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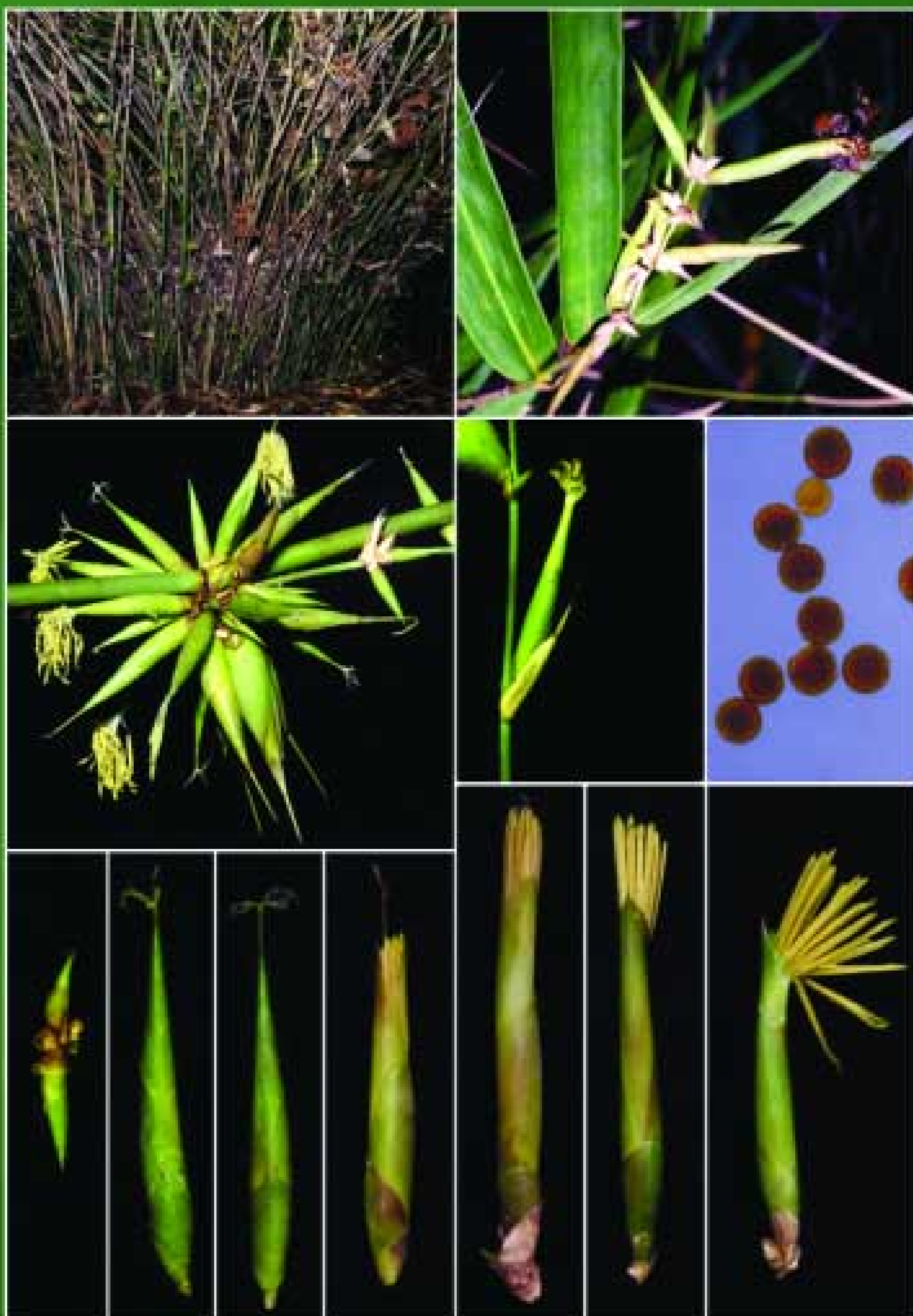

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Cover Photo: ***Ochlandra scriptoria*** by K.C. Koshy. See the accompanying article in this issue.

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Reproductive biology of *Ochlandra scriptoria*, an endemic reed bamboo of the Western Ghats, India

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ABSTRACT

The reproductive biology of the fleshy fruited South Indian reed bamboo *Ochlandra scriptoria* was studied. Flowering phenology, breeding system, opening of spikelets, visitation by bees, pollination, fertilization, fruit structure, germination etc. were all covered in this study. Once flowering is triggered this bamboo flowers every year with a break during rainy season. The process continues for a few years and subsequently the clump dies. The spikelets are bisexual, dichogamous and protogynous. The time gap between female and male phases is 48 to 72 h. The role of bees in pollination is not clear but destructive foraging by *Apis cerana* bees causes heavy losses of pollen. The stiffness of the style and the massive anthers force the opening of floret. The presence of air cavities in mature fruits shows similarities with the Sri Lankan *O. stridula.* There is no dormancy of fruits. The seedlings are woody.

INTRODUCTION

Of the seven bamboo genera with fleshy fruits, three *(Alvimia, Olmeca and Guadua)* belong to the New World and the rest *(Dinochloa, Melocalamus, Melocanna and Ochlandra)* to the Old World (Soderstrom and Londono, 1988). The genus *Ochlandra* Thwaites is charaterized by a one-flowered spikelet, one to many lodicules and many stamens. It is comprised of 13 species (Gamble 1896, Kumar 1995, Seethalakshmi and Kumar 1998, Kumar *et al.* 1999, Ohrnberger 1999) distributed from Madagascar (two species) to the Western Ghats of India (10 species) and Sri Lanka (one species). The reproductive biology of this economically important group which contributes the raw material for paper pulp and basketeries was not well known until Venkatesh (1984) reported dichogamy and protogyny in the most common species, *O. travancorica* (Beddome) Bentham. Later the structure and development of fruit in *O. travancorica* and *O. stridula* Moon ex Thwaites were studied (Hari Gopal and Mohan Ram 1987, Rudall and Dransfield 1989) and of late, the insect visits to *O. ebracteata* Raizada & Chatterji, *O. scriptoria* C. E. C. Fischer and *O. travancorica* were reported (Koshy et al. 2001). The present study deals with the reproductive biology of *O. scriptoria* C. E. C. Fischer (= *O rheedii* Bentham & J. D. Hooker ex Gamble) the species with smallest fruit among south Indian *Ochlandras*.

Locally known as *Ammei, Bheesa, Kolanji or Ottal O. scriptoria* is endemic to the Western Ghats of India (Karnataka, Kerala and Tamilnadu). It is a shrubby, clump forming, 4-8 m tall bamboo with sympodial rhizomes, cylindrical pistachio-green hollow culms of 3 to 5 cm girth and found in riverbeds, on stream banks and in low lying areas. It forms hedges in paddy fields and prevents soil erosion. The culms are widely used in cottage industry for making baskets, mats, flutes, arrows, writing pens, fish traps etc. It is reported to be one of the important bamboo species used in pulp and paper industry (Seethalakshmi and Kumar 1998).

MATERIALS AND METHODS

The study was conducted in the bambusetum (N 8° 45' 328", E 77° 01' 486") of Tropical Botanic Garden and Research Institute (TBGRI), Palode, Thiruvananthapuram, Kerala State, India. In the live bamboo collection of TBGRI (Koshy 1991) 15 clumps of *O. scriptoria,* all introduced in 1987 through offsets and seeds, were available for observation. Of these, seven clumps of offset origin flowered from 1994 to 1998. Gregarious flowering of this species which occurred in 1996 in the natural forests of Ranny forest division, Pathanamthitta district, Kerala State was also studied. Flowering phenology observations were made in the field regularly and continuously from the sign of initiation of flowering to the death of clumps. A large number of young pseudospikelets at a very early stage of development were spotted with a marker pen and morphological changes were noted periodically till maturity of fruits. To calculate the duration of male and female phases, 10 to 15 about-to-open turgid pseudospikelets were observed each day continuously and time taken from the beginning of stigma exposure to its curling and expiring. The stage of anthers up to their complete dehiscence was also noted. The pseudospikelets were observed in the natural and protected conditions. The inflorescences were covered with polyethelene bags to prevent visit of bees during anther emergence. Pollen viability studies were carried out by staining with Acetocarmine (Radford *et al.* 1974) and by the tetrazolium test (Shivanna and Rangaswamy 1993). Germination and viability studies were also conducted through conventional methods. The structure of fruit was studied by taking longitudinal sections. Voucher specimens were deposited at TBGT.

RESULTS

Signs of flowering were first observed in three to five mature culms of two clumps during December 1994. In the vegetative stage, leafy twigs grow up to 35 cm long producing six to nine leaves and remain as such. As a precursor to flowering, the dormant terminal bud of these twigs initiated and elongated to 4-16 cm. Leaves with smaller blades are produced in continuation with those of the vegetative phase. Transition of leaves to bracts occurred on these elongated shoots. In some cases only bracts were formed. A pseudospikelet is developed terminally (Fig B) stopping further elongation of the flowering shoot followed by the production of pseudospikelet buds from other nodes of such shoots. Simultaneously, flowering shoots arose from branch nodes and developed in the same manner. Later, clusters of pseudospikelets developed from the nodes of main culms. The maximum number of pseudospikelets in these culm nodes (Fig. A, C) occurred in March-April 1995 and fruits in May-June. During June-July, the season of rains, the culms involved in flowering gradually stopped activity and remained vegetative. Curiously, new shoots were produced in these clumps. Signs of flowering appeared again in January 1996, this time involving about one third of the culms, resulting in peak flowering and fruiting during March to June. Drying of a few culms and production of a few new shoots were observed this year. The majority of culms started flowering in the third year, including those involved in previous years, resulting maximum flowering and fruiting during March - June. Yellowing of leaves and culms occurred in a number of flowered culms which culminated in the death of these culms (Fig. A) while 30-35 culms remained undried. In March 1997, flowers and fruits though fewer in number appeared on the remaining culms. After fruiting, all culms in one clump dried while in the other 15 culms remained which flowered and dried in 1998. Thus these two clumps started flowering in December 1994, produced new shoots in the initial two years, then flowered every year with a break during the growing season and then completely perished after the fourth and fifth year. Of the remaining five clumps three flowered for three years and rest for only two years before they died. During 1996, gregarious flowering was observed in Ranni forest division, Pathanamthitta district and all clumps involved died after flowering. Other live clumps in the bambusetum, both of seed and offset origin, have not flowered as of June 2001, even after 14 years.

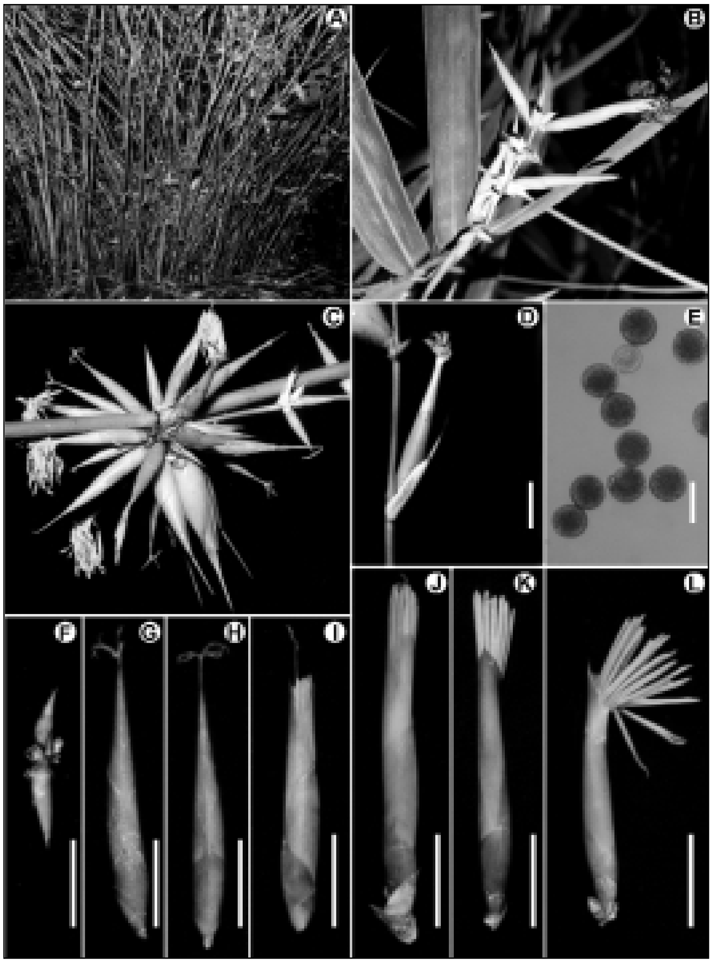

Figure 1. (A) Close up of a flowering clump showing the pseudospikelet-clusters at culm nodes and subsequent death of culms. (B) *Apis cerana* bees foraging on a terminal pseudospikelet at anther emerging stage. (C) Cluster of pseudospikelets on a culm node at different stages of development. (D) Pseudospikelet after bees visit showing the damage created.(E) Pollen grains in Acetocarmine staining. (F) Young bud (5-8 mm) at early stage of development. (G) Beginning of protogyny: stigmatic lobes just emerge out. (H) Female phase: stigma and style exposed. (I) Beginning of male phase: Anthers from a peudospikelet just emerge out (peeping out stage), also seen the dried stigma. (J) Anther emergence masking the stylar portion. (K) Further emergence of anther covering the style and stigma.(L) Drooping of fully emerged anthers followed by dehiscence.

Breeding System

This species has ovate-acute young pseudospikeltets of 5 to 8 mm length which took (Fig. F) 12 to 16 days to develop into 2.5 to 3 cm long, cylindrical, ovate-lanceolate sharply pointed mature pseudospikelets ready to expose the sex organs. Slowly one or two lobes of stigma barely emerged (Fig. G). Then gradually all five plumose stigmas became exposed and they spread out (Fig. H). Since there is no opening of the lemma and palea, the style cme out as if it pierced through the tip of the pseudospikelet (Fig. H). The stigmatic lobes, thus exposed, are white and with a viscous sticky fluid mainly concentrated at the confluence of the lobes and style, the receptive region. The stigmatic papillae were also turgid, lasting for 1-2 (1/2) hours The stigma was ready to receive pollen at this stage. At this point, longitudinal sections of the pseudospikelet revealed that the stamens are under-developed and only in the basal half of the pseudospikelet. The stigmatic fluid then gradually dried up, stigmatic papillae lost their turgidity and the lobes turned pale as the needle like style elongated 3-4 mm above the level of lemma. The lobes ultimately curled, shrunk and joined together in the form of an appendage (Fig I).

The pseudospikelets then entered the male phase. As the stamens elongated and reached half way above the lemma and palea the pseudospikelets became ovate oblong (Fig. I). The tip of the anthers just appeared at the apex of the fertile glumes (peeping out stage) through a 3-4 mm opening at tip created by the openening of the lemma and palea. The anthers of 24 stamens gradually emerged out vertically encircling the exposed style portion (Fig. J, K). The anthers when fully exposed are 11.5 × 1mm. They are at first erect, masking the style and making it invisible (Fig K, L). It took nearly 1-2 ($2^1/_2$) hours for full exposure of the anthers. Once they are exposed, the opening created bbetween the lemma and palea decreased leaving space only for the filaments (Fig C). The elongation of the filaments continued and, as they were exposed, the anthers started drooping followed by dehiscence (Fig. L, C). The dehiscence started with 2-5 anthers initially and completed with all of them in 30 min. As the ambient temperature increased, the dehiscence was faster. The dehisced anthers remain attached for one or two days (Fig. C). The male stage, anther emergence to dehiscence, lasted for 2 to $2^1/_2$ hours in pseudospikelets which were not visited by bees.

Opening of pseudospikelets and exposure of sex organs started at 6.30 am, extended to12 noon and was at maximum during 9-10.30 am. The ambient temperature at opening ranged between 23 and 32°C. Maximum opening was noted at 27-31°C when the relative humidity. was 51-63%.

Pollen is globose and 34.3 to 52.5 mm across. In acetocarmine staining 91.38% (Fig. E) were found viable immediately after anthesis. However in tetrazolium only 83.93% stained. Fifty percent of the pollen was found viable even 7-9 hours after anther dehiscence with the aceetocarmine test.

Pollination and Fertilization

Since there is a long gap of 48-72 hours between the female and male stages, pollination can only happen by pollen from other pesudospikelets of the same or different clumps. Bees were seen visiting the pseudospikelets from 6.30 am to noon with the highest visitation between 9 and 10.30 am. The activity started as early as the peeping out stage of anthers (Fig. B). The bees, mainly *Apis cerana* Fab. (Fig. B) vigourously foraged the anthers and pollen grains producing a peculiar sound which could be heard from a distance. This 'destructive foraging' damaged the anthers (Fig. D) resulting in the heavy loss of pollen before it was shed in the wind. Maximum activity of bees was recorded during the time of optimum floral opening (Koshy *et al.* 2001). No bee activity was observed during stigma exposure (protogyny).

Fertilization usually happens before the male phase and the pericarp increases in thickness. This can be easily distinguished by the girth increase of pseudospikelets (Fig. C) during anther emergence.

Fruit

It took 38 to 42 days for the young pseudospikelets of 5 to 8 mm to produce a mature fruit of 5.6-5.8 × 0.8-0.9 cm which is ovoid and extends upwards into a long beak, the persistant style. The fruits are covered with two empty glumes and the slightly enlarged lemma and palea (Fig. M). The mature fruit weigh 0.9-1.5 gm and detach from the infructescence with a slight shake. The fallen fruits are eaten by squirrels, rats, procupines and even wild boars. A longitudinal section of the mature fruit (Fig. N) shows air filled loose tissues in the upper part of pericarp below the stylar beak which can be felt by pressing the fruit between the fingers at this region. These air cavities

Figure 2. (M) Mature fleshy fruit. (N) L. S. of fruit: showing air cavities in the fleshy pericarp, ovarial cavity, endosperm tissue, and the embryo. (O) Germinating fruit with three roots and a plumule. (P) Germinating fruit with one root and one plumule. (Q) 14 days old seedling. Bars = E, 57 mm; rest 1 cm.

help mature fruits to float in water and aide in dispersal. The pericarp is hard and thick, the thickness is more on the straight side than on the curved side. The pericarp is thin toward the base of the fruit. The soft endosperm tissue fill the ovarian cavity down to the embryo. The oblong embryo which consists of a massive scutellum, plumule and radicle occupy the extreme lower portion of the ovarian cavity. The plumule is basal.

Germination

The fruits germinated within three to four days of sowing. There is no dormancy period. One to three roots arose from the basal region (Fig. O, P) which grew faster than the shoot, e. g. when roots attained 10 to 12 cm length the shoot grew only 7.5 cms. The first leaf formed 10 to 12 days after root emergence and the first tiller after 20 to 23 days. Seedlings are woody (Fig. Q). Viviparous seedlings, germinating on the mother plant were observed during the rainy season but they detached from the infructescence soon after the formation of roots and shoots.

DISCUSSION

While early workers (Gamble 1896, Brandis 1906, Bourdillon 1908, Fischer 1934) believed *O. scriptoria* to flower annually without subsequent death, later workers (Seethalakshmi, 1993,; Seethalakshmi and Kumar, 1998) though they were not sure about the periodicity of flowering, observed that flowering was followed by death. The present study clearly confirms that: 1. Flowering is not annual and flowering is followed by the death of clumps. 2. Clumps with a longer flowering period (i. e. 4 or 5 years) produce flowers every year except during the growth period (July to October). 3. Clumps with a shorter flowering period flower once or twice and die faster. It could be possible that the longer flowering period might have misled earlier workers. The age at which flowering occurs is also not known, as clumps raised from seeds did not flower even after 14 years. Survival after flowering, i. e. reversion to vegetative phase after production of flowers, is doubtful in this species as such incidences have not been reported so far.

The pseudospikelets are bisexual, dichogamous and protogynous, similar to that of *O. travancorica* (Venkatesh 1984). The duration of the male stage in *O. scriptoria* and *O. travancorica* are similar whereas the time gap between the male and female stages in the present study is 48 to 72 hours which is longer than that of *O. travancorica* where it is reported to be about 48 hours (Venkatesh 1984). Such a long time gap between the maturity of opposite sexes coupled with fertilization and development of ovary before anthesis prevents selfing (Faegri and Vander Pijl 1979) and is presumably a mechanism for creating genetic variation in this species. The amount of viable pollen produced by a pseudospikelet is disproportionately high. However, a large quantity of pollen is lost during destructive foraging by bees. The role of these bees in pollination could be indirect as no bees were found visiting the stigma. Whether the sticky viscous stigmatic fluid has any protective chemicals needs further investigation. Pollination, considering the available evidence and dichogamous nature of pseudospikelets (Linder 1998), is by wind.

The role of turgid floral parts during opening and closing of florets has been shown in rice (Kadam 1933, Parmar *et al.* 1979, Ekanayake et al. 1989) where the turgid lodicules exert pressure at the basal joints of the lemma and palea, while turgid filaments and the stigma exsert lateral pressure on the linear joints of stigma. Since the lodicules in *O. scriptoria* are membranous structures and the lemma and palea widen only for 3-4 mm at tip by forming an angle of only 8° between them (Koshy *et al.* 2001) it can be presumed that the lodicules have no role in the opening and closing of florets which happens due only to the pressure of the emerging massive anthers. This is the case in *Bambusa vulgaris* Schrad. ex Wendl. (Koshy and Harikumar 2000). Moreover, during protogyny the style pierces through the flowering glumes since there is no widening of lemma and palea. Significant pressure is required for this and it could be a reason for the stiffness of the style in *Ochlandra* spp.

Air cavities in the pericarp are reported in the case of *O. stridula* by Rudall and Dransfield (1989) which, according to them, are formed by the break down of central areas of ground parenchymatous tissue with cells containing numerous small globular starch grains between vascular bundles as the pericarp reserves become depleted. Hari Gopal and Mohan Ram (1987) reported that the cells of the parenchymatous zone in *O. travancorica* do not collapse but have a large quantity of starch in them and hence the thickness of pericarp remains the same except at the base of fruit where it becomes thin to factilitate the emergence of the plumule and the radicle during germination. They also reported such air cavities in the fruits of *Melocalamus* spp. With regard to the formation of air cavities in the pericarp *O. scriptoria* is related to the Sri Lankan *O. stridula* and *Melocalamus* and not to the Western Ghats species, *O. travancorica.* Since this species is found along riverbanks, slopes and low lying areas, the floating fruits could possibly be an adaptation for dispersal through drainage caused by the torrential rains of June-July. As Rudall and Dransfield (1989) pointed out, vivipary and lack of dormancy are advantages for this species. Also, the seedlings have an edge on their competitors like sedges, grasses and predators because they rapidly establish and form a thick population in their respective habitats especially rain washed areas.

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Bamboo Science and Culture:
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Arundinaria alpina in Mount Elgon National Park, Uganda

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ABSTRACT

A systematic forest inventory on the structure and form of *Arundinaria alpina* along a slope in Mount Elgon National Park showed no significant change across the different soils on which it grows. However, the slope, forest type, canopy cover, and altitude all influence the distribution and abundance of *A. alpina.* Specifically, culm height, diameter, distance between culms, density, internode length, associated vegetation type and specific soil characteristics differed among study sites.

There are more than 1250 species of bamboos. In East Africa only *Oxytenanthara abyssinica* Munro, *Oreobambos buckwaldii* K. Schum, and *Arundinara alpina* (mountain bamboo) K. Schum, are native (ICRAF 1992). In Uganda, mountain bamboo is found growing naturally in pure stands, covering many acres of land on the slopes of mountains and accounting for over 20% of the area of the Mt. Elgon National Park.

Arundinaria alpina is a gregarious bamboo with woody rhizomes. Culms are erect, evenly spaced, green-yellow or brown and downy when young, thick-walled with several branches at each of the upper nodes. The culm sheaths are covered with reddish-brown bristly hairs or are glabrescent, tipped with a linear acute blade and fimbriate lateral auricles. The foliage leaf blades are narrow, linear lanceolate, 5-20 cm long and 6-15 cm wide, glabrous with conspicuous transverse veins and narrowed apically to a fine bristle up to 2 cm long. Panicles are 5-15 cm long, terminal on branches and branchlets. Spikelets are 1.5-4 cm long and 3-4mm wide with 5-10 florets having 4-8 mm long glumes (Katende et al, 1995; Scott, 1994; and Ivan and Greenway, 1966).

Arundinaria alpina is most prevalent in areas where annual rainfall is between 1200 and 1800 mm and it flourishes particularly well on deep rich volcanic soils (Were 1988). It is usually associated with temperate forest tree species. In Uganda it grows in irregular patches between 2290-3360 m above sea level on mountain ranges (Katende *et al.* 1995, Kant *et al.* 1992, and Snowden 1953).

In Mount Elgon National Park bamboo is the most important non-timber forest product resource, and its economic value is twice that of the potential sustainable exploitation of timber from the area (Scott 1994). The consumptive use minimal annual value of bamboo to the community neighboring Mount Elgon National Park is estimated at USD$ 750,000 per year. Utilization potential within East Africa is largely restricted to the domestic sphere and is nowhere near fully exploited.

This study of the population structure and form of *A. alpina* was originally begun to determine the role of slope on its growth and distribution and to amend the inadequate information about the ecology of *A. alpina*. Although bamboo has long been recognized as a multipurpose plant, very useful in rural areas, Songkram (1988) pointed out that it is harvested without any concern for conservation and that there has been virtually no research on it.

Forest structure is a result of species growth, habits, environmental conditions and management practices under which the stand originated and developed. Stand structure, which is defined as the distribution of species and tree sizes on a forest area (Richards 1996) has not received enough study with reference to bamboo in Uganda. Recent research by Scott (1994) indicated that current levels of bamboo extraction are within sustainable levels in Mount Elgon National Park and many people have expressed the desire to establish on-farm bamboo stands for domestic use and for sale. However, the lack of information on the biology and ecology of *A. alpina* makes it difficult for managers to make decisions on sustainable harvesting and limits the cultivation of bamboo in Uganda.

The structure of mature forests on slopes and riverbanks has been described (Halle *et al*, 1978) but with inadequate emphasis on bamboos. The slope of the hill is one of the environmental factors that interact with the other edaphic and climatic factors to give rise to the form, and structure of bamboos and the percent coverage of the associated flora found at a particular spot along a vertical transect on a hill slope. Consequently a forester or a natural resource manager needs to appreciate the relationship between the slope and its influence on bamboo form, structure, and associated species coverage.

The objectives of this study were to assess the effect of a change of slope on the form, structure, and plant composition associated with *Arundinaria alpina*, and to describe the characteristics of the soils on which it grows naturally on the slopes of Mount Elgon National Park.

The results discussed provide useful knowledge about the ecology of *A. alpina* important for afforestation of the surrounding areas with bamboo, and formulating guidelines to help direct rural users to appropriate sites for potential bamboo harvest.

MATERIALS AND METHODS

The study was conducted in Mount Elgon National Park which is situated approximately 100 km Northeast of Lake Victoria and lies on the border between Uganda and Kenya. The Ugandan part of Mount Elgon lies between 0° 52' and 1° 25' N lat. and 34° 14' and 34° 44' E long. The park is managed by the Uganda Wildlife Authority (UWA) whose mission is to conserve and sustainably manage the wildlife and protected areas of Uganda in partnership with neighboring communities and other stakeholders for the benefit of the people of Uganda and the global community. The survey was limited to bamboo forested (mixed and pure) areas within and adjacent to Bunwambu Parish Bulaago Sub County. The data collected were entered into a database, averages taken, and statistical analyses were carried out using SPSS (Pearson and Spearman correlation coefficients) and Microsoft Excel.

Study plots were established in the period between June and September 1999 at an elevation of approximately 3000 m above mean sea level. A total of seven sampling transects (of slopes facing different directions), 70 m in length was established within the forest running from the valley to the top of the hill. Care was taken in placing the transects so that the adjacent transects were at least 50 m apart. Each transect consisted of seven sample plots separated by a distance of 10 m. Each transect was made following a predetermined compass bearing from one end to the other. This was not possible in areas where the bamboo was in irregular clumps and as a result small transects were reselected. Sample plots were determined according to plot sampling procedures described by Brower *et al.* (1989).

The soil characteristics (texture, structure and depth) were investigated by the procedure described by Soil Survey Staff (1990). Soils were sampled to a depth of 1 m after removing the surface litter layer. Two random samples were used at each sample plot. The soil depth was measured from the top of the mineral soil i.e. just under any leaf litter lying on the top of the soil. Soil class names used to describe the soil depth were very shallow, shallow, moderately shallow, moderately deep, deep, and very deep representing depths of <10, 11-20, 21-40, 41-60, 61-80, and > 80 cm respectively.

The color of soils was based on the Munsell soil color charts in which the soil colors were recorded in moist condition. Care was taken to obtain a freshly broken aggregate, and to avoid a smeared surface.

A description of bamboo structure and form was carried out as a total inventory on individual culms to provide data on the number of culms per plot and the average distance between culms. Diameter at breast height and total height were measured for at least 15 culms in each sample plot along four cross-sectional lines selected at random. The length of each internode was measured up to measurable height in cm for each culm. The distance between culms was measured randomly in each sample plot and the density was determined by counting the number of culms per 100 m^2 plot.

Slope and height were measured using a Suunto clinometer and a Spiegle relascope respectively. Site selection and direction were made possible using sketch map of the area surveyed and a compass respectively. Linear measuring tapes were used for taking distances and demarcating the plots, and a diameter tape for taking diameter of bamboo culms.

Data were collected for each plot separately per slope (Table 2) and the relationship between the various variables and the bamboo are reported in Table 3.

RESULTS

Soils

The soils of *Arundinaria alpina* investigated have a high clay loam texture with a dark color, a firm to weak structure, and generally deep profiles (Table 1).

There was no significant change in the soil texture under various slopes considered. The soil parts averaged 37.5% clay loam, 37.5% sand clay, and 25% sandy clay loam. The soil depth ranged from 40-80 cm deep but generally the soils were deep. The soil color changed with soil depth, texture, and the slope. Generally the deep soils had a clay loam texture and were red to brown. On relatively flat slopes with shallow soils having a lot of litter and the soils were very moist, and had a very dark gray color. On moderately steep slopes with moderately deep soils, little litter/humus and not very moist, the soils were very dark brown. The shallow to very deep moist flat bottom valley soils with a clay loam texture were very dark. On steep slopes with deep to very deep soils with a litter layer moderate to light and a loamy clay texture, the soils were black to dark brown.

The structure of the soils measured ranged from very weak to firm. The study showed 62.5% of the soils sampled were firm, 25% weak and 12.5% very weak. The structure of the soils changed according to vegetation cover changes. In open ground or areas of poor bamboo growth, the structure of the soil was weak to very weak while in areas of good bamboo growth and high vegetation coverage there were weak to very firm soils.

Very weak soils were also found to be characteristic of relatively flat slopes (areas of very poor bamboo performance) compared to steep and moderately steep slopes (bamboo rich areas) where soils were firmer.

Table 1. The data collected on soil variables investigated in mount Elgon Park

Slope	soil texture	soil color	soil structure	soil depth
A	Clay loam	dark brown	Firm	>80 (very deep)
B	Clay loam	dark brown	Firm	>80 (very deep)
C	Sandy clay loam	dark brown	Firm	>60 (deep)
D	Sandy clay loam	dark red	Firm	<60 (mod.deep)
E	Sandy clay	dark grey	Weak	<60 (mod.deep)
F	Sandy clay	dark grey	Weak	<40 (shallow)
G	Clay loam	dark red	Firm	<60 (mod.deep)
I	Sandy clay	dark grey	Very weak	<60 (mod.deep)

Table 2. Data from the dependent variables

Plot	Slope (%)	Height (m)	Internodes (cm)	Diameter (cm)	Density (culm number)	Tress/ shrubs (numbers)	Herbs (%) ground coverage)	Distance (cm)
A	54.5	16.7	54.1	7.1	12	3	70	30
B	50	14.9	52.5	7	13	3	65	29
C	45.5	14.4	51.3	6.9	13	2	44	28
D	40.3	13.4	45.1	6.5	13	1	45	25
E	38	13.3	47.2	6.4	13	1	50	23
F	35	13.2	46.6	6.4	14	1	64	19
G	33	14	49.9	6.4	15	1	46	34
H	30	13.5	50.5	6.9	11	–	59	20

Bamboo

Development of bamboos is affected by several climatic and biotic factors. For instance, adequate rainfall and the conditions of the clump have a bearing on the production of new culms. Congested clumps retard the development of new shoots, with only a few culms being produced on the periphery. *Arundinaria alpina* forms a dense closed canopy overhead and it is often difficult to distinguish between the old and young culms in terms of height and diameter. *A. alpina* regenerates naturally by throwing out new shoots from the rhizomes by means of internode elongation with the advent of favorable conditions early in the rain season. They attain their maximum height and diameter by the end of the rainy season, extending over 3-4 months. Soft at first, the culms become hard by deposition of silica in the walls and nodes. The presence or absence of sheaths and changes in color distinguishes the culms of different seasons (Pearson *et al.* 1993, Snowden 1953, and Wimbush 1947). At the beginning of their second year, young culms (yearling culms) lack foliage and are easily identified by the uninterrupted series of pink, green or purple culm leaves that emerge at the nodes and surround the succeeding internodes. The slender blades at the tips of the culm leaves fall within their first year, but the culm leaf sheaths may remain attached for five or six years.

The number and length of the internodes determine the height of a culm; taller culms have more internodes (Pearson *et al.* 1993). The mean heights of mature culms in the study area varied from 13.20-16.70 m (Table2) along the slope. The tallest culms were found on the steep slopes while on the relatively flat slopes short culms occur. There is a high correlation between the culm height and the internodal distance (length). The internodal length varied from 45.1-54.1 cm.

Table 3. Correlation coefficients of both the dependents and independent variables of the data investigated.

	Density	Diameter	Distance	Height	Herbs	Internode	Slope	Trees/ shrub
Density	1							
Diameter	-0.5842	1						
Distance	0.4965	0.2279	1					
Height	-0.0833	0.7539	0.6024	1				
Herbs	-0.2512	0.5074	-0.176	0.5222	1			
Internodes	-0.2	0.856	0.5319	0.8411	0.4813	1		
Slope	-0.0357	0.6646	0.4626	0.8446	0.3875	0.595	1	
Trees/shrub	0.1616	0.6187	0.5675	0.8431	0.4331	0.6627	0.9574	1

A complex vegetation system was determined in which the trees/shrub densities were on the order of 150 individuals among 13,000 Bamboo culms per hectare (Table 2). There were no significant changes in the number of trees and shrubs counted at each of the sample plots along the slope. Underneath the bamboo there is a layer of herbs and grasses forming, on average, 55% of the ground coverage, with the other area usually covered by a thick layer of bamboo leaf litter. On some sample plots however no trees/shrubs were observed. In some areas bamboos were accompanied by a few of the temperate forest trees e.g. *Hagenia abyssinica* and *Podocarpus milanjianus* scattered about either singly or in groups. We also observed that larger trees occur nearer water sources in the valleys. Bamboos when viewed from the hilltop are almost unnoticeable because of the large tree canopies covering them. Along the slope the areas with very tall branching trees housed tall bamboos and a higher general species diversity and taller herbs (up to about 2.5 m high). Here the bamboos are also generally seen in clusters or clumps. On the tops of hills occur grasses that are poor and hardier on the shallow infertile soils characteristic of those areas.

DISCUSSION

The results of this study summarize the role of slope and soil on the population structure and form of bamboos growing naturally in Mount Elgon National Park. Data on the culms in the forest varies considerably with changes on the gradient of the slope. Culm height, diameter and internodal length is greatest near streams, on steep slopes, under tree shade/ canopy and in bamboos growing in pure stands, while culm density is low under the same conditions. Slope as a factor influencing height is supported by Scott (1994) who indicated that, increasing altitude corresponds with an increase in both the average height and width of bamboos.

Though no significant variations were recorded in the soil characteristics on which bamboo's grow along the slope, it was found that soils with a high clay content, deep, firm and having a much darker color were correlated with the highest bamboo growth and that density tends to increase with distance from water (the streams at the base of the slope). The poor performance of bamboo on hill tops is evident from the color of the culms. They are green at the bottom of slopes becoming yellow at the top of the hill. Interestingly, regeneration is low at the bottom/near the stream and high on the top hills. We noted high regeneration occurring in clumps which are old, dying, fire disturbed, cut, wind thrown, suffering from pest attacks or on poor sites. Therefore, this study suggests that regeneration of bamboos is one of the ways that bamboo has adapted to different environmental conditions and environmental stresses on the mountain.

Also, the combined effects of trees/shrubs and associated herbs were found to have a significant correlation with the distribution of bamboos. Other studies (Mailly *et al.* 1997, and Pereira 1952) have shown that bamboo play an important role in nutrient recycling, maintaining soil structure, soil stability and controlling soil erosion through interception of rain and the reduction of run off. This has been confirmed in the present study.

Internodal distance is one factor which determines the fiber length in the culm (Ravikumar, 1997). The present study suggests that the slope is one of the factors, which interacts with other environmental factors that influence the internodal distance due to its influence on the soils and climate. Other factors such as water proximity, and tree shade have also been noted to have influence on the internodal distance and culm height. Where large trees are growing with large canopy, the bamboo have a larger diameter and taller culms. Steeper slopes tend to have taller bamboos; culm density was higher in plots with a NE/E aspect; and a higher average culm diameter was recorded for plots closer to a water source.

On Mount Elgon the average density was estimated at 9,500 culms per hectare in 1994 by Scott (1994). This study shows an average density of 13,000 culms per hectare. The difference in these data can be explained by management practices. Before 1988 the forest management authority had lost control over Mount Elgon Forest reserve, which led to over harvesting of the forest. In September 1992, the cabinet moved that the administration of Mount Elgon be transferred to Uganda National Parks, and after a considerable period of debate it was formally handed over in January 1994. Therefore the data obtained by Scott (1994) was in the transition time just after encroachment, but the present data was obtained at a time when the management authority had restricted bamboo harvesting and thus quick regeneration rates of the bamboo had increased density considerably. The culm density recorded in this study varied from 11-15 culms/m2. This yield is more than the optimum number in any existing bamboo forests according to the index for bamboo suggested by Etsuzo (1980) which depends on conditions of the soil, weather and topography.

It is also suggests that harvesting bamboo leads to high regeneration rates of culms with small diameter since this was observed in areas that had received a lot of harvesting/ cutting of bamboo culms. This suggests that harvest reduces shoot and stem density and opens the vegetation. Thus, competition between sprouts (which is a cause of mortality) will decrease. Harvest reduces competition between sprouts and is expected to have a negative influence (decrease) on mortality and induce regeneration only when the stumps/clumps are mature. This remains very unclear, however, and research is required to investigate it.

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Diversification and endemism in Andean woody bamboos (Poaceae: Bambusoideae)

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ABSTRACT

The woody bamboos (Bambuseae) are represented in the Andes by 127 described species in nine genera. None of the genera are endemic but 110 or 86.6% of the species are known only from the Andes. Fourteen species in two genera are known from the Austral Andes (Chile and Argentina), 41 species in eight genera are recorded from the Central Andes (Peru and Bolivia), and 87 species in nine genera occur in the Northern Andes (Ecuador, Colombia, and Venezuela), with two species shared between the Austral and Central Andes and nine species shared between the Central and Northern Andes. Of the nine genera occurring in the Andes, four (*Aulonemia, Rhipidocladum, Chusquea,* and *Neurolepis*) are Andean-centered, and *Chusquea* and *Neurolepis* together account for 64% of Andean woody bamboo diversity. The percentage of endemism by country among woody bamboos is generally significantly higher than for other grasses, and may be due to a combination of long generation times and isolation of populations. The extensive Andean radiation of the Chusqueinae clade may be due to the combination of a key innovation and the complex biogeography inherent in montane systems.

The Andes is one of the great mountain systems of the world; it extends from approximately 10° N to 51° S and its highest peaks top 6,900 m in elevation. The complex geology and history of the Andes in conjunction with the tropical location of its Central and Northern Andean regions have provided a unique evolutionary opportunity, and indeed the Andes harbor a wealth of biological diversity (Churchill *et al.* 1995). It has been estimated that the plant diversity of the Northern Andes is equal to or greater than that of the Amazon basin (Henderson *et al.* 1991). The woody bamboos (Bambuseae) are only one example of a group that has diversified in the Andes, but their story is an interesting one.

Diversity can be measured in several ways. The total number of species in a genus (or other taxon) or a clade provides one measure (known as species richness), but this can be linked to geography for even more information. One could count the number of species in a given political division, or habitat, or other natural geographic unit (e.g., an island or a mountain chain). Another measure focuses on the number of species unique to a particular political division, or habitat or other unit, that is, species that are found nowhere else. This is known as endemism. It is also possible to measure how common a given species is in a particular habitat, but this is often more difficult to quantify. These measures, either singly or in combination, help us to understand diversification and evolution in groups of organisms, but also provide important data for targeting areas or habitats for conservation.

While it is clear that woody bamboos are an important component of Andean vegetation, from the forested foothills through the montane and cloud forests to the high altitude grasslands known as *páramo* (Clark 1995, Judziewicz *et al.* 1999), we have little hard data on the commonness or relative coverage of woody bamboos in these habitats. Bamboo species diversity is still incompletely understood, but nonetheless some patterns of diversification and endemism of woody bamboos in the Andes are emerging, and are reported in this paper.

METHODS

Only described species were analyzed in this study. Of the Andean countries, the bamboos of Ecuador (Clark 1997), Chile, and Argentina (Clark unpubl.) are the best known. Although significant fieldwork in Colombia and Venezuela has taken place, the rich bamboo diversity of these two countries is still not fully described. The bamboos of Peru and Bolivia are both poorly collected and far from fully described. Among the Andean genera, there is a large number of new species that remains to be described in *Aulonemia, Chusquea,* and *Neurolepis*.

Species numbers for grass diversity and endemism include naturalized species, which necessarily would reduce the levels of endemism to some degree. To correct for this in calculating percent endemism, a more detailed analysis of the grasses of Costa Rica was conducted, and the number of introduced/ naturalized species was counted. These 83 species amounted to 21% of the non-woody bamboo grass flora. This percentage was used to calculate an adjusted percent endemism for the remaining grass floras, including the figures for species occurring above 2,400 m, under the assumption that the percentage would be similar for the other countries. For woody bamboos, the percentage of Andean species was calculated as a percentage of the total number of described species in a given genus or clade. The percentage of endemic Andean species was calculated as a percentage of the number of Andean species for a given genus or clade.

RESULTS

Andean Bamboo Diversity

The woody bamboos are represented in the Andes by 127 species in nine genera (Table 1). None of the genera is endemic but 110 or 86.6% of the species are known only from the Andes. This compares favorably with bamboo diversity in southeastern Brazil, where 100 species in 12 genera are recorded, with four of the genera and 81 or 81% of the species endemic. If we look at diversity according to region of the Andes, 14 species in two genera are known from the Austral Andes (Chile and Argentina), 41 species in eight genera are recorded from the Central Andes (Peru and Bolivia), and 87 species in nine genera occur in the Northern Andes (Ecuador, Colombia, and Venezuela). Two species are shared between the Austral and Central Andes, and nine species are shared between the Central and Northern Andes. There is little overlap between regions, and the greatest number of species is clearly in the Northern Andes.

The two major clades of Neotropical bamboos, the Arthrostylidiinae + Guaduinae Clade and the Chusqueinae Clade, both have diversified in the Andes (Table 1). Fewer than half of the genera of the Arthrostylidiinae + Guaduinae Clade, and only about one-fourth of its species, occur in the Andes, however. Eleven of the 12 genera in southeastern Brazil belong to this clade, and four of those are endemic. In addition, about half of the species in this clade occur in southeastern Brazil, making this region the center of diversity for this clade.

TABLE 1. Andean diversification of Neotropical woody bamboo diversity.

	Arthrostylidiinae + Guaduinae Clade	Chusqueinae Clade	Total
No. Genera	18	2	20
No. Species (described)	190	155	352
No. Andean Genera	7	2	9
No. (%) Andean Species	46 (24%)	81 (52%)	127 (36%)
No. (%) Andean Endemic Species	35 (76%)	75 (92.5%)	110 (86.6%)

Table 2. Andean diversity of Neotropical woody bamboos by genus.
Values for the four Andean-centered genera and total Andean diversity have a double border.

Genus	No. Described Species	Andean Species No. (%)	Endemic Andean Species No. (%)
Arthrostylidium	32	10 (31%)	7 (70%)
Aulonemia	34	17 (50%)	17 (100%)
Elytrostachys	2	2 (100%)	0
Merostachys	46	2 (4.3%)	1 (50%)
Rhipidocladum	19	9 (47%)	8 (89%)
Guadua	26	5 (19%)	2 (40%)
Otatea	2	1 (50%)	0
Chusquea	136	63 (46%)	59 (93.6%)
Neurolepis	21	18 (86%)	16 (89%)
		127 (35%)	110 (86.6%)

The Chusqueinae Clade, on the other hand, has about half of its species in the Andes, with over 90% of them endemic to the Andes. The center of diversity for this clade is clearly the Andes, although *Chusquea* has a secondary center of diversity in southeastern Brazil, with 35 described species there. The 81 species of the Chusqueinae Clade in the Andes account for 64% of Andean woody bamboo diversity.

If we consider the nine genera of woody bamboos that occur in the Andes, four of them contribute the bulk of the species diversity, and the others are represented by relatively little diversity (Table 2) for different reasons. Elytrostachys is only marginally Andean, with its two species occurring in the lower foothills of the Andes in Venezuela and Colombia (Judziewicz *et al.* 1999). *Merostachys* is known from only three or four species (mostly undescribed) scattered in occurrence in Colombia and Bolivia; these are clearly disjunct from the primary center of diversity for this genus in southeastern Brazil (Londoño & Clark 1998, Renvoize 1998, Judziewicz *et al.* 1999). *Otatea* is known from one disjunct population of *O. fimbriata* Soderstrom in northern Colombia (Londoño & Clark, 1998). *Guadua* is primarily a lowland genus, but a few of its species extend into the foothills and lower montane forests of the Andes. The primary center of diversity for *Arthrostylidium* is clearly the Caribbean region, but the Andes serve as a secondary center of diversity.

Clark (1995) identified *Aulonemia, Rhipidocladum, Chusquea,* and *Neurolepis* as Andean-centered genera, based on the criteria that half or more of the species for each are Andean, and each genus has limited or no representation in the Amazon basin or cerrado/caatinga habitats of central Brazil (Gentry 1982). In addition, 90-100% of the Andean species of each genus are endemic (Table 2). All of the sections recognized within both *Rhipidocladum* and *Chusquea* are represented in the Andes (Clark 1995), and although no formal taxonomic subdivision of *Aulonemia* has been recognized, both single-noded and multiple-noded species occur in the Andes. *Neurolepis* is the only genus of the four that is known to be exclusively montane-it is not known to occur below 1,500 m in elevation, and the non-Andean species are found in the Talamanca range of Costa Rica, Pico Neblina on the border between Venezuela and Brazil, or in the tepuis of eastern Venezuela and Guyana (Judziewicz *et al.* 1999).

Endemism in Andean Woody Bamboos.

A relatively high level of endemism in Andean woody bamboos was first noted by Clark (1997) in an analysis of the diversity of Ecuadorian bamboos. All of the woody bamboos endemic to Ecuador occurred at elevations of 2,000 m or higher. Within the last four years, this analysis was extended to all of the Andean countries for the woody bamboos and other grasses based on available treatments, and the results remained consistent (Table 3). Costa Rica was also included for comparison as a country with an extensive tropical mountain system and with relatively well known grass diversity.

Table 3. Grass and Woody Bamboo Diversity and Endemism in the Andes. Data for grass diversity from Pohl (1980), Tovar (1993), Renvoize (1998), and S. Laegaard (pers. comm.); data for bamboo diversity from the previous references, Judziewicz et al. (1999), and L. G. Clark (unpubl.). For percent endemism in grasses, the first figure represents the uncorrected percent endemism, and the second represents the percent endemism adjusted for naturalized species. Endemism values greater than 20% for grasses and less than 20% for woody bamboos have a double border.

	GRASSES (excl. woody bamboos)				WOODY BAMBOOS			
	No. Species	No. & % Endemic Species	No. Species > 2400 m	No. & % Endemic Species > 2400 m	No. Species	No. & % Endemic Species	No. Species > 2400 m	No. & % Endemic Species > 2400 m
Costa Rica	395	17 (4.3/5.4%)	65	11 (16/21%)	39	12 (31%)	21	7 (33%)
Venezuela (Andean)	–	–	–	–	38	9 (24%)	14	2 (14%)
Colombia	–	–	–	–	66	22 (33%)	34	12 (35%)
Ecuador	ca. 457	est. 23						
(< 5/6.4%)	205	7 (3.4/4.3%)	44	15 (34%)	33	13 (39%)		
Peru	629	100 (16/20%)	258	79 (30.6/38.7%)	37	16 (43%)	24	9 (37.5%)
Bolivia	697	66 (9.5/12%)	317	45 (14/18%)	27	6 (22%)	13	4 (31%)
Austral Andes	–	–	–	–	14	12 (86%)	–	–
Average % Endemism	–	8.7/11%	–	16/20.5%	–	39%	–	32%

Endemism in woody bamboos ranged from 22-86%, with an average of 39% (Table 3). For grasses excluding the woody bamboos, endemism ranged from 5.4-20%, with an average of 11% endemism for the total number of native species (Table 3). Endemism in woody bamboos is thus over three times as great as in other grasses overall. In order to more accurately compare endemism in grasses and Andean woody bamboos, endemism for taxa occurring above 2,400 m was calculated. In bamboos, average endemism drops slightly to 32%, due to the apparently low level of endemism in the montane bamboos of Venezuela. For grasses other than woody bamboos, endemism ranges from 4.3-38.7%, with an average of 20.5%. Endemism increases with increasing altitude in both grasses and woody bamboos, but average endemism in woody bamboos is still about one and a half times higher.

DISCUSSION

With respect to the diversity of Andean woody bamboos, the two major patterns to emerge thus far are 1) the high level of endemism of woody bamboos in the Andes, and 2) the extensive radiation of the Chusqueinae Clade in the Andes. Much more data and analysis will be required to explain these patterns, and to understand the origin and subsequent diversification of the Neotropical woody bamboos, but it is possible to put forward working hypotheses that might guide future research.

The high endemism of the woody bamboos in the Andes may be related to their unusual life history and the complex geography of the Andes. The long generation times of these bamboos and the isolation of their populations may have been the major factors in promoting their speciation and endemism. As in other grasses, woody bamboos do have dispersal mechanisms such as awns and hairs on the spikelets (Widmer 1997) but dispersal of propagules is probably a much rarer event than in other grasses due to the infrequency of flowering. Once a seed has dispersed successfully and established itself in a new location, the chances of another propagule from the same parent population reaching the same location are rather remote, which would tend to heighten the founder effect and would skew the genetic structure of the newly established population. In montane environments as complex as the Andes, the subsequent isolation of such populations could have promoted speciation and the accumulation of unique, localized species (i.e., endemism).

All of the evidence to date supports a sister relationship between *Chusquea* and *Neurolepis,* and thus suggests that these two genera shared a common ancestor (Judziewicz *et al.*, 1999 and references cited therein). Whether the Chusqueinae Clade shares a common ancestor with the Arthrostylidiinae + Guaduinae Clade, or whether it might have a more recent common ancestor with the Paleotropical one-flowered genera, is still uncertain, although a study is in progress (Clark and Dransfield unpubl.). Currently available molecular data suggest the former, while the morphological data support the latter. Better resolution of the relationships among these lineages of the woody bamboos will provide important clues toward understanding the origin and geographic radiation of the Neotropical woody bamboos.

Regardless of the origin of the Chusqueinae Clade, its higher altitude Andean species could not have existed until the final uplift of the Andes a few million years ago allowed the development of their upper montane forest and *páramo* grassland habitats (Gentry 1982, Clark 1995, 1997). Therefore, the working hypothesis with regard to the Chusqueinae Clade is that the Andean diversity of this clade is relatively recent in origin, and that the diversification happened relatively rapidly. The factors of long generation time and relative isolation of populations, combined with the emergence of a key innovation in *Chusquea,* may account for the extensive speciation in this clade. The key innovation, which remains to be tested, is the evolution of the multiple dimorphic bud complement that allows indeterminate branching by the central branch and rapid production of some number of smaller determinate leafy branches.

These results suggest that the Northern Andes should be an area of concern for those interested in the conservation of bamboo diversity, and indeed for the preservation of biodiversity generally. Ecuador and Colombia are especially rich in woody bamboo diversity, but it seems highly likely that the bamboo diversity of Peru and Bolivia will approach or equal that of the Northern Andes once it is better known. Although a few species of woody bamboos, especially within *Chusquea,* are opportunistic and have increased their coverage as a result of deforestation (Judziewicz *et al.* 1999), many others appear to be more specialized in their habitat requirements and thus are more vulnerable to habitat destruction.

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Bamboo and cane resources of Arunachal Pradesh: Utilization pattern and implications for management

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ABSTRACT

The Arunachal Pradesh State harbors maximum diversity of bamboo and cane species than any other state of India. A total of 18 genera and over 58 species of bamboo have been reported from Arunachal Pradesh out of 23 genera and 125 species from India. Similarly out of 5 genera and 70 species of cane in the country, Arunachal Pradesh has 4 genera and 17 species, All the tribal communities (26 major and 110 sub-tribes) of the state intimately use and possess huge knowledge regarding use of bamboo and cane species. This paper reports species diversity, utilization pattern and conservation status of bamboo and cane resources in East Siang district comprises Adi tribal group that is having highest population among all the ethnic groups of Arunachal Pradesh. It was recorded that bamboos are used in almost all the household needs, for construction, craft, fencing, rituals, firewood, food and utensils. A total of 18 bamboo and 4 cane species were recorded used by the community. The villagers maintain their own bamboo plantations mainly comprising of highly demanding species, such as *Bambusa tulda, B. balcoa, Dendrocalamus hamiltonii, D. gigenteus, Psedostachyum polymorphum* and *Cephalostachyum pergracile.* Requirement of the cane is met from the natural forest areas and during recent years there has been scarcity in its availability. Interestingly most of the bamboo shoots for food purpose are collected from forests and not from the plantations. A total of 62 bamboo and cane items have been recorded from the study area, which shows high indigenous knowledge for using these resources. Unfortunately there are very few marketing avenues to harvest this skills. Considering the regional and global markets of bamboo and cane products, and the knowledge the indigenous community posses, it is emphasized that suitable intervention are needed to upgrade the local products through value additions and local capacity building, which will have high implications in improving the socio-economic status of the community.

INTRODUCTION

Bamboo plays an important role in the socio-economy of tribal and rural people and has intimately been associated with mankind since ancient time (Tiwari 1992; Ram and Tandon 1997; Seethalakshmi and Kumar 1998). Well over a thousand economic applications of bamboo have been identified by many scientists around the world (Weda 1981). It is popularly known as poor man's timber, and as per one estimate bamboo today contributes to the subsistence needs of over a million people world over (Sastry 2001). Uses of bamboo and canes varied from domestic needs for housing, shelter, fuel, food, tools, to the commercial purpose as material for cottage and pulp industries (Adkoli 1991), which speaks a part of the broad spectrum of their use. India is the second largest producer of bamboo in the world next to China and also has the richest diversity of bamboo species in the world (Bahadur and Jain 1981). The northeastern states of India account for nearly 50 percent of the total bamboo resource of the country (Adkoli 1996). Amongst them, Arunachal Pradesh is a major storehouse and nearly 4590 km^2 area is underneath it (Rai and Chauhan 1998). This resource is owned, managed and grown by the local people. Not owning a bamboo groove is unthinkable in this part of India. Utilization of bamboos go side by side with cane, as they are used together, and in many bamboo products cane is equally utilized. Arunachal Pradesh also harbors high cane diversity (Haridasan 1996). There exists a wealth of indigenous knowledge for utilizing and management of bamboo and cane resources, which needs to be documented and utilized for proper management and conservation of these resources. In this paper an attempt has been made to analyze the diversity of bamboo and cane species used, the annual requirement of these resources along with their source of collection and conservation concerns of Adi tribe, which is most dominant tribal group of the state of Arunachal Pradesh. The study also suggests of the possible implications for management of these precious resources.

STUDY AREA AND METHODS

The northeastern region of India comprises of seven states, viz. Arunachal Pradesh, Assam, Maghalaya, Manipur, Nagaland, Mizoram, and Tripura, which is collectively considered as a major 'Hotspot of Biodiversity' (Rao 1999). Arunachal Pradesh constitutes 60% of total area of the northeast regions and the state has strategic importance as whole of northern side is occupied by China, northeastern side by Myanmar, on south-western side by Bhutan, on the western side the state boundary of the Assam and on the southern side by Nagaland state. The state has an area of 83,743 sq km with an elevation range of 100-7089 m, the population of the state is 1,091,117 comprised of 26 major and over 110 sub-tribes. Adi tribe, which was selected for this study, is having highest population (1,44,615) among all the tribes and distributed in three districts of the state. The present study was conducted in 3 villages (viz, Bamin, Miclung, and Mikong villages) of Abor-Minyong community of Adi tribe, and falls in Bilat circle of Pasighat block in East Siang district. The study area varied from 240 to 500 m elevation above sea level. Bamin, Miclung, and Mikong villages have 283 households with a total population of 1551 with 795 males and 756 females. An average family is having six members. Agriculture is main occupation, rice forms the major crop, which is cultivated on shifting cultivation areas (locally called as jhum) and wet agricultural fields. Animal husbandry is an integral part of the social life. Besides, home garden, horticulture farms, individual forest and bamboo groves are other important land uses in the area. In Abor-Minyong society, the woman is not only a housewife but also equally share responsibility with male partner especially on economic front. The basketry developed from the necessity faced with the increase of population is as per their requirement. The details of the community, their agricultural system, land uses and socio-economic aspects are already available (Upreti *et al.* 1999). This paper describes bamboo and cane diversity, its utilization pattern and indigenous knowledge about traditional craft.

Data on diversity of bamboo and cane in India, northeast region and Arunachal Pradesh was collected by literature surveys (Vermah and Bahadur 1980; Bahadur and Jain 1981; Haridassan *et al.* 1987; Renuka 1996, 1997; Thomas *et al.* 1998). Data on the Adi community were gathered with the help of standard questionnaire by interviewing individual households in the study area, which were selected on the basis of clan and socio-economic status of farmers. Surveys covered all categories (marginal, small, medium and big holdings) house types to determine the utilization pattern of bamboo and cane. A total of 90 households were covered from the three villages (viz. Bamin, Miclung, and Mikong) for the survey. Extensive interviews were conducted and informal discussions were also held with old aged farmers to know the past history of bamboo and cane, and the extent of the availability of different species. Information was gathered on different landuse types including bamboo plantations; sources of bamboo and cane supply, important species collected and their utilization; traditional bamboo and cane crafts, its durability and requirement of raw material; type of damage to the products; and ethical perspectives on cane and bamboos. All the observations and points raised by interviewees were noted. Data were also gathered on farmers preferences in taking up a species for plantation, and mode/ways to manage and conserve their bamboo and cane resources. Local markets were surveyed to find out the cost and demand of the bamboo-based products. Records were made and presented for different bamboo and cane species being used for the craft and type of articles made, for house construction, fencing and ritual practices. Records were also made with reference to the number of bamboo species used for edible shoots and quantities collected annually. Sources of bamboo and cane supply were identified and records were made on extent of collection for different species. An inventory was made for different crafts made, their durability, market value if any and local demand. Local artisans were interviewed to get an idea about the demand and supply of the durability of each of the items. On the basis of preliminary visits a rough map of each of the area was prepared to show the various bamboo communities and characteristics of various sites were identified. Bamboo plantations and natural habitats were randomly sampled with 10 x 10 m quadrats (n=20) for each species. The bamboo species falling under each quadrat were listed, no. of culms/ clumps were counted and cbh (circumference at breast height) was noted. Unfortunately such sampling was not done to cane areas due to inaccessibility. All these results were compiled and combinedly presented for both bamboo and cane resources.

RESULTS AND DISCUSSION

Bamboo and cane species diversity in Arunachal Pradesh

Out of 23 genera and 125 species of bamboos that are found in India, the north east alone comprised of 70% and 46% of total generic and species diversity, respectively (Table 1). With 14 genera and 64 species, the Arunachal Pradesh states harbors 88% and 59% of total generic and species diversity of the northeast, which is highest for any given state in India. Similarly the state also harbors 80%, 25% of total generic and species diversity, respectively, of cane in India, which comparises 74% of total species diversity of the Northeast (Table 1). This bamboo and cane diversity is maximum for any given state in the country. Among important bamboo genera, *Bambusa* had maximum 16 species, followed by *Arundinaria* 12 species, *Schizostachyum* 10 species, *Dendrocalamus* 9 species and *Cephalostachyum* represented by 5 species. Out of total 34 species of bamboo that are present in Arunachal Pradesh, 24 species are cultivated/planted. *Pleioblastus simonii* and *Arundinalia maling* are endemic species to the state. In canes, *Calamus* is represented with 12 species, *Plectocomia* with 3 species, while *Delmonorops* and *Zalacca* are having one species each in the state of Arunachal Pradesh. Use of bamboo and cane go side by side and therefore information on their use by any community is having greater implications for management of these resources.

Table 1. Diversity of bamboo and canes at different regions

Regions	Genera	Species	Reference
Bamboos:			
Arunachal Pradesh	14	34	Haridassan et al. (1987)
North East region	16	58	Bahadur and Jain (1981)
India	23	125	Vermah and Bahadur (1980)
World	75	1250	
Canes:			
Arunachal Pradesh	4	17	Thomas et al. (1998)
North East region	5	23	Renuka (1996)
India	5	70	Renuka (1997)
World	13	600	

Table 2. The indigenous system of classification of land use in the study area including bamboo plantations

Landuse type (local name)	Definition	Average no. of plots per household	Average size of plot per household	Type of plantation
Opin	Clan forest area belonging to entire clan.	2-Jan	1 to 1.5 ha	Wild
Agike	Individual forest land	3-Jan	–	Wild
Takam	Community forest in the village	1	–	Plantation by villagers
Dibang ko among	Bamboo plantation surrounding the village at different site and location planted types of bamboo	15-20 Clumps	–	Wild bamboo plant near by the village
Ditaklok Dajum Arik	Jhum land cultivation in valley land and hill slope above 10-20° slope	1	1-2 ha	Manly grow rice, millet, maize, beans, vegetable and cotton.
Ekum Bari	Vegetable and fruit garden away from the settlement	1	200 sq m	Vegetable, fruit, Toko, and bamboo
Asi Arik	Wet Rice field	1 or more	1 to 4 ha	Rice only
Bari	Fruit and other forestry garden in the 1 to 2 km from the village	3-Jan	0.5-1 ha	Tea, Toko, Orange etc. garden
Ekum	House or homestead within the settlement	1	90 sq m	–
Kunsumg	Seed store house near homestead	1	30 sq m	–
Poyup	Rest house in the jhum and irrigated field	1	30 sq m	–

Land use pattern and bamboo plantations

Land is probably the most precious commodity in the study area and has very high value. The social status of a man in Abor-Minyong society is largely determined by the size of his land holding. A large variety of land uses have been recorded in the study area (Table 2). There is a typical pattern in the topographical relationship of a settlement to the surrounding plantations, forest and agricultural land so that there is barely any difference from one settlement to the next. Land ownership is either individual or belongs to a clan. Shifting cultivation (locally called as jhum) is major land use and the land is community owned, however, a farmer maintains and procure all agriculture products from it. The most important privately owned land uses are wet rice fields *(Asi Arik),* all bamboo *(Dibom ko among)* and Toko *(Taik bari)* plantations, home gardens *(Ekum bari),* granaries, and forest plantations *(Agike).* A clan also has its own forest patches *(Opin),* burial grounds, and the sites for assembly platforms within the settlement. Common village land *(Takam among)* is now minimal and is confined to pasturelands on the outskirts of the village. The scarcity of land has led to the development of an admirably efficient indigenous land management system by the Abor-Minyong community in the area. It shows that the various basic needs are met from different land uses, which are essential for the survival of local community. The community meticulously guards the bamboo plantations. These plantations are properly fenced and each household has 1-2 such plots. Collections and cutting from each plantation is strictly maintained and done at the time of hard needs. The subtropical climatic and physiographic features of the study area have favorably contributed to harboring of bamboos, and particularly *Bambusa, Dendrocalumus, Cephalostachyum* are the principle genera found in the area. Besides plantations, bamboos occupy abandoned habitats and they colonize fast in lower hill slopes.

Bamboo and cane species of the area

Farmers collect bamboos from their own plantations as well as from wild habitats, while cane is collected from forest areas only. A total of 18 bamboo species and 4 cane species were recorded being used by the villagers in the study area. These species differ from each other in their size, strength, and uses and therefore are described in detail. Characteristics and uses of various bamboo and cane species are summarized in Table 3. Some important bamboo species are described below:

Dibang (Bambusa tulda Roxb.)

This is a sturdy bamboo highly preferred for cultivation in low altitude to mid-hills. It is placed in such a way that it surrounds village and *jhum* fields in the study area. It is a tall and less prolific species having profuse branches at lower nodes. The habitat ranges from open valley to mid-hill slopes, and adjoining to thick forest areas. The species is good for timber, pulping, furniture making, handicrafts and other works. Young sprouts are edible but generally not collected from the plantations.

Eppo (Dendrocalamus hamiltonii Nees.)

This is one of the abundant species endemic to the area. Its adaptability zone is up to 600 m above sea level where it is seen in community forests and as a dominant of forests. It is a tall species, and is good for pulping, timber, handicrafts, water pipes and containers. The new shoot of *D. hamitonii* are a delicacy and frequently consumed for food.

Homeng (Bambusa pallida Munr.)

This is a slender, feminine bamboo found in mixed forests and monoculture stands and in semi-wild conditions in the study area. It is a medium tall, medium prolific species, sparsely branched at lower nodes and conspicuous due to smaller leaves with a white ventral surface. The species is widely used for light decorative work, flooring and indoor walling of bamboo houses, furniture work and its edible young sprouts.

Ea (Bambusa nutans Roxb.)

A slender but sturdy bamboo with a close resemblance to B. tulda in height, vigour and clump characteristics except for branching at the nodes and leaf size for which this species has more similarity with *B. pallida.* It is commonly used for timber and pulping purposes.

Surung (Dendrocalamus giganteus Munr.)

This is the giant bamboo, available in cultivated conditions in the community forest in the study area. The clumps are very vigorous. Individual culms measure about 30 m tall and 50 cm in diameter. It is a slow growing bamboo, which is good for timber, pulping, furniture making, handicraft and food.

Tador (Pseudostachyum polymorphum Munr.)

This is a wild species occurring at medium frequency from valleys to mid-hill slopes in the forest under-cover. It has a semi-climbing habit and very thin culms. It is mostly used for tying farm fencing and other works.

Bulukang (bambusa balcooa Roxb.)

The strongest, tall bamboo widely cultivated mostly in the plains and valley areas. A thick tuft of branches at the nodes, which are very close, characterizes this species. Individual culms measure over 25 m tall and 30 cm in diameter. It is good for timber, pulping, handicrafts, furniture and fencing.

Madang (Cephalostachyum pergracile Munr.)

This is a tall bamboo to over 20 m, with a white powdery culm surface. It is cultivated in the community forests of the study area. The species is good for furniture making, handicrafts, timber and food.

Table 3. Important bamboo and cane species, their availability, characteristics and uses in the study area

Species	Local name	Availability	Average outer diameter (mm)	Average wall thickness (mm)	Inter node length (mm)	Uses
Bamboos:						
Bambusa tulda Roxb.	*Dibang*	Planted	30-50	5-6	260-270	Pulping, timber, handicraft, food
Dendrocalamus hamiltonii Nees.	*Eppo*	Planted	80-100	5-6	350-400	Pulping, timber, handicraft, food
Bambusa pallida Munr.	*Homeng*	Wild	25-35	2-3	150-190	Pulping, timber, handicraft, food
Bambusa nutans Roxb.	*Ea*	Wild	30-60	8-10	270-300	Handicrafts, timber furniture, pulping, food.
Dendrocalamus giganteus Munr.	*Surung*	Planted	0.50 m	18-20	450--570	Furniture, timber, handicrafts, *miscellaneous, food*
Pseudostachyum polymorphum Munr.	*Tador*	Wild	5-9	2-3	150-180	Miscellaneous
bambusa balcooa Roxb.	*Mulukang*	Planted	35-40	2-3	480-500	Handicraft, furniture, miscellaneous, live fencing
Cephalostachyum pergracile Munr.	*Madang*	Wild	25-35	2-3	400-500	Timber, handicraft, furniture miscellaneous and food.
(not identified)	*Emmo*	Wild	15-20	2-3	450--570	Miscellaneous
(not identified)	*Tagir*	Wild	10-15	4-5	150-190	Rope in rituals
(not identified)	*Tatpin*	Wild	20-25	5-6	450--570	Miscellaneous
(not identified)	*Tabum*	Wild	15-18	2-3	150-190	Rope
(not identified)	*Tangeng*	Planted	10-15	2-3	150-190	House/comb
(not identified)	*Enning*	Wild	20-25	10-12	260-270	Miscellaneous
(not identified)	*Taok*	Planted	20-25	3-5	260-270	Timber, handicraft, furniture miscellaneous, food
(not identified)	*Talum*	Wild	25-30	3-4	150-190	Miscellaneous
(not identified)	*Tape*	Wild	20-25	2-3	150-190	Pulping, timber, handicraft, food.
(not identified)	*Tabo*	Planted	10-15	15-20	260-270	Ritual, Agriculture tools
Cane:						
Plectocomia himalayan Griff.	*Yoi*	Wild	10	–	100	Housing and fencing twine craft.
Calamus acanthospathus Griff.	*Jeying*	Wild	20	–	150	Craft and traditional rituals (prayer)
Calamus erectus Roxb.	*Ramang*	Wild	15-20	–	250	Craft and twine for house.
Calamus inermis T. Anders.	*Takat*	Wild	10-15	–	320	Craft

Other wild bamboo species

Emmo, Tagir, Tatin, Tabum, Tangeng, Enning, Fnning, Taok, Talum, Tape, Tabo are found in the study area, mainly in wild conditions, and have yet to be scientificaly identified (Table 3). *Emmo, Tagir, Tatpin Tabum, Enning, Talum,* and *Tape* are found in very remote forest areas. Villagers are now planting some of these species.

Cane species

There are four species of canes found and used in the study area. They are locally known as T*akat, Ramang, Jeyingm* and *Yoi*. All these species are collected from forests. The *Jeying* and *Yoi* have a durable core, which is as strong as its outer layer. The matured canes collected from the forest are first cleaned and made into bundles. These bundles are put over the fireplace for about two months for seasoning. Important cane species of study area are described below:

Jeying (Calamus acanthospathus Griff.)

Jeying is the most important cane used in the study area. It is considered the most durable among all four species and is widely used as twine for interior and exterior work in houses, verandas and fencing, and for making woven bamboo craft products. It also has the largest diameter among all the species used the area.

Ramang (Calamus erectus Roxb.)

Ramang is the tallest cane found in hilly areas. This is second most important cane after *jeying* in the area and is used mostly for craft work and to make the thickly braided rope ties for the sacrificial *Mithun*, a local draft animal. Now it is difficult to collect this species from forests and most households make an annual pilgrimage to remote forest areas to collect a coil of this cane for use in various ritual sacrifices during the festivals. This cane species is found in the sub-tropical forests. It has long inter-nodes, a small diameter and a strength and flexibility that make it especially suitable for the rim strengthening elements, feet and side supports of woven products.

Takat (Calamus inermis T. Anders.)

Takat is an important cane used by the Adi villages and it is mostly collected from high altitude mountain areas. It is used for making local caps (Adi cap). It is about 20-25 m length and available in small quantities only.

Yoi (Plectocomia himalayana Griff.)

Yoi is smallest cane mostly growing in the valley forest. This species is rarely used due to its low durability in exposed conditions. The only use is to tie loft floors, ceilings or other similar minor works, such as jungle backpack and low-quality furniture (especially chair) making. The present use is very negligible.

Bamboo and cane utilization

Bamboo is traditionally used in building construction since time immemorial. It is used in the foundation, frames, floors, walls, partitions, ceilings, doors, windows and roofs. *Dibang* is the most commonly used species for housing, crafts and fencing. The fresh bamboo shoots of *Dibang* are eaten in season, though in small amounts. Spoilt, dead or distorted bamboo culms are used as firewood. The use of bamboo and cane was highest for house construction & repairs, followed by fencing, crafts and the minimum requirements for ritual altars. Each species has a specific use based on its properties. Some species are used for making craft products while other are consumed as bamboo shoots. Over 90% of bamboo shoots *(Ikung)* for food purpose are collected from forests.

House construction

The average size of traditional Abor-Minyong house is about 90 m^2, seed store of 30 m^2, and field hut in rice fields and *jhum* field of 30 m^2 are predominantly constructed of bamboo. All Adi Abor-Minyong houses are of identical design with a simple rectangular plan with an open verandah in front *(Gotek)* and at the back *(Tunggo)*. Both these open bamboo platforms are used as sitting outside and for craft work for weaving as well as for drying paddy (rice) and millet on woven bamboo mats. A narrow room at the entrance is used for rice pounding and houses an array of bamboo cages for hens. The main long room is a hall with typically two hearths at either ends of its length. All activities in the house like sleeping, cooking and washing are centered on this hearth. A three tiered drying shelf of cane and bamboo hangs just above the fireplace, where the smoke emanating from the ever-present fire and dries meat, paddy grains and cane

Table 4. Annual bamboo Utilization in the study area
(values are in average no. of culms for bamboos and no. of bundles for cane)

Village	No. of HH	Ritual practices		Housing repair		Craft products		Fencing repair	
		Per HH	Total village	Per HH	Total village	Per HH	Total village	Per HH	Total village
Bamboo:									
Bamin	125	2	250	130	16250	40	5000	60	7500
Mikong	103	2	206	120	12360	35	3605	56	5768
Miclung	55	2	110	120	6600	39	2145	40	2200
Total	283	2	566	124	35210	38	10750	52	15468
Cane:									
Bamin	125	-	-	2	250	5	625	2	250
Mikong	103	-	-	2	206	4	412	1	206
Miclung	55	-	-	2	110	4	220	2	110
Total	283	-	-	2	566	4.3	1257	1.6	566

HH= Household 1 Bundle for cane twine= 20 pieces of 5-6 m length per piece

twine. A loft floor *(Ambin)* is used, as stores to keep bamboo and cane articles. This floor structure is entirely made of a series of entire bamboo poles clamped and tied with cane, and it has a roofing of *Toko* leaves. The main hall has a flooring *(Kok)* of flattened bamboo culms laid together and tied down tightly with a continuous length of cane twine, while that of the verandas and rice pounding room is of half split bamboo lengths laid close together and tied with cane rope. A total of 235 bamboo culms are used by a household every year for its housing, fencing, crafts and ritual needs, of which 130 culms are used for housing repair (house, seed store and field huts), and 60 for fencing repair. It was estimated that the three studied villages annually use nearly 35,000 mature bamboo culms for housing repair and over 15,000 culms for fencing (Table 4). Over five hundred bamboo pieces are used in the making of the ritual altar during the two festivals. Among all the studied villages Bamin village uses the highest number of bamboo culms for housing and fencing and they also have the largest bamboo plantations as compared to the other villages in the study area. Miclung village on the other hand has the lowest consumption of bamboo, proportionate to its size.

Cane is also used in house construction, for tying and for making local craft products for household needs. It was recorded that 110-250 bundles of cane twine are used annually in housing in the different villages (Table 4). On average at least 10 bundles of cane twine (1bundle = 20 pieces of 5-6 m each) was required per household every year in the study area. In all the studied villages the annual use of cane was estimated 2389 bundles of twine, which is very high. Continuous harvesting due to such high demand has definitely affected its availability in the forest during recent years.

Nearly 183 culms of bamboos and at least 150 m of cane twine is used by a household for construction and maintenance annually (Table 5). An Abor-Minyong house has an approximate life span of 8-10 years. During recent years there is an increasing use of cement in wall construction and use of tin for the roof. The upgraded house type with cement concrete pedestals, bamboo walls in a timber framework and corrugated galvanized tin (CGI) sheet roofing has a life of about 30-40 years and does not need complete replacement of its elements. This has greatly reduced the number of houses being built annually. In Bamin village just 10% of the houses have CGI sheet roofs, while Miclung and Mikong villages have far fewer roofs with CGI sheet. There are a large number of bamboo species used for bamboo housing in north east region (Laha 2000), and as this zone falls in a high seismic area, further improvement in bamboo housing technology, particularly for durability and reducing fire hazards, will help locals to use this resource more judiciously. Furthermore, increasing dependence on heavy construction could be reduced substantially.

Table 5. Cane and bamboo utilization for a new house construction in the study area

Village	No. of House-holds	Average no. of houses built every year	Average no. of bamboo use per house (culms)	Total no. of bamboo used annually (culms)	Average quantity of cane twine used per house (in m)	Total quantity of cane twine used annually (in m)
Bamin	125	25	200	5000	150	3750
Mikong	103	15	200	3000	150	2250
Miclung	55	10	150	2000	150	1500
Total/Mean	283	50	183	10000	150	7500

Bamboo and cane crafts

The people of this area abundantly use cane and bamboo for craft purposes. The Adi Abor-Minyong have proficiency in the art of making baskets, which are the most important items of their household. Each household used 40 culms of mature bamboo for craft purposes. The basketry of the Adis depicts their real aspect of material culture. This also reveals high dependency on the natural resources in the community, especially in production of household utensils, mats, mugs, ladle, containers, jars, baskets etc. Bamboo and cane species are widely used for making basketry (Table 6). No separate establishment is maintained for cane and bamboo works. The products vary according to the demands of the daily life. The product of manufacture is mainly checkered, twilled, hexagonal, coiled and with an intricate pattern formed by thin trimmed strips of cane and/or bamboo. Fancy items have higher value. Two types of cutter/knife are used for cane and bamboo articles, one is a sword type with a larger blade, narrow towards the haft and broader towards the tip with a wooden or bamboo handle fixed with a tang. This is known as an *Evok (Dao)*. The other is a small knife of obtuse shape with a wooden handle. This is called a *Yokshik* in the local dialect and is equivalent of pan-knife.

Previously standard size of baskets was used to measure the quantity of food grains when weights and scales were unknown. Baskets were also used to measure the yield of a particular field crop and to exchange grains. Bamboo containers were used for storing and supplying rice beer. Besides, basketry is used in multi-dimensional objects among the Adis. The annual requirement of handicrafts in each village varied from 2100-5000 numbers of bamboo articles and 220-625 number of cane articles. The total requirement of bamboo for craft purpose was recorded as high 10000 culms in three villages. The requirement of cane for craft products was much higher and 220-625 bundles of cane twine used annually for this purpose.

Limited production of bamboo mats used for crop drying was also found. The mats in vogue, are made from leaves of Screwpines *(Pandanus sp.),* which are trimmed into strips of about 5 cm, and woven in checker pattern.

Demand for local products

Some of the traditional uses of bamboo are implements for agriculture, fishing and hunting purposes. Craft products, which have a high local demand, are the *edum* (a storing basket), *ape* (a food grain container), *perop, baye kiro, sopur, papur sakpur, tali, stkya luppper ebong, epo bari, epyop, pasak, epu lgg, tirkak, asidupu, biyem, kaksur* and *petir* (Table 6). Minor products like the *porang, edir tari, porang, gakar akkang, raading, raasi, jamborong iyi, epuk bupur, etku, songki* and *eda* are made and used in every household but are never sold. The *Epo* or winnowing fan though made only by a select few in every village, has good local demand. The demand for items such as the traditional bamboo-*Toko* umbrella and intricately woven cane hats has diminished considerably and at present they are rarely found or made. This can be attributed to readily available synthetic items available in the market. The filter and water carrying and storing bamboo pot *Asidupu* faces stiff competition from the plastic sieves

Table 6. Traditional bamboo and cane craft products and their annual household demand

Domestic Bamboo/ cane items	Local name	Average life with regular use (in year)	Average No. of pieces required every year per household	No. of bamboo and cane used per article	Primary material
1. Storing basket	*Edum*	8-10	1	8	*Epo*
2. Food grain container	*Ape*	1-2	2	1	*Epo*
3. Vegetable container	*Perop*	1-3	1	1	*Epo*
4. Carrying basket	*Baye*	1-2	2	1	*Epo*
5. Carrying basket for firewood and bamboo water tubes	*Kiro*	1	2	3	*Dibang*
6. Food grain container	*Sopur/ Papur*	1-2	2	1	*Dibang*
7. Small basket normally used for agricultural grains	*Sakpur*	1-3	1	1	*Dibang*
8. To support spinning wheel while walking or standing	*Susak*	3-5	1	1	*Dibang*
9. Haver-sack	*Tali*	3-5	1	2	*Jeying*
10. Rope	*Sotkya*	2-3	1		Horjok
11. Japi	*Lupper*	1-2	1	1	*Epo*
12. Bo-tari	*Ebong*	1-2	1	3	*Epo*
13. Botok	*Ebong*	1-2	1	3	*Epo*
14. Winnowing fan	*Epo*	2-4	1	3	*Epo*
15. Storing container of food grains	*Bari*	8-10	-	5	*Epo*
16. A small sized mat used to dry food grains	*Epyop*	2-3	1	6	*Ea*
17. Ginned cotton container	*Pasak*	5-6	-	1	*Ea*
18. Mat	*Epu*	2-3	1	8	*Epo*
19. Weeding implement	*Igg*	5-6	-	1	*Epo*
20. Measuring pot	*Tirkak*	5-6	-	1	*Epo*
21. Bamboo pot for carrying and storing of water	*Asidupu*	4-5	3	6	*Epo*
22. Bamboo basket for storing dry meat and fish at home	*Biyem*	5-6	-	1	*Epo*
23. Bamboo pot for apong (a local beverage) drinking	*Kaksur*	2	1	1	*Epo*
24. Rice plate	*Dore*	3-4	-	1	*Epo*
25. Stool (Mora)	*Hunggeng*	2-3	2	1	*Epo*
26. Cloth hanging road	*Gobe*	5-6	-	1	*Epo*
27. Hen coop and chickens basket	*Petir*	1-2	1	2	*Tabor*
28. Fire wood carrying basket	*Ebar*	1	2	3	*Tabor*
29. Rice carrying basket	*Egin*	1	2	4	*Ea*

Table 6. Traditional bamboo and cane craft products and their annual household demand (cont'd)

Domestic Bamboo/ cane items	Local name	Average life with regular use (in year)	Average No. of pieces required every year per household	No. of bamboo and cane used per article	Primary material
Fishing Implements					
30. Fish trap	*Porang*	1	10	1	*Ea*
31. Single or double valve trap	Edir	1	5	2	*Ea*
32. Thorned fish trap	*Tari porang*	1	5	1	*Ea*
33. Fishing rod	*Gakar akkang*	1-2	1	1	*Ea*
34. Long and big sized trap	*Raading*	1-2	3	1	*Ea*
35. Small sized trap	*Raasi*	1	10	1	*Ea*
36. Arrow for shooting fish	*Jamborong*	1	20	1	*Ea*
Hunting/War and Chase items					
37. Shield	*Temte*	10	1	1	*Ea*
38. Poisons arrow	*Emo Morang*	10	-	1	*Ea*
39. Quiver	*Gatbung*	8-10	1	1	*Ea*
40. Bow	*Iyi*	8-10	1	1	*Ea*
41. Arrow	*Epuk*	8-10	20	1	*Ea*
42. Bupur to keep dead birds and other things	*Bupur*	2-3	1	1	*Ea*
43. Trap for catching mice and squirrel and bird on ground and trees	*Etku*	1	50-100	18	*Ea*
44. Trap for bird and animals on the ground	*Songkit*	1-2	2	-	*Horjok*
45. Trap for catching bird on ground	*Lepam*	1-2	3	8	*Ea*
46. Deer and wild cat trap	*Eda*	1-2	2	6	*Surung*
47. Salt and chilli powder container	*Huksung*	2-3	1	1	*Surung*
48. Drink millet and rice beer cup	*Edung*	2	4	10	*Surung*
49. Cook and serve food spoon	*Lukung*	5	-	1	*Surung*
50. Clamp (Chimta)	*Megap*	1-2	2	1	*Surung*
The Common cane products					
51. Head gear	*Dumlup*	3	1	20	*Jeying*
52. Carrying basket	*Kirko*	1-2	1	3	*Jeying*
53. Storing basket	*Edum*	2-3	1	-	*Horjok*
54. To transfer foodgrain from agri. fields	*Suja*	1-2	1	8	*Ea*
55. Haversack	*Tali*	4	1	1	*Ea*
56. Strap	*Tayi*	2-3	1	3	*Ea*
57. Rope	*Sotkya*	2-3	1	-	*Horjok*
58. Mat	*Epu*	2-3	1	8	*Ea*
59. Dao cover	*Eyokhobuk*	4	-	1	*Ea*
60. Carrying fire wood basket	*Ebar*	1-2	1	3	*Ea*
61. Hat	*Dumyup*	20-30	-	2	*Yoi*
62. Closed weave basket	*Dore*	10		1	*Jeying*

Table 7. Annual consumption of Bamboo shoot in the study area

Village	No. of households	Average quantity of bamboo shoot consumed annually					
		Dry (in kg)		Fermented (kg)		Fresh* (in kg)	
		Per HH	Total	Per HH	Total	Per HH	Total
Bamin	125	2	250	2	250	5	625
Miclung	55	2	110	2	110	7	385
Mikong	103	2	206	2	206	5	515
Total	283	2	566	2	566	5.6	1525

HH= Household; Total = For entire village
*Fresh bamboo shoot use as a vegetable

readily available in the market and is slowly losing its local market. Wooden and tin trunks have replaced the elegant *Gadun* boxes but they could be revived and modified for a different market. Conversely, the demand for the grain carrying head basket *(baye)* and the storage basket *(edum)* is very high and common across all the villages in the study area. An average of 3 bamboo-carrying baskets *(kiro),* 1 cane *kirko* basket, and 1 cane *(edum)* and 1 bamboo *baye* is required annually for each household in all the villages. The demand for the grain drying mat or *(epu)* is equally high and on an average 2 to 3 mats per household were used, each lasts for about 10 years. Every household rears chicken which are kept small baskets or hencoops *(Petir).* The annual demand fluctuates according to the number of hens in the household during a particular year, however on average each household required 3 hencoops per annum. It was found that a small scale industry based on bamboo and cane products still has a considerable local market but one which is inevitably in process of rapid change. The local market will need new and more economically produced products. This implies a complete change, which definitely needs to be addressed for access to outside markets.

Edible bamboo shoots

The local demand for bamboo shoots is very high as other vegetables are scarce, thus bamboo shoots are a major part of the Adi diet. Every household uses bamboo shoots in almost the same quantity and generally collects them from forests or rarely from plantations. Bamboo shoots are used as fresh vegetables *(eting),* in dried *(eup)* and fermented *(ekung)* forms, and each family annually uses 5-7 kg of fresh, and 2 kg each of dry and fermented bamboo shoots (Table 7). Bamboo shoots are collected from surrounding forests during rainy season from June to September, the total annual consumption was estimated 500 kg in Bamin, 220 kg in Miclung and 412 kg in Mikong village. Two species of wild bamboos are commonly used for making dry bamboo shoots, of which the slightly sweet flavored surung is the preferred variety, though less common in occurrence than *Eppo (Dendrocalamus hamiltonii).* The market price of the fresh shoots during the study was Rs 10 per kg, and Rs. 40 per kg (Rs. 45= 1 US$) for dry and fermented shoots.

Sources of bamboo and cane

Housing, craft and fencing needs of bamboo are met from both individual and community plantations and forests, while the cane requirement is entirely met from forests. Housing and fencing repair needs are usually met from bamboo plantations within the village (Table 8). At times villagers also purchase *Dibang* bamboo from other farmers within the village. Bamin, Miclung and Mikong villages have the largest bamboo reserves in their community and clan forests areas, and have cane in their community forests and surrounding forests.

Table 8. Sources of Bamboo and Cane in the study area

	Source of Bamboo (%)		Source of Cane (%)	
Village	Forest (wild)	Plantation	Forest (wild)	Plantation
Bamin	76%	24%	100%	0%
Mikong	60%	30%	100%	0%
Miclung	80%	20%	100%	0%

Implications for management

All the tribal groups are dependent on bamboo and cane resources for their various basic needs such as housing, fencing, food and craft works. In the study are bamboo resource are at present considered enough just to meet the basic requirement of the local community, however, it cannot be said to be in surplus. When a house has to be rebuilt (after every 5 to 6 years), the requirement of mature bamboo is up to 450 culms, which can be collected from an average plantation size of about one hectare. Therefore plantations of more and more bamboo species as well as more area could be of value in near future (Haridasan *et al.* 1987). Furthermore, diversion of a part of the well managed bamboo resource towards income generation activities like ply production and craft products with improved technologies could provide the area with a much needed economic alternative. The small-scale industry based on bamboo and cane products still has a considerable local market but one which is inevitably in a process of rapid change. The local market will also need new and more economically produced products. Bamboo shoots also have tremendous potential as a commercial business, since there is large local demand as well as outside market.

The bamboos are quite useful for soil conservation due to their intricate rhizome system and roots. Villagers prefer bamboo plantation along the river in Miclung village and surrounding the shifting cultivation fields in the Bamin village. Generally planting is started in May-June. A harvesting cycle of 3 to 4 years is generally adopted in bamboo plantations leaving a few old culms and all of the first year culms. Harvesting time is generally in winter months (November to January). Cane used to be found in abundance in the past, now over-exploitation and habitat destruction have made it a scarce material. At present canes are being collected from far off areas in forests. Cane plantations are highly desirable in the future. Even at present, the local need is much higher than the availability of cane resource. Canes are highly habitat specific (Haridasan 1996). The cane habitat destruction is the major problem in this area. Any disturbance in their natural habitat will adversely affect the survival. If the depletion of cane of Arunachal Pradesh continues unabated at the current rate, the future supply is going to be affected remarkably (Thomas *et al.* 1998). As such there is an urgent need for conservation, through establishment of plantations which would greatly help in conservation programmes.

Protection of bamboo young plants in the seedling stage from cattle wild animals is necessary because it provides the best fodder for animals. In village areas, bamboo plantations are properly fenced. However, in forest and other wild habitats, open grazing and fire are the major causes for deterioration of bamboo and cane resources, and is seriously affecting their regeneration in many places. Raising bamboo and cane plantations for economic development could prove a very useful tool for increasing local economy, as there is always a demand for the goods as well as raw material in the market. Such plantations could be raised in shifting cultivation-fallows, on private land and on village lands. Unfortunately the road network is poor in the villages and transportation of material will be the main problem, which could only be improved by the local State Government interventions. Although extensively traded throughout the country, bamboos do not have a standard market price (Tiwari 1992). There is a wide variation in unit price of bamboo in different districts, towns and villages.

The variation in price also largely depends on the variety of bamboo. A good quality bamboo culm of about 6 m length and 18 cm girth sells for about Rs. 20 per piece and one about 8 m length and 18 cm girth costs nearly Rs. 30 per piece in the retail market. It may fetch much higher prices at market centers. Therefore, the government has a larger role to play. Fortunately farmers are skilled and well aware of the role of bamboo and canes.

Development planning for the Adis must be based on and through development of natural resources that are found the area, especially bamboo and cane. Although metal and other implements have overtaken the wooden utensils for convenience in many places, a few traditional items are still widespread in use. Basketry is still a prevalent small-scale cottage industry among the Adis. Cane basketry is extra source of income and it has room for improvements (Biswas and Dayal 1995). For meeting the demand of cane, due incentives for growing cane in the individual forest, *jhum* field areas and plantations needs to be given priority. *Jhum* field can be rehabilitated by cane cultivation, a high value raw material for handy crafts and furniture. Incorporation of cane in *jhum* field *(kheti)* is an indigenous system in Kalimantan Indonesia (Singh 1999). This can be extrapolated to the shifting cultivation area of the state and the whole of the north-east. After clearing a forest plot for *jhum* for one to two years, the fallow land can be planted with cane, when the rotation is allowed to be repeated in 5-15 years, the farmers will first harvest cane for substantial income and clear the plot again for a food crop. This will help to raise the income from same piece of land and protect it from degradation during the fallow period. Similar to other tribal communities, the attitudes of the Adis are intertwined with the traditions prevalent in the society (Upreti *et al.* 1999). The community is marching forward in the arena of education. The young and educated with the help of old skilled artisans can take up bamboo and cane craftwork on a commercial level.

China has exceeded US$ 2.1 billion in business from bamboo, and India is way behind despite good prospects (Sastry 2001). Northeast India has similar potential for economic development from bamboo. Cane is already a prized material for furniture, however, there is a serious depletion of this resource, which needs to be urgently addressed. Considering the potential of bamboo and cane in the region, recently the INBAR has initiated a few programs in Northeast region of India with the help of the Cane and Bamboo Technology Center (CBTC), Guwahati. Various local organizations are being identified and their facilities and capacities are being upgraded. INBAR has proposed designation of one district in each of seven states as a "Bamboo district" to mark its importance and to focus intensive development on bamboo resources. This program will focus on underpinning social, economic and environmental development, and serve as the main center for further development of small and medium enterprises through community involvement. This should be considered as a welcome step. If the vast cane and bamboo resources of the region could be developed scientifically, it would generate significant employment opportunities for artisans, entrepreneurs and farmers of the state, and thus revolutionize the socio-economic status of rural folks.

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Field identification key to the native bamboos of Kerala, India

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ABSTRACT

An artificial key and brief descriptions of the 24 species including 2 varieties of the native bamboos belonging to 6 genera Bambusa, Dendrocalamus, Ochlandra, Pseudoxytenanthera, Schizostachyum and Sinarundinaria of Kerala is provided based on easily observable vegetative and floral characters with appropriate illustrations. Bamboos are diverse group of plants comprising a large number of genera and species in the tropical, subtropical and temperate regions of the world. They comprise a total of 111genera and over 1575 species (Ohrnberger, 1999). Among these, 128 species belonging to 18 genera of bamboos are recorded from India (Seethalakshmi & Kumar, 1998). Bamboos in India are distributed mainly in the geographic zones such as Western Himalayas, Eastern Himalaya including North East India, Peninsular India and Andaman & Nicobar Islands. Peninsular India is one of the richest domiciles of native bamboos second to Eastern Himalayas. So far, 32 species and 2 varieties under 8 genera are known to occur in Peninsular India which include the following 8 species namely, Bambusa multiplex, B. polymorpha, B. vulgaris, Dendrocalamus brandisii, D. giganteus, D. hamiltonii, Thyrsostachys oliveri and T. regia that are cultivated and naturalized by introduction. Among the 32 species and 2 varieties of bamboos 24 species including 2 varieties under 6 genera are native to Kerala (Kumar et al., 2000). Within South India, Kerala is perhaps the richest habitat of natural bamboo species. Evergreen forests of Western Ghats are the largest natural home for bamboos. Based on the extensive survey and field observations throughout Kerala, the authors have collected the specimens and constructed an artificial key for the identification of bamboos of Kerala both at generic and specific levels mainly depending on fresh specimens. The floral and vegetative characters have been taken for the preparation of this key.

MATERIALS AND METHODS

All the species of bamboos collected from the area are maintained in the KFRI Herbarium. The materials were identified on the basis of morphological and floral characters. The specimens deposited in the various herbaria: MH, CAL and CALI and also cibachrome sheets for the type specimens from Kew (K) herbarium were consulted during the study.

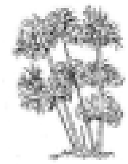
RESULTS

In Kerala there are 24 species of native Bamboos under 6 genera so far recorded. A brief description and a key is also provided for easy identification. During the study three new species and a new record for India under the genus Ochlandra could be collected.

Key to Bamboos of Kerala

The key has been prepared based on easily observable and distinguishable field and vegetative characters and floral characters separately which will enable the user to fix the identity of bamboo species occurring in Kerala.

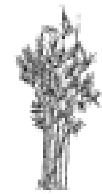
Key to the subtribes of the Bambuseae



1

1a. Bamboos 1-2.5 m tall, spikelets not clustered or fascicled, borne in raceme or panicle like inflorescence, stamen 3..*Arundinariinae*

1b. Bamboos 8-20, spikelets clustered, borne in fascicles or capitate heads, stamen 6 or more 2



2

2a. Bamboos tall arborescent, culms large, hollow to semi solid wall of the culm 3-3.5 cm thick, summit of the ovary pubescent ....*Bambusinae*

2b. Bamboos medium sized culms comparatively small, strictly hollow, thin walled, wall of the culm 0.3-0.5 cm thick, summit of ovary glabrous.................................*Melocanninae*

Key to the genera based on vegetative characters

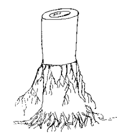
1b

1a. Bamboos 12-20 m tall tree like 2

1b. Bamboos 1-2.5 m tall shrubby in appearance ....*Sinarundinaria*

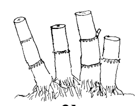
2a. Culms erect leaves narrow, 10-14 x 1.2-1.6 cm...............3

2b. Culms not erect leaves broad 22-60 x 3-6 cm 4



3a

3a. Culms 25-30 m tall, hollow, basal node with fibrous roots...*Bambusa*



3b

3b. Culms 20-25 m tall, semisolid basal node with short and stout thorn like roots ....*Dendrocalamus*

4b

4a. Culms thin walled and reed-like, leaves broad 4-6 cm 5

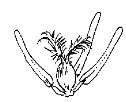
4b. Culms not thin walled and reed-like, leaves comparatively narrow 3-3.5 cm ....*Pseudoxytenanthera*

5a

5a. Bamboos occurs in large patches,culms self supporting...*Ochlandra*

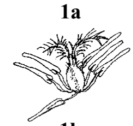
5b. Bamboos occurs in small patches culms straggling or climbing ....*Schizostachyum*

Key to the genera based on floral characters



1a

1a. Flowers with 3 stamens ....*Sinarundinaria*



1b

1b. Flowers with 6 stamens or more 2

2a. Lodicules present 3

2b. Lodicules absent 5

3a

3a. Spikelets with strictly 6 stamens, caryopsis not fleshy....4

3b. Spikelets with more than 6 stamens, caryopsis fleshy ...*Ochlandra*

4a. Caryopsis elliptic with a pubescent nipple at the summit ..*Bambusa*

4b. Caryopsis oblong to ovoid and without pubescent nipple at the summit ....*Schizostachyum*

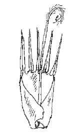

4a

4b

5a. Filaments free, spikelets stout ....*Dendrocalamus*


5a

5b. Filaments united, spikelets thin ....*Pseudoxytenanthera*


5b

Bambusa Schreber

Tufted, arborescent or shrubby bamboos, rhizome sympodial, pachymorph. Culms dense, 25-30 m tall, hollow, rarely solid, basal nodes with fibrous roots. Culm-leaves with blades typically erect. Branching intravaginal. Inflorescence usually a large leafless compound panicle. Caryopsis elliptic with a pubescent nipple at the summit.

Distribution: Native in the tropics and sub tropics of the old world, mainly in South- East Asia. Pakistan, India (with Andaman Islands); Sri Lanka, Nepal, Bhutan, Bangladesh, Burma, Thailand, Laos; Kampuchea, Vietnam, China (Central, Eastern and Southern parts including Taiwan and Hainan); Japan, Malaysia, Singapore, Indonesia, Philippines, Papua New Guinea, Australia and Madagascar

Bambusa Schreber (Vegetative)

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

Bambusa Schreber (Floral)

1a. Spikelets 1-1.3 cm long ....*B. bambos var. gigantea*
1b. Spikelets 0.6-0.8 cm long ....*B. bambos var. bambos*

1. *Bambusa bambos var. bambos* Voss in Vilmorin, Blumengartneri 1:1189. 1896.

Bambusa arundinacea (Retz.) Willd., Sp. Pl. 2: 245. 1799; Wight, Ined., ex Steudel, Nom. Bot. ed. 2,1, 1840; 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.

A very densely tufted bamboo producing large clumps. Culm cylindrical, erect, hollow, dark green, 15-18 cm diameter, branching at all nodes the upper leafy branches bearing small spines. Node slightly swollen and few lower nodes produce short aerial roots. Culm-leaves coriaceous, dark brown, hairy, auricles broad, wrinkled, lobes continuous with the base of the blade. Inflorescence an enormous panicle, spikelets 0.6-0.8 cm long. Caryopsis elliptic, hilum situated in a groove and extending almost the whole length.

Note: This species is distributed throughout Kerala.

2. *Bambusa bambos var. gigantea* (Bahadur & Jain) Bennet & Gaur. Thirty seven bamboos growing in India. 21. 1990.

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

This is a densely tufted tall large culmed variety of Bambusa bambos. Culm light green, 15-25 cm diameter. Node swollen, internodes thick walled, branches developing from the fifth node onwards, generally 3 branches arise from a node of which 2 are prominent, angled upwards. Culm-leaves broad, coriaceous, pubescent with dark brown hairs, deciduous at the time of branch development, ligule continuous with the sheath apex. Leaves lanceolate to linear, highly variable in size. Inflorescence an enormous panicle, spikelets 1-1.3 cm long.

Dendrocalamus Nees

Arborescent, unarmed, 20-25 cm tall bamboo. Culm erect to suberect. Node the basal node with short and stout thorn like roots. Culm-leaves with blades erect or spreading, auricles lobe-like and bristly on the margin or inconspicuous. Leaves shortly petiolate, size variable, leafy branches becoming much branched as they develop inflorescences. Inflorescence large compound panicle, spikelets stout with 6 free stamens. Caryopsis small, the seed surmounted by a crustaceous or hardened pericarp.

Distribution: This is a widely distributed species in South East Asia, India and many other countries found in natural as well as under cultivation.

3. *Dendrocalamus strictus* (Roxb.) Nees, Linnaea 9: 476. 1834. Bambusa stricta Roxb. Pl. Corom. 1: 58, t. 80. 1798.

Deciduous densely tufted bamboo. Culm pale blue green when young dull green or yellow on maturity. Node somewhat swollen, basal nodes often rooting, lower nodes often with branches; internodes thick-walled. Culm-leaves variable, lower ones shorter, striate, rounded at the top, margin hairy, ligule toothed, auricles small, blade triangular, awn shaped hairy on both side. Leaves linear-lanceolate small in dry localities, ligule very short. Inflorescence a large panicle of large dense globular heads. Caryopsis brown shining, ovoid to sub globose, hairy above, beaked.

Ochlandra Thwaites

Shrubby gregarious reed-like bamboo. Culm small, thin walled, erect with comparatively longer internodes. Culm-leaves persistent, auricles small, leaves linear or oblong-lanceolate, leaf sheathe striate, ligule short. Inflorescence a terminal spike or spicate panicle, spikelets more than 6 stamens. Caryopsis large, ovoid, long beaked, supported by persistent glumes, pericarp thick and fleshy.

Distribution: This genus is so far known from India (South India) and Sri Lanka representing 11 species and 1 variety in India and a single species O. stridula from Sri Lanka.

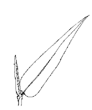
Ochlandra Thwaites (Vegetative)

1a. Leaves 40-60 x 10-12 cm 2

1b. Leaves 20-34 x 2-4 cm 5

2a. Leaf sheath and Culm-sheath with 3.5-4 cm long ligule. ....*O. wightii*

2a



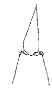
2b. Leaf sheath and Culm-sheath with 1-2 mm long ligule 3

2b

3a. Culms with shiny green nodes, Culm-sheath blade reflexed with conspicuous auricles ....*O. ebracteata*

3a 

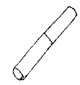
3b. Culms with pale green nodes, Culm-sheath blade erect with inconspicuous auricles 4

3b 

4a. Culms and branches with bulbous based golden brown hairs ....*O. travancorica var. hirsuta*

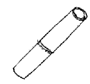
4a 

4b. Culms and branches lacking bulbous based golden brown hairs ....*O. travancorica var. travancorica*

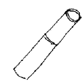
4b 

5a. Culms 3-3.5 cm diameter, leaves 30-34 x 4-5.8 cm 6
5b. Culms 2.3-2.5 cm diameter, leaves 20-26 x 2-2.5 cm 8

6a. Culms smooth, internode 17-25 cm long,nodes sparsely pubescent ....*O. beddomei*

6a 

6b. Culms rough, internodes 47-65 cm long, nodes glabrous 7

6b 

7a. Culms with a greyish band on the node, node with a prominent brown hairs towards the shoot apex ....*O. spirostylis*
7b. Culms without greyish band on the node, node without brown hairs towards the shoot apex ....*O. soderstromiana*

8a. Culms shiny dark green, upper part of the culms, with a powdery mass on the nodal line 9
8b. Culms yellowish green, without powdery mass on the nodal line 10

9a. Culm-sheath caducous, blade reflexed with a lateral extension ....*O. stridula*

9a 

9b. Culm-sheath persistant, blade erect, subulate hair like without a lateral extension ....*O. setigera*

9b 

10a. Culms with rough surface, internode 45-65 cm long .....O. keralensis
10b. Culms with smooth surface, internode 36-45 cm long ..11

11a. Culm sheath purplish with 2 falcate and long ciliate auricles, blade 10-15 cm long ....*O. scriptoria*
11b. Culm sheath not purplish, auricle short, blade 6-8 cm ....*O. sivagiriana*

Ochlandra Thwaites (Floral)

1a. Staminal filaments fused 2

1a 

1b. Staminal filaments free 4

1b 

2a. Spikelets 6 cm long, palea acute at apex, stigma less than 3...3

2a 

2b. Spikelets 4 cm long, palea blunt at apex, stigma 6-9 ....*O. ebracteata*

2b 

3a. Spikelets pubescent ....*O. travancorica var. hirsuta*

3a 

3b. Spikelets glabrous ....*O. travancorica var. travancorica*

3b 

4a. Lodicule single ....*O. wightii*
4b. Lodicule more than one 5

5a. Lodicules three 6
5b. Lodicules more than three 7

6a. Palea notched at apex, style spirally twisted ....*O. spirostylis*

6a 

6b. Palea not notched at apex, style not spirally twisted ....*O. soderstromiana*

6b 

7a. Ovary sub orbicular, style flattened ....*O. beddomei*

7a 

7b. Ovary not suborbicular, style not flattened 8

 7b

8a. Lodicules 4, 3 large 1 small ....*O. keralensis*
8b. Lodicules more than 4, all equal sized 9

9a. Lodicules 5, 3 of them bifid at ape ....*O. setigera*
9b. Lodicules more than 6, all entire 10

10a. Lodicules strictly 6 ....*O. sivagiriana*
10b. Lodicules more than 6 11

11a. Palea with a sulcus at the middle, a rudimentary rachilla at the base ....*O. stridula*

11a 

11b. Palea without sulcus and rudimentary rachilla ....*O. scriptoria*

11b 

4. *Ochlandra beddomei* Gamble, Ann. Roy. Bot. Gard, Calcutta 7: 124. 1896 & in Hook.f. Fl. Brit. India 7: 419. 1897.

An erect reed-like bamboo. Culm erect and arching. Node solitary with singly nodal line, slightly pubescent and green deciduous, internode 17-25 cm long. Culm-leaves glabrous and with a short lanceolate blade. Leaves oblong lanceolate, obliquely rounded at the base, petiole long-acuminate above with a twisted point, ligule very narrow. Inflorescence a short terminal spicate panicle, ovary suborbicular, style flattened. Caryopsis smooth, glabrous, supported by persistent glumes and paleas.

5. *Ochlandra ebracteata* Raizada & Chatterjee, Indian For. 89: 362. 1963.

An erect shrubby or arborescent bamboo with tufted clumps. Culm nodes shining green. Culm-leaves covered with many appressed, chocolate brown to black subulate hairs, blade reflexed with conspicuous auricle. Leaves narrow to broadly oblong lanceolate, glabrous on both sides, petiole grooved and twisted, margin smooth to very slightly glabrous, two short ciliate auricles, ligule arching. Inflorescence a flagellate spike of subverticillate to verticillate clusters. Caryopsis oblong, somewhat wrinkled ending in a conical beak.

6. *Ochlandra keralensis* Muktesh, Remesh and Stephen, J. Econ. Tax. 25(1): 49-51. 2001.

A small straggling bamboo. Culms erect 2-3 m tall. Nodes prominent and swollen, internode 45-65 cm long. Culm-leaves persistent, shiny smooth, auricle ciliate. Leaves alternate, linear lanceolate, acuminate at apex base truncate. Inflorescence terminal or axillary spicate panicle, flowers with 4 lodicules (3 large and 1 small). Caryopsis light green with purplish tinge with tapering beak.

7. *Ochlandra scriptoria* (Dennst.) Fisch. in Gamble, Fl. Pres. Madras 3(10): 1863. 1934.

Ochlandra rheedii (Kunth) Benth. & Hook.f. ex Gamble, Ann. Roy.Bot. Gard. Calcutta 7: 121. 1896 & in Hook.f. Fl. Brit.Idnia 7:418. 1897; Camus, Les Bambusees 181. 1913.

A gregarious shrubby bamboo. Culm erect and smooth. Node somewhat raised. Culm-leaves purplish truncate with 2 falcate, long ciliate auricles, blade 10-15 cm long. Leaves linear lanceolate, smaller and larger ones intermixed, smaller being most frequent, sheath smooth with 2 falcate auricles, fringed with deciduous bristles, ligule very short. Inflorescence a short terminal or axillary spike, flowers having palea without sulcus and rudimentary rachilla. Caryopsis large oblong and long beaked.

8. *Ochlandra setigera* Gamble, Ann. Roy Bot. Gard. Calcutta 7: 128. 1896 & in Hook.f. Fl. Brit. India 7: 420. 1897.

A small straggling bamboo. Culm straggling or erect, smooth without branches below, much branched above. Node hardly swollen, internodes whitish below the nodes. Culm-leaves persistent, thin papery, striate, wrinkled near the top, blade erect, subulate, hairlike without a lateral extension, ligule very narrow, short. Leaves oblong, lanceolate rounded at the base, smooth above minutely hairy beneath with short decurrent auricles. Inflorescence a short terminal or axillary spike on branchlets, flowers with 5 lodicules (3 of them with bifid apex). Caryopsis oblong, fleshy pericarp, glumes persistent.

9. *Ochlandra sivagiriana* (Gamble) Camus, Les Bambusees 181. 1913.

Ochlandra rheedi var. sivagiriana Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 122. 1896.

A small straggling reed-like bamboo. Culm up to 5m high. Culm-leaves not purplish, striate on maturity, auricles short, blade 6-8 cm. Leaves linear-lanceolate, acuminate at the tip, attenuate at the base, smooth sheath glabrous with 3 falcate auricles, fringed with deciduous bristles, ligule very short. Inflorescence a short terminal or axillary spike or spicate panicle on leafy branchlets, flowers with 6 lodicules. Fruit setting has not been observed so far.

10. *Ochlandra soderstromiana* Muktesh & Stephen, Rheedea 9(1): 31-35. 1999.

A small straggling bamboo. Culm erect and smooth without grayish band on node. Node prominent, internode smooth, glabrous. Culms-sheath persistent, ovate, wrinkled when old, inside shiny smooth, ligule short, auricle ciliate. Leaves linear-lanceolate, acuminate at apex truncate at base, petiole grooved above, glabrous, attached to a shiny, smooth, striate leaf sheath, inner and outer ligule present, outer ligule rounded, rigid. Inflorescence terminal or axillary spicate panicle. Caryopsis elliptic oblong, bulbous at base, awn like.

11. *Ochlandra spirostylis* Muktesh, Seetha. and Stephen, Rheedea 9(1): 31-35. 1999.

A gregarious shrubby bamboo. Culm grayish green, rough in texture. Node somewhat raised, grayish band with brown appressed hairs below on each node, which is more prominent towards the apex of the shoot. Culm-leaves thin, papery, striate when old. Leaves alternate, linear-lanceolate, acuminate at apex, base truncate, margin serrulate towards base. Inflorescence terminal or axillary subverticillate spicate panicle, palea with notched apex, styles spirally twisted. Caryopsis ellipsoid.

12. *Ochlandra stridula* Moon ex Thwaites, Enumeratio Plantarum Zeylaniae, VIII, 1864: 376.

A gregarious shrubby bamboo. Culm soft, branching occurring simultaneously from the seventh nodes and above, internodes cylindrical and hollow. Culm-leaves laminiferous, the blade strongly reflexed with a lateral extension and appressed to the sheath, linear lanceolate. Inflorescence developing by way of pseudospikelets, palea with a sulcus at the middle, arudimentary rachilla at the base.

13. *Ochlandra travancorica var. hirsuta* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 126. 1896.

Erect, shrubby or arborescent, reed-like gregarious bamboo. Culm gray green with bulbous based golden brown hairs. Node somewhat swollen and marked with base of fallen sheaths. Culm-leaves thin longitudinally wrinkled and striate. Leaves broadly oblong-lanceolate, petiole often twisted, both surfaces glabrous, short falcate auricles, ligule short. Inflorescence a sub verticillate spicate panicle seen in the axils of ovate lanceolate bracts, spikelets pubescent. Caryopsis very large, pericarp fleshy with persistent glumes and palea.

14. *Ochlandra travancorica var. travancorica* Benth. in Benth & Hook.f., Gen. Pl. 3:1215. 1883. Bheesa travancorica Bedd., Fl. Syl. 239, Pl. 324. 1873.

Shrubby or arborescent, erect, gregarious bamboo. Culm grayish-green, rough nodes marked with base of fallen sheaths. Culm-leaves 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. ligule narrow, entire. Leaves broadly oblong-lanceolate, often obliquely rounded at the base in to a thick, broad, somewhat concave, petiole. Inflorescence sub verticillate, spicate panicle, spikelets glabrous. Caryopsis very large, pericarp fleshy surrounded by persistent glumes and palea.

15. *Ochlandra wightii* (Munro) Fischer in Gamble, Fl. Pres. Madras 3(10): 1864. *Ochlandra brandisii* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 126. 1896 & in Hook.f. Fl. Brit. India 7: 419. 1897.

An erect shrubby bamboo with tufted clumps. Node prominent on the culms with grayish band. Culm-leaves 3.5-4 cm long, covered with many appressed light brown subulate hairs, blade lanceolate acuminate, ligulate. Leaves oblong-lanceolate, acuminate, thick, glabrous on both surfaces, midrib prominent, 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, lodicules single.

Pseudoxytenanthera Soderstrom and Ellis

Reed-like bamboo, Culms forming loose clumps. Leaves 3-3.5 cm long, Culm-leaves abscissile from a thickened girdle. Inflorescence capitate, spikelets non disarticulating with short rachilla segments, spikelets thin, staminal filaments united. Caryopsis with the pericarp separable from the seed below.

Distribution: Sri Lanka; India (Southern and North Eastern parts); Bangladesh (Eastern part); Burma; Thailand; Laos; Kampuchea and Vietnam.

Pseudoxytenanthera Soderstrom & Ellis (Vegetative)

1a. Bamboos erect 2


1a

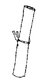
1b. Bamboos not erect, straggling or climbing ....*P. monadelpha*


1b

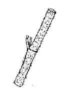
2a. Bamboos with 10-15 m tall culms, culm covered with white powdery mass ....*P. bourdilloni*

2b. Bamboos with 8 m tall culms, culms without a powdery mass 3

3a. Culm surface glabrous, smooth, dark green, ...*P. stocksii*


3a

3b. Culm surface pubescent covered with golden yellow velvety tomentum ....*P. ritcheyii*


3b

Pseudoxytenanthera Soderstrom & Ellis (Floral)

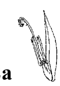
1a. Stigma undivided 2


1a

1b. Stigma strictly divided into 3..3


1b

2a. Spikelets slender and single flowered ....*P. ritcheyii*


2a

2b. Spikelets stout and two flowered ....*P. stocksii*


2b

3a. Spikelets small, anthers apiculate at apex ....*P. monadelpha*


3a

3b. Spikelets robust, anthers not apiculate at apex ....*P. bourdilloni*


3b

16. *Pseudxytenanthera bourdillonii* (Gamble) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990. *Oxytenanthera bourdillonii* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 76, t. 67. 1896 & in Hook.f., Fl. Brit. India 7: 403. 1896.

Straggling bamboo 10-15 m tall. Culm with long internodes covered with white powdery mass. Culm-leaves striate, ligule faintly serrate. Leaves broad linear, lanceolate, sheath striate, ending in a pair of shining calluses with a depression between serrate, ligule long. Inflorescence a large panicle of spicate branchlets, anthers not apiculate at apex. Caryopsis linear oblong.

Note: This species is endemic to Kerala .

17. *Pseudoxytenanthera ritcheyii* (Munro) Naithani, J. Bombay Nat. Hist. Soc. 87: 440. 1990. *Bambusa ritcheyii* Munro, Trans. Linn. Soc. London 26: 113. 1868. *Oxytenanthera monostigma* Bedd. Fl. Syl. 233. 1873.

A straggling bamboo. Culm strong 3-4.5 m tall, nearly solid, densely covered with deciduous soft, golden-yellow velvet tomentum, nodes prominent. Culm-leaves thin papery at the margins, striate sparsely covered with white appressed, stiff hairs; leaves variable. Inflorescence a large terminal panicle of spicate branchlets, spikelets slender and single flowered. Caryopsis narrow, linear oblong.

18. *Pseudoxytenanthera stocksii* (Munro) Naithani, K. Bombay Nat. Hist. Soc. 87: 440. 1990. *Oxytenanthera stocksii* Munro, Trans. Linn. Soc. London 26: 130. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 75. t. 66. 1896 & in Hook.f., Fl. Brit. India 7: 403. 1896.

An erect bamboo. Culm 8-9 m tall, glabrous, when young covered with dense white or gray deciduous tomentum, internodes long, branches few at the node. Culm-leaves striate, silvery shining within, covered outside with reddish hairs mixed with small white hairs with bulbous black bases. Leaves linear lanceolate rounded or attenuate at the base, ligule long dentate. Inflorescence a large panicle of spicate heads with many closely packed stout and spinous spikelets two flowered. Caryopsis not known.

19. *Pseudoxytenanthera monadelpha* (Thw.) Soderstrom & Ellis, Smithson. Contrib. Bot. 72: 52. 1988. *Dendrocalamus monadelphus* Thw., Enum. Pl. Seyl. 376. 1864. *Oxytenanthera thwaitesii* Munro, Trans. Linn. Soc. London 26: 129. 1868.

It is a reed-like subscandent or straggling gregarious bamboo. Culm smooth with small leaves, leaf and flower bearing branches on the same culm, internodes hairy when young. Culm-leaves broad, truncate at the mouth, auricles large rounded, falcate, with stiff curved bristles. Leaves very variable in size. Inflorescence a large leafy panicle with spicate branchlets, spikelets small, anthers apiculate at apex. Caryopsis elliptic and oblong.

Note: Endemic to South central part of Sri Lanka & South India.

Schizostachyum Nees

Arborescent, straggling or climbing bamboo. Culms slender, thin walled. Branches many short and equal in length at each node from the mid culm upwards. Internodes with pale appressed hairs all over and a white waxy zone just below the node, rhizome sympodial. Inflorescence a terminal panicle of spicate branches. Caryopsis oblong to ovoid with thin crustaceous pericarp separable from seed.

Distribution: India (North -Eastern part): Sikkim, Assam, Meghalaya, Manipur, Mizoram; up to 900m altitude; Bhutan upto 1500m altitude, Burma: in the moister districts of the upper part, up to 900m altitude; China; Guangdong and Yunnan.

20. *Schizostachyum* (Fischer) Majumdar in Karthikeyan et al., Fl. Indian Enum. Monocot 281. 1989. *Teinostachyum beddomei* Fischer in Gamble Fl. Pres. Madra. 3(10): 1860. 1934.

Semi scandent, tall bamboo. Culm at first erect, branches pendulous, bright green. Nodes marked by a prominent ring, internodes rough above with a white band below the node, walls thin. Culm-leaves thin papery, sides parallel below, gradually narrowing above to a truncate tip, not auricled, thickly clothed on the back with brown black appressed hairs. Leaves oblong-lanceolate, midrib broad, ligule narrow, faintly toothed. Inflorescence large terminal drooping panicle of spiciform branchlets. Caryopsis glabrous, ovoid on a thick stalk and surmounted by a beak.

Sinarundinaria Nakai

Shrubby bamboos which occurs in the altitudes above 1500m. Culms 1-2.5 m tall, arising from sympodial rhizomes. Dominant branch absent, 3 to many branch complements arise. Culm-leaves persistent or late deciduous, Inflorescence a panicle or a raceme supported by small sheaths, spikelets stalked. Flowers with three stamens.

Distribution: Commonly found in large patches in wet places. Distributed mostly in cool temperate to sub alpine zone.

Sinarundinaria Nakai (Vegetative)

1a. Leaves thick with thickened cartilaginous margins, base nearly truncate 2

1b. Leaves thin margin neither thickened nor conspicuously cartilaginous 3

2a. Culms 1 m tall, leaves 5.2 x 0.8 cm, tip spiny ....*S. microphylla*

2a 

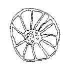
2b. Culms up to 2-2.5 m tall, leaves 15 x 5 cm tip not spiny ....*S. walkeriana*

2b 

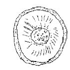
3a. Branch compliment appressed to the culm,crowded 4

3b. Branch compliments continue length wise, not crowded ....*S. floribunda*

4a. Root with air canals ....*S. densifolia*

4a 

4b. Root without air canals...*S. wightiana*

4b 

Sinarundinaria Nakai (Floral)

1a. Ovary with 3 plumose stigma ....*S. walkeriana*

1a 

1b. Ovary with 2 plumose stigma 2

1b 

2a. Spikelets with one fertile floret, palea with a sulcus ......*S. densifolia*

2a 

2b. Spikelets with more than one fertile floret, palea without a sulcus..3

2b 

3a. Spikelets 3 to 5 flowered, ovary elliptic, stigma divided into two at the apex 4

3a 

3b. Spikelets 6-7 flowered, ovary-ovoid, stigma divided into two from the basal portion onwards ....*S. microphylla*

3b 

4a. Spikelets silky pubescent, flowers acuminate ....*S. floribunda*

4a 

4b. Spikelets glabrous, flowers blunt......................................*S. wightiana*

4b 

21. *Sinarundinaria densifolia* (Munro) Chao & Renv. Kew Bull. 44: 354. 1989. *Arundinaria densifolia* Munro, Trans. Linn. Soc. London 26: 32. 1868.

Shrubby bamboos. Culm smooth, internode walls thick; nodes prominent, with 2 to 3 branches. Culm-leaves striate, hirsute with small pointed auricles. Leaves broad, subsessile, lanceolate, rounded at the base, tapering upward and acuminate. Inflorescence and dense raceme in leafy branchlets, spikelets with one fertile floret, palea with a sulcus.

22. *Sinarundinaria floribunda* (Thwaites) Chao & Ren. Kew Bull. 44: 356. 1989. *Arundinaria floribunda* Thwaites, Enum. Pl. Zeyl. 475. 1864.

Erect, shrubby bamboo. Culm small covered with hairs. Node swollen, branch compliments continue length wise, not crowded. Leaves broad lanceolate, leaf sheath striate, covered with hairs ending in to a callus. Inflorescence large, in terminal leafy branches, spikelets silky pubescent, flowers acuminate. Caryopsis linear crowned with the base of the bifid style.

23. *Sinarundinaria microphylla* (Munro) Chao & Renv. Kew Bull. 44: 354. 1989. *Arundinaria microphylla* Munro, Trans. Linn. Soc. London 26: 32. 1868.

Smallest gregarious evergreen shrubby bamboo. Culms erect 1m tall, glabrous, light green when young becoming more yellowish green with age. Node prominent, with many semi verticillate branches. Leaves linear lanceolate, 5.2 x 0.8 cm, tip spiny, leaf sheath striate, dark, ligule scarcely visible, ciliate on the margin, auricle hairy. Inflorescence a panicle, small, terminating at the leafy branches, spikelets 6-7 flowered, ovary ovoid, stigma bifid from the basal portion on wards.

24. *Sinarundinaria walkeriana* (Munro) Chao & Renv. Kew Bull. 44: 354. 1989. *Arundinaria walkeriana* Munro, Trnas. Linn. Soc. London 26: 21. 1869.

Shrubby bamboo. Culm 2-2.5m tall, dense arising from sympodial rhizome, hollow upper part thickly covered with sheaths of fallen leaves, internodes rough, striate. Culm-leaves light green, deciduous. Leaves 15 x 5 cm, ovate-oblong, apex acuminate, midrib prominent, leaf sheath striate glabrous, ligule short. Inflorescence terminal on many flowered spikelet, ovary with 3 plumose stigma. Fruit is a caryopsis.

25. *Sinarundinaria wightian*a (Nees) Chao & Renv. Kew Bull. 44: 356. 1989. *Arundinaria wightiana* Nees Linnaea 9: 182. 1834; Munro, Trans. Linn. Soc. London 26: 19. 1868; *Arundinaria hispida* Steud. Syn. Pl. Glum. 1:335. 1854.

An erect gregarious shrub arising from short rhizome. Culm slender, dark green on maturity yellowish brown. Culm-leaves straw coloured, thickly clothed with stiff golden, tubercle based hairs, ligule short, fimbriate. Leaves broad, ovate lanceolate, leaf sheath keeled, ciliate at the edges, long bristles. Inflorescence terminal or axillary. Caryopsis purplish deeply furrowed on one side.

CONCLUSIONS

Bamboos form a significant component of the natural vegetation in Kerala, particularly in the dry and moist deciduous forests and evergreen forest of the western Ghats. There are major problems in bamboo systematics in finding reliable characters for the delimitation of genera and species. Taxonomists have relied on the floral and vegetative characters for bamboo taxonomy differently. To evolve a natural taxonomic system, both floral and vegetative morphology have to be taken in to consideration. For identification of the sterile specimens, vegetative characters are often given more emphasis at the generic level and the culm, culm-sheath morphology and leaf at the specific level in India. Since the flowering in bamboos is erratic and at very long intervals, the vegetative characters are often given more emphasis to identify specimens. Due to the vast morphological variations found within species and between closely related species, the generic and specific delimitations are still not clearly defined.

Recently, a large number of new species have been reported from across the globe and assigned to different groups, as a result, the whole group has become very complex. Many of the new species are known merely by their vegetative parts, only very few species by flowers. The diversity of spikelets and inflorescence structure remain unknown and many species described could therefore be merely tentatively assigned to a genus. The generic status given with regard to certain genera by earlier workers did not give any justification for the merger and no comparative studies are available to understand the generic limitations of the respective subtribes. Therefore, unless thorough revisionary studies of at least some of the complex groups in the subfamily Bambusoideae is undertaken, the treatment of genera under the respective subtribes and its systematic position cannot be understood.

The Ministry of Environment and Forests (MoEN), as well as the Department of Science and Technology (DST), Govt. of India has recently encouraged such studies in India and the KFRI has been selected as one of the centers for such studies on Indian bamboos under which studies on the various aspects of bamboos including the taxonomic revisionary studies on selected bamboo genera has been taken up.

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Bamboo Notes[1]

A brief note on the forage value of *Apoclada* species

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Two species of *Apoclada* are found in native pasture in the cerrados of central Brazil and have been observed being eaten by cattle (Guala 1992). Silveira (1919) did a small forage analysis on *A. cannavieira* with similar results, but he did not publish the extraction method or the type of material sampled. In this study, material from the apical tuft of leaves from five culms each of two populations of each species was sampled. The samples were thouroughly air dried and homogeneously ground. Analyses were performed in the IFAS Animal Nutrition Laboratory at the University of Florida using the techniques of Van Soest and Wine (1967) and modified by Van Soest and Robertson (1980) with further modifications of Golding et al. (1985) for Neutral Detergent Fiber (NDF). In Vitro Organic Matter Digestion (IVOMD) was determined using the technique of Tilley and Terry (1963) with the modifications of Moore and Mott (1974). Results are presented below. Vouchers are at FTG and FLAS.

Table 1. Nutrient and digestibility analysis of the cerrado species of *Apoclada.* All percentages are scaled to percent dry weight. Shown are Dry Matter (DM), Organic Matter (OM), Phosphorus (P), Nitrogen (N), Crude Protein (CP), Total Neutral Detergent Fiber (NDFtot), Neutral Detergent Fiber minus ash or inorganics (NDFash) and In Vitro Organic Matter Digestibility (IVOMD).

sp.	Col #	%DM	%OM	%P	%N	%CP	%NDF_{tot}	%NDF_{ash}	%IVOMD
A. cannavieira	1307	92.0	94.5	0.032	1.436	8.97	84.2	83.0	30.1
A. cannavieira	1297	92.3	92.0	0.004	0.889	5.56	80.5	77.8	35.4
A. arenicola	1328	92.0	93.0	0.021	0.996	6.22	82.8	80.4	27.2
A. arenicola	1368	92.1	96.3	0.032	1.226	7.66	86.6	85.9	24.7

Although, in comparison to common tropical forage grasses, they are low in phosphorus (P), their crude protein (CP) compares favorably. Given that they are C3 grasses which are rare in cerrado, and stay green during the dry season, unlike other forage grasses, they are clearly a desirable natural forage.

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[1]***Bamboo Notes*** are one page communications of brief and generally self-evident data not requiring extensive discussion or explanation.

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