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Diversity of Bamboo Species in Lubuagan, Kalinga, North Luzon, Philippines

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Abstract*: Biodiversity data are necessary to support conservation efforts of diverse non-wood forest natural resources like bamboos. There is estimated 1,200 bamboo species worldwide and 62 species are identified in the Philippines. This study determined the biodiversity of bamboo species found in Lubuagan, Kalinga of Northern Philippines. The randomized complete block design with sub- block sampling was adopted in this study. The following diversity indices were determined; population density, index of similarity, species richness, diversity and evenness. Results showed that the study sites harbored ten (10) bamboo species belonging to four (4) genera. Of these species, six (6) are introduced and four (4) are indigenous of which one (1) is an unknown species (Byila-ay) belonging to the genus *Schizostachyum*. Results show that bamboo species diversity, richness, and evenness increase as altitude increases, while population density decreases as altitude increases. The east and south aspects harbor higher number of species that have low species evenness. This study indicates that natural forest ecosystems have higher diversity indices than man-made ecosystems such as farm and residential areas. Some endemic bamboo species were found to be restricted to certain altitudinal range and habitats while some were commonly distributed. The 53.33 to 66.67% index of similarity between the study sites reflects the presence of both endemic and introduced bamboo species. The forest and farm habitats with rich in bamboo plants should be conserved as green cover and carbon sinks to mitigate the threats of climate change.

***Keywords*: diversity indices, population density, natural forest ecosystem, endemism.**

I. INTRODUCTION

Bamboo is an amazing alternative that meets our ecological, cultural, economic and social needs. Besides, bamboo has the potential to preserve the forests, and contribute to the conservation of biodiversity (http://blog.agriculture.ph/bamboo-in-the-philippines.html).

It is estimated that there are about 1,200 species scattered in about 18 million hectares in different ecosystems in the continents of Asia, Africa and America (Ohrnberger, 1999). Rojo (1999) reported that there are 62 bamboo species growing in the Philippines, only 21 species are endemic or native Philippine bamboos. The rest are introduced species. The Philippines Recommends for Bamboo Production (2006) added that the following bamboos species are found in the Philippines. These common genera are *Arundinaria, Bambusa, Dendrocalamus, Gigantochloa, Guadua, Schizostachyum, Thyrsostachys, Phyllostachys, Cephalostachyum,* and *Dinochloa.*

Locsin(2000) added that bamboo grows almost everywhere in tropical countries like the Philippines, particularly in places close to water such as on riverbanks and by streams. Because it is so easily found and so easily replaced, it is treated with an almost casual disregard and valued only lightly. It is indeed a relatively cheap raw material.

In most parts of tropical countries, rural poor depend completely on bamboo; almost one billion rural people live in bamboo houses. This is so because bamboo can be easily be grown and harvested. It can be found in varied climates, from the cold mountainous regions to the hot tropical areas (http://www2.bioversityinternational.org/ publications/Web_ version/572/ch30.htm).

The varied topography and climatic conditions of the Cordillera region are suitable for bamboo growth. Bamboos can be found at the low lying warm areas up to the coldest highest peak of Mount Pulag (Merill and Merrit, 1910).

Likewise, Tangan (1991) reported that bamboo species suited to the Cordillera varied altitudes and temperature were *Dendrocalamus asper*, (giant bamboo) *Bambusa oldhamii* (Oldham bamboo), *Dendrcalamus sp* (bayog), *Schizostachyum lumampao* (buho), *Schizostachyum lima* (anos), *Bambusa blumeana* (kawayan-tinik), *Bambusa vulgaris* (kawayan-kiling) and *Phyllostachys aurea* (Hotei-chiku).

Biodiversity information is needed to support conservation policies and management objectives of biological resources especially in natural tropical forest areas. This is considered in three levels; ecosystem, species and genetic diversity. Species diversity is essential in planning for conservation and sustainable management of individual species as well as an indicator of ecosystem status. Identification and description of species provide understanding on its role in the ecosystem and its benefits to mankind. Further, identification of species rich areas is helpful in determining priority areas for preservation and loss of species richness in an area indicates a need for conservation measures (Banwa, 2007). Besides, ecosystem based study for biodiversity conservation is one of the priority research areas of National Higher Education Research Agenda -2 of the Commission on Higher Education for the year 2009-2018. To address such needs, this study was conducted. It determined the biodiversity of bamboo in Lubuagan, province of Kalinga where different bamboos species are found.

II. METHODOLOGY

The study was conducted in Lubuagan, Kalinga of Northern Philippiens from November 2011 to May 2012. The site is composed of nine barangays with a total land area of 234.20 km^2 (90.4 sq mi). These clustered barangays include Dangoy, Mabilong, Mabongtot, Poblacion, Tanglag, Lower Uma, Upper Uma, Antonio Canao and Uma del Norte. Based on actual GPS (76CSX Garmin) receiver readings, these sites were located within the altitudinal range of 370 to 1246 meters above sea level (masl) with coordinates 17^0 22 02.0 N, 121^0 12 32.4 E /17^0 21 03.6 N,121^0 09 40.5 E.

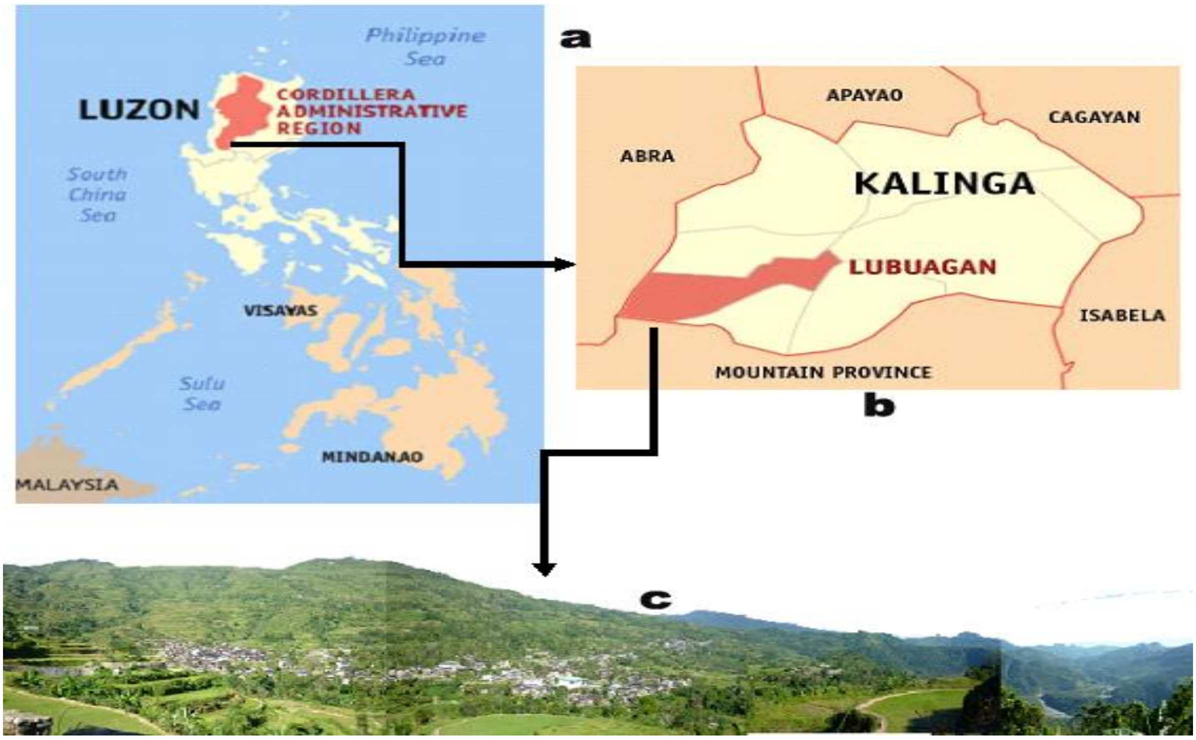

Figure 1. Locale of the study. Map of the Philippines showing the Cordillera Administrative Region (a), map of Kalinga Province showing the municipality of Lubuagan (b), a photographic view of the Lubuagan town proper (c)

The randomized complete block design (RCBD) with sub-block sampling was adopted in this study. The study site was divided first into 3 blocks based on the clustering of barangays located in different sites and altitudes. Site 1 (370-509 masl) was assigned as block I, Site 2 (760-1,100 masl) as block II and Site 3 (902-1,246 masl) as block III. Each block/site was further subdivided into sub-blocks based on the type of habitats; forest, farm and residential areas. Sampling plots were established in each sub-block based on aspects; east, west, north, and south (see Figure 3). Asari, N and M. N.Suratman (2011) found that in Malaysia, the elevation, slope gradient, and slope aspect have impact on the vegetation growth of bamboo.

The 3 habitats (forest, farm and residential areas) were identified in the 3 blocks/sites. The 4 aspects (east west, north, and south) in each habitat were located using a compass. Bamboo stands or patches in each aspect were delineated and measured as sampling plot. At total of 12 sampling plots were established in each block. Biodiversity data and altitude were gathered in each sampling plot.

Through the help of" imong" owners, local guides from the community who are familiar with the area, the bamboos were identified, counted in each sampling plot. Bamboo species were identified based on standard books, monographs and available catalogues with the help of experts in the fields.

The altitude of each sampling site was determined using a Global Positioning System receiver (76CSX Garmin).

Determination of population:

Population was determined by counting the total number of individual bamboo species present in each sampling plot. Population density was computed using the formula;

PD = n/m2
Where: n represents the total number of individual species; m2 will be the land area of each sampling plot.

The species richness was determined by counting the number of bamboo species in each sampling plot. The species diversity (H) was computed using the species diversity index equation proposed by Shannon and Wiener;

$$H = - \sum(p_i \log pi)$$

Where; H is the diversity (or heterogeneity) value
p_i is the percentage importance for each species.

The Species evenness (J) was computed using the Simpson's Index:

$$J = H/\log S$$

Where; J= species evenness, H= Heterogeneity
S=Number of species

The Index of similarity (SI) was computed using the Sorensen`s Index:

$$SI = \frac{2K}{A+B} \times 100$$

Where; K= Number of species common to sites A and B
A=number of species for site A and;
B=number of species for site B

Descriptive statistics such as the mean and percentage were used to describe the population of bamboo species. Analysis of variance (ANOVA) was used to determine significant difference of bamboo population in the study sites, aspects and habitats. The Least Significant Difference (LSD) was used to compare significant means. The computer software SPSS version 12 was used to analyze gathered data for interpretation. The Microsoft Excel program was used for the mathematical and logarithmic aspects of the data.

III. RESULTS AND DISCUSSION

Species Composition:

Table 1 presents the species composition of bamboos in the three study sites. It shows that of the 10 species identified, *Schizostachyum lumampao* has the highest population percentage of 36.50 percent, followed by *Bambusa vulgaris* 27.32

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percent, *Schizostachyum lima* 18.86 percent, *Dendrocalamus asper* with 11.32 percent, *Bambusa multiplex* (Lour) Chinese Dwarf Bamboo 2.46 percent, Schizostachyum spp 1.54 percent, *Dinochloa luconiae* Munro 1.21 percent, *Bambusa* vulgaris var. striata 0.39 percent, *Bambusa blumeana* 0.31 percent, and *Dendrocalamus merrilianus* has the lowest population of 0.09 percent. It further shows that Site 1 has the highest population of 50 percent, followed by Site 2 with 28.00 percent while Site 3 has the lowest population of 22.00 percent.

This study confirms similar study that *Schizostachyum lumampao* has the highest distribution of 64 percent among bamboo species (http://pcarrd.dost.gov.ph/cin/bamboonet).

TABLE I: Bamboo Species Population Composition in the Study Sites

Bamboo species Scientific Names	Common name	Sites Site 1	Site 2	Site 3	Total	Population Percentage
Schizostachyum lumampao	Bulo(Byuyu)*	3264	127	309	3700	36.50
Bambusa vulgaris	Native Kawayan**	1307	1003	459	2769	27.32
Schizostachyum lima	Anos(Alos)*	178	838	896	1912	18.86
Dendrocalamus asper	Giant bamboo**	297	666	185	1148	11.32
Bambusa multiplex Lour.	Chinese dwarf bamboo**	0	101	148	249	2.46
Schizostachyum spp.	Byila-ay*	0	0	156	156	1.54
Dinochloa luconiae Munro	Bikal(Byike)*	0	61	62	123	1.21
Bambusa vulgaris var. striata	Golden bamboo**	0	40	0	40	0.39
Bambusa blumeana	Kawayang Tinik(Puyutan)**	31	0	0	31	0.31
Dendrocalamus merrilianus	Bayog**	0	9	0	9	0.09
Total population		5077	2845	215	10137	
Total percentage		50.0	28.0	22.0		100.00

*Indigenous species **Introduced species

Population Density of Bamboo Species:

Table 2 shows the density of bamboo species. It indicates that the smallest dwarf bamboo *Bambusa multiplex* (Lour) has the highest population density of 2.20 culm per square meter, followed by *Schizostachyum spp* with 2.00, *Schizostachyum lumampao* 1.3 *Schizostachyum lima* 0.98, *Bambusa vulgaris* with 0.6, *Dendrocalamus asper* with 0.46, *Bambusa* vulgaris var. striata 0.38, *Dinochloa luconiae* Munro 0.27, *Bambusa blumeana* 0.20 and *Dendrocalamus merrilianus* has the least population density of 0.12

It is expected that dwarf bamboo species have more dense population than bigger bamboo plants. Nevertheless, this results show similarities to the findings of N. Asari and M.N. Suratma (2011) who found in their study in Malaysia that related species, *Schizostachyum brachycladum*, *S. grande*, S. *latifolium* were the most dominant and have the highest relative density.

TABLE 2. Population Density of Bamboo Species in the Study Sites

Bamboo species	Population (culm)	Area (m^2)	Population Density
Bambusa multiplex (Lour)	249	112.00	2.22
Schizostachyum spp.	156	78.00	2.00
Schizostachyum lumampao	3700	2944.00	1.30
Schizostachyum lima	1912	195.00	0.98
Bambusa vulgaris	2769	4625.00	0.60
Dendrocalamus asper	1148	246.80	0.46
Bambusa vulgaris var. striata	40	104.00	0.38
Dinochloa luconiae Munro	123	45.00	0.27
Dendrocalamus merrilianus	9	45.00	0.20
Bambusa blumeana	31	268.00	0.12
Total	10137	8662.80	

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Diversity Indices of Bamboo Species in the Study Sites:

Table 3 shows the species richness, heterogeneity and evenness of study sites. The low elevation has the least number of 5 species followed by the medium elevation with 7 species and the high elevation with highest number of 8 species.

In terms of species diversity (H), the low elevation still shows the lowest index of 0.41172, followed by the medium elevation with 0.64508 and the high elevation has the highest index of 0.71318.

Likewise, the low elevation shows the lowest computed species evenness of 0.58904, followed by the middle elevation with 0.7143 and the high elevation has the highest index of 0.8439.

This result shows that the medium and high elevation harbor diverse bamboo species than the low elevation. This high number of species, species heterogeneity and evenness could be attributed to the presence of indigenous species such as *Dinochloa luconiae,* Munro, Schizostachyum sp *and Schizostachyum lumampao* in the mediumeevation and in the high elevation. Geographically, the low elevation is located along the Chico River bounded by a mountain in the eastern side, while the medium elevation and the high elevation are located in the western aspect. In this case, the medium and high elevation tends to have more sunlight exposure than the low elevation. This may contribute to the lower number of bamboo species in the low elevation, since bamboo plants prefer open and sun exposed areas.

This study determine thee species richness, diversity and evenness of different habitats. It shows that the farming areas have the lowest number of 5 species, species diversity of 0.49249 but have the highest species evenness. Both the forest and the residential areas have the same number of 8 species each. However, the forested habitats have the highest species diversity of 0.61944 followed by the residential areas with 0.59987. Moreover, the forest habitats have a higher species evenness of 0.68591compared to the residential sites with 0.66424.

The diversity of the different aspects is shown in Table 3. The west and north aspects have 6 species while the East and South have a higher number of 10 species. This implies that the sun exposed east and south harbor higher number of bamboo species than the west and north aspects. Southern part shows the least index of 0.6685025 followed by the west with 0.6717055, and East and North with the highest index of 0.6856073.

Likewise the south shows the lowest species evenness of 0.668502, followed by the east with 0.685607, west with 0.863207, and north with the highest species evenness of 0.881072.

This result shows that the east and the south aspects are more diverse in species as indicated by highest number of species present and their low species evenness. This can be attributed to the longer sun exposure of the east and south aspects during daytime

TABLE: 3. Species richness, heterogeneity and evenness of bamboos species in the study Sites

Parameters	Diversity indices		
	Species Richness	Heterogeneity (H)	Evenness (J)
Elevation			
Low (370-509 masl)	5	0.41172	0.58904
Medium (760-1,100 masl)	8	0.64508	0.7143
High (902-1,246 masl)	7	0.71318	0.8439
Habitats			
Farms	5	0.49249	0.70459
Forests	8	0.61944	0.68591
Residential areas	8	0.59987	0.66424
Aspects			
East	10	0.6856073	0.685607
West	6	0.6717055	0.863207
North	6	0.6856073	0.881072
South	10	0.6685024	0.668502

One objective of this study is to determine the bamboo population in the sites as shown in Table 4. The low elevation has significantly higher mean population of 80. 5873 compared to means of 48.2203 and 47.1277 of the medium and higher elevations respectively.

This result shows that there are more bamboo populations at the low elevation compared to the medium and high elevation. Altitudinal gradients probably explain this significant difference. GPS reading revealed that the low elevation

(370-509 masl) is 251m lower than the medium elevation (760-1,100 masl). It must be noted that the medium and High Eevation overlapped about 198 masl, though the high elevation (902-1,246 masl) extended about 143 meters higher than yhe medium elevation. Altitude and temperature are two related factors which affect the growth and distribution of bamboos. It was found in the ecological modelling of arrow bamboo study of Gao (2012) that temperature decreased at a rate of about 1 °C per 200 m altitude. This means that the low elevation has warmer temperature that favors the vegetative growth of bamboos thus increasing its population.

Table 4 presents the difference in bamboo species population mean in the different habitats. Multiple comparison of the means (LSD) shows that the farming areas has mean population of 45.7577 that is not significantly different to the residential areas but significantly lower when compared to the forested area with a highest mean of 82.7692.

This finding implies that forested areas are thickly populated than the farming and the residential areas.

Table: 4. Mean Population of Bamboo Species at the Study Sites

Parameters	Mean Population	F ratio
Elevation		
Low (370-509 masl)	80.5873A	4.154*
Medium(760-1,100 masl)	48.2203B	
High (902-1,246 masl)	47.1277B	
Habitats		
Farms	45.7377A	5.416**
Residential areas	45.7442A	
Forested areas	82.7692B	
Aspects		
East	59.5660	0.786^{ns}
West	75.0263	
North	54.1750	
South	51.6316	

Note: Means followed by the same letters are not significantly different (LSD)

**=significantly different at .01

*= significantly different at 0.05

ns=not significant

In terms of aspects, Table 4 reflects no significant difference of population means. This shows that bamboo population does not significantly differ regardless of aspects. This implies that the different aspects of the observed area do not influence directly the diversification of bamboo species. This reveals the similar environmental conditions of the place.

Comparing the different elevations, the high and low elevations have the highest similarity index of 66.67 percent followed by medium and low elevations with 61.53 percent. The high and medium elevations have the lowest index of 53.33 (see Table 5)

This results show that the low elevation and high elevation have common species. Four of the 5 species found in the low elevation were found also in the high elevation namely; *Schizostachyum lumampao* , *Bambusa vulgaris*, *Schizostachyum lima* and *Dendrocalamus asper*. There are 3 bamboo species found in high elevation which is not present in low elevation. These are 2 indigenous species Byila-ay and Bikal and 1 introduced species Chinese Dwarf Bamboo. It is interesting to note that of the 4 native bamboo species Byila-ay and Bikal are present in the medium and higher altitudes. It appears that these species are restricted by altitude. Banwa (2011) observed that some plant species were only present in the highest fringes of the Central Cordillera mossy forests.

The lower index of 53.33 percent between the medium and high elevation can be attributed to the presence of bamboo species in high elevation which is the most urbanized site in the area where local government offices are presently located. Besides, the site was once the capital town of the Old Mountain Province until it was subdivided into different provinces composing the present Cordillera Administrative Region.

Table: 5. Similarity Index of Bamboo species of the Different Study Sites

Sampling Sites	**Site 1**	**Site 2**
Site 2	61.53	
Site 3	66.67	53.33

IV. CONCLUSION

This study shows that Lubuagan harbors ten (10) bamboo species belonging to four (4) genera of bamboo plants with six (6) introduced species, and four (4) indigenous species, one (1) of which is unknown species that belongs to genus *Schizostachyum*. Results show that bamboo species diversity, richness, and evenness increase as altitude increases. Meanwhile bamboo population density decreases as altitude increases. Findings of this study reveal that type of habitats affects the biodiversity of bamboo. It shows that natural forest ecosystems are rich in indigenous endemic species and has higher species diversity and population than man-made ecosystems such as farm and residential areas. The east and the south aspects that are exposed longer to sunlight harbor all the ten (10) bamboo species with correspondingly low species evenness. The three (3) study sites have index of similarities that range from 53.33 to 66.67% that indicate the presence of unique indigenous and introduced bamboo species in each site. Results indicate that some bamboo species are restricted to certain habitats and altitudinal range reflecting the unique distribution of common and endemic plant such as bamboo species. Likewise, this study shows that two (2) indigenous (*Schizostachyum lumampao* and *S. lima*) and introduced species (*Dendrocalamus asper* and *Bambusa vulgaris*) can adapt to various habitats and altitudinal range.

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