Traditional Knowledge and Use Value of Bamboo in Southeastern Benin: Implications for sustainable management

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Research

Abstract

Traditional knowledge (TK), use, and economical values of three bamboo species—*Oxytenanthera abyssinica* (A.Rich.) Munro, *Bambusa vulgaris* Schrad. ex J.C.Wendl., and *Dendrocalamus asper* (Schult. & Schult. f.) Backer ex K.Heyne—were assessed in southeastern Benin. Individual interviews were used in 90 randomly selected villages, which cut across 10 socio-cultural groups. We tested and found evidence to support the hypotheses that (1) age, gender, and socio-cultural groups are predictors of TK and plant ethnobotanical use value and (2) bigger bamboo species are more expensive on the market. Bamboo was used for 44 purposes, but the common food use of bamboo shoots was not reported. Men and older people had more knowledge and valued bamboo more than women and younger people, respectively, indicating that they are key stakeholders for conservation actions. The culm was the most harvested part of bamboo, and its selling price was location- and size-dependent. The implications of these results are discussed with respect to conservation and management strategies for bamboo.

Introduction

There is an increasing global concern about the widening gap between the management of dwindling natural resources and the exponentially increasing human population (Trekpo 2003). This is a precarious situation as the livelihood of millions of the world's poor depends on these natural resources for provision of services such as food, energy, medicine, and other aspects of human welfare (MEA 2005). Non-Timber Forest Products (NTFPs) constitute a large part of these natural resources and are increasingly incorporated in development policies (Mahapatra *et al*. 2005). Bamboo (Poaceae) is a major NTFP (Wong 2004), widely used in farming, housing, and for sculpting of musical instruments (Cottingham 2011, Yuming *et al*. 2004). This "woody grass" is highly acclaimed for its properties and its fast growth rate.

Bamboo grows up to a meter per day and can reach maturity in less than five years (Benton *et al*. 2011a). Bamboo has the ability to conserve soil moisture and to prevent its erosion (Rashford 1995) and to sequester carbon (Du *et al*. 2010, Song *et al*. 2011) and thus contribute to the mitigation of the harmful impacts of climate change. The annual revenue generated from the international trade of bamboo amounts to over 2 billion USD (Benton *et al*. 2011a, INBAR 1999). This, however, represents a small fraction of the overall benefits from the plant. The greater fraction (> 80%) of the benefits from bamboo is attribut-

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ed to its domestic purposes (Bystriakova & Kapos 2006) whose value is hardly appreciable.

The domestic uses of bamboo form a cultural heritage for many indigenous societies worldwide. In southeastern Benin, stakes used for cultural dances locally termed **kpodjiguèdè** as well as many farmers' habitations are made up of bamboo culms (Dah-Dovonon 2001). The author reported that bamboo species also have been used as firewood and for fishing. In the past, communities living around the lacustrian areas of southeastern Benin have used the wood of *Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill. (Irvingiaceae) to build shelters for fingerlings in some traditional fishing systems called **acadja** (Niyonkuru & Lalèyè 2010) and as stakes in another traditional fishing system called **mèdokpokonou**. Today, due to the scarcity of *I. gabonensis*, it has been replaced by bamboo culms, indicating that people adapt and select species they use according to local availability (Campos & Ehringhaus 2003). This also points out the threats species can experience, especially when any use framework has not been defined with local people for sustainable use and management (Altieri *et al*. 1987). Finally, this suggests that in the future bamboo could also undergo a local decimation, as was the case of *I. gabonensis*. In spite of its crucial ecological and socioeconomic contributions and the threats to its sustainability, little is known about the knowledge of it held by rural populations and how this could be internalized to sustain its uses.

Understanding traditional knowledge (TK) of plant species is crucial not only to preserve this knowledge, but also to orient management for sustainable usage (Albuquerque *et al*. 2009). Nowadays, research on TK is more interested in studying how demographic factors—including age, gender, ethnicity, and other attributes such as responsibilities at household and community levels, profession, and origin—can shape TK and be internalized in management policies (Ayantunde *et al*. 2008, Begossi *et al*. 2002, Cruz *et al*. 2013). Authors have often highlighted that older people know more than younger people (Beltrán-Rodríguez *et al*. 2014, Camou-Guerrero *et al*. 2008, Case *et al*. 2005), but exceptions exist (see Byg & Balslev 2004). Similarly, men were reported to be more knowledgeable than women, although there is controversy according to the category of use (See Camou-Guerrero *et al*. 2008, Souto & Ticktin 2012, Voeks & Leony 2004). The need to determine whether and how these social specificities (e.g., age, gender, and socio-cultural groups) govern TK and uses of natural resources is in part guided by the possibility to (i) identify who should be the target and most involved in conservation actions, (ii) determine the most valued uses of each group, and (iii) evaluate risk of TK erosion within the rural communities.

Here, we documented TK on uses and ethnobotanical use value of bamboo in southeastern Benin through a quantitative ethnobotanical survey on three bamboo species, *Oxytenanthera abyssinica* (A.Rich.) Munro, *Bambusa vulgaris* Schrad. ex J.C.Wendl. and *Dendrocalamus asper* (Schult. & Schult. f.) Backer ex K.Heyne. Worldwide, over 1200 bamboo species have been identified (Benton *et al*. 2011b), while only five of these are found in Africa (Bystriakova *et al*. 2004). In southeastern Benin, the most common species are *O. abyssinica*, *B. vulgaris*, and *D. asper* (Dah-Dovonon 2001). This study was carried out with the rural communities of the Ouémé-Plateau area (southeastern Benin). The area encompasses the Ouémé River lower valley, a preferred habitat for bamboo because of the presence of water. The objectives of the study were to (1) assess the TK on uses of bamboo and the patterns of their use value according to gender, age, and socio-cultural group; (2) assess the bamboo-use categories; and (3) evaluate the selling price of bamboo species according to sale locations (village versus town) and the morphological size of bamboo. Based on findings of previous studies, the following hypotheses were tested: (1) TK and use value of bamboo vary according to socio-cultural group due to cultural factors (Avohou *et al*. 2012); (2) older people hold more knowledge and use bamboo more than younger people (Souto & Ticktin 2012); and (3) men are more knowledgeable and use bamboo more than women (Beltrán-Rodríguez *et al*. 2014) because of the assumption of gender-related activities (Cruz *et al*. 2013). We also tested whether the selling prices differed according to size of bamboo and place of sale (village versus town), postulating that (4) bigger bamboo species are more expensive (Wong 1995) and bamboo products are more expensive in towns than in villages.

Material and Methods

Study area

The study was carried out in the Ouémé-Plateau area (6°22'–7°41'N and 2°28'–2°47'E) in southeastern Benin, West Africa (Figure 1). The area encompasses 14 districts of which 13 are rural (Kétou, Pobè, Adja-Ouèrè, Sakété, Ifangni, Adjohoun, Akpro-Missérété, Avrankou, Adjarra, Bonou, Dangbo, Sèmè-Kpodji, and Aguégués) and one is urban (Porto-Novo). Only the rural districts were considered.

Ouémé-Plateau is at the border between the Guineo-Sudanian and the Guineo-Congolese climatic zones of West Africa. It is characterized by a subequatorial climate, a bimodal rainfall pattern with average annual rainfall varying between 1100 and 1400 mm, and a dry period of up to five months. The daily temperature ranges from 22.7 to 35.8°C. The vegetation is dominated by forest, woodland, swamp, and tree and shrub savannas on different soil types including ferruginous, ferralitic, and hydromorphic (Akoègninou *et al*. 2006). The population is 1,625,603 with an average density of 358 inhabitants per km^2. Women are more abundant (52% of the total population) (INSAE

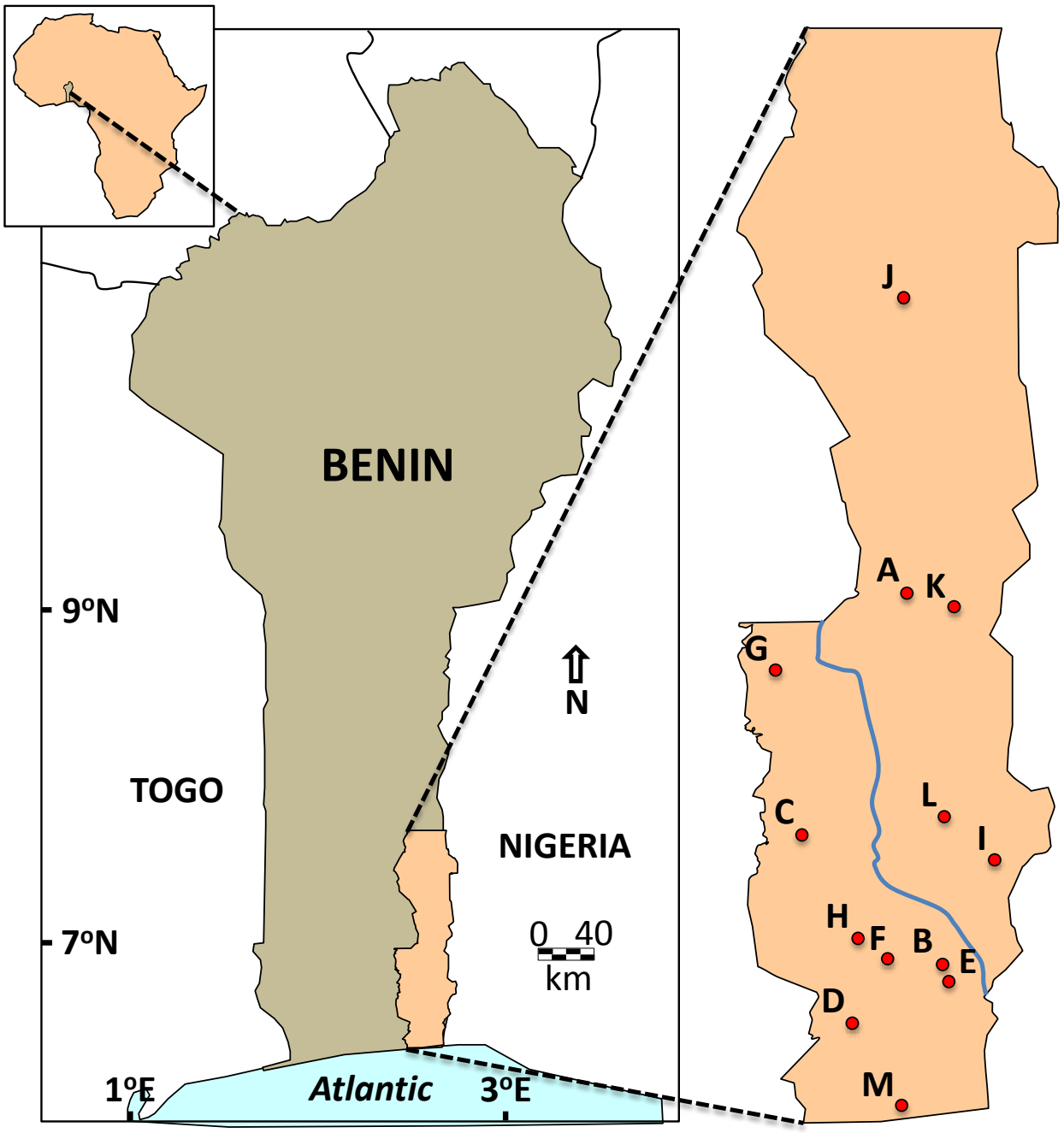

Figure 1. Location of the study area in the Ouémé-Plateau in southeastern Benin. Study districts include: **A**. Adja-Ouèrè, **B**. Adjarra, **C**. Adjohoun, **D**. Aguégués, **E**. Akpro-Missérété, **F**. Avrankou, **G**. Bonou, **H**. Dangbo, **I**. Ifangni, **J**. Kétou, **K**. Pobè, **L**. Sakété, and **M**. Sèmè-Kpodji.

2008), and farming is the main occupation (51% farmers) involving mostly men. The major cultural groups are the Goun (26%), Nago (18%), Wémè (15%), and Toli (12%) (INSAE 2003), while the Adja, Toffin, Xoly, Yoruba, Fon, and Mahi cultural groups are minorities (INSAE 2003).

Study species

Oxytenanthera abyssinica grows on all soil types except saline and swampy clayey soils (CTFT 1962). It is distributed in isolated pockets from Ethiopia to Senegal and

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Mozambique across to Angola but has high cover in Ethiopia (Kigomo 2007). *Bambusa vulgaris* is a pantropical bamboo species (Kigomo 2007) found in tropical countries where it is widely cultivated for its edible shoots (Somen *et al*. 2011). It grows in moist alluvial soils as well as on hilltops with poor soil. Only very compact clay soils and saline soils do not suit *B. vulgaris*. *Dendrocalamus asper* largely occurs throughout Southeast Asia and has been introduced in Africa (Kigomo 2007). It grows in any type of soil but prefers heavy soils with good drainage. Culm height varies from 10–20 m for *B. vulgaris* and *D. asper* and from 3–10 m for *O. abyssinica*. Culm diameter ranges from 4–10 cm for all three species (Akoègninou *et al*. 2006) but is on average larger for *B. vulgaris* and *D. asper* than for *O. abyssinica* (Kigomo 2007, Kokutse *et al*. 2014). Clumps are denser (many culms) for *O. abyssinica* than for *B. vulgaris* and *D. asper* (Akoègninou *et al*. 2006, Kigomo 2007).

Sampling for ethnobotanical surveys

This study was conducted on 10 socio-cultural groups (Adja, Fon, Goun, Holli, Mahi, Nago, Toffin, Toli, Wémè, and Yoruba) in 90 villages, randomly selected in the 13 rural districts of the Ouémé-Plateau. Sample size was determined per district (Table 1). For this purpose, a pilot study was conducted on 55 individuals randomly selected from 4 villages of each district to estimate the proportion, *p*, of people who know and use bamboo. The sample size was then calculated based on the formula (Dagnelie 1998):

$$(1) \qquad n = \frac{(U_{1-\alpha/2})^2 \times p(1-p)}{d^2}$$

In equation (1), n is the sample size to be considered in the district, *p* is the proportion of people who know and use bamboo, $U_{1-\alpha/2}$ is the value of the normal random variable for a risk of α (for α = 0.05, $U_{1-\alpha/2}$ = 1.96), and d is the margin of error of the estimation of any parameter to be computed from the survey and was taken to be 5%.

The computed sample size n (Table 1) was equally distributed between the selected villages of each district. Men and women belonging to the above-listed 10 socio-cultural groups were randomly selected (Table 2), and interviews were conducted at their homes.

Data collection

The interviews were individual and conducted in the local language of the informants, with the researcher accompanied by a translator should the need arise.

The interviews focused on the parts of the bamboo species used, uses, and economic value using a semi-structured questionnaire. To record medicinal uses, a classification scheme based on medical conditions affecting the human body system (Collins *et al*. 2006) was used. These were disorders of the digestive, hormonal, nervous, urogenital, muscular, skeletal, and respiratory and vocal systems, as well as infections and subcutaneous disorders. To evaluate the importance of each specific use (j) of the category of use (k), each informant (i) was asked to score the uses they described based on three defined levels: high importance (3), medium importance (2), and low importance (1). Points of sale of bamboo culms indicated by the informants were also visited to gather information on selling prices. Information on selling prices in town were obtained with the same informants.

Data analyses

Informants were grouped according to their socio-cultural group, gender, and age category (Table 2). Traditional knowledge (TK) of the informants on bamboo was assessed using the Reported Use Value (RUV; Gomez-Beloz 2002). RUV is the total number of uses reported by an informant. Mean value of RUV was computed per socio-cultural group, gender, and age to determine how uses were distributed between and within each socio-cultural group, gender, and age category. Since the data did not meet normality and homoscedasticity assumptions, the Kruskal-Wallis rank sum test was performed to test statistical differences among socio-cultural groups, gender, and age categories (Höft *et al*. 1999).

To identify the most used bamboo part, Organ Use Value (OUV; Gomez-Beloz 2002) was calculated. OUV is defined as the ratio of the total number of uses reported by all informants of a given group for each bamboo organ

Table 1. Sample size per southeastern Benin district.

District	Proportion (p)	Sample size (n)
Adja-Ouèrè	0.960	60
Adjarra	0.985	23
Adjohoun	0.985	23
Aguégués	0.987	20
Akpro-Missérété	0.982	27
Avrankou	0.981	29
Bonou	0.985	23
Dangbo	0.982	27
Ifangni	0.980	32
Kétou	0.940	87
Pobè	0.950	78
Sakété	0.960	60
Sèmè-kpodji	0.982	27

Table 2. Number and characteristics (age and gender categories) of southeastern Benin informants according to each socio-cultural group. Age classes: Young (≤ 29 yrs), Adult (30–59 yrs), and Old (≥ 60 yrs).

Socio-cultural group	Women			Men			Total
	Young	Adult	Old	Young	Adult	Old	
Adja	3	4	-	3	-	-	10
Fon	3	12	-	3	8	-	26
Goun	1	10	-	5	22	1	39
Mahi	1	11	-	3	12	-	27
Nago	8	38	1	11	44	2	104
Toffin	4	1	-	13	10	-	28
Toli	3	10	-	30	50	2	95
Wémè	8	10	-	22	43	-	83
Holli	4	24	3	6	42	3	82
Yoruba	3	9	-	5	5	-	22
Total	38	129	4	101	236	8	516
Total	171			345			516

Table 3. Common names of bamboo in each socio-cultural group from southeastern Benin.

Socio-cultural group	Local name
Adja	**Bochi**
Fon	**Dawé**
Goun	**Kpalo**
Mahi	**Dawé**
Nago	**Akpalun/Akpa'hun**
Toffin	**Akpalo**
Toli	**Kpalon**
Wémè	**Gbaglo**
Holli	**Akpalun/Akpa'hun**
Yoruba	**Akpalun/Akpa'hun**

(RU_{org}) to the total number of reported uses (RU) reported for the three species.

$$(2) \qquad OUV = \frac{RU_{org} \times 100}{RU}$$

To assess the importance of each category (k) of bamboo uses, the Ethnobotanical Use Value (EUV_k; Philips & Gentry 1993) was computed. For each category (k) of use, EUV_k is the ratio of the sum of score (S_{ijk}) assigned by the informant (i) to the specific uses (j) in the category (k) of uses to the total number (N) of informants (Philips & Gentry 1993). For this purpose, specific uses were *a priori* classified according to the category of uses.

$$(3) \qquad EUV_k = \frac{\sum_{j=1}^{n_k} \sum_{i=1}^{N} S_{ijk}}{N}$$

In equation (3), n_k is the total number of specific uses in the category (k) of bamboo uses. Values of EUV_k were submitted to a Principal Component Analysis (PCA) to assess the pattern and variability of category of uses amongst the socio-cultural groups.

The Total Ethnobotanical Use Value (EUV_T), defined as the sum of Ethnobotanical Use Value (EUV_k) of all categories of use (Philips and Gentry 1993), was computed as a measure of the overall use value of bamboo. It is a measure of the importance or intensity of use.

$$(4) \qquad EUV_T = \sum EUV_k$$

Because data of EUV_T were normally distributed with homoscedasticity, one-way analyses of variance were used to test significance of differences among socio-cultural groups, gender, and age categories (Höft *et al*. 1999). All statistical analyses were performed within the R.2.15.3 system (R development Core Team 2012), and the significance level was set up at 5%.

Results

Local designation of the three bamboo species across the socio-cultural groups

Villagers referred to the bamboo by different local names (Table 3). There were different local groupings of bamboo species based on morphological variations of the culms

(color: green, yellow, brown; internode, height, internal, and external diameters) and leaves (color and texture). *Oxytenanthera abyssinica* was simply referred to as bamboo in each language. *Bambusa vulgaris* was commonly referred to with a prefix **yovo**- by the Adja, Fon, Goun, Mahi, Toffin, Toli, and Wémè people and with **ognibo**- by the Nago, Holli, and Yoruba people, both of which mean "white" or "from a European origin." *Dendrocalamus asper* was often called by the local name of *B. vulgaris* in each language, signifying a large diameter and height.

Effect of socio-cultural group, gender, and age category on TK of informants on bamboo

The Reported Use Values (RUV) measuring TK for each socio-cultural group, gender, and age category are summarized in Table 4. RUV significantly varied among socio-cultural groups ($P < 0.001$), gender ($P < 0.001$), and age categories ($P < 0.05$). The Goun, Toli, Yoruba, and Holli knew more uses than the Adja, Fon, Mahi, Nago, Toffin, and Wémè people. Men knew more uses of bamboo than the women regardless of socio-cultural group and age category. The elderly and middle-aged informants knew more uses than younger people.

Pattern in bamboo plant parts usages

Although all parts of the bamboo plants were used, the most used plant parts were the culms (73%) and leaves (23%) (Figure 2). The different specific uses and parts of the bamboo are summarized in Table 5. Thirty uses out of forty-four (68%) were reported by at least 20% of the informants. Only the leaves of *O. abyssinica* were harvested for medicinal use. Culms of the three species were harvested but mostly of *O. abyssinica*.

Use value of bamboo and variation according to categories of use, socio-cultural group, gender, and age category

A total of nine categories of use were recorded including material, implement, agriculture, medicine, firewood, commercial, worship, environment, and social. Use for material and implement were the most extensive, followed by agricultural and medicinal uses, and as firewood. Results from the principal components analysis (PCA) performed on the Ethnobotanical Use Values (EUV_k) per category of use and socio-cultural group showed that the first two axes accounted for 69.75% of the observed variation. Correlations between principal components (axes) and

Table 4. Results of the statistical tests on Reported Use Value (RUV) and Total Ethnobotanical Use Value (EUV_T) of bamboo as related to sociocultural, sex, and age groups of study participants from southeastern Benin. †Kruskal-Wallis test. The Average Rank allows for distinguishing groups with high or low RUV compared to the overall average rank (258.5). ††Analysis of variance test. SE = standard error; *p*-value = probability value.

	RUV †				EUV_T ††		
Factors	**Mean**	**SE of Mean**	**Average Rank**	***p*-value**	**Mean**	**SE of Mean**	***p*-value**
Socio-cultural group							
Adja	18.3	0.84	84.9	< 0.001	4.6	0.80	< 2e-16
Fon	20.2	0.57	159.8		6.8	0.50	
Goun	27.4	0.45	433.9		7.5	0.41	
Mahi	19.8	0.45	138.3		6.6	0.49	
Nago	20.8	0.27	179.6		10.7	0.25	
Toffin	20.1	0.39	148.5		10.7	0.48	
Toli	26.0	0.28	396.0		10.1	0.26	
Weme	21.3	0.26	198.6		8.8	0.28	
Holli	23.3	0.30	290.6		12.1	0.28	
Yoruba	24.2	0.73	316.0		3.7	0.54	
Gender							
Men	23.3	0.19	281.6	< 0.001	10.1	0.14	0.037
Women	21.6	0.27	212.0		8.2	0.19	
Age category							
Young	22.4	0.30	245.0	0.030	9.2	0.21	0.043
Adult	22.8	0.19	260.2		9.5	0.13	
Old	25.0	0.76	362.0		11.1	0.73	

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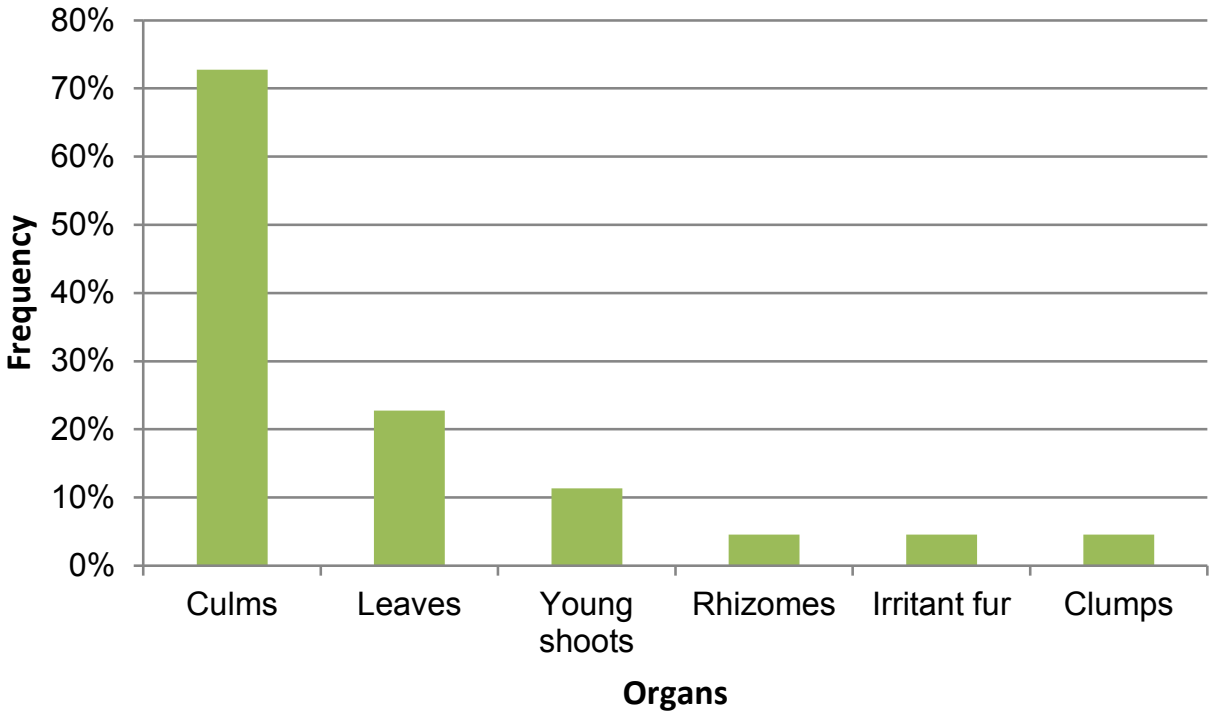

Figure 2. Combined Organ Use Value (OUV) of three bamboo species (*Oxytenanthera abyssinica* (A.Rich.) Munro, *Bambusa vulgaris* Schrad. ex J.C.Wendl., and *Dendrocalamus asper* (Schult. & Schult. f.) Backer ex K.Heyne) in southeastern Benin.

Table 5. Summary of information from study participants from southeastern Benin regarding importance and use of local bamboo species. EUV_k = Ethnobotanical Use Value. Organ(s) used: culm (Cu), clump (Cl), irritant fur (F), leaf (L), rhizome (R), young shoot (S). *f* = proportion of informants who mentioned the specific use.

Use category	EUV_k	Specific uses	Organs	*f* (%)
Materials	2.35	Habitat buildings (wall, stake, framework, ceiling)	Cu	97
		Shed building (**palaver**, market, and other sales places), ceremonial temporary construction (**kpèhounkpè** or **azava** in Goun, Fon, & Toli)		96
		Garret construction (wall, stake, framework, ceiling)		70
		Palisade construction (wall, crosspiece) around habitat or field		96
		Beam: bridge construction, canoe anchor, tomb closure		36
		Bamboo grid-construction		65
		Household goods-construction (bed, sofa, stool, bench, table, shelf)		66
		Electric perch, perch for antenna		76
		Scaffold and flagging perches		69
Implements	1.80	Traps (rodents, fish): fish-hook for perch; bow & arrow for rodent hunting	Cu	35
		Ladder-construction using shoots with nodes (used to climb raffia palm in swamps)		54
		Handles (pickaxe, shovel), canoe oar		6
		Stretchers for transporting dead		20
		Palm wine piping (from cut down tree to calabash)		45
		Tobacco pipe, cigarette handler, and ashtray		6
		Containers: bag, kit, torch case, domestic cashbox, drinking glass/bowl		3

Use category	EUV_k	Specific uses	Organs	*f* (%)
Agriculture	1.25	Watering troughs for poultry and cattle	Cu	30
		Fodder for herbivores (leaves) and rodents (young shoots)	L, S	37
		Stock folds (for pigs, sheep, goats, poultry) or beehives	Cu	60
		Fish breeding systems (enclosure for fish within a lake)		63
		Fish pond erosion protection		12
		Stand and cover for creepers or young plants		20
		Fertilizer	Cu, L, S	7
Medicine	1.09	Treatment of infections and subcutaneous disorders, malaria, and fevers (leaf, young shoot, rhizome). Treatment of smallpox, jaundice, paleness, and elephantiasis (leaf)	L, S, R	74
		Treatment of digestive system disorders or diabetes	L	<1
		Treatment of hormonal system disorders or hypertension		1
		Treatment of nervous system disorders, vertigo, epilepsy, headaches, toothaches, memory trouble	L, S	15
		Treatment of respiratory problems such as asthma (leaf) and vocal system disorders such as stuttering (leaf, young shoot)		20
		Treatment of muscular system disorders through an invigorating effect	L	10
		Treatment of skeletal system disorders such as calcium deficiency	L, Cu	1
		Treatment of urogenital system disorders including standing and/or painful menses, lightening parturition, sexual weakness, or impotence.	F, L	25
		Skin ulcers/irritations	F	15
Firewood	0.79	Firewood	Cu	73
Commerce	0.36	Trading shoots	Cu	87
		Trading firewood		24
		Trading bamboo grids		41
		Trading bamboo leaves for medicinal uses	L	7
Worship	0.36	Animistic religious rites/worship	Cu	35
		Magic to improve social status (only reported by Holli informants)		2
Social	0.23	Flagpole for flags and cultural emblems	Cu	31
		Musical instruments (**kakahoun**, **akohoun**, **balafon**)		62
		Instruments for traditional dance (**kpodji guèdè**, **agbéhoun**)		55
Environment	0.10	Prevention of soil erosion	Cl	21
		Provision of shelter and as a riverside bathing wall		17

different use categories revealed a positive link between agricultural, worship, firewood, material, and social uses (axis 1) and a negative link between agricultural, commercial, and environmental uses and firewood use (axis 2) (Table 6). Figure 3 is a projection of socio-cultural groups onto the two axes of the PCA. The Toli gave the highest commercial, environmental, and agricultural values to bamboo, whereas the Toffin gave the highest values to social, material, agricultural, and medicinal uses of bamboo. The Nago and Holli showed similarities about their preferences for implemental, worship, material, social, and agricultural uses. Likewise, the Mahi gave the highest values to firewood and worship uses.

The Total Ethnobotanical Use Values (EUV_T) of bamboo in the study area are summarized in Table 4. Significant differences were observed among socio-cultural groups, gender, and age categories. There was a large variation in EUV_T, from 3.7 to 12.1. Highest value of EUV_T was recorded for the Holli people (12.1). The lower values were recorded for Adja (4.60) and Yoruba (3.70). Holli, Nago, Toffin, and Toli people thus valorized bamboo more than the other socio-cultural groups. Men and old people also obtained higher values of EUV_T compared to women and young and adult people respectively (Table 4).

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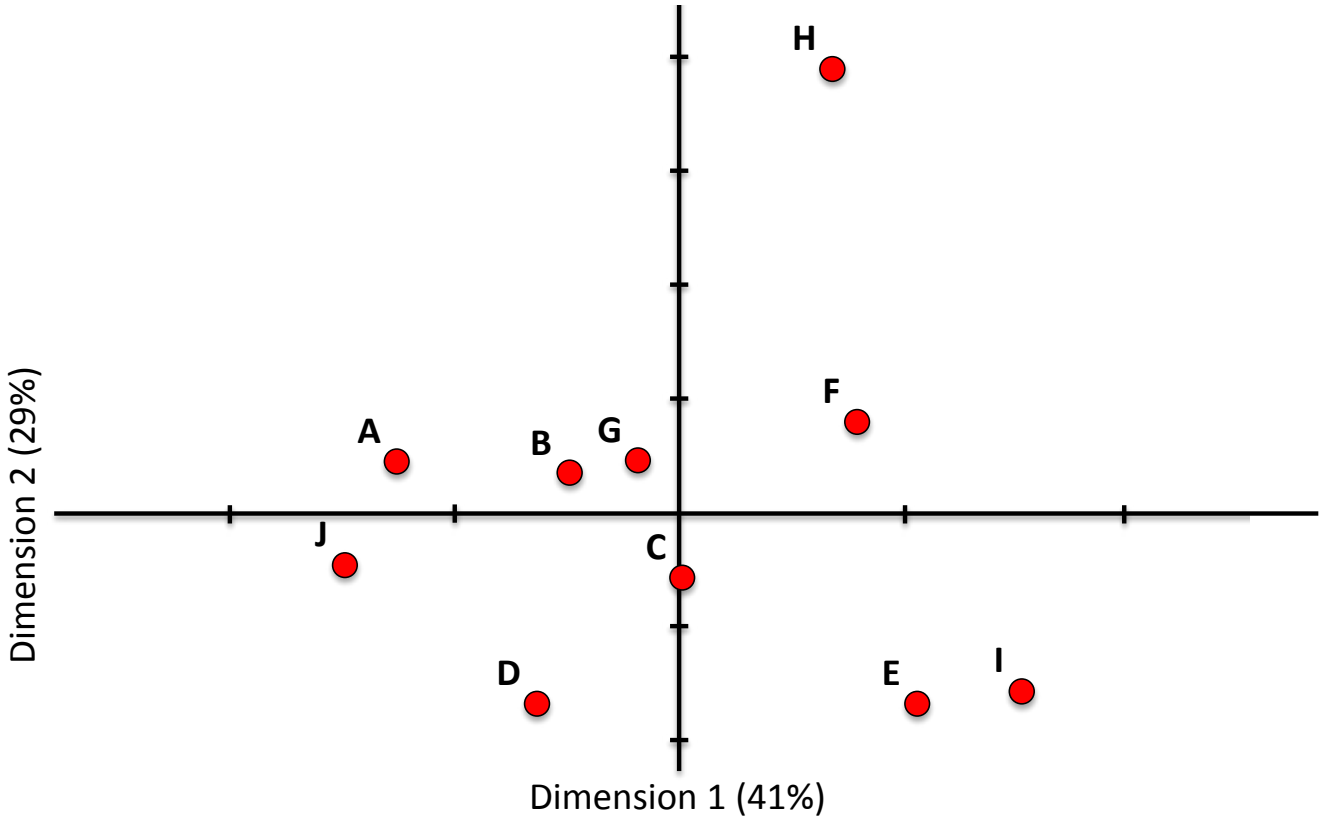

Figure 3. Principal Components Analysis with component dimension axes explaining highest percentages of relationships among socio-cultural groups of southeastern Benin. Socio-cultural groups: **A**. Adja, **B**. Fon, **C**. Goun, **D**. Mahi, **E**. Nago, **F**. Toffin, **G**. Toli, **H**. Weme, **I**. Xoly, and **J**. Yoruba.

Table 6. Correlations between Principal Components Analysis axes and bamboo use categories among socio-cultural groups of southeastern Benin.

Use category	Axis 1 (40.56 %)	Axis 2 (29.19 %)
Agriculture	0.72	0.55
Commerce	-0.02	0.94
Worship	0.74	-0.46
Firewood	0.50	-0.74
Environment	0.30	0.66
Implement	0.70	-0.35
Material	0.97	0.10
Medicine	0.47	0.00
Social	0.77	0.36

Bamboo culms market value

Bamboo culms were sold to foreigners, mostly in the riverine areas of the Ouémé-Plateau, bordering other departments and neighboring Nigeria. Only 10% of informants (from individual interviews) reported that they buy bamboo culms, and 16% indicated they are sellers of bamboo parts. During the study, there were only 5 places of sale for bamboo culms in the 90 villages surveyed. Currently, the places of sale for bamboo culms are mostly located in urban areas together with other timber. Bamboo culm prices varied (Table 7) depending on species, place (village or town), and culm quantity to be sold (wholesale or retail). *Dendrocalamus asper* and *B. vulgaris* were more expensive than *O. abyssinica*. Bamboo culms were about 2.5 and 6.2 times more expensive in town than in village for *B. vulgaris* and *O. abyssinica*, respectively. We did not find any place of sale for *D. asper* culms in villages. Contrary to villages where bamboo culms could be sold retail or wholesale, they were only sold retail in town.

Table 7. Mean and standard error (SE) of bamboo species culm prices (US$) from markets in southeastern Benin.

Species	Market	Retail (US$)		Wholesale (US$)	
		Mean	SE	Mean	SE
Oxytenanthera abyssinica (A.Rich.) Munro	Village	0.25	0.09	0.22	0 .03
	Town	1.55	0.17	-	-
Bambusa vulgaris Schrad. ex J.C.Wendl.	Village	0.88	0.12	0.57	0.05
	Town	2.33	0.33	-	-
Dendrocalamus asper (Schult. & Schult. f.) Backer ex K.Heyne	Town	3.10	0.42	-	-

Discussion

This study reveals the crucial contributions of bamboo to the livelihood of local communities in southeastern Benin as well as the knowledge that these communities hold on it. We focused on variations of traditional knowledge among 10 socio-cultural groups, gender, and age categories and the economic value (sales) of the most used bamboo part. The results provide a substantive database that would help involve both the authorities in charge of natural resources management and the local people in the sustainable use and conservation of bamboo species as well as related traditional knowledge.

Local designation of the three bamboo species across the socio-cultural groups

Although local designations varied among socio-cultural groups, all designations whatever the socio-cultural groups clearly separate the native bamboo species, i.e., *O. abyssinica* from the introduced ones (*D. asper* and *B. vulgaris*). The local designations of the two latter are the same, but informants clearly distinguish them based on morphological variations of the culms and leaves.

Patterns and diversity of bamboo part usage

Results of this study agree with the results of other studies that culms and leaves are the most harvested parts of the bamboo plants (Bystriakova *et al*. 2004, Cusack 1999). Benton *et al*. (2011b) also reported high involvement of bamboo culms in diverse uses of bamboo. In the study area, culms and leaves of bamboo are likely crucial goods for population livelihoods as reported in several areas of Asia and America (Bystriakova & Kapos 2006, Rashford 1995). Specifically, about 97% of informants in the area (N = 516) reported that bamboo culms are frequently used, indicating that culms may have higher use and economic values than other bamboo parts.

There were nine use-categories for bamboo, the most important being material, implement, agriculture, and medicine. Domestic utensils and furniture, stalls, walls, and bridges are commonly made of bamboo culms. The study also revealed that bamboo culms are useful to people in agriculture, as documented by Umara *et al*. (2011). The latter showed the performance of culms of *O. abyssinica* for small-scale irrigation. However, in our study, this was not the case; most of the informants live in lacustrian areas where there is a high demand for *O. abyssinica* for fencing of fingerling breeding grounds to improve fish production in a traditional intensive fish production system called **acadja**. **Acadja** is an artificial system that enhances fish production by providing additional substrate for development of plants and animals upon which the fish feed (Niyonkuru & Lalèyè 2010). This result is quite different from most reports on bamboo-related fishing activities (Rashford 1995, Yuming *et al*. 2004). The high use of bamboo culms is also evidenced by the need to make rafts and canoes for waterway transportation and for dredging activities which are potential income sources. As perspective, the value chain of bamboo and related products needs to be explored in the context of markets at local, national, and international levels to help develop local and national economies. Although international trades of bamboo products in Africa are lagging as a result of the little cultivation of bamboo species (Bystriakova & Kapos 2006), there are promising experiments being carried out in many African countries (Kigomo 2007, Kokutse *et al*. 2014), but little is yet done in Benin.

Apart from the uses of bamboo for its culms, young bamboo shoots and leaves are also used, especially in medicine, in agriculture as fertilizers, and as fodder for herbivores and rodents. Curiously, informants did not report any consumption of young bamboo shoots, in contrast to other regions of Asia and America where young bamboo shoot is a highly popular edible vegetable (Benton *et al*. 2011b). The non-consumption of young bamboo shoots in the area may result from the lack of knowledge on preparation methods. It confirms the cultural-dependence of the use of a species as food (Avohou *et al*. 2012).

Leaves of bamboo, especially of *O. abyssinica*, are traditionally used as an herbal remedy. According to the informants, *O. abyssinica* is a native bamboo species, and its

medicinal uses are strictly suited with particular rites. Instead of using other bamboo species that are considered exotic, they prefer the one indexed by their ancestors as a medicinal plant. The association of *O. abyssinica* with spirits has been evidenced elsewhere for bamboo in general, often seen as a source of spiritual vitality (Yuming *et al*. 2004) and as shelter for dead spirits (Rashford 1995).

Informants cited more uses for *O. abyssinica* than for the two other species although this is not explicitly shown in our analyses. The preferential uses of *O. abyssinica* may first be linked to the fact that *O. abyssinica* is more abundant and is easily accessible in the study area. This may also be a result of a successful transmission of traditional knowledge among generations, despite the introduction of new bamboo species (i.e., *B. vulgaris*, *D. asper*). Indeed as a native species occurring in the area for centuries, a strong relationship would have been established between *O. abyssinica* and the rural people over time such that this knowledge has been passed down over generations (Campos & Ehringhaus 2003).

Traditional knowledge (TK) on bamboo and use value among socio-cultural groups

Six out of the ten surveyed socio-cultural groups have notably common knowledge on uses of bamboo for housing and construction. The majority of knowledge (68%) was also shared according to Tramil criteria which assume consensus when a use frequency attains 20% or more (TRAMIL 4 1989). This means that with time, socio-cultural groups, even if each one had its own cultural practices, would have exchanged their knowledge. Such exchanges could occur through friendship, kinship, and inter-socio-cultural group marriages (Avocèvou-Ayisso *et al*. 2011, Campos & Ehringhaus 2003) due to geographical proximity as reported for Rama and Miskitu indigenous groups in Nicaragua (Coe 2008).

In spite of these possible exchanges, there were significant variations in TK and ethnobotanical use value of bamboo among the socio-cultural groups. The Goun, Toli, Yoruba, and Holli were more knowledgeable about the bamboo uses than the other socio-cultural groups, with the Goun and Toli having the highest reported use value. Similarly the socio-cultural groups valued bamboo differently, with the Holli, Nago, Toffin, and Toli having the highest ethnobotanical use values. Differences in TK on uses of bamboo and ethnobotanical use values among socio-cultural groups have been well documented in past studies. Examples include the Fulani, Gourmantché, Berba, and Bariba with regards to *Tamarindus indica* L. (Fabaceae) (Fandohan *et al*. 2010) in northern Benin; the Kaxinawa and Yawanawa with regards to *Attalea tessmannii* Burret (Arecaceae); and the Seringueiros and Ribeirinhos with regards to *Euterpe precatoria* Mart. (Arecaceae) (Campos & Ehringhaus 2003) in southwestern Amazonia. This supported the first hypothesis suggesting differences in TK and use value of bamboo among socio-cultural groups and indicated that some socio-cultural groups know and valorize bamboo more than others. This variation of knowledge and use value of the people should therefore be taken into consideration when designing sustainable strategies for management of bamboo stands with implications for local people (Cruz *et al*. 2013). Indeed, attempts to promote rural development that reconciles improvements in the quality of life and conservation of natural resources are likely to succeed when based on the local knowledge and current patterns of resource use within the involved communities (IES 1995). As such, the Toffin and Toli would be pleased to be involved in strategies aiming to shift from collection of wild individuals to bamboo species plantation since they highly value bamboo for agricultural and commercial uses. Similarly the Nago and Holli should be involved in management strategies aimed at developing modern local tool making and building technologies and improvement in the use of bamboo species for medicine in Benin.

Results also indicated that Goun and Yoruba people were among the most knowledgeable on bamboo and recorded relatively low use values (see Table 4). This is because Goun and Yoruba people, particularly young and adult people of these socio-cultural groups, give importance to some flourishing marketing activities such as trade of petroleum, taxi-drivers, etc. So, they know many uses of the bamboo species, but they perhaps do not have time to practice them as well.

Traditional knowledge (TK) on bamboo and use value as related to age category and gender

There were also significant variations in TK and use value of bamboo among age categories and according to the gender. Irrespective of gender, older people had more knowledge and valued bamboo more than younger people, supporting our second hypothesis. In this study, the fact that the elderly and middle-aged people were more knowledgeable than younger people is consistent with the hypothesis that knowledge is accumulated over time and from generation to generation (Albuquerque & Hanazaki 2009, Beltrán-Rodríguez *et al*. 2014). However, this result could also mean that younger people are less interested in those categories where most citations were obtained from older and middle-aged people, such as some traditional rites and practices (e.g., mast fishing). Therefore, this could be a great threat for the preservation of TK. A temporal analysis of knowledge and uses (Albuquerque & Hanazaki 2009) will help inform possible exchange of knowledge and give more insight into that.

Men had more knowledge and used bamboo more than women in the studied communities, supporting the third hypothesis. Variation in TK according to gender is supported by the type of labor, professional activity, or so-

cial role (Camou-Guerrero *et al*. 2008). Indeed, bamboo culms were the most harvested parts, and materials and implement uses were most cited. In addition, activities involving harvest of the bamboo culm and its transformation were mostly implemented by men who had greater resource control over bamboo than the women. As also indicated by women in the field, bamboo is mostly "men things." These results imply that conservation actions should prioritize old and adult men but should not neglect young men as they should take over.

Bamboo marketable value according to the area and bamboo species

Bamboo culms have gained marketable value only in the last decade. As testified by the informants, this was not the case some fifteen years ago. About 26% of informants are bamboo traders of which 16% are sellers and 10% are buyers of the bamboo culms. This confirms that bamboo culms which were not traded in the past are now gaining interest in the market. This finding is consistent with the assumption that use and commercial values of plant species are time-dependent and selective (Campos & Ehringhaus 2003). The price of bamboo culms is dependent on the area (village and town) and on the species. As hypothesized, the selling price is higher in town than in villages. Analogously, the price is higher for species with large and tall culms. *Dendrocalamus asper* and *B. vulgaris* had higher prices than *O. abyssinica* whose culms are not as large or as tall. Previous economic studies on bamboo also yielded the conclusion that characteristics such as diameter, height, and hardness determine bamboo price (Wong 1995). Based on that, we believe that a good management plan to master the production of the three studied bamboo species could significantly sustain rural people livelihoods, as the demands for housing and materials (for *D. asper* and *B. vulgaris*) and for both housing and fishing (for *O. abyssinica*) are increasing in the study area. This is especially true since (1) the harvest of bamboo is becoming an important economic activity that could contribute to the overall income of local people (Mukul & Rana 2013) and (2) the lack of an appropriate management scheme may also, in some decades, lead to the rarefaction of the bamboo species due to overharvesting (Bystriakova & Kapos 2006).

Conclusion

This study evidenced that bamboo plays an important role in the enhancement of the livelihoods of rural people. Results support the hypothesis that age, gender, and sociocultural groups are determinant variables of traditional knowledge and use value of plant species. It also clearly evidenced the location- and size-related price of bamboo culms. These findings encourage actions that will contribute to preserve traditional knowledge while sustaining the means of people livelihoods. Actions should involve sociocultural groups according to their knowledge and preferential uses, as described above. These actions must focus on men who are the most involved in bamboo valorization, but should not neglect women in general. Actions must also look at the promotion of new, enhanced ways to efficiently use bamboo plants for construction and decoration purposes, as is the case in China. For instance, handiworks from bamboo plants can be modernized in a way to increase artistic and market values of the products. This is particularly important since the economic improvement will lead people to opt for other materials. The bamboo culms, for example, can also be converted into charcoal as substitute for charcoals from forest trees and mineral coal, instead of being used directly as firewood. Developing a technical framework of bamboo production (plantation), especially *O. abyssinica* for fishing in **acadja**, may also reduce pressure on other tree resources.

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