BAMBOOS OF INDIA

a compendium

K. K. Seethalakshmi
M. S. Muktesh Kumar

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Assisted by

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BAMBOO INFORMATION CENTRE - INDIA,
KERALA FOREST RESEARCH INSTITUTE, PEECHI

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FOREWORD

Bamboo is one of the most ubiquitous, multi-use plant species in the tropical and subtropical regions of the world. It prominently features in the everyday lives of people in many living cultures of ancient lineage, particularly so in Asia. With the plant finding many industrial applications as well (such as in the manufacture of paper and rayon), the pressure on this resource has increased many-fold.

Among Asian countries, India is second only to China in terms of the quantity and variety of bamboo species. However, a problem that India has in common with many other nations is the lack of adequate information on bamboo. This Old World grass is taxonomically difficult to classify and study, and the resultant confusion has come to stand in the way of sustainable management and utilization of bamboo.

Recognizing the immense socio-economic values of bamboo, the International Development Research Centre (IDRC) and the International Network for Bamboo and Rattan (INBAR), have been in the forefront of efforts aimed at a better understanding of bamboo taxa. Both organizations have chosen to work closely with national programs to build and enhance national research and development capacities.

The Kerala Forest Research Institute (KFRI) has been one of the collaborating institutions for several IDRC and INBAR projects on Indian bamboos and rattans. *Bamboos of India - a Compendium* is the fruit of one such project. This compendium by K. K. Seethalakshmi and M. S. Muktesh Kumar of KFRI is a fairly exhaustive account of Indian bamboos, and we hope, will form a solid foundation for further work on the subject.

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Authors

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INTRODUCTION

Bamboos are arborescent grasses belonging to the family *Poaceae* and are grouped under the subfamily *Bambusoideae*. *Bambusoideae* are differentiated from other members of the family by the presence of petiolate blades with tessellate venation, three, four, six or more stamens, gynoecium with a single style, one to three stigmas and fruit or caryopsis. There are three major growth forms of bamboos in India. Tree forms constitute about 45 per cent and are generally found in deciduous forests, shrubs are about 36 per cent and they are found in restricted habitats such as stream banks or in the ecotones of evergreen forests and the rest are climbers which occur in evergreen forests (Prasad and Gadgil, 1981).

◄*Gregarious flowering of* **B. bambos**

TAXONOMIC DESCRIPTION

The compilation on Bamboos of the World brought out by Ohrnberger and Goerrings (1985) reported the occurrence of 110 genera and 1110-1140 species of bamboos in the world. In India, studies on the taxonomy of bamboos started with two genera, *Bambusa* and *Ochlandra*, as early as 1678 with the publication of Hortus (Rheede, 1678-1703). The basic work on bamboo taxonomy was that of Munro (1868) in which he had described 21 genera and 170 species of bamboos of the world and classified

the genera into three divisions. Kurz (1876) was the first to work on living specimens from botanical gardens of Bogor (Indonesia) and Calcutta (India). He realised the importance of vegetative characters like culm-sheath in the identification of bamboo species. The first comprehensive monograph on Indian bamboos was that of Gamble (1896). He reported 15 genera and 115 species. This was followed by the work of Camus (1913) from India and China. A systematic analysis and arrangement of species was attempted by Parker (1929) and Blatter (1929). Other important publications on bamboo taxonomy are that of McClure (1936, 1954, 1966), Dransfield (1980, 1982), Soderstrom (1985), Widjaja (1987), Soderstrom and Ellis (1988), Chao and Renvoize (1989), Bennet and Gaur (1990b), Tewari (1992), Kumar (1990, 1995) and Dransfield and Widjaja (1995). Nomenclatural aspects have been studied by a number of researchers (Bahadur and Naithani, 1976, 1983; Majumdar, 1983; Naithani, 1986, 1990a, 1990b, 1993, 1994a, 1994b; Bennet, 1988, 1989; Bennet and Gaur, 1990a, 1990b; Naithani and Bennet, 1991 and Soderstrom and Ellis, 1988). Most of the taxonomic descriptions, including recent ones, are based on scanty herbarium specimens. As per the latest taxonomic descriptions, there are 18 genera and 128 species of bamboos in India, which include 87 naturally occurring and 41 introduced or cultivated species (Table 1).

Table 1. Genera and number of species of bamboos naturally occurring and cultivated in India

Sl. No.	Genus	Naturally occurring	Introduced/ cultivated	Total No. of species
1	*Arundinaria*	2	0	2
2	*Bambusa*	12	14	26
3	*Chimonobambusa*	1	0	1
4	*Dendrocalamus*	7	8	15
5	*Dinochloa*	5	1	6
6	*Gigantochloa*	2	5	7
7	*Melocanna*	0	2	2
8	*Ochlandra*	9	0	9
9	*Oxytenanthera*	1	1	2
10	*Phyllostachys*	2	3	5
11	*Pleioblastus*	1	0	1
12	*Pseudosasa*	0	1	1
13	*Pseudoxytenanthera*	4	0	4
14	*Racemobambos*	3	0	3
15	*Schizostachyum*	17	1	18
16	*Sinarundinaria*	18	3	21
17	*Thamnocalamus*	3	0	3
18	*Thyrsostachys*	0	2	2
Total		87	41	128

FLOWERING AND FRUITING

Based on the flowering cycle, bamboos are classified into three types.

1. Annual or continuous flowering: species which flower every year and do not die.

2. Gregarious or periodic flowering: the whole clump flowers in an extensive area and dies after seed setting. The flowering may continue for two to three years in an area or in the same clump.

3. Sporadic or irregular flowering: occurs in isolated clumps (in one or two in an area) or in parts of one clump (in one or two culms).

The flowering interval in periodically flowering bamboos varies from three (*Schizostachyum elegantissimum*) to one hundred and twenty years (*Phyllostachys bambusoides*). Different cohorts of the same species may differ in their flowering cycle. Flowering cycles so far reported for various bamboo species are given in Table 2. Descriptions of floral parts of 20 species of bamboos are lacking (Table 3). From India, the major part of the literature on bamboo flowering is limited to the reports on incidence of flowering. Whether flowering is controlled by environmental conditions or by the physiological calendar is not clearly established. *In vitro* flowering has been reported from India (Rao & Rao, 1990; Nadgauda et al., 1990).

Table 2. Flowering cycle of various bamboo species

Arundinaria		**Ochlandra**	
A. racemosa	30	*O. scriptoria*	01
Bambusa		*O. travancorica*	07
B. atra	01	**Oxytenanthera**	
B. balcooa	35-45	*O. abyssinica*	07
B. bambos	30-49	**Phyllostachys**	
B. copelandi	48	*P. bambusoides*	120
B. khasiana	35*	**Pseudoxytenanthera**	
B. longispiculata	20-25	*P. monadelpha*	4-6*
B. multiplex	28-31*	**Schizostachyum**	
B. nutans	35	*S. capitatum* var. *capitatum*	04-08*
B. polymorpha	35-60		
B. tulda	30-60	*S. latifolium*	44*
B. vulgaris	80-88	*S. pallidum*	06*
Chimonobambusa		**Sinarundinaria**	
C. callosa	23-28*	*S. anceps*	45-55
Dendrocalamus		*S. falcata*	48-58*
D. giganteus	40	*S. hirsuta*	20-48*
D. longispathus	30-32	*S. hookeriana*	30-35*
D. hamiltoni	30-40	*S. intermedia*	20*
D. membranaceus	19-20*	*S. pantlingii*	35*
D. strictus	25-45	*S. polystachya*	30*
Dinochloa		*S. wightiana*	01
D. compactiflora	7-14*	**Thamnocalamus**	
Gigantochloa		*T. aristatus*	20*
G. albociliata	27-30*	*T. falconeri*	30
G. rostrata	30-50	*T. spathiflorus*	16-17
Melocanna		**Thyrsostachys**	
M. baccifera	40-45	*T. oliveri*	48-50
		T. regia	40-47

** Flowering cycle based on earlier reports from same area*

Observations on floral biology in *Dendrocalamus strictus* and *Ochlandra travancorica* revealed dichogamy with protogyny (Venkatesh, 1984 and Nadgauda et al., 1993) Although insects are found visiting the flowers, their role in pollination is not clear. There are also reports of albinism and natural selfing in *Bambusa bambos* (Indira, 1988, Adarshkumar et al., 1995).

▲ *A flowered clump of* **Arundinaria**

The size and shape of bamboo fruits vary according to the species. The morphology of fruit is a dependable character for identification of bamboos. McClure (1966) has given an account of bamboo fruits belonging to 17 genera and 22 species. Fruits of 60 species belonging to 14 genera are yet to be described (Table 4). Although bamboo fruit are generally known as caryopsis, based on the morphology, Wen and He (1989) classified them into three types :

1. Caryopsis: The pericarp is membranous, thin, soft and adheres to the seed coat. The fruit has an apparent ventral suture which is nearly as long as the whole fruit. An orbiculate navel is located at the fruit base (e.g. *Bambusa, Chimonobambusa, Gigantochloa, Phyllostachys, Thyrsostachys*).

2. Glans: have hard, smooth, crustaceous pericarp, separated from the seed coat. The fruit has no ventral suture and navel. (e.g. *Dendrocalamus, Schizostachyum*).

3. Bacca: has thick fleshy pericarp, separated from the seed coat. (e.g. *Melocanna, Ochlandra*).

They indicated that the morphology of starch grains can also be used as a distinguishing character for identification. Fruit development in a few species has been reported by Harigopal and Mohanram (1987).

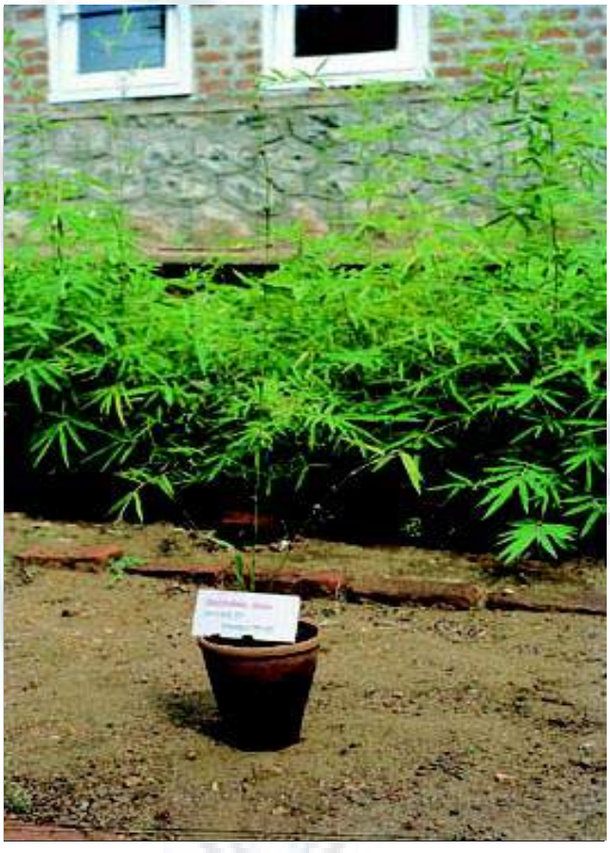
CYTOLOGY AND GENETICS

Cytological investigations reveal that there are triploids, tetraploids, pentaploids, hexaploids and aneuploids in bamboos. (Parthasarathy, 1946; Darlington and Wylie. 1955; Janakiammal, 1959; Christopher and Abraham, 1971 and Sobita Devi and Sharma, 1993; Banik, 1995). The somatic chromosome number varies as 24, 38, 48, 54, 60, 70, 72 and 108 in different species (Table 5).

Considering the high returns reported for bamboo farming (Chadurvedi, 1986; Wagh and Rajput, 1991), selection of elite clones for large scale planting is an important aspect which requires immediate attention. There is

Table 3. Bamboos of India for which floral descriptions are lacking

Sl. No.	Species	Sl. No.	Species
Bambusa		**Racemobambos**	
1	*B. auriculata*	10	*R. mannii*
2	*B. bambos* var. *gigantea*	**Schizostachyum**	
3	*B. jaintiana*	11	*S. arunachalensis*
4	*B. mastersii*	12	*S. capitatum* var. *decompositum*
5	*B. pseudopallida*		
6	*B. wamin*	13	*S. mannii*
Dinochloa		14	*S. seshagirianum*
7	*D. gracilis*	**Sinarundinaria**	
Melocanna		15	*S. arunachalensis*
8	*M. arundina*	16	*S. kurzii*
Phyllostachys		17	*S. microphylla*
9	*P. mannii*	18	*S. nagalandiana*
		19	*S. rolloana*
		20	*S. suberecta*



➤ *Freak flowering of a seedling of* **D. strictus**

➤ *In vitro flowering*

variation among different species and within species in nature. Because of the peculiar flowering pattern, it has been difficult to produce better varieties by breeding. However, reports from China show that intergeneric and interspecific hybrids have been produced using *Bambusa, Dendrocalamus and Phyllostachys* (Zhang et al., 1985). Treatment of seeds of *Dendrocalamus strictus* with colchicine increased seedling vigour indicating the possibility of inducing polyploidy (Rao, 1960). Recently, work has been initiated in many parts of the country for collection of germplasm of various bamboo species.

DISTRIBUTION AND ECOLOGY

India has the second largest reserve of bamboos. Bamboos are naturally distributed in all the states of India except in Jammu and Kashmir. Maximum number of genera has been reported from West Bengal and Arunachal Pradesh (11). The state-wise distribution of bamboo genera is given in Table 6. Bamboos are distributed in the country starting from sea level to an elevation of 3600 m above msl. Although bamboos prefer regions of high rainfall of about 1200 mm to 6350 mm, *Dendrocalamus strictus* is reported from regions of Rajasthan where the rainfall is about 700-1000 mm. Different species of bamboos have different optimum temperatures, humidity, soil types, altitudes and physiography for their best performance. Architectural studies carried out on two species from North-Eastern India showed that the structure is adapted to capitalise the high light regime of the early successional environment (Rao et al., 1990).

ANATOMY

Anatomical characters of bamboos have considerable importance in identification of genera and species. Furthermore, the general properties of the bamboo culm are based on the anatomical, chemical, physical and mechanical characteristics. The outer part of bamboo culm consists of two epidermal layers, the inner one is thicker and highly lignified and the

Sl. No.	Species	Sl. No.	Species
Bambusa		**Oxytenanthera**	
1	*B. affinis*	32	*O. parvifolia*
2	*B. auriculata*	**Phyllostachys**	
3	*B. balcooa*	33	*P. assamica*
4	*B. bambos* var. *gigantea*	34	*P. bambusoides*
5	*B. cacharensis*	35	*P. mannii*
6	*B. griffithiana*	36	*P. puberula*
7	*B. jaintiana*	**Pleioblastus**	
8	*B. khasiana*	37	*P. simonii*
9	*B. kingiana*	**Pseudosasa**	
10	*B. longispiculata*	38	*P. japonica*
11	*B. mastersii*	**Pseudoxytenanthera**	
12	*B. pallida*	39	*P. stoksii*
13	*B. pseudopallida*	**Racemobambos**	
14	*B. striata*	40	*R. clarkei*
15	*B. teres*	41	*R. mannii*
16	*B. vulgaris*	**Schizostachyum**	
17	*B. wamin*	42	*S. arunachalensis*
Dendrocalamus		43	*S. brachycladum*
18	*D. calostachyus*	44	*S. capitatum* var. *decompositum*
19	*D. colletianus*		
20	*D. hookeri*	45	*S. dullooa*
21	*D. sahni*	46	*S. flavescens*
22	*D. sericeus*	47	*S. mannii*
23	*D. somdevai*	48	*S. seshagirianum*
Dinochloa		**Sinarundinaria**	
24	*D. andamanica*	49	*S. arunachalensis*
25	*D. gracilis*	50	*S. densifolia*
26	*D. indica*	51	*S. elegans*
27	*D. nicobariana*	52	*S. griffithiana*
Gigantochloa		53	*S. jainianum*
28	*G. atroviolacea*	54	*S. kurzii*
29	*G. atter*	55	*S. longispiculata*
Melocanna		56	*S. microphylla*
30	*M. arundina*	57	*S. nagalandiana*
Ochlandra		58	*S. rolloana*
31	*O. sivagiriana*	59	*S. polystachya*
		60	*S. suberecta*

outer one is covered by a cutinised layer with a wax coating. In culm, the cells are axially oriented in the internodal region and they provide transverse interconnections in the nodal region. The culm consists of about fifty per cent parenchyma, forty per cent fibre and ten per cent conducting tissues with some variation depending on species. The parenchyma cells are vertically elongated with short cube-like cells interspersed between them. The elongated cells are characterized by thicker walls with polylamellate structure and they become lignified in the early stages of shoot growth. The short cells have denser cytoplasm and thinner walls. They retain their cytoplasmic activity for a long time. The vascular bundles in bamboo culm consist of one or two protoxylem elements, two large metaxylem vessels and the phloem with thin walled, unlignified sieve tubes connected to companion cells. There is a protective layer in the parenchyma cells adjacent to metaxylem vessels consisting of cellulose and hemicellulose (Liese, 1987).

Table 4. Bamboo species for which caryopsis is not described

Table 5. Somatic chromosome number of various bamboo species of India

Genera and species	Chromosome no.	Genera and species	Chromosome no.
Arundinaria		**Melocanna**	
A. racemosa	48	*M. baccifera*	72
Bambusa		**Ochlandra**	
B. atra	72	*O. travancorica*	72
B. balcooa	70	**Phyllostachys**	
B. bambos	70, 72	*P. aurea*	48
B. burmanica	70	*P. bambusoides*	48
B. kingiana	76	*P. puberula*	48
B. multiplex	70, 72	*P. simonii*	48
B. nutans	70	**Pseduosasa**	
B. oliveriana	38	*P. japonica*	48
B. polymorpha	64, 72	**Schizostachyum**	
B. tulda	70	*S. capitatum*	60
B. vulgaris	72	*S. dullooa*	56
Dendrocalamus		*S. kurzii*	54, 108
D. brandisii	72	*S. pergracile*	48, 54, 60, 72
D. giganteus	72	*S. polymorphum*	48
D. hamiltonii	70, 72	*S. anceps*	48
D. hookeri	36	*S. falcata*	48
D. longispathus	48,72	*S. hookeriana*	48
D. membranaceus	46	*S. pantlingi*	48
D. sericeus	60, 72	*S. wightiana*	48
D. stricuts	56, 70, 72	**Thamnocalamus**	
Dinochloa		*T. aristatus*	48
D. compactiflora	72	*T. falconeri*	48
Gigantochloa		*T. spathiflorus*	48
G. atroviolacea	72		
G. macrostachya	72		
G. pseudoarundinacea	72		

Among the anatomical characters, morphology of vascular bundles has been widely used for bamboo identification. In bamboos, four to five major types of vascular bundles are reported (Grosser and Liese, 1971; Liese, 1987; Wen Taihui and Chou Wenwei, 1987).

Type I. Consists of one central vascular strand, supporting tissue only as sclerenchyma sheaths.

Type II. Same as type I, but the sheath at the intercellular space (protoxylem) is strikingly larger.

Type III. Consists of two parts; the central vascular strand with sclerenchyma sheaths and one isolated fibre bundle.

Type IV. Consists of three parts; the central vascular strand with small sclerenchyma sheaths and two isolated fibre bundles outside and inside the central strand.

Type V. A semi-open type representing a further link in the evolution.

▲ *Fruits of bamboos:* **Ochlandra travancorica** var. **hirsuta** *(bacca);* **Bambusa bambos** *(caryopsis) and* **Dendrocalamus strictus** *(glans)*

▼ *Difference in the lumen of bamboo culms*

➤ *New shoot initiation in* **B. bambos**

➤ *(opposite page) Branching out from the new culms after three months*

Table 6. State-wise distribution of bamboo genera in India

States	Genera
Andhra Pradesh	*Bambusa, Dendrocalamus, Pseudoxytenathera* and *Schizostachyum*
Arunachal Pradesh	*Arundinaria, Bambusa, Chimonobambusa, Dendrocalamus, Gigantochloa, Phyllostachys, Pleioblastus, Schizostachyum, Sinarundinaria, Thamnocalamus* and *Thyrsostachys*
Assam	*Bambusa, Dendrocalamus, Dinochloa, Gigantochloa, Melocanna, Oxtenanthera, Phyllostachys, Racemobambos* and *Schizostachyum*
Bihar	*Bambusa, Dendrocalamus, Gigantochloa* and *Schizostachyum*
Goa	*Pseudoxytenathera*
Gujarat	*Bambusa* and *Dendrocalamus*
Haryana	*Dendrocalamus*
Himachal Pradesh	*Dendrocalamus, Phyllostachys* and *Sinarundinaria*
Karnataka	*Bambusa, Dendrocalamus, Thamnocalamus, Melocanna, Ochlandra, Schizostachyum, Thyrsostachys* and *Pseudoxytenanthera*
Kerala	*Bambusa, Dendrocalamus, Ochlandra, Pseudoxytenanthera, Schizostachyum, Sinarundinaria* and *Thyrsostachys*
Madhya Pradesh	*Bambusa, Dendrocalamus, Gigantochloa* and *Schizostachyum*
Maharashtra	*Bambusa, Dendrocalamus, Gigantochloa* and *Pseudoxytenanthera*
Manipur	*Bambusa, Chimonobambusa, Dendrocalamus, Dinochloa, Melocanna, Racemobambos, Schizostachyum* and *Sinarundinaria*
Meghalaya	*Bambusa, Chimonobambusa, Dendrocalamus, Gigantochloa, Melocanna, Racemobambos, Phyllostachys, Schizostachyum* and *Sinarundinaria*
Mizoram	*Bambusa, Chimonobambusa, Dendrocalamus, Gigantochloa, Melocanna, Oxytenanthera, Schizostachyum* and *Sinarundinaria*
Nagaland	*Bambusa, Chimonobambusa, Dendrocalamus, Racemobambos, Schizostachyum* and *Sinarundinaria*
Orissa	*Bambusa, Dendrocalamus, Gigantochloa* and *Schizostachyum*
Punjab	*Dendrocalamus*
Rajasthan	*Dendrocalamus*
Sikkim	*Arundinaria, Bambusa, Dendrocalamus, Melocanna, Phyllostachys, Racemobambos, Schizostachyum, Sinarundinaria* and *Thamnocalamus*
Tamil Nadu	*Bambusa, Dendrocalamus, Ochlandra, Pseudoxytenanthera, Schizostachyum* and *Sinarundinaria*
Tripura	*Bambusa, Dendrocalamus, Gigantochloa, Melocanna* and *Schizostachyum*
Uttar Pradesh	*Bambusa, Dendrocalamus, Dinochloa, Gigantochloa, Oxytenanthera, Phyllostachys, Pseudosasa, Schizostachyum, Sinarundinaria, Thamnocalamus* and *Thyrsostachys*
West Bengal	*Arundinaria, Bambusa, Dendrocalamus, Dinochloa, Gigantochloa, Melocanna, Pseudosasa, Schizostachyum, Sinarundinaria, Thamnocalamus* and *Thyrsostachys*

In addition to these, species of *Dinochloa* and *Schizostachyum* are reported from Andaman and Nicobar Islands.

The leaf lamina has an upper epidermis, two or three layers of mesophyll with or without a distinct palisade layer, fairly large air spaces, lower mesophyll and lower epidermis. Groups of bulliform cells alternate with the air spaces. The plicate or lobed condition is common in many of the outer mesophyll layers. The vascular bundles in the leaves show the regular monocotyledonous structure and a group of sclerenchymatous cells interconnect the vascular bundles with upper and lower epidermis. Stomata are commonly present on the lower epidermis and the guard cells appear smaller than the epidermal cells (Rao, 1987).

Anatomical studies on Indian bamboos are limited mainly to culms and leaves. Ghosh and Negi (1960) studied the stem epidermis of six bamboo species. Pattanath and Rao (1968) worked on twelve species and they found that epidermal features and internodal structures can be used for distinguishing species. A study conducted by Appasamy (1989) on five species revealed that bundle morphology can be used as a diagnostic character. Observations on epidermal features of eight species of *Dendrocalamus* (Bisen et al., 1989), culm and leaf epidermal studies on *Bambusa*, *Dendrocalamus*, *Oxytenanthera* and *Gigantochloa* (Sharma et al., 1986, 1987; Luxmi Chauhan et al., 1988; Agrawal and Luxmi Chauhan 1991, 1992) further proved the role of anatomical characteristics as diagnostic features. Information on root anatomy is very limited. Anatomical and morphological studies carried out on fruits of five species of Bamboos (Appasamy, 1993) reported variations in the structure of seed coat and storage tissues. Work on anatomical aspects carried out so far is confined to about 48 species. No reports are available on species of *Arundinaria*, *Chimonobambusa*, *Phyllostachys*, *Pleioblastus*, *Racemobambos* and *Schizostachyum* occurring in India.

MORPHOLOGY

The vegetative parts of a bamboo plant consist of roots, rhizome, culm, culm-sheaths, branches and leaves. The profuse fibrous roots of bamboos form a dense network in the soil. The basal portion of the culm which grows horizontally under the soil surface with short internodes is called the rhizome. The constricted portion of the rhizome is known as the neck. Based on the structure of the rhizome two types of bamboos are reported. 1. Pachymorph (sympodial): This type is solid, and usually short and thick. Bamboos with this type of rhizome are clump-forming. There are few exceptions. 2. Leptomorph (monopodial): Bamboos with this type of rhizome continue their horizontal growth without forming clumps. Their lateral buds give rise to new culms directly; very few produce long, slender, hollow rhizomes (Bennet and Gaur, 1990b).

Culms in the majority of bamboos are hollow and the wall thickness varies with the species. The culms may be arching or erect, semiscandent or scandent. Species of *Dinochloa* have the unique nature of zig-zag culms and *Bambusa wamin* is characterized by pitcher shaped internodes. The sprouting of new culms occurs soon after the rains and the height growth is completed within three to four months. The new growing culms are protected by culm-sheaths which are modified leaves. Culm-sheaths are arranged in two ranks and they fall off when culms are mature, leaving the scars. Culm-sheaths have imperfect blades, auricles and ligules. The general appearance, size, texture and shape of the culm-sheaths and their blades are useful characters for identification and based on these, a key for 22 species has been developed by Chatterji and Raizada (1963). When the culm attains maximum height growth, the branches open out from the nodes of the culms and the pattern of branching is characteristic to each genus. The typical branching behavior is seen in the mid-culm regions with more branching towards the tip. On the basis of branching pattern, three types of branching are recognised viz., single, triple and multiple branching in monopodial bamboos (Wenyue et al. 1987).

CHEMISTRY

The major chemical constituents of bamboo culm are cellulose, hemicellulose and lignin and the minor constituents are resins, tannins, waxes and inorganic salts. The chemical composition varies with species, conditions of growth, age,

▲ *Collection of seeds after gregarious flowering*

➤ *Separation of seeds by winnowing*

➤ *One year old seedling suitable for multiplication*

season and part of the culm. The nodes contain less water soluble extractives, pentosans and lignin but more cellulose than internodes. Silica content is high in the epidermis, with very little in the nodes and is absent in the internodes. Cellulose in bamboo is holocellulose and consists of 1, 4 bonded hydroglucose units and the degree of polymerization is higher than that of dicotyledonous woods. The bamboo hemicellulose consists of 4-O-methyl D-glucuronic acid, L-arabinose and D-xylose. Bamboo lignin, which is typical of the grasses, is built up from three phenyl-propane units, p-coumaryl, coniferyl and sinapyl alcohols interconnected through biosynthetic pathways (Liese, 1987).

The chemical composition of 18 species belonging to 10 genera is known from India (Singh et al., 1976; Singh and Bhola, 1978). Hemicellulose studied for three species showed a difference in the yield of sugars (Rita Dhawan and Singh, 1982). The difference in lignin content of various species is negligible. A few reports are available on nutritive value of

seeds of *Bambusa, Dendrocalamus* and *Ochlandra* (Rao et al. 1955; Mitra and Nayak, 1972, Appasamy, 1993) and fodder value of leaves of *Dendrocalamus* (Negi et al. 1980). Possibility of using isoenzymes as a tool for identification of species has been attempted in *Bambusa* (Lalithakumari et al., 1985). In addition to its use as a vegetable, bamboo shoot is a rich source for phytosterols (Srivastava, 1990). Limited studies on leachates from degrading bamboo leaves have shown an allelopathic effect on growth of groundnut and maize (Eyini et al., 1989).

SILVICULTURE AND MANAGEMENT

Seed handling: Seeds can be collected in bulk when gregarious flowering occurs from the area by sweeping the forest floor. A small quantity of seed is also available during sporadic flowering. The seeds can be separated from the chaff by winnowing. The germination tests and observations in flowered areas have indicated that the seeds have no dormancy. High percentage of germination (80-100) is obtained if seeds are sown soon after collection under shade. Germination is hypogeal and starts within 2-10 days after sowing (Banik, 1995). Seeds can be sown directly in nursery beds or soil filled polythene bags. A direct relation exists in some species between seed size and seedling vigour (Banik, 1987, 1991). Variation is reported in seedlings with regard to growth pattern and direction of opening of leaves (Bahadur, 1978 and Kondas, 1982). Seed longevity varies with species from one to eight months. Caryopsis and glans types can be stored by controlling moisture content and temperature (White, 1947; Gupta and Sood, 1978; Somen and Seethalakshmi, 1987; Sur et al., 1989; Thapliyal et al., 1991) but for bacca type no storage methods are found successful.

Vegetative propagation: Since seeds are not available regularly and viability of the seeds of many species is very short, propagation by vegetative methods is required for many bamboos. The following methods are generally used for vegetative propagation based on the nature of species.

1. **Seedling multiplication:** When the seedlings start developing rhizomes, the new sprouts with a portion of rhizome are severed from the mother seedling and planted separately. About 3-5 planting units can be obtained from one-year-old seedlings (Adarsh Kumar, 1992).

2. **Offset or clump division:** The rhizome portions and offsets are separated from the mother plant during the active phase of bud development. Offsets or rhizomes of one to two-year old culms are found better. A part of the clump consisting of more than one rhizome also gives promising results (McClure, 1966).

3. **Rhizome cuttings:** This is mainly done for bamboos with leptomorph rhizomes. Rhizome cuttings of about 40 to 50 cm are taken from the mother clump and planted.

4. **Layering:** The mother culms from the parent clump are bent and held in contact with the soil in such a way that the nodes come in contact with the soil and remain like that till the roots are developed. Then the rooted nodes are separated and used for planting.

5. **Culm cuttings:** Different types of culm cuttings such as single-noded, two-noded and three-noded cuttings are used for rooting. The mother culm is cut into pieces using sharp tools. The rooting of culm cuttings is based on various parameters like age of the mother culm, portion from which the cutting is taken, method of planting and the period of the year selected for rooting (Pathak, 1899; Dabral, 1950; Gupta and Pattanath, 1976). The rooting response of culm cuttings is enhanced considerably by use of growth regulating substances (Surendran and Seethalakshmi, 1985; Nath et al., 1986).

6. **Pre-rooted and pre-rhizomed branch cuttings:** Chopping of the top of one-year-old culms and removal of all the emerging culms induced *in situ* roots and rhizome formation at branch bases of many bamboo species. The pre-

rooted and pre- rhizomed branches are removed from the main culm by hack-saw and planted in the fibreglass tents without mist for development (Banik, 1984).

7. **Branch cuttings and nodal bud chips:** The branches which are trimmed off while processing bamboo culms are used for propagation. Up to 50 per cent rooting can be obtained by providing proper environmental conditions and growth regulator treatments. Similarly, trials with the meristematic portion of the node (nodal bud chips) have also indicated the possibility of rooting (Surendran and Seethalakshmi, 1985).

8. **Tissue culture:** Tissue culture has been found successful for different bamboo species. The various explants used are seeds, seedling, embryo, stem and leaves. The success rates vary with the species and cultural conditions. Many successful protocols are used for commercial production of planting stock by various research organisations and private enterprises in India. The work on micropropagation of bamboos has recently been reviewed by Rao et al. (1990) and Zamora (1994).

Planting: For field planting of bamboos, pits are prepared two months in advance. The spacing and size of the pits depend on the species and the type of planting material. The time of planting is a very critical factor in the establishment of plantations. Planting should be done soon after the onset of the monsoon. Cultural operations like soil working, tending and fertilizer application increase the yield considerably (Lakshmana, 1990; Patil and Patil, 1990; Thomas, 1991). It is also reported from Karnataka and Tamil Nadu that irrigation increases productivity. In a comparative study with other tree crops, Wang and Rajput (1991) reported that bamboo plantations have higher rates of return than rubber and cashew.

Management: The important factors for consideration of management of bamboo forests are felling cycle, felling intensity and method of felling. Most of the recommendations on management practices of bamboos are based on the observations on *Bambusa bambos* and *Dendrocalamus strictus* which are widely distributed in India. The general felling rules are:

1. Culms should be cut, according to a thinning out principle so that the culms left are distributed around the young shoots in order to prevent their bending.
2. Immature culms should not be cut unless they are damaged or infected.
3. The oldest and deteriorating culms which cannot last for another cycle should be removed first before any of the good culms are felled.
4. Cutting along the periphery should be avoided as far as possible in accordance with the principle of thinning. Cutting of clumps at the periphery restricts the outward growth of the clump.
5. Culms should be cut at a height of about 15-30 cm from the ground.
6. Cutting at heights more than 60 to 90 cm above ground level should be avoided, as this results in wastage and the stump later causes congestion due to the sprouting of buds.
7. Flowering culms and clumps should not be cut before seed fall is completed.
8. Tending operations should be done along with the felling by cutting any malformed, dead, diseased or otherwise useless culms, stumps and climbers.
9. No clump is considered mature for exploitation unless it contains more than eight mature culms.
10. In a mature clump, culms of current season and eight culms of the previous year should be retained.

11. Digging of rhizome, cutting of tops of bamboo for fodder and use of tender bamboo for building are prohibited.

12. Sharp instruments are to be used during the extraction process.

MYCORRHIZAE

Occurrence of vesicular arbuscular mycorrhizae (VAM) associated with species of *Bambusa*, *Dendrocalamus* and *Ochlandra* is reported from Southern India. The species of VAM recorded are *Glomus albidum*, *G. fasciculatum*, *G. mosseae*, *G. pubescens*, *G. reticulatum* , *Gigaspora* sp. and *Sactellospora* sp. (Appasamy and Ganapathy, 1992).

PESTS AND DISEASES

From India, a number of insects are reported to attack bamboos (Singh, 1990; Mathew and Varma, 1990). Nearly two hundred species of insects are reported to damage various species of bamboos from India and depending on the nature of attack, they are classified into eight types:

1. Defoliating insects. 2. Sap-sucking insects. 3. Shoot and culm-boring-insects. 4. Gall-making insects. 5. Rhizome and root insects. 6. Seed insects. 7. Nursery insects. 8. Post-harvest insects (Wang et al., 1995).

They belong to five orders viz., *Coleoptera*, *Homoptera*, *Isoptera*, *Lepidoptera*, and *Thysanoptera*. Various treatments are found effective against the damage caused by many of these organisms. Recently a manual on bamboo insect pests in Asia has been done by Wang et al., (1995).

A number of diseases are reported from bamboo nurseries, plantations and natural forests. Seed borne fungi also cause serious damage to stored seeds and reduce germinability. A review on the diseases found in bamboos from Asia has been done by Mohanan (1995). The major nursery diseases are damping off, wilt, seedling stem infection, leaf blight, leaf rust, smut on stem, on spikes and ergot. The diseases reported from plantations and natural forests are rhizome bud rot, rhizome decay, decay in the base of the culm, culm rot, culm sheath rot, stem infection, sheath and culm blight, leaf rust, tip blight, leaf spots, leaf rusts, little leaf, witches broom and sooty mould (Mohanan, 1990; Tewari, 1992). Many of these diseases can be controlled by proper management and chemical treatments.

PHYSICAL AND MECHANICAL PROPERTIES

The density of bamboo varies from 500 to 800 kg/m^3, based on the anatomical structure and moisture content. It increases from the central to the peripheral parts of the culms. Bamboos possess a very high moisture content which varies with age and season of felling. The moisture also varies from bottom to top and from the innermost layers to the periphery, and decreases with age. Studies on shrinkage at various moisture content levels have shown that bamboo starts shrinking right from green condition, even when the moisture content is about 100 to 150 per cent, unlike wood which starts shrinking below the fibre saturation point. The term fibre saturation point (FSP) is not applicable to bamboo (Gnanaharan, 1993). The shrinkage in bamboo, which is higher than in wood, is about 10-16 per cent and is related to wall thickness and culm diameter. There is large variation in shrinkage leading to drying defects. Bamboo is known for its high tensile strength. To possess optimum strength there is an age of maturity for each species. In air dry bamboos depending on the species, moisture content varies from 7 to 18 per cent, specific gravity from 0.428 to 0.817, fibre stress at elastic limit from 16 to 120 N/mm^2, modulus of rupture from 33 to 160 N/mm^2, modulus of elasticity from 3 to 22 kN/mm^2 and compression strength parallel to grain from 26-78 N/mm^2 (Tewari, 1992). The methods used to study the strength properties vary. Gnanaharan et al., (1994) compared different testing procedures for determining

▼ *Culm-cutting in the nursery*

➤ *Root formation in culm cuttings*

▲ *Rooted culm cutting ready for planting*

◄ *Root development in branch cutting*

◄ *Tissue culture of* **Bambusa bambos**

▼ *A plantation of bamboo reeds* **(Ochlandra sp.)**

◄*A plantation of* **Thyrsostachys oliveri**

◄*Bamboo planting under teak*

bending strength. There is no information on strength properties and the correlations between moisture control, anatomical structure, growth factors, drying and preservation for most of the species (Kumar et al., 1994).

NATURAL DURABILITY AND PRESERVATION

The natural durability of bamboos is found to vary from 9 to 84 months depending on the species. Variation in durability has also been observed along the length of the culm and the thickness of the wall. The basal portion is more durable than the middle and top portions.

➤*Extraction of bamboos*

⮟ *A clump of* **B. bambos** *ready for harvesting*

Due to the presence of large quantities of starch and less toxic substances, bamboo is easily attacked by fungi and borer beetles. They cause immense damage during drying, storage and subsequent use. Biodegradation of bamboos is a serious problem for pulping. The major fungal problems reported are white rots and brown rots, both of which result in decreases in pulp yield and fibre strength and an increase in pulping costs. Prophylactic treatments are effective but not usually undertaken since they are expensive (Kumar et al., 1994).

In stored bamboos, loss from fungal and insect attack can be significantly reduced by proper treatments at the time of stacking, even under open storage (Kumar et al., 1980). In some instances like reed bamboos the pest attack is sporadic and depends much on felling age of the culms and season of felling. To save the bamboos from termite attack, storing on raised platforms prepared from powdered lime sludge containing 2% BHC is recommended (Nair et al., 1983). It has also been reported that vertical stacking and monthly treatment with borax-boric acid reduces damage (Gnanaharan et al., 1982).

Both traditional and chemical treatments can be used to enhance the service life of bamboos. Traditional non-chemical treatments of bamboos include, felling of bamboo during the period when the sugar content is low, felling of bamboo at maturity, post-harvest transpiration of bamboo culm and water soaking of the culms. Baking the bamboo culms over fire after applying suitable coatings like oil, tar or lime-wash are some other traditional methods for increasing the service life of bamboos. Chemical treatments of bamboos ensure longer life. Some of the generally used chemical preservatives are (1) coal-tar, creosote and fuel oil, (2) copper-chrome-arsenic composition, (3) borated copper-chrome-arsenic composition, (4) acid copper-chrome-composition, (5) copper-chrome-boron composition, (6) ammoniacal copper-arsenite composition, (7) boric acid - Borax, (8) copper naphthenate/abietate and zinc naphthenate/abietate, (9) sodium- penta-chlorophenate-boric acid- borax, (10) sodium pentachlorophenoxide (Kumar et al., 1994). The treatment can be given both in green and dry conditions by various methods. For treatment of green bamboos, the methods used are: 1. Sap displacement. 2. Steeping. 3. Diffusion process and 4. Boucherie process. Dry bamboos can be treated by the following methods: 1. Soaking. 2. Hot-cold process and 3. Pressure treatment (Kumar et al., 1994).

Tests on treated bamboos showed variation in durability depending on species and service conditions (Kumar et al., 1994).

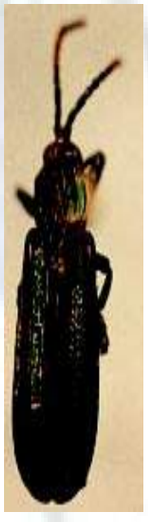
USES

Bamboo has received the attention of mankind mainly due to its multifarious uses. Bamboo culms are widely used as structural material for building purposes, and as raw material for pulp, paper and panel board industries. Recently, it was reported that bamboo skin can be used in cottage industries (Kabir et al., 1993). In rural areas, branches of thorny bamboos are widely used for fencing and the culms are used as water pipes. Thin diameter culms with thick walls are used for umbrella handles, pluckers and fishing rods. Bamboo leaves are used for fodder and thatching. An analysis of the nutritive value of bamboo leaves revealed high nutrient contents (Negi, 1977; Khatta and Katoch, 1983). Bamboo roots, leaves, sprouts and grains are used in the Ayurvedic system of medicine for the treatment of many diseases. Also the silicaceous deposit *Banslochan* found in the interior parts of the hollow culms is used for the treatment of asthma, cough, paralytic complaints and other debilitating diseases. Young bamboo shoots are a delicacy and offer good export opportunities in many Asian countries. Goldsmiths prefer the charcoal made from bamboos. Different types of musical instruments, bows and arrows are made from bamboos. Bamboo rhizomes are used for decorative handicraft items. Bamboo roots are considered poisonous due to the presence of cyanogenic glucosides, but the burnt roots are used for the treatment of ring worm, bleeding gums, painful joints and wounds.

THE SCOPE OF THIS BOOK

This is a comprehensive compilation on bamboo species occurring in India, primarily based on a literature survey. Information on Indian bamboos is presently scattered in numerous publications, floras and other treatises. The diverse and dispersed sources of information add to the difficulties in understanding this group of plants in a holistic manner. Contradictory reports on various aspects of bamboos, especially those of taxonomic and phytogeographic observations have increased the confusion for bamboo classification and for the generic and specific delimitations. The number of bamboo genera and species occurring in India have been reported arbitrarily by various taxonomists, with each author giving a different figure. Some of the bamboos have been merged with another genera or species or have been treated as synonyms. Recently, several changes have been suggested with regard to the taxonomic status as well as nomenclature of several Indian bamboo genera. Many species have been assigned different names by different investigators e.g. the genus *Oxytenanthera*. This genus was described by Munro (1868). Holttum (1956) considered it to be monotypic with *O. abyssinica*. The rest of the species treated earlier under this genus were shifted to *Gigantochloa* or *Dendrocalamus*. Soderstrom and Ellis (1988) maintained *Oxytenanthera* as a new taxon, *Pseudoxytenanthera,* to which they transferred *O. monadelpha*. Majumdar (1989) described it as yet another genus *Pseudotenanthera* which Naithani (1990b) later considered a superfluous name, and treated it as a synonym of *Pseudoxytenanthera,* making new combinations. Some species have been placed under two or more genera by various workers. Similarly, many genera like *Arundinaria, Chimonobambusa, Drepanostachyum, Indocalamus, Melocalamus* and *Teinostachyum* are treated differently by various authors (McClure, 1936; Holttum, 1958; Bahadur and Naithani, 1983; Majumdar, 1983, 1989; Das, 1995). The genus *Arundinaria* Michaux was the largest genus under *Bambusoideae* at one time having 380 binomials under the name *Arundinaria* and representing, taxonomically, a heterogenous group of bamboos. Japanese and Chinese botanists have recognised that certain species in Asia, originally included under *Arundinaria*, differed in various ways and they, therefore, published a new genus to accommodate these divergent species, e.g. *Sinobambusa* Makino ex Nakai, *Chimonobambusa* Makino, *Indocalamus* Nakai, *Pleioblastus* Nakai, *Oreocalamus* Keng, Hsueh & Yi, *Yushaina* Keng. f., *Drepanostachyum Keng*. f., *Himalayacalamus* Keng. f., *Oligostachyum* Wang and Ye., *Bashania* Keng. f. and Yi. In some cases, these segregate from *Arundinaria* are justified, i.e. *Sinobambusa*, *Chimonobambusa*, *Indocalamus* and *Sinarundinaria*; but in others they lead to more confusion and have subsequently been reduced to synonyms (Chao and Renvoize, 1989). Various publications indicate considerable disparity in the number of genera and species reported from different phytogeographic regions of India. This disparity emphasizes the need for a review of the literature on bamboos and compilation of the information on various species, including their synonyms.

The first monograph on Indian bamboos was that of Gamble (1896) and dealt with taxonomy, distribution and uses. McClure (1966) in his book, The Bamboos - A Fresh Perspective, made an extensive coverage of vegetative and reproductive characteristics of the bamboo plant, including descriptions of elite species with their propagation methods, flowering and fruiting behaviour and taxonomic keys to various genera and species. During the last decade the International Development Research Centre, Canada, concentrated their attention on bamboo and rattan research in Asian countries, Five International Bamboo Workshops were organised - in Singapore (1980), China (1985) India, (1988) Thailand (1991) and Indonesia (1995). An account of bamboo resources and research in India was presented in these meetings (Varmah and Bahadur, 1980; Gaur, 1987, Thomas et al., 1987; Sharma, 1987) which helped to arrive at an overall picture of bamboos in India and the major information gaps that exist. One of the major problems highlighted was the correct identification of bamboo species. Bennet and Gaur (1990b) brought out a book, Thirty Seven Bamboos Growing in India, which included descriptions of vegetative characters, habit and habitat, distribution, flowering and uses of bamboos grown in the arboretum of the Forest Research Institute, Dehra Dun. The illustrations of vegetative



characters given in this book are helpful for field identification. The latest comprehensive work, Indian Bamboos, by Tewari (1992) described 23 genera and 128 species with illustrations included for 55 species. For each species, a taxonomic description, distribution, flowering and uses are given separately and information on other aspects like genetics, silviculture, growth, economics, pests and diseases, properties and utilisation is compiled under various chapters.

In this compendium information on 128 bamboo species belonging to 18 genera is presented with detailed illustrations for 113 species. All of the genera and species are arranged in alphabetical order, and the information is categorised under the following headings (1) Description (2) Flowering and fruiting (3) Distribution and ecology (4) Anatomy, morphology and fibre characteristics (5) Chemistry (6) Silviculture and management (7) Pests and diseases (8) Physical and mechanical properties (9) Natural durability and preservation (10) Uses. References are given at the end of each genus. For preparing the illustrations, mostly live specimens and various herbaria were consulted. In certain cases, illustrations were redrawn from earlier publications. The sources of such illustrations are given in the Appendix.

▲ *A population of* **Udonga montana** *- a serious seed pest of bamboo*

➤ *Bamboo flutes*

▲ **Estigmena chinensis** - *a borer beetle*

▼ *Damage caused by* **Dinoderus minutus**

▲ *A bamboo fence*

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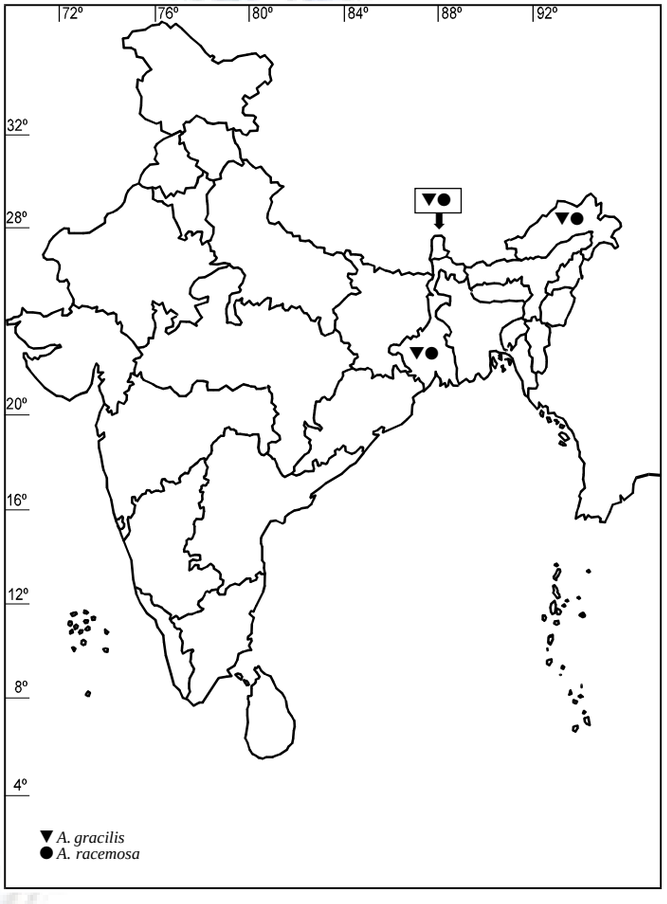
ARUNDINARIA MICHAUX

Usually tufted, erect plants. Rhizome monopodial. Culms hollow, terete, with 3-7 branches at each node, glabrous or hairy; internode striate, glabrous or scabrous; node prominent with 1-3 branches. Culm sheath deciduous or persistent, striate, straw-coloured, chartaceous or coriaceous, glabrous or scabrous, with or without oral setae. Leaves linear-lanceolate to oblong-lanceolate, tip acute to acuminate with conspicuous transverse veinlets; petiole short or long; leaf sheath striate, glabrous or scabrous or covered with bulbous based hairs, callus with or without bristled auricles. Inflorescence generally raceme or racemose-panicle with few to many spikelets; spikelets 2-8-flowered. Stamens 3; anther basifixed. Style undivided with 3 long plumose stigmas.

The genus *Arundinaria* was erected by Michaux in 1803. There are about 380 binomials under the name *Arundinaria* including American, Asian and African species, thus representing a taxonomically heterogenous group of bamboos. McClure (1973) excluded many American species formerly included under the genus *Arundinaria*. However, his studies did not include the Asian and African species of *Arundinaria*, included Munro (1868) included 29 species of *Arundinaria* in the world in his monograph, 28 species in the Himalayan region by Gamble (1896) and 14 species from Indo-China and Madagascar by Camus (1913). Chao and Renvoize (1989) based on their revisionary studies on South-east Asian and African species of *Arundinaria* included only two species in this genus, while the other species were transferred into *Sinarundinaria, Thamnocalamus, Racemobambos, Chimonobambusa, Indosasa, Sinobambusa* and *Acidosasa*. Among the five Indian species of *Arundinaria* recognized by Tewari (1992), three species have been transferred under the genus *Sinarundinaria* as per the revisionary studies of Chao and Renvoize (1989).



◄*Distribution map of* **Arundinaria**

Arundinaria gracilis

Arundinaria gracilis Camus in Revue Horticole 490. 1886 and Les Bambusees 38. 1913; Blatter, Indian For. 55: 546. 1929; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 1. 1980; Tewari, Monogr. Bamboo, 23.1992.

DESCRIPTION

Plants caespitose. **Culms** about 4-5 m in height, 2 cm diameter, green at first, turning yellow with age; branchlets numerous, fasciculate. **Culm-sheaths** 12-15 cm long, narrowed towards the apex; imperfect blade absent in lower culm-sheath. **Leaves** 9-10 cm long and 0.8-1 cm broad, bright green, apex acuminate, base attenuate into a short petiole. **Inflorescence** divaricate panicle; spikelets pedicelled and provided with 1 to many membranous longitudinally striate bracts, 2-3-flowered; empty glumes 2, lanceolate, outer smaller than the inner; lemma ovate, violet, many-nerved; lodicules 3, small, rounded, tip ciliate; stamens 3, pendulous, filaments long. Ovary with 2 stigmas, plumose. **Caryopsis** ovoid, oblong, acuminate at the apex.

DISTRIBUTION

Found in North-East India, Arunachal Pradesh, Sikkim and West Bengal.

Arundinaria racemosa

Arundinaria racemosa Munro, Trans. Linn. Soc. London 26: 17. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7:9. 1896, in Hook. f. Fl., Brit. India 7: 379. 1897; Blatter, Indian For. 55: 542. 1929, J. Bombay Nat. Hist. Soc. 33: 902. 1930; Bahadur, Indian J. For. 2: 238. 1979; Tewari, Monogr. Bamboo, 25.1992. **(Fig. 1).**

Fargesia racemosa (Munro) Yi in J. Bam. Res. 2(1): 39. 1983.

VERNACULAR NAMES

Sikkim - *Sanu maling, Pummoon, Pat-hioo;* Lepcha and Bhutia - *Miknu, Mikner*.

DESCRIPTION

Erect, gregarious shrubs with long rhizomes. **Culms** ca. 4 m high, ca.5 cm in diameter, glaucous when young; internodes ca. 11 cm long, scabrous, yellow, with prominent nodes; branches 1-3, fascicled at the node. **Culm-sheaths** ca. 6 cm long, ca. 2.5 cm broad at base, striate, chartaceous, pubescent and narrowed towards the tip; imperfect blade ca. 1.5 cm long, narrow, ciliate on the margin, acute at the tip; auricles bristly; ligule ca. 2 mm long, fimbriate. **Leaves** ca. 10 cm long and 1 cm broad, linear-lanceolate, apex sharply acuminate, base attenuate into a 3 mm long petiole, ciliate on the edges, glabrous on the surface; midrib prominent, secondary veins 3 pairs, intermediate 6, transverse veinlets many;

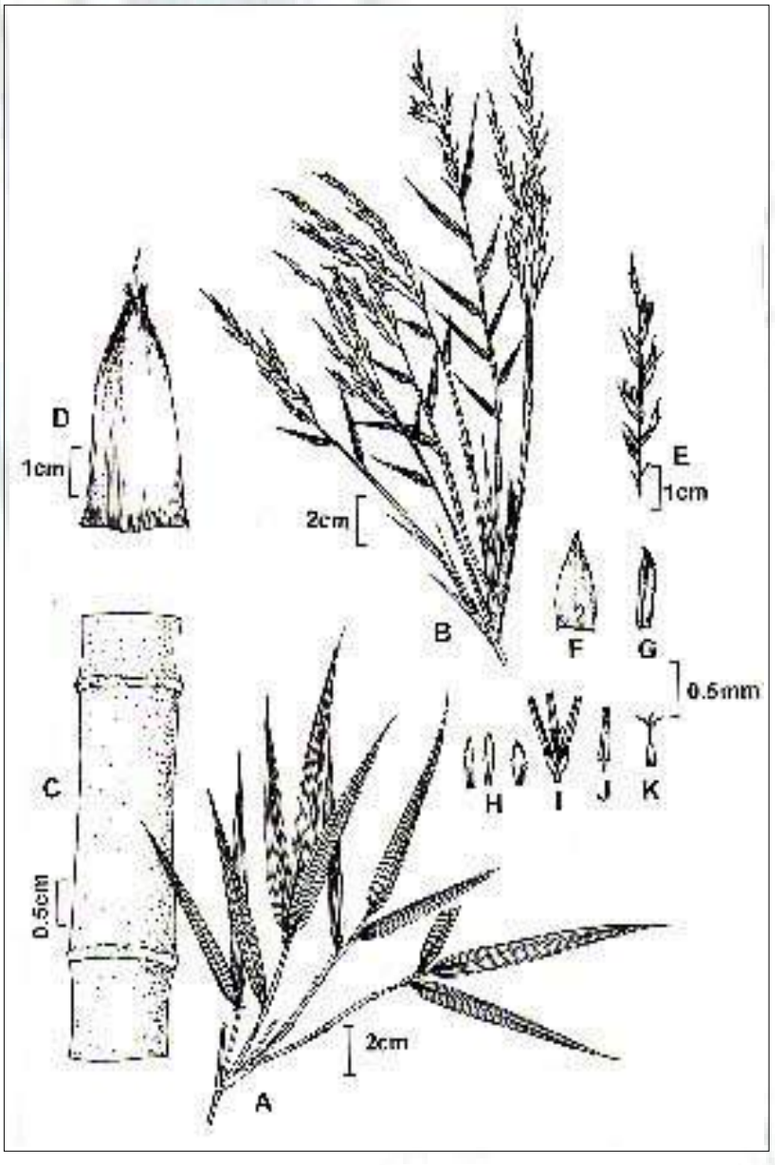


Fig. 1. **A. racemosa** *A - leafy branch; B - flowering branch; C - a portion of culm; D - culm-sheath; E - spikelet; F - flowering glume; G - palea; H - lodicules; I - lodicules with stamens and pistil; J - stamen; K - pistil.*

Leaf-sheath striate, straw-coloured, scabrous on the surface, edges glabrous and ending in a callus with auricles having brown bristles on both sides; ligule short, blunt. **Inflorescence** an axiliary panicle on leafy branches; rachis glabrous, with 3 spikelets; spikelet ca. 3.5 cm long, with 4-8 florets on glabrous pedicels, upper most floret empty; rachilla ca. 5 mm long, clavate, pubescent with tuft of hairs below the flowers; empty glumes 2, very small, ovate, acuminate, papery, hairy at the tip; outer glume ca. 4 x 1 mm, 3-nerved; inner glume ca. 5 x 2.5 mm, 5-nerved; lemma ca. 10 x 4 mm, ovate, tip long- acuminate, ciliate, margin minutely ciliate, brownish- red, 9-nerved; palea shorter than lemma, ca. 8 mm long, tessellate, 2-keeled, ciliate on the keels, tip bimucronate and ciliate; lodicules 3, ovate-lanceolate, acute, ciliate, 5-nerved, ca. 2 mm long, one shorter. Stamens 3; anther ca. 4.5 mm long, bilobed, basifixed, tip-bifid, acute, yellow; filament ca. 1 mm long; ovary ca. 1 mm long, ovoid-oblong, glabrous, orange in colour; style undivided, short; stigmas 3, plumose. **Caryopsis** ca. 5 mm long, elliptic, acute, glabrous, furrowed on one side with persistent base of style and stigmas.

Chromosome number n = 24.

FLOWERING

Flowering cycle is reported as 30 years. Flowering recorded from Sikkim in 1857, 1887, 1890, 1892, and 1897.

DISTRIBUTION AND ECOLOGY

This species is distributed in North-East Himalaya, East Nepal and Sikkim at a height of 2000-3700 m. It is also found commonly growing at higher altitudes in Darjeeling. Gamble (1896) recognised two forms of this species based on distribution, size and flowering behaviour. This bamboo forms a dense undergrowth impeding the natural regeneration. When fire occurs in such areas, the fierce conflagration causes destruction of vegetation.

SILVICULTURE

The species can be propagated by division of the clumps and using rhizome cuttings (Lawson, 1968).

USES

The culms are used for mat-making, roofing, fencing, garden support and the leaves are used as fodder.

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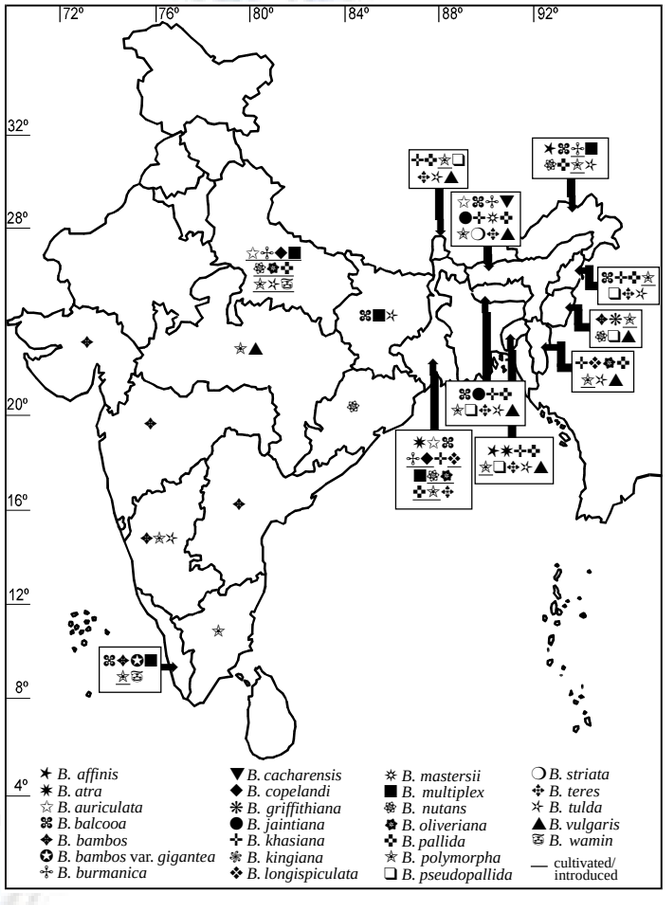
BAMBUSA SCHREBER

Tufted, arborescent or shrubby, or rarely climbing bamboos; rhizomes sympodial, pachymorph, rarely with elongated necks. Culms usually dense, self-supporting; internodes shallowly sulcate above the point of bud or branch emergence, hollow, rarely solid; nodes flat or with ridges, branch-buds broad at nodal line, secondary branches from the lateral primordia while major primordium remains dormant within the prophyllum. Branching intravaginal. Branch complements at mid-culm nodes. Culm leaves variable. Leaf blades petiolate. Inflorescence usually a large leafless compound panicle. Pseudospikelets solitary or more commonly forming fascicles, dense caespitose clusters. Spikelets terminating in a perfect floret; transitional glumes one to several; functional florets 1-many, bisexual, rarely staminate with the pistil obsolete. Glumes 1-3. Lemmas ovate-lanceolate, many-veined. Palea 2-keeled, tips mostly entire. Lodicules 3, membranous, obtuse, ciliate. Stamens 6; filaments free, often exerted; anthers narrow, tip obtuse or apiculate or penicillate. Ovary solid, oblong, obovoid, hairy at the tip; style short or long, branched or unbranched; stigmas 3, 2 or 1, plumose. Fruit a caryopsis, ovate to oblong, beaked, with the base of style and upper part of the pericarp markedly thickened, furrowed on one side; pericarp thin, adherent; embryo conspicuous.

This genus is widely distributed in Southern and Eastern-Asia. About 91 species of this genus are distributed in different parts of the world. In India 26 species are known to occur. In the present compendium, all 26 species have been included.



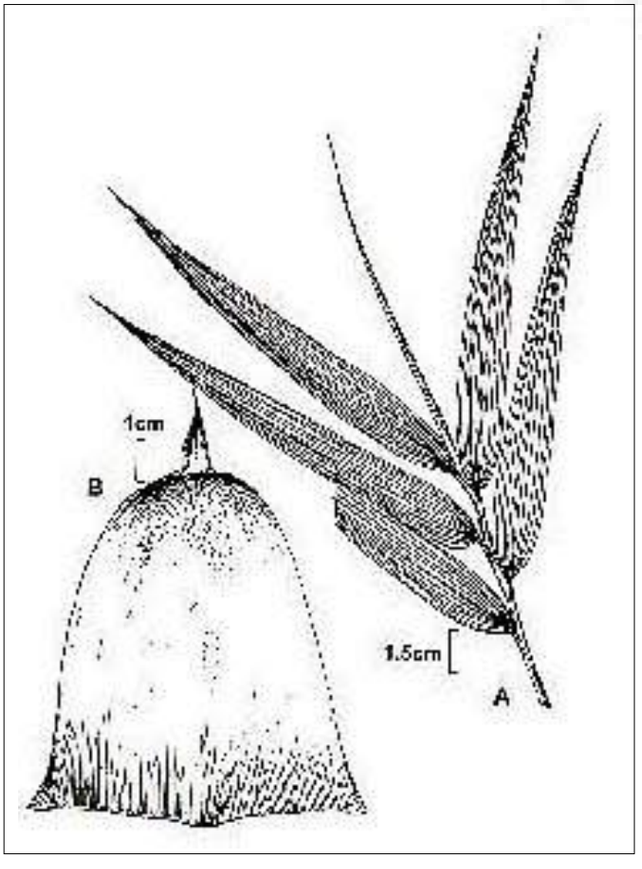
◄ *Distribution map of* **Bambusa**

Bambusa affinis

Bambusa affinis Munro, Trans. Linn. Soc. London 26: 93. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 39. 1896, in Hook. f., Fl. Brit. India 7: 390. 1896; Camus, Les Bambusees 120. Pl. 72. 1913; Naithani, Fl. Pl. India, Nepal and Bhutan 512. 1990; Tewari, Monogr. Bamboo 28.1992. **(Fig. 2).**

DESCRIPTION

A low, tufted, shrubby bamboo. **Culms** 5-7 m high, 2.5-5 cm in diameter, pale green or striped green and white, striate, appressed-hairy; nodes marked with black hairs below, slightly thickened; internodes 30-60 cm long, hollow. **Culm-sheaths** 10-12.5 cm long, as broad as long, round at tip, glabrous or with brown appressed hairs in small patches, bright green when young, later becoming straw-coloured; imperfect blade 2.5-5 cm long and 0.75-1.25 cm broad, lanceolate, usually recurved, appressed, brown hairy within, slightly rounded at base and decurrent to form a very narrow entire wing on the top of the sheath, longer on young shoots; ligule narrow, entire. **Leaves** 15-25 cm long and 2.5-3.7 cm broad, lanceolate or oblong-lanceolate, acuminate, tip scabrous, twisted, smooth above, except the scabrous points on marginal veins, pale and scabrid below, scabrous on the edges; secondary veins 8-10, intermediate 6-8, pellucid-punctate, giving the appearance of transverse veinlets beneath; petiole minute; leaf sheaths keeled, striate, covered on the back with stiff brown hairs, ending above in a short callus. **Inflorescence** a terminal spike or panicle, usually on leafy branchlets; rachis 10-15 cm long, bearing 2-3 branchlets with few shining ca.2.5 cm long coriaceous spikelets in small verticils. Spikelets 6-10-flowered, pale brown, shining; rachillae short, striate, shortly hairy at the apex; flowering glume acuminate, folded at the base, more than 20-nerved; palea much narrower, 2-keeled, 7-nerved between the keels, 4-nerved outside, ciliate on the keels; lodicules 3, the two longer ones often united at the base, many-nerved and somewhat folded. Ovary almost obovoid, almost hairy at the apex and tapering into a style; stigmas 3.



➤*Fig. 2.* **B. affinis.** *A - Leafy branch; B - culm-sheath.*

FLOWERING

The years of occurrence of gregarious or sporadic flowering of this species has not been recorded.

DISTRIBUTION

Chakraborty (1988) reports the occurrence of this species in the State of Tripura. It is also grown in the National Botanic Gardens, Calcutta.

USES

This is the main species used in Tripura and other states for fishing rods and javelins.

Bambusa atra

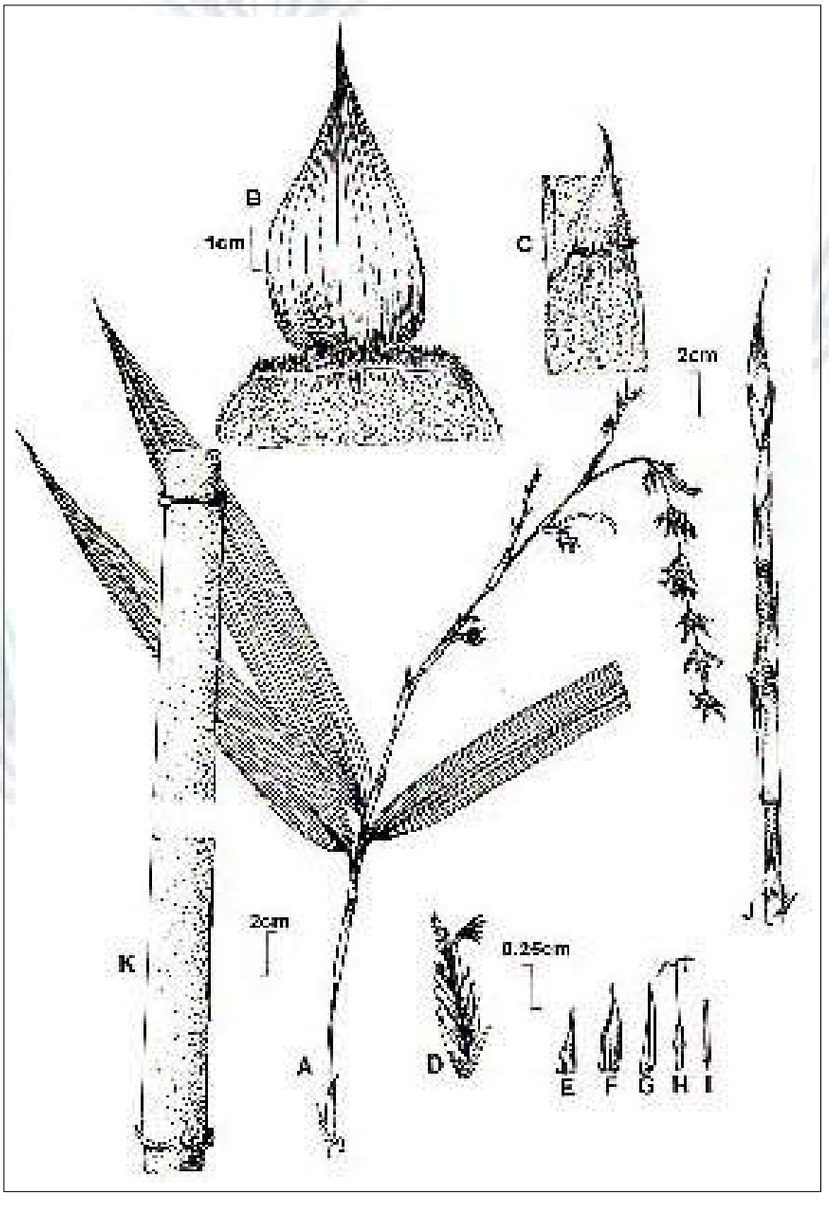
Bambusa atra Lindl., Penny, Cyclop. 3: 357. 1835; Merrill, Interpr. Rumph. Herb. Amb. 98. 1917; Holttum, Kew Bull. 21: 268. 1967; Tewari, Monogr. Bamboo 28.1992. **(Fig. 3).**

Bambusa lineata Munro, Trans. Linn. Soc. London 26: 120. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 46. 1896. excl. specimen of Andaman Islands. *Bambusa rumphiana* Kurz, J. Asiat. Soc. Bengal 39(2): 86. 1870 (excl. Syn. *B. amahussana*), Indian For. 1: 341. 1876.

DESCRIPTION

A tufted reed-like bamboo. **Culms** 5-8 m tall, 3-4 cm diameter near

▼ *Fig. 3.* **B. atra.** *A - flowering branch; B - culm sheath (ventral view); C - culm sheath (dorsal view); D - spikelet; E - empty glume; F - flowering glume; G - palea; H - pistil; I - stamen; J - young shoot; K - a portion of culm.*



base; green or dark-green, or yellowish with green stripes; internodes 40-70 cm long; nodes marked by prominent ring-like sheath scar. Young shoots slender, sheath flame-shaped, auricles distinct, ciliate. **Culm-sheaths** 12-18 cm long, 8-10 cm broad at base, soon drying, with golden-brown hairs on back towards base, top truncate; ligule 1 mm tall, fringed with 5-7 mm long stiff hairs; auricle 1-1.5 cm long, horizontal each side of the blade, with long bristles; blade as long as the sheath, erect, ovate-lanceolate, acuminate, base 5 cm broad and rounded, attached by a narrow constriction. **Leaves** on main culms up to 60 cm long and 10 cm broad, on branches upto 30 cm long and 5 cm broad, dull green above, pale beneath, ovate-lanceolate to linear-lanceolate; auricles with long bristles and ligule with short bristles; petiole short and broad. **Inflorescence** a terminal spike or panicle at the tip of leafy branchlets, bearing clusters of sessile spikelets supported by a truncate bract; rachis rounded flattened on one side, striate. Spikelets ovate-acute, 1-1.25 cm long, about 5 mm broad, much compressed, and often spirally twisted, bearing usually 1 to 2 basal empty glumes, about 10 fertile flowers and a terminal imperfect flower; rachillae short, glabrous; empty glume ovate, long-mucronate, 5-7-veined; flowering glume similar but longer, and white-ciliate on the margins; palea a little shorter than the flowering glumes, narrow, 2-keeled, minutely ciliate on the keels, sometimes bifid at the apex; lodicules apparently none. Stamens exserted; anthers narrow, the connective penicillate, apiculate; filaments often apparently monadelphous but separable. Ovary oblong, whitish, pubescent, gradually passing into an elongated style which is finally divided into three purple plumose stigmas. **Caryopsis** not recorded.

Chromosome number 2n = 72, hexaploid.

FLOWERING

Kurz (1876) mentioned that it flowered regularly and the culms do not die after flowering as in other bamboos; flowered abundantly in the Botanical Gardens of Java and in Calcutta, however, without setting any fruit. It is often described as constantly flowering and observations of cultivated plants for more than 100 years at Bogor, Calcutta and Peradeniya confirm that the plants do not die after flowering (McClure, 1966).

DISTRIBUTION AND ECOLOGY

Native of Moluccas and New Guinea; planted elsewhere. Holttum pointed out that the plants have been sent at various times from Bogor to the Indian Botanic Gardens, Calcutta, Peradeniya and Singapore. It is grown along river banks and on lower hill slopes. *B. atra* is also found on lime stone.

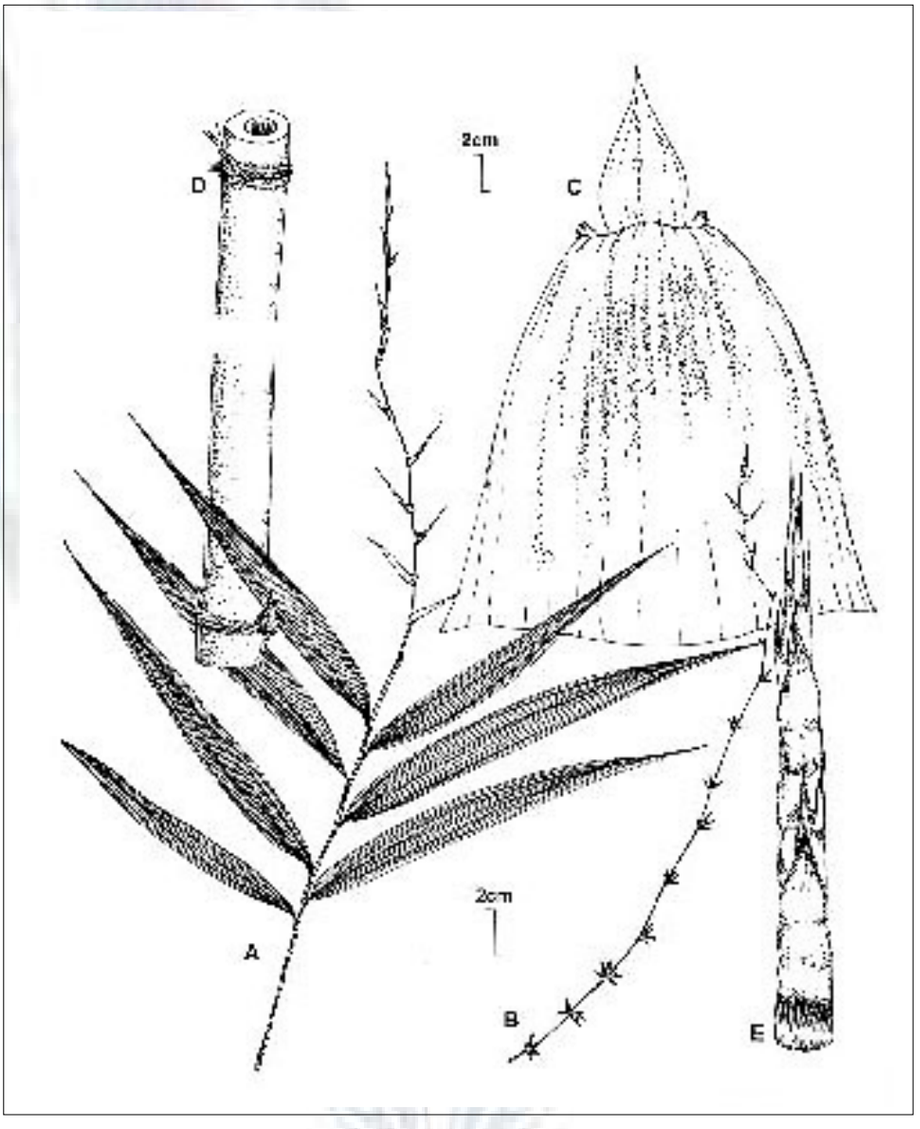
USES

Culms are used for basketry, handicrafts, building materials and fish traps.

Bambusa auriculata

Bambusa auriculata Kurz, J. Asiat. Soc. Bengal 39: 86. 1870; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 55. 1896, Hook. f., Fl. Brit. India 7: 396. 1987. Tewari, Monogr. Bamboo 31.1992. **(Fig. 4).**

Gigantochloa auriculata Kurz, For. Fl. Brit. Burma 2: 557. 1877.



◄*Fig. 4.* **B. auriculata**
A - leafy branch;
B - flowering branch;
C - culm-sheath;
D - a portion of culm;
E - young shoot.

DESCRIPTION

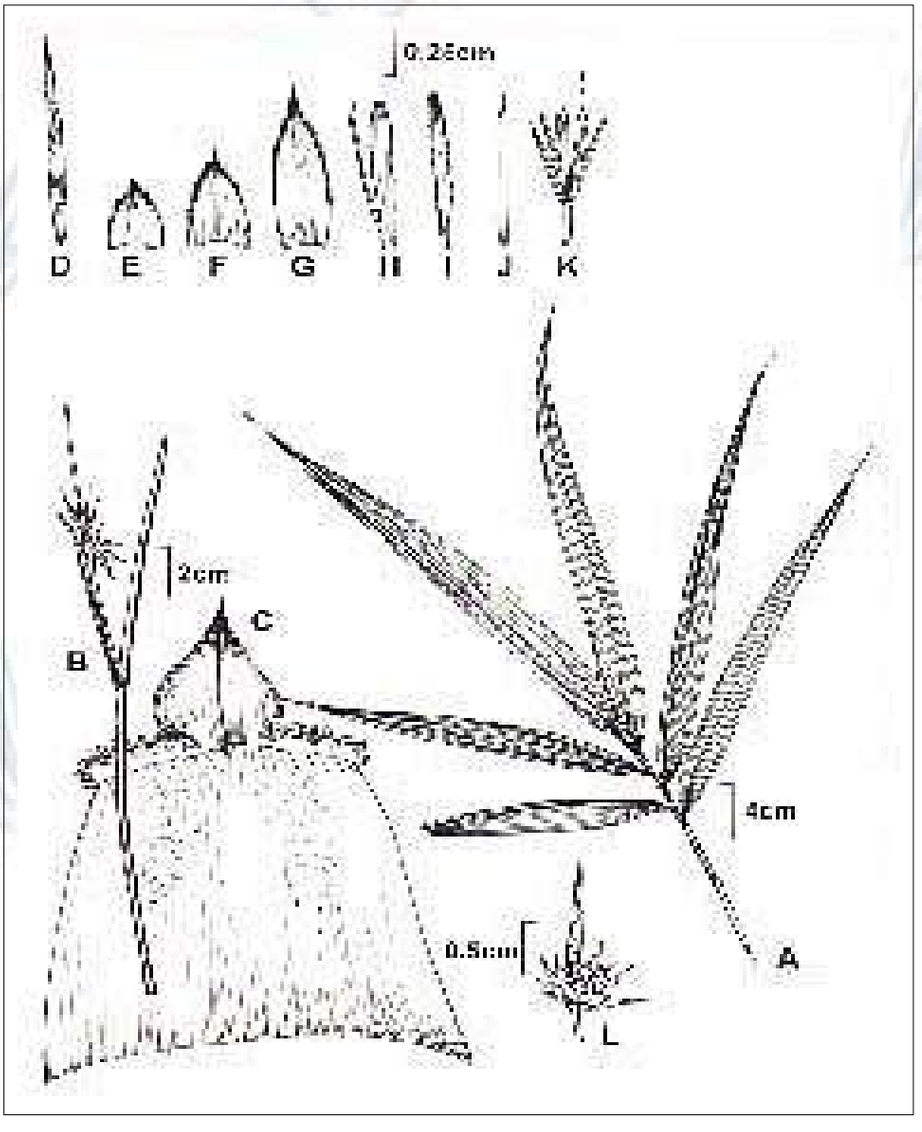
An evergreen, tufted bamboo. **Culms** 12-16 m high, 5-7 cm in diameter, glossy green, scurfy when young, yellowish when old; branches curving downwards; nodes brown, strigose; internodes 45-75 cm long, the lower ones shorter, walls thick. Young shoots spear-shaped, green or yellowish-tinged green, sheath with wavy margin, blade erect with 2-4 horizontal ridges. **Culm-sheaths** 25-30 cm long, 22-25 cm broad at base, attenuate upwards and convexly truncate top with about 10 cm in breadth, thickly black ciliate on the margins, the abaxial side covered with appressed black or tawny bristles except for a vacant patch down the middle; blade 16-23 cm long, triangular, acute, base about 10 cm broad and slightly rounded, striate on both sides, hairy within, densely appressed-hairy outside; ligule 5 mm high, sharply dentate; auricles rounded, naked, green when fresh. **Leaves** 20-40 cm long, 2.5-6 cm broad, lanceolate or linear-lanceolate, ending above in long twisted scabrous point, smooth above, minutely puberulous beneath when young, glabrous or rough on aging, often glaucous; petiole 2.5-5 mm long, rounded or attenuate at the base; leaf-sheath striate, hairy when young, smooth when old, auricles rounded, naked and often dark.

DISTRIBUTION

This species is distributed in Bangladesh, Myanmar and North-Eastern regions of India. It has been introduced in Indian Botanic Gardens, Calcutta and at Forest Research Institute, Dehra Dun.

ANATOMY

Leaf epidermal stomata arranged in two bands in 1 to 3 alternate rows; subsidiary cells high-domed to triangular, surrounded by 8 to 9 globose papillae. Interstomatal cells short to long with sinuous walls and almost straight ends, width uniform. Papillae conspicuous, in a row in the middle. Short cells solitary and paired, costal and intercostal. Cork cells, costal inconspicuous, intercostal distinct. Silica cells common. Silica bodies, costal saddle to acute angled, intercostal '8' shaped. Prickles frequent; intercostal with round base and long acute apex, base surrounded by a ring of papillae.



➤ *Fig. 5.* **B. balcooa** *A - leafy branch; B - part of leafy branch; C - culm sheath; D - a part of flowering branch; E - spikelet; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil; K - young shoot; L - a portion of culm.*

Microhairs common, apical and basal cell equal in length, apex long, tapering. Macrohairs absent.

In culm epidermis stomata evenly distributed, square in shape, 14-20 mm long and 14-18 mm wide; subsidiary cells parallel sided to low-domed, not surrounded by papillae. Epidermal cells long and narrow, uniform in width, 40-75 mm long and 5.5-7.5 mm wide; papillae small, scattered. Short cells solitary, occasionally paired. Cork cells silicified, equal or slightly larger than silica cells, small, rectangular. Silica bodies rod shaped to rectangular. Prickles, macro hairs and micro hairs absent (Luxmi Chauhan et al., 1989, Agrawal and Luxmi Chauhan, 1992).

▲ **B. balcooa** - *New shoot*

◀ **B. balcooa** - *A clump*

Bambusa balcooa

Bambusa balcooa Roxb., Fl. Ind. 2: 196. 1832; Munro, Trans. Linn. Soc. London 26: 100. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 42. 1896, in Hook. f., Fl. Brit. India 7: 391. 1897; Brandis, Indian Trees 670. 1906; Camus, Les Bambusees 122. 1913; Tewari, Monogr. Bamboo 31. 1992. **(Fig. 5).**

Dendrocalamus balcooa (Roxb.) Voigt, Hort. Suburb. Calcutta 718. 1845.

VERNACULAR NAMES

Assam - *Baluka*; Bengal - *Balku bans*, Duars - *Boro bans*; Garo - *Wamnah, Beru*; Tripura - *Barak*.

DESCRIPTION

A tall caespitose bamboo. **Culms** 12-20 m high and 8-15 cm in diameter, grayish green, thick-walled, the diameter of the cavity about one-third of that of the culm; nodes thickened with a whitish ring above, hairy below; internodes 20-40 cm long; branches from the lower nodes leafless and hard, mostly spreading, sometimes thorn-like; young shoots blackish-green, green with yellow, brown or orange tinged culm-sheath, clothed sparsely with dark brown hairs: **Culm-sheaths** green when young, deciduous, tapering above and rounded at tip, adaxial surface glabrous, abaxial surface with densely appressed dark brown hairs, margin ciliate; lower ones much shorter and broader than upper ones; blade 6-8 cm long, 5-7 cm broad, triangular, acute to acuminate, adaxial surface with dark brown pubescence, margin ciliate; ligule 5-8 mm high, denticulate, membranous; auricles absent or very small, ciliate. **Leaves** 15-30 cm long, 2.5-5 cm broad, oblong-lanceolate, glabrous above, pale and puberulous beneath, margins rough, apex pointed, sub cordate, or rounded at base with a short petiole. **Inflorescence** a large panicle, bearing spikate branching with bracteate heads, 0.6-1.2 cm long, 4-6 mm broad with 0-2 empty glumes; empty glumes ovate-acute, many- nerved; flowering glumes similar but larger, ciliate on the edges; palea as long as flowering glumes, ovate-acute, 2-keeled, long, fimbriate on the edges. Stamens hardly exserted; anthers glabrous; style hairy; stigma 3, plumose.

The species is distinguished by the following characters: (1) Young shoot blackish green with acute tip; (2) Culm coarse, stout, dull grayish-green with pointed recurved branchlets towards the base; (3) Culm-sheath without auricles (Alam, 1982).

Chromosome number n = 35, 2n = 70, aneuploid (Sobita Devi and Sharma 1993).

FLOWERING

Gregarious flowering is reported in this species. The clump dies after flowering without setting any seed. Flowering cycle is 35-45 years. It flowered gregariously twice in Bangladesh during 1983-85 and in Eastern Uttar Pradesh in 1986 (Rawat, 1987). Flowering was reported from Manipur during 1987-88 (Sharma - personal communication).

DISTRIBUTION AND ECOLOGY

The species is indigenous to North-Eastern India distributed in Nagaland, Meghalaya, Tripura, Assam, W. Bengal and Bihar extending to Eastern-Uttar Pradesh. It is cultivated in villages of different states in India. *B. balcooa* is grown up to an altitude of 600 m in any type of soil, but prefers heavy textured soil with good drainage.

ANATOMY AND FIBRE CHARACTERISTICS

Internode shows alternate arrangement of vascular bundles and sclerenchymatous bundle sheaths. At middle and inner region vascular bundles are double broken type. In the nodal region 2-3 layers of sclerenchymatous hypodermis is found below the epidermis. Next to that 5-6 layers of parenchyma cells occur. The arrangement of vascular bundles is not in order as in internode and it is closed at the outer region. The protoxylem elements in vascular bundle vary from 8 to 12. There is a gradual decrease in size of the bundle sheath sclerenchyma towards inner region (Appasamy, 1989). In culm macerates very thick, thick and thin walled fibres and septate fibres are present. Fibre tips pointed or blunt, wall

lamellation 3-10 layers. Fibre length 2807 µm, lumen width 5.1 µm and wall thickness 8.2 µm. Slenderness ratio 241.9, flexibility ratio 43.9 and Runkel ratio 3.2 (Sekar and Balasubramanian - personal communication).

Leaf epidermal stomata arranged in two bands in 1 to 3 alternate rows; subsidiary cells low-domed to triangular, surrounded by 6 to 8 elliptical papillae. Interstomatal cells shorter and broader than the long cells, walls wavy. Papillae scattered in the middle. Long cells narrow with uniform width. Papillae conspicuous, in a row in the middle. Short cells solitary and paired, costal and intercostal. Cork cells, costal inconspicuous, intercostal distinct. Silica cells common. Silica bodies, costal saddle shaped, intercostal dumbbell to '8' shaped. Prickles common, intercostal with round base and short to medium acute apex, base filled with vitreous silica and surrounded by a ring of papillae. Microhairs common, bicelled, apical and basal cell equal, apex rounded to tapering. Macrohairs infrequent, medium to long, base surrounded by a ring of papillae (Luxmi Chauhan et al., 1989).

CHEMISTRY

Electrophoretic pattern of peroxidases revealed one dark band in the zone of low mobility, three medium intense bands in the zone of medium mobility and two bands of high mobility in this species (Lalitha Kumari et al., 1985). Spectral absorbance values (FTIR) recorded for cellulose and lignin have been 0.425 and 0.383 respectively (Sekar and Balasubramanian - personal communication).

SILVICULTURE

The species can be propagated vegetatively by branch and culm cuttings pre-treated with growth promoting substances such as coumarin or NAA or a mixture of both. Cuttings from 2 and 3-year old culms and basal part of the culm gave maximum rooting response (Seethalakshmi et al., 1983). Genetic improvement work has been initiated in Arunachal Pradesh during 1980. Annual production of 1200-1600 culms/ha is reported from Bangladesh.

PESTS AND DISEASES

Affected by bamboo blight caused by *Sarocladium oryzae*. Blight affects the culms in August, the disease progresses by November. The disease can be controlled by cultural practices such as removal of blighted culms, burning debris *in situ*, adding new soil around clumps before the onset of the monsoon in April and application of a fungicide, dithane M45 as a soil drench (Rahman, 1990).

PHYSICAL AND MECHANICAL PROPERTIES

Moisture content decreases from 100 to 66 per cent from base to top, specific gravity (based on oven dry weight) varied from 0.57-0.74 from base to top in green and 0.79-0.85 in oven dry. Shrinkage in wall thickness reduced from 11.1 to 4.8 per cent, while shrinkage in diameter reduced from 4.2 to 2.5 per cent. The compressive strength ranges from 39.4 to 50.6 N/mm^2 in green and 51.0 to 57.3 N/mm^2 in air dry condition from base to top. Modulus of rupture varied between 85.0-62.4 N/mm^2 in green and 92.6-69.6 N/mm^2 in air dry condition. Modulus of elasticity 7.2-10.3 kN/mm^2 in green, 9.3-12.7 kN/mm^2 in air dry condition (Kabir et al. 1991).

NATURAL DURABILITY AND PRESERVATION

Physical treatments like soaking in muddy pond for 1-8 weeks and slow drying under shade were found to reduce insect attack. Chemical treatments with copper, arsenic, boron and fluoride compounds were effective. Treatment of green bamboo is done by diffusion and dry bamboo by Boucherie (sap displacement) method. Commercial oil

preservatives can also be used. Chemical treatment costs 25 per cent more, but durability is extended almost 5-6 times (Chowdhury, 1993).

USES

The best and strongest species for building purposes much used for scaffolding. This is also used for agarbathi sticks and in bamboo wood chip industry.

Bambusa bambos

Bambusa bambos Voss in Vilmorin, Blumengartneri 1: 1189. 1896; McClure, Blumea Suppl. 3: 95. 1946; Nicolson et al., Regnum Vegetable 119: 306. 1988; Bennet and Gaur, Thirty Seven Bamboos Growing in India 19. 1990; Tewari, Monogr. Bamboo 33. 1992. **(Fig. 6).**

B. bambos - *Natural growth*

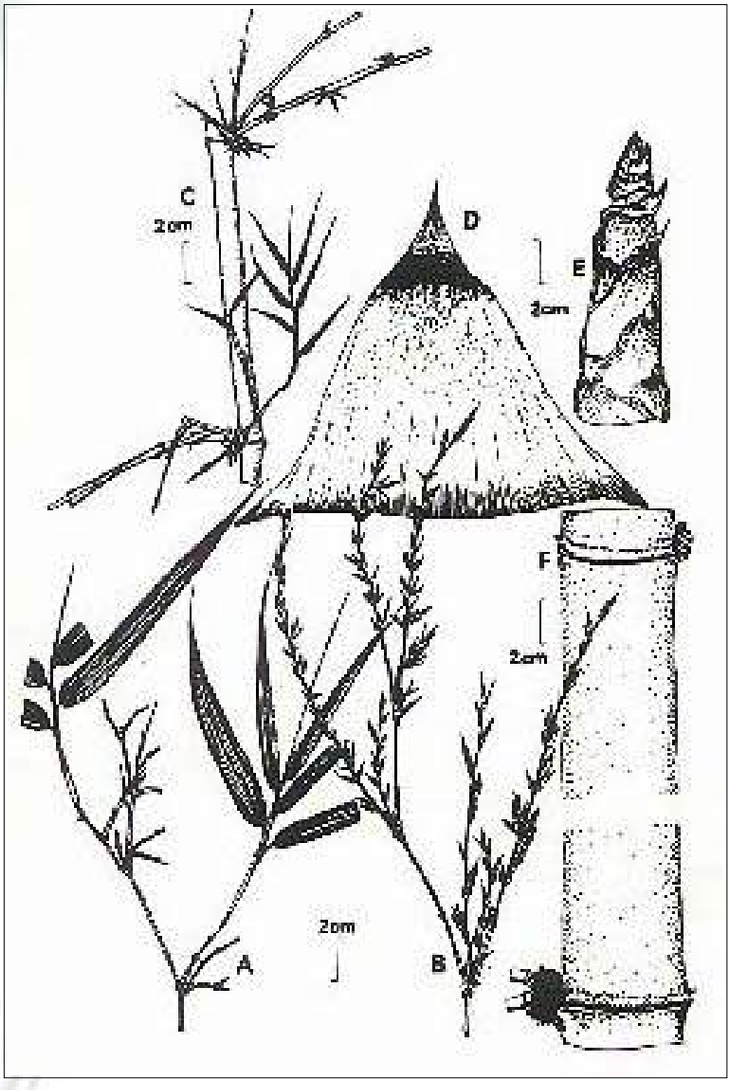
Arundo bambos L., Sp. Pl. 81. 1753. *Bambusa arundinacea* Retz., Observ. 5: 24. 1789; Roxb., Pl. Corom. 1: 56, t79. 1796. *Bambusa arundinacea* (Retz.) Willd., Sp. Pl. 2: 245. 1799; Munro, Trans. Linn. Soc. London 26: 103. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 51. 1896; Hook. f., Fl. Brit. India 7: 395. 1897.

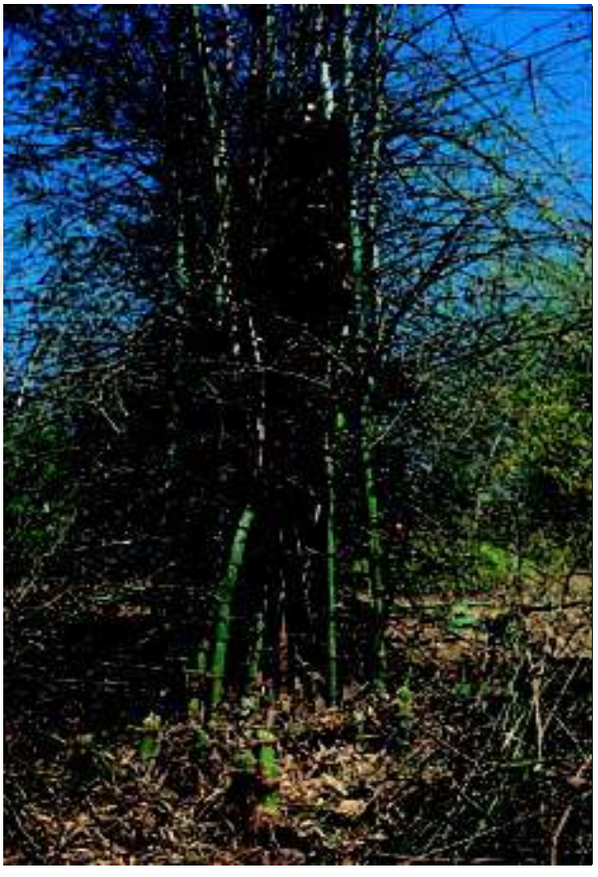
VERNACULAR NAMES

English - *Thorny bamboo*; Assam - *Kotoba*; Bengal - *Baroowa*, *Behor;* Manipur - *Saneibo*; Orissa - *Daba*.

DESCRIPTION

A very densely tufted bamboo, producing large dense clumps of closely





▲ **B. bambos** - *A clump*

◀ *Fig. 6.* **B. bambos** *A - leafy branch; B - flowering panicle; C - part of culm with leafy branch; D - culm sheath; E - young shoot; F - a portion of culm.*

▼ **B. bambos** - *Inflorescence*

packed culms. **Culms** strong, cylindrical, erect, hollow, dark green-coloured, up to 30 m tall, 15-18 cm diameter, the walls very thick with a lumen; branching at all nodes, those from the lower nodes recurved and bent downward towards the ground with the upper branches arching and producing a fan like plume, the upper leafy branches bearing small spines. Nodes slightly swollen and few lower nodes produce short aerial roots. Nodes contain a single branch bud at the ridged nodal line. Central dominant branch is produced first, with one or two laterals from the lower nodes, usually the primary and one secondary branch produced at the lower nodes of the culm, often spine-like, usually 3 branches produced at the upper nodes, leafy, with some branches. **Culm-sheaths** coriaceous, glabrous to pubescent with dark brown velvety hairs. **Leaves** diffuse in complements, 15-30 cm long and 8-15 mm broad, with about 10 leaves in each complement. Leaf blades linear and variable in size, lanceolate, narrowed to an acuminate tip, with mid-vein inconspicuous on the abaxial side and prominent on adaxial side. **Inflorescence** an enormous panicle, branchlets spicate with loose clusters of about 5 pale spikelets; rachis variable, usually stiff, shining, smooth, striate, occasionally angular. Spikelets lanceolate, acute, 1.25-2.5 cm long and 0.5 cm broad, sessile. Fertile florets, without empty glumes. Lemma broadly obovate - triangular; palea elliptic, 2-keeled; lodicules 3. Stamens 6, filaments long, filiform, anthers free, basifixed. Ovary with the styles and arising from shortly above the summit variable in length and fusion, stigmas 3. **Caryopsis** elliptic, the hilum situated in a groove and extending almost the whole length.

Chromosome number 2n = 70-72 (Parthasarathy, 1946; Janaki Ammal, 1959).

FLOWERING AND FRUITING

Different flowering cycles of 30-34, 30-45 and 44-49 years are reported. Gregarious flowering reported from South Kanara and Malabar in 1866, Satapuras in 1874-1884, Karnataka in 1881, Kumaon Hills in 1896, Walayar in 1913-1915, Wynad and Kollegal in 1913, 1991, Bihar and Orissa in 1913-1915, Coorg in 1977-79, Chalakudy in 1981, Parambikulam in 1984-85, Nilambur in 1991, Wynad, 1991-92 and in Attappady 1994-95.

Though no natural hybrids are found in bamboos, segregation in seedling characteristics showing the hybrid status of the parent has been observed. On analysis of the frequencies of the albinos produced by two albino gene carriers, it has been inferred that this species prefers selfing. It is reported from the progeny trial that albinos segregated in 3: 1 ratio. The albinos survived only for about 15 days after germination (Indira and Koshy, 1986).

Fruit is a fusiform caryopsis, pale brown in colour and covered by three persistent glumes. Average length and width varies from 7.2-8 mm and 1.5 to 2mm respectively. Rostrum mucronate resulting from acute extended apex, erect or curved. Surface is smooth, navel at one side of the fruit base, orbiculate with a protuberance at the centre. Ventral suture extends from fruit base to the apex (Appasamy, 1993).

A single clump on flowering gives about 50-100 kg of seeds with a total production of 50-100 quintals of seeds/hectare (Prasad and Gadgil, 1985). About 70,000 to 85,000 seeds weigh one kilogram. Seeds are generally viable for a period of 6-8 months. Viability can be prolonged by adopting suitable storage conditions by controlling moisture content and temperature (White, 1947). Storing in low temperature under refrigeration as well as under low moisture content using desiccants prolonged the viability for about 3 years (Somen and Seethalakshmi, 1989). Biochemical analysis of the seeds stored in different storage conditions showed qualitative and quantitative changes in food reserves specially sugars and proteins (Appasamy, 1993).

Embryological observation shows that the terminal and basal cells resulting from a transverse division of the zygote undergo further segmentation by transverse walls producing a 4-celled assemblage. The first vertical division takes place in the terminal cell of the 4-celled proembryo which at a later stage extends to the subterminal tiers also.

Later each of these cells divides in such a way that a central core of cells is surrounded by its own sister cells. The latter divides only anticlinally and functions as protodermal cells. The cells of terminal tier undergo an overall increase in volume. One half of the terminal tier grows at a faster rate. Shoot apex is terminal as the proembryonal axis and both the loci of epicotyl and scutellum are situated adjacent to each other (Philip, 1972).

DISTRIBUTION AND ECOLOGY

This species occupies 15 per cent of the total bamboo area in India. Native to South-East Asia, widely introduced and cultivated throughout the tropics. Found almost throughout India in the wild. It is one of the species commonly found in homesteads of Southern India. The species prefers rich, moist, soil and grows along perennial rivers and valleys. It attains the best development in moist deciduous forests up to an altitude of 1000 m and receiving nearly 2000-2500 mm rainfall. Good seed setting is found in dry deciduous forests receiving 700 to 1000 mm rainfall. In flat alluvial soil, the culms are reported to attain a height of 25-30 m and a diameter of 20-25 cm.

ANATOMY, MORPHOLOGY AND FIBRE CHARACTERISTICS

Rhizome is pachymorph, woody. Leaf epidermis (adaxial) has conspicuous bulliform cells, raised, fan-shaped; central cell of the group large and shield-shaped with single bulliform cell on either side; bulliform cell files 3-cells wide, no thick cuticle, no papillae or hairs. Abaxial epidermis has no bulliform cells; each cell with thickened cuticular papillae; macrohairs absent. Intercostal long cells elongated, sinuous walls thin, bulliform cells absent. Stomata in each intercostal zone located in 2 files. Intercostal cells paired, long and narrow. Silica bodies smooth in outline, tall, saddle-shaped. Cork cells irregular in shape. Papillae small, thick; cuticular papillae on all inter costal long cells; absent on costal zone. Microhairs bicellular; basal cell long, twice as long as the tapering, thin-walled distal cell. Macrohairs not present. The midrib consists of a single ‘S’ - shaped vascular bundle located in a slightly thicker part of the lamina. Sclerenchyma absent between the vascular bundles. Small sclerenchyma cap present along the margin. Chlorenchyma devoid of fusoid cell cavities irregularly present near the midrib (Soderstrom and Ellis, 1988). Occurrence of intra cortical roots has been reported (Pant and Mehra, 1961). Culm macerate showed fibre length 2.73 mm, fibre diameter 18.14 µm, lumen diameter 7.44 µm, wall thickness 5.37 µm.

Seed coat is made up of one or two layers of thick-walled parenchyma cells and covered by a thin cuticle. Endosperm well-developed, with abundant reserve foods and occupies much of the fruit body. Two layers of aleurone cells occur below the seed coat, filled with dark stained bodies. Well-developed embryo occurs at the chalazal end of the fruit (Appasamy, 1993).

CHEMISTRY

Proximate chemical analysis showed ash 3.26 per cent, solubility in cold water 4.59 per cent, hot water 5.95 per cent, alcohol benzene 1.22 per cent, ether 0.82 per cent, 1 per cent NaOH 19.35 per cent, pentosan, lignin and cellulose 19.62, 30.09, and 57.56 per cent respectively. Analysis of hemicellulose showed xylose 78.8 per cent, arabinose 11.6 per cent, galactose 1.8 per cent (Guha and Pant, 1967). The physico-chemical properties of wax showed a refractive index Abbey’s 1.4869, melting point 53^{o}C, saponification value 54.8, acid value 11.9, iodine value 104.5, unsaponified matter 51.63 per cent (Beri et al., 1967).

Beating characteristics showed caustic soda 21 per cent, kappa No.27.4. Lignin in bamboo 24.2, in pulp 3.1, pentosan in bamboo 20.8, in pulp 16.2, pulp yield unscreened 52.1 and screened 51.8 per cent (Guha and Bhola, 1976). The properties vary with age and position of culm.

The chemical composition of the seed shows crude protein 13.68 per cent, true protein 12.77 per cent, starch 72.91 per cent, ash 1.74 per cent, calcium 86.88 mg/100g, phosphorus 162.9 mg/100g, moisture 7.98 per cent. It has been reported that the bamboo seed protein is predominantly glutein in nature with isoelectric point 4.6. Prolamin constitutes only a minor fraction of the seed protein. The protein efficiency ratio (P.E.R.) of the seed protein had been reported by Rao et al., 1955; Rao et al., 1969. The starch content and protein are comparable to those of the rice variety, IR8 (Mitra and Nayak, 1972).

Water extract from leaves showed allelopathic effect on the growth of groundnut and maize. The extract contains chlorogenic, ferulic, coumaric, protocatechuic, vanillic and caffeic acids (Eyini et al., 1989).

SILVICULTURE AND MANAGEMENT

Natural regeneration: Profuse natural regeneration occurs from seeds after gregarious flowering. Seeds have no dormancy and this helps to utilise the favourable condition soon after seed fall. Protection from fire and grazing is essential for proper establishment of the seedlings.

Artificial regeneration: Seeds are collected by sweeping the ground under flowered clumps and cleaned by winnowing. Cleaning process can be minimised by spreading cloth or sheets under the flowered clumps and collecting the falling seeds directly. Seeds can be sown directly in nursery beds during March-May in patches and covered lightly with soil. About 90 to 100 per cent germination occurs when fresh seeds are sown. Partial shade is necessary for initial establishment of seedlings. The seedling can be polypotted after 45 days. There is considerable increase in biomass when large size containers are used (Chacko and Jayaraman, 1990). Fertilizer application also increased biomass of seedlings (Thomas, 1990). According to the direction of unfolding of seedling leaves, right handedness and left handedness are observed. Left handed seedlings had faster rate of growth and higher chlorophyll content (Bahadur et al., 1978). Another type of variation identified in seedlings is grassy, grassy erect, erect and very erect. The last two types are more vigorous (Kondas, 1982).

Large scale production of planting stock is reported by macro-proliferation (Adarsh Kumar, 1992). Offset planting can be done during the onset of monsoon. But this method is expensive since extraction of rhizome is difficult. Propagation using culm cuttings showed that two-nodded culm cuttings treated with growth regulating substances (100 ppm of NAA or IBA) by cavity method and planted horizontally during summer months gave 80 per cent of rooting. Rooting of cuttings depended on age of the culm, position of cutting, growth regulator treatment, method and season of planting (Surendran and Seethalakshmi, 1985; Saharia and Sen, 1990). About 50 per cent rooting is obtained when branch cuttings are treated with growth regulating substances and planted in the mist propagation units (Seethalakshmi, 1991; Philip and Chacko, 1992). About 20 per cent of the nodal bud chips rooted when treated with growth regulating substances (Surendran and Seethalakshmi, 1985).

Tissue culture: Tissue culture was attempted from embryo, seeds, callus, seedlings, nodes, shoots and leaves as explants. Multiple shoot induction and rooting were reported (Zamora, 1994).

Growth: Observations on clumps growing in Karnataka showed that there is no set pattern for appearance of young culms. The percentage of new culms formed from one-year-old clumps was 77; from two-year-old clump, 20; and from older clumps, 3 (Lakshmana, 1990). The rate of growth of young culms varied with locality and moisture availability. Maximum growth recorded is 90 cm/day. The height growth is caused by successive elongation of the internodes. There is no terminal bud in the culm. Several internodes from the base upwards grow simultaneously. The internodes become

visible above the edges of the sheaths after they complete 65 percent of their potential length. Basal portion of the internode is the most active. The growth rate is slow, initially 5-7.5 cm/day. Maximum growth recorded from Madhya Pradesh was 33 cm/day (Tomar, 1963). Observations on irrigated plantations from Tamil Nadu recorded a growth of 16 culms/clump, with the average height, girth and nodes/culm being 28.9 m, 8.3 cm and 127 numbers respectively at the end of six years after planting (Shanmugavel and Francis, 1993). There are several phenotypes available in nature with regard to stature, branchiness, hollowness etc. and the possibility of selection is high (Kondas, 1982).

Yield: Above ground biomass from a 3-year-old plantation is estimated to be about 8527 kg/ha. Height and girth of culms varied from 4 to 15 m and 6 to 21 cm respectively (Rao et al., 1991). Fertiliser application and soil working increased the yield. Application of nitrogen showed maximum response, followed by potassium and phosphorus (Thomas, 1991). Culm potential is estimated as 150 per cent as that of the previous year (Kondas, 1982).

MYCORRHIZAE

Presence of vesicular arbuscular mycorrizhae (VAM) *Glomus albidum, G. fasciculatum, G. mosseae, G. reticulatum, G. intraradices, G. magnicaulis* and *Gigaspora sp.* were found from samples collected from Kerala (Appasamy and Ganapathy, 1992).

PESTS AND DISEASES

Pathogens reported are *Alternaria alternata* (leaf blight), *Chaetospermum sp.* (leaf spot), *Colletotrichum gleosporioides* (leaf blight, stem infection), *C. crassipes* (leaf spot), *Chaetospermum sp.* (leaf spot), *Coniothyrium* (leaf spot), *Curvularia sp.* (stem infection, leaf spot), *C. lunata* (leaf spot), *Dactylaria sp.* (leaf spot), *Dasturella divina* (leaf rust), *Drechslera sp.* (leaf spot), *Exserohilum rostratum* (leaf spot), *Fusarium sp.* (damping off, rhizome bud rot), *Fusarium equiseti* (culm rot), *F. moniliforme* (damping off, basal culm decay), *F. oxysporum* (culm rot), *F. pallidoroseum* (stem infection), *Glomerella cingulata* (culm sheath rot, leaf spot), *Helminthosporium sp.* (leaf spot), *Graphium sp.* (seedling rhizome rot), *Meliola* sp. (sooty mould), *Pestallozziella sp.* (culm sheath rot), *Petrakomyces sp.* (leaf spot), *Phomopsis* (leaf spot), *Phyllachora* (leaf spot), *Pseudomonas sp.* (rhizome decay), *Puccinia sp.* (leaf rust), *Pythium sp.* (rhizome bud rot), *Rhizoctonia solani* (damping off, seedling stem infection), *Septogloem sp.* (leaf spot), *Spiropes scopiformis* (sooty mould), *Stagonospora sp.* (leaf spot), (Mohanan, 1990). Species of *Alternaria, Aspergillus, Beltraniopsis, Cercospora, Chaetomium, Cladosporium, Curvularia, Drechslera, Dactylaria, Fusarium, Memnoniella, Mucor, Nigrospora, Penicillium,* and *Phoma* are reported on stored seeds (Mohanan, 1990).

Rats and porcupines which gnaw through the rhizome and bases of culms; squirrels which gnaw the tender growing shoots, pigs which dig up and eat rhizomes; hares, deer, goats and cattle which browse and trample growing seedlings are the enemies in the seedling stage. Monkeys and langurs (*Pithecus enlellees*) damage the tender shoots and elephants and other wild animals pull down, trample and destroy the whole clump. Spotted deers do considerable damage to new culms during the rains. Insects like *Estigmena chinensis* and *Cyntotrachelus longimanus* attack growing culms, but insect pests like *Dinoderus ocellaris* and *Stromatium barbatum* attack cut culms and *Dinoderus minutus* attack both cut and living ones. The most important precautionary measure that could be taken against beetle attacks is to restrict bamboo cutting to cold and rainy periods. Mass build-up of a bug, *Udonga montana* was found in flowered areas during 1992 in Wynad (Mathew and Sudheendra Kumar, 1992).

PHYSICAL AND MECHANICAL PROPERTIES

Fibre stress at limit of proportionality varied between 18.3-26.5 N/mm^2, modulus of rupture 35-39.3 N/mm^2, modulus of elasticity 1.5-4.4 kN/mm^2 and maximum crushing stress 39.1-47 N/mm^2 (Gnanaharan, 1991).

NATURAL DURABILITY AND PRESERVATION

General preservative treatment used for bamboos can be adopted for this species (Kumar et al., 1994). In addition to the traditional method of adjusting cutting season (for regulation of starch) and immersion in mud ponds, many chemical treatments especially copper based preservatives are effective. Preservatives can be given by dipping the cut ends in solutions for two to three days and allowing the excess solution to drip under gravity. It is better to leave the branches and leaves as such in order to accelerate the process of absorption of preservatives (Jayanetti, 1975). A field experiment of chemical treatment showed that the use of 10 per cent copper sulphate solution (butt end immersed in chemical solution for seven days) can extend service life considerably. For bamboos stored without ground contact, boric acid is better (Gnanaharan, 1991).

USES

Important use of this bamboo is as a raw material for pulp, paper and panel products. Other uses include scaffoldings, rafters, thatching and roofing, basket making, bows and arrows, furniture, floating timber and rafting, cooking utensils and fencing. Shoots and seeds are edible. The leaves are used as fodder and medicine.

Bambusa bambos var. **gigantea**

Bambusa bambos var. *gigantea* Bennet and Gaur. Thirty Seven Bamboos Growing in India: 21. 1990; Tewari, Monogr. Bamboo 36. 1992. **(Fig. 7).**

Bambusa arundinacea var. *gigantea* Bahadur and Jain. Indian J. For. 4: 283. 1981.

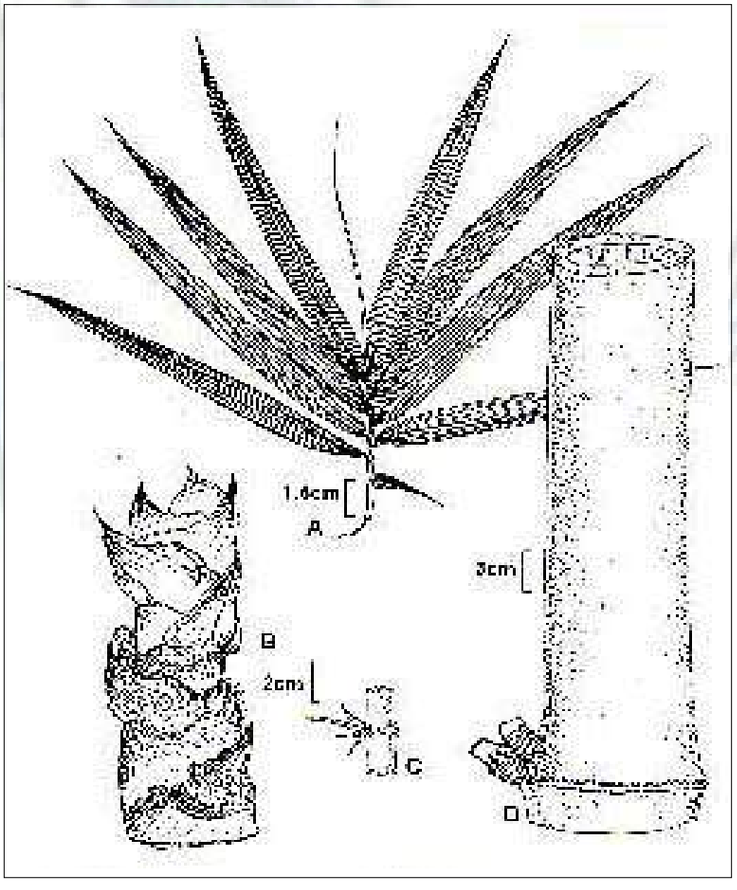
DESCRIPTION

A densely tufted bamboo. **Culms** light green, large, usually about 20-35 m high and 15-25 cm in diameter. Nodes swollen, internodes 27-35 cm long, thick walled; branches developing from the fifth node onwards. The branches arise from the nodal line, the girdles becoming prominent; generally 3 branches arise from a node of which two become prominent, angled upwards. **Culm-sheaths** usually 25-40 cm long and 30-50 cm broad, coriaceous, tip rounded, margin plated, pubescent with dark brown hairs, deciduous at the time of branch development; ligule continues with the sheath apex, margin fringed with cilia; auricle short, blade up to 12 cm long, adaxial surface with dense dark brown hairs, velvety, base cordate, tip acute. **Leaves** lanceolate to linear, highly variable in size, 10-30 cm long and 1.5-4 cm broad acute, margin scabrous; leaf-sheath ligulate, pubescent.

This variety is the giant type of *B. bambos*. Bahadur and Jain (1981) mentioned that this rare variety is represented in the bambusetum of Forest Research Institute, Dehra Dun and differs from the typical form. The general appearance of the young shoots of this variety was quite distinct from the typical *Bambusa bambos* (see page 48 for photograph of *B. bambos* var. *gigantea*).

FLOWERING

Flowered in 1984 in the bambusetum of Forest Research Institute, Dehra Dun and subsequently died in 1985 (Bennet and Gaur, 1990).



DISTRIBUTION

Rare and found in few localities in South India. Recently collected from Chittoor (Attappady) in Kerala.

USES

Used for a variety of purposes similar to *B. bambos.*

◄*Fig. 7.* **B. bambos** var. **gigantea** *A - leafy branch; B - young shoot; C - node with branches; D - a portion of culm.*

Bambusa burmanica

Bambusa burmanica Gamble, Ann. Roy. Bot. Gard. Calcutta 7(1):35. 1896, in Hook. f., Fl. Brit. India 7: 388. 1897; Brandis, Indian Trees 668. 1906; Camus, Les Bambusees 118. 1913; Holttum, Gard. Bull. Singapore 16: 62. 1958; Varmah and Bahadur, Indian. For. Rec. (n.s.) Bot. 6(1): 2. 1980; Tewari, Monogr. Bamboo 36.1992. **(Fig. 8).**

VERNACULAR NAMES

Assam - *Thaikawa*.

DESCRIPTION

This is a caespitose bamboo having a height of 10-20 m. **Culms** 7-10 cm in diameter, green, solid; nodes with white ring of hairs and waxy powder, internodes 25-40 cm long. **Culm-sheaths** green when young, turning pale along the margins when old, glabrous on the back, blade cordately rounded at base, apex acuminate, auricles with 1-2 mm long cilia, fringed ligule more or less entire. **Leaves** 25-30 cm long and 3.5-5 cm broad, oblong- lanceolate; leaf-sheath reddish

➤ **B. bambos** var. **gigantea** - *A clump*

brown, truncate at tip; ligule minutely dentate. **Inflorescence** with spicate branches, bearing heads of few spikelets. Glumes 2, mucronate. Spikelets upto 2.5 cm long, many-flowered; fertile flowers 5-6; lemma ovate, mucronate, many-nerved; palea ovate, elliptic, 2-keeled, ciliate on the keels, 4-5-veined. Sterile flowers 1 or 2. Lodicules 3, 5-6-nerved. Anthers apiculate. Ovary with short style and stigmas 3, pubescent. **Caryopsis** 5-8 mm long, hairy on the tip.

Chromosome number 2n = 70, aneuploid (Sobita Devi and Sharma, 1993).

FLOWERING

The flowering of this bamboo was reported in the year 1890 from Katha District of Myanmar (Gamble, 1896).

DISTRIBUTION

The species occurs in North Cachar Hills of Assam, Myanmar and Malaysia. It is grown in the bambusetum of Forest Research Institute, Dehra Dun, Indian Botanic Garden, Calcutta and Van Vigyan Kendra, Chessa (Arunachal Pradesh).

ANATOMY

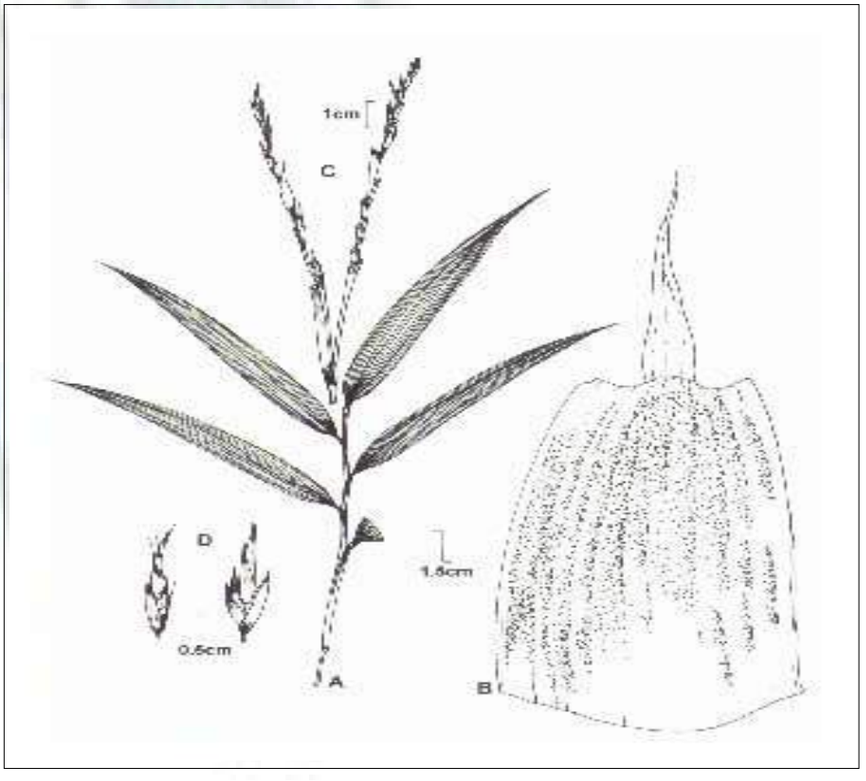
Leaf epidermal stomata arranged in two bands in 1-3 or 1-4 alternating rows; subsidiary cells high-domed to triangular, surrounded by 4-6 globose papillae. Long cells long and narrow with uniform width, papillae conspicuous. Interstomatal cell shorter and broader than the long cells, end concave, walls sinuous and straight, papillae distinct. Short cells solitary and paired, costal and intercostal. Cork cells costal not distinct, intercostal distinct. Silica cells costal, common; intercostal frequent. Silica bodies, costal, saddle-shaped, intercostal dumb-bell to '8'-shaped. Prickles frequent, intercostal, base round with small pointed apex. Microhairs common, intercostal, bicelled, apical and basal cells equal, apex tapering. Macrohairs common, costal and intercostal, long to medium, unicellular, base raised, not surrounded by papillae (Luxmi Chauhan et al., 1989).

CHEMISTRY

Studies on peroxidases-isoenzymes showed seven bands, two dark bands in the zone of low mobility, four medium intense bands and one band in the zone of highest mobility. Hence this species is not recommended for grouping along with other species of *Bambusa* (Lalitha Kumari et al., 1985).

SILVICULTURE

Observations on growth of new shoots show that growth is continued during the following year also when the monsoon stops early in the previous year (Trevor, 1927).



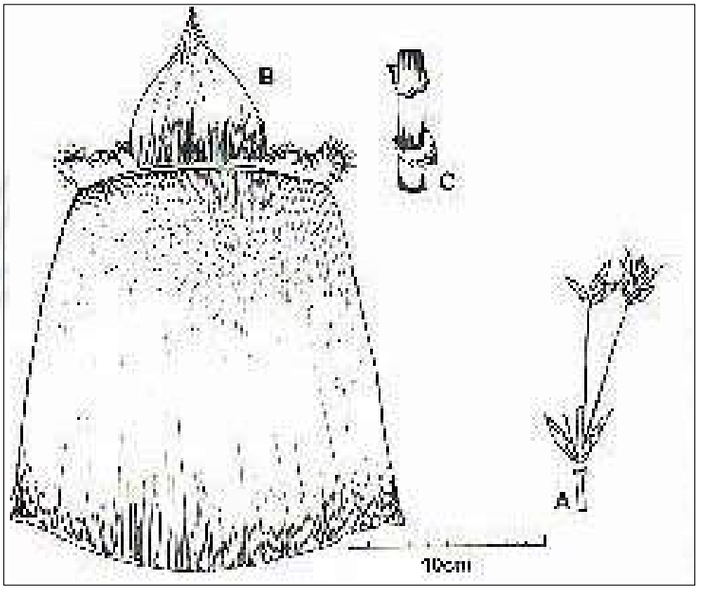
USES

The local inhabitants use this bamboo for roofing, thatching, construction and basket making.

◀*Fig. 8.* **B. burmanica.** *A - leafy branch; B - flowering panicle; C - culm-sheath; D - spikelet; E - flower; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil.*

▼*Fig. 9.* **B. cacharensis.** *A - part of inflorescence; B - culm-sheath; C - portion of an young shoot showing spreading culm-sheath-blade.*

Bambusa cacharensis



Bambusa cacharensis Majumdar, Bull. Bot. Surv. India 25: 237. 1983; Naithani, Fl. Pl. India, Nepal and Bhutan 513: 1990; Tewari, Monogr. Bamboo 36.1992. **(Fig. 9).**

DESCRIPTION

Tall bamboo, like *B. tulda*; young shoots are without white powdery excretions below the culm-sheaths. **Culm-sheaths** 12-15 cm long and 25-27 cm broad, sheath-blades orange-yellow and spreading at right angles to the axis; covered on the back with chocolate-brown sharp spicular hairs; blade with wavy auricles with thick rigid cilia on the margins and short dense hairs outside on the body. **Inflorescence** panicle occupying the whole culm; spikelets aggregated at the nodes of the ultimate branchlets, 3-3.5 cm long and 3-6 flowered, rachilla internodes articulated; florets 10-15 mm long, glossy green. Can be easily spotted in the field due to the coloured reflexed blades of the culm-sheaths.

DISTRIBUTION

Commonly found in the Brahmaputra Valley and in the Cachar Hills of Assam.

Bambusa copelandi

Bambusa copelandi Gamble in Brandis, Indian Trees 671. 1906; Camus, Les Bambusees 127. 1913; Blatter, Indian For. 55: 557. 1929; Tewari, Monogr. Bamboo 37.1992. **(Fig. 10).**

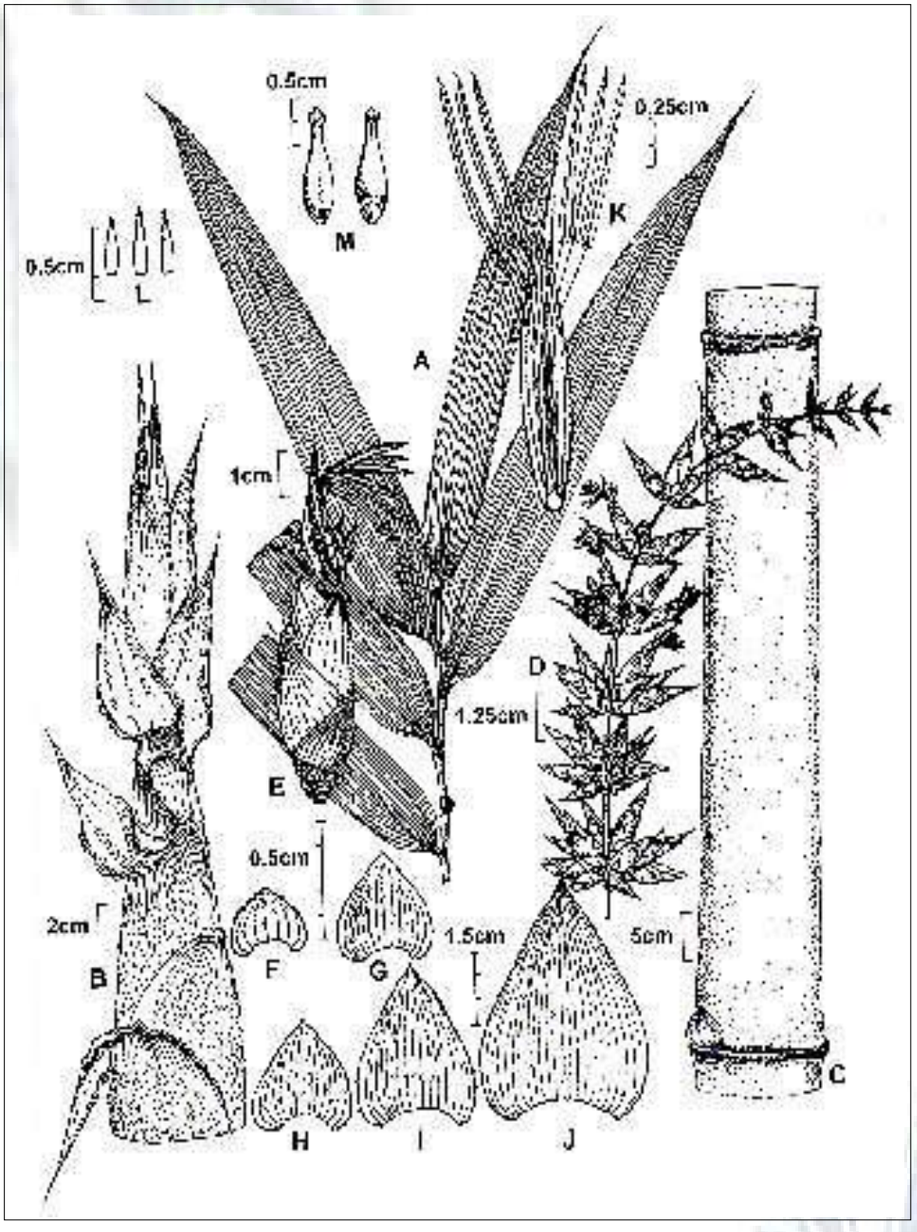
Sinocalamus copelandi (Gamble) Raizada, Indian For. 74: 10. 1948; *Thyrsostachys copelandi* Gamble Mss. 1923; Raizada, Indian For. 74: 8. 1948.

DESCRIPTION

A large, elegant, tufted bamboo. **Culms** up to 20 m tall, 16-19 cm in diameter at the base, walls fairly thick at the base; nodes hardly prominent; internodes upto 45 cm long on robust culms, when young covered with appressed silvery hairs. **Culm-sheaths** 38 cm long and 30 cm broad at the base, thick, covered with scanty golden-yellow hairs outside, polished inside, top rounded towards the short and narrow blade. Blade and edge of sheath in young shoots very sharp, copper coloured; auricles absent or minute. **Leaves** 33-38 cm long and 4.5-8 cm broad, ovate-lanceolate, rounded at the base, almost smooth and glabrous above, softly hairy and scabrous beneath, secondary nerves quite prominent, transverse veinlets visible on the lower surface. **Inflorescence** a large compound panicle of long, whip-like curved spikes; spikelets clustered in heads of 2-10 with 2 small bracts at the base, bracts broadly ovate, ciliate on the margin; rachis between the heads 1-4.5 cm long, glaucous or somewhat puberulous; spikelets 2.5-3.8 cm long, 5-7 mm broad, ovate, acute, faintly pubescent, slightly compressed, with 4-7 florets, tinged purple outside, top most floret sterile; lower glume broadly ovate, acute, about 12-nerved and with conspicuous transverse veinlets, ciliate on the edges, ca.7 mm long, pubescent and purple tinted; upper glume very similar to the lower glume in shape, texture and pubescence, 12 mm long, 22 nerved with anastamosing strands. First lowest floret lemma broadly ovate, 12 mm long, pubescent outside, ciliate on the edges, margins convolute clasping the rachilla at the base, longitudinal nerves ca.24, transverse veins obscure; palea 13 mm long, almost membranous, prominently keeled, ciliate on the keels and margins, deeply cleft at the apex, 3-5 nerved. Stamens 6, exserted; anthers 8 mm long, sagitate at the base, apiculate, pale-yellow; filaments free, ca.15 mm long, thread like. Ovary turbinate, 6 mm long, densely hairy at the top; style long (upto 15 mm), sparsely hairy all over, ending in a simple plumose stigma, exserted at the apex; lodicules 3, lanceolate, hyaline, hairy on the margins. **Caryopsis** 1.2-1.6 cm long, contracted towards the apex, almost bottle-shaped, slightly grooved on one side; pericarp rather thick and loose.

FLOWERING

Flowering cycle reported as 48 years. Flowered in 1896 in Myanmar and in 1943 in Dehra Dun. The species was discovered by Copeland in 1896 from Myanmar. The seedlings were planted in and around Dehra Dun and these flowered in November, 1943.



◄*Fig. 10.* **B. copelandi.** *A - leafy branch; B - young shoot; C - a portion of culm; D - flowering branch; E - spikelet; F - lower bract; G - upper bract; H - lower glume; I - upper glume; J - lemma of the first floret; K - palea with stamens, ovary and style of the lowest floret; L - lodicules; M - caryopsis.*

DISTRIBUTION

This species was described from Myanmar. Brandis (1906) states - "Largely cultivated in the Northern Shan States" (Myanmar). Cultivated in Indian Botanic Gardens, Calcutta and also in Forest Research Institute, Dehra Dun.

CHEMISTRY

Studies on electrophoretic pattern of peroxidase isoenzymes showed seven bands as in *B. balcooa* and this species shows an affinity to it (Lalitha Kumari et al., 1985).

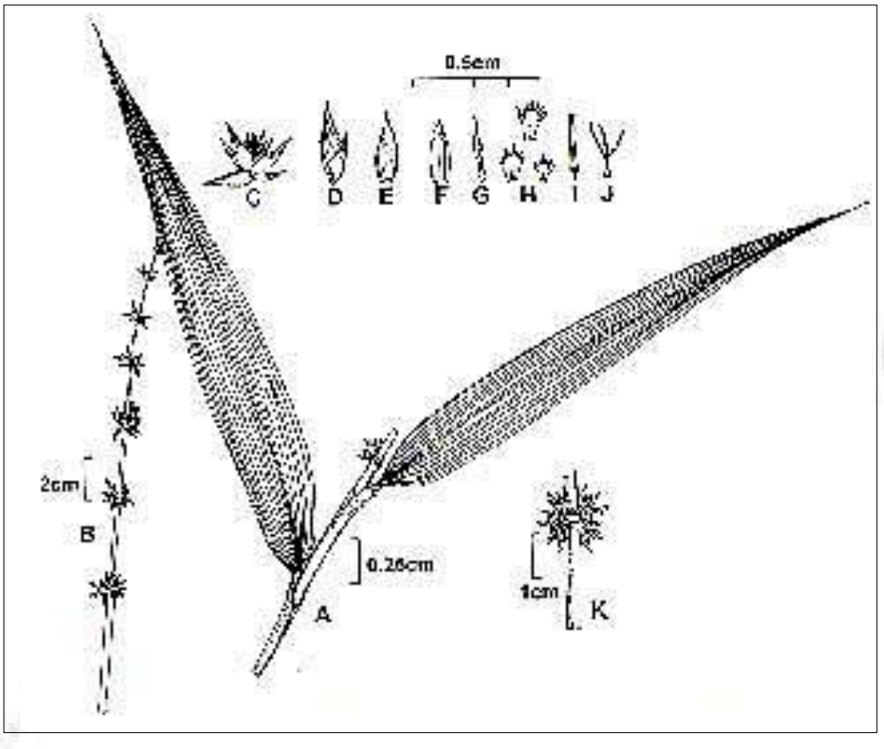
Bambusa griffithiana

Bambusa griffithiana Munro, Trans. Linn. Soc. London 26: 99.1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 48. 1896 and in Hook. f. Fl. Brit. India 7: 394. 1896; Camus, Les Bambusees 128. 1913; Naithani, Fl. Pl. India, Nepal and Bhutan 513. 1990; Tewari, Monogr. Bamboo 37. 1992. **(Fig. 11).**

Dendrocalamus griffithiana (Munro) Kurz, Fl. For. Burma 2: 562. 1877.

DESCRIPTION

A subscandent, soft bamboo. **Culms** slender, hollow. **Culm-sheaths** not known. **Leaves** with petiole, thick, 5 mm long; lanceolate, 2.5-3.7 cm long, acuminate ending in a subulate, twisted scabrous point, unequally narrowed at the base; smooth above, except on the scabrous marginal veins, glaucous beneath; scabrous on the margins; secondary veins 13-17, intermediate 5, pellucid punctate appearing like strong transverse veinlets on the lower surface; leaf-sheath striate, keeled, glabrous, ending in a narrow shining callus, and furnished at the mouth with large crescent-shaped reflexed auricles upto 17 mm long and strongly fringed with long bristles; ligule elongate, obtuse or triangular, ciliate, often deeply cleft. **Inflorescence** a terminal panicle, branches spicate bearing heads of spikelets 2.5-10 cm apart; rachis soft, hollow. Spikelets cylindrical, 12-13 mm long, ovate-lanceolate, acute, with two empty glumes, one fertile flower and one rudimentary flower on a terminally produced rachilla; the rudimentary flower thrice as long as the rachilla; empty glumes ovate-acute, many-nerved; flowering glumes mucronate, convolute; palea long, 2-keeled, membranous, the



◄*Fig. 11.* **B. griffithiana.** *A - leafy branch; B - part of flowering branch; C & D - spikelets; E - flowering glume; F - palea; G - terminal imperfect flower; H - lodicules; I - stamen; J - pistil; K - part of flowering branch (enlarged).*

keels many-nerved, bearing in the deep concavity between the keels, the rachilla of the rudimentary flower; lodicules 3, hyaline, long-fimbriate, two ovate-obtuse, the third smaller, acute. Stamens exserted; anthers obtuse, bifid at the apex. Ovary ovoid, gradually tapering into a very minute style; stigmas 3, long, plumose.

FLOWERING

Griffith in 1837 reported this species in flower in Upper Myanmar.

DISTRIBUTION

The species is found distributed in Manipur and Monganung Valley, Myitkynia District of Myanmar.

Bambusa jaintiana

Bambusa jaintiana Majumdar, Fl. Ind. Enum. 275. 1989; Tewari, Monogr. Bamboo 39.1992.

DESCRIPTION

Allied to *Bambusa tulda* Roxb. but differs in glabrous culm-sheaths, smaller auricle and shrubby habit.

FLOWERING

It has been observed in flower and reported by Kanjilal in 1915 from North Cachar Hills of Assam and Mokim in 1903 had collected a flowered specimen.

DISTRIBUTION

This species is found in Khasi and Jaintia Hills of Meghalaya, North Cachar Hills of Assam and also found in Myanmar.

Bambusa khasiana

Bambusa khasiana Munro, Trans. Linn. Soc. London 2: 97. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 39. 1896; and in Hook f., Fl. Brit.India 7: 390. 1897; Camus, Les Bambusees 120. 1913; Bor, in Kanjilal, Fl. Assam 5: 31. 1940; Varmah and Bahadur, Indian. For. Rec. (n.s) Bot. 6(1): 2. 1980; Tewari, Monogr. Bamboo 39. 1992. **(Fig. 12).**

VERNACULAR NAMES

Cachar - *Wa-chiusa*; Khasi - *Serim, Tumoh, Tyrah*; Kuki - *Chattur*; Mikir - *Bewar*; Naga - *Tirriah*.

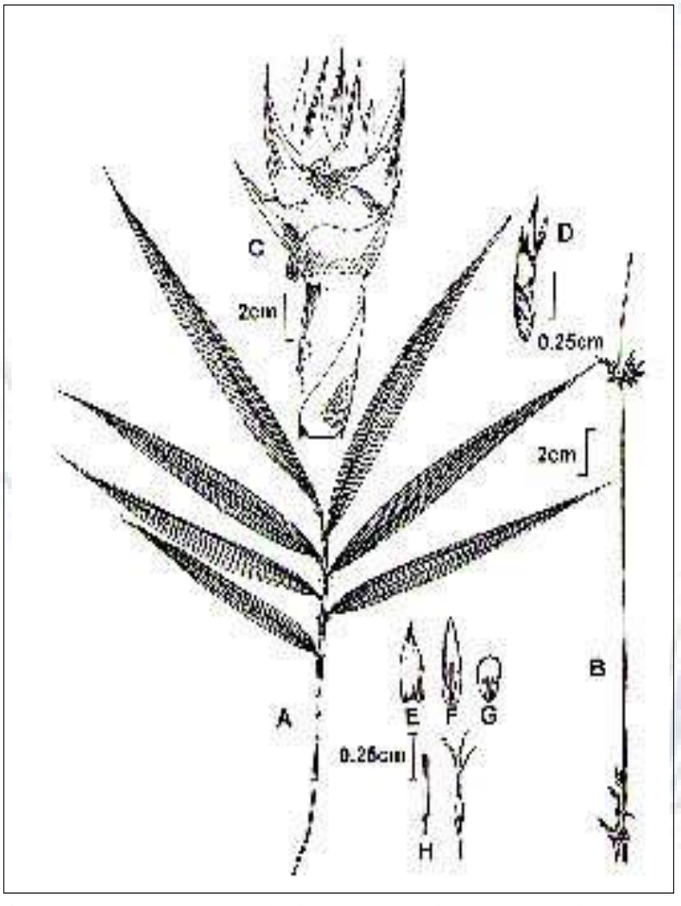


Fig. 12. **B. khasiana.** *A - leafy branch; B - flowering branch; C - young shoot; D - spikelet; E - flowering glume; F - palea; G - lodicule; H - stamen; I - pistil.*

DESCRIPTION

Culms 10-15 m tall, singly growing from a creeping rhizome; internodes 15-25 cm long, covered with golden yellow hairs and transverse blotches, thin-walled. **Culm-sheaths** 12-15 cm long and 10-12 cm broad, striate, covered with dense, appressed hairs; imperfect blade as long as or longer than the sheath, narrow, the sides widened out into large, inflated, membranous wings, broadly rounded on the sheath; ligule very short. **Leaves** 10-15 cm long and 2-2.5 cm broad, lanceolate, rounded at the base into short petiole; leaf-sheath glabrous, striate, minutely auricled. **Inflorescence** a panicle made up of branches bearing distant sub-verticillate groups of spikelets, many sterile. Fertile spikelets 1.5-2.5 cm long, at first cylindrical, afterwards compressed, glabrous, 5-6-flowered, the lower hermaphrodite, the upper 1-2 imperfect, sterile; rachilla striate, fimbriate at the top; glumes short, ovate, mucronate, brown on the margins, glabrous; lemmas same as glumes, 11-13-nerved, glabrous; palea 2-keeled, ciliate on the keels; lodicules ovate-orbicular, many-nerved, shortly fimbriate. Stamens with obtuse anthers. Ovary linear-oblong with short style; stigmas 3, plumose.

FLOWERING

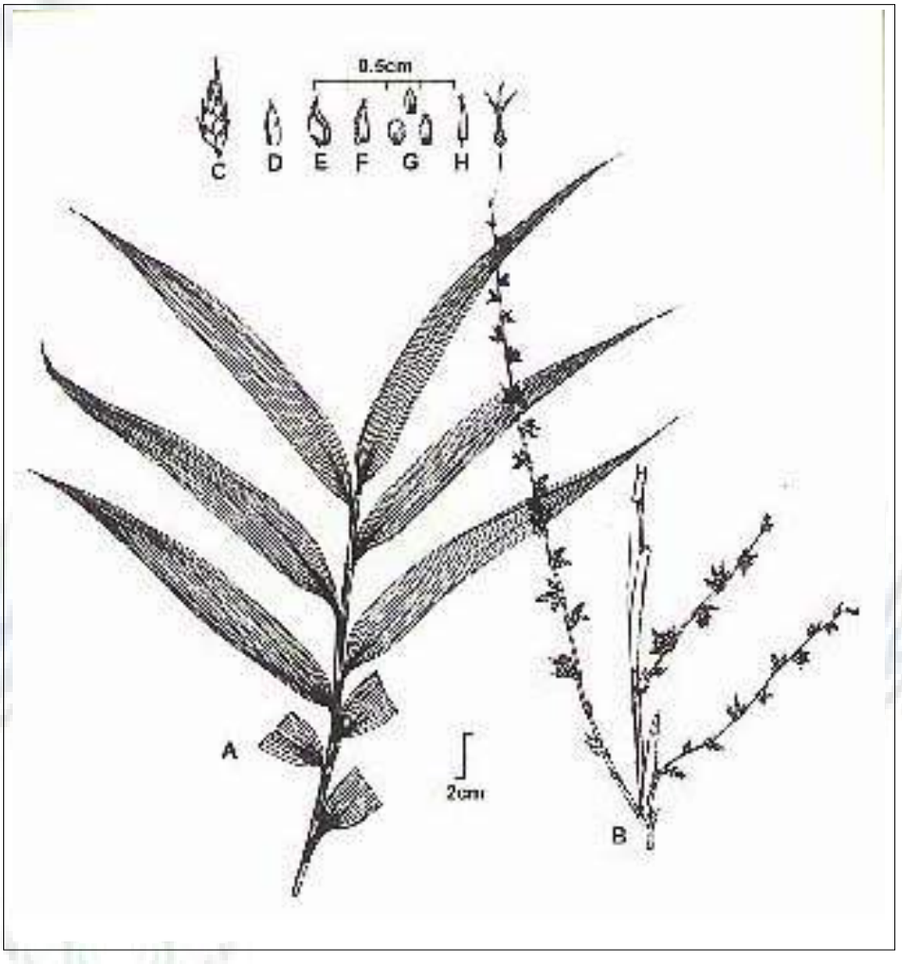
Collected in flowering during 1850 and 1885 from Jaintiapur (Meghalaya) and Manipur by Clarke (Gamble, 1896).

DISTRIBUTION

Found in Khasi and Jaintia Hills of Meghalaya and North Cachar Hills of Assam in India. Also found in Myanmar.

Bambusa kingiana

Bambusa kingiana Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 46. 1896 and in Hook. f., Fl. Brit. India 7: 393. 1896; Camus, Les Bambusees 123. 1913; Naithani, Fl. Pl. India, Nepal and Bhutan 513. 1990; Tewari, Monogr. Bamboo 39. 1992. **(Fig. 13).**



➤ *Fig. 13.* **B. kingiana.** *A - leafy branch; B - flowering branch; C - spikelet; D - empty glume; E - flowering glume; F - palea; G - lodicules; H - stamen; I - pistil.*

DESCRIPTION

Culms height varied from 20-23 m with a diameter of about 10 cm. **Culm-sheaths** characteristics are not described. **Leaves** 25-30 cm long and 2.5-6.3 cm broad, lamina linear-lanceolate, base oblique with thick 0.5-0.7 mm long petiole, acuminate, scabrous at the tip and margins smooth above except the scabrous marginal veins, pale and sparsely hairy below when young glabrous on aging; mid rib prominent, shining, secondary veins 10-14 pairs, intermediate 5-7, pellucid glands appear as transverse veinlets beneath; leaf-sheath smooth, striate, ciliate on the edges, ending in a broad shining callus and a very small rounded naked auricle; ligule rather broad, dentate, long-fimbriate. **Inflorescence** a compound leafy panicle, bearing spicate branchlets with somewhat regularly spaced clusters of 1-6 purple-tipped spikelets; rachis flexuose, 1.2-2.5 cm long, joints flattened on one side, pubescent when young, glabrous on aging, bracts small. Spikelets 12 mm long and 0.5 mm broad, flattened, purplish, with 2 empty glumes, 4-6 fertile flowers and single terminal imperfect flower; rachilla clavate, flattened, ca. 0.25 mm long; empty glumes ovate-acute, mucronate, ciliate on the edges, flowering glumes larger; palea oblong, acute or acuminate, long ciliate on the keels, 2-nerved in between; lodicules 3, 2 ovate blunt, 1 lanceolate, all along fimbriate, usually 3-nerved. Stamens half exserted, anthers narrow, apiculate with a tuft of penicillate hairs. Ovary broadly ovoid, stalked, hairy; style short, thick, almost basally separating into 3 purple plumose stigmas. **Caryopsis** not known.

Chromosome number n = 36, 2n = 72 and hexaploids (Sobita Devi and Sharma, 1993).

FLOWERING

Flowering is reported from Manipur during 1987-88 (Sharma - personal communication).

DISTRIBUTION

The species is distributed in Irong (Manipur), Petsut and Naba Katha Districts of Myanmar.

Bambusa longispiculata

Bambusa longispiculata Gamble ex Brandis, Indian Trees 668, 1906; Camus, Les Bambusees, 116. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1):2. 1980; Tewari, Monogr. Bamboo 41. 1992. **(Fig. 14).**

VERNACULAR NAMES

Bengal - *Metenga*; Burma - *Thaikwa*.

DESCRIPTION

Culms 10-15 m high, 7-10 cm in diameter, green in fairly open clumps; nodes slightly thickened, with a circular band of white pubescence above and occasionally lower few nodes have an additional narrow circular band below; internodes 30-70 cm long. Young shoots grayish green with dark brown hairs; blades leathery, acute. **Culm-sheaths** 16-25 cm long and 16-30 cm broad, generally covered with brownish-black appressed hairs; blade broadly triangular, cordate, erect, hairy within, the base narrowed to a wavy fringed band along the upper edge of the sheath; ligule 4 mm high, entire or lacerate, ciliate; auricles unequal, prominent, falcate, with bristles, deciduous. **Leaves** 18-30 cm long and 2.5-6.5 cm broad, linear-oblong, glabrous above, whitish below. **Inflorescence** erect, often branching; spikes 28-38 cm long; spikelets polished, compressed in the axils of long coriaceous sheaths without a blade. Empty glumes 2, fertile, 15-30, 2.5 cm long.

FLOWERING

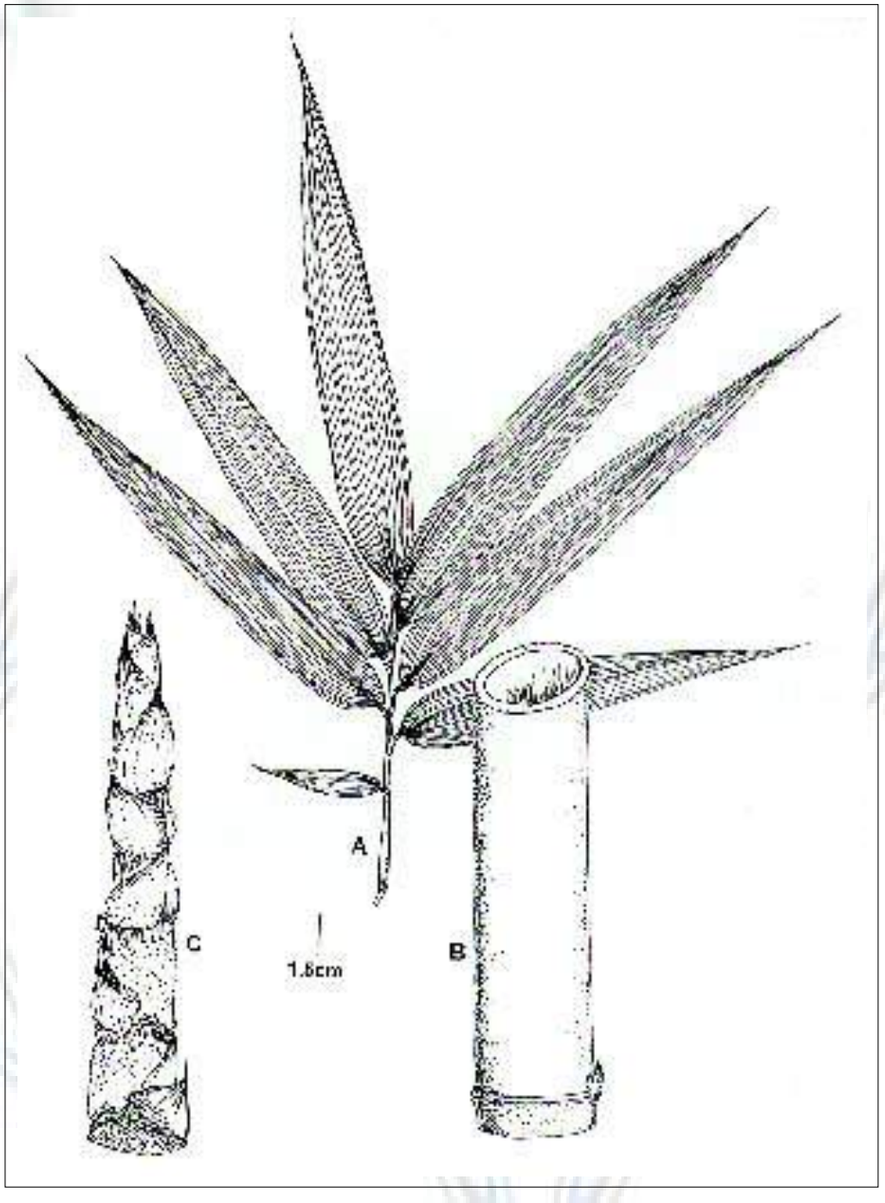
Cultivated plants flowered in Europe during 1912. In Bangladesh, it flowered sporadically during 1978-85 and gregariously during 1983-85.

DISTRIBUTION

The species is found in Mizoram (India), Bangladesh, Thailand and Myanmar growing up to an altitude 1000 m. Cultivated in Indian Botanic Gardens, Calcutta and Forest Research Institute, Dehra Dun. Fairly common in the villages of Bangladesh (Alam, 1982).

CHEMISTRY

Eight peroxidase isoenzymes were separated. First three bands of low mobility were dark, the two bands of medium mobility were medium intense and the remaining three bands were light (Lalitha Kumari et al., 1985).



➤ *Fig. 14.* **B. longispiculata.** *A - leafy branch; B - a portion of culm; C - young shoot.*

SILVICULTURE

Observations on growth for 10 years of clumps raised by planting vegetative propagules showed that culm production gradually increased upto fifth year and then decreased. Similarly, girth expansion also reached maximum within six years. Depending on the clump expansion, a spacing of 5 m is recommended (Banik, 1988).

PESTS AND DISEASES

Attack by *Oregma bambusae* was observed. Mortality in emerging culms at early development stages has been reported (Banik, 1983).

NATURAL DURABILITY AND PRESERVATION

The preservation methods used for *Bambusa balcooa* is applicable for *B. longispiculata* as well (Chowdhury, 1993).

◄**B.longispiculata** - *A clump*

▼ **B. longispiculata** - *Internode and branches*

➤**B. multiplex** - *A clump*

Bambusa mastersii

Bambusa mastersii Munro, Trans. Linn. Soc. London 26: 113. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 56. 1896 and in Hook. f., Fl. Brit. India 7: 396. 1896; Camus, Les Bambusees 133. 1913; Varmah and Bahadur Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980; Tewari, Monogr. Bamboo 41. 1992.

VERNACULAR NAMES

Assam - *Benti bans.*

DESCRIPTION

A climbing bamboo. **Culms** small, reed-like. **Leaves** with a short, sometimes hairy petiole; Lamina oblong-lanceolate, 25-30 cm long and 36 mm broad, glabrous on both surfaces except towards the base of the midrib, glaucescent below, attenuate at the base, terminating in a rostrate-acuminate hairy tip; margins rough; median nerve yellow, shining, secondary nerves 10-12 pairs, intermediate 5, tessellate because of the reticulation of oblique lines of pellucid glands; leaf-sheaths striate, ciliate on the margins; covered on the sides with a coat of stiff appressed hairs, fimbriate at the

throat, terminating in a narrow callus and short auricle bearing several, stiff, long, folded bristles; ligule very short. **Inflorescence** not known.

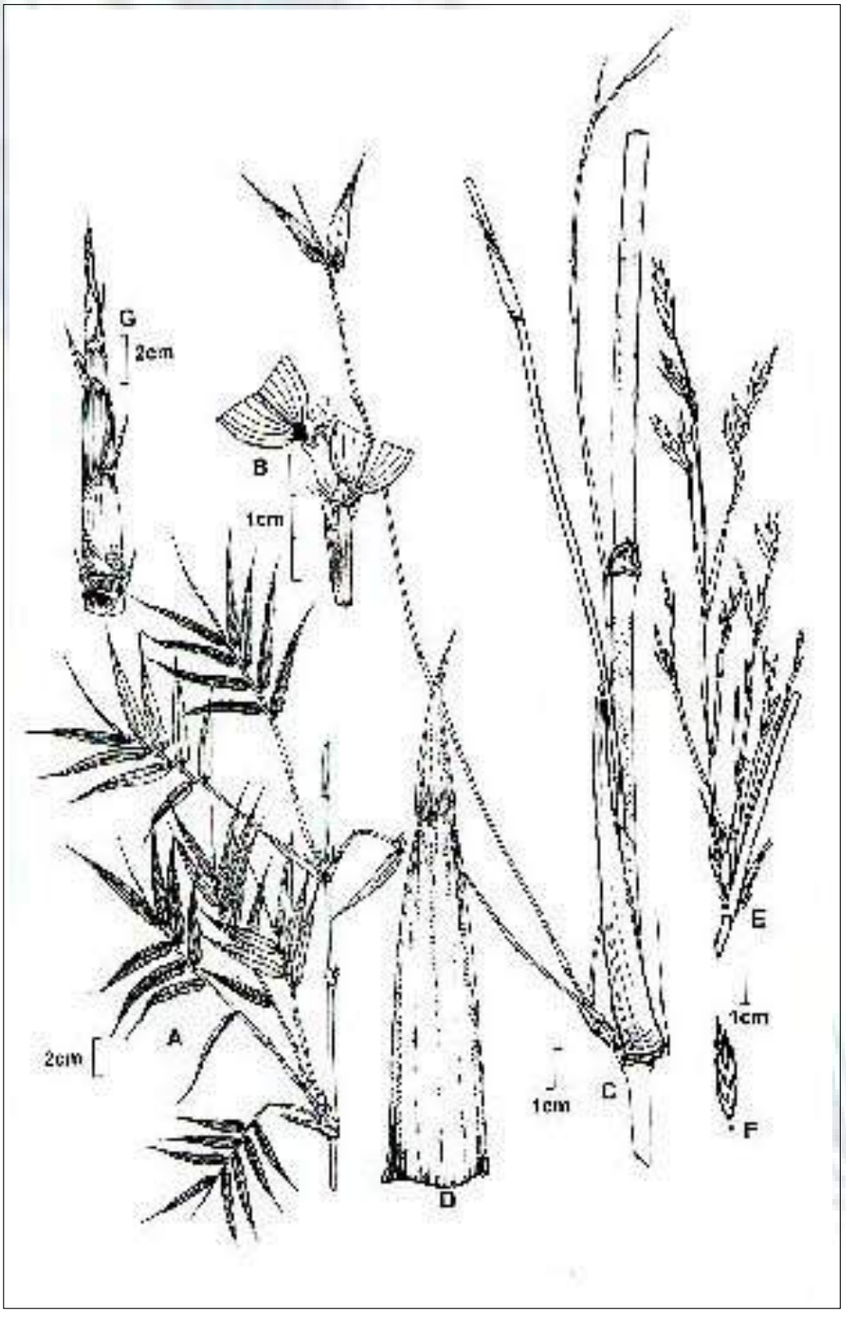
DISTRIBUTION

Found in Dibrugarh, Assam.

Bambusa multiplex

Bambusa multiplex (Lour.) Raeusch ex Schult. and Schult. f., Syst. Veg. 7: 1350. 1830; Merrill, Enum. Philip. Fl. Pl. 1: 94. 1923 and Trans. Amer. Phil. Soc. 24: 83. 1935; Soderstrom, J. Amer. Bamboo Soc. 6: 7. 1985; Bennet and Gaur, Thirty Seven Bamboos Growing in India 27. 1990; Tewari, Monogr. Bamboo 42.1992. **(Fig. 15).**

Arundo multiplex Lour., Fl. Cochinch. 58. 1790; Camus, Les Bambusees 132. 1913; *Ludolphia glaucescens* Willd; in Ges. Naturf. Fr. Berl. Mag. 2: 320. 1808; *Bambusa nana* Roxb. Fl. Ind. 2: 199. 1832; Gamble, Ann. Roy. Bot. Gard.



◄*Fig. 15.* **B. multiplex.** *A - leafy branch; B - leaf-sheath; C - culm with branches; D - culm-sheath; E - a portion of flowering branch; F - spikelet; G - young shoot.*

Calcutta 7: 40. 1896; Camus, Les Bambusees 121. 1913; *Bambusa glaucescens* (Willd.) Sieb. ex Munro, Trans. Linn. Soc. London 26: 89. 1868; Holttum, Kew Bull. 11(2): 207. 1956 and Gard. Bull. Singapore 16: 67. 1958

DESCRIPTION

A thickly growing, evergreen caespitose bamboo. **Culms** usually 2-4 m high, 1.5-2.5 cm in diameter, glabrous, smooth, green when young, yellowish on aging, hard, much branched from the base; nodes prominently thickened; internodes usually 20-40 cm long. Young shoots slender, glabrous; sheath yellowish green, auricles caducous, blade erect, brown to purple brown, spear-shaped with broad base. **Culm-sheaths** 10-15 cm long and 5-8 cm broad, green when young, yellowish on aging, stiff, glabrous, striate, slightly narrowed upwards and rounded at the tip; ligule up to 1.5 mm high, entire; auricles small, bristly; blade 5-8 cm long, triangular, linear, acuminate. **Leaves** usually 5-10 cm long, 8-13 mm broad, linear-lanceolate, base broadly cuneate with a very short stalk, pale, glaucous and velvety-hairy beneath. **Inflorescence** a short, diffuse, leafy panicle with solitary or clustered spikelets. Spikelets 1.2-3.7 cm long, 0.5 mm broad, very glabrous, straw- coloured, bearing 5 or more flowers, separated by glabrous, flattened, 0.25-0.5 mm long rachillae; only the terminal flower imperfect; empty glumes none, or very rarely one; flowering glume 2-keeled, minutely ciliate only at the tip, many-nerved; lodicules 3, unequal, 0.25-0.5 mm long,

entire, linear, somewhat concave or thickened below, usually 2-nerved. Stamens exserted, pendulous; anthers blunt or slightly apiculate, yellow. Ovary obovate, rough, pubescent above; style very short, almost immediately dividing into 3 long feathery stigmas. **Caryopsis** elliptic, furrowed, roughly hairy above, with a short beak.

Chromosome number n = 35; 2n = 70 aneuploid (Sobita Devi and Sharma, 1993). Darlington and Wyle (1955) reported 2n = 72.

FLOWERING

It has been reported to have flowered in Germany in 1808 and 1839; Bangladesh in 1851 and 1879; Sri Lanka in 1863; India (Calcutta) in 1890, Singapore in 1892 (Gamble, 1896 and Holttum, 1956). During 1977-1985, it flowered sporadically in Bangladesh.

DISTRIBUTION AND ECOLOGY

Indigenous to China and Japan. Introduced into Indian Botanic Garden, Calcutta, in 1794 and in Europe before 1800. Holttum's (1956) reference to a *B. nana* specimen dated 1812 from Patna in Wallich's herbarium shows its early introduction into Bihar. Cultivated in many countries, mainly in Asian countries such as India, Sri Lanka, Myanmar, Malaya, Bangladesh. This is one of the major species of China. *B. multiplex* grows on various soil types up to an altitude of 1500 m. It is frost resistant and survives on sandy loam type of soil.

ANATOMY AND FIBRE CHARACTERISTICS

Note: Tewari (1992) treated *B. multiplex* as synonymous with *B. nana*. But the data on anatomy, chemistry and physical and mechanical properties clearly manifested differences indicating the distinctness of the two species. The variation shown in *B. nana* is given in brackets.

Epidermis of the culm internode, single-layered with thick walled elongated lignified cells. Hypodermis not distinct. Cortex 4-5 layers of parenchyma cells (3-4 layers). Fibre strands present (absent) vascular bundles are of type III. Retention of protoxylem cap absent. Isolated fibre strands not seen. Inner lining of the cavity, consisting of 4-6 layers of parenchyma cells undulated (5-6 layers of thick-walled parenchyma in tangential rows and 10-15 layers of thin walled parenchyma in radial rows of cells). Fibre 1971 µm long (2000 µm), diameter 10.8 µm (10 µm) lumen width 7.1 µm (7.4 µm), wall thickness 4 µm (4.2 µm). Fibres very thick, thick, thin walled. Septate fibres absent, fibre tip pointed or blunt (pointed, blunt or forked). Wall lamellation 3-7 layers (3-6 layers) (Sekar and Balasubramanian - personal communication). These fibres have a slenderness ratio 182.5 (200) flexibility ratio 65.7 (74) Runkel ratio 1.1 (1).

CHEMISTRY

There were a total of 9 isozymes; 3 bands in the zone of lower mobility. Bands of Rf value 0.04 and 0.13 were intensely stained and band 0.8 was light. Three bands were discerned in the zone of medium mobility, band 0.25 was intense. Three more bands were revealed in the region of high mobility all being light. (Lalitha Kumari et al., 1985). Spectral absorbance value (FTIR) of cellulose 0.225 (0.259) and lignin 0.282 (0.215) have been recorded (Sekar and Balasubramanian - personal communication).

SILVICULTURE AND MANAGEMENT

Three types of seedlings such as grassy, grassy erect and erect were identified and the erect type showed faster growth with elongated nodes and wider culm diameter than the other two types (Banik, 1980).

PESTS AND DISEASES

Bamboo-aphid, *Pseudoregma bambucicola* colonises on shoots and stems. The soldier ratio is higher on thick shoots than on thin or small shoots (Sakata et al., 1991).

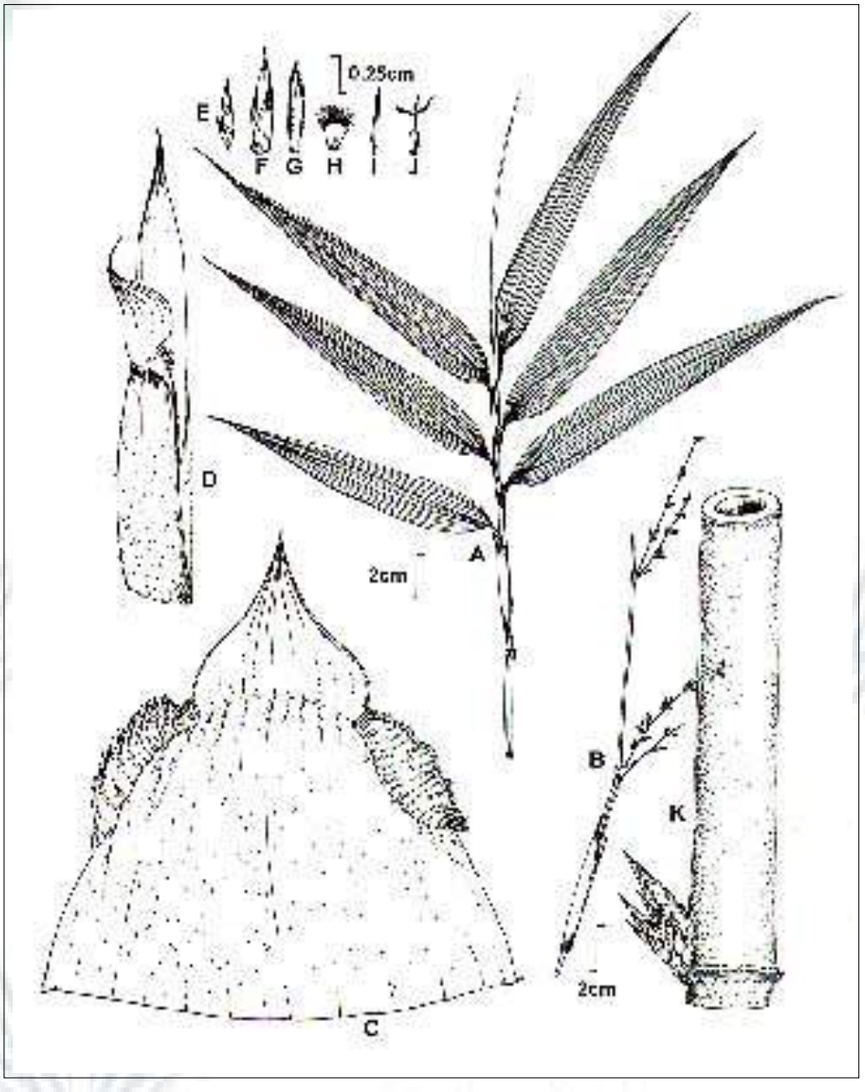
USES

This reed-like bamboo which looks quite beautiful is largely used for hedges. Used for construction purposes, basketting and handicrafts in Thailand and is also ornamental.

Bambusa nutans

Bambusa nutans Wall. ex Munro, Trans. Linn. Soc. London 26: 92. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 32. 1896 and in Hook. f., Fl. Brit. India 7: 387. 1897; Camus, Les Bambusees 116. 1913; Varmah and Bahadur, Indian

B. nutans - *Internode and branches*



➤ *Fig. 16.* **B. nutans.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - young shoot; E - spikelet; F - flowering glume; G - palea; H - lodicule; I - stamen; J - pistil; K - a portion of culm.*

For. Rec. (n.s.) Bot. 6(1): 2. 1980; Bennet and Gaur, Thirty Seven Bamboos Growing in India 29. 1990; Tewari, Monogr. Bamboo 44.1992. **(Fig. 16).**

VERNACULAR NAMES

Assam - *Bidhuli, Mukial*; Lepecha - *Mallo, Mahi bans*; Orissa - *Badia bansa*; Tripura - *Kali, Beng, Makla*.

DESCRIPTION

A medium sized graceful bamboo. **Culms** 6-15 m high, 5-10 cm in diameter, loosely clumped, much-branched above, usually unbranched below, straight, green, smooth, not shining, white-ringed below the nodes; node slightly thickened, often hairy, lower ones bearing rootlets; internodes usually 25-45 cm long, thick-walled. **Culm-sheaths** 10-23 cm long, upto 30 cm wide at base, with appressed scattered black hairs on the back, base with soft deciduous hairs, top truncate;

ligule ca.2 mm, entire to dentate; auricles 2, at the top of the sheath, large, wavy, unequal in size, one erect and the other decurrent, both fringed, with long curved bristles; base rounded, margin recurved, adaxial surface clothed with appressed brownish black hairs. Young shoots yellowish-green at apex. Sheaths covered sparsely with dark-brown and yellow hairs. **Leaves** 15-25 cm long and 2-3.5 cm broad, linear-lanceolate, acuminate at apex, rounded and usually oblique at base, upper surface dull green, lower surface glaucous; petiole 3-5 mm long; leaf-sheaths hairy when young, striate; auricle falcate with few long hairs. **Inflorescence** a stiff panicle bearing spicate branches with clusters of stiff erect spikelets in bracteate heads, rachis smooth. Spikelets, many sterile, few fertile, 1.4-2.5 cm long, glabrous, acute; empty glumes 2-3, glabrous, mucronate, gemmiparous; fertile flowers 3-5; flowering glumes ovate, acute, mucronate, many-nerved, minutely hairy within; palea shorter than flowering glume, flattened, ovate, 2-keeled, with the long white ciliae on the edges of the keels overlapping; rachillae clavate, hairy and ciliate at the top, uppermost 2-3 flowers usually imperfect; lodicules 3, broad, obtuse, long fimbriate, fleshy at first, many-nerved, one narrower than the other two. Stamens sometimes 7, anthers long apiculate or slightly penicillate at apex. Ovary sub-obovate, stalked, glabrous below, pubescent above; style short, pubescent; stigmas 2-3, shortly plumose, twisted, nearly glabrous. **Caryopsis** oblong, obtuse, hairy on the tip. The species is extremely difficult to distinguish from *B. tulda* in the absence of flowers.

Chromosome number n = 35; 2n = 70 aneuploid (Sobita Devi and Sharma, 1993).

FLOWERING

Though there are many flowering records for different years from 1893, authentic gregarious flowering reports after 1840 are for the years 1894-96, 1966, 1979-80 and 1987-88. Apart from sporadic flowering, the bamboo seems to flower gregariously after 35 years and at least two separate flowering cycles are involved.

DISTRIBUTION AND ECOLOGY

It is commonly cultivated in North-West India especially in and around Dehra Dun; extensively cultivated in Orissa and West Bengal. One of the widely cultivated species in Bangladesh and one of the commercial species of Thailand. In moist hill slopes and flat uplands in well-drained sandy loam to clayey loam. Naturally occurring in Sub-Himalayan tracts from Yamuna eastwards to Arunachal Pradesh between 600-1500 m altitude. Common in Brahmaputra valley.

ANATOMY AND FIBRE CHARACTERISTICS

Long cells of culm epidermis rectangular with wavy walls; papillae scattered; stomata surrounded by papillae. Microhairs not observed. Cortex homogeneous with thin-walled cells. Peripheral vascular bundles reduced. Transitional vascular bundle caps and sheaths fused. Central vascular bundles with five and six fibre groups, lining of cavity parenchymatous (Pattanath and Rao 1969). In leaf epidermis stomata common, arranged in two bands in 1-3 alternate rows, subsidiary cells high-domed, over-arched and surrounded by four elliptical papillae. Long cells long, narrow with uniform width, ends straight to convex, walls sinuous. Papillae conspicuous in a row in the middle. Interstomatal cells short and narrow with concave ends, walls wavy to sinuous. Papillae scattered, small in the middle. Short cells solitary and in pairs, cork cells, costal and intercostal, costal inconspicuous or absent, intercostal distinct. Silica cells costal common, intercostal frequent. Silica bodies costal saddle shaped, intercostal crescent to dumbbell shaped; prickles intercostal, frequent with round base and short to long pointed apex. Microhairs common, bicelled, apical cell shorter than the basal cell, apex round. Macrohairs common, costal and intercostal long, base raised but not surrounded by papillae (Luxmi Chauhan et al., 1989).

Fibre length 2.49 mm, diameter 15.43 µm, lumen diameter 3.74 µm, wall thickness 5.86 µm, parenchyma 23.4 per cent.

CHEMISTRY

Studies on peroxidase isozymes showed 8 bands. Two with lowest mobility were intense, four showed medium mobility and medium intense. The other two bands were light (Lalitha Kumari et al., 1985). Proximate chemical analysis showed caustic soda 20 per cent, Kappa No.24.3, lignin in bamboo 21.7 per cent, lignin in pulp 2.8 per cent, pentosans in bamboo 20 per cent, pentosans in pulp 16.8 per cent, pulp yield unscreened 54.7 per cent, screened 54.5 per cent (Singh et al., 1976).

SILVICULTURE AND MANAGEMENT

Propagation trials conducted with culm cuttings showed the possibility of rooting 3-noded culm cuttings from base and middle portions of one-year-old culms. Genetic improvement work has been initiated in Arunachal Pradesh in 1980. Plantation by offset planting was tried by Orissa Forest Department. In Bangladesh, trials with culm cuttings showed 38 per cent of rooting under controlled conditions. Offset planting is also in practice.

PESTS AND DISEASES

Four diseases namely rhizome rot caused by *Ganoderma lucidum*, culm rot caused by *Botryodiplodia theobromae*, blight caused by *Sarocladium oryzae*, gray leaf spot caused by *Hendersonula toruloidea* are reported. Heavy mortality is seen in Orissa due to blight. High humidity and temperature are found favourable for infection. Bavistin (0.15%) combined with Dithane M-45 (0.3%) or Fytolan (0.3%) are found effective for controlling the blight. Attack by insect borers, *Dinoderus sp.* and *Chlorothorus annularis* is reported (Deka et al., 1990; Gupta et al., 1992).

PHYSICAL AND MECHANICAL PROPERTIES

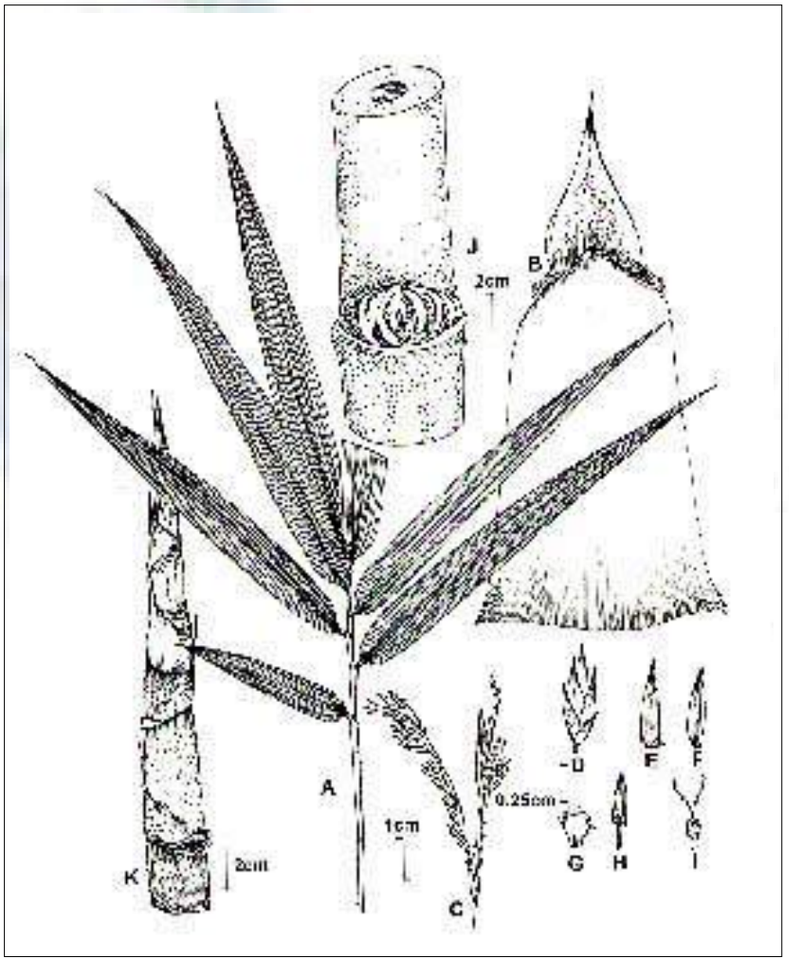
There is no longitudinal shrinkage for culm, diameter shrinkage is 4.6-6.6 per cent and wall shrinkage is 3.8-6.3 per cent for different ages (Sekar et al., 1962; Sekar and Rawat, 1964). Moisture content 88.3 per cent in green, 14.0 in air-dry, average specific gravity 0.603 in green, 0.673 in air-dry, fibre stress at elastic limit 29.5 in air-dry and 29.6 N/mm^2 in green, modulus of rupture 52.9 in green and 52.4 N/mm^2 in air-dry, modulus of elasticity 6.7 in green and 10.7 kN/mm^2 in air-dry, compression strength parallel to grain 456 kg/cm^2 in green and 479 kg/cm^2 in air-dry bamboo respectively. Variation was observed in materials collected from different states.

NATURAL DURABILITY AND PRESERVATION

Treatment of fresh bamboo pieces with water for leaching water soluble substances helped to reduce borer attack (Roonwal et al., 1966). Seasoning behaviour shows that it dries rapidly, but is liable to crack and collapse; cracks occurring mostly at the nodes; cracks at the other places close up late during drying; drying by passing hot air from solar air heaters through the bamboo tube obtained by puncturing the nodal partitions improve the drying behaviour with reduced surface cracking (Jain and Kambo, 1991; Sharma et al., 1992).

USES

It is a graceful bamboo worth growing as ornamental (Gamble, 1896), one among the six species commonly used in Indian paper industry. The culm is good, strong, straight and used locally for various purposes, mainly as poles.



Bambusa oliveriana

Bambusa oliveriana Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 130. 1896; Brandis,Indian Trees 670. 1906; Camus, Les Bambusees 126. 1913; Tewari, Monogr. Bamboo 45. 1992. **(Fig. 17).**

DESCRIPTION

A pretty, moderate sized, tufted bamboo. **Culms** 13-15 m high, 2.5-5 cm in diameter, glossy green; walls thick; internodes about 35 cm long; branches many from the base upwards. **Culm-sheaths** 20-25 cm long and 10-13 cm broad, pale, glabrous on both sides or hirsute on the back when young; ligule 2-3 mm high, serrate; auricles fringed; blade 10-20 cm long and 5-8 cm broad, triangular-lanceolate, cordate at the base, covered on both sides with scattered stiff brown hairs. Young shoots columnar, sheath green with membranous margin, blade brown, apex pointed; auricles brown. **Leaves** 10-18 cm long and 1-1.5 cm broad, linear, ending in a long twisted needle-like point; attenuated or rounded at base into 3-4 mm long petiole, glabrous, scabrous on the margins; leaf-sheath glabrous, striate, callus emarginate, ligule long. **Inflorescence** a much-branched panicle of drooping, one-sided spikes with rather distant bracteate clusters of few (1-3) spikelets; bracts glabrous, striate, truncate; spikelets flattened, ca. 1.5 cm long, straw coloured or greenish, glabrous; empty glumes 1-2, ovate-lanceolate, 3-4 fertile flowers, distichous, separated by conspicuous rachillae; terminal flower imperfect on a long flattened glabrous rachilla; flowering glume ovate-lanceolate, acuminate, 9-nerved; palea rather shorter, 2-keeled, acute, glabrous, except for a minute tuft of hairs at the apex, 3-nerved in between, 3-nerved on either side of the keels; lodicules 3, rounded, obtuse, long-fimbriate, many-nerved. Stamens long, exserted, anthers obtuse, striped red and yellow when young, dull purple on aging. Ovary ovate, elongate, hairy; style short, soon dividing into 2 plumose stigmas. **Caryopsis** 0.75 mm long, ovate, furrowed on one side, slightly hairy at tip.

Chromosome number 2n = 38, aneuploid (Sobita Devi and Sharma, 1993).

FLOWERING

Gregarious flowering was reported from Myanmar in 1893-94.

DISTRIBUTION AND ECOLOGY

Distributed in Mizoram (India) and Myanmar. Also cultivated in Indian Botanic Gardens, Calcutta and in the bambusetum of Forest Research Institute, Dehra Dun. The species occurs from 300-600 m altitude in moist deciduous forests along ravines.

▲ *Fig. 17.* **B. oliveriana.** *A - leafy branch; B - culm-sheath; C - a portion of flowering branch; D - spikelet; E - flowering glume; F - palea; G - lodicule; H - stamen; I - pistil; J - culm with node; K - young shoot.*

CHEMISTRY

Studies on peroxidase isozymes showed 6 distinct bands. One dark band, three medium intense bands and two light bands are observed (Lalitha Kumari et al., 1985).

PESTS AND DISEASES

The presence of bamboo-pit scale insect *Asterolecanium logum* is reported.

B. pallida - *Internode and branches*

Bambusa pallida

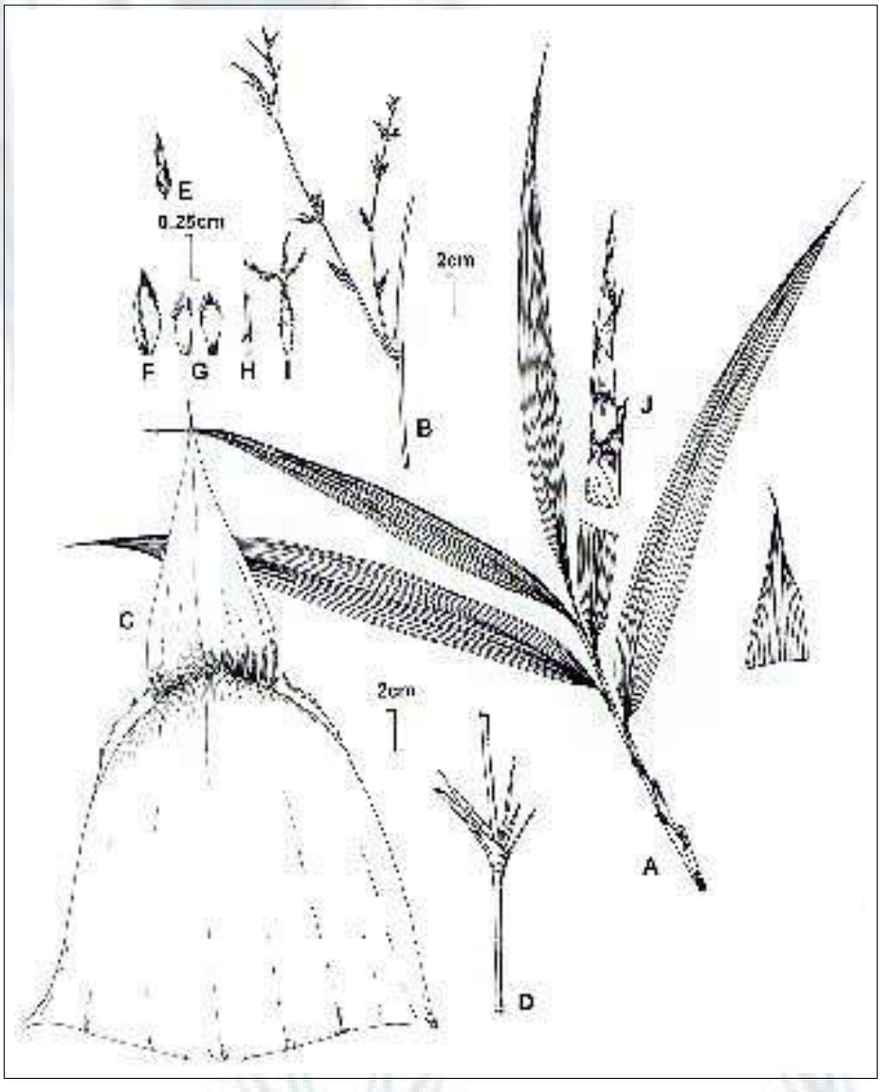
Bambusa pallida Munro, Trans. Linn. Soc. London 26: 97. 1868; Tewari, Monogr. Bamboo 45. 1992. **(Fig. 18).**

VERNACULAR NAMES

Assam-*Bijli, Jowa, Makal, Walkthai*; Cachar-*Bakhal, Burwal*; Khasi-*Seskien, Skhen, Tneng, Usken*; Lepcha-*Pashipo, Pshi, Pushee*; Mikir-*Loto*; Naga: *Tesero, Watoi*, Tripura-*Makal*.

B. pallida - *A clump*

B. pallida - *Young shoots*



◄*Fig. 18.* **B. pallida.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - node showing branching; E - spikelet; F - palea; G - lodicules; H - stamen; I - pistil; J - young shoot.*

DESCRIPTION

A caespitose bamboo, growing in thick clumps. **Culms** 13-20 m high, 5-8 cm in diameter, smooth, olive green, covered with white powder; nodes not prominent; internodes 45-70 cm long, walls thin. **Culm-sheaths** 18-30 cm long and 25 cm broad, slightly attenuate upwards and truncate at top. When young, blade often 35 cm long, triangular-acuminate from a broad base covered with appressed white hairs; abaxial surface appressed black hairy, adaxial surface glabrous or sparsely hairy; ligule very short; auricle quite small, rounded, with bristles. Young shoots spear-shaped, smooth, sheath green with darker tinge, culm-sheaths fall off from bottom of the culms upwards within 15 days, before falling become straw-coloured, blades at first greenish, changing to straw colour within few days. **Leaves** 10-20 cm long and 1-2 cm broad, linear-lanceolate, rounded or sub-cuneate at the base, glabrous above, whitish and hirsute beneath, margins scabrous; leaf-sheath glabrous, striate, ending in a smooth prominent callus; auricle rounded, erect, with scattered long bristles; petiole very short. **Inflorescence** a large branching panicle, with spicate branchlets bearing heads with many

sterile and few fertile spikelets; rachis fistular, that of branchlets slender, wiry, glabrous. Spikelets pale, 2.5-3 cm long, sometimes curved, bearing usually 1-2 small ovate-acute empty glumes, 1 male or gemmiparous glume, 3-8 fertile flowers, 3-5 imperfect ones gradually decreasing in size; rachilla short, club-shaped, ciliate at top; flowering glume ovate-acute, mucronate, many- nerved, glabrous, minutely pubescent within; palea much short, acute, 2-keeled, shortly ciliate on the keels, 3-5 veins between them; lodicules 3, oblong or narrowly obovate, two rather unequally sided, large, and the third acute, smaller, all somewhat thickened at base and veined. Stamens hardly exserted, anthers narrow, apiculate, with 1 or 2 long hairs or not. Ovary narrowly oblong, attenuate upwards into a hairy thickened style which soon branches into 3 plumose stigmas.

FLOWERING

Specimens collected with flowers from Bangladesh in 1850 and from Kamrup in Assam in 1890.

DISTRIBUTION AND ECOLOGY

It is distributed over North-East India (Arunachal Pradesh, Assam, Northern Bengal, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura), Bhutan and Myanmar. Cultivated in the plains, mostly in North-Eastern India, also in Indian Botanic Garden, Calcutta and in the bambusetum of Forest Research Institute, Dehra Dun. This species occurs in hills mainly between 700-2000 m altitude.

ANATOMY

Stomata common in leaf epidermis and arranged in two bands in 1-2 alternate rows; subsidiary cells triangular, surrounded by 6-8 globose papillae. Long cells long and narrow, width uniform, walls wavy, ends straight. Papillae inconspicuous and scattered. Interstomatal cells long and medium broad, walls wavy, ends concave, papillae scattered. Short cells solitary and paired, costal and intercostal. Cork cells costal, inconspicuous, intercostal distinct. Silica cells costal common, intercostal common to frequent. Silica bodies costal saddle shaped, intercostal dumbbell-to crescent-shaped. Prickles frequent to infrequent, intercostal, base round with medium long pointed apex. Microhairs frequent, intercostal, apical cell longer than the basal cell, apex rounded. Macrohairs frequent, intercostal and costal, medium, base raised (Luxmi Chauhan et al., 1989).

CHEMISTRY AND BIOCHEMISTRY

Studies on peroxidase isozymes showed seven bands, the band at lowest mobility is dark, following one is light. In the region of medium mobility there are three bands of which two are of medium intensity and one is light. The two bands at the high mobility are light (Lalitha Kumari et al., 1985).

SILVICULTURE

Vegetative propagation can be done by using one year old, two nodded culm-cuttings treated with NAA and kinetin (filled in internodal cavity) in July gave the best results (Nath et al., 1986). Cuttings of two-year-old culms gave better response than one-year or three-year-old culms. Genetic improvement work had been initiated in 1980 at Arunachal Pradesh (Saharia and Sen, 1990).

USES

The species is mainly used for house building, baskets, mats, toys, wall plates, screens and wall hangers.

Bambusa polymorpha

Bambusa polymorpha Munro, Trans. Linn. Soc. London 26: 98. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 36. 1896 and in Hook f., Fl. Brit. India 7: 389. 1897; Brandis, Indian Trees 669. 1906; Camus, Les Bambusees 119. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980; Bennet and Gaur, Thirty Seven Bamboos Growing in India, 35. 1990; Tewari, Monogr. Bamboo 47.1992. **(Fig. 19).**

VERNACULAR NAMES

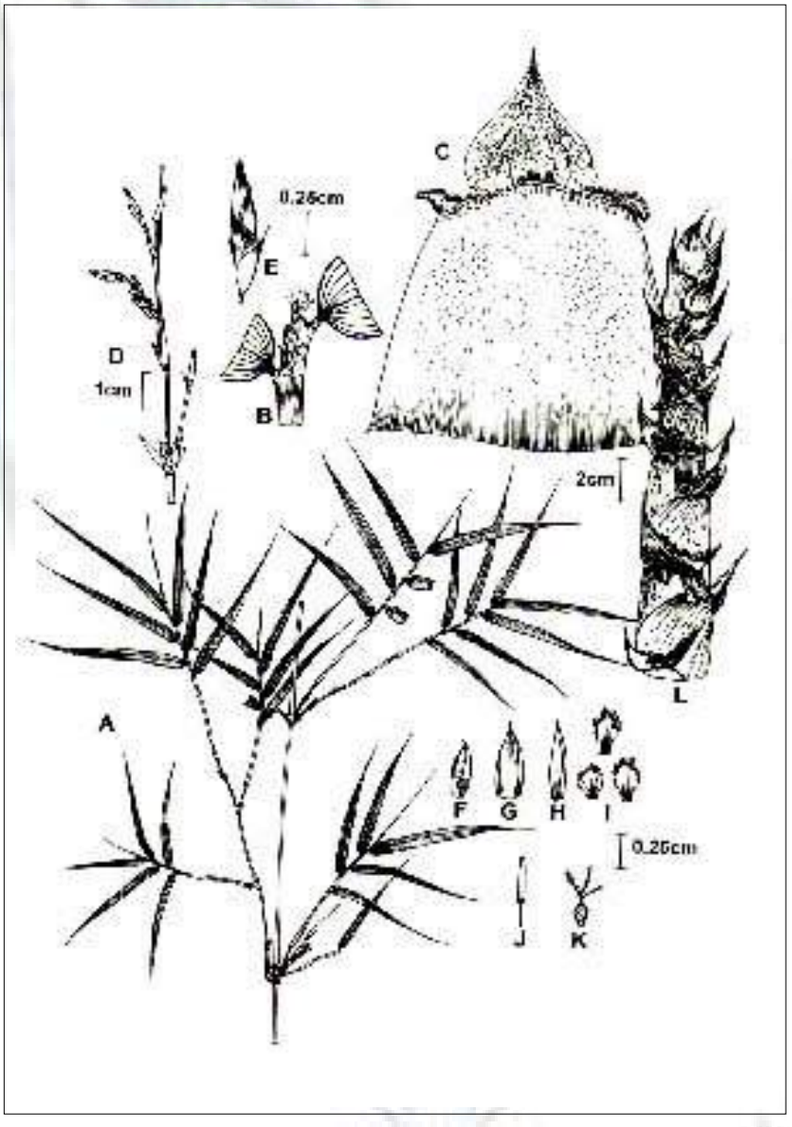
Assam - *Jama betwa, Betwa*; Bengal - *Betua, Jaibaroowa, Jama*; Madhya Pradesh - *Narangi bhas*; Tripura - *Bari*.

DESCRIPTION

A large evergreen, densely tufted bamboo; sometimes leaf-shedding in dry season. **Culms** 16-25 m high, 8-15 cm diameter, gray to grayish- green, white scurfy when young; nodes thick, lower ones rooted; internodes 40-60 cm long. **Culm-sheaths** 20-25 cm long and 30-35 cm broad, persistent, broader at base and narrowed into a rounded top, covered on back with densely and closely appressed brown to dark-brown deciduous hairs; ligule narrow, irregularly dentate, ciliate; auricles two, unequal, falcate, continuous with sheath, fringed with deciduous stiff bristles; blade 6-10 cm long, reflexed, deciduous, base triangular cordate, apex acuminate, abaxial surface with brown pubescence and adaxial surface felted with dark hairs, margins ciliate. Young shoots brownish-

▲ **B. polymorpha** - *Young shoot*

➤ **B. polymorpha** - *Basal part of the clump*



◄ *Fig. 19.* **B. polymorpha.** *A - leafy branch; B - leaf-sheath; C - culm-sheath; D - a portion of flowering branch; E - spikelet; F - empty glume; G - flowering glume; H - palea; I - lodicules; J - stamen; K - pistil; L - young shoot.*

green. Sheath light brown, or sometimes greenish or golden yellow, covered with dark brown hairs, blades greenish with dark brown hairs; lower half margin with whitish or yellowish cilia, boat-shaped, at the tip of the shoot auricles biseriate, prominent, wavy, with whitish or yellowish cilia. **Leaves** 7-18 cm long and 1-2 cm broad, linear-lanceolate, base obliquely rounded; petiole 2-3 mm long; ligule very thin; auricle with brown bristles. **Inflorescence** a much- branched panicle, with curving spikes of frequent heads bearing few spikelets surrounded by brownish, glabrous, mucronate, chaffy bracts; rachis smooth, the upper part covered with appressed whitish pubescence, ultimate segments very slender, wiry. Spikelets shining, often brownish, 1-1.5 cm, in lower heads 5-6, number gradually decreasing upwards, somewhat pedicellate and enclosed in a long, curved, glabrous bract; empty glumes 1-3, ovate mucronate, then 2-3 fertile flowers, a terminal imperfect flower supported by a long, flattened, glabrous rachilla; flowering glumes ovate-mucronate, many-nerved; palea somewhat longer, lanceolate, acute at tip, keels not ciliate; lodicules 3, sub-orbicular, short- fimbriate all round, 3-5-nerved, one smaller than the others. Stamens partly exserted; anthers purple, usually blunt, but sometimes apiculate. Ovary obovate, hairy at tip, style soon divided into 3 short, white-hairy stigmas. **Caryopsis** ovate, 5 mm long, depressed, flattened on one side, rounded on the other, hairy above, with short hairy mucro.

Chromosome number 2n = 64, aneuploid (Sobita Devi and Sharma, 1993). Another report showed 2n = 72 (Darlington and Wylie, 1955).

FLOWERING AND FRUITING

Both gregarious as well as sporadic flowering has been reported. Flowering cycle 55-60 years. The earliest report of flowering was from Myanmar during 1854-1860. The gregarious flowering in 1914 reported from Myanmar was after 55 years. The data available on flowering is not enough to decide its flowering cycle accurately. Sporadic and gregarious flowering occurred in Myanmar during 1929-30 which was confined to only drier tracts. Gaur (1987) reported its flowering cycle as 35-60 years. In Bangladesh, it flowered during 1981-82. Seed number varies from 21000-40000/kg depending on the location with 40 per cent germination.

DISTRIBUTION AND ECOLOGY

This bamboo is indigenous to India, Bangladesh and Myanmar. Also reported in wild state in Hoshangabad Division of Madhya Pradesh. Introduced in Coimbatore Division of Tamil Nadu, and Palghat, Nilambur and Wynad Divisions of Kerala. One of the important bamboo species cultivated in North Bengal. Introduced in Karnataka State at Coorg between 1913-1924. Gamble (1896) mentioned that this is common in Myanmar extending North-Westwards into Sylhet, Bangladesh. Though it has been cultivated in most of the North-Eastern States of India, its occurrence in some parts of Arunachal Pradesh, Manipur, Meghalaya and Tripura appears to be its natural distribution zone. Grown in Forest Research Institute campus, Dehra Dun. Low hill slopes along the valleys with deep fertile, well-drained loam and riverine alluvial soil is suitable for the growth of this species. It is found associated with teak *(Tectona grandis).*

ANATOMY AND FIBRE CHARACTERISTICS

Internodal epidermis uniseriate, hypodermis 4-6 layers, parenchymatous. The vascular bundles arranged in tangential rings in alternating radial rows. Morphology of bundles and the association of sclerenchyma vary from periphery to centre. Inner lining of the pith cavity, thick-walled, parenchymatous. Vascular bundles at the nodal region complex. Bundle sheath sclerenchyma much pronounced in the abaxial side. Protoxylem elements many. Transfer cells present between the metaxylem (Appasamy, 1989). In the nodes and internodes, long and narrow and short and wide librifom fibres present. The metaxylem elements short and wide. Perforation plate simple, transverse and lateral pits alternate and elliptical. Fibre length 2.41 mm, fibre diameter 17.29 µm, lumen diameter 5.53 µm, wall thickness 5.87 µm, parenchyma 20.4 per cent. Epidermal cells long, erect and rhomboidal, broadest in the middle and tapering at the ends. Epidermal and short cells alternate in vertical rows. Average width of epidermal cell 8.7 µm, length varies from 13.2 µm to 99.0 µm. Wall thick, septa-like partitions absent. Cork cells and silica cells squarish, or rectangular, silica cells sometimes pointed at the ends; short cell pairs 1208 per mm^2. Occasionally short cells substituted by a spine or bicellular hair alternating with epidermal cell. Spines solitary, may also develop in place of silica cell in pair or in combination with a pair of short cells. Bicellular hairs frequently solitary, a few large unicellular hairs sometimes present (Ghosh and Negi, 1960). In leaf epidermis stomata common, arranged in two bands in 1-2 alternate rows; subsidiary cells high-domed to triangular, surrounded by 6-9 globose and elliptical papillae. Long cells long and narrow with uniform width; walls sinuous, ends straight, papillae conspicuous, in a row in the middle. Interstomatal cells short and broad, walls sinuous, ends deep. Concave papillae scattered. Short cells solitary and paired, costal and intercostal. Cork cells, costal inconspicuous to absent, intercostal distinct. Silica cells costal common, intercostal, frequent. Silica bodies, costal cross-shaped to saddle-shaped, intercostal dumbbell to ‘8’ shaped. Prickles frequent, intercostal, base round with short pointed apex. Microhairs frequent to common, bicelled, apical cell shorter than basal cell, apex rounded. Macrohairs long, absent to infrequent, costal (Luxmi Chauhan et al., 1989).

CHEMISTRY

Seven bands were seen for peroxidase, 4 dense bands and one medium and two light (Lalitha Kumari et al., 1985). Proximate chemical analysis showed ash 1.67 per cent, cold water solubles 2.93 per cent, hot water solubles 6.88 per cent, alcohol benzene solubles 1.70 per cent, ether solubles 0.99 per cent, caustic soda solubles 18.39 per cent, pentosans 21.48 per cent, lignin 24.9 per cent, cellulose 61.79 per cent. Beating characteristics showed caustic soda 20 per cent, kappa No.27.2, lignin in bamboo 24.7 per cent, lignin in pulp 3 per cent, pentosans in bamboo 18.5 per cent, pentosan in pulp 17.0 per cent, pulp yield unscreened 44.4 per cent screened 43.4 per cent (Singh et al., 1976).

SILVICULTURE AND MANAGEMENT

Seedlings are raised in the nursery and planted out. About 90 cm long segments of 2-3-years old culms with branches trimmed to 7.5-10 cm length gave promising result. It can be propagated by pre-rooted and pre-rhizomed branch-cuttings with 45-56 per cent rooting (Banik, 1984). Plantations mature for extraction within 8 years. Selection felling cycle of 3 or 4 years can be adopted (Prasad, 1948). The general felling rules adopted for *B. bambos* is applicable for this species also. Another study recommends that felling should be started only after the mother clump develops thirty culms.

PESTS AND DISEASES

Bamboo seed bug, *Ochrophara montana* is reported. Both adults and nymphs feed on the developing seed. It is a serious pest of developing bamboo seed.

PHYSICAL AND MECHANICAL PROPERTIES

Moisture content is about 95.1 per cent and 13.9 per cent in green and air- dry conditions respectively. Average specific gravity 0.619 and 0.659; fibre stress at elastic limit 13.6 and 16.1 N/mm^2, modulus of rupture 28.3 and 35.5 N/mm^2, modulus of elasticity 3.1 and 4.1 kN/mm^2 in green and air-dry conditions respectively. Compression strength parallel to grain 32.1 N/mm^2 in green (not reported in air-dry condition).

NATURAL DURABILITY AND PRESERVATION

Preservative treatment by sap displacement method was tried. Culm of 9.5 m long was cut without removing branches and crown and placed in buckets with butt-end (25 cm) immersed in 10 per cent solution of copper sulphate or zinc chloride for 11 days. The concentration of solution can be altered as per requirement. In another method, the specimens were cut to 1.85 m long pieces and the butt-end was immersed (25 cm) in the solution for 72 hours. After 72 hours the specimens were inverted for another 72 hours (Singh and Tewari, 1980).

USES

It is popular for house building in Manipur. The species is used for the production of pulp and paper, agarbathi sticks and fibre boards. In Myanmar, this species is considered the best for walls, floor and roof of houses. This is one of the ten species used for building construction in Indonesia. Of the 27 bamboos belonging to 10 genera growing in Puerto Rico tested for the edibility of the shoots, this bamboo was the best to produce shoots with a distinctly sweet taste. It is also a graceful species suitable for landscaping.

Bambusa pseudopallida

Bambusa pseudopallida Majumdar in Fl. Ind. Enum. 275. 1989; Tewari, Monogr. Bamboo 48.1992.

DESCRIPTION

A species resembling *Bambusa pallida* having shrubby habit. **Culm-sheath** blade longer than the sheath but auricles pointed, one projecting upward and the other downward.

FLOWERING

Flowering has been reported from Assam in 1965 by Kanjilal.

DISTRIBUTION

It is found in Assam and Meghalaya.

▲ **B. striata** - *New shoot*

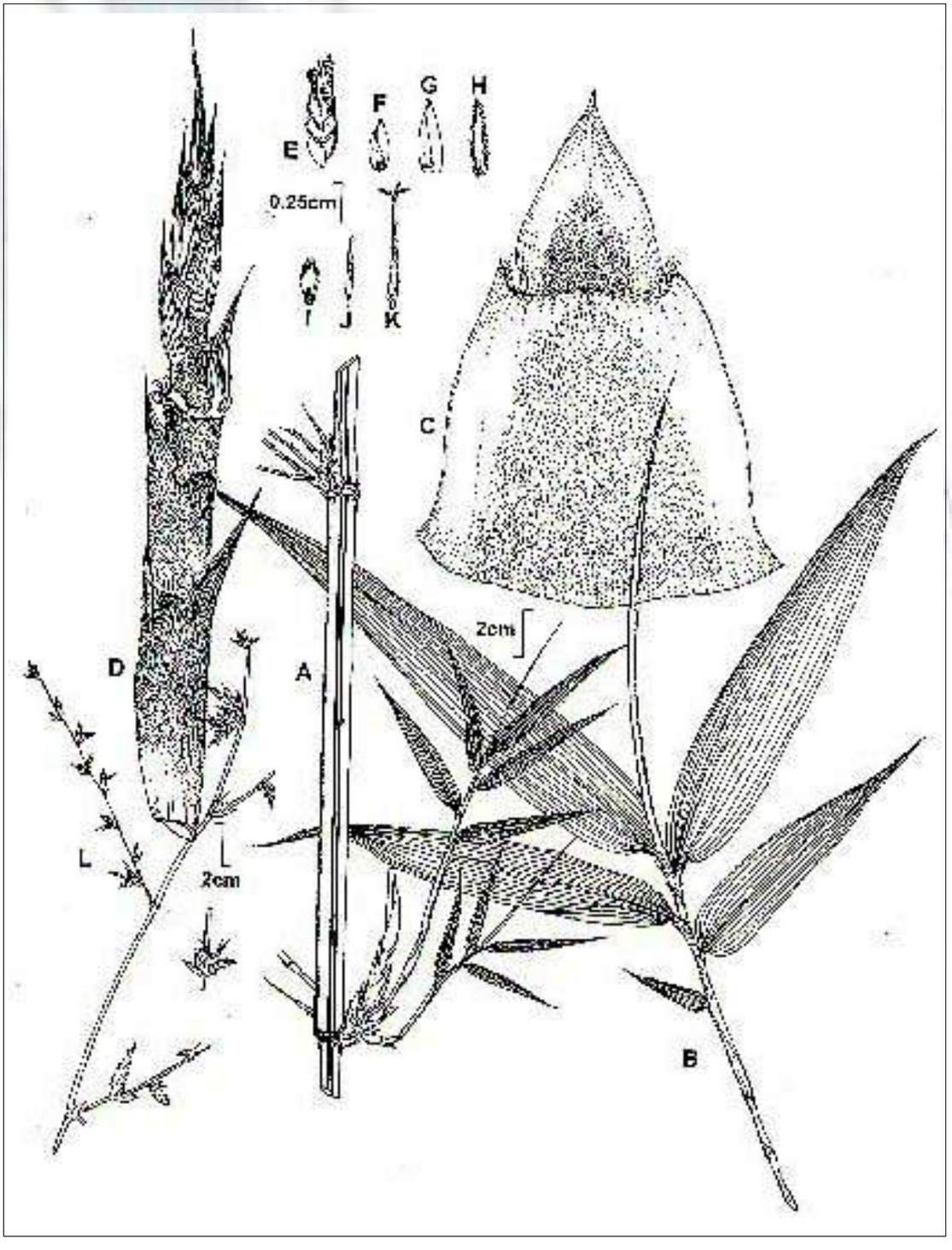
➤ **B. striata** - *colour variation in the culms*

➤ *(opposite page)* **B. striata** - *A clump*

Bambusa striata

Bambusa striata Lodd. ex Lindl. Penny Cyclop 3: 357. 1835; Munro Trans. Linn. Soc. London 26: 121. 1868; Curtis, Bot. Mag. 30: t. 6079. 1874. **(Fig. 20).**

B. vulgaris var. *striata* (Lodd. ex Lindl.) Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 44. 1896; Camus, Les Bambusees 123. 1913; Blatter, Indian For. 55: 556. 1929; Holttum, Gard. Bull. Singapore 16: 63. 1958; Bennet and Gaur, Thirty Seven Bamboos Growing in India 37. 1990; Tewari, Monogr. Bamboo 48.1992. *B. vulgaris* var. *vittata* A and C. Riviere, Les Bambos 191. 1877.



▲ *Fig. 20.* **B. striata.** *A - a portion of culm with branches; B - leafy branch; C - culm-sheath; D - young shoot; E - spikelet; F - empty glume; G - flowering glume; H - palea; I - lodicules; J - stamen; K - pistil.*

VERNACULAR NAMES

Bengal - *Basini bans, Bansini bans*; Orissa - *Sundrogai*.

DESCRIPTION

A graceful, tufted bamboo. **Culms** 4-8 m high, 5-8 cm in diameter, glabrous, yellow with light green stripes or rarely light green with yellow stripes, shining; internodes 10-15 cm long, thick- walled. **Culm-sheaths** somewhat similar to *B. vulgaris* but smaller. **Leaves** 15-20 cm long and 2-2.5 cm broad, linear-oblong or oblong-lanceolate, base obtuse and oblique, glabrous and glaucous beneath; petiole short; leaf-sheath smooth, glabrous; ligule short, truncate, ciliate. **Inflorescence** a large leafy compound panicle bearing spicate branches with heads of spikelets in bracteate clusters of 3-10, clusters larger at the nodes; rachis somewhat furrowed, end segments hairy. Spikelets 1.5-2 cm long, oblong, acute bearing 1-2 empty glumes; flowers 6-10; empty glumes ovate-acute, ciliate at tip, many-nerved; flowering glume larger; palea bluntly acute, 2-keeled, faintly 3-nerved. Lodicules 2, unequal, ovate-oblong, membranous. Stamens exserted; anthers narrow, apiculate; ovary narrowly oblong, hairy; style 3; stigma plumose.

FLOWERING

Hooker (1874) reported flowering of this species in November 1873.

DISTRIBUTION AND ECOLOGY

Native to China and Japan. Commonly cultivated all over India, as an ornamental. This species grows up to an altitude of 1000 m.

ANATOMY

Internodal epidermis consisting of a single row of thick-walled cells, and hypodermis with 1-2 layers of thick-walled sclerenchyma cells. Cortex parenchymatous 6-8 layered. Fibre strands present. Protoxylem cap persistent. Inner lining of the cavity 5 to 6 layered, of thick-walled parenchyma cells (Sekar and Balasubramanian, Personal communication). Vascular bundles irregular at the nodes. Sclerenchymatous bundle sheath and cap present on the side of phloem and protoxylem. Vascular bundles are more at the peripheral region. Parenchymatous tissue oval in shape with inclusion (Appasamy, 1989). Fibre types - very thick, thick, thin and very thin, septate fibres absent, tips pointed or blunt, wall lamellation 3-7 layered. (Sekar and Balasubramanian - personal communication). Vessel elements short and wide with simple perforation plates. Lateral wall pitting opposite and pits elliptic.

Fibre length 2028 µm, diameter 10.2 µm, lumen width 6.7 µm, wall thickness 5.1 µm. Slenderness ratio 198.8, flexibility ratio 65.6, Runkel ratio 1.5.

CHEMISTRY

Chemical composition of culms from Philippines showed holocellulose 63.6%, pentosan 21.5%, lignin 25.9%, solubility in alcohol benzene 3.7%, hot water 3.9 per cent, 1 per cent NaOH 24.7 per cent, ash 3.0 per cent, silica 1.3 per cent (Tamolang et al., 1980).

Spectral absorbance value for cellulose 0.313, lignin 0.302 (Sekar and Balasubramanian - personal communication).

USES

It is mainly used for ornamental planting; culms are used as poles. In Indonesia, it is used in building construction.

Bambusa teres

Bambusa teres Buch. Ham. ex Munro, Trans. Linn. Soc. London 26: 33. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 33. 1896 in Hook. f., Fl. Brit. India 7: 388. 1897; Brandis, Indian Trees 668. 1906; Camus, Les Bambusees 117. 1913; Tewari, Monogr. Bamboo 49. 1992. **(Fig. 21).**

VERNACULAR NAMES

Tripura - *Paora*; Assam - *Bhaluki-makel*.

DESCRIPTION

A large tufted bamboo. **Culms** upto 20 m high and 8 cm in diameter, smooth; internodes 50 cm long. **Culm-sheath** 20-25 cm long and broad, nearly glabrous, rounded at tip, black inside; blade 10-15 cm long, triangular, cuspidate, appressed hairy beneath, rounded at the base; ligule 2 mm high, white-hairy outside; auricles wavy, fringed with deciduous bristles. Young shoots whitish-green. **Leaves** 20-35 cm long and 3-4 cm broad, oblong-lanceolate, base oblique, petiole short; leaf-sheath glabrous or sparsely hairy, mouth truncate, ligule short. **Inflorescence** a large compound panicle with spicate branches bearing heads of sterile and fertile spikelets with chaffy bracts; rachis usually fistular, striate. Spikelets 5 cm with 1-2 empty gemmiparous glumes, 5-6 fertile flowers, and 1-2 terminal imperfect flowers; rachilla obcuneate, striate, minutely ciliate at top; empty glumes ovate-acute, mucronate; flowering glume ovate-lanceolate with a broad base, acute, glabrous, sometimes with a soft sub-foliaceous point, many-nerved; palea ovate, 2-keeled, scabrous, toothed on the keels, 5-6-nerved in between, tip

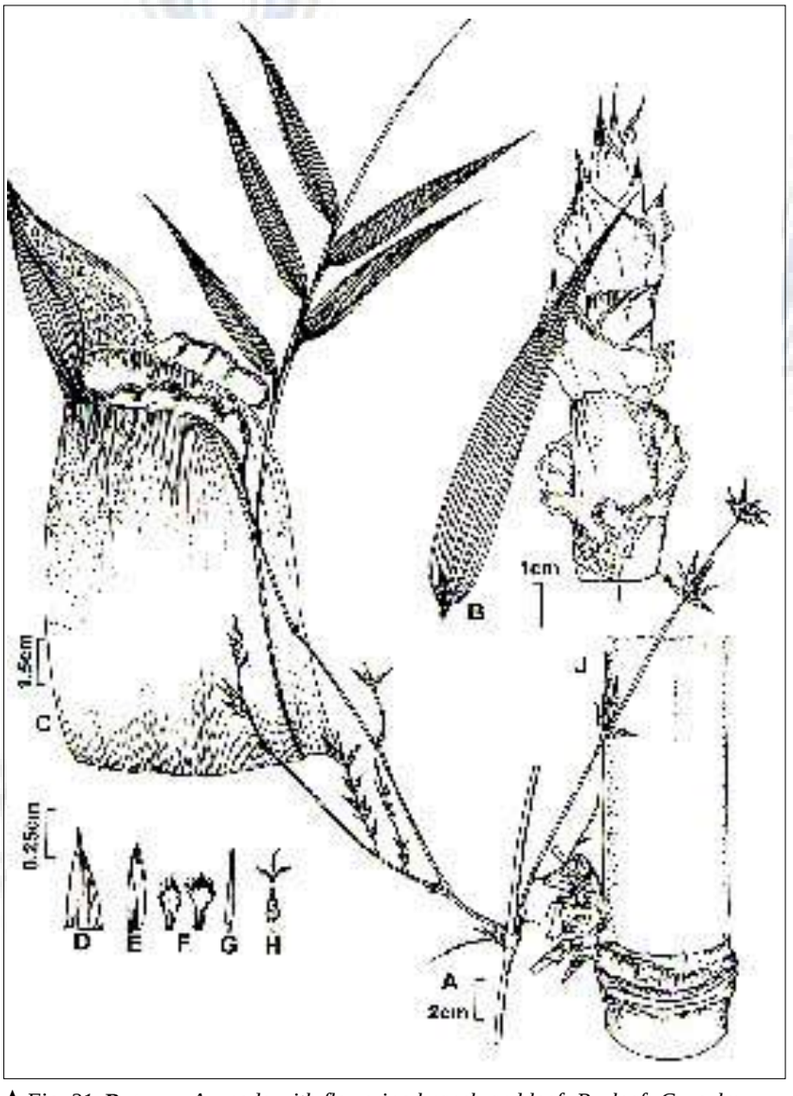


Fig. 21. **B. teres.** *A - node with flowering branch and leaf; B - leaf; C - culm-sheath; D - flowering glume; E - palea; F - lodicules; G - stamen; H - pistil; I - young shoot; J - a portion of culm.*

glabrous or penicillate; lodicules almost obovate, long-fimbriate, many- nerved. Anthers narrow, penicillate at the apex. Ovary ovate, acute, hairy above, with a short style and long hairy stigmas. **Caryopsis** not known.

FLOWERING

Flowering has been reported from Assam in 1891 and 1889, from Bangladesh during 1981-82. Most of the culms died after flowering.

DISTRIBUTION

Distributed in India (Arunachal Pradesh, Assam, West Bengal, Meghalaya, Nagaland and Tripura) and in Bangladesh.

USES

This species is used for making agarbathi sticks, mats and baskets.

▲ **B. tulda** - *A clump*

➤ **B. tulda** - *Internode and branches*

Bambusa tulda

Bambusa tulda Roxb., Fl. Ind. 2: 193. 1832; Munro, Trans. Linn. Soc. London 26: 91. 1868; Kurz, For. Fl. Brit. Burma 2: 552. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 30. 1896 and in Hook f., Fl. Brit. India 7: 387. 1897; Brandis, Indian Trees 668. 1906. Camus, Les Bambusees 115. 1913; Tewari, Monogr. Bamboo 49. 1992. **(Fig. 22).**

Dendrocalamus tulda (Roxb.) Voigt. Hort. Suburb. Calc. 718. 1845.

VERNACULAR NAMES

Assam - *Wamunna, Wagi, Nal-bans*; Bengal - *Tulda, Jowa*; Duars (West) - *Kiranti, Matela*; Garo - *Wati*; Kamrup - *Bijuli, Jati, Jao, Ghora*; Tripura - *Mirtinga*.

DESCRIPTION

This species is an evergreen or deciduous, tufted, gregarious bamboo. **Culms** usually 7-23 m high and 5-10 cm in diameter, glabrous, green when young, gray-green on maturity, sometimes streaked with yellow, almost unbranched below; nodes slightly thickened, lower ones have fibrous roots; internodes 40-70 cm long, white-scurfy when young, with white ring below the nodes, thin-walled. **Culm-sheaths** ca. 15-25 cm long and broad, attenuate upwards and rounded or truncate at top, deciduous, adaxial surface smooth and often with whitish powder, abaxial surface sometimes covered with appressed brown hairs; blade broadly triangular, reniform or cordate, cuspidate, erect, hairy within; ligule continuous with the sheath top, narrow, entire; auricles 2, unequal, larger one continuous with the blade and rounded with ciliate margin. **Leaves** 15-25 cm long and 2-4 cm broad linear-lanceolate or lanceolate, except for the scabrous veins, glabrous above, glaucescent and puberulous beneath, apex acuminate, base obliquely rounded into a short 2.5 mm long hairy petiole; leaf-sheath striate, glabrous; ligule very small; auricle rounded, fringed with long white hairs. **Inflorescence** variable, sometimes an immense radical leafless panicle, sometimes a short leafy paniculate or spicate branch; branches spicate, bearing interrupted clusters of few (1-5) usually fertile long spikelets supported by shining chaffy bracts; rachis smooth, striate, spikelets variable in length from 2.5-7.5 cm long, 5 mm broad, sessile, glabrous; cylindrical and acute at first, afterwards divided into many flowers separated by conspicuous rachillae, bearing first 1- 2 short bracts, then 2-4 usually gemmiparous empty glumes, 4-6 fertile flowers, and 1 or 2 imperfect or male terminal flowers; empty glumes acute, many-nerved; flowering glume many-nerved, glabrous, striate 1.2-2.5 cm long and 7.5 mm broad, ovate acute or acuminate, mucronate, sometimes minutely ciliate on the edges; palea rather shorter, boat-shaped, 2- keeled, with long white ciliae on the keels and penicillate at the tip, 5-7 nerves in the groove between the keels; rachillae clavate, flattened, striate, glabrous except on the ciliate tip and occasionally the faintly ciliate edges, articulate below the glumes, so that the spikelets readily breaks up; lodicules 3, 2.5 mm long, 2 cuneate, oblong, obliquely truncate, thickened and fleshy below, especially on one side,

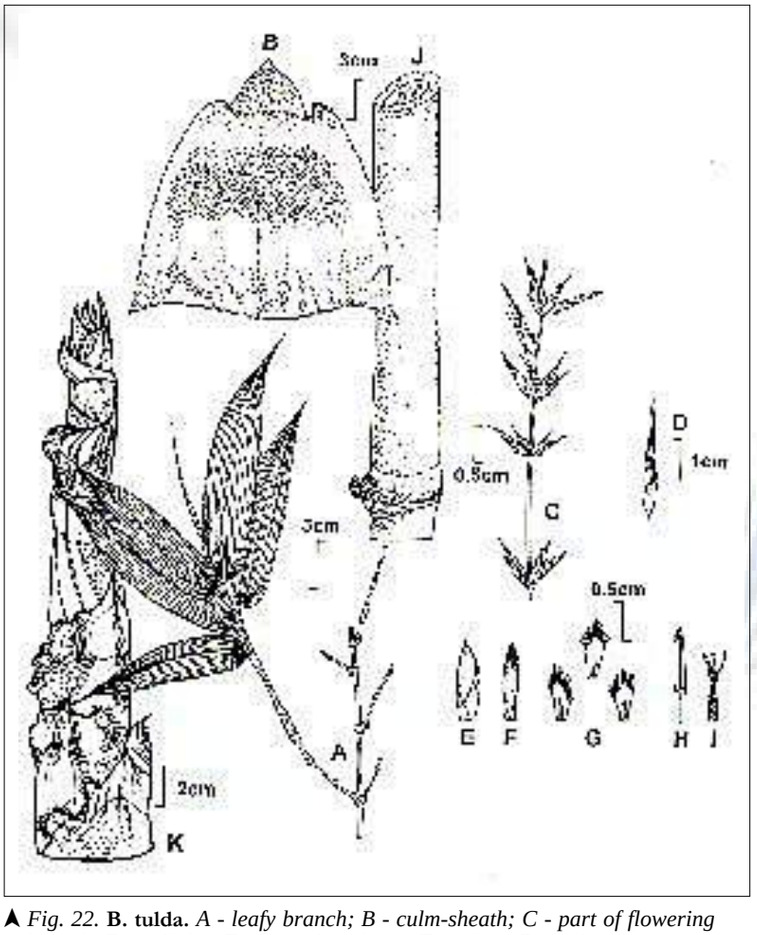


Fig. 22. **B. tulda.** *A - leafy branch; B - culm-sheath; C - part of flowering branch; D - spikelet; E - flowering glume; F - palea; G - lodicules; H - stamen; I - pistil; J - a portion of culm; K - young shoot.*

hyaline and about 5-nerved above, the upper part long, white fimbriate, the third not thickened, hyaline, acute, long, fimbriate. Stamens long exserted; anther 7.5 mm, purple, glabrous, blunt at the tip or emarginate. Ovary obovate-oblong, white, hairy above, surmounted by a short hairy style, divided into 3 long plumose wavy stigmas. **Caryopsis** 7.5 mm long, oblong, hirsute at the apex, furrowed.

Chromosome number 2n = 70 (Christopher and Abraham, 1971, Sobita Devi and Sharma, 1993).

FLOWERING AND FRUITING

Flowering cycle is reported to vary from 30-60 years. It flowers gregariously over considerable areas. Flowering was observed in Bengal during the years 1867-68, 1872, 1884, 1919, 1930 and 1936; in Assam during 1886, 1910 and 1930; in Myanmar during 1892, 1903, 1908, 1911 and 1914 and in Bangladesh in 1876, 1886, 1929-30, 1976-77, 1978-79, 1982-83 and 1983-84. Recently it flowered at Dehra Dun in 1986.

Fruit development has been studied by Harigopal and Mohan Ram (1987). Ovule, hemi-anatropus, pseudocrassinucellate. Micropyle is not seen since the integuments do not cover the nucellus completely. The nucellar epidermis is unilayered except at the micropylar end where two to four cells divide periodically to form a two to four layered tissue. The embryo sac development is of the polygonum type. Development of endosperm is free nuclear in the beginning and later cellular. Meristematic activity is restricted to outermost two to four layers of cells. The outermost two to four layers of cellular endosperm (aleurone tissue) are made up of rectangular cells with prominent nuclei and are devoid of starch. Ovary wall of megaspore tetrad has outer and inner epidermis and six to ten layers of cells between them. Cells at the periphery of ovary wall are small and have dense cytoplasm while the cells at stylar base are long and sparsely cytoplasmic. The outer integument degenerates during megasporogenesis and the inner one during embryo sac development. The nuclear epidermis persists up to globular stage and the outer surface becomes cutinised. During later development, only cutinised outer surface persists. The cells of the outer epidermis of pericarp become thick-walled during embryo development. Three to four layers below the epidermis also become thick-walled.

DISTRIBUTION AND ECOLOGY

In India, it is found in the states of Assam, Bihar, Meghalaya, Mizoram, Nagaland and Tripura. Cultivated in Arunachal Pradesh, Uttar Pradesh, Karnataka and Bengal. The species is extensively grown in low hills of Central Assam (Rajkhowa, 1964). The species also occurs in Bangladesh, Myanmar and Thailand. It is one of the major species of Bangladesh. The species occurs in moist alluvial flat land along water courses up to an altitude of 1500 m. Occurs in finer textured soils in the semi-evergreen forests in relatively low rainfall areas in Assam. Soils under this species contained high reserve of organic matter, nitrogen, calcium, potassium and phosphorus (Qureshi et al., 1969).

ANATOMY

In culm epidermis, long cells are rectangular with sinuous walls, papillae in small groups, stomata overarched by papillae, micro hairs fan-like, bicellular. Internodal cortex heterogeneous, peripheral vascular bundles reduced. Transitional vascular bundles with the caps and sheaths fused. Central vascular bundles with five or six fibre groups. The average fibre length is 1.84 mm and diameter 17.7 microns (Singh et al., 1976). Lining of the cavity parenchymatous. Leaf epidermal stomata arranged in two bands of 1-3, mostly 1-2 alternate rows, subsidiary cells triangular, surrounded by 6-9 globose papillae. Long cells long and narrow with uniform width, walls wavy, ends straight to convex. Papillae small, scattered. Interstomatal cells medium long and broad with wavy walls and concave ends, papillae small, scattered. Short cells solitary and paired, costal and intercostal. Cork cells costal inconspicuous, intercostal conspicuous. Silica cells

costal common, intercostal frequent. Silica bodies costal saddle-shaped, intercostal dumbbell-shaped. Prickles common to frequent, intercostal, base round with small to medium pointed apex. Microhairs common, intercostal, bicelled, basal and apical cell equal, apex rounded to tapering. Macrohairs common, costal and intercostal, long to medium, base raised, not surrounded by a ring of papillae (Luxmi Chauhan et al., 1989).

CHEMISTRY

Proximate Chemical analysis showed percentages of ash 2.02, cold water solubles 2.64, hot water solubles 4.97, alcohol benzene solubles 1.86, ether solubles 0.86; 1 percent caustic soda solubles 21.80. Studies on peroxidase isozymes showed two dark bands in the high mobility, three medium intense and one light band at medium mobility and two light bands at low mobility region (Lalitha Kumari et al., 1985). Beating characteristics gave caustic soda 21 per cent, kappa no. 28.2, lignin in bamboo 23.1 per cent, lignin in pulp 4.7 per cent, pentosans in bamboo 18.1 per cent, pentosans in pulp 17.3 per cent, pulp yield unscreened 54.8 per cent, screened 53.4 per cent.

SILVICULTURE AND MANAGEMENT

Observations on morphology of seeds showed a length of 2.49 cm, mid width 0.35 cm, mid breadth 0.28 cm; 13900 to 14000 seeds weighed in one kilogram. Studies on seed viability from Bangladesh showed that under natural conditions seeds are viable only for 35 days and this can be extended to about 18 months by storing over anhydrous silica gel in a desiccator. When seeds were stored over silica gel for longer period, germination was delayed. In a petri dish, germination is complete within 2-5 days whereas in polybags it takes 5-20 days, and in nursery beds about 7-25 days (Banik, 1987). Storage experiments in India showed that the seeds exhibit orthodox behaviour and can be stored by proper control of moisture content and temperature (Thapliyal et al., 1991).

Vegetative propagation using one-year-old, 2-noded culm cuttings treated with NAA + kinetin or IAA + kinetin in July gave maximum rooting. Planting in summer season was better (Adarsh Kumar et al., 1988). An efficient protocol for *in vitro* propagation through shoot proliferation is developed (Saxena, 1990). About 80 per cent survival is reported when the seedlings are transferred to soil after hardening. It takes six to ten years for the new seedlings to mature after gregarious flowering. Culm diameter and height and clump girth expansion increased rapidly upto 5th year. As per the felling rules, felling cycle of four years is suggested. Culms less than one year should be retained. Cutting should be made 30 cm above the ground. A minimum of six culms should be left in a clump, as far as possible felling should be done on the opposite side of the clump where young culms are seen (Prasad, 1948). Fertilizer application of N100 and P50 is found suitable at the nursery level. Split application at 4, 6 and 8 weeks after germination gives better results (Raina et al., 1988). This species is one of the twelve species of high yielding bamboos suggested for large scale planting (Uppin, 1980).

PESTS AND DISEASES

The sap sucker, *Oregma bambusae* Buchet which causes the wilting and death of young shoots has been reported. Bavistin, DDT or BHC powder or dialdrin or aldrin (0.5 per cent solution or powder) are effective controls (Chatterjee and Sebastian, 1964). Fungal infection affects the yield and quality of pulp. The species is also affected by blight caused by *Sarocladium oryzae*. This can be controlled by cultural practices and application of Dithane M45 as soil drench. Microflora on stored seeds comprise *Alternaria alternata, Aspergillus niger, A. fumigatus, Cercospora* sp., *Cladosporium cladosporioides, Curvalaria lunata, Drechslera rostrata, Epicoccum purpurascen, Fusarium semitectum, Penicillium* sp., *Phoma* sp., *Phomopsis* sp., *Rhizopus* sp., and *Trichoderma harzianum, Trichoconis padwickii, Pseudomonas* sp., *and Xanthomonas* sp.

PHYSICAL AND MECHANICAL PROPERTIES

Moisture content 73.6 per cent in green, 11.9 percent in air-dry; average specific gravity in green 0.658, air-dry 0.722; fibre stress at elastic limit 26.2 N/mm^2 in green, 38.1 N/mm^2 in air-dry; modulus of rupture 51.1 N/mm^2 in green, 66.7 N/mm^2 in air-dry; modulus of elasticity 8.0 kN/mm^2 in green, 10.0 kN/mm^2 in air-dry; compression strength parallel to grain 40.7 N/mm^2 in green, 68 N/mm^2 in air-dry.

NATURAL DURABILITY AND PRESERVATION

The culms if soaked in water for some weeks prior to their use last much longer and are stronger.

USES

This species is used throughout North-East India for covering the houses and scaffolding. The tender shoots are used for making excellent pickles. It is suitable for the manufacture of wrapping, writing and printing paper. Used in Tripura for making toys, mats, screens, wall plates, wall hangers, hats, baskets, food grain containers etc. In Arunachal Pradesh, the species is used for flute, locally called eloo and used by priests during Dree festival with the belief that the sound will keep the evil spirits away. In Northern Thailand, it was one of the two most important edible species until half a century ago. It has long been exported to Europe and the United States of America under the names 'Calcutta cane' or 'East India Brown Bamboo'. This is one of the five quick-growing species of bamboos preferred for raising plantations in India. It can be used as reinforcement in cement concrete. The succulent shoots are rich in phytosterols and the fermented shoots can be used for production of sterol drugs (Srivastava, 1990).

Bambusa vulgaris

Bambusa vulgaris Schrad. ex Wendl. Collect Pl. 2: 26 t. 47. 1810; Munro, Trans. Linn. Soc. London 26: 106. 1868; Kurz, For. Fl. Brit. Burma 2: 551. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 43. 1896 and in Hook. f., Fl. Brit. India 7: 391. 1897; Brandis, Indian Trees 670. 1906; Camus, Les Bambusees 112. 1913; Tewari, Monogr. Bamboos 51. 1992. **(Fig. 23).**

VERNACULAR NAMES

Bengal and Manipur - *Bakal*; Orissa - *Sunderkania bansa*.

DESCRIPTION

A moderate sized bamboo not densely tufted. **Culms** 8-20 m high, 5-10 cm in diameter, bright green, glossy, erect, mature culms yellowish, walls 7-15 mm thick, branching usually from mid-culm to top; nodes prominent, lower ones often with a narrow ring of roots, usually covered with brown hairs; internodes up to 45 cm long. Young shoots dark brown to yellowish green. **Culm-sheaths** 15-25 cm long and 25-35 cm broad, rounded and truncate at top, often beautifully streaked when young with green and yellow, striate, adaxial surface densely covered with thick appressed brown-black hairs, edges ciliate; ligule 5-8 mm tall, continuous with the top of the sheath, dentate or sometimes entire,

margin ciliate; auricle 2, subequal, continuous with the blade, ca. 1 cm high with pale stout curved bristles 6-8 mm long; blade somewhat triangular, bright yellow, acute, 5-15 cm long and up to 10 cm broad, appressed-hairy with shining black hairs on adaxial surface, margins bristly. **Leaves** narrowly or broadly lanceolate, 15-25 cm long and 2-4 cm broad rounded or attenuate at the base into a 5 mm long petiole, glabrous on both surfaces, occasionally sparsely hairy when young, margin scabrous. **Inflorescence** a large leafy compound panicle bearing spicate branches with heads of spikelets in bracteate clusters of 3-10, the clusters larger at the nodes; rachis rounded or somewhat furrowed, scurfy, end segments hairy. Spikelets 1.5-2 cm long, oblong, acute, compressed, bearing 1-2 empty glumes, 6-10 flowers, and one imperfect flower; rachillae cuneate, glabrous, not apparent; empty glumes ovate-acute, ciliate at tip, many-nerved; flowering glumes similar but larger; palea as long as or a little longer than flowering glume, bluntly acute, 2-keeled, white-ciliate on the keels, faintly 3-nerved; lodicules unequal, usually two, ovate-oblong, the third longer, acute, long white-ciliate, 3-veined, membranous. Stamens exserted, purple; anthers narrow, blunt, hairy, apiculate. Ovary narrowly oblong, hairy, surmounted by a long, thin, hairy style with 3 short plumose stigmas.

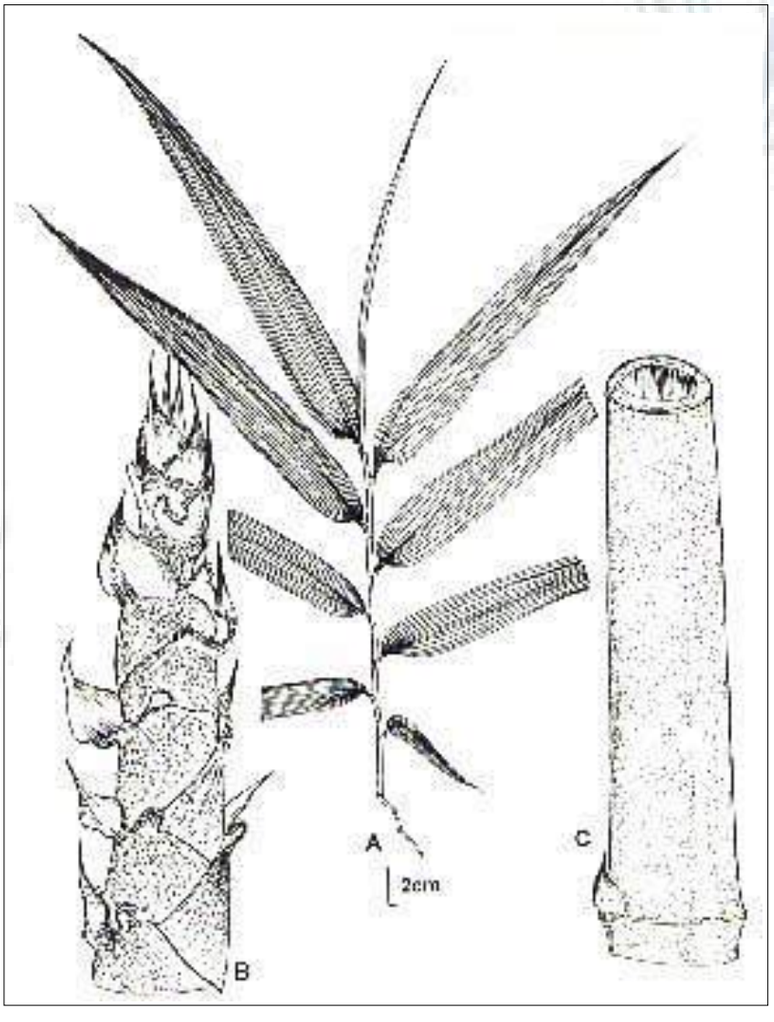
Chromosome number 2n = 72, hexaploid.

FLOWERING

Flowering is reported from Bangladesh in 1851, 1863, 1879, 1890 and 1892. Flowering has also been reported from Indian Botanic Gardens and Singapore Garden (Blatter, 1930). During 1977-1985 this species flowered sporadically in Bangladesh; during 1980-81 and 1983-84 it flowered but did not produce seeds (Banik, 1987).

DISTRIBUTION AND ECOLOGY

This species is cultivated extensively in many parts of the world, in India mainly in North-East and also in many other parts of the country. It is found in Surguja District of Madhya Pradesh and sporadically almost throughout the state. This is a common bamboo grown in homesteads and gardens. The suitable site for this species is moist soil, periphery of



➤ *Fig. 23.* **B. vulgaris.** *A - leafy branch; B - young shoot; C - a portion of culm.*

cultivated lands, creeks and at the foot of the hills. *B. vulgaris* grows up to an altitude of 1200 m and it is frost tolerant. It is the only bamboo species on Kutubdia in the Bay of Bengal which indicates a certain degree of salt tolerance.

ANATOMY AND FIBRE CHARACTERISTICS

Internodal epidermis consists of a single layer of thick-walled cells, hypodermis not distinct, cortex 6-8 layers of parenchyma cells, fibre strands absent, vascular bundles of type IV. Protoxylem cap not retained in the inner region, isolated fibre strands absent. Inner lining of the cavity with 6-8 layers of thick-walled parenchyma cells. Three types of fibres, very thick, thick and very thin present. Septate fibres absent, fibre tips pointed or blunt. Wall lamellation 4-7 layered (Sekar and Balasubramanian - personal communication). The anatomical features like vascular bundle size, distribution and fibre types are correlated with mechanical properties (Mohmod et al., 1990). Studies on fine structure of sieve element plastids revealed the typical monocotyledonous type (P-type) with cuneate proteinaceous bodies and lattice like crystalloids (Parameswaran, 1978). Fibre length 2.07 µm, fibre diameter of 16.06 µm, lumen diameter of 6.3 µm, wall thickness of 4.24 µm, parenchyma. 20.7 per cent leaf epidermais stomata arranged in two bands of 1-5 alternating rows, subsidiary cells triangular, surrounded by 7-9 globose to elliptical papillae over-arching the stomata. Long cells long and narrow with uniform width, walls sinuous, ends almost straight. Papillae conspicuous, arranged in a row in the middle. Interstomatal cells short and broad with deeply concave ends, papillae scattered, conspicuous. Short cells solitary, costal and intercostal. Cork cells costal not distinct, intercostal distinct. Silica cells costal common, intercostal frequent. Silica bodies costal saddle shaped, intercostal dumbbell shaped. Prickles frequent, intercostal with round base and short pointed apex, base not surrounded by papillae. Microhairs frequent, bicelled, apical cell much shorter than the basal cell, apex tapering. Macrohairs not seen (Luxmi Chauhan et al., 1989).

CHEMISTRY

Chemical analysis of the culms showed caustic soda 22 per cent, kappa no. 24.3, lignin in bamboo 22.9 per cent, in pulp 3.6 per cent, pentosans in bamboo 21 per cent, in pulp 17.6 per cent. Pulp yield unscreened 44.4 per cent, screened 43.8 per cent (Singh et al., 1976). Analysis of leaves gave the following results. Moisture 8.6 per cent, crude protein 10.1 per cent, ether extract 2.5 per cent, crude fibre 21.7 per cent, ash 21.3 per cent, phosphorus 86.0, iron 13.4, vitamin (B_1) 0.1, vitamin (B_2) 2.54 and carotene 12.32 mg/100g. Studies on chemical composition of culms from Philippine showed holocellulose 66.5 per cent, pentosans 21.1 per cent, lignin 26.9 per cent, solubility in alcohol-benzene 4.1 per cent, hot water 5.1 per cent, in 1 per cent NaOH 27.9 per cent; ash 2.4 per cent and silica 1.5 per cent (Tamolang et al., 1980). Peroxidase isozymes showed seven bands, two were dark in the low mobility, three in the medium mobility (two medium and one light) and two in high mobility (light) (Lalitha kumari et al., 1985). Analysis of starch and sugar in culms of different age showed that three-year-old culms gave maximum amount of starch and no trend was observed in the distribution of sugars (Mohmod et al., 1992).

SILVICULTURE AND MANAGEMENT

This species when planted at an espacement of 12 m x 12 m, the rate of productivity is almost 10 tonnes/ha/annum. It establishes quickly and assumes luxuriant growth. This is one of the five quick-growing bamboo species preferred for raising plantations in India. Multiple shoot production is reported from mature shoots in MS medium supplemented with coconut milk, kinetin and BAP. Treatment with a mixture of auxin and kinetin improves rooting. Pre-rooted rhizome and culm cuttings can also be used. Ground layering and air layering are found successful. Easy to propagate by culm and branch cuttings. Rooting enhanced by growth regulating substances and mist propagation system. Vegetative propagation by ordinary water culture is also reported. Cuttings taken from 1-2-year-old culms planted in summer months gave maximum response (Banik, 1984; Jayasree, 1989; Dhuria and Chadhar, 1990; Seethalakshmi, 1991).

PESTS AND DISEASES

This species is affected by blight caused by the fungus *Sarocladium oryzae*. Blight can be controlled by cultural practices such as removal of blighted culms, burning debris *in situ* in clumps during April-May and by the application of the fungicide, dithane M45 as a soil drench (Rahman and Khisha, 1981). Leaf blight caused by *Cercospora* sp. is also reported. Other diseases are basal culm rot caused by *Fusarium* sp., culm sheath rot by *Glomerella cingulata*, leaf rust by *Dasturella divina*, leaf spot by *Dactylaria* sp. and *Glomerella cingulata*. Nymphs of bamboo pit scale insect, *Asterolecanium bambusae* and *Boisduval* sp. feed on the sap under leaf-sheath. Attack by powder post-beetle (*Dinoderus minutus*) is also reported. For controlling the attack, external application of DDT is effective (Plank, 1947).

PHYSICAL AND MECHANICAL PROPERTIES

The abrasive resistance was about 30 per cent superior to kempas and 5 per cent superior to rubberwood.

NATURAL DURABILITY AND PRESERVATION

Copper based preservative treatments can be given by (1) dipping the cut ends in drums of preservative for 2-3 days, (2) by connecting the bamboos with tubing to a drum or bag of preservative and allowing the preservative to drip through under gravity. If branches and leaves are left as such the process is accelerated by transpiration (Jayanetti 1975).

Traditional method of immersing in water for a month provides considerable resistance against the attack of *Dinoderus minutus*.

USES

It is used for paper-making, scaffolding, construction, poles, curios and handicrafts. in different parts of India. Commonly used for fencing in Manipur and the longevity of the culm is comparable to that of the best timber. Rings prepared from the split culms are put into ear perforations by the Tunkul-Naga tribes of Manipur. In Sri Lanka, it is the most widely used bamboo. Occasionally cultivated in Malaysia for its edible shoots. Laboratory studies and pilot trials of pulp made from this species growing in Africa indicate its potential value especially for mixing with hardwood pulps. Chloroform extract of leaves is active against *Mycobacterium tuberculosis*. It can be planted on slopes to control erosion.

Bambusa wamin

▲ **B. wamin** - *Young shoot*

Bambusa wamin Camus, Les Bambusees 135. 1913; Bennet and Gaur, Thirty Seven Bamboos Growing in India, 45. 1990; Tewari, Monogr. Bamboo 53. 1972. **(Fig.24).**

Bambusa vulgaris cv. *wamin* McClure, Bamboos 162. 1966.

DESCRIPTION

This species is a medium sized graceful bamboo. **Culms** usually 4-8 m high, loosely tufted, usually arching at the top, dark green, shining and glabrous; internodes 10-15 cm long, rarely longer, much swollen (pitcher shaped) in the lower half; the swollen part 10-12 cm diameter, lowest 3 or 4 nodes with rootlets. **Culm sheaths** ca. 12 cm blade 5.75 cm long with 2 rounded ciliate auricles at the base, brown hairy outside resembling those of *Bambusa vulgaris*. Young shoots are totally green when very young, yellowish green later, glabrous. **Leaves** 18-30 cm long and 2-3 cm broad.

DISTRIBUTION

So far not known in the wild. Cultivated in the Northern Shan States of China.
The species is believed to have been introduced from China or Thailand. Planted in many gardens mainly in the subtropical regions including India.

ANATOMY AND FIBRE CHARACTERISTICS

Internodal epidermis consists of single layered, compactly arranged cells followed by a hypodermis, 4-6 layered sclerenchymatous cells. Cortex with 1-2 layers of thick-walled and 8-10 layers of thin walled parenchymatous cells. Fibre

◀ *(0pposite page)* **B. wamin** - *Basal part of the clump*

strands ensheath the tracheary elements. Vascular bundles of type II. Protoxylem cap absent. Isolated fibre strands not seen. Inner lining of the cavity, 8-10 layered, thick walled parenchyma and the innermost cells radially elongated. Fibres thin and very thin-walled, septate fibres present, fibre tips pointed, blunt or forked, wall lamellation 3-5 layered. Fibre dimensions 1521 µm long, diameter 13.3 µm, lumen width 10.9 µm, wall thickness 3.8 µm. This species has shown slenderness ratio 114.3, flexibility ratio 81.9, runkel ratio 0.7, (Sekar and Balasubramanian - personal communication).

CHEMISTRY

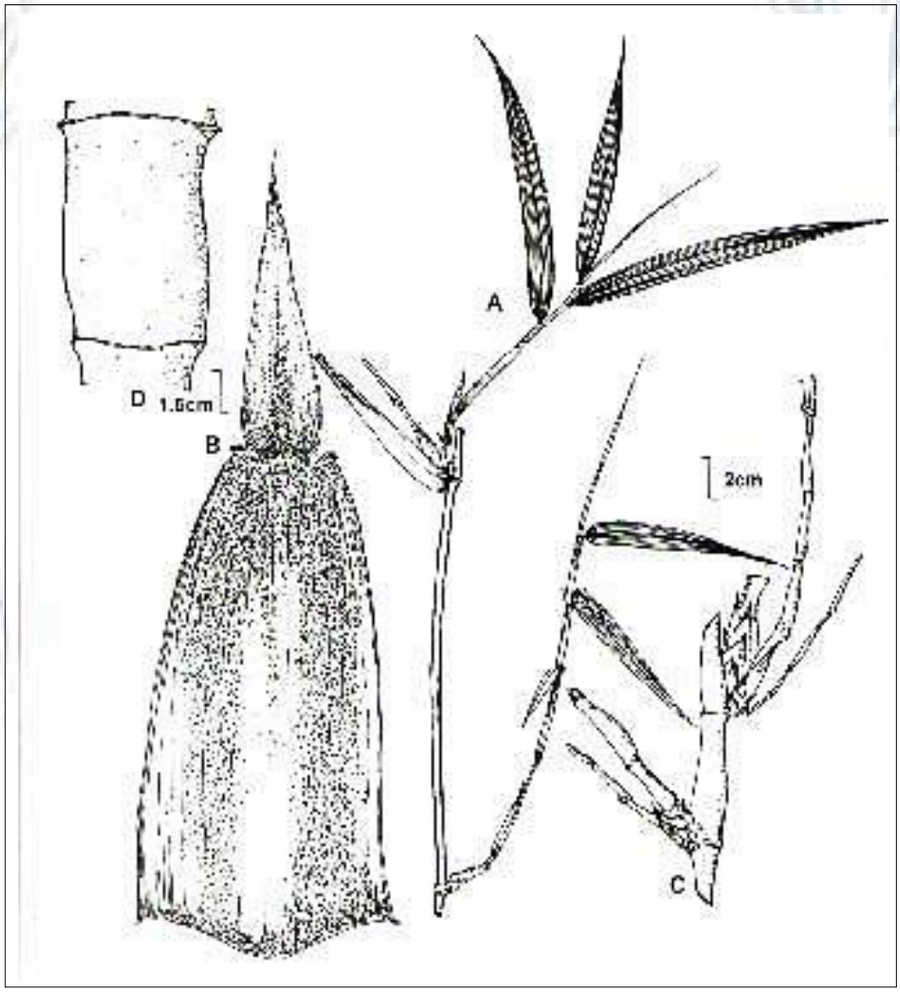
Peroxidase isozymes show 7 bands, 2 in lowest mobility (both dark) 3 in medium mobility (two medium, one dark) and 2 in high mobility (one medium and one light). The species is characterised by the intense band in the medium mobility region (Lalitha Kumari et al., 1985). Spectral absorbance value of cellulose 0.203, lignin 0.19 (Sekar and Balasubramanian - personal communication).

SILVICULTURE AND MANAGEMENT

It can be propagated by branch and culm cuttings using mist propagation system. A special solvent system containing DMSO with IAA and IBA is reported to give maximum rooting.

USES

B. wamin is grown in gardens as an ornamental bamboo. The culm is used for handicrafts.



➤ *Fig. 24.* **B. wamin.** *A - leafy branch; B - culm-sheath; C - node with branches; D - a portion of culm.*

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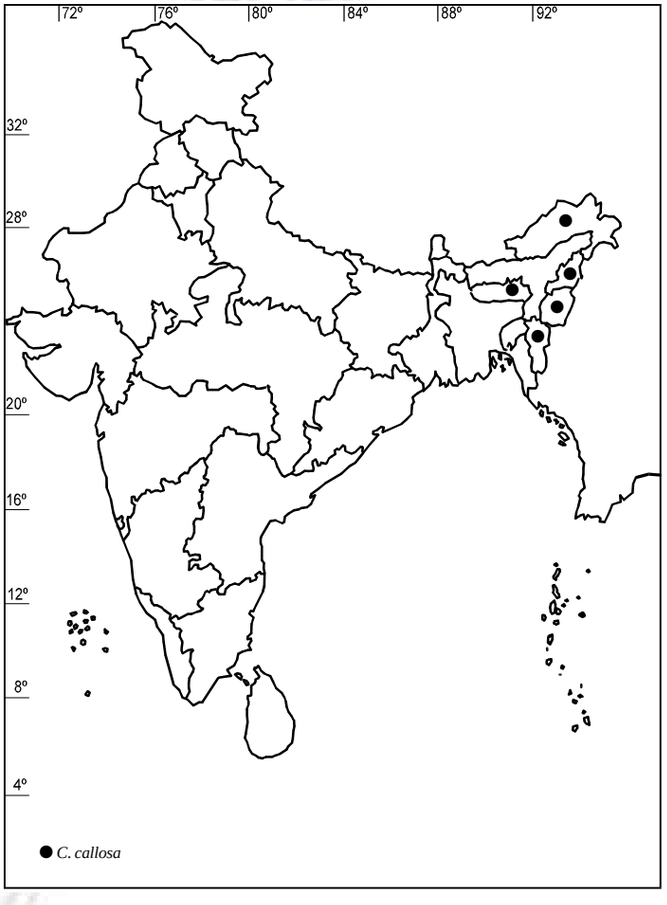
CHIMONOBAMBUSA MAKINO

Erect, shrubby, either single-stemmed or clump forming plants. Culm hollow, glabrous or hairy, node woolly with a ring of thorns and 3 culm branches. Culm-sheath deciduous or persistent, usually covered with long stiff hairs having auricles with bristles. Leaves linear lanceolate to oblong lanceolate, glabrous or scabrous, transverse veinlets present; leaf sheath striate, keeled, bristled auricles present or absent. Inflorescence paniculately or racemosely arranged, axillary or terminal, on leafy or leafless branches; spikelet with 2 to 12 florets; stamens 3, anther basifixed; style divided, each having one plumose stigma.

Tewari (1992) reported 4 species of *Chimonobambusa* from India, 3 from North Eastern India and one from Peninsular India. In the present compendium, only one species of the genus has been retained while the other species have been transferred under the genus *Sinarundinaria* based on the revisionary studies of Chao and Renvoize (1989).



◄*Distribution map of* **Chimonobambusa**

Chimonobambusa callosa

Chimonobambusa callosa (Munro) Nakai, J. Arn. Arb. 6: 151. 1925; Bor in Kanjilal, Fl. Assam 5: 46. 1940; Bahadur, Indian J. For. 2: 237. 1979; Tewari, Monogr. Bamboo. 54. 1992. **(Fig. 25).**

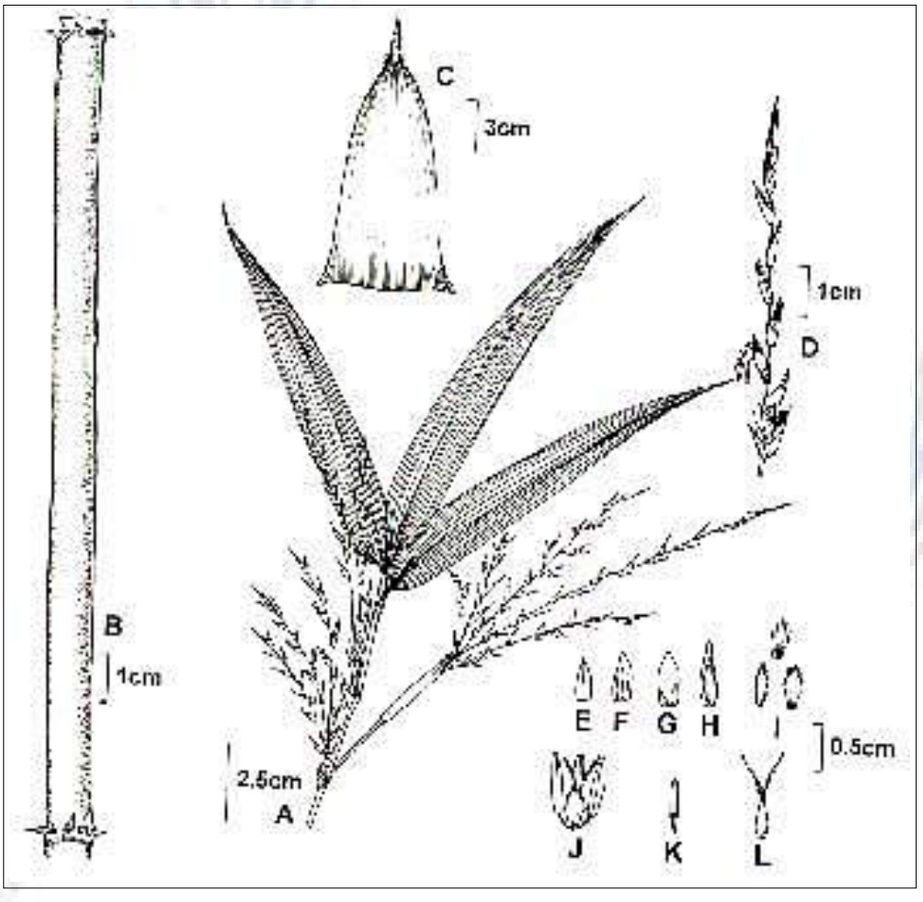
Arundinaria callosa Munro, Trans. Linn. Soc. London 26: 30. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 11. 1896, and in Hook. f., Fl. Brit. India 7: 381. 1897; Camus, Les Bambusees 37: 1913; Blatter, J. Bombay Nat. Hist. Soc. 33: 900. 1930; *Chimonobambusa callosus* (Munro) Hsuesh and Yi, Acta Botanica Yunnanica 1: 84. 1979; *Sinobambusa callosa* (Munro) Wen, J. Bamboo Res. 1(1): 35. 1982.

VERNACULAR NAMES

Khasi hills - *Uskong, Uspar, Spar, Sypar*.

DESCRIPTION

Shrubby, thorny plants. **Culms** ca. 6 m high and ca. 2.5 cm diameter, grayish green; internodes ca. 15 cm long, striate; nodes swollen, subtended by a ring-like scar formed by the fallen sheath, fringed with soft brown hairs and studded with



◄*Fig. 25.* **C. callosa.**
A - leafy twig with flowering branch;
B - a portion of culm;
C - culm-sheath;
D - spikelet;
E & F - empty glumes;
G - flowering glume;
H - palea; I - lodicules;
J - flower with glume and palea removed;
K - stamen; L - pistil.

short thick conical spines. **Culm-sheaths** ca. 15 cm long and 7 cm broad gradually attenuate upwards to 0.5 cm broad mouth with long bristles on both sides, edges ciliate; striate, loose, thin, yellowish, covered with bulbous-based hairs on the surface especially dense towards the base; imperfect blade ca. 2 cm long, striate, subulate, decurrent on the sheath; ligule short, up to 2 mm, fimbriate. **Leaves** ca. 20 cm long and 3 cm broad oblong-lanceolate, scabrous on the ventral surface, base unequal and attenuate into a ca. 2 mm long swollen petiole, tip acute; main vein prominent, secondary veins 6 pairs, intermediate 7, transverse veinlets many, distant; leaf-sheath striate, scabrous, ciliate on the edges, ending in a callus with short ciliae and few long bristles; ligule short, hairy, fimbriate. **Inflorescence** an axillary panicle, ending in leafy branchlets, subtended by sheathing papery bracts; rachis striate, flattened on one side, clavate, hairy; spikelet ca. 5 cm long, 8-12-flowered, the uppermost floret imperfect; rachilla ca. 5 mm long, flattened, glabrous; empty glumes 2, ovate-lanceolate, thin, ciliate, tip acute, outer glume ca. 5 mm long and 1.5 mm broad and 3-nerved; inner glume ca. 6 mm long and 2 mm broad, 5-nerved; lemma ca. 8 mm long and 3 mm broad, ovate, 7-nerved, tip mucronate and ciliate; palea ca. 7 mm, 2-keeled, ciliate on the keels, 2-nerved on either side of the keel, tip acute and ciliate; lodicules 3, ca. 2 mm, faintly nerved, fimbriate, two ovate-obtuse and one ovate-acute. Stamens 3; anther ca. 5 mm long, blunt or slightly pointed at the apex, basifixed; filament up to 1 mm long. Ovary ca. 3 mm long, ovoid-oblong, glabrous; style divided up to the base and each having one plumose stigma. **Caryopsis** ca. 6 mm long, linear-oblong, tipped with persistent base of style and stigma.

FLOWERING

Flowering has been reported from Khasia hills during 1857-58 and 1885. Flowering also has been reported from Arunachal Pradesh in 1957 and 1980.

DISTRIBUTION AND ECOLOGY

The species is distributed in Arunachal Pradesh, Nagaland, Manipur, Meghalaya and Mizoram. Distributed mostly in warm temperate to sub-tropical zones. Grows in open clumps in evergreen forests, common in oak forests. It is the only underwood in evergreen hill forest which flourishes in deep shade (Tewari, 1992).

USES

The culms are used for thatching small houses. Young shoots are edible.

REFERENCES

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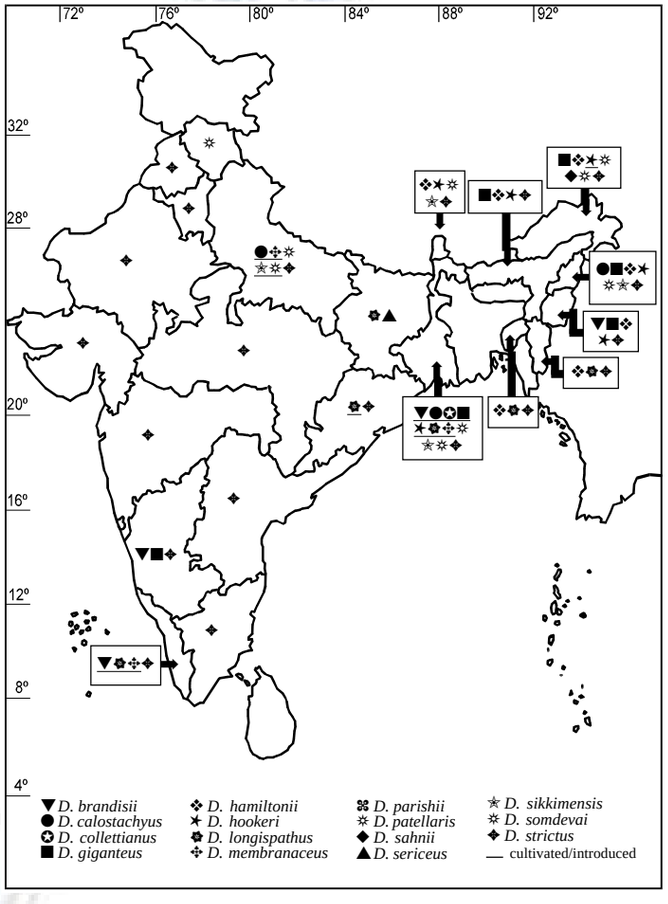
DENDROCALAMUS NEES

Arborescent, unarmed, often large sized bamboo. Culms usually erect from a densely ramified rootstock. Culm-sheaths deciduous, often very large, variably auricled, elongate. Imperfect blade narrowly triangular. Leaves shortly petiolate, size variable. Inflorescence large compound panicle, the spikelets in round congested heads; flowers few, rarely more than six, hermaphrodite, empty glumes 2-3, many-nerved, ovate, acute or mucronate; flowering glumes similar to empty glumes; palea ovate, acute or truncate or emarginate or cleft, lower flowers 2-keeled, ciliate, uppermost flower usually rounded on the back and not ciliate. Lodicules absent. Stamens 6, filaments free; anthers mucronate or with tufted hairs. Ovary ovoid, or sub-globular, often depressed, hairy above; style long, usually hairy, base persistent; stigma usually simple. Caryopsis small, the seed surmounted by a crustaceous or hardened pericarp.

This genus is considered to have a large number of species in South-East Asia. However, *Dendrocalamus strictus* is the most widespread species occurring in India, Myanmar, Bangladesh and Southern China to Vietnam. There are 12 species in North-East India, 4 in North-West India, 2 in Indo Gangetic plain, 1 in Peninsular India and 1 in Andaman and Nicobar Islands. However, in South India the common species occurring is *Dendrocalamus strictus* and there are 7 more species that are being cultivated. In the present compendium, details of 15 species of *Dendrocalamus* have been compiled.



◄*Distribution map of* **Dendrocalamus**

Dendrocalamus brandisii

Dendrocalamus brandisii (Munro) Kurz, For. Fl. Burma 2: 560. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 90. 1896; Brandis, Indian Trees 678. 1906; Camus, Les Bambusees 157. 1913; Bennet and Gaur, Thirty Seven Bamboos Growing in India 49. 1990; Tewari, Monogr. Bamboo 57. 1992. **(Fig. 26).**

Bambusa brandisii Munro, Trans. Linn. Soc. London 26: 109. 1868.

VERNACULAR NAMES

Bengal - *Bulka*; Manipur - *Wanan*.

DESCRIPTION

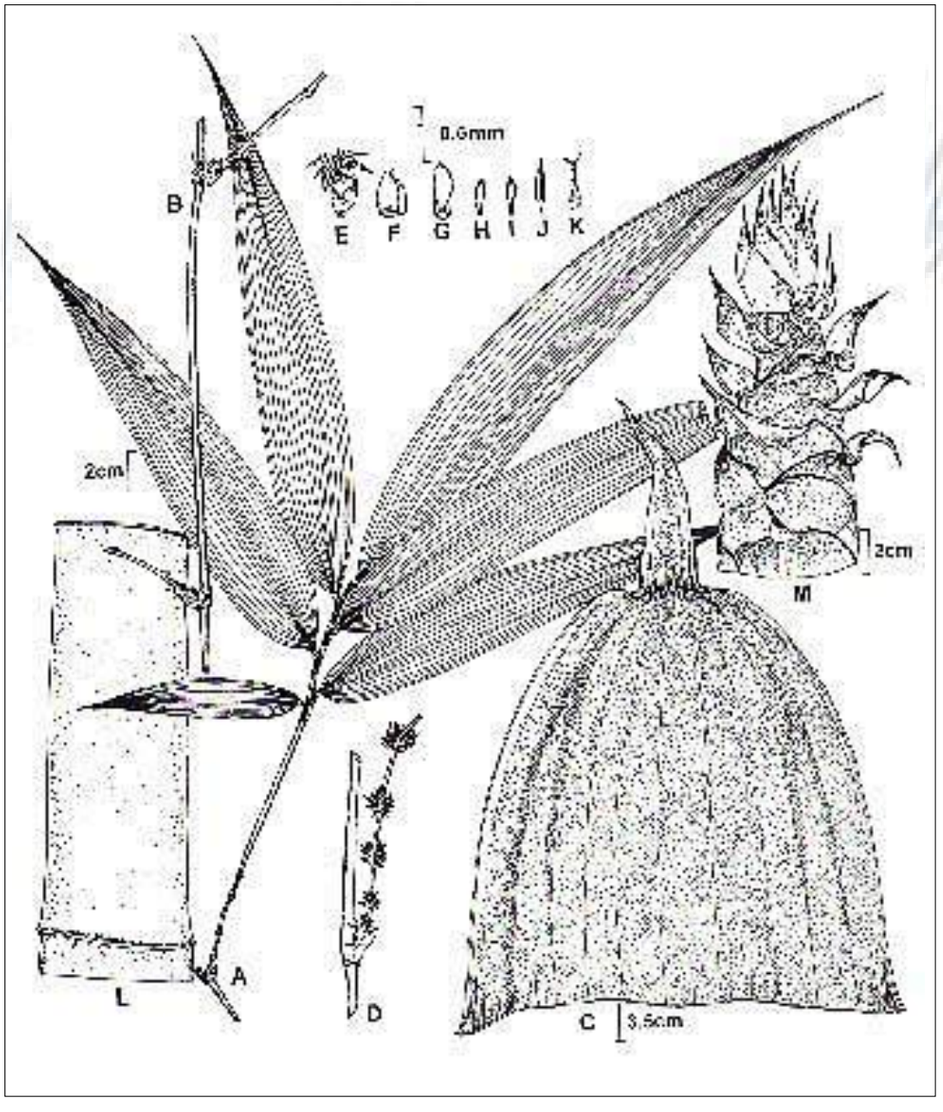
A very large evergreen tufted bamboo. **Culms** ashy-gray to greenish-gray, 19-33 m high and 13-20 cm diameter; nodes slightly swollen, lower ones with rootlets; internodes 30-38 cm long. **Culm-sheaths** up to 60 cm long, 30-35 cm broad, thick, leathery with white pubescence on the back, otherwise

▲ **D. brandisii** - *A clump*

◀ **D. brandisii** - *New shoot*

smooth, rounded and depressed at the top; ligule 1-2 cm high, deeply lacerate; auricles small, plaited; blade 15-46 cm long, 8-13 cm broad, linear-lanceolate, recurved, appressed-hairy within, base rounded. Young shoots dark-gray, blade dark-brown. **Leaves** 20-30 cm long and 2.5-5 cm broad, oblong-lanceolate, glabrous petiole; leaf-sheath striate, pubescent when young with long deciduous ciliae at mouth; ligule long, fimbriate. **Inflorescence** a huge much-branched panicle, with long spicate flagelliform branches, bearing bracteate heads of 1-1.3 cm diameter with many small spikelets; rachis densely pubescent, flattened on one side, segments 2.5-4 cm long. Spikelets 5-7.5 mm long, nearly as broad, ovate, depressed, minutely pubescent; empty glumes 1-2, broadly ovate, mucronate, nearly glabrous; flowers 2-4; flowering glume similar, prominently few-nerved, ciliate on the edges, hairy near the tip; palea oblong, acute or bi-mucronate, 3-nerved, ciliate on the keels, side wings narrow; lodicules 1-2, lanceolate or spathulate, 3-nerved, long-ciliate. Stamens exserted; anthers greenish-yellow, short, broad, apiculate or penicillate; filaments short, thick at first. Ovary ellipsoid, hairy; style short, stigmas purple ending in a thick club-shaped, or dividing into two plumose stigmas. **Caryopsis** ovoid, 2.5-4 mm, hairy above, tipped with the persistent style, pericarp crustaceous.

Chromosome No. n = 36, 2n = 72, hexaploid (Sobita Devi and Sharma, 1993).



➤*Fig. 26.* **D. brandisii.**
A - leafy branch;
B - culm with branches;
C - culm-sheath;
D - flowering branch;
E - spikelet;
F - flowering glume;
G - palea;
H & I - lodicules;
J - stamen; K - pistil;
L - a portion of culm;
M - young shoot.

FLOWERING

The species is known to flower sporadically as well as gregariously. It was collected in flower from Myanmar in 1862 by Brandis, in 1870 by Kurz and in 1890 and 1894 by Oliver. Gregarious flowering was reported from Coorg during 1961-62 and from Manipur in 1987-88. *In vitro* flowering and seed set has been reported (Nadgauda et al., 1993).

DISTRIBUTION AND ECOLOGY

Distributed in Jiribam area of Manipur and Andamans. Cultivated in Indian Botanic Gardens, Calcutta. Introduced in Karnataka at Coorg between 1913-24; plantation was raised at Asoga between 1971-73. This species has been tried in Kerala as well. The species is found growing in the tropical forests, chiefly on calcareous rocks up to an altitude of 1300 m.

ANATOMY AND FIBRE CHARACTERISTICS

In the culm internode, epidermis consists of a single layer of thick-walled cells followed by 1-2 layered sclerenchymatous hypodermis. Cortex parenchymatous, 4-5 layered. Fibre strands absent. Vascular bundles of type IV. Protoxylem caps at inner region persistent and isolated fibre strands absent. Inner lining of the cavity 4-5 layered, sclereids and 1-2 layered thin-walled parenchyma cells. Four types of fibres; very thick, thick, thin and very thin-walled present. Septate fibres present. Fibre tips pointed, blunt or forked. Wall lamellation 3-9 layered (Sekar and Balasubramanian - personal communication). Stomata common in leaf epidermis, arranged in two bands in 1-4 alternate rows, subsidiary cells high-domed to triangular, surrounded by small papillae. Long cells long and narrow with uniform width, walls sinuous, end walls almost straight. Papillae small and scattered. Interstomatal cells similar to long cells, relatively shorter and broader with concave ends. Short cells costal and intercostal, solitary. Cork cells costal, not distinct, intercostal distinct. Silica cells costal abundant, intercostal common. Costal silica bodies saddle-shaped, intercostal dumbbell-shaped. Prickles costal and intercostal, frequent, apex small, pointed, base round, depressed containing vitreous silica. Microhairs frequent, bicelled, intercostal, apical and basal cells, equal, apex rounded. Macrohairs infrequent to frequent, medium, fragile, costal and intercostal, base raised, surrounded by a ring of papillae (Luxmi Chauhan et al., 1988). Maceration studies showed a fibre length of 1846 µm, diameter 12 µm, lumen width 5-6 µm, and wall thickness of 5.3 µm. Fibres have slenderness ratio 153.8, flexibility ratio 46.6, Runkel ratio 1.9.

CHEMISTRY

Spectral absorbance value (FTIR) recorded for cellulose and lignin are 0.315 and 0.242 respectively (Sekar and Balasubramanian - personal communication).

SILVICULTURE

This species can be vegetatively propagated by culm cuttings. Use of growth regulating substances (NAA and IBA) promotes rooting in culm cuttings. Propagation by tissue culture reported from seeds as explant, seedlings with multiple shoots and rooting were obtained in MS medium supplemented with BAP (Zamora, 1994). Plantation trials from Karnataka recorded an average height of 6.1 m and a diameter of 14.3 cm.

USES

It is used for house building, baskets and decoratives. Young shoots are edible.

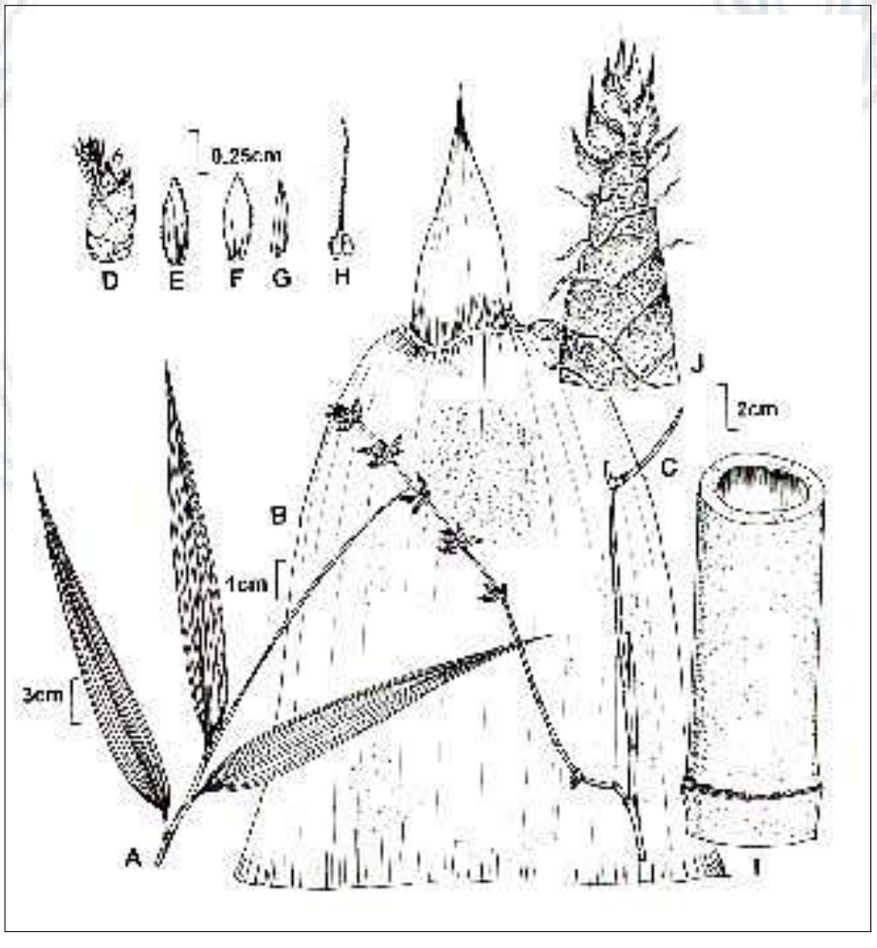
Dendrocalamus calostachyus

Dendrocalamus calostachyus (Kurz) Kurz, For. Fl. Burma 2: 562. 1877; Brandis, Indian Trees 678. 1906; Tewari. Monogr. Bamboo 60. 1992. **(Fig. 27).**

Bambusa calostachya Kurz, J. Asiat. Soc. Bengal 42: 249. 1873.

DESCRIPTION

A tufted large bamboo. **Culms** usually 20-30 m high, green with appressed silvery hairs; nodes thickened and annulate; internodes 30-40 cm long. **Culm-sheaths** covered with appressed tawny hairs, truncate at the mouth; ligule very short, entire. In young shoots, sheath orange-brown turning to green with brown hairs (not dense), blades spreading at right angles or reflexed, brownish. **Leaves** 22-30 cm long and 3-6.5 cm broad, lanceolate, acuminate, pubescent beneath, base rounded, petiole short; leaves of the side shoots are smaller; leaf-sheath striate, with white ciliae at the margins; ligule prominent, truncate, entire or serrulate. **Inflorescence** a large panicle of long, whip-like, curved spikes; spikelets clustered in heads of 2 to 5 with a few small empty bracts at base; rachis between the heads 1.5-5 cm long, flattened on one side, alternate sides glaucous, somewhat puberulous. Spikelets 1-1.5 cm long, 5 mm broad, faintly pubescent, ovate, acute, slightly



➤*Fig. 27.* **D. calostachyus.** *A - leafy branch; B - culm-sheath; C - flowering branch; D - spikelet; E & F - palea of lower and uppermost flowers; G - stamen; H - pistil; I - a portion of culm; J - young shoot.*

compressed, with 4 to 6 fertile flowers; empty glumes 2 to 3, broadly ovate, acute, many-nerved, with conspicuous transverse veinlets, ciliate on the edges; flowering glumes similar but rather longer; palea of lower flowers keeled, acute, 5-nerved between the keels and transversely veined, 1-nerved on either side of keel, ciliate on the keels, that of uppermost flower ciliate on the edges, but not on the keels. Stamens exserted; anthers yellow, mucronate. Ovary ovate, rounded, sub-hemispheric, hairy, ending in a long hairy style with a simple fringed purple stigma.

FLOWERING AND FRUITING

It was first collected in flowering from Myanmar in 1868. At FRI, Dehra Dun, flowering was observed in 1973. Seeds collected from FRI, Dehra Dun weighed 200 seeds/g. More than 30 per cent germination was reported under nursery trial.

DISTRIBUTION

This species is a native of Myanmar; occurs up to 1000 m elevation. Naithani (1985) reported its occurrence in wild from Meghalaya and Nagaland. It is grown in Indian Botanic Gardens, Calcutta and Forest Research Institute, Dehra Dun.

ANATOMY AND FIBRE CHARACTERISTICS

In the culm internode, epidermis consists of a single layer of thick-walled cells followed by 1-3 layered sclerenchymatous hypodermis. Cortex 2-3 layered, thick walled parenchymatous cells. Fibre strands absent in the outer region. Vascular bundles of type IV. Protoxylem cap persistent at the inner region. Isolated fibre strands absent. Inner lining of the cavity with 5-6 layers of irregularly shaped sclereids. Culm contains four types of fibres thick, very thick, thin and very thin walled. Septate fibres present. Fibre tips pointed or blunt and wall lamellation 4-8 layered (Sekar and Balasubramanian - personal communication). Leaf epidermal stomata arranged in two bands in 1-2 alternate rows, subsidiary cells triangular surrounded by small inconspicuous papillae. Interstomatal cell short and broad with concave ends; papillae scattered, conspicuous. Long cells long and narrow with uniform width, walls markedly sinuous, ends straight, papillae conspicuous in a row in the middle. Short cell costal and intercostal, solitary and paired. Cork cells costal, not distinct, intercostal conspicuous; silica cells costal, very common, intercostal frequent, obscured by prickles. Silica bodies costal, saddle-shaped, intercostal dumbbell-shaped. Prickles very common, costal infrequent having long pointed apex, intercostal frequent with round base and short pointed apex surrounded by a ring of papillae. Microhairs frequent, bicelled, basal cell slightly longer than apical cell, apex tapering. Macrohairs infrequent, costal and intercostal, medium, base raised (Luxmi Chauhan et al., 1988). Maceration studies showed a fibre length of 1.87 mm, diameter 7.2 µm, lumen width 4.6 µm, wall thickness 5.4 µm. Fibres have slenderness ratio of 259.7, flexible ratio 63.8, Runkel ratio 2.3 (Sekar and Balasubramanian - personal communication).

CHEMISTRY

Spectral absorbance values (FTIR) recorded for cellulose and lignin are 0.326 and 0.315 respectively.

USES

In Myanmar, it is used for the construction of small buildings and domestic purposes. Nagas use it for water chungas (vessels).

Dendrocalamus collettianus

Dendrocalamus collettianus Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 93. 1896; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 60. 1992. **(Fig. 28).**

DESCRIPTION

Culms, **culm-sheaths** and **leaves** unknown. **Inflorescence** a large compound panicle with spicate branchlets bearing heads of spikelets; heads 1-2 cm in diameter with 6-12 fertile spikelets and a few sterile spikelets with small ovate bracts; the rachis flexuose, pubescent, striate, joints about 2 cm in length. Spikelets 1-1.5 cm long, white pubescent, soft; fertile flowers 2-4 with 1 imperfect terminal flower; flowering glume ovate-lanceolate, shortly mucronate, pubescent, many-veined; paleas longer than flowering glume, blunt, 2-veined between the keels, with long white ciliae on the keels. Stamens exserted; anthers rather short, bluntly apiculate. Ovary narrowly ovoid, stalked, hairy, produced upwards into a narrow hairy style with club-shaped purple stigma. **Caryopsis** not known.

DISTRIBUTION

This species is a native of Myanmar. This is cultivated in Indian Botanic Gardens, Calcutta.

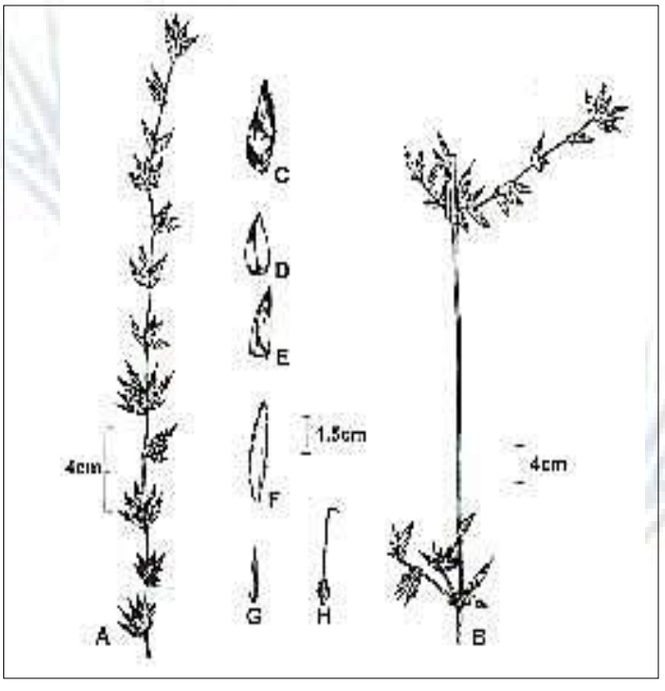


Fig. 28. **D. collettianus.** *A & B - flowering branch; C - spikelet; D - empty glume; E - flowering glume; F - palea; G - stamen; H - pistil.*

Dendrocalamus giganteus

Dendrocalamus giganteus Munro, Trans. Linn. Soc. London 26: 150. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 87. 1896; Brandis, Indian Trees 678. 1906; Tewari, Monogr. Bamboo 60. 1992. **(Fig. 29)**.

Bambusa gigantea Wall., Cat. Bot. Gard. Calcutta 79. 1829.

VERNACULAR NAMES

Assam - *Worra*; Manipuri - *Maroobob*; Sikkim - *Bhaloo bans*.

DESCRIPTION

The tallest of bamboos with close culms and slender branches. **Culms** 24-30 m tall, 20-30 cm diameter, usually 2-2.5 cm thick-walled, dull green, covered with white waxy crust when young; internodes 35-40 cm long, lower nodes with root scars. **Culm- sheaths** 30-50 cm long and broad, falling early, hard, smooth, shining within, dull yellow and covered with dark-brown hairs on the back; ligule 8-13 mm high, stiff, dark, serrate; auricles prominent, brown, crisped; blade 13-38 cm long and up to 9 cm broad, spreading at right angles, stiff, acuminate, edges inflexed. Young shoots cone shaped, pinkish brown, glabrous, glaucous green on maturity; auricles very small or absent; blades sharply pointed, generally reflexed. **Leaves** variable in size, in main culm up to 50 cm long and 10 cm broad, oblique, oblong, acuminate, smooth above, hairy beneath; petiole 3-5 mm long; ligule 2-3 mm high, serrulate; auricle small, glabrous. **Inflorescence** a huge panicle with long slender curved branchlets, bearing lax heads of few spikelets; heads upto 2.5 cm diameter, rachis joints 1.2-2.5 cm or more slender, hairy below, white-scurfy above, often curved, furrowed on one side. Spikelets 1.2-1.5 x 7.8 mm, minutely pubescent, somewhat flattened, ovate acute, spiny, many-flowered; empty glumes 1 to 2, ovate, mucronate, elongate; flowering glumes thin, papery, striate, many-nerved, mucronate, minutely hairy; palea of lower flowers 2- keeled and ciliate on the keels, of upper flowers usually not keeled and glabrous. Stamens with long filaments; anthers 7.5-10 mm long, acuminate at the tip. Ovary ovoid, hairy; style long, hairy, ending in a feathery purple stigma. **Caryopsis** oblong, about 7-8 mm long, obtuse, hairy above. The distinguishing features are large diameter of the culms and broad culm sheath.

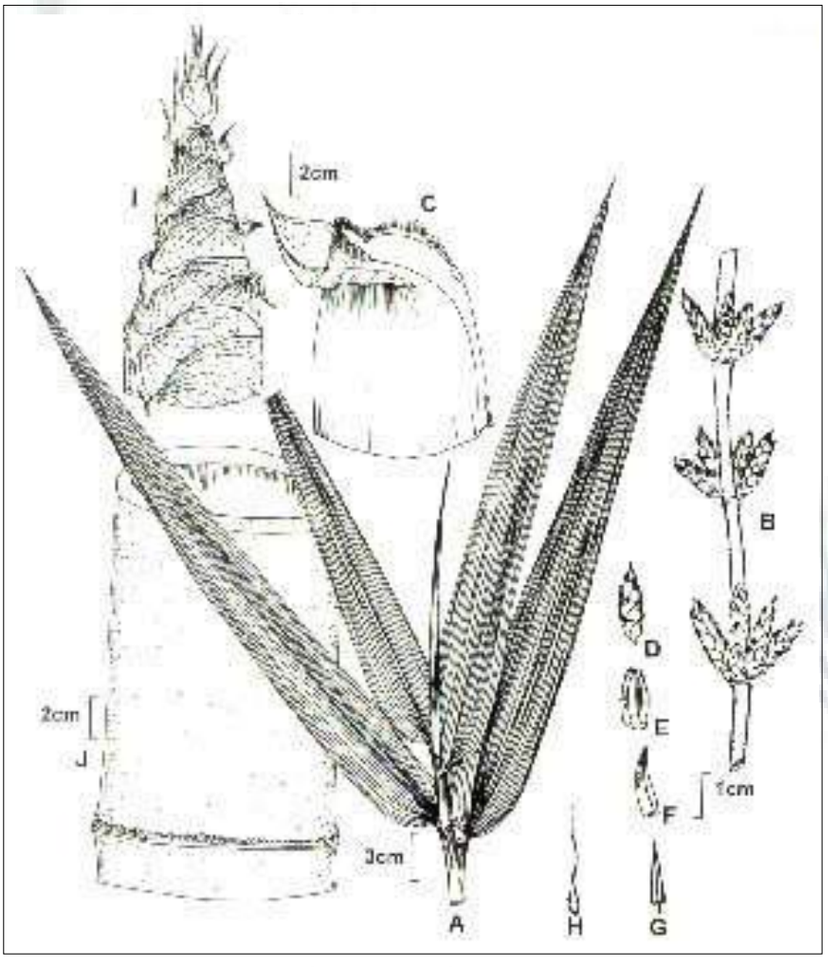


Fig. 29. **D. giganteus.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - spikelet; E - flowering glume; F - palea; G - stamen; H - pistil; I - young shoot; J - a portion of culm.*

Chromosome number 2n = 72, hexaploid (Sobita Devi and Sharma, 1993).

➤ **D. giganteus** - *Basal part of clump*

⮟ **D. giganteus** - *A clump*

FLOWERING

Flowering has been reported from Kurseong Division of West Bengal during 1880-88. Flowering cycle is reported to be about 40 years. From North-Eastern India flowering was reported during 1974 and 1981-82.

DISTRIBUTION AND ECOLOGY

Distributed in India and Indonesia. It is a native of Myanmar and cultivated in Arunachal Pradesh, Assam, Manipur, Nagaland and West Bengal; occasionally in other parts of the country. Plantations were raised in Kurseong Division in 1880-1888; introduced to Coorg between 1913-1924. *D. giganteus* is found associated with teak (*Tectona grandis*). Moist hill slopes and flat lands with rich loam soil are suitable for the growth of this species and it is found growing up to an altitude of 1200 m.

ANATOMY AND FIBRE CHARACTERISTICS

In the culm internode, epidermis is single-layered with thick-walled cells followed by a single layer of sclerenchymatous hypodermis. Cortex 6-8 layered parenchyma cells. Fibre strands absent. Vascular bundles of type IV. Protoxylem cap present at the inner region. Isolated fibre strands absent in the inner region. Inner lining of the cavity of 6-8 layered thick-walled parenchyma, 5-6 layers of sclereids and one layer of thin walled parenchyma cells. Three types of fibres, very thick, thick and thin-walled present. Septate fibres absent. Fibre tips pointed, blunt or forked and wall lamellation 4-7 layered (Sekar and Balasubramanian - personal communication). Stomata common in leaf epidermis, arranged in two bands, in 1-5 alternate rows, subsidiary cells high-domed to triangular, surrounded by globose to elliptical papillae. Long cell medium and broad, walls sinuous, width uniform, ends straight. Papillae scattered and globose. Interstomatal cells short and broad, walls sinuous, ends concave. Papillae scattered. Short cell solitary and paired, costal and intercostal. Cork cells costal not distinct, intercostal distinct; silica cells costal common, intercostal infrequent. Silica bodies costal,

saddle-shaped to acute angled, intercostal dumbbell-shaped to 8-shaped. Prickles costal and intercostal common with round base and short pointed apex, base containing vitreous silica and surrounded by a ring of papillae. Microhairs frequent, costal infrequent, intercostal common, bicelled, basal and apical cells equal, basal cell containing, vitreous silica, apex round to tapering. Microhairs absent (Luxmi Chauhan et al., 1988). Maceration studies showed a fibre length of 0.325 µm, diameter 19.8 µm, lumen width 10.7 µm, wall thickness 5.0 µm. Slenderness ratio 117.4, flexibility ratio 54.0, Runkel ratio 0.9.

CHEMISTRY

Spectral absorbance value (FTIR) recorded for cellulose and lignin are 0.294 and 0.284 respectively (Sekar and Balasubramanian - personal communication). Fermented succulent shoots are reported to be rich in phytosterols. About 1.6 to 2.81 per cent sterols are reported (Srivastava, 1990).

SILVICULTURE

Culm cuttings planted in polyethylene or a fibre-glass tent gave 45-56 per cent rooting. Pre-rooted, pre-rhizomed branch cuttings are good planting materials. Propagation by tissue culture is reported. Multiple shoots were obtained from the nodes of non-flowering clumps in MS medium at 25°C, 16 hour photoperiod. Callusing was also observed when leaves are used as explants (Zamora, 1994). Preliminary plantation trials are reported from Orissa by the Forest Department. Genetic improvement work has been initiated in Arunachal Pradesh. In Taiwan, this species gave an annual yield of 20 to 30 t/ha. The yield was 2.7 times more than that of native *Dendrocalamus latiflorus*. Sometimes clumps may build up a mound by newer rhizomes piling upon older, often dead ones. The species comes up in tropical and subtropical moist areas of India, produces good amount of biomass and is easy to harvest. It is one among the twelve high yielding bamboos worth raising as a large scale plantation as it is very good for paper and its young shoots are good for vegetable products (Uppin, 1980). Observations on growth of new culms showed that development started by August and was completed by November. Growth was slow initially. Faster growth was recorded during the night (Osmaston, 1918).

PESTS AND DISEASES

Attack of bamboo pit scale insect, *Asterolecanium coronatum* and *A. longum* has been observed. The nymphs of the scale insects feed on sap. Emerging culm mortality has been observed from Bangladesh (Banik, 1983).

NATURAL DURABILITY AND PRESERVATION

It has been reported that mud submersion treatment can increase the durability of bamboo culms against the fungus, *Pycnoporus sanguineus* (Suhirman and Khusniati, 1987). Seasoning and preservation in round form can prevent cracking, splitting, fungal decay, discolouration or insect attack after giving an anti-shrink-cum antiseptic treatment to the green, freshly felled bamboo. Polyethylene glycol (PEG) in combination with other chemical preservatives such as boric acid 2 per cent by weight and sodium pentachlorophenate (1:1) are used as antishrink agents (Sharma et al., 1972).

USES

In North-Eastern States of India the culm is used for building purposes, boat masts, vases, buckets, and various other decorative purposes. In Siang District of Arunachal Pradesh, Abors and Mishmis mainly use this bamboo as water pitchers. Young shoots of this species are used for the preparation of many delicacies in Manipur. Guha et al., (1975) after conducting pulping experiments on this species have concluded that the raw material is better than that of *D. strictus* for paper-making.

Dendrocalamus hamiltonii

Dendrocalamus hamiltonii Nees and Arn. ex Murno, Trans. Linn. Soc. London 26: 151. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 84. 1896 and in Hook. f., Fl. Brit. India 7: 405. 1896; Camus, Les Bambusees 154. 1913; Bor in Kanjilal, Fl. Assam 5: 9.1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 63. 1992. **(Fig. 30).**

◄*Fig. 30.*
D. hamiltonii.
A - leafy branch; B - culm with branches; C - single branch; D - culm-sheath; E - a portion of leafy branch; F - flowering branch; G - spikelet; H - flowering glume; I - palea of lower flower; J - palea of uppermost flower; K - stamen; L - pistil.

DESCRIPTION

A large caespitose bamboo sometimes growing tall and erect often culms at an angle or curved downwards. **Culms** large, 12-20 m or up to 25 m tall, usually naked below, much branched above, 10-18.5 cm diameter, grayish-white when young with dense appressed pubescence, dull green when old; lower nodes marked with root scars; internodes 30-50 cm long, wall ca, 1.2 cm thick. **Culm-sheaths** long and stiff, variable in size, those of the lower part of large culms 35-45 cm long and ca. 20 cm broad, glabrous, shining within, rough and glabrous or with scanty patches of stiff brown hairs on outer side, truncate at the tip; imperfect blade about three-fourths the length of the sheath, often 30 cm long, ovate-lanceolate, sides incurved, glabrous on outer surface closely covered with black hairs at the base of the inner surface; ligule smooth, entire. **Leaves** variable, small on side branches, but on new shoots reaching 37.5 cm long and 3.75 cm broad, rounded at the base into a short thick petiole, broadly lanceolate, ending in an acuminate scabrous twisted point, smooth above, rough beneath, finely serrate on the margins; leaf-sheaths covered with white appressed stiff hairs on outer surface, glabrous inside, shining on the callus, somewhat keeled; ligule long, oblique, truncate. **Inflorescence** a much branched large panicle with many whorls of branches, bearing half-verticillate semi-globular heads of purple

▼**D. hamiltonii** - *An internode*

flowers supported by round scarious bracts; rachis joints 2.5 cm long or less, thick, fistular, scabrous and white pruinose; heads variable, 1.7-3.2 cm diameter. Spikelets purple, ovoid, depressed, ca. 10 mm long, glabrous; empty glumes usually two, short, rounded, nerved; lemmas broad, orbicular, somewhat recurved, ciliate on the edges; paleas of lower flowers 2-keeled, ciliate on the keels and bifid at the acute apex, many-nerved. Stamens exserted, pendulous; anthers purple, connective produced into a long black hairy twisted point. Ovary sub-orbicular, hairy; style long, hairy; stigmas 3, plumose. **Caryopsis** broadly ovoid, beaked, glabrous or hairy above.

The distinguishing features of this species are brown pubescent culm with bent top in mature culms, root verticils are seen in almost all the nodes of the culm; largely broad ovate branch buds; zig-zag internodes in some culms (Alam, 1982).

Chromosome number 2 n = 70, aneuploid (Sobita Devi and Sharma, 1993).

FLOWERING AND FRUITING

In this species, the flowering cycle is reported to be 30-40 years. Flowering is reported from Assam in 1905, 1912, 1956, 1981-82 and from Punjab in 1992. The entire clump flowers profusely and dies soon after seeding. The embryological studies have shown that the ovule is hemianatropus, pseudocrassinucellate, bitegmic. The integuments do not cover the nucellus completely, thus no micropyle is formed. The nucellar epidermis is unilayered except at the micropylar end where two or four cells divide periclinally to form a two to four-layered tissue. The embryo sac development is of the polygonum type. Endosperm free nuclear at the beginning and later becomes cellular. The meristematic activity is restricted to the outermost two to four layers of cells, which by mitotic division add to the bulk of endosperm tissue. The outermost two to four layers of the cellular endosperm are made up of rectangular cells with prominent nucleus and are devoid of starch. This constitutes aleurone tissue. Fruit wall development is similar to that of *Bambusa tulda*. Embryotegmium is clear (Harigopal and Mohan Ram, 1987).

DISTRIBUTION AND ECOLOGY

This species is distributed in the North-West Himalaya, Sikkim, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. It is also distributed in Bhutan and Bangladesh. Generally cultivated in other parts of India. This species occurs in finer textured soil in semi-evergreen forests in lesser rainfall area. It is known to be a light demanding early successional species after shifting cultivation in the Himalayas. A deciduous type and produces larger total leaf area in the early part of growth. It helps to conserve potassium during Jhum cultivation. Architectural design and branching pattern was found suitable to capitalise high light regime (Rao and Ramakrishnan, 1988).

ANATOMY AND FIBRE CHARACTERISTICS

Culm epidermis consists of rectangular cells with sinuous walls. Papillae scattered and stomata overarched by papillae. Microhairs cylindrical, bicellular, hairy with bladders. Internodal cortex homogeneous with thin walled cells. Peripheral vascular bundles reduced. In transitional vascular bundles, only xylem or both xylem and phloem caps distinct. Central vascular bundles possess six fibre groups each (Pattanath and Rao, 1969). In leaf epidermis stomata common, arranged in two bands in 1-2 alternate rows, subsidiary cells triangular, covered by large elliptical papillae. Long cells long and narrow with uniform width, walls sinuous, ends almost straight, papillae large globose, in a row in the middle. Intercostal cells long and narrow, walls sinuous, ends concave. Papillae large, globose. Short cells solitary and paired, costal and intercostal. Cork cells costal inconspicuous, intercostal distinct, silica cells costal common, intercostal frequent. Silica

bodies costal, acute angled, intercostal dumbbell-shaped. Prickles common with round base and short pointed apex, base surrounded by a ring of papillae. Microhairs frequent, bicelled, basal and apical cells equal, apex tapering. Macrohairs common, costal and intercostal, long unicellular, base raised, surrounded by a ring of papillae (Luxmi Chauhan et al., 1988). Maceration studies have shown that the average fibre length is 3.36 mm and diameter 13.78 µm.

CHEMISTRY

The nutritive value of leaves as fodder shows seasonal variation. In July-August, leaves contained dry matter 40.9 per cent, crude protein 22.6 per cent, ether extract 4.04 per cent, grade fibre 33.12 per cent, nitrogen free extract 29.12 per cent, total ash 11.12 per cent, soluble ash 7.26 per cent, calcium 0.82 per cent, phosphorus 0.23 per cent, tannins 0.40 per cent, *in vitro* digestible dry matter 41.7 per cent (Negi et al., 1980). Proximate chemical analysis of culm showed percentages of 1.80 silica, 0.44 hot water solubles, 4.42 pentosan, 21.49 lignin, 26.21 cellulose, 63.26 oven dry weight. The air dry material yielded 46.4 per cent and 42.5 per cent unbleached and bleached pulp respectively. Further analysis of hemicellulose materials showed pentosans 87.5 per cent, methoxyl 1.5 per cent, xylose 91.9 per cent, arabinose 5.4 per cent, rhamnose 0.3 per cent, glucose 2.4 per cent and glucuronic acid 4.4 per cent (Rita Dhawan and Singh, 1982). Caustic soda 19 per cent, kappa no.27.4, lignin in bamboo 22.4 per cent, in pulp 3.7 per cent, pentosan in bamboo 16.9 per cent, in pulp 16.1 per cent, pulp yield 56.6 per cent in unscreened and 54.2 per cent in screened (Singh et al., 1976).

SILVICULTURE AND MANAGEMENT

Presence of litter enhances seedling regeneration. About 153 to 210 seedlings per square meter were observed and one and two year old seedlings recorded a height of 12 and 18 cm respectively. The species can be multiplied from seedlings by separating the tillers (Adarsh Kumar et al., 1992). This also can be propagated easily by rooting culm cuttings using growth regulators (Nath et al., 1986). For rooting of culm cuttings basal ten nodes of less than one year old culms were found ideal (Sharma and Kaushal, 1985). About 70 per cent of rooting was obtained with culm cuttings in Nepal. Horizontal planting was found better than vertical planting. Silvicultural studies and germplasm establishment has been undertaken in Arunachal Pradesh (Beniwal and Singh, 1988). Suggested felling cycle is four years. The culms that are three-year-old or above are cut from the clumps (Prasad, 1948). The clump should be worked within 6-7 years. Cuttings should be done from inside of the clump at a height of 30 cm above ground leaving only one node. Congested clumps should be clearfelled, leaving 4-5 new culms (Dubey, 1991). This is one of the twelve species of bamboos recommended for large scale planting (Uppin, 1980). Also suggested for wasteland development in Himachal Pradesh with a projected net profit of Rs.33,776/ha (Chauhan et al., 1992).

PESTS AND DISEASES

Infestation with aphids was noticed on the stem (Gupta, 1988). Attack by *Oregma bambusae* was also seen. Chlorosis caused by *Paecilomyces lilacinus* was reported from North-East India (Deka et al., 1990).

USES

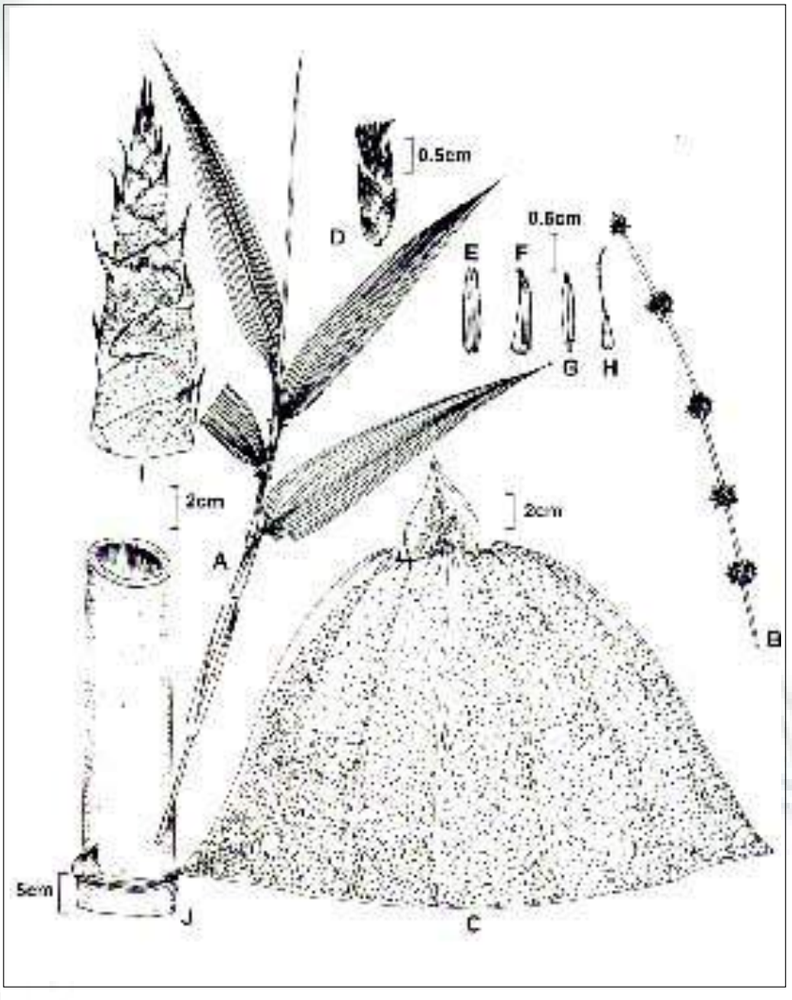
The species is used for walls of native huts, construction purposes, basket-making, mats, water and milk vessels, fuel, floats for timber-rafts. The tribals of Arunachal Pradesh use the tender shoot for preparation of ‘hiyup’, a sour pickle. Recently, it was observed that the skin of this bamboo can be used in cottage industry for binding and caning of chairs (Kabir et al., 1993b).

Dendrocalamus hookeri

Dendrocalamus hookeri Munro, Trans. Linn. Soc. London 26: 151. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 83. 1896; Brandis, Indian Trees 677. 1906; Bennet and Gaur, Thirty Seven Bamboos Growing in India 55. 1990; Tewari, Monogr. Bamboo 66. 1992. **(Fig. 31)**.

VERNACULAR NAMES

Assam - *Seiat, Sejsai, Sijong, Ukotang, Ussey*; Jaintia - *Siejong*, Khasi - *Denga*; Lepcha- *Patu*; Manipur - *Ooei*; Nepal - *Tili bans*.



▲ *Fig. 31.* **D. hookeri.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - spikelet; E - palea of lower flower; F - palea of uppermost flower; G - stamen; H - pistil; I - young shoot; J - a portion of culm.*

DESCRIPTION

A large tufted bamboo. **Culms** 15-20 m high, 10-15 cm diameter, dark green, usually naked below, curving branches above, with many long internodes 40-50 cm long, rough, hairy; walls ca. 2.5 cm thick. **Culm-sheaths** 20-30 cm long, ca. 40 cm broad at the base; sheaths of upper nodes narrower, densely covered with black or brown hairs outside, glabrous inside; ligule 5-8 mm high, glabrous, serrate; auricles 2, small, rounded, with long stiff ciliae; blade 8-18 cm long, triangular cuspidate, hairy above. Young shoots covered with black tomentum, blade stiff and pointed with long bristles at the margins. **Leaves** large, oblong-lanceolate, with a long acuminate tip, smooth above, rough below, hairs scattered near the base, scabrous on the margin, base oblique and rounded, short-stalked; leaf-sheath striate. **Inflorescence** a large compound panicle bearing at intervals of 5-7 cm, dense globular heads of spikelets of ca. 2.5 cm diameter. Spikelets 7.5-10 mm long and 2.5 mm broad, ovate, acute, minutely pubescent; empty glumes 2, ovate, blunt; fertile flowers 2 to 3; flowering glumes ovate, acute, with

many veins and frequent transverse veinlets, the upper most mucronate; palea of lower flowers 2-keeled, acute, ciliate on the keels, hardly veined between, that of upper flower not or only slightly keeled and ciliate at tip. Stamens little exserted; anthers long, ending in a penicillate point. Ovary narrowly ovoid, acuminate, hairy, surmounted by a hairy style and ending in a twisted plumose stigma. **Caryopsis** not known.

FLOWERING

Flowering is reported from Khasi Hills in 1850, in Nainital (U.P.) during 1980-81, in Shillong in 1966. A few clumps were seen in flower in 1982 in East-Khasi Hills.

DISTRIBUTION

The species is found distributed in the hills from 600 to 1500 m altitude in Arunachal Pradesh, Nagaland, Mizoram, Meghalaya, North Bengal, Sikkim and Manipur. Widely cultivated in Shillong. Introduced in Nainital before 1881, also planted in Garhwal. Cultivated in Indian Botanic Gardens, Calcutta.

ANATOMY

Stomata common in leaf epidermis, arranged in 1 or 2 bands in 1-4 or 1-10 alternate rows, subsidiary cells triangular, surrounded by large globose to elliptical papillae. Interstomatal cells short and narrow with sinuous walls, papillae prominent, scattered. Short cells solitary and paired, costal and intercostal. Cork cells costal inconspicuous, intercostal distinct. Silica cells costal common, intercostal infrequent. Silica bodies costal, saddle-shaped to dumbbell-shaped, intercostal dumbbell to '8' shaped. Prickles common, intercostal with round base and short to long pointed apex, base raised, surrounded by a ring of papillae. Microhairs frequent to infrequent, bicelled, apical cell shorter than the basal cell, apex tapering. Macrohairs infrequent, medium, unicellular, base raised, surrounded by a ring of papillae (Luxmi Chauhan et al., 1988).

SILVICULTURE

This species can be propagated vegetatively using culm cuttings and about 70-84 per cent rooting is reported.

USES

The culm is used for construction purposes and for making baskets and buckets.

Dendrocalamus longispathus

Dendrocalamus longispathus Kurz, For. Fl. Brit. Burma 2: 561. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 89. 1896; Brandis, Indian Trees 677. 1906; Bennet and Gaur, Thirty Seven Bamboos Growing in India 57. 1990; Tewari, Monogr. Bamboo 69. 1992. **(Fig. 32)**.

VERNACULAR NAME

Tripura - *Rupai*.

▲ **D. longispathus** - *New shoot*

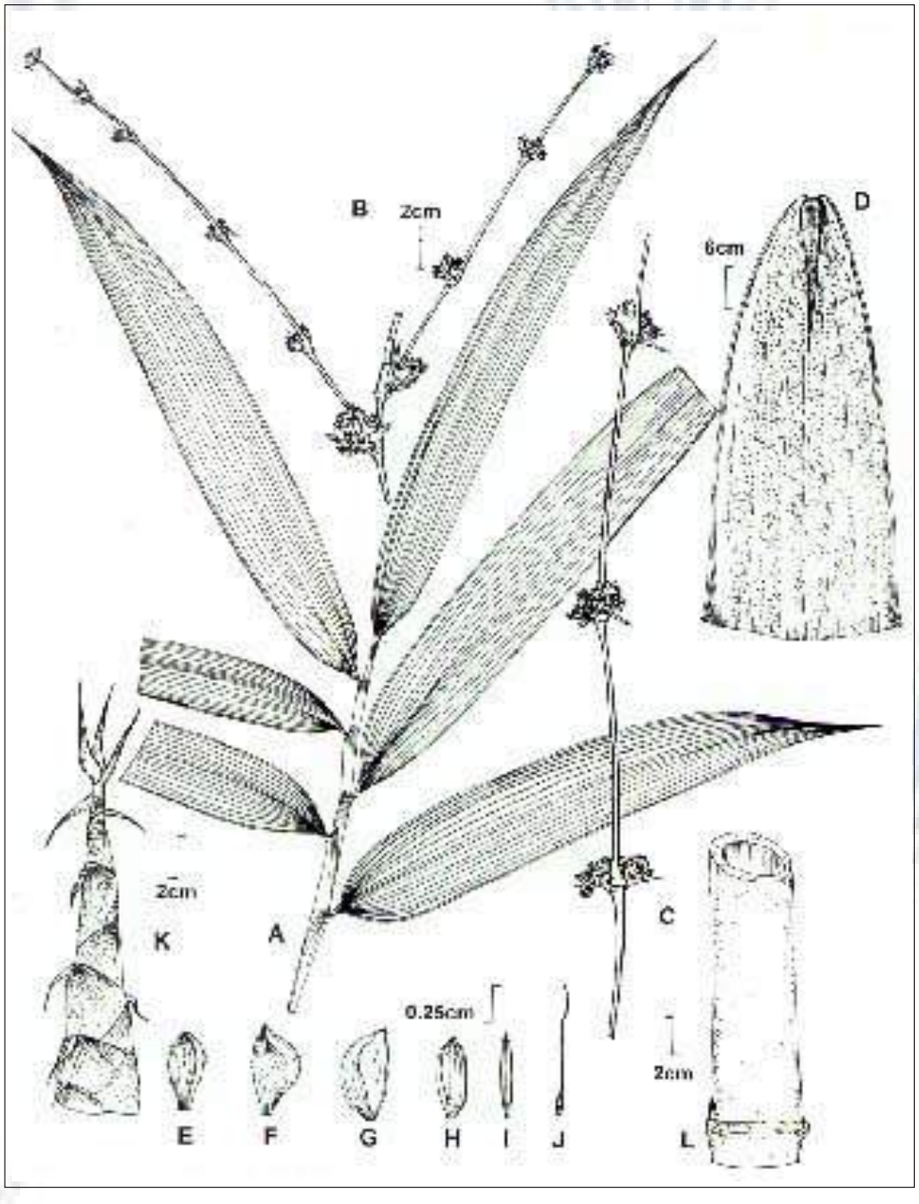
◀ **D. longispathus** - *A clump*

▼ **D. longispathus** - *In flower*

DESCRIPTION

A large tufted bamboo. **Culms** usually 10-18 m high, glaucous green when young, grayish-green on maturity; nodes slightly swollen, often rooting; internodes 25-60 cm long, 6-10 cm diameter, covered by long papery remnants of sheaths and dark-brown pubescence, walls ca. 1.2 cm thick. **Culm-sheaths** 35-50 cm long and 10-20 cm broad, inner surface glabrous and outer surface clothed densely with patches of stiff dark-brown hair; margin light straw-coloured in the upper half; ligule broad, much serrate or often long fimbriate; auricles usually absent,

sometimes very small on one side; blade 25-40 cm long and 2.5-3.5 cm broad, lanceolate-acuminate, recurved. Young shoots spear-shaped. **Leaves** 10-30 cm long and 2.5-4.5 cm broad, oblong-lanceolate to linear-lanceolate, acuminate, short-stalked margins rough; leaf-sheath ligulate, covered with brown pubescence, margin ciliate. **Inflorescence** a large panicle of interruptedly spicate clusters of spikelets, sometimes leafy rachis flexuose, flattened on alternate sides 1.3-3.8 cm between clusters, glaucous-green, sometimes rough. Spikelets in heads, sometimes few-flowered blunt, nearly glabrous, 5-7.5 mm long; empty glumes 2-3, obovate, blunt, with short rachillae between; flowers 2-3 fertile; flowering glume blunt, obovate, cucullate, ciliate on the edges, many-nerved; palea oval, truncate, faintly keeled, 2-nerved between the keels, faintly pubescent. Stamens short; anther yellow, short, ending in a black mucronate point; filaments short. Ovary broadly ovoid, somewhat acute, hairy, ending in a rather short style and short purple stigma. **Caryopsis** ovoid, somewhat oblique, yellow, surmounted by a beak formed by the base of the style.



The distinguishing vegetative features are long papery culm-sheath with depressed sinuous top covering almost the whole internode and the young shoot with reflexed blades. (Alam 1982).

Chromosome number 2n = 48 aneuploid (Sobita Devi and Sharma, 1993).

◄*Fig. 32.* **D. longispathus.** *A - leafy branch; B & C - flowering branch; D - culm-sheath; E - empty glume; F & G - flowering glumes; H - palea; I - stamen; J - pistil; K - young shoot; L - a portion of culm.*

FLOWERING AND FRUITING

Flowering has been reported from Bangladesh during the years 1876, 1879, 1880, 1885, 1930 and 1977-79, from Myanmar during 1862, 1871, 1875, 1887, 1891, 1912 and 1913. Flowering was observed in the clumps planted at Nilambur and Wynad (Kerala) in 1990. Embryological studies have shown that the ovule, embryosac, endosperm and fruit wall development is similar to that of *Dendrocalamus hamiltonii* except that the cells of the fruit wall are thick and round. The position of the embryo cannot be made out from the surface (Harigopal and Mohan Ram, 1987).

DISTRIBUTION

This species is distributed in Mizoram and Tripura and generally found in the village area of Dhalbhum tract of Singhbum District of Bihar. This species has been introduced to Orissa and Western Peninsula. It is cultivated in Calcutta and Malabar. Also reported from Bangladesh and Myanmar.

ANATOMY AND FIBRE CHARACTERISTICS

In the culm epidermis, long cells rectangular with straight walls, papillae in small groups, stomata overarched by papillae, microhairs spiculate. Internodal cortex thick-walled with peripheral vascular bundles. In transitional vascular bundles both the caps and sheaths fused, central vascular bundles with both five and six fibre groups, lining of the cavity parenchymatous. In leaf epidermis stomata common, arranged in two bands in 1-2 alternate rows, subsidiary cells triangular to high domed surrounded by a ring of papillae. Interstomatal cell long to short and narrow to broad with sinuous walls, papillae in a row in the middle. Long cells long and narrow of uniform width, ends almost straight, papillae in a row in the middle. Short cells solitary and paired, costal and intercostal, intercostal generally obscured by prickles. Cork cells costal not distinct, intercostal distinct; silica cells costal common, intercostal infrequent. Silica bodies costal saddle-shaped to acute, intercostal dumbbell-shaped to '8' shaped. Prickles common, intercostal with round base and short to long apex, base containing vitreous silica surrounded by a ring of papillae. Microhairs frequent, intercostal bicelled, basal and apical cell equal, apex tapering or round. Macrohairs infrequent to frequent, costal, base raised, surrounded by a ring of papillae (Luxmi Chauhan et al., 1988). The average fibre length is 3.5 mm, fibre diameter 16.25 µm, lumen diameter 5.83 µm, wall thickness 5.26 µm, parenchyma 18.3 per cent.

CHEMISTRY

Proximate chemical analysis of culm gave ash 2.45 per cent, silica 2.03 per cent, hot water solubles 5.07 per cent, pentosan 19.76 per cent, lignin 24.54 per cent and cellulose 62.96 per cent. Yield of kraft pulp 62.0, unbleached pulp 45.3 and bleached pulp 41.3 per cent. Chemical composition of bamboo and pulp showed caustic soda 20 per cent, kappa number 25.2, lignin in bamboo 25 per cent, lignin in pulp 3.9 per cent, pentosan in bamboo 18.6 per cent, pentosan in pulp 15.8 per cent, screened yield 48.4 per cent, for unbeaten sheaths breaking length 1450 m. Burst factor 4.2, tear factor 70.1. For beaten sheaths breaking length 7360 m, burst factor 52 and tear factor 164.70.

SILVICULTURE AND MANAGEMENT

About 1,34,880 to 1,35,320 seeds weighed one kg. The seeds recorded a diameter of about 0.19 cm. During gregarious flowering, one culm produces about 40-90 g seeds. Seeds may be sown in boxes and beds under cover. When seeds are sown in a petri dish and polythene bags, 50 and 33 per cent germination is observed respectively. Germination started from second day onwards and was completed in 8 days. The seeds are viable for about 60 days (Banik 1987). The seedlings with 120-150 cm height are transplanted to 45 cm cube pits at a distance of 60 cm. The species can be propagated by rhizome as well. Vegetative propagation by two-nodded culm cuttings treated with NAA and IBA gave

good rooting response. Cuttings after filling with 200 ppm aqueous solution of NAA is planted horizontally in nursery beds. 50-70 per cent rooting is obtained depending on the season and age (Seethalakshmi, 1991). Cutting cycle of 3 years is recommended with usual selection methods adapted for other bamboos (Prasad, 1948). This is one of the high yielding species recommended for large scale planting (Uppin, 1980).

PESTS AND DISEASES

Attack by *Oregma bambusae* has been observed in this species. About 21.4 per cent emerging culm mortality is reported (Banik, 1983). Culm rots caused by *Fusarium equiseti* , leaf rusts caused by *Dasturella divina, Puccinia* sp. and leaf spots caused by *Dactylarla* sp. have been reported.

PHYSICAL AND MECHANICAL PROPERTIES

A study on the effect of age and height on strength properties showed that the culms attain maturity at the age of 3.5 years in respect of compressive and bending strength. The top portion is found to be the strongest for compressive strength and modulus of elasticity, while bottom shows the highest ultimate strength (Kabir et al., 1993a).

USES

This species is generally used for the manufacture of paper. In Tripura it is used for making basket and containers. This is found as an ideal material for the manufacture of good quality tooth picks. This being an elegant species is grown in gardens.

Dendrocalamus membranaceus

Dendrocalamus membranaceus Munro, Trans. Linn. Soc. London 26: 149. 1868; Kurz, For. Fl. Brit. Burma 2: 560. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 81. 1896; Brandis, Indian Trees 676. 1906; Bennet and Gaur, Thirty Seven Bamboos Growing in India 59. 1990; Tewari, Monogr. Bamboo 69. 1992. **(Fig. 33)**.

DESCRIPTION

A moderate-sized, strong bamboo forming loose clump. **Culms** straight, 20-24 m high, 6-10 cm diameter covered with white powdery deciduous scurf when young, green on maturity; nodes strongly ringed, basal ones with rootlets; internodes 22-38 cm long; upper branches slender, leafy, drooping. **Culm-sheaths** 30-50 cm long and 12-20 cm broad, glabrous outside or with appressed dark-brown hairs, narrowed upwards; ligule ca. 5 mm high, dentate; auricles 2, wavy, fringed; blade 25-40 cm long and 2-3 cm broad, tapering. **Leaves** 12-25 cm long and 1.5-2.5 cm broad, hispid above, hairy on the midrib beneath, margins scabrous, apex acuminate, base attenuate into a short petiole; leaf-sheath striate; ligule very short, hairy; auricles falcate with long ciliae. **Inflorescence** a large compound panicle with distant globular heads, 2.5-5 cm apart, rachis glabrous or often white-pruinose in the upper part; heads 0.7 to 1 cm in diameter, spinescent. Spikelets slightly compressed, glossy, nearly glabrous, 10-13 mm long and 2.5 mm broad, with 2 to 3 fertile flowers; empty glumes 2, ovate, blunt or acute; flowering glumes ovate, often ciliate on the edges, mucronate, striate, glabrous;

DISTRIBUTION AND ECOLOGY

This species is a native of Myanmar. Cultivated in Indian Botanic Gardens, Calcutta, F.R.I., Dehra Dun and introduced in Kerala. This is one of the common species occurring in China and Taiwan. It occurs in moist forests and low lands and is found below 1000 m altitude. Also tolerates arid and barren condition. Preferred soils are laterite and black limestone.

ANATOMY AND FIBRE CHARACTERISTICS

The epidermal cells have undulating vertical walls, the end walls more or less curved in acute line. The average width is 7 µm and the length varies from 13.2 µm-82.5 µm. Cells have septa-like partitions. Usually 1-2 pairs of short cells alternate with one epidermal cell. The cork cells squarish or rectangular with silica cells mostly round. There are 2024 couples of short cells per cm^2. Spines common, solitary or replaced by silica cell, occa-

few-nerved, acute. Stamens exserted; filaments long, fine; anthers yellow, shortly apiculate. Ovary ovoid, hairy above, glabrous below, ovate, produced into a long hairy style, ending in a purple plumose stigma. **Caryopsis** broadly ovate, rounded at base, 5-7.5 mm long, grooved on one side and somewhat flattened, ending in a sharp point formed by the persistent base of the style.

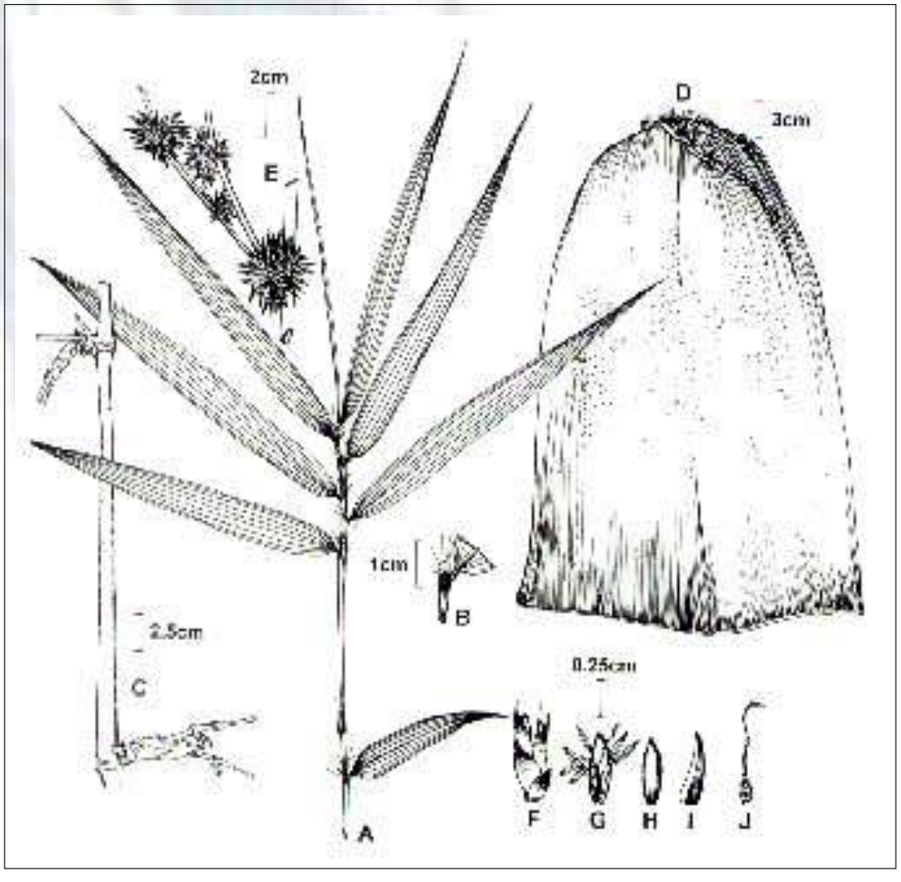
Chromosome number 2n = 46 (Sobita Devi and Sharma, 1993).

FLOWERING

Flowering has been reported in this species in 1973, 1992 and 1994 from North-Eastern India.

◀**D. membranaceus** - *Part of a clump*

▼**D. membranaceus** - *Internode and branches*



◄*Fig. 33.* **D. membranaceus.** *A - leafy branch; B - leaf-sheath; C - culm with branches; D - culm-sheath; E - flowering branch; F - spikelet; G - palea stamens and pistil; H - palea of lower flower; I - palea of upper flower; J - pistil.*

sionally in couplets of short cells. The number of stomata per microscopic field (0.17 cm^2) is about 28 (Ghosh and Negi, 1960). Culm internodal epidermis single layered with thick walled lignified cells, followed by single layered sclerenchymatous hypodermis. Cortex 3-4 layered parenchymatous. Fibre strands absent in the outer region. Vascular bundles are of type IV. Protoxylem cap at the inner region present. Isolated fibre strands absent in the inner region. Inner cavity lined with 4-5 layered sclereids and 1-2 layered thin-walled parenchyma cells. Culm macerates show very thick, thick and thin-walled fibres. Septate striate fibres are seen. Fibre tips pointed, wall lamellation 4-10 layered. Fibre dimension 2489 µm, diameter 9.7 µm, lumen width 5.1 µm, wall thickness 7.8 µm. Studies of the fibres have shown that this species has slenderness ratio of 256.5, flexibility ratio 52.5, Runkel ratio 3. (Sekar and Balasubramanian - personal communication). Stomata common in leaf epidermis, arranged in one band of 1-5 alternate rows, subsidiary cells triangular to high domed surrounded by papillae. Interstomatal cells long and narrow of uniform width, wall sinuous, ends straight to concave; papillae scattered. Long cells long and narrow, walls sinuous, ends straight, papillae scattered, prominent. Short cells solitary and paired, costal and intercostal. Cork cells costal not distinct, intercostal distinct. Silica cells costal common, intercostal frequent. Silica bodies costal saddle-shaped, intercostal dumb-bell shaped. Prickles common, with round base and short pointed apex, surrounded by a ring of papillae. Microhairs infrequent to frequent, bicelled, basal cell longer than the apical cell, apex rounded, base surrounded by a ring of papillae. Macrohairs costal and intercostal, frequent, medium in length, with raised base, surrounded by a ring of papillae (Luxmi Chauhan et al., 1988).

CHEMISTRY

Spectral absorbance value (FTIR) recorded for cellulose and lignin are 0.4 and 0.357 respectively (Sekar and Balasubramanian - personal communication).

SILVICULTURE

Seeds from FRI arboretum gave 38 per cent germination. Vegetative propagation by tissue culture method has been attempted using node, shoot, and leaves as explants at Thailand. Multiple shoots and rooting have been reported (Zamora, 1994).

PESTS AND DISEASES

Attack by *Oregma bambusae* has been reported in this species.

PHYSICAL AND MECHANICAL PROPERTIES

Moisture content is 102 and 7 per cent in green and air-dry culms respectively. Average specific gravity 0.551 and 0.664; fibre stress at elastic limit 12.4 and 17.8 N/mm^2; modules of rupture 26.3 and 37.8 N/mm^2, modulus of elasticity 2.4 and 3.7 kN/mm^2 in green and air-dry condition respectively. Compression strength parallel to grain is 40.5 N/mm2 in green (Not reported in air-dry condition).

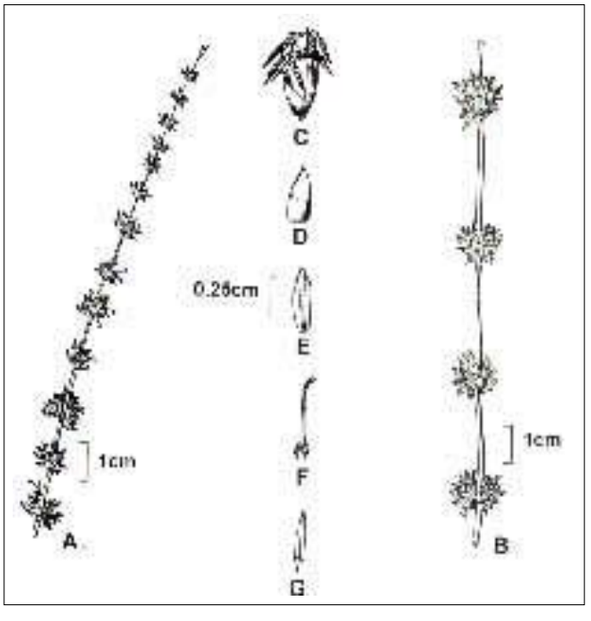
USES

This species is used for building purposes in Myanmar and Thailand. It is one of the most promising species for pulp. Kennard and Freyre (1957), after studying selected 27 bamboos belonging to 10 genera for the edibility of the shoots, considered this bamboo to be excellent from the processing point of view, as the young shoots are smooth and easy to handle. In China, it is used for making chopsticks, shreds and paper.

Dendrocalamus parishii

Dendrocalamus parishii Munro, Trans. Linn. Soc. London 26: 149. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 93. 1896 and in Hook. f., Fl. Brit. India 7: 408. 1896; Camus, Les Bambusees 156. 1913; Tewari, Monogr. Bamboo 70. 1992. **(Fig. 34)**.

Dendrocalamus hookeri Munro var. *parishii* (Munro) Blatter, Indian For. 55: 594. 1929; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980.



➤ *Fig. 34.* **D. parishii.** *A & B - flowering branch; C - spikelet; D - flowering glume; E - palea; F - pistil; G - stamen.*

DESCRIPTION

Culms, **culm-sheaths** and **leaves** unknown. **Inflorescence** a panicle of interrupted, globose, densely-flowered heads, the rachis pruinose-glaucous at the apex. Spikelets ovate, somewhat blunt, nearly glabrous, flattened 0.7-1 cm long and 0.7 cm broad, fertile flowers 2-3; glumes 1-2, ovate-acute, many-nerved, ciliate on the edges and very minutely pubescent near the apex; lemmas similar to glumes but glabrous, those of upper flowers mucronate, longitudinally and transversely nerved, ciliate on the edges paleas ovate, blunt, emarginate, 2-keeled, ciliate on the keels and edges, 2- nerved between the keels, that of uppermost flower more acute and not keeled. Stamens not exserted; anthers with the connective produced in an obtusely acute point. Ovary hairy, ovoid-globose, ending in a long style and feathery stigma. **Caryopsis** large, obovate, smooth above, beaked.

This species has been included by Gamble (1896) under imperfectly known species. The flowers are distinct from those of *D. strictus* and come nearest to those of *D. hookeri*, but differ in the glabrous flowering glume and bluntly acute anthers.

DISTRIBUTION

This species is known to be a native of Himachal Pradesh.

Dendrocalamus patellaris

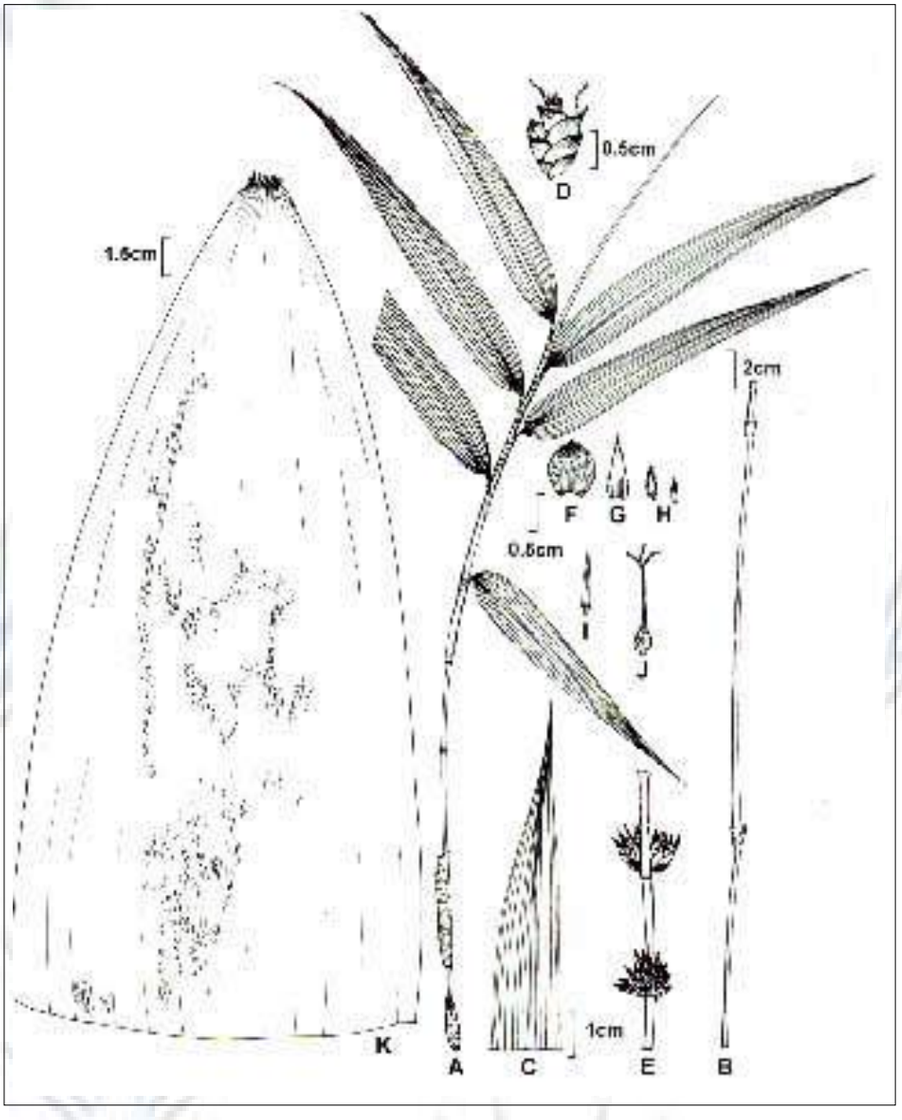
Dendrocalamus patellaris Gamble, Ann. Roy. Bot. Gard. Calcutta 86. 1896 and in Hook. f., Fl. Brit. India 7: 406. 1897; Camus, Les Bambusees 154. 1913; Bor in Kanjilal, Fl. Assam 5: 10. 1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 3. 1980; Naithani, J. Bombay Nat. Hist. Soc. 88: 141. 1991; Tewari, Mongr. Bamboo 70. 1992. **(Fig. 35)**.

VERNACULAR NAMES

Lepcha - *Pagjiok, Pagjiok-pao*, Mikir - *Footoong*.

DESCRIPTION

An evergreen, caespitose bamboo. **Culms** 7-10 m tall, 2.5-4 cm diameter, green; nodes with soft hairy rings; internodes 30-45 cm long, whitish below the nodes, thin-walled. **Culm-sheaths** 25-30 cm long and 7.5 cm broad, at the base; imperfect blade lanceolate, 15 cm long, usually recurved with fimbriate ligule. **Leaves** 20-40 cm long and 2.5-10 cm broad, oblique at the base, shortly petioled, scaberulous on the margins; leaf- sheaths fringed on the margins. **Inflorescence** a large panicle with spicate branches; heads upto 2.5 cm diameter; greenish brown. Spikelets 1 cm long, dark brown, depressed; empty glumes 1 or 2, many-nerved, membranous; florets 2-3, usually all fertile; lemmas orbicular, ciliate on the edges and densely tomentose within, 9-11-nerved; palea much shorter, ovate-lanceolate, ciliate on the keels, 2-nerved between the keels, densely tomentose within; lodicules 1 or 2, narrow, linear-lanceolate, ciliate; rachilla prolonged, bristle-like. Stamens with purple anthers, tip conical, hairy, apiculate. Ovary broadly ovate, hairy above, stigmas 3, short, plumose. **Caryopsis** rounded, shining, hairy above.



➤ *Fig. 35.* **D. patellaris.** *A - leafy branch; B - a portion of culm; C - leaf tip; D - spikelet; E - a portion of flowering branch; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil; K - culm-sheath.*

DISTRIBUTION

The species is found distributed in Uttar Pradesh, West Bengal, Sikkim, Nagaland and Arunachal Pradesh. It is found growing at an altitude of 1200-1500 m.

ANATOMY

In the leaf epidermis stomata common, arranged in two bands, 1-4 alternate rows, subsidiary cells high-domed to triangular, surrounded by papillae. Interstomatal cells long and narrow, walls sinuous, ends concave. Papillae scattered, prominent. Long cells long and narrow, walls sinuous, ends almost straight; papillae scattered, prominent. Short cells solitary and paired, costal and intercostal. Cork cells costal, not distinct, intercostal distinct; silica cells costal, common, intercostal frequent. Silica bodies costal, saddle-shaped, intercostal dumbbell-shaped. Prickles common, with round base and short to long, acute apex, base containing silica, depressed, surrounded by a ring of papillae. Microhairs infrequent, bicelled, apical cell and basal cell equal. Macrohairs infrequent to rare, with raised base surrounded, by a ring of papillae (Luxmi Chauhan et al., 1988).

USES

This species is mainly used for basket making in Nagaland. In Sikkim, it is used for making huts, flutes, straw, knife edge and arrow head (Holstrom, 1993).

Dendrocalamus sahnii

Dendrocalamus sahnii Naithani and Bahadur, Indian For. 108: 212. 1982; Tewari, Monogr. Bamboo 74. 1992. **(Fig. 36)**.

DESCRIPTION

A caespitose bamboo. **Culms** up to 3 m tall, 2-3 cm diameter, pale green, striate; internodes glabrous, 8-20 cm long. **Culm-sheaths** 15-20 cm long and 8.5-10 cm broad, glabrous and shining inside, rough with scattered stiff brown hairs outside, truncate at the top; blade 2-2.5 cm long, bifid, ovate-lanceolate; ligule dentate or fimbriate, 3-5 mm long. **Leaves** unknown. **Inflorescence** a long panicle; heads at intervals of 5-9 cm, 2-3 cm diameter, globose, glabrous, bracts scarious. Spikelets densely arranged, 8-15 mm long and 4.5-5 mm broad, empty glumes 2, ovate, keeled, nerved, ciliate on keels and margins; lemmas 10 x 8 mm, orbicular, thin, many-nerved, ciliate on the margins; palea 1 cm long, bifid or acute at the apex, 2-keeled, ciliate on the keels. Stamens 6, as long as the palea; anthers yellow with a short hairy point at apex. Ovary conical, hairy; style long; stigma single and hairy. **Caryopsis** unknown.

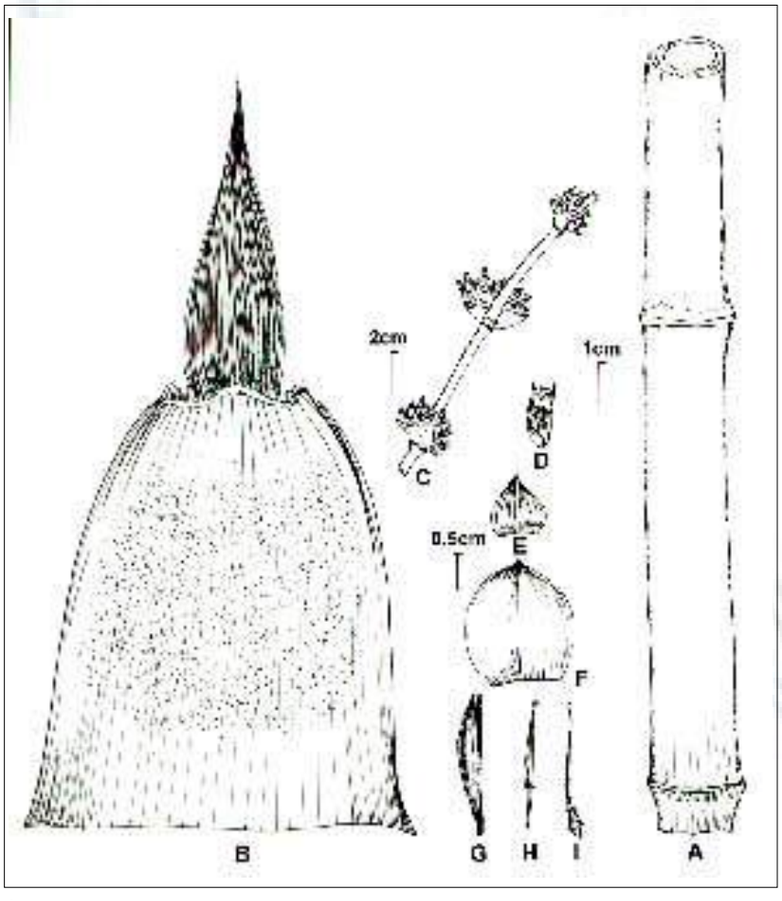


Fig. 36. **D. sahnii.** *A - a portion of culm; B - culm-sheath; C - flowering branch; D - spikelet; E - empty glume; F - flowering glume; G - palea; H - stamen; I - pistil.*

FLOWERING

This species has been reported to have flowered in 1982 for the first time from Arunachal Pradesh.

DISTRIBUTION

This species has been collected for the first time from Subansiri District, Arunachal Pradesh and is found associated with *Phyllostachys assamica* in the hills at an altitude of ca. 1800 m.

Dendrocalamus sericeus

Dendrocalamus sericeus Munro, Trans. Linn. Soc. London 26: 148. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 81. 1896 and in Hook. f., Fl. Brit. India 7: 404. 1896; Tewari, Monogr. Bamboo 74. 1992. **(Fig. 37)**.

Dendrocalamus strictus (Roxb.) Nees var. *sericeus* (Munro) Gamble, Man. Indian Timb. 751. 1902; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 3. 1980.

DESCRIPTION

A densely tufted strong bamboo. **Culms** resembling those of *D. strictus*. **Culm-sheaths** striate, long-ciliate on the edges, covered with stiff bristles and swollen bases; imperfect blade short, triangular, acute. **Leaves** lanceolate, long-acuminate, 12-35 cm long and 1.5-2.5 cm broad, usually rounded at the base into a long petiole, hairy or hispid above, hairy beneath, scabrous on the edges; midrib prominent beneath, shining, secondary veins 6-7 pairs, intermediate about 7; leaf-sheaths striate, somewhat keeled, strigosely hairy in lines down the sides, ending in a ciliate truncate callus; ligule narrow, fimbriate, serrate. **Inflorescence** a large panicle with stout branches bearing distant globular heads 3.5-5 cm apart and supported by glabrous or sparsely hairy triangular bracts. Spikelets spinescent, acute, densely silky, hairy, the fertile intermixed with many small sterile ones, 0.7-1 cm long, with 2-3-fertile flowers; glumes 2, blunt, many-nerved, densely silky on the edges and upper part outside, glabrous within; lemma ovate-acute, or ending in long sharp spines and bearded with silky hairs below; paleas acute or emarginate, lower flower 2-keeled and glabrous, uppermost flower not keeled and silky hairy at the apex. Stamens apparently little exserted; anthers yellow, bluntly apiculate and sometimes minutely penicillate. Ovary narrowly ovoid, gradually passing into a long hairy style ending in a purple plumose stigma. **Caryopsis** not known.

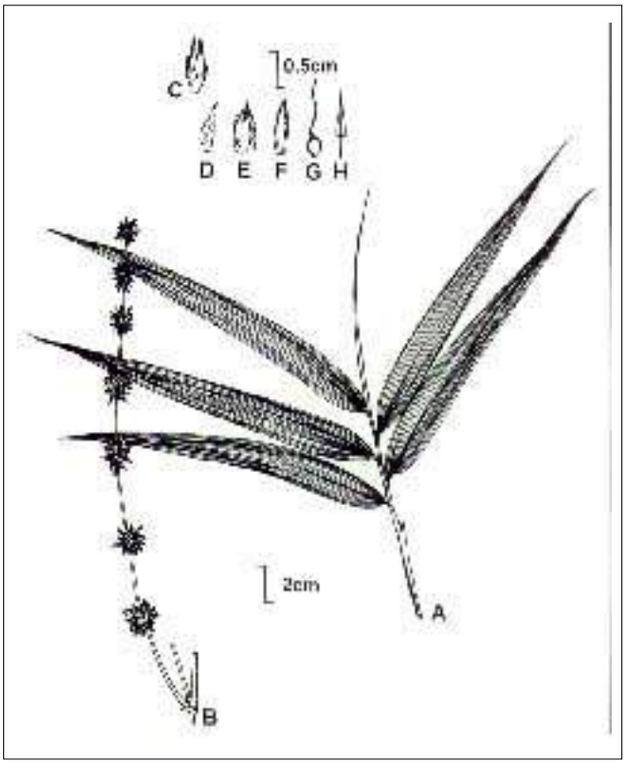
Chromosome number n = 36, 2n = 72, 60 hexaploid (Sobita Devi and Sharma, 1993).

FLOWERING

Flowering is reported from Manipur in 1987-88 (Sharma - personal communication).

DISTRIBUTION

This species is known to occur in Chota Nagpur in Bihar.



➤ *Fig. 37.* **D. sericeus.** *A - leafy branch; B - flowering branch; C - spikelet; D - empty glume; E - flowering glume; F - palea; G - pistil; H - stamen.*

Dendrocalamus sericeus

Dendrocalamus sericeus Munro, Trans. Linn. Soc. London 26: 148. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 81. 1896 and in Hook. f., Fl. Brit. India 7: 404. 1896; Tewari, Monogr. Bamboo 74. 1992. **(Fig. 37)**.

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DESCRIPTION

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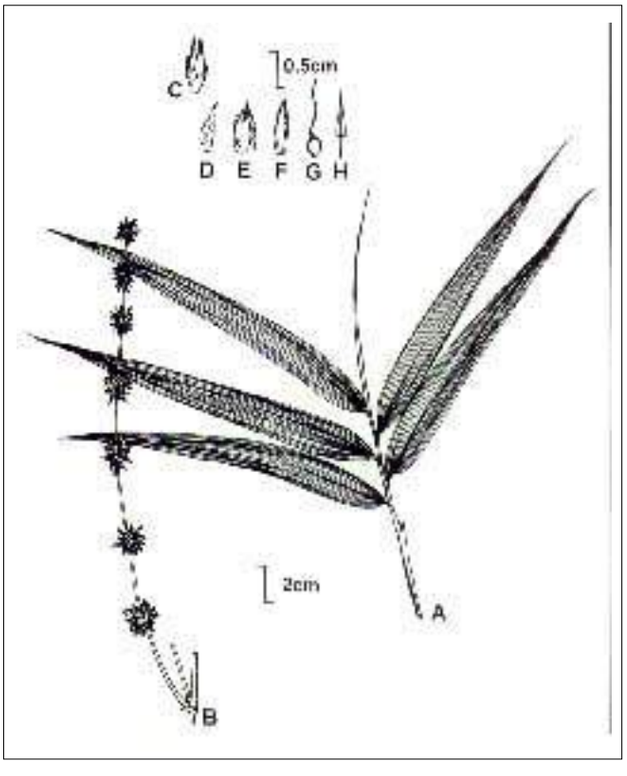
This species is known to occur in Chota Nagpur in Bihar.



➤ *Fig. 37.* **D. sericeus.** *A - leafy branch; B - flowering branch; C - spikelet; D - empty glume; E - flowering glume; F - palea; G - pistil; H - stamen.*

Dendrocalamus sikkimensis

Dendrocalamus sikkimensis Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 82. 1896 and in Hook. f., Fl. Brit. India 7: 405. 1897; Camus, Les Bambusees 15. 1913; Bor in Kanjilal, Fl. Assam 5:7. 1940. Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1):2. 1980; Tewari, Monogr. Bamboo 74. 1992. **(Fig. 38)**.

◄**D. sikkimensis** - *A clump*

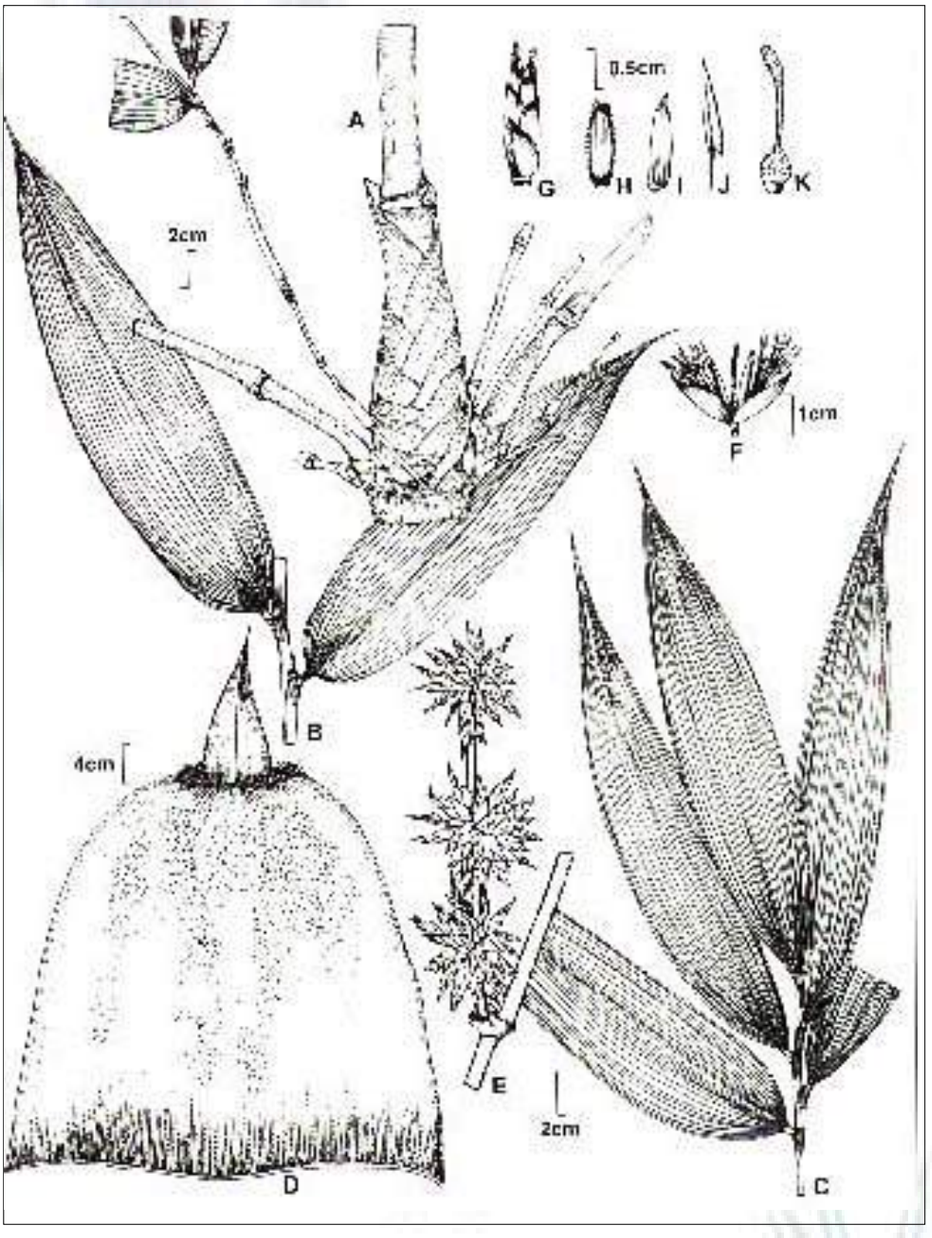
▼**D. sikkimensis** - *New shoot*

VERNACULAR NAMES

Garos - *Wadah*; Lepcha - *Pugriang*; Mizoram - *Rawami, Sangau*; Nepal - *Bhalu-bans*.

DESCRIPTION

A large bamboo with caespitose stems and few culms. **Culms** large, 17-20 m high, bare at the base, 12-20 cm diameter, dark green; internodes up to 45 cm long, rough. **Culm-sheaths** 36 cm long and 30 cm broad, densely covered with golden-brown hairs; imperfect blade lanceolate, often as long as the sheath, recurved, decurrent into two auricles fringed with pale bristles; ligule 5 mm wide, sharply serrate. **Leaves** 15-25 cm long and 3.5-5 cm broad, oblong-lanceolate, unequal at the base, tapering into a twisted point, shortly petiolate, smooth above, strigosely hirsute and rough below; leaf sheaths smooth, edges falcate, auricles fringed with stiff bristles; ligule short, fimbriate. **Inflorescence** a large panicle with stiff nodose branches bearing large red-brown globose heads; rachis dull brown, sparsely pubescent. Spikelets 1.2-2 cm long, lanceolate; empty glumes 3-4, broadly ovate, rounded with ciliate keels; fertile florets 2-3; lemmas ovate-acute, glabrous, mucronate, ciliate; palea of the lowest floret 2-keeled, hairy on the keels, many-nerved, shortly bifid. Stamens 6. Ovary sub-globular, hairy; style hairy with club-shaped stigma. **Caryopsis** obovate, depressed, apiculate, shining above with few hairs.



◄*Fig. 38.* **D. sikkimensis.** *A - culm with branches; B & C - leafy branches; D - culm-sheath; E - flowering branch; F - open spikelet; G - spikelet; H - palea of lower flower; I - palea of upper flower; J - stamen; K - pistil.*

FLOWERING AND FRUITING

Flowering in this species has been observed in Kalimpong Forest Division in 1916, 1930 and 1982. Flowering has also been reported from Mizoram during 1977-79. It has been estimated that about 123 kg seeds are obtained from one clump.

DISTRIBUTION

This species is distributed in North-Eastern India, West Bengal, Sikkim, Arunachal Pradesh, Nagaland and Meghalaya (Garo Hills). This is cultivated in Indian Botanic Gardens, Calcutta and elsewhere. It is found growing up to an altitude of 2100 m.

ANATOMY

In the leaf epidermis, stomata common, arranged in one band in 1-11 alternate rows, subsidiary cells not distinct, appear triangular due to overarching by large elliptical papillae. Long cells long and narrow with uniform width with sinuous walls and almost straight ends, few in the middle row; papillae scattered, distinct. Interstomatal cells common, similar to long cells but shorter and broader with deep concave ends. Short cells solitary and paired, costal and intercostal. Cork cells costal distinct, intercostal distinct. Silica cells costal, common, intercostal frequent. Silica bodies costal, saddle-shaped, intercostal dumbbell to crescent shaped. Prickles costal and intercostal, frequent to few, with round base and short to medium pointed apex, base surrounded by a ring of papillae. Microhairs common, bicelled, apical cell shorter than the basal cell, apex tapering. Macro hairs common, costal and intercostal, long to medium, base raised, not surrounded by papillae (Luxmi Chauhan et al., 1988).

USES

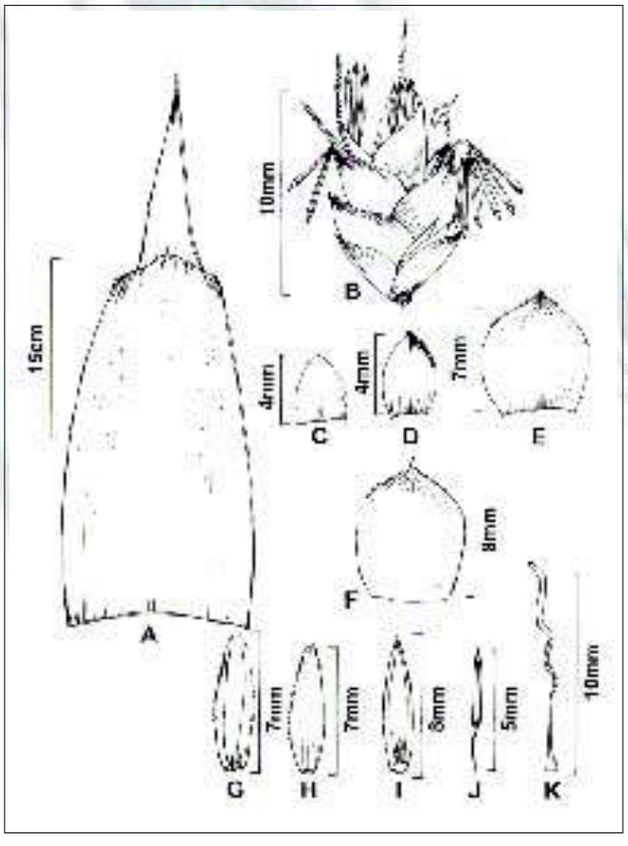
In Sikkim Himalaya, this is one of the largest bamboos preferred by Lepchas and Bhutias for making the 'Chungas' for carrying water and milk. In Sikkim, it is used for fencing, posts, huts, ropes, boxes, water pipes and as animal fodder. It also can be used for pulp and paper (Holstrom, 1993).

Dendrocalamus somdevai

Dendrocalamus somdevai Naithani, Indian For. 119: 504-506. 1993. **(Fig. 39)**.

DESCRIPTION

A caespitose bamboo. **Culms** greenish white with dense, appressed, pubescent, 12-20 m high and 6-7 cm diameter; nodes raised, internodes 15-40 cm long, 2.5-3 cm broad, thick. **Culm-sheaths** longer than internode, variable in size, 20-75 cm long, 10-32 cm broad, striate, stiff, glabrous or covered with patches of stiff blackish-brown hairs on outer surfaces, under surface shining and glabrous, convexly truncate at the apex; imperfect blade variable in size, 2.5-4.0 cm long, 1.5-8 cm broad, striate, triangular with straight sides and long acute apex, covered with blackish brown hairs near the base on under surface, ligule glabrous, 7-12 mm high with dentate margin. **Leaves** 20-30 cm long, 2-4 cm broad, broadly lanceolate, acuminate at the apex, hairy when young, otherwise glabrous, base unequally rounded, petiole thick, 3 mm long, margins, serrate; midrib prominent, raised, secondary veins 6-10 pairs, intermediate 5-7; leaf sheaths striate, shining, with deciduous stiff hairs at the mouth; ligule 1 mm high, dentate. **Inflorescence** a huge, much branched, leafless panicle, with many whorls of branchlets, bearing globular heads of greenish-purple spikelets, supported at the base by scarious rounded bracts; heads variable, 1-2.5 cm diameter; rachis fistular, scabrous and white pruinose, 2.5 cm long. Spikelets 1 cm long, 5 mm broad, ovate, broader at apex 3-4 flowered, greenish with purple tinge at apex; glumes 1-2 ovate, acute at apex, 4 mm long; lemmas 7-8 mm long and almost equally broad, glabrous, acute at apex, the upper most with a long mucro, many-nerved often with transverse veins, margins ciliate; palea as long as the lemmas, 2-keeled, ciliate on the keels, that of upper most flower not keeled, many-nerved between the keels, margins ciliate. Stamens long exserted; filaments dilated near the base; anthers purple, apiculate, tip glabrous. Ovary ovoid, hairy, tapering into a long hairy style; stigma one, plumose, often curled. **Caryopsis** not known.



◀*Fig. 39.* **D. somdevai.** *A - culm-sheath; B - spikelet; C - bract; D - glume; E & F - lemmas; G, H & I - paleas; J - stamen; K - pistil.*

FLOWERING

Flowering has been reported from Uttar Pradesh in 1991.

DISTRIBUTION

This species has been collected for the first time from Uttar Pradesh.

Dendrocalamus strictus

Dendrocalamus strictus (Roxb.) Nees, Linnaea 9: 476. 1834; Munro, Trans. Linn. Soc. London 26: 147. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 78. 1896 and Hook. f., Fl. Brit. India 7: 404. 1897; Camus, Les Bambusees 152. 1913; Bennet and Gaur, Thirty Seven Bamboos Growing in India 61. 1990; Tewari, Monogr. Bamboo. 77. 1992. **(Fig. 40).**

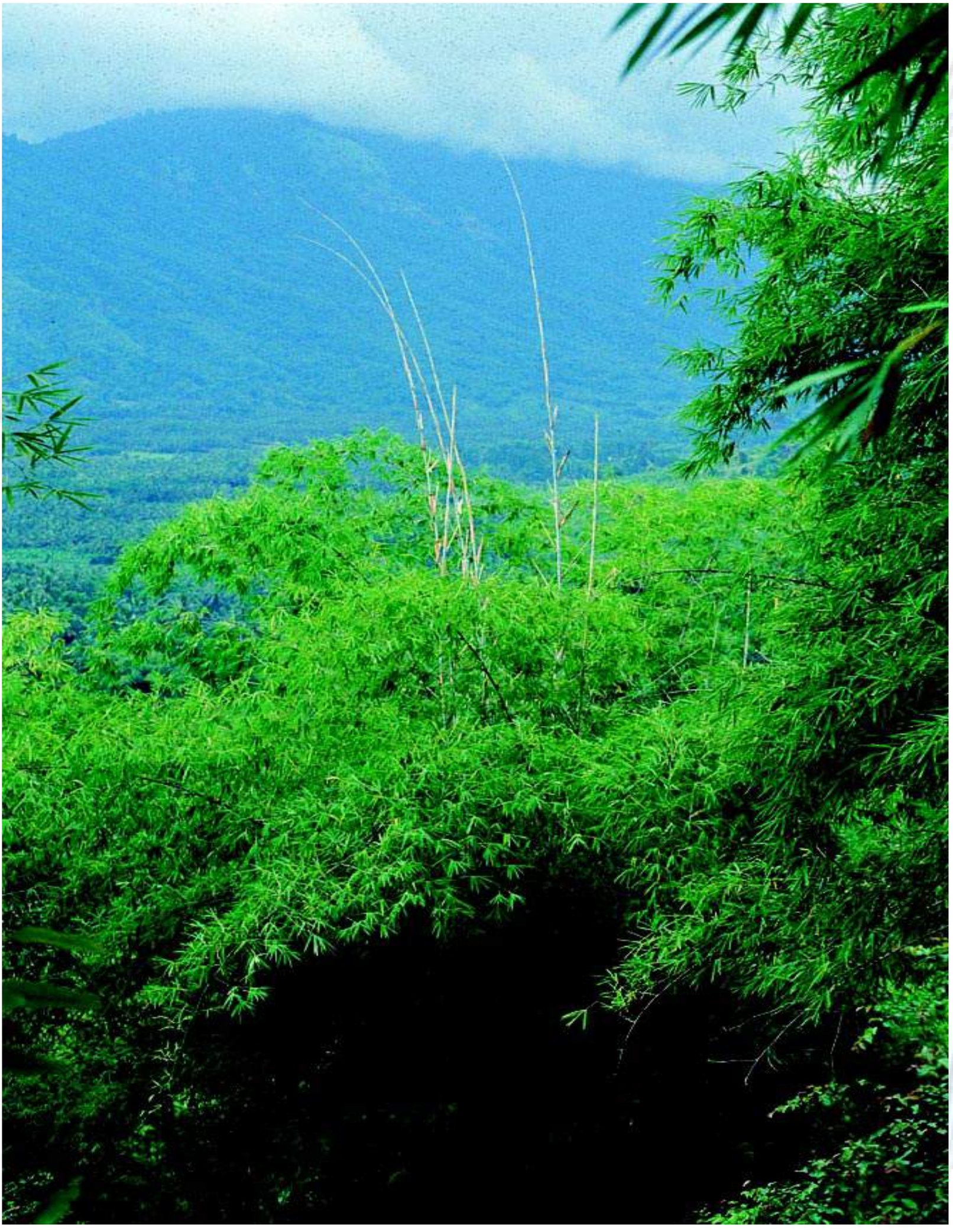
Bambusa stricta Roxb. Pl. Corom. 1: 58, t. 80. 1798.

VERNACULAR NAMES

Bengal - *Karali*, Gujarat - *Nakur bans; Kiri bidiru*; Maharashtra - *Male bamboo, narvel*; Orissa - *Salia*; Tamilnadu - *Kalmungil*; Andhra - *Sadanapa Veduru*; Tripura - *Lathi bans*; Kerala - Kallumula.

DESCRIPTION

A deciduous densely tufted bamboo. **Culms** 8-16 m high, 2.5-8 cm diameter, pale blue green when young, dull green or yellow on maturity, much curved above half of its height; nodes somewhat swollen, basal nodes often rooting, lower



nodes often with branches; internodes 30-45 cm long, thick-walled. **Culm-sheaths** variable, lower ones shorter, 8-30 cm long with golden brown stiff hairs on the back, sometimes glabrous in dry localities, striate, rounded at the top, margin hairy; ligule 2-3 mm high, toothed; auricles small, blade triangular, awl-shaped, hairy on both sides. **Leaves** linear-lanceolate, small in dry localities, up to 25 cm long and 3 cm broad in moist areas, rounded at the base into a short petiole, tip sharply acuminate with twisted point, rough and often hairy above, softly hairy beneath; ligule very short. **Inflorescence** a large panicle of large dense globular heads 4-5 cm apart; rachis rounded, smooth. Spikelets spinescent, usually hairy, the fertile intermixed with many sterile smaller ones, 7.5-12 mm long and 2.5-5.0 mm broad, with 2 or 3 fertile flowers; empty glumes 2 or more, ovate spinescent, many-nerved; flowering glumes ovate, ending in a sharp spine surrounded by ciliate tufts of hair; palea ovate or obovate, emarginate, lower ones 2-keeled, ciliate on the keels and 2-nerved between them, uppermost not keeled, often nearly glabrous, 6 to 8-nerved. Stamens long-exerted; turbinate, stalked, hairy above and surmounted by a long style ending in a purple feathery stigma. **Caryopsis** brown, shining, ovoid to sub-globose, ca.7.5 mm long, hairy above, beaked with persistent base of the style, pericarp coriaceous.

Different chromosome numbers are reported as 2n=72,70 and 56 hexaploid (Sobita Devi and Sharma, 1993).

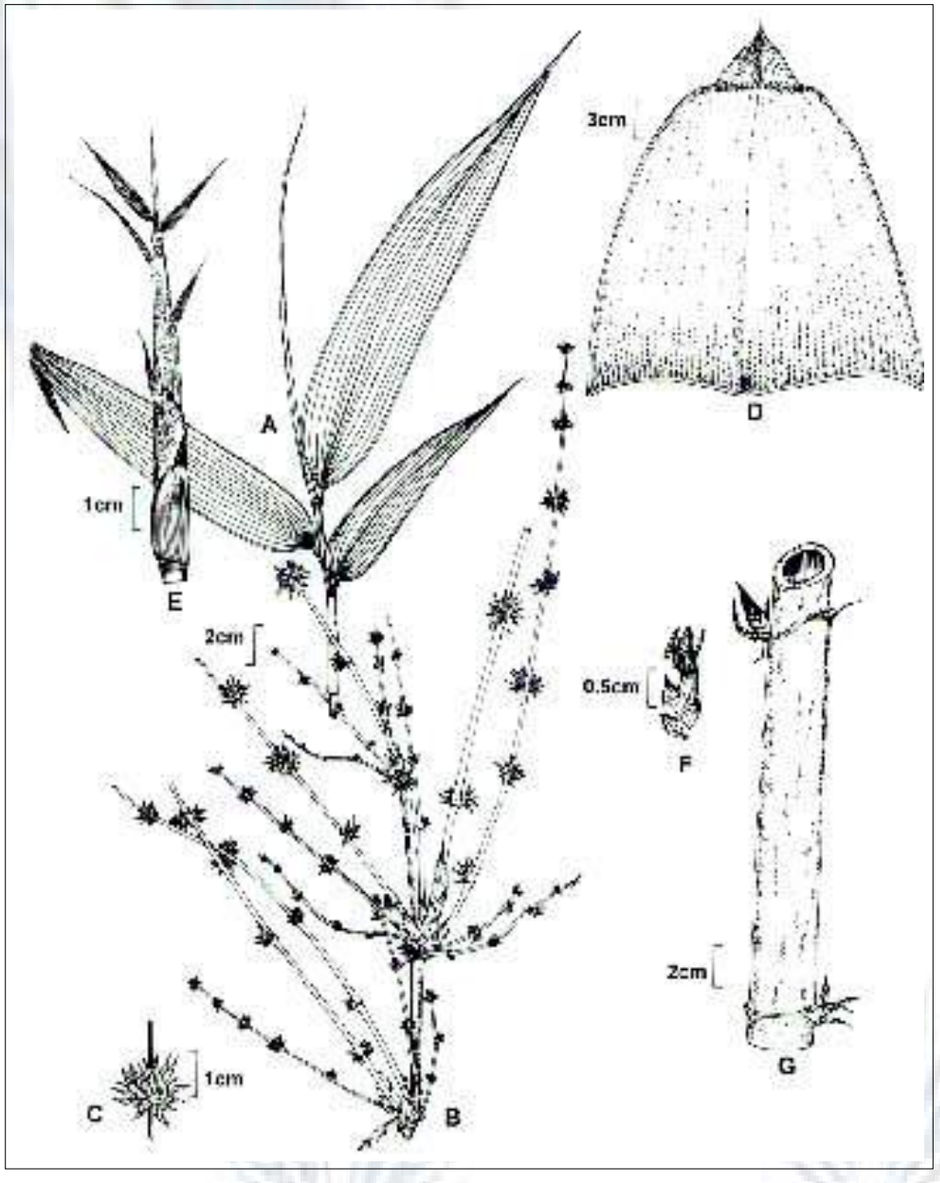
FLOWERING AND FRUITING

Gregarious flowering cycle varies from 25-45 years. This does not mean that all the clumps of a tract flower at the same time. It commences with intensive sporadic flowering for 2-3 years, increasing progressively resulting in the flowering of all the clumps in a period of five years. Sporadic flowering is seen almost every year. Gregarious flowering is related to injury, nutrition, climatic conditions and soil factors. Management practices and biotic

◄ **D. strictus**
- Natural growth

➤ **D. strictus**
- Close-up of new shoot

➤ **D. strictus**
- New shoot



◄*Fig. 40.* **D. strictus.** *A - leafy branch; B - flowering branch; C - a portion of flowering branch enlarged; D - culm-sheath; E - young shoot; F - spikelet; G - a portion of culm.*

interference influences flowering of *D. strictus*. When proper silvicultural practices are adopted flowering is reported to be delayed by 3-5 years. Flowers appear from November to February and fruits are seen from February to April. Freak flowering of 1-3 year old seedlings in nurseries and natural forests are occasionally reported. Studies have shown that precocious flowering was induced by tissue culture and mutants through gamma irradiation of seeds. Gregarious flowering has been reported from different parts of the country; Kalagarh Forest Division of Uttar Pradesh during 1950-56 and in Kalahandi and Rayagada Division of Orissa State in 1967, Mandal Division of Madhya Pradesh during 1961-63; various localities of Maharashtra during 1940-1942, 1948-49, 1957-1958, 1961-1962, 1978-1980. Blatter (1930) listed the flowering years of this species from various parts of India and adjacent regions for the period 1865-1914. Ahmed (1969), Uppin (1978) and Kadambi (1949) reported that non-production of new culms in the preceding years could be an important event which signifies the approach of flowering in this species, but Banik (1981) observed that all the clumps produced new culms in the preceding years, some in the first year of flowering and no new culm production in the second year of flowering. Studies on floral biology and breeding behaviour showed that the species is dichogamous and protogynous. The gynoecium matures 3 to 4 days

before the androecium. Flower opens between 6 to 13 hours and opening depends on atmospheric temperature. The species is anemophilous. The insects feed on pollen but not pollen vectors. Parthenocarpy and apomixis do not occur. Pollen fertility is about 98 per cent (Nadgauda et al., 1993).

Fruit is a glans, fusiform with obtuse or aristate rostrum at the apex covered with white pubescence. The length of rostrum varies from 2 to 4 mm. The fruit is covered with three persistent glumes. Surface is smooth with hard seed coat. Average length and width of seed varies from 7 to 7.3 mm and 2.98 to 3.33 mm respectively. Fruit navel and ventral suture are absent and pericarp is crustaceous (Appasamy, 1993).

DISTRIBUTION AND ECOLOGY

This species occupies 53 per cent of total bamboo area in India. This is one of the predominant species of bamboo in Uttar Pradesh, Madhya Pradesh, Orissa, and Western Ghats. Widely distributed in India in semi dry and dry zone along plains and hilly tracts usually up to an altitude of 1000 m., also commonly cultivated throughout the plains and foot hills. *D. strictus* is widely adaptable to temperatures as low as -5ºC and as high as 45ºC. This species is mainly found in drier open deciduous forests in hill slopes, ravines and alluvial plains. It prefers well-drained, poor, coarse, grained and stony soils. It occurs naturally in tracts receiving as low as 750 mm of rainfall and also in extensive gregarious patches or as an understorey in mixed forests and teak plantations.

ANATOMY, MORPHOLOGY AND FIBRE CHARACTERISTICS

Rhizome is pachymorphic type. There are two kinds of buds on the rhizome, the scaly pointed and the flat buds. The scaly pointed buds develop into rhizome and the flat ones develop into culms. Apical dichotomy is observed as a rare phenomenon (Krishnamoorthy, 1978). Three growth types are reported, common type, large type and dwarf type. The first type is common, second type is seen in depressions and third type is found in ridges and hotter places.

The culm internode consists of a single layered epidermis followed by a layer of sclerenchymatous hypodermis. Cortex 4-5-layered parenchymatous fibres constitute 40-50 per cent. Across the wall, the fibre length increases from periphery, reaches its maximum at about the middle and decreases towards the inner part. Fibres in the inner zone of culm 20-40 per cent shorter, shorter fibres always near the nodes. With increasing height of the culm a slight reduction in fibre length occurs. Culm macerate shows very thick, thin and very thin-walled fibres, septate fibres present, fibre tips pointed or blunt, wall lamellation of 3-7-layered (Sekar and Balasubramanian - personal communication). In leaf epidermis, stomata common, arranged in two bands, in 1-3 alternate rows, subsidiary cells triangular, surrounded by small, globose papillae. Long cells long and narrow with uniform width, ends almost straight, walls sinuous. Papillae small, scattered. Interstomatal cells short and broad with sinuous walls and deep concave ends; papillae scattered. Short cells mostly solitary, costal and intercostal. Cork cells costal not distinct, intercostal distinct. Silica cells costal, distinct, common, intercostal, frequent. Silica bodies costal nodular, intercostal dumbbell to ‘8’-shaped. Prickles frequent, intercostal, with round base and small pointed apex, base surrounded by a ring of papillae. Microhairs frequent, bicelled, apical cell larger or equal to basal cell, apex tapering. Macrohairs common, long, costal and intercostal, base raised, surrounded by a ring of papillae (Luxmi Chauhan et al., 1988). The average fibre length of *D. strictus* is 2237µm, diameter 8.2 µm, lumen width 5.1 µm and wall thickness 6.2 µm, slenderness ratio 272.8, flexibility ratio 62.2, Runkel ratio 1.4.

The thick-walled bamboo fibres exhibit a polylamellate structure with alternate broad and narrow lamellae. Its composition is such that narrow lamellae regularly alternate with broad ones. Width of the broad lamellae appears to vary. The

◄**D. strictus** - *Flowering*

microfibrillar arrangement in these two types of lamellae is of crisscross type. The narrow lamellae show a fibrillar angle of 80 to 90° to the cell axis, while in the broad ones the fibrils are almost parallel to the axis (Parameswaran and Liese, 1976). Seed coat is made up of palisade like cells of sclereids in a single row. It is followed by dark stained 4 to 5 layers of crushed cells. The seed coat is covered by a thick cuticle. Two to three layers of aleurone cells occur next to the crushed cells. It is followed by endosperm with reserve foods. The embryo is located at the chalazal end (Appasamy, 1993).

CHEMISTRY

Proximate chemical analysis showed cold water solubility 6.6 per cent, hot water solubility 7.6 per cent, 1 per cent NaOH solubility 22 per cent, alcohol benzene solubility 6.9 per cent, holocellulose 70.9 per cent, Klason lignin 27.6 per cent, pentosan 17.1 per cent, ash 4.6 per cent (Maheswari and Satpathy, 1990). The pulping characteristics vary with age, locality and position of culm. Pulping properties of the species show moisture 10 per cent, screened pulp yield 45.2 per cent, total pulp yield 46.8 per cent, kappa No.285, viscosity 30.2 (Cp) at 25°C' lignin in bamboo 26 per cent, lignin in pulp 3 per cent, pentosan in bamboo 23.2 per cent, in pulp 15.3 per cent, pulp yield unscreened 57 per cent, screened 50.9 per cent (Singh et al. 1976). Yield and chemical analysis of holocellulose and hemicellulose is also reported by Rita Dhawan and Singh (1982). Spectral absorbance of cellulose 0.354, lignin 0.296 (Sekar and Balasubramanian - personal communication).

The hemicellulose of bamboo is similar to hemicellulose of hardwoods. The sugar composition of hemicellulose consists of xylose, arabinose and glucose. Glucuronic acid is also present in small amounts with xylose as the main constituent. The nodal portion has lower holocellulose content, but pentosan, lignin and ash are higher compared to internodal region (Maheswari and Satpathy,1988). Studies on the effect of pH on prehydrolysis of *D. strictus* indicate that pulp yield decreases at higher pH. Analysis of seeds showed 73 mg starch, 8 mg total sugars, 1 mg phenol, 4 mg lipid and 14 mg protein per 100 mg of sample (Appasamy, 1993).

SILVICULTURE AND MANAGEMENT

Site requirements: *Dendrocalamus strictus* grows on practically all types of soils provided there is good drainage. It does not grow on water-logged or heavy soils such as pure clay or a mixture of clay and lime. Well-drained localities with sandy loam are the best for bamboo growth. The species is found growing well in the areas having a rainfall between 750 mm-4000 mm and it flourishes in regions where the relative humidity of the air is low. The species is usually not found on precipitous slopes or on flat ground unless it is well-drained. It prefers hilly ground and is resistant to frost and drought.

Seed storage: The seeds if not sown immediately after collection, may be stored in bags. If it is to be sown after one year, it should be dried and stored in sealed tins. The seeds can be stored for longer duration by keeping over silica gel or anhydrous calcium chloride in desiccator at 3°C to 5°C after reducing the moisture content to 8 per cent (Gupta and Sood, 1978). Hydration and dehydration treatments also reduce loss of viability (Sur et al., 1989). Abnormalities observed in seeds during storage were such as coagulated ball embryo, concentrated sporulation of storage fungi, embryo detachment along the epithelial layer, black encrustation of inner walls, discontinuous black spots, embryoless endosperm, jelly like embryo fragments, shrunken embryo, shredded endosperm and pitly air space (Karivaratharaju et al., 1987).

Natural Regeneration: After gregarious or sporadic flowering, under natural conditions, the seeds germinate soon after the first monsoon showers. It is observed that large number of seedlings survive particularly on newly exposed soils.

Artificial Regeneration: (1) Seedling: When fruiting occurs seeds are collected by sweeping the ground under the clumps during seed fall. Mature seeds are separated from the chaff by winnowing. Seeds are better collected before the onset of monsoon. One kilogram contains approximately 30,000 seeds. Germination varies from 25 to 61 per cent. A temperature of 30°C and 50 to 70% moisture level in the germinating medium is ideal for germination. Degluming the seeds accelerates germination.

A good irrigated nursery with standard sunken beds (12 x 1.25 x 0.3 m) is preferred. The soils in the bed is worked and sterilized by burning the debris and mixed with farmyard manure. Seeds are pretreated for 24-48 hrs in cold water. About 1/2 kg of seeds are sown in a bed in drills 24 cm apart and lightly covered with soil. Germination starts after 7 days and completes in about 17 days. One-year-old seedlings are transplanted in the pits of 30 cm^3 at the espacement of 6 m x 6 m. However, it was reported that 2-year-old seedlings give better survival percentage. The roots of the seedlings should not be exposed to sun and care should be taken that the buds on the rhizomes are not injured.

(2) Vegetative propagation: Different methods like offset planting, rhizome planting, rooting of culm cuttings and tissue culture are used. One-year-old culms are cut through with a slanting cut about 90 or 120 cm from the ground and the rhizomes to which they are attached are dug up with roots intact and cut off to a length sufficient to include a well-developed bud. Planting is done before the onset of the rainy season. Rhizomes are separated from the mother plant during the onset of monsoon and planted in pits of 45 x 45 cm. Culm cuttings can be used for propagation when seeds are not available. About 40 to 70 per cent of rooting can be obtained in culm cuttings depending on the period of collection, age of culm and treatment with growth regulating substances. Cuttings treated with NAA 100 ppm during February to March gave maximum rooting response (Surendran and Seethalakshmi, 1985). Horizontal planting in the nursery beds was better than the vertical and oblique planting methods. Seasonal variation in rooting response is

reported and it is attributed to the variation in nutrient contents in the culm (Gupta and Pattanath, 1976). Observations on fertilizer and spacing trials in the nursery of less than two years, indicated that closer spacing is better and the application of NPK enhance the biomass production by three times (Patil and Patil, 1990). Considerable work has been done on the tissue culture of this species. The various explants used are, node, seed, seedling, shoot, excised embryo and other methods like multiple shoot production, rooting and *in vitro* flower induction are used, (Zamora, 1994).

Growth: The main period of growth of the bamboo is 2-3 months during which time they attain their full height and diameter. The development of lateral branches takes place during the second season of growth. After the first season silicification and hardening of culms take place. Growth is completed about 2 months after the rainy season. There is an initial short period of 14-18 days showing maximum rate of growth (22-33 cm/day) accounting for 25 to 56 per cent followed by moderate growth (11 to 16 cm/day) and subsequently slow growth (9 to 13 cm/day). During the day time, height increment is about 40 per cent as against the night increment of 60 per cent. Maximum growth per day is 37 cm. The months of June-July-August is the season of continuous vegetative activity which indicates that there exist a definite periodicity with regard to growth (Shanmuganathan et al., 1980).

Yield: It has been estimated that one hectare may contain a growing stock of 4000 to 5000 culms (250 to 300 clumps) and provide an annual harvest of 750 to 1000 culms on a three year felling cycle. From a plantation having a spacing of 5 x 5 m yield is about 3.5 t/ha/ year. In favorable localities, *D. strictus* in each clump has 30-50 culms of 15-18 m height and 6-10 cm diameter.

Plantation trials from Karnataka reports annual net income of Rs.35,000/ha/year starting from 6th year onwards (Yellappa Reddy et al., 1992). Intercropping with *Sesbania grandiflora, Leucaena leucocephala, Lotononis bainesii* and *Casuarina equisetifolia* are reported from Karnataka. Another study on the yield of *D. strictus* from a plantation with a spacing 5 x 5 m for a period of eleven years showed a net income of Rs.70,000/-. This was found to be more profitable than rubber and cashew (Wagh and Rajput, 1991).

Felling cycle suggested is 3 to 5 years. Although a three year felling cycle has been adopted, a cutting cycle of 4 years is preferable since it allows the clumps rest and the rhizomes are not disturbed too frequently. Congestion can occur by cutting the culms from the periphery of the clumps, grazing and extraction by neglecting the cutting rules. This can be avoided by observing the general 'horse shoe' pattern for cutting. Cultural operations like thinning, cleaning, protection from fire and grazing need to be followed (Gupta, 1964).

PESTS AND DISEASES

Young shoots are susceptible to fungal attack. The green young shoot turns brown and comes off easily when pulled, leaving the area of transformation soft and brown, smelling strongly of molasses. Preventive measure is drenching the clumps with blue copper in advance. Many diseases like, damping off caused by *Fusarium* spp., leaf spots, leaf blight and leaf rusts caused by species of *Alternaria, Colletotrichum, Dactylaria, Dasturella* and *Helminthosporium*, culm rot caused by *Fusarium oxysporum*, culm-sheath rot by *Glomerella cingulata* and little leaf disease by *Mycoplasma*-like organisms are reported from Kerala (Mohanan, 1990). The major spermoplane fungi reported on stored seeds were species of *Fusarium, Drechslera, Curvularia, Alternaria, Dactylaria, Aspergillus, Chaetomium* and *Penicillium* (Mohanan, 1990). A rust due to *Dasturella bambusina* affects bamboo. The other causal agents are white ants and rodents. The application of termiticide and rodenticide will reduce the damage considerably.

The major insect pests of *D. strictus* are *Ochrophara montana* (affects seeds) *Holotrichia consanguinea* (affects rhizomes) *Hieroglyphus banian* (defoliates) termites (damages roots) *Estigmene chinensis* (culm borer) *Cyrtotrachelus dux* and

C. longimanus (young shoot borers) *Myocalandra exarata* (green shoot borer) *Chelyophora caratitina* (young shoots) *Olethreutes paragramm* (young shoots) *Calamochrous pentasaris* (defoliator) *Crocidophora ptyophora* (leaf roller) *Messepha absolutalis* (defoliator) *Pionea flavofimbriata* (leaf skeletoniser) *Pyrausta bambucivora* (leaf roller) *Pyrausta coclesalis* (defoliator) *Dinoderus* sp. and *Lyctus africanus* (shoot borer) (Tewari, 1992).

PHYSICAL AND MECHANICAL PROPERTIES

Mechanical properties vary according to the age, position of culm and locality. Average properties from ten locations in India are given below. Specific gravity 0.719, moisture content 10.7 per cent, modulus of rupture 118.4 N/mm^2, modulus of elasticity 1.59 kN/mm^2, crushing strength parallel to grain 64.5 N/mm^2 (Sekar and Gulati, 1973).

As compared to teak, bamboo has in general higher basic strength. A comparative study with mild steel has shown that the average ultimate tensile strength of *Dendrocalamus strictus* is nearly equal to the strength of mild steel. The specific ultimate tensile strength of bamboo specimen is nearly six times the specific ultimate tensile strength of mild steel. The notch impact strength of bamboo specimens is only about 15-20 per cent of the impact strength of mild steel. But by taking into account the densities of mild steel and bamboo, the specific impact strength of bamboo specimens is 50 per cent greater and specific impact strength of bamboo specimens soaked in araldite is 100 per cent greater than the specific impact strength of mild steel. Bamboo specimens have poor torsional shear strength in comparison to the torsional shear strength of mild steel. Bamboos have maximum stiffness along the fibres and minimum stiffness transverse to the fibres. The variation of modulus ratio (E/E2) for bamboo specimen is similar to the variation of modulus ratio of fibres reinforced composities.

NATURAL DURABILITY AND PRESERVATION

Fresh bamboos can be treated by the following methods (1) Steeping (2) Sap displacement (3) Diffusion process (Singh and Tewari, 1981). Dry bamboos can be treated by soaking and hot- cold process. In another study, brush application with the oil type or water soluble type or solvent type of preservatives, particularly of the last kind is recommended. It is found that the untreated bamboo has a service life of 2-5 years. By open tank treatment the service life can be extended to 10-15 years and by pressure process further it can be enhanced to 10-20 years. Untreated bamboo used as posts are destroyed by termites and fungi in about 1 or 2 years. It is reported that bamboo under cover, or used for structural use lasts for 2 to 5 years. Natural durability varies from 18 to 30 months. Loss due to fungi and insects can be reduced by proper treatments at the time of stacking and storage. To prevent termite attack stacking is done on raised ground along with the application of lime sludge and 2 per cent BHC.

Traditional non-chemical methods of preservation include controlling starch content by adjusting felling season, age of felling, water soaking and post-harvest transpiration. Other methods include baking on open fire, lime washing and other coatings. Preservative treatment of dry bamboos, the methods used are soaking, hot-cold process and pressure treatment (Kumar et al., 1994).

USES

This species is one of the two most important bamboos in India. It is found suitable for reclamation of ravine land. It is extensively used as raw material in paper mills and also for a variety of purposes such as construction, agricultural implements, musical instruments, furniture etc. Young shoots are commonly used as food. Decoction of leaves and nodes and silicious matter is used in the traditional medicine.

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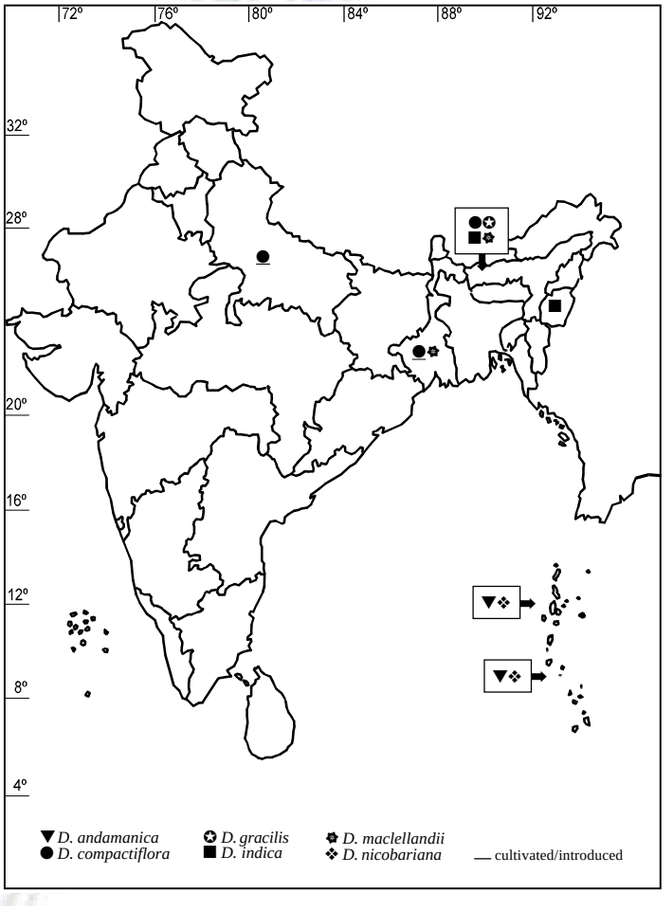
DINOCHLOA BUSE

Open tufted, climbing bamboo; culms zig-zag, moderately thick, usually solid, covered by persistent sheaths. Culm-sheaths thick, loose clasping, lower portion leathery and persistent. The culm-sheath proper smooth, usually glabrous, purplish or green when young, very often covered with white wax; auricles usually present, often with long bristles; ligule very short or long and laciniate; blades broadly ovate or ovate-lanceolate, glabrous, purplish or green, covered with white wax when young. Branches 3-18 at each node with middle branch dormant but developing as the main culm when the apex gets damaged. Leaves large, soft in texture with transverse veinlets. Inflorescence a large compound panicle of thin spicate clusters of spikelets. Spikelets numerous, very minute, 1 or 2-flowered; empty glumes 1-4, broad, very obtuse, blunt, gradually larger upwards; flowering glume similar; palea convolute, equal to or larger than the flowering glume, not keeled, lodicules absent. Stamens 6, free, short. Ovary oval, glabrous; stigma 3; style short. Caryopsis ovoid, acuminate, smooth or rugose; pericarp thick and fleshy when young, thinner when mature; endosperm almost absent in mature fruit.

The genus consists of 20 species distributed in Indonesia, Laos, Philippines, Malaysia and India. From India, 6 species have been reported. In North-Eastern India, 4 species and North-Western and Andaman Islands, 2 species each are known to occur. In this compendium, details of 6 species of *Dinochloa* have been compiled.



◄*Distribution map of* **Dinochloa**

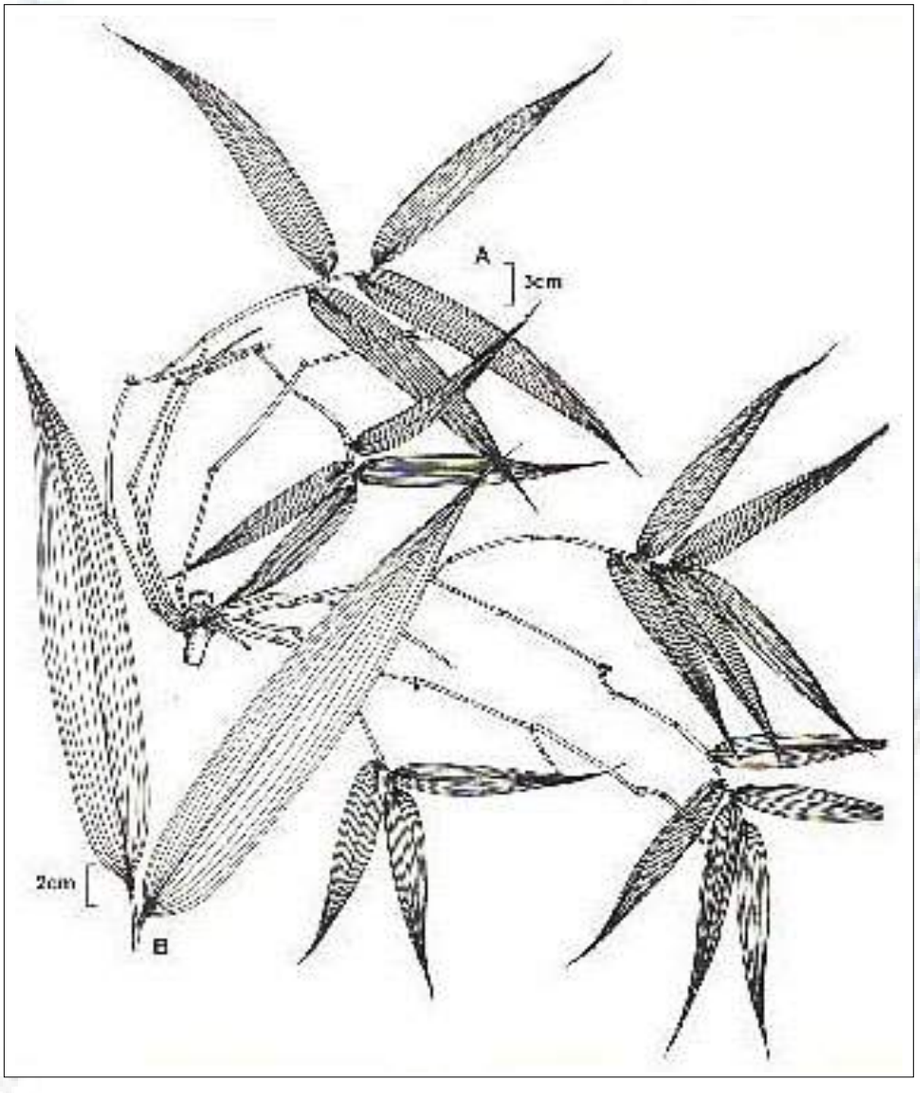
Dinochloa andamanica

Dinochloa andamanica Kurz, J. Asiat. Soc. Bengal 42(11): 253. 1873; Camus, Les Bambusees 169. 1913; Blatter, Indian For. 55: 602. 1929; Varmah and Bahadur, Indian For. Rec. (n.s.) 6(1): 3. 1980; Tewari, Monogr. Bamboo 78. 1992. **(Fig. 41).**

Dinochloa tjankorreh var. *andamanica* (Kurz) Gamble Ann. Roy. Bot. Gard. Calcutta 7: 112-113. 1896; and in Hook. f., Fl. Brit. India 7: 414. 1897.

DESCRIPTION

Plants with long, green, glossy, creeping culms. **Culms** single, creeping along the ground, and rooting at the nodes or climbing over tall trees usually to a height of 35 m; branches geniculate, single, as long and stout as the culms; branchlets slender, numerous, in whorls, hanging with dense foliage; nodes swollen, marked by the base of fallen culm-sheath; internodes 23-46 cm long, 2.5 cm diameter, walls thin. **Culm-sheaths** green, less than one-fourth of the



◄*Fig. 41.* **D. andamanica.** *A - leafy branch; B - leaves enlarged.*

length of the internodes, with a fugacious white bloom; imperfect blade leafy, deciduous, nearly as broad as sheath. **Leaves** 23-30 cm long and 5-7.5 cm broad, ovate-lanceolate, attenuate at the base into a very short petiole, apex setaceous, smooth on both surfaces, scabrous on the edges, midrib prominent, secondary veins 7-9 pairs, transverse veinlets conspicuous owing to pellucid dots; leaf-sheaths appressed hairy when young, glabrous when old, ending in a callus and rounded mouth with white cilia; ligule broad, truncate, ciliate, fimbriate. **Inflorescence** a large compound panicle of spicate thin branches; rachis curved and nodes with a ring formed by the bases of fallen bracts.

➤ **D. andamanica** - *Natural growth*

➤ **D. andamanica** - *Internode*

Spikelets clustered, 2-2.5 mm long, glossy, straw-coloured, one-flowered; empty glume 1 with 1 or 2 smaller glumes at the base below the articulation, broad, obtuse, convolute, blunt, 5-7-nerved; flowering glume similar to empty glume; palea round, much convolute. Stamens included; filaments short; anthers with an acute tip. Ovary oval, ending in a thick style and bifid non-plumose stigma. **Caryopsis** not known.

DISTRIBUTION

The species is distributed in Andaman and Nicobar Islands. Mostly occurs as impenetrable tangled thickets and often climbing on the tall trees.

USES

The long-cane like culm of this bamboo is used as rope by the aborigines of the Nicobar.

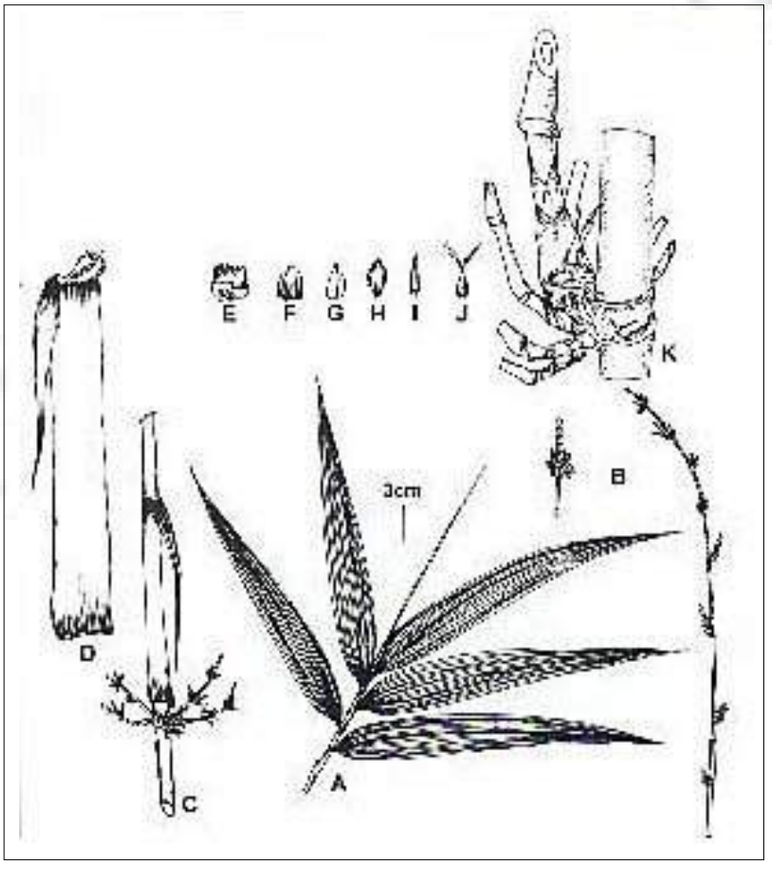
Dinochloa compactiflora

Dinochloa compactiflora (Kurz) McClure, Kew Bull. 253. 1936; Bennet, Van Vigyan 27: 120. 1989; Tewari, Monogr. Bamboo 82. 1992. **(Fig. 42).**

Melocalamus compactiflorus (Kurz) Benth. and Hook. f., Gen. Pl. 3: 1212. 1883; *Pseudostachyum compactiflorum* Kurz, J. Asiat. Soc. Bengal 42: 252. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 94. 1896; Bahadur and Naithani, Indian Forester 109: 266. 1983.

DESCRIPTION

This is an elegant climbing bamboo. **Culms** solid, grayish-green, rough, scandent, spreading, climbing over tall trees, 10-33 m long and 1.2-2.5 cm diameter; nodes swollen, whitish; internodes 30-62 cm long. **Culm-sheaths** about 15 cm long and 8 cm broad, persistent, hard, brittle, cylindrical, smooth or covered with white appressed hairs; blade more or less equal to the length of the sheath, recurved, long-acuminate, rounded at the base; auricle narrow, dark, crescent-shaped, fringed with stiff bristles; ligule narrow, entire. Young shoots spear-shaped, glabrous. **Leaves** 15-25 cm long and 2.5-5 cm broad, oblong-lanceolate, subulate towards apex and ending in a twisted point, base rounded; petiole 3-5 mm long and hairy; leaf-sheath striate with appressed white hairs when young, glabrous on maturity, mouth truncate; ligule very small, entire; auricle lunate, reflexed, fringed with stiff bristles, early caducous. **Inflorescence** a large compound interrupted panicle of small subglobose heads, often leaf-bearing; heads with several fertile and many sterile spikelets, 7.5-12.5 cm diameter; rachis pubescent, flexuose, flattened on one side. Spikelets 2.5 mm long, glabrous, blunt or truncate, 2-cleft, with 2 fertile flowers and 1 empty, terminal on a protruded rachilla;



➤*Fig. 42.* **D. compactiflora.** *A - leafy branch; B - flowering branch; C - culm with flowering branch; D - culm-sheath; E - spikelet; F - empty glume; G - palea; H - lodicule; I - stamen; J - pistil; K - a portion of culm with branches.*

glumes 2, broadly ovate, blunt, long ciliate. Stamens free; filaments short; anthers yellowish, bluntly acute at the tip. Ovary glabrous, ovoid-globose, surmounted by a short thick style; stigmas 2 or 3, plumose. **Caryopsis** large, subglobular, 2.5-3.7 cm diameter.

Chromosome number - 2n = 72, n = 36, hexaploid (Lalithakumari, 1983).

FLOWERING AND FRUITING

This species has been reported to have flowered in Myanmar during 1871, 1878, 1894, 1902, 1917, 1920 and 1933; at Cachar of Assam in 1921; FRI arboretum, Dehra Dun in 1980. The seeds are globular and much like a miniature wood-apple in shape; the testa is somewhat leathery. Fruit is 2.5 to 3.7 cm in diameter and fleshy. The germination is 100 per cent and viviparous.

DISTRIBUTION

This species is found growing in Cachar, Assam. It is cultivated at Forest Research Institute, Dehra Dun. Also found growing in hills and mountains, frequently between 1200-1800 m altitude, rarely below 900 m.

ANATOMY

Culm epidermis made up of long and short cells arranged in longitudinal rows. Long epidermal cells uniform in width, about 3-5 µm long with undulating walls; length ranging from 18 to 83 µm, short cells paired, alternating with long cells, 2-3 pairs occasionally present. Epidermal cork cells rectangular to saddle-shaped, 8 µm wide. Silica cells rectangular. Short cell pairs numerous, when in groups occasionally replaced by spicules. Macrohairs present. Base of macrohair encircled by a ring of micropapillae. Sometimes a thin walled bladder cell occurring in the place of short-cell and encircled by micropapillae. Stomata overarched by micropapillae. The average stomatal frequency 14 per 0.08 mm^2. Leaf epidermis consists of paired short cells between and over the veins, saddle-shaped silica bodies and long cells with sinuous walls; macro hairs absent; 2-celled microhair having slightly longer distal cell from the intercostal zone. Prickle hairs absent, micropapillae overarching the stomata unequal. Four micropapillae with broad base originating from four corners of stomata and the smaller ones originating from the broad base. Papillae flatly placed. Internodal epidermis followed by narrow cortex with the fibro-vascular region, three concentric intergrading regions-a narrow peripheral region, a transition region and a wide central region present. Cortex 53-66 µm wide, homogeneous, with thin-walled parenchyma larger than epidermal cells. Peripheral part of the fibro-vascular region narrow; towards cortex small strands of isolated fibres and small oval, roundish vascular bundles consisting of two vessels and phloem found. Sieve tubes very narrow. The intra- and intervascular parenchyma thick-walled. Width of the transitional region varying from 35-50 µm, vascular bundles larger towards the centre, than those of the periphery. Sclerenchyma strand separated by a patch of parenchyma cells. Vessels surrounded by parenchymatous cells. Phloem elongated and oval, the average tangential diameter of the sieve tube being 13.3 µm. The intra-and inter-vascular parenchyma thick walled. Vascular bundles of central region larger, scattered. Vascular bundles of type II and III. Sclerenchymatous fibre strands often intercepted by parenchymatous cells into two or three groups. Vascular bundles of this region wide in tangential diameter. Cavity surrounded by thin-walled parenchymatous cells. Phloem elongated and parenchyma thin-walled (Alam and Dransfield, 1981).

USES

The culm is used for basket-making in Yunnan (China) and Shan (Myanmar). Fibrous layers of the internodes which are pliable and soft, are twisted into strands and shoes/sandals are made by interlacing them.

Dinochloa gracilis

Dinochloa gracilis (Majumdar) Bennet and Jain, in Tewari, Monogr. Bamboo 82. 1992.

Melocalamus gracilis Majumdar, Fl. Ind. Enum. Monocots 278. 1989.

DESCRIPTION

This species differs from *M. mastersii* in having non-falcate deciduous auricles and from *M. indicus* in having ciliate auricles, terete culms and acute nodal buds. The young shoot unlike other species with spreading, large leafy, culm-sheath blades. **Inflorescence** not known.

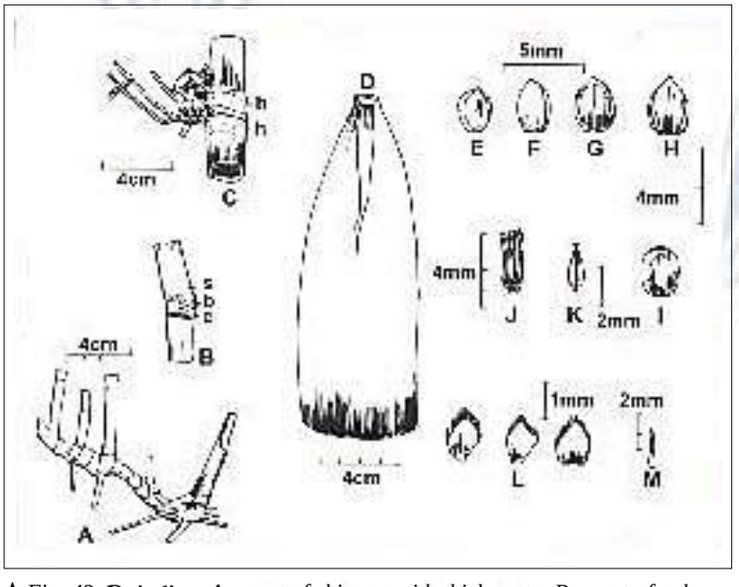
DISTRIBUTION

The species is known to occur in the Borail Range of North Cachar Hills of Assam.

Dinochloa indica

Dinochloa indica (Majumdar) Bennet, Van Vigyan 27(2): 121. 1989; Tewari, Monogr. Bamboo 81. 1992. **(Fig. 43).**

Melocalamus indicus Majumdar, Bull. Bot. Surv. India 25: 236. 1985.



▲ *Fig. 43.* **D. indica.** *A - part of rhizome with thick roots; B - part of culm with white felty zone(h); culm-sheath base(b); culm-sheath(s); C - a portion of solid culm with hairy zone and slender branches; D - culm-sheath; E - lower glume; F - upper glume; G - lower lemma; H - upper lemma; I - upper palea; J - stamens; K - single stamen; L - lodicules; M - pistil.*

DESCRIPTION

An evergreen, scandent bamboo. **Culms** very long, solid, arching over tall trees and hanging downwards with tufts of green leaves at the branch-tips; culm-nodes with woody ring formed by the persistent lower part of the cylindrical culm-sheaths; internodal region white scurfy; branches many in tufts, supporting often a solitary large bud that develops into a branch as thick as the main culm. **Culm-sheaths** cylindrical, crustaceous and deciduous. **Inflorescence** large with globular clusters of spikelets on the nodes of the flexuous branches. Spikelets, 2-flowered, lower floret sterile and the upper hermaphrodite, but without extended rachilla.

DISTRIBUTION

Commonly found in the tropical lowland and rain forests of Cachar, Manipur and other adjoining parts of Assam.

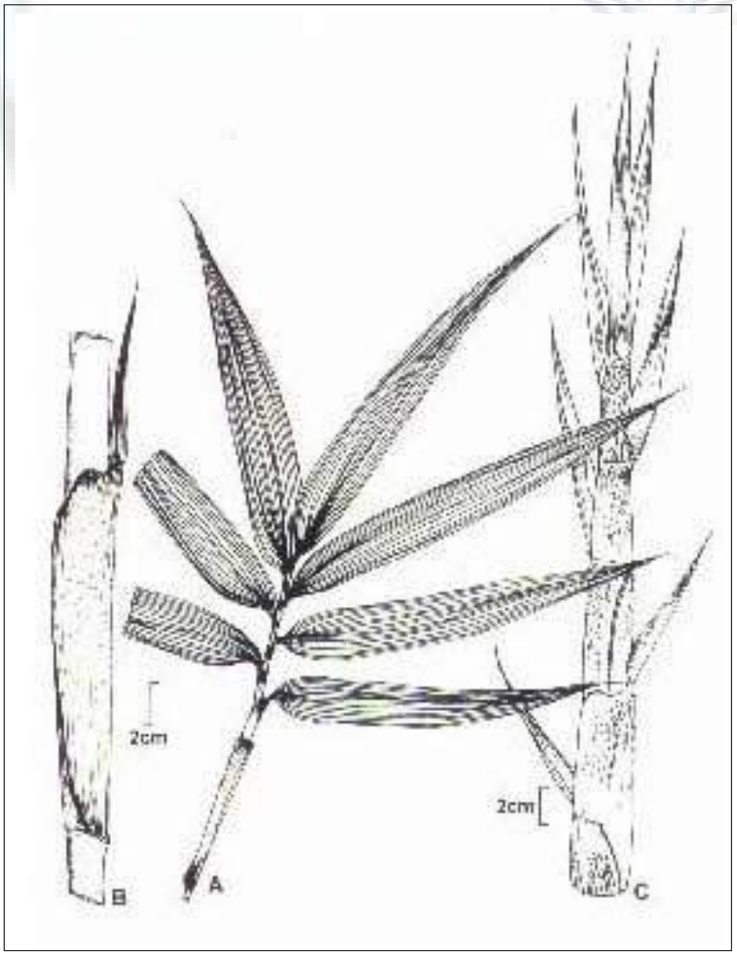
USES

Culms are used for basket-making.

Dinochloa maclellandii

Dinochloa maclellandii (Munro) Kurz, J. Asiat. Soc. Bengal 42 (2): 253. 1874 and For. Fl. Brit. Burma 2: 571. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 115. 1896; Hook. f., Fl. Brit. India 7: 415. 1897; Brandis, Indian Trees 681. 1906; Camus, Les Bambusees 171. 1913; Tewari, Monogr. Bamboo 81. 1992. **(Fig. 44).**

Bambusa maclellandii Munro, Trans. Linn. Soc. London 26: 114. 1868.



▲ *Fig. 44.* **D. maclellandii.** *A - leafy branch; B - culm and culm-sheath; C - young shoot.*

DESCRIPTION

An evergreen, lofty, often scandent bamboo. **Culms** upto 30 m long, if climbing, shorter and straggling if growing unsupported, 2.5-3 cm diameter, geniculate, covered by persistent loose sheaths, gray-green, walls thin; nodes swollen; internodes 15-20 cm long, often angled when young, scabrous with brown appressed hairs. **Culm-sheaths** cylindrical, leathery, persistent, 15-23 cm long, and 17-22 cm broad at the base, 5-7 cm wide at the top, covered with densely appressed golden-brown pubescence, ending above in a narrow dark glabrous margin edging the whole of the truncate top outside the base of the imperfect blade; imperfect blade lanceolate-acuminate, rounded at the base and decurrent on the sheath, 15-30 cm long and 2.5-6 cm broad, recurved or spreading, glabrous outside, densely brown hairy within; ligule short, entire or faintly serrate. **Leaves** large to very large, broadly oblong, lanceolate, acuminate, unequal at the base, rounded into a short thick petiole upto 1.2 cm long, ending in an acuminate setaceous scabrous twisted tip; leaf-sheath striate, transversely veined, produced at the mouth into a naked rounded auricle, keeled at the back, appressed hairy when young, afterwards glabrous; ligule often broad, entire or serrate.

FLOWERING

This species is reported to have flowered in Katakhal in Assam in 1968. Regeneration was not observed. Flowering has not been reported earlier to this and description of the inflorescence is not available (Gupta, 1972).

DISTRIBUTION AND ECOLOGY

It is known to occur in Assam and West Bengal. This species is found growing mainly in tropical lowland rain forests where ample water is available throughout the year.

Dinochloa nicobariana

Dinochloa nicobariana Majumdar, Fl. Ind. Enum. Monocot 277. 1989; Tewari, Monogr. Bamboo 81. 1992. **(Fig. 45).**

DESCRIPTION

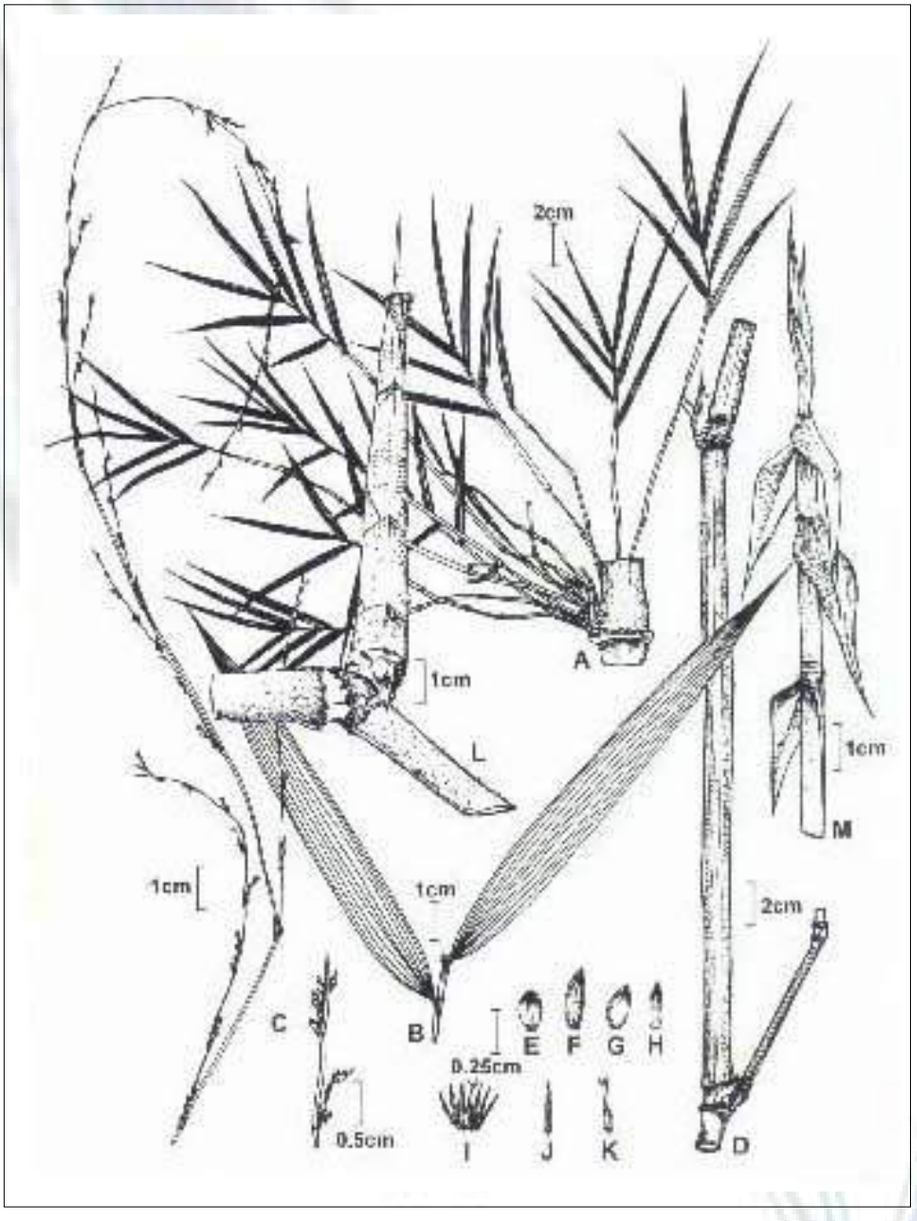
A climbing bamboo. **Culms** green, hairy, climbing over the trees, branchlets numerous from the nodes, slender; nodes marked by prominent nodal rings; internodes up to 30 cm long. **Culm-sheaths** green, long, having white dense tomentum, imperfect blade leafy, deciduous, nearly as broad as sheath. **Leaves** 5-12 cm long and 0.6-1 cm broad, lanceolate, attenuate to the base with very short petiole, apex setaceous, smooth on both surfaces. Midrib narrow, secondary veins 4-5 pairs, leaf sheaths appressed, hairy. **Inflorescence** a large compound panicle of loosely arranged spikelets. Branch smooth and nodes with a ring formed by the base of fallen bracts. Spikelets clustered, 0.2-0.4 cm, straw-coloured, one-flowered; empty glumes 2, 2.5-3.5 mm broad, obtuse. Flowering glume similar to empty glume, 2.5 mm long; palea long, convolute, 2.5 mm long. Stamens 6, included, free, acute tip, filament short; ovary oval ending in a thick style and three plumose stigmas. **Caryopsis** not known.

FLOWERING

This species has been collected in flower for the first time by Renuka and Vijayakumar from 16 km, Nicobar during 1993. The specimen has been deposited at KFRI Herbarium.

DISTRIBUTION

This species is distributed in North Nicobar (Katchal Island).



◄*Fig. 45.* **D. nicobariana.** *A - leafy branchlet with part of culm; B - leaves; C - flowering branch; D - a portion of culm; E - empty glume; F & G - flowering glumes; H - palea; I - flower with pistil and stamens; J - stamen; K - pistil; L - vegetative shoot arising from the node with juvenile sheaths; M - young shoot with culm-sheath and auricles.*

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Bennet, S. S. R. and Gaur, R. C. 1990. Thirty Seven Bamboos Growing in India. Forest Research Institute, Dehra Dun, India: p 64.

▲ **D. nicobariana** - *Flowering*

Gupta, K. K. 1972. Flowering in different species of bamboos in Cachar District of Assam in recent years. Indian Forester, 98: 83-85.

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Tewari, D. N. 1992. A Monograph on Bamboo. International Book Distributors, Dehra Dun: 78-82.

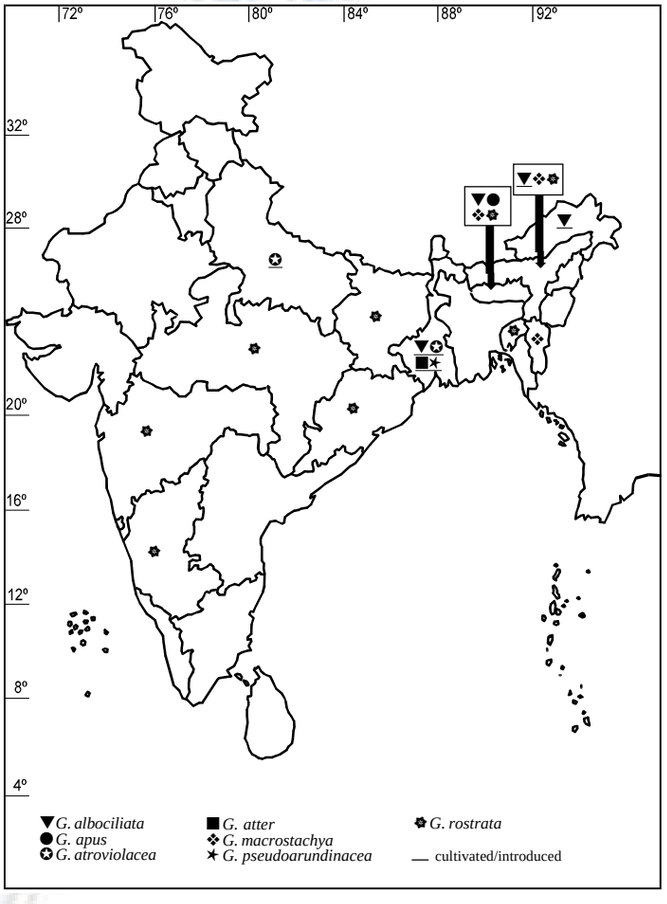
◄ **D. nicobariana** - *Internode and branches*

▼ **D. nicobariana** - *Development of a new branch*

GIGANTOCHLOA KURZ

Arborescent or climbing bamboo. Culms usually robust and bare at the base; sheaths generally stiff, auricled. Leaves rather large, usually attenuate at the base. Inflorescence a compound panicle; spikelets with imperfect flowers at the summit and at the base; hermaphrodite flowers few. Stamens 6. Style elongate; stigmas 1-3, hairy.

Sixteen species are reported from the world; distributed in Thailand, Singapore, Philippines and Malaysia. Seven species of *Gigantochloa* are known to occur in India, out of these 3 species are naturally occurring and 4 species are introduced. All the seven species of *Gigantochloa* are dealt with in this compendium.



◄*Distribution map of* **Gigantochloa**

Gigantochloa albociliata

Gigantochloa albociliata (Munro) Kurz, For. Fl. Brit. Burma 2: 555. 1877; Bennet and Gaur, Thirty Seven Bamboos Growing in India 67. 1990; Tewari, Monogr. Bamboo 91.1992. **(Fig. 46).**

Oxytenanthera albociliata Munro, Trans. Linn. Soc. London 26: 129. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 70. 1896, in Hook. f., Fl. Brit. India 7: 401. 1897; Camus, Les Bambusees 147. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.

VERNACULAR NAMES

Assam: *Kalisuneti*

DESCRIPTION

A densely tufted bamboo. **Culms** 6-9 m high, 1.5-2.5 cm diameter, grayish-green with white stripes, hirsute above, nodes raised in a ring formed by the base of the sheath; internodes 15-38 cm long, walls moderately thick. **Culm-sheaths** 10-20 cm long and ca.15 cm broad, covered with dense appressed hairs in the early stage, afterwards smooth, somewhat truncate, folded and coriaceous at the base, terminating at the truncate mouth in a narrow naked band; ligule 1.5-2.5 cm long, auricles small. **Leaves** linear-lanceolate, 15-20 cm long and 2-2.5 cm broad; petiole short, leaf sheath smooth. **Inflorescence** a large spreading panicle of spicate branchlets; rachis smooth, slender, 2.5-7.6 cm long between the verticils; spikelets slender, 1.5-2 cm long, often curved,

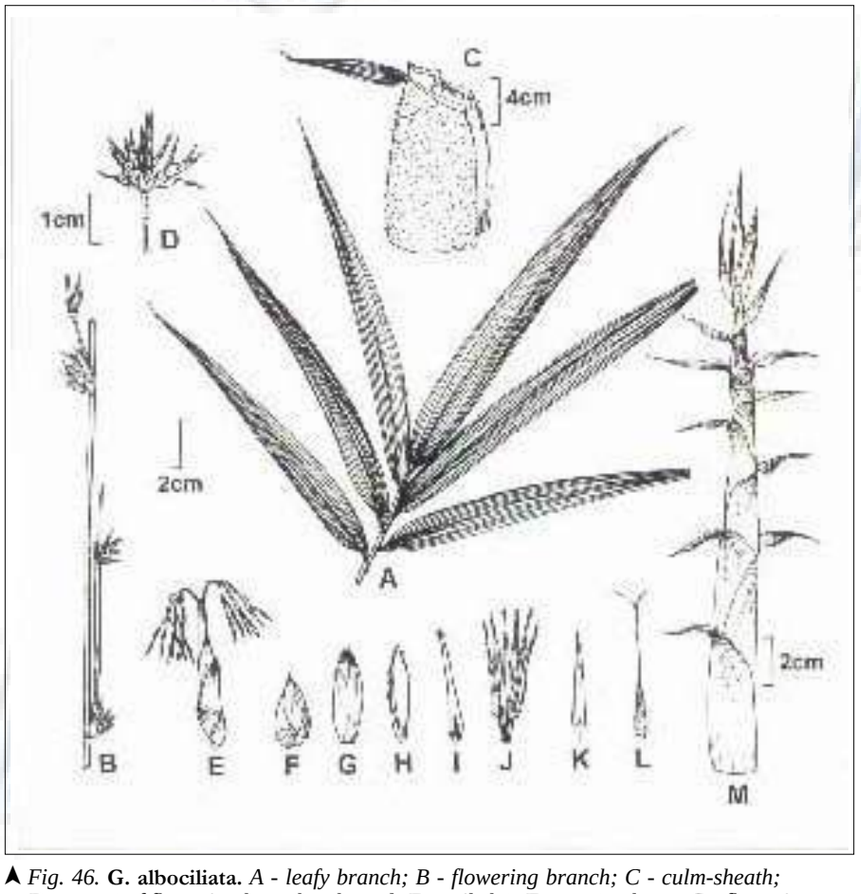


Fig. 46. **G. albociliata.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - a part of flowering branch enlarged; E - spikelet; F - empty glume; G - flowering glume; H - palea; I - palea of upper most flower; J - staminal tube and stamens of lower male flower; K - stamen; L - pistil; M - young shoot.*

▲ **G. albociliata** - *A close-up of clump*

2.2 mm broad, fertile flowers mixed with few sterile ones; empty glumes 1-2, ovate, acute, white ciliate, one male flower followed by 1 or 2 hermaphrodite flowers, flowering glumes elliptic, acute or faintly emarginate, many-nerved, white ciliate on the edges, convolute; palea short, ovate obtuse, 2-keeled, ciliate on the keels, convolute, ciliate only at the tip. Stamens long, exserted, filaments at first connected in a short thick tube, afterwards into a long and membranous one; anthers long, greenish-yellow, long hirsute, apiculate. Ovary narrowly ovoid, much acuminate, pubescent, ending in a long style divided above into 2 white stigmas. **Caryopsis** elongate, oblong, cylindrical and acuminate.

FLOWERING

It has been reported to have flowered in Assam during 1956-60 and in 1987 (Gupta, 1987). Gupta also mentioned that it flowers sporadically almost every year. Seeds from sporadic flowering are not fertile. Clump flowering also has been reported (Anantachote, 1990). A flowering cycle of about 30 years has been reported from India.

DISTRIBUTION

The species is widely cultivated in West Bengal. It is also introduced in Arunachal Pradesh, Assam, Meghalaya and elsewhere in the country.

ANATOMY

In the leaf epidermis, stomata common, arranged in two bands in 3-4 alternate rows, subsidiary cells high-domed, surrounded by 4-5 elliptical and 5-8 small, globose papillae. Long cells long and narrow, width uniform, walls sinuous, ends almost straight, 40-70 µm in length and 14-20 µm in width, papillae paired or single, arranged in a row in the middle. Interstomatal cells slightly shorter than long cells with concave ends. Short cells costal and intercostal, solitary and paired, cork cells costal indistinct, intercostal distinct. Silica cells costal, saddle-shaped, intercostal dumbbell to rectangular. Silica bodies costal saddle-shaped, intercostal oval to rod-shaped. Prickles common, intercostal, with short to long, acute apex, surrounded by a ring of papillae. Microhairs frequent to infrequent, intercostal, bi-celled, distal cell, equal or shorter than basal cell, apex rounded. Macrohairs costal and intercostal, infrequent to frequent, short to medium in length, more towards the midrib. In the culm epidermis stomata clear, 20-25 µm long and 12-16 µm in width, surrounded by inconspicuous papillae. Long cells not uniform in width, slightly tapering at ends. 40-100 µm in length and 5.0-7.5 µm in width. Papillae small, scattered inconspicuous. Silica cells and silica bodies rectangular, rod-shaped to rectangular. Cork cells silicified, slightly larger or equal to silica cells (Agrawal and Luxmi Chauhan, 1992).

SILVICULTURE AND MANAGEMENT

Seed weight varies from 28.1 to 137.7 gms per 100 seeds depending on the locality with a germination percentage of about 3 (Anantachote, 1987). Propagation by tissue culture has been reported using node, shoot and leaf as explants and multiple shoots as well as rooting have been obtained (Zamora, 1994).

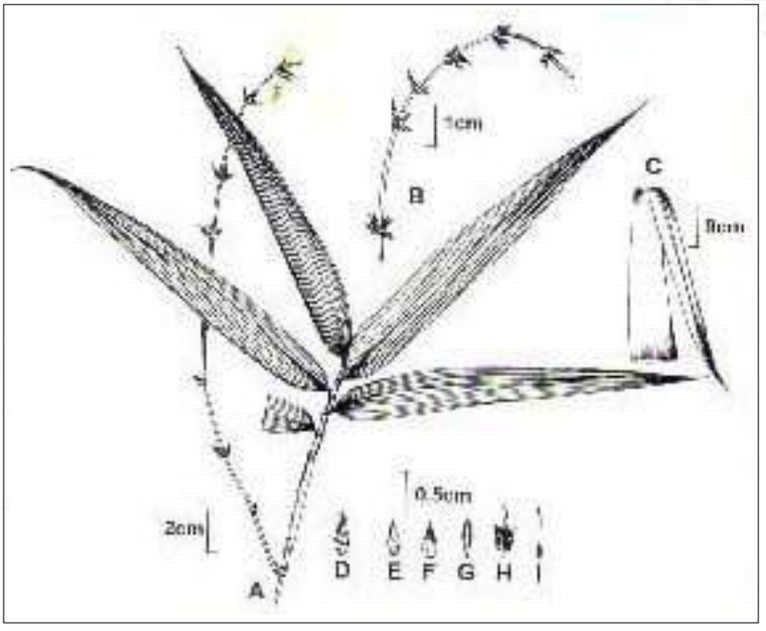
USES

This species was considered to be of very little use and a troublesome weed in the teak plantation of Burma (Gamble, 1896). In Thailand, it is considered to be a commercial species and the young shoots are edible (Anantachote, 1987).

Gigantochloa apus

Gigantochloa apus (Bl. ex Schult.f.) Kurz, Tijdschr Ned. Ind. 27: 226. 1868; Parker, Indian For. 57: 108. 1931; Tewari, Monogr. Bamboo 93.1992. **(Fig. 47).**

Bambusa apus Bl. ex Schult. f., Syst. Veg. 7: 1353. 1830. *Gigantochloa takserah* Camus, Les Bambusees 141. 1913; Blatter, Indian For. 55. 591. 1929. *Gigantochloa kurzii* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 65, t. 56.1896.



▲ *Fig. 47.* **G. apus.** *A - leafy twig with flowering branch; B - flowering branch; C - culm-sheath; D - spikelet; E & F - empty glumes; G - palea; H - staminal tube and stamens around the pistil; I - pistil.*

DESCRIPTION

Strongly tufted bamboo with erect drooping culms. **Culms** bright green or yellow, hollow at the base, 2.5-9 cm diameter, wall thickness 6-13 mm, little swollen at the nodes and constricted between the nodes. **Culm-sheaths** 35-45 cm with small rounded auricle; blade curved up towards middle, very acute, dark brown with spreading white soft hairs outside, inside glabrous, old sheaths persistent, yellowish and brown. **Leaves** linear-lanceolate, 10-15 cm long and 1.5-2 cm broad, petiole short. **Inflorescence** very large pseudo-panicle; apparently leafless, with finely hairy axes and clusters of up to 20 pseudo-spikelets. Spikelets ovate-lanceolate, acute, straight, distinctly laterally compressed; glumes 4-5; lemmas shortly mucronate below, apex with long dark brown cilia; palea 4-5-nerved; keels ciliate. Staminal tube longer than palea, anthers dark purple, 8-18 mm, connective prolonged into ca.1 mm, hairy, acute at tip. Ovary oblong with densely long hairy apex; style with upwardly directed hairs. **Caryopsis** ovate oblong with long attenuate furrow on one side.

FLOWERING

Kurz recorded flowering of this species in 1878 from Tenasserim in Myanmar.

DISTRIBUTION AND ECOLOGY

This species is distributed in Meghalaya (Garo hills). Holttum (1958) mentioned that this bamboo was probably native in Tenasserim, Myanmar and introduced a long time ago in Java and now it is widely cultivated. *G. apus* grows well either on sandy soil or clay soil. It grows in the lowland along river banks or on hill slopes upto 1500 m above sea level. This bamboo grows in open areas or disturbed forests.

ANATOMY

Macrohairs in the leaf lamina none, microhairs few, distal cell 36-43 µm. Prickle hairs numerous 23-63 µm long. Papillae 4-8 long, 2-6 short overarching the individual stoma. Stomata in 2-3 files, outlines obscured by overarching long papillae. Long cells in 5-7 files on inter costal zone. In T.S. of leaf lamina, four small vascular bundles on the adaxial side and four on abaxial side and a large vascular bundle in the middle of the midrib are seen. In the culm epidermis short cells mostly rectangular to trapezoid, papillae none. Stomata 50 µm x 25 µm wide. Long cells 170-290 µm long, rectangular, sometimes with tapering ends with slightly wavy walls (Widjaja, 1987).

CHEMISTRY

Chemical composition of the culm has holocellulose 52.1 per cent; ash 2.7-2.9 per cent; silica 1.8-5.2 per cent; solibility in cold water 5.2 per cent; in hot water 5.4-6.4 per cent; in alcohol benzene 1.4-3.2 per cent and in one per cent NaOH 21.2-25.1 per cent. Starch content fluctuates between 0.24-0.71 per cent based on the season. Nodes contain deposits of silicic acid.

SILVICULTURE

Multiple shoot production and rooting are induced from nodes and shoots respectively by tissue culture method. Callusing is reported from the leaf (Zamora, 1994).

PESTS AND DISEASES

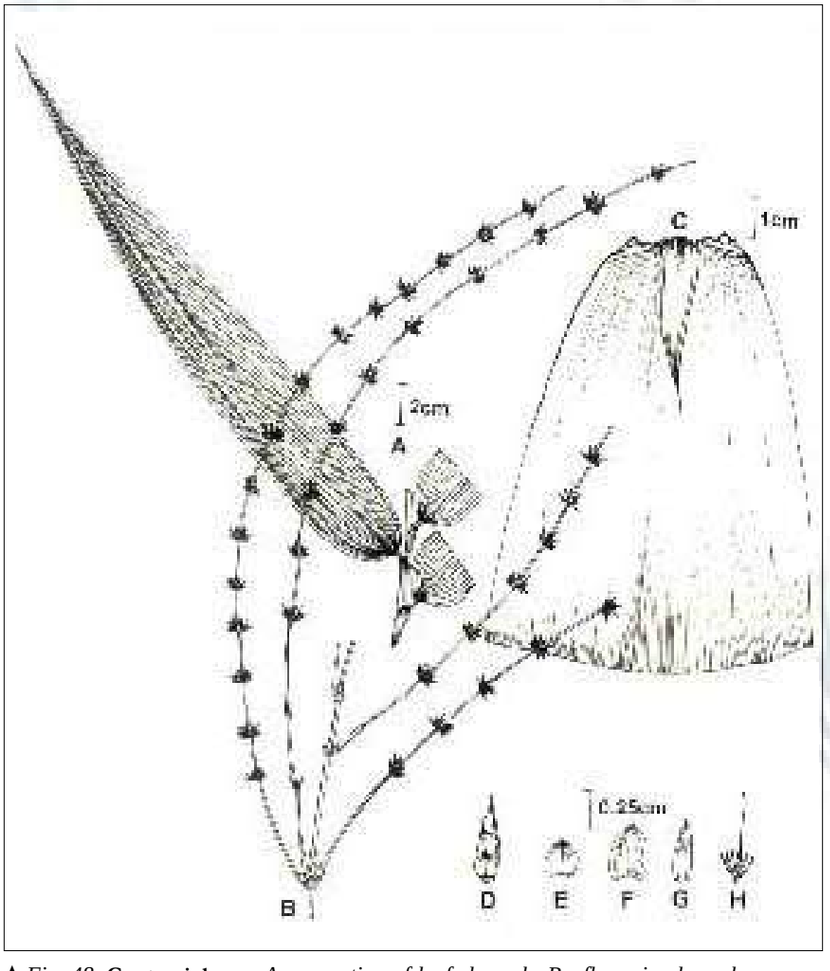
Culm rot caused by *Encoelia helvola* and Witches broom caused by *Epichole bambusae* are reported. *Dinoderus minutus* is the most serious borer attacking harvested culms.

PHYSICAL AND MECHANICAL PROPERTIES

The strength properties of this species were tested in green (Moisture content 54.3%) and in air dry (M.C 15.1%) condition. Average MOR 102.0 in green and 87.5 N/mm^2 in air dry, maximum crushing stress varies from 21.73 to 26.50 in green and 27.29 to 48.64 kN/mm^2 in air dry. Average tensile strength was 294.1 in green and 298.9 kN/mm^2 in air dry. Average shear strength in green varied from 5.99 to 7.68 whereas in air dry it was 7.47 to 7.65 kN/mm^2 (Prawirohatmodjo, 1990).

USES

Gigantochloa apus is the most important bamboo in Java, especially in the handicraft and furniture industries. Moreover, it is used extensively for building materials such as roofing, scaffolding, bridges walls etc. This bamboo is called *Bambu tali* by most Indonesians, because it is the best bamboo used for making string.



▲ *Fig. 48.* **G. atroviolacea.** *A - a portion of leafy branch; B - flowering branch; C - culm-sheath; D - spikelet; E - empty glumes; F - flowering glume; G - palea; H - stamens around pistil.*

Gigantochloa atroviolacea

Gigantochloa atroviolacea Widjaja, Reinwardtia 10: 323. 1987; Bennet and Gaur, Thirty Seven Bamboos Growing in India 69. 1990; Tewari, Monogr. Bamboo 94.1992. **(Fig.48).**

Gigantochloa atter sensu Kurz, Indian For. 1: 344. 1876; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980. *G. verticillata* (Willd.) Munro sensu Backer, Handb. Fl. Java 2: 275. 1928.

DESCRIPTION

Clumps loosely tufted. **Culms** 8-12 m high, 6-8 cm diameter at the base, purple on maturity; internodes usually 30-50 cm long, 5-8 mm thick-walled, nodes with whitish ring, lower ones with aerial roots. **Culm-sheaths** deciduous, with dark brown hairs appressed on the back,

15-20 cm long, triangular; ligule 1-2 mm high, denticulate; auricles 3-5 mm, rounded, slightly curved outward, not joined with the blade with 7 mm long bristles; blade 4-9 cm long, spreading or reflexed, ovate-oblong. **Leaves** 20-30 cm long and 2-5 cm broad, lanceolate, acute; petiole 3-5 mm long; leaf sheaths covered with white hairs; ligule 1-2 mm long, toothed; auricles upto 1 mm tall, rim-like. **Inflorescence** spikelets upto 18 in a cluster, ovate-lanceolate, 8-11 mm long, 3 mm wide, wide with 4 perfect and one sterile flower; glumes broadly ovate, mucronate, 3-5 mm long, brown hairy; lemmas 6-10 mm long, acuminate at the apex; paleas shorter than lemmas, acute and pointed; lodicules absent. Stamens 6; anthers 4-5 mm long, slightly hairy at the tip. Ovary hairy, oblong.

Chromosome number 2n = 72, hexaploid.

DISTRIBUTION AND ECOLOGY

This species grows widely in West Java especially in Banten and Sukabani District as well as Central Java and brought to Indian Botanic Gardens Calcutta, 100 years ago. It prefers to grow in dry areas on soil rich in limestone. The purplish colour of the culm is more prominent when it grows in dry areas.

ANATOMY

In the leaf epidermis stomata common, intercostal arranged in 2 bands in 2-3 alternate rows, 20 µm long and 11 µm wide. Subsidiary cell high-domed, surrounded by 4 large elliptical and 5-6 small globose papillae, not obscuring the stomatal pore. Long cell long and narrow, ends almost straight, uniform in width, walls sinuous; papillae conspicuous, large, compound, arranged in the middle in a row. Interstomatal cells similar to long cells but slightly shorter with concave ends. Short cells costal and intercostal, solitary or in pairs. Cork cells costal indistinct to distinct, intercostal inconspicuous to distinct, larger than the silica cells. Silica cells costal, saddle-shaped, inter costal dumbbell to '8' shaped. Silica bodies costal, saddle-shaped, intercostal dumbbell or of '8' shaped. Prickles intercostal, frequent to infrequent with short acute apex, common towards the margins, base filled with vitreous silica. Microhairs common, intercostal basal cell almost equal to the distal cell, apex rounded. Macrohairs infrequent small to medium sized, 140-210 µm long, more towards midrib. In the culm, stomata almost clear, slightly sunken, 18-22 µm in width. Long cells rhomboidal in shape, 45-95 µm in length and 9-11 µm in width. Papillae scattered, conspicuous, silica cells and silica bodies rectangular, small, oblong to rectangular. Cork cells silicified, larger than the silica cells. Macrohairs thin, long and also small, stiff pointed (Agrawal and Luxmi Chauhan, 1992).

SILVICULTURE

This species can be propagated vegetatively by rhizome or culm cuttings. Recommended planting distance in the field is 8 x 7 m (Dransfield and Widjaja, 1995).

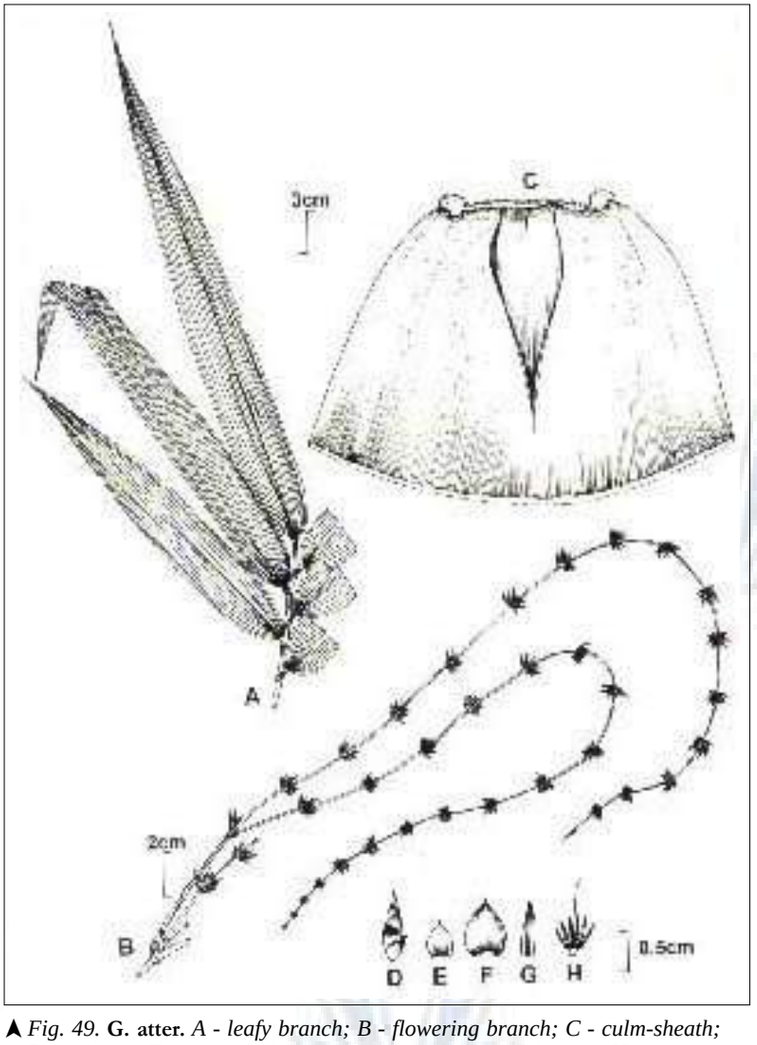
PHYSICAL AND MECHANICAL PROPERTIES

The strength properties of the species were tested in green (Moisture content 54%) and in air dry (M.C 15%) condition. Average MOR in green 92.31 N/mm^2 air dry 94.11 (N/mm^2)compression strength parallel to grain in green, 23.83 N/mm^2 in air dry 35.74, kN/mm^2, maximum tensile strength in green 237.4 N/mm^2 air dry 237.4 N/mm^2. Average shear strength varies from 6.4 to 11.3 N/mm^2 in green and 79.5 to 95.7, in air dry (Prawirohatmodjo, 1990).

USES

In Indonesia, this species is used for building construction and for making furniture. It is also used for making traditional musical instruments and handicrafts.

Gigantochloa atter



▲ *Fig. 49.* **G. atter.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - spikelet; E - empty glume; F - flowering glume; G - palea; H - stamens around pistil.*

Gigantochloa atter (Hassk.) Kurz, Nat. Tijdschr. Ned. Ind. 27: 226. 1864; Munro, Trans. Linn. Soc. London 26: 125. 1868; Camus, Les Bambusees 140. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Widjaja, Reinwardtia 10: 315. 1987; Tewari, Monogr. Bamboo 94. 1992. **(Fig. 49).**

Bambusa thouarsii Kunth, *Bambusa atter* Hassk., Pl. Jav. Rar: 41. 1848; *Gigantochloa verticillata* (Willd.) Munro sensu Backer, Hand. B. Fl. Java 2: 275. 1928.

DESCRIPTION

Large tufted bamboo. **Culms** up to 22 m high, 5-10 cm diameter. **Culm-sheaths** 21-36 cm long, narrowly triangular with truncate apex, black, hairy, auricle rounded or slightly curved outward; ligule 3-6 mm high, irregularly toothed, blades reflexed, deciduous. **Leaves** lanceolate, oblong, 20-44 cm long and 3-9 cm broad. **Inflorescence** spikelets up to 35 in a cluster, ovate, lanceolate, 9-12 mm long consisting of four perfect florets; glumes acute-mucronate at the apex, 3-9 mm long, brown ciliate; lemmas broadly acuminate at the apex, 6-9 mm long, with brownish ciliae; palea shorter than lemma, acuminate at apex with brownish to white cilia, 3-4 veins between keels, 1-2 veins between keel and margin, 5-8 mm long; lodicules absent. Anthers 6, 4-5 mm long, slightly hairy. Ovary hairy, oblong.

DISTRIBUTION AND ECOLOGY

This species is native of Malaya, cultivated in Indian Botanic Gardens, Calcutta. In Java and Sumatra, it is commonly cultivated in village areas and very rarely found near the forest, on the forest edge and in other disturbed areas probably as remnants from previous human settlement. This bamboo is found in the low land and it has been observed growing from near the coast to about 1400 m above sea level.

ANATOMY

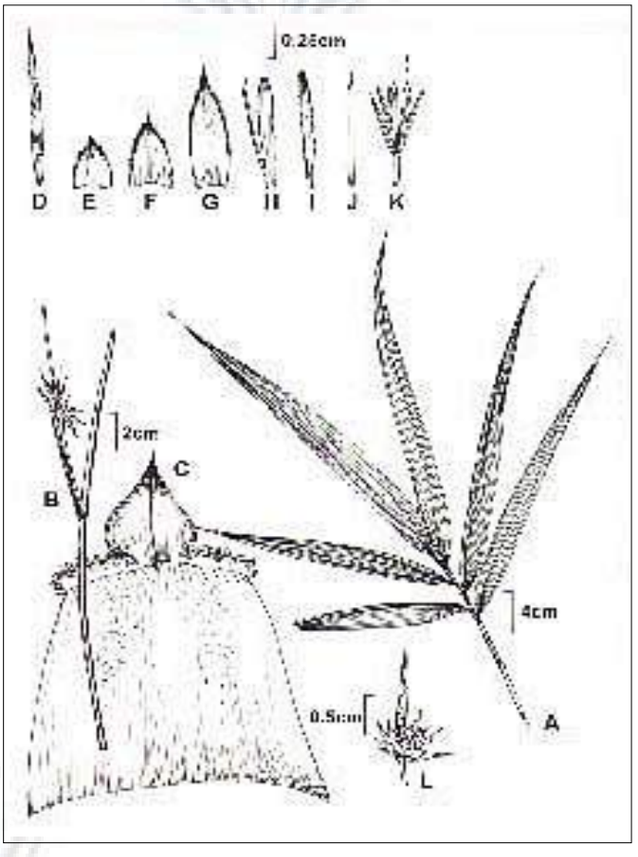
In the leaf epidermis macrohairs present on the abaxial side on the costal zone, 182-360 µm long; microhairs distal, 36-46 µm long, basal cell 33-36 µm long; prickles few, 23-39 µm long; papillae overarching each stoma; stomata 3-4 files; long cells in 6-7 files on intercostal zones with sinuous walls. A cross section of lamina shows two smaller vascular bundles on the adaxial side and 6 on the abaxial side with large vascular bundle in the middle of the midrib, seven small vascular bundles between successive large ones. Epidermal cells of the culm are short, trapezoid and some rectangular. Stomata 40 µm long and 30 µm wide; long cells short 40-70 µm, sinuous, thick, rhomboid, broadest in the middle and slightly tapering at the ends (Widjaja, 1987).

PHYSICAL AND MECHANICAL PROPERTIES

The strength properties of the species were tested in green (Moisture content 72.3%) and in air dry (M.C 14.4%) condition. Average MOR varied from 87.9 to 108.1 N/mm^2 from base to top in green and 117.7 to 127.7 N/mm^2 in air dry. Compression strength parellel to grain 24.77 to 27.97 N/mm^2 in green, 32.87 to 30.98 N/mm^2 in air dry. Average tensile strength was 299.8 to 273.0 N/mm^2 from base to top in green and 33.15 to 24.70 N/mm^2 in air dry. Average shear strength was 5.8 to 10.8 N/mm^2 in green and 9.5 to 10.8 N/mm^2 in air dry (Prawirohatmodjo, 1990).

USES

In Central Java, people call this species bambu legi which means sweet bambu. Young shoots of this bamboo are as delicious as those of *Dendrocalamus asper*. The culm of this species is very useful for building material. It is also used for making musical instruments and other handicrafts. (Prawirohatmodjo, 1990).



Gigantochloa macrostachya

Gigantochloa macrostachya Kurz, For. Fl. Burma 2: 557. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 63 t. 54. 1896 and in Hook. f., Fl. Brit. India 7: 399. 1896; Camus, Les Bambusees 140. 1913; Bor in Kanjilal, Fl. Assam 5: 36. 1940; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 94. 1992. **(Fig. 50).**

Oxytenanthera macrostachya (Kurz) Brandis, Indian Trees 719. 1906.

◄ *Fig. 50.* **G. macrostachya** *A - leafy branch; B - flowering branch; C - culm-sheath; D - spikelet; E & F - empty glumes; G - flowering glume; H - palea with imperfect terminal flower; I - palea; J - stamen; K - staminal tube and stamens around pistil; L - a portion of the flowering branch enlarged.*

▲ **G.macrostachya** - *An internode*

VERNACULAR NAMES

Garo Hills - *Takserah.*

DESCRIPTION

A large evergreen bamboo. **Culms** 10-16 m tall, 6-10 cm diameter. Internodes 45-75 cm long. **Culm-sheaths** short, 12-20 cm long, broader than long. It is easily known by the white longitudinal stripes on the internodes. **Leaves** thin, lanceolate, 16-40 cm long and 1.2-5 cm broad. **Inflorescence** a very large leafy panicle, composed of heads of spikelets more or less distichously and alternately spaced on the branches, bracts at the base of the branchlets large, sub-foliaceous. Spikelets up to 5 cm long, acuminate, subulate, narrow, covered in part by the long ciliae of the glumes and lemmas, hermaphrodite florets 2-3, terminal barren, glumes 2-3, ovate-mucronate, long-ciliate, lemmas of the hermaphrodite florets ovate-mucronate, many-nerved. Palea very narrow, 2-keeled, ciliate on the keels, bifid at the top; lodicules absent. Stamens purple, filaments exserted, connate at the base into a short tube, connective produced into a hairy acumen. The style is neither bifid nor trifid, the lower and the greater portion of its length is covered with short stiff hairs, while the upper portion is densely papillose and has numerous short papillose branches. Ovary narrowly ellipsoid surmounted by a long slender style ending in a stigma. **Caryopsis** narrow, linear, mucronate.

FLOWERING

Brandis recorded flowering of this species in 1862.

DISTRIBUTION

The species is distributed in Assam, Meghalaya and Mizoram in India and in Myanmar.

USES

The species is used for making mats, baskets, and for construction.

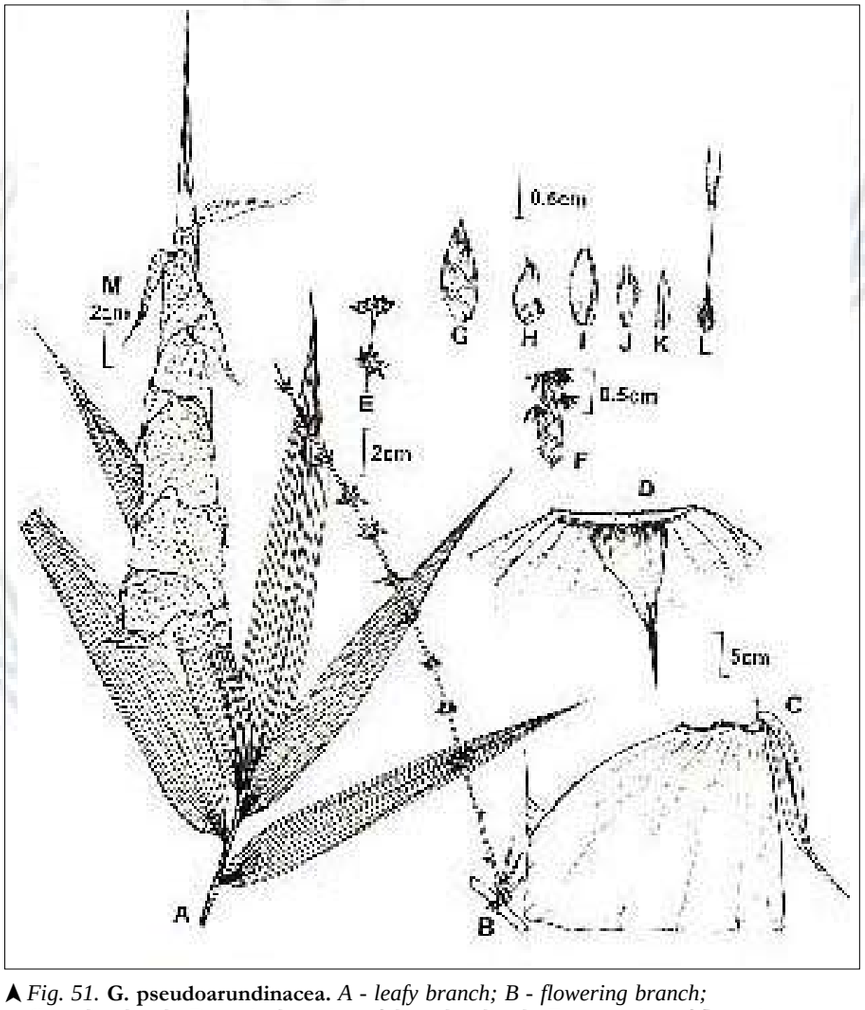
Gigantochloa pseudoarundinacea

Gigantochloa pseudoarundinacea (Steud.) Widjaja, Reinwardtia 10: 304. 1987; Bennet and Gaur, Thirty Seven Bamboos Growing in India, 71. 1990; Tewari, Monogr. Bamboo 97.1992. **(Fig. 51).**

Bambusa pseudoarundinacea Steud., Syn. Glum. 1: 330. 1854; *Bambusa verticillata* Willd., Spec. Pl. 2: 245. 1799; *Gigantochloa verticillata* (Willd.) Munro, Trans. Linn. Soc. London 26: 124. 1868; *Gigantochloa maxima* sensu Kurz, Tijds. Ned. Ind. 27: 226. 1864 and Indian For. 1: 343. 1876; Holttum, Gard. Bull. Singapore 16: 114. 1958.

DESCRIPTION

A large evergreen bamboo, **Clumps** densely tufted, rhizomes developing a mound at the centre. **Culms** 10-30 m high, 7-13 cm diameter, green to yellowish green with thin yellow stripes. Internodes 40-45 cm or rarely 60 cm. **Culm-sheaths** upto 30 cm long covered with golden brown hairs when young and becoming glabrous on maturity. **Leaves** 20-25 cm long, 2.5-5 cm broad, lanceolate, glabrous, petiole ca. 5 mm long; ligule ca. 4 mm high, irregularly toothed and hairy; auricle ca. 1 mm high, connected with ligule. **Inflorescence** a large leafy panicle bearing spicate branchlets with heads of spikelets, many together, rachis striate, heads upto 7.5 cm diameter. Spikelets linear 2.5-5 cm long, acuminate, marked by black fringes to the glumes; fertile flowers 2-3, terminal flower incomplete or reduced to a subulate protruded rachilla; empty glumes 2-3, ovate, mucronate, few appressed black stiff hairs on the back; flowering



▲ *Fig. 51.* **G. pseudoarundinacea.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - apical portion of the culm sheath; E - a portion of flowering branch; F & G - spikelets; H - flowering glume; I - palea; J - lodicule; K - stamen; L - pistil; M - young shoot.*

glumes similar, linear- lanceolate, longer than palea, very narrow, 2-keeled, white-ciliate on keels. Stamens exserted; anthers purple, ending in a fine setaceous hairy point. Ovary narrowly ellipsoid, rounded above, style curved, hairy; stigmas simple. **Caryopsis** narrow, linear, minutely pubescent, tipped with persistent style.

Chromosome number 2n = 72, hexaploid.

FLOWERING

This species has been reported to have flowered in 1854 and 1982 (Widjaja, 1987).

DISTRIBUTION

G. pseudoarundinacea is a native of Java. It is grown in the Indian Botanic Gardens, Calcutta and distributed in Myanmar and Indonesia.

ANATOMY

Macrohairs of the leaf lamina few and short, 107-175 µm; microhairs with distal cell 23-36 µm, slightly smaller than basal cell, 33-40 µm. Prickle-hairs numerous. Papillae 4 long and 4 short, overarching each stoma. Stomata in 3-4 files. Long cells in seven files on intercostal zone, with sinuous walls. In the cross-section of lamina, there are seven small vascular bundles between successive large vascular bundles. Bulliform cells 3. Epidermal cells of culm short, mostly rectangular, 10 µm in pairs with rectangular and narrow silica bodies (Widjaja, 1987). Stomata common, intercostal, arranged in two bands in 2-3 alternate rows; subsidiary cells high-domed surrounded by 4-5 large elliptical and 5-6 globose papillae. Long cells long and narrow, rectangular, 62-85 µm long, 11-15 µm wide, walls sinuous, ends straight. Papillae compound in a single row in the middle of the cell. Interstomatal cell similar to long cells but shorter and wider with concave ends. Short cells costal and intercostal in pairs or solitary, cork cells costal not distinct, intercostal ‘8’ shaped, inconspicuous; silica cell costal, saddle-shaped, intercostal dumbbell to ‘8’ shaped. Silica bodies costal saddle-shaped, intercostal dumbbell to ‘8’ shaped. Prickles frequent to infrequent with long acute apex, base not surrounded by a ring of papillae. Microhairs frequent, bicelled, intercostal basal cell equal to distal cell. Macrohairs infrequent, costal and intercostal, costal medium sized, 120-160 mm long, base not surrounded by a ring of papillae. In the culm epidermis stomata subsidiary cells not clear due to overarching the surrounding papillae 18-23 µm long and 12-15 µm wide. Long cell not uniform in width slightly tapering at ends, 37-95 µm long and 7.5-11 µm wide. Papillae scattered and conspicuous. Silica cells and silica bodies rectangular, small rod-shaped to rectangular. Cork cells silicified, equal or larger than silica cells. Microhairs and Macrohairs in groups (Agrawal and Luxmi Chauhan, 1992).

SILVICULTURE

It is propagated vegetatively by rhizome, culm or branch cuttings. A spacing of 8 x 8 m is recommended for plantations.

PESTS AND DISEASES

It is usually attacked by witches broom (*Epichole bambusae*) and the most serious pest is the borer (*Dinoderus minutus*) attacking harvested culms.

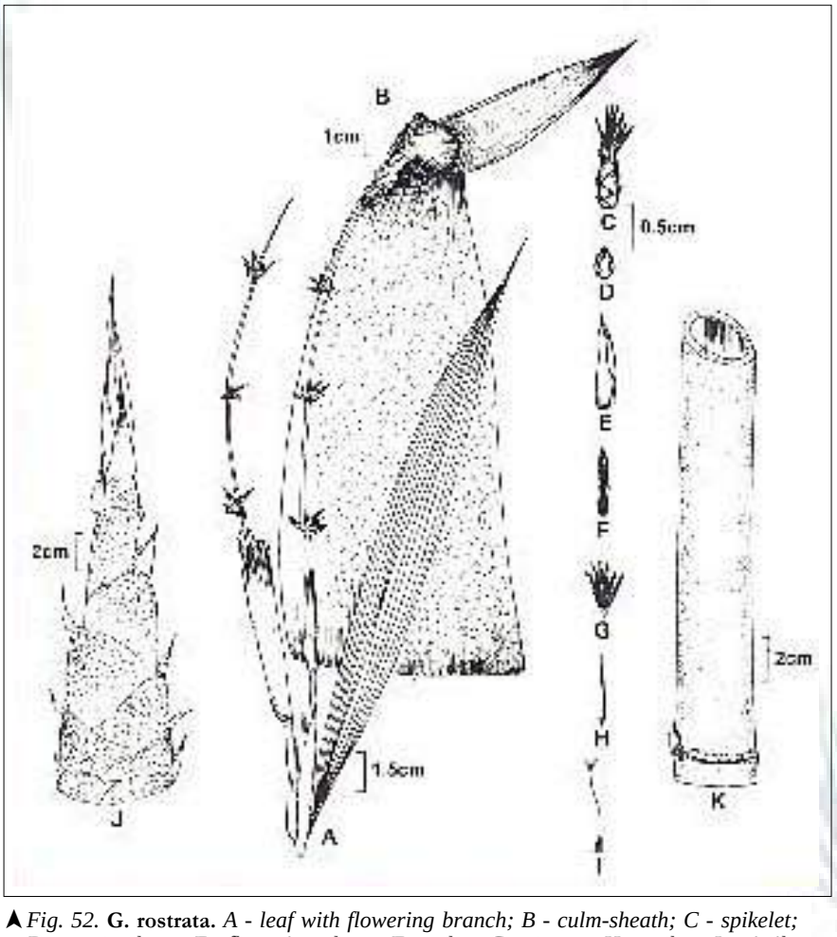
USES

It is widely used as poles and also used for roofings and walls of village houses in Indonesia. This is also used as water pipes and for making furniture, musical instruments and basketry (Widjaja, 1987). This is an important source of edible shoots in Java.

Gigantochloa rostrata

Gigantochloa rostrata Wong, Malay. Forester 45(3): 349. 1982; Widjaja, Reinwardtia 10(3): 333. 1987; Bennet and Gaur, in Thirty Seven Bamboos Growing in India 73. 1990; Tewari, Monogr. Bamboo 99. 1992. **(Fig. 52).**

Gigantochloa maxima var. *minor* Holttum, Gard. Bull. Singapore 16: 116. 1958; *Oxytenanthera nigrociliata* Munro, Trans. Linn. Soc. London 26: 128. 1868. p.p. non *Bambusa nigrociliata* Buse Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 69. 1896; Camus, Les Bambusees 145. 1913.



▲*Fig. 52.* **G. rostrata.** *A - leaf with flowering branch; B - culm-sheath; C - spikelet; D - empty glume; E - flowering glume; F - palea; G - stamen; H - anther; I - pistil; J - young shoot; K - a portion of culm.*

VERNACULAR NAMES

Madhya Pradesh - *Panibans*; Orissa - *Bolangi*; Tripura - *Kailyai*.

DESCRIPTION

Tufted dark green bamboo. **Culms** 5-8 m tall 2.5-5 cm diameter. Thick-walled, slightly drooping, basal portion with yellowish stripes; internodes 20-30 cm long. **Culm-sheaths** upto 10 cm long and 5.5 cm broad, deciduous, with dark brown hairs on the back; auricles low, glabrous; ligule 1-1.5 mm high, irregularly toothed, blade upto 8 cm long, leaf like, spreading or reflexed. Young shoots green, sheath covered with glossy black pubescence, blades erect imbricating, apex long-pointed. **Leaves** 15-22 cm long, 2-3 cm broad, puberulous; petiole 3-4 mm long, auricles an inconspicuous rim, glabrous; ligules 3-8 mm high. **Inflorescence** spikelets slender, 26-31 mm long and 2-3 mm broad, with 3 perfect flowers, glumes 3, 6-11 mm long, narrowly ovate, apiculate; lemma 15-30 mm long, apex long, pointed and rostrate, hairy on the back,

fringed by dark brown hairs; upper lemma inrolled; palea 10-22 mm long, keeled, notched to bifid, 5-veined between keels; anthers 6, 6-10 mm long with rostrate and hairy apex, maroon. **Caryopsis** cylindrical, 10-14 mm long grooved along the dorsal side, pale brown.

FLOWERING

It was reported that gregarious flowering and seeding occurred in Bastar in 1960. *G. rostrata* flowered gregariously in Bangladesh during 1961 and 1978 (Banik, 1987). The species is also reported to flower sporadically. A flowering cycle of 30-50 years has been reported.

DISTRIBUTION

G. rostrata is distributed in Assam, Meghalaya, Tripura, Orissa, Bihar, Madhya Pradesh, Maharashtra and Karnataka. It is also cultivated in different parts of the country.

ANATOMY AND FIBRE CHARACTERISTICS

The culm epidermis shows long cells rectangular with sinuous to wavy walls, papillae in single large groups, guard cells dumbbell shaped and subsidiary cells absent, microhairs with spicules. Internodal cortex homogeneous, thin-walled, peripheral vascular bundles reduced, transitional vascular bundle have both the caps and sheath fused, central vascular bundle with six fibre groups, lining of the cavity parenchymatous (Pattanath and Rao, 1969).

The culm macerate of the species showed a fibre length of 2.54 mm, fibre diameter 15.68 µm, lumen diameter 4.41 µm, wall thickness 5.80 µm and parenchyma 19.25 per cent (Sekar and Balasubramanian - personal communication).

CHEMISTRY

Beating characteristics showed caustic soda 23 per cent, Kappa No.27.9, Lignin in bamboo 22.6 per cent, Lignin in pulp 3.8 per cent, Pentosans in bamboo 16.2, Pentosans in pulp 16.7 per cent, pulp yield unscreened 52 per cent, screened 50.9 per cent (Singh et al., 1976).

SILVICULTURE AND MANAGEMENT

Seeds linear-oblong in shape with either acute or truncate tips. Length 1.91 cm, mid width 0.29 cm, mid breadth 0.21 cm. About 26500 seeds weighed one Kilogram. Seed germination observed was 39 per cent and the germination period is reported to be 1-9 days (Banik, 1987).

Studies on soil profile from Assam indicates that good growth is observed in brown forest soils having less oxides. Also occurs in lighter textured soil under high rain fall. This species can easily be propagated by culm cuttings. A three year felling cycle has been generally recommended for the species.

USES

The culms are used for building huts and making baskets. Also used as a raw material for paper industry. Seeds are used as food by the local people.

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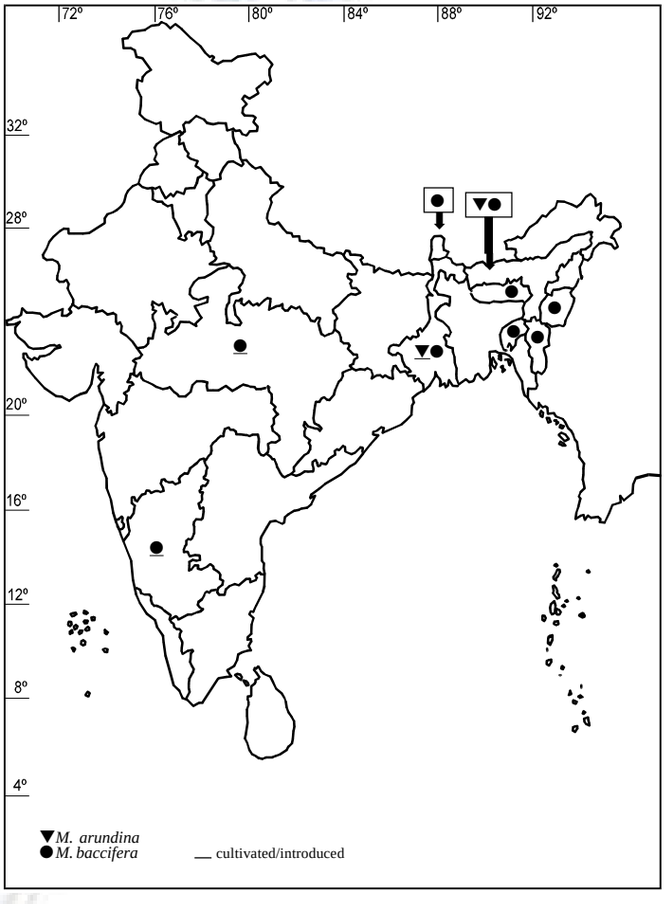
MELOCANNA TRIN.

Arborescent bamboo of moderate size; unarmed. Culms erect, arise singly from the rhizomes at distance. Culm-sheaths often persistent, brittle, short with short, auricles; imperfect blade very long. Leaves broad, petiole, smooth, no transverse veinlets. Inflorescence a large compound panicle of spikes. Spikelets 2-3, fasciculate in bracts in the axils of the spikes, acuminate, with one fertile and one or more sterile flowers; empty glumes indefinite, acuminate, mucronate, striate; flowering glume similar to empty glumes; palea also similar, convolute, not keeled; lodicules 2, narrow. Stamens 5-7; filaments free or irregularly joined. Ovary glabrous; style elongate; stigma 2-4, short hairy. Caryopsis very large, pear-shaped, long-beaked; pericarp very thick.

So far, only two species are known. *M. arundina* is native to Myanmar and cultivated in several parts of the world. *M. baccifera* is found natural in Bangladesh, Myanmar and North Eastern parts of India. It is occasionally introduced and cultivated in different botanical gardens.



◄*Distribution map of* **Melocanna**

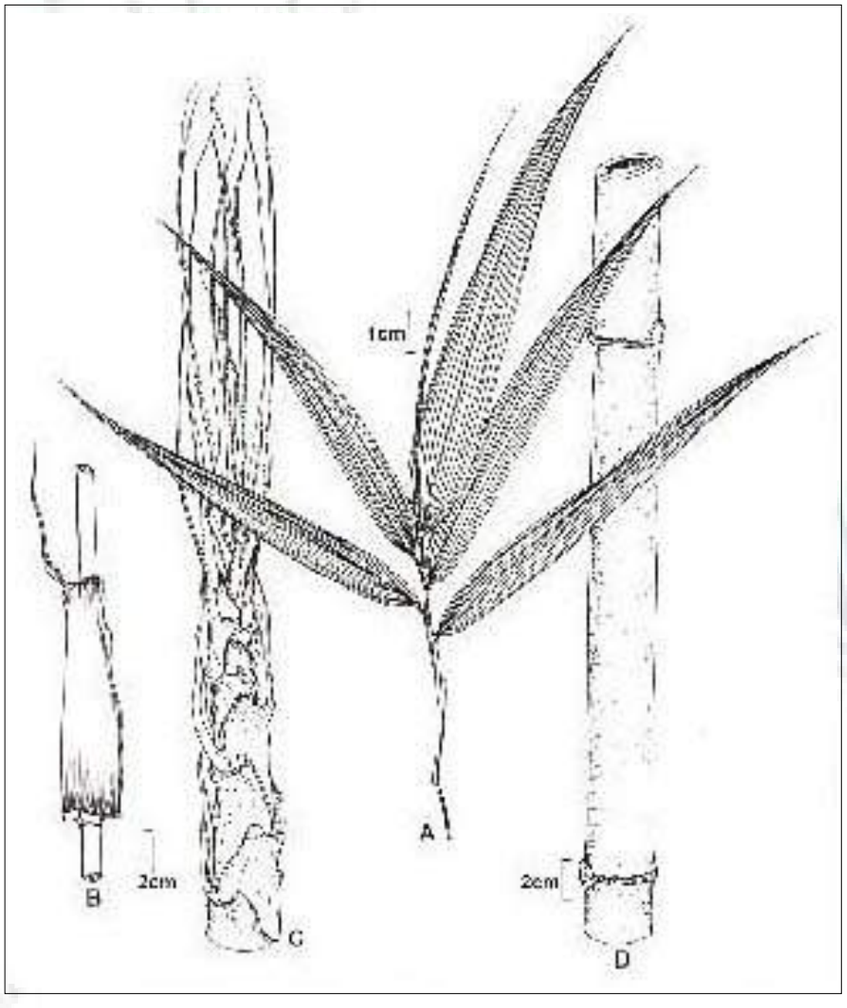
Melocanna arundina

Melocanna arundina Parkinson, Indian For. 61: 326. 1935; Bennet and Gaur, Thirty Seven Bamboos Growing in India 77. 1990; Tewari, Monogr. Bamboo 104. 1992. **(Fig. 53).**

Melocanna humilis Kurz, For. Fl. Brit. Burma 2: 569. 1877; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 120. 1896 and in Hook. f., Fl. Brit. India 7: 418. 1897; Camus, Les Bambusees 180. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980.

DESCRIPTION

An evergreen bamboo. **Culms** 3-5 m high, ca.2.5 cm diameter, dark green, very hollow, nodes hardly thickened, internodes ca.30 cm long. **Culm-sheaths** shining, cylindric, very short, rounded and inflated at the sinuate mouth, blade linear, subulate-acuminate, erect, decurrent into a narrow naked green stripe bordering the sinuses; ligule very short, entire. Young shoots with grooved depression at the upper part of the sheath, blade long, green, flagellate, attached to the centre of the groove. **Leaves** 10-15 cm long and 2-2.5 cm broad, lanceolate to linear-lanceolate, obtuse at the base, under surface slightly rough; petiole ca. 2-3 mm long, leaf-sheath glabrous, with long deciduous bristles at the minutely auricled mouth.



◄*Fig. 53.* **M. arundina.** *A - leafy branch; B - culm-sheath; C - young shoot; D - a portion of culm.*

DISTRIBUTION

This species is native of Myanmar. It has a restricted distribution in Assam. Cultivated in Indian Botanic Gardens, Calcutta.

PESTS AND DISEASES

Brown leaf disease of *M. arundina* has been reported during 1986 in bamboo plantations in Assam Agricultural University. Lesions on the leaves eventually become brown. The causal agent was identified as *Fusarium pallidoroseum* (Deka et al., 1990).

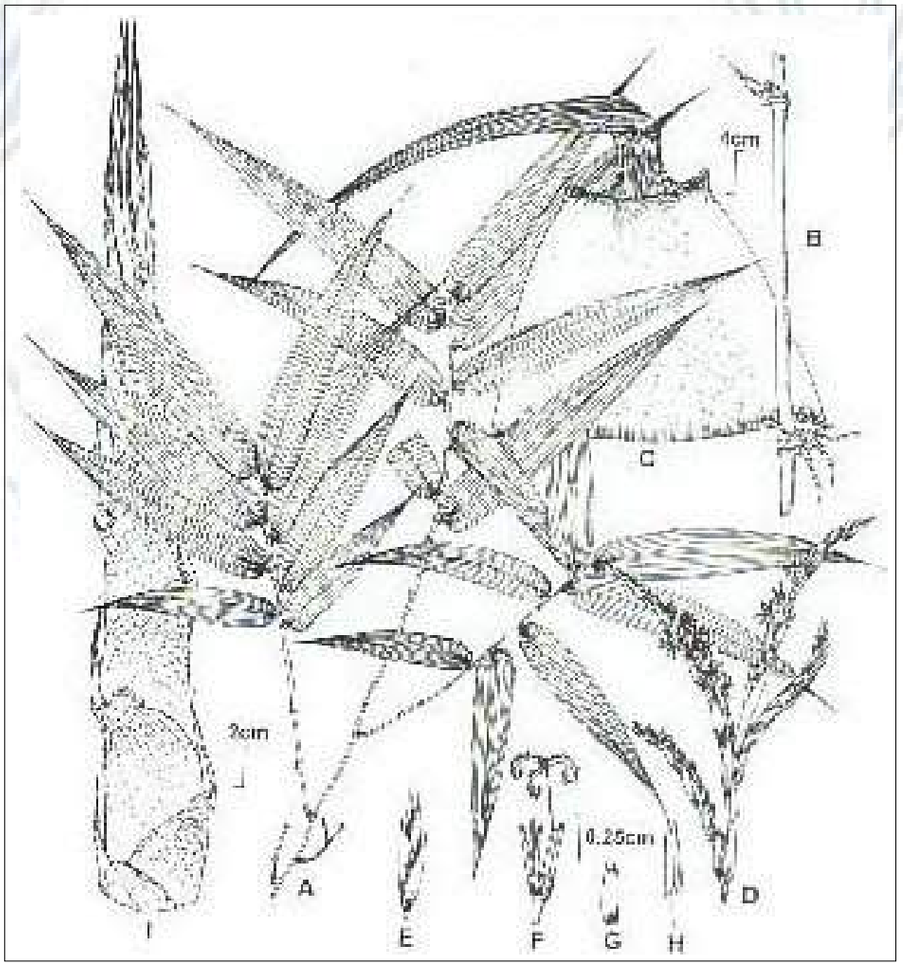
USES

Culms are used for construction purposes and fencing.

Melocanna baccifera

Melocanna baccifera (Roxb.) Kurz, Prelim. Report Fl. Pegu, Append. B. 94. 1875; Skeels, U.S. Dept. Agr. Bur. Pl. Ind. Bull. 223: 50. 1911; Tewari, Monogr. Bamboo 104. 1992. **(Fig. 54).**

Bambusa baccifera Roxb, Pl. Corom. 3: 38, t. 243.1819. and Fl. India 2: 197. 1832; *Melocanna bambusoides* Trin, Sprengel, Neue Entd. 2: 43. 1821; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 118. 1896.



➤ *Fig. 54.* **M. baccifera.** *A - leafy branch; B - a portion of culm; C - culm-sheath; D - flowering branch; E - spikelet; F - stamens aroung pistil; G - lodicule; H - stamen; I - young shoot.*

➤ **M. baccifera** - *Natural growth*

➤ **M. baccifera** - *A clump*

➤ **M. baccifera** - *Internode with culm sheath*

VERNACULAR NAMES

Assam - *Tarai*; Bengal - *Muli*; Cachar - *Wati*; Garo - *Watrai*; Manipur - *Moubi;* Mikir - *Arten*; Nagaland - *Turiah*; Sylhet - *Bajail*; Dhaka - *Nali.*

DESCRIPTION

Evergreen bamboo, clump diffuse. **Culms** 10-20 m high, 3-7 cm diameter, green when young, straw coloured when old; longest internodes 20-25 cm long. **Culm-sheaths** 10-15 cm long, yellowish green when young and yellowish brown on maturity, brittle, striate, truncate or concave at the tip, glabrous or sparsely with whitish appressed hairs on the back. Ligule very short with undulated or toothed margin, auricles small, sub-equal, membranous, fringed with silvery bristles; blade deciduous, usually 15-30 cm long, 2-3 cm broad, subulate. Young shoots smooth, light purple or purplish green; ligule with long hairs, soon

caducous, blades linear, green. **Leaves** 15-30 cm long, 2.5-5 cm broad, oblong lanceolate, apex acuminate, leaf sheath thick, ligulate; auricles very small with silvery bristles. **Inflorescence** a large compound panicle of one-sided drooping, spicate branches, bearing clusters of 3 to 4 spikelets in the axils of short, blunt, glabrous bracts, empty glumes 2-4. Palea glabrous, convolute, mucronate, acuminate not keeled. Lodicules 2, narrow, linear-oblong, obtuse and erose-fimbriate at the tip. Stamens free at base or irregularly joined, filaments flat; anthers yellow,

notched at the apex; ovary ovoid; style elongate, divided in to 2-4 hairy recurved stigmas. **Caryopsis** very large, fleshy, pear-shaped, the stalk is inserted at the thick end and the apex terminates in a curved beak.

The species can be recognised easily by diffused clump habit, having culm-sheath straight for about two-third of the way up, then once or twice transversely waved with subulate flagelliform blade (Alam, 1982).

Chromosome number 2n = 72.

FLOWERING AND FRUITING

Flowering has been reported during 1863, 1866, 1892, 1893, 1900-1902, 1910-1912, 1933 and 1960 (Chatterjee, 1960; Vaid, 1972). Sporadic flowering was reported in Cachar and Manipur in 1967 (Nath, 1968). Sharma (1992) reported flowering at FRI, Dehra Dun. Flowering and fruiting was observed at Pune during 1993. Length of flowering period according to Gamble (1896) is 30 years, according to Kurz (1876) is 30-35 years, according to Troup (1921) is about 45 years. Culms and rhizomes die after flowering. Profuse natural regeneration has been observed.

Seed is green, smooth, sessile, very large having a mid length and diameter of 6.9- 7.2 cm and 4.1-4.3 cm, respectively; obliquely ovoid, thick fleshy, onion shaped and the apex terminating in a curved beak. There is no endosperm in the ripe seed, but it has a 7-13 mm thick white to creamy coloured fleshy pericarp filled with starch just below the green surface of the seed. A more or less round shaped white-coloured embryo with a broad fleshy cotyledonary body is present inside the seed cavity. The fruit is not a true caryopsis, it can be termed as a bacciform caryopsis. Vivipary is observed.

DISTRIBUTION AND ECOLOGY

The species is distributed in India, Bangladesh and Myanmar, cultivated in many Asian countries. In India, it is mainly seen in Assam, Manipur, Meghalaya, Mizoram, Tripura, West Bengal and other parts of Eastern India in the plains and low hills (Biswas et al., 1991). Also found in Singtam, East Sikkim. Seen in cultivation in Maharashtra and parts of Karnataka. It grows almost equally on the well-watered sandy clay loam, alluvial soil and on the well drained residual soils consisting of almost pure sand even at the summits of the low sand stone hills. It springs up in practically pure patches where natural forests have been cleared for agricultural purposes (McClure 1966).

ANATOMY AND FIBRE CHARACTERISTICS

The epidermis is made up of long cells alternating with short cells longitudinally. The long epidermal cells uniform in width (about 7.4 µm) with undulating walls, vary in length from 16.5 µm-122 µm. The cell wall thick and septa-like partitions absent. One pair of short cells alternate with an epidermal cell, two pairs of short cells present occasionally. The cork cells small and rectangular or reniform. Silica cells very small, angular or rectangular. The average number of short cell couples is 1894 per mm^2. Bicellular and fan-like hairs common often occurring in place of short cells. Spines present, few, mostly solitary, as many as 22 per microscopic field (0.17 mm^2). The average number of stomata 10 per field (Ghosh and Negi, 1960). In culm macerates three fibre types are seen; very thick, thick, and thin walled. Septate fibres absent, fibre tips pointed, blunt or forked and wall lamellation 4-7-layered. Slenderness ratio 142.2, flexibility ratio 75.6, Runkel ratio 0.8, fibre length 2.68 mm; fibre diameter 14.37 µm, lumen diameter 4.08 µm, wall thickness 5.15 µm, parenchyma 20 per cent (Singh et al., 1976).

CHEMISTRY

Proximate chemical analysis showed ash 1.9 per cent, cold water solubles 3.25 per cent. hot water solubles 6.4 per cent, alcohol benzene solubles 1.43 per cent, ether solubles 0.81 per cent, caustic soda solubles 18.97 per cent, pentosans

15.13 per cent, lignin 24.13 per cent, cellulose 62.25 per cent (Bhargava, 1945). Analysis of hemicellulose showed 17.3 per cent yield with the following sugars, pentosans 79.8 per cent, methoxyl 0.8 per cent xylose 79.4 per cent, arabinose 79.4 per cent, rhamnose 0.2 per cent, glucose 16.2 per cent, glucuronic acid 2.1 per cent (Rita Dhawan and Singh, 1982).

Beating characteristics of the species showed caustic soda 25 per cent; kappa no.25; lignin in bamboo 27 per cent, in pulp 4.1 per cent, pentosans in bamboo 19.6 per cent, in pulp 15.5 per cent, pulp yield unscreened 43.9 per cent, screened 43.8 per cent (Bose et al., 1988). Spectral absorbance value of cellulose 0.275, lignin 0.255 (Sekar and Balasubramanian - personal communication).

SILVICULTURE AND MANAGEMENT

One clump produces about 5-7 Kilogram of seeds. Average seed weight is about 55.3 g. In a sample of 1000 seeds, the length, diameter and weight varied from 3.6- 10.9 cm, 0.2-6.1 cm and 7.8-150.6 g, respectively. Freshly collected seeds have high viability (78.4%). Under normal conditions the viability is for about 35 days. Storage under air dry condition prolongs viability to 45 days and storage in dry sand in jute bags upto 60 days (Banik, 1991). Seeds have a high germination percentage under shade (negatively photoblastic). Mature seeds germinate even in storage. Number of shoots produced from a single seed vary from 1-6. Fresh seeds start germination within 5-7 days and continue for the next 20-25 days. Shoots are thick (4-6 mm) soft and conical in shape. Germination is hypogeal. Survival and health of seedlings are influenced by seed weight. Seeds can be classified into three grades according to weight. Seedlings from the medium and light seeds develop abnormalities like stunted radicle, albino forms, leafless plumule and radicles growing upward. Generally 1 to 2 plumules develop and form 1-2 stems. Soon after 2-3 weeks of germination fibrous roots develop from the base of young shoot. Shoots emerge successively, new shoots are taller and bigger, biomass gradually increases, recording 86.7g in about 10 months. Rhizome development starts within 40 days after germination. The leaves produced by seedlings are bigger than the mature leaves (Banik, 1991).

Seedlings are kept in the nursery for 10-12 months before planting in the next rainy season. To prevent interlogging between seedlings, they are transplanted to other beds after six months. Pruning of the three months old seedling stem tip induce bud activation. The excised seedlings become woody and it minimises seedling damage during transportation (Banik, 1991).

This species is easy to regenerate from rhizomes. Rhizomes with one to two buds may be planted at a spacing of 4 to 5 m. Using culm cuttings rooting up to 75 per cent is obtained from two-year-old culms. Such propagules produce on an average 20 culms after 4 years of transplanting (Saharia and Sen, 1990). Treatment with growth regulating substances enhances rooting response. The offsets can be planted during April to June. Younger offsets of about oneyear-old showed better survival than the older ones. It is better to plant 2-3 offsets at a time than a single offset.

Due to elongated rhizome necks, the culms are produced at varying intervals in all directions forming a diffuse and open type of clump formation, which can accommodate the space required for the increased number of culm production in later years. Due to this type of growth, the pattern of clump expansion is different in this species.

PESTS AND DISEASES

Root rot caused by *Poria rhizomorpha*, has been reported from North Bengal and Assam. Emerging culm mortality (about 10%) is reported (Banik, 1983).

PHYSICAL AND MECHANICAL PROPERTIES

Strength properties tested under air dry condition showed a moisture content of 12.8 per cent, specific gravity 0.751, fibre stress at elastic limit 43.4 N/mm^2, modulus of rupture 57.6 N/mm^2, modulus of elasticity 12.93 kN/mm^2, compression strength parallel to grain 69.9 N/mm^2.

USES

This species is used for building houses, for making woven ware and as an important source of superior paper pulp. Highly suitable for kraft paper making. The culms are strong, durable with inconspicuous nodes. 'Tabasheer' an ancient elixir of Manipur can be isolated from the culms and branches. Fruits are edible. The culms are used for making floats to transport wooden logs. Enormous logs can be transported by these floats.

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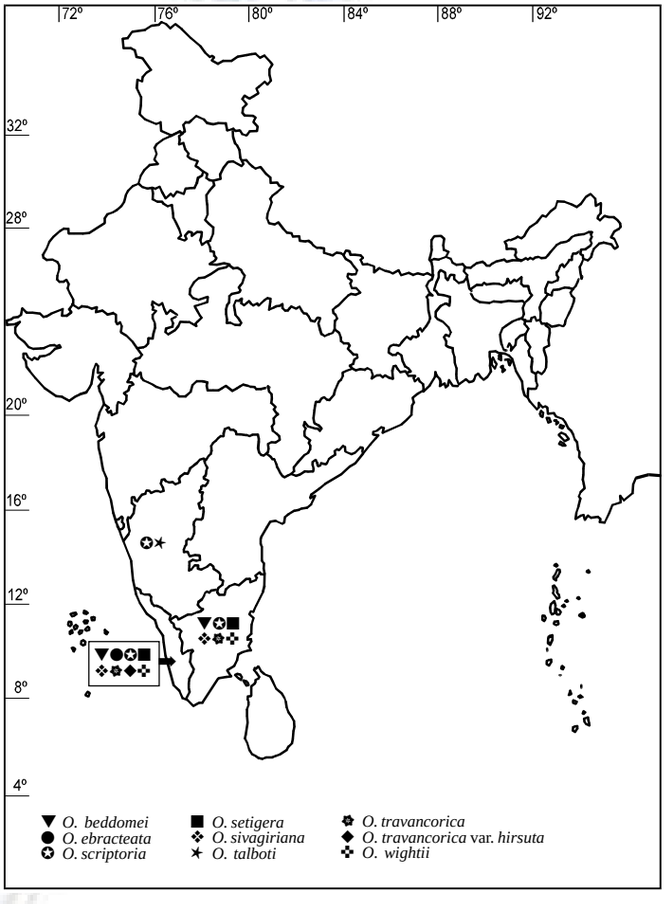
OCHLANDRA THWAITES

Shrubby gregarious reed like bamboo. **Culms** small, thin-walled, erect with comparatively longer internodes. **Culm-sheaths** thin persistent, auricles small. **Leaves** small to moderate-sized, rarely large, linear or oblong-lanceolate, acuminate, shortly petiolate, veins many, margin cartilaginous; leaf sheath striate, fringed, ligule short. **Inflorescence** a terminal spike or spicate panicle on a leafy branchlet. Spikelets in verticils, partly fertile, partly sterile, 1-flowered, empty glumes 2-5, variable, usually mucronate. Flowering glume similar to empty glume; palea membranous, not keeled, lodicules one to several, conspicuous, variable, usually appressed to the filaments. Stamens many, filaments free or monadelphous, exerted, anthers long, mucronate. Ovary narrow; style elongated; stigmas 4-6, plumose, before opening either close together or twisted. **Caryopsis** large, ovoid, long-beaked, supported by persistent glumes; pericarp thick, fleshy.

The genus *Ochlandra* is known to have nine species of which eight species are endemic to Western Ghats of Southern India and one to Sri Lanka (*O. stridula*). The single species reported from Malaya *(O. ridleyi* Gamble), has since been transferred (Holttum, 1958) to *Schizostachyum* (Kumar, 1995).



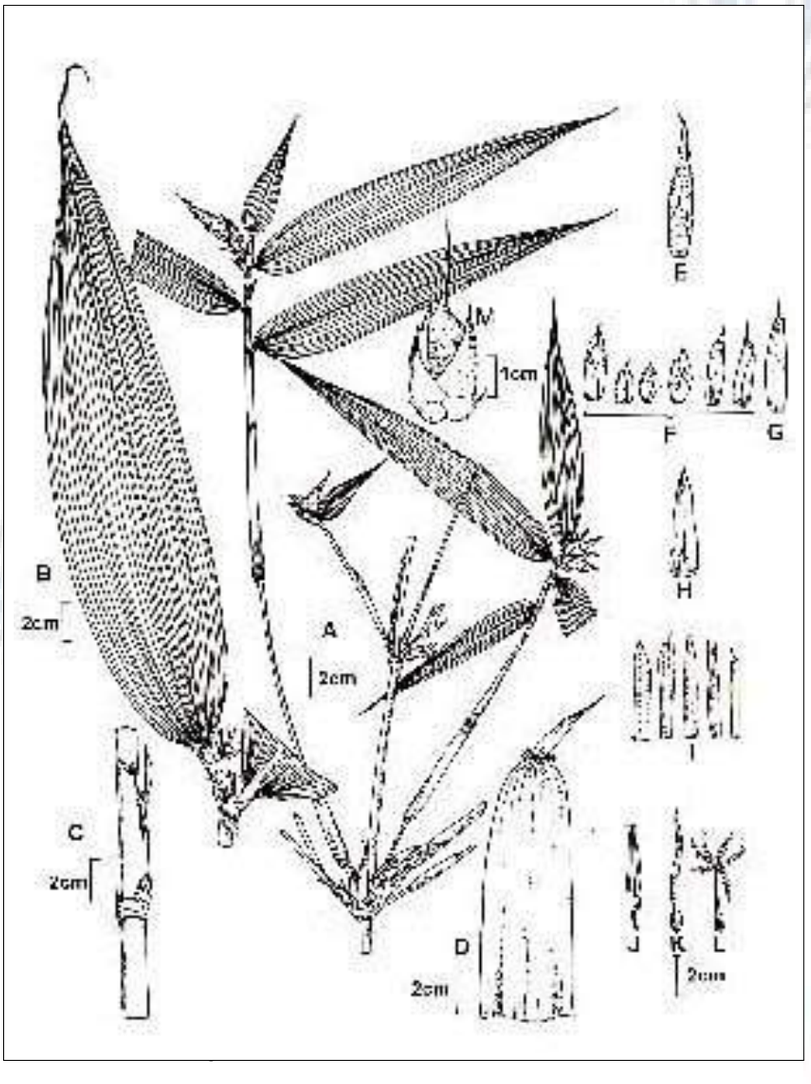
◄*Distribution map of* **Ochlandra**

Ochlandra beddomei

Ochlandra beddomei Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 124. 1896 and in Hook. f., Fl. Brit. India 7: 419. 1897; Camus, Les Bambusees 182. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 109.1992; Chand Basha and Kumar, Rheedea 4(1): 25.1994; Kumar, Rheedea 5(1): 66.1995. **(Fig. 55).**

DESCRIPTION

Culms erect, arching, 10-12 m. high; nodes solitary with single nodal line, slightly pubescent and green. Internodes 15-17 cm long, 3-4 cm diameter. **Culm-sheaths** 11 cm long and 3.5 cm broad, deciduous, glabrous and with a short-lanceolate blade, progressively smaller towards the culm apex, blade reflexed horizontally. **Leaves** oblong, lanceolate 10-14 cm long and 1.5-2.5 cm broad, obliquely rounded at the base into a 5 mm long petiole, long-acuminate above with a twisted setaceous point. Seedling leaves up to 50 cm long, leaf surface smooth above except on the veins towards the edge, smooth and somewhat glaucous below; margins cartilaginous, revolute, midrib narrow. Secondary nerves about 8 pairs, intermediate 6-7, transverse veinlets none. Petiole 2-5 mm long, sheaths auricled and bristly, striate, pubescent, callus at tip; callus with a few erect, stiff, pale bristles; ligule very narrow. **Inflorescence** short terminal spicate panicle on leafy branches or on leafless nodes. Spikelets clustered, 2-3.5 cm long, sub cylindric, covered with scattered, stiff bulbous-based, brown



➤ *Fig. 55.* **O. beddomei.** *A - leafy branch; B - leaf and leaf-sheath; C - culm with branches; D - culm-sheath; E - spikelet; F - empty glumes; G - flowering glume; H - palea; I - lodicules; J - stamen; K - pistil; L - pistil with stigma spread; M - caryopsis.*

hairs. Bracteate 2-4, empty glumes 2, basal ovate, often long mucronate at apex, many-nerved, hirsute, outer glume 2 cm long, linear, longer than the inner flower, 1-1.5 cm in fruit; flowering glume ovate-lanceolate, mucronate, 2.8 cm long, many-nerved; glabrous, in flower, 2.3-3 cm long in fruit. Palea membranous, lanceolate-subobtuse, shorter than the flowering glume, 2.6 cm in flowers, in fruits 3 cm long. Lodicules 5, narrowly elongate, 2 lodicules bipartite at the apex 2-2.5 cm and 0.2-0.4 cm, 2-5-nerved, glabrous. Stamens many, exerted, filaments free; anthers narrow, 1.2-1.6 cm long, bifid at apex, mucronate. Ovary glabrous, sub-orbicular, beak of the perigynium produced into an angular stylar sheath enclosing the style which is terminated by 6 plumose whitish stigmas. **Caryopsis** 5 x 1.7 cm, beak 2.5 cm long, smooth, glabrous, supported by persistent glumes and paleas. Pericarp thick and fleshy.

FLOWERING

Flowering of this species was reported in 1875, 1876. Recently collected in flower in 1986, 1988 and it flowered under cultivation at KFRI, Peechi in 1992. The clump dried after flowering.

DISTRIBUTION AND ECOLOGY

This species is endemic to Western Ghats. Rare and localised in distribution, located at few places in Kerala and Tamil Nadu.

USES

Mainly used for basket and mat making. This is also used for the construction of huts and as a raw material for pulp.

O.beddomei - *Natural growth*

Ochlandra ebracteata

Ochlandra ebracteata Raizada and Chatterji, Indian For. 89: 362. 1963; Tewari, Monogr. Bamboo 110.1992; Kumar, Rheedea 5(1): 68.1995. **(Fig. 56).**

VERNACULAR NAME

Kerala - Valleeta.

DESCRIPTION

An erect, shrubby or arborescent, reed-like, gregarious bamboo, clumps tufted, comprising 60-70 culms. **Culms** up to 4.6 m high. 1.9-3.8 cm diameter, nodes shining green, internode 45.7 cm long. **culm-sheaths** 13-15 cm long excluding the blade, 6-11 cm broad, covered with many appressed, chocolate-brown to black subulate hairs; blade 12-15 cm long, 1.5-2 cm broad, lanceolate-acuminate; ligule 5-9 mm long. **Leaves** narrow to broadly oblong-lanceolate, 40-50 cm long, 6-11 cm broad; more or less cuneate at base, glabrous on both sides; petiole grooved and twisted, 2-10 mm long, apex long acuminate and scabrous, both surfaces glabrous, margin smooth to very slightly scabrous, midrib thick and raised below, secondary veins 10-15 pairs, intermediate 6-8, transverse veinlets numerous; leaf-sheath longitudinally striate, glabrous and 2 short ciliate auricles; ligule 2-4 mm, arching. **Inflorescence** a flagellate spike of sub-verticillate to verticillate clusters of sessile spikelets with a few comparatively large fertile spikelets mixed with smaller sterile ones. Fertile spikelets 2.5-3 cm long 0.5-0.7 cm broad, cylindro-conical, smooth, shining, glabrous. Sterile glumes 2-4, 0.6-1.3 cm long in flower, 1.3-1.8 in fruit, fertile glume 1.75 cm long in flower, 2.5-3 cm in fruit. Palea slightly shorter than fertile lemma, thinner in texture, lodicules 4. Stamens numerous, monadelphous; anthers 10-15 mm long; ovary very small, dorsally compressed, somewhat spherical; styles fused into a long and thick rostrum surmounted by 7-9 plumose, spirally twisted stigmas. **Caryopsis** 6.0 x 1.5 cm, light chocolate brown, oblong, somewhat wrinkled ending in a conical beak.

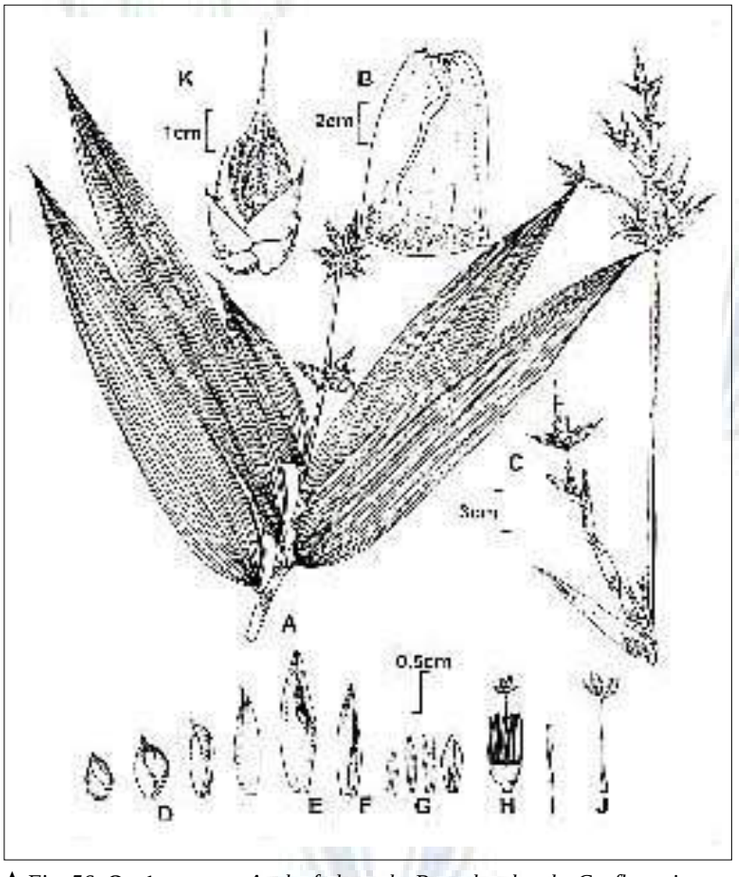


Fig. 56. **O. ebracteata.** *A - leafy branch; B - culm-sheath; C - flowering branch; D - empty glumes; E - flowering glume; F - palea; G - lodicules; H - stamens around pistil; I - stamen; J - pistil; K - caryopsis.*

FLOWERING AND FRUITING

Flowering was first noted during March-April 1961 and 1963. It flowers gregariously and the clump dries after flowering. Recently collected in flower during 1987, 1988 and 1992 from Achenkoil and Edapalayam of Southern Kerala. Flowering started in January and first set of mature seeds were available by April. The local people reported that they observed flowering once in six years.

Fruits arise in clusters at the base of branches and in one cluster 3-10 fruits are seen. Rarely solitary. Fruit length vary from 3.2 to 4.1 cm excluding the length of long beak which is about 2.9 to 3.7 cm. Fresh weight vary from 3.6 to 4.8 g/ fruit. In one kilogram there would be 200 to 280 fruits. The fresh fruits contain 58 to 61 per cent moisture, soon after collection. Profuse natural regeneration was seen in the flowered areas soon after the onset of monsoon. Vivipary was observed (Seethalakshmi, 1993).

DISTRIBUTION AND ECOLOGY

This species was first recorded from Parithipally range, Kottur Reserve, Trivandrum Division, Kerala in the year 1963. It is endemic to Western Ghats and is confined to the hilly districts of Kerala along the stream side.

ANATOMY AND FIBRE CHARACTERISTICS

Culm anatomy of the species show vascular bundles predominantly of Type III (based on Grosser and Liese, 1971) in the internodal region. The bundles of the outer region with thick sclerenchymatous sheath, enclose a patch of parenchymatous tissue towards inner protoxylem. The innermost bundles show Type I structure. Additional patches of sclerenchyma found scattered in the inner region. Type II bundles rarely found at basal part of the culm, more common in the upper region (Bhat - unpublished). Culm macerates show very thick, thin and very thin-walled fibres. Septate fibres present and striate. Fibre tips pointed, blunt or forked. Wall lamellation 3-10 layered (Sekar and Balasubramanian - personal communication). Seed anatomy shows navel and ventral sutures are absent. The seed coat is made up of palisade-like sclereids, followed by 2-3 layered spherical or oval-shaped cells with dark stained thick walls. Aleurone tissues observed between fleshy pericarp and embryo. Endosperm absent. Developed embryo occurs at the centre of the fruit. Pericarp thin walled and parenchymatous. (Appasamy, 1993).

CHEMISTRY

Biochemical analysis of seed showed starch 73.88 per cent, total sugar 8.61 per cent, phenol 3.46 per cent, protein 9.84 per cent and lipid 4.24 per cent. The amount of protein was less when compared to *B. bamboos* and *D. strictus* seeds and phenol was high (Appasamy, 1993).

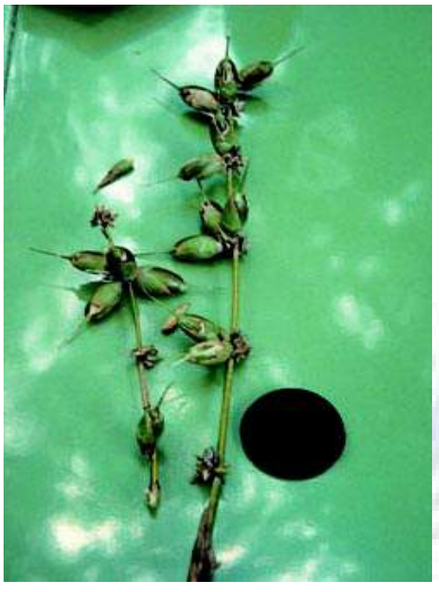
SILVICULTURE AND MANAGEMENT

Seeds are sown in raised nursery beds filled with soil sand mixture. Germination starts within 3 days and complete by 10 days. It is essential to protect the seeds from rodents by covering with wire mesh. Partial shade is necessary for proper germination. The seedlings reach a height of 0.5-1 m within one year. Trimming of the top portion helps to reduce damage during transport. (Seethalakshmi - unpublished). Germination of seeds vary from 57 to 73 per cent initially and it was observed that the germination was reduced to 4 percent within a period of 3 months (Seethalakshmi, 1993). Rhizomes can be planted directly during the onset of monsoon. For vegetative propagation, two-noded culm cuttings treated with growth regulating substances (NAA 100 ppm, aqueous solution) by cavity method gives 30 per cent rooting (Seethalakshmi - unpublished).

◄*Flowering of* **O. ebracteata**

▼ *Fruits of* **O. ebracteata**

➤*(opposite page) A clump of* **O. scriptoria**



PESTS AND DISEASES

Witch's broom disease has been reported in this species causing profuse growth of axillary shoots and pronounced reduction of internodal length and size of the stem, sheath and leaves. The fungus, *Balansia linearis* was seen associated with this disease. It produced dark brown to black fructifications on the affected leaves and usually spread lengthwise from the leaf base to the apex. Often the whole leaf appeared to be a fungal fructification with the exception of a small portion at the tip. The infection was recorded throughout the year (Mohanan, 1990). Sooty mould caused by *Spiropes scopiformis, Meliola* sp., and leaf spot caused by *Glomerella cingulata, Dactylaria* sp. have also been recorded. The major fungi reported on stored seeds were species of *Alternaria, Aspergillus, Penicillium, Dactylaria, Mucor* and *Rhizopus* (Appasamy, 1993).

USES

Used in paper industry and for making baskets and mats. Powder prepared from the dried seeds is used as cattle feed.

Ochlandra scriptoria

Ochlandra scriptoria (Dennst.) Fisch. in Gamble, Fl. Pres. Madras 3(10):1863. 1934; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1):3. 1980; Tewari, Monogr. Bamboo 110.1992; Kumar, Rheedea 5(1):70.1995. **(Fig. 57).**

Bambusa scriptoria Dennst., Schluessel Hort. Malab. 31. 1818; *Bheesa rheedii* Kunth, Enum. 1:434.1822; *Ochlandra rheedii* (Kunth) Benth. & Hook. f. ex Gamble, Ann. Roy. Bot. Gard. Calcutta 7:121. 1896 and in Hook.f., Fl. Brit. India 7:418.1897; Camus, Les Bambusees 181. 1913.

VERNACULAR NAMES

Kerala- *Ammei, Bheesa, Kolanji, Ottal.*

DESCRIPTION

A gregarious shrubby bamboo. **Culms** erect up to 5m tall, smooth; nodes somewhat raised; internodes ca.45 cm long, 2.5 cm diameter. **Culm-sheaths** truncate with 2 falcate, long-ciliate auricles; blades long, ensiform, 10-15 cm long, purplish. **Leaves** linear lanceolate, 10-25 cm long and 1-3 cm broad, smaller and larger ones intermixed, smaller being most frequent, rounded at base, pointed at apex, smooth on both surfaces, sheath smooth, with 2 falcate auricles fringed with deciduous bristles, ligule very short. **Inflorescence** a short terminal or axillary spike. Spikelets cylindric, acute, glabrous, sterile in heads, smaller, 1.2-1.8 cm long, fertile few, subsolitary with bracts, empty glumes 2-3, flowering glume larger, sub-acute, palea convolute, not keeled, lodicules many. Stamens 15-18 or more, exserted, filaments free, slender, anthers mucronate. Ovary oblong, surmounted by perigynium containing the style, which is cleft at the apex into 3 plumose stigmas. **Caryopsis** oblong, large, long- beaked, 7.5 x 1.2 cm.

FLOWERING AND FRUITING

Although flowering is reported to be annual, it is not very frequent. From the Western Ghats, this species was collected in flower during 1988, 1989, 1992 and 1995. Clumps dry after gregarious flowering.

Of all the species of *Ochlandra* reported from Southern India, the fruits of this species is found to be the smallest. The length of the fruit vary from 2.8 to 3.9 cm with a beak of 2.7 to 3.4 cm. Fresh weight is 1.56 to 1.6 gm/fruit. One kilogram contains about 625 to 640 fruits. The moisture content vary from 65 to 70 per cent (Seethalakshmi, 1993).

DISTRIBUTION AND ECOLOGY

This species is endemic to Western Ghats. Distributed in Karnataka, Tamil Nadu and Kerala, found growing mostly on river banks.

ANATOMY AND FIBRE CHARACTERISTICS

Vascular bundles at the internode scattered, triangular, radially elongated at outer region and tangentially elongated at the inner region. Sclerenchymatous bundle sheaths prominent towards the outer region. Sheath size vary in the protoxylem and metaxylem elements. At the nodal region, the hypodermis has 4 to 5 layered sclerenchyma, bundle sheath sclerenchyma found adjacent to the phloem and protoxylem. Three variants of libriform fibres present. The vessel elements are long, narrow with simple perforation plate (Appasamy, 1989). Recent observations (Bhat - unpublished) show that vascular bundles of Type I occur along with the Type II in this species. The central bundles are of Type II with a transition to Type I towards the inner region. The upper height levels of the culm do not show a distinct transition in bundle morphology from Type II to Type I as evident at lower height levels.

Fibre characteristics in this species showed a fibre length of 1954 µm diameter 12.0 µm, lumen width 6.9 µm wall thickness 4.8 µm, slenderness ratio 162.8, flexibility ratio 57.5 and Runkel ratio 1.3 (Sekar and Balasubramanian - personal communication).

SILVICULTURE AND MANAGEMENT

Seeds are sown after collection in nursery beds filled with sand and soil mixture, partial shade is necessary for initial two months. Initial germination is about 70 per cent. Seeds are viable only for a period of two months (Seethalakshmi, 1993). Seedlings can be transplanted after a period of one year. Rhizomes can be separated from the culms during the

onset of monsoon and can be used for field planting. Two-noded culm cuttings treated with IBA 100 ppm give the highest percentage of rooting in culm cuttings (50%). The rooting and shooting responses can be significantly enhanced by the application of suitable growth regulating substances. The cuttings are treated by the cavity method and planted horizontally in nursery beds (*Seethalakshmi* et al., 1990).

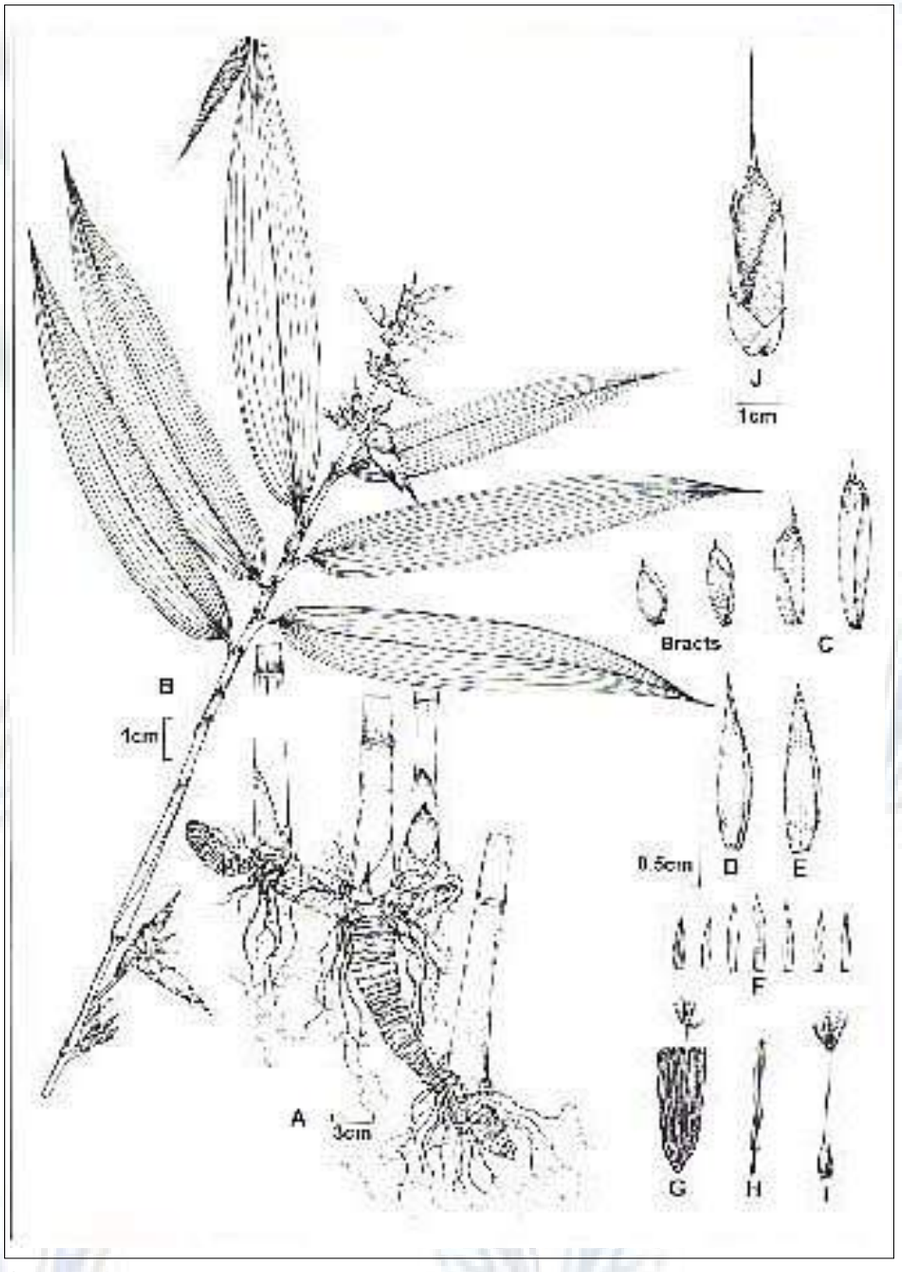


Fig. 57. **O. scriptoria.** *A - rhizome; B - leafy branch with inflorescence; C - empty glumes; D - flowering glume; E - palea; F - lodicules; G - pistil surrounded by stamens; H - stamen; I - pistil; J - caryopsis.*

MYCORRHIZAE

The presence of vesicular arbuscular mycorrhizae (VAM) *Glomus fasciculatum* is reported in the rhizo-sphere. About 86 per cent infection was observed in the roots collected from plants growing near Pudukode lake, Wynad District. (Appasamy and Ganapathy, 1992).

PESTS AND DISEASES

Damping-off and seedling rot has been recorded in this species, caused by *Fusarium moniliforme*. Leaf spots caused by four new pathogens, *Dactylaria* sp., *Exserohilum* sp., *Glomerella cingulata* and *Pythomyces* sp. has been found. Two other diseases recorded from Kerala are Sooty mould and Witch's broom caused by *Spiropes scopiformis* and *Balansia linearis* respectively (Mohanan, 1990).

USES

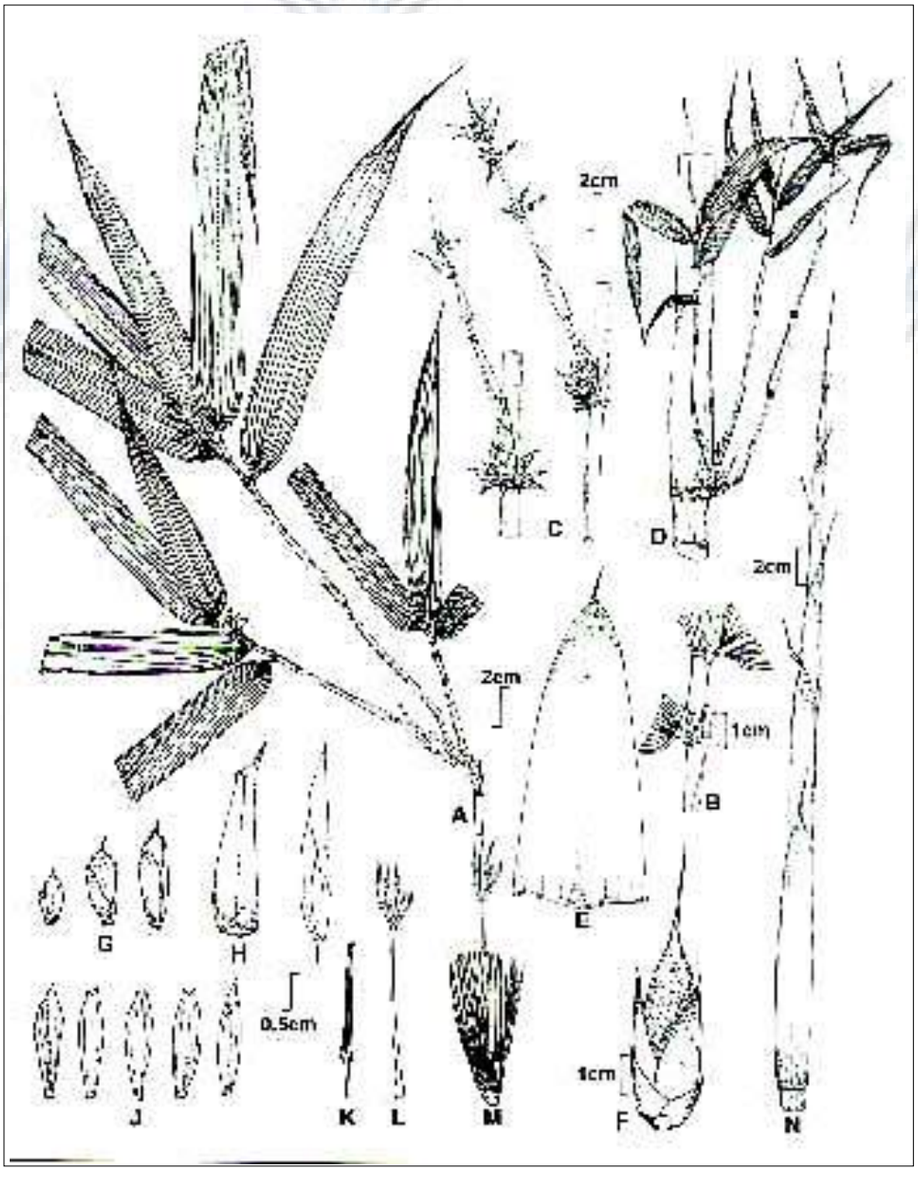
This is one of the important bamboo species used mainly in pulp and paper industry. Also used for making mats, baskets, floats and rafts. Bamboo boards are made from the mats. Small culms are used for making flutes.

Ochlandra setigera

Ochlandra setigera Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 128. 1896 and in Hook. f., Fl. Brit. India 7: 420. 1897; Camus, Les Bambusees 184. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 113. 1992; Chand Basha and Kumar, Rheedea 4(1): 26. 1994; Kumar, Rheedea 5(1):72.1995. **(Fig. 58).**

DESCRIPTION

Culms erect or straggling, culms ca.6 m high, 1.2-1.8 cm thick, smooth, without branches below, much branched above; nodes hardly swollen; internodes 25-30 cm long, whitish below the nodes, walls 0.2-0.5 mm thick. **Culm-sheaths** persistent, 15-19 cm long, thin, papery, striate, wrinkled near the top, gradually attenuate to a narrow apex, 1.1-2 cm long, subulate, hair like, edges incurved and hairy within; ligule very narrow, short. **Leaves** oblong-lanceolate, acuminate 12-26 cm long and 1.8-3 cm broad, rounded at the base, smooth above minutely



➤ *Fig. 58.* **O. setigera.** *A - leafy branch with inflorescence; B - leaf-sheath; C - flowering branch; D - culm with branches; E - culm-sheath; F - caryopsis; G - empty glumes; H - flowering glume; I - palea; J - lodicules; K - stamen; L - pistil; M - stamens aroung pistil; N - young shoot.*

hairy beneath scabrous on margins, tip twisted and hair-like; midrib narrow, secondary veins 5-7 pairs, intermediate 6-7, pellucid glands many; 3-6 mm long petiole; sheath smooth with short decurrent auricles, fringed with long stiff curved bristles. **Inflorescence** a short terminal or axillary spike on leafy branchlets. Sterile spikelets in heads, smaller than the fertile, rachis smooth, spikelets cylindric, tip pointed, clothed with white hairs. Spikelets 1.8-2.2 cm long, empty glumes 3, hairy, 0.7-1.3 cm long, many-nerved, ovate, acute and mucronate. Flowering glume larger, glabrous, acute at the apex 2.4 cm. Palea more or less same length of lemma, membranous many-nerved, acute at the tip. Lodicules 5, 1.3-1.4 cm long, 3-6-nerved, 3 of them bifid. Stamens many, 26-32, exserted, filaments free, short; anthers 1.2-1.5 cm long. Ovary narrow, glabrous; style surmounted by perigynium, at the tip 5 plumose stigmas, 3 long and 2 short. **Caryopsis** oblong, 6.8 x 1.3 cm, fleshy pericarp, glumes persistent, beak 3 cm long.

➤ **O. setigera** - *A clump*

FLOWERING

For the first time, flowering was reported from Nilambur in 1988 and subsequently in 1994 (Chand Basha and Kumar, 1994).

DISTRIBUTION AND ECOLOGY

The species is endemic to Western Ghats. Restricted in distribution, found in Tamil Nadu (Nilgiris) and Kerala (Nilambur) at an elevation of 1000 m and above.

ANATOMY

Sub-epidermal layers are mostly sclerenchymatous showing no distinct demarcation between fibrous and fibro-vascular bundles in the peripheral region. In the mid-part of the ground tissue bundles are of Type I. The innermost bundles lining the cavity are of Type II. Fibre strands absent in the inner region (Bhat - unpublished).

USES

Local people use the culm of this species for tying bundles of firewood, basket and mat making. Leaves are used as fodder.

➤ **O. setigera** - *New shoots*

➤ **O. setigera** - *Internode and branches*

Ochlandra sivagiriana

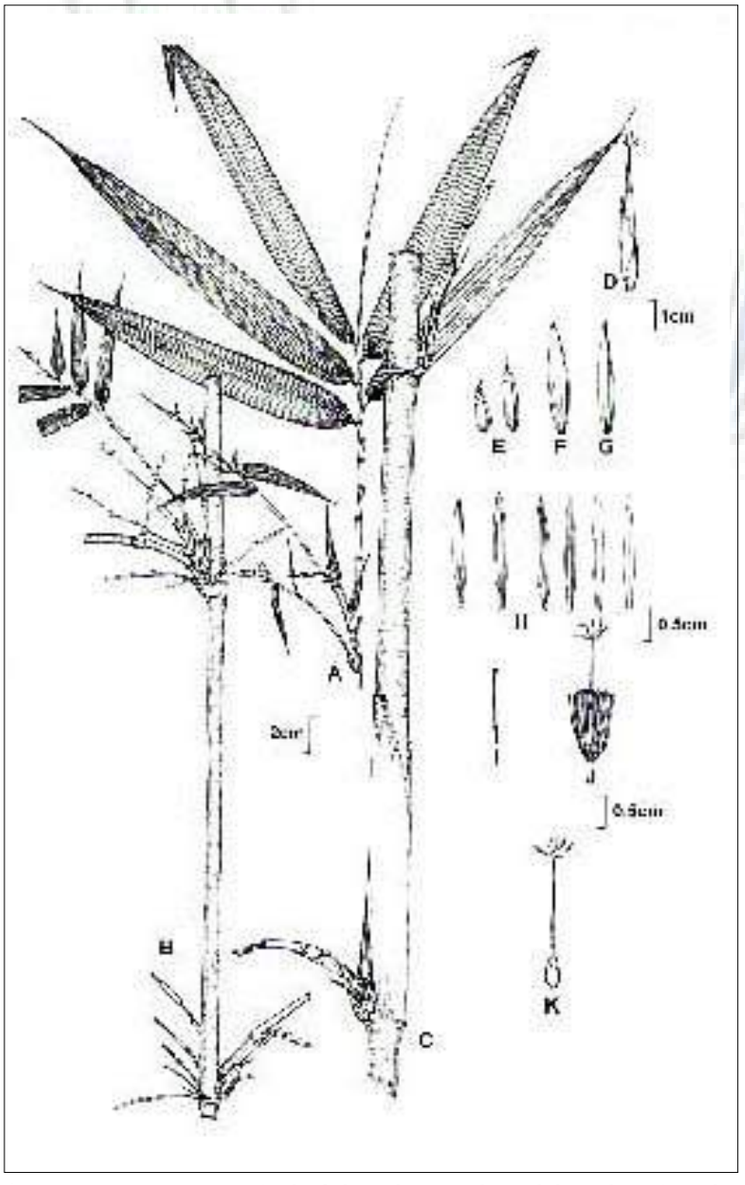
Ochlandra sivagiriana (Gamble) Camus, Les bambusees 181. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 113.1992; Kumar, Rheedea 5(1):74.1995. **(Fig. 59).**

O. rheedii var. *sivagiriana* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 122. 1896.

DESCRIPTION

Small straggling reed-like bamboo. **Culms** up to 5 m. high nodes somewhat raised, internode 36 cm long 1.8 cm diameter. **Culm-sheaths** 18 cm long, striate on maturity. **Leaves** linear-lanceolate, acuminate at the tip, 8-22 cm long and 1-2.5 cm broad, attenuate at the base. Petiole 2-4 mm long. midrib narrow, secondary veins 7-10 pairs; sheath smooth, glabrous, with two falcate auricles fringed with deciduous bristles; ligule very short. **Inflorescence** a short terminal or axillary spike or spicate panicle on leafy branchlets; spikelets cylindric, acute, slightly hairy, fertile, few, 4 x 0.5 cm. Empty glumes 2, many-veined, acuminate at the tip. Flowering glumes larger, 3 cm long, many-veined; palea 3.2 cm long, convolute, long, mucronate, membranaceous at the base. Lodicules 6, ca.1.5 cm long; 1-5-nerved. Stamens 27 to 32 exserted, filaments free; anthers slightly apiculate. Ovary oblong, surmounted by perigynium containing the style which is cleft at the apex in 5 plumose stigmas.

This species is similar to *O. scriptoria* in general appearance. It differs from *O. scriptoria* in having 27-32 stamens, shorter connectives, 6 lodicules; leaves attenuate at the base into a petiole ca.4 mm long. Leaf-sheath hairy and ciliate.



▲ *Fig. 59.* **O. sivagiriana.** *A - leafy branch; B - culm with branches; C - culm with culm-sheath; D - spikelet; E - empty glume; F - flowering glume; G - palea; H - lodicules; I - stamen; J - stamens around pistil; K - pistil.*
(see page 190 for picture of Plant habit)

FLOWERING

For the first time, flowering was observed in the few clumps growing naturally at Vazhachal (Trichur, Kerala) in 1993. After flowering, the clumps dried. Fruit formation was not observed (Kumar, 1995).

DISTRIBUTION

Very restricted in distribution, found only in Sivagiri and Palni Hills of Tamil Nadu and Vazhachal of Kerala.

ANATOMY

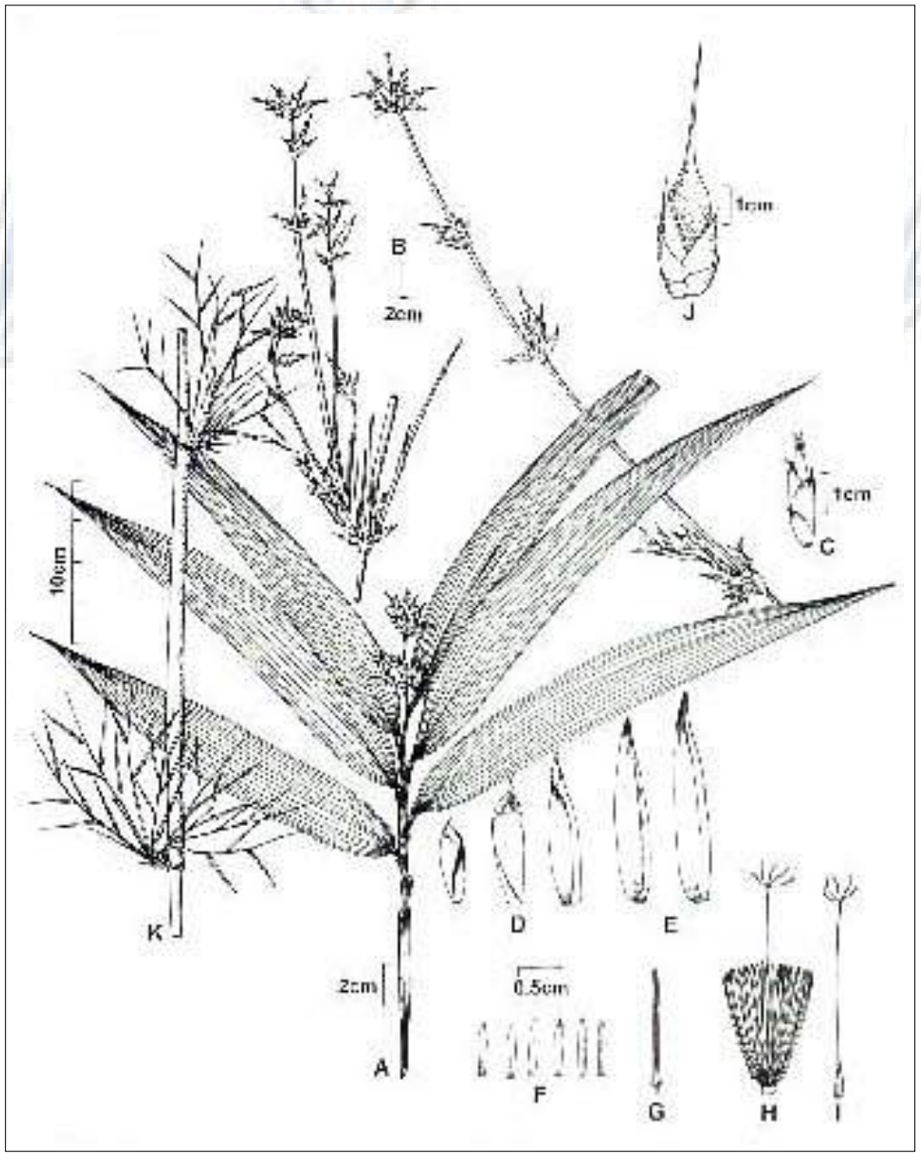
In the internode, fibrous patches present with fibro-vascular strands in the peripheral region. The central bundles are of Type II. Fibrous strands occasionally present in the inner region. Between different height levels no appreciable anatomical variations found. (Bhat-unpublished).

USES

Used for basket making and tying purposes. Culms are used by tribals for fencing.

Ochlandra talboti

Ochlandra talboti Brandis, Indian Trees 684. 1906; Camus, Les Bambusees 181. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 3. 1980; Tewari, Monogr. Bamboo 115. 1992; Kumar, Rheedea5 (1):80.1995. **(Fig. 60)**.



➤*Fig. 60.* **O. talboti.** *A - leafy branch with inflorescence; B - flowering branch; C - spikelet; D - empty glumes; E - flowering glume and palea; F - lodicules; G - stamen; H - stamens around pistil; I - pistil; J - caryopsis; K - culm with branches.*

◄ **O. sivagiriana** - *Natural growth*

O. rheedii var. *sivagiriana* sensu Talbot, Trees of Bombay 348. 1902, non Gamble 1896; *O. stridula* Woodr., J. Bombay Nat. Hist. Soc. 13: 442. 1901.

DESCRIPTION

Erect, arborescent bamboo, growing in dense clump. **Culms** 3 to 6 m high, 1.2-1.8 cm diameter, slender and drooping at the top; internode about 40 cm long; **Culm-sheaths** smooth, striate, ciliate on the margin, rounded with two small ciliate auricles at the tip; blade subulate, acuminate, hairy within at the base; ligule short. **Leaves** lanceolate, 20-26 cm long and 3-3.5 cm broad, ending in a long setaceous point at the apex, cordate or subacute at the base, pale green beneath; midrib prominent, secondary veins 10 pairs; petiole short ca. 4 cm long, broad and grooved above; sheath smooth, striate, truncate at the tip, bearded with long stiff bristles, ligule very short. **Inflorescence** terminal or axillary spike, 10-20 cm long. Spikelets 2-6, 1-3 cm long in half whorls which are 2 cm apart at the base and congested at the top of the rachis; fertile spikelets ovoid, cylindric, few. Empty glumes 3-4, 1-1.9 cm long, broadly ovate, acute, spinous, mucronate with spreading white hairs at the tip. Lemma larger, acute, 2.8 cm long; palea similar to lemma; lodicules 6-7, linear. Stamen 26-40, exserted, pendulous; filaments long, slender; anther linear, sagittate at the base. Ovary prolonged into a slender style, 2 cm long and surmounted by 5 plumose stigmas. **Caryopsis** ovoid, 7.8 cm long, glabrous, shining, prolonged into a long slightly curved beak, completely enclosed by 4 persistent glumes. Pericarp thick, fleshy.

FLOWERING

In North Canara, it flowered sporadically in 1896. Recently, flowering was observed in Karnataka in 1994 near Virajpet. (Kumar, 1995).

DISTRIBUTION AND ECOLOGY

The species is distributed in Karnataka (Coorg and North Canara), and endemic to Western Ghats. It is found growing well in the rain forests, often along the banks of rivers and nallahs.

USES

It is used for mat and basket making.

Ochlandra travancorica

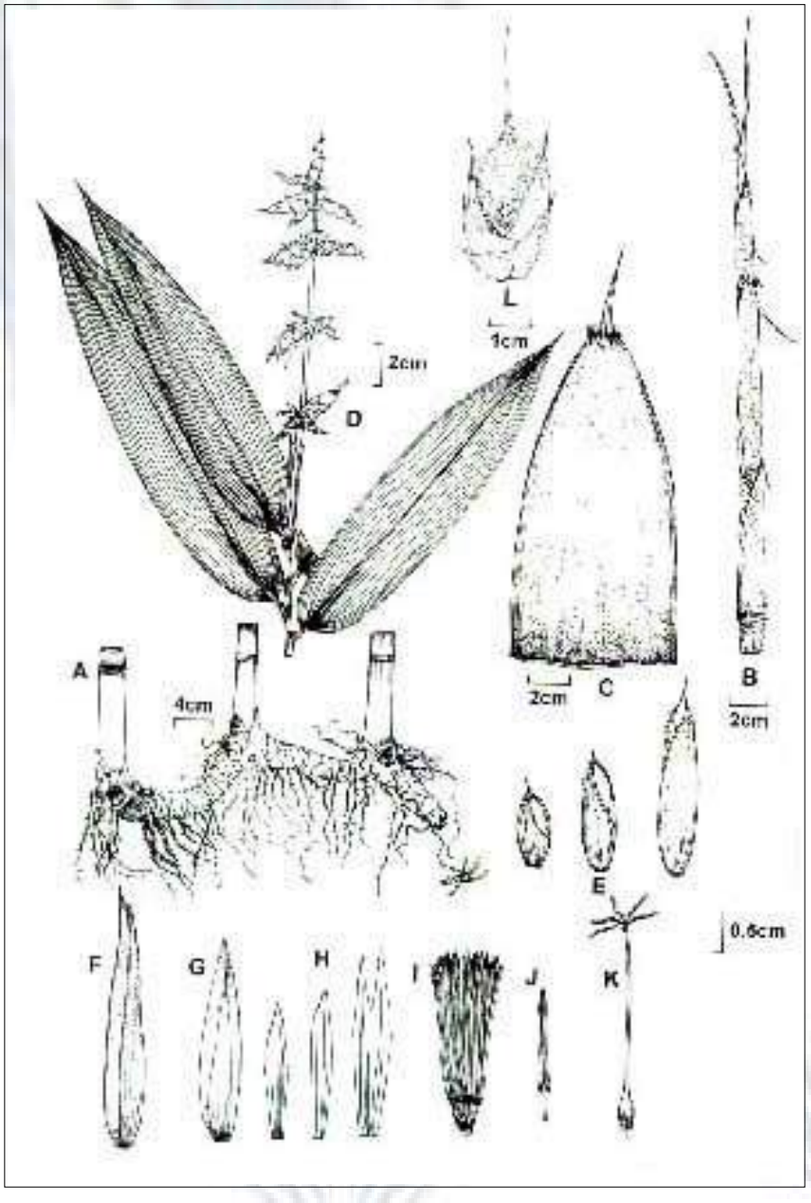
Ochlandra travancorica Benth. in Benth and Hook. f., Gen. Pl. 3: 1215. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 125, pl. 111. 1896 and in Hook. f., Fl. Brit. India 7: 419. 1897; Camus , Les Bambusees 182. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; Tewari, Monogr. Bamboo 115.1992; Kumar, Rheedea 5(1):82.1995. **(Fig. 61)**.

Bheesa travancorica Bedd., Fl. Syl. 239, pl. 324. 1873.

VERNACULAR NAMES

Kerala - *Etta, Kar-eetta, Vei*; Tamilnadu - *Eeral, Eerakalli, Iral, Irul, Ita-kalli, Nanal, Odai.*

O. travancorica - *Natural growth*



◄*Fig. 61.* **O. travancorica.** *A - rhizome; B - young shoot; C - culm-sheath; D - leafy branch with inflorescence; E - empty glumes; F - flowering glume; G - palea; H - lodicules; I - stamens around pistil; J - stamens; K - pistil; L - caryopsis.*

DESCRIPTION

Erect, shrubby or arborescent, reed-like, gregarious bamboo. **Culm** 2-6 m high, grayish-green, rough, 2.5-5 cm diameter; nodes somewhat swollen and marked with base of fallen sheaths; internodes usually 45-60 cm long, sometimes even 1.5 m long, walls very thin 2.5 mm. **Culm-sheaths** 15-20 cm long, thin, longitudinally wrinkled, striate, covered densely with appressed golden or black bulbous-based hairs when young, glabrous afterwards, truncately rounded above and with a fringe of erect stiff bristles, ciliate on the margins; imperfect blade narrow, subulate, 4-8 cm long; ligule narrow, entire. **Leaves** broadly oblong-lanceolate, 9-30 cm long and 5-12 cm broad, often obliquely rounded at the base into a thick, broad, somewhat concave, 0.7-1.0 cm long petiole, apex long, setaceous, often twisted, both surfaces glabrous or slightly rough, edges scabrous, midrib prominent at the base, tapering upwards; secondary veins 12-17 pairs; intermediate 6-8; regular transverse veinlets none but pellucid glands, present; sheath striate, glabrous, keeled, ciliate on the edges, ending in a smooth callus and short falcate auricles, mouth furnished with several bristles upto 2.5 cm. long; ligule short, truncate. **Inflorescence** a sub-verticillate spicate panicle with a few large fertile spikelets and a few much smaller sterile spikelets in the axils of ovate- lanceolate, smooth bracts which bear deciduous imperfect blades. Spikelets ovate or oblong-ovate, 3-4 x 0.8-1 cm, glabrous, striate, supported by 2-4 small sheathing bracts; empty glumes usually 3, concave, ovate, truncate at the top and tipped with

a subulate apex, many-veined and faintly transversely veined; flowering glume similar to the third empty glume; palea shorter and narrower, thinner, acute, faintly 2-keeled; lodicules 3, unequal, membranaceous, 1.6-2.2 cm long, 3-7 nerved, one 2-cleft. Stamens up to 120, monadelphous, at first included and afterwards long exserted; filaments slender; anthers ca 2.5 cm long, narrow, long-hairy, apiculate. Ovary narrow, smooth, surmounted by tri- or quadrangular perigynium enclosing the style with 5-6 plumose stigmas, spirally twisted together. **Caryopsis** very large, 7.5 x 2.4 cm, brown, oval-oblong, wrinkled, tipped with ca.5 cm long beak; pericarp fleshy, surmounted by persistent glumes and palea.

Chromosome number 2n = 72.

FLOWERING AND FRUITING

Although flowering cycle reported by Gamble is 7 years, later field observations do not agree with this. Reported flowering dates are 1868, 1875, 1882 and 1905. Gregarious flowering is reported in Kerala during 1976. About a total area of 65 km^2 flowered in Sholayar, Kodanad, Erumeli, Vallakkadav, Ranni, Goodrical and Parithipally ranges during this period (Asari, 1976). Recently, this species was collected in flower during 1988, 1992 and 1993 from Southern parts of Western Ghats. The dichogamous characteristics of the flowers in this species has been reported to be favourable for cross-pollination and advantageous for controlled breeding purposes (Venkatesh, 1984).

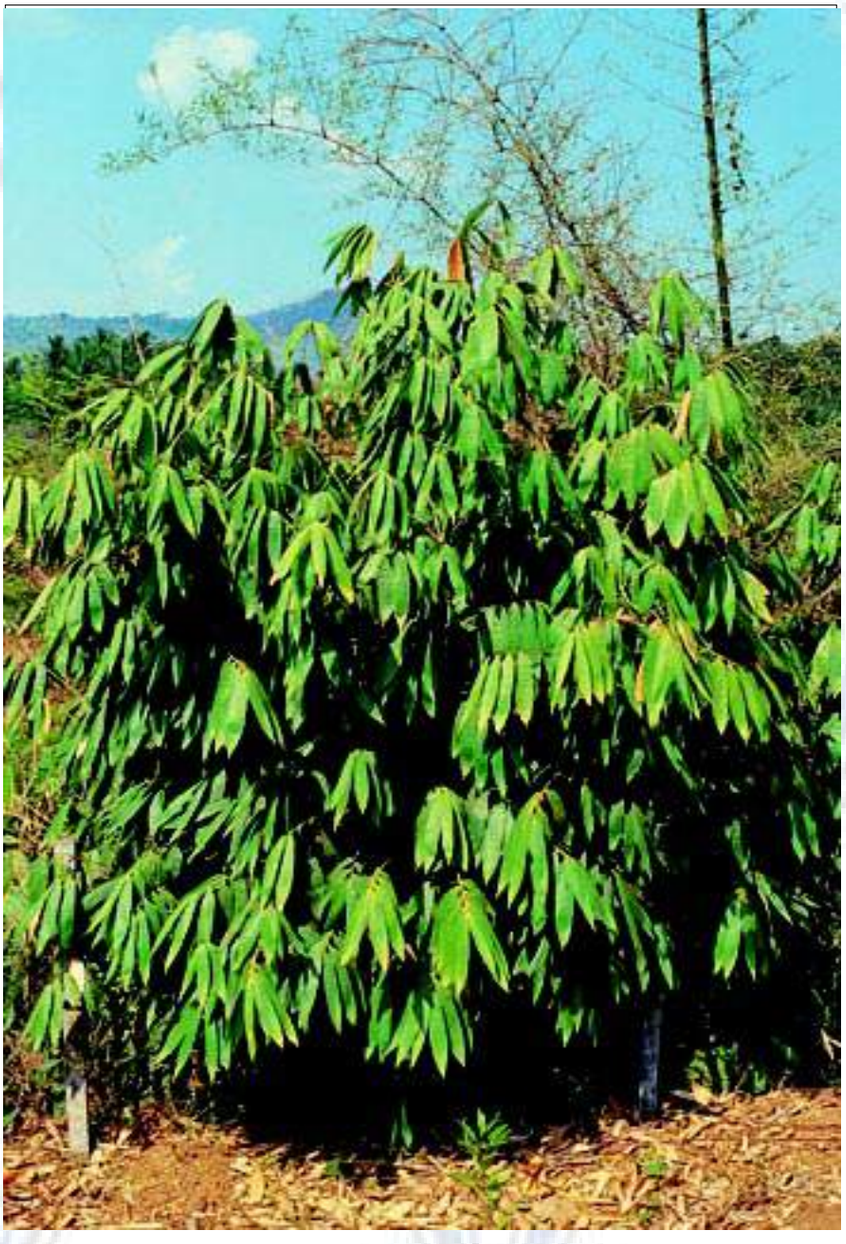
The fruit is large in size. About 45 to 57 fruits weighed in one kilogram and the weight of individual fruit varied from 17.5 to 22.2 gm. Fruit recorded a length of 4.1 to 5.7 cm. The moisture content varies from 62 to 72 per cent. The seeds are viable only for 45 days (Seethalakshmi, 1993). Ovule hemi-anatropus and unitegmic. All the cells of nucellar epidermis divide periclinally to form a multilayered tissue over the nucellus. Embryo sac development is of polygonum type. Endosperm is completely cellular during the globular stage and is absorbed during development. Do not contain any starch grains. The fruit development is similar to *Melocalamus compactiflorus* except that the cells of parenchymatous zone do not collapse, but have a large quantity of starch in them. The thickness of pericarp remains same except at the base of the fruit where it becomes thin to facilitate the emergence of the plumule and radicle during germination. The style persists as long beak even at maturity (Hari Gopal and Mohan Ram, 1987).

DISTRIBUTION AND ECOLOGY

This species is distributed throughout the Western Ghats and is more abundant in South Kerala. It occurs widely as an undergrowth in the low level evergreen and semi evergreen forests. Pure patches which grow as impenetrable thickets are also found along the sides of rivers and streams where other tree species are not allowed to come up. This species prefers diffused light, requires a rainfall of more than 1500 mm, and requires good drainage for proper growth (Asari, 1976). The soil under this species in general is dark brown, acidic, sandy loam with granular structure, high porosity, good aggregate stability and with high water holding capacity. A comparison of soil under *O. travancorica* with other species from natural forests reveals that this species is very efficient for soil conservation (Thomas and Sujatha, 1992).

ANATOMY AND FIBRE CHARACTERISTICS

The culm internode consists of uniseriate layer of epidermis followed by 4-5 layered hypodermal parenchyma. The morphology and frequency of the vascular bundle vary from outer to inner region. Peripheral vascular bundles are intermixed with variably shaped isolated bundles. Sclerenchymatous bundle sheath is pronounced towards the outer region. At the nodal region, a single layered epidermis is followed by 5-6 layered sclerenchymatous tissue. At the inner side the vascular bundles are slender waist type and less frequent. Two types of libriform fibres present. The vessels are short and wide with simple perforation plates (Appasamy, 1989). During the recent anatomical investigations, it was



➤ **O. travancorica** - *A clump*

observed that in the peripheral region fibrous patches occur along with the fibrovascular bundles. The vascular bundles are predominantly of Type II. However, the bundles lying nearest to the cavity are almost of Type I in their morphology. There is no appreciable difference in distribution of these bundle types across the stem between different height levels of the culm (Bhat - unpublished). This species has the largest fibre length up to 9 mm. The fibre studies have shown a slenderness ratio 148.7, flexibility ratio 81.6 and Runkel ratio 0.9 (Sekar and Balasubramanian - personal communication).

CHEMISTRY

The average chemical composition of culms (oven-dry) is as follows: cellulose, 61.8, lignin 26.9, pentosan 17.8, hot water solubles 5.1, ash 2.6 and silica 2.1 per cent. Pulping tests have shown that among the Indian bamboos, this species gives the maximum yield of pulp (unbleached, 48.3 per cent; bleached 45.8 per cent). Analysis of bleached pulp yielded 32 per cent by the water pre-hydrolysis sulphate process; followed by multi- stage bleaching and refining gave the following values; cellulose 96.9, pentosans 4.1, ash 0.11 per cent; iron 33 ppm; copper 0.7 per cent; cuprammonium viscosity 13.9 cp, bleaching degree 85.2 per cent, GE (General Electric Brightness Tester) and filtration factor of viscose prepared from pulp 330 (Bhat and Veeramani, 1961). Spectral absorbance value recorded for cellulose 0.277 and for lignin 0.239. (Sekar and Balasubramanian - personal communication).

SILVICULTURE AND MANAGEMENT

Natural regeneration occurs from seeds and rhizomes. Soon after the seeds fall, they germinate and within a period of 6-8 years develop into full clumps which last for a period of 25 years. The sprouting season is usually after

▲ **O. travancorica** - *Internode and branches*

➤*Fruits of* **O. travancorica**

pre-monsoon showers and during rainy season. The height growth is completed within two months. One year growth is sufficient for a culm to attain full size (Asari, 1976).

O. travancorica can be propagated from seeds and by vegetative methods. Seeds are sown after collection in nursery beds filled with sand and soil mixture in partial shade initially for two months. Seedlings can be transplanted after a period of one year. Rhizomes can be separated from the culms during the onset of monsoon and used for field planting. Two-noded culm cuttings of two year old plants treated with NAA or coumarin by cavity method and planted horizontally in nursery beds during summer gives 50 per cent rooting. After one year, the rooted cuttings can be transplanted to field. During field planting, many plantlets are obtained from the rooted cuttings by separating the sprouts along with the rhizome. A comparative study for two years on growth of plants raised from seedlings and rooted cuttings showed 76 to 85 per cent survival. Average 5 culms are produced from seedlings and 9 culms from the cuttings. The average height of culms in seedlings is found to be 93 cm and in cuttings 160 cm (Seethalakshmi et al., 1990).

Recently, propagation by tissue culture using nodal vegetative buds as explants and *in vitro* flower induction have been reported (Shaji Philip and Baby Chacko, 1996).

To effectively manage the existing resource, the following management strategies are recommended. Scientific extraction depending on the annual increment, protection from fire and grazing, periodic assessment of growing stock and strict adherence to the felling rules. The management in general involves a selective felling system with a felling cycle of four years. The suggested felling rules are: (1) culms less than two years old should not be cut; (2) all the new culms and 25 per cent of the old culms should be retained; (3) no clump should be clear-felled before seeding; (4) culms should be cut at one internode above ground; (5) cutting should be done without disturbing the new emerging culms (Kumar, 1990).

MYCORRHIZAE

Occurrence of vesicular arbuscular mycorrhizae (VAM), *Glomus albidum* is reported from the rhizosphere and cent per cent infection was reported in the roots collected from Ponmudi, Kerala (Appasamy and Ganapathy, 1992).

PESTS AND DISEASES

Witch's broom disease has been reported widespread in the natural reed growing areas. It causes profuse growth of axillary shoots and pronounced reduction of internodal length and size of the stem, sheath and leaves. The normal size of the leaf (40 x 10 cm) is reduced to 3-10 x 0.5-1 cm due to infection. The fungus, *Balansia linearis* has been associated with this disease. Leaf spot caused by *Dactylaria* sp., *Glomerella cingulata* and *Pythomyces* sp. have been recorded. Sooty mould disease caused by *Spiropes scopiformis* has also been reported (Mohanan, 1990).

The main insects associated with damage of stored culms and products are termites and some of the beetles including *Dinoderus ocellaris, D. minutes, Heterobostrychus aequalis, Minthea rugicollis* and *Myocalandra exarata* (Nair et al., 1983).

NATURAL DURABILITY AND PRESERVATION

Storing the reeds under water or chemicals prevents staining and deterioration of mats woven from them. The cheapest method is storing in bundles completely immersed in running water. If facility for this is not available, storing under copper sulphate or boric acid solution (2%) is also equally effective and the finished products have a glossy greenish tinge and pleasing appearance (Gnanaharan et al., 1993).

USES

An ideal raw material for paper manufacture. Culms are used for mat and basket making, umbrella handles, fishing rods, handicraft, and for making walls of huts. Leaves are used for thatching. The mats made from reeds are used for making 'Bamboo ply'.

Ochlandra travancorica var. **hirsuta**

Ochlandra travancorica Benth var. *hirsuta* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 126. 1896; Camus, Les Bambusees 183. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; Tewari, Monogr. Bamboo 117.1992; Chand Basha and Kumar, Rheedea 4(1): 28.1994; Kumar, Rheedea 5(1):85.1995. **(Fig. 62)**.

DESCRIPTION

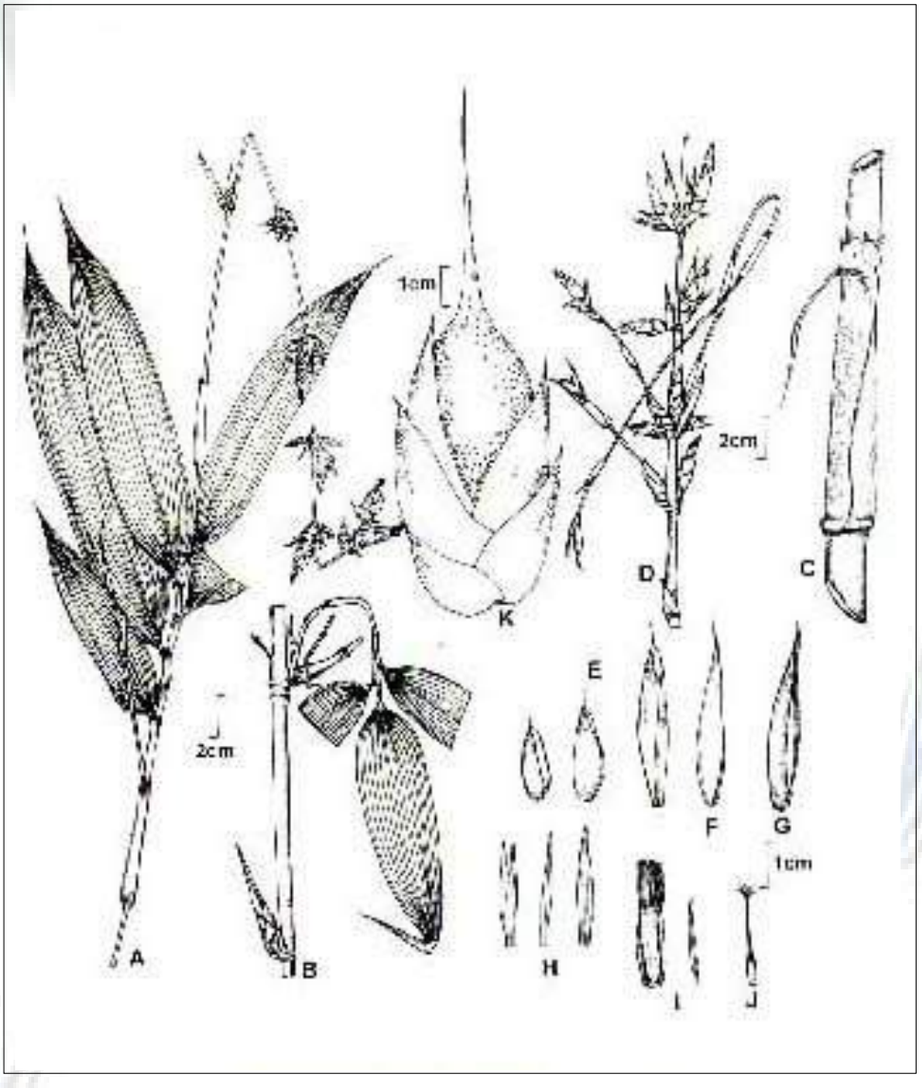
Erect shrubby or arborescent, reed-like gregarious bamboo. **Culms** 2-6 m tall, gray-green, rough, 2.5-5 cm diameter, nodes somewhat swollen and marked with base of fallen sheaths; internodes 45-60 cm long, sometimes even 1.5 m long, walls very thin, 2.5 mm. **Culm-sheaths** 20 cm long, thin longitudinally wrinkled and striate, covered densely with appressed golden or black, bulbous-based hairs when young, glabrous afterwards, truncately rounded above with a fringe of erect stiff bristles, ciliate on the margins; imperfect blade 4 cm long, narrow, subulate; ligule narrow, entire. **Leaves** broadly oblong-lanceolate, 9-32 cm long and 5-6 cm broad, thicker, edges more cartilaginous, often obliquely rounded at the base into a thick broad somewhat concave, 0.4-0.8 cm long petiole, apex long, setaceous, often twisted, both surfaces glabrous, midrib thick below. Secondary veins 7-10 pairs, intermediate 6-8, pellucid glands present, leaf sheath with appressed bulbous based hair, ending in a smooth callus, short falcate auricles, ligule short, truncate. **Inflorescence** a sub-verticiliate spicate panicle, a few large fertile spikelets, few much smaller sterile spikelets in the axils of ovate-lanceolate bracts. Spikelets thickly clothed with light brown velvety pubescence. Spikelets ovate or oblong ovate 2.5-3.5 x 0.6-0.8 cm, empty glumes 3, concave ovate, truncate at the top and tipped with a subulate apex, many-nerved. Flowering glume 4.5 cm long, oblong with a ciliate tip, margin inrolled. Palea 4.5 cm, slightly narrower, thinner and acute, faintly 2-keeled; lodicules 3, unequal, membranous 2.6-2.9 cm long, 1-4-nerved, one bifid. Stamens up to 120, monadelphous, filaments slender; anthers 2-2.5 cm long, narrow, apiculate and hairy. Ovary narrow, smooth,

perigynium 3-4 angled; style linear, stigma 5, plumose. **Caryopsis** very large, 12 x 3.5 cm, brown, oval-oblong, tipped with a 5 cm beak, pericarp fleshy with persistent glumes and palea.

FLOWERING AND FRUITING

Flowering has been recorded for the first time from Pandimotta of Kulathupuzha range, Southern Kerala, in 1992 and 1993. The flowering appeared to be sporadic in nature. Flowering initiated in January and fruits matured by April.

Large single fruits are seen attached to the base of the branches. About 31 to 41 fruits weighed in one kilogram and the weight of individual fruits vary from 24 to 32 gm/fruit. The fruit length is about 5.2 to 7.4 cm with a beak of 4.1 to 5.7 cm. The fruits are the largest among the species of *Ochlandra* and probably will come next to the fruits of *Melocanna baccifera* which is reported as the largest bamboo fruit. Moisture content of the fruit was 60-70 percent. Within one month, the fruits get dried and wrinkled completely (Seethalakshmi, 1993).



◄*Fig. 62.* **O. travancorica** var **hirsuta.** *A - leafy branch with inflorescence; B - culm with branches; C - culm with sheath; D - flowering branch; E - empty glumes; F - flowering glume; G - palea; H - lodicules; I - staminal tube and stamen; J - pistil; K - caryopsis.*

DISTRIBUTION AND ECOLOGY

Endemic to Kerala region of Western Ghats. Distributed mainly in Thenmala, Ranni, Konni and Trivandrum Forest Divisions.

ANATOMY AND MORPHOLOGY

The structure and distribution of vascular bundles resemble that of *O. ebracteata.* The sub-epidermal layers are mostly sclerified showing no sharp demarcation between fibro-vascular bundles and fibrous strands. In the basal part of the culm, the outer vascular bundles are of Type III with a transition to Type I towards the central cavity. However, at upper height levels of the culm Type I are more common with occasional Type II in the mid-part of the ground tissue (Bhat - unpublished). In the seed, rostrum mucronate at the apex, acuminate. Naval and ventral sutures absent. Seed coat formed by scleroids and covered with a thin cuticle, followed by 4-5 layered parenchyma cells, rectangular, pericarp fleshy, parenchymatous, four, thin-walled, devoid of any dark contents. Aleurone tissues often found adjacent to the pericarp and to the embryo; embryo non-endopsermous (Appasamy, 1993).

CHEMISTRY

Biochemical analysis of seeds of this species showed major portion to be of starch, followed by protein and sugar. Small quantities of lipids and phenols were also detected (Appasamy, 1993).

SILVICULTURE AND MANAGEMENT

Seeds can be sown soon after collection in nursery beds. Initial germination was about 40 to 50 per cent, vivipary is observed. The seeds are viable only for a month. Nursery techniques used for other *Ochlandra* species can be used. Rhizomes can be separated from the mother clumps during the onset of monsoon and planted in pits. Two-noded culm cuttings can be used for propagation. Treatment with NAA, enhance rooting response and vigour of rooted cuttings (Seethalakshmi - unpublished). Management strategies are similar to *Ochlandra travancorica.*

USES

As the species yields superior quality pulp, it offers possibility for use in rayon manufacture. Other uses are similar to that of *O. travancorica.*

◄*Flowered culm of* **O. travancorica** var. **hirsuta**

Ochlandra wightii

Ochlandra wightii (Munro) Fischer in Gamble, Fl. Pres. Madras 3(10): 1864. 1934; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; Tewari, Monogr. Bamboo 117. 1992; Kumar, Rheedea 5(1): 88. 1995. **(Fig. 63)**.

O. brandisii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 126. 1896 and in Hook. f., Brit. India 7: 419. 1897; Camus, Les Bambusees 182. 1913.

VERNACULAR NAME

Tamilnadu - *Ira-Calli.*

DESCRIPTION

An erect shrubby bamboo, much resembling *O. ebracteata*. Clumps tufted comprising about 30-50 culms. **Culms** up to 6.5-7.5 m tall, 1.5-2 cm diameter; nodes prominent with a grayish band on both sides, internode ca.48 cm. **Culm-sheaths** 8-15 cm long excluding the blade, 5 cm broad, covered with many appressed light brown subulate hairs; blade 6 cm long and 1-1.5 cm broad, lanceolate acuminate. **Leaves** oblong-lanceolate, acuminate, thick 18-36 cm long and 3.5-7.5 cm broad, attenuate at the base, glabrous on both surfaces, whitish beneath, margins cartilaginous, smooth, midrib prominent. Secondary veins 10-14 pairs; sheath striate ending in a smooth rounded callus with two short auricles and a few stiff deciduous bristles; ligule very long. **Inflorescence** on terminal spike with thick rachis. Spikelets several in the verticils in the axils of bracts, glabrous, 2.3-2.8 x 0.4-0.6 cm, conical, striate; empty glumes 4, basal, many-nerved, glabrous, 0.6-2 x 0.2-0.4 cm, outer two thicker, ovate-truncate with a subulate point, the inner 2 ovate, acute mucronate, flowering glume thin, membranaceous, 1.8 x 0.15 cm, many-nerved; palea as long

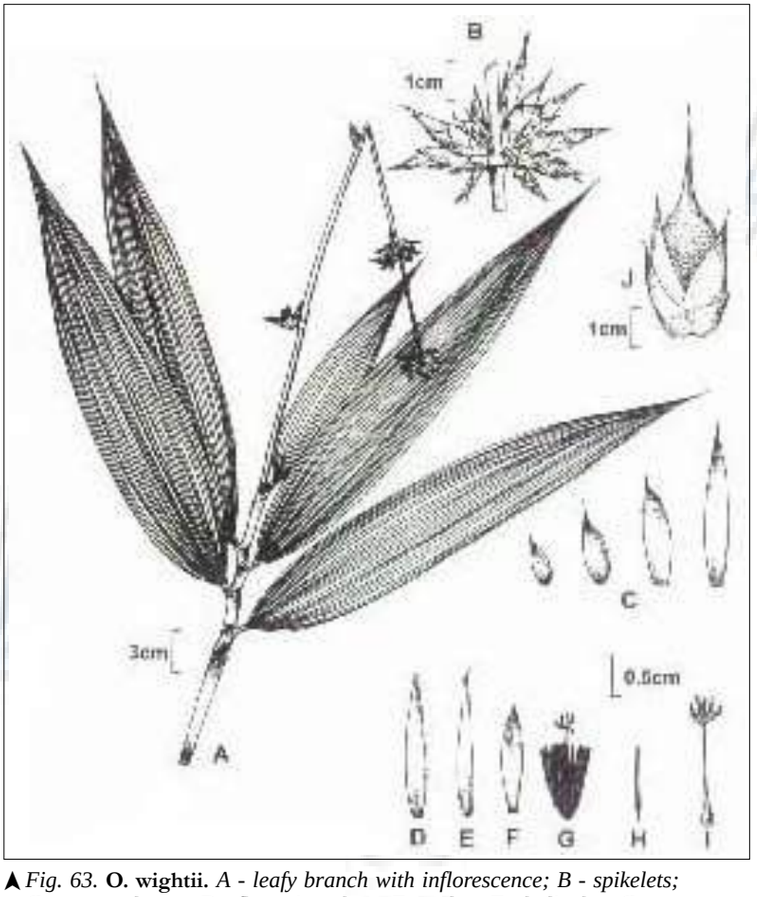


Fig. 63. **O. wightii.** *A - leafy branch with inflorescence; B - spikelets; C - empty glumes; D - flowering glume E - palea; F - lodicules; G - stamens around pistil; H - stamen; I - pistil; J - caryopsis.*

as flowering glume, narrow; lodicule 1, large, 1.3 x 0.25 cm, many-nerved, tip serrate; stamens upto 60, filaments narrow, long, apiculate. Ovary glabrous, perigynium thick enclosing the style; stigmas 5, plumose. **Caryopsis** fleshy, covered by persistent glumes, 5.5 x 1.8 cm, beak small, 1.5 cm long.

FLOWERING

Flowering in this species was reported in 1835 and 1882. Recently collected in flower in 1992 from Achenkoil, Kerala.

DISTRIBUTION

This species is endemic to Western Ghats. It is restricted in distribution to Tamil Nadu and Kerala. This species occurs from low elevations up to an altitude of about 1000 m.

ANATOMY

Fibrous strands are common in the peripheral region of the internode. In the middle part, vascular bundles are of Type II. Towards the inner side, the bundles are of Type I. Additional fibre strands occasionally present in the inner region. The internodal structure remains basically the same in the upper levels of the culm except for the absence of a clear-cut radial transition of bundles from Type II to Type I (Bhat - unpublished).

USES

This species is used for basket and mat making. Also found suitable for paper pulp. The culms are used for making huts and leaves are used as fodder.

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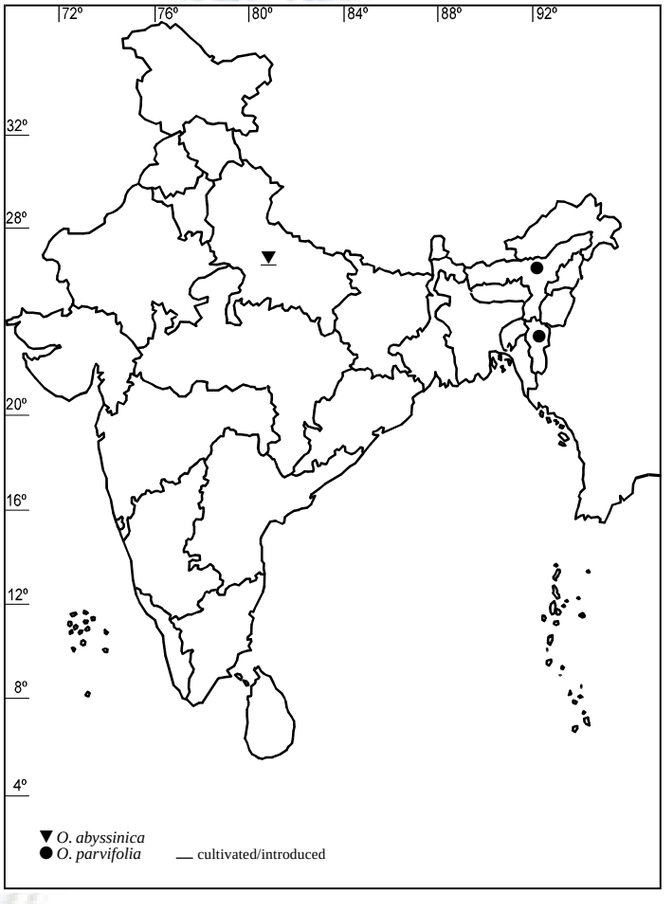
OXYTENANTHERA MUNRO

Arborescent or climbing bamboo. Culm-sheaths various usually rather narrow. Leaves variable but generally small, shortly petiolate. Inflorescence a large panicle with spicate heads of few or many spikelets; glumes 1-3. Stamens 6, monadelphous. Ovary ovoid; style slender; stigmas 3.

There are a total of 16 species for the genus. In India, 2 species are known to occur, of which *O. abyssinica* is an introduced one. The other is distributed in Assam and Mizoram. In this compendium 2 species of *Oxytenanthera* are described.



◄*Distribution map of* **Oxytenanthera**

Oxytenanthera abyssinica

Oxytenanthera abyssinica (A. Rich.) Munro in Trans. Linn. Soc. London. 26: 127, 1868; Camus, Les Bambusees, 144, 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980. Bennet and Gaur, Thirty Seven Bamboos growing in India, 81. 1990. **(Fig. 64).**

Bambusa abyssinica. A. Rich. Text. Fl. Abyss. 2: 439. 1851.

DESCRIPTION

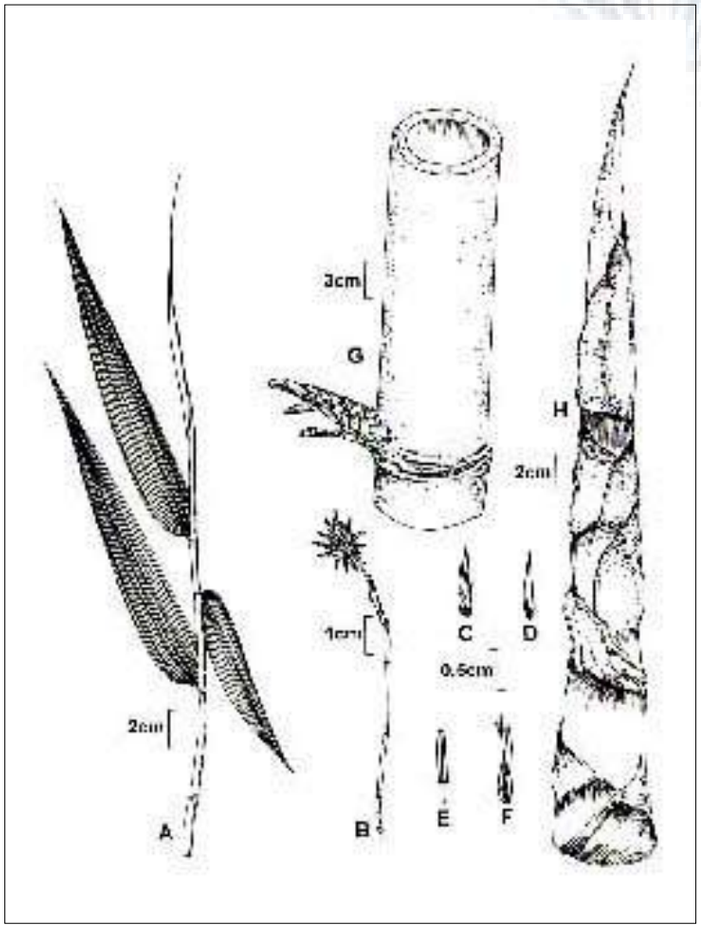
A fine distinct looking tufted bamboo. Young shoots bluish green with creamish yellow blades, apex shortly pointed. **Culms** 6-10 m tall; 6-10 cm diameter, bright green, unarmed; internodes about 20 cm long; branches sometimes in dense fascicles. **Culm-sheaths** about 20 cm long, 4-10 cm broad, tight, overlapping, covered with dark-brown bristly hairs; ligule short; blade 10-13 cm long, involute. **Leaves** 5-25 cm long, 1-3 cm broad, linear-lanceolate to lanceolate, some what glaucous, with inconspicuous transverse veins, gradually narrowed in to a fine tip. **Inflorescence**, spikelets 15-40 mm long, narrowly lanceolate, acuminate in globose clusters 5-6 cm diameter which are some times aggregated into an interrupted false spike; fertile florets 1-2; lemmas sharply mucronate, convolute, merging into glumes below, stamens 6, monadelphous; style long, hirsute; stigmas 3, long, hairy, **caryopsis** linear-oblong.

FLOWERING

Breitenbach (1961) mentioned that this species, in Ethiopia, flowered and died over seven years.

DISTRIBUTION

Found in Tropical Africa - cultivated at Forest Research Institute, Dehra Dun.



➤ *Fig. 64.* **O. abyssinica.** *A - leafy branch; B - flowering branch; C - spikelet; D - palea; E - stamen; F - flower with stamens removed; G - culm with branches; H - young shoot.*

ANATOMY AND FIBRE CHARACTERISTICS

In the culm epidermis, long cells rectangular with sinuous wall, papillae scattered, guard cell overarched by papillae; microhairs cylindrical, bicellular (Pattanath and Rao,1969). Stomata common, unevenly distributed, 25-30 per mm, 18-22 µm long, 15-18 µm wide; subsidiary cells high-domed to parallel-sided, long cells narrow, width not uniform, walls almost straight but appear wavy due to inconspicuous papillae on the cell, 40-130 µm long and 50-100 µm wide. Papillae small, scattered. Short cells solitary and paired, cork cells silicified, equal or smaller than silica cell. Silica cell rectangular. Silica bodies rectangular to oval, distinct. Microhairs, macrohairs and prickles absent (Agrawal and Luxmi Chauhan, 1991). In the leaf epidermis stomata common, arranged in two bands in 2-3 alternate rows, subsidiary cell not clear, appear high-domed to triangular, surrounded by 7-10 elliptical and globose papillae. Interstomatal cell similar to long cells but smaller in length, ends concave. Long cells long and narrow, arranged in 4-5 files, walls prominently sinuous, rectangular, ends almost straight, Papillae conspicuous, arranged in two rows. Short cells costal and intercostal, mostly solitary, cork cells costal inconspicuous, intercostal distinct. Silica cells costal common, intercostal frequent, distinct. Silica bodies costal, saddle-shaped, intercostal mostly '8' shaped. Prickles, microhairs and macrohairs present (Agrawal and Luxmi Chauhan, 1991) Internodal structure - cortex homogenous, thin-walled, peripheral vascular bundles reduced, both caps and sheaths fused, central vascular bundles all with five fibre groups, lining of the cavity parenchymatous (Pattanath and Rao, 1969).

The fine structure of thick-walled bamboo fibres is polylamellate. Its composition is such that narrow lamella regularly alternate with broader ones, whereby the width of the broad lamella varies. The microfibrillar angle is 80-90^{o} to the cell axis, while in the broad ones, the fibrils are almost parallel to the axis (Parameswaran and Liese, 1976).

SILVICULTURE

Under suitable soil and climatic conditions *O. abyssinica* produces 8-12 tonnes/ha /yr and with irrigation, productivity can be enhanced (Waheed Khan, 1968).

USES

Culms are used to paddle canoes and the smaller ones as shaft for spears. This species gives good yield of pulp, but it is not comparable in quality with other pulp-yielding species.

Oxytenanthera parvifolia

Oxytenanthera parvifolia Brandis ex Gamble in Ann. Roy. Bot. Gard. Calcutta. 7: 72. 1896 and in Hook. f. Fl. Brit. India. 7: 402. 1896; Camus, Les Bambusees 147. Pl. 91. F. B. 1913. Tewari, Monogr. Bamboo 119.1992. **(Fig. 65).**

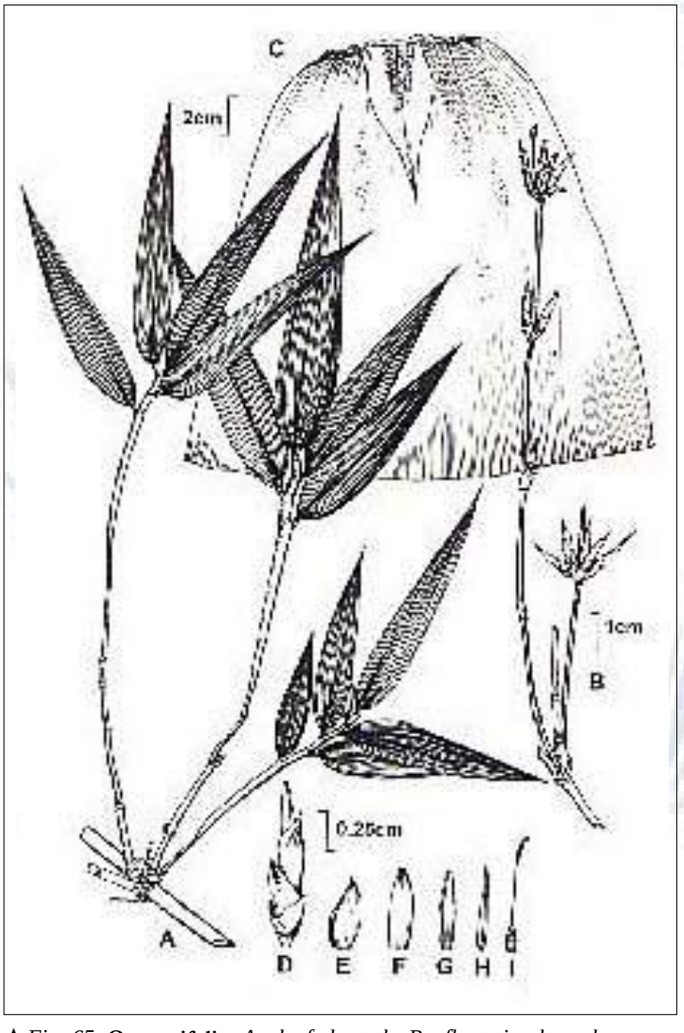
VERNACULAR NAMES

Burmese *Tseikdoo-mindoo*.

DESCRIPTION

A large sized-bamboo with culms up to 7.6 cm in diameter. **Culm-sheaths** 20.3-22.8 cm long and 20.3-25 cm broad, striate, rounded at the top and truncate, appressed brown hairy on the back, imperfect blade 5-7.6 cm long and

ca. 2.5 cm broad, ovate-acuminate, decurrent on the top of the sheath in a narrow, naked, slightly auricled band, base rounded; ligules rather broad, dentate. **Leaves** linear-lanceolate 7.6-10 cm long and ca. 1.2 cm broad. rounded at base, apex with a short subulate twisted point marginal veins scabrous above, pale and slightly pubescent beneath. Scabrous on one or both margins, leaf sheaths hairy in the beginning, later ending in a prominent callus and furnished with a few deciduous bristles at the top; ligule acute faintly dentate, pubescent. **Inflorescence**, a large panicle of spicate branchlets bearing verticils of spikelets, each verticil with 4-10 spikelets, bracts small, polished, rachis thin, wiry. Spikelets narrow, glabrous 13-20 x 0.25-5 mm fertile and sterile mixed, empty glumes 2-3, flowering glumes longer; palea as long as flowering glume. Stamens exserted; anthers obtuse. Ovary ovoid acuminate, hairy, style long, slender with 1-2 shortly plumose stigma.



▲ *Fig. 65.* **O. parvifolia.** *A - leafy branch; B - flowering branch; C - culm sheath; D - spikelet; E - empty glume; F - flowering glume; G - palea; H - stamen; I - pistil.*

FLOWERING

Brandis recorded its flowering in 1880 from Yonzalin Valley (Myanmar). Gupta recorded gregarious flowering in Haflong (Assam) during 1987.

DISTRIBUTION

Distributed in Assam, Mizoram and Myanmar.

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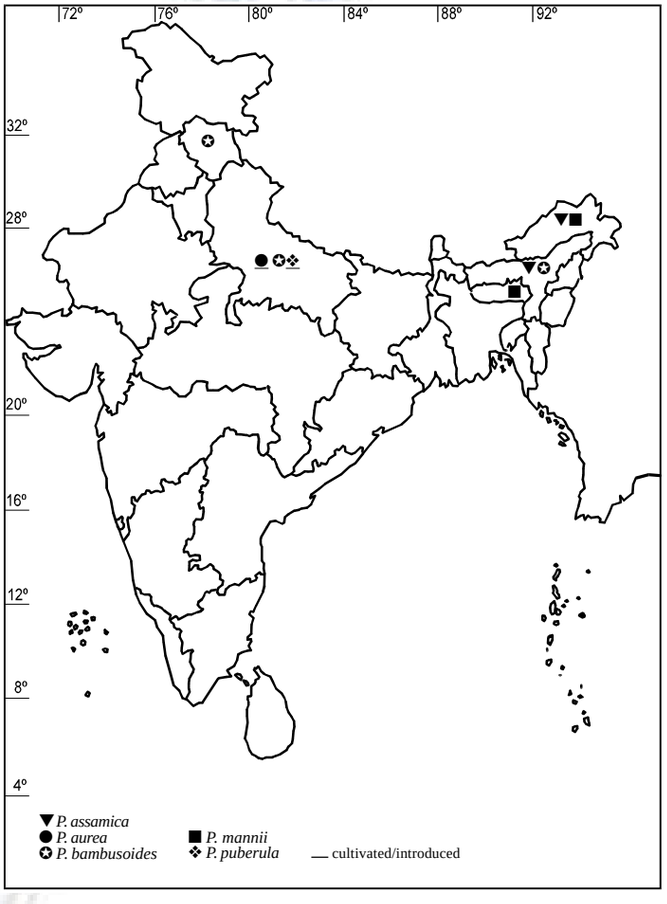
PHYLLOSTACHYS SIEB. AND ZUCC.

Shrubby or arborescent caespitose bamboo. Culms smooth, flattened on one side in alternate nodes; nodes prominent, internodes short; branches 2-3, alternate at the nodes. Culm-sheaths papyraceous, tessellate. Leaves articulate on the sheath; sheaths loose, smooth. Inflorescence a terminal panicle, base covered with spathiform imbricate bracts which often end in an imperfect limb. Spikelets sessile, 1-4-flowered, glumes 1-2, many-nerved; lemmas ovate-lanceolate, acuminate, *P. assamica* many-nerved; paleas 2-keeled, often bi-mucronate, many-nerved. Lodicules often 3 unequal. Stamens 3, long exserted; anthers linear. Ovary stipitate, ovoid or globose, glabrous; stigmas 3, long, plumose.



This genus is represented by 41 species of which 5 species are seen in India. Two species naturally occur in Arunachal Pradesh, Assam and Meghalaya and 3 species are introduced. In this compendium, details of 5 species of *Phyllostachys* are given.

◄*Distribution map of* **Phyllostachys**

Phyllostachys assamica

Phyllostachys assamica Gamble ex Brandis, Indian Trees 667. 1906; Camus, Les Bambusees 65. 1913; Bor in Kanjilal, Fl. Assam 5: 55. 1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6: 4. 1980; Tewari, Monogr. Bamboo 119. 1992.

DESCRIPTION

A caespitose bamboo. **Culms** 10-12 m tall, bright green in colour, up to 20 cm diameter, with a waxy ring below the nodes which disappears on maturity; nodes glabrous and internodes short. **Culm-sheaths** 15-25 cm long, thin, contracted at the summit into a short, truncate or rounded collar, covered with black hairs, imperfect blade subulate, lanceolate, wrinkled; ligule fringed with long hairs. **Leaves** broadly linear glaucous, shortly petioled, somewhat long acuminate, setaceous at the tip. 8-12 cm long, 12-16 mm broad, toothed on the margins, covered on the lower surface with stiff white hairs; sheaths keeled, ciliate on the margins, shortly auricled, throat with a few hairs. **Inflorescence** a panicle made up of lanceolate spikelets; bracts ciliate at the throat, with a foliaceous limb, large. Spikelets brownish or greenish, 20-25 mm long, with 3-5 perfect florets, the upper floret imperfect. Lemma ovate acute, many-nerved. Paleas as long as the lemmas, narrow, bimucronate at the tip, 2-keeled, ciliate on the keels. Lodicules ovate- lanceolate or oblanceolate, some times emarginate or bifid fimbriate. Stamens exserted, pendulous, connective apiculate; ovary ovoid, furrowed at base.

DISTRIBUTION

Found in patches in Assam and Arunachal Pradesh at an elevation of 2400 m.

USES

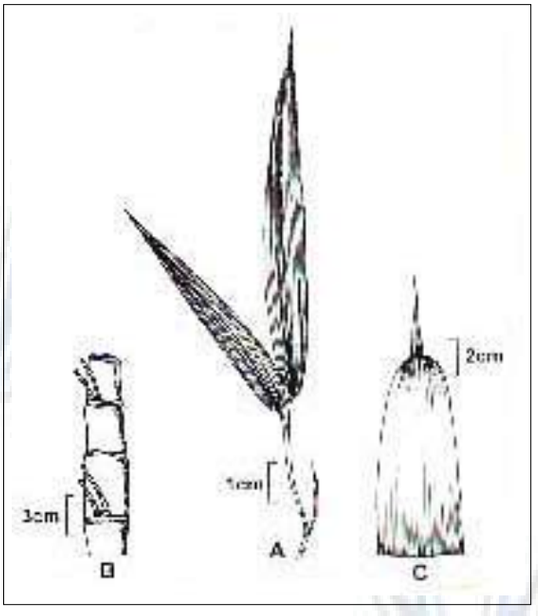
Used for making walking sticks.

Phyllostachys aurea

Phyllostachys aurea Carrie ex A and C. Riviere, Bull. Soc. Accl. 3, 5: 716. 1878; Camus, Les Bambusees 64. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6: 4. 1980; Tewari, Monogr. Bamboo 121. 1992. **(Fig. 66).**

DESCRIPTION

Tufted bamboo with creeping rhizome. **Culms** 2-8 m tall, 2-3 cm diameter; internode 8-10 cm long, cylindrical or grooved, green, golden-yellow when old, smooth glabrous, the lower ones often irregularly shortened and swollen; thrusting the sheath scars into an irregularly slanted zig-zag pattern, nodes swollen above the sheath scar, the latter always fringed with short white hairs when newly formed, wall 4-6 mm thick. **Culm-sheaths** 12-18 cm long, promptly deciduous, green or light orange-yellow when fresh, with purple red or light green ribbed striation and brown spots on



➤ *Fig. 66.* **P. aurea.** *A - leafy branch; B - culm with branches; C - culm-sheath.*

outer surface, covered with short white hairs towards the base, auricles lacking, imperfect blade 3-6 cm long, lanceolate to narrowly lanceolate bent downwards, some times wrinkled; ligule 1-2 mm high, fringed with long hairs. **Leaves** 5-8 cm long and 5-11 mm broad, lanceolate, densely softly hairy, almost glabrous with rectangular tessellate veins on lower surface; auricles lacking or rudimentary when present with three bristles; ligule 1 mm high, long ciliate. **Inflorescence** a large foliate panicle, occupying nearly whole stem, straw-coloured with deciduous spathes. Spikelets 18-25 mm long, 2-flowered, glume usually one, papery; lemmas glabrous, lightly inrolled; paleas with fine rough hairs at apex, 2-keeled. Lodicules ovate lanceolate. Stamens exserted, filaments 3-5 cm long; anthers yellow; ovary ovoid, glabrous; style long; stigmas 3 plumose. Caryopsis linear - lanceolate, 6-8 mm x 1.5-2.0 mm, grooved on back, style persistent.

Chromosome number 2n = 48, tetraploid (Chengde and Widjaja, 1995).

FLOWERING

This species is reported to have flowered in 1963. Gregarious flowering may occur when clumps are 15-30 years old after which the clumps do not die (Chengde and Widjaja, 1995).

DISTRIBUTION AND ECOLOGY

This species is native of China. Cultivated at Dehra Dun and Mussoorie. *P. aurea* is frost hardy, grows on rich, deep and well-drained sandy soils.

SILVICULTURE AND MANAGEMENT

This can be propagated by seed and by clump division. Seeds being rarely available, normal propagation method is by clump division. Clump parts, 0.5-1 metre are taken having a rhizome, roots and one to several culm parts. They are planted in previously prepared holes, enriched with organic manure (Chengde and Widjaja, 1995). Propagation by tissue culture is attempted from shoot tips, nodes and leaves as explants and found successful (Zamora, 1994).

NATURAL DURABILITY AND PRESERVATION

Preservation of culms has been tried using cold soaking treatment. Boron penetration after an immersion period of 5 days was about 93 per cent for split and 79 per cent for unsplit culm parts. (Chengde and Widjaja, 1995)

USES

The species is cultivated as an ornamental. The culms are used for making handicrafts.

Phyllostachys bambusoides

Phyllostachys bambusoides Sieb. and Zucc., Abh. Akad. der Phys. Wissensch Munchen 3: 745, tab.5, fig.3, 1843; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 27, Pl. 27. 1896 and in Hook f., Fl. Brit. India 7: 386. 1897; Camus, Les Bambusees 56. 1913; Kedharnath and Chatterjee, Indian For. 92: 429. 1966; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6: 4. 1980; Tewari, Monogr. Bamboo 121., 1992. **(Fig. 67).**

Phyllostachys reticulata sensu Koch., Dendr. 2(2): 350. 1873.

DESCRIPTION

A caespitose bamboo. **Culms** graceful, yellow, 2-4 m high, flattened at one side, 1-1.5 cm diameter, rarely attaining 2 cm diameter, glabrous, smooth, polished, green with waxy ring below the nodes, disappears with age, internodes 20-30 cm long. **Culm-sheaths** variable, yellowish-brown, back conspicuously purplish-brown or black spot and blotches; imperfect blade lanceolate, less than 2 cm long, auricles usually 2, sometimes only one or entirely lacking with bristles; ligule 2-4 mm high, laciniate. **Leaves** 4-6 at first, later only 2-3 remain, 12-16 cm long and 11-25 mm broad, linear, attenuate at the base into a short petiole, long acuminate, setaceous at the apex; sheath with well developed auricles and long bristles; ligule well developed, 2-3 mm high. **Inflorescence** consisting of multispiculate lanceolate spikes, 40 x 10-15 mm long, bracts ciliate near the mouth, limb imperfect, foliaceous, large, ovate lanceolate, cordate 35 x 20 mm. Spikelets 20-25 mm, fertile flower 3-5, terminal flower imperfect; flower greenish; glumes 2, lower very large, sheath like, bluntly truncate with a foliaceous green cordate blade, becomes smaller or disappears in the upper flowers, upper short, 7 mm long, oblique, keeled, ciliate on the keels, few-nerved, those of the upper flowers longer and more unequal sided in terminal spikelets, sometimes absent. Lemmas 20 x 7 mm, ovate-acuminate, main nerve strong, secondary nerves 5-6

◀**P. bambusoides** - *Internodes*

pairs paleas, about as long, narrow, two-keeled, minutely scabrous, ciliate on the keels, bimucronate at the apex. Lodicules ovate-lanceolate, unequal, emarginate or bifid, ciliate, 3-7-nerved. Stamens exserted; filaments long, 4-4.5 cm; anthers 1 cm long; ovary ovoid, stipitate, glabrous; styles 2.5-3 cm long, stigmas 3, plumose.

FLOWERING

Reported flowering cycle in the species is 120 years. Flowering is reported from Sikkim for the first time in 1968 (Majumdar et al., 1985). Gregarious flowering was observed in 1961 from Soviet sub-tropics.

DISTRIBUTION

The species is a native of China and Japan. Introduced to Assam and Himachal Pradesh. It is cultivated in Darjeeling and Dehra Dun.

CHEMISTRY

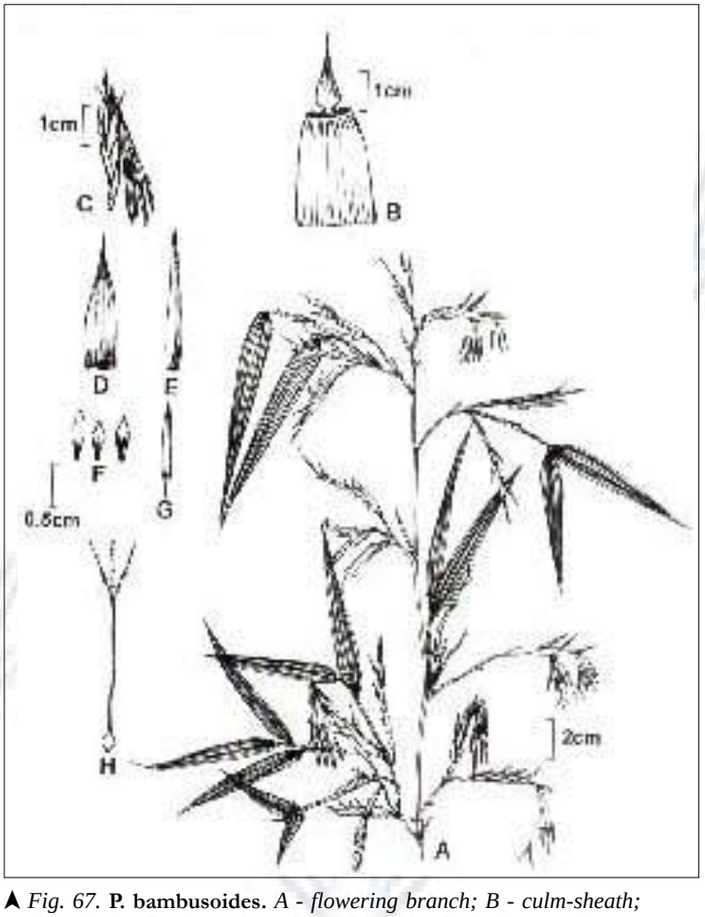
Laboratory pulping test using 30-50 per cent sodium xylene sulphonate as pulping agent, gave 41.6 per cent unbleached and 39.5 per cent bleached pulp. The cellulose content of the unbleached pulp was 93.6 per cent and that of bleached 92.5 per cent.

SILVICULTURE

Observations on growth showed that short slender culms originate before flowering at the base of tall culms, emergence of these culms are not seasonal. Soon after flowering, the tall culms and rhizomes die and short slender culms grow from nodes of dead rhizomes. They bear bottle-shaped leaves or no leaves at all and seem to die gradually. The next set of short slender culm start the new generation. They have large leaves and no flower. Gradually the culms grow and attain normal size and shape. Propagation by tissue culture has been attempted from nodes, stem and leaves and root induction was obtained (Zamora, 1994).

USES

Young shoots are edible. In China, the roots are considered as a tonic. The oral administration of the extract of culms has been reported to produce rapid hyperglycemia in rabbits.



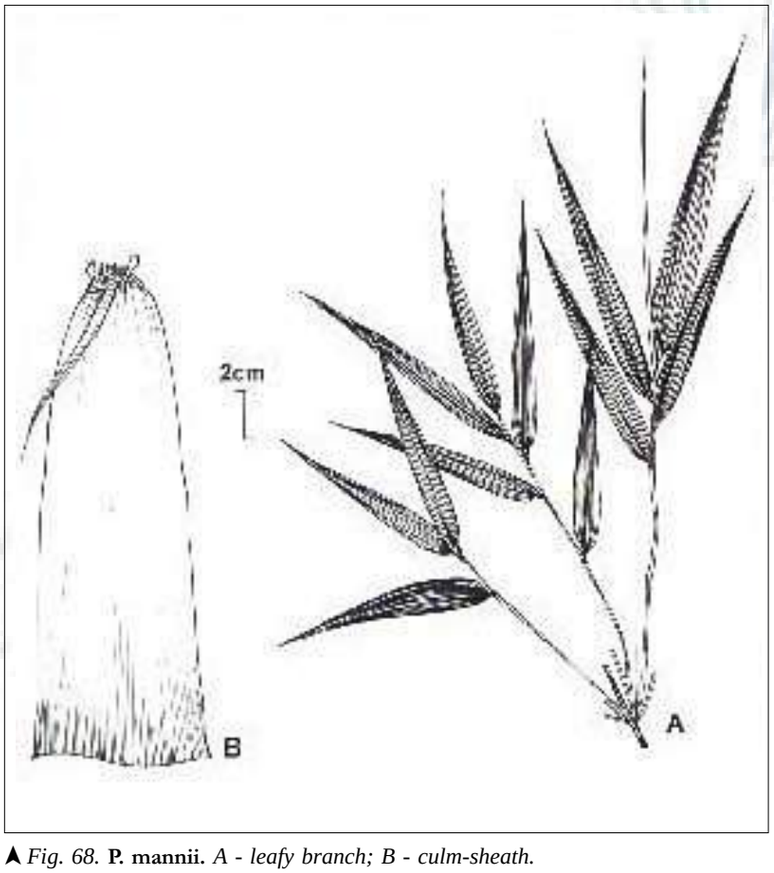
▲ *Fig. 67.* **P. bambusoides.** *A - flowering branch; B - culm-sheath; C - spikelet; D - flowering glume; E - palea; F - lodicules; G - stamen; H - pistil.*

Phyllostachys mannii

Phyllostachys mannii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 28, Pl. 28. 1896, and in Hook f., Fl. Brit. India 7: 386. 1897; Camus, Les Bambusees 65, Pl. 33 fig. A. 1913; Bor in Kanjilal, Fl. Assam 5: 56. 1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6: 4. 1980; Tewari, Monogr. Bamboo 122. 1992. **(Fig. 68).**

DESCRIPTION

A caespitose shrubby bamboo. **Culms** 5-6 m tall, nodes prominent; internodes 20 cm long and 2.5-3 cm diameter, green or yellow, flattened on one side. **Culm-sheaths** 20-22 cm long and 2.5-5 cm broad, papery, straw-coloured, rounded at the tip and truncate, extended at the base of the blade into two conspicuous fimbriate, caducous, curved auricles; imperfect blade 5-7.5 cm long, recurved, narrow, subulate, decurrent on the sheath; ligule broad, long, pectinate. **Leaves** in pairs in branches, thick, 10-12.5 cm long and 1.25-2 cm broad, rounded at the tip smooth and glabrous on both surfaces except for a few white hairs near the midrib below, spinulose serrate on the margins, midrib prominent below, shining, secondary veins 5 pairs, intermediate veins 7-8, transverse veinlets extremely numerous and finely tessellate; sheaths loose, glabrous, smooth, straw coloured, ending in narrow ciliate callus with few deciduous bristles; ligule short. **Inflorescence** not known.



▲ *Fig. 68.* **P. mannii.** *A - leafy branch; B - culm-sheath.*

DISTRIBUTION

The species is distributed in Arunachal Pradesh, Meghalaya and Naga Hills. Cultivated in Khasi Hills at an elevation of 1500 m.

USES

Culms are used for making walking sticks.

Phyllostachys puberula

Phyllostachys puberula (Miq.) Munro, Gard. Chron. (n.s.) 6: 773. 1876; Camus, Les Bambusees 57. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6: 4. 1980; Tewari, Monogr. Bamboo 122.1992. **(Fig. 69).**

Bambusa puberula Miq. Ann. Mus. Lugd. Bat. 2: 285. 1866.

DESCRIPTION

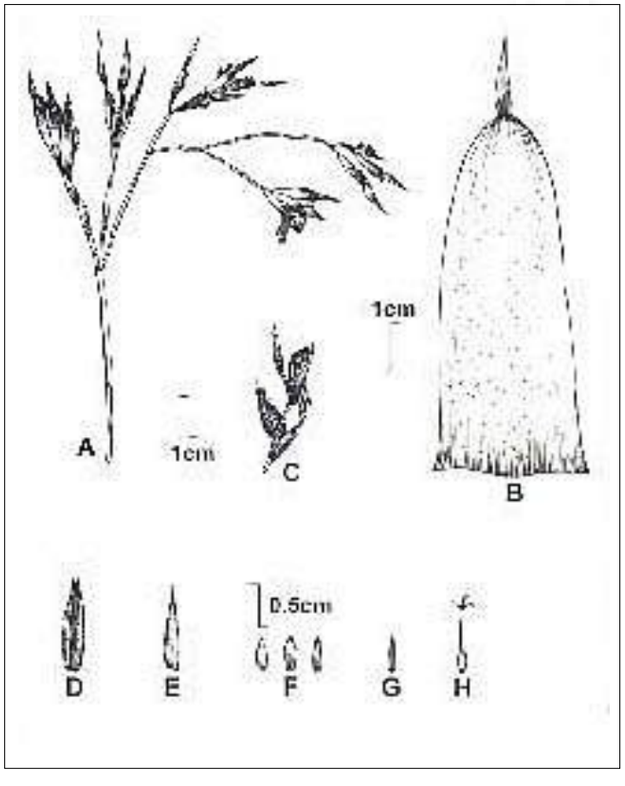
A shrubby bamboo. **Culms** 3-6 m tall, 2-4 cm diameter, nodes with prominent rings; internodes green, dull, grayish-green when mature; **Culm-sheaths** yellowish green to light orange-yellow when young, ciliate, ciliated auricles conspicuous with scabrous bristles; imperfect blade short, reflexed, lanceolate; ligule 2- 2.5 mm long, ciliate. **Leaves** 2-3 on twigs, 5-10 cm long and 8-12 mm broad, lanceolate, chartaceous, acuminate, glaucescent and pubescent near base, slightly hairy along nerves, tessellate, margins minutely spinulose, sheath auricles lacking substituted with none to few bristles, ligule membranous, 0.5 mm high, ciliate. **Inflorescence** a fasciculate spike, 2.5-3 cm long, bracts shorter than the spike, lanceolate, short-pubescent on the back near the tip, with a short subulate blade at the apex. Spikelets linear, usually 2-flowered; glumes 1, 12 mm long, 9-11-nerved, lemmas linear lanceolate, ca.15 mm long, pubescent, gradually tapering at the apex; paleas a little shorter than the lemmas, pubescent. Stamens 3, elongate, pendulous; anthers 7-8 mm long, yellow. Ovary oblong-ovate, style 1, elongate, glabrous; stigmas 3.

DISTRIBUTION

The species is native of China. Introduced in India.

USES

This is cultivated as an ornamental bamboo.



➤*Fig. 69.* **P. puberula.** *A - flowering branch; B - culm-sheath; C - spikelet; D - flowering glume; E - palea; F - lodicules; G - stamen; H - pistil.*

R E F E R E N C E S

Chengde, Chu and Widjaja, E. A. 1995. *Phyllostachys aurea* Carrie ex A & C. Riv. *In* S. Dransfield and E. A. Widjaja (Eds.). Plant Resources of South East Asia No.7. Bamboos. Backhuys Publishers, Leiden: 129-130.

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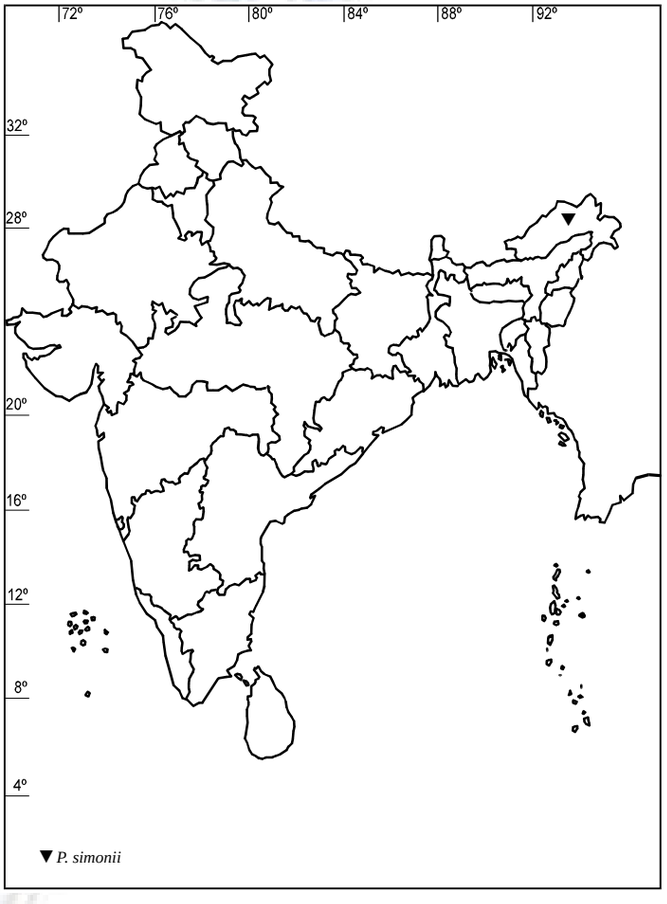
Tewari, D. N. 1992. A Monograph on Bamboo. International Book Distributors, Dehra Dun: 119-123.

Zamora, A. B. 1994. Review of micropropagation research on bamboos. *In* Constraints to Production of Bamboos and Rattans. INBAR Technical Report, 5: 45-100.

PLEIOBLASTUS NAKAI

A reed-like bamboo with long creeping rhizome. Culms hollow, glabrous below the nodes. Culm-sheath longitudinally striate. Branches up to seven from each node. Inflorescence arises from the culm on axils of the branches.

Only one species, *P. simonii* is reported from India (Arunachal Pradesh).

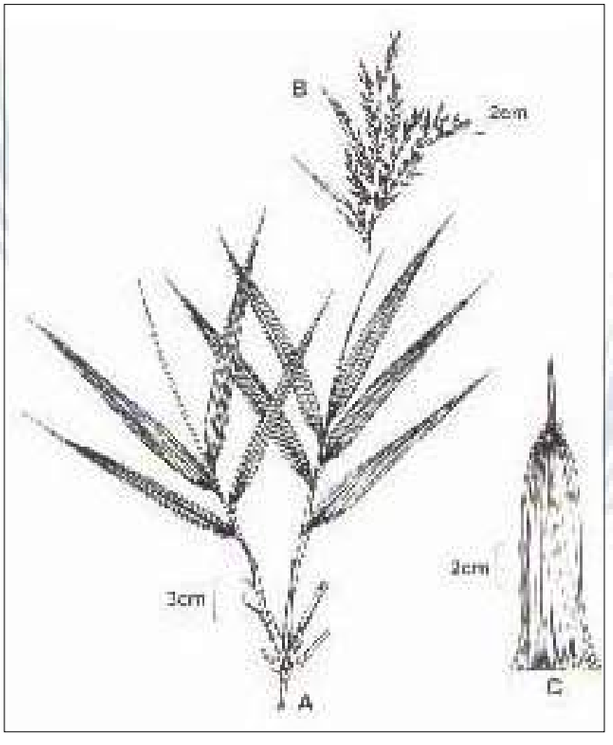


◄*Distribution map of* **Pleioblastus**

Pleioblastus simonii

Pleioblastus simonii (Carr.) Nakai, J. Arn. Arb. 6: 145. 1925; Tewari, Monogr. bamboo. 123. 1992. **(Fig. 70).**

Bambusa simonii Carr., Rev. Hort. 37: 380. 1866; *Arundinaria fortunei* Fenzi, Gard. Chron. 773. 1876 (non. Riv.); *Arundinaria simonii* (Carr.) A. and C. Riv., Bull. Soc. Accl. 3. Ser. 774. 1878; *Arundinaria brachyclada* Hack. ex Matsumura, Ind. Pl. Jap. 2: Pt. 1: 89. 1905.



▲ *Fig. 70.* **P. simonii.** *A - leafy branch; B - flowering branch; C - culm-sheath.*

DESCRIPTION

A reed-like bamboo with long, creeping rhizome. **Culms** generally monopodial, 90 cm to 6 m tall, 2-2.5 cm diameter, hollow, green, glabrous below the nodes at first with powdery covering; buds in each node 3-7; branches 1-7 divaricate, spreading. **Culm-sheaths** green or pale, glabrous, longitudinally striate, lanceolate with small appendages, upper half with transverse veins, margins ciliate; **Leaves** 4-30 cm long, 7-30 mm broad, linear lanceolate, base narrowed to a short petiole, margins serrulate, nerves tessellated; bristles parallel, white, smooth. **Inflorescence** laterally growing from culm or from branches. Spikelets 2-7 cm long, lax-flowered, with two bracts, 8-10 mm long, tessellate. Glumes 11-16 mm long. Lemma 10-14 mm long, apex bidentate, dorsally hairy, 2-keeled. Palea 3, 3 mm long, hyaline. Stamens 3; anthers 6-7 mm long with no connective. Style short; stigma 3, pilose.

Chromosome number 2n = 48.

DISTRIBUTION

The species is distributed in China, Japan and India. It grows in Arunachal Pradesh at an elevation of 3000 m. Cultivated in Europe, South Korea and Argentina.

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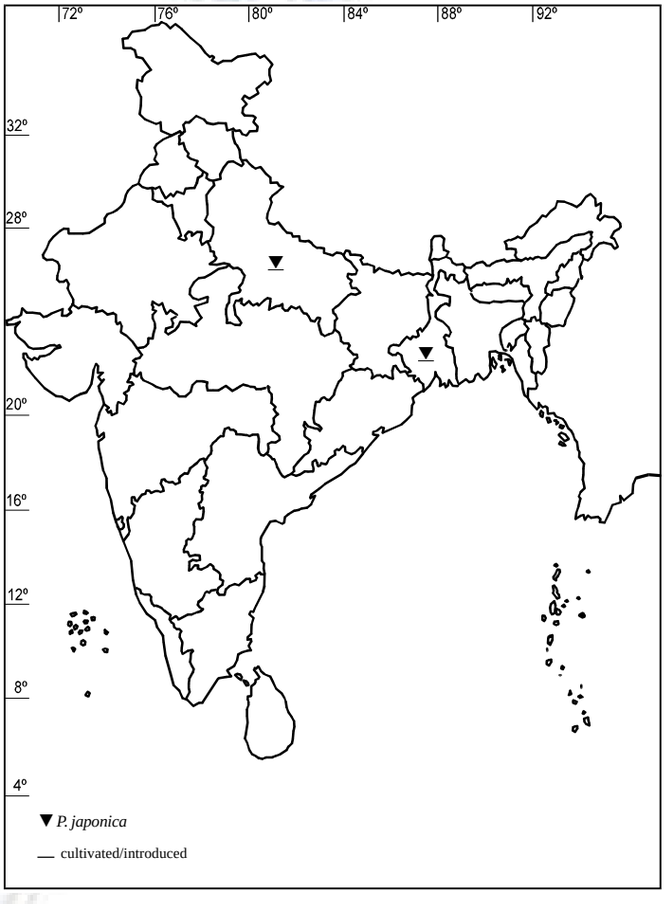
Tewari, D. N. 1992. A Monograph on Bamboo. International Book Distributors, Dehra Dun: p 123.

PSEUDOSASA MAKINO

Rhizome monopodial. Culms erect. Branches arise from the upper part of the culm. Culm-sheath persistent. Inflorescence a panicle, spreading, stalked. Stamens 3. Style 1; stigma 2-3. Caryopsis oblong, longitudinally sulcate.

The genus is represented by only one species, *Pseudosasa japonica*, which is native to Japan and is reported from India under cultivation in several botanical gardens.



◄*Distribution map of* **Pseudosasa**

Pseudosasa japonica

Pseudosasa japonica (Sieb. and Zucc. ex Steud.) Makino ex Nakai, J. Arn. Arb. 6: 150. 1925; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6: 4. 1980; Tewari, Monogr. Bamboo 123.1992.

Arundinaria japonica Sieb. and Zucc. ex Steud., Syn. Pl. Gram. 334. 1855.

DESCRIPTION

Rhizome creeping. **Culms** erect, 2.5 m high, 5-15 mm diameter, glabrous, tufted, usually branched in upper half. **Culm-sheaths** 17-27 cm long, persistent, white or yellow, appressed, deciduous hairs on dorsal surface, apex narrow and elongated, ligule 1-2 mm, with hairy edge, blade linear or narrowly lanceolate, 1.5-6 cm long and 3-8 mm broad, at first erect and later deciduous. **Leaves** 8-35 cm long and 1.5 cm broad, narrowly lanceolate, long acuminate, acute at base, deep green above, glabrous, oral setae usually absent. **Inflorescence** a panicle, 7-20 cm long. Spikelets ca. 10, purplish or purplish-brown; empty glumes 2, first glume 5-8 mm long and acuminate, second glume 7-10 mm long; lemmas 10-12 mm long, oblanceolate or narrowly ovate, more or less scabrous on the dorsal surface, apex acute; palea 8-12 mm long with ciliate keels.

Chromosome number 2n = 48 (Mehra and Sharma, 1975).

DISTRIBUTION

The species is native to Japan and is largely cultivated in Botanical Gardens of India, particularly in Eastern Himalaya, Lloyd Botanical Garden, Darjeeling.

ANATOMY

Distribution of short cells is in rows of 3-5 in both surfaces of leaf, shape of silica bodies tall and narrow approaching oryza type, bulliform cells and arm cells present. Macro hairs, microhairs and prickles are absent (Sharma et al., 1986).

SILVICULTURE

Propagation by tissue culture is attempted from shoots, leaves and nodes of the species (Zamora, 1994).

USES

It is grown in the garden as an ornamental and for aesthetic landscaping.

R E F E R E N C E S

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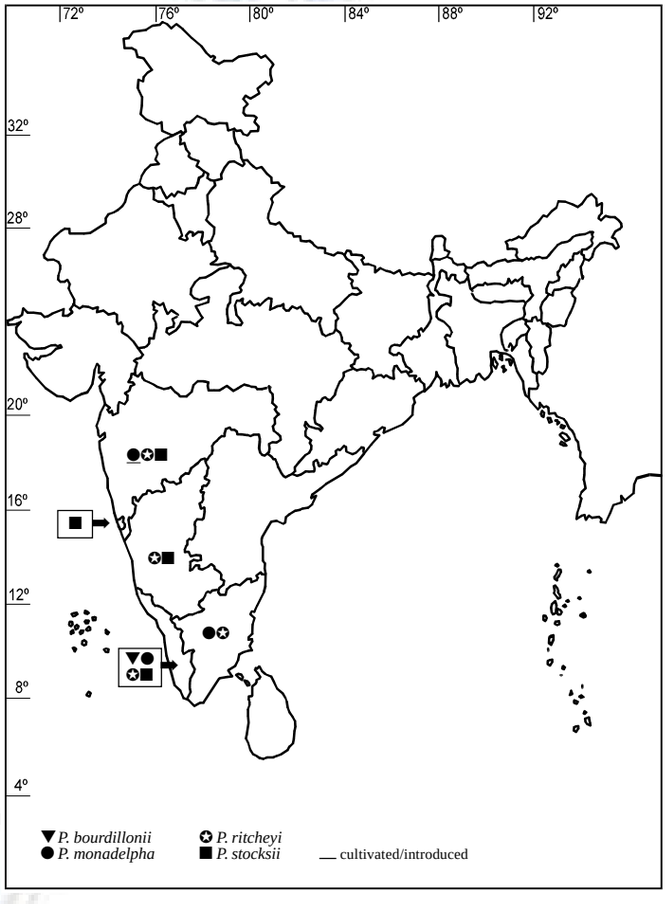
PSEUDOXYTENANTHERA SODERSTROM AND ELLIS

Culms forming loose clumps, becoming thin and whip-like at the tip and bending over. Culm-sheaths abscissile from a thickened girdle. Inflorescence capitate, spikelets non-disarticulating with short rachilla segments; glumes 10-11-nerved. Stamens 6, anthers penicillate. Ovary glabrous, style long, hairy, stigmas 3. Fruit a caryopsis, with the pericarp separable from the seed below.

This genus is endemic to South India and Sri Lanka. From South India, 4 species are reported and all the four are included in this compendium.



◄*Distribution map of* **Pseudoxytenanthera**

Pseudoxytenanthera bourdillonii

Pseudoxytenanthera bourdillonii (Gamble) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990; Tewari, Monogr. Bamboo 124.1992. **(Fig. 71).**

Oxytenanthera bourdillonii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 76, t. 67. 1896 and in Hook.f., Fl. Brit. India 7: 403. 1896; Camus, Les Bambusees 149. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.

VERNACULAR NAMES

Kerala - *Arambu*, Tamil Nadu - *Ponmungil*.

DESCRIPTION

A moderate sized, straggling bamboo forming open clumps. **Culms** with long internodes. **Culm-sheaths** 15-30 cm long and 15 cm broad, striate, glabrous except for a few stiff black hairs below; imperfect blade triangular, 5-7.5 cm long, sharply mucronate, decurrent at the base into rounded recurved entire wings lining the whole of the upper edge of the sheath; ligule faintly serrate. **Leaves** 15-22.5 cm long and 2.5-3.5 cm broad linear, lanceolate, acuminate, unequally attenuate, ending above in a twisted scabrous point, scaberulous near the margin and midrib above, smooth below, edges scabrous; sheath striate, ending in a pair of shining calluses with a depression between; ligule long, serrate. **Inflorescence** a large panicle of spicate branchlets bearing globular heads of many spikelets, heads up to 5 cm diameter, rachis striate.

▲ **P. bourdillonii** - *New shoot*

➤ **P. bourdillonii** - *Part of a culm*

Spikelets 14-16 mm long, 3-flowered mucronate; empty glumes 2, ovate, mucronate; flowering glumes long; palea 2-keeled, terminal, rachilla ciliate, with a short setaceous imperfect flower; stamens exserted; anther apiculate; ovary ovoid acute; style hairy; stigmas 3, small, sub-plumose. **Caryopsis** linear-oblong, crowned by the hairy persistent enlarged base of the style, grooved on one side.

FLOWERING

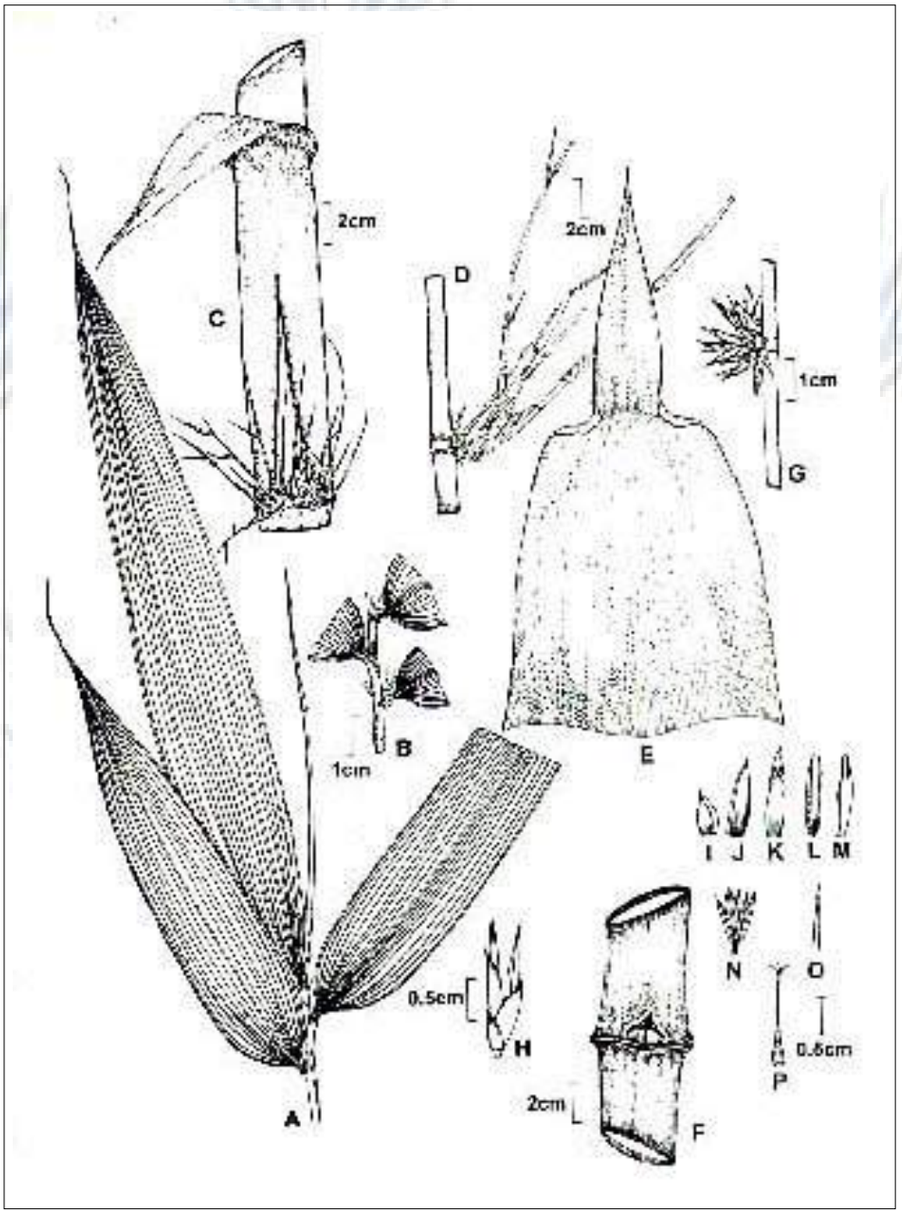
Blatter (1929) reported its flowering in 1889. According to Brandis, it flowers at long intervals. Flowering was observed in Vazhachal, Chalakudy Forest Divisions of Central Kerala in the year 1983. The flowered clump dried subsequently.

DISTRIBUTION

The species is endemic to Kerala. Distributed in the hills between an altitude of 900-1500 m.

USES

Culms are ideal for the manufacture of high quality toothpicks and combs. Young shoots are edible.



➤*Fig. 71.* **P. bourdillonii.** *A - leafy branch; B - leaf-sheath; C - nodal region with culm-sheath with juvenile branches; D - culm with branches; E - culm-sheath; F - culm with bud; G - a portion of flowering branch; H - spikelet; I, J & K- empty glumes; L - flowering glume ; M - palea; N - staminal tube with stamens; O - stamen; P - pistil.*

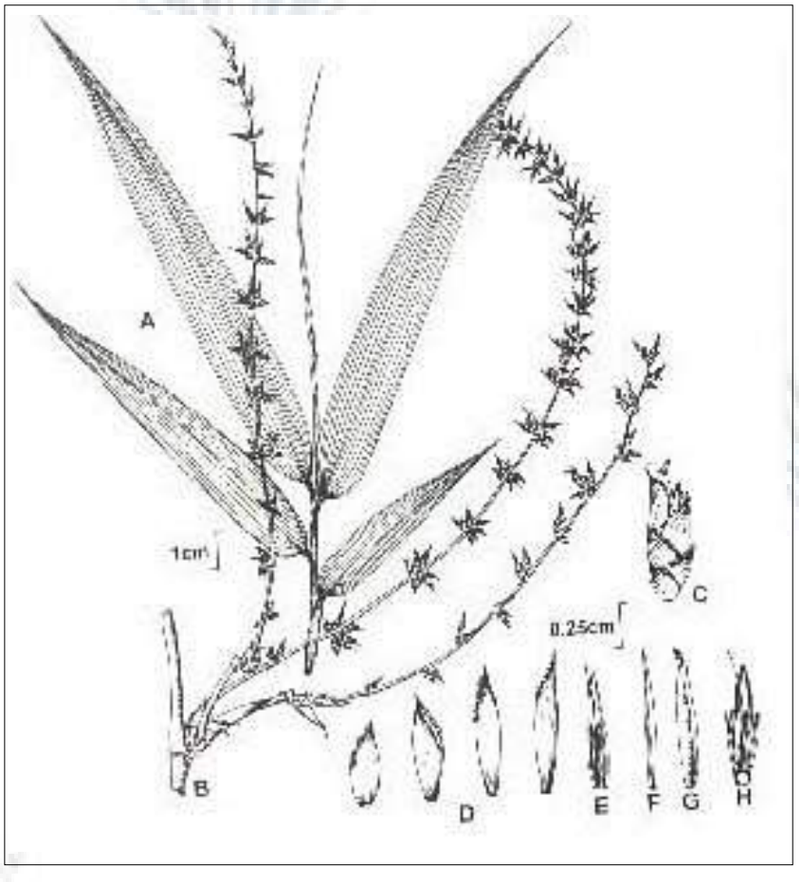
Pseudoxytenanthera monadelpha

Pseudoxytenanthera monadelpha (Thw.) Soderstrom and Ellis, Smithson. Contrib. Bot. 72: 52. 1988; Tewari, Monogr. bamboo 124.1992. **(Fig. 72).**

Dendrocalamus monadelphus Thw., Enum. Pl. Zeyl. 376. 1864; *Oxytenanthera thwaitesii* Munro, Trans. Linn. Soc. London 26: 129. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 64. 1896 and in Hook f., Fl. Brit. India 7: 402. 1896; Camus, Les Bambusees 147. 1913; *Oxytenanthera monadelpha* (Thw.) Alst. in Trim., Handb. Fl. Ceylon (Suppl.) 342. 1931; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.

DESCRIPTION

A small gregarious, straggling or subscandent, reed-like bamboo. **Culms** 3-3.5 m high, ca.2.5 cm diameter, smooth, usually ending in a curved whip with small branchlets in verticils and very small leaves, branched from the base; leaf and flower bearing branches on the same culm; internodes 30-45 cm long, rough, hairy when young. **Culm-sheaths** ca.15 cm long and 7.9 cm broad, truncate at the mouth, ciliate on the margins, those of thicker shoots appressed hairy on the back, younger and thinner shoots nearly glabrous; imperfect blade 7.5-12.5 cm long and 2.5 cm broad ovate-acuminate, rounded at the base and decurrent; auricles large, rounded, falcate, with stiff curved bristles. **Leaves** very variable in size, lanceolate, acuminate, ending in a sharp twisted setaceous point; petiole small, glabrous above, sparsely hairy beneath, margins scabrous; sheaths striate, keeled, often very hirsute, ligule variable. **Inflorescence** a large leafy panicle with spicate branchlets bearing heads of more or less closely packed spikelets, bracts small, ovate, rachis smooth; spikelets often in pairs, usually 1-flowered; empty glumes 2-3, ovate, mucronate, sometimes ciliate on edges; flowering glume ovate-acute, mucronate, palea



◄*Fig. 72.* **P. monadelpha.** *A - leafy branch; B - a portion of flowering branch; C - spikelet; D - empty glumes; E - palea with staminal tube of outer flower; F & G - flowering glumes; H - palea with stamens and pistil.*

convolute, glabrous except at the ciliate point. Stamens exserted; anthers narrow, long, apiculate, hairy at the tip. Ovary ovate acuminate, style hairy, stigmas 3, short, plumose. **Caryopsis** elliptic-oblong, glabrous except at the long mucronate apex.

FLOWERING

Wight recorded its flowering in 1847 and 1851 from Nilgiris; Beddome from Anamalai in 1865 and 1871; Clarke from Coonor in 1870; King from Ochterlong Valley in 1878 and Gamble in 1883 and 1889 from various places in India. Recently in 1994, flowering was observed on few cultivated culms in Maharashtra.

DISTRIBUTION AND ECOLOGY

This species is endemic to South India and the mountains of South-Central Sri Lanka.

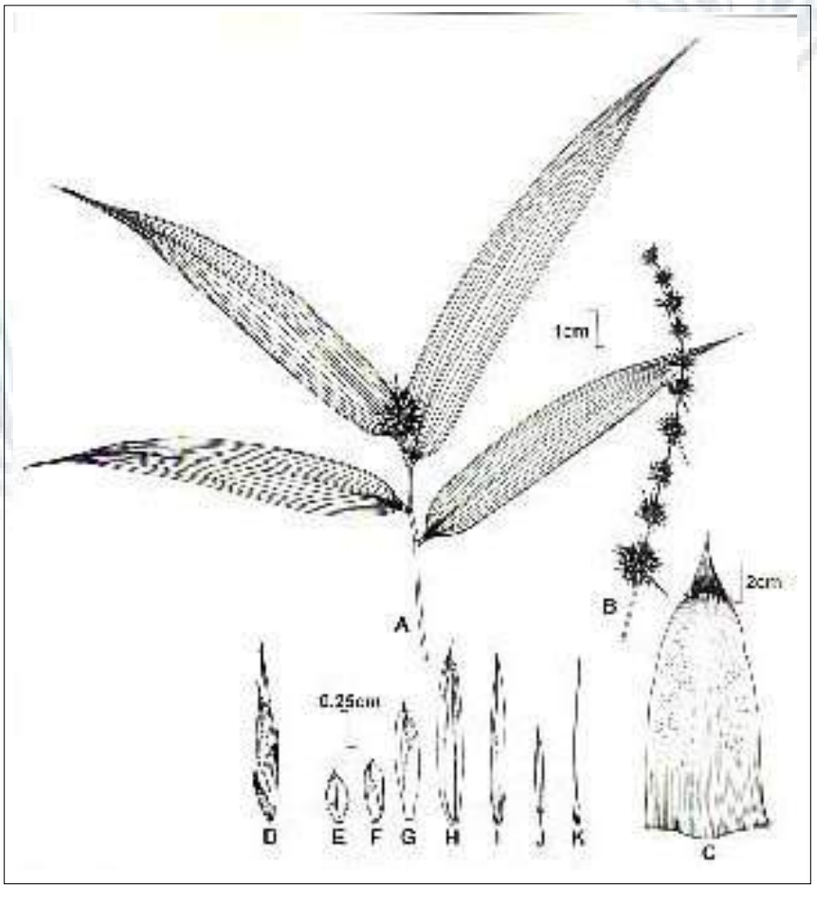
USES

P. monadelpha is found suitable for fencing, thatching and basket making.

Pseudoxytenanthera ritcheyi

Pseudoxytenanthera ritcheyi (Munro) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990; Tewari, Monogr. Bamboo 127.1992. **(Fig. 73).**

Bambusa ritcheyi Munro, Trans. Linn. Soc. London 26: 113. 1868; *Oxytenanthera monostigma* Bedd. Fl. Sylv. 233. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 74, t. 65.1896 and in Hook f., Fl. Brit. India 7: 402.



➤ *Fig. 73.* **P. ritcheyii.** *A - leafy branch with spikelets; B - flowering branch; C - culm-sheath; D - spikelet; E, F & G - empty glumes; H - flowering glume; I - palea; J - stamen; K - pistil.*

1896; Camus, Les Bambusees 148. 1913; *Oxytenanthera ritcheyi* (Munro) Blatter and McCann, J. Bombay Nat. Hist. Soc. 33: 773. 1929. Varmah and Bahadur, Indian For. Rec. (n.s) 6(1): 4. 1980.

▲ **P. ritcheyi** - *Seeds*

VERNACULAR NAMES

Maharashtra - *Huda, Udhe, Manga, Tandali*; Karnataka - *Choomaree, Choua, Chiwa, Chiwan, Chawa*.

DESCRIPTION

A medium sized strong bamboo. **Culms** 3-4.5 m high, nearly solid, densely covered with deciduous soft, pale-yellow velvety tomentum; nodes prominent; internodes 37-45 cm long, 2.5-3.5 cm diameter. **Culm-sheaths** thin, papery at the margins, striate, sparsely covered with white appressed, stiff hairs, 15-22 cm long, 7.5 cm broad at the base, gradually attenuate upwards the apex, rounded on either sides with deep sinus with imperfect blade attached at the base. **Leaves** variable, 5-20 cm long and 2-4 cm broad, linear-lanceolate, acuminate, rounded at the base, unequally into a 5 mm long flat petiole, apex setaceous, twisted, pointed, glabrous above except for the scabrous points on vein near the margins and on the midrib, sparsely hairy and pale beneath, scabrous on one side of the margin, mid vein yellow. **Inflorescence** a large terminal panicle of spicate branchlets bearing dense globular heads of 5-6.5 cm diameter. Spikelets 2-2.5 cm long, less than 2.5 cm broad, 1-flowered, glabrous, long-spinose apiculate, numerous, fertile and sterile about equal in numbers, glumes ovate-mucronate, lower smaller, upper ovate-lanceolate, lemmas linear-lanceolate, convolute, long mucronate. Paleas shorter than the lemma, not keeled, blunt. Stamens exserted, fused; anthers 5-7 mm long, bristly-apiculate, bristles some what hairy at the apex. Ovary ovate acuminate, rounded, glabrous; style long; stigma one, plumose. **Caryopsis** narrow, linear oblong, grooved ending in a conical mucro formed by the persistent base of the style.

FLOWERING AND FRUITING

According to Blatter (1929), this species flowered in 1852 in Kala Naddi; in 1870 in Satara Ghat; in 1884 and 1889 in North Kanara; in 1892 in Mahabalashwar and Ahmednagar. Gregarious flowering was observed in Ambumala (Nilambur) during 1987-88. Profuse fruit formation was observed during the flowering in 1987-88 in Nilambur, Kerala. Flowering was again observed during 1995-96 from natural forests, Silent Valley, Kerala.

DISTRIBUTION AND ECOLOGY

The species is distributed in Maharashtra, Karnataka, Kerala and Tamil Nadu. It is a light-demanding species and generally found on tops of the ridges and hills in the Western Ghats.

FIBRE CHARACTERISTICS

Fibre characteristics of this species showed a fibre length 2.40 mm, diameter 14.6 µm, wall thickness 5.3 µm, lumen diameter 4.0 µm (Bhanadri, 1981).

CHEMISTRY

Proximate chemical analysis of oven-dry culms showed ash 2.02 per cent, solubility in cold water 4.32 per cent, hot water solubility 6.03 per cent, 1 per cent NaOH solubility 21.31 per cent, alcohol benzene solubility 3.44 per cent. Percentages of lignin 27.3, holocellulose 68.5, (Bhanadri, 1981).

SILVICULTURE

About 75000-78000 seeds weighed 1 kg. Initial viability of the seeds is about 70 per cent. The seeds can be stored for a period of more than one year over anhydrous calcium chloride in a desiccator or in deep freeze (Seethalakshmi, 1991). Plantation trials are reported from Asoga (Shivanagi, 1980).

PESTS AND DISEASES

Basal culm rot caused by *Fusarium* species is reported.

USES

Culms are used for fencing, walking sticks, umbrella handles and baskets.

Pseudoxytenanthera stocksii

Pseudoxytenanthera stocksii (Munro) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990; Tewari, Monogr. Bamboo 129.1992. **(Fig. 74).**

Oxytenanthera stocksii Munro, Trans. Linn. Soc. London 26: 130. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 75, t. 66. 1896 and in Hook. f., Fl. Brit. India 7: 403. 1896; Camus, Les Bambusees 149. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.

VERNACULAR NAMES

Maharashtra - *Chivari*, *Mes*; Karnataka - *Konda*, *Oor - shema*.

DESCRIPTION

A medium-sized bamboo. **Culms** up to 9 m tall, glabrous, when young covered with dense white or gray deciduous tomentum, internodes 15-30 cm long and 2.5-4 cm broad; branches few at the node. **Culm-sheaths** 15-22 cm long and 7-17 cm broad, striate, silvery shining within, covered outside with matted deciduous reddish hairs mixed with small white hairs with bulbous black bases, tapering gradually upwards and somewhat concavely truncate at apex, imperfect blade, subulate-acuminate, rounded at the base and again expanded in rounded wavy long- fringed auricle on the top of the sheath; ligule 7 mm, fimbriate. **Leaves** 10-20 cm long and 1-2 cm broad, linear-lanceolate, rounded or attenuate at the base into a 2 mm long petiole at apex ending in a setaceous point, glabrous above, except the scabrous margins, ligule long, dentate. **Inflorescence** a large panicle of spicate heads with many closely packed spinous spikelets; heads about 2.5 cm diameter supported by rounded chaffy bracts. Spikelets 1-1.2 cm long, narrow, glabrous, mucronate, fertile florets many and mixed up with a few sterile. Glumes ovate, mucronate, 5-7-nerved, 2 hermaphrodite flowers; lemmas ovate, sub acute, mucronate at the back; palea of the lower flowers as long as lemma, 2-keeled, ciliate on the keels. Stamens long, exserted; anthers short, acute; ovary ovoid, hairy; style long; stigma 1 plumose. **Caryopsis** not known.

FLOWERING

Flowering has been reported in 1884 and 1889 in North Kanara (Blatter 1929). Flowering was observed recently in 1994 at Silent Valley, Kerala.

DISTRIBUTION AND ECOLOGY

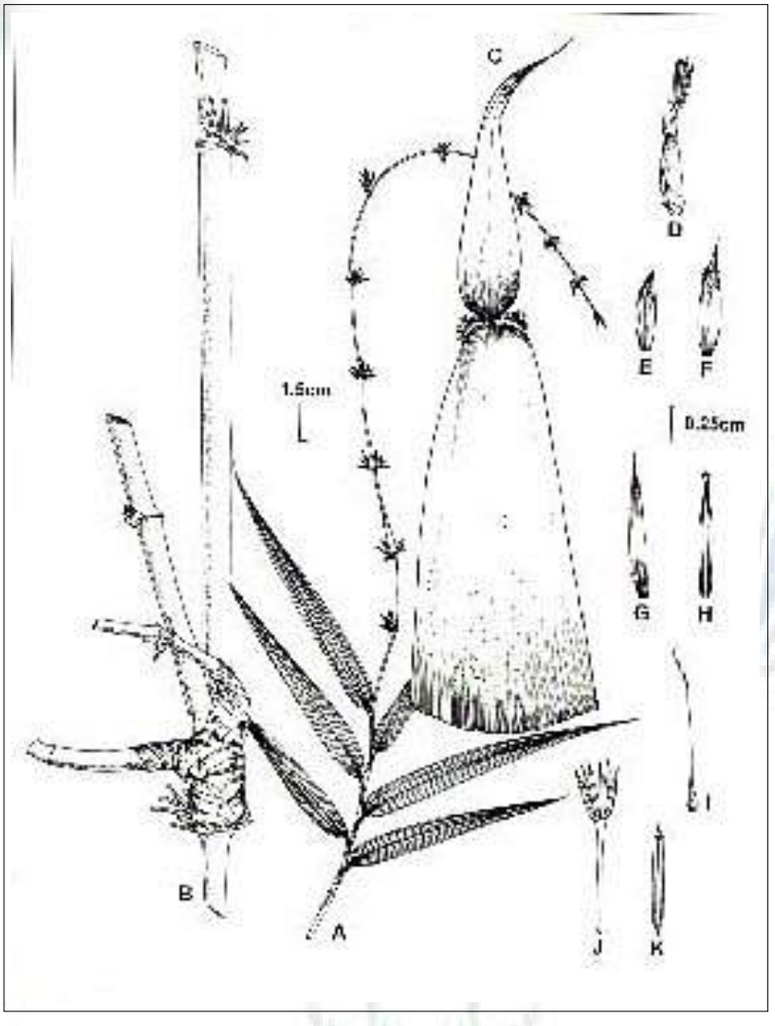
This species is distributed in Maharashtra, Karnataka, Kerala and Goa. It is cultivated in the costal belts of Karnataka. This bamboo is mostly confined to the banks of streams and requires a well drained deep loamy soil.

SILVICULTURE AND MANAGEMENT

Vegetative propagation by two-noded culm cuttings from more than one year old culms planted in nursery beds filled with red earth, sand and farm yard manure in equal proportions gives 90 per cent rooting (Yellappa Reddy and Yekanthappa, 1989).

USES

The culms are used for construction purposes, umbrella handles and basket making.



➤*Fig. 74.* **P. stocksii.** *A - flowering branch with leaf; B - culm with branches; C - culm-sheath; D - spikelet; E & F - empty glumes; G - flowering glume; H - palea; I - pistil; J - monadelphous stamens; K - stamen.*

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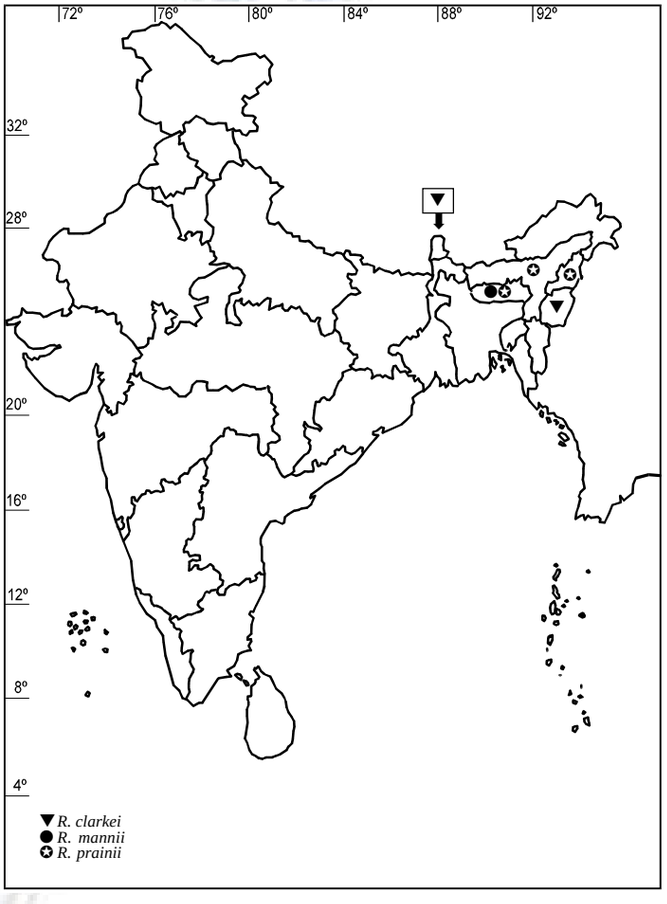
Yellappa Reddy, A. N. and Yekanthappa, K. 1989. Propagation technique for *Oxytenanthera stocksii*. Myforest, 25: 30-32.

RACEMOBAMBOS HOLTTUM

Usually climbing or scrambling bamboo. Rhizome sympodial. Culm very long and climbs upto a height of 10 m or more on trees, solid, slender; internode long, walls thick; nodes swollen with a small ring; branchlets many, fascicled. Culm-sheath persistent, very long; imperfect blade striate. Leaves oblong-lanceolate, transverse veinlets inconspicuous. Inflorescence a terminal or axillary panicle in leafy or leafless branches. Spikelets sessile subtended by small bracts. Stamens 6; anthers basifixed. Style undivided, very short, with 3 long plumose stigmas.

This genus was erected by Holttum in 1956. Chao and Renvoize (1989) consider 18 species in South Asia. The genera *Mycrocalamus* and *Neomicrocalamus* are treated as cogeneric by them. The genus *Racemobambos* is reported to be confined to Malaysia (Dransfield and Widjaja, 1995). However, this genus is quite different from *Arundinaria* and matches well with *Neomicrocalamus* Keng. Chao and Renvoize (1989) have included only one Indian species under *Racemobambos*. The remaining two species earlier known as *Neomicrocalamus* now fall under *Racemobambos*. Therefore, two new combinations have been proposed in this compendium. Three species of this genus are distributed in North-Eastern parts of India. In this compendium, details of 3 species of *Racemobambos* are given.



◄*Distribution map of* **Racemobambos**

Racemobambos clarkei

Racemobambos clarkei (Gamble ex Brandis) Muktesh kumar comb. nov.

Arundinaria clarkei Gamble ex Brandis, Indian Trees 666. 1906; Camus, Les Bambusees 49. 1913; Blatter, Indian For. 55: 547. 1929; Varmah and Bahadur, Indian For. Rec.(n.s) Bot. 6(1): 1-2. 1980. *Neomicrocalamus clarkei* (Gamble ex Brandis) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 279. 1989; Tewari, Monogr. Bamboo 108. 1992.

VERNACULAR NAMES

Manipur - *Lading wa*.

DESCRIPTION

A shrubby bamboo. **Culm** ca. 3m high, solid. **Leaves** ca. 9 cm long and 1.2 cm broad, oblong-lanceolate, rounded, attenuate, towards the base into a thick ca. 4 mm long ciliate petiole, glabrous, striate, slightly ciliate at the margin, apex long, acuminate, midrib prominent; secondary veins and intermediate veins not distinct; transverse veinlets inconspicuous, leaf sheath thick, glabrous, striate, ending in to a callus with 2 or 3 very small bristles. **Inflorescence** a loose panicle with 10 spikelets in leafy branches. Spikelet with 2 empty glumes and 1 or 2 fertile flowers, stamens 6, ovary with very short undivided style having 3 long plumose stigmas.

DISTRIBUTION

This species is distributed in Manipur and Sikkim.

Racemobambos mannii

Racemobambos mannii (Gamble) Muktesh kumar, comb. nov. **(Fig. 75)**.

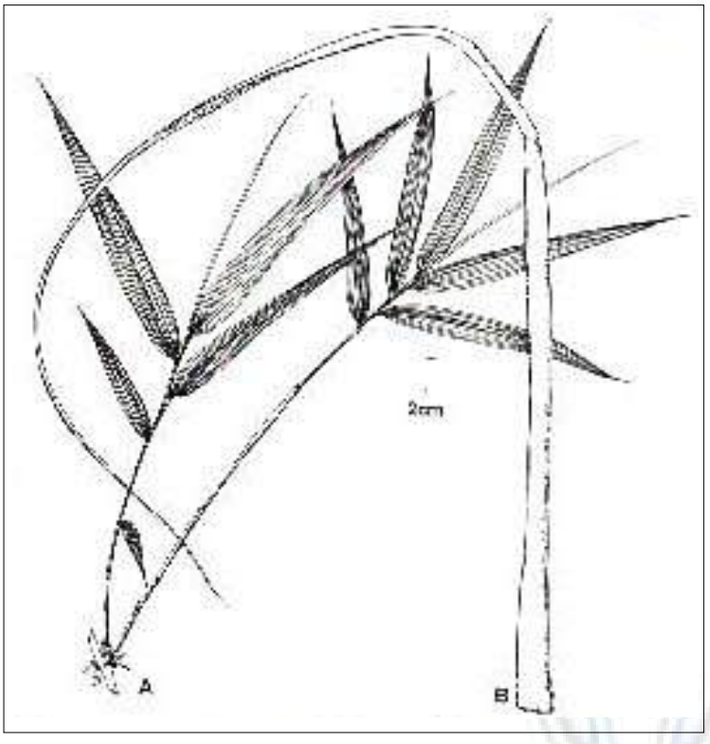
Arundinaria mannii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 26. 1896 and in Hook. f., Fl. Brit. India 7: 385. 1897; Camus, Les Bambusees 50. 1913; Blatter, Indian For. 55: 547. 1929; Bor in Kanjilal, Fl. Assam. 5: 42. 1940; Bahadur and Jain, Indian J. For. 4: 280. 1981. *Neomicrocalamus mannii* (Gamble) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 279. 1989; Tewari, Monogr. Bamboo 108. 1992.

VERNACULAR NAMES

Khasi Hills - *Beneng*; Jaintia Hills - *Kabeneng*.

DESCRIPTION

This is a slender, graceful, tufted, climbing, wiry, bamboo. **Culms** ca. 10 m long, ca. 8 mm diameter, solid, much branched; internode ca. 90 cm long, smooth, node thickened. **Culm-sheaths** 30-40 cm long and ca.0.7 cm broad at the top, thin and slender, persistent, outer surface rough with stiff brown bristles; imperfect blade ca. 25 cm long, continuous with the sheath, hairy on the ventral surface at the base, linear, apex narrowed into a long setaceous point; ligule narrow, dentate. **Leaves** ca.20 cm long and 2 cm broad, lanceolate, thin and papery, glaucous, glabrous on the dorsal



➤*Fig. 75.* **R. mannii.** *A - leafy branch; B - culm-sheath.*

surface, hairy on the ventral surface, scabrous on the edge, attenuate at the base into ca.5 mm long wrinkled petiole, tip hirsute with long setaceous point; midrib narrow, shining, secondary veins 5 pairs, intermediate 6; transverse veinlets inconspicuous; leaf sheath glabrous, striate, ending on one side a round shining callus without auricle, on the other side into a pointed auricle with few long bristles, ligule small, hairy.

DISTRIBUTION

The species is reported from North-East India - Meghalaya (Jaintia Hills).

USES

The culms are split and used as a binding material for building huts (Bahadur and Jain, 1981).

Racemobambos prainii

Racemobambos prainii (Gamble) J. Campbell, Gen. Himal. Bamb. 10. 1985. Keng.f. & Wen, J. Bam. Res. 5(2): 13. 1986. **(Fig. 76).**

Arundinaria prainii. Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 21. 1896 and in Hook. f., Fl. Brit. India 7: 383. 1897; Blatter, Indian For. 55: 546. 1929 and J. Bombay Nat. Hist. Soc. 33: 902. 1930; *Thamnocalamus prainii* (Gamble) Camus, Les Bambusees 54. 1913; Bor in Kanjilal, Fl. Assam. 54. 1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 4. 1980; Biswas, Indian For. 114: 528. 1988; *Microcalamus prainii* Gamble, J. Asiatic Soc. Bengal 59(2): 207. 1890; Holttum, Gard. Bull. Singapore 15: 267. 1956. *Neomicrocalamus prainii* (Gamble) Keng, J. Bamboo Res. 2(1): 38. 1983; Tewari, Monogr. Bamboo 108. 1992.

VERNACULAR NAMES

Khasi and Jaintia Hills-*Sampit, Usepeit, Uppit*; Naga Hills- *Kevva*.

DESCRIPTION

A wiry climbing shrubby bamboo. **Culms** ca. 10 m long and ca. 8 mm diameter, solid, slender, smooth yellowish; internode ca. 20 cm long, walls thick, nodes swollen with a well marked ring; branchlets many, fascicled. **Culm-sheaths**

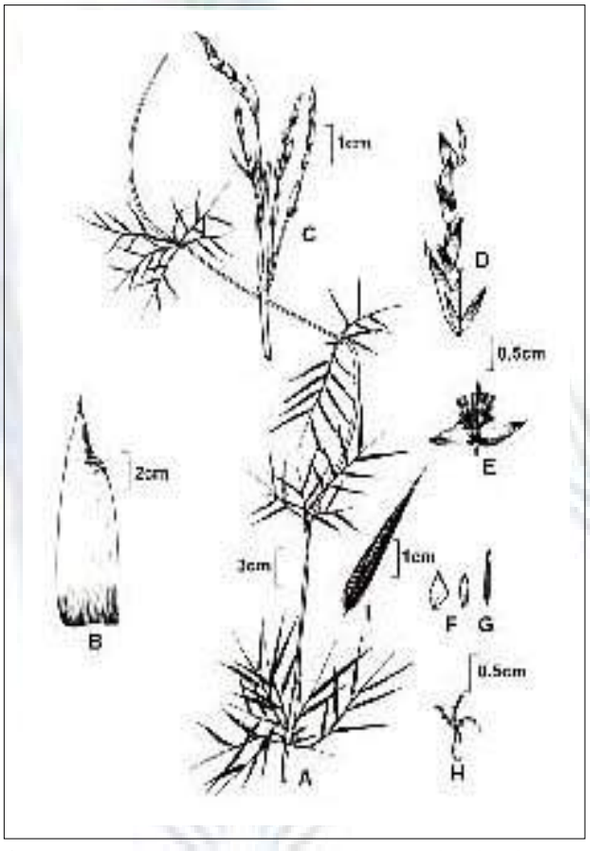


Fig. 76. **R. prainii.** *A - leafy branch; B - culm-sheath; C - flowering branch; D - spikelet; E - opened flower; F - lodicules; G - stamen; H - pistil; I - single leaf.*

5-15 cm long and ca. 2 cm broad, at the base striate, thin, scabrous on the outer surface, imperfect blade ca. 5 mm long, needle like; ligule short, rounded. **Leaves** ca. 6 cm long and 0.7 cm broad, thin, oblong lanceolate, rounded at the base in to ca. 2 mm long petiole, glabrous except one, scabrous at margin, terminating above in a long curved scabrous setaceous point; midrib not prominent, secondary veins 2-3 pairs, intermediate 7 pairs, transverse veinlets not conspicuous, leaf-sheath smooth, striate ending into a prominent glabrous callus below the petiole, protruding upwards to meet the long rounded ligule. **Inflorescence** terminal or axillary panicle, rachis slender, wiry, smooth, spikelet ca. 3.5 cm long on slender pedicels, 5-6-flowered, terminal flower empty; rachilla ca.6 mm long, clavate, flattened, empty glumes 2, outer glume with ciliate keels, inner glume 5-nerved and ovate acute with ciliate tip; lemma ca.8 mm long and 3 mm broad, triangular, falcate, acute, ciliate on the edges, palea as long as lemma, with two minutely ciliate bifid keels, lodicules 3; stamens 6; anther purple, bluntly apiculate basifixed, filament short. Ovary ovoid-oblong, glabrous style thick, bulbous at the base with three long plumose stigmas.

FLOWERING

This species is reported to flower rarely. Prain (1886) recorded its flowering from Naga Hills.

DISTRIBUTION

Reported from North-East India, Meghalaya, Assam and Nagaland. Distributed mostly in subtropical zone.

USES

Culms are used for basket making and for the construction of huts.

REFERENCES

Bahadur, K. N. and Jain, S. S. 1981. Rare bamboos of India. Indian Journal of Forestry, 4: 280-286.

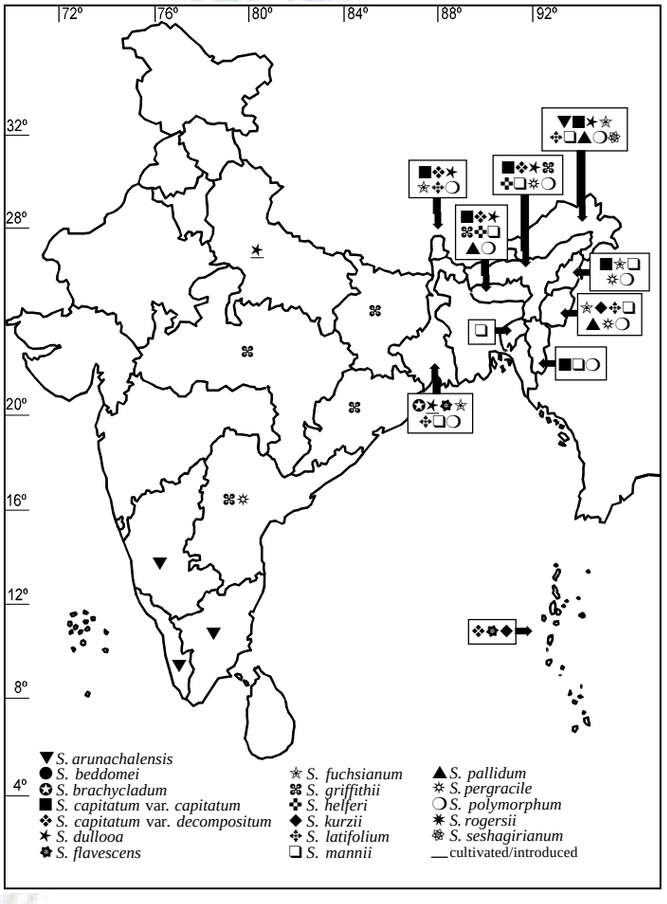
Chao Chi-son and Renvoize, S. A. 1989. Revision of the species described under *Arundinaria* (Graminae) in Southeast Asia and Africa. Kew Bulletin, 44: 349-367.

Dransfield, S. and Widjaja, E.A. (Eds.). 1995. Plant Resources of South East Asia No.7 Bamboos. Backhuys Publishers, Leiden: 189 p.

Tewari, D. N. A Monograph on Bamboo. International Book Distributors, Dehra Dun: 107-109.

SCHIZOSTACHYUM NEES

Arborescent or shrubby bamboos, usually erect. Culms slender, thin-walled, usually drooping at tip. Branches many short and equal in length at each node from the mid culm upwards. Young branches at each node burst almost simultaneously from the culm-sheath. Young shoots and culm sheaths are covered with appressed golden brown, light or pale brown or white hairs. Inflorescence a terminal panicle of spicate branches, bearing heads of spikelets often reduced to a spike are sometimes very few; rachis slender. Spikelets slender, fasciculate in heads, glumes 0-4, persistent, lemmas acute to pungent; uppermost palea rounded or sulcate, convolute, exceeding lemma. Lodicules 0-3, rarely 10. Stamens 4- 6, usually free but sometimes united. Ovary appendage with free central stand; stigmas 2-3. Caryopsis oblong to ovoid with thin crustaceous pericarp separable from seed.



◄*Distribution map of* **Schizostachyum**

This is a large genus comprising 45 species distributed in Laos, Malaysia, Philippines, Singapore, Thailand, Africa and India. In India, 17 species and one variety are seen, of which *S. brachycladum* is introduced from Malaya; 12 species occur in North Eastern part, 3 in Andaman Islands and 2 in Southern India. In this compendium, 17 species and one variety of *Schizostachyum* are described.

Schizostachyum arunachalensis

Schizostachyum arunachalensis Naithani, Indian For. 118:230. 1992; Tewari, Monogr. Bamboo 130.1992. **(Fig. 77).**

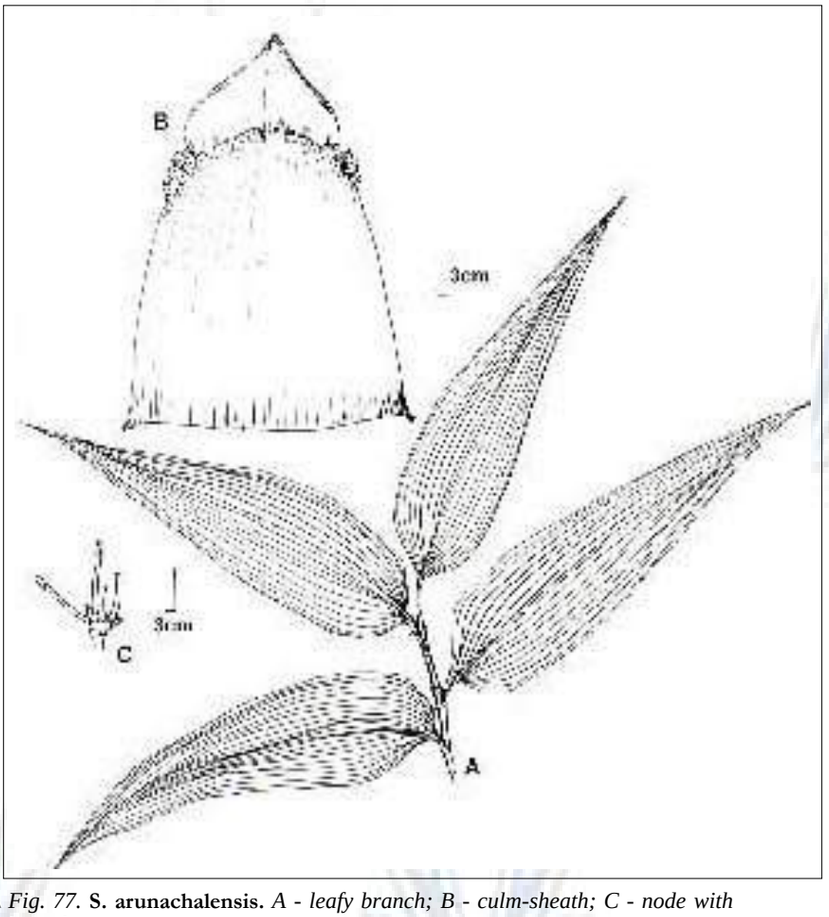


Fig. 77. **S. arunachalensis.** *A - leafy branch; B - culm-sheath; C - node with branches.*

DESCRIPTION

A semi-scandent bamboo. **Culms** ca.10-15 m tall, at first erect, and then pendulous; nodes swollen with thick 1 cm broad ring of brown hairs; internodes at base 20 cm long and up to 1 m long above, 10-12 cm in girth, smooth, dark green when young, turning yellow on maturity, wall 5-10 mm thick; branch bud rounded at apex, keeled. **Culm-sheaths** 15-26 cm long and 12-14 cm broad, thick, crustaceous, covered with yellow brown hairs on upper surface, glabrous on undersurface, oblique at the apex, margin with yellow brown cilia on upper half; imperfect blade 10-25 cm long and 9-11 cm broad, triangular, striate with transverse veins, base rounded, one side larger than the other, inflated with reticulate veins, margins with bristles on lower half; ligule narrow, entire. **Leaves** 30-48 cm long and 7.5-18 cm broad, oblong-lanceolate, base oblique, ending into a 1.5 cm long thick petiole, apex acuminate into a twisted point, glabrous on both surfaces, margins minutely scabrous, midrib prominent; secondary veins 12-18 pairs; intermediate 6-8, sheaths glabrous or pubescent, ending in a smooth callus and prominent long setaceous, reticulate auricles; ligule oblique, narrow, entire. **Inflorescence** not known.

Allied to *S. seshagirianum* Majumdar, but differs in having swollen nodes with thick ring of brown hairs; imperfect blade of culm-sheath with reticulate veins; leaves 7.5-18 cm broad with 12-18 pairs of secondary veins; leaf-sheaths with prominent reticulate auricle.

DISTRIBUTION AND ECOLOGY

The species is distributed in Arunachal Pradesh and it occurs in wet mountain slopes at an altitude of 300-700 m.

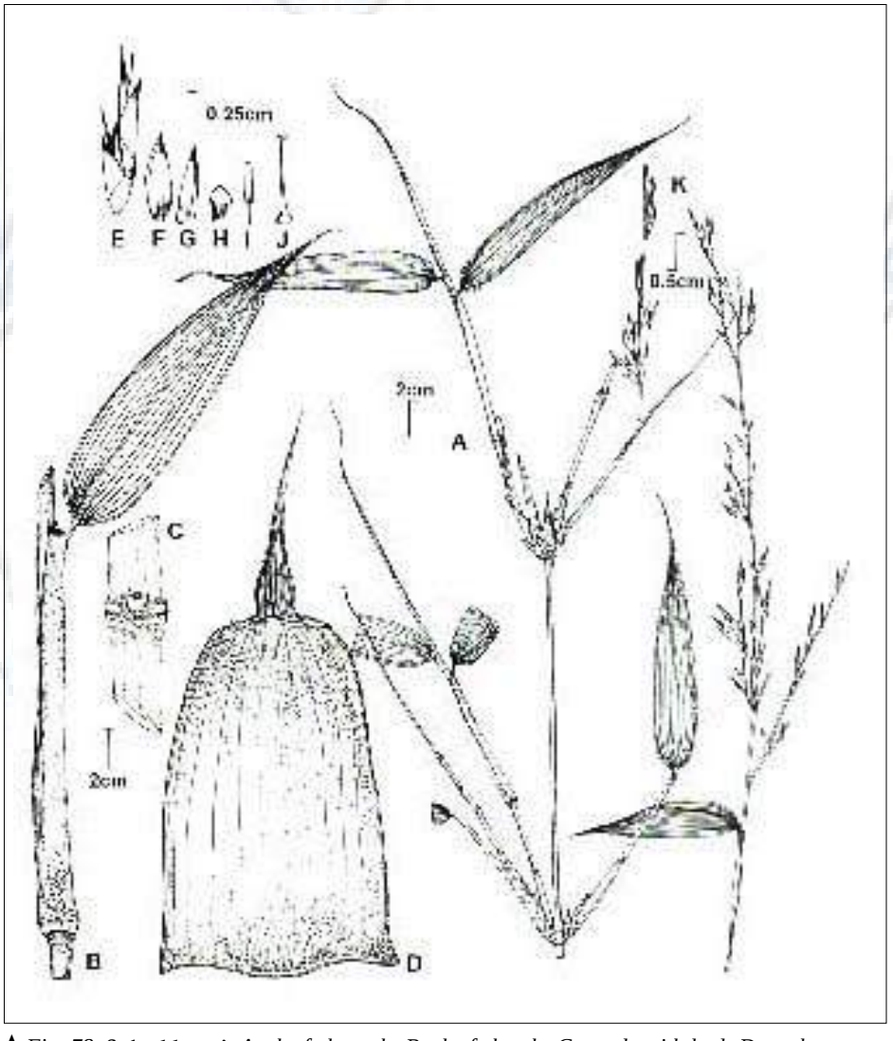
Schizostachyum beddomei

Schizostachyum beddomei (Fischer) Majumdar in Karthikeyan et al., Fl. India Enum. Monocot 281. 1989; Tewari, Monogr. Bamboo 130. 1992. **(Fig. 78).**

Teinostachyum beddomei Fischer in Gamble Fl. Pres. Madras. 3(10): 1860. 1934; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; *T. wightii* Beddome, Fl. Sylv. Pl. 323. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 99, Pl. 87. 1896, and in Hook. f., Fl. Brit. India 7: 410. 1897; Camus, Les Bambusees 163. 1913.

DESCRIPTION

Tall, semi-scandent bamboo. **Culms** 3-6 m high, 2.5-3.7 cm diameter, at first erect, branches pendulous, bright green, nodes marked by a ring, internodes 35-45 cm long, rough above with a white band below the node, walls thin, 4 mm in thickness. **Culm-sheaths** thin, papery, 25-30 cm long and 7.5-10 cm broad, sides parallel below, gradually narrowing above to a truncate tip, not auricled, thickly clothed on the back with brown black appressed hairs, imperfect blade subulate, acuminate, reflexed, slightly decurrent on the sheath 12.5-17.5 cm long and 2.5-3 cm broad, striate, hairy; ligule 2.5 mm, entire. **Leaves** oblong-lanceolate, acuminate, 12-38 cm long and 2.5-5 cm broad, unequal at the base, rounded or attenuated into a 7-10 mm long petiole, ending above in a twisted point, glabrous above, sparingly hairy and whitish beneath, scabrous on one margin,



▲ *Fig. 78.* **S. beddomei.** *A - leafy branch; B - leaf-sheath; C - node with bud; D - culm-sheath; E - spikelet; F - flowering glume; G - palea; H - lodicule; I - stamen; J - pistil; K - flowering branch.*

◄**S. brachycladum** - *New culm*

midrib broad, secondary veins 8-10 pairs, intermediate 6-7, transverse veinlets scanty, not prominent, formed by glands; sheath glabrous, striate, truncate at the top; ligule narrow, faintly toothed. **Inflorescence** large terminal drooping panicle of spiciform branchlets. The spikes supported by bracts at the joints of the rachis and bearing mainly fertile spikelets. Spikelets 1.2-2.5 cm long bearing 2-3 fertile flowers and one terminal incomplete flower, empty glume ovate mucronate, 5 mm long, faintly hirsute on the back, 5-7-nerved, flowering glumes 1 or 2, similar but longer, mucronate and transversely veined. Palea shorter than the flowering glumes, 2-keeled, blunt or emarginate, ciliate on the keels. Lodicules small, 2.5 mm long ovate, ciliate above concave below, 3-5-nerved, persistent. Stamens exserted; filaments slender; anthers obtuse. Ovary depressed, globose, smooth, stipitate; style included in the long beak of perigynium and ending in 2 short plumose stigmas. **Caryopsis** glabrous, ovoid on a thick stalk and surmounted by a beak.

FLOWERING

The species is reported to flower at long intervals and die after flowering.

DISTRIBUTION

It is found distributed in the slopes of Western Ghats from North Kanara down to Cape Comarin at an altitude of 900-1500 m.

USES

The culms of this species are used for making mats, baskets and for fencing.

Schizostachyum brachycladum

Schizostachyum brachycladum (Kurz) Kurz, J. Asiat. Soc. Bengal 39(2): 89. Pl. 6, f. 2. 1870; Camus, Les Bambusees 179. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 4. 1980: Tewari, Monogr. Bamboo, 131.1992.

Melocanna brachyclada Kurz, Cat. Hort. Bogor 20. 1866; *M. zollingeri* var. *brachyclada* (Kurz) Munro, Trans. Linn. Soc. London 26. 134. 1868.

DESCRIPTION

Densely tufted, sympodial bamboo. **Culms** close, erect, tips drooping culms upto 10-13 m high, 8 cm diameter, green or yellow with a few narrow green longitudinal streakes; nodes not swollen, without root primordia. Branches arising from the midculm nodes upward, at each node with a tuft of 25-30 slender subequal branches. **Culm-sheaths** long persistent to ca.18 cm long, rigid, densely covered with appressed fine red brown hairs, blade erect, slightly convex, triangular with stiff acuminate apex, usually glabrous, many-nerved; ligule 3 mm long, entire; auricles small 2.5 mm, bearing 4-5 mm long crisped bristles. **Leaves** 26-32 cm long and 3.5-6 cm broad, lower surfaces softly hairy, ligule short entire; auricles very small with long bristles. **Inflorescence** 16-30 cm long with dense tufts of pseudo spikelets at the nodes on the rigid distal part of a leafy branchlet; spikelet 15-25 mm long 1 or 2-flowered, lodicules 3, translucent, or purplish, anthers purple, 6 mm long, stigma white.

DISTRIBUTION AND ECOLOGY

The species is widespread in South-East Asia occurring in Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi, Moluccas, Boli and Luzon. In India, it is grown in Indian Botanic Garden, Calcutta. Generally found in disturbed or secondary forests in South East Asia up to 600 m altitude. It grows well in a well drained sandy clay or sandy loam soil.

SILVICULTURE AND MANAGEMENT

Vegetative propagation by branch and culm cuttings is not very promising (Othman and Nor, 1993). Culm cuttings are planted in the beginning of the monsoon, they are planted horizontally with fresh buds sideways, about 20-30 cm deep at an espacement of 3 x 3m. Attempts to propagate by tissue culture methods from various explants like node, shoot, leaves, culm-sheath and root obtained different results (Zamora, 1994).

USES

It is used for roofing, water containers, handicrafts and banana props. Young shoots are edible.

Schizostachyum capitatum var. **capitatum**

Schizostachyum capitatum (Munro) Majumdar var. *capitatum* (Gamble) Majumdar in Karthikeyan et al. Fl. India Enum., Monocot 281. 1989; Tewari, Monogr. Bamboo 131. 1992. **(Fig. 79)**.

Cephalostachyum capitatum Munro, Trans. Linn. Soc. London 26: 139. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 104, Pl. 91. 1896 and in Hook. f., Fl. Brit. India 7: 412. 1897; Camus, Les Bambusees. 165 Pl. 93, A. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980.

VERNACULAR NAMES

Nepal - *Gope bans;* Lepcha-*payong*.

DESCRIPTION

A shrubby, sub-arborescent, semi-scandent bamboo. **Culms** 4-10 m long, green or yellow, pendulous; nodes not prominent, internodes often 1 m long 2.5-3 cm diameter, wall 5-8 mm thick. **Culm-sheaths** 15-30 cm long and 5-7.5 cm broad, somewhat thin, papyraceous towards the top on young culms, covered on back with an appressed pale brown pubescence, truncate at the top of long sheaths, on the shorter lower ones rounded with concave sinus; imperfect blade long, erect or recurved, covered with white hairs, rounded at the base and decurrent into two small auricles, sometimes fringed; ligule narrow, serrate. **Leaves** 10-20 cm long and 2.5-5 cm broad, pale green, whitish beneath; petiole prolonged at the tip into a twisted, scabrous, setaceous tip, glabrous on both surfaces, margins scabrid; sheaths glabrous, shining, fimbriate in the throat with long caducous hairs; ligule short. **Inflorescence** a dense, globular, terminal or axillary, brownish head, 2-3.8 cm diameter. Sterile spikelets numerous, hidden by shining scarious scales often keeled on the back.

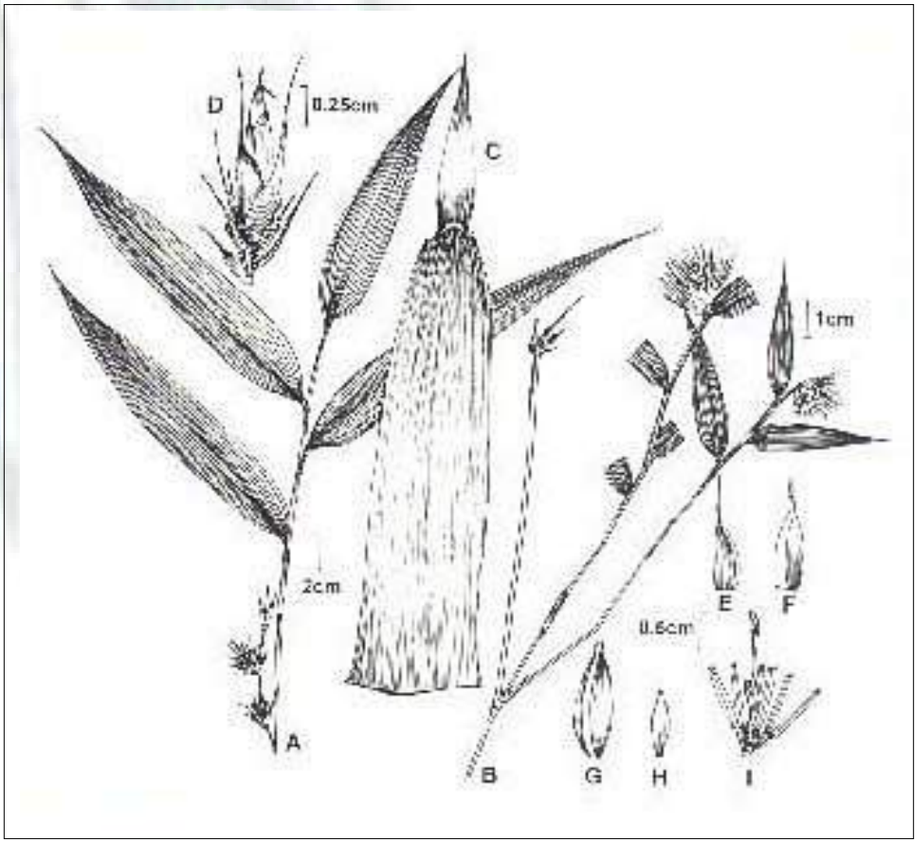


Fig. 79. **S. capitatum** var. **capitatum.** *A & B - leaves with flowering branch; C - culm-sheath; D - spikelet; E - empty glume; F - flowering glume; G - palea; H - lodicule; I - stamens around pistil.*

Fertile spikelets 1.5-2 cm long, few, with 1-3 sterile florets at the base. Glumes 2, ovate, glabrous at the top or slightly pubescent, with anastomosing nerves, tip ending in a scabrous awn; lemmas of the fertile floret similar in shape but with a shorter awn; palea as long as the lemma, convolute, thin, conspicuously nerved, both longitudinally and transversely, 2-keeled, the keels close together and hairy between, shortly hairy and mucronate at the tip. Lodicules 3, oblong-lanceolate, nerved, obtuse, attenuate and ciliate at the tip. Stamens 6, exserted, filaments long, anthers emarginate at the top. Ovary ovoid, furrowed, glabrous, attenuate into a twisted style; stigmas 2, hairy. **Caryopsis** chest-nut-brown, smooth, shining, depressed, surmounted by the remains of the style.

Chromosome number 2n=60 (Sobita Devi and Sharma, 1993).

FLOWERING

This species seems to flower at very frequent intervals. Gamble recorded its flowering during 1848, 1866, 1869, 1874, 1878 and 1892 in Sikkim and during 1830, 1835, 1850, 1871 and 1872 in Khasi Hills, Meghalaya.

DISTRIBUTION

This species is found distributed in Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland, North-Eastern India and in Sikkim and Bhutan.

USES

Culms of the species are used for construction works and for making bows and arrows; leaves are used as fodder.

Schizostachyum capitatum var. decompositum

Schizostachyum capitatum (Gamble) Majumdar var. *decompositum* (Gamble) Majumdar in Karthikeyan et al., Fl. India Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 132.1992.

Cephalostachyum capitatum Munro var. *decompositum* Gamble, Ann. Roy. Bot. Gard. Calcutta 7:105. 1896; Camus, Les Bambusees 165. 1913.

DESCRIPTION

This variety differs from *S. capitatum* var. *capitatum* in spicate arrangement of spikelet in almost paniculate clusters with many fertile spikelets.

DISTRIBUTION

This species is found distributed in Sikkim and Meghalaya.

Schizostachyum dullooa

Schizostachyum dullooa (Gamble) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 132. 1992. **(Fig. 80)**.

Teinostachyum dullooa Gamble, Ann. Roy. Bot. Gard. Calcutta 7. 101, Pl. 89. 1896 and in Hook f., Fl. Brit. India 7: 411. 1897; Camus, Les Bambusees 164. Pl. 92. 1913; *Neohouzeana dullooa* (Gamble) Camus, Bull. Mus. Nat. Hist. 100. 1922; Gamble, Kew Bull. No.2. 89. 1923; Bor in Kanjilal, Fl. Assam 21. 1940; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980.

VERNACULAR NAMES

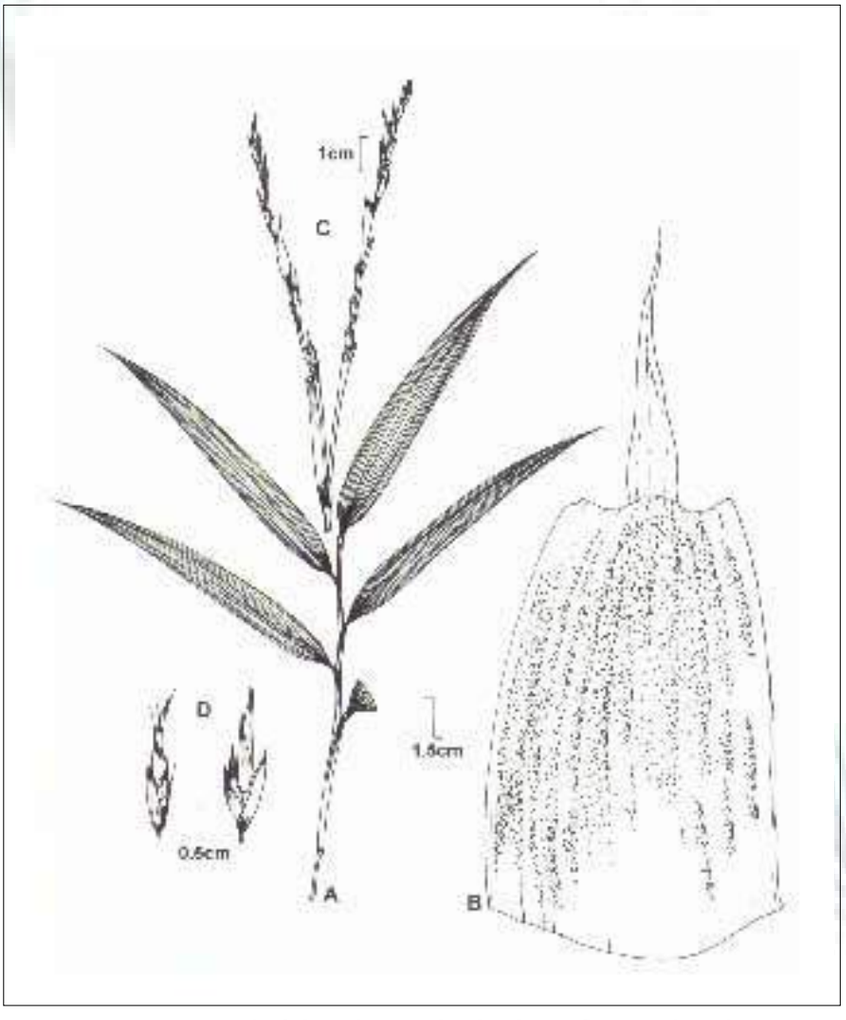
Assam - *Dullooa*; Lepcha - *Puksalu*; Meghalaya - *Wadroo*.

DESCRIPTION

Moderate sized to large tufted bamboo, sometimes scandent. **Culms** variable in size, 6-9 m tall and 2.5-7.5 cm diameter, dark green with a few white hairs. Whitish below the nodes, glossy when dry; nodes slightly prominent; internodes 40-75 cm, sometimes up to 1 m long, with thin walls. **Culm-sheaths** variable, 12-30 cm long and 10-25 cm broad, striate with white appressed hairs, rounded at the tip somewhat concavely truncate and loosely fringed with bristles; imperfect blade narrow, subulate, recurved, hairy within, edges convolute, 7.5-15 cm long and 0.8-1.8 cm broad; ligule prominent, long, fimbriate. **Leaves** variable, oblong-lanceolate, acuminate, rounded unequally at the base into a 5-10 mm long

petiole, subulately acuminate above, the tip scabrous, twisted, rough on the upper surface, almost glabrous beneath, edges scabrous, midrib not very prominent, secondary veins 6-10 pairs, intermediate ca.7, transverse veinlets absent but with a few pellucid dots; sheath striate, ciliate on the edges, callus ciliate or glabrous with a few long deciduous bristles, ligule broad, long, fimbriate. **Inflorescence** a panicle of spiciform branches with verticils of few spikelets, subtended by long, truncate bracts. Spikelets usually in pairs, slender, bracteate at the base, empty glumes 2-4, small, mucronate, flowering glume oblong-lanceolate, mucronate, strigosely hirsute. Palea convolute, glabrous except near the apex. Stamens 6, monadelphous; anthers 9 mm long, obtuse at the apex, exserted. Ovary elongate, glabrous; stigmas 3, short, red. This species can be recognised by its thin walls, silvery pubescence on the culm and subulate blade, concavely depressed sheath apex.

Chromosome number 2n=56, aneuploid (Sobita Devi and Sharma, 1993).



▲ *Fig. 80.* **S. dullooa.** *A - leafy branch; B - culm-sheath; C - flowering branch; D - spikelets.*

FLOWERING

Flowering has been reported from Singla in 1951, 1957 and 1968. (Gupta, 1972, 1982). Sporadic flowering has been reported from Cachar in 1961 and gregarious flowering in 1971.

DISTRIBUTION AND ECOLOGY

The species is distributed in North Bengal, Sikkim, Khasi and Jaintia Hills. It is cultivated in Calcutta and Dehra Dun (Qureshi et al., 1969). Architectural design was found to be adopted to capitalise on the high light regime of the early successional environment. *S. dullooa* is capable of growing on the coarse textured soil provided there is moisture and seen on soils originating from sand stone. (Rao and Ramakrishnan 1987, 1988). This grows in the lower elevations up to an altitude of 1200 m in the North-Eastern region of India.

CHEMISTRY

Proximate chemical analysis showed percentages of ash 1.78, cold water solubles 4.99, hot-

water solubles 0.61, alcohol solubles 3.24, ether solubles1.78, caustic soda solubles 20.40, pentosans 18.10, lignins 23.82 and cellulose 64.64.

SILVICULTURE AND MANAGEMENT

Architecture, growth pattern and population dynamics of this species have shown that regeneration period is about 15 years and is less than the fallow age (Rao and Ramakrishnan, 1987, 1988).

Vegetative propagation using one-year-old two-noded culm cuttings have been reported (Nath et al., 1986). Felling on a selection basis at an interval of three years is recommended (Prasad, 1948).

PESTS AND DISEASES

Fusarium leaf spot caused by *Fusarium pallidoroseum* has been reported (Deka et al., 1990). This disease was first observed in Assam in 1986.

USES

Used by the people of Garo Hills for carrying water and for making umbrellas. Generally used for making baskets, mats and small boxes.

Schizostachyum flavescens

Schizostachyum flavescens (Kurz) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 135.1992. **(Fig. 81).**

Cephalostachyum flavescens Kurz, J. Asiat Soc. Bengal 42: 252. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 109, Pl. 96. 1896 and in Hook f., Fl. Brit. India 7: 413. 1897; Camus, Les Bambusees 168. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980.

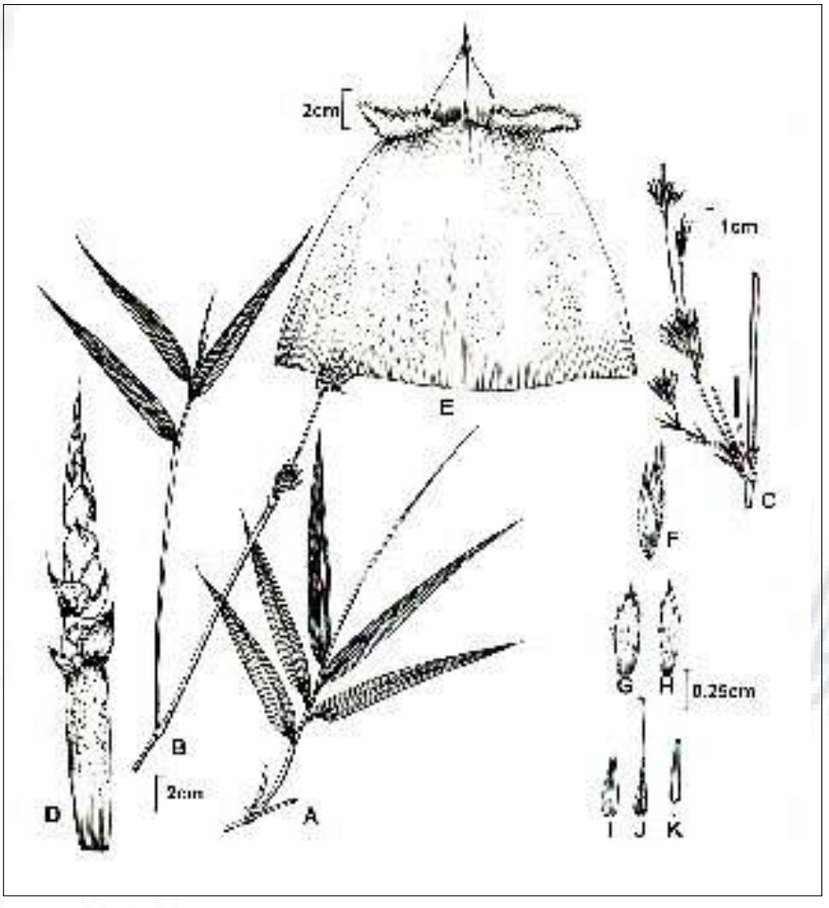
DESCRIPTION

An evergreen tufted, semi-arborescent bamboo. **Culms** 3-6 m high, dull green, turning yellow, smooth; nodes not prominent; internodes long, 2.5-3.8 cm diameter. **Culm-sheaths** 10-35 cm long and 12-27 cm broad, smooth or curved with appressed white hairs or pale brown bristly hairs; imperfect blade 2.5-9 cm long and broad, erect, triangular or ovate, margins usually long, ciliate, decurrent into a wavy fringes bordering the top of the sheath and ending on either side in a long pointed auricle; auricles margined with stiff curved bristles; ligule entire or slightly toothed. **Leaves** 7-19 cm long and 1-2 cm broad, linear, contracted at the base into a very short petiole, acuminate at apex in a long slightly scabrous point, glabrous except for a few long hairs on under surface, margins scabrous, sheaths glabrous, auricles furnished with a few short deciduous cilia, ligule narrow, inconspicuous. **Inflorescence** a leafy branched panicle of few verticillate branchlets, bearing heads of spikelets supported by a glabrous bract, rachis slender, spikelets mostly fertile, linear acuminate, hairy, ca.1 cm long, with few empty bract-like glumes or sterile spikelets between, glumes ovate-lanceolate, mucronate, white hairy, 7-9-nerved; lemmas similar to glumes. Palea as long as the lemma, 2-keeled, keels

close together, white-pilose on the margins, the apex deeply bifid. Lodicules ca.5 mm long, oblong, obtuse, ciliate at apex, concave at base 3-5-nerved. Stamens at first greenish, then turning yellow; anthers obtuse or acute. Ovary ovoid-acuminate, rounded, stipitate, smooth, style long, stigmas 3, slightly white hairy. **Caryopsis** not known.

DISTRIBUTION AND ECOLOGY

This species is distributed in the Andaman Islands and Myanmar and also cultivated at the Indian Botanic Gardens, Calcutta.



➤ *Fig. 81.* **S. flavescens.** *A & B - leafy branch; C - flowering branch; D - young shoot; E - culm-sheath; F - spikelet; G - empty glume; H - flowering glume; I - palea; J - pistil; K - stamen.*

Schizostachyum fuchsianum

Schizostachyum fuchsianum (Gamble) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 135.1992. **(Fig. 82).**

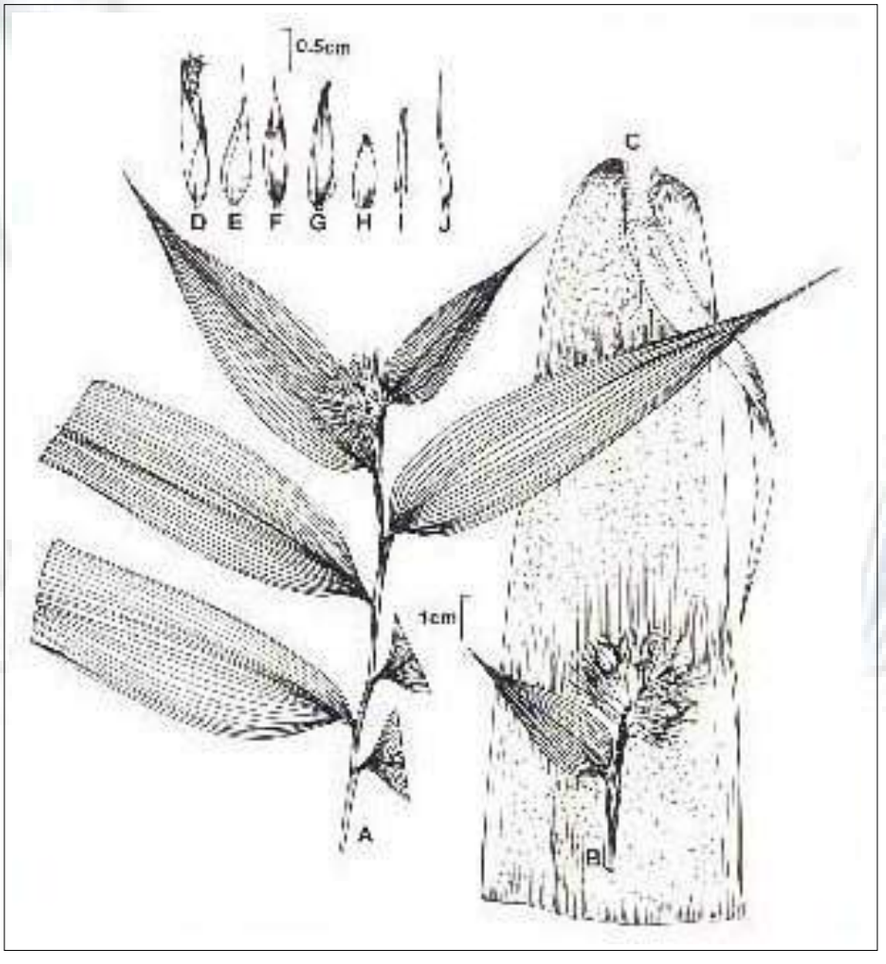
Cephalostachyum fuchsianum Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 107, Pl. 107. 1896 and in Hook f., Fl. Brit. India 7: 423. 1897; Camus, Les Bambusees 166. Pl. 93, Fig. B. 1913; Varmah and Bahadur. Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980.

VERNACULAR NAME

Lepcha - *Palom.*

DESCRIPTION

A medium sized, arborescent, semi scandent bamboo, **Culms** 5 m tall, green or pale, soft, thin-walled, nodes prominent, verticillately branched, internodes grayish near the nodes, 80 cm-1 m long. **Culm-sheaths** 30 cm long and 10 cm broad,



➤*Fig. 82.* **S. fuchsianum.**
A - leafy branch;
B - flowering branch;
C - culm-sheath; D - spikelet;
E - empty glume;
F - flowering glume;
G - palea; H - lodicule;
I - stamen; J - pistil.

thin, striate, reticulately veined on the edges, sides nearly parallel, rounded at the tip on each side into a deep concave, long-bristly fringed sinus, clothed on the back, with appressed light brown pubescence; imperfect blade 15-20 cm long and 1.7-2 cm broad, inserted at the base of sinus, reflexed, subulate, pubescent below; ligule small. **Leaves** 14-35 cm long and 5-10 cm broad, ovate lanceolate, angled or rounded at the base with a long (12-15 mm) petiole, cuspidately acuminate ending in a scabrous twisted point, glabrous on both surfaces, margins scabrous; mid vein prominent, shining, secondary veins 7-10 pairs, intermediate 8-10, pellucid glands giving the appearance of transverse veinlets; sheaths soft, dark green, striate, long, ciliate on the edges ending in a round callus and produced at the top into an elongated auricle, thickly clothed with stiff white bristles, ligule moderately long, ciliate. **Inflorescence** a dense, globular terminal head, 3.25 cm diameter, densely packed, terminal, congested spike of superposed heads, with many fertile spikelets, aristate bracts. Spikelets elongated, 2-2.5 cm long, glabrous. Glumes 1.5-1.7 cm, ovate at the base, long-scabrous, aristate above, glabrous, striate, 17-19-nerved; lemma similar but more elongate and more shortly aristate, palea longer than lemma, thin, ovate-lanceolate, bifid at apex, mucronate at tip, pubescent, 2-keeled. Lodicules linear-lanceolate or spathulate, blunt, 3-5-nerved, minutely ciliate above and papillose on the sides. Stamens long, exserted, pendulous; anthers sharply apiculate or forked at the tip. Ovary narrowly ellipsoid, style thick; stigmas 2, short. **Caryopsis** 6 x 2.5 mm, chestnut brown, shining, broadly ovoid, rounded at the tip.

FLOWERING

Blatter (1929) recorded its flowering in 1875, 1877, 1880 and 1892 from Paphla Hills, Arunachal Pradesh. Bor (1940) stated that it flowered in Naga Hills in 1935 and produced seeds in large quantity.

DISTRIBUTION

This species is distributed in Arunachal Pradesh, Manipur, Nagaland and Sikkim

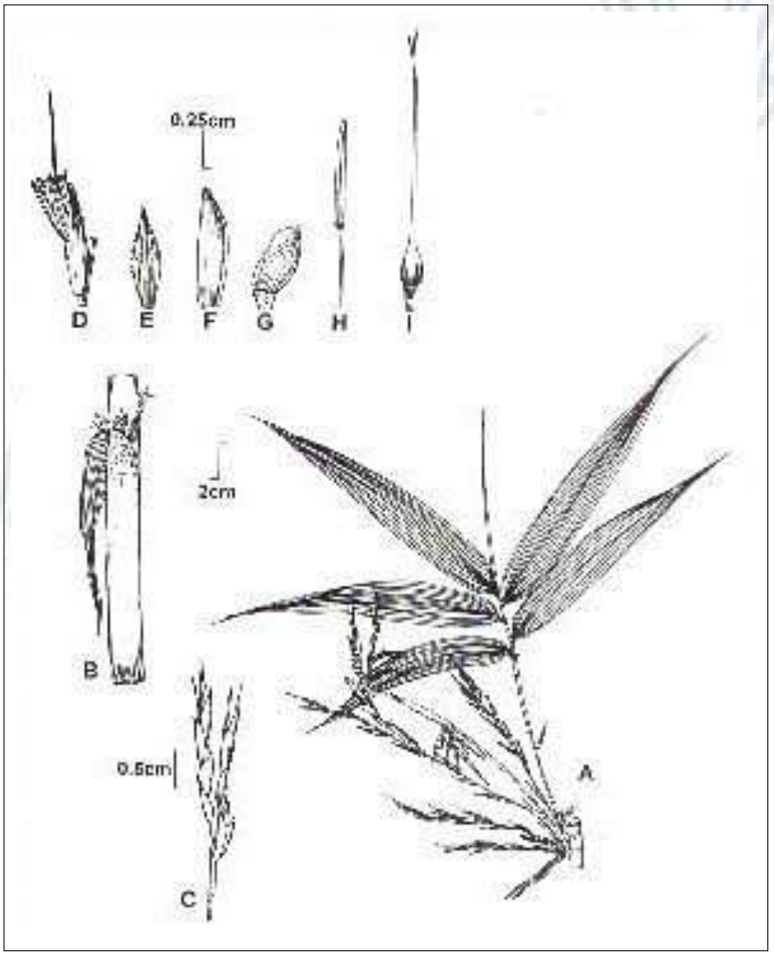
USES

Culms are used for basket-making. Seeds are edible.

Schizostachyum griffithii

Schizostachyum griffithii (Munro) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 137.1992. **(Fig. 83).**

Teinostachyum griffithii Munro, Trans. Linn. Soc. London 26: 143 t. 3. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 98, Pl. 86. 1896. and in Hook. f., Fl. Brit. India 7: 410. 1897; Camus, Les Bambusees 162, Pl. 92. Fig. B. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; *Cephalostachyum griffithii* (Munro) Kurz, For. Fl. Burma 2: 566. 1877.



➤ *Fig. 83.* **S. griffithii.** *A - leaf and flowering branches; B - culm-sheath; C & D - spikelets; E - flowering glume; F - palea; G - lodicule; H - stamen; I - pistil.*

DESCRIPTION

Straggling or sub-erect bamboo. **Culms** erect at first, afterwards drooping, 7.5-15 m long, verticillately branched from the nodes; internodes 45-65 cm long, 1.5-2 cm diameter, scabrous above, walls 5 mm thick. **Culm-sheaths** 15 cm long or more, 4 cm broad, glabrous and shining below, covered with white appressed hairs above, edges ciliate, margins convolute. Imperfect blade 7.5-10 cm long, reflexed, ovate-acuminate, rounded at the base with a large rounded auricle on either side, auricles and base of blade bristly; ligule short, pubescent. **Leaves** oblong-lanceolate, 15-25 cm long and 1.7-4 cm broad, glaucous, rounded at the base into a thick wrinkled 5 mm long petiole, cuspidate above with a scabrous point, scabrous on both edges, glabrous on both sides except for clusters of long hairs at the base, mid-rib, conspicuous, secondary veins 8-10 pairs, intermediate 7, no transverse veinlets, but occasionally pellucid glands present; sheath striate, keeled, glabrous or appressed, ending in a narrow callus with 2 falcate auricles, fringed with ciliae, 5-10 mm long, ligule short, fringed. **Inflorescence** a leafy panicle. Spikelets very narrow, 5 mm broad, often pedicelled, minutely pubescent with 3-5 fertile flowers and usually one or more sterile; rachilla smooth, jointed below the flowers; empty glumes 1 or 2, the second bearing a sterile flower, 7-10 mm long, narrow, striate, ovate mucronate; flowering glume 1.2 cm long, ovate acute, mucronate, 9-11-nerved, pubescent; palea longer than flowering glume, 2-keeled, ciliate near the tip, 4-nerved on either side, faintly purple, mucronate. Lodicules ovate-lanceolate, concave, equal, glabrous, 7-9-nerved; stamens exserted, filaments narrow. Anthers yellow, blunt or emarginate. Ovary stalked, glabrous, ovate, narrowing into a long triquetrous beak forming the style; stigmas 2-3, white or purplish. **Caryopsis** obliquely ovoid, glossy, tapering at both ends, beaked.

DISTRIBUTION

This species is found in North-Eastern India in Khasi Hills (Meghalaya), Sibsagar and Dibrugarh (Assam) and Arunachal Pradesh

USES

The culms are used for making baskets and pipes.

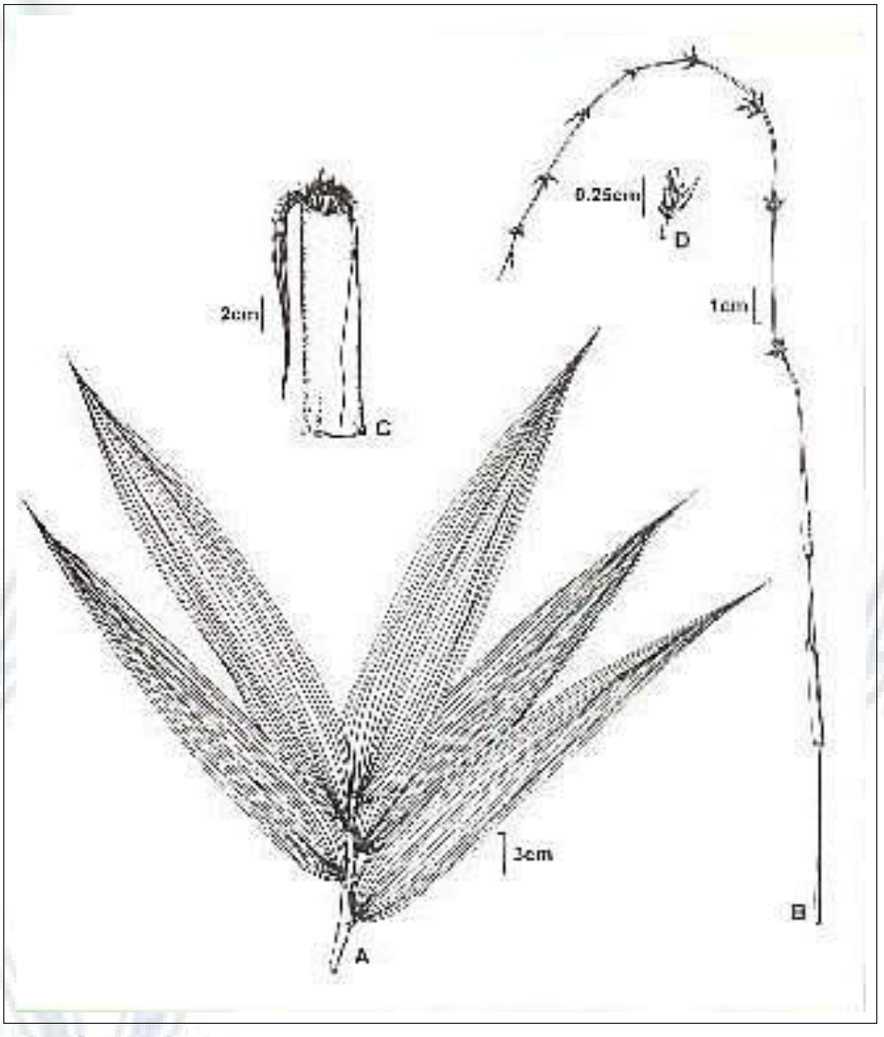
Schizostachyum helferi

Schizostachyum helferi (Munro) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 139.1992. **(Fig. 84)**.

Bambusa helferi Munro, Trans. Linn. Soc. London 26: 114. 1868; *Pseudostachyum helferi* (Munro) Kurz, J. Asiat. Soc. Bengal 42: 253. 1872; *Teinostachyum helferi* (Munro) Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 102. Pl, 90. 1896 and in Hook. f., Fl. Brit. India 7: 411. 1897; Camus, Les Bambusees 164. 1913; *Neohouzeana helferi* (Munro) Gamble, Kew Bull. No.2: 91. 1923; Blatter, Indian For. 55(11): 600. 1929; Bor in Kanjilal Fl. Assam 5: 21. 1940; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 3. 1980.

VERNACULAR NAMES

Meghalaya - *Wali;* Garo Hills-*Tumoh*.



➤*Fig. 84.* **S. helferi.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - spikelet.*

DESCRIPTION

Evergreen tufted bamboo, forming large impenetrable thickets, sometimes scandent. **Culms** 6-12 m high and 2.5-3.6 cm diameter, spreading in all directions, grayish green to green when young, much arched so as to bend completely and touch the ground; nodes somewhat inflated and whitish; internodes 0.5-1.25 m long or even more, velvety pubescent in the upper part when young with white band on maturity, walls thin. **Culm-sheaths** 20-25 cm long, persistent, thick, brittle when young with a few appressed white bristles, sheath-scar persistent, rough towards the base, truncate at the top; imperfect blade nearly as long as sheath, recurved, lanceolate, acuminate, glabrous or shortly hispid, rounded at the base and decurrent as a very narrow long fringed band on the top of the sheath; ligule narrow conspicuously fringed with white stiff hairs, 5-8 mm long. **Leaves** variable in size, oblong-lanceolate, 15-45 cm long and 2.5-7.5 cm broad, unequal at the base and then contracted into 7-10 mm long twisted scabrous point; sheath glabrous, smooth, seriate, ending in a smooth callus and a short very deciduous, long fringed auricle; ligule narrow and fringed. **Inflorescence** long terminal whip like spikes, bearing distant heads of spikelets, often upto 5 cm diameter at the base; empty glumes usually 2, small, 5-8 mm long, mucronate, margins slightly strigosely hirsute; flowering glume ovate, lanceolate, long, mucronate, strigosely hirsute, 1.2-2.5 cm long, many-nerved; palea convolute, glabrous except at the tip, 3.2-4.0 cm long, biseriate at the base, sometimes with a free terminal rachilla. Stamens 6, monadelphous; anthers 1.2-1.8 cm long, obtuse at the apex, exserted. Ovary oblong, elongate, glabrous; stigmas 3, short, red. **Caryopsis** with leathery pericarp, oblong, including the beak over 5 cm long.

FLOWERING

Flowering has been reported in 1888 from Jaintia Hills and in 1940 from Garo Hills of Assam.

DISTRIBUTION

This species is distributed in Meghalaya and Assam of North- Eastern India.

USES

The culms are used for basket-making.

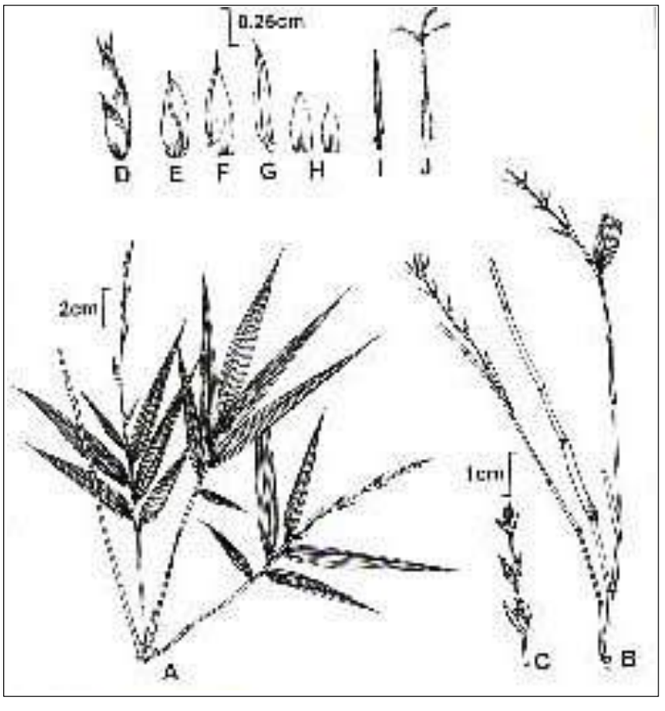
Schizostachyum kurzii

Schizostachyum kurzii (Munro) Majumdar, in Karthikeyan et al. Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 139. 1992. **(Fig. 85)**.

Melocanna kurzii Munro, Trans. Linn. Soc. London 26: 134. 1868; *Teinostachyum schizostachyoides* Kurz, J. Asiat. Soc. Bengal 39: 89. 1870; *Bambusa schizostachyoides* (Kurz) Kurz ex Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 48 Pl. 44. 1896 and in Hook. f., Fl. Brit. India 393. 1897; Camus, Les Bambusees 126, Pl. 71, Fig. B. 1913; Parkinson, For. Fl. Andaman Island 271. 1923; Varmah and Bahadur Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980; *Bambusa kurzii* (Munro) Balakr., Bull. Bot. Surv. India 22:176. 1980.

DESCRIPTION

An arborescent, evergreen, tufted bamboo. **Culms** 5-8 m high, 8-10 cm diameter, green, glossy; nodes not thickened; internodes 45- 60 cm long, walls very thin; branches 1-4 in each node. **Culm-sheaths**



➤*Fig. 85.* **S. latifolium.** *A - leafy branch; B & C - flowering branches; D - spikelet; E - empty glume; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil.*

not known. **Leaves** lanceolate to linear-lanceolate, 10-15 cm long and 1-3.5 cm broad, rounded or attenuate below into 2 mm long petiole, scabrous above along marginal veins and hairy near the base, otherwise smooth, pale and glabrous beneath, scabrous on the margins, mid- vein shining, conspicuous, sheaths striate, hispid at first then glabrous, furnished with 6-10 long, white, twisted, stiff bristles on a long falcate auricle, ciliate on the margins; ligule long. **Inflorescence** a spicate terminal panicle, bearing bracteate heads of few spikelets, narrow, smooth, truncate, acuminate; rachis truncate, pubescent, joints 2.5 cm long. Spikelets 1-1.5 cm long, smooth, cylindric with 1-2 glumes, 2-3 fertile flowers, terminating with one imperfect flower; rachilla short, glabrous; glumes ovate, mucronate, many-nerved; lemma similar, but longer, 1 cm long, rough above; palea narrow, acuminate, membranous, 12 mm long, 3-nerved on the back, ciliate on the keels. Lodicules 0 or 3, when present lanceolate, blunt, 3-5-nerved, shortly ciliate, one much longer than others. Stamens scarcely exserted; anther purple, 5-7 mm long, roughly apiculate; ovary stalked, hairy, style long, stigmas 3, hairy. **Caryopsis** obliquely oblong, ca. 7.5 mm long, smooth, ending in a long stiff beak.

Chromosome number 2n = 54 and 108, aneuploid (Sobita Devi and Sharma, 1993).

DISTRIBUTION

This species is distributed in Andaman Islands, Manipur and Myanmar.

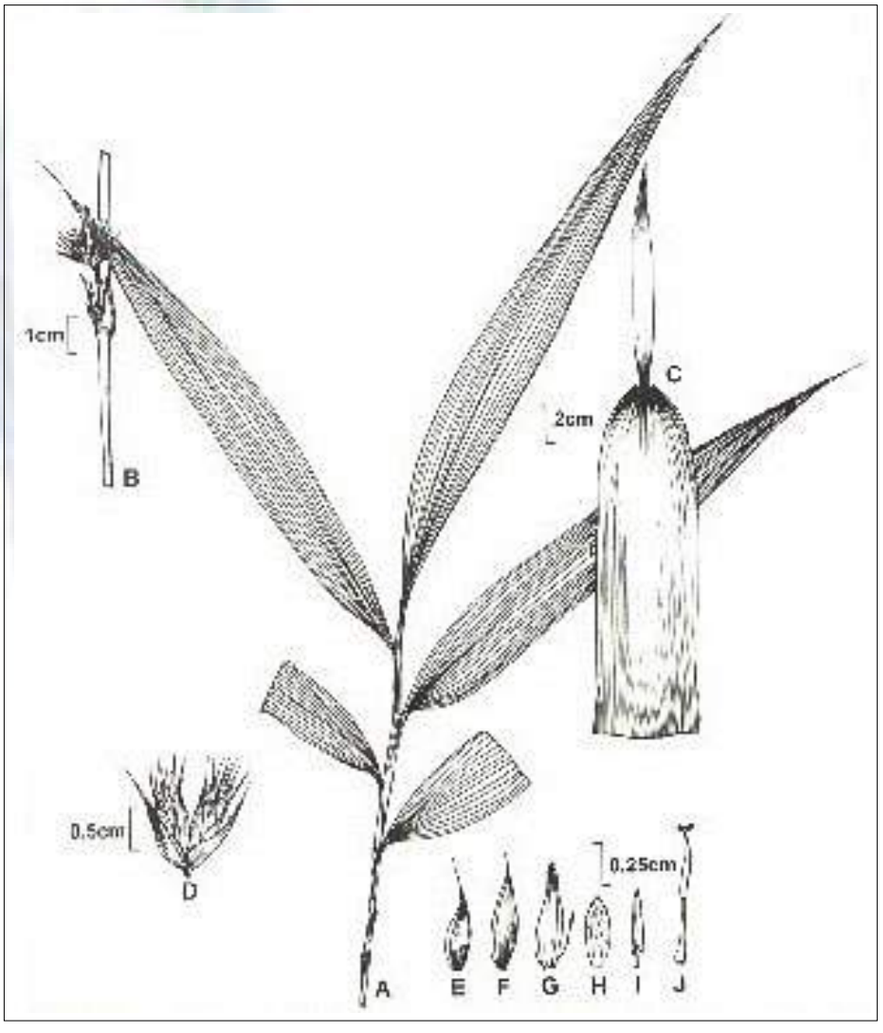
Schizostachyum latifolium

Schizostachyum latifolium (Munro) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 281. 1989; Tewari, Monogr. Bamboo 140. 1992. **(Fig. 86)**.

Cephalostachyum latifolium Munro, Trans. Linn. Soc. London 26: 140. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 106, Pl. 93. 1896 and in Hook. f., Fl. Brit. India 7: 412. 1897; Camus, Les Bambusees 166. 1913; Bor in Kanjilal, Fl. Assam 5: 17. 1940; Varmah and Bahadur, Indian For. Rec. (n.s.). Bot. 6(1): 2. 1980.

DESCRIPTION

A shrubby, scrambling bamboo. **Culms** 2-3 m tall, dark green, whitish below the nodes. **Culm-sheaths** thin, papyraceous, 15-22 cm long and 5-7.5 cm broad, straw coloured, not attenuate but rounded at the top into a concave sinus furnished with two small, triangular, erect auricles; imperfect blade 10-12.5 mm long and 8-12 mm broad, acuminate-subulate, somewhat attenuate at the base, ligule broad. **Leaves** 25-40 cm long and 2.5-10 cm broad, ovate or ovate-lanceolate, oblique at the base or rounded abruptly, narrowed into a short petiole, lateral veins up to 18 pairs, conspicuous, intermediate 7-10, without regular transverse veinlets, but distant pellucid dots appear as transverse veinlets on the undersurface; sheaths striate, ciliate, ending in an emarginate callus, rounded at the top; ligule long. **Inflorescence** composed of groups of spikelets in globular heads, 5 cm diameter at the tips of leafy branches, some spikelets sterile, some fertile, seated in the axis of broad keeled bracts. Spikelets 1-flowered, acuminate, 12-20 mm long, aristate. Glume 14 mm long, ovate-lanceolate, long aristate, glabrous except on the keel, striate; lemmas lanceolate-acuminate, with a short arista and anastomosing nerves; palea membranous tesellately nerved, rounded at the summit, convolute. Lodicules ovate-lanceolate or spathulate, ciliate, 3-nerved, pubescent. Stamens exserted; filaments long; anthers mucronate at



◄ *Fig. 86.* **S. latifolium.** *A - leafy branch; B - a portion of flowering branch; C - culm-sheath; D - spikelets; E - empty glume; F - flowering glume; G - palea; H - lodicule; I - stamen; J - pistil.*

apex. Ovary ovoid, attenuate in to a long, flattened style; stigmas 2, plumose. **Caryopsis** blackish brown, shining, broadly ovoid, grooved.

FLOWERING

Blatter (1929) recorded its flowering during 1835 and 1879 in Bhutan and during 1882 in Manipur. Dransfield (1995) reported that it flowers every year.

DISTRIBUTION

This species is distributed in Arunachal Pradesh, North Bengal, Sikkim, Manipur and Bhutan. It grows upto an altitude of 1000 m.

USES

Culms are used for making baskets, tobacco containers and blow pipes.

Schizostachyum mannii

Schizostachyum mannii Majumdar in Karthikeyan et al., F1. Ind. Enum. Monocot. 282. 1989; Tewari, Monogr. Bamboo 144. 1992.

Bambusa khasiana Sensu Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 39, Pl. 37. 1896. non Munro, 1868.

DESCRIPTION

Shrubby bamboo; branches tufted. **Culm-sheaths** triangular, deciduous, fragile; blade inflated at the base.

DISTRIBUTION

This species is found distributed in the North-Eastern India.

Schizostachyum pallidum

Schizostachyum pallidum (Munro) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monoct. 282. 1989; Tewari, Monogr. Bamboo 145. 1992. **(Fig. 87).**

Cephalostachyum pallidum Munro, Trans. Linn. Soc. London 26: 139. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 105, Pl. 92. 1896, and in Hook. f., Fl. Brit. India 7: 412. 1897; Camus, Les Bambusees 166. 1913; Bor in Kanjilal, Fl. Assam 5: 17. 1940; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980.

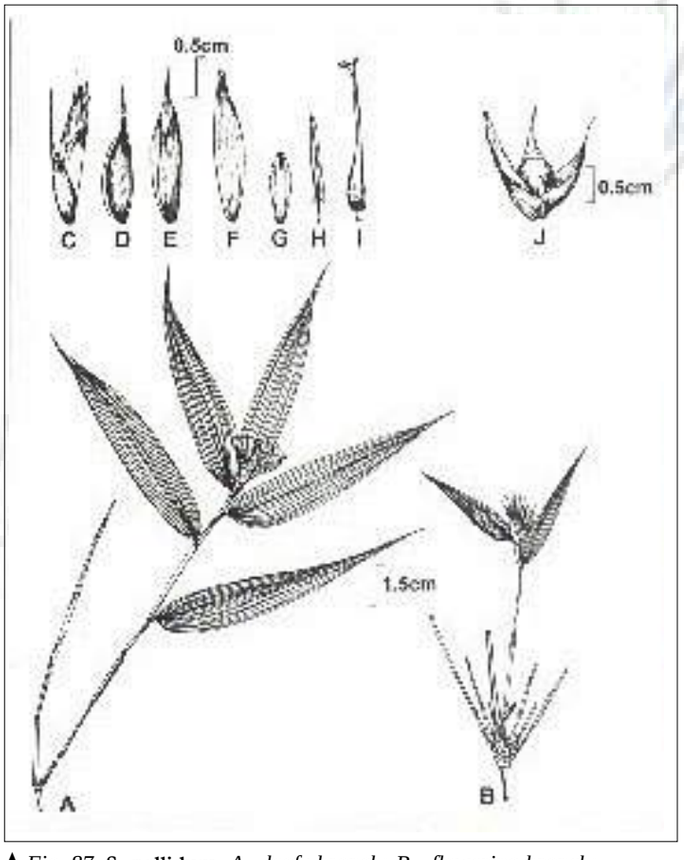


Fig. 87. **S. pallidum.** *A - leafy branch; B - flowering branch; C - spikelet; D - empty glume; E - flowering glume; G - lodicule; H - stamen; I - pistil; J - caryopsis.*

DESCRIPTION

A shrubby or small arborescent bamboo. **Culms** not more than 2 m tall. **Culm-sheaths** not known. **Leaves** pale green 2.5-12.5 cm long and 1.25-2.5 cm broad, ovate- lanceolate, unequally rounded at the base into a 5 mm long petiole, often wrinkled, suddenly narrowed above into scabrous, subulate point ending in long hair like tip, glabrous on both surfaces, minutely pubescent below, margins rough and somewhat cartilaginous; mid vein pale, secondary veins 4-6 pairs, intermediate 7, without transverse veinlets. Sheaths striate, ciliate on the margins, ending in a short rounded auricle furnished with a few, very early deciduous cilia; ligule long, sometimes ciliate. **Inflorescence** a pale terminal head about 2.5 cm diameter, supported by a leafy and broad, rounded, glabrous sheath like bracts and consisting of many, long, aristate, empty glumes or sterile spikelets, with a

few exserted fertile spikelets. Spikelets 17.5-20 mm long. Glumes empty, sessile or with a few empty bracts at the base, 12.5-15 mm long, ovate, concave, ending in a 5 mm long awn, many-nerved, sometimes pubescent on the back below the awn; lemma similar but with a shorter awn; palea as long as lemma, thin, many-nerved, tessellate, closely 2-keeled, bifid-mucronate at the apex, hairy below the keels and the tip, rachilla protruded, short. Lodicules lanceolate or spathulate 3-5-nerved, minutely papillose, pubescent, ciliate at the tip. Stamens exserted; filaments long; anthers long apiculate; ovary ovoid, lanceolate; style conical; stigmas 2, hairy, **Caryopsis** chestnut brown, glabrous, ovoid-globose.

FLOWERING AND FRUITING

Gamble (1896) recorded its flowering during 1835, 1872, 1878 1885 and 1886. Fruit is a glans, ovoid, 14.6 mm long and 10.9 mm wide; pericarp hard and glossy, separated from seed coat; no navel and ventral suture; a fruit stalk at base; a melon stalk-like rostrum at apex with a mucronate head. Starch grain ovate with an average diameter of 41 µm, several times larger than the common bamboo fruits, containing 3-19 small grains, small starch grains polyhedral or orbiculate with a diameter of 7.5-22.5 µm (Wen and He, 1991).

DISTRIBUTION

This species is distributed in Arunachal Pradesh, Manipur and Meghalaya.

Schizostachyum pergracile

Schizostachyum pergracile (Munro) Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot. 282. 1989; Tewari, Monogr. Bamboo 144.1992. **(Fig. 88).**

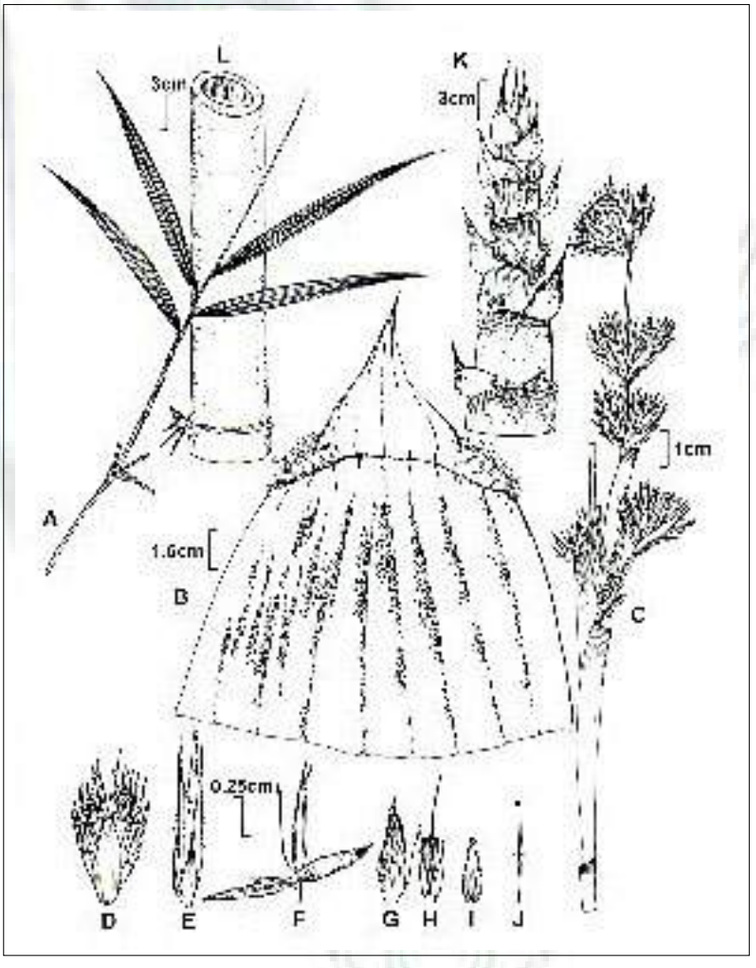
Cephalostachyum pergracile Munro, Trans. Linn. Soc. London 26: 141. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 108, Pl. 95. 1896 and in Hook. f., Fl. Brit. India 7: 413. 1897; Camus, Les Bambusees 167. 1913; Bor in Kanjilal, Fl. Assam 19. 1940; Bahadur and Naithani, Indian. For. 102: 596, Fig. A.H. 1976; Varmah and Bahadur, Indian For. Rec. (n.s). Bot. 6(1): 2. 1980.

VERNACULAR NAMES

Madhya Pradesh - *Bhalan bans*; Assam - *Madang*; Manipur - *Wootang*; Nagaland - *Latang*; Orissa - *Dangi*.

DESCRIPTION

A deciduous, arborescent, tufted bamboo. **Culms** 10-30 m tall, erect, glaucous green, somewhat whitish, puberulous below the nodes; nodes scarcely thickened; internodes 30-45 cm long and 5-7.5 cm broad, wall very thin. **Culm-sheaths** chestnut brown, broader than long, 10-15 cm long and 15-20 cm broad, covered with black, stiff deciduous hairs, imperfect blade 5 cm long, ovate, cordate, cuspidate, densely hairy within, decurrent into a wavy fringe bordering the top of the sheath and ending on either side in a rounded auricle; both fringes and auricle edges with long, stiff, curved white bristles; ligule very narrow, entire. **Leaves** variable, 15-35 cm long and 2.5-3.25 cm broad linear- lanceolate,



◄*Fig. 88.* **S. pergracile.** *A - leafy branch; B - culm-sheath; C - flowering branch; D - spikelet cluster; E - spikelet; F - open spikelet with sterile flower; G - palea; H - stamens and lodicules; I - lodicule; J - stamen; K - young shoot; L - a portion of culm.*

thin, rounded or cuneate at the base into a short petiole, terminating above in short, subulate, scabrous, acuminate tip, glaucescent beneath, rough on both surfaces and margins, midrib conspicuous, secondary veins 7-13 pairs, intermediate usually 5, sheaths glabrous, faintly striate, ending in a small, ciliate callus, auricles at the mouth with a few, early caducous cilia; ligule very narrow, entire. **Inflorescence** a large panicle with verticils of long, drooping, filiform spikes bearing distant broad heads of spikelets, supported by small, chaffy, sheathing bracts, rachis very slender. Spikelets in bracteate clusters, 1.25-1.75 cm long, without glumes, but bearing 1-2 sterile florets, followed by a fertile floret, ending in a terminal sterile floret; lemma 1.25-1.75 cm long, ovate-lanceolate, many-nerved, densely pale, hairy, long-mucronate, palea as long as lemma; lodicules 2, narrow, lanceolate, obtuse and ciliate at the tip, 3-5-nerved persistent. Stamens with narrow filaments; anthers purple, obtuse. Ovary smooth, sub-globular; style 1. Stigmas 2-3, stout, recurved. **Caryopsis** 1.25 cm long.

Chromosome number 2n = 72, 48, 54 and 60. Hexaploid (Ghorai and Sharma, 1980; Sobita Devi and Sharma, 1993).

FLOWERING

This species often flowers sporadically and occasionally flowers gregariously over extensive areas. Troup (1921) recorded its gregarious flowering from Tharrawaddy in Myanmar during 1865, 1875, 1887-1888, 1894-1895 and during 1913-1914; in Pyinmana during 1899-1900 and 1906-1908; in Upper Chidwin, Myettha and Katha during 1900-1907 and

▲ **S. pergracile** - *A part of the clump*

1913-1914. In India, it flowered in Dibrugarh (Assam) in 1936. Bahadur and Naithani (1976) have recorded its gregarious flowering in Dehra Dun in 1972.

DISTRIBUTION AND ECOLOGY

In India, it is found in Assam, Manipur, Nagaland, Bihar, Orissa, Madhya Pradesh and Andhra Pradesh. It prefers moderately moist soil and profuse watering in summer and responds readily to fertilizers. (Bahadur and Naithani, 1976).

ANATOMY AND FIBRE CHARACTERISTICS

Long cells of the culm epidermis rhomboidal with straight to sinuous walls, papillae in small groups. Stomata overarched by papillae, diverging microhairs. Cortex homogeneous, thin-walled, peripheral vascular bundles reduced, in transitional vascular bundles both the caps and sheaths fused, central vascular bundles all with the four fibre groups, lining of the cavity sclerenchymatous in patches (Pattanath and Rao, 1969).

The fibre length of the culm is variable in this species within a culm is as follows in mm. Bottom 2.1, one-fourth height 1.9, middle height 1.9, three-fourth height 2.0. Fibre length 2.48 mm, fibre diameter. 16.46 µm, lumen diameter 6.48 µm, wall thickness 4.57 µm parenchyma 17.7per cent (Singh and Bhola, 1978). Study on fine structure of fibres showed

polylamellate nature. Narrow lamellae alternate with broader ones. The microfibrillar orientation in broad and narrow lamellae is criss-cross. Narrow lamellae possess high lignin and xylan (Parameswaran and Liese, 1976).

CHEMISTRY

Beating characteristics of the species have shown presence of caustic soda 20 per cent. kappa no.28.2, lignin in bamboo 24.9 per cent, lignin in pulp 4.3 per cent, pentosans in bamboo 18.4 per cent, pentosans in pulp 15.9 per cent, pulp yield- unscreened 54.5 per cent, screened 52.8 per cent. (Singh and Bhola, 1978).

SILVICULTURE AND MANAGEMENT

Observations on flowered areas in Katha Division showed abundant natural regeneration (Blanford, 1918). This can be propagated by seed, rhizome and culm cuttings. A spacing of 8 x 8 m is recommended for plantations. Application of fertilizer promotes clump and culm production.

PESTS AND DISEASES

This species is found susceptible to hispine beetle (*Estigmene chinensis*), leaf roller (*Pyrausta bambusivora*) and defoliator (*Pyrausta coclesalis*).

USES

The culms of this species are beautiful and are largely used for building, mat and basket making. In Myanmar culm with a node is used as a container for making rice mould which can conveniently be carried while traveling. It is good for paper pulp; split culms are used as fishing rods. It is a commendable species for landscaping and the best species of lacquerware.

Schizostachyum polymorphum

Schizostachyum polymorphum (Munro) Majumdar in Karthi-keyan et al., Fl. Ind. Enum. Monocot. 282. 1989; Tewari, Monogr. Bamboo 145. 1992. **(Fig. 89).**

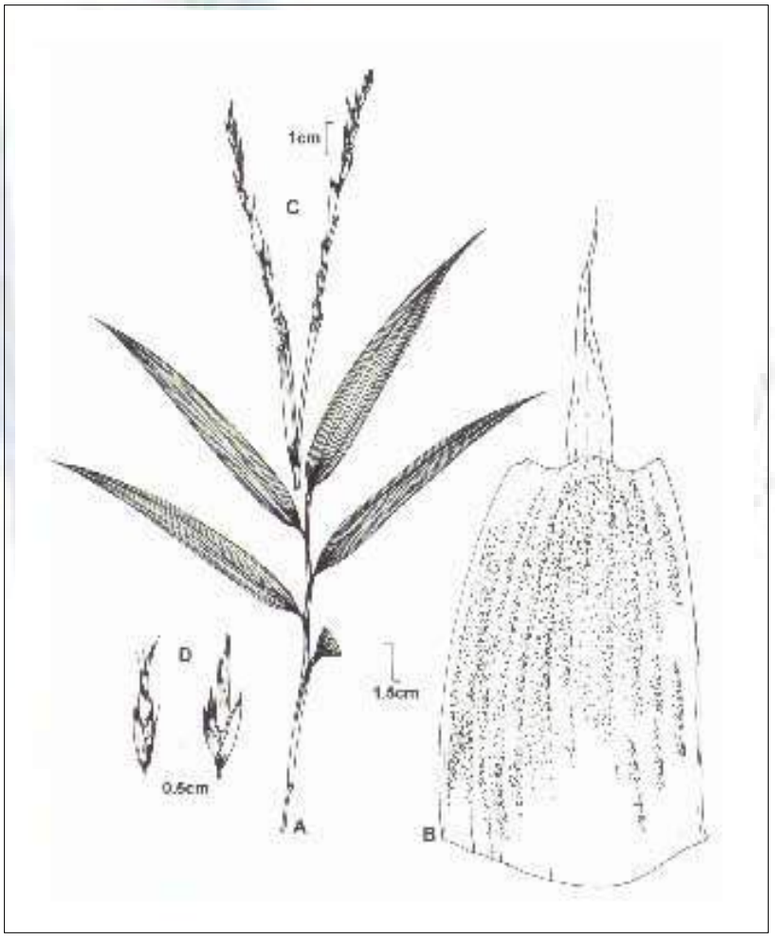
Pseudostachyum polymorphum Munro, Trans. Linn. Soc. London 26: 142, t.4. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 96. 1896 and in Hook. f., Fl. Brit. India 7: 409. 1897; Camus, Les Bambusees 161. 1913; Bor in Kanjilal, Fl. Assam. 5: 13. 1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 4. 1980.

VERNACULAR NAMES

Assam - *Bajal, Nal, Tolli*; Garo Hills - *Wachall*; Lepcha - *Purphiok, Paphak.*

DESCRIPTION

Bamboo with single culm from a long creeping, jointed rhizome Culms 15-20 m tall, thick walled, 3-3.5 cm diameter; internodes 20-23 cm long, glaucous in the beginning, afterwards dark green. Culm-sheaths smaller than the internodes,



◄*Fig. 89.* **S. polymorphum.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - a portion of flowering branch; E - spikelet; F - empty glume; G - flowering glume; H - palea; I - pistil; J - pistil and lodicules; K - stamen.*

triangular, truncate, auricled with a tuft of short bristles; imperfect blade long acuminate on the young culms, striate and furnished with purplish transverse nerves; ligule short, narrowly dentate. Leaves 10-20 cm long and 2.5-6 cm broad, oblong-lanceolate, unequally rounded at the base into a short petiole, attenuate at the top into a long twisted point, smooth on both surfaces, scabrid on one margin; sheaths faintly white, pubescent, glabrescent; ligule short. Inflorescence a very large leafy panicle, compound branches fascicled at the nodes, pendulous or curved. Spikelets 5 mm long, with 1 fertile floret. Glume one, broad mucronate, 7-nerved; lemma similar to the glume, ciliate above; palea thin convolute, 2-keeled, ciliate on the keels. Lodicules 3-5, usually 4, truncate at the apex, persistent; stamens 6, free; filaments short with apiculate anthers. Ovary linear-oblong, ending in a rigid style with 2 hairy stigmas. Caryopsis globose-depressed, surmounted by the base of the style; pericarp crustaceous.

Chromosome number 2n = 48, tetraploid (Sobita Devi and Sharma, 1993).

FLOWERING AND FRUITING

This species flowers frequently and has been reported from Sikkim during the year 1857. Mohan Ram and Hari Gopal (1981) reported its sporadic flowering in the state of Mizoram during 1978-79. They believed that the non-availability or insufficiency of pollen for cross pollination resulted in poor seed production in this species. The flowers were found very often diseased. Flowering was reported from Namsai-Chouken area of Lohit District in Arunachal Pradesh during 1991 but no fruiting could be seen (Haridasan, 1991). Flowering of the bamboo results in the death of the entire clump.

Embryological studies show that the embryo is ovate, embryo sac and endosperm development is similar to that of *Dendrocalamus* and *Bambusa*. Fruit development beyond the stage of globular embryo showed that integument and nucellus had already degenerated leaving behind a thick mat of disintegrated cells around the embryo and endosperm. The cells of the outer epidermis and two or three layers below this zone are large and have abundant starch.

The amount of starch is less in the adjacent four to six layers, but is abundant in the innermost two to four layers and the inner epidermis. All the cell layers on the hilum side have abundant starch grains. During maturation of the embryo, those cell layers that have low amount of starch collapse and leave behind their remnants. Consequently the thickness of the fruit wall decreases. Embryo tegmium is not clear (Hari Gopal and Mohan Ram, 1987).

DISTRIBUTION AND ECOLOGY

This species is found distributed in North Bengal, Sikkim, Arunachal Pradesh, Assam, Mizoram, Nagaland, Manipur and Meghalaya upto 1000 m in India. It is also found in Nepal, Bhutan and Myanmar. It occurs predominantly near water sheds and valleys where the climate is cool, moist and shady.

USES

In Sikkim and Assam, it is used largely for basket and mat making. The culms can be easily split and are flexible. It is used as a monsoon belt below 2000 m in Sikkim Himalayas.

Schizostachyum rogersii

Schizostachyum rogersii Brandis, Indian Trees 679. 1911; Camus, Les Bambusees 178. 1913; Parkinson, For. Fl. Andaman Island 272. 1923; Blatter, Indian For. 55: 603. 1929; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980; Tewari, Monogr. Bamboo 147. 1992.

DESCRIPTION

Culms tufted, weak, up to 9 m high and 1.9 cm diameter, overarching or supported by trees, walls thin. **Culm-sheaths** much shorter than the internodes, thin, 7.6-10 cm long, hairs very fugaceous, base 5-6.3 cm broad, tapering to 2 cm, with 2 small auricles at the apex; blade narrow, reflexed, as long as the sheath. **Leaves** 18-23 cm long and 2.5-3.8 cm broad, long fine hairs on the underside, transverse veins prominent, oblique and bent. Inflorescence a long spike terminating leafy branchlets with distant half whorls of spikelets supported by bracts which are often furnished with a blade. Spikelets 1-flowered, glabrous, the fertile 1.2 cm long, the sterile shorter. Empty glumes 2-4; palea convolute, minutely 2-dentate, keels distinct. Lodicules 3, unequal. Anthers yellow, obtuse, 4 mm long. Ovary glabrous; style thick, cylindric, hollow, terminated by 3 long plumose stigmas. **Caryopsis** ellipsoid-cylindric, crowned by the long persistent style.

DISTRIBUTION

This species is known to be endemic to Andamans.

USES

The culms are used for making arrows and blowpipes.

Schizostachyum seshagirianum

Schizostachyum seshagirianum Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot 282. 1989; Tewari, Monogr. Bamboo 148. 1992.

DESCRIPTION

Scandent, shrubby bamboo with tufted branches. Culms-sheaths tubular, crustaceous; blade long, inflated at base, thick, leathery.

DISTRIBUTION

The species is found distributed in Arunachal Pradesh.

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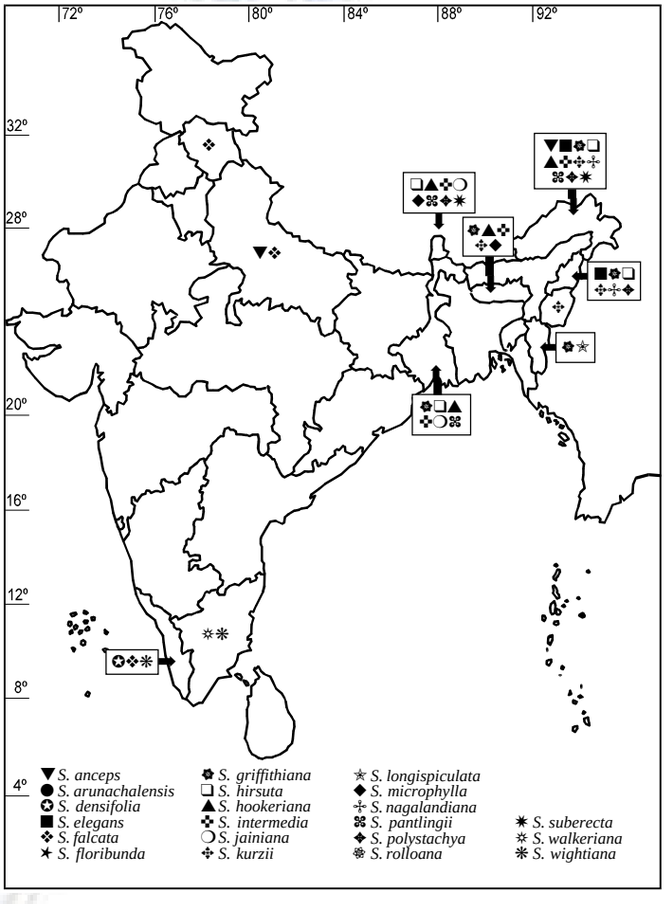
SINARUNDINARIA NAKAI

Culms arising from sympodial rhizomes or long or short necks, the absence of a dominant branch, 3 to many branch complements, culm-sheath persistent or late deciduous; inflorescence a panicle or a raceme supported by small sheaths, spikelets stalked.

Chao and Renvoize (1989) proposed that the genus *Chimonocalamus* Hsuch and Yi should be treated as a section of *Sinarundinaria* Nakai due to the similarities in the inflorescence type, the structure of spikelet, floret and rhizome type. It differs only in the culm nodes, which have root thorns. Munro (1868) divided the genus *Arundinaria* into the section designated I & II, but did not name them. Gamble (1896) also adopted Munro's section in the monograph but did not name them either. Keng (1983) erected a new genus *Drepanostachyum* recognizing Munro's Section II. After examining a large number of specimens, Chao and Renvoize (1989) could not justify recognition of a separate genus or section and merged the genus *Drepanostachyum* under *Sinarundinaria*. Based on their studies, the Indian species of the genera, *Arundinaria, Chimonobambusa, Drepanostachyum, Indocalamus, Semiarundinaria* and *Sinobambusa* are all included under *Sinarundinaria*. Chao and Renvoize (1989) suggested approximately 50 species in the world, 2 in Central America, 3 in Africa and Madagascar, the rest in Asia. In this compendium, 21 species of this genus have been described. Among these, 2 new combinations have been proposed.



◄*Distribution map of* **Sinarundinaria**

Sinarundinaria anceps

Sinarundinaria anceps (Mitf.) Chao & Renv. Kew Bull. 44: 359. 1989. **(Fig. 90).**

Arundinaria anceps Freeman Mitford, Bamboo Garden 181. 1896; Camus, Les Bambusees 33. 1913; Blatter, Indian For. 55: 548. 1929, *Arundinaria jaunsarensis* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 23. 1896 and in Hook. f., Fl. Brit. India 7: 384. 1897; Camus, Les Bambusees 50. 1913; *Chimonobambusa jaunsarensis* (Gamble) Bahadur and Naithani, Indian J. For. 1: 40. 1978; Bahadur and Jain, Indian J. For. 4: 283. 1981; Tewari, Monogr. Bamboo 56. 1992. *Yushania jaunsarensis* (Gamble) Yi, J. Bamboo Res. 5(1): 8. 1986.

VERNACULAR NAMES

Jaunsar - *Ningal, Ringal*: Garhwal - *Jumra, Gyons, Sarura, Sarurha*.

DESCRIPTION

Reed-like plants, non clump-forming, with single culm at intervals; rhizome long and creeping, 0.7 cm diameter. **Culms** ca. 4.5 m high, bright glaucous green when young, greenish brown when old; internode ca. 28 cm long, glabrous, striate; node marked by a narrow ring; branchlets usually 3, semiverticillate. **Culm-sheaths** ca. 15 cm long and 5 cm broad, striate, straw-coloured, papery, ciliate on the edges, narrowed to a truncate apex; auricles narrow, falcate, with long hairy bristles; imperfect blade 2.5-6 cm long, narrow, subulate, recurved; ligule short, pubescent. **Leaves** ca. 15 cm long and 1.8 cm broad, linear-lanceolate, thin, unequally attenuate at the base into a very short petiole, acuminate at the tip, rough beneath, margin serrate; mid-rib hardly prominent; secondary veins 3-5 pairs; intermediate 7-8; transverse veinlets prominent, numerous; leaf-sheath smooth, striate, keeled, loose, glabrous, ending in a falcate auricle with few stiff long bristles; ligule white, short, truncate, pubescent. **Inflorescence** in axillary recemose panicles; rachis smooth, long, green; spikelet ca. 4.5 cm long, 6-10-flowered, the upper floret imperfect; rachilla ca. 5 mm long, clavate, yellowish hairy; empty glumes ovate, acute, thin, tessellate, yellow, tip ciliate, outer glume ca. 4 mm long and 1.7 mm broad and 3-nerved, inner glume ca. 6 mm long and 2 mm broad and 5-nerved; lemma ca. 8 mm long and 3.5 mm broad ovate, acute, thin, tessellate, ciliate at the tip and upper margins; palea ca. 8 mm long, 2-keeled, ciliate on the keels, 2-nerved on either side of the keels, tip bifid and ciliate; lodicules 3, ovate, acute, fimbriate, 5-9-nerved, yellow, one is narrower and longer than the other two. Stamens 3; anther ca. 2.5 mm long, apiculate, basifixed; filament ca. 5 mm long. Ovary ca. 2 mm long, linear-oblong, glabrous, reddish-yellow; styles with long plumose stigma. **Caryopsis** ca. 4 mm, linear, trigonous, reddish-brown with persistent base of styles.

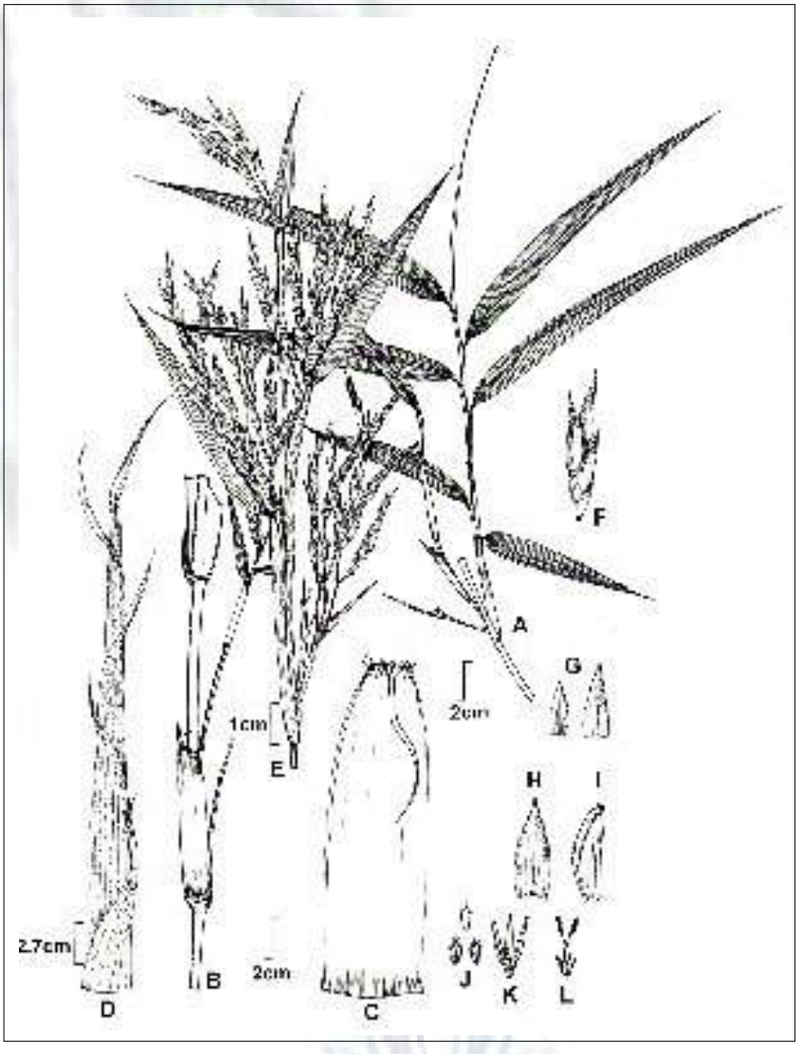
Chromosome number 2n = 48 (Janaki Ammal, 1959).

FLOWERING

Flowering of this species has been reported during 1861-1865. Later during 1978, it was also found in flower from Chamoli District of Uttar Pradesh. The species is known to have a flowering cycle of 45-55 years.

DISTRIBUTION AND ECOLOGY

Distributed in North-West and Central Himalaya from Jaunsar, near Chakrata through Chamoli in Garhwal to the source of Pindar River in Kumaon between 1800-3300 m. Cultivated in United Kingdom and Ireland. There are two



◄*Fig. 90.* **S. anceps.** *A - leafy branch; B - culm with branches; C - culm-sheath; D - young shoot; E - flowering branch; F - spikelet; G - empty glumes; H - lemma; I - palea; J - lodicules; K - stamen; L - pistil.*

clones: one growing to a height of 4 m and the other to 10 m. The dwarf clones grow in south-facing slopes of Himalaya at a lower altitude and the large one in north-facing slopes at a higher altitude. The top canopy and understory tree species associated with this species are *Quercus dilatata, Abies pindrow, Aesculas indica* and *Symplocos ramocissima*. The underground shrubs were *Strobilanthes atropurpurens, Phoebe* sp., *Ilex dipyrena, Rosa macrophylla* and *Vitis himalayana* (Prasad et al., 1989).

SILVICULTURE

The average densities of culm population per ha was found to be 1330. The ratio of 'new culms' to 'old culms' defined as growth index varied from 0.20 to 0.95 with a mean of 0.37. A well-managed plantation of smaller clone will yield about 2 tons/ha/yr. and bigger clone about 6 tons/ha/yr. (Prasad, et al., 1989).

USES

The split culms are used for making mats and baskets. This species is a potential raw material for pulp and paper.

Sinarundinaria arunachalensis

Sinarundinaria arunachalensis Naithani, Indian For. 117: 78. 1991.

Chimonocalamus longispiculatus Majumdar in Karthikeyan et al., Fl. Ind. Enum. Monocot.276. 1989.

DESCRIPTION

Plants unarmed. **Leaves** with setaceous apices. Spikelets green, many-flowered in terminal panicles.

DISTRIBUTION

This species has been reported from Subansiri District, Arunachal Pradesh.

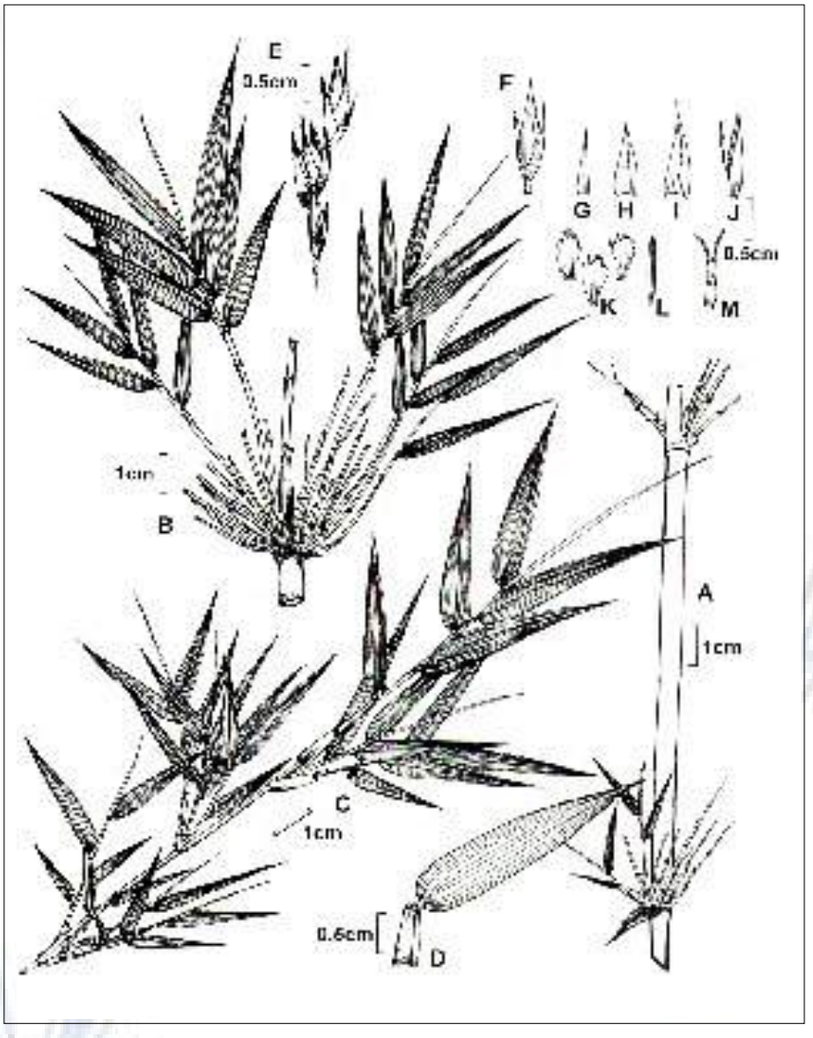
Sinarundinaria densifolia

Sinarundinaria densifolia (Munro) Chao & Renv. Kew Bull. 44: 354. 1989. **(Fig. 91).**

Arundinaria densifolia Munro, Trans. Linn. Soc. London 26: 32. 1868. Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 8. 1896 and Hook f., Fl. Brit. India 7: 379. 1897; Camus, Les Bambusees 31. 1913; Blatter, J. Bombay Nat. Hist. Soc. 33: 900. 1930. *Chimonobambusa densifolia* (Munro) Nakai, J. Arn. Arb. 6: 151. 1925; Bahadur, Indian J. For. 2: 240. 1979; Varmah and Bahadur, Indian For. Rec. 6(1): 2. 1980; Varmah and Pant, Indian For. 107: 672. 1982. Bahadur and Jain, Indian J. For. 4: 283. 1981; Tewari, Monogr. Bamboo, 55. 1992.

DESCRIPTION

Shrubby plants; rhizome thick, covered with imbricating scales. **Culms** ca. 0.9 m high, smooth; internodes ca. 7.5 cm long, walls thick; nodes prominent, with 2 or 3 branches. **Culm-sheaths** ca. 2.5 cm, striate, hirsute, with small pointed auricles; imperfect blade short, ovate, rounded at base. **Leaves** ca. 3.7 cm long and 0.5 cm broad, subsessile, lanceolate, rounded at the base, tapering upwards and acuminate, edges spinulose-serrate; midrib prominent, shining; secondary veins 2 pairs, inconspicuous; intermediate 4-5; transverse veinlets many forming horizontal narrow rectangles; leaf-sheath striate with whitish stiff hairs, edges ciliate; ligule short, rounded, hairy. **Inflorescence** a dense raceme in leafy branchlets; raceme with 5-6 spikelets; rachis angled, strigosely hairy; spikelet ca. 1 cm long, with 2 empty glumes and 1 fertile and another imperfect flower; rachilla ca. 4 mm long, clavate, hairy; lemma ca. 9 mm long and 3 mm broad, ovate, 7-nerved, tip long mucronate and ciliate, margin scabrous; palea ca. 9 mm with keels which are ciliate, 1-nerved on either side of the keel, tip ciliate and bimucronate; lodicules 3, ovate-obtuse, fimbriate, 3-5-nerved, two ca. 3 mm long and one shorter and narrower than the other two. Stamens 3; anther long, basifixed, tip bifid; filament short. Ovary elliptic, glabrous; style divided to the base with each branch having one plumose stigma.



➤*Fig. 91.* **S. densifolia.** *A - culm with branches; B & C - leafy branches; D - leaf with sheath; E - raceme; F - spikelet; G & H - empty glumes; I - flowering glume; J - palea and imperfect terminal flower; K - lodicules; L - stamen; M - pistil.*

DISTRIBUTION

Restricted in distribution to South India (Anamudi Hills); occasionally found in patches.

ANATOMY

Leaf blade in transverse section V-shaped; asymmetry not evident, margins differ markedly in outline; midrib comprises a single median bundle only; embedded in stereome tissue. Vascular bundle elliptical in shape; phloem tissue adjoins the inner bundle sheath, inner bundle sheath entire, single-layered, cells with uniformly thickened secondary walls. Sclerenchymatous girders associated with all bundles. Chlorenchyma non-radiate, of arm and fusoid cells. Arm cells with prominent invaginations; adaxial cells without conspicuous vertical orientation of the invaginations. Colourless cells absent. Intercostal long cells of abaxial epidermis elongated, with parallel side-walls and vertical end walls; walls thin, slightly sinuous; bulliform cells absent. Stomata shape indistinguishable due to overlapping papillae; two files on either side of the costal zones; stomata alternate with short silica cells along stomatal files. Papillae large, with thick cuticle, present on long cells; four papillae overlap the subsidiary cells. Prickles and hooks absent. Microhairs common

in central intercostal files. Macrohairs absent. Silica bodies large, saddle-shaped along the costal zones; cross-shaped silica body present between the intercostal long cells.

Intercostal long cells of the adaxial epidermis elongated, rectangular with slightly sinuous, slightly thick walls, separated by long and narrow silica cells. Stomata absent. Intercostal short cells long with narrow silica cells. Papillae absent on all cells except the outer tangential walls of the bulliform cells. Prickles, hooks micro and macro hairs absent. silica bodies vertically elongated, saddle-shaped. Intercostal bodies very narrow and long. Costal cells of the costal zones consist of a single row of cells; alternating silica cells and rectangular long cells (Soderstrom and Ellis, 1988).

USES

Not much use has been reported for this species except for fodder.

Sinarundinaria elegans

Sinarundinaria elegans (Kurz.) Chao & Renv., Kew Bull. 44:359. 1989. **(Fig. 92).**

Arundinaria elegans Kurz, J. Asiat.Soc. Bengal 42: 248. 1873; Gamble, Ann. Roy. Bot. Gard. Calcutta 7:6. 1896 and in Hook. f., Fl. Brit. India 7: 378. 1897; Camus, Les Bambusees 29. 1913; Blatter, J. Bombay Nat. Hist. Soc. 33: 900. 1930; *Burmabambusa elegans* (Kurz) Keng, J. Bamboo Res. 1(2): 40. 1982. *Sinobambusa elegans* (Kurz) Nakai, J. Arn. Arb. 6: 152. 1925; Tewari, Monogr. Bamboo. 149.1992.

VERNACULAR NAME

Naga Hills - *Jilli*.

DESCRIPTION

An evergreen shrubby slender, tufted bamboo. **Culms** ca.6 m. high, ca. 0.7 cm diameter, flattened on one side in alternate joints, blackish; internode ca. 22.5 cm long, smooth; nodes prominent, somewhat raised, branchlets 3. **Culm-sheaths** ca.10 cm long and 2.5 cm broad, papery, striate deciduous, covered with stiff hairs on the outer surface, ciliate on the edges, narrowed at the tip into a 0.3 cm broad mouth; auricles bristly on both sides; imperfect blade ca.2 cm long, striate, narrow, subulate edges ciliate; ligule rather broad, finely ciliate. **Leaves** ca.15 cm long and 1.5 cm broad, linear-lanceolate, attenuate at the base into a short petiole, ending above in an acuminate tip, glaucescent beneath with white hairs, margin scabrous; midrib conspicuous; yellow, shining beneath; secondary veins 4 pairs; intermediate 8, transverse veinlets many, raised beneath; leaf sheath striate, glabrous, ending into a minutely ciliate callus; auricles short with few long bristles; ligule very short. **Inflorescence** a terminal panicle or raceme of few pedicellate spikelets on leafy branches, ca.5 cm long; rachis ca.2 cm long, wiry, curved, pubescent; spikelet ca.1.5 cm long, flattened, 6-flowered, the uppermost floret is empty, rachilla ca. 4 mm long, hairy, clavate, yellow; empty glume 2, ovate, acuminate, outer glume ca.2.5 mm long and 3-nerved, inner glume ca.5 mm long and 5-nerved, lemma ca.10 mm long, ovate, long

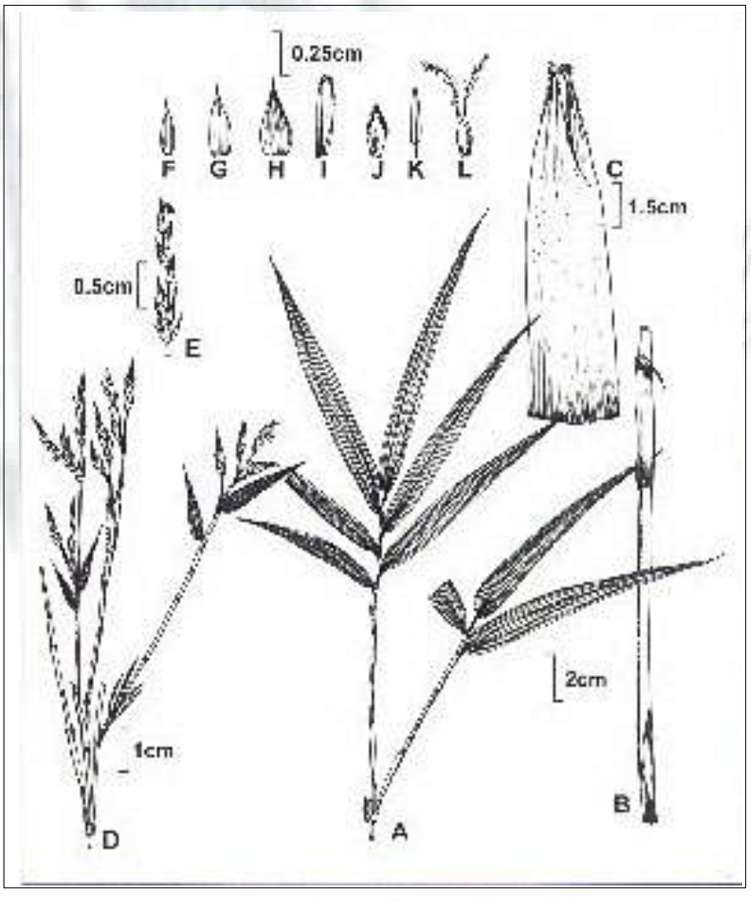


Fig. 92. **S. elegans.** *A - leafy branch; B - culm with culm-sheath; C - culm sheath; D - flowering branches; E - spikelets; F & G - empty glumes; H - flowering glume; I - palea; J - lodicule; K - stamen; L - pistil.*

acuminate, 7-nerved, palea shorter than lemma, 2-keeled, ciliate on the keels, 2-nerved on either side of keel, tip ciliate with 2 clefts; lodicules 3, ca. 1.5 mm long, ovate, fimbriate, 3-nerved, one is narrower than the other two and obtuse, others ovate and acute. Stamens 3, hardly exserted; anther ca.5 mm long, purple, basifixed, tip rounded. Ovary ca.1.5 mm long, oblong, glabrous, yellow, style divided at the base and each having one plumose stigma.

FLOWERING

The only report of flowering is from Naga Hills in 1937.

DISTRIBUTION

This species is found distributed in Arunachal Pradesh, Nagaland of North-Eastern India. Also known to occur in China and Myanmar and considered rare and highly threatened (Bahadur and Jain, 1981).

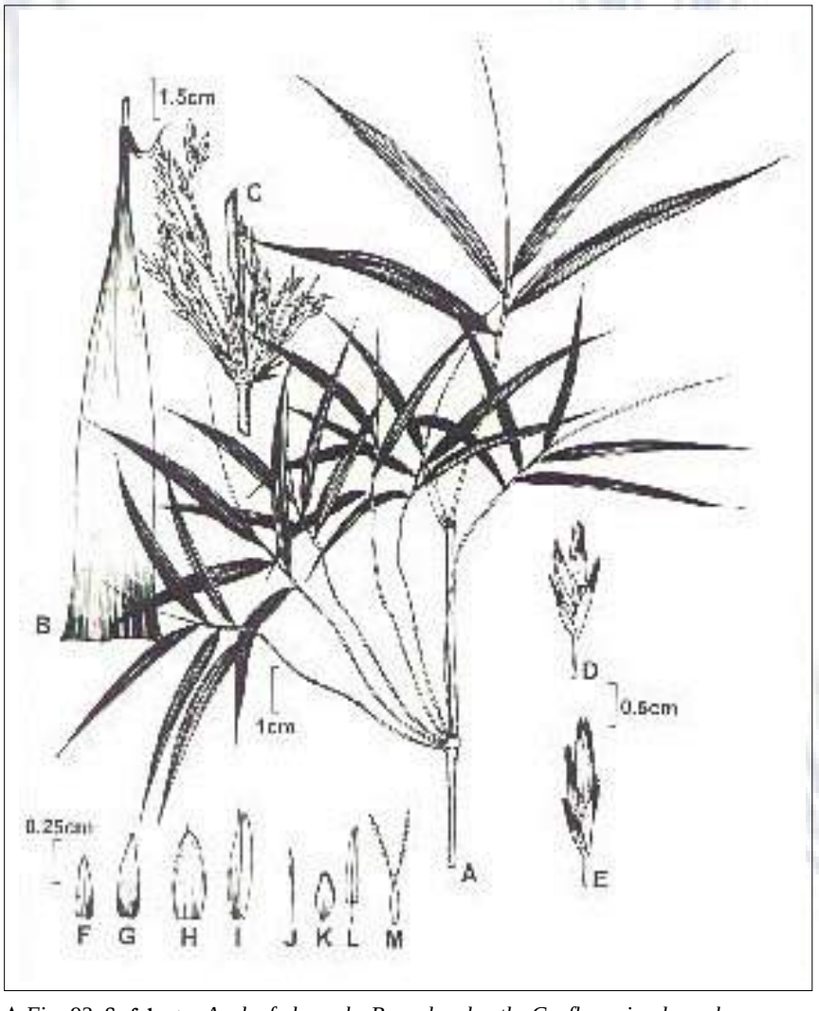
USES

Culms are used for strengthening the mud walls of native huts. In Naga hills, the young shoots are used for making pickles. Shoots are also used as vegetables and food.

Sinarundinaria falcata

Sinarundinaria falcata (Nees) Chao & Renv. Kew Bull. 44: 357. 1989. **(Fig. 93).**

Arundinaria falcata Nees, Linnaea 9: 478. 1834; Munro, Trans. Linn. Soc. London 26: 26. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 12-13. 1896 and in Hook. f., Fl. Brit. India 7: 381. 1897; Bean, Kew Bull. No.6: 229-230. 1907; Camus, Les Bambusees 37. 1913; Gamble, Kew Bull. No.8: 302-306, 1921; *Arundinaria falcata* var. *glomerata* Gamble in Ann. Roy. Bot. Gard. Calcutta 7.13, Pl.12. 1896. *Arundinaria utilis* Cleghorn, J. Agri. Soc. India 13: 368. 1865; *Arundinaria interupta* Trin., Mem. Acad. Petersb. 6(3): 620. 1835; *Chimonobambusa falcata* (Nees) Nakai, J. Arn. Arb. 6: 148. 1925; Blatter, J. Bombay Nat. Hist. Soc. 33: 900. 1930. Varmah and Bahadur, Indian For. Rec. 6(1): 2. 1980; Varmah and Pant, Indian For. 107: 671. 1981. *Drepanostachyum falcatum* (Nees) Keng. f. J. Bamboo Res. 2(1): 17. 1983. Tewari, Monogr. Bamboo 83.1992. *Drepanostachyum khasianum* (Munro) Keng. f. J. Bamboo Res. 18. 1983. *Ludolfia falcata* Nees ex Munro, Trans. Linn. Soc. 26:26. 1868.



▲ *Fig. 93.* **S. falcata.** *A - leafy branch; B - culm-sheath; C - flowering branch; D & E - spikelets; F & G - empty glumes; H - flowering glume; I - palea; J - rudimentary flower on terminal rachilla; K - lodicule; L - stamen; M - pistil.*

DESCRIPTION

Shrubby bamboo. **Culms** ca.4.5 m high, ca.1 cm diameter, smooth, cylindrical, green with white scurf when young; internode ca. 15 cm long, thin, scabrous; node swollen, hairs present below the cup-like structure formed by the base of the fallen sheath; culm branches numerous, densely fasciculate.

Culm-sheaths 17-30 cm long and 3-7 cm broad, papery, striate, straw-coloured, glabrous on the outer surface, hairy on inner surface in the upper half only, ciliate on the upper edges, narrowed towards the apex into a 0.3 cm broad ciliate mouth; imperfect blade ca. 4 cm long (1 cm long in young culms), narrow, striate, acute subulate, recurved; ligule ca. 1.2 cm long, elongate, dentate. **Leaves** ca.8 cm long and 0.5 cm broad (much longer and broader in young shoots), linear-lanceolate, attenuate at the base into a ca.2 mm long petiole, tapering above into an acuminate tip with setaceous point, margin serrate, ventral surface with few white hairs towards the petiole, glabrous on the edges; midrib prominent; secondary vein 4 pairs; intermediate 6, transverse veinlets inconspicuous; leaf-sheath long, striate, yellow, usually glabrous, ending into a ciliate callus, edges ciliate; ligule long, dentate, membranous. **Inflorescence** usually on separate leafless branches; spikelets ca. 1.5 cm long, 2(1)-flowered with a terminal rudimentary flower, yellow or sometimes purple; rachilla ca.5 mm long, clavate, ciliate; empty glumes 2, chartaceous, ovate, tip acute, ciliate, outer glume ca.7 mm long and 2 mm broad and 3-nerved; inner glume ca.9-nerved, tip mucronate, ciliate; palea as long as the lemma, 2-keeled, glabrous on keels, tip bimucronate, ciliate; lodicule 3, ovate, fimbriate, one ca.1.5 mm long and 3-veined, the other two ca. 2 mm long and 5-veined. Stamens 3; anther ca. 5 mm long, bilocular, obtuse, basifixed; filament ca. 2 mm long. Ovary linear-oblong, glabrous; style divided upto base, each having one plumose stigma. **Caryopsis** ca. 5.5 mm long, linear, slightly trigonous, furrowed, brown coloured having persistent base of styles.

FLOWERING

This species is reported to have both gregarious and sporadic flowering. Flowering has been reported from Simla during 1858, 1916; Mussoori 1916; Jaunsar in 1868, 1916 and Tehri Garhwal in 1916. This species appears to have a flowering cycle of 48-58 years.

DISTRIBUTION AND ECOLOGY

S. falcata is distributed in North-West Himachal Pradesh (Simla); Uttar Pradesh (Kumaon and Garhwal Hills) at an altitudinal range from 1200 m to 2550 m. The top canopy and understory tree species associated with *S. falcatum* (*A. falcata*) were found to be *Quercus leucotrichophora, Q. glauea, Daphniphyllum himalayense, Rhododendron arboreum, Alnus nepalensis, Hyonia ovalifolia, Machilus odoratissima, Litsea umbrosa* and *Eurya acuminata*. Shrub layer consisted of saplings of the above species and *Daphic cannabina*, *Reinwardtia* sp. *Hedychium spicatum*, ferns such as *Polystychium acuminatum* and *Pteris* sp. (Prasad et al., 1989).

FIBRE CHARACTERISTICS

Maceration studies have shown that the species has a fibre length of 1.01 mm, diameter11 µm.

CHEMISTRY

Proximate chemical analysis showed ash 3.6 per cent, solubility in cold water 4.55 per cent, in hot water 5.9 per cent, in alcohol benzene 4.43 per cent, in 1 per cent NaOH 21.5 per cent. Cellulose 51.6 per cent, lignin 27.85 per cent and pentosan 21.5 per cent (Guha et al., 1966).

USES

Culms are used for basket-making, hookah pipes and fishing rods.

Sinarundinaria floribunda

Sinarundinaria floribunda (Thwaites) Chao & Renv. Kew Bull. 44: 356.1989. **(Fig. 94).**

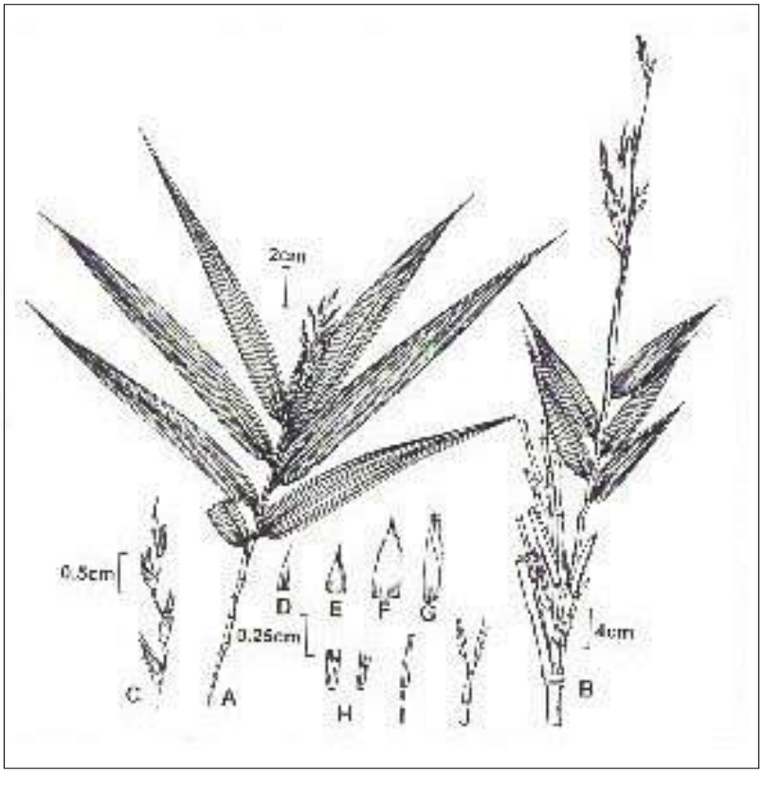
Arundinaria floribunda Thwaites, Enum Pl. Zeyl. 475. 1864; Munro, Trans. Linn. Soc. London 26:20. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7:5. 1896 and in Hook f., Fl. Brit. India 7: 377. 1897; Camus, Les Bambusees 28. 1913; Ram Rao, Fl. Pl. Travancore 446. 1914. *Indocalamus floribundus* (Thwaites) Nakai J. Arn. Arb. 6: 148. 1925; Tewari, Monogr. Bamboo 101.1992.

DESCRIPTION

Erect, shrubby bamboo. **Culms** ca. 1.5 cm high; internode ca. 9 cm long, covered with hairs, nodes swollen. **Leaves** ca. 20 cm long and 1.8 cm broad lanceolate, narrowed towards the base into a glandular short petiole, ending above into long acuminate tip, serrated on the edges; leaf sheath striate, covered with hairs ending into a callus; auricles short and furnished with bristles on the margin; ligule short, fimbriate. **Inflorescence** large, terminal in leafy branches. Spikelet ca. 2.5 cm long, minutely silky pubescent, 8-flowered and the uppermost sterile; rachilla ca. 4 mm long, clavate hairy; empty glumes 2, ovate acute, ciliate at the apex and on the edges, outer ca.4 mm long and 1.5 mm broad, and 3-nerved; inner ca. 5 mm long and 2 mm broad and 5-nerved; lemma ca. 8 mm long and 3 mm broad, ovate acuminate, ciliate at the apex, 7-nerved. Palea as long as lemma, 2-keeled, ciliate on the keels, bicuspidate; lodicules 3, two broad and long, third one small and narrow, ovate obtuse, fimbriate; stamens 3, long, basifixed, brown, blunt, filament short. Ovary ovoid, glabrous, style divided with 2 stigmas. **Caryopsis** 0.5 cm long, red, linear, crowned with the base of the bifid style.

DISTRIBUTION

The species is reported from Sri Lanka and is also found distributed in the Western Ghats region of Kerala (Rao, 1914).



➤*Fig. 94.* **S. floribunda.** *A & B - leafy branch with young flowering panicle; C - spikelets; D & E - empty glumes; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil.*

Sinarundinaria floribunda

Sinarundinaria floribunda (Thwaites) Chao & Renv. Kew Bull. 44: 356.1989. **(Fig. 94).**

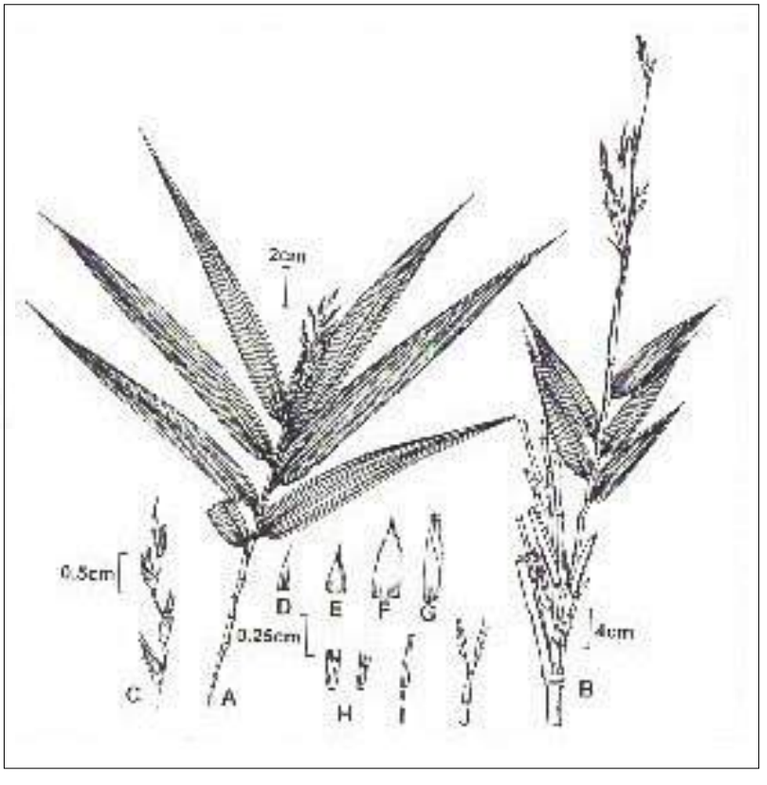
Arundinaria floribunda Thwaites, Enum Pl. Zeyl. 475. 1864; Munro, Trans. Linn. Soc. London 26:20. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7:5. 1896 and in Hook f., Fl. Brit. India 7: 377. 1897; Camus, Les Bambusees 28. 1913; Ram Rao, Fl. Pl. Travancore 446. 1914. *Indocalamus floribundus* (Thwaites) Nakai J. Arn. Arb. 6: 148. 1925; Tewari, Monogr. Bamboo 101.1992.

DESCRIPTION

Erect, shrubby bamboo. **Culms** ca. 1.5 cm high; internode ca. 9 cm long, covered with hairs, nodes swollen. **Leaves** ca. 20 cm long and 1.8 cm broad lanceolate, narrowed towards the base into a glandular short petiole, ending above into long acuminate tip, serrated on the edges; leaf sheath striate, covered with hairs ending into a callus; auricles short and furnished with bristles on the margin; ligule short, fimbriate. **Inflorescence** large, terminal in leafy branches. Spikelet ca. 2.5 cm long, minutely silky pubescent, 8-flowered and the uppermost sterile; rachilla ca. 4 mm long, clavate hairy; empty glumes 2, ovate acute, ciliate at the apex and on the edges, outer ca.4 mm long and 1.5 mm broad, and 3-nerved; inner ca. 5 mm long and 2 mm broad and 5-nerved; lemma ca. 8 mm long and 3 mm broad, ovate acuminate, ciliate at the apex, 7-nerved. Palea as long as lemma, 2-keeled, ciliate on the keels, bicuspidate; lodicules 3, two broad and long, third one small and narrow, ovate obtuse, fimbriate; stamens 3, long, basifixed, brown, blunt, filament short. Ovary ovoid, glabrous, style divided with 2 stigmas. **Caryopsis** 0.5 cm long, red, linear, crowned with the base of the bifid style.

DISTRIBUTION

The species is reported from Sri Lanka and is also found distributed in the Western Ghats region of Kerala (Rao, 1914).



➤*Fig. 94.* **S. floribunda.** *A & B - leafy branch with young flowering panicle; C - spikelets; D & E - empty glumes; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil.*

ANATOMY

Leaf blade outline expanded, asymmetrical, ribs and furrows very shallow, furrows present above all bulliform cell groups; slight ribs present on one side of midrib and near margin on same side. Midrib abaxially projecting, broadly 'S' shaped, asymmetrical structure, all vascular bundles embedded in sclerenchyma fibres. Intercostal long cells of abaxial epidermis elongated, rectangular, side walls parallel, unthickened and sinuous; cell shape differs across intercostal zone. No bulliform cells. Short cell pairs, stomata, microhairs or prickles separate successive long cells. Stomata low dome-shaped, flange-like papillate outgrowths from the subsidiary cells conceal guard cells, three rows of stomata on either side of each costal zone. Short cells paired in central files; silica cell tall and narrow and cork cell square to tall and narrow, present between all long cells in the central files except where hooks or microhairs emerge. Small hooks present. Microhairs elongated, finger-like, present on the central intercostal files and immediately adjacent to the costal files. Macrohairs absent. In adaxial epidermis, intercostal long cells elongate, rectangular with very slightly sinuous walls; separated by short cell, central four files of each zone consist of shorter, angular bulliform cells arranged in an interlocking manner; stomata, papillae, prickles and microhairs absent (Soderstrom and Ellis, 1988).

USES

The culms of the species are used for making roofs, fencing and agricultural implements.

Sinarundinaria griffithiana

Sinarundinaria griffithiana (Munro) Chao & Renv. Kew Bull. 44: 353. 1989. **(Fig. 95).**

Arundinaria griffithiana Munro Trans. Linn. Soc. London 26: 20. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 10. 1896 and in Hook. f., Fl. Brit. India 7: 379. 1897; Gamble, Kew Bull. 135. 1912; Camus, Les Bambusees 36. 1913; Blatter, J. Bombay Nat. Hist. Soc. 33. 901. 1930. *Chimonobambusa griffithiana* (Munro) Nakai, J. Arn. Arb. 6: 151. 1925; Bor. in Kanjilal, Fl. Assam 5: 45. 1940; Varmah and Bahadur, Indian For. Rec. 6(1): 2. 1980; Tewari, Monogr. Bamboo 55. 1992.

VERNACULAR NAMES

Khasi and Jaintia - *Khnap, Uspar, Knap, Ukhnap, Usknap.*

DESCRIPTION

Shrubby, erect plants. **Culms** ca. 8 m high, 3 cm diameter, olive green; internodes ca. 14.5 cm, striate, furrowed; nodes prominent, woolly, bearing a circle of conical stout short spines. **Culm-sheaths** 18-30 cm long and 10-12 cm broad, papery, striate, straw-coloured, covered with scattered stiff bulbous-based hairs, ciliate on the edges, convexly attenuate upwards to a 1 cm broad apex with rounded auricles; imperfect blade ca. 2.5 cm long, triangular, acute, hairy; ligule short, hairy. **Leaves** ca. 12.5 cm long and 1.5 cm broad, linear-lanceolate, smooth, apex acuminate with a setaceous point, base attenuate into a 5 mm long petiole; midrib conspicuous, shining, secondary veins 4-5 pairs, intermediate 5,

transverse veinlets many; leaf-sheath striate, glabrous, with few stiff curved bristles; ligule broad, hairy. **Inflorescence** a terminal panicle with sheathing bracts; rachis hairy, flattened on one side; spikelets ca. 3 cm long, narrow, in verticillate clusters on thin wavy scabrous hairy pedicels; 4-6-flowered, uppermost floret empty; rachilla ca. 5 mm long, flattened, hairy, clavate at the top; empty glumes 2, ovate lanceolate, mucronate, scabrous, lemma 5-7, 2-keeled, ciliate on the keels, tip bimucronate; lodicules 3, obovate, faintly nerved, long ciliate, 1 rather shorter than the other two. Stamens 3, anther tip with few white hairs. Ovary linear-oblong, glabrous; style divided to the base with each branch having one plumose stigma.

FLOWERING

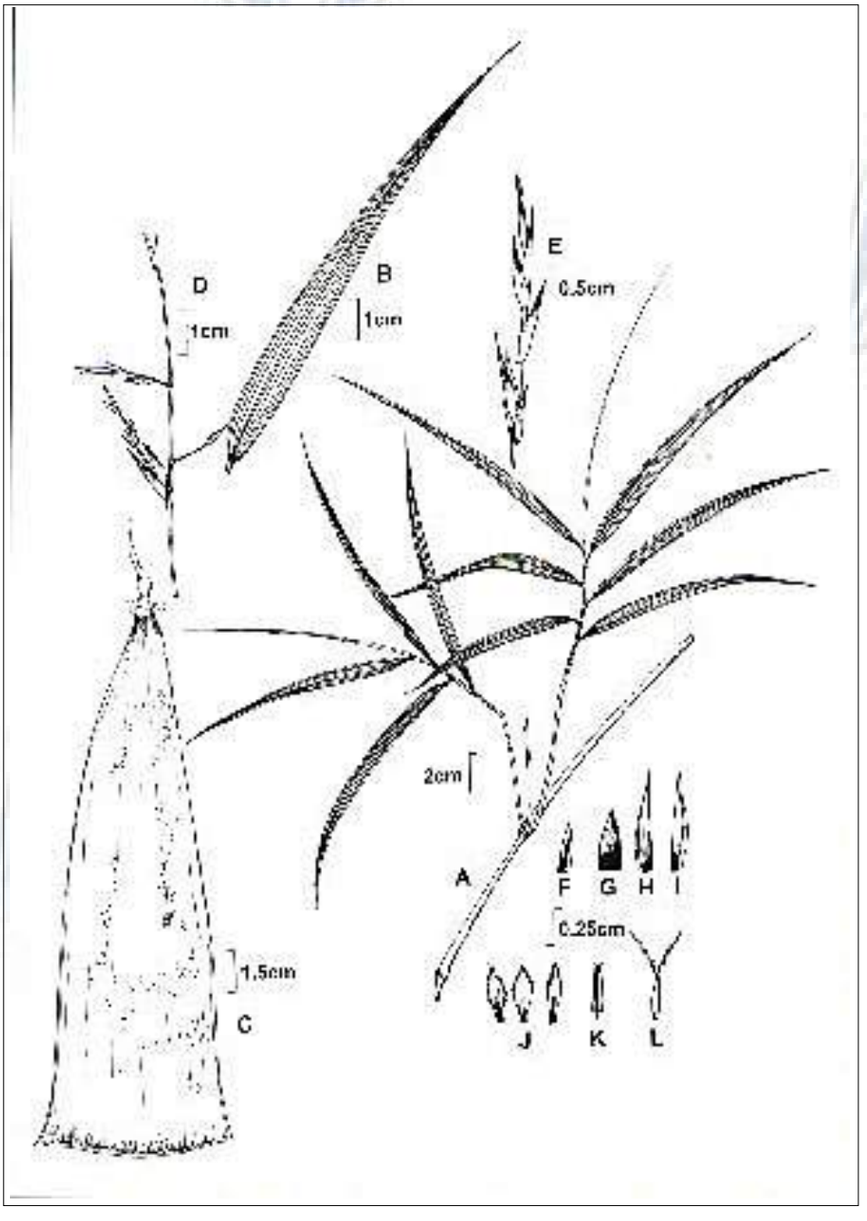
Flowering has been reported from Assam in 1833, Meghalaya in 1894 and Mizoram in 1953.

DISTRIBUTION

This species is distributed in Arunachal Pradesh, Meghalaya, Mizoram, Nagaland and West Bengal at an elevation of 2400-3000 m.

USES

The culms are used for thatching houses.



➤ *Fig. 95.* **S. griffithiana.** *A - leafy branch; B - leaf; C - culm-sheath; D - flowering branch; E - spikelets; F & G - empty glumes; H - flowering glume; I - palea; J - lodicules; K - stamen; L - pistil.*

Sinarundinaria hirsuta

Sinarundinaria hirsuta (Munro) Chao & Renv. Kew Bull. 44: 355. 1989. **(Fig. 96).**

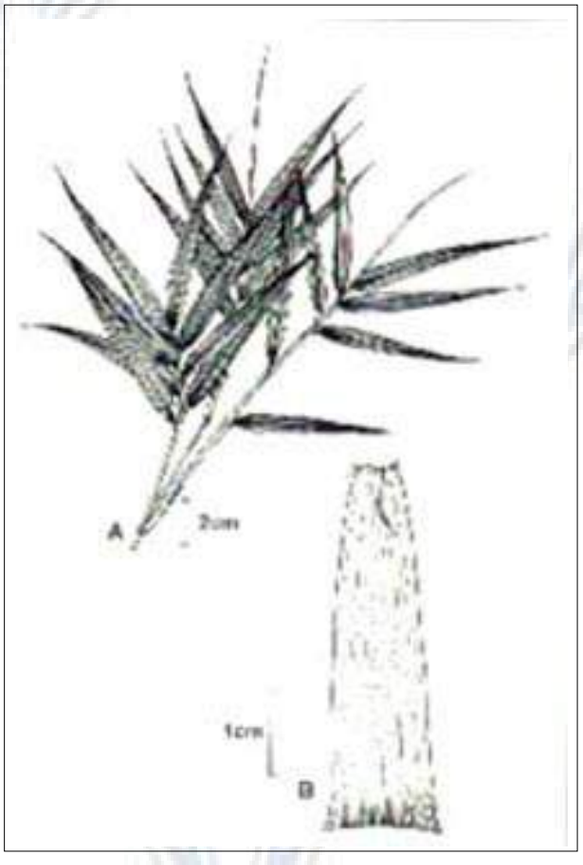
Arundinaria hirsuta Munro, Trans. Linn. Soc. London 26: 30. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 22. 1896, in Hook. f., F1, Brit. India 7: 384. 1897; Camus, Les Bambusees 50. 1913; Bor in Kanjilal, Fl. Assam 5: 40. 1940; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 1. 1980; Tewari, Monogr. Bamboo, 23.1992.

VERNACULAR NAMES

Khasi Hills - *Ustoh, Uskong, Daitsisal*.

DESCRIPTION

Tufted, shrubby bamboo with single stem from the rhizome. **Culms** ca. 2 m high, grayish green; internode ca. 15 cm long, striate, strigosely hirsute, young culms scabrous, node not much swollen, with 1-2 thick branches and a ring of scars of the fallen sheath. **Culm-sheaths** 10-15 cm long and 2.5 cm broad, papery, striate, covered with long brown hairs on the dorsal surface, rounded at the tip and ending in large, recurved, long ciliate auricles; imperfect blade subulate, acuminate, recurved; ligule narrow, pubescent. **Leaves** lamina with a short petiole 2.4 cm long oblong-lanceolate, 7-12 cm long, 1.2 to 1.6 cm broad, base rounded, tip subulate, twisted, smooth above, pale and strigosely white hairy beneath; margins scabrous-serrate, midrib narrow, shining, secondary veins 4-6 pairs, intermediate 7, transverse veinlets numerous, straight, regular and strong; leaf sheaths striate, covered with long shift bristles, ending in rounded, reflexed auricle bearing long, stiff, almost spinescent bristles; ligule elongate, hairy, often dark coloured. **Inflorescence** a panicle, inner glume ca. 9 mm long, 5-nerved; lemma ca. 12 mm long and 4 mm broad, ovate, setaceous, acuminate, striate, 9-nerved, ciliate at the tip; palea ca. 8 mm long, with 2 ciliate keels, 1-nerved on either side of keel, apex bifid; lodicules 3, ca. 2 mm long, ciliate on the margin, 2 are ovate-acute and 5-nerved, third one is ovate-obtuse and 1-nerved. Stamens 3, free; anther basifixed, tip bifid, blunt; filament very short, delicate, twisted. Ovary ca. 1.5 mm long, oblong ovoid, hairy at the base; Style undivided. Stigma 3, Plumose. **Caryopsis** ca. 3 mm long, oblong, dorsally furrowed with persistent base of style.



▲ *Fig. 96.* **S. hirsuta.** *A - leafy branch; B - culm-sheath.*

FLOWERING

Flowering is recorded from Sikkim in 1837, 1899, 1927 and 1956; from Darjeeling in 1904, 1950-51, and 1960. The flowering cycle appears to vary from 28 to 48 years.

DISTRIBUTION

This species is widely distributed in Naga Hills and Khasi Hills at an elevation of 1600-3000 m. Also reported from Sikkim, West Bengal and Arunachal Pradesh.

USES

The *maling* bamboo mats are extensively used as roofing material, temporary partition walls, doors and nursery sheds in Darjeeling and Sikkim. The culms are used for fencing and garden supports. Young leaves are good fodder for cattle and pony. Emerging young shoots are edible.

Sinarundinaria hookeriana

Sinarundinaria hookeriana (Munro) Chao & Renv. Kew Bull. 44: 358-359.1989. **(Fig. 97).**

Arundinaria hookeriana Munro, Trans. Linn. Soc. London 26: 29. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 16. 1896 and in Hook. f., Fl. Brit. India 7: 382. 1897 and in Kew Bull. No.3: 135. 1912; Camus, Les Bambusees 39. 1913; *Chimonobambusa hookeriana* (Munro) Nakai, J. Arn. Arb. 6: 151. 1925; Blatter, J. Bombay Nat. Hist. Soc. 33: 901. 1930. Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 2. 1980. *Drepanostachyum hookerianum* (Munro) Keng. f. J. Bamboo. Res. 2(1): 17. 1983; Tewari, Monogr. Bamboo 84.1992.

VERNACULAR NAMES

Lepcha - *Praong, Prong, Praing, Preng, Pareng, Prem*; Nepal- *Singhane, Singhani, Suighani.*

DESCRIPTION

A caespitose bamboo. **Culms** ca. 6 m high, striate, slender, glaucous green with white scurf; internode ca. 25 cm long, 3 cm diameter, fistular with a bluish ring at the top; node not much swollen but prominently ringed with the persistent base of the fallen sheath; branchlets numerous, chiefly from the upper nodes. **Culm-sheaths** 20-50 cm long and 5-16 cm broad, papery, striate, tessellate, straw-coloured, smooth, tapering in the upper half to a truncate point; imperfect blade ca. 8 cm long and 0.5 cm broad, linear, striate; ligule ca.3 mm long, dentate, curved upwards. **Leaves** ca. 23 cm long and 2 cm broad, linear-oblong, lanceolate, glaucous green when young, glabrous beneath except for few white hairs along the midrib at the base, margin scabrous, apex acuminate into a setaceous point, base attenuate into ca. 3 mm long petiole; midrib prominent beneath, shining; secondary veins 4-8 pairs; intermediate veins 5, transverse veinlets inconspicuous; leaf-sheath striate, glabrous, ending into a broad callus, edges ciliate; ligule long. **Inflorescence** a racemose panicle, usually on separate leafless branches or sometimes fascicled at the node, spikelet ca. 1.2 cm long,

➤*Fig. 97.* **S. hookeriana.** *A - leafy branch; B - culm-sheath; C - a portion of culm; D - flowering branch; E & F - spikelets; G & H - empty glumes; I - flowering glume; J - palea; K - stamen; L - pistil.*

pedicellate, 2-flowered, 1 fertile and other imperfect; rachilla scabrous; empty glumes 2, oblong-mucronate, thin, membranous, tip and edges ciliate, midrib prominent; outer glume ca.5 mm long and 1.5 mm broad and 3-nerved, inner glume ca. 6 mm long and 2 mm broad and 5-nerved; lemma ca. 10 mm long and 4 mm broad, broadly ovate, hard with thickened edges, shortly mucronate, ciliate at the tip, 7-nerved; palea equal to lemma or slightly longer, 2-keeled, ciliate on the keels and bifid tip; lodicules 3, thickened at the base, ovate with acute tip, fimbriate, 3-5-nerved, one is narrow and shorter than the other two. Stamens 3; anther sub-acute, basifixed; filament short. Ovary ovoid-oblong, glabrous; style divided and each branch having one short plumose stigma. **Caryopsis** ca.8 mm long, oblong, dark-coloured, smooth, with persistent base of styles.

Chromosome number n=24 (Mehra and Sharma, 1975).

FLOWERING

Flowering has been reported from Sikkim in 1848 and 1885, from West Bengal in 1901, 1902, 1932 and 1963. The flowering cycle is about 30-35 years.

DISTRIBUTION AND ECOLOGY

The species is distributed in the North-East India; Arunachal Pradesh, Meghalaya, Sikkim and West Bengal. Distributed mostly in warm temperate to subtropical zone at an elevation of 650-1600 m. It grows on hill sides often in evergreen Oak forests. Cultivated in various botanical gardens and by farmers in West Bengal.

ANATOMY

Leaf epidermis has short cells in rows of three to five cells in both surfaces. Shape of silica bodies generally *Oryza* type, but intermediate shapes between cross and dumbbell seen in the adaxial (costal) region. Bulliform cells, arm cells, micro hairs, macrohairs and prickles are present. Microhairs panicoid type (Sharma et al., 1986).

USES

In Sikkim, this species is used for fencing, panels, thatching, mats, flag poles, and water pipes. Leaves are used as fodder. Young shoots are edible. The seeds of this species are cooked like rice or used for the preparation of beer (Holstrom, 1993).

Sinarundinaria intermedia

Sinarundinaria intermedia (Munro) Chao & Renv. Kew Bull. 44: 357.1989. **(Fig. 98).**

Arundinaria intermedia Munro, Trans. Linn. Soc. London 26: 30. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 15. 1896, in Hook. f., Fl. Brit. India 7: 381. 1897, Kew Bull. No.3: 135. 1912; Camus, Les Bambusees 39. 1913; Blatter, J. Bombay Nat. Hist. Soc. 33: 902. 1930. *Chimonobambusa intermedia* (Munro) Nakai, J. Arn. Arb. 6: 151. 1925; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 2. 1980. *Drepanostachyum intermedium* (Munro) Keng, J. Bamboo Res. 2(1): 18. 1983; Tewari, Monogr. Bamboo 87.1992.

VERNACULAR NAMES

Lepcha - *Purmiok, Purmiak, Purmak, Permyok, Parmiok, Prongnok, Purmia*; Nepal - *Tite, Titi, Titay, Ningalo, Nigalai, Lushai-Lik.*

DESCRIPTION

A thin caespitose shrubby bamboo. **Culms** ca. 4 m high, ca. 1.2 cm diameter, smooth, grayish green; internode ca. 25 cm long; node swollen with a prominent ring and a whitish line below; branchlets many from the node, fasciculate. **Culm-sheaths** ca. 21 cm long and 4 cm broad, glabrous, papery, strongly striate, broader at the base, tapering to a truncate tip; imperfect blade ca.4 cm long, narrow, subulate, recurved; ligule ca. 5 mm long, blunt. **Leaves** ca. 15 cm long and 1.5 cm broad, linear-lanceolate to oblong-lanceolate, scabrous, attenuate at the base into ca. 5 mm long petiole, acuminate above in a setaceous point; midrib prominent; secondary veins 4 pairs; intermediate veins 6; transverse veinlets inconspicuous; leaf sheath striate, yellowish, hairy; callus ciliolate; auricles with long brownish-yellow bristles; ligule obtuse or triangular. **Inflorescence** a racemose panicle on leafless branches; spikelets ca. 2.5 cm long, yellowish, 3-5-flowered, upper flower imperfect; rachilla clavate, hairy; empty glumes 2, ovate, membranous, ciliate at the tip, outer glume ca. 4 mm long and 1.5 mm broad and 5-nerved, inner glume ca. 7 mm long and 2 mm broad, 7-nerved; lemma 9 mm long and 3 mm broad, ovate, mucronate, scabrous, 9-nerved; palea 2-keeled, lodicule 3, ovate, 3-7 nerved, margin fimbriate. Stamens 3; anthers ca. 3 mm long, basifixed; filaments short. Ovary ca. 1.5 mm long, oblong; style

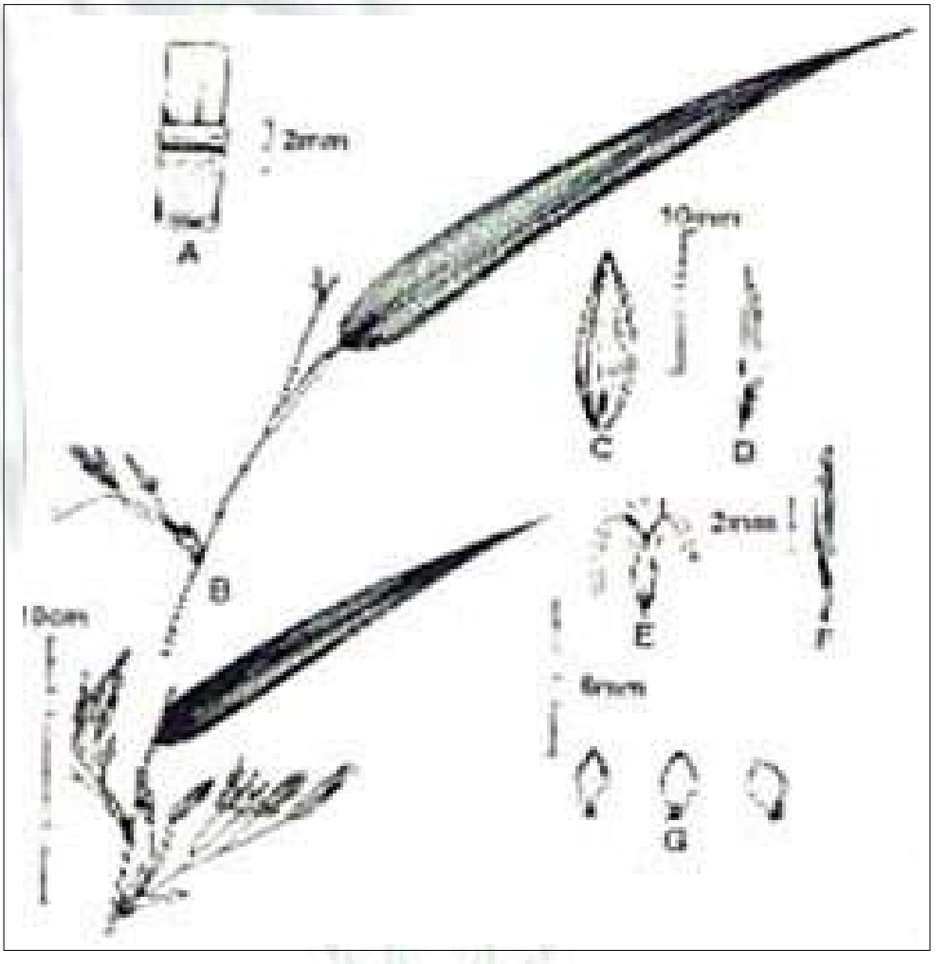


Fig. 98. **S. intermedia.** *A - leafy branch; B - culm with flowering branch; C - culm-sheath; D - spikelet; E & F - empty glumes; G - flowering glume; H - palea; I - lodicule; J - stamen; K - pistil.*

divided and each having one plumose stigma. **Caryopsis** short, oblong, swollen in the middle and furrowed in front, tipped with persistent base of style.

FLOWERING

Flowering has been recorded from Sikkim in 1848, 1868, 1879, 1899 and 1968. The flowering cycle is about 20 years.

DISTRIBUTION AND ECOLOGY

The species is distributed in North-East India; Arunachal Pradesh, Meghalaya, Mizoram, Sikkim and in West Bengal. Distributed mostly in warm temperate to subtropical zone. Grows gregariously as forest undergrowth often in Oak and *Rhododendron* forest. Also cultivated at different places in West Bengal. Found at an elevation of 650-2200 m.

USES

Culms are used for making fishing rods and arrows. Leaves are used for thatching, roofing and basket making. It is an excellent hedge plant. Young shoots are edible.

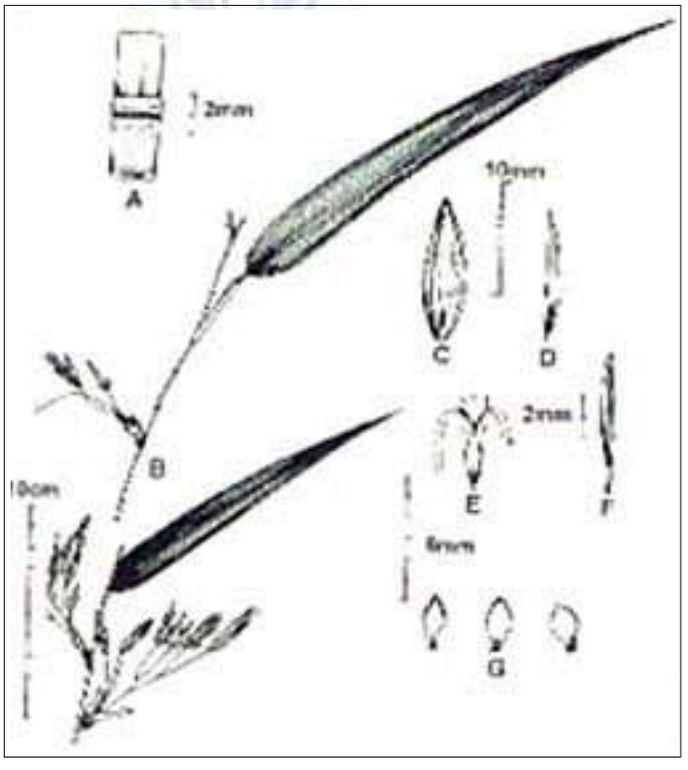
Sinarundinaria jainiana

Sinarundinaria jainiana (Das and Pal) Naithani Indian For. 116 (12): 990. 1990. **(Fig. 99).**

Ampelocalamus patellaris (Gamble) Stapleton. *Chimonobambusa jainiana* Das and Pal, J. Econ. Tax. Bot. 4: 1023. 1983. *Drepanostachyum jainianum* Majumdar, Bull. Bot. Surv. India 25: 235. 1983; Tewari, Monogr. Bamboo 88. 1992.

DESCRIPTION

An elegant caespitose bamboo. **Culms** ca. 6 m high, ca. 2 cm diameter, striate, light brown; internode striate, hairy; nodes having a peltate hairy disc; branches many, fasciculate. **Leaves** ca. 8 cm long and 4 cm broad, oblong-lanceolate, attenuate at the base into a short petiole, apex acuminate, hairy on the lower surface along the midrib, glabrous on the edges; midvein prominent, secondary and intermediate veins are indistinguishable, transverse veinlets inconspicuous; leaf-sheath striate, hairy on the edges with bristles on both side of the callus, yellow; ligule ca. 6 mm long. **Inflorescence** a loose drooping panicle, terminating at the leafy branches; spikelet ca. 2.5 cm long, usually 5-flowered, uppermost floret imperfect; rachilla ca. 4 mm long, clavate, ciliate; empty glumes 2, membranous; lemma ca. 12 mm long and 4 mm broad, with long hairs towards the edges on the back, 11-nerved, tip acute; palea ca. 11 mm long, 2-keeled, glabrous on the keels, tip ciliate and bimucronate; lodicule 3. Ovary ca. 1.5 mm long, ovoid-oblong, glabrous; style divided and each having one plumose stigma.



▲ *Fig. 99.* **S. jainiana.** *A - part of the culm with a nodal ring; B - part of inflorescence; C - a floret with rachilla; D - terminal sterile floret; E - pistil with withered stamens; F - stamen; G - lodicules.*

FLOWERING

Flowering has been reported from Sikkim in 1905, 1908 and from Darjeeling in 1979.

DISTRIBUTION AND ECOLOGY

This species is distributed in Sikkim and West Bengal (Darjeeling). Distributed mostly in subtropical zone; apparently very rare; prefers very humid and cooler habitats.

USES

The culms are ideal for weaving since it is flexible and has long internodes. Leaves are used as fodder.

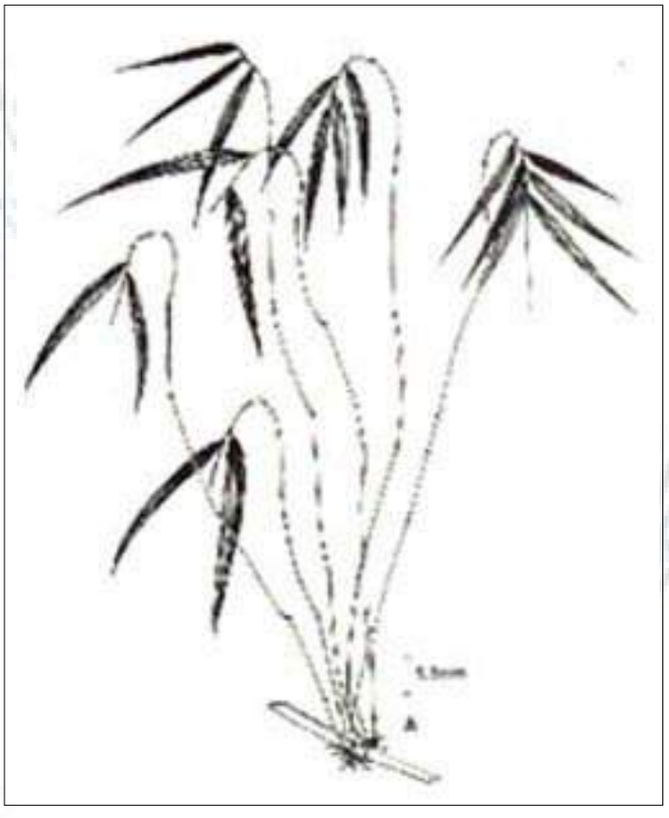
Sinarundinaria kurzii

Sinarundinaria kurzii (Gamble) Muktesh kumar Comb. nov. **(Fig. 100)**.

Arundinaria kurzii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 25. 1896, in Hook. f., Fl. Brit. India 7: 385. 1897; Camus, Les Bambusees 50. 1913; Biswas, Indian For. 114: 526. 1988. *Drepanostachyum kurzii* Majumdar, Bull. Bot. Surv. India 25:236. 1983; Tewari, Monogr. Bamboo 90. 1992.

DESCRIPTION

A low level bushy bamboo. **Culms** ca.1.2 cm diameter, thin, smooth; internode ca.18 cm long, striate, yellow; nodes prominent, having a thick ring-like scar formed by the base of the fallen culm-sheath; branchlets many, fascicled, with swollen joints. **Leaves** ca. 8 cm long and 0.5 cm broad, linear-lanceolate, very thin, attenuate at the base into a short petiole, tip mucronate, glabrous on dorsal surface, with scattered long white hairs on the ventral surface, edges smooth; midrib prominent, secondary veins 3 pairs, intermediate 6, transverse veinlets inconspicuous; leaf-sheath striate, slender, glabrous, ending into a callus with few bristles; ligule short, ciliate. **Inflorescence** unknown.



▲ *Fig. 100.* **S. kurzii.** *A - leafy branches with part of culm.*

DISTRIBUTION

This species is distributed in North-East India; Meghalaya (Khasi Hills), Manipur and Nagaland. This is a rare bamboo.

Sinarundinaria longispiculata

Sinarundinaria longispiculata (Bor) Chao and Renv. Kew Bull. 43:411. 1988; Tewari, Monogr. Bamboo 149.1992. **(Fig. 101).**

Arundinaria longispiculata Bor, mss.

DESCRIPTION

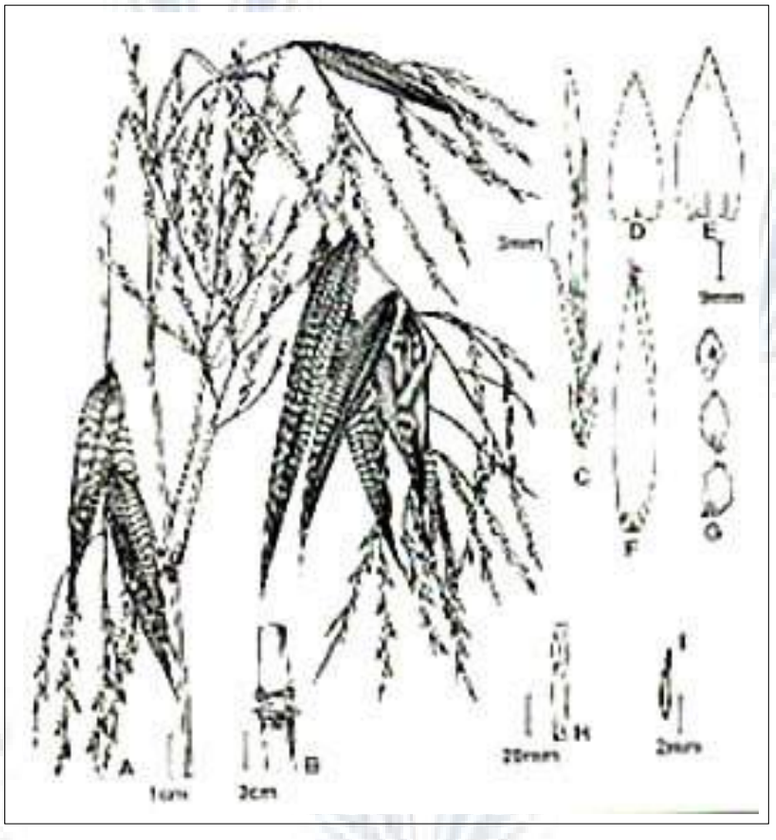
A reed-like bamboo. **Culms** erect; internodes glabrous; nodes yellowish-velvety. **Leaves** 7-15 cm long and 0.8-1.5 cm broad, lanceolate or linear-lanceolate, tapering at the apex, cuneate at the base, tessellate with 3-4 secondary veins on each side; sheaths glabrous with small auricles and erect oral setae; ligules conspicuous. **Inflorescence** loosely paniculate, leafy, up to 15 cm long. Spikelets 4-8 cm long, numerous, pedicels up to 2 cm long, pubescent, slightly flexuous, floret 5-10; rachilla 0.8-1 cm long, tomentose; empty glumes 2, first glume 6 mm long, second 7-8 mm long, lemma 1.2-1.5 cm long, glabrous except at the apex, 5-7-nerved, long acuminate or subulate at the apex; palea 1-1.5 cm long, 2-keeled; lodicules 3, more or less ovate, ciliate at the margin. Stamens 3, 5-6.5 mm long. **Caryopsis** not known.

FLOWERING

Flowering has been reported from Lushai Hills, Mizoram in 1953.

DISTRIBUTION

The species is distributed in Mizoram (Lushai Hills) at an elevation of 1300 m. The species appears to be endemic to Mizoram.



➤*Fig. 101.* **S. longispiculata.** *A - a portion of flowering branch; B - node; C - spike; D - lower glume; E - upper glume; F - floret; G - lodicules; H - pistil; I - caryopsis.*

Sinarundinaria microphylla

Sinarundinaria microphylla (Munro) Chao & Renv. Kew Bull. 44: 354. 1989.

Arundinaria microphylla Munro, Trans. Linn. Soc. London 26: 32. 1868; Gamble, Indian For. 14: 314. 1888, Ann. Roy. Bot. Gard. Calcutta 7: 22. 1896, in Hook. f., Fl. Brit. India 7: 383. 1897; Brandis, Indian Trees 667. 1906; Camus, Les Bambusees 51. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.)Bot. 6(1): 1. 1980; Tewari, Monogr. Bamboo 25. 1992.

DESCRIPTION

Smallest bamboo; caespitose, shrubby. **Culms** ca. 1.2 m high; internode ca. 7 cm long, glabrous; node prominent, with many semi-verticillate branches. **Leaves** ca. 3 cm long and 0.3 cm broad, linear-lanceolate, acute; secondary veins 2 pairs, inconspicuous, transverse veinlets many, forming squares and rectangles; leaf sheath striate, dark, scabrous, fimbriate at the top; ligule scarcely visible. **Inflorescence** not known.

DISTRIBUTION AND ECOLOGY

Found in North-East India; Sikkim (Bahadur, 1979) and Khasi Hills in Meghalaya. Distributed mostly in cool temperate to sub-alpine zone. Commonly found in large patches in wet places.

USES

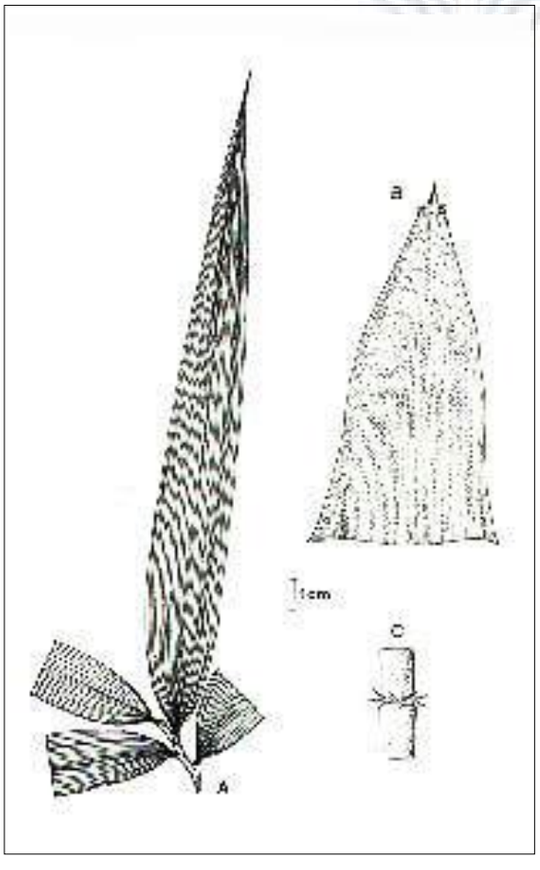
This can be planted in water-logged areas since the long and hollow rhizome neck will help in drainage and aeration. The leaves can be used as a fodder.

Sinarundinaria nagalandiana

Sinarundinaria nagalandiana Naithani, Indian For. 120:1120. 1994. **(Fig. 102).**

DESCRIPTION

An erect thorny bamboo. **Culms** caespitose, 3-7 m high, olive-green; branches greenish black; nodes prominent, bearing a circle of conical, stout short spines; internodes up to 15 cm long, 2.5 cm diameter, at base bear a belt of soft brown hairs. **Culm-sheaths** ca. 22 cm long and 9.5 cm broad, papery, striate, trasversely veined, covered on the back with scattered, stiff, bulbous hyphen based brown hairs, margins ciliate, broader at base, tapering upwards to a 1.2 cm broad, non convexly, sometimes obliquely truncate apex with very small auricles fringed with deciduous bristles. Ligule absent; imperfect blade 1.5 x 0.5 cm, triangular, transversely veined, brown ciliate near the margin,



➤ *Fig. 102.* **S. nagalandiana.** *A - leafy branch; B - culm-sheath; C - a portion of culm.*

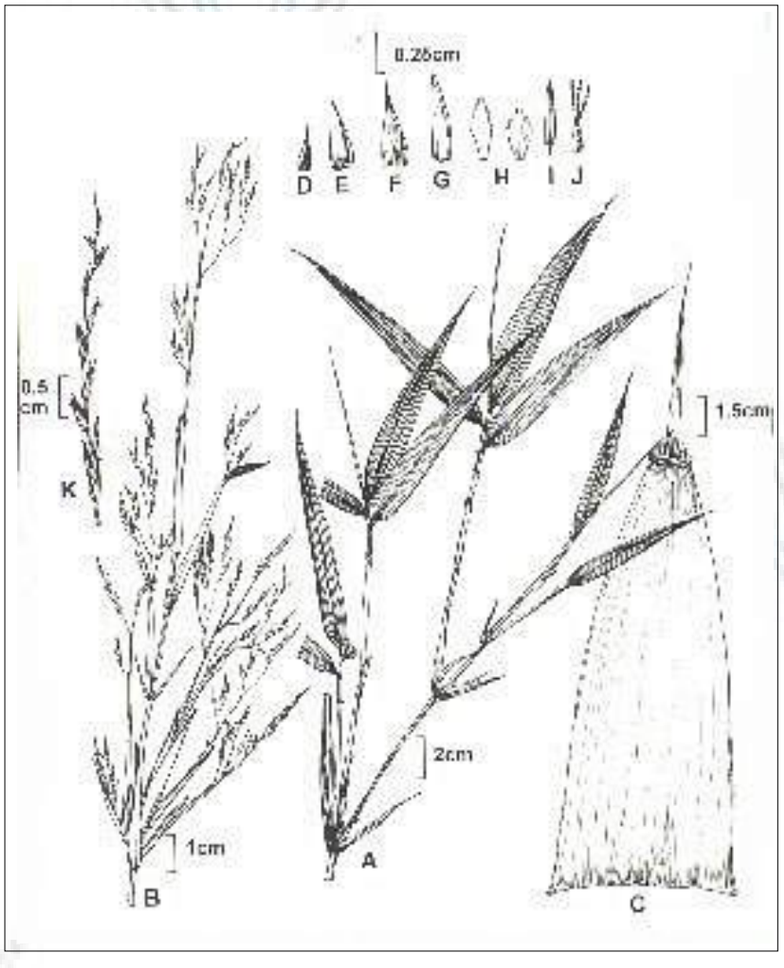
Leaves 7-26 cm long and 1.7-2.8 cm broad, oblong-lanceolate, alternate at the base into 2 mm long petiole ending in a scabrous acuminate point. Sometimes slightly pubescent above, faintly scabrous-serrate on the margin, mid-rib prominent, shining glabrous; secondary veins 5-7 pairs; transverse veinlets conspicuous, raised; sheaths striate, glabrous, ciliate on the margins, ending in a short ciliate callus, furnished with few, long, deciduous bristles; ligules short, glabrous, entire. **Inflorescence** not known.

This species is allied to *Sinarundinaria griffithiana* (Munro) Chao & Renv. but differs by culm-sheath without ligule and having broad nonconvexly truncate apex; leaves broader.

DISTRIBUTION

This species is reported from Nagaland as a new taxa collected during 1986 (Naithani, 1994).

Sinarundinaria pantlingii



Sinarundinaria pantlingii (Gamble) Chao & Renv. Kew Bull. 44: 359. 1989. **(Fig. 103).**

Arundinaria pantlingii Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 129. 1896 and in Hook. f., Fl. Brit. India 7: 380. 1897; Camus, Les Bambusees 28. 1913; Blatter, J. Bombay Nat. Hist. Soc. 33: 902. 1930; *Butania pantlingii* (Gamble) Keng, J. Bamboo Res. 1(2): 42. 1982. *Semiarundinaria pantlingii* (Gamble) Nakai, J. Arn. Arb. 6: 121. 1928; Tewari, Monogr. Bamboo 148. 1992.

◄*Fig. 103.* **S. pantlingii.** *A - leafy branch; B - flowering branch; C - culm-sheath; D & E - empty glumes; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil; K - a portion of flowering branch.*

DESCRIPTION

An erect caespitose, shrubby bamboo. **Culms** ca. 6 m long, ca. 1.5 cm diameter, smooth, internode ca. 14 cm long, thin-walled; nodes prominent bears a soft hairy ring formed by the base of the fallen sheath. **Culm-sheaths** 16-22 cm long and 3.5-9 cm broad, coriaceous, striate, straw-coloured, covered with stiff hairs on the outer surface, tessellate in inner surface, attenuate towards the apex into a very long ciliate tip, with 0.8 cm broad mouth; auricles rounded, hairy with few long bristles; imperfect blade ca. 9 cm long, erect, subulate, striate, ciliate on the edges; ligule ca. 2 mm broad, faintly ciliate, dentate. **Leaves** ca. 11 cm long and 1 cm broad, linear-lanceolate, glabrous, attenuate at the base into a very short petiole. Leaf sheath ca. 5 cm long, striate glabrous, ciliate on the edges, ending into a callus with long twisted bristles on both sides; ligule long, glabrous, white. **Inflorescence** on axillary or terminal panicle, supported by ca. 6 cm long sheathing bracts, on separate leafless branches, spikelet ca. 3.5 cm long, 8-flowered, uppermost 2 flowers empty, pedicels long, wavy, glabrous, capillary with glandular bases, rachilla ca. 6 mm long, clavate, scabrous, with a tuft of white hairs below the flowers, empty glumes 2, ovate-lanceolate, ciliate on the edges, outer glume ca. 7 mm long and 2 mm broad and 3-nerved, inner glume ca. 10 mm long and 3 mm broad and 5-nerved, lemma ca. 13 mm long and 3 mm broad, ovate-lanceolate, ciliate on the edges, tip long, acuminate, ciliate; palea ca.10 mm long, 2-keeled lodicules 3, ovate, acute, faintly nerved, ciliate on the edges, one is narrower than the other two. Stamens 3; anther bilobed, ca. 3 cm long, linear, acute, basifixed, filament ca. 1 mm long. Ovary oblong, ovoid, glabrous, style undivided, short, curved with 3 plumose stigmas. **Caryopsis** oblong, grooved, dark-brown, surmounted by the persistent bases of style.

Chromosome number n = 24.

FLOWERING

Flowering is rare in this species. Flowering has been reported from Sikkim in 1895, 1897 and 1932. Flowering has also been reported from West Bengal in 1968. Flowering cycle appears to be about 35 years.

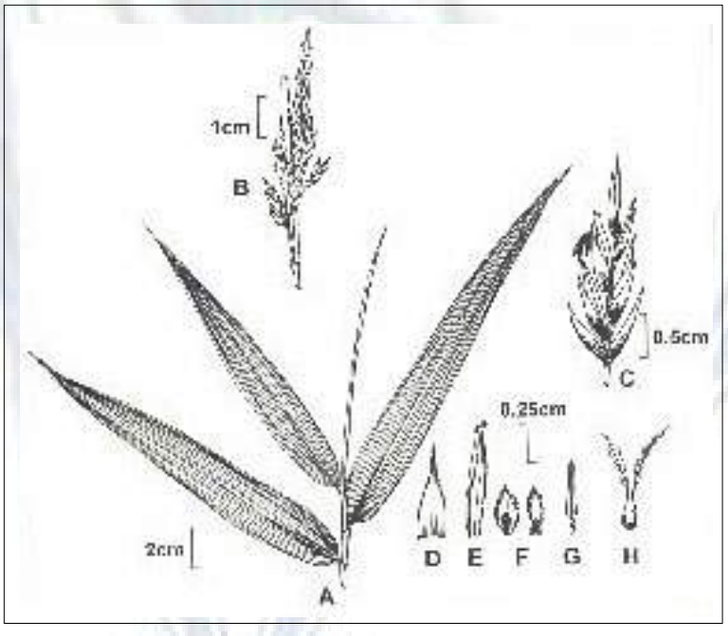
DISTRIBUTION AND ECOLOGY

The species is found distributed in Arunachal Pradesh, Sikkim, West Bengal. It is distributed mostly in subalpine zone. It grows in mountain slopes, rocky area and as undergrowth in *Abies*, *Betula* and *Rhododendron* forests. It often forms almost pure stands. Found at an elevation of 2400-3000 m.

Sinarundinaria polystachya

Sinarundinaria polystachya (Gamble) Chao & Renv. Kew Bull. 44: 359. 1989. **(Fig. 104).**

Arundinaria polystachya Kurz ex Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 7. 1896 in Hook. f., Fl. Brit. India 7: 378. 1897, Kew Bull. No.3: 135. 1912; Camus, Les Bambusees 30. 1913; Blatter, J. Bombay Nat. Hist. Soc. 33: 902. 1930; *Chimonobambusa polystachya* (Kurz ex Gamble) Nakai, J. Arn. Arb. 6: 151. 1925; Varmah and Bahadur, Indian. For. Rec. (n.s.) Bot. 6(1): 2. 1980; *Drepanostachyum polystachyum* (Kurz ex Gamble) Majumdar, in Karthikeyan et al., Fl. Ind. Enum. Monocots. 278. 1989; Tewari, Monogr. Bamboo 90. 1992.



▲ *Fig. 104.* **S. polystachya.** *A - leafy branch; B - flowering branch; C - spikelet; D - flowering glume; E - palea; F - lodicules; G - stamen; H - pistil.*

DESCRIPTION

A shrubby bamboo. **Culms** ca. 4 m high, soft; branchlets many, fasciculate. **Leaves** ca.20 cm long and 3.5 cm broad, rounded and attenuate at the base into a very short petiole, ending above into a twisted setaceous point, rough above, smooth beneath, scabrous on one edge; midrib prominent, broad; secondary veins 5 pairs, conspicuous, intermediate 5, transverse veinlets inconspicuous; leaf-sheath striate, glabrous, ending into a broad bifid callus with deciduous oral setae, greenish-yellow; ligule long, striate, blunt, fimbriate. **Inflorescence** an axillary panicle on leafy branches; spikelet ca. 1.8 cm long, pedicellate, 5-flowered, upper flower empty; rachilla ca. 4 mm long, clavate, white bearded; empty glumes 2, membranous, ovate, acuminate, tip hairy, outer glume ca. 6 mm long and 1.5 mm broad 5-nerved; inner glume ca. 7 mm long and 2 mm broad, 7-nerved; lemma ca. 8 mm long and 3.0 mm broad, ovate-acuminate, ciliate at the tip and on the upper margin, 9-nerved; palea slightly longer than lemma, 2-keeled, ciliate on the keels, tip bifid and mucronate, 1-nerved between and 1-nerved on either side of the keel; lodicules 3, ca. 3 mm long, 2 ovate-obtuse, 1 ovate-acute and narrower than the other two, fimbriate. Stamens 3; anther long, basifixed, brown, tip shortly apiculate; filament short, flexuose. Ovary oblong-ovoid, glabrous; style divided with 2 plumose stigmas.

FLOWERING

Flowering has been recorded from Sikkim in 1868, 1897, 1898 and from Khasi Hills in 1876 and the flowering cycle is about 30 years.

DISTRIBUTION AND ECOLOGY

This species is distributed in North-East India; Meghalaya (Khasi Hills) and Sikkim. Distributed mostly in warm temperate to subtropical zone. It usually grows on dry hills, ridges or rocky slopes and occasionally near the streams. Distributed at an elevation of 900-1600 m.

ANATOMY

Leaf epidermis has short cells in rows of 3-5 on costal and solitary in the intercostal region. Shape of silica bodies *Oryza* type. Bulliform cells, arm cells, macrohairs, microhairs and prickles present. Microhairs present on both surfaces of epidermis (Sharma et al., 1986).

Sinarundinaria rolloana

Sinarundinaria rolloana (Gamble) Chao & Renv. Kew Bull. 44: 355. 1989. **(Fig. 105).**

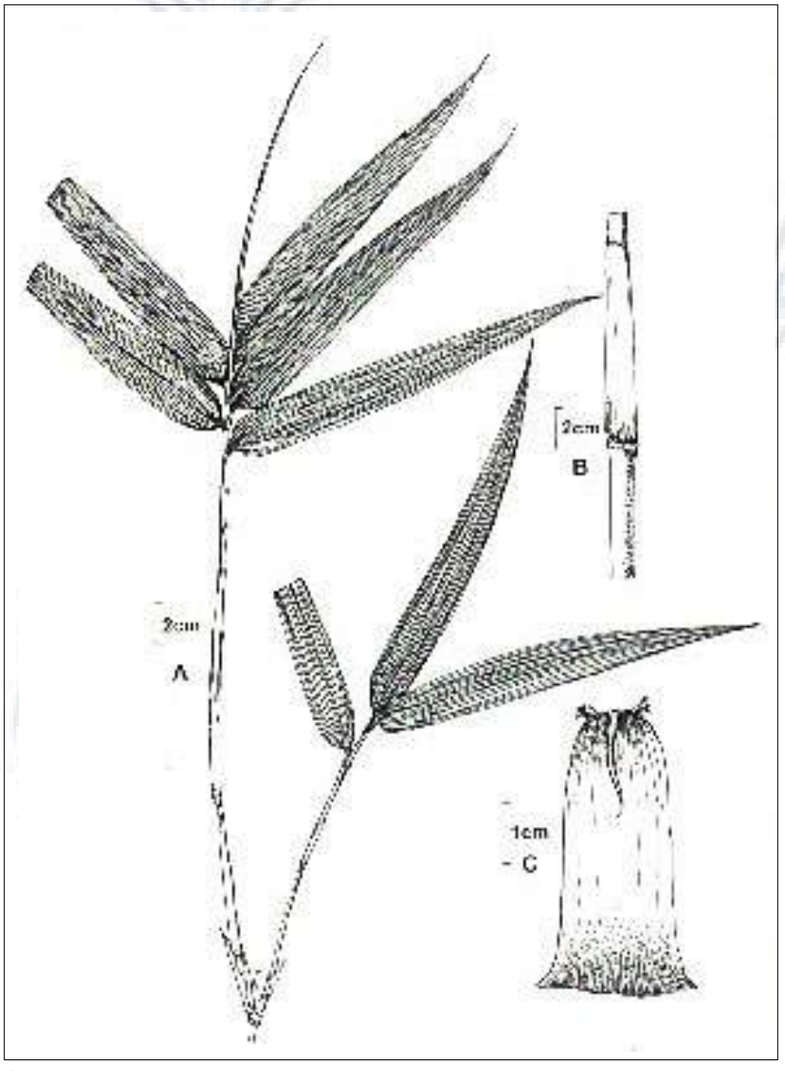
Arundinaria rolloana Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 24. 1896, in Hook. f., Fl. Brit. India 7: 384. 1897; Camus, Les Bambusees 57. 1913; Bahadur and Jain, Indian J. For. 4: 282. 1981; Biswas, Indian For. 114: 526. 1988; Tewari, Monogr. Bamboo 27. 1992. *Yushania rolloana* (Gamble) T.P.Yi in J. Bamboo Res. 2(1): 39, 1983.

VERNACULAR NAME

Naga Hills - *Jipvo*.

DESCRIPTION

Shrubs, culms arising at distance; rhizome creeping, covered with scales, imbricate. **Culms** ca. 3 m high, 1 cm diameter, greenish yellow, flattened on one side; internode ca. 20 cm long, walls thin; node somewhat swollen, with 1-3 branchlets. **Culm-sheaths** ca. 10 cm long and 4 cm broad, narrowed into a broad truncate mouth, thin, striate, covered with brown stiff hairs on the dorsal surface, ciliate on the edges, auricles rounded with long bristles; ligule long, fimbriate, narrow; imperfect blade ca. 5 cm long, subulate, recurved. **Leaves** ca. 20 cm long and 3.5 cm broad, oblong, lanceolate, tip acute, base rounded, glabrous above, scabrous on the ventral surface; midrib conspicuous, shining beneath; secondary veins 6 pairs; intermediate 7; transverse veinlets numerous, ruminant beneath, straight and regular; petiole short, flat; leaf-sheath striate, hairy, with long rounded ciliate auricles; ligule long, membranous. **Inflorescence** not known.



▲ *Fig. 105.* **S. rolloana.** *A - leafy branch; B - culm with culm-sheath; C - culm-sheath.*

DISTRIBUTION

The species is found in Naga Hills and is rare and restricted in distribution. It

is known only by two collections during 1889 by Rollo and Banerjee. The species is remarkable for its very long rhizome and broad leaves.

USES

Local children make whistles from the culms.

Sinarundinaria suberecta

Sinarundinaria suberecta (Munro) Muktesh kumar *Comb. nov.* **(Fig. 106).**

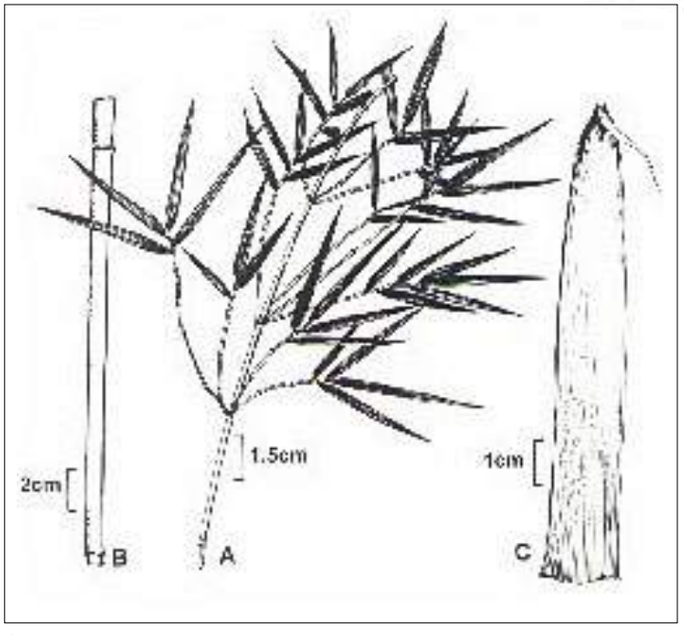
Arundinaria suberecta Munro, Trans. Linn. Soc. London 26: 32. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 25. 1896, in Hook. f., Fl. Brit. India 7: 385. 1897, Kew Bull. No.3: 135. 1912; Camus, Les Bambusees 52. 1913; Varmah and Bahadur, Indian For. Rec. (n.s) 6(1): 1. 1980. *Drepanostachyum suberectum* Majumdar, Bull. Bot. Surv. India 25: 236. 1985; Tewari, Monogr. Bamboo 91. 1992.

VERNACULAR NAMES

Khasi Hills - *Ukadai namlang, Lambnang, Namlang.*

DESCRIPTION

A graceful shrubby bamboo, wiry, erect, thick clumps. **Culms** ca. 4 m high, 0.7 cm diameter, yellowish-brown, smooth; internode ca. 20 cm long, cavity very small; nodes swollen; branchlets in fascicle. **Culm-sheaths** ca.10 cm long and 1.5 cm broad, papery, glabrous on the inner surface and scabrous on the outer surface towards the tip, attenuate upwards into a 0.3 cm broad mouth; imperfect blade ca. 3 cm long, striate, leafy, recurved; ligule long, fimbriate at the tip. **Leaves** ca. 10 cm long and 0.7 cm broad, linear-lanceolate, attenuate at the base into a very short petiole, acuminate tip with setaceous point, glabrous above, pale beneath, edges scabrous and serrate; midrib not conspicuous, secondary veins 4 pairs, intermediate 6, transverse veinlets inconspicuous, pellucid glands many; leaf-sheath striate, straw- coloured, loose, glabrous, slightly hairy when young, ending into a callus with bristles on both sides; ligule long, pubescent. **Inflorescence** not reported.



▲ *Fig. 106.* **S. suberecta.** *A - leafy branch; B - a portion of culm; C - culm-sheath.*

DISTRIBUTION AND ECOLOGY

This species is distributed in North-East India; Arunachal Pradesh, Meghalaya (Khasi and Jaintia Hills) and Sikkim. Distributed mostly in warm temperate to subtropical zone. Common in the hill forests and profuse along the banks of rivers and streams.

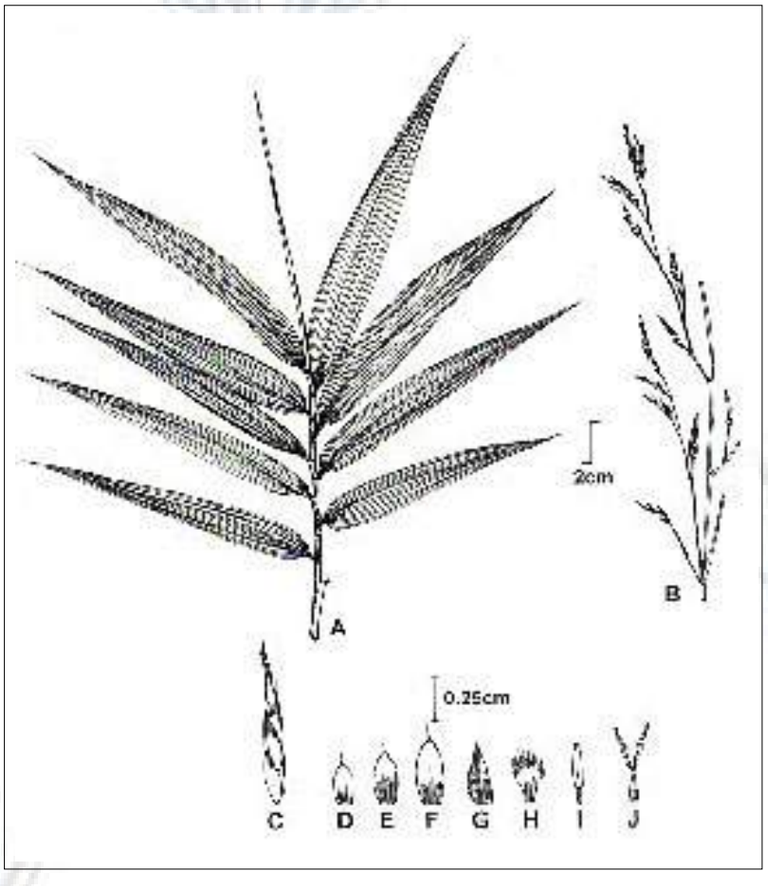
PESTS AND DISEASES

Leaf rust caused by *Puccinia phyllostachydis* has been reported from India, China and Japan.

USES

Culms are used in building of native huts.

Sinarundinaria walkeriana



Sinarundinaria walkeriana (Munro) Chao & Renv. Kew Bull. 44: 354. 1989. **(Fig. 107).**

Arundinaria walkeriana Munro, Trans. Lin. Soc. London 26: 21. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 3. 1896 and in Hook. f., Fl. Brit. India 7: 377. 1897; Camus, Les Bambusees 27. 1913; Blatter, Indian For. 55: 542. 1929 and J. Bombay Nat. Hist. Soc. 33: 903. 1930. *Indocalamus walkerianus* (Munro) Nakai, J. Arn. Arb. 6: 148. 1925; Bahadur and Jain Indian J. For. 4: 280- 286. 1981; Tewari, Monogr. Bamboo 101. 1992.

◄*Fig. 107.* **S. walkeriana.** *A - leafy branch; B - flowering branch; C - spikelets; D & E - empty glumes; F - flowering glume; G - palea; H - lodicules; I - stamen; J - pistil.*

DESCRIPTION

Shrubby bamboo of densely placed culms from sympodial, pachymorph rhizome. **Culms** 2m high, ca. 3 cm diameter, hollow, upper part thickly covered with sheaths of fallen leaves, internodes rough, striate. **Culm-sheaths** deciduous, sheath light green, strongly ribbed, ciliate along the overlapping margin on the back, glabrous above, sparsely papillose below and at the base densely hirsute. **Leaves** ca. 16 cm long and 3.5 cm broad, ovate-oblong, apex acuminate, rounded at the base with ca. 5 mm long petiole, glabrous margin cartilaginous; midrib prominent; secondary vein 6-7 pairs, intermediate 7, transverse veinlets many. Leaf sheath striate glabrous, ending in to a ciliate mouth with bristly auricles on both sides of callus, ligule short. **Inflorescence** terminal, purple on leafy branches, 20-30 cm long, the pedicels up to 17 mm long, each bearing a many-flowered spikelet. Spikelet ca. 2.5 cm long, glabrous 3-4 flowered and the upper one empty, each separated by a narrow rachilla, segment flat and glabrous below, empty glumes 2, nearly equal, ciliate on the margin, 3-5 nerved; palea as long as the flowering glume, ciliate, 2-keeled, apex acute, lodicules 3, obtuse, fimbriate, 3-nerved. One is smaller than the other two. Stamens 3; anthers obtuse, filament short. Ovary glabrous, undivided with 2 feathery stigmas. **Caryopsis** 5 mm long with a short beak, embryo basal, one-fifth the length of the fruit, the hilum linear, extending the entire length of caryopsis in a furrow on the convex side (Soderstrom and Ellis, 1988).

FLOWERING

This species is reported to flower frequently.

DISTRIBUTION

Distributed in Southern India, particularly in Palni Hills. Reported to be endemic to Sri Lanka.

ANATOMY

The transverse section of the leaf shows intercostal long, cells of the abaxial epidermis rectangular, no bulliform cells. Stomata shape not distinct, three files appear to be present on either side of costal zone; one interstomatal cell present between successive stomata in a file. Intercostal short cells single with crenate outlines. Papillae conspicuous, darkly staining, present on all long cells, overlapping stomata and adjacent long cells. Prickles and hooks identical, costal and intercostal prickles dominate the surface; bases elliptical, associated with short cells. Microhairs narrow and rod-shaped, common. Silica bodies tall, saddle-shaped, few present on costal zone, apparently absent intercostal zone. Adaxial epidermis intercostal long cells elongated, rectangular with slightly sinuous walls separated by single or paired short cells; costal and lateral intercostal files of identical cells, but costal zones recognisable due to underlying fibres, central files consist of bulliform cells. Stomata absent. Intercostal short cells single or paired, cork and silica cells tall and narrow but silica cell much smaller than cork cell. Papillae, prickles and microhairs absent. Silica bodies small, tall and narrow to crescent-shaped, irregular in occurrence in the intercostal zones, present between all costal long cells (Soderstrom and Ellis, 1988). In root, the epidermal cells radially elongated, walls are thick, larger in size than adjacent cells. Exodermis thin-walled and iso-diametric, occasionally ruptured. In cortex small intercellular spaces occur between cells. Endodermis conspicuous due to incomplete ‘U’ shaped thickening. Pericycle consists of one layer. Phloem strands occur scattered among metaxylem vessels as well as alternating between xylem poles. Protoxylem difficult to distinguish from pericycle. The ground tissue of stele consists of large thin-walled cells in the centre surrounded by thick- walled cells in the outer pith (Raechal and Curtis, 1990).

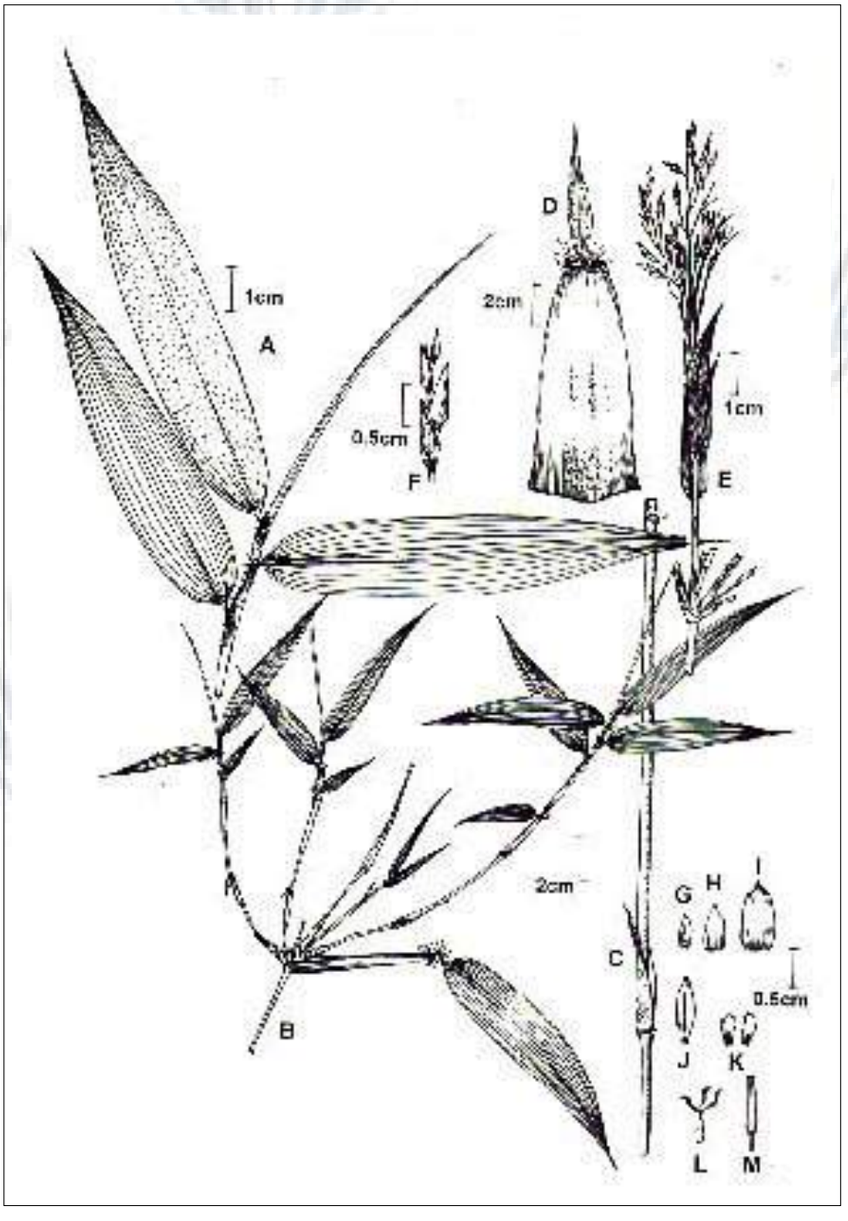
USES

The culms are used for fencing and roofing.

Sinarundinaria wightiana

Sinarundinaria wightiana (Nees) Chao & Renv. Kew Bull. 44: 356. 1989. (Fig. 108).

Arundinaria wightiana Nees Linnaea 9: 182. 1834; Munro, Trans. Linn. Soc. London 26: 19. 1868; Gamble. Ann. Roy. Bot. Gard. Calcutta 7: 4. 1896 and in Hook. f. Fl. Brit. India 7: 377. 1897; Camus, Les Bambusees 28. 1913; Blatter, Indian For. 55: 542. 1929 and J. Bombay Nat. Hist. Soc. 33: 903. 1930 and 34: 135. 1931; *Arundinaria hispida* Steud. Syn. Pl. Glum.1: 335. 1854. *A. wightiana* var. *hispida* (Steud.) Gamble. Ann. Roy. Bot. Gard. Calcutta 7: 5. 1896 and in Hook.f. Fl. Brit. India 7: 377. 1897. *Indocalamus wightianus* (Nees) Nakai in J. Arn. Arb. 6: 148. 1925; Bahadur, Indian J. For. 2: 240. 1979., Varmah and Pant, Indian



➤*Fig. 108.* **S. wightiana.** *A & B - leafy branches; C - a portion of culm; D - culm-sheath; E - flowering branch; F - spikelet; G & H - empty glumes; I - flowering glumes; J - palea; K - lodicules; L - pistil; M - stamen.*

For. 107: 471. 1981; *Indocalamus wightianus* var. *hispidus* (Steud.) Nakai, J. Arn. Arb. 6: 149. 1925; Bahadur. Indian J. For. 2: 240. 1979; Tewari, Monogr. Bamboo 103. 1992.

VERNACULAR NAMES

Southern India - *Chewari*; Common name: Nilgiri bamboo.

DESCRIPTION

An erect, gregarious shrub with slender culm arising from short rhizome. **Culms** 2 to 3 m or more high, slender, dark green, on maturity yellowish brown. **Culm-sheaths** 10 to 20 cm long, 2.5 to 7.5 cm broad, narrowed slightly upwards, straw coloured, thickly clothed with stiff, golden, tubercle-based hairs imperfect blade ca. 3.8 cm long, 0.5 cm broad, wavy, scabrous, ligule short, fimbriate. **Leaves** 13.5 cm long and 2 cm broad, ovate-lanceolate, glabrous except at the scabrous margins, short, swollen petiole, leaf sheath keeled, striate, ciliate at the edges, mouth with long bristles, ligule short, blunt. **Inflorescence** purplish, terminal or axillary. Spikelet ca. 1 cm long, 2-flowered the upper most floret usually sterile and glabrous, empty glumes 2 ovate-acute, membranous, tip ciliate; palea equal to lemma, 2-keeled, ciliate on the keels. Lodicules 3, ciliate, 3-7-nerved; stamens 3, anther brown, acute, basifixed, filament short. Ovary ovoid-oblong, glabrous, style divided with 3 plumose stigmas. **Caryopsis** ca.5 mm, elliptic, acute, deeply furrowed on one side.

Chromosome number n = 12, 2n = 48.

FLOWERING

This species is reported to flower annually. The plant does not die after seeding. Flowering was observed in Nilgiri District during 1872, 1878, 1882, 1883-1889 (Tewari, 1992).

DISTRIBUTION AND ECOLOGY

S. wightiana is distributed in the hills of Southern India and Sri Lanka. Common in Nilgiri where it covers the upper slopes of the hills above 1800 m; chiefly as an undergrowth in evergreen sholas; gregarious in moist areas. In Kerala this species is located at Palghat and Munnar forests.

USES

This species is used for making baskets, mats, sheds, roofs and fencing.

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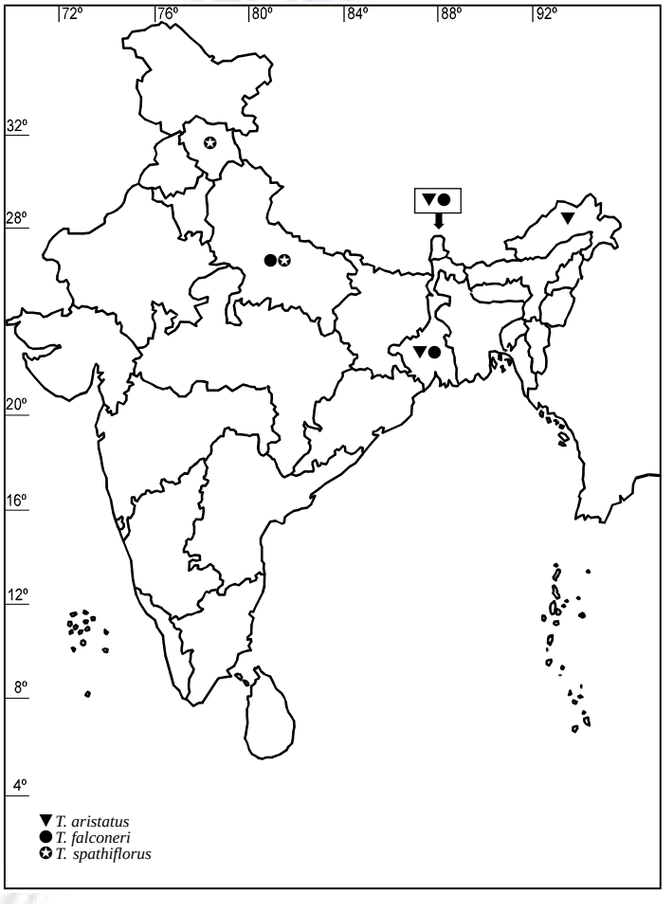
THAMNOCALAMUS MUNRO

A shrubby bamboo. Rhizome sympodial, without elongated neck, forming culms in single caespitose clumps; culms erect; nodes marked by a ring; branchlets 3, mainly from the upper node; leaf blades tessellate; inflorescence racemose, usually on the leafless branches; spikelets few, 2-5 together, each with 4-8 florets, enclosed by a broad spathe; rachilla with remote segments, the latter clavate-shaped and hairy at the tip; lemmas ovate, long acuminate at apex; lodicules 3, stamens 3; styles slender, with plumose stigma.

There are different generic concepts with regard to this group. Several related genera have been merged with this genus by various taxonomists. Chao and Renvoize (1989) consider 6 species of the genus in the world, 2 species in China, 1 in Africa and 3 in India. The genera earlier known as *Himalaya calamus* has been merged with the genus *Thamnocalamus*. In the present compendium, three species of this genus have been included.



◄*Distribution map of* **Thamnocalamus**

Thamnocalamus aristatus

Thamnocalamus aristatus (Gamble) Camus, Les Bambusees 54. 1913; Bor in Kanjilal, Fl. Assam 5: 52. 1940; Champion and Seth, Rev. Surv. Forest Types India 316. 1968; Bahadur, Indian J. For. 2: 237. 1979; Varmah and Pant, Indian For. 107: 672. 1981; Tewari, Monogr. Bamboo 150.1992. **(Fig. 109).**

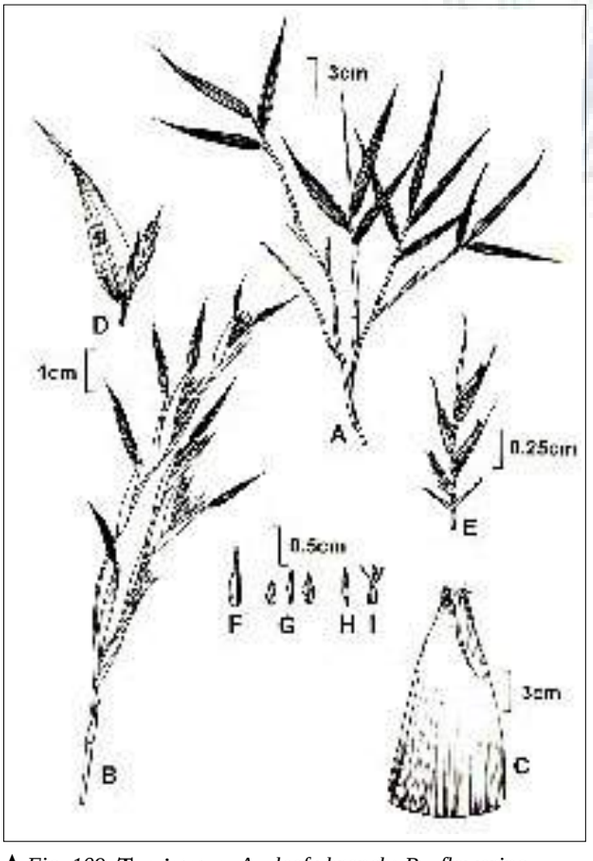
Arundinaria aristata Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 18. 1896 and in Hook. f., Fl. Brit. India 7: 382. 1897 and Kew Bull. No.3:135. 1912; Blatter, J. Bombay Nat. Hist. Soc. 33: 900. 1930.

VERNACULAR NAMES

Sikkim - *Babain, Babam*; Darjeeling - *Rato, Nigalo*; Sikkim/Nepal border - *Rato - Nigala, Pat - hioo*.

DESCRIPTION

A shrubby erect, caespitose bamboo. **Culm** ca. 4 m high, ca. 1.5 cm diameter, glaucous green with white-scurf when young becoming yellow at maturity; internode ca. 10 cm long, striate, pubescent, walls hard. **Culm-sheaths** ca. 15 cm long and 6 cm broad, coriaceous, striate, attenuate upwards into a 7 mm broad mouth, surface with white bulbous based hairs; imperfect blade ca. 3.5 cm long and 0.5 cm broad, striate, subulate; ligule short, minutely pubescent. **Leaves** clustered in group of 2-3, ca. 15 cm long and 1.2 cm broad, oblong - lanceolate, attenuate at the base; petiole; ca. 5 mm long; leaf sheath ca. 3.5 cm long, loose striate, keeled, ending into a callus with long stiff purple bristles on both sides; ligule long, acute. **Inflorescence** a panicle of 3 racemes with large spathe-like bracts, usually on separate leafless branches; rachis smooth, slender, jointed with papery bracts at the joints; bracts ca. 5.5 cm long and 1.5 cm broad, striate, golden yellow, ending into a callus with bristles on both sides and foliaceous; imperfect blade encloses 3-5 pedicellate spikelets. Spikelet ca. 3 cm long,6-flowered, the upper one is imperfect; rachilla ca. 4 mm long, clavate, ciliate on the margin and tip. Empty glumes 2, oblong lanceolate, keeled, membranous, tip ciliate and long mucronate, outer glume ca. 10 mm long, 3-nerved, inner glume ca. 15 mm long and 5-nerved; lemma ca. 20 mm long and 4 mm broad, ovate, tessellate, scabrous on the edges, dark coloured, 7-nerved, tip ciliate, aristate; palea ca. 10 mm long, 2-keeled, ciliate on the keels, tip bimucronate, ciliate; lodicule 3, ca. 2 mm long, ovate-lanceolate, acute,



▲ *Fig. 109.* **T. aristatus.** *A - leafy branch; B - flowering branch; C - culm-sheath; D - spikelet; E - spikelet spread out; F - palea; G - lodicules; H - stamen; I - pistil.*

3-nerved, ciliate, one narrower than the other 2; stamens 3; anther ca. 6 mm long, purple, basifixed, tip bifid and blunt, filament short. Ovary ovoid, glabrous, 2-4 mm long, style short, divided into 3 feathery stigmas. **Caryopsis** linear-oblong, glabrous, furrowed in the back, dark brown, with persistent bases of 3 long plumose stigmas.

Chromosome number n = 24 (Mehra and Sharma, 1975).

FLOWERING

Usually, it flowers gregariously. Flowering has been recorded during 1868, 1869, 1890 and 1895 from Sikkim, from Darjeeling 1949-50. Naithani and Biswas (1990) reported its gregarious flowering in Sikkim Himalayas during 1989-90. The reports on flowering from Sikkim indicate a flowering cycle of 20 years.

DISTRIBUTION AND ECOLOGY

This species is found distributed in Arunachal Pradesh, Sikkim and in West Bengal. It grows in the moist mountain slopes and ravines, mostly under broken forest cover at an elevation of 3000-3600 m.

ANATOMY

In the leaf epidermis, stomata are common, arranged in two bands along the veins in one to two alternate rows, subsidiary cells not clear due to over-arching papillae. Interstomatal cells same as long cells, but smaller with deep concave ends. Long cells long and narrow, rectangular, walls sinuous, ends straight, papillae small to large, scattered (Agrawal and Luxmi Chauhan, 1995). Short cells in rows of 3-5 cells on both surfaces, shape of silica bodies costal intermediate between cross and dumbbell shaped, intercostal tall and narrow approaching oryza type; bulliform cells and prickles present on both sides. Arm cells, macrohairs and microhairs absent (Sharma et al., 1986). In the culm epidermis, stomata infrequent, widely distributed, slightly sunken, subsidiary cells clear, parallel to low-domed, surrounding papillae absent. Long cells medium long and narrow, not uniform in width, walls slightly wavy to dentate, ends straight, papillae absent. Cork cells and silica cells not differentiated, solitary or up to four cells, almost rectangular in shape, few filled with vitreous silica. Silica bodies, prickles, microhairs and macrohairs absent (Agrawal and Luxmi Chauhan, 1995).

USES

The culms are strong and used for pipes. Young shoots are edible.

Thamnocalamus falconeri

Thamnocalamus falconeri Hook. f. ex Munro, Trans. Linn. Soc. London 26: 34. 1868; Stapf, Curtis's Bot. Mag. 60: 7947. 1904; Rao, Bull. Bot. Surv. India 2: 91. 1960 and 6: 56. 1964; Bahadur. Indian J. For. 2: 238. 1979; Tewari, Monogr. Bamboo 100. 1992. **(Fig. 110).**

Arundinaria falconeri (Hook. f. ex Munro) Benth. in Benth. and Hook. f., Gen. Pl. 3. 1208. 1883; Gamble, Ann. Roy.

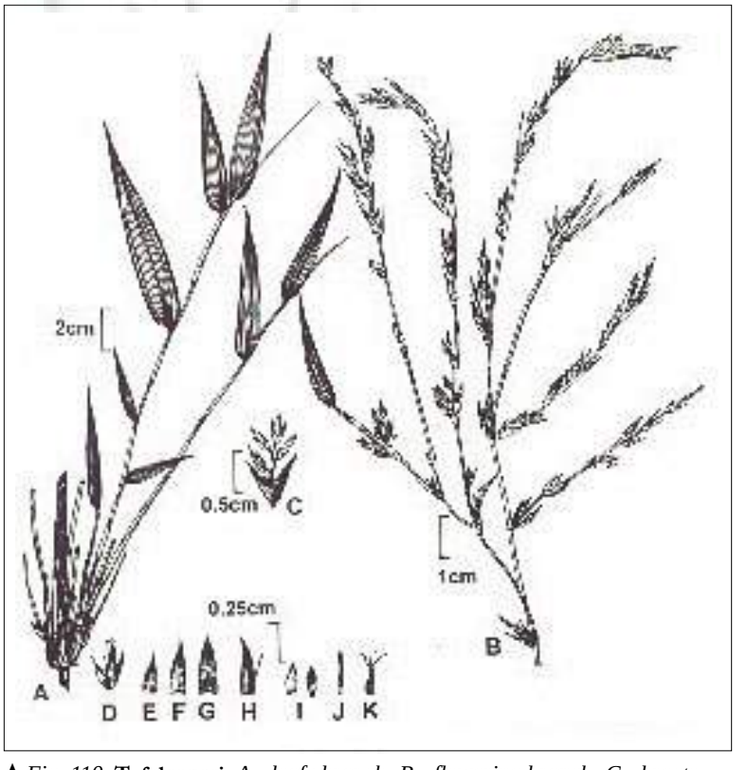
Bot. Gard. Calcutta 7: 20-21. 1896 and in Hook. f., Fl. Brit. India 7: 383.1897; Rogers, Indian For. 27: 185. 1901; Bean, Kew Bull. No.6: 230. 1907; Gamble, Kew Bull. No. 3: 135. 1912; Camus, Les Bambusees 53. 1913; Osmatson, For. Fl. Kumaon. 555. 1927; Blatter, J. Bombay Nat. Hist. Soc. 33: 901.1930; *Fargesia gyirongenis* Yi, J. Bamboo Res. 2(2): 37. 1983., *F. collaris* Yi, J. Bamboo Res. 2(2): 21. 1983. *Himalayacalamus falconeri* (Hook. f. ex Munro) Keng, J. Bamboo Res. 2(2): 24. 1983

VERNACULAR NAMES

Garhwal-*Deo-ringal, Dev-ringal, Ningal*; Darjeeling-*Singhane, Maling;* West Bengal-*Phurse, Dueorenigalo*; Sikkim-*Pao-muarg, Purnoon*.

DESCRIPTION

Shrubby, slender, clump-forming thornless bamboo. **Culms** ca. 6 m high and 2 cm diameter, smooth when young and covered with white scurf when old, fistular; internode ca. 20 cm long. Walls thick, striate, nodes raised at the joint with the persistent base of fallen sheath, branchlets many, rigid, filiform and fascicles at the node. **Culm-sheaths** ca. 25 cm long and 7.5 cm broad oblong, straw coloured, striate coriaceous, ciliate on the margin narrowed towards tip to a truncate mouth; **Leaves** 10 cm long and 1.2 cm broad, oblong-lanceolate, thin, base alternate into a short petiole, apex acuminate, scabrous on the edges, smooth on both surfaces, leaf sheath long glabrous, striate, callus minute, ligule elongate, hairy. **Inflorescence** a panicle on leafy or separate leafless branches; bracts ca. 2 cm long. Spikelets 5-7 in each raceme, glabrous, 2-flowered, one fertile and other imperfect. Stamens 3, ca. 5 mm long anther bilobed shortly apiculate, basifixed, reddish brown filament, ca. 2 mm long. Ovary ca. 2 mm long, ovoid, glabrous, style undivided, thick with 3 long plumose stigmas. **Caryopsis** ca. 4.5 mm long, elliptic, trigonous, furrowed on one side, blackish-brown with persistent base.



▲ *Fig. 110.* **T. falconeri.** *A - leafy branch; B - flowering branch; C - bracts and spikelets; D - spikelet; E & F - empty glumes; G - flowering glume; H - palea; I - lodicules; J - stamen; K - pistil.*

FLOWERING

It flowers gregariously and the flowering cycle is 30 years. Flowering has been recorded from Sikkim during 1846; from Garhwal and Kumaon Hills during 1876, 1924, 1954 and from Simla during 1897-1900, 1914-1915, 1972 and 1983.

DISTRIBUTION AND ECOLOGY

The species is distributed in North-West India, Uttar Pradesh (Garhwal and Kumaon Hills), North-East India (Sikkim) and West Bengal. This is found mostly in temperate zones at an elevation of 1800-2400 m. It grows on steep mountain slopes, especially on limestone rocky areas. Also found in moist ravines. It forms dense undergrowth in moist temperate forests.

ANATOMY

Leaf epidermal stomata common, arranged in two bands along the veins in 1-2 alternate rows, subsidiary cells appear high-domed, inconspicuous due to over-arching papillae. Interstomatal cells same as long cells but smaller with concave ends. Long cells long and narrow, walls sinuous, ends almost straight; papillae conspicuous, arranged in row in the middle of the cell, solitary or paired. Short cells common, solitary or paired. Cork cells costal inconspicuous to absent, intercostal distinct, larger than the silica cell; silica cells infrequent, not always with cork cells. Silica bodies costal saddle-shaped to cross shaped but horizontally elongated, intercostal rectangular to rod-shaped. Prickles costal and intercostal, frequent, more towards the margins of the leaf, base round with short pointed apex, on the costal zone arranged in rows. Microhairs intercostal, common, bi-celled, small, basal and distal cell equal in length, base filled with vitreous silica. Macrohairs infrequent to rare, costal, present towards the leaf margin, short to medium in length, base slightly raised. In the culm epidermis stomata infrequent to frequent rather widely distributed, slightly sunken, subsidiary cells parallel to high-domed, not surrounded by papillae. Long cells long and narrow, rectangular, walls straight to wavy, ends straight; papillae inconspicuous or absent. Short cells common, solitary or paired; cork cells rectangular conspicuous, numerous; silica cells infrequent, not found always with silica cells, rectangular in shape. Silica bodies distinct, round to oblong. Prickles, microhairs and macrohairs absent (Agrawal and Luxmi Chauhan, 1995.)

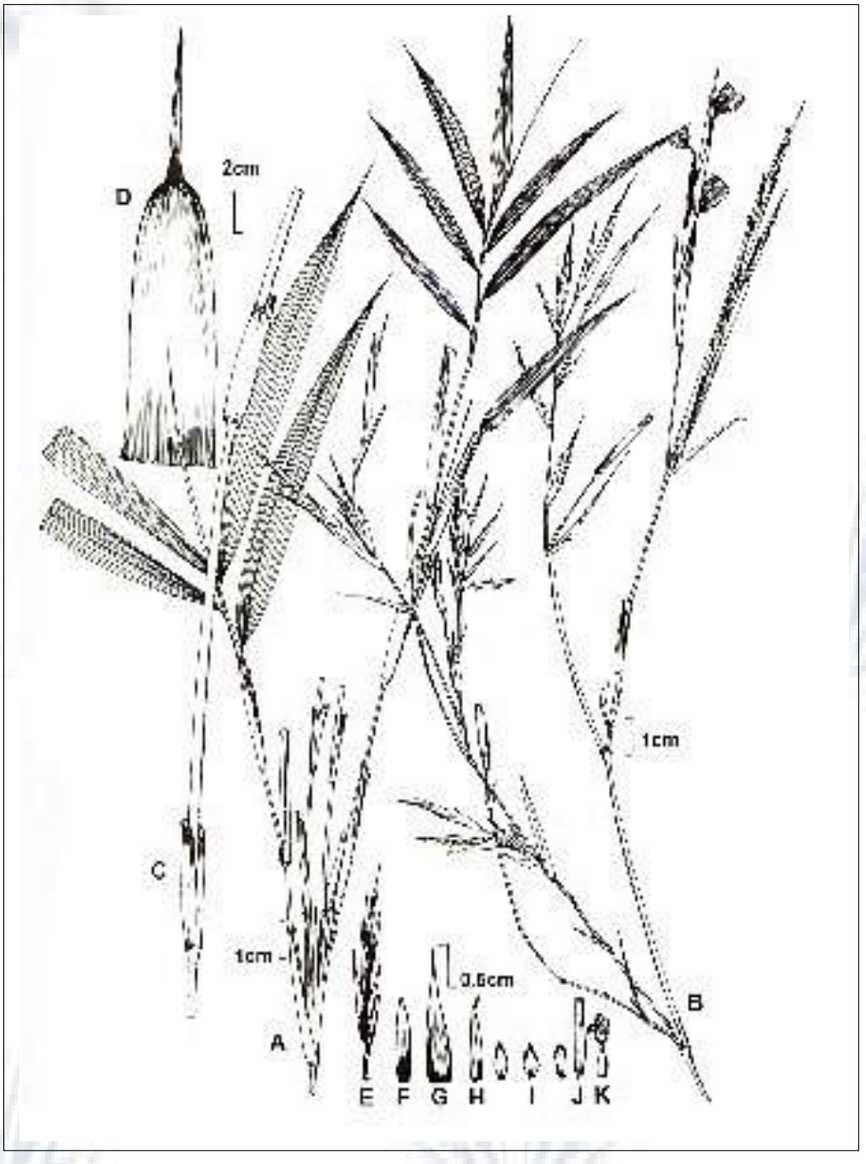
USES

The culms of this bamboo is used for making mats. This is also used as fodder. It is cultivated in Europe as an ornamental plant. The shoots are edible.

Thamnocalamus spathiflorus

Thamnocalamus spathiflorus (Trin.) Munro, Trans. Linn. Soc. London 26: 34. 1868; Camus, Les Bambusees 55. 1913; Rao, Bull. Bot. Surv. India 1: 120. 1959 and 6: 56. 1964; Champion and Seth, Rev. Surv. Forest Types India, 335. 1968; Bahadur, Indian J. For. 2: 238. 1979; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 4. 1980; Varmah and Pant, Indian For. 107: 671. 1981; Tewari, Monogr. Bamboo 151.1992. **(Fig. 111)**.

Arundinaria spathiflora Trin. Mem. Acad. Petersb. Ser. 6: 617. 1835; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 17. 1896 and in Hook. f., Fl. Brit. India 7: 382. 1897; Blatter, J. Bombay Nat. Hist. Soc. 33: 903. 1930; *A. procera* Wallich ex Munro, Trans. Linn. Soc. London 26: 34. 1868.



➤ *Fig. 111.* **T. spathiflorus.** *A - leafy branch; B - flowering branch; C - culm; D - culm-sheath; E - spikelet; F - empty glume; G - flowering glume; H - palea; I - lodicules; J - stamen; K - pistil.*

DESCRIPTION

A densely tufted, shrubby erect bamboo. **Culms** ca. 6 m high and 2 cm diameter, fistular, smooth, glaucous green when young, shining yellow at maturity internode ca. 25 cm long, striate; nodes much raised, dark coloured, marked by a ring formed by the scars of fallen sheath, branchlets chiefly from the upper nodes. **Culm-sheaths** ca. 13 cm long and 5 cm broad, loose, striate, coriaceous, glabrous, ciliate on the edges, light yellow coloured, shining inside, slightly narrowed at the apex with ca. 1 cm broad mouth with few stiff bristles on both sides. Imperfect blade ca. 5.5 cm long, striate, erect, decurrent on the sheath; ligule short, fimbriate. **Leaves** clustered in groups of 2-4 at the ends of short branchlets, ca. 10 cm long and 1 cm broad, linear-lanceolate, attenuate at the base into ca. 5 mm long petiole, ending above in an acute hairy point, glabrous, scabrous on the margins, midrib not prominent from dorsal surface, shining and conspicuous from ventral surface; sheath ca. 6 cm long, loose striate, yellow or black, ciliate on the edges, truncate at the top into a ciliate callus with short auricles having purple bristles; ligule long, dark coloured. **Inflorescence** a drooping panicle, usually on separate leafless branches; panicle 7-9 cm long with 3-6 spikelets; rachis slender bracts 5.5 cm long 0.6 cm broad ending into a callus having bristles and leafy imperfect blade which encloses 3 pedicellate spikelets. Spikelet ca.

5.5 cm long, 5-7-flowered, the upper floret imperfect; rachilla ca. 5 cm long, clavate, hairy at the tip; empty glumes 2, linear lanceolate, ciliate at the tip and edges, thin and membranous, outer glume ca. 13 mm long and 2 mm broad and 6-nerved, inner glume ca. 18 mm long and 2.5 mm broad and 9-nerved; lemma ca. 20 mm long and 3.5 mm broad ovate, lanceolate, long acuminate with ciliate tip, 11-nerved; palea ca. 10 mm long, 2-keeled, ciliate on the keels, 2-nerved on either side of the keel, tip bifid and ciliate; lodicules 3, ca. 2.5 mm long, ovate acute, fimbriate, 3-nerved, one is narrower than the other two. Stamens 3; anthers ca. 8 mm long, basifixed, tip blunt. Ovary ca. 2.5 mm long, oblong, ovoid, glabrous, style short, undivided with 3 long plumose stigmas. **Caryopsis** ca. 4.5 mm, elliptic, trigonous, furrowed, dark brown with persistent base of style and stigmas.

FLOWERING

In this species the flowering cycle is reported to be 16-17 years. Recorded flowering years are 1818-21 by Wallich from North-Western Himalayas, 1863-66 by Gamble, 1881-82 by Brandis from Jaunsar, 1892-93 by Gamble from Jaunsar, 1902 by Collett from Himachal Pradesh and in 1942 by Raizada from Chakrata forests.

DISTRIBUTION AND ECOLOGY

This species is found distributed in North-West India, Kumaon and Garhwal Hills (Utter Pradesh) and Simla (Himachal Pradesh). It grows gregariously as a common undergrowth of evergreen coniferous forests, also found in a variety of forest types, growing in the understory of evergreen forests, less frequent in deciduous forest; generally in moist shady localities at an altitude between 2,400 and 3,100 m.

ANATOMY

In the leaf epidermis, stomata common, intercostal arranged in two bands along the veins in one to two alternate rows, subsidiary cells appear to be high-domed surrounded by large papillae. Long cells long and narrow, walls sinuous, ends straight, papillae inconspicuous to distinct, scattered. Interstomatal cells same as long cells, but smaller in length with concave ends. Short cells costal and intercostal, solitary or paired, cork cells costal inconspicuous, infrequent, intercostal conspicuous, larger than the silica cell. Silica cells costal, distinct, intercostal inconspicuous to distinct, frequent. Silica bodies costal, saddle to cross shaped or dumb-bell shaped, horizontally elongated, intercostal rectangular, tall and narrow to crenate-shaped. Prickles costal and intercostal, confined towards the leaf margins, infrequent to frequent in occurrence, with round base and short pointed apex. Microhairs intercostal, frequent to common, bicelled, basal cell slightly shorter than the distal cell. Macrohairs not seen. Stomata infrequent in culm epidermis, widely distributed, subsidiary cells clear, parallel-sided, not surrounded by papillae. Long cells long and narrow, almost rectangular, walls straight to slightly wavy, thin, ends straight; papillae absent, cells sometimes filled with vitreous silica. Short cells solitary or paired or up to four, cork cells and silica cells not differentiated, almost rectangular in shape, sometimes filled with vitreous silica. Silica bodies, microhairs and macrohairs absent (Agrawal and Luxmi Chauhan, 1995).

PESTS AND DISEASES

Leaf rust caused by *Puccinia melanocephala* is reported at the nursery level.

USES

Culms are strong and used for a variety of purposes. It is used for making mats, baskets, pipes, hookah tubes, fishing rods etc. Considered as an elegant ornamental plant.

R E F E R E N C E S

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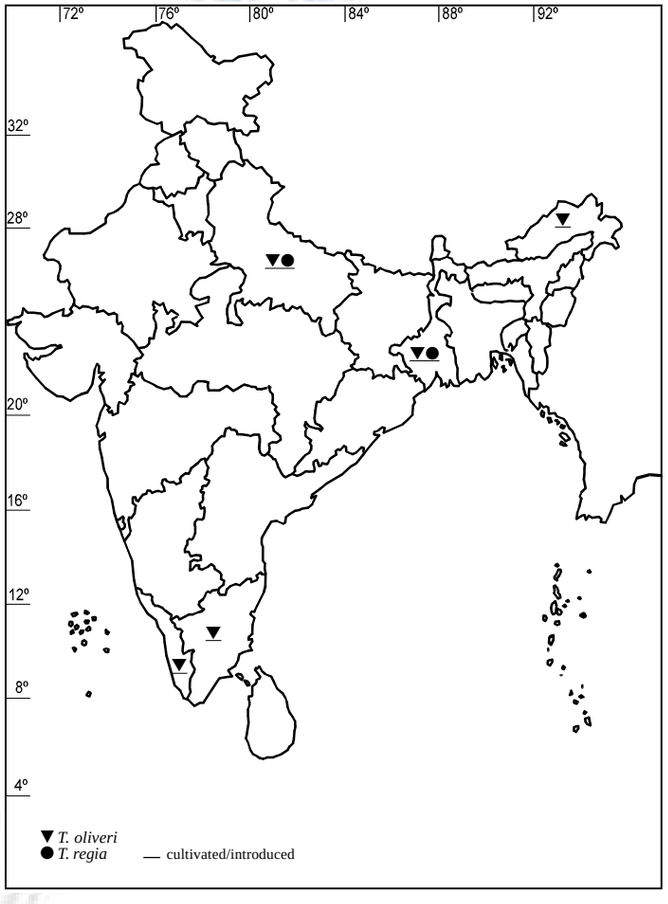
THYRSOSTACHYS GAMBLE

Arborescent bamboo. Culms straight, erect, branching above, often covered with long persistent sheaths. Culm-sheaths elongate, thin; imperfect blade long, narrow. Leaves small to moderate sized. Inflorescence a large compound panicle. Spikelets sessile or stalked in the axils of prominent bracts, 2-3-flowered with a terminal lower flower deeply 2-cleft, 2-keeled; keels ciliate, that of upper flower not keeled or cleft and elongate; rachilla hairy. Lodicules very thin, 1-3, long acuminate. Stamens 6, long exserted; anther mucronate. Ovary depressed, stalked. Style long; stigmas 3, feathery. Caryopsis cylindrical, smooth, glabrous, grooved on one side, long-beaked.

This genus is native of Myanmar, cultivated in several parts of India. Two species have been described in this compendium.



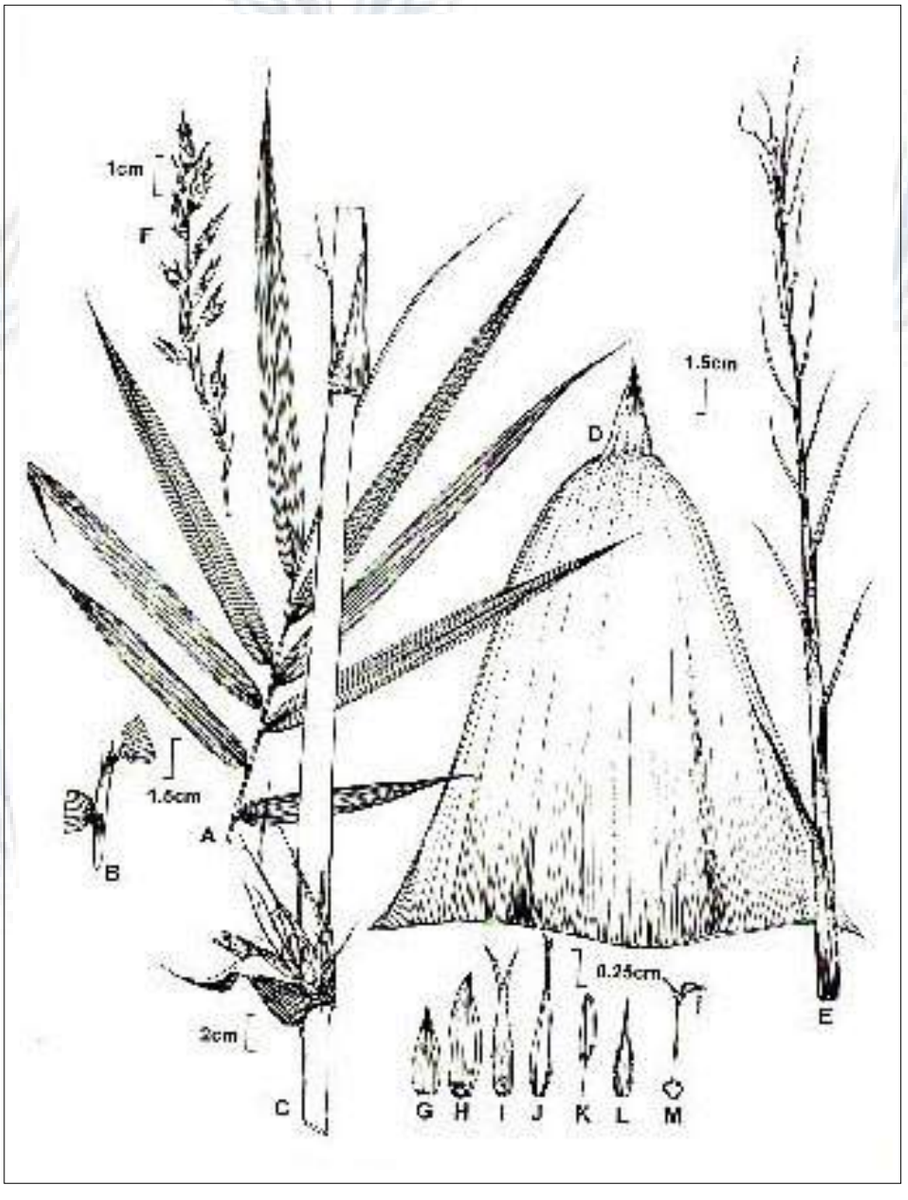
◄*Distribution map of* **Thyrsostachys**

Thyrsostachys oliveri

Thyrsostachys oliveri Gamble, Indian For. 20:1. 1894 and in Ann. Roy. Bot. Gard. Calcutta 7: 58. 1896; and in Hook. f., Fl. Brit. India 7: 397. 1897; Brandis, Indian Trees 671. 1906; Camus, Les Bambusees 137. 1913; Bor, Indian For. Rec. (n.s) Bot. 2(2): 222. 1941; Varmah and Bahadur, Indian For. Rec. (n.s) Bot. 6(1): 4. 1980; Bennet and Gaur, Thirty Seven Bamboos Growing in India 83.1990; Tewari, Monogr. Bamboo 152.1992. **(Fig. 112).**

DESCRIPTION

A large tufted elegant bamboo. **Culms** straight 15-25 m high, ca. 5 cm diameter, bright green with whitish silky surface when young, dull green or yellowish on maturity; nodes hardly thickened; internodes 40-60 cm long, thin walled; branches fascicled at the nodes, lower ones ascending and upper ones horizontal. **Culm-sheaths** fibrous, imbricating at the base, green when young, turning orange and finally brown,



➤*Fig. 112.* **T. oliveri.** *A - leafy branch; B - leafy sheath; C - culm with branches; D - culm-sheath; E - young shoot; F -spikelet; G & H - empty glumes; I - flowering glume; J - palea; K - stamen; L - lodicules; M - pistil.*

persistent, clothed on the back with thick, white, stiff, pubescence, rounded at the top margins thin and ciliate; ligule ca. 4 mm high, dentate; auricles 2, very small, triangular blade upto 23 cm long, 2-3 cm broad, recurved, awl-shaped, hairy on both surfaces. Young shoots cone shaped, orange mixed with light green colour, covered with white hairs blade narrow erect. **Leaves** 15-20 cm long and 1.2-1.5 cm broad, light green, linear-lanceolate, acuminate, base rounded into a short petiole, both surfaces rough, hairy beneath, scabrous on the margins. **Inflorescence** a large compound curved, thyrsoid panicle, with usually one long and two shorter flower- bearing spikelets and one or more sterile ones; rachis flexuose, hairy, swollen at the top; bracts straw coloured, blunt; sheath 1.2-2.4 cm or more long, sometimes with a deciduous, green imperfect blade. Spikelets 1.5-2.5 cm, longer ones with long jointed rachis, shorter ones with very short joints; rachis hairy, flexouse; fertile flowers 2-3, with an uppermost rudimentary flower on a slender terminal rachilla; empty glumes 2, ovate-acute, ca. 1.3 cm, striate, many-nerved with conspicuous transverse veinlets, sparsely hairy outside; flowering glume similar, 2-5-nerved and hairy between the keels, divided often one-fourth of the way down into long hairy cleft, glabrous except the acute tip, many-nerved; rachilla hairy; lodicules 2, lanceolate, acuminate, ciliate, very thin. Stamens long exserted, drooping; filaments purple; anthers yellow, the connective protruded into a blunt point. Ovary yellow, depressed-turbinate, stalked, surmounted by a long style, bearing three broad feathery stigmas. **Caryopsis** about 1 cm long, glabrous, cylindrical, with a somewhat broader top, spongy below, ending in a long beak formed by the persistent base of the style; pericarp crustaceous, shining above.

FLOWERING

Flowering cycle is reported to be 48-50 years. This species gregariously flowered in Myanmar in 1891. The plants raised at Dehra Dun flowered in November 1938 and seed ripened in January 1939. It flowered in 1962-63 at Haldwani (U.P.) and during 1986 and 1987 at Dehra Dun (Rawat, 1987). Flowers are protrandrous, three florets are hermaphrodite, only the uppermost floret produces a seed. At the time of flowering all the foliar leaves turn yellow and fall away and the whole clump is gradually transferred into a gigantic inflorescence. Majority of the floriferous shoots are apical elongations of ordinary branches, some are special lateral shoots from an ordinary branch.

DISTRIBUTION

This species is a native of Myanmar. Planted in Indian Botanic Gardens Calcutta, FRI, Dehra Dun, Haldwani in Uttar Pradesh and Chessa in Arunachal Pradesh. *T. oliveri* is also found in many other places as the seeds from Haldwani has been distributed to many forest divisions in Uttar Pradesh and in some other states (Rawat, 1987). Plantation trials were conducted in 1940 in Palghat, Nilambur and Wynad (Kerala) and Coimbatore (Tamil Nadu) and it has established very well.

ANATOMY AND FIBRE CHARACTERISTICS

In the culm epidermis, long cells rhomboidal with straight walls, papillae in single large groups, guard cells of stomata dumbbell shaped, subsidiary cells absent, spicules present. Internodal structure shows heterogeneous cortex with hypodermis, complete peripheral vascular bundles, scattered fibres also present, in transitional vascular bundles only phloem cap distinct, central vascular bundles all with six fibre groups, lining of the cavity parenchymatous (Pattanath and Rao, 1969).

Fibre characteristics showed a fibre length of 2.50 mm, fibre diameter 15.47 µm, lumen diameter 5.41 µm, wall thickness 5.52 µm, parenchyma 20.2 per cent. Fibre length varies in different parts of the same culm. The fibre length of different part of this species in mm is as follows: 2.0, 1.9, 1.89, 1.88, at bottom, one-fourth, middle and three-fourth height of the culm respectively (Pattanath, 1972). The fine structure of thick walled bamboo fibres is polylamellate. Its

➤ **T. oliveri** - *A clump*

➤ **T. oliveri** - *A new shoot*

➤ **T. oliveri** - *Close-up of a new shoots*

composition is such that narrow lamella regularly alternate with the broader ones, whereby the width of the broad lamella varies. The microfibrillar angle varies from 80-90° to the cell axis, while in the broad ones the fibrils are almost parallel to the axis (Parameswaran and Liese, 1976).

CHEMISTRY

Elemental analysis of lignin in this species showed carbon 60.27 per cent, hydrogen 6.37 per cent, oxygen 32.36 per cent methoxyl 9.78 per cent molecular weight 2718, empirical formula $C_9 H_{11.51} O_{3.69} (OCH_3)_{0.57}$, number of C_9 units 14. Beating characteristics have shown caustic soda 22 per cent, kappa no.27.2, lignin in bamboo 20.9 per cent, in pulp 3.0 per cent, pentosan in bamboo 18.5 per cent, in pulp 17 per cent, pulp yield unscreened 48.9 per cent, screened 37 per cent (Singh and Bhola, 1978).

SILVICULTURE AND MANAGEMENT

When seeds are sown soon after collection, hundred percent germination has been recorded (Rawat, 1987). Preliminary investigations on rooting of 1-3 year old culm cuttings indicated the possibility of rooting (Dabral,1956). Recent observations showed that 80 per cent rooting can be obtained in cuttings taken from basal one-third of the culms and treated with a solution of NAA 250 ppm, by dip method (Seethalakshmi, 1995).

Work carried out on tissue culture showed the possibility of multiple shoot induction and rooting. Various explants used were nodes, shoots and leaves (Zamora, 1994).

Growth data from bambusetum established in Bangladesh during 1986 have shown that the culm height varied from 1-7 m, average height being 4 m, girth varied from 2-7 cm, average being 4.5 cm and total number of culms per/clump being 11. Observations on growth of clumps from 1983-1986 from a plantation established in 1963 have shown that the removal of older culms enhances new culm production (Chaturvedi, 1986).

PESTS AND DISEASES

Culm rot caused by *Fusarium oxysporum*, culm necrosis caused by *Curvularia lunata* sp., leaf rust caused by *Puccinia* and *Helminthosporium* sps., rhizome and root rot caused by *Merulius eurocephalus* have been reported.

PHYSICAL AND MECHANICAL PROPERTIES

Strength properties of this bamboo showed moisture content of 53 per cent in green and 7.8 per cent in air-dry. Similarly, specefic gravity in green is 0.733 and in air-dry 0.758. Fibre stress at elastic limit is 33.3 in green and 50.6 N/mm^2 in air-dry condition. Modulus of rupture is 61.9 in green and 90.0 N/mm^2 in air-dry. Modulus of elasticity is 9.7 and 12.2 kN/mm^2 in green and air-dry respectively. Compression strength parallel to grain is 46.9 N/mm^2 in green and 58.0 N/mm^2 in air-dry.

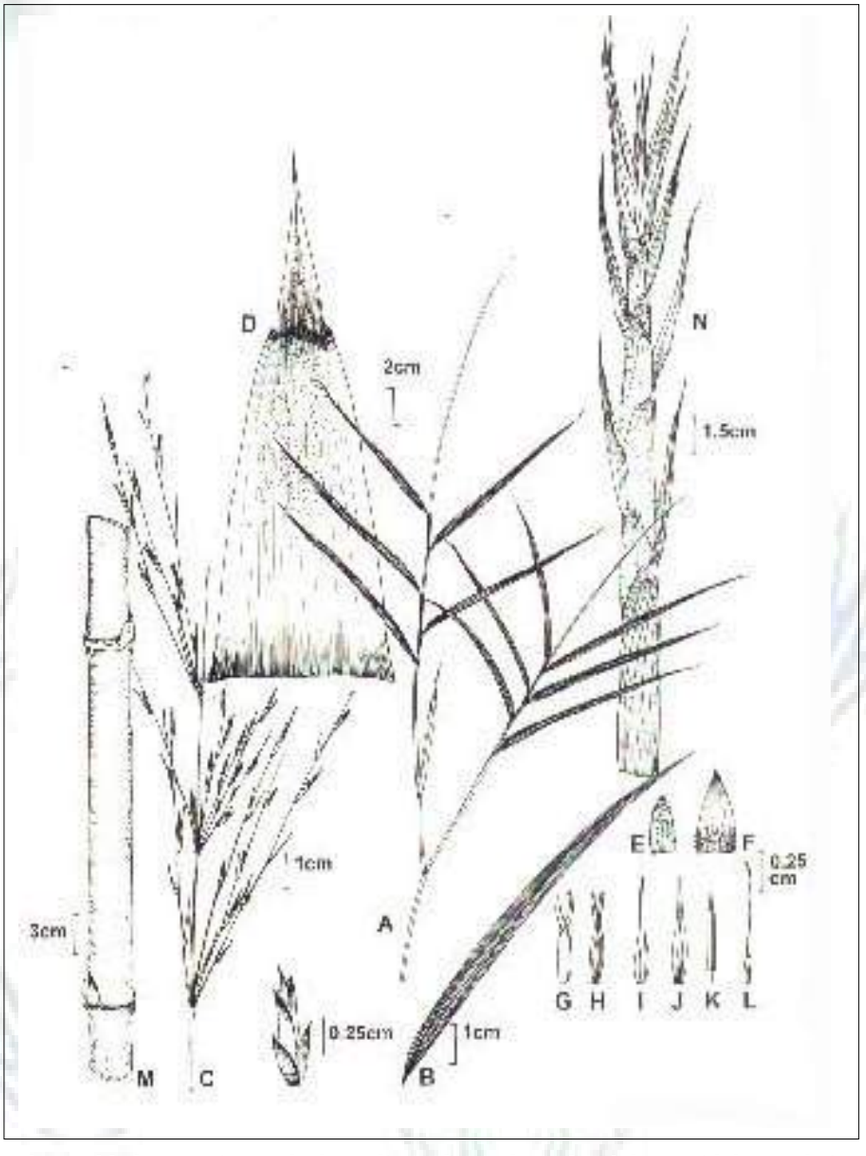
USES

Culms are in great demand for construction purposes in Myanmar; reinforcement for concrete slabs, poles, basketing and handicrafts (Ramyarangsi, 1990). Young shoot is commonly used in Thailand for edible purposes. This species is used for canning in Thailand for the production of steamed bamboo shoots for export (Thammincha, 1990).

Thyrsostachys regia

Thyrsostachys regia (Munro) Bennet, Indian For. 114: 711. 1988; Bennet and Gaur, Thirty Seven Bamboos Growing in India 85. 1990; Tewari, Monogr. Bamboo 155.1992. **(Fig. 113).**

Bambusa regia Munro, Trans. Linn. Soc. London 85: 116. 1868, non *B. regia* Thomson nom. invalid; *Thyrsostachys siamensis* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 59. 1896 and in Hook. f., Fl. Brit. India 7: 397. 1897; Camus, Les Bambusees 137. 1913; Varmah and Bahadur, Indian For. Rec. (n.s.) Bot. 6(1): 4. 1980.



➤ *Fig. 113.* **T. regia.**
A - leafy branch; B - leaf; C - flowering branch; D - culm-sheath; E & F - empty glumes; G & H - paleas of lower flower; I & J - paleas of upper flower; K - stamen; L - pistil; M - a portion of culm; N - new shoot.

DESCRIPTION

A very graceful, tufted bamboo. **Culms** 8-10 m high and 4-5 cm diameter, straight, thick-walled, usually covered with the persistent culm-sheaths; internodes 20-30 cm long, green. **Culm-sheaths** 20-25 cm long, 10-20 cm broad, covered with fine white pubescence on the back, attenuate into a 3.5-4 cm broad, truncate top; ligule 2 mm high, narrow, slightly or irregularly toothed, finely ciliate; auricles short, triangular; blade 10-13 cm long, erect, narrowly triangular, edges incurved. In young shoots, blades tapering at the base, linear-lanceolate, sheath long with brown hairy margin. **Leaves** 8-15 cm long and 0.8-1.2 cm broad, narrow, linear, glabrous, short-stalked. **Inflorescence** a large graceful panicle, with many thin branchlets, bearing bracteate clusters of few fertile spikelets which are pedicellate and intermixed with sterile ones, the bract boat-shaped, glabrous, truncate at tip; rachis smooth, very fine wiry, curved, clavate. Spikelet nearly white, 3-flowered; empty glumes 2, 7.5-10 mm long, ovate-acute, covered at the base with long, white pubescence, about 4-nerved on either side; palea of lower flowers narrow, 2-keeled, ciliate on the keels, cleft half-way down into narrow ciliate tails, that of the uppermost flower not keeled but bi-mucronate, concave, striate, glabrous, gradually attenuate into a long beak, longer than the flowering glume; lodicules none. Stamens exserted; filaments free; anthers pale yellow, narrow, connective produced into a conical purple mucro. Ovary at first oval, afterwards depressed, flattened, attenuated,curved stigmas. **Caryopsis** ca.5 x 2.5 mm, cylindric, surmounted by an yellowish, glabrous soft apex which is produced into a long beak, sulcate on one side.

FLOWERING

Flowering has been reported from Indian Botanic Gardens, Calcutta in 1892; from FRI, Dehra Dun in 1941 and 1989 (Naithani, 1990). At Penang, it flowered in 1948 and in Singapore in 1949 (Holttum, 1958). In its native country, Thailand. this species is reported to flower every year (Anantachote, 1987). In India, it flowers only at intervals of more than 40 years.

DISTRIBUTION AND ECOLOGY

This species is mainly distributed in Thailand and Myanmar. Cultivated in Malaysia, India and China. It was introduced in Indian Botanic Gardens, Calcutta before 1892 and FRI, Dehra Dun before 1941. Mostly occurs in dry and poor soil. Chaomao (1987) mentions it as an intolerant bamboo and grows on south ridge of mountains in Thailand and Myanmar.

CHEMISTRY

The chemical composition of culms is approximately holocellulose 68 per cent, lignin 24 per cent, pentosans 17 per cent, ash 2 per cent, solibility in hot water 5.7 per cent and in alcohol-benzene 6.1 per cent.

SILVICULTURE AND MANAGEMENT

Weight of seeds collected from different provenances of Thailand showed a variation of 14.5 to 82 g per 40 seeds. The germination percentage varied from 1 to 86 per cent (Anantachote, 1987). Seed viability can be extended by proper storage with control of moisture content and temperature (Ramyarangsi, 1990). *In vitro* callus induction has also been observed.

PESTS AND DISEASES

The seed-borne fungi recorded from Thailand include *Alternaria tenuis*, *Curvularia lunata*, *Fusarium semitectum* and *Myrothecium* sp. (Anantachote, 1987).

USES

In Thailand, tender shoots are considered as delicacies, consumed fresh or made into pickles. It is used as vegetables and in dried forms. *T. regia* is grown as ornamental in China and Malaysia.

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GLOSSARY

A

abaxial : the side facing away from the axis of the plant *syn*. dorsal, opp. ventral

abjoint : to separate at a joint

abrupt : terminating suddenly as though cut off

acantha : a spine, prickle, or thorn

acanthocephalous : having a hooked beak

accrescent : increase in size with age

accumbent : lying against and face to face; lying in contact; reclining

acerate, acerose : having the shape of a needle; needle-like

acicular : needle-shaped, having needle like projections

aculeate : prickly, thorny, armed with spines

acuminate : having a long, slender, sharp point with concave sides, margins straight to convex

acute : sharp-pointed, margins straight to convex

adaxial, adaxial surface : the sides towards the axis; the surface of a leaf that faces the stem during development, eg. the upper side of the leaf. *syn*. ventral

adelphous : stamens united by their filaments

adherent : a condition where two dissimilar organs touch each other but are not fused together

adnate, adnation : organically united or fused with another dissimilar part

adpressed (appressed) : lying flat for the whole length of the organ

adventitious : plant organs produced in an unusual or irregular position as in adventitious buds, roots or shoots

adventitious embryo, the embryony : an embryo found without fertilization, which develops directly from the outer tissue of parental sporophyte, usually from the integument of the nucellus

affinis : closely related to another

affinity : similarity between entities in regard to morphological traits

aggregate : clustered together to form a dense mass or head, usually applied to an inflorescence

albino : a plant having colourless chromatophores due to lack of chlorophyll

alluvial soil : a type of azonal soil which is highly variable and is classified by texture from fine clay/silt soils through gravel and boulder deposits

alluvium : soil, usually rich in minerals, deposited by water, as in a flood plain

alternate : arrangement of leaves or plant part which are not opposite or whorled out are placed singly on the axis or stem at different heights

amplexicaul : clasping the stem, as the base of certain leaves

ancipital : two-edged; flowered or compressed axis stems of certain grasses

anemophilous, anemophily : referring to flowers which are wind-pollinated

aneuploid, aneuploidy : an organism whose somatic chromosome number is not an exact or even multiple of the basic haploid number

aniso : a prefix meaning unequal

anisolateral : with unequal sides

anisomerous : with unequal number

antrorse : bent or directed upwards or forward. opp. retrorse

aperturate : with aperture, an opening

apex, apices : the tip, the terminal end

apical : at, near, or belonging to the apex or point of the tip

apiculate : a short, abrupt or acute point

apomixis : reproduction, including vegetative propagation, which does not involve sexual processes; the ability of plants to produce seeds without fertilization

appendage : an attached subsidiary or secondary part, as a projecting or hanging organ

applanate : flattened horizontally; without vertical curves or buds

appressed : closely and flatly pressed against the entire length of an organ or part

approximate : close to each other but not united

arborescent : of tree like habit; resembling a tree in growth or appearance

arboretum : a place where trees, shrubs, and other plants are grown for scientific and/or educational purposes

arcuate : moderately curved or arched, like a bow

arista : a bristle-like appendage as on the glumes of many grasses; a bristly awn

aristate : bearing a stiff bristle-like awn or seta; tapering to a narrow elongated apex

aristulate : bearing a small awn

articulate : jointed

asymmetrical : lacking symmetry; irregular in shape or outline

attenuate : with a long, slender taper, more gradual than acuminate; applied to base or apices of parts; gradually tapering

atypical : not typical, departing from the type form

auricle : an ear-like lobe

auriculate : bearing auricles

auriculiform : usually obovate in outline with two small rounded basal lobe

awl-shaped : narrow and gradually tapering to a sharp point; sharp-pointed from a broader base

awn : a bristle like appendage or part of, as in the back or at the tip of glumes and lemmas of many grasses

axial : of or pertaining to an axis, especially main axis

axil : the angle between the stem axis and a leaf petiole, branch or other appendage attached to it

axile : of, belonging to, or located in the axis; central in position

axillary : in an axil

axis, pl. axes : the main stem of a plant; the main or central line of development of any plant or organ

B

bacca : fruit with thick fleshy pericarp separated from seed coat

baccate : like a berry, pulpy or fleshy

bacciferous : producing berries

bacciform : shaped like a berry

BAP : benzyl amino purine

barbate : bearded with long stiff hairs (trichomes), usually in a tuft, line or zone

barbed : bristles or awn that have short-terminal or lateral spine like hooks that are bent sharply backward

barbellate : with short, usually stiff hairs

barbellulate : finely barbed

basicaulous : near the base of the stem

basifixed : a structure attached or fixed by its base to a support

beak : a firm, slender projection on certain fruits seeds and carpels

beaked : ending in a beak

beard : a cluster of bristle-like hairs or awns

bearded : bearing 1ong or stiff hairs

berry : a fruit developed from an ovary containing one to several carpels in which the ovary wall and the inner structures of the ovary become enlarged and juicy, seeds within have their own hard seed coat

BHC : benzene hexachloride

bifid : forked; two-cleft; divided into two parts or lobes

bifurcate : divided into two forks or branches

bilobed : having two divisions, often rounded

bilocular : two-celled or with two locules

biotic : pertaining to life

bipartite : divided into two parts almost to the base

bisected : completely divided into two parts

biseriate : in two whorls or cycles; in two rows or series

biserrate : margin type with smaller sharply cut teeth on the margins of larger sharply cut teeth; doubly-serrate

blight : a plant disease where there is a sudden wilting or death of plant parts.

bract : a modified, often much reduced leaf subtending a flower or inflorescence; morphologically a foliar organ

bracteate : possessing or bearing bracts

bracteolate, bracteole : possessing small bracts; a secondary bract, often very small

bracteose : having many bracts

bractlet : a small secondary bract-borne on a pedicel as petiole, instead of subtending it

bristle : a stiff strong trichome (hairs)

bud : an undeveloped shoot containing the embryonic meristems which develop into flowers, stem, or leaves, and are enclosed in protective specialized leaves termed bud scales

bud scales : specialised protective leaves which cover the shoot apex and embryonic leaves of a winter bud, preventing dessication and injury

bud scale scars : scars left on a twig by the abcision of bud scales from the terminal buds of the previous year

bulliform cells : large, thin-walled cells present in the leaves of most of monocots

bundle cap : sclerenchyma or thick-walled parenchyma associated with a vascular bundle and appearing like a cap on the phloem or xylem side, as seen in cross-section

bundle sheath : a special layer, or layers of cells which enclose the vascular bundles of dicot and monocot leaves. The cells are of often parenchyma or some times of sclerenchyma

butt : the base of a plant from which the root springs

C

caducous : falling or dropping off very early

caespitose : see cespitose

calcarate : with a spur; spurred

callus : a tissue composed of large thin-walled parenchyma cells which develop on or below a wounded surface often resulting in a firm thickening or protruberance

calyculus : a simulated calyx composed of bracts or bractlets

campanulate : bell-shaped

canescence, canescent : covered with dense, fine, greyish-white hairs; becoming hoary, usually with a grey pubescence

canopy : the cover or horizontal projection of the vegetation of a plant formed by its leaves, branches etc.

capillary, capillate : very slender, resembling a hair

capitate : formed like a head; aggregated into very dense clusters or heads

carnose : fleshy

cartilaginous : like cartilage in texture; firm and elastic

caryopsis : a one-seeded, dry, indehiscent fruit with the seed coat adnate to the fruit wall (pericarp), derived from a one-loculed superior ovary; the grain or fruit of grasses

caudate : bearing a tail, or tail-like appendage

caudex : a shoot thickened, often woody, vertical or branched perennial stem, usually subterranean or at ground level

cellulose : a complex carbohydrate, the chief component of the cell walls of most plants; it consists of long chain-like molecules of glucose which form microfibrils

ceraceous, ceriferous : waxy; wax-bearing

cernuous : nodding or drooping

cespitose, caespitose : matted, growing in tufts or small dense clumps; plants forming a cushion

chartaceous : papery in texture, opaque and thin

ciliate : fringed with conspicuous hairs along the margins

clasping : a leaf blade which partly or wholly surrounds the stem

clavate : club-shaped; gradually thickened towards the apex from a slender base

claw : the modified auricle of some grass leaves

closed bundle : a vascular bundle in which a cambium does not develop

closed venation : leaf characterised by anastomosing veins

comose : bearing a tuft of trichomes, usually apically

coleoptile : a protective sheath like structure enclosing the epicotyl in seeds of grasses

concrescent : growing together of parts originally separate

congeneric : belonging to the same genus

conglomerate : densely clustered

connate : union or fusion of like parts or organs to one another

connate-perfoliate : opposite, sessile leaves, instead at their bases, surrounding the stem

connective : an extension of the filament, connecting the two cells of an anther

conspecific : within or belonging to the same species

convolute : rolled up longitudinally and usually twisted apically

cordate : heart-shaped, having notched end at the base and the pointed end at the apex

coriaceous : thick, tough and leathery

corniculate : bearing or terminating in a small horn-like process

corrigate : irregularly folded or wrinkled

crassinucellate ovule : one of two general type of nucellar organization found in angiosperms in which the megasporocyte forms a sporogonous cell deeply embedded with in the nucellus

crenate : shallowly ascending round toothed or teeth obtuse

crispate, crisped : irregularly curled leaf margin or trichome

crustaceous : hard, thin and brittle

cucullate : hooded or hood-shaped

culm : the stem of a grass or sedges

culm leaf : consists of a sheath, blade, ligule and auricles

culm sheath : the sheath of the culm leaf, borne singly at each node of the culm proper, below the level at which the sheath of foliage leaves originate

cuneate, cuneiform : wedge-shaped; triangular, with the narrow part at the point of attachment

cuspidate : with an apex somewhat abruptly and sharply constricted into an elongated, sharp-pointed tip or cusp

cuticle : a noncellular layer of waxy or fatty materials on the outer wall of epidemal cells

cutting : a vegetative portion removed (cut) from a plant for the purpose of propagation

D

damping off : a fungal disease of seedlings which causes them to rot and shrivel at soil level, or to die before they emerge from the soil

deciduous : the falling of parts at the end of a growing period

declinate : bend or directed downwards or forward

decumbent : a growing habit in which a portion of the stems or shoots lie close to the ground, without rooting adventitously, the upper parts of the stem are erect or ascending

decurrent : an extension of tissue occuring down the stem below the point of insertion of a leaf petiole or ligule, forming a wing or ridge

decussate : opposite leaves alternating at right angles with those above and below

deflexed : reflexed; bent or turned abruptly downward

dentate : with toothed margin

denticulate : minutely toothed, finely dentate

depressed : pressed downward close to the axis

determinate : growth of limited duration

determinate inflorescence : an inflorescence in which the terminal or central flower develops first, thereby asserting further elongation of the inflorescence axis

dichogamy : in a bisexual flower, maturation of stamens and stigma at different times, thus preventing self-pollination

dichotomous : branching by repeated forking in pairs

dieback : a progressive death of plant shoots beginning at the tip

diffuse : the loosely branching or spreading; widely spread

digitate : finger like

dilated : flattened and broadened

dimidiate : unequally divided in two

discrete : separate, not coalesced

dissected : deeply divided

distal : opposite from the point of origin or attachment towards the apex

diurnal : opening during the day

DMSO : dimethyl sulphoxide

dorsal : the lower or undersurface of a leaf; abaxial

E

ebracteate : without bracts

ecotone : a transition zone; a region of overlapping plant association, between two adjascent ecosystems

edaphic : pertaining to, or influenced by, soil conditions

elliptical, elliptic : oval in outline but widest about the middle

emarginate : bearing a shallow notch at the apex

endemic : native or confined naturally to a particular and usually very restricted geographical area or region

endocarp : the innermost layer of the pericarp or fruit wall

ensiform, ensate : sword-shaped

entire : without indentations or incisions on the margin; smooth

epicotyl : portion of the axis of an embryo

erect : directed towards summit, not decumbant

explorate : spread out flat

explant : an exised tissue or organ fragment which is used to initiate an *in vitro* culture

exserted : projecting beyond, sticking out or protruding

extrorse : opening or facing outwards

F

falcate : sickle-shaped

fallow : agricultural land left uncultivated for one or more seasons to allow for the accumulation of moisture, destruction of weeds, and the decomposition of organic matter

fariaceous, farinose : covered with a mealy powder

fascicle, fascicled : a close cluster of flowers, leaves etc. in groups (bundles)

filiform : thread like, flexuous

fimbriate : margins fringed, with long and coarse hairs

fistular, fistulose : hollow and cylindrical

fibre : long, narrow cell of wood or bark other than vessel or parenchyma elements

fibre saturation point : the point at which there is no more free water in the culm, but the cell walls are still saturated with water

flagelliform : whip-shaped

flexibility ratio : parameter used by the pulps and paper industry, desired from the fibre dimensions of the culm, fibre lumen diameter divided by fibre diameter, multiplied by 100

flexuous : coarsely sinuous or wavy; curved alternately in opposite directions

FRI : forest research institute

FTIR : fourier transform infra-red

furcate : forked

fusiform : spindle-shaped

G

gemmiparous : producing a bud or reproducing by a bud

germplasm : collection of genotypes of an organism

geniculate : abruptly bent at a joint, like a bent on knee

genus : the smallest natural group containing distinct species

gibbous : swollen on one side near the base

girdle : a conspicuous horizontal band of tissue inserted circumaxially at the node of some bamboos

glabrous : without pubescence; not hairy

glans : a fruit with hard, smooth crustaceous pericarp separated from seed coat

glaucous : covered with a removable waxy coating which gives the surface a whitish or bluishs green cast

globose, globular : spherical or rounded

glomerate : in dense or compact clusters or head

glumes : a pair of small scale like bracts subtending a grass spikelet

glutinous : with sticky exudate

gregarious : growing in groups or colonies; in bamboos, gregarious flowering is used to indicate that a whole population flowers over a period of time

H

habit : the general appearance or characteristic form of a plant, or other organisational erect, prostrate, climbing etc.

habitat : the natural environment of an organism; the place where it is usually found

hemi : a prefix meaning half

hemicellulose : a polysaccharide resembling cellulose but more soluble and less complex; a common component of the cell wall matrix

herbarium : a collection of dried and pressed plant specimens, systematically arranged and labelled; used for taxonomic studies

heterogeneous : not uniform

hexaploid : having six haploid chromosome sets (6n)

hilum : a scar on a seed marking the point of attachment to the funiculus

hirsute : covered with rather rough and stiff hairs

hispid : covered with long, stiff trichome; usually stiff enough to penetrate the stem

hoary : coverd with a white or greyish-white pubescence: syn. canescent

holosericeous : covered with fine and silky pubescence

holotype : the single specimen, the type specimen designated to carry the name of a new species

homogenous : uniform, alike; having the same nature or consistancy

homonym : in nomenclature, a name rejected because it duplicates a name previously and validly published for a group of the same taxonomic rank and based on a different type

humus : decomposing organic matter in the soil

hypogeal, hypogean : describing seed germination in which the cotyledons remain beneath the surface of the soil

I

IAA : indole acetic acid

IBA : indole butyric acid

imbricate : with margins of structures overlapping

incanescent : becoming grey

incised : leaf margins cut sharply, irregularly and deeply

incrassate : thickened

increment : addition, increase

incumbent : lying or leaving upon; anthers turned inward

incurved : curved inward or upward

indefinite : indeterminate

indehiscent : not dehiscent, remaining closed at maturity

indeterminate growth : unrestricted growth, as with a vegetative apical meristem, capable of producing an unlimited number of lateral organs

indigenous : native to a region or country

inflexed : bent abruptly inward

innate : borne at the tip of a supporting structure

imperfect stage : the part of life cycle which reproduces only by asexual means

inserted : growing upon or attached to

integument : the outer cell layer which surrounds the nucellus of the angiosperm ovule and develops into the seed coat

intercoastal : space between ribs

internode : the portion of the stem between two successive nodes

introduced : brought into one area or region from another

introrse : turned inward towards the axis; as the opening of an anther towards the inside of a flower

invaginated : enclosed within a sheath

inverted : upside down; turned over

involute : margins rolled or turned in over the upper or ventral surface

isotype : a specimen of the type collection other than the holotype; a duplicate of the holotype

isozymes : different forms of the same enzyme

K

keel : a sharp crease or ridge; the two united petals of a paplionaceous flower

keeled : having a keel, sharply creased

KFRI : kerala forest research institute

kiln dried : being seasoned in a kiln

KN/mm^2 : kilo newton per millimetre square

kraft pulp : sulphate pulp

L

labiate : lipped; having a lipped structure

lacerate : cut irregularly, appearing torn, as in certain leaves and ligules

laciate : cut deeply into closely parallel, narrow divisions

lamella : a thin plate or layer of photosynthetic membranes

lamina : thin and flattened, a leaf blade

lanate, lanose : woolly, cottony, covered with long, fine, intertwined trichomes (hairs)

lanceolate : much longer than broad; widened above the base and tapering towards the apex

lateritic soil : a relatively infertile soil characteristics of tropical and subtropical areas, usually red in colour due to the presence of iron oxides, they are highly acidic and have little organic matter

lax : loose, not densely packed

leach : downward movement of minerals through the soil by percolating water

leaf scar : a scar or mark left on a stem when a leaf falls, indicating the former place of attachment of the petiole or leaf base

leaf sheath : the basal portion of a leaf blade or petiole that more or less completely surrounds the stem

lectotype : a specimen selected from the original collection of plant material, to serve as the nomenclatural type when the holotype is missing, or if it was not designated when the taxon was first published

lemma : one of the pairs of bracts (lemma and palea) that subtends the floret. The lemma is lower, usually larger, and frequently bears an awn, which is the extension of its midrib

lenticular : lens-shaped; double convex with two edges

leptomorph : one of two general type of rhizomes, characterised by a slender stem, long internode and indeterminate growth

librifom fibre : a xylem fibre commonly with thick walls and simple slit-like pits

lignin : a complex organic substance derived from phenylpropane and distinct from carbohydrates

ligule : a membranous out growth on the upper surface of a grass leaf at the junction of the sheath and the blade. It may be presented by a ridge or by a line of hairs; an elongated flattened strap shaped structure

linear : long and narrow with sides parallel

lobate : divided into lobes

lodicule : one of two or three minute hyaline scales of the base of the stamens of most grasses (poaceae)

longitudinal : lengthwise

lumen : the space enclosed by the walls of an organ, such as the central cavity of a cell. the central cavity of a hollow internode of a bamboo plant

M

maculate : spotted or blotched

marginate : having a distinct margin

membranaceous, membranous : thin, soft, flexible, and more or less translucent

meristem : undifferentiated tissue of the growing points whose cells are capable of dividing and developing into various organs and tissues

mesophyll : the photosynthetic tissue between the upper and lower epidermis of a leaf

microclimate : the climate in the immediate vicinity of an organism

microfibril : the primary structural components of a plant cell wall, composed of chain-like cellulose molecules

micropyle : a small opening with integuments of an ovule through which the pollen tube usually enters to reach the nucellus

midrib : the main vein of a leaf which is a continuation of the petiole

middle lamella : an inter cellular substance, composed mostly of pectic compounds, that counts the primary walls of contiguous cells

modulus of elasticity (MOE) : modulus of elasticity (in N/mm^2) indicates the ratio between the bending stress in the material and the relative deformation caused by this bending stress; it is a measure of rigidity

modulus of rupture (MOR) : fibre stress at maximum load, maximum fibre stress, ultimate bending stress necessary to bring about future of the tested material when bent (in N/mm^2)

moisture content (MC) : the weight of water in the culm expressed as a percentage of the dry weight of the culm

monadelphous : stamens united by connation of their filaments into a single group forming a tube or column

monopodial : a form of branching in which lateral branches usually originate at some distance from the apex of the main axis. In bamboos, a primary axis continues its original line of growth from the same apical meristem to produce successive lateral branches

mosaic : with a variegated or mottled appearance

mother cell : precursory cell

mottled : with blotched or spotted appearance

MS medium : murashige and skoog's medium

mucronate : terminated abruptly in a short stiff point

multicoastal : many-ribbed

muricate : rough, as a surface covered with many minute, sharp protruberances

muticous : pointless, blunt, awnless

N, O

NAA : naphthalene acetic acid

naturalized : an organism which is well-established and reproducing in one area but originally came from another area, introduced to a new area

neck : the constricted basal part

necrosis : the death of cells

N/mm² : newton per millimetre square

node : a region on this stem where leaves are attached; or the point of branching of the stem

nomenclature : naming of things, particularly organisms; correct usage of scientific name used in taxonomy

nucellus : the tissue of an ovule, from which the embryo sac develops

obcordate : inversely cordate with the notch at the apex

oblanceolate : inversely lanceolate; with the broadest portion nearest the apex and tapering toward the base

oblique : slanted; with unequal sides

oblong : much longer than broad with nearly parallel sides

obovate : inversely ovate, with the terminal half broader than the basal

obtuse : blunt or rounded at the apex

offset : a short, lateral shoot or branch which develops from the main stem producing a means of vegetative propagation

orbicular, orbiculate : more or less circular in outline or shape

oval : broadly elliptical, the width more than half the length

ovate : egg-shaped in outline, with the axis widest below the middle

ovoid : an object that is oval in outline

ovulate : bearing ovules

P

pachymorph : one of two general types of rhizome, characterised by a shortened thick and fleshy stem end determinate growth; its growth produces many-branched clumps which terminate in flowering stalks

palea : the upper or inner of a pair of bracts that subtends the floret

paleaceous : having small membranous scales

panicle : an indeterminate inflorescence, the main axis of which is branched, with pedicellate flowers borne upon the secondary branches

paniculate : having a panicle type of inflorescence

pantropical : distributed throughout the tropics

papillae : a soft, nipple-shaped protuberance

parenchyma : tissue composed of more or less isodiametric cells, as in pith and mesophyll

parthenocarpy : the natural or artificially induced development of fruit without sexual fertilization

pedicel : the stalk of an individual flower in an inflorescence or the stalk of a grass spikelet

PEG : poly ethylene glycol

pendent, pendulous : suspended, drooping, hanging down from a support

penicillate : ending in a tuft of fine hairs or branches

percolation : the downward movement of water through the soil

perennial : a plant which lives for more than two years and usually flowers every year

perfect flower : a flower having both stamens and carpels

pericarp : the mature fruit wall which develops from the ovary wall, frequently differentiated into distinct layers; exocarp, mesocarp and endocarp (outer, middle, and inner layers)

periclinal : parallel to the surface

perigynium : a sac like bract which surrounds the pistillate flower or achene

persistent : remaining attached, not falling off

petiolate : having a petiole

petiole : the stock of a leaf

phloem : the principal food-conducting tissue of a vascular plant which is usually composed of sieve elements, parenchyma cells, fibres and sclereids

pileate : having a cap or cap-like structure

piliferous : hair-like, flexuous

pilose : having soft, long, shaggy trichomes

plicate : plaited, fan-like

plumose : covered with a fine, feather like pubescence

plumule : the first bud of an embryo, the part of the embryonic axis above the cotyledonary node

prickle : a sharp-pointed epidermal or cortical outgrowth

proembryo : an embryo in the early stages of development

proproots : aerial roots

propagule : a part of a plant that becomes detached and grows into a new plant

prophyll : one of the first leaves of a lateral branch; a bracteole or small scale like appendage

protogyny : flowers in which the stigma becomes receptive prior to maturation of anthers and dehiscence of pollen in the same flower

proximal : the part nearest the axis

pruinose : having a heavy waxy bloom on the surface

pruning : cutting off the superfluous branches or shoots of a plant for better shape or more fruitful growth

pseudospikelet : a spikelet-like branch of an indeterminate inflorescence

pubescence, pubescent : covered with short, soft trichomes

punctate : dotted with minute depressions

pulp : the soft fleshy part of the fruit; mechanically ground or chemically digested wood used in manufacturing paper and allied products

Q, R

quadr, quandra, quadri : a prefix meaning four

raceme : an unbranched, indeterminate inflorescence, in which the individual flowers are borne on pedicels along the main axis

racemose : like a raceme; having flowers in raceme like inflorescence that may or may not be true racemes

rachilla : a diminutive or secondary axis, as the stalk of the spikelets of grasses

rachis : the axis of a compound leaf upon which the leaflets are attached; the major axis of an inflorescence

radial : lengthwise, in a plane that passes through the pit; radiating, as from a centre

ramified, ramiform : branched; branching

radical : arising from the root, or its crown

radicle : the first root of an embryo or germinating seed

rhomboidal : diamond-shaped

recurved : bent or curved downward or backward

reflexed : abruptly bent or turned downward or backward

reniform : kidney-shaped

reticulate : forming a network

rhizome : an underground stem which is distinguished from a root by the presence of nodes, buds and leaves or scales

rostrate, rostrum : having a beak

ruffled : having a very strong wavy margin

rugose : wrinkled, covered with coarse reticulate lines

Runkel ratio : parameter used by the pulp and paper industry, derived from the fibre dimensions of the culm; twice the fibre wall thickness divided by the fibre lumen diameter

runner : a specialized stem that develops from a leaf axil at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes, usually at or near the tip

S

sagittate : shaped like an arrow head; triangular-ovate with two straight or slightly concave basal lobes

scabrid : roughened

scabrous : having a surface that is rough to touch, because of the presence of short stiff hairs

scale : any thin, usually small and dry, scarious to coriaceous bract

scandent : climbing

scarious : a thin, nongreen, dry, membranous structure

sclerenchyma cell : a supporting cell, variable in form and size, having a more or less thick, often lignified secondary cell walls. Includes fibres, fibre-tracheids and sclerieds

scurfy : covered with minute, branch like scales; with scaly incrustation

scutellum : single cotyledon of a grass embryo

seepage : percolation of water through the soil

senescence : the aging process

septate : being divided or partitioned by cross walls into locules or cells

sericeous : having a saw-toothed margin with sharp teeth pointing forward or toward the apex

serrate : toothed like a saw

sessile : without a stalk

setaceous : having bristle like hairs; bristly

sheathing base : a leaf base that surrounds a stem

sieve element : a cell of the phloem concerned mainly with the longitudinal transport of food materials.

siliceous, silicious : composed of or impregnated with silica (silicon dioxide)

sinuous : having a strongly wavy margin

slenderness ratio : parameter used by the pulp and paper industry, derived from the fibre dimensions in the culm; fibre length divided by fibre diameter

sparsely : scattered

spatulate : spoon or spatula-shaped

spicate : having the form of or produced in a spike

spike : a simple indeterminate infloresence with sessile flowers along a single axis

spikelet : a secondary spike, one of the units of which the inflorescence consisting of one or more florets on a thin axis, subtended by a common pair of glumes as in grasses

spinose, spinous : spine-like, or having spines

sporadic : widely dispersed or scattered; irregular in time, flowering at irregular intervals

stipitate : borne on a stipe or stalk

straggling : extremely divergent, spreading very far apart

striate : marked with fine longitudinal parallel lines, as grooves or ridges

subspecies : a subdivision of a species, in rank between a variety and a species

subulate : awl-shaped, tapering from base to apex

sulcate : having longitudinal grooves, furrows or channels

strigose : having straight, sharp, stiff, appressed hairs frequently with a bulbous base

sympodial : of a stem in which the growing point either terminates in an inflorescence or dies, growth being continued by a new lateral growing point

T

tangential : lengthwise, in a plane at right angles to the radius but not passing through the pith

tawny : dull yellowish-brown; fulvous

terete : more or less circular in cross section; cylindrical and elongated

terminal : found at the tip, apex or distal end

tesselate : having a checkered pattern

tomentose : covered with dense, matted, woolly hairs

tortuous : cut off more or less squarely at the end; a base or apex which ends abruptly

trigonal : three-angled

truncate : a base or apex which ends abruptly almost right angles to the main axis

tufted : in clumps; clustered, cespitose

turbinate : shaped like a top; inversely conical

unarmed : devoid of thorns, spines or prickles

undulate : a margin wavy (up and down) in the vertical plane

uni : a prefix meaning one or single

unitegmic ovule : an ovule with a single integument

V

vaginate : sheathed

varicose : abnormally and irregularly enlarged or swollen

vein : a strand of vascular tissue in the organs like leaf or petals

ventricose : enlarged or swollen unequally; inflated on one side near the middle. syn. gibbose;

velvety : with a matting of the soft hairs; the same as tomentose but dense so that the surface feels very smooth

ventral : facing central axis

verticillate : arrangement in whorls, arising at same node

villose : with long weak hairs

viviparous, vivipary : germinating or sprouting of bud or seed still attached to the parent plant

SOURCES OF ILLUSTRATIONS

Arundinaria racemosa Munro. A - K = Gamble, J. S. 1896. The Bambuseae of British India. Annals of the Royal Botanical Garden, Calcutta 7. Plate 8.

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Bambusa griffithiana Munro. A - K = Gamble, J. S. 1896. The Bambuseae of British India. Annals of the Royal Botanical Garden, Calcutta 7. Plate 45.

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Bambusa longispiculata Gamble ex Brandis. A - C = Bennet, S. S. R and Gaur, R. C. 1990. Thirty seven bamboos growing in India.Forest Research Institute, Dehra Dun. p26.

Bambusa multiplex (Lour.) Raeusch ex Schult. and Schult. f. A - D = Original illustrations from herbarium specimen (KFRI) 6794; E - F = Tewari, D. N. 1992. A Monograph on Bamboo. International Book Distributors, Dehra Dun. p43. G = Bennet, S.S.R and Gaur, R. C. 1990. Thirty seven bamboos growing in India, Forest Research Institute, Dehra Dun. p28.

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