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Status of bamboo species (Poaceae) (Kunth) in Menoua, Agroecological Zone 3 of Cameroon

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Studies on bamboo resources are limited in Congo Basin. This study assessed species diversity, distribution, characterisation and socio-economic importance of bamboo to livelihood in Menoua, Cameroon. Ninety questionnaires, one focus group discussion per village, observation and interviews were administered in 9 villages. *Yushania alpina* (K. Schum.) W.C.Lin, *Phyllostachys aurea* Carrière ex Rivière & C. Rivière, *Bambusa vulgaris* Schrad. ex. J.C.Wendl., *Bambusa vulgaris* var. *vittata*, *Bambusa* species Longinternode, *Oxytenanthera abyssinica* (A. Rich.) Munro, *Dendrocalamus asper* (Schult. & Schult.f) Backer ex K.Heyne and *Dendrocalamus strictus* (Roxb.) Nees were identified. *P. aurea* dominated cultivated lands and settlement areas covered the greatest land surface of 2137 m² with an altitudinal range (1200-1400 m). Internodes vary (21.8-40 cm) per culm and length (9.8-34.5 cm). The number, length of internodes, height, diameter and number of culms varied significantly across Menoua (P<0.005). The culm (56%) was the greatest used parts. Bamboos had several uses such as aesthetics, soil erosion and landslide control, and landscape restoration. Municipalities are proper to lead bamboo resource management and conservation.

Key words: Bamboo species, biodiversity conservation, Cameroon, Menoua, Poaceae, status.

INTRODUCTION

The global management of natural resources with respect to the increasing demography relying on these resources is a call for concern (Tovissodé et al., 2015; Honfo et al., 2015; Gadinga et al., 2020), especially when millions of local population livelihoods solely depend on these resources for food, medicine, energy and other socio-economic and cultural aspects (Gadinga et al., 2019; Gadinga et al., 2020). Bamboos constitute one of the few selected categories of plants which are taxonomically related, very rich in species (1642) (Vorontsova et al., 2016) and of vital economic and ecological importance (Yigardu et al., 2016; Canavan et al., 2017; Yuen et al.,

2017; Huy and Trinh, 2019; Nfornkah et al., 2020). A total of 115 bamboo species is reported in Africa (Tinsae and Yulong, 2021). Bamboo is a non-timber forest product (NTFPs) with a rapid growing rate, and with tremendous importance to humans (Nath et al., 2015; Yuen et al., 2017; Terefe et al., 2019; Nfornkah et al., 2020). Bamboos are renewable and harvested (Wu et al., 2009), as some species grow a meter per day and attain maturity during five years (Jayaraman and Trinh, 2019).

Bamboos are cultivated in many rural areas to support subsistence agriculture through the supply of forage and manure, fencing and tools (e.g. ladders, etc.), and other

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art works like sculpting of musical instruments (Cottingham, 2011; Honfo et al., 2015; Tovissodé et al., 2015; Nath et al., 2015; Akoto et al., 2018), building fish-traps and shelter in the traditional fishing locals (Ingram et al., 2010; Tovissodé et al., 2015; Neba et al., 2020). Bamboo conserves soil moisture, as it has the ability to recharge underground water and maintain surface water, prevent soil erosion because of its well-developed rhizome or root system (Terefe et al., 2019); sequester carbon, and thus mitigate climate change (Du et al., 2010; Song et al., 2011; Nath et al., 2015; Yuen et al., 2017; Terefe et al., 2019; Nfornekah et al., 2020). Economically, bamboos generate an accrued amount of over 60 billion USD in the international market and 39.6 billion for the China Market (INBAR, 2019a; Nfornekah et al., 2020); this, however, represents just a small fraction of the overall benefits from the plant.

The circular N°059/C/MINFOF/CAB of April 21, 2016, of the Ministry of Forestry and Wildlife (MINFOF), suspended the exploitation of tree poles in the national domain of Cameroon. Since then, the exploitation of bamboo as an alternative for poles has intensified. This triggered a growing concern about the guarantee of bamboo species and ecosystem's sustainability, as very insufficient knowledge is available on bamboo distribution, diversity and resource availability, especially in natural forests (Tchamba et al., 2020; Neba et al., 2020; Zhao et al., 2018). Sustainable management can only be achieved with real statistics on the population structure and dynamics (Canavan et al., 2017; Zhao et al., 2018; INBAR 2018; Tchamba et al., 2020). Several studies have been done especially in Asia-Pacific (Nath et al., 2015; Yuen et al., 2017; Terefe et al., 2019) but little has been done elsewhere, particularly in Africa (Tovissodé et al., 2015; Honfo et al., 2015; Gurmessa et al., 2016; Nfornekah et al., 2020). In Cameroon, despite its importance, limited studies have been reported on the occurrence, distribution, availability, and utilisation of bamboo in Cameroon (Ingram et al., 2010; Ingram and Tieguhong, 2013; Nfornekah et al., 2020; Neba et al., 2020; Tchamba et al., 2020) making it difficult to put in place a management strategy.

In the Menoua Division, West Region of Cameroon, which is the focus of this study, the report of Chimi et al. (2021) identifies various bamboo uses and products in the Western Highlands of Cameroon including Menoua. Ananfack et al. (2022) report the propagation of *Bambusa vulgaris* in order to ensure the sustainability of the bamboo resource base and contribute towards improving the livelihoods of rural bamboo-dependent communities. Furthermore, Meyabeme et al. (2022) examine the different actors involved in the bamboo value chain as well as assess the different strategies to adequately develop bamboo in the Menoua Division. These recent

publications have not provided information on the diversity, distribution, and dominating bamboo species characteristics that will buffer its utilisation in diverse domains in the Menoua Division.

This study was initiated to evaluate the current bamboo status for proper conservation and management strategies for the resource. This study had the following objectives: (1) identify bamboo species and their distribution, (2) characterize the bamboo structure and (3) evaluate the socio-economic importance of bamboo to the livelihood of the local people.

MATERIALS AND METHODS

Study area

The study was carried out in Menoua Division, West Region of Cameroon, situated between longitude 9°50' and 10°20' East (E) and latitude 5°12' and 5°38' North (N). The climate is remarkable with two main seasons, including a short dry season that lasts from November to March, and a long rainy season that lasts from April to October. The annual precipitation rate rises between 1500 and 2000 mm/year. The temperature fluctuates between 18 and 30°C with a strong daily variation and an average temperature of 25°C. The relief is mountainous. In the high altitude, the soils are ferrallitic; and in the valleys, they are hydromorphic and fertile. The land is undulating and accidental (risk zones), with marshy areas and slopes at lower altitudes. The soils are generally black coloured and rich in humus, thus favourable for agriculture. Human activities have transformed the vegetation and forest cover gradually into agricultural land use systems (Letouzey, 1985). Some forest galleries are present in areas usually called "holy places" or "sacred forests" as well as in swampy areas, and around waterfalls.

Sites selection

The study site was selected purposefully based on: (1) bamboo distribution in Cameroon guided by Ingram et al. (2010), who reported bamboo availability in Menuao and (2) convenience, that is having the resource availability (fund and time), for data collection. In Menoua, 3 subdivisions out of 6 were selected based on bamboo availability and easy access to bamboo stands (forests) or collection zones during data collection. Sampled villages were selected based on their activities vis-à-vis bamboo in the subdivisions. A reconnaissance visit was carried out prior to the primary data collection in order to identify the different data collection zones within the Menoua Division. These zones were categorized after the visit according to two criteria: bamboo production and accessibility. Based on these criteria, three subdivisions and nine villages were chosen. In Dschang Foreke, Toutsang and Foto were selected. In Nkong-Ni, Baleveng, Bafou, and Sa-ah were selected and in Fokoue Fonakeukeu, Fotomena and Fomopea were chosen (Figure 1).

Data collection

Two types of data were collected; namely, social and ecological data. The social data were collected according to Angelesen et al. (2011). Semi-structured questionnaire designed for household (HH)

STUDY ZONE LOCALISATION

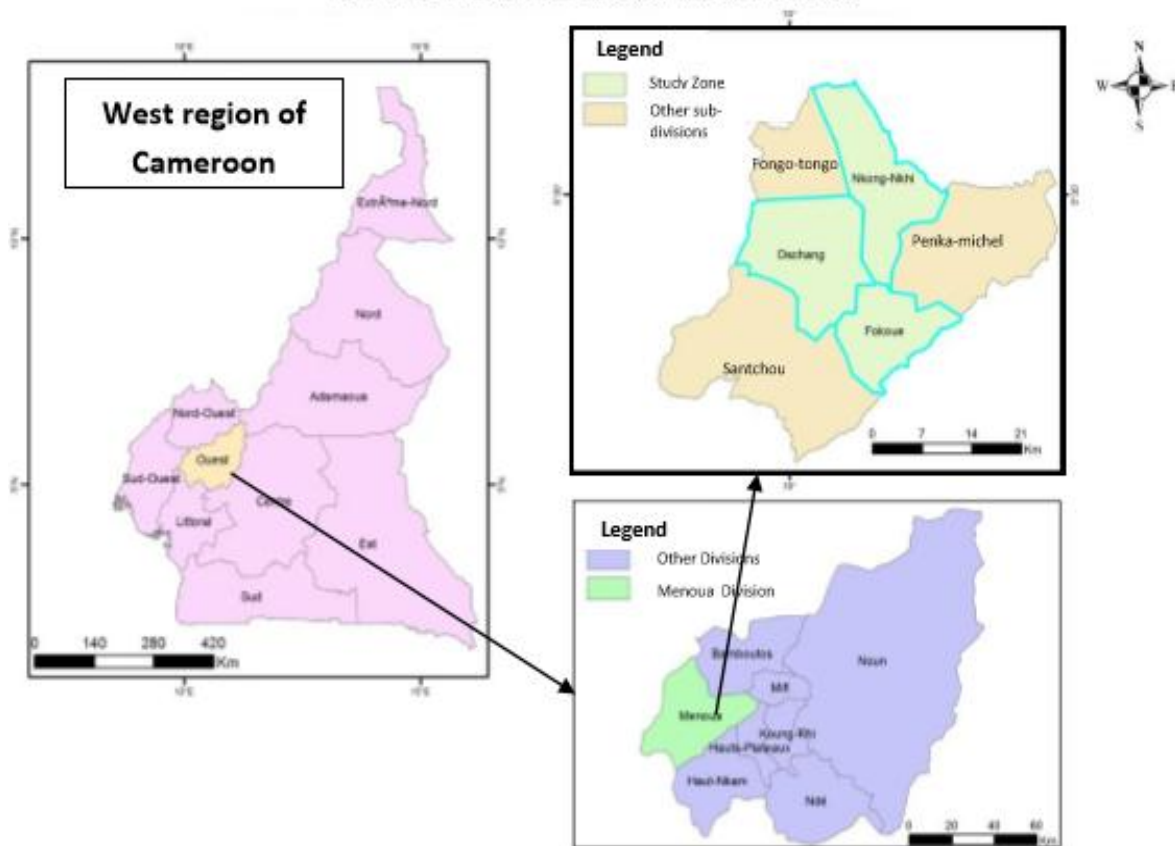


Figure 1. Study area.
Source. Authors

information, interview guide for focus group discussion (FGD), informants interview, and observations characterised the socioeconomic data collection tools and methods. A simple random selection was used to choose 10 respondents for the HH survey in each target village. Each HH must have an activity in the bamboo sector. This study was designed to pursue relatively few HHs per village but increased the number of villages in the study area (Angelsen et al., 2011). This permits us to understand variation within the study population. HH was defined, thus a home husband, wife, and children; in a polygamous family, the house of each wife was a HH, and in a compound where the children have grown, married and live within the same family concession, a couple's hut is a HH. Respondents to the questionnaires were household leaders (male or female). In nine villages in the study area, 90 questionnaires were administered to bamboo user HHs. This questionnaire was designed to capture information on collection zones, bamboo diversity, the social and economic importance of bamboo. Focus group discussions (FGD) were organised per village selected for the study. FGD was organised in a way that involves key bamboo stakeholders of the village including: traditional administration (chief) and notable in some cases, primary stakeholders (producers, harvesters, craftsmen/artisans, traders, consumers, etc.), and tertiary stakeholders (civil society

organisations). The number of participants in the group was maintained to 7-10 maximum members, to ensure easy coordination. A key informant was used to assist the numerator during discussions. This key informant acted as a translator when the need arises and assist the numerator in the entire exercise coordinating the group. The numerator animates the group in asking questions, follow-up, and taking down salient responses. The FGD captured information on, the origin of bamboo in the village, species exploited, uses, distributions, marketing, methods of conservations, etc. Nine FGD were administered in this study.

The key informant was preferably, a native of the village, who was knowledgeable in such activity. He could speak and translate difficult phrases to dialect and French. He was interviewed on missing data, and also used to triangulate the information from the group discussion.

To assess the distribution, status and cultivation needs of bamboo species, field inventory was carried out in three different plot shapes: circular plot of 200 m², rectangular plot of 200 m² and square plot of 1 m² (Huy and Trinh, 2019). Circular plot was used in bamboo stands in accidental topography having slope above 10°. The rectangular and square plots were in gentle topography. Circular and rectangular plots were used to survey both monopodial and sympodial bamboos, while the square plot of 1 m² was used to

survey only monopodial of small diameter bamboo species. Within a plot, the total number of bamboo culms was estimated by counting. To minimize the impact of destructive harvesting on bamboo stands, 3 bamboo culms representing minimum, medium, and maximum sizes and heights of bamboos per plot were harvested and information on structural characterisation was recorded. Parameters such as, mean length of internodes, mean height, and mean diameter at breast height (D) of culms of the individual species were documented using measuring and diameter tapes. The number of plots per village grows with respect to the increasing bamboo stand population. A hand pocket GPS was used to estimate bamboo surface area (coverage). During coverage estimation, the GPS was used to track the bamboo stands and obtain the area covered automatically at the end. The limitation of this method was that only accessible bamboo stands were tracked. GPS was also used to collect coordinates of different bamboo species stands and this was used to produce a map of species distribution in the study area. Herbarium vouchers were deposited at the National Herbarium in Yaounde Cameroon for identity confirmation.

Data analysis

Data from questionnaires and bamboo parameters for characterisation were entered in separate Excel spreadsheets. SPSS version 20.1 software was the main software used for data analysis. Both descriptive and inferential statistical analyses were performed. Shapiro-Wilk test showed that the data were normally distributed and the parametric test of ANOVA was performed to test for significant levels with respect to variations in the number of internodes on culms, length of internodes, the height of culms, and diameter at breast height (D) of culms in the nine selected villages. Significant levels were also tested amongst the different species of bamboo. Descriptive representations (tables, percentages, etc.) were used in the social characterisation of the study population. Focus group data were analysed by content analysis. Interpretation and triangulation were made with reference to the literature review. The QGIS version 2.18 was used to produce bamboo distribution in the Menoua Division.

RESULTS

Bamboo species and distribution in Menoua Division

Socio-demographic characteristics of respondents

The age class 20-29 years were highly represented in 30% and 30 - 39 (27%) and age class 60+ years was the least (10%). Males (75.5%) were more represented in bamboo activities than females (24.5%). Most respondents were married (58%) and had attended secondary education (44%), and 44.4% of the native villagers had large family sizes (Table 1).

Identification and distribution of bamboo species

The bamboo species identified were at least 6 species

including *Phyllostachys aurea* Carrière ex Rivière & C. Rivière, *B. vulgaris* Schrad. ex J.C.Wendl. *Bambusa* species Longinternode, *Oxytenanthera abyssinica* (A. Rich.) Munro, *B. vulgaris* var. *vittata* (painted bamboo), *Yushania alpina* (K. Schum.) W.C.Lin, *Dendrocalamus asper* (Schult. & Schult.f.) Backer ex K.Heyne and *Dendrocalamus strictus* (Roxb.) Nees. *P. aurea* dominated cultivated or agricultural lands and settlement areas, *B. vulgaris* were mostly found along streams and on the Foreke escarpment, and *Y. alpina* was restricted on hills.

Informants affirmed that the *B. vulgaris* had been planted during the colonial period by the Germans to stake crops, and those on the Foreke escarpment were planted to control soil erosion and landslides. These bamboos were identified on their natural stands and on cultivated sites, with *B. vulgaris* (44%) and *P. aurea* abundance in Fokoue (15%) with medium and small culm sizes, whereas, *Y. alpina* was restricted in some areas of Dshang and Fokue. *P. aurea* (41%) was dominant in the Menoua Division because of its availability in natural stands especially in the sacred forests, as well as cultivated lands. Also *P. aurea* was widely distributed as live fences or on cultivated plots; hence, they were the most harvested for domestic uses. The population did not know about *B. vulgaris* var. *vittata*, *Bambusa* spp. Longinternode, and *O. abyssinica* because they were newly introduced into the Botanical Garden of the University of Dshang, Cameroon.

Two growth forms of bamboo were recognised. All the *Y. alpina* grew and spread in all directions and individually (monopodial) while the *Bambusa* spp. and *O. abyssinica* grew in groups or clusters with the youngest always on the outer surface of the cluster (sympodial).

Bamboo planting and frequency of harvesting in the Menoua Division

Planting bamboo was not a common phenomenon. Only 32% of the respondents have planted bamboo on their lands. Bamboo planters were motivated by greening in live fences (75%), erosion and landslide control (14%). About 10% of respondents used planted bamboo for construction materials, 6% for live fences/hedges and land boundary demarcations and finally 03% from the local community. Dshang recorded the highest percentage of bamboo planted on plots (46%) followed by Fokoue and Nkong-Ni with 39 and 15%, respectively.

Bamboo regeneration was natural in all areas surveyed; and the resource was largely unmanaged. No regular harvesting techniques were used by harvesters to harvest culms. The local harvesters had and currently used the notion of colour to differentiate matured culms

Table 1. Demographic characteristics of respondents.

Variable	Frequency	Percentage
Age (years)		
20 - 29	27	30
30 - 39	25	27.7
40 - 49	12	13.3
50 - 59	17	18.8
60+	9	10.2
Gender		
Male	68	75.5
Female	22	24.5
Marital status		
Married	52	57.7
Single	23	25.5
Divorced	1	1.1
Widowed	5	5.5
No answer	9	10
Education level		
Primary	14	15.5
Secondary	40	44.4
High education	25	27.7
Never schooled	1	1.1
No answer	10	11.1
Family size		
2 - 4	14	15.5
5 - 8	21	23.3
9+	40	44.4
No answer	15	16.6
Origin		
Native	87	96.6
Non-native	3	3.4

Source. Authors

from young ones. Desirable matured culms were identified by the yellowish-brown colour and were harvested usually with a cutlass or manual saw. Bamboo harvesters did not have modern tools such as chain saws. The quantity harvested was difficult to estimate by the bamboo users, but it was possible to count the number of bamboo culms exploited, amounting to about 5642 bamboo in 3 years. Harvesting was more at certain periods, especially in the dry season when traditional ceremonies like funerals are many. Respondents (40%) harvested bamboos according to demand and not seasonal. Some respondents (29%) could not estimate

their harvest, while 20% harvested bamboo for fuelwood.

The growth duration of bamboo to maturity depended upon the species. Respondents said *B. vulgaris* takes between 5 and 8 years, *Y. alpina* takes 3 to 5 years to mature. *B. vulgaris* was collected for construction because of the larger diameter and height.

Constraints on bamboo planting and management strategies in Menoua Division

A number of respondents (29) had planted bamboo in

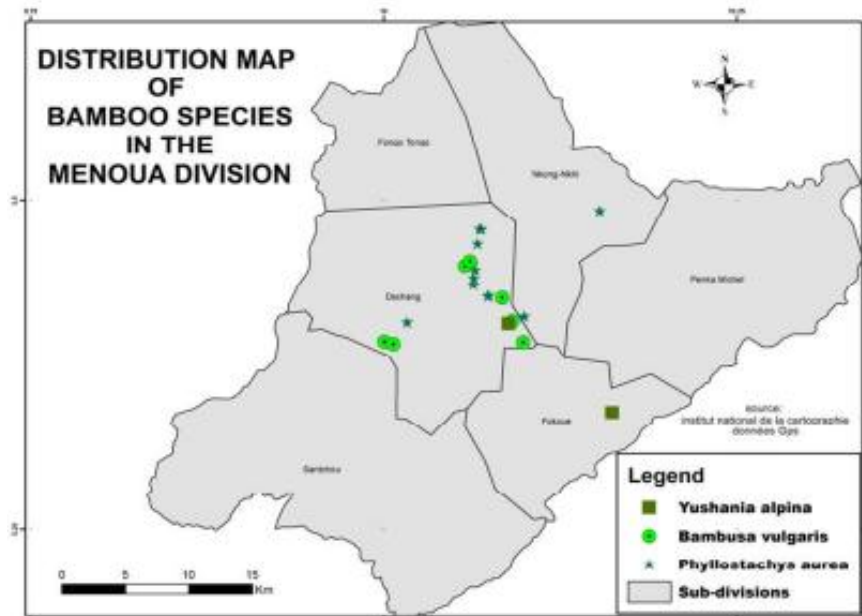


Figure 2. Bamboo distribution/location in the Menoua Division.
Source. Authors

their lands. Nine of them faced no management problems with bamboo presence on their land, while 20 encountered problems with bamboo on their land. Two main problems were reported including rapid growth and invasiveness in nature. 66% of the planters dug off bamboo to free their lands for other use; meanwhile 34% cut or pruned to reduce bamboo invasion. 93% of the bamboo sites visited were natural bamboo stands, and only 2 were planted by the National Forest Development Agency (ANAFOR) and the University Botanical Garden in Dschang. The University of Dschang has planted bamboos in its garden; amongst which were new species (*B. vulgaris* var. *vittata*, *Bambusa* spp. Longinternode, *D. asper*, *D. strictus* and *O. abyssinica*). Few farmers were interested in knowing how to cultivate bamboos by vegetative propagation. Most (59%) of the planters had no interest in cultivating bamboos.

Bamboo production zones distributed and growth morphology in Menoua Division

The surface area covered by bamboo varied across sub-divisions, villages as well as bamboo species. Generally, *P. aurea* had the highest mean surface area coverage (2137 m²) in the Menoua Division, followed by *Y. alpina* (1225 m²) and *B. vulgaris* (893.8 m²). *B. vulgaris* var. *vitata*, *Bambusa* spp. Longinternode and *O. abyssinica*

occupied an area of 960 m² each in the Botanical Garden of the University of Dschang. The altitudinal range for bamboo production was between 1200 and 1400 m. For *B. vulgaris*, it grew in a wide altitude in the tropics, this may be why it is referred to as a pantropical bamboo species. *Y. alpina* and *P. aurea* were largely seen on altitudinal range of 1300 to 1400 m. Figure 2 shows the distribution or location of different bamboo species in Menoua. For distribution pattern, all *Bambusa* spp., *Dendrocalamus* spp., and *O. abyssinica* found in the study area grow in clusters (sympodial), while all *Phyllostachys* spp. grows by spreading out its rhizomes horizontal in all directions in so far as their rhizomes are not perturbed. This growth form is called monopodial growth. *Yushania*'s growth pattern is trickish as it assumed both growth forms. It could be seen with monopodial or sympodial or mixed form.

Structural characteristics of bamboo stand in the Menoua Division

It was observed that the mean number of internodes on bamboo in the Menoua Division varied from ca. 22 to 40 internodes on a culm and its length also varied from 9.8 to 34.4 cm (Table 2).

The bamboo with the largest size was found in Dschang, precisely in the village of Foreke with an

Table 2. Characteristics of bamboo stands in the selected villages.

Village	Number of internodes on a Culm	Length of internodes (cm)	Height of Culm (m)	Diameter of Culm (cm)
Foreke	40.0±1.8	34.4±1.3	16.3±0.7	21.6±1.1
Sa-ah	40.1±3.1	34.2±2.2	16.0±1.3	20.2±2.0
Fonakeukeu	37.3±2.0	27.0±1.4	10.3±1.0	14.4±1.2
Fotomena	30.6±3.1	34.4±2.2	12.9±1.4	20.2±2.0
Fomopea	37.2±4.2	20.3±3.0	9.0±2.0	9.0±2.6
Foto	35.8±1.3	18.3±1.0	6.5±0.6	8.6±1.0
Baleveng	35.8±4.2	17.2±3.00	4.7±2.0	6.3±2.6
Toutsang	31.9±1.8	13.9±1.3	4.3±0.8	6.4±1.2
Bafou	21.8±4.2	9.8±3.0	1.5±1.8	2.1±2.6
Pr > F	0.0018	0.0002	0.0013	0.0003
LSD	6.29	4.52	2.77	3.86

Source. Authors

Table 3. Dendrometric characteristics of bamboo species in the Menoua Division.

Bamboo species	Number of internodes on a culm	The length of internodes (cm)	Height of culms (m)	Diameter	Number of bamboo/m ²
<i>B. vulgaris</i>	37.8±1.2	34.2±0.6	15.0±0.4	6.5±0.5	1.8±0.7
<i>Y. alpina</i>	41.7±2.4	18.9±1.2	8.4±0.9	2.8±1.1	56.0±16.9
<i>P. aurea</i>	32.6±1.1	14.4±0.5	4.2±0.4	1.80±0.5	130.94±12.6
Pr> F	0.0002	0.0012	0.0035	0.00024	0.0001
LSD	3.65	1.73	1.29	1.68	37.84

Source. Authors

average height (H) and diameter (D) of 16.3 ± 0.7 m and 21.6 ± 1.1 cm, respectively. The village of Foto had the most abundant distribution of bamboos. The bamboo with the smallest size was found in Nkong-Ni precisely at Bafou with an average H and D of 1.5 ± 1.8 m and 2.1 ± 2.6 cm, respectively. ANOVA test indicated that the number of internodes on a culm, the length of internodes, H of culms as well as D of culms varied significantly across the nine selected villages ($p < 0.05$).

Y. alpina had the highest number of internodes (42) with a moderate length of internodes (19 cm), with average H of 8.4 m, and average D of 2.8 cm. Meanwhile, *B. vulgaris* had a moderate number of internodes (38), with average length of internodes (34.2), average H of 15 m and average D of 6.5 cm. *P. aurea* on its part was the least, although with the largest number of shoots/m² (Table 3).

The number of internodes on a culm, the length of internodes, H of culms as well as D of culms and number of bamboos in 1 m² varied significantly across the three main species of bamboo found in the Menoua Division ($p < 0.05$).

Socio-economic importance of bamboo species in the Menoua Division

Local knowledge of bamboo

The local population (93%) identified the different bamboo species using the following: (1) H of culms, D and leaves, (2) size and (3) on very rare occasions their flowers. In Dschang, respondents (45%) identified *P. aurea*, 42% respondents identified *B. vulgaris* and 41% identified *Y. alpina*. In Fokoue, 48% respondents identified *Y. alpina* and followed by 35% with *B. vulgaris*. The local population of Nkong-Ni knew two main bamboo species: *P. aurea* (45%) and *B. vulgaris* (23%).

Uses of bamboo in the Menoua Division

All the parts of the bamboo from the roots, culms, branches and leaves were utilised differently. The culm (56%), branches (25%), roots (16%) and leaves (2.2%) in order of importance were used. Bamboos had numerous

uses (Figure 3). In Dschang, *B. vulgaris* and *P. aurea* were highly used to stake crops like bananas, plantains, tomatoes, beans, yams, protection of young plants or trees, construction of pig and rabbit houses, feeders for broilers and fishing tools. Most of the respondents said staking farm crops with bamboo increased yields.

Dschang recorded the highest uses of bamboo for live fences and hedges, as well as aesthetics or ornaments, including use for soil erosion control and landslide; followed by Fokoue community who used *P. aurea* leaves as forage for goat. Meanwhile in Nkong-Ni, bamboo was highly used as construction material (Dschang > Fokoue > Nkong-Ni). *B. vulgaris*, *Y. alpina* and *P. aurea* were used as poles in building of houses, house supports, electricity poles, antenna masts, as well as construction of traditional bridges, garner, and local football goal posts. Other uses of bamboo in the Menoua Division were domestic utensils. *Y. alpina*, *B. vulgaris* and *P. aurea* were used to manufacture domestic utensils like cups, flower plots/jars, walking sticks (13%) and water pipes to collect water from running river or streams (2%). Bamboos were also used in traditional ceremonies (10%) in funerals (e.g., *B. vulgaris*) and the birth of twins (*P. aurea*).

Bamboo trade in the Menoua Division

Trade in bamboo was not lucrative, as 93% of bamboo planters never sold bamboo. The remaining 7% sold with very low prices ranging from 200 (\$ 0.4) to 1000 F CFA (\$ 2) for each bamboo culm, depending on the size and height with respect to its maturity (Table 4). Two bamboo species were mostly sold: *B. vulgaris* during funeral ceremonies and *P. aurea* distributed to farmers cultivating crops for support (stake tomatoes, beans, yams etc). Only 7% traded bamboo directly to earn income (Figure 4).

DISCUSSION

Bamboo species and distribution in Menoua

The results revealed that males of youthful ages were largely implicated in the bamboo sector, most of which were natives and literate. This suggests that the bamboo arts are laborious, and warrant hard manual work. The literacy level suggests that respondents know more of the cultural uses of bamboo. Their marital status implies that the families were more stable in the villages.

This study results on bamboo species diversity corroborates with those of Ingram et al. (2010) who identifies similar bamboo species (*B. vulgaris* and *Y.*

alpina) in the Western Highlands of Cameroon, otherwise called Agroecological zone 3 (AEZ) and *B. vulgaris* and *O. abyssinica* in the dense forest of Centre and East Cameroon or AEZ 5, respectively.

The distribution of bamboo is determined by its growth form and origin. The results agree with the observations of different authors. The Germans were particularly influential in introducing bamboo in Cameroon to be used in the Agro plantation in the Coast of Cameroon to support bananas, rubber, palm nut harvesting and road side hedges to act as breaks to landslides and erosion (Ingram et al., 2010; Nfornekah et al., 2020). These bamboo species became naturalised in Cameroon. The *B. vulgaris* var. *green* and the *P. aurea* are introduced species in Menoua and Cameroon that have been naturalised. They are also used for roadside and water banks stabilisation to prevent landslides, beehive construction, etc. (Nfornekah et al., 2020).

The *B. vulgaris* var. *vittata*; *Bambusa* spp. Longinternode, *D. asper*, *D. strictus* and *O. abyssinica* are newly introduced in Dschang with the help of the University of Dschang in collaboration with INBAR. Note should be taken that *O. abyssinica* is an African endemic bamboo with origin in Ethiopia (Kwame et al., 2020).

Bamboo distribution was highly influenced by their growth morphology. This study identified two spatial patterns in growth forms, which were running (monopodial) and clusters (sympodial). This distribution has got particular importance in the theme of tropical ecology and theories which explain the coexistence of bamboo species (Wiegand et al., 2007; Yigardu et al., 2016). The results showed high clusters of bamboo species on small scales with a progressive reduction in density as they spread outwardly with respect to distance. The bamboos are said to be growing in clumps or sympodial form where very old bamboos are found in the centre of the clumps with young shoots on the periphery. This particular type of spatial distribution is reported by many authors (Nath et al., 2015; Tovissodé et al., 2015; Yigardu et al., 2016; Yuen et al., 2017; Terefe et al., 2019; Nfornekah et al., 2020).

Truly, aggregation is a usual phenomenon in species distribution in nature (Wiegand et al., 2007). The spatial patterns observed in bamboo individuals are reproductive characteristics which favour the regeneration species mode of life. A single rhizome develops many buds which grow up to new shoots emerging from the ground surface and differentiating into stems or culms (Jayaraman and Trinh, 2019; Huy and Trinh, 2019; Kaushal et al., 2018). The clusters whose culms grow tightly together have short necked rhizomes and those with loose culms have long necked rhizomes (Jayaraman and Trinh, 2019; Kaushal et al., 2018). The other growth form observed with *Phyllostachys* was running otherwise called

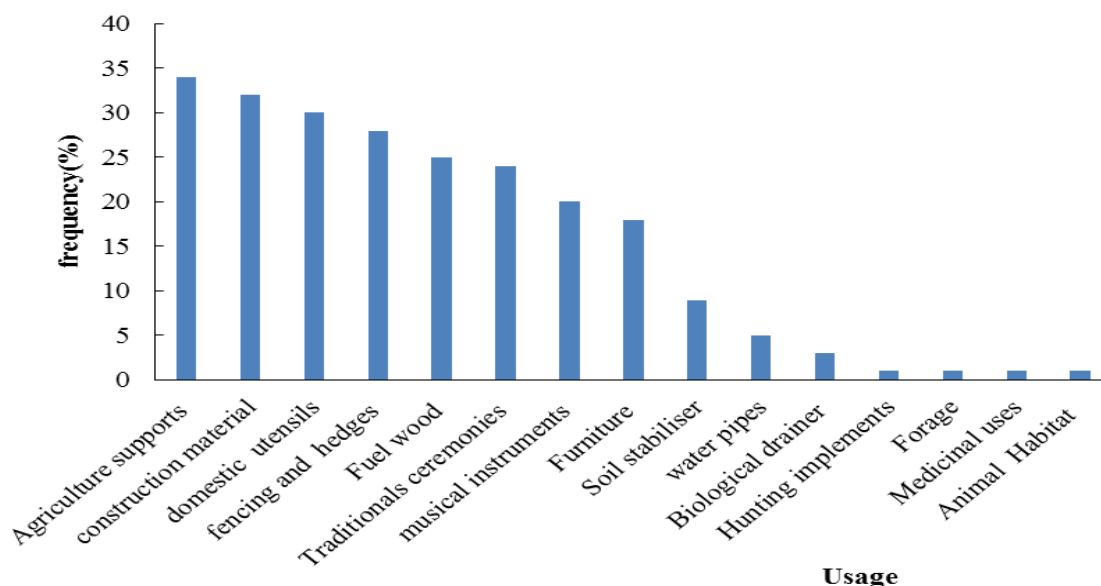


Figure 3. Uses of bamboo in Menoua Division.
Source. Authors

Table 4. Bamboo trade in Menoua.

No.	Bamboo sold	species	Prizes (CFA Frs)	
			Village	Town
1	Bamboo culms	<i>B. vulgaris</i>	200/culm	400-500/culm
2	Bamboo culms in bundles	<i>P. aurea</i>	400/bundle	700-1000/bundle

Source. Authors

monopodial. This growth form is due to the rhizomes of the plant that grow horizontally in the subsoil, with the node buds producing shoots as they spread out (Jayaraman and Trinh, 2019; Kaushal et al., 2018). The results showed that more people are getting involved in the bamboo sector. This might be as a result of the increasing scarcity and growing demand for wood. Bamboo plays a substitute role for wood for craft, infrastructural and other needs.

The ministry in charge of forestry in Cameroon has regulated Non-Timber Forest Products (NTFPs) with Decision No. 0209/D/MINFOF/CAB of 26 April 2019, that classifies special forest products and NTFPs. On the list of NTFPs, bamboo is one and indicated that its conservation status is not threatened. Decision N° 0034/D/MINFOF/CAB of 05 February 2020, lay down conditions for transportation of NTFPs from plantations. Ingram et al. (2010) in their study point out that even in the absence of statutory laws, continued customary regulation is important in ensuring sustainable harvesting

of these species. The people believe that bamboo invades lands and excludes existing biodiversity. This problem is most critical in the case of monoculture bamboo stands where bamboos aggressively invade, replacing local species, and reducing existing biodiversity (Kleinn et al., 2006), although introducing a new form of ecological system.

The results on altitudinal distribution showed bamboo within a range of altitudes. Thus, it is clearly noticed that bamboo species distribution varies according to the altitude. This corroborates with the results of Deo Kumar et al. (2013) who report the altitudinal range of *Bambusa* spp. as 300 to 1500 m.a.s.l., and *P. aurea* as 600 to 1400 m.a.s.l. It was also reported that bamboo can develop well at altitudes of about 1400 m and above (Tran, 2010; Ram et al., 2010; Song et al., 2011). Grimshaw (1999) in a review reports that *Y. alpina* characteristically occurs between 2,400 and 3,000 m, with isolated occurrences in altitudes as low as 1,630 m. This study shows the very rear occurrence of *Y. alpina* at altitudes < 1,630 m in

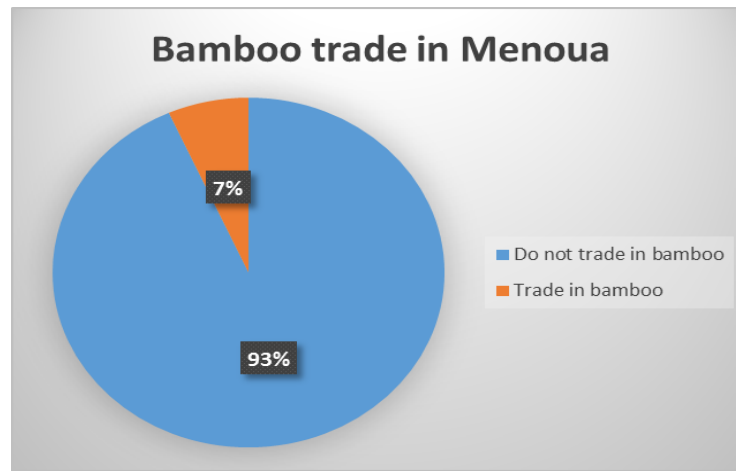


Figure 4. Participation in bamboo trade in Menuoa.
Source. Authors

Menuoa. Tovissodé et al. (2015) however, find a significant difference between wetlands and plateaus ($p < 0.001$) on bamboo species development indicating a strong influence of the topographical units on the relative neighbourhood density. Most bamboo species were found distributed around valleys with high humidity. Bamboo is very important in water recharging and pulling the water table towards the earth surface (Terefe et al., 2019; Kaushal et al., 2018).

Structural characteristics of bamboo stands

These structural characteristics of bamboo is of importance here as it permits to make choices of which bamboo species is good for use depending on the type of project e.g. construction, transformation or wood processing. These study results are in accordance with the findings of Nforokah et al. (2020) with respect to *O. abyssinica* recording the range of 2.01 to 6.61 cm and with the mean value of 3.93 ± 0.66 cm, with the diameter and height of range of 2.00 to 11.02 m with the mean value of 8.40 ± 0.36 m.

Tovissodé et al. (2015) found that culms with a diameter ≥ 50 mm were more frequent for *B. vulgaris* than for *O. abyssinica* and when only *B. vulgaris* was considered, culms with $D \geq 50$ mm were mostly encountered in the Ouémé-valley phytodistrict.

Socio-economic importance of bamboos

The results showed that local people differentiate three bamboo species found in the study area using

morphological differences. This was in agreement with the results of Honfo et al. (2015) which support that different local grouping of bamboo species based on morphological variations of the culms (colour: green, yellow, brown; internode, height, internal, and external diameters) and leaves (colour and texture) to identify different bamboo species. With respect to age morphological differentiation using phenology, many authors have described the different observations found on different species of bamboo during their growth cycle (Li et al., 2016; Kaushal et al., 2018; Jayaraman and Trinh, 2019).

Bamboo occupies a very important place in the socio-cultural and economic aspects of the population. Its uses were numerous. These results corroborate with those of Ingram et al. (2010) and Ingram and Tieguhong (2013). The different parts of bamboo have been used for different purposes. Although all parts of the bamboo plants were used, the most used bamboo part was the culms (73%) and leaves (23%) (Honfo et al., 2015). Honfo et al. (2015) in Benin found a total of nine categories of uses recorded including material, implement, agriculture, medicine, firewood, commercial, worship, environment, and social purposes. In the three sub-divisions of this study, Dschang registered the highest uses of bamboo for live fences and hedges as well as aesthetics or ornaments.

This shows that *P. aurea* is very good for live fences, which is in accordance with the research work of Ogunjinmi and Ijeomah (2009). Ingram and Tieguhong (2013) report that bamboo is used as yam props and supports for plantain and bananas. Bamboo is also used as fishing stick (Ogunjinmi and Ijeomah, 2009; Honfo et al., 2015), to build fish-traps and shelter in the traditional

fishing systems (Tovissodé et al., 2015). Again, bamboo is greatly used as soil stabilizers in this area. The bamboo species found in Menoua Division were also used to control soil erosion and landslide. The main reason *B. vulgaris* was planted in the Foreke escarpment of Dschang was to protect the asphalted road linking the West region to the Littoral region of Cameroon. According to Ingram and Tieguhong (2013), bamboo leaves serve as fodder or forage for elephants in the Lobeke National Park of Cameroon. This result showed bamboo leaves used as medicine. This is supported by other results of Anonymous (2013), Honfo et al. (2015) and Yigardu et al. (2016). However, East Africans mostly use bamboo for furniture and specially to make ladders, market tables, rack to dry maize, hanging screens, and dress traps. Bamboo is mostly used in India for furniture (Prasad, 2009), bamboo pulp and paper; textile, composites, panels, boards, chemicals, energy (bio-ethanols) (Anonymous, 2013).

The short supply of timber and other conventional construction materials accompanied by rising costs makes it imperative to increasingly use bamboo as a building material (Nath et al., 2015; Yuen et al., 2017; Terefe et al., 2019; INBAR, 2019b). Bamboo is also used in this community as fuel wood, because of its availability, workability and low cost (INBAR, 2019b). According to the study of Prasad (2009), bamboo is used to manufacture household items and bamboo pipes used for rain water collection from roof tops. Ingram and Tieguhong (2013) also report that musical instruments are made from bamboo.

Trade in bamboo in Menoua was not lucrative. The local people have other activities that are more lucrative such as market gardening and other forms of farming, livestock (poultry and piggery) and petit trading. This agrees with the findings of Bystriakova and Kapos (2006) that international trade in bamboo products across Africa is not well-developed owing to little cultivation of bamboo species, but there are promising experiments being carried out in many African countries (Kokutse et al., 2014). Honfo et al. (2015) find that Bamboo culms have gained marketable value only in the last decade; that was not the case some fifteen years ago and that about 26% of informants were bamboo traders of which 16% were sellers and 10% buyers. The price of bamboo culms was determined by the area (village and town) and on the species (Ingram et al., 2010; Neba et al., 2020). Analogously, the price is higher for species with large and tall culms (Neba et al., 2020). Two bamboo species highly sold were: *B. vulgaris* during funerals ceremonies for the construction of make shift tents; which are cost effective when compare with hiring a readymade canopy and *P. aurea* to farmers cultivating crops to stake tomatoes, beans and yams. This corroborates with

previous economic studies on bamboo that led to the conclusion that characteristics such as diameter, height, and hardness determine bamboo price (Wong, 2004).

Honfo et al. (2015) observe that housing materials demand for *D. asper* and *B. vulgaris* was increasing with that of *O. abyssinica* for both housing and fishing materials in Benin. This is especially true since: (1) bamboo harvesting is becoming an important economic activity that could contribute to the overall income of local people (Mukul and Rana, 2013), (2) the insufficient management strategies that may in some decades, lead to the rarity of the bamboo species because of unsustainable exploitation (Bystriakova and Kapos, 2006) and (3) the increasing demand for wood and biofuels.

Conclusion

This study identified 9 bamboo species in Menoua Division: *P. aurea*, *Phyllostachys* spp., *B. vulgaris* var. *green*, *Bambusa* spp. Longinternode, *O. abyssinica*, *B. vulgaris* var. *vittata*, *Y. alpina*, *D. asper*, and *D. strictus* with five recently introduced (*Bambusa* spp. Longinternode, *O. abyssinica*, *D. asper*, *D. strictus* and *B. vulgaris* var. *vittata*) in Dschang Cameroon. Two bamboo growth morphologies were observed: sympodial for *Bambusa* spp. Longinternode, *O. abyssinica*, *B. vulgaris* var. *vittata*, *B. vulgaris* var. *green* and the monopodial for all *Y. alpina*. *P. aurea* occupied the greatest surface area coverage (2137 m²) in the Menoua Division, followed by *Y. alpina* (1225 m²) and *B. vulgaris* (893.8 m²). The mean number of internode ranges from 21.8 to 40.1 on culms and its length also varied from 9.8 to 34.5 cm. This showed a significant ANOVA result with (P<0.05). Out of the three bamboo species in the communities, two (*P. aurea* and *B. vulgaris*) were of great importance to the population as they were used for funeral ceremony, crop support and soil stabilization, thus improving on their livelihood. A majority of the population could identify the three different bamboo species using morphological differences. The bamboo marketing was still not lucrative in Menoua but has a promising future when valorised. There has been no management and conservation strategy put in place for Bamboo in Menoua. The Council Support Fund for Mutual Assistance (FEICOM) is a veritable income source to the local councils in Menoua, with INBAR as technical partner could invest in the bamboo sector development. Local Council could integrate this in the Council Development Plans, source funds from FEICOM and other development partners to develop this sector to respond to the sustainable development goals 1: no poverty; 7: sustainable energy; 11 sustainable consumptions; 13: combat climate, and 15: life on terrestrial land.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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