Morphology-based Diagnostics of Edible Young Shoots of Bamboo Species (Subfamily Bambusoideae: Family Poaceae) from the Philippines

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Abstract

Phenetic investigation and cluster analysis were done in eight taxa of edible bamboo shoots in the Philippines using quantitative and qualitative characters. A dichotomous key was generated based on the characters used. Cluster analysis was carried out to determine distances among species within three genera using paired group algorithm and Euclidean similarity measure utilizing PAST ver. 2.17c. Cluster analysis resulted to four pairings with a number of shared characters. Based on the index of similarity and distance coefficients and dendrogram generated, *Bambusa vulgaris* Schrad. ex J.C. Wendl. and *Bambusa vulgaris* var. *striata* (Lodd. ex Lindl.) Gamble among all the taxa used have the highest degree of similarity (lowest coefficient) of 1.0004. The two taxa shared all the vegetative characters except on the presence of culm sheath striations on *B. vulgaris* var. striata. Other paired species include *Gigantochloa levis* (Blanco) Merr. and *Bambusa philippinensis* (Gamble) McClure, *Bambusa blumeana* J. H. Schultes and *Bambusa merrilliana* (Elmer) Rojo & Roxas comb. nov., and *Dendrocalamus asper* (Schult. & Schult. F.) Backer ex K. Heyne and *Dendrocalamus latiflorus* Munro. On the other hand, the most distantly similar species are *B. blumeana* and *B. vulgaris var. striata* despite being on the same genera due to a number of differences having the highest coefficient value of 6.3828. It can be concluded that characterization of bamboos on shoot level can be used to identify and differentiate species. This preliminary study on morphology-based diagnostics of bamboos shoots provided additional information which can be useful for taxonomists and bamboo enthusiasts.

Introduction

Bamboos known as the world's tallest grasses belong to Family Poaceae and Subfamily Bambusoideae. Characters shared by the members of this subfamily include rhizomatous habit, hollow and segmented culms, petiolate blade with tessellate venation, seeds with small embryo and linear hilum. Unlike other angiosperms, flowering is infrequently observed among bamboos. As a result, species identification deals mostly with vegetative characters like the culm, leaf sheath, blade, ligule and auricle.

Bamboos are of global interest due to its wide range of uses. They prevent soil erosion, can be used in the production of various bamboo-based products like panels, flooring, pulp, charcoal, and most especially young shoots are consumed as food. The availability of young shoots is limited since most of them only grow during rainy season. Across the Philippines, bamboo shoots are variously called as "labong", "dabong", "rabong", "tambo" and "uvug." According to Caasi-Lit (1999), the best shoot that can be used as food would be those reaching 1.5 feet high. The young shoots emerge from the rhizome, alternately covered by culm sheaths. These sheaths once removed will reveal the yellowish to white edible portion. The culm sheaths on the shoot apex can be left attached as these are still tender and flavorful (Chongtham 2011). Young bamboo shoots can be used in native Filipino

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dishes like ginataan, kilawen, lumpia, dinengdeng, adobo, ensalada, and omelette. It can also be sweetened and pickled. (Caasi-Lit 1999).

Morphological variability is evident among young bamboo shoots and this can be useful in identifying bamboo species. Currently, no comprehensive study has been conducted on the taxonomy of edible young bamboo shoots in the country. This paper will focus on the following objectives:

a. morphological characterization of edible young shoots of eight (8) bamboo taxa in the Philippines;
b. construct a dichotomous key that will be useful in identifying the young shoots based on these vegetative characters, and;
c. generate a cluster or grouping based on these characters using PAST ver. 2.17c software

In the Philippines, 8 taxa of bamboos (7 species and a variety) belonging to 3 genera (*Bambusa, Dendrocalamus, Gigantochloa*) are commonly consumed as food in 26 provinces. These are: *Bambusa blumeana* J.H. Schultes, *Bambusa merrilliana* (Elmer) Rojo&Roxas comb. nov., *Bambusa philippinensis* (Gamble) McClure, *Bambusa vulgaris* Schrad. ex J.C. Wendl., *Bambusa vulgaris* var. *striata* (Lodd. ex Lindl.) Gamble, *Dendrocalamus asper* (Schult. & Schult. f.) Backer ex K. Heyne*, Dendrocalamus latiflorus* Munro*,* and *Gigantochloa levis* (Blanco) Merrill (Caasi-Lit et al. 2010). Of these, *B. philippinensis and B. merrilliana* are endemic.

Materials and Methods

Data Gathering

Young shoots of bamboos were collected from the bamboo plantations of the Institute of Plant Breeding (IPB), UP Los Banos and Ecosystems Research and Development Bureau (ERDB). Only shoots with a height of two feet were randomly harvested from different populations. Standard measurement of the shoot is from shoot apex (excluding the blade) down to the base above the ground. Characterization and measurements were done in the laboratory. Photographs were taken using a 12.2MP DSC-TX9 Sony Cybershot.

Phenetic Investigation

Thirty-one characters (7 quantitative, 24 qualitative) were used for analysis (Table 1). Quantitative characters were measured using a centimeter ruler and measuring tape. Vegetative characters used are based on field observations and from the previous descriptions on the mature shoots of bamboos made by McClure (1965), Wong (2004) and Zhang et al. (2014). A dichotomous key was generated using the analyzed characters.

Table 1. Characters and character states of the edible young shoots of 8 bamboo taxa.

Abbreviation	Variable	Type	Scale
CSS	Culm sheath striations	Binary	0= absent 1= present
CSLT	Location of trichomes in culm sheath	Nominal	0= absent 1= entire 2= upper half 3=medial
CSCT	Concentration of trichomes in culm sheath	Nominal	0= absent 1=very few 2= moderate 3= abundant
CSAS	Culm sheath apex shape	Nominal	0= upcurved towards the middle

			1= not upcurved towards the middle 2= sometimes upcurved, sometimes not
CSC	Culm sheath ciliation	Binary	0= absent 1= present
CSCL	Culm sheath color	Nominal	0=green 1= brown 2=green tinged with purple on young culm sheaths
CSW	Culm sheath width	Interval metric (cm)	
CSAW	Culm sheath apex width	Interval metric (cm)	
CSL	Culm sheath length	Interval metric (cm)	
CSLWA	Culm sheath length to culm sheath width to culm sheath apex width ratio	Ratio	
BP	Blade posture	Nominal	0= appressed 1= reflexed 2= inclined
BTP	Blade transverse posture	Nominal	0= applanate 1= undulate
BLP	Blade longitudinal posture	Nominal	0=straight 1=slightly involute to involute
BC	Blade color	Nominal	0= not green 1= green
BAS	Blade apex shape	Nominal	0=acuminate 1=narrowly acute
BS	Blade shape	Nominal	0= deltate 1= narrowly triangular 2=triangular 2= lanceolate 3=lance-ovate
BADH	Distribution of abaxial hairs	Nominal	0= absent 1=few 2= moderate 3= abundant
BMC	Ciliation on blade margins(subbasal)	Binary	0= absent 1= present
BB	Blade base	Nominal	0= not decurrent 1= decurrent
BWCS	Width of base and culm sheath	Nominal	0= as wide as apex 1= narrower
BL	Blade length	Interval metric (cm)	

BBW	Blade basal width	Interval metric (cm)	
BLW	Blade length to blade width ratio	Ratio	
APO	Auricle position	Nominal	0= auricle absent 1= contiguous with blade 2= not contiguous
AI	Auricle indument	Nominal	0= glabrate to very few 1= long-fimbriate 2= short fimbriate
AIP	Auricle indument location	Nominal	0= marginal 1= abaxial
AP	Auricle posture	Nominal	0= erect 1= not erect or sometimes not erect
AS	Auricle size	Nominal	0= wanting to small 1= medium-sized 2=large
ASR	Relative size of auricle	Nominal	0= more or less equal 1= strongly unequal
ASH	Auricle shape	Nominal	0= lobe-like 1=rim-like
LT	Ligule type	Nominal	0= membranous 1= long-fringed 2=short-fringed

Cluster Analysis

The degree of similarity among the 8 taxa was determined by integrating the quantitative and qualitative data from the generated dendrogram from the software PAST (Paleontological Statistics) Version 2.17c (Hammer et al., 2001). Cluster analysis was performed to calculate distances between the three genera (*Bambusa, Dendrocalamus, Gigantochloa*) and between species using Euclidean similarity measure and paired group algorithm.

Results and Discussion

Within subfamily Bambusoideae, the genera *Bambusa, Dendrocalamus* and *Gigantochloa* are difficult to identify due to the large range of characteristics especially on *Dendrocalamus* which is often confused with *Sinocalamus*. Of the 3 genera, *Bambusa* is the most common occurring in the Philippines, India to South China and the rest of Southeast Asia. *Dendrocalamus* is cultivated in India, Thailand, Peninsular Malaysia, Sumatra, Borneo and the Philippines. *Gigantochloa* is distributed from Northeast India to south China, Indo-China, Malay Peninsula, Sumatra, Java, Borneo, Philippines, and Sulawesi (Wong, 2004).

In 1908, Merrill enumerated eight genera, 24 species and a variety of bamboos in the Philippines. Out of the 24, 15 are said to be endemic. However, Uchimura (1977) enumerated 11 genera, 45 species and three varieties by recognizing those which Merrill had excluded and assigned as synonyms which turned out to be valid names (Santos et al. 1986).

Figure 1 shows the distribution of the edible bamboo species belonging to the 3 aforementioned genera. The predominant species are *G. levis*, *D. asper*, *B. philippinensis*, *B. vulgaris*, *B. blumeana* and *B. merrilliana.*

Bamboo shoots being tagged as “king of forest vegetables” is revealed in Table 2, being consumed in almost all the regions in the Philippines.

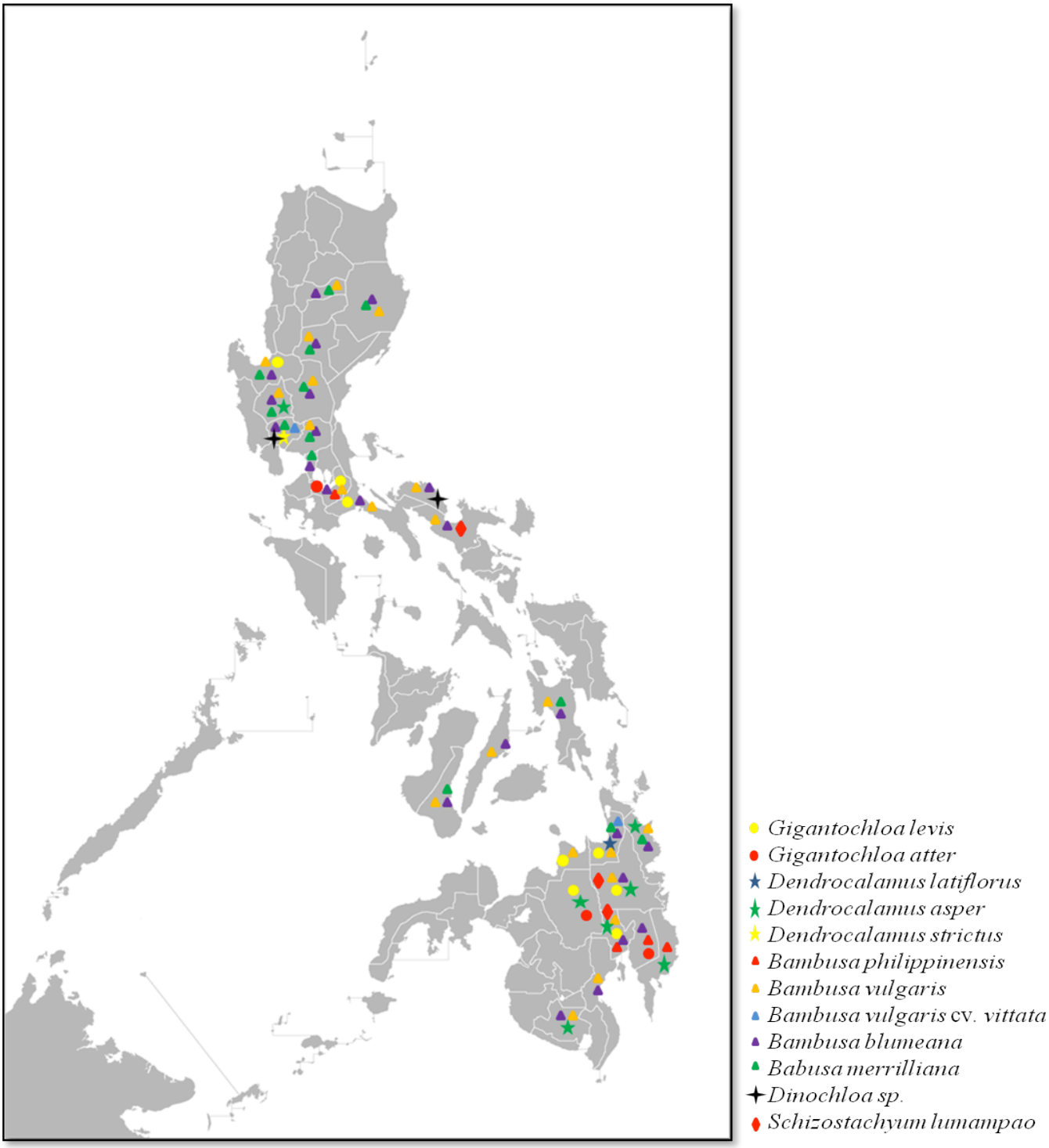

Figure 1

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Table 2. Distribution of bamboo species and edible shoots in different regions of the Philippines (after Caasi-Lit et. al 2010)

Region no./ Province	Town	Local name	Bamboos species present in the region	Predominant Bamboo species used as food
1 Pangasinan	Alaminos Bani Mangatarem Urdaneta	Rabong	*Bambusa blumeana* *B. merrilliana* *B. vulgaris* *Gigantochloa levis*	*B. blumeana*
2 Nueva Ecija	Cabanatuan	Dabong	*B. merrilliana* *B. blumeana* *B. vulgaris*	*B. merrilliana* *B. vulgaris* *B. blumeana*
2 Nueva Vizcaya	Bambang	Dabong	*B. merrilliana* *B. vulgaris* *B. blumeana*	*B. merrilliana* *B. blumeana* *B. vulgaris*
2 Isabela	Ilagan	Dabong	*B. merrilliana* *B. vulgaris* *B. blumeana*	*B. merrilliana*
3 Pampanga	Magalang	Rabong	*B. blumeana* *B. vulgaris* cv. *vittata* *Dendrocalamus strictus* (Roxb.) Nees *B. merrilliana* *Dinochloa sp.*	*B. blumeana*
3 Tarlac	Camiling Tarlac City	Rabong	*D. asper* *B. blumeana* *B. merrilliana* *B. vulgaris*	*B. blumeana* *B. merrilliana*
3 Bulacan	Pulilan	Labong	*B. vulgaris* *B. blumeana* *B. merrilliana*	*B. blumeana* *B. vulgaris* *B. merrilliana*
4 Laguna	Los Banos Sta. Cruz Majayjay Binan	Labong	*B. blumeana* *B. philippinensis* *G. levis* *B. vulgaris* *G. atter*	*B. blumeana*
4 Quezon	Sariaya Tayabas Gumaca	Labong	*B. blumeana* *G. levis* *B. vulgaris*	*B. blumeana* *G. levis*
Manila	Quiapo	Labong	*B. blumeana* *B. merrilliana*	*B. blumeana* *B. merrilliana*
5 Camarines Norte	Daet Labo	Lambo Labong	*B. blumeana* *Dinochloa sp.* *B. vulgaris*	*B. vulgaris*
5 Camarines Sur	Naga Sipocot Bula Rinconanda District	Lambo Lambong Puwag	*B. blumeana* *Schizostachyum lumampao* (Blanco) Merrill *B. vulgaris*	*B. vulgaris*
6 Negros Oriental	Dumaguete	Dabong	*B. merrilliana*	*B. blumeana*

			B. vulgaris *B. blumeana*	
7 Cebu	Cebu City	Dabong	*B. blumeana* *B. vulgaris*	*B. blumeana* *B. merrilliana*
8 Leyte	Baybay Ormoc	Dabong	*B. blumeana* *B. vulgaris* *B. merrilliana*	*B. blumeana* *B. vulgaris* *B. merrilliana*
9 Bukidnon	Malaybalay	Dabong	*D. asper* *G. atter* *G. levis*	*D. asper*
10 Misamis Oriental	Cagayan de Oro	Dabong	*B. vulgaris* *G. levis*	*G. levis*
11 Davao del Norte	Tagum Mawab Panabo	Dabong	*D. asper* *B. vulgaris* *B. blumeana* *S. lumampao* *G. levis* *B. philippinensis*	*B. philippinensis*
11 Compostella Valley	Nabunturan	Dabong	*B. blumeana* *G. atter* *B. philippinensis*	*B. philippinensis*
11 Davao del Sur	Calinan, DC Sta. Cruz	Dabong	*B. blumeana* *B. vulgaris*	*B. blumeana*
12 South Cotabato	Lake Sebu	Dabong	*D. asper* *B. blumeana* *B. vulgaris*	*D. asper*
CARAGA Agusan del Norte	Butuan	Dabong	*B. vulgaris* *D. lariflorus* *G. levis* *B. merrilliana* *B. vulgaris* cv. *vittata* *B. blumeana* *S. lumampao*	*B. blumeana*
CARAGA Agusan del Sur	Bayugan	Dabong	*B. vulgaris* *G. levis* *B. blumeana*	*D. asper*
CARAGA Surigao del Sur	Tandag	Dabong	*B. blumeana* *B. merrilliana* *D. asper* *B. vulgaris*	*G. levis* *B. merrilliana*
Indigenous People's Group				
Ibanag – Isabela		Uvug	*B. vulgaris* *B. blumeana*	*B. blumeana* *B. vulgaris*
Minaubo Agusan del Sur	Sibagat	Dabong	*D. asper*	*D. asper*
Mandaya Davao Oriental		Dabong	*D. asper*	*D. asper*
Mansaka Davao Del Norte			*B. philippinensis*	*B. philippinensis*
Ifugao	Lagawwe	Hubwal	*B. merrilliana*	*B. merrilliana*

Mountain Province	Banaue	Harepeng	*B. vulgaris* *B. blumeana*	*D. asper*

The dichotomous key below was constructed using vegetative characters of the bamboo shoots. The habit of each young shoot, and other vegetative characters distinct of each taxon can be seen in Figs. 2, 3, and 4.

Key to the identification of edible young bamboo shoots using vegetative morphological characters

1	Culm sheath blades generally appressed ……	2
1’	Culm sheath blades not appressed ……..	3
2	Culm sheath tinged with purple when young ……..…..	*B. philippinensis*
2’	Culm sheath not tinged with purple when young…….....	4
3	Ligule membranous…… ……	*D. latiflorus*
4	Culm sheath with green striations……..	*B. vulgaris* var. *striata*
4’	Culm sheath without striations……..……	*B. vulgaris*
5	Auricles low and rim-like……	6
5’	Auricles lobed……..	*G. levis*
6	Transverse posture of blade undulate…….	7
6’	Transverse posture of blade applanate…….	*D. asper*
7	Culm sheath apex upcurved towards middle…….....	*B. blumeana*
7’	Culm sheath apex not upcurved towards middle……..	*B. merrilliana*

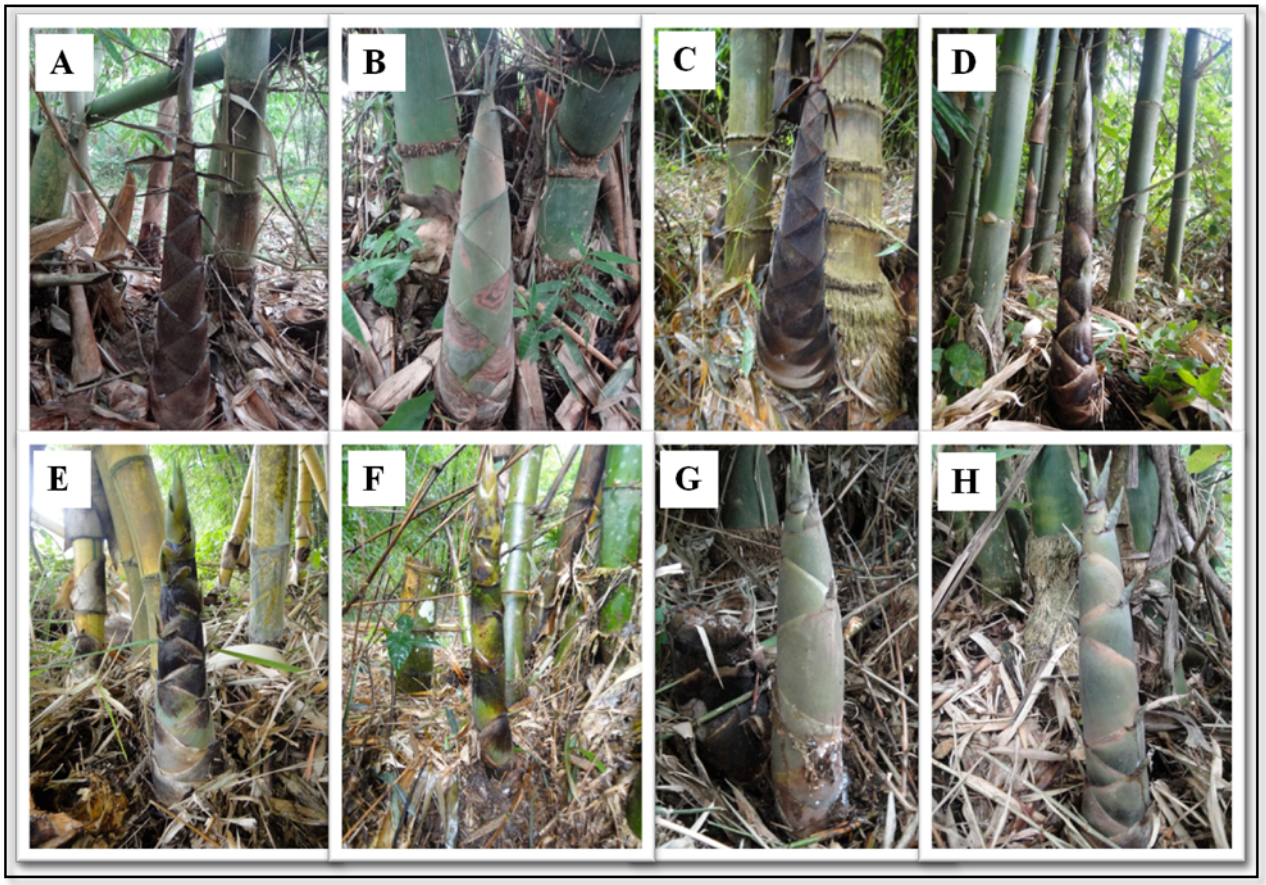

Figure 2

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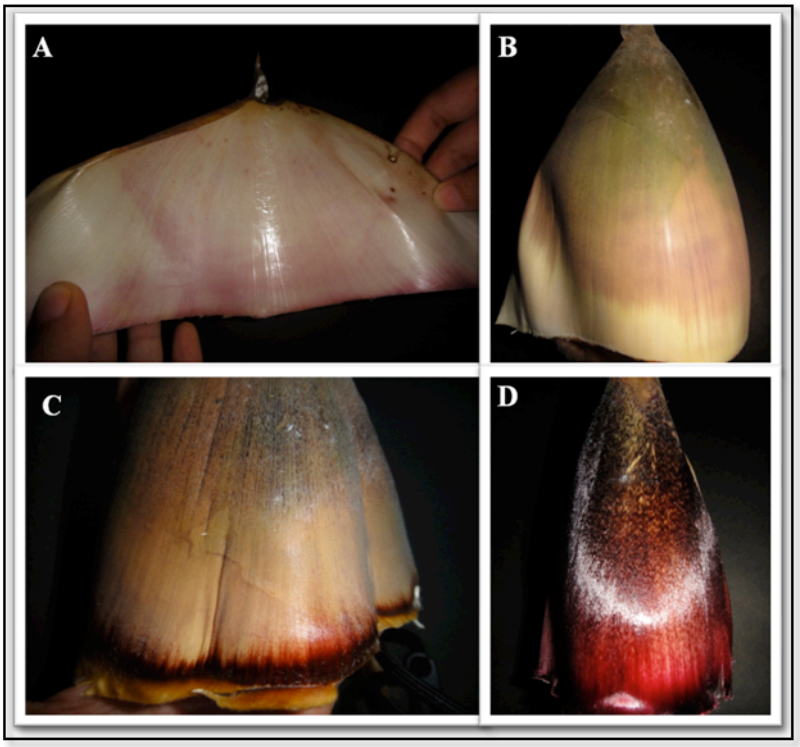

Figure 3

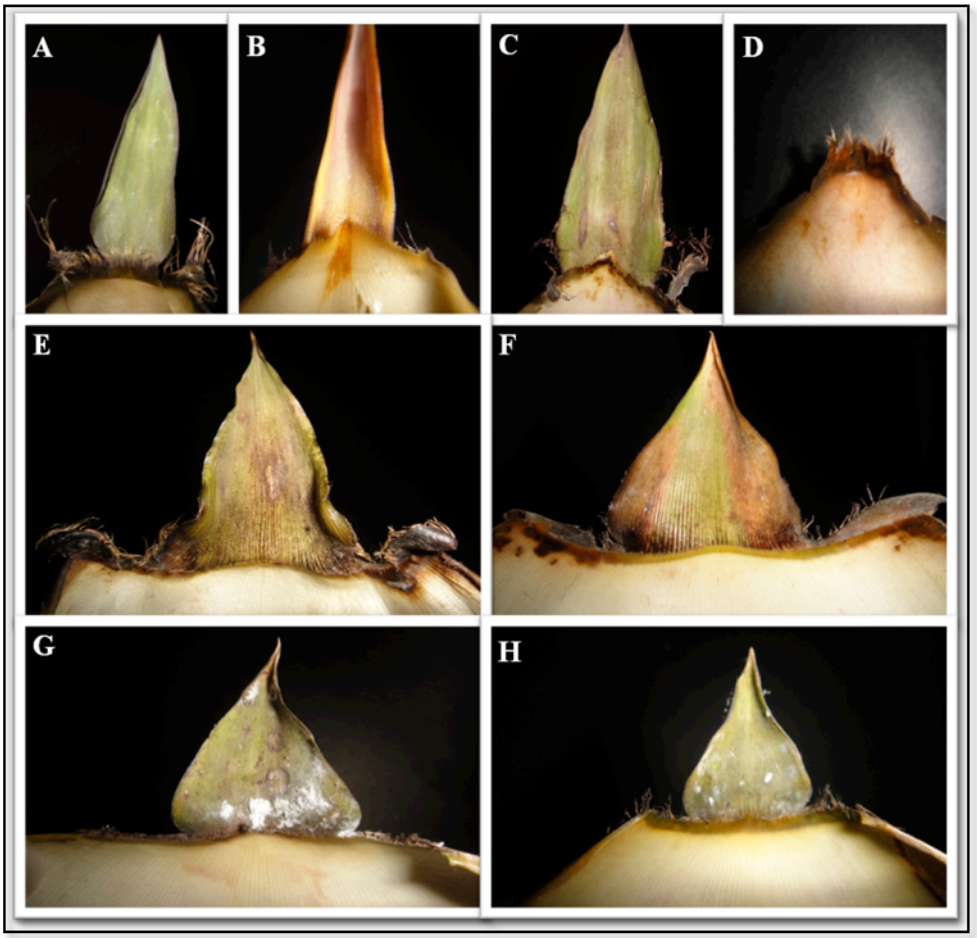

Figure 4

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Morphological Characters

Out of the 31 vegetative characters evaluated, variation was not observed in 5 characters: blade longitudinal posture, blade base of culm sheath, width of blade base of culm sheath, auricle position and auricle indument position. Sub-basal blade of all species were not decurrent to the culm sheath and are all narrower than the culm sheath apex. All species exhibit auricles although *D. latiflorus*, *D. asper*, *B. blumean*a and *B. merrilliana* exhibit low, rim-like auricles. Blade shape character showed the most variation in having five character states: deltate, narrowly triangular, triangular, lanceolate and lance-ovate.

Blade length for all species ranged from 1.1 cm to 16.9 cm (Table 4) and width from 0.3 cm to 7.3 cm (Table 5). Blade length to blade width ratio range from 1:1 to 7:1 (Table 6).

Culm sheath length ranged from 5.1 cm to 30.9 cm (Table 7), width from 6.5 cm to 53.9 cm (Table 8), and apex width from 0.3 cm to 12.8 cm (Table 9). Culm sheath length to culm sheath width to culm sheath apex width ratio ranged from 38:173:1 to 1:1:1 (Table 10). Table 11 summarizes the means of all the vegetative characters used in this study.

Table 3. Similarity and distance coefficients of eight species of bamboo used in the study.

	GL	DL	DA	BP	BVVS	BV	BB	BM
GL	0	5.0141	3.8964	3.6137	5.8668	5.7800	5.9259	4.8794
DL	5.0141	0	4.3442	6.1114	6.3081	6.2281	6.0151	6.0449
DA	3.8964	4.3442	0	5.1616	5.4066	5.3151	5.1528	4.4772
BP	3.6137	6.1114	5.1616	0	4.7169	4.6103	6.1826	5.1417
BVVS	5.8668	6.3081	5.4066	4.7169	0	1.0004	6.0965	6.3828
BV	5.7800	6.2281	5.3151	4.6103	1.0004	0	6.0146	6.3049
BB	5.9259	6.0151	5.1528	6.1826	6.0965	6.0146	0	2.6845
BM	4.8794	6.0449	4.4772	5.1417	6.3828	6.3049	2.6845	0

As seen on Table 3, similarity and distance coefficients ranged from 1.0004 to 6.3828. The pair of species with the lowest coefficient, *B. vulgaris* and B. *vulgaris* var. *striata*, indicated closest resemblance. This could be attributed to being similar in all characters except in the presence of striations in the latter species. Other pair of species with close resemblance is *B. blumeana* and *B. merrilliana* with 2.2656. On the other hand, the highest coefficient for *B. merilliana* and *B. vulgaris* var. *striata* indicate that they are the most unlikely pair. This could be attributed to wide divergences on characters except on location of trichomes on culm sheath plus the five characters where variation was not observed.

Figure 5 shows the generated dendrogram which reveals the similarities among the taxa. Four pairings resulted from the quantitative and qualitative vegetative characters used.

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Next to the first cluster with the least similarity and distance coefficient is *B. blumeana* and *B. merrilliana.*They share all characters except for four. *B. blumeana* exhibit few trichomes, upcurved culm sheath apex towards the middle, deltate blade an erect auricles. However, *B. merrilliana* has moderate trichomes, no upcurved culm sheath apex towards the middle, triangular blade and sometimes not erect auricles. Table 12 summarizes all the characters for all taxa used.

With similarity and distance coefficient of 3.6137. *B. philippinensis* and *G. levis* paired together. Absence of culm sheath striations, abundant trichomes on culm sheath, presence of culm sheath ciliation, narrowly acute apex and applanate transverse posture of culm sheath blade, not erect culm sheath blade, medium-sized and lobed, auricle with long fimbriations are the characters shared plus the five characters where variation was not observed for all species.

Lastly, *D. asper* and *D. latiflorus* paired with similarity and distance coefficient of 4.3442. They shared 18 qualitative characters. *D. latiflorus* has green culm sheath, without trichomes on the surface and no upcurved towards the middle of the apex as opposed to *D. asper* having brown culm sheath and abundant trichomes on entire surface of culm sheath. The former species also exhibit and membranous ligule compared to the latter species with shortly fringed ligule.

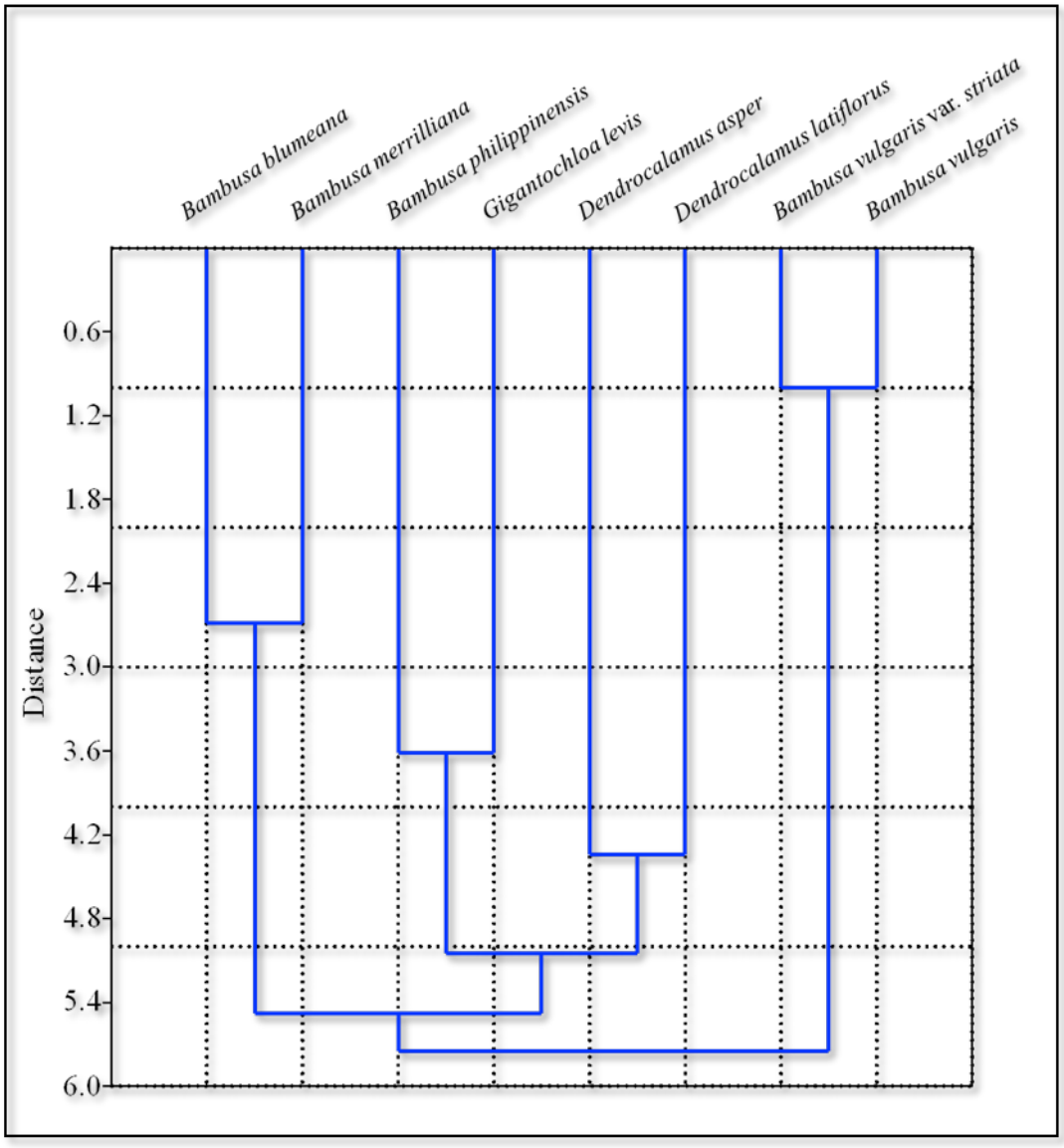

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Figure 5

The cluster analysis shows there is a separation within the three genera according to the morphological characters used. Each of the cluster was grouped in accordance to a number of similar characters.

Table 4. Blade lengths in centimeter of eight bamboo taxa used in this study.

Species	Sample no.	Blade Number														Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Gigantochloa levis	1	3.2	3.5	3.8	4.0	4.7	5.5	6.6	7.7	9.3	14.41	13.8	16.9	-	-	7.7583
	2	3.5	4.0	4.5	5.1	5.9	6.5	7.1	8.4	9.7	11.0	12.1	13.5	-	-	7.6083
Dendrocalamus latiflorus	1	1.9	2.1	2.7	3.3	3.9	4.6	4.6	5.8	6.0	6.7	7.2	8.2	-	-	4.7500
	2	1.2	1.6	1.7	2	2.4	3.0	3.7	4.4	5.6	6.7	8.0	9.4	-	-	4.1417
	3	1.1	1.1	1.3	1.4	1.7	2.3	2.6	3.3	3.9	4.3	4.9	5.4	-	-	2.7750
Dendrocalamus asper	1	1.2	1.5	1.4	1.5	1.7	2.4	2.5	3.0	3.4	3.9	3.7	4.6	5.5	6.8	3.0786
Bambusa philippinensis	1	1.6	1.6	2.0	2.7	3.3	3.9	5.0	5.8	7.1	9.4	9.1	10.0	11.6	11.9	6.0714
	2	2.1	2.5	3.1	3.5	4.5	5.1	5.8	6.8	7.3	8.5	9.5	10.5	11.5	12.3	6.6429
	3	2.1	2.7	3.2	4.6	5.6	6.3	7.6	9.1	10.5	11	12.6	13.5	14.6	-	7.9583
Bambusa vulgaris var. *striata*	1	2.2	2.3	2.5	3.0	3.9	4.1	4.8	6.7	7.0	7.1	7.5	-	-	-	4.6455
	2	2.2	2.9	3.0	3.4	3.6	4.5	5.5	5.8	6.5	6.9	8.1	8.8	-	-	5.1000
Bambusa vulgaris	1	4.1	4.5	5.1	6.0	6.7	7.3	7.8	8.3	9.2	9.6			-	-	6.8600
Bambusa blumeana	1	1.5	2.0	2.4	2.6	3.0	3.5	3.8	3.9	4.5	5.2	5.6	6.1	-	-	3.6750
Bambusa merrilliana	1	2.0	2.0	2.2	2.5	2.6	2.9	3.0	3.0	3.1	3.1	3.3	3.4	-	-	2.7583

Table 5. Blade widths in centimeter of eight bamboo taxa used in this study.

Species	Sample no.	Blade Number														Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Gigantochloa levis	1	0.6	0.6	0.9	1.1	1.2	1.6	1.8	2.2	2.4	3.0	3.5	4.2	-	-	1.92500
	2	0.8	0.8	1.0	1.1	1.5	1.6	1.7	2.1	2.3	2.5	2.9	2.9	-	-	1.76670
Dendrocalamus latiflorus	1	0.5	0.5	0.6	0.5	0.6	0.9	0.9	0.9	0.9	1.2	1.4	1.6	-	-	0.76670
	2	0.4	0.4	0.4	0.4	0.4	0.6	0.8	0.8	1.3	1.6	1.7	1.9	-	-	0.89167
	3	0.3	0.4	0.3	0.4	0.5	0.8	0.9	0.9	0.9	1.0	1.0	1.0	-	-	0.70000
Dendrocalamus asper	1	0.3	1.0	0.8	0.8	1.1	0.9	0.9	0.9	0.9	0.8	0.9	1.0	1.2	1.3	0.9143
Bambusa philippinensis	1	0.8	0.9	1.1	1.5	1.7	2.1	2.1	2.4	3.6	3.0	2.9	3.1	3.2	3.2	2.28571
	2	1.2	1.6	2.0	2.1	2.2	2.4	2.4	2.6	2.7	2.8	2.9	2.9	3.0	2.8	2.43571
	3	1.2	1.8	2.1	2.4	2.5	2.6	2.8	3.4	3.4	3.6	3.8	4.0	4.0	-	2.92308
Bambusa vulgaris var. *striata*	1	1.5	2.1	2.6	3.5	4.9	5.8	5.8	6.3	7.3	7.2	7.0	-	-	-	4.90910
	2	1.9	2.1	2.7	3.5	4.2	5.3	5.9	5.5	6.2	6.2	5.7	5.8	-	-	4.58330
Bambusa vulgaris	1	4.9	5.5	6.1	6.6	7.0	7.0	7.0	7.3	6.8	6.4	-	-	-	-	6.46000
Bambusa blumeana	1	1.5	2.0	2.1	2.4	2.5	3.0	3.2	3.0	3.2	2.9	2.4	2.2	-	-	2.53330
Bambusa merrilliana	1	1.3	1.3	1.3	1.6	1.6	1.7	1.7	1.4	1.3	1.3	1.4	1.6	-	-	1.45830

Table 6. Blade length to blade width ratio of eight taxa used in this study.

Species	Sample no.	Blade length to Blade width Ratio													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Gigantochloa levis	1	5:1	6:1	4:1	4:1	4:1	3:1	4:1	4:1	4:1	5:1	4:1	4:1	-	-
	2	4:1	5:1	5:1	5:1	4:1	4:1	4:1	4:1	4:1	4:1	4:1	5:1	-	-
Dendrocalamus latiflorus	1	4:1	4:1	5:1	7:1	7:1	5:1	5:1	6:1	7:1	6:1	5:1	5:1	-	-
	2	3:1	4:1	4:1	5:1	6:1	5:1	5:1	6:1	4:1	4:1	5:1	5:1	-	-
	3	4:1	3:1	4:1	4:1	3:1	3:1	3:1	4:1	4:1	4:1	5:1	5:1	-	-
Dendrocalamus asper	1	4:1	2:1	2:1	2:1	2:1	3:1	3:1	3:1	5:1	4:1	5:1	5:1	5:1	5:1
Bambusa philippinensis	1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	3:1	3:1	4:1	4:1	4:1
	2	2:1	2:1	2:1	2:1	2:1	2:1	2:1	3:1	3:1	3:1	3:1	4:1	4:1	4:1
	3	2:1	2:1	2:1	2:1	2:1	2:1	3:1	3:1	3:1	3:1	3:1	3:1	4:1	-
Bambusa vulgaris var. *striata*	1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	-	-	-
	2	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	2:1	-	-
Bambusa vulgaris	1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	2:1	-	-	-	-
Bambusa blumeana	1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	2:1	2:1	3:1	-	-
Bambusa merrilliana	1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	-	-

Table 7. Culm sheath lengths in centimeter of eight bamboo taxa used in this study.

Species	Sample no.	Blade Number														Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Gigantochloa levis	1	-	14.8	16.0	16.7	17.2	17.6	18.1	18.9	19.4	19.6	19.5	18.5	-	-	17.8450
	2	11.2	12.0	12.4	14.6	13.5	14.7	15.0	15.4	15.6	16.1	16.6	16.7	-	-	14.4830
Dendrocalamus latiflorus	1	24.3	26.4	26.6	30.7	31.1	32.0	32.5	30.9	30.8	29.4	27.1	24.1	-	-	28.8250
	2	17.6	21.0	21.7	25.0	26.3	27.1	27.8	26.5	24.0	21.2	18.8	-	-	-	23.3640
	3	16.5	18.5	22.2	23.0	24.5	24.5	24.5	23.9	20.2	18.6	15.7	13.0	-	-	20.4250
Dendrocalamus asper	1	11.4	12.5	12.3	12.4	15.2	13.9	17.7	18.0	21.5	22.9	23.0	23.9	25.0	25.0	18.1930
Bambusa philippinensis	1	8.2	9.6	11.1	12.0	13.3	14.9	15.3	15.9	16.2	16.0	16.0	13.0	11.2	8.3	12.857
	2	8.6	9.0	9.9	10.5	12.0	13.0	14.3	15.0	15.5	15.4	15.0	15.1	13.8	11.4	12.7500
	3	10.6	11.9	13.0	14.4	16.0	16.6	17.4	17.8	18.0	17.1	14.8	12.4	9.6	-	14.585
Bambusa vulgaris var. *striata*	1	7.2	8.5	8.9	9.1	10.1	10.9	11.5	11.1	11.4	9.9	8.1	-	-	-	9.7000
	2	8.0	8.5	8.8	9.4	10.1	11.2	11.1	12.4	11.9	11.1	9.3	7.4	-	-	9.9333
Bambusa vulgaris	1	10.7	11.6	12.6	12.8	14.0	14.1	14.1	13.2	12.2	10.2	-	-	-	-	12.55
Bambusa blumeana	1	5.5	10.9	11.8	12.4	13.1	13.4	13.0	12.6	11.0	9.8	8.5	6.8	-	-	10.733
Bambusa merrilliana	1	5.1	8.0	9.1	9.4	11.0	12.9	12.2	13.0	13.5	13.5	12.9	12.0	-	-	25.7330

Theme: Biology, Morphology and Taxonomy

Table 8. Culm sheath widths in centimeter of eight bamboo taxa used in this study.

Species	Sample no.	Culm sheath Number													Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Gigantochloa levis	1	-	23.9	23.3	22.0	19.4	18.9	16.6	16.3	14.0	10.0	10.2	8.2	-	-	16.6180
	2	20.5	23.5	20.4	20.3	19.0	20.0	16.7	15.0	13.7	13.2	11.2	11.0	-	-	17.0420
Dendrocalamus latiflorus	1	41.0	40.2	38.0	34.8	27.5	28.9	25.6	23.6	23.1	17.5	15.1	12.7	-	-	27.3330
	2	36.2	31.7	25.7	26.1	26.2	22.0	18.9	18.1	15.1	12.5	11.2	9.1	-	-	21.0670
	3	36.5	38.5	36.0	32.7	31.5	27.5	25.4	22.0	19.3	16.7	12.3	11.5	-	-	25.8250
Dendrocalamus asper	1	51.8	53.9	53.4	53.0	52.6	47.8	46.4	40.2	39.2	34.5	31.5	29.5	27.1	25.5	41.8860
Bambusa philippinensis	1	25.5	32.0	28.5	28.7	26.7	22.0	21.0	20.0	17.2	12.8	14.8	11.2	9.5	7.7	19.8290
	2	25.0	26.2	24.5	20.4	19.5	19.0	16.9	16.0	14.7	13.1	12.3	9.6	8.4	6.5	16.5790
	3	34.5	35.0	32.0	26.9	26.0	24.5	22.7	20.1	17.2	15.8	11.1	10.9	8.6	-	21.9460
Bambusa vulgaris var. *striata*	1	32.0	29.4	27.5	28.1	25.1	24.5	22.4	18.0	18.0	15.0	14.1	-	-	-	23.1000
	2	28.1	31.2	27.7	21.5	23.3	17.0	16.0	15.9	15.6	16.2	14.0	11.1	-	-	19.8000
Bambusa vulgaris	1	26.4	25.1	25.0	22.8	24.1	21.6	18.7	18.4	17.0	15.0	-	-	-	-	21.4100
Bambusa blumeana	1	28.5	30.5	30.6	29.2	25.4	24.2	21.2	20.1	16.0	15.1	14.5	11.4	-	-	22.2250
Bambusa merrilliana	1	24.3	30.0	35.9	32.7	29.9	28.9	26.0	25.0	23.0	19.4	17.5	16.2	-	-	25.7330

Theme: Biology, Morphology and Taxonomy

Species	Sample no.	Culm sheath Number													Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Gigantochloa levis	1	2.9	3.0	2.8	2.9	2.9	3.1	3.1	3.4	3.6	4.4	4.2	3.9	-	-	3.3500
	2	2.6	2.6	2.4	2.9	2.9	3.4	3.0	3.4	2.8	3.8	3.7	3.9	-	-	3.1167
Dendrocalamus latiflorus	1	1.0	1.0	1.1	1.4	1.6	1.6	1.6	2.0	2.0	2.0	2.6	2.3	-	-	1.6833
	2	0.4	0.8	1.0	1.0	1.0	1.0	1.0	1.4	1.6	2.2	-	-	-	-	1.1400
	3	0.3	0.6	0.9	1.0	1.0	1.2	1.2	1.5	1.8	2.0	2.0	2.0	-	-	1.2917
Dendrocalamus asper	1	0.3	1.1	3.6	1.2	1.3	1.5	1.6	1.7	1.7	2.1	2.0	2.3	2.6	2.8	1.8429
Bambusa philippinensis	1	1.0	1.5	2.0	2.4	3.3	3.8	4.3	4.3	5.2	6.0	-	-	-	-	3.38
	2	1.6	2.4	3.0	3.4	3.5	4.0	4.0	4.0	4.2	4.2	5.6	5.2	5.1	4.8	3.9286
	3	1.9	2.2	3.2	3.5	4.1	4.5	4.9	6.0	6.8	6.7	6.6	6.5	5.0	-	4.7615
Bambusa vulgaris var. *striata*	1	3.5	4.4	5.2	6.4	7.7	9.6	10.5	11.0	10.5	10.7	10.1	-	-	-	8.1455
	2	4.4	5.5	6.5	7.2	7.6	9.2	9.2	9.7	10.3	12.8	9.9	10.0	-	-	8.5250
Bambusa vulgaris	1	9.6	10.4	10.5	11.2	11.1	12.2	12.3	12.5	11.9	11.5	-	-	-	-	11.3200
Bambusa blumeana	1	3.3	4.2	5.1	5.2	6.3	6.6	7.0	7.2	7.2	6.3	5.7	5.5	-	-	5.8000
Bambusa merrilliana	1	3.0	3.2	3.5	4.6	4.0	4.1	4.2	4.3	4.4	4.5	4.7	4.4	-	-	4.0750

Table 9. Culm sheath apex width of eight bamboo taxa used in this study.

Theme: Biology, Morphology and Taxonomy

Species		Culm sheath length to culm sheath width to culm sheath apex width ratio													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Gigantochloa levis	1	-	5:8:1	6:8:1	6:8:1	6:7:1	6:6:1	6:5:1	6:5:1	5:4:1	4:3:1	5:2:1	5:2:1	-	-
	2	4:8:1	5:9:1	5:9:1	5:7:1	5:7:1	4:6:1	5:6:1	5:4:1	6:5:1	4:4:1	4:3:1	4:3:1	-	-
Dendrocalamus latiflorus	1	24:41:1	26:40:1	24:35:1	22:25:1	19:17:1	20:18:1	20:16:1	15:12:1	15:12:1	15:9:1	10:6:1	10:6:1	-	-
	2	44:91:1	26:40:1	22:26:1	25:26:1	26:26:1	27:22:1	28:19:1	19:13:1	15:9:1	10:6:1	-	-	-	-
	3	55:122:1	31:64:1	25:40:1	23:33:1	25:32:1	20:23:1	20:22:1	16:15:1	11:11:1	9:9:1	8:6:1	7:6:1	-	-
Dendrocalamus asper	1	38:173:1	11:49:1	3:15:1	10:44:1	12:41:1	9:32:1	11:29:1	11:24:1	13:23:1	11:16:1	12:16:1	10:13:1	10:10:1	9:9:1
Bambusa philippinensis	1	8:26:1	6:21:1	6:14:1	5:12:1	4:8:1	4:6:1	4:5:1	3:3:1	3:2:1	-	-	-	-	-
	2	5:16:1	4:11:1	3:8:1	3:6:1	3:6:1	3:5:1	4:4:1	4:4:1	4:4:1	4:3:1	3:2:1	3:2:1	3:2:1	-
	3	6:18:1	5:16:1	4:10:1	4:8:1	4:6:1	4:5:1	4:5:1	3:3:1	3:3:1	3:2:1	2:2:1	2:2:1	2:2:1	-
Bambusa vulgaris var. *striata*	1	2:9:1	2:7:1	2:5:1	1:4:1	1:3:1	1:2:1	1:2:1	1:2:1	1:1:1	1:1:1	1:1:1	-	-	-
	2	2:2:1	2:2:1	1:1:1	1:1:1	1:1:1	1:1:1	1:1:1	1:1:1	1:1:1	1:1:1	1:1:1	1:1:1	-	-
Bambusa vulgaris	1	1:3:1	1:2:1	1:2:1	1:2:1	1:2:1	1:2:1	1:2:1	1:2:1	1:1:1	1:1:1	1:2:1	1:2:1	-	-
Bambusa blumeana	1	2:9:1	3:7:1	2:6:1	2:6:1	2:4:1	2:4:1	2:3:1	2:3:1	2:3:1	2:3:1	1:3:1	1:2;1	-	-
Bambusa merrilliana	1	2:9:1	3:9:1	3:10:1	2:7:1	3:7:1	3:7:1	3:6:1	3:6:1	3:5:1	3:4:1	3:3:1	3:4:1	-	-

Table 10. Culm sheath length to culm sheath width to culm sheath apex width ratio of eight taxa used in this study

Species	Blade length	Blade width (cm)	Blade length to width	Culm Sheath	Culm sheath	Culm sheath	Culm sheath length to width to

Table 11. Mean measurements of vegetative traits of eight taxa used in this study.

Theme: Biology, Morphology and Taxonomy

Characters	(cm)		ratio	length (cm)	width (cm)	apex width (cm)	apex width ratio
	Species						
Gigantochloa levis	7.68333	1.845830	4.260210 : 100000	16.09130	16.839100	3.223330	4.99353 : 5.502270 : 1.00000
Dendrocalamus latiflorus	3.88889	0.822220	4.620050 : 100000	24.228600	24.741400	1.385280	21:01080 : 26.23850 : 1.00000
Dendrocalamus asper	3.078571	0.914286	3.330445 : 100000	18.192860	41.885710	1.842875	12.12217 : 35.23112 : 1.00000
Bambusa philippinensis	6.863415	2.507317	2.551894 : 100000	13.362890	19.390240	4.072873	3.773465 : 7.081918 : 1.00000
Bambusa vulgaris var. *striata*	4.882609	4.739130	1.052384 : 100000	9.821739	21.378260	8.343478	1.295587 : 2.363202 : 100000
Bambusa vulgaris	6.860000	6.460000	1.050943 : 100000	21.410000	21.410000	11.320000	1.110422 : 1.924704 : 1.00000
Bambusa blumeana	3.675000	2.533333	1.448814 : 100000	10.733330	22.225000	5.800000	1.873988 : 4.188995 : 1.00000
Bambusa merrilliana	2.758333	1.458333	1.901796 : 100000	11.050000	25.733330	4.075000	2.683998 : 6.526055 : 1.00000

Table 12. Summary of 24 qualitative characters for all eight taxa used in this study.

Theme: Biology, Morphology and Taxonomy

	Levis	*latiflorus*	*asper*	*philippinensis*	*vulgaris* var. *striata*	*vulgaris*	*blumeana*	*merilliana*
CSS	Absent	absent	absent	absent	present	absent	absent	absent
CSLT	Entire	absent	entire	upper half	upper half	upper half	upper half	upper half
CSCT	Abundant	absent	abundant	abundant	abundant	abundant	few	moderate
CSAS	not upcurved	not upcurved	upcurved	upcurved	upcurved	upcurved	upcurved	not upcurved
CSC	Present	present	present	present	present	present	absent	absent
CSCL	Brown	green	brown	green tinged with purple	green	green	green tinged with purple	green tinged with purple
BP	Reflexed	reflexed	reflexed	appressed	appressed	appressed	inclined	inclined
BTP	Applanate	applanate	applanate	applanate	applanate	applanate	undulate	undulate
BLP	slightly involute to involute	slightly involute to involute	slightly involute to involute	slightly involute to involute	slightly involute to involute	slightly involute to involute	slightly involute to involute	slightly involute to involute
BC	not green	green	not green	green	green	green	green	green
BAS	narrowly acute	narrowly acute	narrowly acute	narrowly acute	acuminate	acuminate	narrowly acute	narrowly acute
BS	Lanceolate	narrowly triangular	narrowly triangular	lance-ovate	deltate	deltate	deltate	triangular
BADH	Absent	moderate	moderate	few	abundant	abundant	few	few
BMC	Absent	absent	absent	present	present	present	absent	absent
BB	not decurrent	not decurrent	not decurrent	not decurrent	not decurrent	not decurrent	not decurrent	not decurrent
BWCS	Narrower	narrower	narrower	narrower	narrower	narrower	narrower	narrower
APO	contiguous with blade	contiguous with blade	contiguous with blade	contiguous with blade	contiguous with blade	contiguous with blade	contiguous with blade	contiguous with blade

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AI	long-fimbriate	glabrate to very few	glabrate to very few	long-fimbriate	long-fimbriate	long-fimbriate	short-fimbriate	short-fimbriate
AIP	Marginal	marginal	marginal	marginal	marginal	marginal	marginal	marginal
AP	not erect	erect	erect	not erect	erect	erect	erect	not erect
AS	medium-sized	wanting to small	wanting to small	medium-sized	large	large	wanting to small	wanting to small
ASR	more or less equal	more or less equal	more or less equal	strongly unequal	strongly unequal	strongly unequal	more or less equal	more or less equal
ASH	lobe-like	rim-like	rim-like	lobe-like	lobe-like	lobe-like	rim-like	rim-like
LT	long-fringed	membranous	short fringed	membranous	membranous	membranous	short-fringed	short-fringed

Summary, Conclusions and Recommendations

Harvested specimens of eight edible taxa of young bamboo shoots were characterized. Phenetic investigation and cluster analysis were performed. Cluster analysis was carried out to determine distances among species within three genera using paired group algorithm and Euclidean similarity measure utilizing PAST v.2.17c (Hammer et al. 2001). A dichotomous key was also generated.

Based on the index of similarity and distance coefficients and dendrogram generated, *B. vulgaris* and *B. vulgaris* var. *striata* among all the taxa used have the highest degree of similarity. The two taxa shared all the vegetative characters except on the presence of culm sheath striations on *B. vulgaris* var. *striata.* Other paired species include *G. levis* and *B. philippinensis*, *B. blumeana* and *B. merrilliana* and *D. asper* and *D. latiflorus.* On the other hand, the most distantly similar species are *B. blumeana* and *B. vulgaris var. striata*.

This preliminary study on morphology-based diagnostics of edible young shoots of bamboos can be used to identify and differentiate between species aside from the characters of mature bamboos. It can be very useful for taxonomists and bamboo enthusiasts.

Morphological characterization of other bamboo species on its juvenile stage is recommended to further differentiate all the available edible species of bamboos found in the Philippines using young shoot characters.

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Figure 1. Distribution of edible taxa of bamboos in the Philippines (based on data extracted from Caasi-Lit, et.al 2010)

Figure 2. Habit of bamboo shoots used in the study. (A) *Gigantochloa levis*; (B) *Dendrocalamus latiflorus*; (C) *D. asper*, (D)*Bambusa philippinensis*; (E) *B. vulgaris* var. *striata*; (F) *Bambusa vulgaris*; (G) *B. blumeana*; and (H) *B. merrilliana.*

Figure 3. Young culm sheaths tinged with purple. (A) Adaxial and (B) abaxial of culm sheath of *B. blumeana;* C abaxial culm sheath of *B. merrilliana*; D abaxial culm sheath of *B. philippinensis*

Figure 4. Blade, ligule, auricle and culm sheath apex of 8 taxa used in this study. (A) long-fringed ligule and not upcurved culm sheath apex of *G. levis*; (B) membranous ligule and not upcurved culm sheath apex of *D. latiflorus*; (C) membranous ligule and upcurved culm sheath apex of *B. philippinensis*; (D) short-fringed ligule and sometimes upcurved and sometimes not culm sheath apex of *D. asper*; (E) membranous ligule, unequal and lobed auricles, and upcurved culm sheath apex of *B. vulgaris* var. *striata*; (F) membranous ligule, unequal and lobed auricles, and upcurved culm sheath apex of *B. vulgaris*; (G) short-fringed ligule and upcurved culm sheath apex of *B. blumeana*; and (H) short fringed ligule and not upcurved culm sheath apex of *B. merrilliana.*

Figure 5. Dendrogram generated from integrated quantitative and qualitative characters using PAST v2.17c.