikrishnan 74022* (CALI); Munnar, Chokkanad, *N Unnikrishnan 74206* (CALI). Palakkad Dist. Mutthikulam, *Stephen Sequiera & Michiale 8821* (KFRI); Sispara, *M Remesh & Stephen 20712* (KFRI). Wayanad Dist. Manantoddy, *Rodes Morgen* s.n. (MH); Mundakai, *Stephen Sequiera & Michiale 8162* (KFRI). TAMIL NADU: Madura Dist. Highway Mountains, *Cheriyan Jacob 17614* (MH). Nilgiri Dist. Nilgiris, *Perrottet 1344:773* (DD); Nilgiris, *JS Gamble 20642* (DD); Nilgiris, *JS Gamble 21450* (MH); Ochterlomy

valley, *JS Gamble 20531* (DD); Coonoor, *JS Gamble 12155* (DD); Coonoor, *JS Gamble 12165* (MH). Thirunelveli Dist. Thirunelveli, *Forest Ranger 40544* (DD).

Uses: Local people use the culms for making fences, huts, supports, etc. and use the leaves for thatching.

Oxytenanthera ritchiei (Munro) Blatt. & McCann, J. Bombay Nat. Hist. Soc. 33: 773. 1929, "ritcheyi"; Nair & Ansari, J. Econ. Tax. Bot. 3: 616. 1982 [Figures 22 and 23; Plate 18].

Type: India, Bombay, Kalanuddi, *Ritchie* 820 (holotype K).

Bambusa ritchiei Munro, Trans. Linn. Soc. London 26: 157. 1968.

Pseudoxytenanthera ritcheyi (Munro) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990; Tewari, Mongr. Bamb. 127. 1992; Seethalakshmi & M. Kumar, Bamb. India Comp.225. 1998.

Pseudoxytenanthera ritchiei (Munro) Ohrnberger, Bamb. World 313. 1999.

Oxytenanthera monostigma Bedd., Fl. Sylv. S. India 3: 233. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 74, t. 65. 1896 & in Hook. f., Fl. Brit. India 7: 402. 1897; Brandis, Indian Trees 674. 1906; Bourd., For. Trees Travancore 400. 1908; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1861. 1934.

Pseudotenanthera ritchiei (Munro) R. B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 280. 1989.

Vernacular names: Erankoel (Malayalam)

An erect strong medium sized gregarious, straggling bamboo forming loose clumps. Rhizome sympodial, pachymorph, solid with slightly long necks. Culms erect, strong, self supporting, solid, 3-5 m tall; nodes slightly swollen, sheath scar and nodal ridge prominent, nodal bud present, enclosed inside prophyllum; internodes 25-34 cm long, 2.5-5 cm diameter, densely clothed with golden yellow to white velvet tomentum when young, smooth when old; culm sheath coriaceous, sparsely hirsute, with bulbous based golden brown hairs when young, margins papery, brittle, striate, shining, glabrous when old, 15-26 cm long, 6-9 cm broad at base, conical, gradually attenuate towards tip, tip narrow and having a semi-round sinus from which the blade arise, deciduous; blade erect, narrow, glabrous, linear-lanceolate, persistent; inner

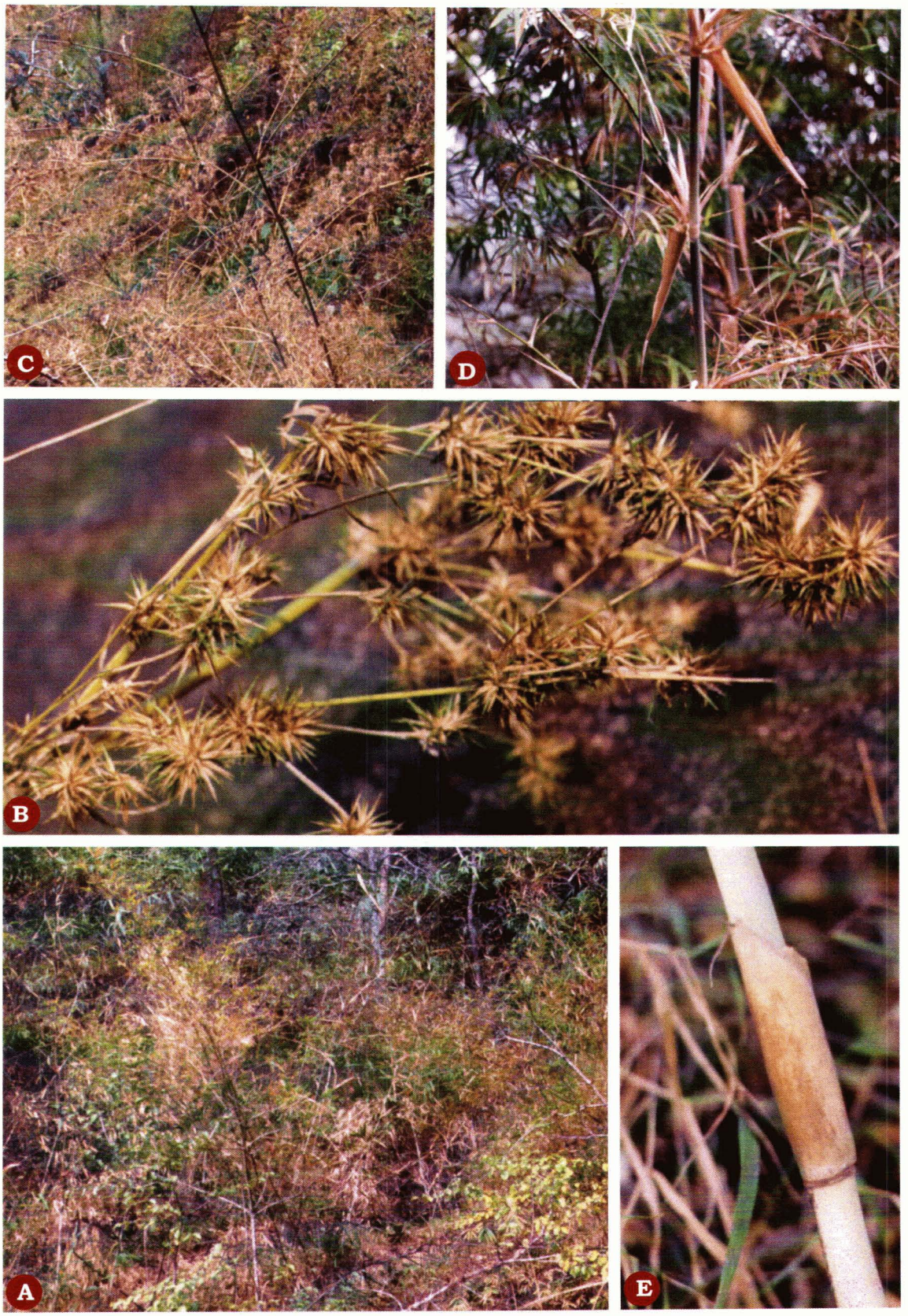


Plate 18. ***Oxytenanthera ritchiei*** (Munro) Blatt. & McCann **A.** habit; **B.** inflorescence; **C.** flowering ; **D. & E.** culms and sheath

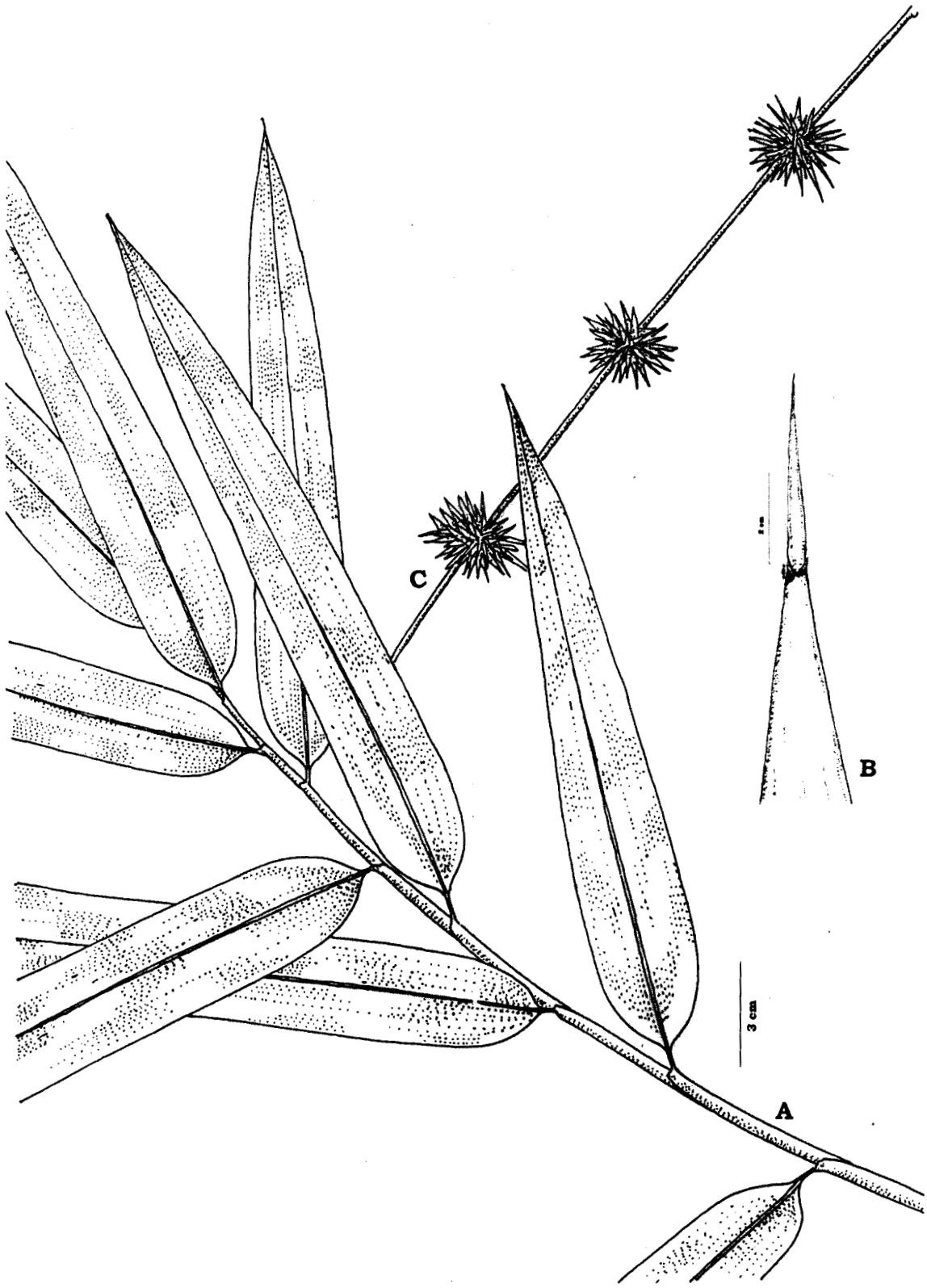


Figure 22. *Oxytenanthera ritchiei* (Munro) Blatt. & McCann **A.** leafy branch; **B.** culm sheath; **C.** inflorescence

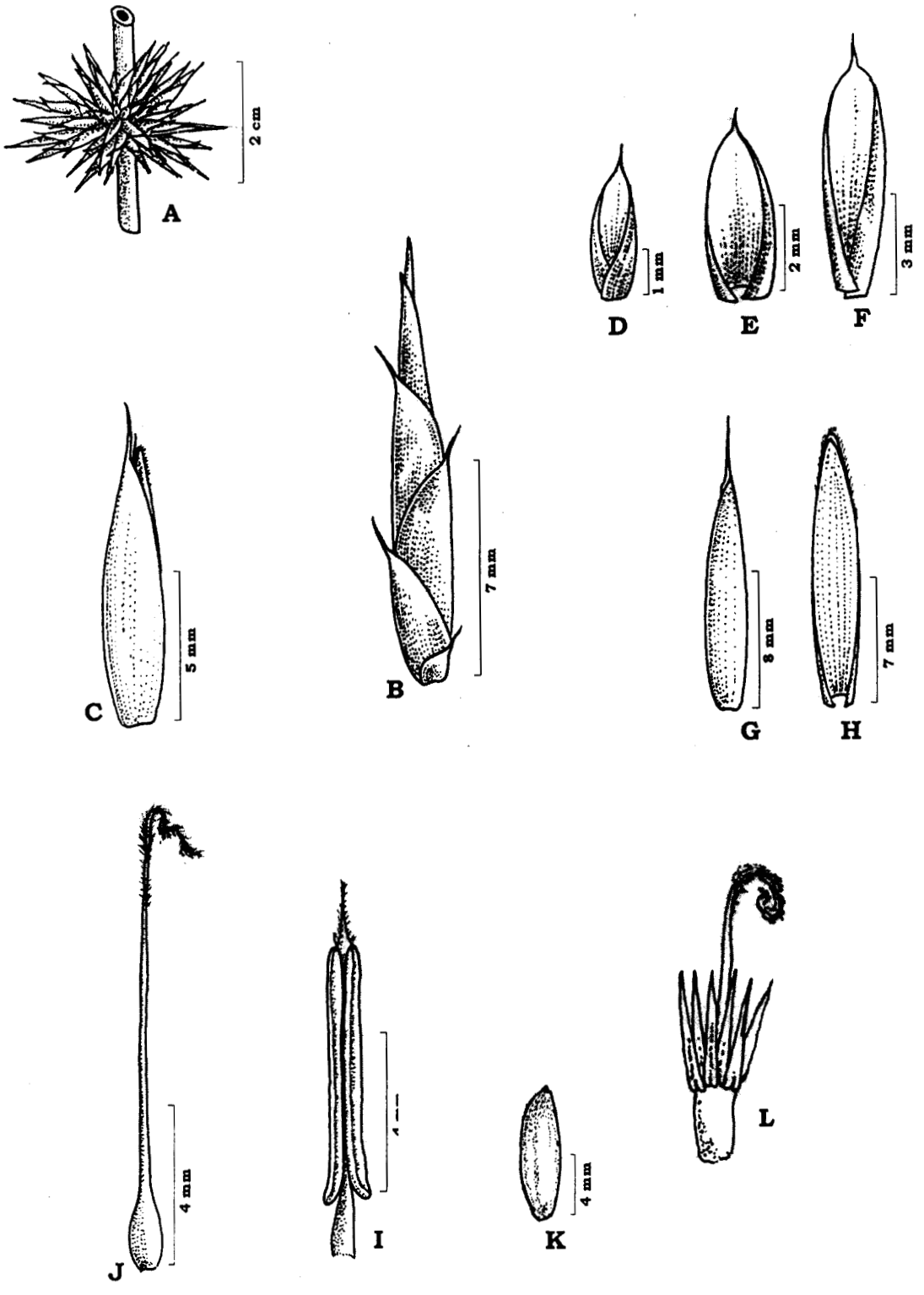


Figure 23. *Oxytenanthera ritchiei* (Munro) Blatt. & McCann **A.** portion of inflorescence; **B.** spikelet; **C.** floret; **D., E. & F.** sterile glumes; **G.** lemma; **H.** palea; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

ligule 0.4-0.5 cm high, membranous, fimbriate at tip, outer ligule inconspicuous; auricle absent; branches arise from the lower nodes, the central primary branch develops first and become dominant, 3-4 secondary branches develop from its lowermost nodes, branches are almost equal size, the branches rebranch from their nodes to form a cluster; leaves arise on branches, leaf blade 12-24 cm long, 1.2-3 cm wide, pale green, linear-lanceolate, glabrous on both sides, scabrous along one of the margins, base shortly attenuate to a very short petiole; inner ligule prominent. Inflorescence a large compound spikate, terminal panicle, arise on the nodes of branches as dense globose heads, the heads are very large at the nodes of the main axis, heads close towards the tip of the branches forming a dense cluster of spikelets; spikelets usually single flowered, sometimes 2, lanceolate, both fertile and sterile mixed, 1.5-1.8 cm long, 0.2 cm broad, glabrous, mucronate, spinose; sterile glumes 2-3, stiff, coriaceous, glabrous, ovate or ovate-lanceolate, mucronate, many nerved, first one 0.2-0.3 cm long, second 0.3-0.4 mm and third 0.5-0.7 mm long; fertile glumes, lemma linear-lanceolate, glabrous, coriaceous towards the base, 1.4-1.6 cm long, tip thick hard, strongly mucronate, spinose; palea membranous, glabrous, 1.2-1.4 cm long, concave, margins folded towards inside and ciliate towards tip, tip narrow, acute; stamens 6, monadelphous, exserted, anthers 0.6-0.8 cm long, strongly apiculate, tip ciliate. Ovary glabrous, ovate; style 1.2-1.4 cm long, slightly ciliate towards the tip; stigma single, curved plumose. Fruit a caryopsis, linear-oblong, faintly grooved with a small beak.

Distribution and ecology: This species is endemic to Peninsular India. It is distributed in northern Kerala and Karnataka. It was also reported from Maharastra. It is found growing from an altitude of 200-1100 m. It is a component of moist deciduous forests and also forms pure patches. Sporadic flowering is common in summer months. Gregarious flowering was observed in the year 2001 at Nilambur forests, Malappuram district, Kerala.

Specimens examined: KARNATAKA: Uttara Kannda Dist. s.loc. *WA Talbot 583* (BSI); *WA Talbot 906* (BSI); *WA Talbot 549966* (CAL); Dandeli, *RN Sarkar 2142* (DD). KERALA: Kannur Dist. Panathur, *VJ Nair 59948* (MH); Panathady, *VS Ramachandran 59291* (BSI). Malappuram Dist. Nilambur, *HG Champion 1135* (DD); Manikkamudy, *M Remesh & N Unnikrishnan 20650* (KFRI);

Vazhikkadavau, *Philip Mathew 34163* (CALI). Palakkad Dist. Manthanpotti, *M Kumar & Stephen Sequiera 20635* (KFRI).

Uses: The solid culms of this bamboo are used for making furniture, lathi, etc. It is used as a support for betal plants, also for making baskets, umbrella handles and walking sticks.

Note: This species was first described by Munro (1868) as *Bambusa ritcheyi*. He corrected the spelling of the specific epithet as '*ritchiei*' in the corrigenda, Page 157. But, most of the workers followed the spelling '*ritcheyi*' for the specific epithet. The correct spelling of the specific epithet accepted here is '*ritchiei*' (ICBN 1994, Art. 60.11, Rec. 60C.1.a) and the binomial is *Oxytenanthera ritchiei* (Munro) Blatter and McCann.

Subtribe: **Melocanninae** Benth.

Melocanninae Benth., J. Linn. Soc. London 19, 31. 1881; Clayton & Renvoize, Kew Bull. Addl. Ser. 13, 46. 1989; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 35. 1995; Ohrnberger, Bamb. World 20. 1999.

Type: *Melocanna* Trin.

Melocanneae Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 111. 1896.

Schizostachydinae Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Grass Syst. Evol. 237. 1987.

Medium sized or tall arborescent, gregarious bamboos forming tufts. Rhizomes sympodial, pachymorph, short necked, sometimes with long neck. Culms erect, clump forming, sometimes scandent, vining or drooping above; culm sheath mostly deciduous; branches intravaginal, many, subequal. Inflorescence iterauctant, in fascicles on leafy or leafless branches, large compound, spicate panicle, sometimes composed of pseudospikelets; spikelets 1-many flowered; sterile glumes 2-4; lemma convolute; palea keeled or not keeled; lodicules 3 to 7, sometimes absent; stamens 6 to many, rarely up to 130; style elongated, persistent; stigma 3 to 7; ovary glabrous. Fruit a caryopsis with strongly thickened pericarp, easily separable from the seed, nut-like or drupaceous, fleshy.

Clayton and Renvoize (1986) accepted this subtribe in their new system of grass classification. Soderstrom and Ellis (1987) treated this subtribe as *Schizostachydinae.* This classification was modified by Dransfield and Widjaja (1995) and treated *Schizostachydinae* as a synonym of *Melocanninae.* The genera included under this subtribe are *Cephalostachyum, Davidsea, Melocanna, Neohouzea, Ochlandra, Pseudostachyum, Schizostachyum* and *Teinostachyum.*

Distribution and ecology: The members of this subtribe are distributed in the Old World tropics. They are found growing in Africa, Madagascar, Sri Lanka, India, China, Myanmar and South East Asia. In South India, there are two genera under the subtribe Melocanninae such as *Ochlandra* and *Teinostachyum.*

Key to the genera

1a. Branches numerous forming a cluster at the nodal region, spikelets many flowered, sterile glumes 2; lodicules 3; stamens 6; fruit with dry pericarp ..... **Teinostachyum**

1b. Branches few; spikelets single flowered, sterile glumes 3-4; lodicules 3-7; stamens numerous; fruit with fleshy pericarp ..... **Ochlandra**

Ochlandra Thwaites

The name Ochlandra was derived from the Greek, '*Ochlos*', means '*Crowd*', and '*Andra*' means *androecium*; indicating the presence of numerous stamens.

This genus was first mentioned in Rheede's *Hortus Malabaricus* (1685) as *Beesha.* It was first scientifically described by Thwaites (1864) based on the Sri Lankan species, *O. stridula.* Munro (1868) accepted this genus name and described three species. Beddome (1873) treated this genus as *Irulia.* Gamble (1896) accepted the genus name *Ochlandra* and he described seven species and one variety.

In 1913, E. G. Camus described *Ochlandra capitata* based on *Nastus capitatus* (*Beesha capitata* (Kunth) Munro). This species was distributed in Madagascar. Another species of *Ochlandra, O. perrieri* was described by A. Camus (1935)

from Madagascar. Dransfield (1998a) after a detailed study on these species and found that they were not *Ochlandra.* She transferred *O. capitata* to *Cathariostachys capitata* and *O. perrieri* to *Valiha perrieri.* Gamble (1896) described another species of *Ochlandra, O. ridleyi* from Malay Peninsula. He raised another new species, *Schizostachyum latifolium* based on the same species. Dransfield (1983b) treated *Ochlandra ridleyi* as a synonym of *Schizostachyum latifolium.*

All other species of *Ochlandra* other than *Ochlandra stridula,* the type genus is endemic to Peninsular India. Eleven species and one variety of *Ochlandra* were reported from South India. Two species and one variety are synonymised in the present study and one new species is included.

Ochlandra Thwaites, Enum. Pl. Zeyl. 376. 1864; Benth. & Hook. f., Gen. Pl. 3: 1215. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 121. 1896 & in Hook. f., Fl. Brit. India 7: 418. 1897; E. G. Camus, Les Bamb. 180. 1913; Blatt., Indian For. 55(11): 609. 1929; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1863. 1934; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Grass Syst. Evol. 237. 1987; Soderstr. & R.P. Ellis, Smith Contr. Bot. 72: 66. 1988; Clayton & Renvoize, Kew Bull. Addl. Ser. 13, 57. 1989; Tewari, Monogr. Bamb. 109 1992; Seethalakshmi & M. Kumar, Bamb. India Comp.177. 1998; Ohrnberger, Bamb. World 326. 1999.

Type: *Ochlandra stridula* Thwaites

Beesha Rheede Hort. Malab. 5: 119. t. 60, 1685; Munro, Trans. Linn. Soc. London 26: 144. 1868.

Irulia Bedd., Fl. Sylv. S. India 235. 1873.

Medium sized, caespitose, gregarious plants with closely packed culms. Rhizome sympodial with short necks. Culms erect or semi-erect with hollow internodes, wall thin; branches few to numerous, subequal, unarmed; culm sheath strong with reflexed blades; leaves glabrous, petiolate. Inflorescence a large compound, spicate panicle, composed of pseudospikelets; spikelets single flowered; sterile glumes several; palea not keeled, glabrous; lodicules 3-7, stamens free, numerous, 15-130; ovary glabrous, style long, stigma 5-7. Fruit a caryopsis, long beaked, pericarp fleshy.

Distribution and ecology: This genus is distributed in India and Sri Lanka. In India, the genus *Ochlandra* is endemic to southern Western Ghats. They are growing from sea level to an altitude of 1500 m. This genus is commonly known as reed bamboo and requires high rainfall. They prefer stream sides, river banks and areas where water is available. They also grow as a component of moist deciduous and semi-evergreen forests, and sometimes form pure reed breaks (Plate 5).

Key to the genus ***Ochlandra*** *Thwaites*

1a. Leaves broad, 8-10 cm across, spikelet ovate-oblong, lodicules broad, 3-4, fruit subglobose to ovate-oblong 2

1b. Leaves narrow, 1.5-3.5 cm across, spikelets ovate-lanceolate, lodicules narrow, 6-7, fruit oblong-lanceolate 7

2a. Internodes rough, ventral side of the leaf rough, stamens around 40..... ..... **O. kadambaranii**

2b. Internodes smooth, ventral side of the leaf smooth, stamens 55-130 3

3a. Ligule conspicuous 4

3b. Ligule inconspicuous 5

4a. Ligule stiff, short, lacerate, 0.3-0.5 cm long ..... **O. ebracteata**

4b. Ligule membranous, long, fimbriate, 1.5-2.5 cm long..... **O. wightii**

5a. Auricle conspicuous; leaf sheath hirsute..... **O. keralensis**

5b. Auricle inconspicuous; leaf sheath smooth 6

6a. Style coiled or having a bend ..... **O. spirostylis**

6b. Style straight..... **O. travancorica**

7a. Branches few, unequal 8

7b. Branches numerous, subequal ..... **O. talboti**

8a. Culm sheath tip thick; spikelets hirsute, inner side of the blade hirsute..... ..... **O. beddomei**

8b. Sheath tip thin; spikelets glabrous, inner sides of the blade glabrous..... 9

9a. Sheath papery, persistent, blade needle like ..... **O. setigera**

9b. Sheath coriaceous, deciduous, blade narrow ..... **O. scriptoria**

Ochlandra beddomei Gamble, Ann. Roy. Bot. Gard. Calcutta 7:124. t. 110.1896 & in Hook. f., Fl. Brit. India 7: 419.1897; E. G. Camus, Les Bamb. 182. 1913; Rama Rao, For. Pl. Travancore 448. 1914; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1863.1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamb. 109. 1992; Chand Basha & M. Kumar, Rheedea 4(1): 25. 1994; M. Kumar, Rheedea 5(1): 66. 1995; Seethalakshmi & M. Kumar, Bamb. India Comp.178. 1998; Ohrnberger, Bamb. World 327. 1999 [Figures 24 and 25; Plate 19].

Type: India, West slopes of Nilgiris-Wayanad, 3000-4500 ft., *Beddome* s.n. (lectotype K. designated here. Cibachrome seen).

Typification: This species was first collected by Beddome from Wayanad. The specimen was deposited at K. Based on which Gamble (1896) described this species. This specimen is selected for lectotypification and designated here as lectotype [Plate 20].

Vernacular names: Oda (Malayalam)

Medium sized, caespitose, gregarious bamboo growing in tufts. Rhizome sympodial, pachymorh, solid, short necked, clothed with scale leaves. Culms erect, self supporting, hollow, 6-7 m tall, tip slightly arched; node somewhat swollen, sheath scar and nodal ridge prominent, a single nodal bud is present which is enclosed inside prophyllum; internodes 30-45 cm long, 2-3.5 cm diameter, glabrous, pale green; culm sheaths 14-22 cm long, 7.5-12 cm broad at base, coriaceous, covered with bulbous based brown hairs when young, sparsely hirsute, persistent or deciduous, striate, when old, tip thick and truncate; blade reflexed, glabrous, subulate, 3.5-5.5 cm long, 0.2-0.3 cm broad at base; auricle short with numerous stiff bristles; inner ligule short, 0.1-0.2 cm high, outer ligule not clear; branches arise from the 5th or 6th node, just above the sheath scar, intravaginal, the primary axis develops first and become prominent, 6-8 laterals develop from its basal buds, subequal; leaves arise on branches towards the tip, oblong-lanceolate, 15-28 cm long, 1.5-3.8 cm broad, glabrous on both sides, margins rough, scabrous, midrib prominent on lower side, tip acuminatus, setaceous and scabrous, obtuse at the base in to a short thick petiole; leaf sheaths imbricate, slightly hirsute, striate, ciliate along the margins; auricle prominent, decurrent with erect, stiff bristles; inner

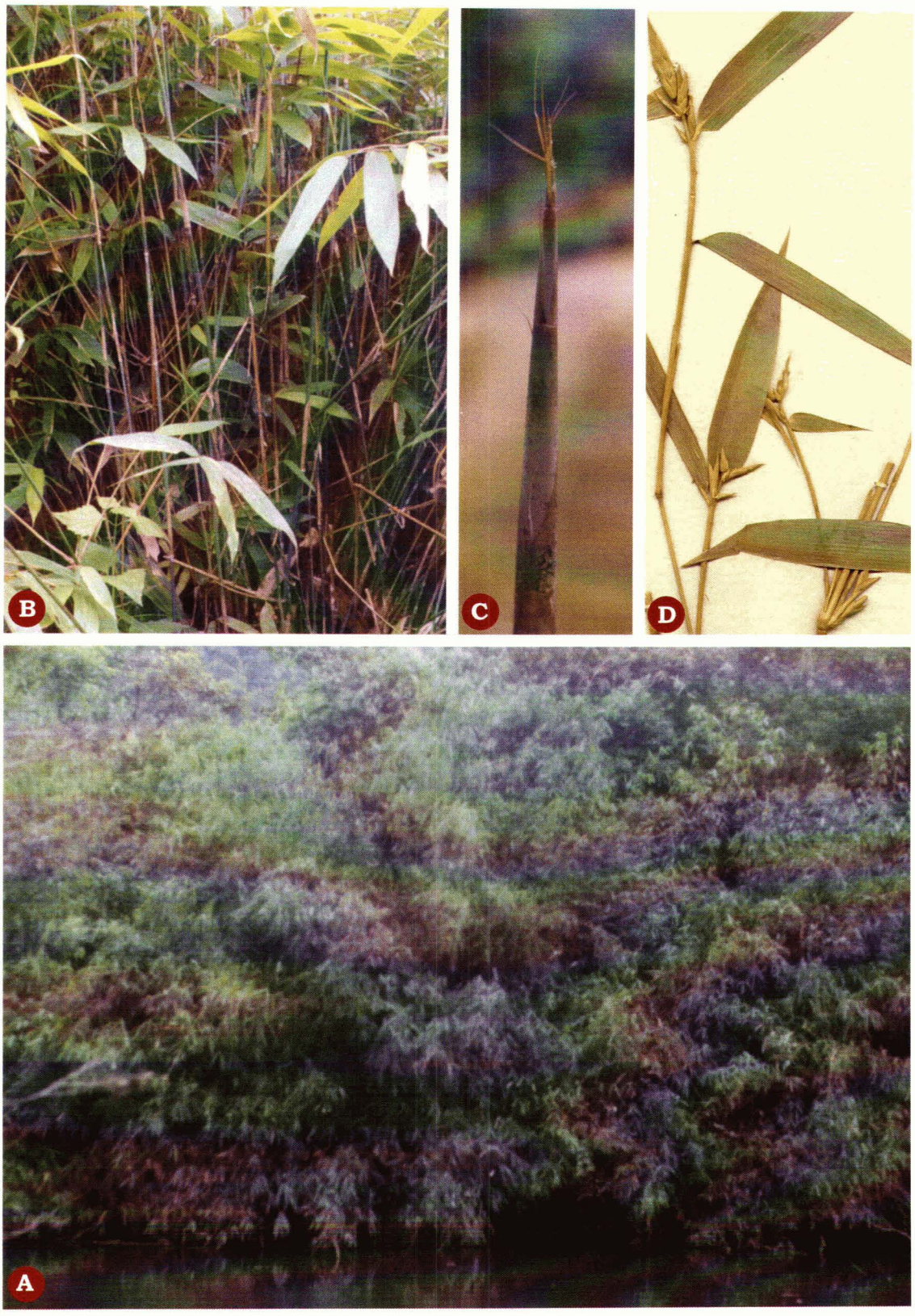


Plate 19. ***Ochlandra beddomei*** Gamble **A.** habit; **B.** culms; **C.** young shoot with sheath; **D.** inflorescence

Plate 20. ***Ochlandra beddomei*** Gamble - lectotype (K)

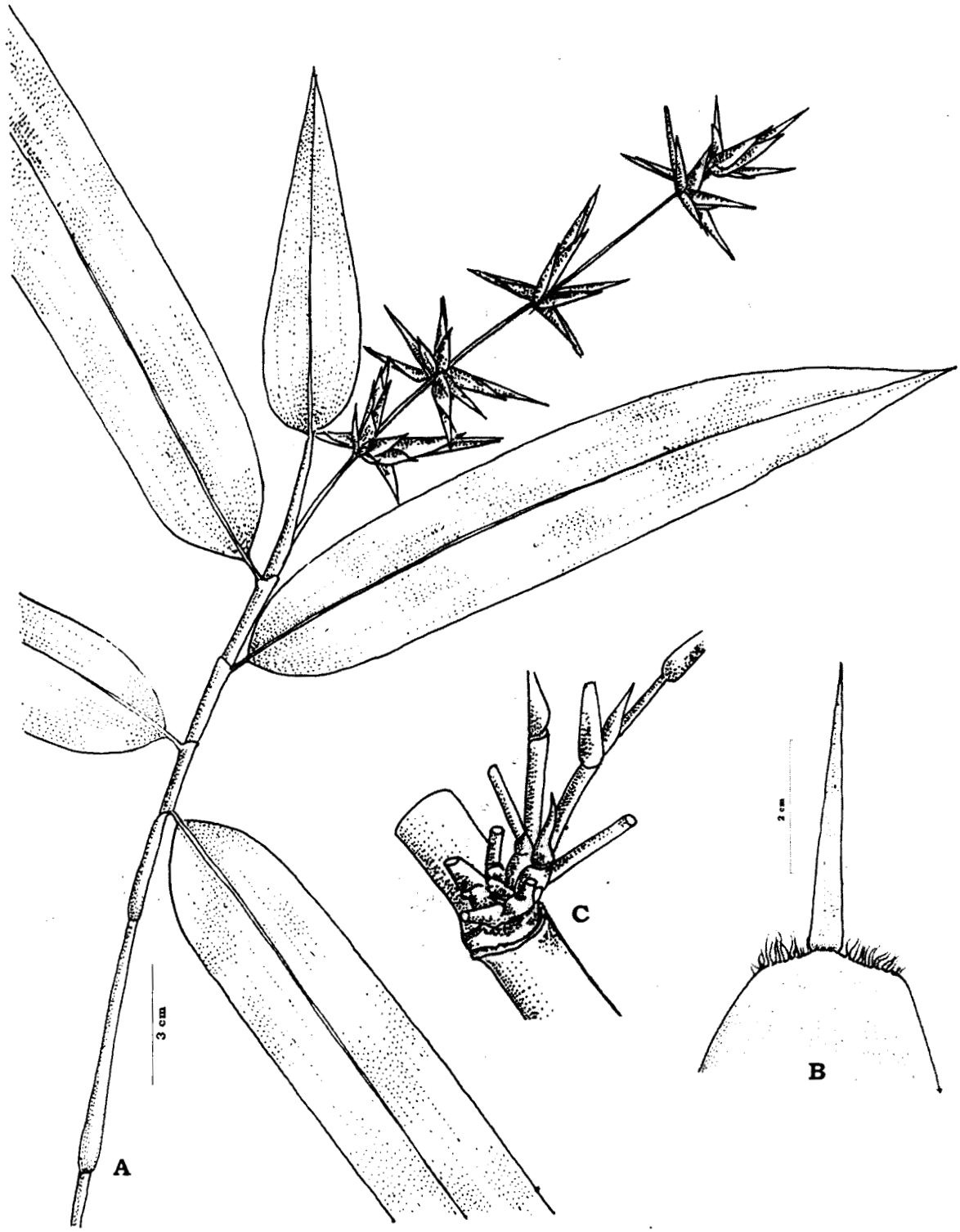


Figure 24. *Ochlandra beddomei* Gamble **A.** flowering branch; **B.** culm sheath; **C.** branching

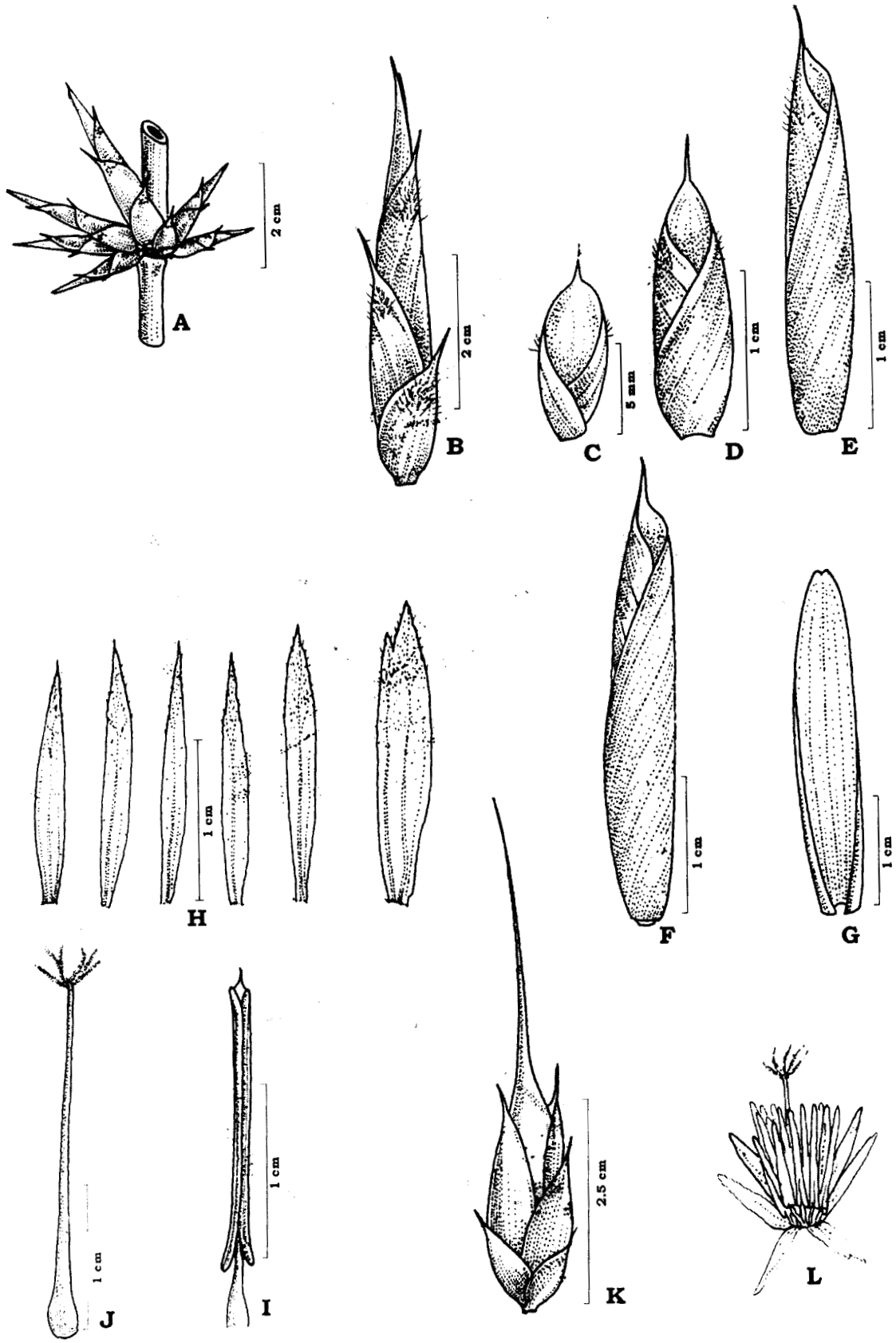


Figure 25. *Ochlandra beddomei* Gamble **A.** portion of inflorescence; **B.** spikelets; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

ligule very short, outer not prominent. Inflorescence a short terminal or auxiliary spicate panicle on leafy branches, spikelet arise on all branches at successive nodes as semiverticillate clusters, composed of pseudospikelets; spikelets single flowered, ovate-lanceolate, hirsute, 1.6-2.8 cm long, 0.2-0.4 cm broad, very short stalked, basal portion supported by 2-3 bracts; sterile glumes three, stiff and coriaceous, first two ovate-lanceolate, third one lanceolate, mucronate, hirsute towards the tip, many nerved; fertile glumes, lemma lanceolate, glabrous, thin, coriaceous, many nerved, 2.5-3 cm long, mucronate; palea thin, membranous, glabrous, ovate-lanceolate, 2.2-2.8 cm long, 0.2-0.3 cm broad, many nerved, convolute, tip acute, slightly bifid; lodicules 6, hyaline, narrow, all equal size, 1.3-1.5 cm long, 3-4 nerved, margins fimbriate, ciliate; stamens 28-32, yellowish, filaments free, short, 1.5-1.7 cm, basifixed, anthers apiculate, tip ciliate; ovary glabrous, slightly globose at the base, style covered by an angular perigynium, 2.3-2.7 cm long; stigma 6, plumose. Fruit a caryopsis, fleshy, long beaked, 5-6 cm long, 0.7-1.2 cm diameter, oblong, supported by persistent glumes.

Distribution and ecology: This species is endemic to Wayanad district, Kerala, growing at an altitude of 1000 to 1500 m. It is a component of moist deciduous and semi-evergreen forests. Flowering is rare. It flowered sporadically in 1998 at Thariyode, Wayanad district.

Specimens examined: KERALA: Wayanad Dist. Thariyode, *M Kumar 6466C* (KFRI); Thariyode, *N Unnikrishnan 74109* (CALI).

Uses: Tribes use it for making arrows, fish traps and the leaves for thatching their huts.

Ochlandra ebracteata Raizada & Chatterjee, Indian For. 89:362. 1963; Tewari, Monogr. Bamb. 110. 1992; M. Kumar, Rheedea 5:68.1995; Seethalakshmi & M. Kumar, Bamb. India Comp.180. 1998; Ohrnberger, Bamb. World 327. 1999 [Figures 26 and 27; Plate 21].

Type: India, Paruthipally range, Kottur Reserve, Trivandrum, *Managing Agents, Punalur Paper Mill 132695* (holotype DD !).

Vernacular names: Eetta (Malayalam)

Medium sized, caespitose, gregarious, bamboo with closely packed culms. Rhizome sympodial, pachymorph, solid short necked, covered with scale leaves. Culms erect, self supporting, hollow, 6-7 m tall, tip arched; nodes swollen, sheath scar and supranodal ridge very prominent, single nodal bud is present enclosed by prophyllum; internodes, 60-65 cm long, and 2-2.3 cm in diameter, pale green, smooth; culm sheath 14-22 cm long, 9-12 cm broad at base, coriaceous, striate, covered with dark brown bulbous based hairs when young, the upper part become smooth in old sheath, deciduous, striate, tip truncate; blade refluxed, smooth, subulate, 7-11 cm long, 0.8-1.2 cm broad at base; auricle very short with numerous stiff bristles; ligule prominent, inner ligule 0.8-1 cm long, lacerate, margins fimbriate, outer ligule inconspicuous; branches, arise from the upper nodes from the 6th or 7th node, just above the sheath scar, intravaginal emergence, the central axis develops first and dominates, 2-3 laterals develop from its basal buds, branches subequal, rebranch; leaves arise from branches towards the tip, oblong-lanceolate, 20-35 cm long, 5-7 cm broad, smooth on both sides, margins rough, one of the margins scabrous, midrib prominent on the lower side, tip acuminate, setaceous, scabrous, sometimes twisted, truncate at the base, petiole short and thick; leaf sheaths overlap, closely attached and smooth, striate; auricle short with stiff bristles; inner ligule prominent, 0.2-0.3 cm long, outer inconspicuous. Inflorescence a large compound, spicate panicle, arise on leafy branches, spikelets arise on all branches at successive nodes, form semiverticillate clusters, composed pseudospikelets; spikelets single flowered, fertile mixed with small sterile ones, ovate-lanceolate, glabrous, 2.5-4 cm long, 0.3-0.5 cm across, supported by 3-4 bracts, stalk very short; sterile glumes 3, stiff, coriaceous, ovate-lanceolate, mucronate, many nerved, 1.5-3 cm long; fertile glumes, lemma linear-lanceolate, thin, coriaceous, many nerved, 2.2-3.7 cm long, acuminate, mucronate; palea thin, membranous, glabrous, oblong, tip retuse, 2-3.4 cm long; lodicules 3, hyaline, 1.2-1.5 cm long, 0.6-0.9 cm broad, 3-4 nerved, margins fimbriate, ciliate; stamens 65-75, yellowish, filaments free, long, filiform, anthers 1.2-1.6 cm long, basifixed, apiculate, tip ciliate; ovary glabrous, spherical at the base, tip elongates into a perigynium enclosing the style; style long, 2.5-2.9 cm long, stigma 6, plumose. Fruit a caryopsis, large, pericarp fleshy, ovate-oblong, long beaked, 6-6.5 cm long, supported by persistent glumes.

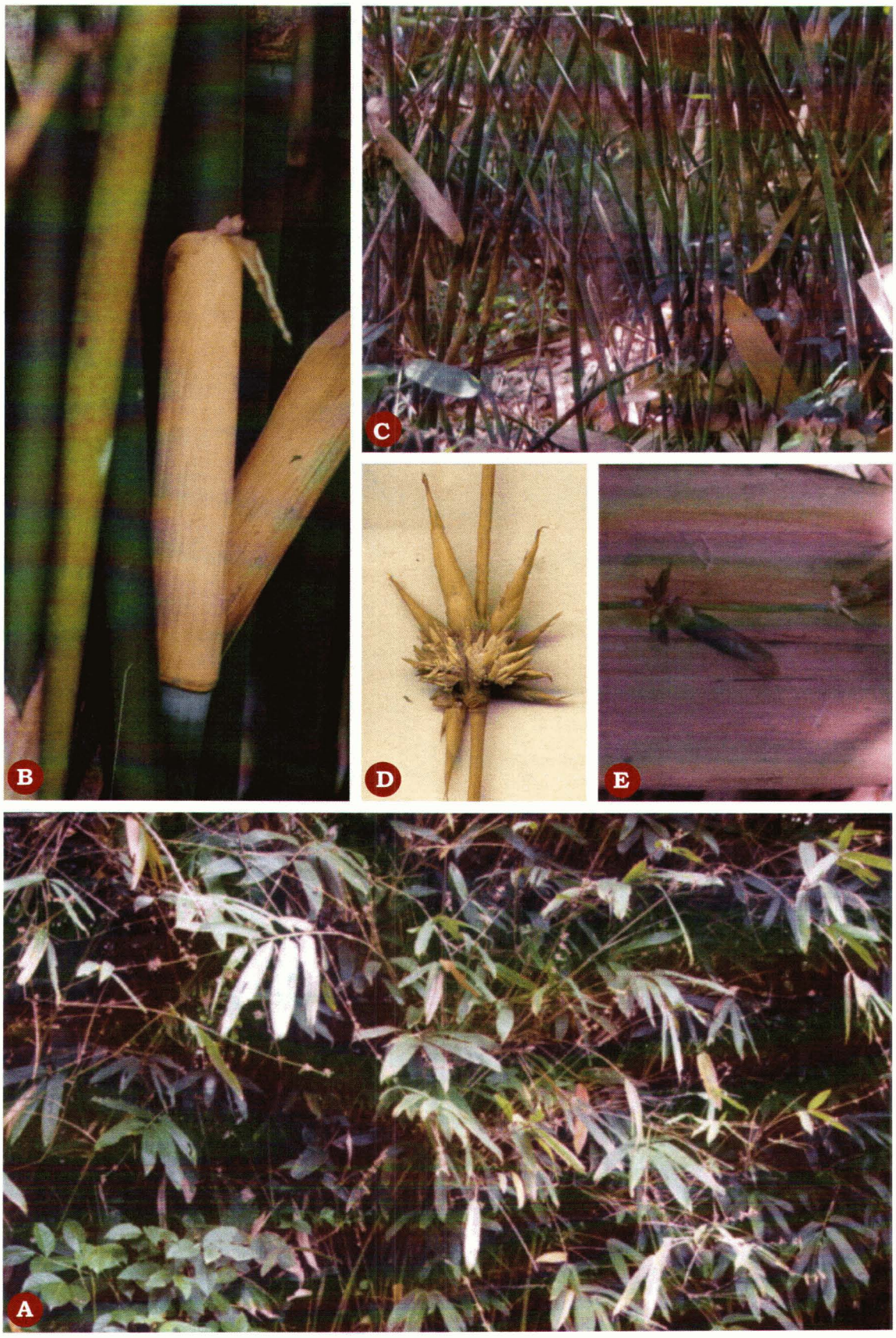


Plate 21. ***Ochlandra ebracteata*** Raizada & Chatterjee **A.** habit; **B.** culms with sheath; **C.** culms; **D. & E.** inflorescence

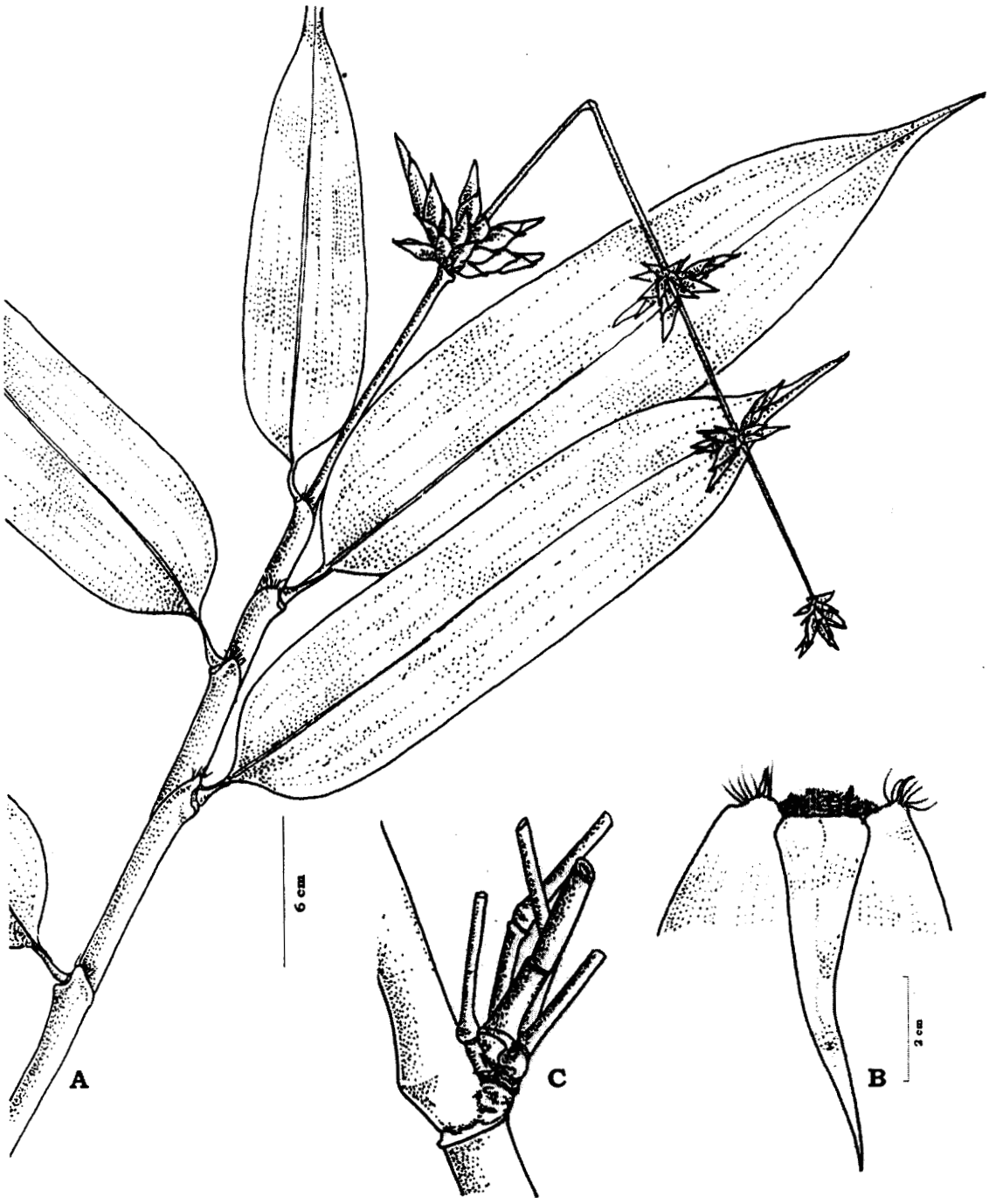


Figure 26. *Ochlandra ebracteata* Raizada & Chatterjee **A.** flowering branch; **B.** culm sheath; **C.** branching

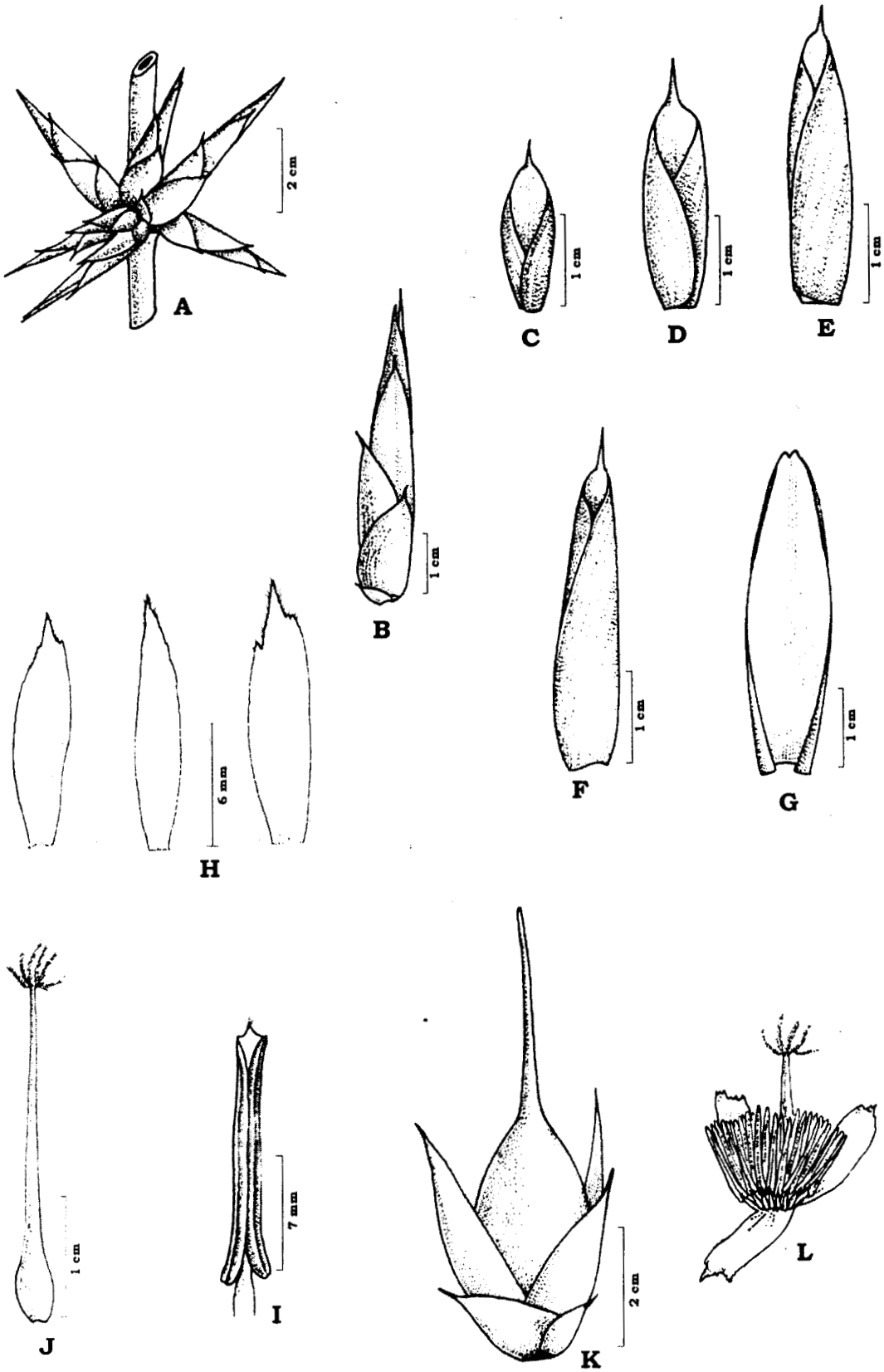


Figure 27. *Ochlandra ebracteata* Raizada & Chatterjee **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

Distribution and ecology: Endemic to Southern Western Ghats (Kerala), from an altitude of 500 to 1000 m. It is a component of semi-evergreen forests. It flowers gregariously and sporadically. Flowering starts in summer months. Gregarious flowering was observed at Thenmala, Achenkoil area, Kollam district in 1999. Flowering continuous for one year and all the culms die after fruiting.

Specimens examined: KERALA: Kollam Dist. Achenkoil, *M Kumar & Stephen Sequiera 7610* (KFRI); Kottavasal, *Jayalakshmi* 6494 (KFRI); Thenmala, Ambanadu, *N Unnikrishnan 74006* (CALI). Thrissur Dist. Palapilly, *M Kumar & CC Joy 6769* (KFRI). Thiruvanthapuram Dist. Kottoor, *Managing Agents, Punalur Paper Mill 132695* (DD).

Uses: It is a raw material for pulp, paper and plywood industry. It is also used for making mats and baskets.

Note: This species was first described by Raizada and Chatterjee (1963). According to them, this species is without bracts and the stamens are monadelphous. During this study it was observed that the spikelets are with bracts and also the filaments of the stamens are free.

Ochlandra kadambaranii M. Kumar, Unnikrishnan & Remesh, **sp. nov.** [Figures 28 and 29; Plate 22].

Type: India, Kerala, Kollam district, Nilamel, 150 m, *Unnikrishnan 74009* (holotype CALI, Isotype KFRI)

Medium sized, gregarious, caespitose bamboo growing in tufts. Rhizome sympodial, pachymorph, solid, short necked, covered with scale leaves. Culms slender, erect or semi-erect, self supporting, hollow, 3-5 m tall, tip slightly arching; nodes swollen, sheathscar and nodal ridge prominent, each node with a single prophyllate bud; internodes 23-38 cm long, 1.5-2.5 cm diameter, dark green, rough; culm sheath 11-15 cm long, 4-6.5 cm broad at base, coriaceous, thick brittle, glabrous except at the centre, middle portion sparsely hirsute, striate, tip truncate, persistent; balde narrow, subulate, reflexed, 5-7 cm long, 0.5-1 cm broad at base, glarbous, deciduous; auricles inconspicuous, bristles numerous, persistent; ligule not distict; branches arise from the 5th or 6th node,

Plate 22. ***Ochlandra kadambaranii*** M. Kumar, Unnikrishnan & Remesh **sp. nov.**
A. habit; **B.** branches; **C.** & **D.** flowers and fruits; **E.** leaves

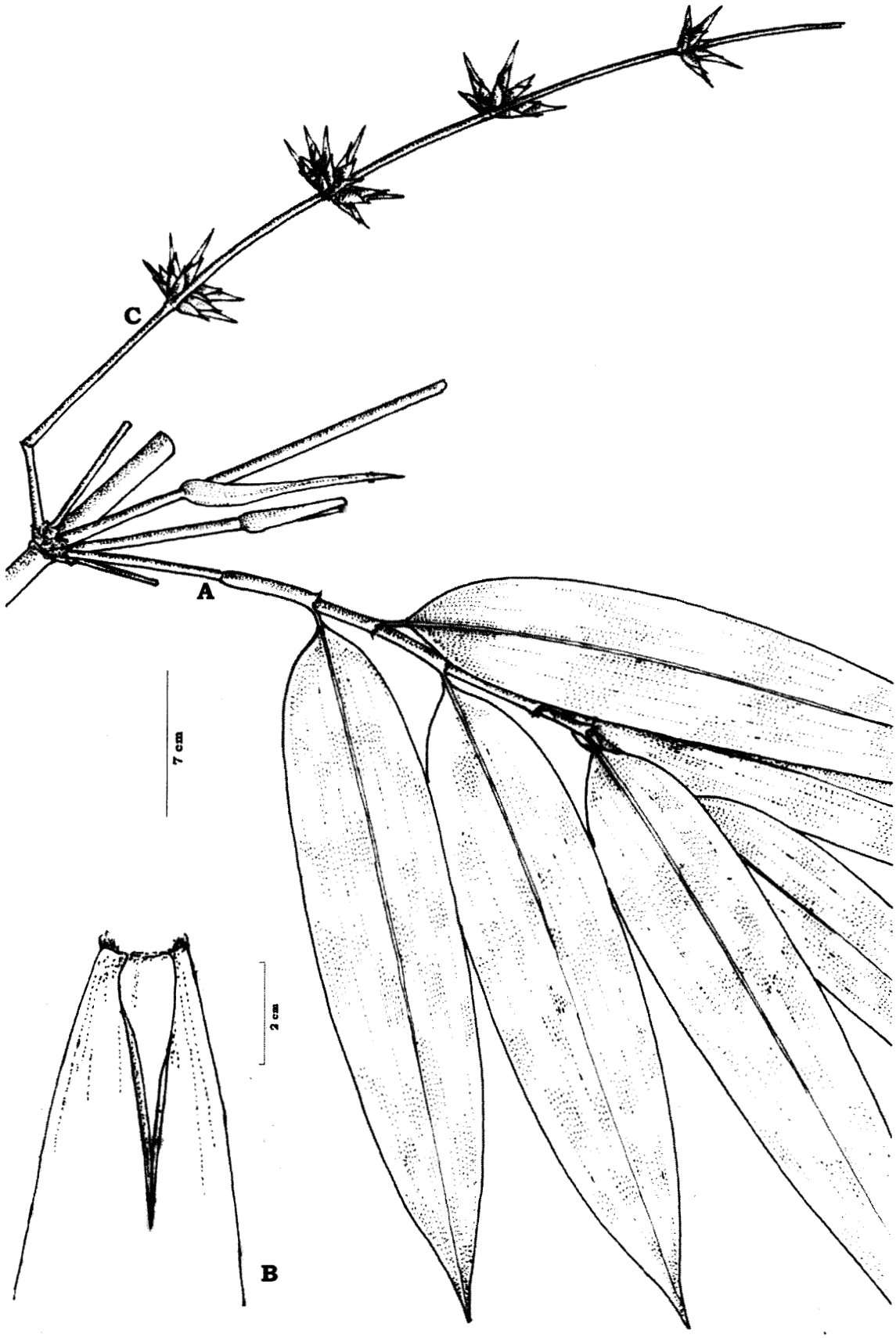


Figure 28. *Ochlandra kadambaranii M. Kumar, Unnikrishnan & Remesh* **sp. nov.** **A.** leafy branch; **B.** culm sheath; **C.** inflorescence

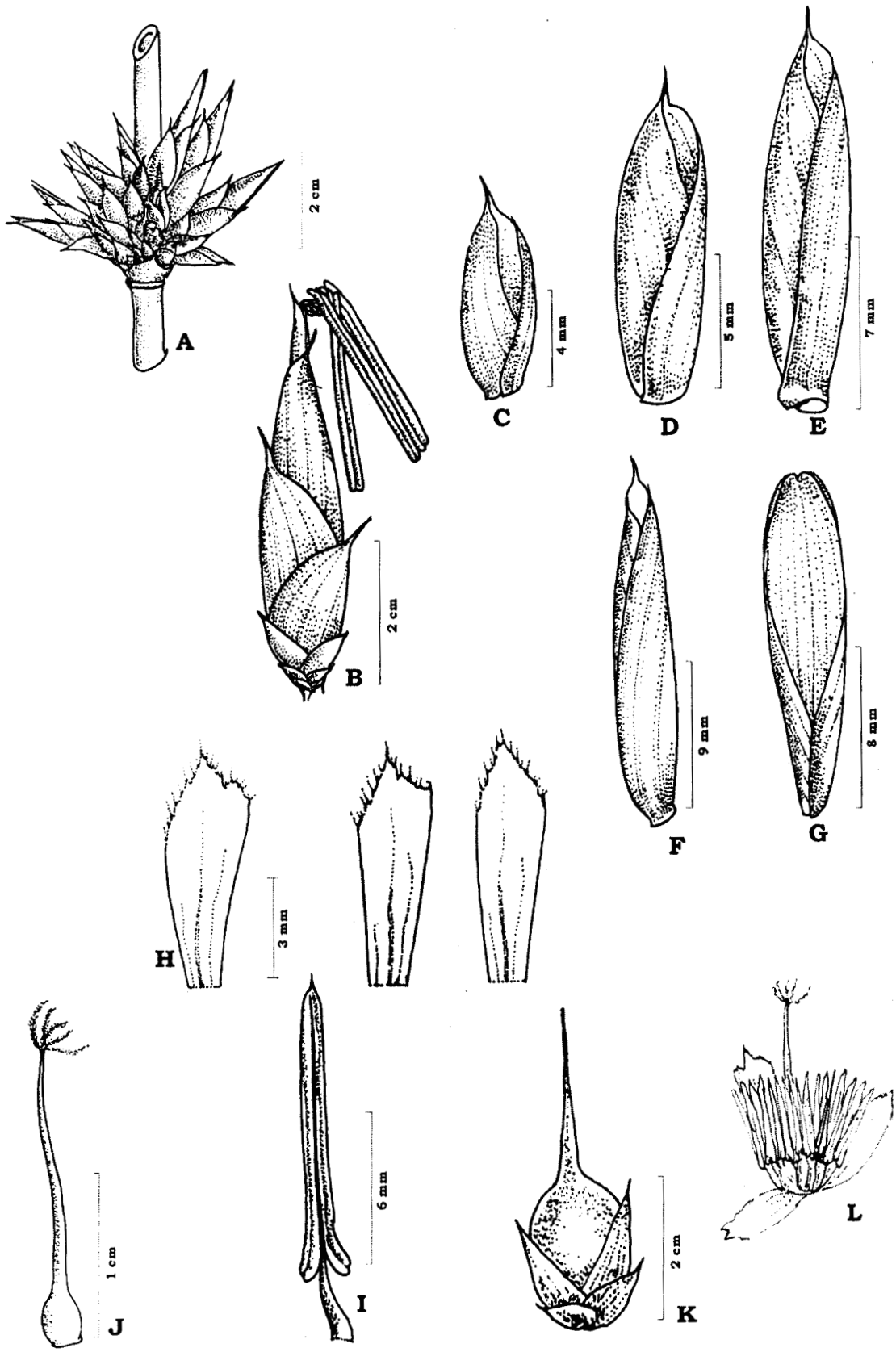


Figure 29. *Ochlandra kadambaranii* M. Kumar, Unnikrishnan & Remesh **sp. nov.** **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

intravaginal, the primary central axis develops first, 2 or 3 laterals develop from its basal buds, become subequal; leaves arise from the branches towards the tip, linear-lanceolate, 20-38 cm long, 5-10 cm broad, glabrous on dorsal side and rough on the ventral side, the ventral side of leaves of young plants pubescent, margins rough and scabrous, midrib prominet on lower side, tip acuminate, scabrous and sometimes twisted, attenuate at base in to a thick, short petiole; leaf sheaths overlap closely attach, glabrous, striate; auricle inconspicuous, bristles absent; inner ligule prominent, 0.2-0.3 cm high, membranous, outer ligule not distinct. Inflorescence a compound spikate panicle arise on leafy branches, composed of pseudospikelets, spikelets borne at all branches at successive nodes, form semiverticillate clusters, fertile and sterile mixed; spikelets single flowered, stout, short ovate-lanceolate, glarbous, 2.2-2.5 cm long, 0.3-0.4 cm diameter, very short stalked, supported by 2-3 bracts; sterile glumes 3, stiff, coriaceous, mucronate, many-nerved, first two ovate, 0.8-1 cm long, third one ovate-lanceolate, 1.2-1.5 cm long, fertile glume, lemma ovate-lanceolate, membranous, many-nerved, glabrous, acute, 1.5-1.8 cm long; palea oblong, thin, membranous, glabrous, 1.5-1.7 cm long, tip retuse, ciliate; lodicules 3, hyaline, broad, almost of the same size, 0.6-0.7 cm long, 3-4 nerved, bilobed, margins fimbriate, ciliate; stamens 37-40, brownish, short, form bundles of 5-9 stamens, anthers basifixed, 1.2-1.4 cm long, apiculate, tip ciliate; ovary glabrous, slightly globose; style enclosed inside perigynium, 2-2.3 cm long, stigmas 7, plumose. Fruit a caryopsis, globose, long beaked, 3.5-4 cm long, pericarp fleshy, fruit supported by persistent glumes.

Distribution and ecology: This new species is endemic to Southern Western Ghats and distributed in Southern Kerala. It was first collected from Nilamel, Kollam district. It was also reported from Pandimotta, Kollam district and found under cultivation at Kottayam district and Palapilly, Thrissur district. The species flowered gregariously in 1999-2000 at Pandimotta and Nilamel, Kollam district, Kerala.

Etymology: This is named after late Prof. Kadambaran Namboodiri, Head of the Department, Botany, NSS Hindu College, Changanassery, Kottayam district to commomorate his sound knowledge in taxonomy.

Specimens examined: KERALA: Kollam Dist. Pandimotta, *VB Sreekumar 20652* (KFRI). Kottayam Dist. Kottayam, *N Unnikrishnan* 74046 (CALI). Thrissur Dist. Palapilly, *M Remesh & N Unnikrishnan 20651* (KFRI).

Note: This species has affinities with *Ochlandra travancorica*. It is characterised by rough internodes. Leaves rough on the ventral side, prominent ligule, stamens around 40 and globose fruits. The ventral side of the leaves are pubescent in seedlings and in young plants.

Ochlandra keralensis Muktesh, Remesh & Stephen, J. Econ. Tax. Bot. 25: 49. 2001 [Figures 30 and 31; Plate 23].

Type: South India, Kerala, Pathanamthitta district, Pachakkanam, 1000 m, *Remesh & Stephen 20730* (Holotype KFRI !).

Medium sized, caespitose, gregarious, bamboo with closely packed culms. Rhizome sympodial, pachymorph, solid, short necked, clothed with scales. Culms erect, strong, self supporting, hollow, 5-6 m tall, tip slightly arched; node swollen, sheath scar and supranodal ridge prominent, single nodal bud present enclosed by prophyllum; internodes, 45-60 cm long, 2-3.5 cm diameter, pale green, slightly rough towards the tip; culm sheath 13-21 cm long, 6-9 cm broad at base, coriaceous, greyish or black bulbous based hairs present when young, hairs restricted to base when old, deciduous, striate, tip truncate, inner side smooth and shining; blade reflexed, glabrous, subulate, 5-8 cm long, 0.5-1 cm broad at base; auricle prominent, ear shaped, decurrent, bearing numerous stiff bristles; ligule very short, inconspicuous; branches arise from the 5th or 6th node, intravaginal emergence, the primary central axis dominates and develops first, 2-3 laterals develop from its basal buds, become subequal, branches rebranch; leaves arise towards the tip of the branches, linear-lanceolate, 18-40 cm long, 3.5-6.5 cm broad, glabrous on both sides, margins rough and scabrous, midrib prominent, clear on the ventral surface, tip acuminate, scabrous, truncate at the base, petiole short, thick, leaf sheaths overlap, closely attached, hirsute, clothed with stiff hairs, striate, auricle prominent, falcate, bear stiff bristles, bristles deciduous when old; inner ligule short, outer inconspicuous. Inflorescence a large compound spicate panicle, arise on leafy branches, terminal, spikelets arise on nodes of

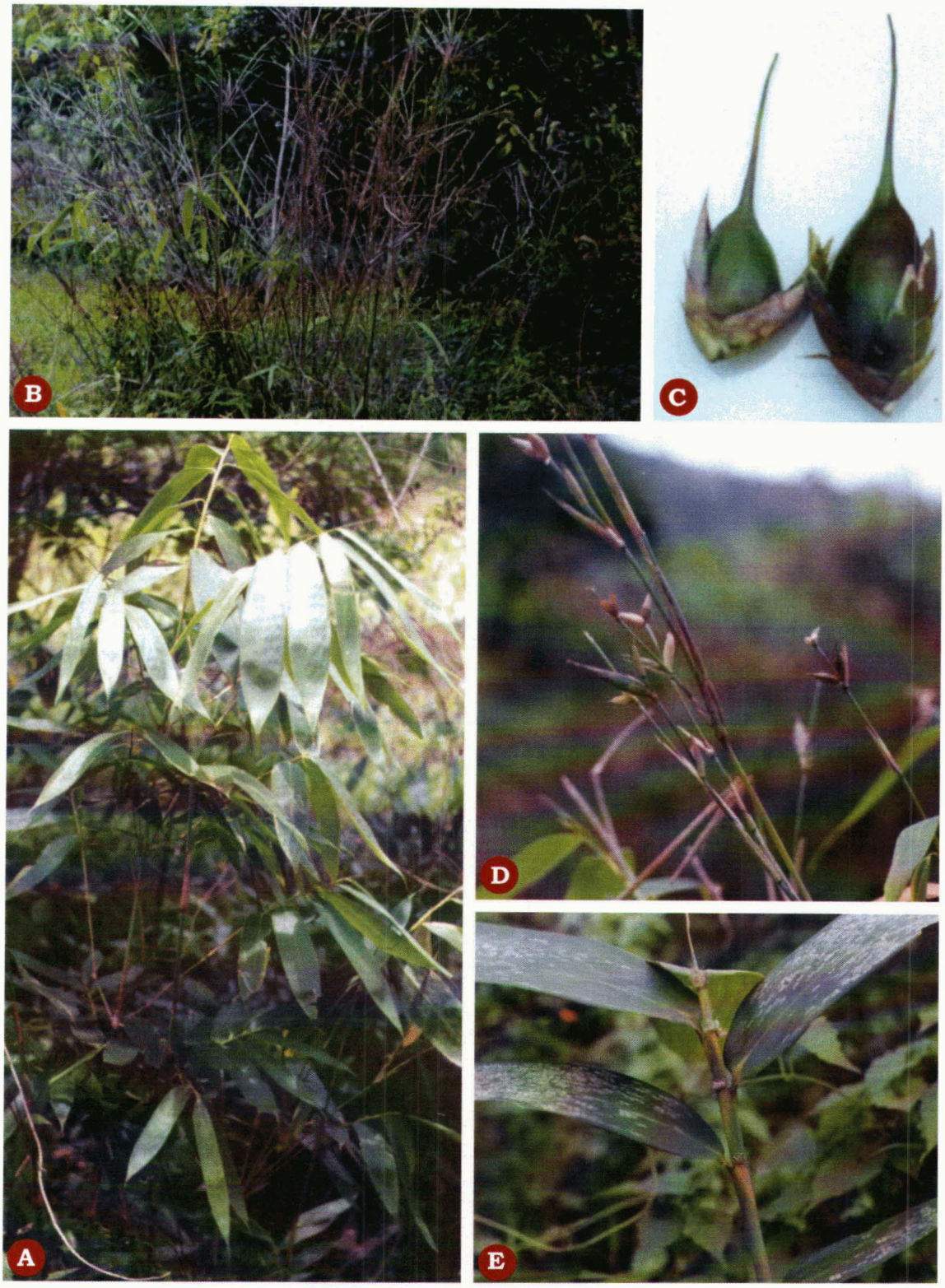


Plate 23. ***Ochlandra keralensis*** Muktesh, Remesh & Stephen **A.** habit; **B.** drying culms after flowering; **C.** fruits; **D.** inflorescence; **E.** leaves

Figure 30 *Ochlandra keralensis* Muktesh, Remesh & Stephen
A. leafy branch; **B.** culm sheath; **C.** inflorescence

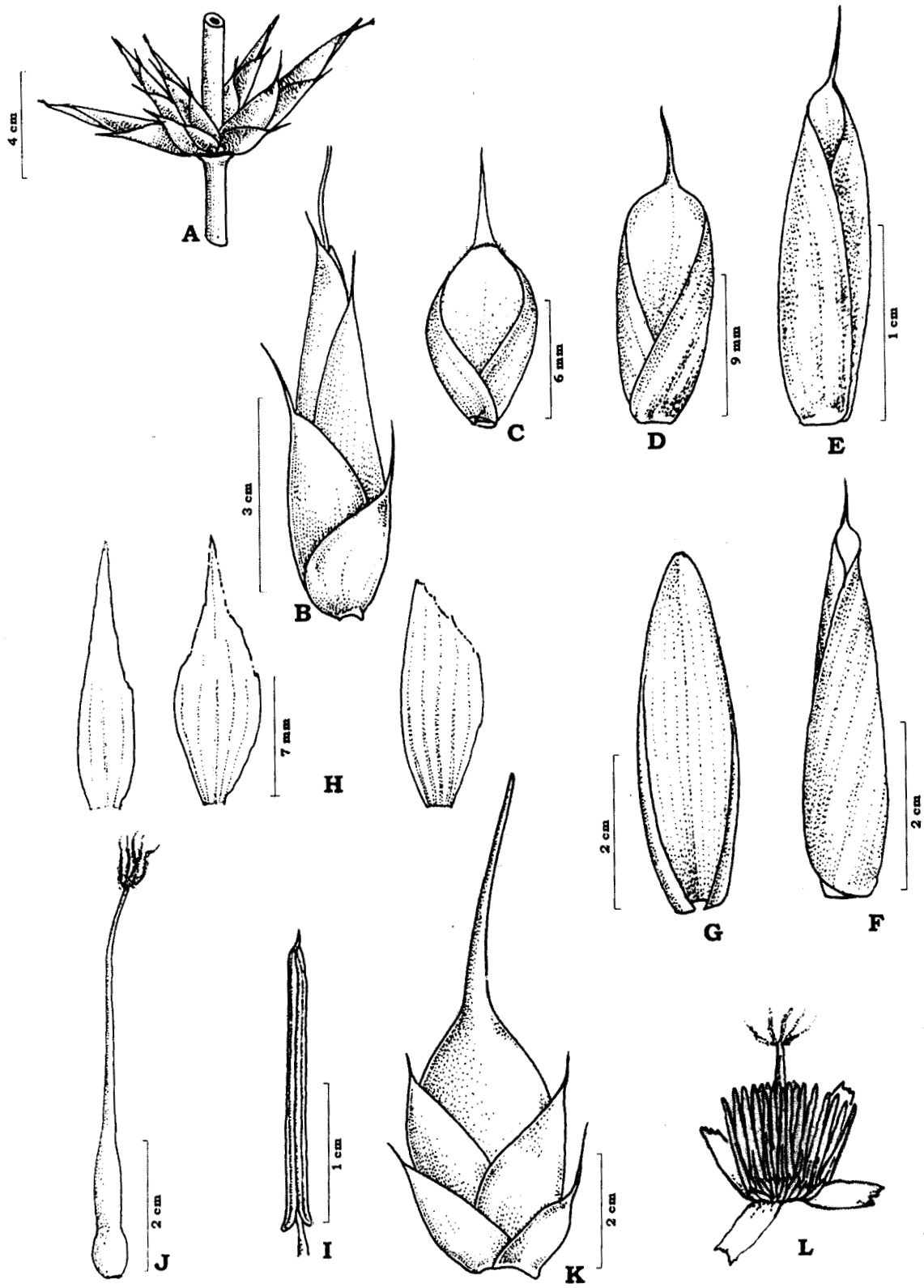


Figure 31. *Ochlandra keralensis* Muktesh, Remesh & Stepehn **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

all branches, composed of pseudospikelets, form semiverticillate clusters on nodes; spikelets single flowered, oblong-lanceolate, smooth, 5-6.7 cm long, 0.5-0.8 cm broad, short stalked, supported by 2-3 bracts; sterile glumes 3, stiff, coriaceous, first two are ovate-elliptic, 1.6-2 cm long, 0.5-0.7 cm broad, the third one lanceolate with acuminate tip, 2-2.3 cm long, 0.6-0.8 cm broad, mucrone prominent stiff bristles arise from the base of mucrone; fertile glumes, lemma ovate lanceolate, membranous, many nerved, 3.5-5 cm long, 0.7-0.9 cm broad, mucronate; palea thin, membranous, margins overlap, ovate-lanceolate, tip slightly notched, ciliate, 4.5-5 cm long; lodicules 3-4, filmy, hyaline, almost of equal size, 1.3-1.5 cm long, narrow towards the base, 4-5 nerved, margins fimbriate, ciliate; stamens 90-92, number varies from flower to flower, yellow coloured, filaments free, long, filiform, basifixed, anthers 2.0-2.2 cm long, apiculate, tip ciliate; ovary glabrous, slightly spherical at base, gradually elongates in to a perigynium enclosing a long style; style5.5-6.5 cm long, tip divides to form 5-7 plumose stigma. Fruit a caryopsis, large, fleshy, ovate-oblong, 8-9 cm long, 2.5-3 cm across, supported by persistent glumes.

Distribution and ecology: Endemic to South India, distributed only in the type locality. Not reported from anywhere. Growing near and an open marshy place at an elevation of 1000 m.

Specimens examined: KERALA: Pathanamthitta Dist. Pachakkanam, *M Remesh & Stephen Sequiera 20730* (KFRI); Pachakkanam, *N Unnikrishnan 74012* (CALI).

Note: This species has close affinity with *O. travancorica.* In the protologue it was mentioned that the number of lodicules is four. But it was found that majority of flowers have 3 lodicules. When 4 lodicules are present one is very small.

Ochlandra scriptoria (Dennst.) C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1863. 1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamb. 110. 1992; M. Kumar, Rheedea 5(1): 70.1995; Seethalakshmi & M. Kumar, Bamb. India Comp.182. 1998; Nicolson *et al.*, Interpr. Hort. Malab. 311. 1998; Ohrnberger, Bamb. World 327. 1999 [Figures 32 and 33; Plate 24].

Type: India, Malabar, *Johanstone* s.n. (lectotype CAL. designated here).

Bambusa scriptoria Dennst., Schluess. 9, 19, 31. 1818.

Beesha rheedei Kunth, Enum. 1: 434.1833; Munro, Trans. Linn. Soc. London 26:144.1868.

Beesha Rheede, Hort. Malab. 5: 119. t. 60, 1685.

Ochlandra rheedei (Kunth) Benth. & Hook.f. ex Gamble, Ann. Roy. Bot. Gard. Calcutta 7:121, t.107.1896 & in Hook. f., Fl. Brit. India 7:418.1897; Brandis, Indian Trees 684. 1906; Bourd., For. Trees Travancore 403. 1908; E. G. Camus, Les Bamb. 181. 1913.

Typification: This species was first mentioned in Rheede's Hortus Malabaricus (1685) as *Beesha*. Dennstedt (1818) named this species as *Bambusa scriptoria*. This species was first scientifically described by Munro (1868) as *Beesha rheedei*. The description was based on the specimens collected by Wight and also by Johanstone. According to Gamble (1896) this species was first collected by Wight and by Johanstone in 1836. From this description it is evident that Munro (1868) used specimens collected by Wight and Johanstone for his description. The specimen collected by Johanstone was deposited at CAL. Wight's collections was found missing [Plate 25].

Specimen collected by Johanstone was deposited at CAL which is selected here for lectotypification and designated as lectotype.

Vernacular names: Pal oda, Ottal, Ama (Malayalam)

Medium sized, caespitose, gregarious, shrubby bamboo. Rhizome sympodial, pachymorph, solid, short necked. Culms erect, sometimes straggling, hollow, 5-6 m tall, tip arched or drooping; node swollen, sheath scar and nodal ridge clear, each node bear a prophyllate bud; internodes 20-60 cm long, 1-2 cm diameter, pale green, smooth; culm sheath 15-20 cm long, 6-8 cm broad at base, sparsely hairy when young, hairs restricted to the base and margins when old, deciduous or persistent, striate, papery, tip rounded and truncate, inner side smooth and shining; blade erect, glabrous, narrow, deciduous, 2.5-4.5 cm long, 0.3-0.5 cm broad at base; auricles falcate with stiff bristles, auricle and bristles fall off at maturity; ligule very short, 0.2 cm high; branches arise from the 5th or 6th node onwards, young branches arise just

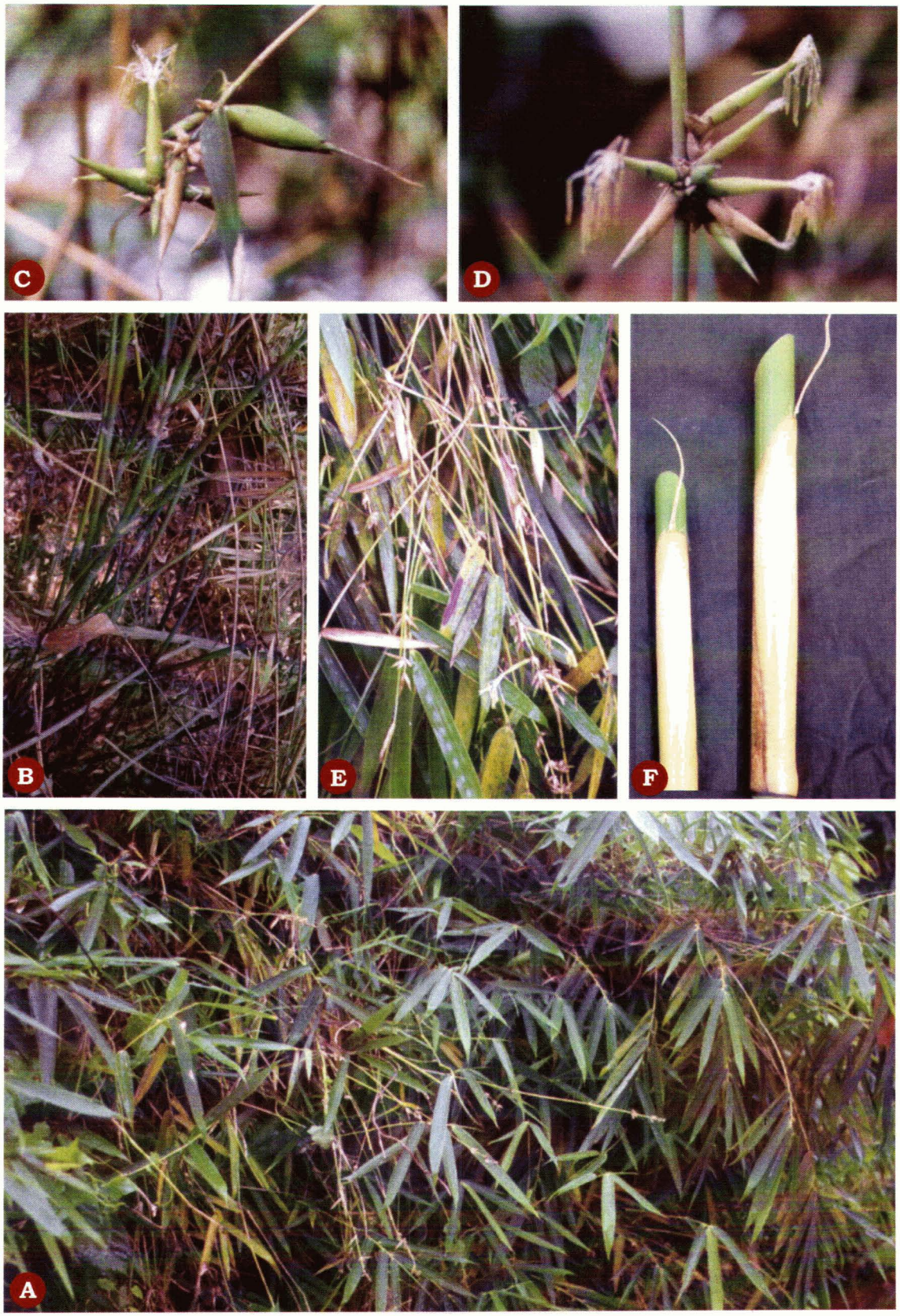


Plate 24. ***Ochlandra scriptoria*** (Dennst.) C.E.C. Fisch. **A.** habit; **B.** culms; **C. & D.** flowers and fruit; **E.** inflorescence; **F.** culm sheath

Plate 25. ***Ochlandra scriptoria*** (Dennst.) C.E.C. Fisch. - lectotype (CAL)

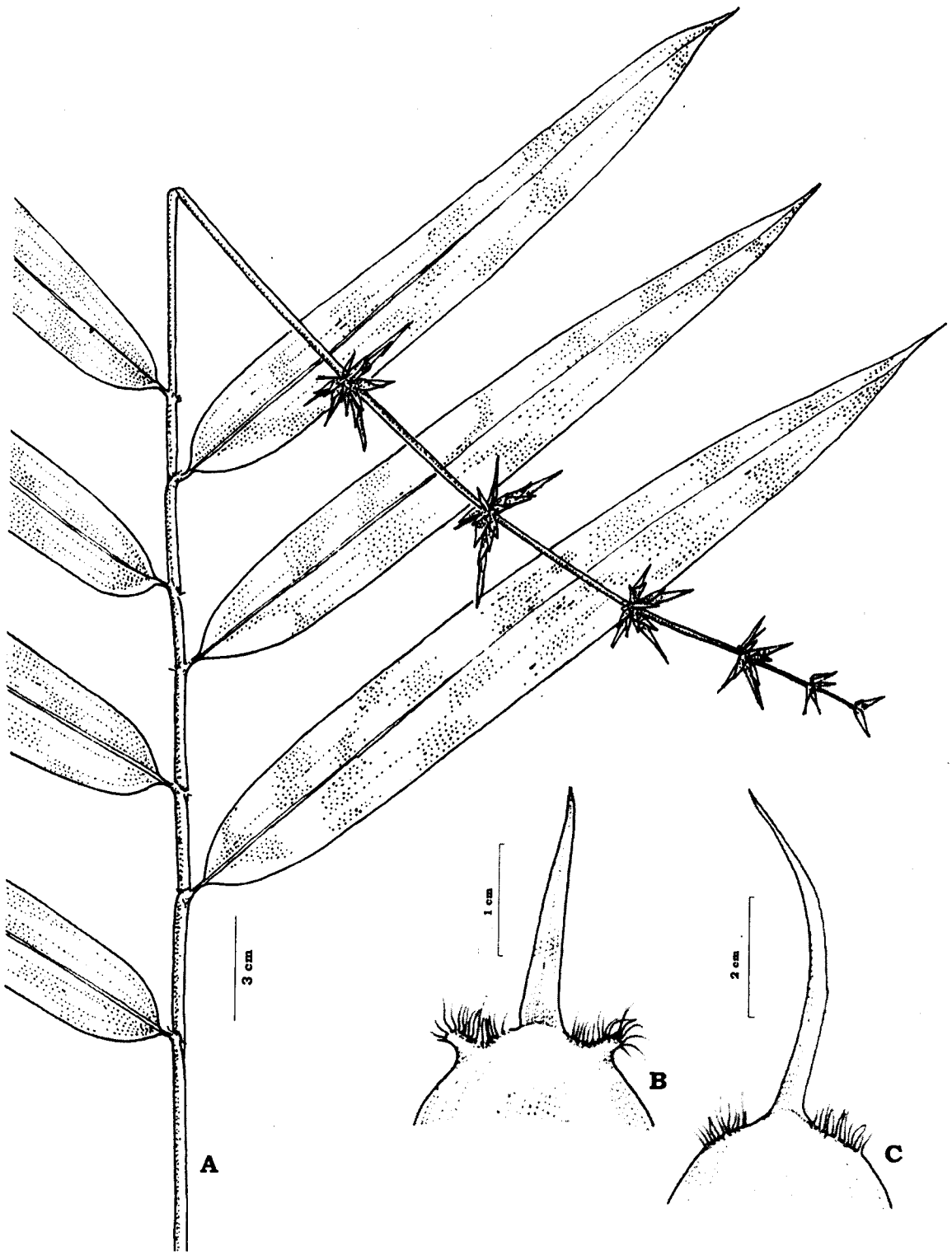


Figure 32 *Ochlandra scriptoria* (Dennst.) C.E.C. Fisch. **A.** flowering branch; **B. & C.** culm sheaths

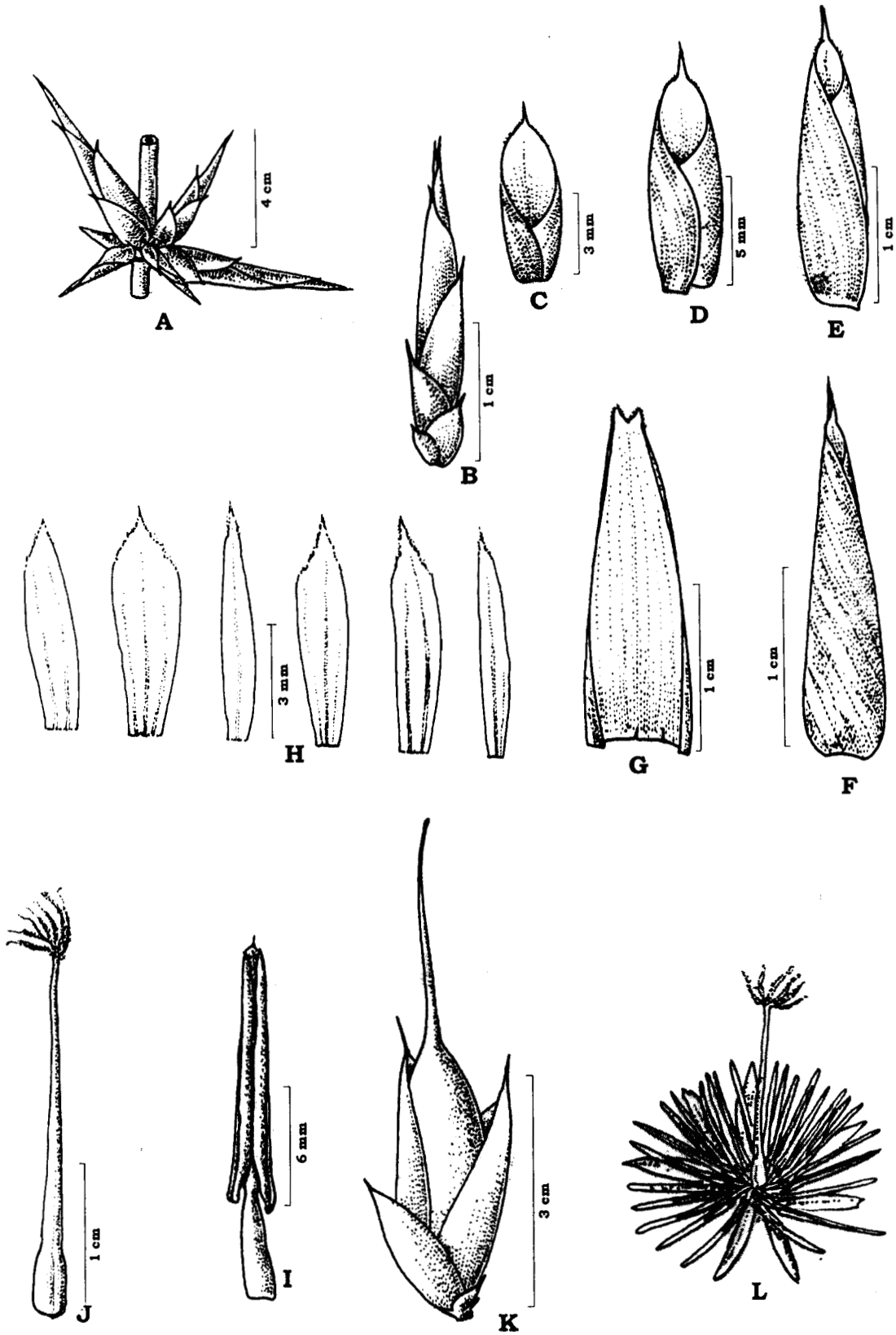


Figure 33. *Ochlandra scriptoria* (Dennst.) C.E.C. Fisch. **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

above the sheath scar, intravaginal emergence, the central primary axis arise first and three or four laterals produce from its base, subequal, branches some times rebranch; leaves arise from the nodes of branches towards the tip, linear- lanceolate, narrow, 11-30 cm long 1.5-3.5 cm broad, glabrous on both sides, one of the margins scabrous, midrib prominent, clear on the lower side, tip acuminate, scabrous, truncate at the base in to a very short petiole, leafsheaths overlap, smooth, striate, auricles small, falcate with stiff bristles, bristles deciduous; ligule very short outer ligule absent. Inflorescence a compound spicate panicle, arise terminal on the leafy branches, composed of pseudospikelets, from the nodes of all branches as semiverticillate clusters, fertile and sterile flowers mixed; spikelets single flowered, ovate-lanceolate, glabrous, 0.8-2.4 cm long, 0.2-0.3 cm across, short stalked, spikelets supported at the base by 2-3 sterile bracts, sterile glumes 3, the first two ovate, 0.6-1.2 cm long, 0.4-0.6 cm broad, and the third one 2-2.3 cm long, 0.8-1 cm broad, ovate-lanceolate, coriaceous, acute, mucronate, many nerved, hairy along the margins; fertile glumes, lemma lanceolate, thin, many nerved, sub-mucronate, 1.9-2.1 cm long, 0.3-0.5 across; palea, smaller than lemma, membranous, ciliate along the margins, retuse, tip slightly fimbriate, 1.5-1.7 cm. long, 0.3-0.4 broad; lodicules, 6-7, hyaline, narrow, equal size, 0.5-0.7 cm long, 0.2-0.3 cm broad, 3-4 nerved; stamens 15-25 numbers, number not fixed, filaments free, short filiform; anthers 1-1.2 cm long, yellow, apiculate, tip ciliate; ovary glabrous, oblong, terminating into a perigynium enclosing a style; style 1.3-2.8 cm long, tip divides to 5-6 plumose stigma. Fruit a caryopsis, fleshy, oblong, 6-6.5 cm long, 0.7-1 cm across, supported by persistent glumes.

Distribution and ecology: This species is endemic to South India, found growing in Kerala and Southern Karnataka. It is distributed from sea level to an altitude of 600 m. It is common along the river and stream sides. Sporadic flowering is frequent in this species. Gregarious flowering was observed in Pathanamthitta district in the year 2000.

Specimens examined: KERALA: Malabar, s.loc. *Johanstone* s.n. (CAL); Flora of Travancore, s.loc. *JF Bourdillon 6821* (DD). Ernakulam Dist. Peruvannamuzhi, *M Kumar 6418* (KFRI). Kannur Dist. Iritti, *N Unnikrishnan 74037* (CALI). Kollam Dist. Kallada, *N Unnikrishnan 74036* (CALI); Pattazhi, *N Unnikrishnan*

74205 (CALI). Kottayam Dist. Mundakkayam, *A Meebold 12783* (DD); Erattupetta, *N Unnikrishnan 74001* (CALI); Puthupally, *N Unnikrishnan 74003* (CALI); Manimala, *N Unnikrishnan 74007* (CALI). Malappuram Dist. Nilambur, *N Unnikrishnan 74016* (CALI). Pathnanmthitta Dist. Kattoor, *N Unnikrishnan 74043* (CALI). Thrissur Dist. Vazhachal, *N Unnikrishnan 74035* (CALI). Wayanad Dist. Chandanathode, *VS Ramachandran* 66838 (KFRI); Cherukattorr, *N Unnikrishnan 74030* (CALI).

Uses: It is a very good soil binder and planted on riverbanks to prevent erosion of soil. Tribes use the culms for making arrows, animal traps, etc. In folk medicine and tribal medicine the splited culms have been using for minor surgeries. This species is medicinal and used for treating toothache and also for menstrual problems.

Note: *Ochlandra scriptoria* is common along the river banks in different parts of Kerala and South Karnataka. It flowers almost every year. According to Bourdillon, this species flowers annually, and culms are not dying after flowering (Gamble, 1896). During this study gregarious and sporadic flowering were observed in *O. scriptoria*. In the first case the whole culms dead after seed setting. In the second case the flowered culms dried and the other culms of the clump survived. Presence of falcate auricle is considered as a key character of this species. But it was observed that it is visible only in young shoots.

Ochlandra setigera Gamble, Ann. Roy. Bot. Gard. Calcutta 7:128.1896 & in Hook. f., Fl. Brit. India 7:420.1897; Brandis, Indian Trees 685. 1906; E. G. Camus, Les Bamb. 184. 1913; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1863. 1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamb. 113. 1992; Chand Basha & M. Kumar, Rheedea 4(1): 26. 1994; M. Kumar, Rheedea 5(1): 66.1995; Seethalakshmi & M. Kumar, Bamb. India Comp.185. 1998; Ohrnberger, Bamb. World 328. 1999 [Figures 34 and 35; Plate 26].

Type: India, Nilgiris, Gudallur, 3000 ft., *JS Gamble 25503*, (holotype K. Cibachrome seen).

Vernacular names: Oda (Malayalam)

Medium sized caespitose gregarious bamboo growing in tufts. Rhizome sympodial, pachymorph, solid, neck short, covered with scales; culms erect or straggling, hollow, 5-8 m height, the tip is whip like and pendulous; node slightly swollen, sheath scar and supranodal ridge prominent, each node with a single bud enclosed by a prophyllum; internodes 23-35 cm long, 1.5-2.2 cm diameter, yellowish green, smooth, a white band present just below the nodes; culm sheath 12-18 cm long, 7-9 cm broad at base, papery, sparsely hirsute when young, become glabrous, the tip of the sheath become wrinkled and break off and the rest remain persistent, dry, thin, striate when old, tip narrow, rounded; blade very narrow, needle like, involute, hirsute inside, 2-3 cm long; auricle absent, oral setae inconspicuous; ligule not prominent; branches arise from the 5th or 6th node, arise just above the sheath scar, intravaginal, the central primary axis develops firsts, numerous laterals develop from its basal buds, almost of equal size; leaves arise on branches towards the tip, linear-lanceolate, 6-23 cm long, 1-2.3 cm broad, glabrous on both sides, one of the margins rough, scabrous, midrib prominent on the lower side, many pellucid glands present on the blade, tip acuminate, setaceous, scabrous, truncate at the base, narrows into a short, thick petiole; leaf sheath closely adhere on the branch, smooth, striate; auricle very short with stiff bristles, bristles deciduous; inner ligule very short, outer not prominent. Inflorescence a short spicate panicle on leafy branches, terminal or axillary, composed of pseudospikelets, form semiverticillate clusters at the nodes; spikelets single flowered, ovate-lanceolate, sparsely hirsute, 2-3 cm long, 0.3-0.4 cm across, almost sessile, supported by 2-3 bracts; sterile glumes 3, stiff and coriaceous, mucronate, hirsute towards the apex, many nerved, first two ovate, 0.6-1.8 cm long, 0.3-0.7 cm broad, the third one ovate-lanceolate, 1.2-1.8 cm long, 0.6-1 cm broad; fertile glumes, lemma ovate-lanceolate, mucronate, thin, membranous, 2-2.8 cm long, 0.3-0.4 cm broad, many nerved, smooth; palea thin membranous, ovate-oblong, 2.2-2.6 cm long, 0.3-0.5 cm broad, glabrous, many nerved, tip obtuse, slightly notched; lodicules 6-7, hyaline, almost same size, 1-1.3 cm long, margins fimbriate, ciliate; stamens 25-32, yellow, filaments free, short, anthers 1.8-2 cm long, basifixed, non apiculate; ovary glabrous, slightly globose at base, tip elongates into a perigynium which encloses a narrow, long style inside; style 2.4-2.7 cm long, glabrous, tip divides to 6 plumose stigma. Fruit a caryopsis, oblong, long

Plate 26. ***Ochlandra setigera*** Gamble **A.** habit; **B.** culms; **C. & D.** young shoot with sheath; **E.** inflorescence; **F.** branches

Figure 34. *Ochlandra setigera* Gamble **A.** flowering branch; **B.** culm sheath

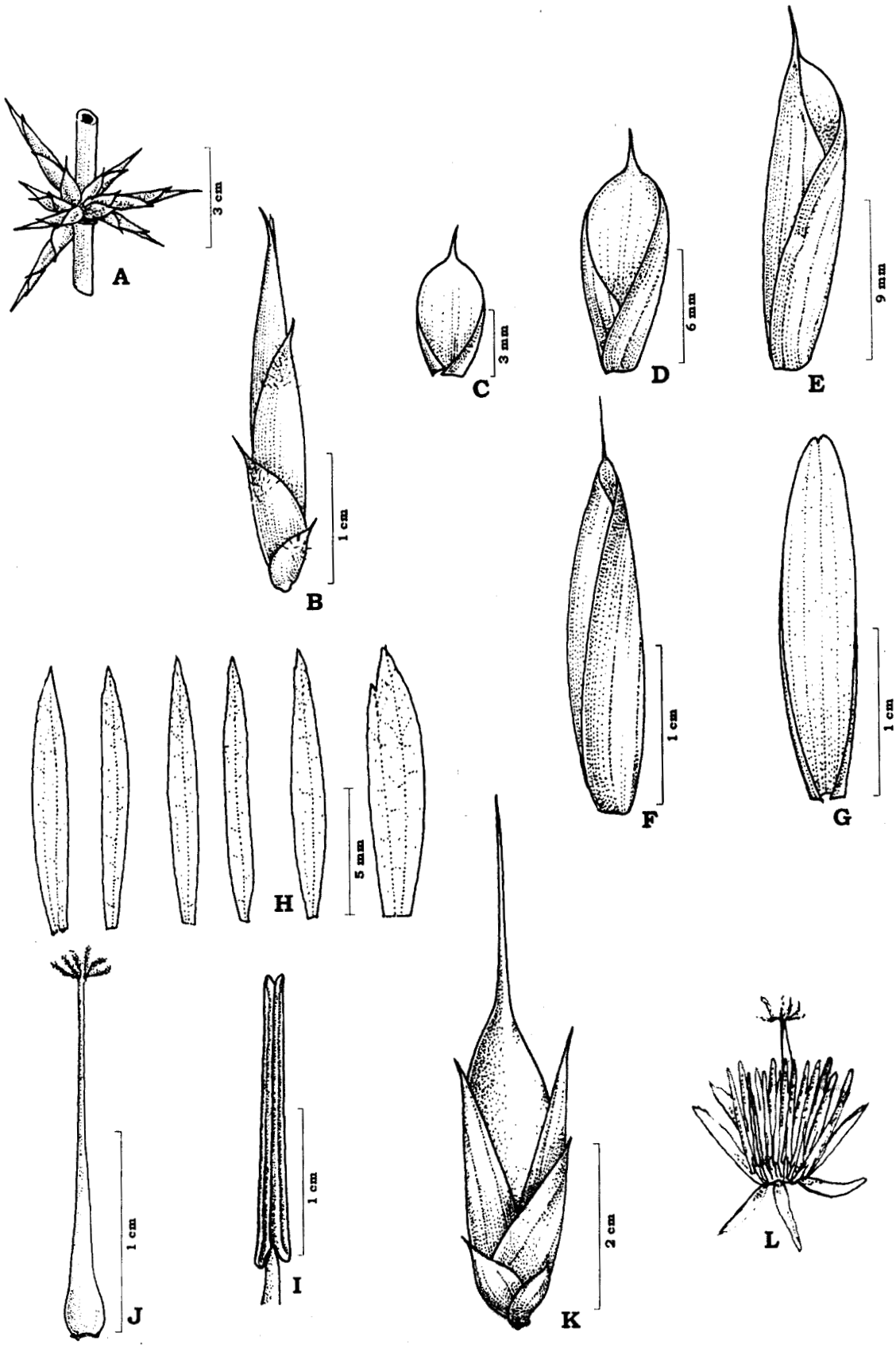


Figure 35. *Ochlandra setigera* Gamble **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

beaked, fleshy, 6 to 6.5 cm long, 1-1.5 cm wide, partially surrounded by persistent glumes.

Distribution and ecology: Endemic to Nilgiri Biosphere Reserve. It is distributed in Malappuram and Palakkad districts, Kerala and Gudallur, Tamil Nadu at an elevation of 600-1000 m. It is a component of moist deciduous and semi-evergreen forests. It forms pure reed breaks in the Silentvalley National Park. Gregarious flowering is at long intervals. Sporadic flowering is common in summer months.

Specimens examined: KERALA: Malappuram Dist. Nilambur, *M Kumar 6413B* (KFRI); Nilambur, *M Kumar 6413C* (KFRI); Nilambur, *N Unnikrishnan 74044* (CALI).

Uses: Tribes use this bamboo for making huts, baskets, animal and fish traps.

Note: This species was first described by Gamble (1896) based on vegetative specimen collected from Gudallur, Tamil Nadu. Chand Basha and Kumar (1994) collected flowers of this species from Nilambur, Malappuram district, Kerala and illustrated the floral parts for the first time.

Ochlandra spirostylis Muktesh, Seetha. & Stephen, Rheedea 9(1):31.1999 [Figures 36 and 37; Plate 27].

Type: India, Kerala, Idukki District, Adimali, Chattuparakkudy, 900 m, *Stephen 00884* (holotype, KFRI !).

Medium sized, caespitose, gregarious, densely tufted bamboo. Rhizome sympodial, pachymorph, solid, short necked, covered with scales. Culms erect, self-supporting, hollow, 5-6 m tall, tip slightly arched, node slightly swollen, the sheath scar and supranodal ridge prominent, each node with a single prophyllate bud; internodes, 30-48 cm long, 1.5-3 cm diameter, pale green, rough towards the upper part, a greyish band with appressed hairs present just below the sheath scar; culm sheath, 13-16 cm long, 6-10 cm broad at base, coriaceous, covered with dark or grey bulbous based hairs when young,

Plate 27. ***Ochlandra spirostylis*** Muktesh, Seetha. & Stephen **A.** habit; **B.** fruit; **C.** flowers; **D.** culm sheath; **E.** branches with leaves

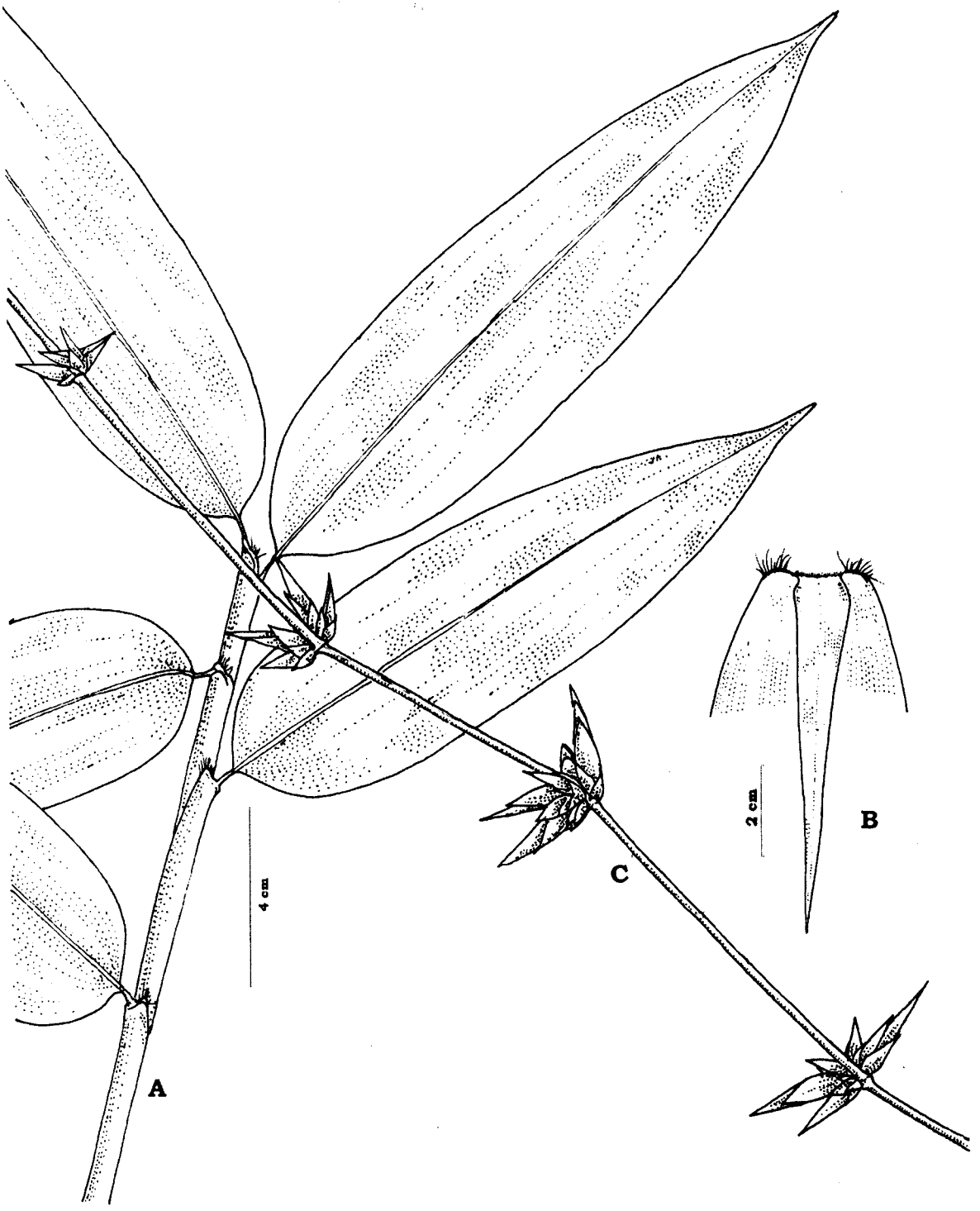


Figure 36. *Ochlandra spirostylis* Muktesh, Seetha. & Stephen **A.** leafy branch; **B.** culm sheath; **C.** inflorescence

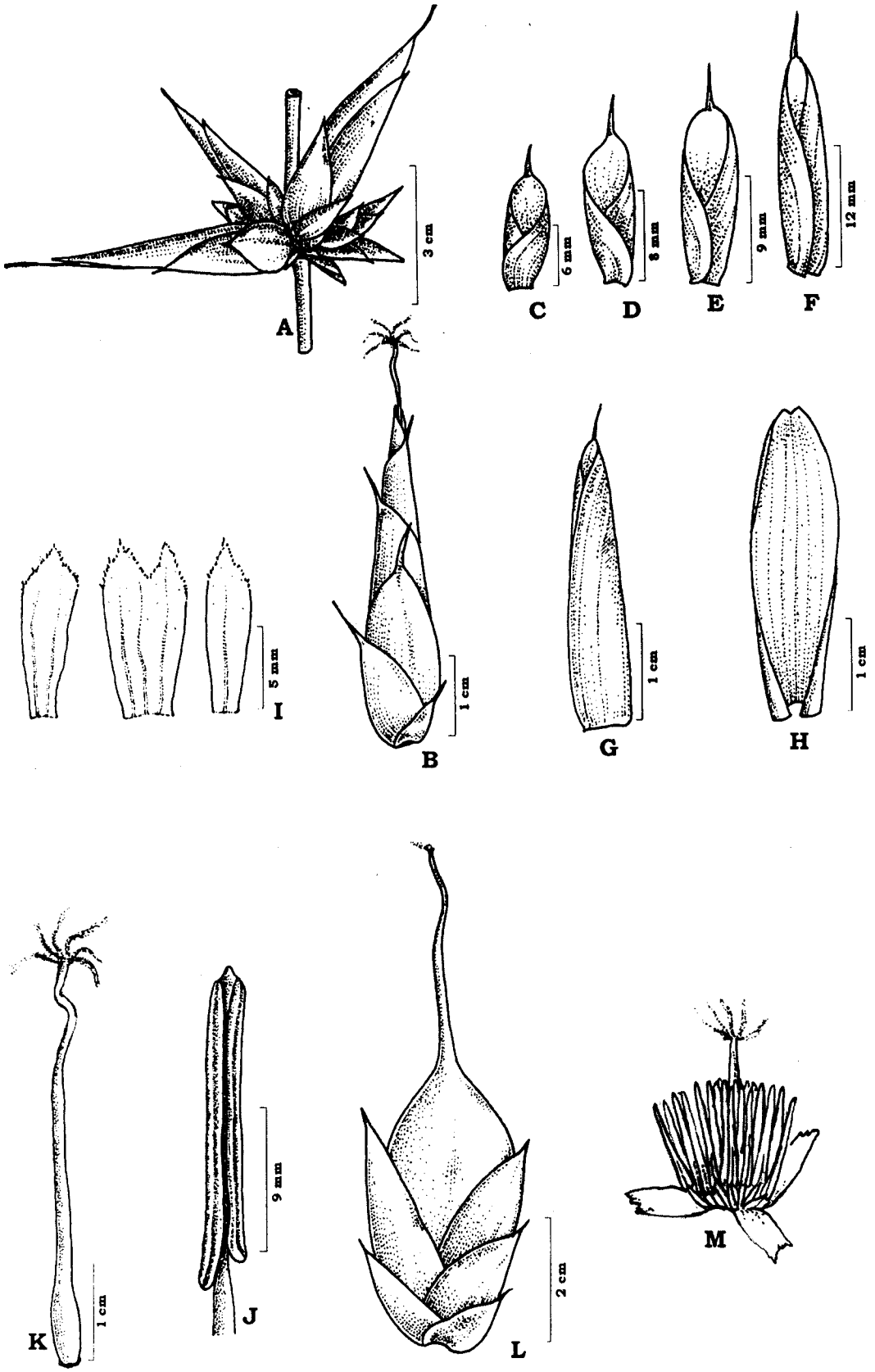


Figure 37. *Ochlandra spriostylis* Muktesh, Seetha. & Stephen **A.** portion of inflorescence; **B.** spikelet; **C., D., E. & F.** sterile glumes; **G.** lemma; **H.** palea; **I.** lodicules; **J.** stamen; **K.** ovary with style; **L.** fruit; **M.** open floret (diagrammatic)

hairs restricted to the lower portion when old, striate deciduous when mature, tip truncate, inner side smooth and shining; blade reflexed, glabrous, subulate, 6-8 cm long, 0.5-1 cm broad at base; auricle short, inconspicuous, oral setae numerous, stiff, deciduous when old; inner ligule very short, outer not prominent; branches arise from the 5th or 6th node, the young branches form just above the sheath scar, intravaginal emergence, the primary, central axis develops first, its basal buds develop to form 2-3 or more laterals on each side, almost subequal; leaves arise on the branches towards the tip, linear-lanceolate, 16-38 cm long, 2-4.5 cm broad, glabrous on both sides, margins rough and scabrous, midrib prominent in the lower side, tip acuminate, setaceous, scabrous, the base truncate, petiole short, thick, leaf sheath imbricate, closely attached, glabrous, striate, tip of the sheath bear very short auricles and bristles, bristles deciduous when old; ligule very short. Inflorescence a large spicate panicle on leafy branches, spikelets arise on the nodes of all branches, composed of pseudospikelets, form semiverticillate clusters at the nodes; spikelets single flowered, ovate-lanceolate, glabrous, 4-5.5 cm long, 0.4-0.7 cm broad, short stalked, 2-3 bracts at the base; sterile glumes 4, stiff, coriaceous, glabrous, margins ciliate, mucronate, many nerved, first two glumes ovate, 1.5-1.7 cm long, other to ovate-lanceolate, third 1.7-1.9 cm long, fourth 2-2.5 cm long; fertile glumes, lemma, lanceolate, strongly mucronate, many nerved3.5-3.8 cm long; palea ovate-lanceolate, thin, membranous, margins overlap, many nerved, tip acute, notched, ciliate, 3-3.3 cm long; lodicules 3, thin, hyaline, 3-4 nerved, one large, 1-1.2 cm long, 0.2-0.4 cm broad; stamens 68-75, yellow, filaments free, long, filiform, basifixed, anthers narrow, 1.5-1.8 cm long, apiculate, tip ciliate; ovary glabrous, globose at the base, tip terminates in to a perigynium which encloses a long style; style 3.8-4.5 cm long, spirally coiled or having a bend, tip divides to form 5-6 plumose stigma. Fruit a caryopsis, large, fleshy, ovate-oblong 7.5-8 cm long, 2-2.8 cm diameter, pericarp fleshy, caryopsis supported by persistent glumes.

Distribution and ecology: Endemic to South India. Reported only from the type locality.

Specimens examined: KERALA: Idukki Dist. Chattuparakkudy, *Stephen Sequiera 884* (KFRI); Chattuparakkudy, *N Unnikrishnan 74045* (CALI)

Note: In the protologue it is mentioned that this species is allied to *O. setigera.* But, comparative studies proved that it is closely related to *O. travancorica.* Two types of flowers were found in this species. In majority of the flowers the style is spirally coiled. But in some flowers the style is with an 'S' shaped bend.

Ochlandra talboti Brandis, Indian Trees 684. 1906; Talbot, For. Fl. Bombay Pres. Sind. 2: 572. 1912; E. G. Camus, Les Bamb. 181. 1913; Blatt. & McCann, J. Bombay Nat. Hist. Soc. 33: 774. 1929; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamb. 115. 1992; M. Kumar, Rheedea 5(1): 80.1995; Seethalakshmi & M. Kumar, Bamb. India Comp.189. 1998; Ohrnberger, Bamb. World 328. 1999 [Figures 38 and 39; Plate 28].

Type: India, North Canara, Gursoppa falls, *WA Talbot* 3628 (lectotype BLAT !. selected by Bole and MR Almeida, 1979).

Medium sized, caespitose, gregarious, bamboo, growing in tufts. Rhizome sympodial, pachymorph, solid, short necked, covered with scale leaves. Culms slender, erect, self supporting or straggling, sometimes scandent, hollow, 4-8 m tall, when erect tip arching, or drooping; nodes swollen, sheath scar and nodal ridge prominent, a single node bud is present, enclosed inside prophyllum; internodes 25-45 cm long, 2-3 cm diameter, pale green, rough towards the tip; culm sheath 14-22 cm long, 7.5-11 cm broad at base, coriaceous, covered by dark brown hairs when young, sparsely hirsute, striate when old, tip truncate; blade narrow, 2-4.5 cm long, 0.2-0.3 cm broad at base, deciduous; auricle very short, oral setae numerous, stiff, deciduous; ligule not prominent; branching starts from 5thor 6th node, just above the sheath scar, intravaginal, the central one develops first, numerous branches develop from its basal buds, 18-20 numbers, almost equal; leaves arise on the branches, oblong-lanceolate, 18-32 cm long, 3.5-5.5 cm broad, glabrous on both sides, scabrous along one margin, tip acuminate, setaceous, scabrous, midrib clear along the lower side, base truncate leading to a short, thick petiole; the leaf sheaths overlap, closely adhere to the branches, smooth, striate; auricle small, falcate with stiff bristles, bristles deciduous when old; inner ligule very short, outer inconspicuous. Inflorescence a short spicate panicle on leafy branches,

Plate 28. ***Ochlandra talboti*** Brandis **A.** habit; **B. & C.** branches; **D.** culm sheath; **E.** young shoot; **F.** inflorescence

Figure 38. *Ochlandra talboti* Brandis **A.** flowering branch; **B.** culm sheath; **C.** branching

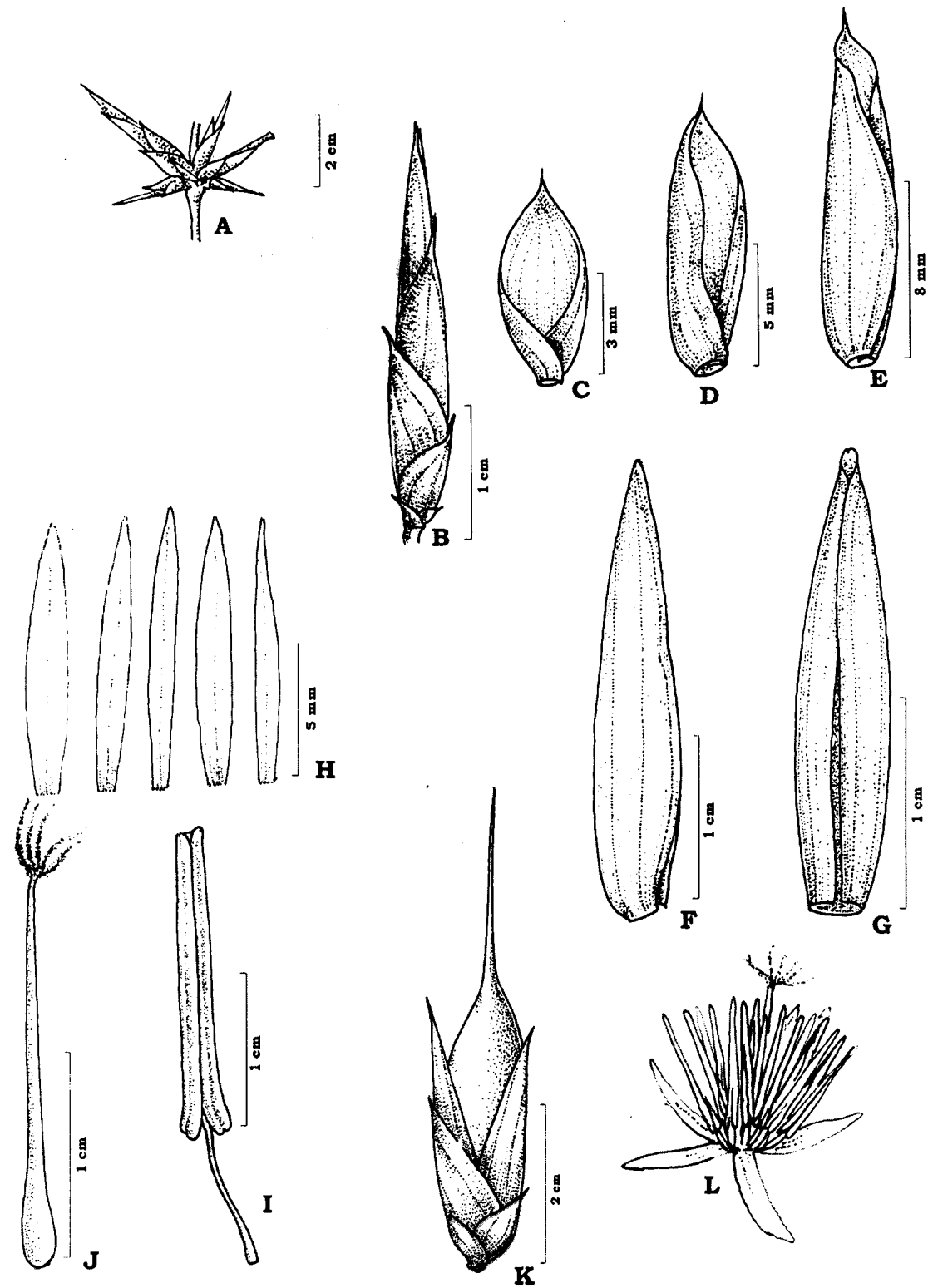


Figure 39. *Ochlandra talboti* Brandis **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

terminal, spikelets arise on the nodes of branches, composed of pseudospikelets, form semiverticillate clusters at the nodes, fertile and sterile spikelets mixed; spikelets single flowered, ovate-lanceolate, glabrous, 2.5-3 cm long, almost sessile, supported by 2-3 bracts; sterile glumes 3, stiff, coriaceous, first one 0.5-0.8 cm long, second 1-1.2 cm long and third 1.2-2 cm long, ovate-lanceolate, pungent, mucronate, many nerved, sparsely hirsute towards the tip; fertile glumes, lemma ovate-lanceolate, thin, membranous, many nerved, acute, 2.3-2.8 cm long; palea oblong, thin membranous, smooth, tip retuse, 2-2.5 cm long; lodicules 5-6, hyaline, narrow, 2-3 nerved, 1-1.3 cm long, margins fimbriate, ciliate; stamens 25-40, yellowish, filaments free, short, anthers 1.7-2 cm long, basifixed, non apiculate, retuse; ovary glabrous, narrow, tip elongates to a perigynium enclosing the style;style1.8-2.3 cm long, glabrous, tip divides to 5 plumose stigma. Fruit a caryopsis, oblong, long beaked, 5.6-6 cm long, pericarp fleshy, supported by persistent glumes.

Distribution and ecology: This species is endemic to Peninsular India and distributed in Karnataka ad Goa. It grows from an altitude of 200-1000 m. It is a component of moist deciduous and semi-evergreen forests. It is also found growing along river and stream sides. Flowering is in summer months. Sporadic flowering is frequent.

Specimens examined: KARNATAKA: Kodagu Dist. Vir Rajpetta, Makutta, *M Kumar* 7533 (KFRI); Vir Rajpetta, Makutta, *N Unnikrishnan & M Remesh 74110* (CALI). North Kanara Dist. Gaursoppau falls, *WA Talbot* 3569 (BSI); Gaursoppau falls, *WA Talbot* 3628 (BLAT); Sool Geri, *TR Bell* 3351 (BSI); Sampkhadu, *Hallberg & McCann* s.n. (BLAT).

Uses: Used by local people for making baskets, mats, fences and as supports.

Ochlandra travancorica (Bedd.) Benth. in Benth. & Hook.f., Gen. Pl. 3: 1215. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7:125.t.111.1896 & in Hook. f., Fl. Brit. India 7:419.1897; Brandis, Indian Trees 684. 1906; Bourd., For. Trees Travancore 403. 1908; E. G. Camus, Les Bamb. 182. 1913; Rama Rao, For. Pl. Travancore 448. 1914; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1863.1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980;

Tewari, Monogr. Bamb. 115. 1992; M. Kumar, Rheedea 5:82.1995; Seethalakshmi & M. Kumar, Bamb. India Comp.191. 1998; Ohrnberger, Bamb. World 328. 1999 [Figures 40 and 41; Plate 29].

Type: India, Travancore Hills, *Beddome* s.n. (lectotype K. designated here. Cibachrome seen).

Beesha travancorica Bedd., Fl. Sylv. 239. t. 324.1873.

Nola-illy Rheede, Hort. Malab. 5: 119, 120. 1685.

Ochlandra travancorica Benth. var. *hirsuta* Gamble Ann. Roy. Bot. Gard. 7: 126. 1896. **syn. nov.**

Ochlandra sivagiriana (Gamble) E. G. Camus, Les Bamb. 181. t. 99. 1913. **syn. nov.**

Ochlandra soderstromiana Muktesh & Stephen, Rheedea 9(1): 33. 1999. **syn. nov.**

Typification: Three specimens of *O. travancorica* collected by Beddome in 1873 from Travancore hills were deposited at MH, labelled as holotype. But, a specimen collected by Beddome in 1869 is deposited at K. This specimen was used by Beddome for describing the species. In the present study, Beddome's specimen collected in 1869 and deposited at K is designated as lectotype. Kumar (1995) designated this specimen as type [Plate 30].

Vernacular names: Eera, Eetta, Eerakalli, Kareetta, Oda (Malayalam), Odai (Tamil)

Medium sized, caespitose, gregarious bamboo, growing in tufts, culms very close and impenetrable. Rhizome, sympodial, pachymorph, solid, short necked, covered with scales. Culms erect, self supporting, hollow, 4-10 m tall, tip slightly arched or some times whip like; node slightly swollen, sheath scar and nodal ridge prominent, a single nodal bud is present, enclosed by prophyllum; internodes 0.5-1.2 m long, 4-6 cm in diameter, dark green, smooth below and rough towards the tip; culm sheath 15-26 cm long, 8-12 cm broad at base, coriaceous, covered with bulbous based golden brown hairs when young, smooth, or sparsely hirsute, deciduous and striate when old, truncate at the tip, inner side smooth and shining; blade reflexed, glabrous, subulate, 5-12 cm long, 0.6-1.2 cm broad at base; auricle short,

Plate 29. ***Ochlandra travancorica*** (Bedd.) Benth. **A. & B.** habit; **C.** culms; **D. & F.** flowers and fruits; **E.** young shoot with sheath

Plate 30. ***Ochlandra travancorica*** Benth. -lectotype (K)

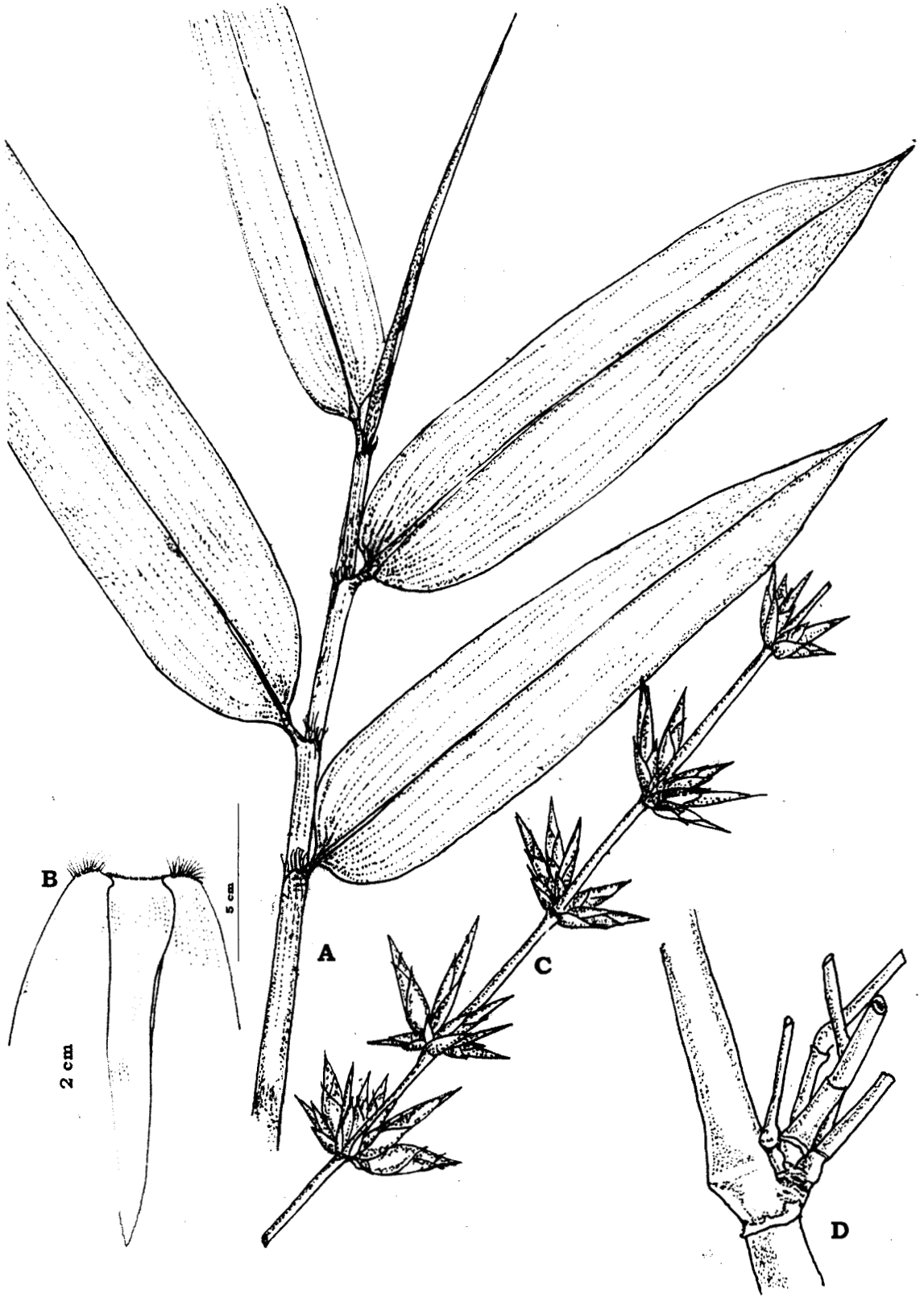


Figure 40. *Ochlandra travancorica* (Bedd.) Benth. **A.** leafy branch; **B.** culm sheath; **C.** inflorescence; **D.** branching

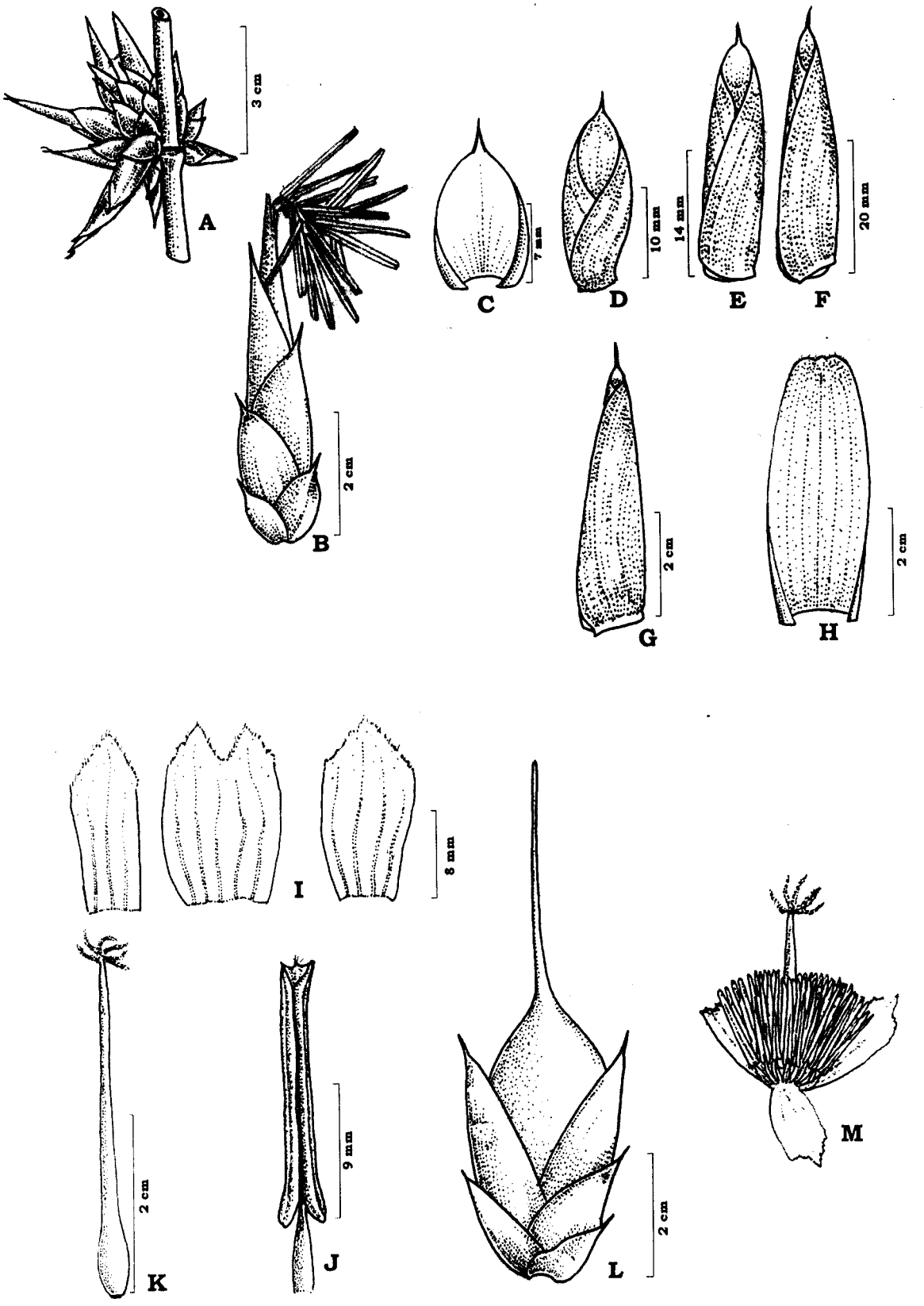


Figure 41. *Ochlandra travancorica* (Bedd.) Benth. **A.** portion of inflorescence; **B.** spikelet; **C., D., E. & F.** sterile glumes; **G.** lemma; **H.** palea; **I.** lodicules; **J.** stamen; **K.** ovary with style; **L.** fruit; **M.** open floret (diagrammatic)

inconspicuous, ornamented with numerous stiff bristles; inner ligule 0.2-0.3 cm high, outer ligule not clear; branches arise from the fifth or sixth node, the young branches form just above the sheath scar, intravaginal eruption, the primary central branch develops first, numerous laterals arise from its basal buds, rebranches; leaves arise on branches, linear-lanceolate, 19-40 cm long, 2-6 cm broad, glabrous on both sides, margins rough and scabrous, midrib prominent, clear on the lower side, tip acuminate, setaceous, scabrous and sometimes twisted, truncate at the base into a short, thick petiole, leaf sheaths over lap, closely attached, smooth, striate, the sheaths have very short auricle and oral setae at the tip, oral setae deciduous when old, ligule short. Inflorescence a large compound spicate panicle on leafy branches, spikelets borne at all branches at successive nodes, also on the main culm nodes, composed of pseudo-spikelets, form semiverticillate clusters at the nodes, fertile and sterile flowers mixed; spikelets single flowered, ovate-lanceolate, glabrous, 4-6 cm long, 0.7-1 cm broad, very short stalked, basal portion supported by 3-4 bracts, sterile glumes 3-4, the first glume ovate, 1.2-1.5 cm long, 0.6-0.8 cm broad, the second ovate-lanceolate, 1.8-2.3 cm long, 1-1.2 cm broad, the third ovate-lanceolate, 2.5-3 cm long, 1.7-2 cm broad, the fourth glume lanceolate, 4-4.5 cm long, 2-2.5 cm broad, stiff and coriaceous, ciliate along the margins, many nerved, acute, strongly mucronate, stiff hairs arise from the base of mucro in the lower glumes; fertile glumes, lemma long-lanceolate, mucronate, thin, many nerved, 4-5 cm long, 2.5-3.2 cm broad; palea ovate-oblong, thin, membranous, margins overlap, ciliate, tip retuse, slightly notched, ciliate, 4.3-4.5 cm long, 1.8-2.3 cm broad; lodicules 3, hyaline, almost of the same size, 1.3-1.8 long, 3-4 cm broad, narrow towards the base, 5-6 nerved, margins fimbriate, ciliate; stamens 65-130, number not fixed, yellow, filaments free, long, filiform, basifixed, anthers about 1.6-2 cm long, apiculate, tip ciliate; ovary glabrous, rounded at the base and gradually elongated in to a, perigynium enclosing the style; style 3.8- 4.7 cm long, divides at the tip to form 6 plumose stigmas. Fruit a caryopsis, large, fleshy, ovate-oblong, about 8-9.5 cm long, 2.8-3 cm diameter, pericarp fleshy, caryopsis partially covered by persistent glumes.

Distribution and ecology: This is the most common reed bamboo and has a wider distribution in southern Western Ghats. It is found growing in Kerala,

South Karnataka and Tamil Nadu from sea level to an elevation of 2000 m. It is a component of moist deciduous and semi-evergreen forests, and form reed breaks. It also grows along river and stream sides. Sporadic flowering is very common in summer months. Gregarious flowering was observed during the present study at Goodrical Range, Pathanamthitta district in 1998.

Specimens examined: KERALA: Ernakulam Dist. Pooyankutty, *AG Pandurangan* 79243 (MH); Edamalayar, *N Unnikrishnan 74025* (CALI). Idukki Dist. Adimali, *N Unnikrishnan 74024* (CALI); Vallakkadavu, *BD Sharma* 43940 (MH); Pambanar *MY Ansai* 51549 (BSI); Kallar, *N Unnikrishnan 74018* (CALI); Vagamon, *N Unnikrishnan 74002* (CALI). Kollam Dist. Shenduruny, *Punalur Paper Mill* 140613 (DD); Shenduruny, *KJ Joseph* 130257 (DD); Kulathupuzha, *N Unnikrishnan 74017* (CALI). Kottayam Dist. Mundakkayam, *N Unnikrishnan 74015* (CALI). Malappuram Dist. Nilambur, *N Unnikrishnan 74027* (CALI); Nilambur, Thalichola, *Philip Mathew 33922* (CALI). Pathanamthitta Dist. Plapilly, *M. Kumar* 6429 (KFRI); Goodrical, *N Unnikrishnan 74005* (CALI). Thrissur Dist. Kollethirumudi, *M. Kumar* 6412 (KFRI); Poringal *GS Puri* 15905 (BSI). Thiruvananthapuram Dist. Agasthyarmalai, *M Kumar* 6481 (KFRI); Agasthyarmalai, *N Mohanan 11463* (CALI); Bonnaccord, *M Mohanan* 61719 (MH); Nedumangad, *CA Barber* 7178 (MH); Kottur RF, *J Joseph* 44088 (MH); Travancore hills, *Beddome* s.n. (MH). TAMIL NADU: Kanyakumari Dist. Muthukuzhivayal, *AN Henry* 4945 (MH). Thirunelveli Dist. Thirunelveli, *EAC Forests* 39687 (DD); Nangunery Range, *Forest Ranger* 40541 (DD).

Uses: This bamboo is economically very important. It is being used widely for making different types of baskets, mats, handicrafts. Tribes use it for making huts. It is a raw material for pulp, paper and plywood industry.

Note: This species shows a great variation in its growth habits. It grows normally up to a height of 4-10 m. The tip is normally arched. Plants with very long whip like pendulous tip were also observed during the field study. Beddome (1873) was the first to describe this species. Beddome (1873) and Gamble (1896) described this species as having monadelphous stamens. The number of stamens is not fixed in this species. It varies from 55-130. Detailed studies of numerous specimens from different parts of south India showed that stamens are free. They remain very close in young buds, which appear as monadelphous.

The variety *Ochlandra travancorica* var. *hirsuta* was first described by Gamble (1896). He treated this as a variety because the spikelets of this species are clothed with light brown velvety pubescence. However, there is no difference in floral characters and in other vegetative characters in *O. travancorica* and in *O. travancorica* var. *hirsuta*. During this study, it was found that the hairy nature is not a stable character. This variety flowered under cultivation at Kerala Forest Research Institute, Peechi and it was observed that the spikelets were glabrous. The hairy nature may be due to some environmental factors. Owing to these reasons, in this treatise, *Ochlandra travancorica* var. *hirsuta* is treated as a synonym of *O. travancorica*.

Ochlandra sivagiriana was first described by Gamble (1896). He first proposed it as a variety of *O. rheedii* (*O. scriptoria*). In the description, he commended that '*it is possible that this should have been described as a species*'. This comment was written on the sheet of *Ochlandra sivagiriana* deposited at MH, Coimbatore. Based on this, Camus (1913) recognized it as a species *Ochlandra sivagiriana*. His description is very brief and without any proper illustration. Kumar (1995) described and illustrated this species based on a specimen collected from Vazhachal, Thrissur district, Kerala, but in the present study revealed that it was revealed the specimen collected by Kumar (1995) is that of *O. scriptoria*.

The type locality of *Ochlandra sivagiriana* is Palani and Sivagiri hills (Gamble, 1896). Extensive field study was conducted at Palani hills and was not able to relocate this species. In the flora of Palani hills, Matthew (1999) commented '*presumably not collected since the first report*'.

In 2002, this species flowered at Sivagiri and adjacent hills. A detailed study of the herbarium sheet at MH and specimens collected from Sivagiri hills proved undoubtedly that the species is *Ochlandra travancorica*. So in this work, *Ochlandra sivagiriana* is synonymised with the species *Ochlandra travancorica*.

Ochlandra soderstromiana was first described by Kumar and Stephen (1999). This species was collected from Kallar Valley, Idukki district, Kerala. In the protologue, it was mentioned that affinity of this species was to *Ochlandra talboti* which is a species growing in Karnataka and Goa. During this study, it was found that this species is closely related

to *Ochlandra travancorica*. The broad leaves, large spikelets, three large lodicules, the numerous stamens and the large caryopsis are characters of *Ochlandra travancorica*. The distinct characters of *O. soderstromiana* mentioned in the protologue are not adequate to retain this as a separate species, and hence in this work, *O. soderstromiana* is synonymised under *O. travancorica*.

Ochlandra wightii (Munro) C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1864.1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; Tewari, Monogr. Bamb. 117. 1992; M. Kumar, Rheedea 5(1): 88.1995; Seethalakshmi & M. Kumar, Bamb. India Comp.199. 1998; Ohrnberger, Bamb. World 329. 1999 [Figures 42 and 43; Plate 31].

Type: India, Courtallam-Tennavelly, *Brandis* s.n. (neotype K. Cibachrome seen. designated here).

Bambusa wightii Munro, Trans. Linn. Soc. London 26:111.1868.

Ochlandra brandisii Gamble, Ann. Roy. Bot. Gard. Calcutta 7:126, t.113.1896 & in Hook.f., Fl. Brit. India 7:420.1897; Brandis, Indian Trees 684. 1906; Bourd., For. Trees Travancore 405. 1908; E. G. Camus, Les Bamb. 182. 1913.

Typification: This species was first collected by Wight (1835) from Courtallam. Later, it was collected by Brandis in flower in 1882 from the same locality (Gamble, 1896). The first specimen collected by Wight was found missing. Brandis's specimen is deposited at K and is designated here as neotype [Plate 32].

Vernacular names: Eera, Eerakalli (Malayalam)

Medium sized, caespitose, gregarious, bamboo, forming closely packed culms. Rhizome sympodial, pachymorph, solid, short necked, clothed with scale leaves. Culms erect, self supporting, hollow, 5-6 m tall, slightly arched above; nodes swollen at the region of supra nodal ridge, sheath scar prominent, a single nodal bud present, enclosed by prophyllum; internodes 50-70 cm long, 1.2-1.3 cm in diameter, light green, rough; culm sheath 15-19 cm long, 6.5-8.5 cm broad at base, coriaceous, hirsute, covered with bulbous based brown hairs when young, glabrous when old except at the base, deciduous, striate,

Plate 31. ***Ochlandra wightii*** (Munro) C.E.C. Fisch. **A.** habit; **B.** culms; **C. & D.** inflorescence; **E.** fruits; **F.** culm sheath

Plate 32. ***Ochlandra wightii*** (Munro) C.E.C. Fisch. -neotype (K)

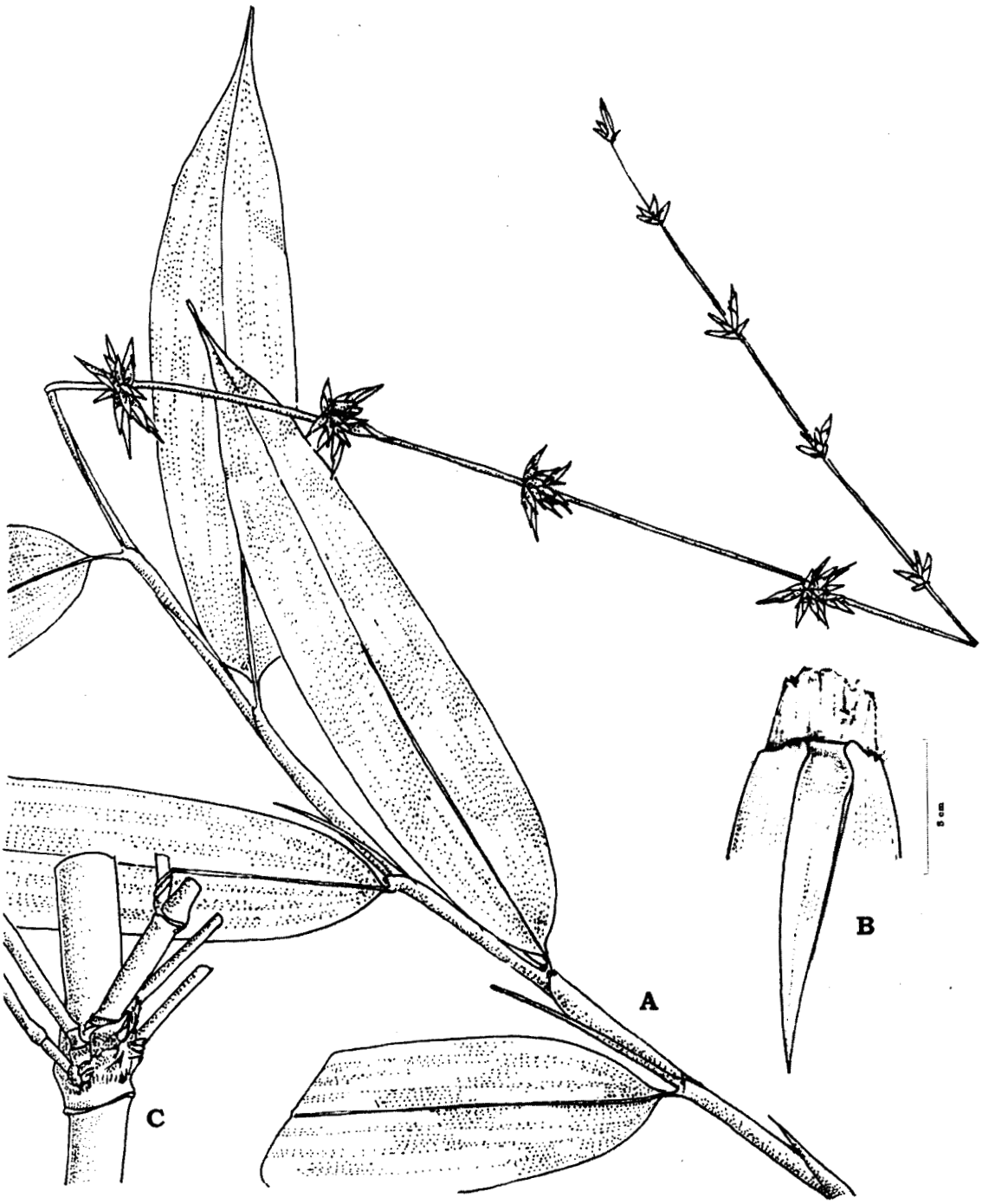


Figure 42. *Ochlandra wightii* (Munro) C.E.C. Fisch. **A.** flowering branch; **B.** culm sheath; **C.** branching

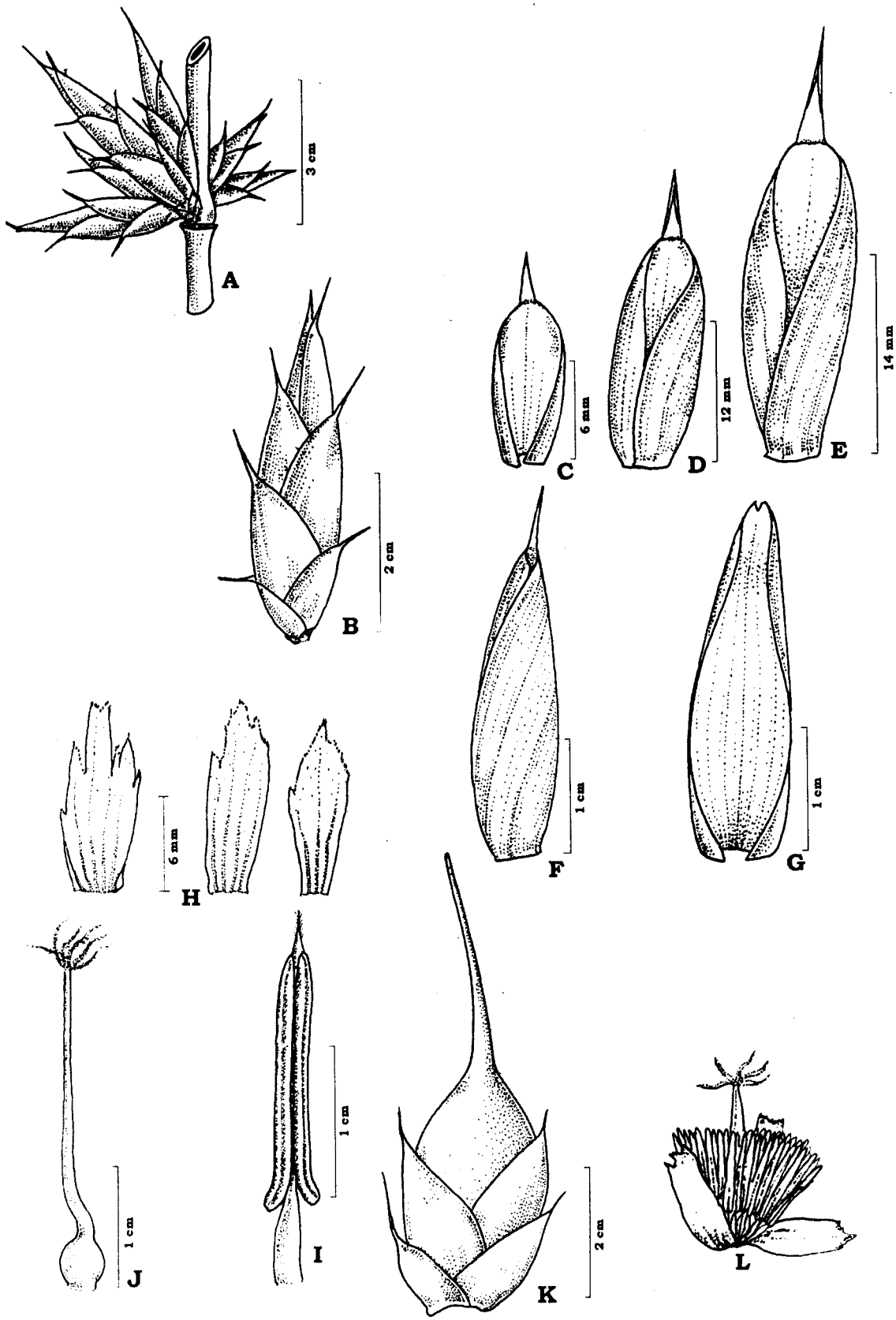


Figure 43. *Ochlandra wightii* (Munro) C.E.C. Fisch. **A.** portion of inflorescence; **B.** spikelet; **C., D. & E.** sterile glumes; **F.** lemma; **G.** palea; **H.** lodicules; **I.** stamen; **J.** ovary with style; **K.** fruit; **L.** open floret (diagrammatic)

tip truncate, inner side smooth and shining; blade reflexed, smooth, subulate, 8-10 cm long 0.7-1 cm broad at the base, deciduous; auricle inconspicuous, bear stiff erect oral setae; inner ligule very prominent, large, 1.8-2.5 cm high, striate, thin, membranous, margins fringed; branches arise from the 5th or 6th node, intravaginal emergence, one strong central axis arise first, with 3-4, laterals from its base, subequal, branches rebranch; leaves arise on branches, oblong-lanceolate, 28-45 cm long, 3-11 cm broad, glabrous on both sides, margins rough and scabrous, midrib prominent on the lower side, tip acuminate, scabrous, base attenuate to a thick, short petiole, leaf sheath overlapping, striate, smooth; auricle short with stiff deciduous bristles; inner ligule very prominent, papery, 1.5-2 cm high, fimbriate, outer ligule very short, 0.1-0.2 cm long. Inflorescence a large spicate panicle, terminal on leafy branches, spikelets arise on the nodes of all branches, composed of pseudospikelets, form semiverticillate clusters at the nodes; spikelets single flowered, ovate, glabrous, 3.5-4 cm long, 0.7-0.9 cm broad, short stalked, base covered by 2-3 bracts, the prominent mucrones of the glumes project outwards; sterile glumes 4, stiff, coriaceous, the first two ovate, 1-1.5 cm long, second 2-2.5 cm long and third 2.8-3 cm long, ovate-lanceolate, many nerved, strongly mucronate, inner side of the mucron hirsute; fertile glumes, lemma lanceolate, mucronate, glabrous, thin, many nerved, 2.5-3 cm long, 1.8-2.3 cm broad; palea thin, membranous, margins overlap, smooth, tip retuse, notched, ciliate, 2.5-2.8 cm long, 1.3-1.5 cm broad; lodicules 3 thin, filmy, hyaline, almost of the same size, 1-1.2 cm long, 0.2-0.4 cm broad, 5-6 nerved, margins fimbriate, ciliate; stamens 75-80, number varies, yellow, filaments free, long, filiform, basifixed, anthers1.8-2 cm long, apiculate, tip ciliate; ovary glabrous, globose at the base, tip gradually terminates into a perigynium which encloses the style; style 2.6-3 cm long, divides at the tip to 6-7 plumose stigma. Fruit a caryopsis, large, fleshy, ovate-oblong, 7-8 cm long, 2.3-2.5 cm diameter, supported by persistent glumes

Distribution and ecology: Endemic to South India and has a restricted distribution in South Kerala and Tamil Nadu at an altitude from 200 m to 1000 m. It is reported from the southern most part of Western Ghats. It is a component of moist deciduous and semi-evergreen forests at Trivandrum district, Kerala and Keerippara, Thirunelveli and Courtallum in Tamil Nadu.

Flowering starts in summer months. Sporadic flowering is common. Gregarious flowering was observed in 2001 at Bonnaccord and on the way to Agasthyamala in Trivandrum district.

Specimens examined: KERALA: Thiruvananthapuram Dist. Kallar, *CA Barber 7176* (MH); Palode, *N Unnikrishnan 74008* (CALI); Nanniode, *N Unnikrishnan 74033* (CALI); Bonnaccord, *N Unnikrishnan 74034* (CALI); Nedumangad, *N Unnikrishnan 74204* (CALI). TAMIL NADU: Kannyakumari Dist. Keerippara, *N Unnikrishnan 74004* (CALI).

Uses: Using for making huts, leaves for thatching. Local people use it as a support and also for making fence. It is also good for baskets and mats. Along with *Ochlandra travancorica* it is used for making pulp, paper and plywood.

Note: Munro (1868) first described this species as *Bambusa wightii*. Gamble (1896) treated it as *Ochlandra brandisii*. The characteristic feature of this species is the presence of a large ligule. It is the largest among the genus Ochlandra. According to Gamble (1896) this species has one lodicule and the stamens are monadelphous. A detailed study of specimens collected from different localities of southern Western Ghats revealed that this species is having 3 lodicules and the stamens are free.

The species *Ochlandra travancorica* was originally described by Beddome (1873). According to him, the stamens of this species are monadelphous. *Ochlandra wightii* and *O. ebracteata* were also described as species with manodelphous stamens. This was considered as a major character in all the keys. A detailed study of all the species mentioned above, collected from different localities in the southern Western Ghats revealed they possess free stamens. In all these species the number of stamens vary from 55-130. The filaments remain very close in buds and appear as monadelphous.

A critical evaluation of the *Ochlandra* showed that this genus could be categorized under two groups. The species *O. scriptoria* and *O. travancorica* were the first species described under the genus *Ochlandra*. All other species of *Ochlandra*, which were described later, show affinity to either *O. scriptoria* or to *O. travancorica*. Based on the affinity, the species under this genus can be included under the Travancorica group and the Scriptoria group.

A comparison of these two groups is given in the following table.

Character	Character state	
	Travancorica group	**Scriptoria group**
Habit	caespitose, gregarious, erect, sometimes drooping	caespitose, gregarious, drooping, sometimes scandent
Culms	strong, erect, tip arching, sometimes drooping	strong or slender, tip whiplike, drooping or scandent
Branches	few, strong, subequal	numerous, weak, subequal
Spikelets	long and broad	short and narrow
Glumes	apex mucronate	apex not mucronate, acuminate
Lodicules	3-4, broad	6-7, narrow
Stamens	numerous, 55-130	few, 15-42
Caryopsis	large, subglobose to ovate-oblong	small, linear-lanceolate

Travancorica group: In this group, the culms are strong, erect, arching at the tip and rarely drooping. The branches are few in number and almost subequal. The spikelets are large, long and broad (Plate 1). The apex of the sterile glumes is strongly mucronate. The number of lodicules is usually 3, rarely 4. The number of stamens varies from 55-130, rarely less than 55. The fruit is large, subglobose to ovate-oblong.

Scriptoria group: In this group, the culms are strong or slender and the tip is drooping or whiplike, sometimes scandent. Branches are numerous, weak and subequal. The spikelets are short and narrow (Plate 1). The apex of the glumes is acuminate, not mucronate. Lodicules are narrow and 6-7. Stamens are less in number are vary from 15-42. The caryopsis is small and linear-lanceolate.

Teinostachyum Munro

This genus was originally described by Munro (1868) and he treated two species under this genus. He distinguished this genus from other related genera by the presence of elongated spciula (spikelets) with several perfect flowers and long joints of the rachilla. Gamble (1896) also followed this and included three more species under this genus. In South India, only a single species is represented.

Teinostachyum Munro, Trans. Linn. Soc. London 26: 142. 1868; Bedd., Fl. Sylv. S. India 3: 233. 1873; Gamble, Ann. Roy. Bot. Garn. Calcutta 7: 97. 1896; Brandis, Indian Trees 679. 1906; Bourd., For. Trees Travancore 402. 1908; E. G. Camus, Les Bamb. 162. 1913; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1859. 1928; Soderstr. & R.P. Ellis in Soderstr. *et al.* (eds.), Grass Syst. Evol. 237. 1987; S. Dransf. & Widjaja (eds.), Plant Reso. S.E. Asia 7: 35. 1995; Ohrnberger, Bamb. World. 336. 1999.

Type: *Teinostachyum griffithii* Munro

Shrubby or arborescent bamboos with closely packed culms. Rhizome sympodial, pachymorph. Culms erect and whip like, drooping, culm sheath with long, lanceolate, reflexed, blades; auricle absent; branches numerous, almost equal, intravaginal, leaves with minute silky pubescence, on the lower side. Inflorescence terminal, drooping panicles, iterauctant; spikelets 3-4 flowered with a terminal sterile flower; sterile glumes 1-2; lemma convolute; palea 2 keeled, ciliate on the keels; lodicules 3; stamens 6, free, anthers exerted, obtuse or slightly apiculate; ovary globose or ovate, style enclosed inside a perigynium, stigma 3. Fruit a caryopsis, ovoid, acuminate, short beaked.

Distribution and ecology: This genus is distributed in India, Bangladesh, Myanmar and Thailand. In India, this genus is represented by 4 species and is distributed in north-eastern states and South India. In South India, this genus is represented by one species, *Teinostachyum wightii.*

Note: The species described under the genus *Teinostachyum* was treated under other genera like *Pseudostachyum, Neohouzea* and *Schizostachyum* by various authors. Holttum (1956a) suggested that *Cephalostachyum, Teinostachyum* and *Pseudostachyum* should be merged with the Malaysian genus *Schizostachyum.* However, he did not give any justification for this opinion, and there are no comparative studies to investigate generic delimitation in this subtribe (Stapleton, 1994a).

Clayton & Renvoize (1986) and Majumdar (1989), followed Holttum's suggestions and treated all 4 genera as congeneric. Based on this, Majumdar (1989) transferred all Indian species of *Teinostachyum* under the genus *Schizostachyum* without giving any proper justification.

Although, *Teinostachyum* and *Schizostachyum* are closely related, Munro (1896) clearly distinguished these two species. Gamble (1896) also followed Munro and treated *Teinostachyum* and *Schizostachyum* separately. Dransfield (1980) and Stapleton (1994) treated *Cephalostachyum, Teinostachyum, Pseudostachyum* and *Schizostachyum* as separate genera.

In this treatise, the treatment of Munro (1868), Gamble (1896), Dransfield (1980) and Stapleton (1994) are followed and the genus name *Teinostachyum* Munro is retained.

Teinostachyum wightii Bedd., Fl. Sylv. 3: 233 t. 323. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 99, t. 87. 1896 & in Hook. f. Fl. Brit. India 7: 410. 1897; Brandis, Indian Trees 679. 1906; Bourd., For. Trees Travancore 402. 1908; E. G. Camus, Les Bamb. 163. 1913; Rama Rao, For. Pl. Travancore 448. 1914; Ohrnberger, Bamb. World 336. 1999 [Figures 44 and 45; Plate 33].

Type: India, Tamil Nadu, Nilgiris, *Beddome 62* (lectotype K. designated here. Cibachrome seen).

Teinostachyum beddomei C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1860. 1934; Varmah & Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.

Schizostachyum beddomei (C.E.C. Fisch.) R. B. Majumdar in Karthikeyan *et al.*, Fl. Ind. Enum. Monocotyl. 281. 1989; Tewari Monogr. Bamboo. 130. 1992; Seethalakshmi & M. Kumar, Bamb. India Comp.235. 1998.

Typification: This species was collected by Beddome from the Anamalai hills in 1873. This specimen was deposited at MH. Another specimen collected by Beddome in 1869 from Nilgiris was deposited at K. This is the specimen used by Beddome for the description and is selected for lecto typification and designated as type [Plate 34].

Vernacular names: Valli eetta (Malayalam)

Medium sized semi-scandent, bamboo with caespitose habit, producing a dense clump with closely packed culms. Rhizomes sympodial, pachymorph, with a short neck. Culms erect below, gradually become whip-like terminally and strongly arching, hollow, 10-12 m tall; node not swollen, the sheath scar

Plate 33. ***Teinostachyum wightii*** Bedd. **A.** habit; **B. & C.** culms; **D.** inflorescence; **E.** young culm with sheath

Plate 34. ***Teinostachyum wightii*** Bedd. -lectotype (K)

Figure 44. *Teinostachyum wightii* Bedd. **A.** flowering branch; **B.** culm sheath; **C.** inflorescence

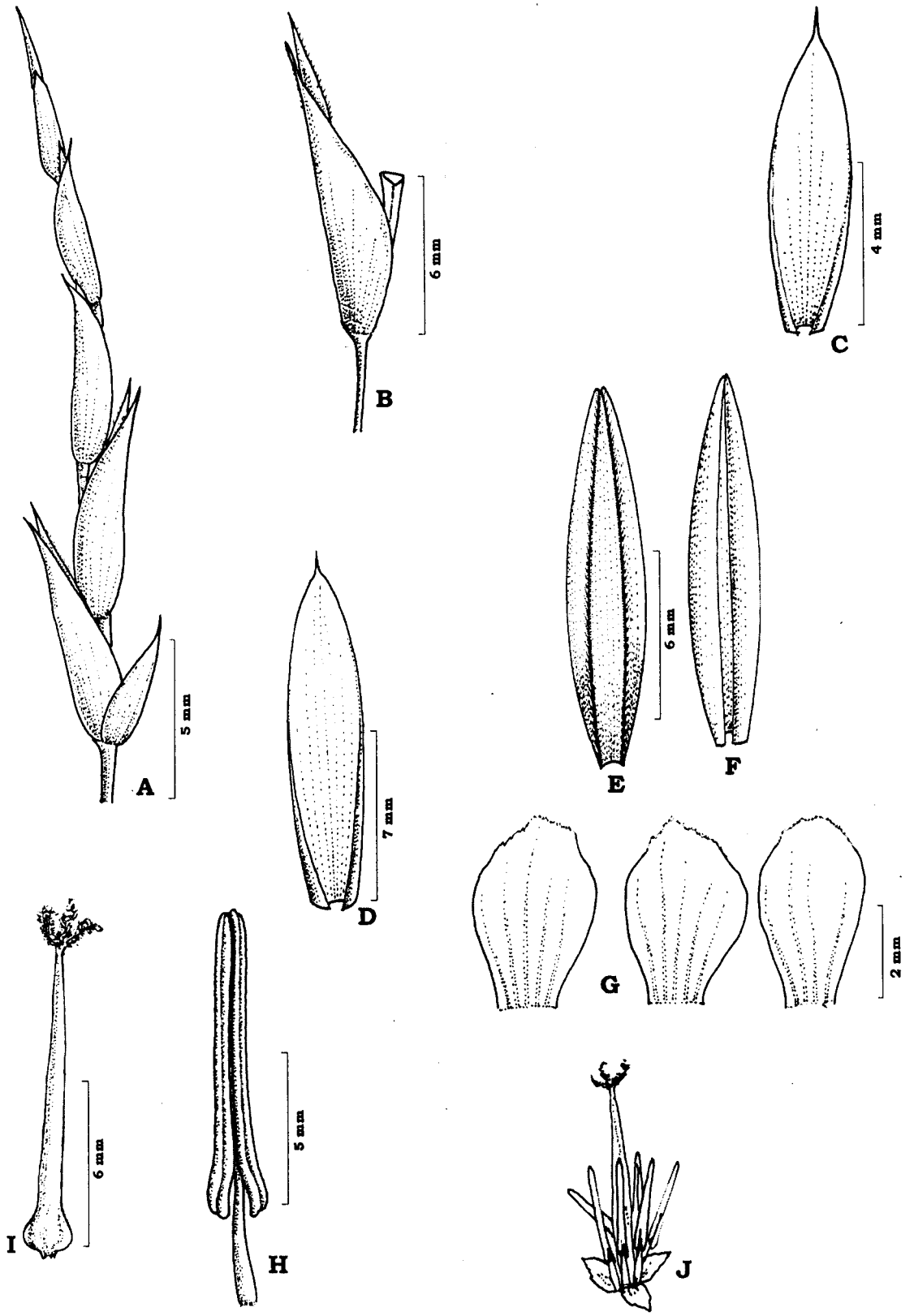


Figure 45. *Teinostachyum wightii* Bedd. **A.** spikelet; **B.** floret; **C.** sterile glume; **D.** lemma; **E.** palea-surface view; **F.** palea-inner side; **G.** lodicules; **H.** stamen; **I.** ovary with style; **J.** open floret (diagrammatic)

become very prominent, conspicuous girdle or ring, a single branch bud present enclosed inside prophyllum; internodes 30-50 cm long, 2.5-3.8 cm diameter, rough, cylindrical, pale green, having a white band towards the summit; culm sheath 15-40 cm long, 6-18 cm broad at base, glabrous, coriaceous, covered with scattered appressed black hairs when young, smooth and striate when old, tip truncate, acuminate; auricle absent; blade reflexed, long, narrow, linear-lanceolate, striate, sparsely hirsute; inner ligule membranous, entire, 0.1-0.2 cm high, fimbriate; branches arise from the 5th or 6th node, the central dominant primary branch develops first followed 2 or 3 lateral secondary branches, additional orders of branches develop to form a cluster of 20-25 branches, the primary branch elongates, become whip-like, intravaginal emergence; leaves arise on branches, 8-32 cm long, 1.5-4.5 cm broad, lanceolate, dorsal side glabrous, ventral side with minute silky pubescence, midrib prominent on the lower side, margins scabrous, tip acuminate, scabrous, the base attenuate to a short petiole; leaf sheath overlapping, glabrous, striate, auricle and oral setae absent; inner ligule very short, outer not prominent. Inflorescence large, terminal, drooping panicles, arise on short leaf less branches clustered at the nodes, rachilla flat below and becomes thickened upwards, each spike at the base supported by a firm, persistent, ovate-acuminate, glabrous, bracts; spikelets 3-4 fertile flowers and a terminal sterile flower, glabrous, lanceolate, 4-4.5 cm long, rachilla narrow, glabrous, slightly swollen at the tip; sterile glume 1, 0.8-1 cm long, coriaceous, lanceolate, many nerved, mucronate, faintly hirsute; fertile glume, lemma 1.2-1.4 cm, ovate-lanceolate, mucronate, glabrous, many nerved, tightly convolute; palea shorter than lemma, membranous, thin, 2-keeled, ciliate on the keels, 1-2-nerved between the keels, 1-1.2 cm long, tip obtuse, ciliate; lodicules 3, equal, 0.3-0.5 cm long, hyaline, 2-3 nerved, ovate, margin fimbriate, ciliate; stamens 6, filaments free, short, anthers 0.8-1 cm long, basifixed; ovary glabrous, base globose, tip gradually narrow in to a perigynium enclosing a style; style 1.2-1.5 cm long, stigmas 3, plumose. Fruit a caryopsis, glabrous, ovoid, short beaked.

Distribution and ecology: This species is endemic to Southern Western Ghats and distributed in Kerala, Karnataka and Tamil Nadu. It is found growing from an altitude of 300-1300 m. It grows in moist deciduous and semi-evergreen

forests. Flowering is rare and at long intervals. Sporadic flowering was observed in 1999 at Siruvani, Palakkad district, Kerala.

Specimens examined: KERALA: Travancore, *JF Bourdillon* s.n. (DD). Idukki Dist. Anamally, *RH Beddome* s.n. (MH); Munnar, *DB Deb 30762* (MH). Kannur Dist. Paithalmala, *M Remesh & N Unnikrishnan 20628* (KFRI). Palakkad Dist. Karappara, *N Unnikrishnan 74212* (CALI); Siruvani, *Stephen Sequiera & Michiale 8817* (KFRI). Pathanamthitta Dist. Kakki, *N Unnikrishnan 74011* (CALI). Thrissur Dist. Sholayar, *N Unnikrishnan 74019* (CALI). Wayanad Dist. Nalukettumchola, *N Unnikrishnan 74020* (CALI). TAMIL NADU: Nilgiri Dist. Nilgiris, *JS Gamble 18267* (DD); Ochterlomy valley, *JS Gamble 20549* (DD).

Note: This species was first described by Beddome (1873). Fischer (1934) changed the specific epithet and treated it as *Teinostachyum beddomei*. Holttum (1956a) treated *Teinostachyum* as congeneric with *Schizostachyum*. Majumdar (1989) followed Holttum (1956a) and transferred the genus *Teinostachyum* to *Schizostachyum*. He described *Teinostachyum wightii* as *Schizostachyum beddomei*.

The *Teinostachyum* can be separated from the genus *Schizostachyum* by several characters such as inflorescence as a panicle of loosely arranged spikelets, absence of gemmiparous bracts in spikelets and perfectly keeled palea.

In the present study, the generic concept of Munro (1868), Beddome (1873), Gamble (1896), Dransfield and Widjaja (1995) and Stapleton (1994a) are followed and *Teinostachyum* is considered as a separate genus. The change in the specific epithet to *beddomei* is invalid (ICBN Section 3, Art. 11.4). In this treatise the binomial *Teinostachyum wightii* is retained.

Summary

V. SUMMARY

The present study entitled **The Taxonomic Studies on the Bamboos of South India** is aimed at a detailed taxonomic study of native bamboos of South India. Extensive field work was done in the four States of South India and fresh specimens were collected. Herbarium specimens were prepared using standard techniques and were deposited at CALI. Comparative studies of collected specimens of each species were made. These specimens were compared with types and other herbarium specimens deposited at various national and international herbaria for authenticity. Protologue and early literature of all species were studied in detail.

In South India, Bambusoideae was represented by 22 species and two varieties under six genera. *Ochlandra* is the dominant genus of South India having wide distribution. Eleven species and one variety of *Ochlandra* were reported from South India. In the present study, the species *Ochlandra travancorica* var. *hirsuta, O. sivagiriana* and *O. soderstromiana* were synonymised under *O. travancorica.* The species *O. beddomei, O. scriptoria, O. travancorica* and *O. wightii* are typified. Critical and detailed studies reveal that monadelphous condition does not exist in the genus *Ochlandra.* Based on the affinities, the species of *Ochlandra* are grouped into Travancorica group and Scriptoria group. During the field study, an unidentified *Ochlandra* sp. was collected, which cannot be treated under any of the existing species, and hence is treated as a new species.

The type of the genus *Ochlandra* is *O. stridula* and is endemic to Sri Lanka. Some specimens of *O. stridula* were deposited at MH. A comparative study of these specimens with the South Indian species reveals that *O. stridula* is closely related to *O. scriptoria.* It may be a continental form.

A new combination is made under the genus *Dendrocalamus.* The species *Oxytenanthera stocksii* is transferred under the genus *Dendrocalamus.* The species *Dendrocalamus strictus* is typified in the present study. After a detailed study, the variety *Bambusa bambos* var. *gigantea* is treated as synonym of *Bambusa bambos.*

The genus *Oxytenanthera* was previously treated as *Pseudoxytenanthera*. In the present study, the genus name *Oxytenanthera* is retained. The spelling changes in the specific epithet of *O. bourdillonii* and *O. ritchiei* are corrected and *O. bourdillonii* is typified. The species of the genus *Arundinaria* in South India were previously treated under the genus *Sinarundinaria*. In the present treatise all the species are treated under the genus *Arundinaria*. The genus *A. wightiana* is typified.

Teinostachyum wightii was previously treated under the genus *Schizostachyum* in the name *S. beddomei*. The basionym was *Teinostachyum wightii* and it is accepted here. It is typified in the present study.

According to the present study, now there are 21 species of bamboos in South India. Out of the 21 species, 20 are distributed in Kerala, 6 species in Karnataka, 5 species in Tamil Nadu and 2 species in Andhra Pradesh (Appendix 1). Among these, 13 species are endemic to this phytogeographic region (Appendix 2).

In South India especially in the Southern Western Ghats bamboos form a major component of the biodiversity. South Indian bamboos show a high degree of endemism and most of the species have a restricted distribution. Some of the South Indian species are also distributed in Sri Lanka. This is an indication of the affinities of the Sri Lankan flora with the flora of South India.

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Appendix I. List of South Indian bamboos

Genus	Species	Habitat	Distribution*
Arundinaria Michaux	*Arundinaria densifolia* Munro	High altitude open grasslands, 2,000-2,695 m	KL
	Arundinaria floribunda Thwaites	High altitude mountains, ecotone of sholas and semi-evergreen forests, 1,600-2,200	KL, TN
	Arundinaria walkeriana Munro	High altitude mountains, open areas, ecotone of semi-evergreen forests, 1,800-2,200 m	KL
	Arundinaria wightiana Nees	High altitude mountains, open areas and semi-evergreen forests, 1,800-2,400 m	KL, TN
Bambusa Schreber	*Bambusa bambos* (L.) Voss.	Sea level to 1,200 m, component of moist deciduous forests	AP, KA, KL, TN
Dendrocalamus Nees	*Dendrocalamus stocksii* (Munro) M. Kumar, Remesh & Unnikrishnan **comb. nov.**	Coastal plains and also under dry deciduous condition up to an altitude of 800 m	KA, KL
	Dendrocalamus strictus (Roxb.) Nees	Plains, component of dry deciduous and moist deciduous forests, up to 800 m	AP, KA, KL, TN
Ochlandra Thwaites	*Ochlandra beddomei* Gamble	Moist deciduous forests and semi-evergreen forests, stream sides, 1,000-1,500 m	KL
	Ochlandra ebracteata Raizada & Chatterjee	Moist deciduous forests, 1,000 m	KL
	Ochlandra kadambaranii M. Kumar, Unnikrishnan & Remesh **sp. nov.**	Stream sides, moist deciduous forests	KL

*AP: Andhra Pradesh; KA: Karnataka; KL: Kerala; TN: Tamil Nadu

Genus	Species	Habitat	Distribution*
Ochlandra Thwaites	*Ochlandra keralensis* Muktesh, Remesh & Stephen	Moist deciduous and semi-evergreen forests, 1,000 m	KL
	Ochlandra scriptoria (Dennst.) CEC Fisch.	Stream sides, moist deciduous forests, sea level to 600 m	KA, KL
	Ochlandra spirostylis Muktesh, Seetha. & Stephen	Semi-evergreen forests, 900m	KL
	Ochlandra setigera Gamble	Moist deciduous and semi-evergreen forests, 600-1,200 m	KL
	Ochlandra talboti Brandis	Stream sides, moist deciduous forests, 200-1,000 m	KA
	Ochlandra travancorica (Bedd.) Benth.	Stream sides, moist deciduous and semi-evergreen forests, sea level to 2,000 m	KA, KL, TN
	Ochlandra wightii (Munro) CEC Fisch.	Moist deciduous and semi-evergreen forests, 200-1,200 m	KL, TN
Oxytenanthera Munro	*Oxytenanthera bourdillonii* Gamble	Moist deciduous and semi-evergreen forests on steep precipitous places, 800-1,200 m	KL
	Oxytenanthera ritchiei (Munro) Blatt & McCann	Moist deciduous forests, 200-1,100 m	KA, KL
	Oxytenanthera monadelpha (Thwaites) Alston	Moist deciduous and semi-evergreen forests, 300-1,500 m	KA, KR, TN
Teinostachyum Munro	*Teinostachyum wightii* Bedd.	Moist deciduous and semi-evergreen forests, 300-1,300 m	KA, KL, TN

*AP: Andhra Pradesh; KA: Karnataka; KL: Kerala; TN: Tamil Nadu

Appendix II. List of bamboos endemic to South India

Species	Distribution*
Arundinaria wightiana Nees	Palakkad (KL), Nilgiris (TN)
Ochlandra beddomei Gamble	Wayanad (KL)
Ochlandra ebracteata Raizada & Chatterjee	Kollam, Trivandrum (KL)
Ochlandra kadambaranii M. Kumar, Unnikrishnan & Remesh **sp. nov.**	Kollam (KL)
Ochlandra keralensis Muktesh, Remesh & Stephen	Pathanamthitta (KL)
Ochlandra scriptoria (Dennst.) C.E.C. Fisch.	All districts (KL), Southern Karnataka
Ochlandra setigera Gamble	Palakkad, Malappuram (KL); Gudallur (TN)
Ochlandra spirostylis M.Kumar, Seetha.& Stephen	Idukki (KL)
Ochlandra travancorica (Bedd.) Benth.	All districts (KL); Southern Karnataka; Kanyakumari, Thirunelveli, Madurai (TN)
Ochlandra wightii (Munro) C.E.C. Fisch.	Trivandrum (KL); Kanyakumari, Thirunelveli (TN)
Oxytenanthera bourdillonii Gamble	Idukki, Thrissur, Palakkad, Malappuram (KL)
Teinostachyum wightii Bedd.	Trivandrum, Kollam, Pathanamthitta, Idukki, Thrissur, Wayand, Palakkad, Malappuram, Kannur (KL); Madurai, Thirunelveli (TN); Southern Karnataka

* KL: Kerala; TN: Tamil Nadu

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