



Phytodiversity, socioeconomic and ethnomedicinal study of bamboos *Dendrocalamus* nees in new forest of Forest Research Institute (FRI), Dehradun (Uttarakhand), India

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Abstract

Bamboo is a renewable and versatile resource with low weight and high strength. Bamboo is most important non-timber plants that have highly socio-economic benefits worldwide. It is the world's fastest growing non-timber woody plant with three time faster growth rate than others. Bamboos belong to subfamily Bambusoideae, family Poaceae under the class Monocotyledonae of phylum Spermatophyta. These are usually tall, erect and woody arborescent grasses with great morpho-phenological diversity. The present study was carried out in the New Forest of Forest Research Institute (FRI), Dehradun (Uttarakhand), India campus that has huge diversity in bamboos genus *Dendrocalamus* Nees. Authors reported seven species of *Dendrocalamus* Nees during investigations that have been known for their socioeconomic values were: *Dendrocalamus giganteus*, *D. calostachyus*, *D. longispatus*, *D. somdevai*, *D. hamiltonii*, *D. membranaceus* and *D. strictus*. The maximum leaves size was recorded in *D. hamiltonii* and *D. giganteus*. However, the minimum size of leaves was documented in *D. membranaceus*. The heights of culms were measured for all species and found to be maximum in *D. membranaceus* and minimum in *D. strictus*. The peak culm sheath area was observed in *D. calostachyus* on contrary the minimum examined in *D. strictus*. The bamboo plants having great socioeconomic and ethnomedicinal significance in conventional therapeutic practices. The authors wish to recommend that there should be a strong strategic management of *Dendrocalamus* sp. for sustainable livelihood and economy.

Keywords: Bamboo, *Dendrocalamus*, Poaceae, Bambusoideae, Phytodiversity, Socioeconomic, FRI, Culm sheath

Introduction

Bamboo is the roof and crown of all plants, having close association with man's existence from primeval times to the time of information technology and bamboo has been man's closest friend (Devi, 2013; Dwivedi *et al.*, 2019) [11, 12]. Bamboos used by Gods and humans, the haves and have-nots, the sophisticated and the rustic, the artistes and the artisans (Kaushik *et al.*, 2015; Singh *et al.*, 2020a) [20, 32]. Bamboo plants play important role to cover 21.1% of forest of Indian sub-continent and contributing 12.8% total forest area of country (FSI, 2011; Singh *et al.*, 2018) [15, 30]. It is the world's fastest growing non-timber woody plant with three time faster growth rate than others (Jha, 2010; Brar *et al.*, 2012) [5, 19]. Bamboo occurs in different bioclimatically defined forest types ranging from tropical, subtropical to subalpine zones and temperate regions except Europe (Bystrakova *et al.* 2003; Jha, 2010) [6, 19]. The bamboos have strong adaptability from equator zone to boreal zone and occupied habitats from sea level to high mountains up to an altitude of 3300-4000 m as well (Goyal *et al.*, 2012) [17]. Most of the bamboo species need warm and humid climate and are distributed over plain and hilly area in tropical and subtropical monsoon zone between the Tropic of Capricorn and the Tropic of Cancer (Banik, 2015) [2]. The diversity has considerably dwindled from natural habitats due to over exploitation, shifting cultivation, gregarious flowering and extensive forest fires (Zheng *et al.*, 2020) [40]. Bamboo is a grass of subfamily Bambusoideae, family Poaceae under the class Monocotyledonae of phylum Spermatophyta and spread over with more than 88 genera and nearly 1,642 species worldwide, of which 28 genera and

more than 120 species are herbaceous bamboo (Vorontsova *et al.*, 2016) [37]. After China India has the second position in bamboo cropping and production after China (Bystrakova *et al.* 2003; Loushambam *et al.*, 2017; Luo *et al.*, 2020) [6, 23, 24]. The Bambusoideae appears to be one of the most successful and diverse subfamilies of grasses and can play an important role in protecting our planet from pollution and improving the soil (Emamverdian *et al.*, 2020; Singh *et al.*, 2020b) [13, 33]. The genus *Dendrocalamus* was first described by Nees in Linnaea 9: 476 during 1834, under tribe Bambuseae, sub-tribe Bambusinae and etymologically derived from Greek word dendron, tree; kalamos, reed, tree-like reeds (Banik, 2016) [3]. The bamboos are contributing billions of dollars in international trade using young bamboo culm flour as a new ingredient for food products, improving the intake of insoluble fiber and considering the consumer demand for healthier products (Jha, 2010; Felisberto *et al.*, 2017; Singh *et al.*, 2019; Singh *et al.*, 2020c) [19, 14, 31, 34]. The bamboo shoots are a good source of vitamins, minerals, amino acids, and dietary fibers (Singh *et al.*, 2020c) [34]. The soft shoots and leaves of bamboos contain vitamin A, vitamin B6, vitamin C and vitamin E as well as 17 amino acids, of which 8 were essential for the human body (Chongtham *et al.*, 2011) [8]. *Dendrocalamus asper* commonly called giant bamboo used for housing at many rural areas, and it has been used for handicrafts, daily utensils, furniture and paper as well (Akwada and Akinlabi, 2016) [1]. The therapeutic application of plant products and parts of plant known since ancient period as traditional medicine (Singh *et al.*, 2020a, b, c) [32, 33, 34]. This traditional knowledge of ethnomedicine and socioeconomic values of

native wild plants have been handed down from one generation to the next by spoken word and through lifestyle (Hossain *et al.*, 2015; Singh *et al.*, 2019) [18, 31]. The bamboos are applicable in cure of various digestive system disorders, haematuria, fever, after birth complication in women (Tangjitman *et al.*, 2015; Chaudhry and Murtem, 2016) [36, 7]. *D. strictus* nodes and decoctions of leaves used as medicine to cure jaundice and young shoots for food (Chaudhry and Murtem, 2016) [7]. The antifertility, antidiabetic, antibacterial, anthelmintic, anti-inflammatory,

antiulcer and insecticidal properties of bamboo worked out by various scientists during yesteryears (Kumar *et al.*, 2012; Rathaur, 2013) [21, 28]. Thus the herbal drugs have got tremendous momentum in global health care system. Therefore the present study was designed to work out the taxonomical diversity and socioeconomic values of *Dendrocalamus* Nees that will be helpful in planning strategies for sustainable conservation of these natural resources.

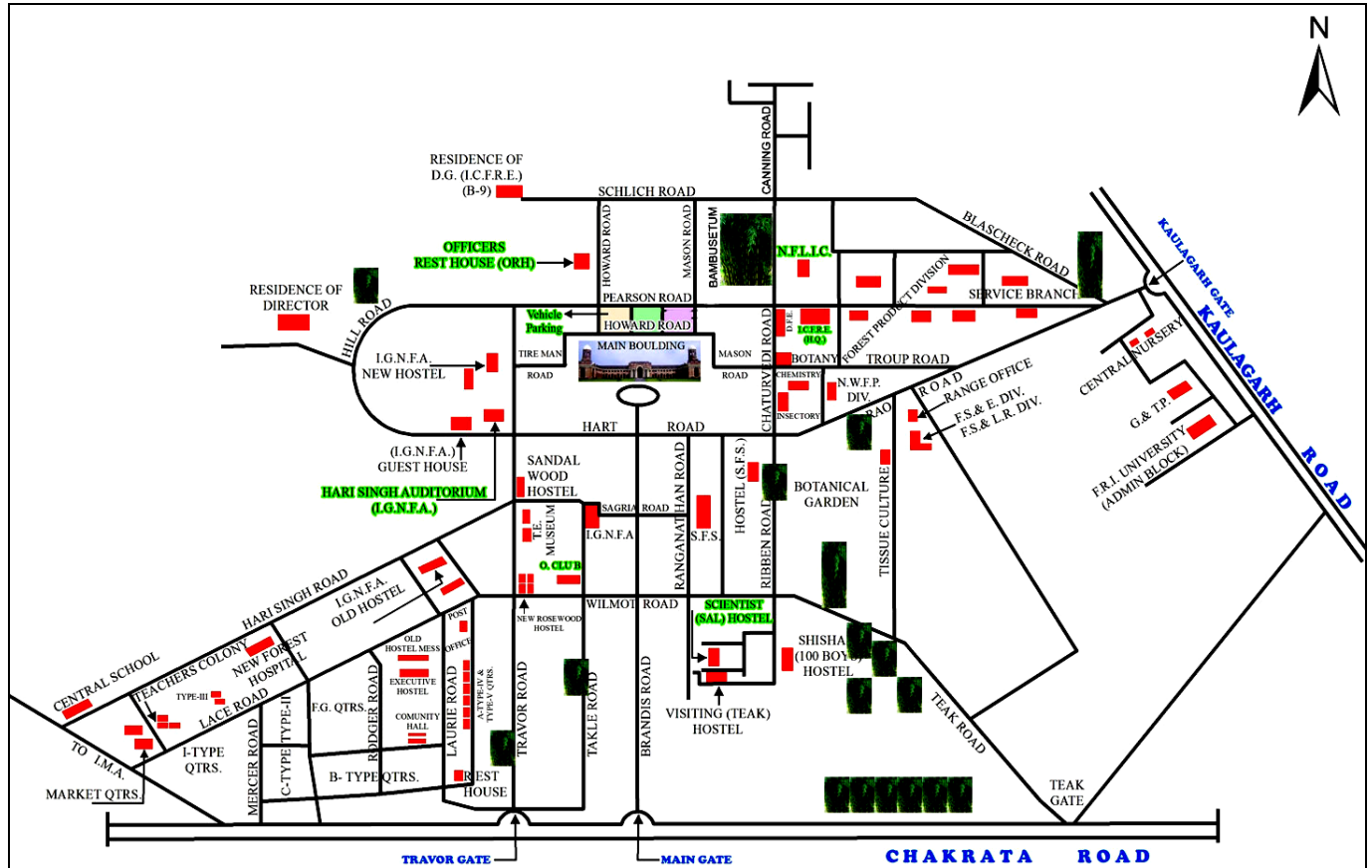


Fig 1: Map showing the sites of investigation to study diversity of *Dendrocalamus* sp. in Forest Research Institute (FRI), Dehradun (Uttarakhand), India.

Materials and Methods

Present study was designed to reveal the taxonomical diversity and distribution of *Dendrocalamus* Nees (Poaceae: Bambusoideae) on the basis of survey in New Forest, Forest Research Institute (FRI), Dehradun (Uttarakhand) India (Fig. 1). Vegetations were evergreen and deciduous in an expansion of more than 1100 acre area situated between N30°20'31.56" Latitude and E77°59'50.28" Longitude. The climate was marked by hot summer, well distributed rainfall during South-West monsoons (average precipitation 360mm), however winter season marked with less rain. The entire campus was thoroughly surveyed including Bambusetum, Botanical garden, Beeson road, Canning road, Chaturvedi road, Circular road, Parker road, Takle road, Hospital road, Howard road, Tierman road, Lace road, Teak road, Trevor road, Troup road, Shalich road and Rao road. The wild as well as planted species of bamboos considered for the study. For each species taxonomic characters were recorded on site, photographs captured, phenology compared using literatures to assess the correct taxonomic summary. The specimens identified were further

substantiated and validated through relevant literature and herbarium specimens housed in Systematic Botany Discipline, Forest Research Institute, Dehradun (Uttarakhand).



Fig 2: *Dendrocalamus* sp. with culm sheath: (A) *D. giganteus*, (B) *D. calostachyus*, (C) *D. longispathus*, (D) *D. somdevai*, (E) *D. hamiltonii*, (F) *D. membranaceus* and (G) *D. strictus*.

Results and Discussion

The findings of the present work reflected that the New Forest, Forest Research Institute (FRI), Dehradun (Uttarakhand), India has been found a rich source of bamboo *Dendrocalamus* sp. Nees which taxonomically belonged to subfamily Bambusoideae, family Poaceae under the class Monocotyledonae of phylum Spermatophyta. The identification and characterization of 7 species of *Dendrocalamus* was well documented during thorough examination of survey area. The morphotaxonomic and morphometric examinations of individual species showed remarkable variability among the recovered 7 species: *D. giganteus* (Giant bamboo or Dragon bamboo), *D. calostachyus* (Indian bamboo), *D. longispathus* (Long-sheath bamboo), *D. somdevai* (Magar bamboo), *D. hamiltonii* (Hamilton's bamboo), *D. membranaceus* (White bamboo) and *D. strictus* (Male bamboo or Solid bamboo or Calcutta bamboo) (Fig. 2). The significant taxonomic attributes documented were: Plant height, culm sheath, blade length, ligule length, presence or absence of auricle, petiole length, internodal length, leaf dimensions summarized in Table 1. The maximum leaf size 35x10 cm² and 50x7 cm² were calculated in *D. hamiltonii* and *D. giganteus* respectively. However, the minimum size of leaves 17x2 cm² was documented in *D. membranaceus*. The heights of culms were measured for all species and found to

be maximum in *D. membranaceus* (20-40 m) and minimum in *D. strictus* (8-16 m). The peak culm sheath area was observed in *D. calostachyus* (110x45 cm²) on contrary the minimum calculated in *D. strictus* (28x17 cm²). The blade and leaf sheath proper length were maximum in case of *D. calostachyus* and measured as 50 cm and 60 cm respectively. The maximum internode length was enumerated was 40-60 cm in *D. giganteus*. The interrelationships among the selected taxonomical attributes were assessed using advanced numerical tools and showed rich variability (Fig. 3). The socio-financial importance was assessed on the basis of information collected from the rural populace and validated by published reports as well. The bamboos were considered in numerous traditional practices and contributed in societal economy as well. The investigation uncovered that bamboo utilized for tangle board planning, flooring, bin making, fiber making, house construction, etc. The ethnomedicinal significance was surveyed through close to home cooperation with the general population living in the neighborhood approved by the accessible writing also. It was seen that the various parts of bamboos including stem, leaves and barks utilized as a conventional solution for digestive ailment, abscesses, jaundice, heart issues, respiratory problems, haematuria, fever, etc. in different forms.

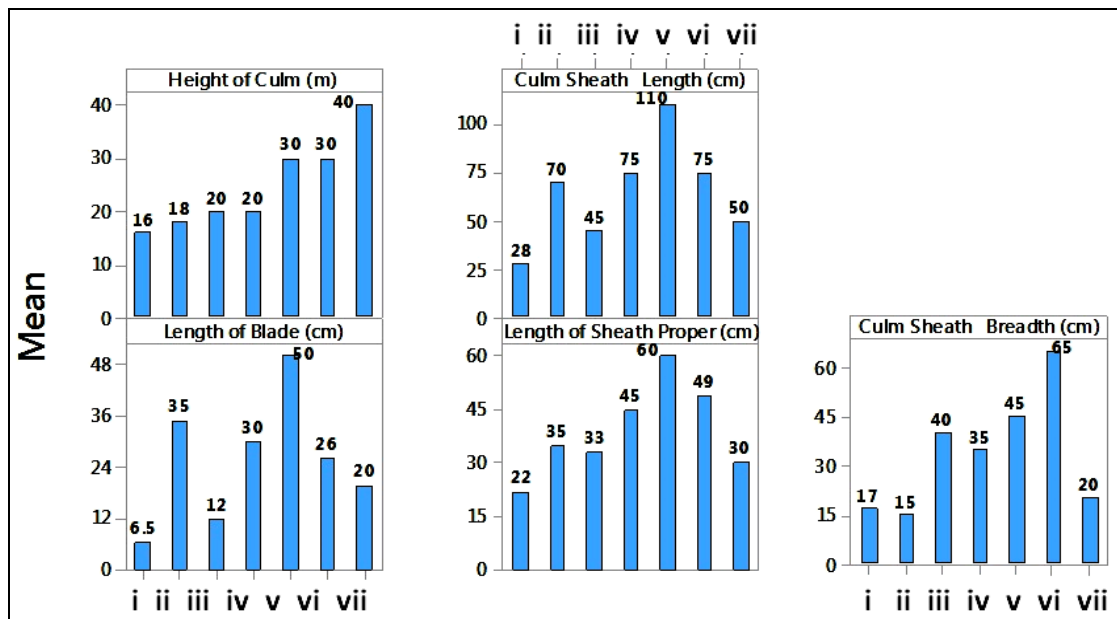


Fig 3: Correlation of morphotaxometric attributes among *Dendrocalamus* sp. Where: i, *D. strictus*; ii, *D. longispathus*; iii, *D. hamiltonii*; iv, *D. somdevai*; v, *D. calostachyus*; vi, *D. giganteus*; vii, *D. membranaceus*.

Table 1: Morphological and morphotaxometric attributes of different *Dendrocalamus* sp. (Where: L, Length; B Breadth; m, Meter; cm, Centimeter; mm, Millimeter)

S. No.	Botanical name (Common name)	Height (m)	Culm sheath (LxB) cm ²	Blade (L) cm	Sheath proper (L) cm	Ligules (mm)	Auricles	Inter node (L) cm	Leaf (LxB) cm ²	Petiole (mm)
1.	<i>Dendrocalamus giganteus</i> (Giant bamboo)	24-30	75x65	26	49	8-13	absent	42-50	50x7	3-5
2.	<i>Dendrocalamus calostachyus</i> (Indian bamboo)	20-30	110x45	50	60	1-2	absent	30-40	30x5	1-2
3.	<i>Dendrocalamus longispathus</i> (Long-sheath bamboo)	10-18	70x15	35	35	1	absent	39-40	30x4	1
4.	<i>Dendrocalamus somdevai</i> (Magar bamboo)	15-20	75x35	30	45	7-12	absent	20-40	30x4	3
5.	<i>Dendrocalamus hamiltonii</i>	12-20	45x40	12	33	1-2	absent	30-40	35x10	1

	(Hamilton's bamboo)									
6.	<i>Dendrocalamus membranaceus</i> (White bamboo)	20-40	50x20	20	30	5	present	25-40	17x2	1
7.	<i>Dendrocalamus strictus</i> (Calcutta bamboo)	8-16	28x17	6.5	22	2-3	absent	30-40	25x3	1

The Life cycle of bamboo is more long approximately 3 to 120 years. The identification of the bamboo species on the basis of floral characters was not a good practice, therefore important taxonomical attributes were taken in consideration during present investigation. The pattern of branching and leaf morphometric dimensions helped in identification of *Dendrocalamus* species and supposed to be key feature in taxonomy (Pattanaik and Hall, 2014; Das *et al.*, 2018) [27, 9]. The flowering of bamboos species was studied and found to be gregarious in nature, even it was uncertain and incidentally observed in some wild species (Banik and Islam, 2005; Das *et al.*, 2018) [4, 9]. The findings of the present investigation in favor of important taxonomical attributes including size of leaves, size of culm-sheath, blade size, leaf sheath proper, ligule, petiole, internode length and number of auricles substantiated by earlier literatures also important in the taxonomical studies (Pattanaik and Hall, 2014; Felisberto *et al.*, 2017; Rojas-Sandoval, 2019; Wang and Li, 2019) [27, 14, 29, 38]. *D. giganteus* and *D. hamiltonii* are important species widely used for multiple purposes, facing their depletion due to heavy extraction in the hilly terrain (Meena *et al.*, 2019) [25]. Hence the conservation of bamboos is utmost necessity to fulfill the socioeconomic need of peoples and country. The medicinal plants including wild flora, bamboos etc. of hilly terrain have always been the principle sources of medicine worldwide (Daswad *et al.*, 2020) [10]. India sustains a very rich traditional medicinal plant wealth and *D. strictus* was found to be an excellent source of many bioactive compounds such as crude protein, crude fiber, ash and other minerals (Goyal and Middha, 2011) [16]. The leaves found to contain several chemical constituents which were pharmacologically important and have claimed to be beneficial in many specific diseases like cancer, inflammation, infectious, cardiopathy, diabetes, hepatotoxicity, memory enhancement and many microbial attacks (Singhal and Satya, 2011; Lin and Miao, 2012; Mulyono *et al.*, 2012; Wangawar *et al.*, 2017; Daswad *et al.*, 2020) [35, 22, 26, 39, 10].

Conclusion

Bamboo forests are undoubtedly one of the most abundant non-timber plants on Earth and cover a wide area of tropical and subtropical regions. The present investigation carried out at New Forest, Forest Research Institute (FRI), Dehradun (Uttarakhand), India showed rich diversity of *Dendrocalamus* sp. Nees. There were 7 species recovered from new forest on the basis of key taxonomic attributes and morphometry *viz.* Plant height, culm-sheath, blade length, ligule length, presence or absence of auricle, petiole length, inter-nodal length and leaf dimensions. As these are the socioeconomically and ethnomedicinally important plants, therefore it was assessed by personal interactions to the population living in the local area. Bamboo has many uses, mainly in construction (flooring, roofing designing, and scaffolding), furniture, food, biofuel, fabrics, cloth, paper, pulp, charcoal, ornamental garden planting, and environmental characteristics, such as a large carbon sink

and good phytoremediation option, improving soil structure and soil erosion. The authors finally concluded that the proper and strategic management of bamboos is the utmost need for sustainable development. There is a need of more exploration of medicinal values through pre and post clinical assessment for the restoration of conventional therapeutic approaches.

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