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ASSESSMENT OF TAXONOMIC AFFINITY THROUGH CHARACTER BASED CLUSTER ANALYSIS: A NOVEL APPROACH TOWARDS TAXONOMIC DISCRIMINATION OF SOME GENERA UNDER BAMBUSOIDEAE COMPLEX

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ABSTRACT

Bamboo, is the fastest growing perennial, evergreen, arborescent plant and placed under the family Poaceae under this placed under the subfamily or tribe Bambusoideae. Eighteen bamboo species belonging to Six bamboo genera such as *Dendrocalamus*, *Bambusa*, *Melocanna*, *Gigntochloa*, *Dinochloa* and *Guadua* were analyzed for morphological character based matrix by using NTSYS-pc version 2.0 to generate similarity coefficient. The matrix was subjected to Unweighted Pair Group Method for Arithmetic average analysis (UPGMA). Dendrogram based on morphological cluster analysis reveals two clusters. Cluster I further subdivided in to Sub-Cluster I represented by six species of genera *Bambusa* and four species of genera *Dendrocalamus*. However, Sub-cluster-II of Cluster-I represented by *Gigntochloa ablociliata.* Moreover, Cluster-II also subdivided in to two sub-clusters, the sub-cluster-I represented by species under *Guadua*, *Dendrocalamus*, *Bambusa* and *Melocanna*. Sub-Cluster-II of Cluster-II represented by *Dinochloa scandens* ver *andamanica*.

KEYWORDS: Taxonomy, Bamboo, Cluster Analysis, Morphology.

INTRODUCTION

India has 136 species of Bamboo and is the second largest country in the world after China. The Bamboo is fast growing species in the Poaceae under tribe Bombusoideae and it occupies an economic status in the lives of the people especially in Asia.[1] The first recognized species of bamboo, *Arundo bambos* (now known as *Bambusa bambos)*, was described by Linnaeus in his Species Plantarum (1753).[2] Several groups of scientists have been working on the diversity, distribution and taxonomy of bamboo in India. About 113 bamboo species have been reported by Bahadur and Jain (1983),[3] whereas 102 species reported by Ohrnberger 2002[4] to 136 by Sharma, 1980.[5] There are over 1600 species of Bamboo distributed in the tropical forests and the Asia 65%, Africa 7% and America 28%.[6] About 89 bamboo species out of 136 under 75 genera recorded in India fewer than 16 genera grow naturally in different forest areas or are cultivated. The density of Bamboo in Forest Area is 7, 71,821 sq km and India share is 45 % and about 12.8 % of the total forest area of the country in context to global scenario of bamboos.[7] The wide distribution of bamboo species in India and Indian subcontinents because of humFan, up to some extent depends upon the geography, ecological condition, microclimatic influence and rain fall.[8,9] Bamboo, is the fastest growing perennial, evergreen, arborescent plant and placed under the family Poaceae and under this placed under the subfamily or tribe Bambusoideae.[10] The Bambusoideae now-a-days divided into the tribes Bambuseae and Olyreae. However, woody bamboos placed under Bambuseae and consist of approximate 77 genera and 1030 species worldwide. The division of Bambusodae diverges further into nine subtribes, one of which is Bambusinae, consisting of ten to 13 genera and mostly restricted to tropical Asia.[11] Under the Bambusoideae subfamily includes tribe Bambuseae and Olyreae, however, former includes woody bamboos and later includes herbaceous bamboo.[12] The differential character between these tribes was presence of abaxial ligule in Olyreae and absent in Bambuseae tribe. [13,14] When we trace the history of bamboos a giant grasses belongs under Poaceae closely related to the Cyperaceae. [15,16] However, on the basis of flower reduction and chemical characteristics have been relate Poaceace closer to the Joinvilleacea, Restionaceae, Anarthriaceae and Ecdeiocoleaceae.[17,18] Robert Brown (1810)[18] has beautifully canvassed ideas on relationships within the family Poyaceae. He opined that, when grasses were connected in a reticulate fashion, he was nonetheless able to recognize three groups, delimited chiefly by modifications in the fruiting (spikelet) structure. The group of genera that contained Poa was characteristic of temperate regions and the other, which contained Panicum, was characteristic of hot and tropical regions.

Bamboos are giant grasses and the taxonomy of these plants has been neglected for long time. Moreover, taxonomy of bamboos is quite complicated because of flowers are the main organ used as a major taxonomic character for discrimination of species in the Angiosperms taxonomically.[20] But bamboo plants produces only flower at long intervals and some species have never been known to flower, bamboos are among the least studied of all higher plants. Names and descriptions developed in the past have been difficult to apply until the bamboos flower again, because they may rely upon floral characteristics for their identification. Among bamboo species, the vegetative growth phase varies from 1 year to 120 years.[21] Moreover, identification and classification is necessary for collection and conservation of germplasms.[22,23] Plant identification keys are mostly based on floral characters. Depending on the flowering cycle, the bamboos are categorized into three major groups, viz. annual flowering bamboos it includes species like *Indocalamus wightianus*, *Ochlandra* sp., sporadic or irregular flowering bamboos for example *Chimonobambusa* sp., *D. hamiltonii* and gregarious flowering bamboos like B. *bambos*, *B. tulda*, *D. strictus*, *T. spathiflora*.[24,25] Because of the difficulty in flowering the identification depending on reproductive structure was found to be difficult in some genera under Angiosperms. Moreover, the taxonomic status identification has been a difficult task, so to resolve this problem during early part of the 19th century anatomical as well as micromorphological characters are also utilized for segregating the lower taxonomic categories. Non reproductive organs are also used for identification and segregation and among them, of which leaf is the most widely used organ in plant taxonomy.[26,27] However, up to some extent for identification and classification of bamboos in the world dependant on vegetative characters such as culm and culm-sheath, for the identification because of the unusually long sexual cycle and unavailability of any other diagnostic taxonomic structure.[28] And for the classification and identification of bamboos needs greater attention in order to resolve the taxonomic crunch. [29]

Despite the enormous economic and ecological importance of grasses in general and bamboos in particular, the phyletic relationship of the group is still only partially understood. Phylogenies studies has been carried out over the past 20 years, but restricted on specific groups.[30,31] Multivariate analysis has been found to be potent biometrical tool in quantifying the degree of divergence among all possible pairs of population at genotypic level.[32] Phylogenetic studies across the entire tree of life over the past decades have left us with improved understanding of how the major groups of organisms are related to one another. [33]

For the classification of bamboos taxonomist usually relied on vegetative characters because these plants rarely produce flowers. Taxonomists thus rely solely on vegetative characteristics such as culm sheath and ligule for classification. Thus, rendering bamboo classification quite challenging. [34,28]

In this context, we analyzed 18 bamboo species and examined the morphological characteristics by applying cluster based approach to resolve the taxonomic identification and evolutionary problems in Bamboos. However, morphology based identification and cluster based approaches were very useful for quick identification at the field as well as conservatory level.

MATERIALS AND METHODS

Plant Material

Eighteen bamboo species belonging to Six bamboo genera such as *Dendrocalamus* to which species are *D. giganteus* Wall. Ex Munro, *D. strictus* (Roxb.) Nees, *D. hamiltonii* Nees et Am. Ex Munro, *D. asper* (Schult. & Schult.F.) Barker Ex K., *D. membranaceus* Munro and *D. longispathus* (Kurz) Kurz, Genera *Bambusa* with *B. balcooa* Roxb., *B. bambos* (Linn.) Voss, *B. polymorpha* Munro, *B. arundinaceae* (Retz.) Wild., *B. vulgaris* Schard ex WendI, *B. burmanica* Gamble, *B. multiplex* (Loureiro) Raeusschel ex Schultes & J. H., *B. tulda* Roxb and *B. ventricosa* Munro, the genera *Melocanna* with single species such as *M. basifera* (Roxb) Kurz, Genera *Gigntochloa* with again single species i.e. *G. ablociliata* Munro, Moreover, Genera *Dinochloa* with signal species such as *D. scandens* (Bl. exNees) O. Ktz ver *D. andamanica* (Kurz) Nainthani and genera *Guadua* with single species i.e. *Guadua angustifolia* , were studied morphologically as per the morphological descriptors laid down by present investigator from Central Forest Nursery, Wadali, Amravati, Forest Department, Government of Maharashtra, Maharashtra, India.

Morphological descriptors

Each species was considered as a separate, independent taxonomic unit. Forty Six key morphological traits such as Culm with Seven differential Characters it includes Nature, Habit, Color, Surface, Height, Hollowness, Shape in cross section. Second significant morphological character considered as Node with Six parameters for example its occurrence, Shape, Structure, Architecture, Surface, Special Characters. However, another taxonomic trait considered by present investigator was Internodes with six parameters i.e. Length, Diameter, Comparative length, Color, Surface, Shape in cross section. The Culm Sheath with

fourteen parameters such as Width, Length, Auricle, Auricle hair, variability, ligule, surface, hair color, hair on edges, blade posture, blade length, blade width, blade surface. In support of above the Branching pattern was also considered as taxonomic trait for discrimination of species with the parameters like Occurrence, Arrangement, origin, modifications, Posture at node and lastly, the Leaf taken as a taxonomic trait with eight micro-morphological characters such as Length, Width, Surface, Appendages, Auricle hairs, ligule, color, leaf sheath hairs etc.

Data analysis

In calculating score for an alignment, only residue locus identities were considered. Essentially, using a unitary matrix (Sparse), matching of identical residues in different lane was scored as '1' and non-matched as '0'. The matrix was prepared in Microsoft Excel. Only the clear, unambiguous characters were considered for scoring. Each character was denoted as single locus. Genetic similarity (GS) between individuals was estimated according to the formula given by Nei and Li (1979). [35]

Morphological phylogenetic analysis

The unitary data was analyzed by using NTSYS-pc version 2.0 to generate similarity coefficient. The matrix was subjected to Unweighted Pair Group Method for Arithmetic average analysis (UPGMA) to generate dendrogram using average linkage procedure. [36,37]

RESULT AND DISCUSSION

The Bambusoideae complex includes tribe Bambuseae it includes woody bamboos and Olyreae comprises herbaceous bamboo.[12] The first identification and monograph was put forth by Gamble (1986) [9] from India. After the comprehensive monograph of Gamble, Camus (1913) [38] worked on bamboo species from India and China. Plant systematics study approach has been applied by Blatter and Parker (1929). [39] The taxonomic work on bamboo species from Asia further extended for the identification and for taxonomic status by many taxonomists like McClure (1966), Dransfield (1980), Tewari (1992), Kumar (1996) [40,41,42,43] etc. Taxonomists were relied on the flower for taxonomic identification of species and however, in flowers rarely and at long intervals, some species are produced scanty flowering. However, some of the reports noted flowering cycle in some bamboo species completed after 85 to 100 years. The sporadic flowering has been reported by so many workers in some of the species of bamboo by Koshy and Pushpangadan (1997); Islam *et al* (2012). [44,45] Because of this taxonomic characterization of bamboo species is found to be a difficult task, so

microscopic characters such as roughness, venations, epidermal cells, stomata, cuticle, surface contours and ornamentation (hairs, papillae, trichomes) and micro-morphological characters such as hair, wax etc.[26,27] considered and included under lower taxonomic category. In support of above mentioned characters the present investigation deals with cluster based approach in order to resolve this taxonomic crunch.

Dendrogram based on morphological cluster analysis reveals two clusters this is because of due to growth habit and morphological characteristics. [46] Cluster I further subdivided in to Sub-Cluster I and II. Wherein, *Bambusa bambos* exhibited close relationship with *Bambusa vulgaris* at 0.70 similarity coefficients. Although these two species placed genetically closer to each other but did not share the same sub-sub-cluster because of difference in plant height former with 15-20m, Surface of stem non pubescent, Internodal length 20-25 cm, difference in culm sheath length and width, ligule with lateral appendage, non hairy, branched, thorny nodes, leaf sheath hairs and latter with 25-25m, surface of stem pubescent, Internodal length 30-40cm, ligule without lateral appendage, hairy, unbranched, non hairy etc., these characters differentiate these species. However, *Bambusa vulgaris* and *Bambusa burmanica* exhibited close morphological relationship because of 0.78 similarity coefficient. These two species clustered together due to some morphological characters such as Closely packed clum, dark green color of clum, height of plant ranging from 10-20m, Single node line, length of internode 30-40 cm, Culm sheath 15-20cm, sheath auricles with hairs, creamy whitish hairs on ligule, erect leaf blade, branched, pubescent leaf blade with auriculate hairs etc, these characters placed these species genetically closer under sub-cluster-I of Cluster-I (Table-1, 2, 3, Figure-1).

As on the basis of dendrogram *Dendrocalamus asper* was found to be outgrouped from *Bambusa bambos*, *Bambusa vulgaris* and *Bambusa burmanica*, but placed closer to the other species of *Dendrocalamus* such as *D. hamiltonii* and *D. giganteus*. *Dendrocalamus asper* and *B. balcooa* exhibited close morphological affinity with 0.68 similarity coefficient. It is interested to note that although these two species belonging to the separate genera but exhibited great morphological similarity in lower taxonomic characters such as closely packet erect culm, surface pubescent, height 15-20m, leaf sheath hairs etc. Although, the species under the genus *Dendrocalamus* and *Bambusa* exhibited more similarity but these genera have some minor morphological differences. In *Bambusa* culm size is small, thicker culm wall, small leaves, younger culm with furry wax, uniform branching, and auriculate culm

sheath as compare to *Dendrocalamus*. Never the less, dendrogram by applying UPGMA supports the clustering of *Bambusa balcooa*, *Dendrocalamus hamiltonii* and *Dendrocalamus giganteus* in the same sub-sub-cluster of Cluster-I, because of 0.81 and 0.78 genetic similarity between *Bambusa balcooa* - *Dendrocalamus hamiltonii* and *Dendrocalamus hamiltonii* - *Dendrocalamus giganteus* respectively. *Bambusa balcooa* and *Dendrocalamus hamiltonii* have 56 monomorphic characters it includes Closely packed erect culm, semi solid, surface pubescent along with these characters some differential lower taxonomic characters has been exhibited by these species, these characters able to place these two species under different genera, the characters are auricles absent, leaf sheath with brown hairs, culm more than 10m with waxy coat as in *Bambusa balcooa* and culm with thick fur, culm nodes uniformly cylindrical, Long leaf sheath ligule, auricles on culm sheath etc. in *Dendrocalamus hamiltonii*. However, *Dendrocalamus hamiltonii* and *Dendrocalamus giganteus* exhibited morphological closeness because of 0.78 similarity coefficient and these two species showed 55 monomorphic characters and 85 polymorphic characters, this situation able to place these two species close to each other but exhibit separate lineage under this cluster.

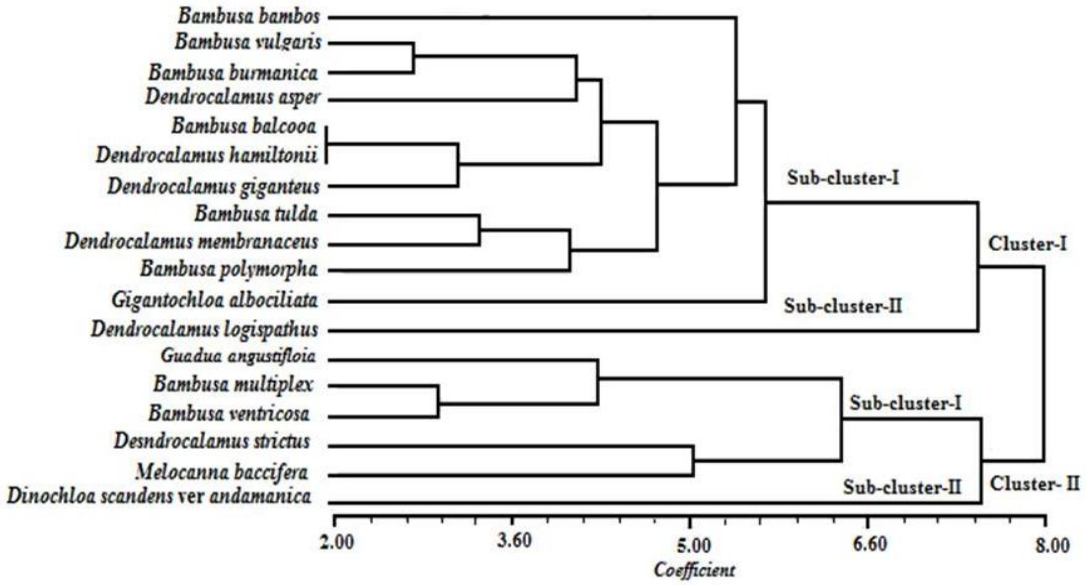

Figure1: Dendrogram based on UPGMA for Eighteen Bamboo Species.

The dendrogram reveals close morphological relationship between *Bambusa tulda* and *Dendrocalamus membranaceus* because of sharing of 53 taxonomic characters and 0.75 genetic similarity coefficient. Although, *Bambusa tulda* and *Dendrocalamus membranaceus* share same cluster and also show close affinity with each other, in spite of this these two species have marked differential morphological characters. There are differential morphological characters such as in *Bambusa tulda* grayish green color, longer, internodal

distance more, diameter of culm less, dominant with subsidiary branches, pubescent leaf, hairless leaf auricle etc. as compare to *Dendrocalamus membranaceus.* Das *et al*., (2007) when worked for phylogenetic relationships among the bamboo species as on morphological characters they also faced difficulties when distinguishing *B. tulda* from the *B. auriculate* morphologically, similar was the situation during present investigation. [46]

Table1: Total Number of Taxonomic Characters in Eighteen Bamboo Species.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	69																	
2	133	64																
3	133	128	64															
4	137	132	132	68														
5	138	133	133	137	69													
6	137	132	132	136	137	68												
7	141	136	136	140	141	140	72											
8	137	132	132	136	137	136	140	68										
9	142	137	137	141	142	141	145	141	73									
10	133	128	128	132	133	132	136	132	137	64								
11	132	127	127	131	132	131	135	131	136	127	63							
12	134	129	129	133	134	133	137	133	138	129	128	65						
13	125	120	120	124	125	124	128	124	129	120	119	121	56					
14	120	115	115	119	120	119	123	119	124	115	114	116	107	51				
15	122	117	117	121	122	121	125	121	126	117	116	118	109	104	53			
16	121	116	116	120	121	120	124	120	125	116	115	117	108	103	105	52		
17	122	117	117	121	122	121	125	121	126	117	116	118	109	104	106	105	53	
18	120	115	115	119	120	119	123	119	124	115	114	116	107	102	104	103	104	51

Species designation: **1)** *B. bambos* **2)** *B. vulgaris* **3)** *B. burmanica* **4)** *D. asper*
5) *B. balcooa* **6)** *D. hamiltonii* **7)** *D. giganteus* **8)** *B. tulda*
9) *D. membranaceus* **10)** *B. polymorpha* **11)** *G. ablociliata* **12)** *D. longispathus*
13) *B. gavadova* **14)** *B. multiplex* **15)** *B. ventricosa* **16)** *D. strictus*
17) *M. basifera* **18)** *Dinochloa scandens*

The genera *Bambusa* and *Gigantochloa* were included by taxonomists under the sub-tribe Eubambuseae, because of the similarity in the taxonomic characters, it is interested to note that in present investigation *Gigntochloa ablociliata* was found to be outgrouped species under Sub-cluster-II of cluster-I but placed nearer to the *Bambusa polymorpha* in the dendrogram. Because of 38 monomorphic and 89 polymorphic taxonomic characters in these species under investigation. *Gigntochloa ablociliata* differ from the *Bambusa polymorpha* due to presence of culm with alternate green and yellow strips, branching all over, non auriculated leaf, absence of leaf hairs, ligulate leaf etc. in former and upper internodes are long, leaves small, branching on upper nodes, leaf auricle present, leaf hairs, non ligulate leaf in latter. Moreover, *Dendrocalamus longispathus* maintain separate entity under cluster-I because of culm sheath height long, leaves long and broad as compare to species under genus

Bambusa, Leaf blade is shorter than that of culm sheath; culm sheath length is same through and waxy culm intend this species for to maintain separate entity under this cluster.

Table2: Total Number of Monomorphic Taxonomic Characters in Eighteen Bamboo Species.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	69																	
2	47	64																
3	44	50	64															
4	41	47	47	68														
5	47	48	51	47	69													
6	43	46	48	49	56	68												
7	39	45	43	50	52	55	72											
8	47	44	47	42	51	49	47	68										
9	52	47	50	45	48	51	48	53	73									
10	41	44	44	45	42	43	44	47	49	64								
11	41	45	39	42	39	46	43	40	45	38	63							
12	38	41	40	49	42	51	52	42	43	42	42	65						
13	34	32	32	28	35	36	33	36	35	34	28	33	56					
14	34	31	35	32	32	31	31	35	38	35	28	30	36	51				
15	34	32	30	26	29	28	28	32	33	30	29	26	40	40	53			
16	39	35	39	31	36	36	34	37	39	35	30	32	34	36	34	52		
17	37	34	37	37	38	36	37	38	44	37	36	38	29	33	29	35	53	
18	35	31	47	30	33	36	29	32	30	28	30	28	29	28	28	33	29	51

Species designation: **1)** *B. bambos* **2)** *B. vulgaris* **3)** *B. burmanica* **4)** *D. asper* **5)** *B. balcooa* **6)** *D. hamiltonii* **7)** *D. giganteus* **8)** *B. tulda* **9)** *D. membranaceus* **10)** *B. polymorpha* **11)** *G. ablociliata* **12)** *D. longispathus* **13)** *B. gavadova* **14)** *B. multiplex* **15)** *B. ventricosa* **16)** *D. strictus* **17)** *M. basifera* **18)** *Dinochloa scandens*

The Cluster- II represented by six species to which Sub-cluster-I represented by five species, *Bambusa multiplex* and *Banbusa ventricosa* placed under the same dendric lineage. Placing of these species under the same dendric lineage was also supported by the sharing of 40 morphological characters and also have 0.64 similarity coefficient. In spite of this, these two species having shrubby habitat, similarity in culm sheath characters, glabrous culm sheath, culm blade senescence earlier, branching all over, leaf size same, auriculate leaf sheath etc. these characters bring these species morphologically closer. However, *Dendrocalamus strictus* and *Melocanna basifera* placed morphologically closer under Sub-cluster-II of cluster-II. These two species although placed under different genera but share common morphological characters such as Height, Diameter, while younger light green color, culm sheath auricle absent, leaf blade erect, branching pattern etc. intend this species fall under the same cluster, this supported by the 0.66 similarity coefficient. Although, these species placed morphologically closer but taxonomically these two species circumscription under two

different genera because of different morphological characters such as in *Melocanna basifera* culm distance more, waxy culm, culm sheath blade long, less white hairs, non overarch branching, however, in *Dendrocalamus strictus* culm distance less, non waxy culm, culm sheath blade short, dense brown hairs, overarch branching. Moreover, placing of two distinct genera i.e. *Guadua* species *G. angustifolia* under the cluster-II, close with genera *Bambusa* species *B. multiplex* but under separate dentric line because of 71 distinct different morphological characters. However, there are some common characters shared by these species such as shrubby habitat, similar height, culm diameter is almost same, leaf blade erect and leaf auricle with hairs. Lastly, *Dinochloa scandens* ver *andamanica* was totally outgrouped from all species under genera *Bambusa*, *Dendrocalamus* and *Gigntochloa* because of the different morphological characters such as Climbing habit, bulbous node with culm sheath base persistent, spiny internodes, branches small etc. These characters placed variety *andamanica* under the genera *Dinochloa* (Table-1,2, 3, Figure-1).

Table 3: Nei and Li Similarity coefficient of Eighteen Bamboo Species.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	1																	
2	0.70	1																
3	0.66	0.78	1															
4	0.59	0.71	0.71	1														
5	0.68	0.72	0.76	0.68	1													
6	0.62	0.69	0.72	0.72	0.81	1												
7	0.55	0.66	0.63	0.71	0.73	0.78	1											
8	0.68	0.66	0.71	0.61	0.74	0.72	0.67	1										
9	0.73	0.68	0.72	0.63	0.67	0.72	0.66	0.75	1									
10	0.61	0.68	0.68	0.68	0.63	0.65	0.64	0.71	0.71	1								
11	0.62	0.70	0.61	0.64	0.59	0.70	0.63	0.61	0.66	0.59	1							
12	0.56	0.63	0.62	0.73	0.62	0.76	0.75	0.63	0.62	0.65	0.65	1						
13	0.54	0.53	0.53	0.45	0.56	0.58	0.51	0.58	0.54	0.56	0.47	0.54	1					
14	0.73	0.53	0.60	0.53	0.53	0.52	0.50	0.58	0.61	0.60	0.49	0.51	0.67	1				
15	0.55	0.54	0.51	0.42	0.47	0.46	0.44	0.52	0.52	0.51	0.50	0.44	0.73	0.76	1			
16	0.64	0.60	0.67	0.51	0.59	0.60	0.54	0.61	0.62	0.60	0.52	0.54	0.62	0.69	0.64	1		
17	0.60	0.58	0.63	0.61	0.62	0.59	0.59	0.62	0.69	0.63	0.62	0.64	0.53	0.63	0.54	0.66	1	
18	0.58	0.53	0.59	0.50	0.55	0.50	0.47	0.53	0.48	0.48	0.52	0.48	0.54	0.54	0.53	0.64	0.55	1

Species designation: 1) *B. bambos* **2)** *B. vulgaris* **3)** *B. burmanica* **4)** *D. asper* **5)** *B. balcooa* **6)** *D. hamiltonii* **7)** *D. giganteus* **8)** *B. tulda* **9)** *D. membranaceus* **10)** *B. polymorpha* **11)** *G. abloclliata* **12)** *D. longispathus* **13)** *B. gavadova* **14)** *B. multiplex* **15)** *B. ventricosa* **16)** *D. strictus* **17)** *M. basifera* **18)** *Dinochloa scandens*

Although, eighteen species of Bamboo exhibited great morphodiversity as on the basis of cluster based analysis. Wherein cluster-I and II has showed mixing of species under genera *Dendrocalamus* and *Bambusa*, mixing of these genera in the dendrogram is not fully agree with the classical taxonomic classification view on bamboos proposed by Gamble (1896) [9],

he placed all bamboo plants under the tribe *Bambuseae* of the family *Poaceae*. Furthermore the genera *Bambusa* and *Gigantochloa* were included under the sub-tribe Eubambuseae, while the genus *Dendrocalamus* was included within the sub-tribe Dendrocalameae. The placing of *Gigntochloa ablociliata* in between *Bambusa polymorpha* and *Dendrocalamus longispathus* support the view of placing of genera *Bambusa* and *Gigntocholoa* under *Eubambuseae* proposed by Gamble (1896) [9]. Moreover, mixing of these genera and placing in to two different clusters was also supported by the work carried out by Loh et al (2000) [47] that two species of *Dendrocalamus* i.e. *D. giganteus* and *D. brandissi* were grouped into two different clusters. The appearance of two different cluster groups was due to growth habit and morphological characteristics.

In conclusion cluster based approach for taxonomic discrimination of species under Bambusoideae complex was found to be significant however, for an accurate reconstruction of bamboo evolutionary history needs to require more attention towards morphological and molecular combine data sets.

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