International Journal of Engineering Applied Sciences and Technology, 2022
Vol. 6, Issue 12, ISSN No. 2455-2143, Pages 40-48
Published Online April 2022 in IJEAST (http://www.ijeast.com)

SPECIES AND STATUS OF BAMBOO KNOWN FOR THE CONICAL HAT OF NORTHWESTERN LAYA: A UNIQUE CULTURE IN GASA, BHUTAN

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Abstract: **Montane bamboo is of very importance to the indigenous people inhabiting mountains of the Himalayas, and is a necessary component of high-altitude temperate forest ecosystems. Particularly, in Laya it is commonly used for weaving conical hat and other implements. Thamnocal amusspathiflorus (Trin.) Munro bamboo was documented as a main element of the conical hat making, displaying the highest altitude frost hardy bamboos in mixed coniferous forest. The cluster analysis specified major habitat of 60% significance (p-value ≤ 0.72) indicating a strong influence of bamboo density with associated species composition and other ecological factors. Unregulated harvesting of young culms and the harvesters repeatedly congregating in the same site resulted in unhealthy clump. Its narrow distribution pattern might threaten to population decline or total wipe off and also remote cause possibly by the spread of secondary forest tree species such as Picea spinulosa & Abies dens a that have gradually taken over areas previously occupied by the bamboo forest. Seventy percent of Laya pinter viewed agreed with the decline inthe production and use of conical hats. The element of this unique culture is under constant threat, for it was challenged by various factors including the stereotypical believes of the people.**

Keywords: **Bamboo, conical hat, Laya Bhutan, status, species**

I. INTRODUCTION

Montane bamboo grows gregariously within most mountain forests of Asia and tropical Africa (Bitariho & Mosango, 2005). Bambusoideae the subfamily of Poaceae comprises both woody and herbaceous bamboos are an essential component of forest and tropical high altitude grassland ecosystems with over 1718 species worldwide (Schroder, 2021; Clark et al. 2015).Bamboos occupy vast areas from the sea level to 4000m of natural and disturbed forest (Bystriakovaet al. 2003). Bamboo in general, plays a dynamic roleeconomically, culturally, and ecologically important plantthrough out the world and is of major national and international commercial importance (Attigalaet al. 2017; INBAR, 1999), referred to as ‘green gold’ and also as poor man’s timber being the plentiful availability and low cost (Bahadur, 1974), especially used as a substitute of the wood and as a food product in numerous cases for human and wildlife (Bahadur, 1974; Kumar et al. 2016; Dorjiet al. 2011; Gairaet al. 2021).

Although some of the native bamboos are not of economic importance, their ecological value is significant (Abayasingheet al. 2014). Moreover, bamboos are traditionally important in supplying housing, implements, musical instruments, and other handicrafts (McClure, 1966).Bamboos are known for their long flowering cycles and typically occur once in their lifetime, they flowers gregariously over the whole area producing a huge amount of seeds followed by mass dying of the whole clumps and some bamboos flower sporadically over large areas, but their dying is not as severe as those of gregarious flowering (Wangdaet al. 2011).

In Bhutan, culturally important bamboo species had a history of gregarious flowering in 2008 along the ridges of Pelela, Yotongla, and Gedu top (Wangdaet al. 2011).Although bamboo species constitute a non-timber forest product of major cultural and economic importance in Bhutan (Wangdaet al. 2011), however no detailed assessment of the social and conservation significant inventory of bamboo species distribution especially in natural forests is very limited. Thus, this study assessed the species and status of bamboo known for the conical bamboo hat, and their possible threats to the bamboo population and conical hats' culture of Laya, Gasa District.

II. MATERIAL AND METHODS

Study area

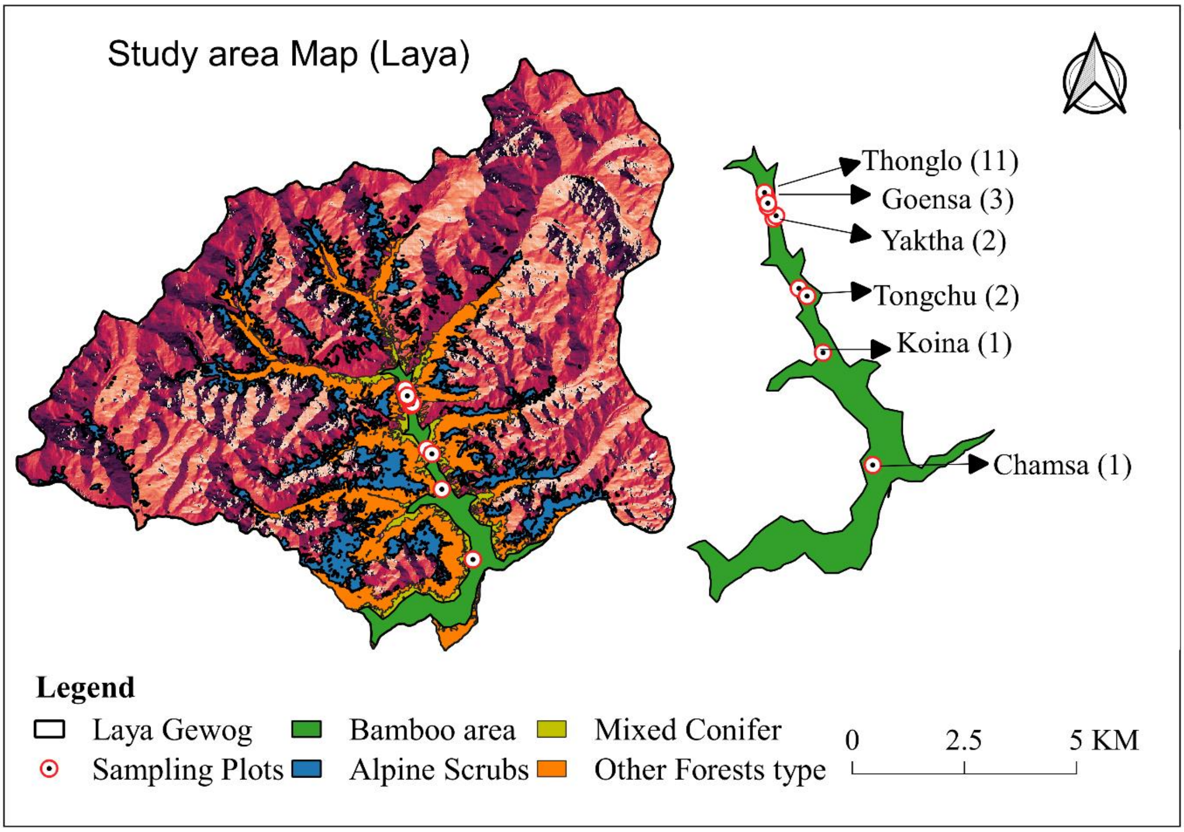

Figure 1. Study area Map of Laya, Gasa District showing Plots details: Bamboo extent and vegetation types.

Located on the southern slopes of the eastern Himalayas, the Kingdom of Bhutan has approximately 71% forest cover, predominantly mountainous with rugged terrain (FRMD, 2016). Forests in Bhutan are largely managed as a state reserved forest (SRF) for biodiversity conservation, water supply, grazing, fodder collection, timber and non-timber products, and aesthetics (Covey et al. 2015).

We conducted the study in the montane bamboo forest of Bhutan; Laya Gewog situated in the North-Western part of Gasa District (Figure 1), bordering Tibet in the North. The district falls under the Jigme Dorji Wangchuck National Park and provides important habitat for different species of birds and wild animals including Takin (National animal of Bhutan). Laya, an amazing small pocket of ethnic groups survived and is known for its unique culture of a distinctive conical bamboo hat. It is made of bamboo; usually the bamboo from the natural stand. Gasa District has about 68% of its land area under forest cover (District profile, 2022), Laya experiences extremely cold and frosty long winters with the highest temperatures of 6.0°C and minimum temperatures of -11.7°C with about 344mm annual average rainfall (climate-data.org, 2022). Gasa District in general received an average maximum temperature of 14.3°C and an average minimum temperature of 4.5°C (NCHM, 2021).

Sampling design

We used a systematic sampling of (20 x 20m) bamboo plots transect with a 50 m distance between the sample plots of commonly harvested and undisturbed sites of bamboo forest alternatively on each side of the transect line (Trans, 2010). In each of the plots, data on bamboo diameter at breast height (dbh), age-class distribution (identified by specialists' bamboo harvesters and also validated (Stapleton, 1994 and Bitariho and Mosango, 2005), bamboo stem death, and signs of harvesting/cutting of bamboo were recorded. Furthermore, individual tree and shrubs species (diameter dbh≥5 cm and height ≥ 150 cm) were recorded in the mixed bamboo strata where sampling intensity of 0.03% and 0.05% for bamboo stems and trees respectively (Bitariho and McNeilage, 2007). Semi-structured questionnaire (Bitariho and McNeilage, 2007), was focused on the bamboo harvesters and village interviews of 32 heads randomly of Laya and Gasa to determine the bamboo population extent and the importance of bamboo and conical bamboo hats' culture. We referred to the Flora of Bhutan (Grierson et al. 2002) and Bamboos of Bhutan (Stapleton, 1994) for proper species identification. Soil pH via digital pH meter (KETOTEK).

Data analysis

Vegetation and environmental data sets were processed in MS Excel 2015.The data collected from the 20 sampling sites revealed the presence of 22 trees and seven shrubs species including one bamboo species. The primary vegetation and social interviewed dataset along with six environmental variables (altitude, aspect, slope, canopy cover, soil pH) were analyzed using PCORD version 7.08 (McCune and Mefford, 2018). The Cluster Analysis (CA) was run to identify the similarity pattern in the species and sampling area for plant community classification using Sorensen measures.To obtain trends and relationships between vegetation, environmental and ecological factors, we employed ordination techniques using Canonical correspondence analysis and Indicator Species Analysis (ISA) to link the floristic composition and abundance data with the environmental variables. This combined information provided knowledge of the concentration of associate species abundance in a particular to the occurrence of the bamboo habitat. Indicator values for each species in each group were obtained and tested for statistical significance using the Monte Carlo test. The vegetation types were chosen from thedominant species present, as suggested by (Kuchler, 1967; Wangda and Ohsawa, 2006; Shaheenet al. 2012).

III. RESULTS AND DISCUSSION

Bamboo species

Thamnocalamusspathiflorus(Trin.) Munro (Figure 2), locally known as Meme (Hima) isdocumented for the conical hatmaking in Laya, Gasa District.It is the highest altitude clump-forming thornless frost hardy bamboos found from 2800 to 3500 m in a mixed coniferous forest (Stapleton, 1994). Along with T. spathiflorusbamboo strips, the conical hat is supplemented with other two secondary materials extracted from Juniper and Betula tree species. The pointed spear at the top of the hat, ornamented with colorful beadwork is made from a Juniper tree. The bark from Betula utilis and Betula alnoide is used between the two layers of a conical hat, it not only adorns the outfit but also protects them from rain. This unique and distinctive conical hat is worn by the women in the community.

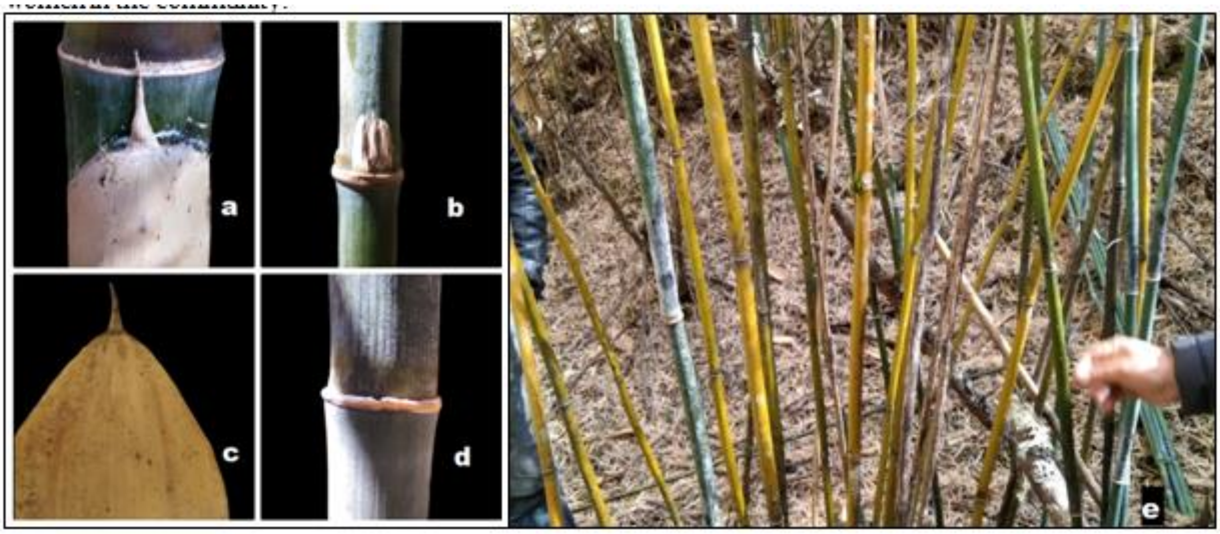

Figure 2. Bamboo species known for conical hat making in Laya, Gasa District; (a) symmetrical upright blade, (b) young bud, (c) culm sheath apex (flat ligule), (d) culm and culm node, (e) clump structure

Bamboo habitat composition

Indicator Species Analysis evaluated each species for the strength of its response to the environmental variables (20 sample units × 9 environmental gradients). A threshold level of indicator value of 25 % with 60% significance (p-value $\leq$ 0.72) and 50 % similarity (Figure 3) was chosen as the cut off for identifying indicator species (Dufrene and Legendre, 1997; Ter Braakand Prentice 1988) and naming the communities (Wangda and Ohsawa, 2006; Shaheenet al. 2012).

Stem density of associated plant species (trees & shrubs) was lesser in more bamboo strata plots (Table 2). The stems density of trees and shrubs increased from the pure bamboo to the mixed bamboo strata (Bitariho and McNeilage, 2007).

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This is because some forest areas of Gasa are mostly open with herbaceous vegetation, about 35% are scrubs forest, 27% under fir forest, 15% under mixed conifer forest, 4% under broad-leafed forest, and the rest as pasture (District profile, 2022).

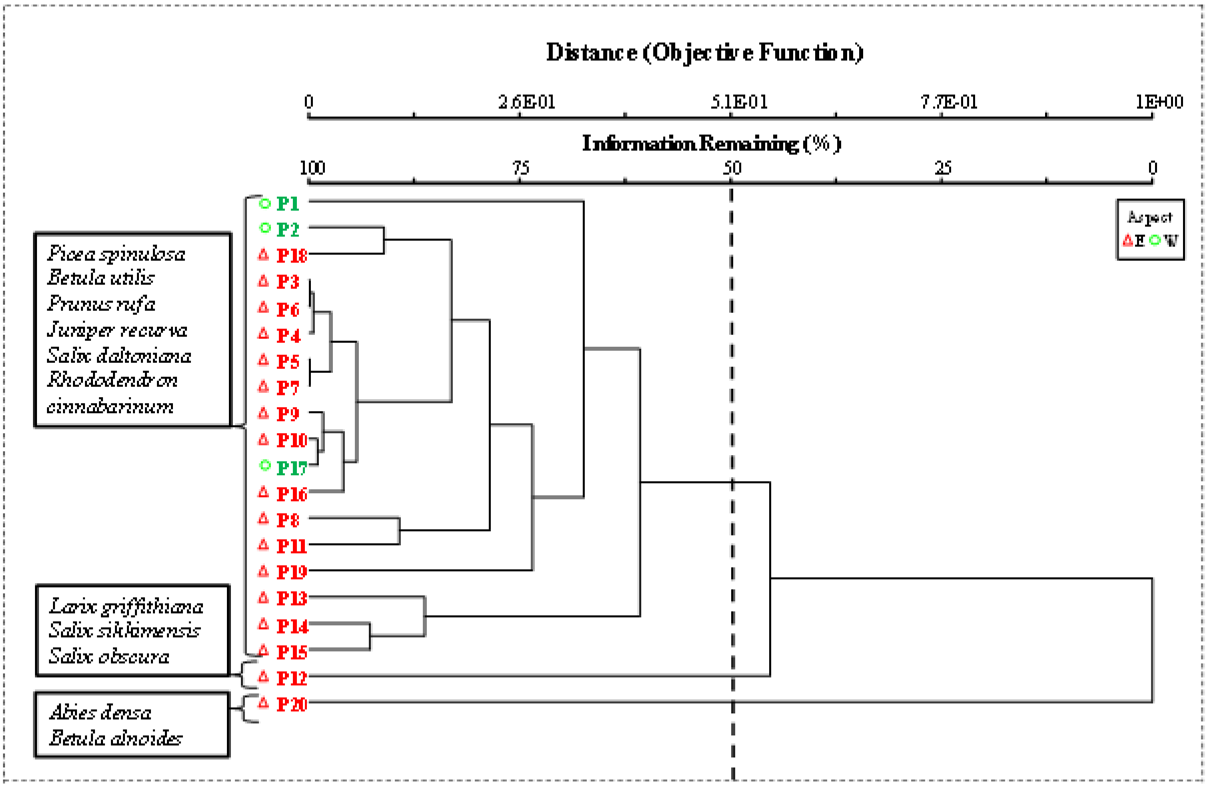

Figure 3.Cluster Dendrogram of 20 stations based on Sorensen measures showing 3 plant communities in the T. spathiflorus bamboo habitat.

The bamboo vegetation is composed of 29 plants species with secondary vegetation covers of 22 trees and seven shrubs species from 20 sampling plots. Cluster Analyses broadly separated the plant species into 3 communities/habitat typesin the Thamnocal amuss pathiflorus habitat of 50% significance (p-value ≤ 0.72),which could be seen in three main branches of the dendrogram; (i) Mixed spruce forest types dominated by Picea spinulosa (P≤0.589), Betula utilis (P≤0.146), Prunus rufa(P≤ 0.149), Juniperus recurva(P≤0.446), Salix daltoniana(P ≤ 0.843), and Rhododendron cinnabarinum (P ≤ 0.744), (ii) Larch and willow forest communities dominated by Larix griffithiana (P≤1.00),Salix sikkimensis (P≤0.426), and Salix obscura (P≤ 0.528), and (iii) Fir Forest dominated by Abies densa (P≤ 0.277), and Betula alnoides (P ≤ 1.00). Indicator Species Analysis (ISA) results show that slope degree, bamboo clump density, soil pH, species richness, maximum DBH, and canopy cover have the strongest influence and positive correlation on T.spathiflorus occurrence (Table 1).

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Table 1.Pearson and Kendall Correlations score with Ordination, from PC-Ord CCA output, for the first three axes with the key environmental variables.

CORRELATIONS AND BIPLOT SCORES for				14 Variables		
	Correlations*			Biplot Scores		
Variable	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3
1 Canopy %	-0.519***	-0.082n.s.	0.179n.s.	-0.447***	-0.056n.s.	0.114n.s.
2 Elev, m	0.364***	-0.212n.s.	-0.057n.s.	0.313**	-0.145n.s.	-0.036n.s.
3 SlopeDeg	0.585***	-0.293*	-0.289*	0.505***	-0.199n.s.	-0.184n.s.
4 Culm,dens	0.106n.s.	-0.143n.s.	-0.615***	0.091n.s.	-0.097n.s.	-0.391***
5 Loggd,Past	-0.091n.s.	0.118n.s.	-0.560***	-0.078n.s.	0.081n.s.	-0.356***
6 Dead,Culm	-0.218n.s.	-0.182n.s.	-0.337**	-0.188n.s.	-0.124n.s.	-0.214n.s.
7 Max.ht(m)	-0.489***	0.382***	-0.018n.s.	-0.422***	0.260*	-0.012n.s.
8 Max.DBH(cm)	-0.407***	0.657***	-0.023n.s.	-0.351**	0.448***	-0.014n.s.
9 Spp,Rich	-0.115n.s.	-0.590***	-0.563***	-0.099n.s	-0.402***	-0.357***
10 Total,BA	-0.360***	0.409***	-0.032n.s.	-0.311**	0.278*	-0.020n.s.
11 Soil.pH	0.857***	0.229n.s.	-0.202n.s.	0.738***	0.156n.s.	-0.128n.s.
12 Harv,Culms	-0.200n.s.	0.046n.s.	-0.679***	-0.176n.s.	0.032n.s.	-0.403***
13 1-2 yrs,Culms	-0.020n.s.	-0.287*	-0.640***	-0.018n.s	-0.201 n.s.	-0.380***
14 >2yrs,Culms	-0.226n.s.	-0.072n.s.	-0.621***	0.200n.s	-0.050n.s.	-0.368***

•* Correlations are "intra-set correlations" of ter Braak (1986), recommended for use with the LC scores by Palmer (1993). *** P < 0.001; ** P < 0.01; * P < 0.05; n.s. P > 0.05.

Bamboo age class distribution

The age-class distribution of bamboo in bamboo forest strata shows an inverse-J shaped kind of distribution characteristic of (1-2 >2 years) maximum mature culms (Figure 4). Young bamboo stems (<1 year) are the best age for conical hat weaving. Bamboo being heliophilous in nature competes for light and soil nutrients with trees in the mixed bamboo forest (Reid et al. 1991; Bitariho,1999; Bitariho and Mosango, 2005). Tree canopy cover regulate light penetration to the bamboo stems, which is possibly the cause of bamboo healthier in a mixed bamboo forest than in pure bamboo where canopy cover is low.

The bamboo clump density were calculated at the significant (r^2= 0.883, P< 0.426,F=5.215)and classified into five major groups: Harvestable culms < 1 year (r^2 = -0.679), culms of 1-2 years (r^2 = -0.640), Culms of more than 2 years (r^2 = -0.621), Culms harvested last year (r^2 = -0.560) and dead culms (r^2 = -0.337) forming contrasting physiognomic patterns along ecological gradients (Figure 4).

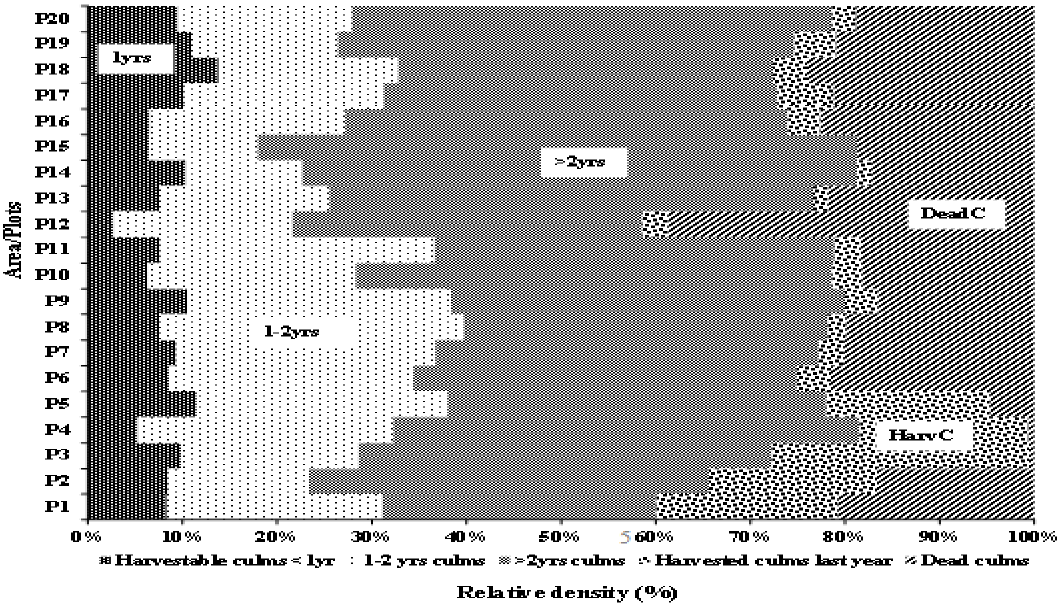

Figure 4. Density pattern of T. spathiflorus in 20 plots: 1yrs-harvestable culms <1 year, 1-2yrs- culms of more than 1 to 2 years, >2yrs- culms of more than 2 years, HarvC-total harvested culms last year and DeadC-total no. of dead culms.

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The harvestable culms < 1 year consisted of culms within one year, which was observed as best for bamboo hat making and other accessory products. From the past collection history, wherein plots 1, 2, 3, and 4 have observed the high intensity of collection which reviled that the bamboo habitat was located near to the community and the future harvestable culms are declining, but in plots 3 to 5 displays the significant balance of the bamboo harvest as the collection was observed at minimum level with the rotation system. Where the dead culms are detected minimum and the culms more than 1-2 and >2 years also indicate the average range of harvestable culms density, which results in the healthy bamboo density.

In all the sampled plots of different harvesting sites, old bamboo culms had the highest culm densities and young bamboo (harvestable culms) the least (Figure 4). The endemic Thamnocal amuss pathiflorusvar. bhutanensis and other bamboo species such as Yushania species were observed outside the study plots in the lower part of Laya.

CCA Ordination

A Monte Carlo test of 100 randomizations was carried out to test the robustness of the analysis. Ordinations presented here use the linear combinations of variables (LC) scores as recommended by (McCune et al. 2002). The result of the CCA of the quadrat data is presented for the key contributing factors to vegetation variation and species composition formation in the region. To test this hypothesis, both the species and environmental data matrices were treated by CCA and ISA methods to examine whether the establishment of Thamnocal amusspathi florus and associate plant species were aligned with the measured environmental variables or not and also to optimize the site scores.

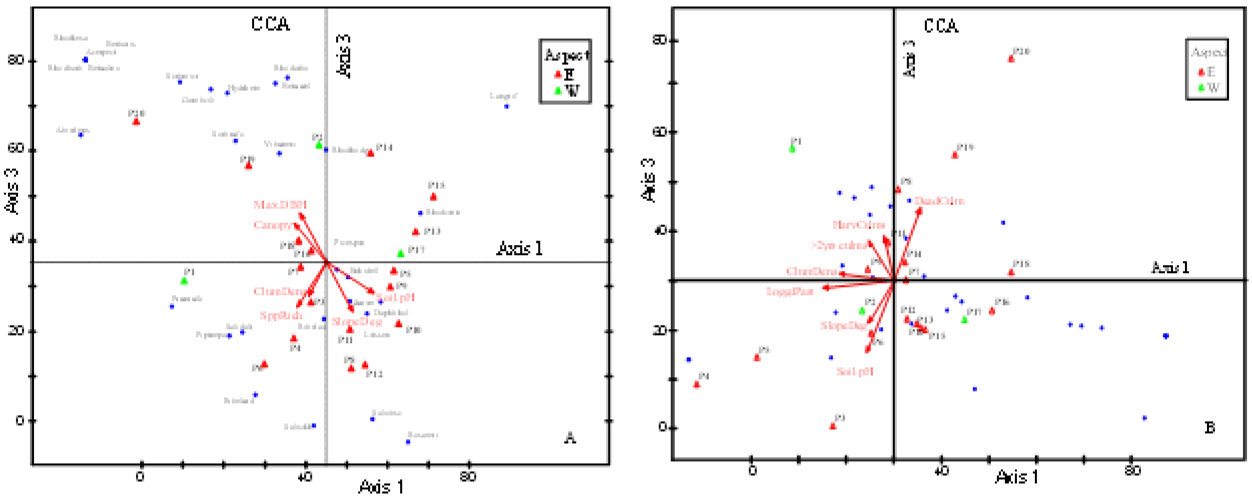

Figure 5. Canonical correlation analysis (CCA) ordination axis 1 plotted against axis 3, with **A** and **B**. In site A, Cluster analysis groupings and environmental variables are shown and species are labelled. In site **B**, ordination of T. spathiflorus habitats 'ecological and social factors to the community on the harvesting of bamboo. Each closed triangle (∆) represents a sampling plot, green triangle, station plots at the west aspect; red triangle, station plots at the east aspect. Each blue dot represents plant species. Each joint-plot red arrow line indicates environmental variables with high significance with the T. spathiflorus habitat types. Clum Dens-Clump density; Slope Deg-Degree of slope; Max.DBH-Maximum diameter at the breast height; Canopy-Canopy cover percentage; Spp Rich-Species richness; Soil. pH-Soil pH; Harv Culms-Harvestable culms <1year; >2yearCulm-above two years culms; Loggdpast-Harvested culms last year; Dead Culm-No. of Dead culms.

CCA bi-plot **A** shows the distribution of 20 sampling plots among three plant communities to various environmental/ecological factors. The strongest ecological variable was with axes 1and axes 3. Axes 1 (e= 0.638), 33 % variance explained with 33% Cumulative explained (r^2 = 0.923, P<0.001), primarily associated with soil pH, species richness and bamboo clump density; where the Axes 3 (e = 0.124),10 % variance explained and 51% Cumulative explained (r^2 = 0.863, P<0.001) were correlated mainly with aspect, canopy and maximum DBH. Pearson's correlations with ordination axes for the CCA plot indicate a significant correlation of the axis with the ecological variables (aspect, elevation, canopy, species richness, and soil pH). Pearson's correlations (Table 1) with CCA ordination axis specify that the axis 1(e = 0.609) was mostly correlated with the soil pH (r^2 = 0.857) and slope degree (r^2 = 0.585). The second axis (e = 0.221) was correlated mainly with Maxi. DBH (r^2 = 0.657) and species richness (r^2 = -0.590), while the third axis (e = 0.186) was associated primarily with bamboo clump density (r^2 = -0.615) (Figure 5A). CCA bi-plot **B** shows the distribution of 20 sampling sites/stations among three plant communities to ecological and social factors. Axis 1 and axis 3 showed high variability for certain ecological parameters. Ecological parameters, soil pH(r^2 = 0.734) and slop degree (r^2 = 0.475) indicate the high variability of axis 3. Clump density (Clum Dens) is almost parallel to axis 1, which means axis 1 can be described by the bamboo clump density. On the other hand, dead culms (Dead Culm) and harvestable culms (Harv Culms) show a high correlation with axis 3(r^2 = -0.426 and r^2 =-0.377, respectively), which explains the high changeability of this axis in future on the community with the collection of bamboo (Figure 5 B).

Axes 3, represented 55% of the variance in plant species composition. Higher scores on the first axis, which accounted for 33% of the variance (r^2 = 0.903),represented a positive greater cover of Picea spinulosa, Prunus rufa, Salix sikkimensis, Juniper recurva, and Salix obscura. This axis clearly distinguished the Spruce forest type. The second axis represented 15% of the variance and correlated (r^2 = 0.963) strongly with the cover of many species, including Larix griffithii and Rhododendron cinnabarinum (Figure 5A), which strongly displayed the larch community type. The third axis, which represented 10% of the variance, (r^2 = 0.687)related most strongly to Abies densa, Betula utilis, Viburnum nervosum, Gambleaciliata Rhododendron hodgsonii, Hydrangea heteromalla and further separated these types from the rest.

Table 2. Plot details with species

Plots	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P*
Plot size (m2)	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	
Altitude (m)	3319	3407	3361	3400	3369	3380	3362	3400	3364	3374	3379	3385	3373	3357	3369	3350	3235	3236	3276	3306	0.364
Aspects (o)	West	west	East	East	East	East	East	East	East	East	East	East	East	East	East	East	West	East	East	East	0.705
Clump Density	18	12	13	24	15	19	19	23	23	13	14	6	9	11	6	10	9	12	13	11	0.615
Number of Culms/ plot	810	351	250	760	657	638	769	1370	928	572	594	65	285	330	113	386	389	446	630	638	0.671
Harvestable culms <1yr	112	45	34	49	97	73	93	132	122	46	57	3	28	42	9	34	54	85	92	77	0.377
1-2 yrs culms	308	80	65	252	223	220	273	564	323	160	219	21	67	50	16	108	113	117	131	150	0.391
>2yrs culms	390	226	151	459	337	345	403	674	483	366	318	41	190	238	88	244	222	244	407	411	0.285
Culms harvested last year	259	95	94	166	146	31	26	33	40	23	21	3	6	6	0	18	32	22	37	21	0.560
Dead culms	280	89	2	6	39	183	201	349	192	133	138	43	81	70	26	118	113	148	177	153	0.337
Canopy %	50	10	30	30	40	30	30	10	10	20	20	30	10	60	40	10	30	20	30	50	0.519
SlopeDeg	38	40	60	60	70	65	50	60	50	50	60	60	50	35	40	35	70	60	50	30	0.585
SppRich	7	5	6	9	5	8	5	8	8	7	8	12	7	6	5	7	5	8	13	16	0.563
Total BA	4324.1	5425.5	3205.4	3673.4	7317.8	3395.1	12394	1713	1347.7	1732.6	990.81	861.19	3970.2	4995.9	5572.4	5025.8	2306.7	3425.1	5875.6	8659.8	0.409
Soil.pH	4.5	4.7	4.5	4.6	4.4	4.3	4.4	4.5	4.7	4.8	4.2	4.2	4.4	4.3	4.6	4.5	4.7	4.5	3.5	3.2	0.857
Picea spinulosa	60.30	76.45	84.24	77.63	96.73	85.65	93.90	58.96	78.32	79.15	64.29	33.65	54.90	75.27	62.37	79.25	83.55	68.93	63.01		0.590
Abies densa	25.65																			78.08	0.277
Prunus rufa	4.44															3.52					0.149
Salix sikkimensis	4.01		10.20	11.72	2.62	8.68	4.14	24.76		6.57	8.96	22.34									0.427
Salix daltoniana	3.11		3.14	6.97		3.35	1.79									13.28					0.843
Juniper recurva	2.20					0.95			4.72	4.53	11.49	1.46					5.75	2.29	5.71		0.447
Piptanthus nepalensis	0.29	0.23	0.61	0.19	0.17	0.37	0.06														0.158
Betula utilis		22.09																12.13			0.146
Rhododendron cinnabarinum		0.71	1.17	0.19				1.65	2.10	2.90	2.85	4.47			17.27	1.27	4.12	4.49	3.01	1.10	0.745
Viburnum nervosum		0.52	0.61	0.09	0.39	0.58								1.01					1.92	0.73	0.689
Berbaris aristata			0.03				0.05					0.03									1.000
Salix obscura				2.67				10.36	8.45		7.57	14.14									0.528
Rhododendron hodgsonii				0.53									1.60						3.42		0.877
Ribes lurdum					0.10	0.21	0.06														0.877
Ribes laciniatum						0.21		0.73	0.52			1.46							1.34	0.23	0.496
Enkianthus deflexus								1.65	2.86	2.22	2.85	5.84			0.90	1.56	4.90	6.17	4.50	1.31	0.911
Litsea sericea								1.15	2.10		1.27	3.28	0.97	0.77		0.56		1.86		0.58	0.246
Daphne bholua								0.73	0.93	1.13	0.71	2.28	0.49	0.39		0.56	1.67	0.83	0.65	0.23	0.968
Rosa sericea										3.49		11.05									1.000
Larix griffithii													42.04	21.29	18.32						1.000
Rhododendron arboreum														1.27	1.14				4.33	2.04	0.693
Sorbus rufopilosa																		3.30	4.54	1.10	0.886
Acer pectinatum																				0.91	1.000
Gamblea ciliata																			4.54	1.78	1.000
Hydrangea heteromalla																			1.92	0.44	1.000
Sorbus microphylla																			1.08	0.91	1.000
Rhododendron kesangiae																				4.15	1.000
Betula alnoides																				3.63	1.000
Rhododendron barbatum																				2.79	1.000

Additionally, our results show that the density of T. spathiflorus is “unhealthy” with sparse clumps since most of the culms were old (more than 2 years). There is also a considerably high intensity of younger culms (less than one year) of bamboo harvesting in all the sites (figure 4 and figure 5). Besides, there was a prevalence of bamboo culm damage caused by wild animals such as bears (personal observation). Furthermore, the study suggests in-depth studies on population structure and area extent in response to climate change.

IV. RECOMMENDATIONS

This is the first of its kind, and the study showed most of the sampled plots from the regular bamboo harvesting sites in Laya look "unhealthy" as it was observed and concluded that the growth of bamboo is already narrow, though abundant culms, the population density was highest with the older culms to the young culms (Figure 4).

The declining bamboo forest is a cause for concern, since bamboo contributes to cultural significance in the community besides, supporting biodiversity and the rural economy. The subsequent loss of the bamboo forest from these areas will not only lead to the loss of fauna and flora that depend on it but also the loss of the most distinctive cultural significance associated with this bamboo species, and ultimately the rural income for the local people that depend on it.

Taking a long-term outlook based on the ever-increasing demand for bamboo for subsistence and commercial exploitation while also considering other threats including climate change, the considerable pressure exerted on the bamboo by harvesting only young culms may deplete the bamboo forest. Similar studies in Bhutan showed that there was a profound decline in the population of Neomicrocal amusandropogonifolius (the bamboo species used for weaving Bangchung) in many local forests due to unregulated and lack of scientific knowledge (Dorjeeand Rai, 2018).

Important insight into the bamboo status and its connection with the unique culture of the region is a significant initial step towards the conservation management of this culturally important bamboo species. The study suggests possible measures to avoid unforeseen flowering risk in the future along with the recommendations: If the current harvesting trend continues, annual allowable cut or the harvesting quotas needs to be initiated as recommended by many experts. The quotas of up to 10% for the harvest of young culms and up to 50% for the old/matured culms in a clump (Ssali and Bitariho, 2013). This requires the full participation of all the stakeholders including bamboo harvesters. Bamboo off-takes are regulated and enforced to minimize harvesting pressure being exerted on the young culms, as unsustainable harvesting technique impacts the bamboo clump which needs careful management. Bamboo rotational harvesting (at least 2-3 years between harvests) from the current harvesting sites, and discourage harvesters from repeatedly congregating in the same site. The study discourages any commercial exploitation of bamboo, specifically from the upper mixed coniferous forest of the Laya region in the future owing to very narrow and mostly unhealthy clumps. Also, to a feasible extent, limit the timber extraction from the bamboo harvesting sites.

V. ACKNOWLEDGMENTS

We express our sincere thanks to the National Biodiversity Centre, Serbithang, Thimphu for funding and technical support. We also thank the Department of Forests and Park Services, UgyenWangchuck Institute for Conservation and Environmental Research, and Jigme Dorji National Park Office for providing the necessary research permit. We would also like to thank bamboo artisans, and the people of Laya gewog for the interview and other necessary support during the field work.

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