Above-Ground Biomass and the Growth of Bamboo Stands in the Philippines

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Introduction

In the philippines, 30 species of 17 erect and 13 climbing bamboos were found.[1] They grow in marginal lands, hillsides, along the banks of rivers and streams and in village homesteads. Gamble (1910)[3] gave a rough estimate of around 200,000 ha of bamboo forests, while the Bureau of Forest Development reported that the area planted to bamboo was 7,924 ha as of 1978.[2]

Many useful characteristics of the bamboo such as easiness of working on it, versatility, strength, and availability make the bamboo suitable to be used for various purposes for domestic and commercial consumption. As a matter of fact, the bamboo is utilized for extremely diversified purposes. Moreover, the bamboo stand is known to have important ecological significance. Bamboo groves play an important role in preventing soil from erosion in mountain sides, and serve as a defense against flood along river banks, due to the denseness of standing bamboo culms and roots under the ground. In addition, some bamboo species are excellent for landscaping and ornamental purposes with their beautiful appearance and pliant culms. Unfortunately, these characteristics of bamboos have not been well understood by people and not thoroughly studied yet.

Some research works on general aspects of production and management of bamboo forests have so far been conducted resulting in substantial accumulation of information. However, it seems that the available knowledge is still not enough for designing proper management of bamboo forests in the Philippines. It is needless to say that ecological studies on biomass, productive structure, and productivity of bamboo stands are very important not only for selecting a suitable species for a given site, but also for making a better prediction of the future yield. In the present study, composition, biomass and production structure of the stands of *Gigantochloa levis* and *Schizostachyum lumanpao* were investigated, and these ecological characteristics were discussed in comparing with some stands of tree species.

Materials and methods

The plantation of *G. levis* used in the present study belongs to the Davao Fruits Corporation located at Davao Del Norte, Mindanao Island. It was established at the end of 1970's so that the bamboo culms have reached the stage to be used for supporting poles in banana plantations. Meteorological reports of the corporation show no severe dry season but pronounced maximum rainfall in December and January in this area as shown in Table 1. The plantation of *S. lumanpao* is in the Makiling Botanical Garden, University of the Philippines at Los Baños, and is located at the foot of Mt. Makiling at around 100 m above sea level. It was originally established by the Forest Research Insti-

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tute at Los Baños for the experimental purpose in 1976. This area has 2 pronounced seasons, that is, dry season from December to April, and rainy season during the rest of the year, as shown in Table 2.

Table 1. Climatic condition data in 1980 (Davao Fruits Corp.)

Month	Temperature (°C) Min.	Temperature (°C) Max.	Rainfall (mm)	Rain day (No. days)
January	23.4	29.7	384.8	25
February	20.5	30.8	148.6	11
March	20.6	33.6	37.3	5
April	21.3	33.3	79.8	15
May	31.7	34.1	140.4	8
June	21.6	32.7	310.7	21
July	23.1	31.8	185.2	17
August	20.9	31.9	179.6	18
September	20.5	32.4	127.8	14
October	20.5	32.9	218.7	16
November	20.5	32.9	130.5	16
December	20.0	31.9	407.3	19

Table 2. Climatic condition data (UPLB-CF)

Month	1981 Mean temp. (°C)	1981 Rainfall (mm)	1982 Mean temp. (°C)	1982 Rainfall (mm)
January	23.6	27.4	24.9	17.3
February	25.5	9.2	25.4	7.9
March	27.0	1.6	26.4	17.2
April	25.2	5.0	28.1	23.8
May	25.3	87.5	28.6	151.1
June	23.9	136.5	28.1	146.3
July	24.0	173.7	27.6	128.7
August	24.4	173.5	27.4	161.4
September	23.4	114.5	27.5	175.9
October	—	—	27.1	171.9
November	22.5	184.5	26.4	170.3
December	20.8	74.3	25.4	43.7

After some preliminary surveys and cleaning and salvage cutting of the stands, the field investigation was carried out in October, 1982, for *G. levis* stand, and May, 1983, for *S. lumanpao* stand. Sample plots of 300 m² (20 m × 15 m) for *G. levis* and 108 m² (12 m × 9 m) for *S. lumanpao* were set up. The diameter at 1.3 m high above the ground (DBH) of all standing bamboos in the plots was calipered. Then 9 or 10 bamboo culms of various classes in DBH were felled. After the height of each bamboo was measured, the bamboo was divided into strata of 1 or 2 m depth except the base and top portions. Fresh weight of culms, branches and leaves was measured separately for each stratum. For conversion of fresh weight to dry weight, small samples of each part were dried at 105°C to constant weight. Bamboo leaf specimens (40-50 pieces) were collected from October to December in 1982, in Los Baños. Length, width and weight of them were measured, and leaf area was estimated by an area meter.

Results and discussion

The arrangement of bamboo clumps in the plots and the number of standing bamboos in each clump

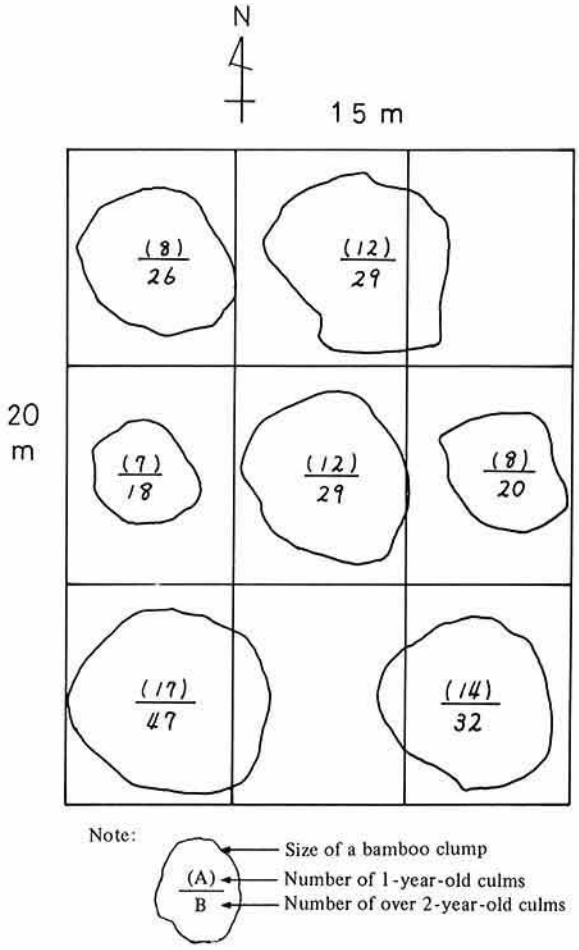

Fig. 1. Distribution of clumps and the number of standing culms in the plot of *Gigantochloa levis*

Table 3. Composition of standing culms in the stands investigated

(per ha)

	Number of culms		Average DBH (cm)	Average height (m)	Number of clumps	Average number of culms per clump
	Number	%				
(Gigantochloa levis)						
1-year-old	2597	27.9	6.2	15.3		11.1
Over 2-year-old	6693	72.1	6.7	17.3		28.7
Total	9290	100.0	6.5	16.7	233	39.8
(Schizostachyum lumanpao)						
1-year-old	10915	28.7	3.7	9.5		4.7
Over 2-year-old	27102	71.3	3.4	8.3		11.7
Total	38017	100.0	3.5	8.6	2312	16.4

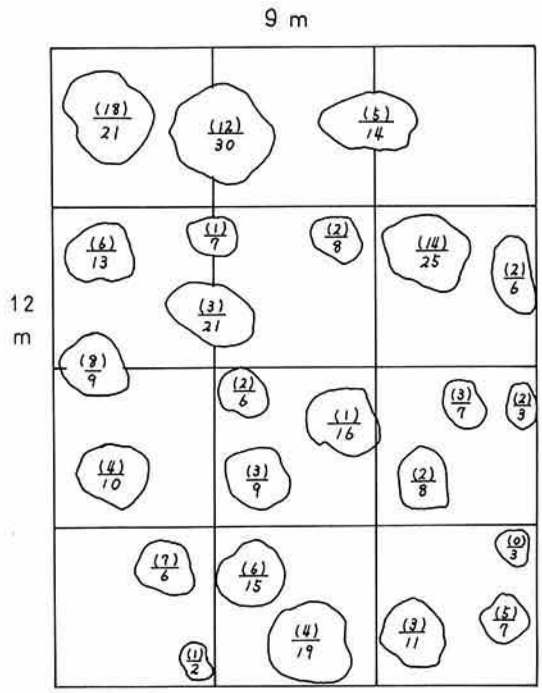

Fig. 2. Distribution of clumps and the number of standing culms in the plot of *Schizostachyum lumanpao*

are shown in Figs. 1 and 2. The compositions and sizes of standing bamboos in the stands are shown in Table 3.

There were 233 clumps per ha, with the average of 39.8 culms per clump, or the total of 9,290 culms per ha in the *G. levis*. stand. One-year-old culms which can usually be identified by culm sheath at the basal portion accounted for 27.9% of the total number of culms. The average DBH of this stand seems to be slightly small as *Gigantochloa* species, and that of 1-year-old culms was smaller than that of over 2-year-old culms. It is indicated that the productivity of this stand may decrease, probably due to over cutting of several years.

On the other hand, the stand of *S. lumanpao*, showed 2,312 clumps per ha, with the average of 16.4 culms per clump, or the total of 38,017 culms per ha. The number of one-year-old culms was 28.7% of the total, and the average DBH was larger than that of over 2-year-old culms. The density of this stand, seems to be too high and in need of thinning management.

The ratios of 1-year-old bamboos to the total observed in both stands were more or less larger than the values such as 24.5% estimated in *Bam-*

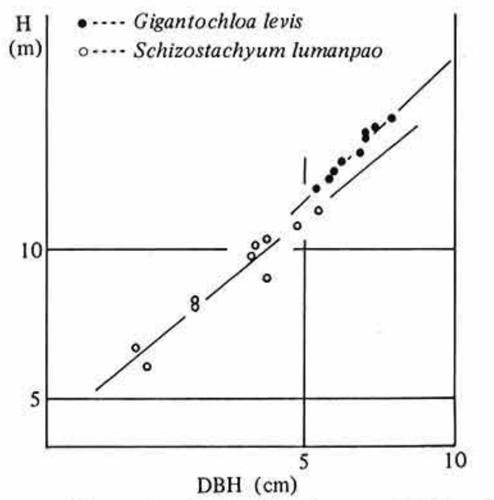

Fig. 3. Allometric relationships between DBH and height of *Gigantochloa levis* and *Schizostachyum lumanpao*

busa blumeana stand[12] and ca. 13% in *Thyrsostachys siamensis* stand.[15]

The allometric relationships between DBH and height, and those of culm (stem) weight, branch weight and foliage weight to D^2H (D cm, H m) are shown by logarithmic graphs in Figs. 3, 4 and 5. The regression formulae for them obtained by the least square method are as follows:

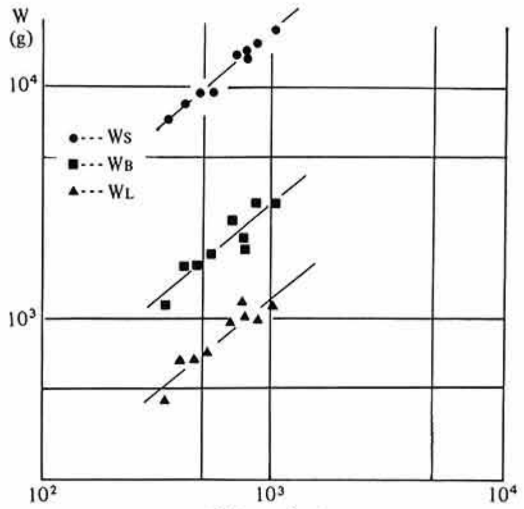

Fig. 4. Allometric relationship between D^2H and dry weight of stem (W_S), branch (W_B) and leaf (W_L) of *Gigantochloa levis*

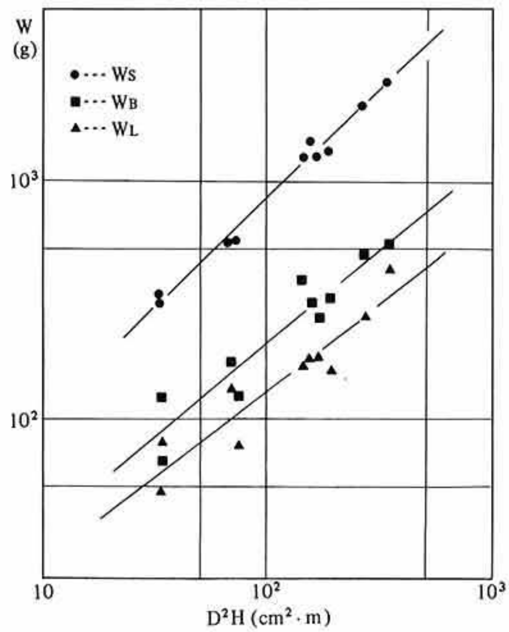

Fig. 5. Allometric relationship between D^2H and dry weight of stem (W_S), branch (W_B) and leaf (W_L) of *Schizostachyum lumanpao*

(*Gigantochloa levis*)

$\log H=0.9565 \log D+0.4345$ .... (1)

$\log W_S=0.8303 \log D^2H+1.7468$ .... (2)

$\log W_B=0.8517 \log D^2H+0.9461$ .... (3)

$\log W_L=0.7733 \log D^2H+0.7679$ .... (4)

(*Schizostachyum lumanpao*)

$\log H=0.8720 \log D + 0.4833$ .... (5)

$\log W_S=0.9734 \log D^2H+0.9796$ .... (6)

$\log W_B=0.8266 \log D^2H+0.6648$ .... (7)

$\log W_L=0.7590 \log D^2H+0.5831$ .... (8)

Table 4 shows the above ground biomass of *Gigantochloa levis* and *Schizostachyum lumanpao* stands estimated by the regression formulae, (1) to (8), together with some values obtained in Japan.[8,9,16]

The above ground biomass (total dry weight) of *G. levis* stand was estimated at about 146.8 ton/ha composed of 8.8 ton/ha of foliage, 22.2 ton/ha of branch and 115.8 ton/ha of culm. That of *S. lumanpao* was about 58.2 ton/ha composed of 5.8 ton/ha of foliage, 9.8 ton/ha of branch and 42.6 ton/ha of culm. The above ground biomass of 5 bamboo species shown in Table 4 ranges from 48.2 to 146.8 ton/ha. On the other hand, in cases of tree stands, 254.4 ton/ha[10] was shown by *Chamaecyparis obtusa* forest in Japan, or 260.5 ton/ha by *Swietenia macrophylla* stand, 261.8 ton/ha by dipterocarp forest, 75.6 ton/ha by *Albizia falcata* stand, and 127.0 ton/ha by *Gmelina arborea* stand in the Philippines.[6] Besides, on grass land, 4–8 ton/ha in *Miscanthus sinensis* community,[5] and 4–19.5 ton/ha in *Solidago altissima* population[4] are known. Thus, the above ground biomass of bamboo stands is considered to be smaller than that of ordinary tree stands, but is roughly similar to that of some fast growing tree species such as *A. falcata* and *G. arborea* in the Philippines.

The total above ground biomass divided by the average height gives the apparent density of dry organic matter per unit space occupied by the forest.[7] As shown in Table 4, the dry organic matter density of bamboo stands of 5 species was in the range of 0.52–0.88 kg/m³. On the other hand, fully

Table 4. Above ground biomasses of bamboo stands

	G. levis	*S. lumanpao*	*P. edulis*[8]	*P. puberula*[9]	*P. bambusoides*[16]
Number ×1000 (pcs/ha)	9.3	38.0	8.8	15.2	8.9
Average diameter (cm)	6.5	3.5	0.2	4.4	7.2
Average height (m)	16.7	8.6	13.3	9.2	14.1
Dry weight of culms (ton/ha)	115.8	42.6	87.6	36.6	61.2
Dry weight of branches (ton/ha)	22.2	9.8	12.5	7.2	13.7
Dry weight of leaves (ton/ha)	8.8	5.8	5.5	4.4	6.0
Total dry weight (ton/ha)	146.8	58.2	105.6	48.2	80.9
Dry matter density (kg/m^3)	0.88	0.67	0.80	0.52	0.57
Average length of leaves (cm)	30.6	21.9	9.1	9.2	
Average width of leaves (cm)	6.1	3.3	1.2	1.1	
Average area of leaves (cm^2)	142.9	53.4	7.6	7.6	
Average dry weight of leaves (g)	0.65	0.31	0.036	0.041	
Area/weight (cm/g)	219.8	172.3	211.1	185.4	
Leaf area index (ha/ha)	19.4	10.0	11.6	8.1	

closed tree stands in Japan tend to be 1.0-1.5 kg/m^3,[7] although that in *S. macrophylla* stand and dipterocarp forest was 1.3 and 1.5 kg/m^3 [6] which was about the same as those of Japanese forests. The dry organic matter density of the fast growing tree species, *A. falcata* and *G. arborea*, was estimated at 0.6 and 0.8 kg/m^3 [6] which is similar to that of bamboo stands mentioned above. Kawahara[6] (1981) noted that the relatively small dry matter density given to the fast growing tree stands was due to their low specific gravity of stems. The small dry matter density shown by the bamboo stands may probably be caused by big hollow portions of culms.

The leaf biomass of bamboo stands was in the range of 4.4-8.8 ton/ha. These values were somewhat greater than 1.6-1.7 ton/ha of *A. falcata* stands and 1.4 ton/ha of *G. arborea* stand in the Philippines,[6] and also greater than 3.1±1.5 ton/ha of Japanese deciduous broadleaved forests.[11] However, it was a little smaller than 9.3 ton/ha of *S. macrophylla* stand[6] and 8.6 ± 2.5 ton/ha of Japanese evergreen broadleaved forests.[11]

The average size and weight of leaves of 2 tropical bamboo species investigated in this study were much bigger than those of 2 *Phyllostachys* species growing in the temperate zone. The thickness of leaves as proved by the leaf area per unit dry weight was, however, not appreciably different among them. The leaf area index was in the range of 8.1-11.6 ha/ha for the stands of 3 bamboo species, except *G. levis*. These values nearly correspond to 10.4 ha/ha of *S. macrophylla* stand, 8.9 ha/ha of dipterocarp forest, and much greater than 2.2 ha/ha of *A. falcata* stand and 1.6 ha/ha of *G. arborea* stand in the Philippines.[6]

The leaves of bamboo stand usually fall yearly or

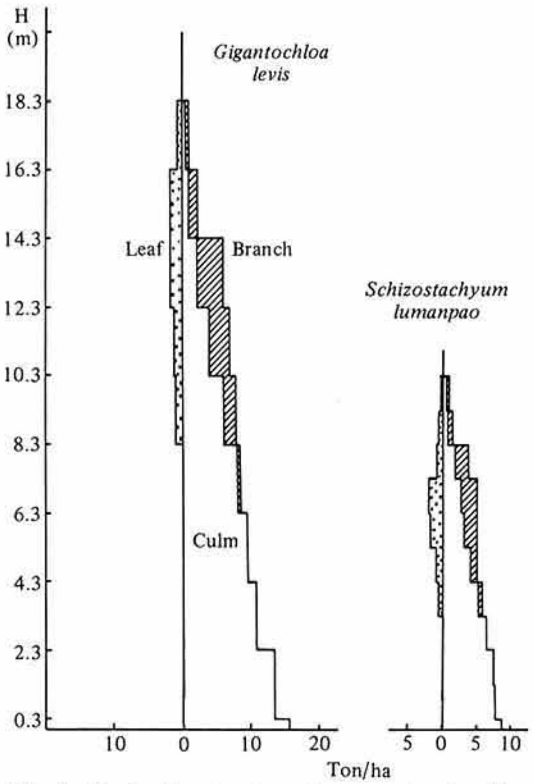

Fig. 6. Production structure diagrams showing dry weight of culm (stem), branch and leaf

every other year, but they are immediately renewed. Bamboos of *Phyllostachys* species change their foliage in around May or June when most bamboo sprouts have appeared on the ground, while the tropical bamboo species change their leaves in dry season. Ueda et al. (1961)[14] analized the seasonal changes of chemical properties of *Phyllostachys reticulata* foliage in detail and reported that the contents of water and some chemical nutrients varied periodically, especially in the renewing season of leaves. Therefore, the size and thickness of leaves may vary with seasons.

Production structure as expressed by vertical distribution of dry weight of both assimilative and non-assimilative parts observed by using the stratified method is shown in Fig. 6. The crown was formed widely and the vertex of vertical distribution of foliage was at the part ranging about two thirds of culm length or so. It seems that this type might be a kind of broadleaved tree forest.

Abstract

Compositions of standing bamboos and above ground biomass of *Gigantochloa levis* and *Schizostachyum lumanpao* stands were investigated in the Philippines. There were 233 clumps per ha, with the average of 39.8 culms per clump, in the *G. levis* stand, and 2,312 clumps per ha, with the average of 16.4 culms per clump, in the *S. lumanpao* stand. The number of one-year-old culms in the total was 27.9% in the *G. levis* stand and 28.7% in the *S. lumanpao* stand. These ratios were somewhat larger than those in some stands of other tropical bamboo species. The above ground biomass of *G. levis* stand was 146.8 ton/ha and that of *S. lumanpao* was 58.2 ton/ha. The apparent dry matter density, the quotient of the above ground biomass of bamboo layer divided by its average height, was 0.88 kg/m^3 for *G. levis* stand and 0.67 kg/m^3 for *S. lumanpao* stand. These values were in rough agreement with those of some fast growing tree species in the Philippines. The leaf amount was, however, 8.8 ton/ha in the *G. levis* stand and 5.8 ton/ha in the *S. lumanpao* stand, which were much greater than those of fast growing tree species.

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