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Local Values, Social Differentiation and Conservation Efforts: The Impact of Ethnic Affiliation on the Valuation of NTFP-Species in Northern Benin, West Africa

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Abstract Non-timber forest products contribute significantly to rural livelihoods in the West African savannas. This study investigates differences in use preferences for native woody species in six categories of plant use and their economic returns among five ethnic groups in Northern Benin. Ethnobotanical survey data from 230 households revealed that both ethnic affiliation and location significantly impact species' valuation. Of a total of 90 species, 61 % were used for medicinal applications, 41 % as firewood, 39 % for construction, and 32 % as human foods. While certain plant species were used by all rural dwellers, others were used exclusively by particular ethnic groups. *Vitellaria paradoxa, Parkia biglobosa* and *Adansonia digitata* are key economic species for all groups. Conservation measures should consider multi-purpose trees fulfilling subsistence and cash needs while taking into consideration cultural differences in use preferences.

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Introduction

Non-timber forest products (NTFPs) have been an important element in traditional livelihoods and cultural traditions in West Africa for centuries. Rural communities pass on knowledge about traditional uses of plant species for various household requirements, their cultural importance and roles in spiritual applications and ceremonies, as well as their ecological relevance in complex ecosystems and their ecological status through the generations. Wild fruits, leaves, seeds, bark, grasses, wood, fish and game are essential components for meeting household subsistence and consumption needs and at the same time provide a safety-net in the event of crop failure or other income shortages. NTFPs also contribute to total household income.

Recent studies have highlighted the economic importance of NTFPs for livelihood maintenance in sub-Saharan Africa in terms of both subsistence and cash income. For example, in Malawi, Kamanga *et al.* (2009) report fruit trees on common land on average contribute 15 % to total household income, and de Merode *et al.* (2004) report that wild plants account for up to 10 % of total food consumption in the Republic of Congo. For Northern Ethiopia, NTFPs constitute 27 % of total income (Babulo *et al.* 2009), and in Zimbabwe is even higher at 35 % (inclusive animal and soil products). This latter figure corresponds with recent findings in Northern Benin where NTFPs accounted for approximately 39 % of household income, representing the second largest share within total income. Similarly, Faye *et al.* (2010) reported that households in Mali obtained at least 40 % of their annual revenue from selling tree and shrub products.

However, recent scientific observations have led to growing concern that NTFP-producing trees have been undergoing

a subtle decline due to newly introduced agricultural practices), land-use intensification, introduction of alien species, over exploitation, and declining rainfall (Faye *et al.* 2010; Paré *et al.* 2010), as well as unsuitable law regulations and land tenure that hamper proper and sustainable management of important NTFP-producing trees.

There is increasing evidence that the inclusion of local use preferences and traditional knowledge in the design of conservation strategies to maintain and sustainably use these species contributes considerably to preserving both socio-economically important species and those that play critical roles in maintaining ecosystem functions Taita 2003; Lykke *et al.* 2004; Ticktin 2004; Paré *et al.* 2010; Schumann *et al.* 2010). Unsurprisingly, since traditional conservation practices are based on long-term observations by rural communities (Berkes and Folke 2002) coping with complex environmental changes, local knowledge provide a "library of information" in terms of dynamic change management (Berkes *et al.* 2000).

Traditional knowledge and plant use can differ among groups in diverse localities and with differing cultural backgrounds, as well as among individual users depending on characteristics such as gender, age, present place of domicile, amongst others, and contextual factors such institutional regulation (e.g., de facto access to plant resources), ecological conditions and abundance of species. Kepe (2008) noted that social differentiation is a key factor determining resource use in forest-based communities due to specific combinations of social affiliation to certain groups or networks (e.g., ethnic groups, user groups) and individual characteristics which, in addition, may be subject to changes. Knowledge is differently expressed and transmitted within communities due to diverging preferences of users (Gaoue and Ticktin 2009) entailing heterogeneity in species valuation among members of the same and/or between different groups and leading to a culturally conditioned regulation of natural resource use (Belem *et al.* 2009; Vodouhê *et al.* 2009).

Recent studies in Benin and Burkina Faso, West Africa, showed that use values for particular woody plant species differed according to ethnic affiliation and regional proximity of ethnic groups in addition to age, gender, access to farmland as well as marketability of species. De Caluwé *et al.* (2009) found significant differences in use values and use patterns of baobab (*Adansonia digitata*) between the Ottamari and the Dendi in Northern Benin, where Fandohan *et al.* (2010) found differences between ethnic groups with regard to knowledge of *Tamarindus indica*. In the Sudanian zone of Burkina Faso, Schumann (2011) identified differences in baobab uses among Gulimanceba villages. Gouwakinnou *et al.* (2011) noted variations among different locations in usage of products of *Sclerocarya birrea*.

However, few studies have investigated the relative cultural importance of a wider set of multi-purpose species, particularly for different ethnic groups (Schreckenberg 1999; Lykke *et al.* 2004; Vodouhê *et al.* 2009; Paré *et al.* 2010). This study contributes to further understanding of the impact of ethnic affiliation on local use preferences and valuation of local native woody plants (cf. Kepe 2008; Taita 2003). Additionally, by explicitly incorporating the economic role of NTFP-producing trees into our analysis we are complementing the existing scientific record substantially since such data are essential to design appropriate conservation measures.

We conducted a quantitative ethnobotanical survey among five different ethnic groups in two villages of the Sudanian zone of Northern Benin, West Africa, to identify patterns of and differences between these groups with regard to use and valuation of different native woody plant species and their products (NTFPs). In particular, we sought to investigate species' use-values for their various subsistence uses and detect whether and to what extent they are also economically relevant for rural households.

We addressed the following questions: Do ethnic groups differ in terms of use preferences for woody species, and does location influence their preferences? Which are the most important plant species for rural households in terms of cash income in general and does their economic relevance change by virtue of ethnic affiliation? And lastly which are the 30 most important ligneous species of our sample, within which categories of plant use are they most valued and for what reasons?

Methods

Study Area: Biophysical Environment and Socio-Economic Setting

We conducted our study in two villages, Papatia and Chabi-Couma, in northern Benin, Department of Atakora (Fig. 1). Both villages are located about 33 km from the closest urban centre, Natitingou, and display similar socio-economic profiles: they have piped water, a local primary school and a small market; neither have electricity and energy demand is primarily covered by firewood. Differences exist with regard to the number of households (Chabi-Couma roughly 860 and Papatia 450 households), market size (considerably larger in Chabi-Couma), and large plantations of non-native tree species (e.g., *Tectona grandis*, *Mangifera indica, Musa spec*.) occur only in Chabi-Couma. The majority of residents belong to one of the five major ethnic groups, i.e., Fulani, Ditammarie, Yom, Bariba and Kabiyé.

The study region belongs to the southern Sudanian zone, which is characterized by a tropical climate with a rainy season lasting from May to November. Mean annual precipitation is about 1,300 mm per m^2 and the annual average temperature is 27 °C (see Krohmer 2004).

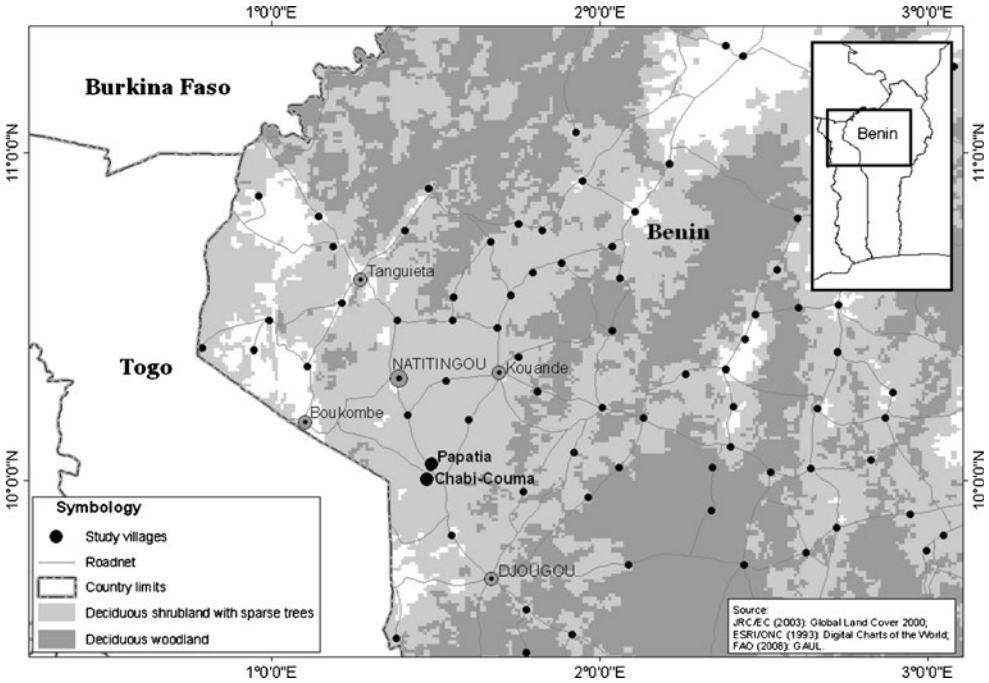

Fig. 1 Map of the study area (Department of Atakora) with the two studied villages Papatia and Chabi-Couma. Large black dots (*labelled*) represent the two study villages; other smaller black dots (*unlabelled*) are displayed in order to show the density of villages located within the savanna ecosystem

According to the land cover map of the European Commission Joint Research Centre (Mayaux *et al.* 2003) the area under investigation is covered with deciduous shrublands with sparse trees (Fig. 1). Vegetation ranges from tree, shrub and grass savanna to dry forests being dominated by the woody species *Isoberlinia doka.* The herb layer is dominated by annual and perennial grasses reaching considerable heights (> 2 m; see Krohmer 2004).

The dominant livelihood in the region is rain-fed crop production (sorghum, millet, maize, legumes, yams and manioc, groundnuts, amongst others) in traditional shifting cultivation systems (agroforestry systems), i.e., fallow of between five up to 15 years. Due to the small-scale land use a typical mosaic pattern of fields and fallows emerges. Additionally, by virtue of sparing particularly useful tree species from felling while clearing areas for cultivation, so-called parklands form part of the savanna landscape. Conserved tree species on fields are principally mature trees providing high-valued NTFPs (Schreckenberg 1999), e.g. *Vitellaria paradoxa*, *Adansonia digitata* and *Parkia biglobosa*. Livestock include cattle, medium-sized livestock (goats, sheep, and hogs), and poultry (chickens, guinea fowl). Animal husbandry is not major income source (Heubach *et al.* 2011). It should be noted that due to a severe epidemic in 2008, the year before our study, the entire livestock population in the region dropped dramatically.

Key Characteristics of the Ethnic Groups

Historically, the Bariba people are autochthonous to the study area, whereas the other groups migrated into the region: The Fulani from east of the Beninese Atakora chain, the Ditammarie and the Kabiyé from Togo, and the Yom from the Beninese Department of Bassila, to the south of the study area. Four of the five groups are traditional tiller societies (Ditammarie, Bariba, Yom and Kabiyé). The Fulani are originally nomadic pastoralists herding cattle on fixed annual transhumance routes, but, due to ongoing pressure for agricultural land and severe drought events many in the region have quit transhumance and started to settle and adopt farming as their major livelihood activity (de Bruijn and van Dijk 1994; Bolwig and Paarup-Laursen 1999), with only a small proportion maintaining recognizable herds of cattle. Regardless of ethnic affiliation, all households were headed by males and showed similar characteristics in terms of average household size, average formal education of household head, and farm size. However, the Fulani were the only group owning cattle and engaging in animal husbandry (Table 1).

Within the traditional land tenure system, immigrants mostly borrow- or rent land and have fewer rights than land holders (usually autochthonous villagers). Extracting NTFPs from trees remaining on fields is the exclusive right of land owners even when the land is cultivated by others: The larger the land holding, the greater the opportunities to gather NTFPs from 'private' trees without competing with other collectors. Conversely, households with borrowed land have to compete for common woodland resources to meet their needs. Common woodland within the village area is divided into distinct areas allocated to the different ethnic groups. Beyond the village boundary, access to woodland resources is open to everyone.

Table 1 Household characteristics of studied ethnic groups (Fulani, Ditammarie, Yom, Bariba, Kabiyé)

	Fulani		Ditammarie		Yom		Bariba		Kabiyé	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Socio-economic attributes of households										
Household size (head count)	9.1	0.9	8.7	0.6	11.8	1.5	7.5	0.8	10.0	1.0
Major age group of household head (years)	36–45		36–45		36–45		36–45		36–45	
Education of household head (years)	0.7	0.4	2.2	0.6	1.2	0.5	0.2	0.1	0.2	0.2
Household with polygamy (%)	64.3		37.0		41.3		11.9		23.8	
Main employment: tiller (%)	92.9		95.7		100.0		97.6		100.0	
Main employment: livestock breeder (%)	4.8		–		–		–		–	
Households with secondary employment (%)	38.1		80.4		60.9		61.9		78.6	
Households with tertiary employment (%)	14.3		4.3		0.0		16.7		4.8	
Secondary employment: retail dealer (%)	11.9		60.9		50.0		31.0		66.7	
Secondary employment: traditional healer (%)	16.7		6.7		0.0		4.8		0.0	
Mean income per aeu (in Euro)	704	65	694	47	690	29	731	61	644	36
Index of diversification	1.90	0.09	2.02	0.05	2.03	0.04	2.05	0.07	2.03	0.04
Household assets										
Farmland size (ha/household)	3.0	0.2	4.4	0.3	4.2	0.2	3.6	0.3	3.7	0.2
Cattle per household	8.4	2.0	–		–		–		–	

Data Collection

We conducted a structured household survey containing questions concerning, firstly, socio-economic profiles of the households (closed questions) and, secondly, use preferences for and knowledge about useful woody species (open questions). The survey yielded a total of 230 households representing 26 % and 13 % of the population of Papatia and Chabi-Couma, respectively. Households were selected randomly but by means of their ethnic affiliation (46 households of each ethnic group, i.e., 23 per village). The interviews took place between May and July as well as September and December 2009 and were carried out in the five ethnic languages. Plant species were recorded by their local names and later on identified through field work with local healers complemented by specimens. Information about general aspects of the two villages (population size, land tenure, access, etc.) was gathered through both formal key informant interviews (e.g., administrative chiefs) and informal participatory discussions with villagers and interviewers assisting with the scientific work.

In accordance with local tradition, we interviewed both the male household head (aged between 20 and 95) and his (first) wife (aged between 19 and 84) individually for particular categories of plant use. Categories were selected according to Belem *et al.* (2009). Women gave information about the species collected for human food, firewood, traditional medicine, as dyes, as well as for commercial use. They were asked to report quantities and prices of NTFPs sold on local markets. Men reported plant species used for construction purposes (tools, material for mats, cord, etc.) and provided information about the household's socio-economic status (number of household members, sources of income, levels of education, etc.).

Careful enumeration and data cleaning secured a response rate of usable questionnaires of 98.7 % (N=227). Following Borgatti and Halgin (2011), all species mentioned by at least two respondents were included in the analysis. Triangulation of data was performed by comprehensive key-informant interviews (e.g., with traditional healers, market-women, the elderly), market analysis of locally traded NTFPs and participatory observation.

We here use the term 'NTFPs' for all parts of uncultivated native plants extracted from savanna shrublands, i.e., seeds, fruits, vegetative textures (leaves, bark, bulbs etc.) as well as diverse small woody items (twigs, stems) (Cunningham 1996). We excluded cultivated, alien tree species (e.g., *Anacardium oxidentale*, *Mangifera indica*) as they are planted in large plantations and are therefore considered as cash crops, as well as plants grown in home gardens.

Income Accounting and Adjusting

The survey contained questions concerning the amount of NTFPs harvested, their current market prices, as well as the annual income from their sale. In order to calculate both annual total household income (the sum of cash income and the monetary equivalent of a household's subsistence use of respective products) and cash income from NTFPs we used means of local market prices (observed monthly at the markets of Chabi-Couma and Papatia) and households' own-reported values given the local units of measure (e.g., *lasoytatiya,*

Table 2 Wood uses: List of species covering the five most important tree species used for construction wood (A), tool wood (B) and firewood (C) by ethnic group. Species were ordered according to their importance within the use category (UV_{SC}). Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
A	**CONSTRUCTION WOOD** (35 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	16	Rank	19	Rank	16	Rank	18	Rank	14	Rank
1	*Oxynanthera abyssinica*	0.357	0.83	1	0.07		0.22	6	0.39	1	0.28	3
2	*Lophira lanceolata*	0.269	0.37	2	0.30	1	0.28	2	0.26	2	0.12	
3	*Parinari curatellifolia*	0.251	0.33	4	0.22		0.33	1	0.09		0.30	2
4	*Terminalia avicennioides*	0.216	0.30	5	0.28	2	0.09		0.17	5	0.23	5
5	*Anogeissus leiocarpus*	0.185	0.22		0.28	2	0.22		0.15		0.05	
6	*Hannoa undulata*	0.150	0.37	2	0.04		0.26	3	0.07		-	
7	*Monotes kerstingii*	0.145	0.26		-		0.24	5	0.20	3	-	
8	*Pterocarpus erinaceus*	0.128	0.09		0.07		0.15		0.09		0.26	4
9	*Diospyros mespiliformes*	0.119	-		0.15		0.26	3	0.11		0.07	
10	*Khaya senegalensis*	0.097	-		0.07		-		-		0.40	1
11	*Swartzia madagascariensis*	0.093	0.13		0.28	2	-		0.04		-	
14	*Afzelia africana*	0.066	-		0.26	5	-		-		0.07	
15	*Pericopsis laxiflora*	0.057	-		0.11		-		0.17	5	-	
18	*Hexalobus monopetalus*	0.040	-		-		-		0.20	3	-	
B	**TOOL WOOD** (29 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	16	Rank	11	Rank	1	Rank	16	Rank	9	Rank
1	*Vitellaria paradoxa*	0.374	0.52	1	0.59	1	0.07	1	0.50	1	0.14	2
2	*Terminalia avicennioides*	0.137	0.13		0.39	2	-		0.07		0.09	
3	*Pterocarpus erinaceus*	0.132	0.20	4	0.09	4	-		0.20	4	0.12	4
4	*Dichrostachys cinerea*	0.106	0.15		-		-		0.26	2	0.12	4
5	*Swartzia madagascariensis*	0.088	0.37	2	-		-		0.07		-	
6	*Khaya senegalensis*	0.075	0.17	5	0.04		-		-		0.07	
7	*Manilkara multinervis*	0.066	0.35	3	-		-		-		-	
9	*Pteleopsis suberosa*	0.062	0.07		-		-		0.09		0.16	1
10	*Erythrophleum africanum*	0.057	-		-		-		0.26	2	-	
11	*Afzelia africana*	0.048	-		0.15	3	-		-		0.05	
11	*Hannoa undulata*	0.048	0.04		0.09	4	-		0.11		-	
13	*Pericopsis laxiflora*	0.044	-		0.07		-		0.15	5	-	
16	*Diospyros mespiliformes*	0.035	-		0.09	4	-		-		-	
18	*Parinari curatellifolia*	0.022	-		-		-		-		0.14	2

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
A	**CORD** (19 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	6	Rank	7	Rank	8	Rank	8	Rank	4	Rank
1	*Piliostigma thonningii*	0.485	0.59	2	0.43	1	0.59	1	0.50	1	0.30	1
2	*Hexalobus monopetalus*	0.278	0.83	1	0.22	3	0.09	4	0.24	4	-	
3	*Raphia sudanica*	0.225	0.52	3	0.17	4	-		0.41	2	-	
4	*Adansonia digitata*	0.119	0.26	4	0.24	2	0.07		-		-	
5	*Cochlospermum planchonii*	0.093	-		-		0.13	2	0.28	3	-	
6	*Pteleopsis suberosa*	0.066	-		0.04	5	0.13	2	-		0.14	2
7	*Lannea microcarpa*	0.031	-		0.04	5	-		0.11	5	-	
7	*Saba comorensis*	0.031	0.07	5	-		-		-		0.07	4
9	*Detarium microcarpum*	0.018	-		-		0.09	4	-		-	
9	*Elaeis guineensis*	0.018	-		-		-		-		0.09	3
11	*Lannea barteri*	0.013	0.07	5	-		-		-		-	
16	*Pseudocedrela kotschyii*	0.009	-		0.04	5	-		-		-	
D	**MATS** (4 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	3	Rank	3	Rank	4	Rank	3	Rank	3	Rank
1	*Borassus aethiopum*	0.339	0.52	1	0.28	1	0.13	2	0.59	1	0.16	2
2	*Hyphaene thebaica*	0.273	0.30	3	0.15	3	0.35	1	0.43	2	0.12	3
3	*Raphia sudanica*	0.238	0.35	2	0.24	2	0.13	2	0.04	3	0.44	1

Table 3 Construction material: List of species covering the five most important tree species used for making cord (A) and mats (B) by ethnic group. Species were ordered according to their importance within the use category (UV_{SC}). Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
B	**FIREWOOD** (37 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	25	Rank	19	Rank	23	Rank	17	Rank	11	Rank
1	*Vitellaria paradoxa*	0.846	0.85	1	0.89	1	0.65	1	0.89	1	0.95	1
2	*Parkia biglobosa*	0.599	0.59	4	0.61	2	0.48	3	0.65	2	0.67	2
3	*Isoberlinia tomentosa*	0.339	0.61	3	0.30	3	0.39	4	0.37	3	-	
4	*Isoberlinia doka*	0.326	0.28		0.30	3	0.52	2	0.13		-	
5	*Hymenocardia acida*	0.273	0.67	2	0.22	5	0.20		0.20	5	0.07	
6	*Pterocarpus erinaceus*	0.260	0.26		0.15		0.22		0.30	4	0.37	3
7	*Daniellia oliveri*	0.247	0.48	5	0.15		0.24	5	0.07		0.30	4
8	*Detarium microcarpum*	0.194	0.39		0.07		0.22		0.11		0.19	

aguwe, bassine) of marketed products (means corresponded with reported inflation of market prices due to seasonality and, subsequently, abundance of products). Where products had no market equivalent, we used imputed values from close substitutes, i.e., we calculated using the market price of a product with the same characteristics and being used for the same purpose as the non-marketed one (Campbell and Luckert 2002). For example, we used the market price of sticks chewed for dental care imported from China, which are comparable to those gathered locally and have been widely adopted by the villagers, to value sticks from local trees. Since opportunity costs of NTFP extraction are low (no labor alternatives, no high-capital equipment required), labor was not deducted from gross benefits, i.e., net benefits equal gross benefits.

Since the sample households differed considerably in terms of number and sex of adults and children, we adjusted our income calculations with regard to different economies of scale. Following Hagenaars *et al.* (1994) we applied the OECD-modified equivalence scale using the economy-of-scale coefficient suggested by Deaton (1982) resulting in income per adult equivalent units (aeu), i.e., mean income displays the adjusted income per person in the respective household.

Data Analysis

To assess the cultural importance of woody plant species, we calculated their overall and categorial use-values displaying the appreciation of local users attributed to the respective

Table 4 Wild foods: list of species covering the five most important tree species harvested for edible fruits (A) and edible leaves (B) by ethnic group. Species were ordered according to their importance within the use category (UV_{SC}). Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
A	**EDIBLE FRUITS** (29 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	13	Rank	11	Rank	15	Rank	11	Rank	8	Rank
1	*Vitellaria paradoxa*	0.877	0.83	1	0.98	1	1.00	1	0.80	1	0.77	1
2	*Parkia biglobosa*	0.863	0.76	2	0.96	2	0.91	2	0.78	2	0.74	2
3	*Adansonia digitata*	0.273	0.43	4	0.48	3	0.28	3	0.09		0.07	
4	*Blighia sapida*	0.216	0.46	3	0.15	5	0.11		0.26	3	0.09	4
5	*Diospyros mespiliformes*	0.145	0.26		0.11		0.07		0.22	4	0.07	
6	*Vitex doniana*	0.132	0.33	5	0.11		0.04		0.17	5	0.05	
7	*Tamarindus indica*	0.079	0.07		0.20	4	0.13	4	-		-	
9	*Ceiba pentandra*	0.044	-		-		0.13	4	-		-	
11	*Elaeis guineensis*	0.040	-		-		-		0.07		0.12	3
11	*Hyphaene thebaica*	0.040	-		-		0.09		-		0.09	4

A	**EDIBLE LEAVES** (3 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	2	Rank	3	Rank	2	Rank	3	Rank	2	Rank
1	*Adansonia digitata*	0.225	0.26	1	0.33	1	0.13	2	0.04	2	0.05	1
2	*Vitex doniana*	0.053	0.15	2	0.11	2	0.17	1	0.15	1	0.05	1
3	*Ceiba pentandra*	0.040	-		0.11	2	-		0.04	2	-	

Table 5 Health care: list of species covering the five most important tree species used as medicinal plants (A) and for dental care (B) by ethnic group. Species were ordered according to their importance within the use category (UV_{SC}). Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
A	**MEDICINAL PLANTS** (55 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	23	Rank	11	Rank	19	Rank	13	Rank	19	Rank
1	*Parkia biglobosa*	0.088	0.24	1	-		0.11	2	-		0.09	
1	*Piliostigma thonningii*	0.088	0.09		0.07	3	0.11	2	-		0.16	2
3	*Terminalia avicennioides*	0.079	0.04		0.09	1	0.07		-		0.21	1
4	*Pteleopsis suberosa*	0.070	0.09		0.07	3	0.09		-		0.12	3
5	*Khaya senegalensis*	0.066	0.15	2	-		0.09		-		0.09	
5	*Vitellaria paradoxa*	0.066	0.11	4	0.07	3	0.09		0.07		-	
7	*Monotes kerstingii*	0.053	-		-		0.17	1	0.07		-	
8	*Gmelinia arborea*	0.048	-		-		0.07		0.07		0.12	3
8	*Pavetta crassipes*	0.048	0.07		0.09	1	0.04		-		0.05	
8	*Sarcocephalus latifolius*	0.048	0.04		-		-		0.04		0.12	3
11	*Hymenocardia acida*	0.044	0.13	3	-		0.04		-		-	
11	*Maytenus senegalensis*	0.044	-		-		0.07		-		0.12	3
14	*Pterocarpus erinaceus*	0.040	0.11	4	0.07	3	-		-		-	
14	*Anogeissus leiocarpus*	0.040	0.07		-		0.11	2	-		-	
16	*Adansonia digitata*	0.035	0.07		0.07	3	0.04		-		-	
16	*Entada africana*	0.035	0.09		-		-		0.09	3	-	
18	*Opilia celtidifolia*	0.031	0.11	4	-		-		-		-	
18	*Vitex simplicifolia*	0.031	-		-		-		-		0.12	3
20	*Bombax costatum*	0.026	-		-		-		0.13	1	-	
20	*Trichilia emetica*	0.026	-		-		-		0.13	1	-	
25	*Cochlospermum planchonii*	0.022	-		-		0.11	2	-		-	
29	*Combretum collinum*	0.018	-		-		-		0.09	3	-	
29	*Flueggea virosa*	0.018	-		-		-		0.09	3	-	
29	*Tamarindus indica*	0.018	-		0.07	3	-		-		-	
B	**DENTAL CARE (CHEW STICKS)** (44 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	25	Rank	15	Rank	15	Rank	19	Rank	8	Rank
1	*Prosopis africana*	0.485	0.52	1	0.35	2	0.57	2	0.20	3	0.81	1
2	*Terminalia avicennioides*	0.396	0.50	2	0.09		0.76	1	0.52	1	0.09	
3	*Anogeissus leiocarpus*	0.242	0.35	3	0.43	1	0.09	4	0.15	4	0.19	5
4	*Parinari curatellifolia*	0.141	-		0.09		0.09	4	0.07		0.44	3
5	*Bridelia ferruginea*	0.137	0.11		-		0.07		0.04		0.47	2
6	*Pseudocedrela kotschyii*	0.123	0.09		0.17	4	0.11	3	0.24	2	-	
7	*Pteleopsis suberosa*	0.115	-		0.11		-		0.04		0.42	4
8	*Vitellaria paradoxa*	0.097	0.26	5	0.20	3	-		-		-	
9	*Burkea africana*	0.093	0.30	4	-		0.09	4	-		-	
10	*Tamarindus indica*	0.070	0.04		0.13	5	0.04		0.11		-	
11	*Desmodium velutinum*	0.053	0.26	5	-		-		-		-	
12	*Entada africana*	0.044	0.04		-		-		0.15	4	-	
16	*Crossopterix febrifuga*	0.035	-		-		-		0.15	4	-	
16	*Hannoa undulata*	0.035	-		-		0.09	4	-		-	

species. According to Phillips and Gentry (1993) and simplified by Albuquerque *et al.* (2006) the overall use-value (UV_s) of each species was calculated as:

$$UV_s = \sum UV_{sc} = \sum U_i / N \quad (1)$$

where U_i is the sum of all use-reports mentioned for species s by each informant i and N is the total number of informants interviewed. Splitting UV_s into its use categories delivers the categorial use-values UV_{sc} for species s.

Additionally, we calculated the relative importance of a species within a particular use category as:

Table 6 Decoration: list of species covering the five most important tree species harvested for colouring matter (decoration) by ethnic group. Species were ordered according to their importance within the use category (UV_{SC}). Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
	COLOURING MATERIAL(14 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	4	Rank	7	Rank	4	Rank	4	Rank	2	Rank
1	*Lonchocarpus caynescens*	0.330	0.13	4	-		-		0.78	1	0.77	1
2	*Cochlospermum planchonii*	0.159	0.30	2	0.17	1	0.30	2	-		-	
3	*Piliostigma thonningii*	0.137	0.39	1	0.13	2	0.11	3	0.04	3	-	
4	*Bridelia ferruginea*	0.075	-		-		0.37	1	-		-	
5	*Parkia biglobosa*	0.062	0.17	3	0.11	3	-		-		-	
7	*Pterocarpus erinaceus*	0.031	-		-		-		0.07	2	0.09	2
8	*Terminalia avicennioides*	0.026	-		0.07	5	-		0.04	3	-	
9	*Bridelia scleroneura*	0.022	-		0.11	3	-		-		-	
12	*Ficus spec.*	0.009	-		-		0.04	4	-		-	

$$UV_{sc} = \sum UV_{sc} \Big/ N_{sc} \quad (2)$$

where UV_{sc} is divided by the total number of informants in the respective category.

Subsequently, use-reports (U_i) for each use category were analyzed by means of a Principal Component Analysis (PCA) in order to assess differences and similarities of use patterns among informants. To establish which species account for most of the differences between respondents we correlated the set of species with the PCA-scores of the first two axes. All species showing a correlation coefficient of at least 0.6 (= marked degree of correlation) were referred to as "explaining species." Furthermore, we ran a stepwise logistic regression of both axes-scores against socio-economic variables, i.e., village and ethnicity, to test whether the use patterns for these species differed between investigated groups. Statistical analyses were performed using PC-ORD 5.3.1 (McCune and Mefford 2006) and PASW Statistics 9.0.0 (SPSS 2011).

For clarity in the Tables we do not show the entirety of plants used for each category but list all the species needed to cover the five most important species by ethnic group (Tables 2, 3, 4, 5, 6, 7, and 8). We ordered the species according to their overall use-value (UV_S; Table 2) and their importance within the use category (UV_{SC}; applies to Tables 2, 3, 4, 5, 6, 7, and 8). In cases where multiple species obtained the same use-value (in terms of magnitude), we assigned them the same rank within the order; if, for instance, two species were ranked first we proceeded with number 3 for the third species in order to keep the continuity of counting.

Results

Similarities and Differences Concerning Use-Values of Woody Species Among Ethnic Groups

Construction Wood

Construction wood is used for walls and roofs of traditional clay huts. Thirty-five plant species (39 % of all species reported) were reported as valued for construction wood, of which the three most important were *Oxynanthera abyssinica*,

Table 7 Commercial use: list of species covering the five most important tree species harvested for commercial use by ethnic group. Species were ordered according to their importance within the use category (UV_{SC}). Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

			Fulani		Ditammarie		Yom		Bariba		Kabiyé	
	COMMERCIAL USE (22 species mentioned in total)											
R	**Species /** Species per cat.	UV_{SC}	11	R	7	R	9	R	4	R	7	R
1	*Vitellaria paradoxa*	0.811	0.74	1	0.93	1	0.94	1	0.70	1	0.74	1
2	*Parkia biglobosa*	0.718	0.61	2	0.85	2	0.85	2	0.61	2	0.67	2
3	*Adansonia digitata*	0.137	0.15	5	0.15	3	0.28	3	0.07	3	0.07	3
3	*Blighia sapida*	0.137	0.35	3	0.13	4	0.11	4	-		-	
5	*Vitex doniana*	0.048	0.20	4	0.04	5	-		0.07	3	0.05	4
6	*Diospyros mespiliformes*	0.044	0.13		-		-		-		-	
7	*Hyphaene thebaica*	0.026	-		-		0.04		-		-	
7	*Tamarindus indica*	0.026	-		-		0.11	4	-		-	
14	*Ceiba pentandra*	0.009	-		0.04	5	-		-		-	

Table 8 The thirty most important woody plant species according to overall use-values (UV_S) are shown in Table 1. These thirty species coevally cover – in most cases - the three most important species per use category. In total, ninety ligneous species were mentioned by the informants (N=227) as useful for one or more of the investigated use categories (for full list please see Appendix). Colours indicate the three most important species per category (dark grey = first rank; middle grey = second rank; light grey = third rank). R = Rank; CW = construction wood; TW = tool wood; FW = firewood; C = cord; M = mats; EF = edible fruits; EL = Edible leaves; MP = medicinal plants; TT = tooth-twigs; CM = colouring material; CU = commercial use

		UV_S	UV_{SC}											N
			Construction material				Firewood	Human foods		Traditional Medicine		Colouring material	Commerce	
	Species		CW	TW	C	M	FW	EF	EL	MP	TT	CM	CU	
	Total species per category	90	35	29	19	4	37	29	3	55	44	14	22	
R	Share of total species (%)		39	32	21	4	41	32	3	61	49	16	24	
1	*Vitellaria paradoxa*	3.084	-	0.374	-	-	0.846	0.877	-	0.066	0.097	0.013	0.811	7
2	*Parkia biglobosa*	2.339	-	0.009	-	-	0.599	0.863	-	0.088	-	0.062	0.718	6
3	*Terminalia avicennioides*	0.956	0.216	0.137	-	-	0.101	-	-	0.079	0.396	0.026	-	6
4	*Adansonia digitata*	0.789	-	-	0.119	-	-	0.273	0.225	0.035	-	-	0.137	5
5	*Piliostigma thonningii*	0.736	-	-	0.485	-	-	-	-	0.088	0.026	0.137	-	4
6	*Prosopis africana*	0.656	0.084	0.044	-	-	0.044	-	-	-	0.485	-	-	4
7	*Anogeissus leiocarpus*	0.626	0.185	0.044	-	-	0.106	-	-	0.040	0.242	0.009	-	6
8	*Pterocarpus erinaceus*	0.621	0.128	0.132	-	-	0.260	0.009	-	0.040	0.013	0.031	0.009	8
9	*Raphia sudanica*	0.515	0.031		0.225	0.238	0.009	-	-	0.013	-	-	-	5
10	*Parinari curatellifolia*	0.511	0.251	0.022	-	-	0.070	0.018	-	-	0.141	-	0.009	6
11	*Diospyros mespiliformes*	0.427	0.119	0.035	-	-	0.022	0.145	-	0.018	0.044	-	0.044	7
12	*Blighia sapida*	0.401	-	-	-	-	0.013	0.216	-	0.026	0.009	-	0.137	5
13	*Pteleopsis suberosa*	0.396	0.026	0.062	0.066	-	0.057	-	-	0.070	0.115	-	-	6
14	*Borassus aethiopum*	0.392	-	-	0.013	0.339	-	0.009	-	-	0.026	-	0.004	5
15	*Isoberlinia doka*	0.383	0.026	-	-	-	0.326	-	-	-	0.031	-	-	3
16	*Isoberlinia tomentosa*	0.379	-	-	-	-	0.339	-	-	0.018	0.022	-	-	3
17	*Hymenocardia acida*	0.370	0.044	0.009	-	-	0.273	-	-	0.044	-	-	-	4
18	*Hyphaene thebaica*	0.361	-	-	0.009	0.273	-	0.040	-	0.013	-	-	0.026	5
19	*Hexalobus monopetalus*	0.357	0.040	-	0.278		-	-	-	0.009	0.018	0.013	-	5
19	*Oxynanthera abyssinica*	0.357	0.357	-	-	-	-	-	-	-	-	-	-	1
21	*Lophira lanceolata*	0.352	0.269	0.018	-	-	0.035	-	-	0.022	0.009	-	-	5
22	*Khaya senegalensis*	0.348	0.097	0.075	-	-	0.057	0.022	-	0.066	0.031	-	-	6
23	*Lonchocarpus cyanescens*	0.330	-	-	-	-		-	-	-	-	0.330	-	1
24	*Detarium microcarpum*	0.304	-	-	0.018	-	0.194	0.053	-	0.026	-	-	0.013	5
25	*Daniellia oliveri*	0.286	0.013	-	-	-	0.247	-	-	0.026	-	-	-	3
26	*Cochlospermum planchonii*	0.278	-	-	0.093	-	-	-	-	0.022	-	0.159	0.004	4
27	*Bridelia ferruginea*	0.273	0.013	-	-	-	0.035	-	-	0.013	0.137	0.075	-	5
28	*Hannoa undulata*	0.269	0.150	0.048	0.009		0.026	-	-	-	0.035	-	-	5
29	*Vitex doniana*	0.260	-	0.009	-	-	0.009	0.132	0.053	0.009	-	-	0.048	6
30	*Tamarindus indica*	0.247	0.040	0.013	-	-	-	0.079	-	0.018	0.070	-	0.026	6

Lophira lanceolata and *Parinari curatellifolia* (Table 2). While the number of species mentioned by ethnic groups was similar (from 14 (Kabiyé) to 19 (Ditammarie)) the species' relevance differed. Fulani and Bariba people most often cited *O. abyssinica* as construction wood, Ditammarie mainly mentioned *L. lanceolata*, Yom *P. curatellifolia,* and Kabiyé *Khaya senegalensis. L. lanceolata* additionally was cited commonly second most by three ethnic groups: Fulani, Yom and Bariba. Other species listed second were *Hannoa undulata* (Fulani), *Anogeissus leiocarpus* and *Swartzia madagascariensis* (Ditammarie), as well as *P. curatellifolia* (Kabiyé).

The ordination plot (Appendix 2) did not show distinct patterns between ethnic groups with the exception of the Ditammarie from Papatia who were slightly separated from all other informants along the first axis. The ordination's first axis highly correlated with *Afzelia africana*, *S. madagascariensis*, *Prosopis africana* and *Tamarindus indica,* the second axis with *Pericopsis laxiflora*. For these species, we found strong significant differences between both villages and ethnic groups (Appendix 3). That is, *S. madagascariensis*, *P. africana*, *T. indica* and *P. laxiflora* were mentioned only by villagers from Papatia while *A. africana* was exclusively cited by Ditammarie in Papatia and Kabiyé in Chabi-Couma.

Tool Wood

Tools crafted in the region include mortars, pestles, ladders, farm implements (billets, handles etc.) and wooden spoons, amongst others. There was a large overlap between species mentioned as feasible for tool wood (29 species) with those reported for construction (35 species, Table 2). The major difference concerned *V. paradoxa*, which is exclusively cited as tool wood and most commonly valued equally by four of the ethnic groups, the exception being the Kabiyé. While four ethnic groups reported using a considerable diversity of species for making tools (up to 16 species), the Yom infrequently cited only *V. paradoxa*. Apart from *V. paradoxa*, there were obvious differences between ethnic groups concerning the most favored species for tool wood: For instance, the Fulani mostly cited *S. madagascariensis*, whilst the Ditammarie preferred *T. avicennioides,* and the Bariba *Dichrostachys cinerea*.

We found neither a distinct grouping of ethnic groups in the ordination plot nor plant species being highly correlated to socio-economic characteristics (results of correlation and regression not shown).

Material for Cords

Cord is needed to attach wooden poles for roofs, storage huts and fences as well as for handicrafts and to leach livestock. In total, informants mentioned 19 species, of which two were particularly valued: the bark fibers of *Piliostigma thonningii* (assigned first place by four ethnic groups) and *Hexalobus monopetalus* (most mentioned by the Fulani, Table 2). Moreover, the leaves of *Raphia sudanica* were highly valued by the Fulani and the Bariba whereas the fibers of *Adansonia digitata* (fibers of the inner bark are twisted into ropes) were especially valued by the Ditammarie. The Yom described *Cochlospermum planchonii* and *Pteleopsis suberosa* as very useful for making cord; the latter was also frequently mentioned by the Kabiyé. Several species were only mentioned by particular ethnic groups.

No distinct patterns were to be found within the ordination plot (Appendix 2). However, the first axis of the PCA highly correlated with *Entada africana* for which we found significant differences with regard to location and ethnicity (Appendix 3) – *E. Africana* was only mentioned by respondents from Papatia.

Material for Mats

Mats are woven with leaves of palm trees of four species. Most valued for three of the ethnic groups were the leaves of *Borassus aethiopum* (Fulani, Ditammarie and Bariba) while for the Yom the leaves of *Hyphaene thebaica* and for the Kabiyé the leaves of *Raphia sudanica* were the most valued (Table 2). However, use preferences were rather consistent between groups: all ethnic groups cited all three species as providing useful mat material.

Along the first axis of the ordination plot (Appendix 2) informants were significantly separated by location for *B. aethiopum* and *H. thebaica* (Appendix 3). Both species were harvested by all five ethnic groups in Papatia while in Chabi-Couma only Fulani and Bariba reported to use these species.

Firewood

Informants reported using 37 species as firewood. Ethnic groups showed very similar patterns of firewood collection (Table 3). All ethnic groups ranked *V. paradoxa* first and *P. biglobosa* was assigned three times second rank across groups. Highly valued by at least four of five groups (exception: Kabiyé) were *Isoberlinia doka*, *I. tomentosa*, *Hymenocardia acida*, amongst others.

The ordination plot (Appendix 2) did not show discrete patterns. We found strong correlations for *H. acida*, *I. doka* and *I. tomentosa* along the first axis (Appendix 3). Differences among informants were explained by village and ethnicity - all three species were mainly mentioned by Fulani and Yom villagers from Papatia.

Human Foods

We distinguish between edible fruits and edible leaves.

Edible Fruits Wild vegetable foods, i.e., edible fruits, seeds and leaves from woody species complement the daily diet of rural households both in terms of quality (vitamins, nutrients, minerals, micronutrients etc.) and quantity (e.g., in times of crop failure or lean seasons between crop production). In total, 29 species were mentioned as fruit providers. The two species most valued by far were *V. paradoxa* and *P. biglobosa* (Table 4), which are both typical field trees. For both species, respondents from all five ethnic groups showed consistent preferences: The seeds of *V. paradoxa* were assigned first place and the seeds of *P. biglobosa* second. In addition, fruits of *Adansonia digitata* and *Blighia sapida* were mentioned frequently – both were cited two times most commonly in third place. The seeds of *B. sapida* also refine sauces. Other generally harvested species are *D. mespiliformes*, *V. doniana* and *T. indica*. Ethnic groups value fruit species similarly; only few are mentioned by a single or two ethnic groups only.

We found significant differences between villages and ethnicity for *D. mespiliformes* and *V. doniana* along the first axis of the PCA (Appendix 3). Both were mainly consumed by Fulani and Bariba in both villages but more commonly by households in Papatia.

Edible Leaves Like edible fruits, edible leaves are highly appreciated in daily cooking. Notably the leaves of *A. digitata*, *V. doniana* and *Ceiba pentandra* were valued equally across all ethnic groups (Table 4). While Fulani, Ditammarie and Kabiyé mentioned *A. digitata* most often, Yom and Bariba preferred the leaves of *V. doniana*.

In the PCA informants were separated along the first axis by location and ethnicity for all three leave-providing species (Appendix 3). That is, all villagers interviewed in Papatia reported harvesting edible leaves from these trees for but only two informants in Chabi-Couma mentioned *A. digitata* and only one mentioned *V. doniana* as important.

Traditional Medicine

Due to their frequency of use, we separate the plants used in traditional medicine into medicinal plants and chew-sticks. While the latter are used on a daily basis focusing on

prevention, plants cited as medicinal plants are, in general, only applied to cure acute or emergent diseases.

Medicinal Plants Roughly 61 % of all mentioned species was reported to be used in medical care (Table 5). Most important and used across households were *A. digitata* (e.g., against malaria, fever), *P. thonningii* (e.g., antiseptic, wounds) and *T. avicennioides* (e.g., antibacterial, wounds). However, overall, ethnic groups showed very different use patterns for medicinal plants. The Fulani valued *P. biglobosa* highest, whereas the Ditammarie and the Kabiyé assigned *T. avicennioides*, the Yom *Monotes kerstingii,* and the Bariba *Bombax costatum* and *Trichilia emetica* first priority.

Dental Care (Chew Sticks) Informants reported using a great diversity of twigs for dental care: About 49 % of mentioned species were considered good chew sticks because they appear antibacterial and antiseptic. While for the Fulani and the Kabiyé *P. africana* is most important, the Yom and Bariba valued *T. aviciennioides* highest and the Ditammarie gave *A. leiocarpa* first place (Table 5). High priority was given to *Bridelia ferruginea* and *Parinari curatellifolia* by the Kabiyé, *Pseudocedrela kotschyii* by the Bariba and Yom as well as *V. paradoxa* by the Ditammarie and the Fulani.

We found strong significant differences among informants' answers with regard to village and ethnicity along the first axis of the ordination plot for three species (Appendix 3): *Acacia spec.*, *Securinega virosa* and *Vernonia colorata* were mainly mentioned by informants from Papatia.

Coloring Matter

Leaves, bark, timber and roots are used for producing coloring matter to decorate houses (plaster) and terraces, dye clothes and drapery as well as face paints for traditional ceremonies. Moreover, plant dye is a favored means to enrich dishes (sauces and soups) in terms of color. Informants mentioned 14 species used for these applications, of which the most frequently cited species by far was *Lonchocarpus cyanescens* (Table 6) whose fruits provide an indigo blue color that is used primarily for decorative purposes and dyeing drapery. In particular for the Bariba and the Kabiyé, indigo blue is of high cultural value. The rootstock of *Cochlospermum planchonii* is used for making a reddish powder preferred by the Fulani, the Ditammarie and the Yom as an additive for sauces and soups. For coloring lips and teeth, the reddish dye of the roots of *Piliostigma thonningii* is used by four ethnic groups (the exception being the Kabiyé). *Bridelia ferruginea,* whose bark provides a black or purple dye for clothes and pottery, was in particular valued by the Yom. Other important species were those supplying red coloring for decoration: *P. biglobosa* (bark) for the Fulani and the Ditammarie and *P. erinaceus* (timber) for the Bariba and the Kabiyé. *T. avicennioides* is also valued by two ethnic groups as it provides several colorings: a brown dye extracted from the bark, a yellow dye (roots) and a black dye (leaves) for fabrics

Differences among respondents were mostly explained by *C. planchonii* and *P. thonningii* (first axis) and *T. avicennioides* (second axis, Appendix 3). The former showed significant differences for both location and ethnicity.

Commercial Use and Cash Income

Only fruits and their components were sold by the respondents; leaves were merely consumed at home. Table 7 shows the nine most important species (of a totality of 22) with regard to local economic value, i.e., the commercial use of their fruits by villagers. The fruit-tree species reported to generate cash income were preponderantly congruent with those used to fulfill home consumption requirements (see Table 4). Top priority across all ethnic groups was given to the fruits of *V. paradoxa* and *P. biglobosa.* Highest mean annual returns from *V. paradoxa* seeds were obtained by Yom households (115 €, Fig. 2) equaling 16.7 % of mean income per aeu (Appendix 4) in the year under investigation. The highest relative income from *V. paradoxa*-fruits was obtained by the Bariba who generated 13.3 % of annual mean income per aeu through respective sales (equivalent to 97 €). The Fulani generated the lowest respective income (mean income per aeu: 46 €; share in total income: 6.5 %). The other two ethnic groups lay within this range (see Appendix 4 for further details).

The second most important cash income was gained by the sale of fruits of *P. biglobosa*: Highest mean returns were obtained by Ditammarie households (89 € per aeu, equivalent to 12.84 % of mean income per aeu). The Yom, the Bariba and the Kabiyé generated only slightly lower income (82 €, 73 € and 73 €, respectively). The Fulani again generated the lowest returns (35 €; 4.9 % of total income).

A. digitata ranked fourth place in terms of cash income. The Yom were paramount in the sale of *A. digitata*-fruits (45 € mean income per aeu; 6.6 % of mean income). The other four ethnic groups obtained considerably less mean income from respective sales (Appendix 4). Of further economic importance for at least three of the ethnic groups were the fruits and the calyx of *B. sapida* as well as the fruits of *Vitex doniana* and *Saba senegalensis* (Fig. 2). Several species were only marketed by particular ethnic groups: the Fulani sold *D. mespiliformes*, *D. microcarpum*, *and S. senegalensis* and *X. americana*, the Ditammarie sold *C. pentandra,* and the Yom sold *T. indica*, *P. erinaceus*, *H. thebaica* and *P. curatellifolia* in smaller quantities (Appendix 4).

We found a strong correlation for *V. doniana* and the first axis; informants were significantly separated due to location and ethnicity – this species was predominantly mentioned

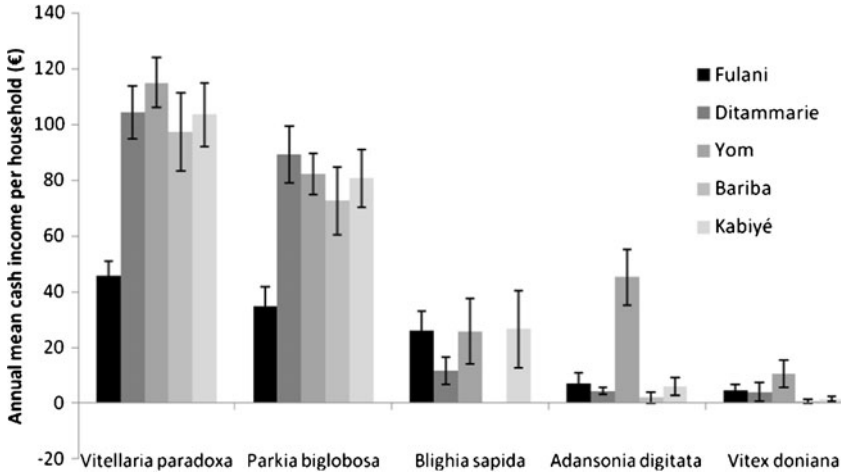

Fig. 2 Comparison of annual mean per household cash income (in Euro) generated by the sale of fruits of the five most important fruit trees by ethnic group

by Fulani in Papatia (Appendix 3). For the second axis, ethnic affiliation explained most of the observed differences but we found no strong correlations with single species.

The Thirty Most Important Woody Species of the Sampled Population

A total of 90 ligneous species were mentioned by the informants as useful in one or more of the 11 use categories (Appendix 1), of which 61 % were used for medicinal applications, 49 % for dental care, 41 % as firewood, 39 % for construction purposes and 32 % as tool wood. Furthermore, 32 % of species also contributed to household consumption needs, of which 24 % had commercial use. Out of the 90 species 79 % have at least two and up to eight different uses.

Vitellaria paradoxa and *Parkia biglobosa* were assigned by far the highest overall use-values (Table 8). Out of 11 categories, *V. paradoxa* was assigned first place four times whereas *P. biglobosa* was placed second in three of these categories. *Terminalia avicennioides* was assigned third place and *Adansonia digitata* fourth place. *T. avicennioides, A. digitata, P. thonningii, P. africana, A. leiocarpus, P. erinaceus, R. sudanica* and *P. curatellifolia* were within the ten most frequently valued multi-purpose species. Of the 21 % of species (N=19) mentioned in one use category the three most important were *O. abyssinica* (for construction), *L. cyanescens* (for coloring) and *D. cinerea* (for tool wood).

Discussion

Preferences for Woody Species: Similarities and Differences Between Ethnic Groups

The number of species mentioned by the respondents (N=90) reflects the high level of local knowledge about and actual use of woody plants and the essential role trees and shrubs play in the maintenance of rural communities adjacent to savanna woodlands. NTFPs constitute a critical component of the household economy.

While certain plant species are used by all study households others are used exclusively by particular ethnic groups for specific purposes. *V. paradoxa* is by far the most valued species for a number of reasons: its fruits, processed as sheabutter, are critical to the household's diet because they supply rich fatty acids used for cooking. Boffa (1999) reported the average annual consumption of sheabutter in sub-Saharan countries to be from 7.3 to 10 kg per person. For the same reason, these fruits can generate the highest cash income. Secondly, *V. paradoxa* wood is a readily available primary energy source –easily accessible on farmland – and used for making tools (the soft wood is easy to carve). The second most important common species is *P. biglobosa* whose seeds (processed into the highly valued condiment *moutarde* used in sauces) also contribute to daily nutrition needs and are frequently sold in local markets. Its wood is also a preferred firewood. In addition, several of its parts are used in traditional medicine. *A. digitata* is a third highly valued species, whose vitamin C-rich fruit pulp is added to the local drink *l'eau blanche* and the local porridge *bouille* (Gebauer *et al.* 2002); the roasted seeds are used in sauces (Sidibé and Williams 2002). The leaves of *A. digitata* are a particularly important source of protein and minerals (Yazzie *et al.* 1994). However, there are differences among ethnic groups with regard to the cash income generated by the sale of fruits. The Fulani earned considerably less than the other groups, reflecting their continued reliance on income generated from animal husbandry, especially the sale of cow's milk (Gaoue and Ticktin 2009; Heubach *et al.* 2011).

Location also impacted NTFP knowledge and use. In particular, we found that villagers from Chabi-Couma comparatively valued fewer native species than those from Papatia. This might be due to the fact that the local market of Chabi-Couma is considerably larger than that of Papatia, allowing villagers to buy NTFPs rather than extract them themselves, and to substitute locally gathered products by modern ones (e.g., replacing wooden kitchen utensils with plastic ones). Further, because of the comparatively greater extent of plantations and settlement area, people in Chabi-Couma have longer walks to extraction areas, i.e., higher opportunity costs for NTFP extraction. Wealthier households in particular may thus lack an incentive for NTFP harvesting. Lykke *et al.* (2004) reported distinctions in local knowledge and actual use of woody species among Fulani from different villages in the Sahelian zone of Burkina Faso resulting from different ecological environments and individual characteristics of informants. Vodouhê *et al*. (2009) showed that gender, ethnicity and species' marketability influence valuation priorities for local plant resources in Northern Benin, whereas in Central Benin Schreckenberg (1999) identified, in particular, institutional settings as shaping peoples' de facto plant uses.

Improving Conservation Measures for NTFP-Providing Species

As key economic species, *V. paradoxa, P. biglobosa* and *A. digitata*, along with *B. sapida and V. doniana* are accorded high conservation priorities by both villagers and the government: adult trees left in fields and fallows are the most important sources of NTFPs (Schreckenberg 1999; Schumann *et al*. 2010). In Burkina Faso, the average yield of *V. paradoxa* kernels in agroforestry systems was significantly higher (4 kg per tree) than from uncultivated trees (1.5 kg per tree) (Lamien *et al.* 2004). We conclude that conservation efforts should consider, first of all, woody species that fulfill both subsistence needs and have commercial value: Our study listed five subsistence use categories and found 90 species to meet particular subsistence needs while 22 of these also contributed to household income. Species with high economic value can buffer possible cash shortfalls; this especially holds true for women since they are the main collectors and traders of NTFPs. Markets positively affect values assigned to species (Gustad *et al.* 2004) resulting in greater incentives to protect important native trees while at the same time helping to mitigate destructive but more economically-driven forest-based activities such as logging (Vadez *et al.* 2004; Avocèvou-Ayisso *et al.* 2009; Vodouhê *et al.* 2009). This incentive-based 'conservation-through-use' approach is, however, only suitable for tree species characterized by marketability (stable demand and local purchasing power for particular NTFPs) and profitability for producers (i.e., adequate financial returns) in connection with land tenure security (Newton 2008). Moreover, they must not compete with agricultural products in terms of cultivation area or labor allocation (Newton 2008).

Lastly, locally feasible conservation schemes should incorporate traditional ecological knowledge (Ford 2001; Donovan and Puri 2004) and an understanding of the social mechanisms behind traditional uses and conservation practices (Berkes *et al.* 2000). In this regard, it is imperative to give consideration to culturally conditioned differences in use preferences, e.g., with regards to ethnic affiliation, as well as securing land tenure and access to extraction sites.

Conclusion

Our findings provide important information for local policy-makers to improve existing conservation measures for useful woody species in Northern Benin. We determined that ethnic affiliation impacted NTFP knowledge and uses, as a feature of social differentiation, presupposing use-values and, thus determining the extent of plant diversity to be conserved in order to meet all use preferences. There are both several NTFP-producing tree species jointly valued plus a wider range of species necessary to meet ethnically-conditioned household requirements. Further small-scale research should be conducted concerning differences among local beneficiaries of NTFPs, as well as extraction modes and rates, complemented by the analysis of land tenure and market dynamics. Additionally, ecological features of NTFP-producing trees (abundance and population dynamics) as well as information about their de facto abundance (or decline, respectively) gathered both scientifically and through traditional ecological knowledge should supplement these data in order to ensure the sustainable use of the culturally and economically most important tree species in the savanna ecosystem.

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Appendix

Table 9 Full list of plant species mentioned as useful by respondents

			UV_S				UV_{SC}						
			Construction material				Firewood	Human food		Health care		Colour	Commerce
	Species per category		CW 35	TW 29	C 19	M 4	FW 37	EF 29	EL 3	MP 55	TT 44	CM 14	CU 22
R	Species												
1	*Vitellaria paradoxa*	3.084		0.374			0.846	0.877		0.066	0.097	0.013	0.811
2	*Parkia biglobosa*	2.339		0.009			0.599	0.863		0.088		0.062	0.718
3	*Terminalia avicennioides*	0.956	0.216	0.137			0.101			0.079	0.396	0.026	
4	*Adansonia digitata*	0.789			0.119			0.273	0.225	0.035			0.137
5	*Piliostigma thonningii*	0.736			0.485					0.088	0.026	0.137	
6	*Prosopis africana*	0.656	0.084	0.044			0.044				0.485		
7	*Anogeissus leiocarpus*	0.626	0.185	0.044			0.106			0.040	0.242	0.009	
8	*Pterocarpus erinaceus*	0.621	0.128	0.132			0.260	0.009		0.040	0.013	0.031	0.009
9	*Raphia sudanica*	0.515	0.031		0.225	0.238	0.009			0.013			
10	*Parinari curatellifolia*	0.511	0.251	0.022			0.070	0.018			0.141		0.009
11	*Diospyros mespiliformes*	0.427	0.119	0.035			0.022	0.145		0.018	0.044		0.044
12	*Blighia sapida*	0.401					0.013	0.216		0.026	0.009		0.137
13	*Pteleopsis suberosa*	0.396	0.026	0.062	0.066		0.057			0.070	0.115		
14	*Borassus aethiopum*	0.392			0.013	0.339		0.009			0.026		0.004
15	*Isoberlinia doka*	0.383	0.026				0.326				0.031		
16	*Isoberlinia tomentosa*	0.379					0.339			0.018	0.022		
17	*Hymenocardia acida*	0.370	0.044	0.009			0.273			0.044			
18	*Hyphaene thebaica*	0.361			0.009	0.273		0.040		0.013			0.026
19	*Hexalobus monopetalus*	0.357	0.040		0.278					0.009	0.018	0.013	
19	*Oxynanthera abyssinica*	0.357	0.357										
21	*Lophira lanceolata*	0.352	0.269	0.018			0.035			0.022	0.009		
22	*Khaya senegalensis*	0.348	0.097	0.075			0.057	0.022		0.066	0.031		
23	*Lonchocarpus cyanescens*	0.330										0.330	
24	*Detarium microcarpum*	0.304			0.018		0.194	0.053		0.026			0.013
25	*Daniellia oliveri*	0.286	0.013				0.247			0.026			
26	*Cochlospermum planchonii*	0.278			0.093					0.022		0.159	0.004
27	*Bridelia ferruginea*	0.273	0.013				0.035			0.013	0.137	0.075	
28	*Hannoa undulata*	0.269	0.150	0.048	0.009		0.026				0.035		
29	*Vitex doniana*	0.260		0.009			0.009	0.132	0.053	0.009			0.048
30	*Tamarindus indica*	0.247	0.040	0.013				0.079		0.018	0.070		0.026
30	*Burkea africana*	0.247	0.079	0.031			0.044				0.093		
32	*Monotes kerstingii*	0.238	0.145	0.018				0.013		0.053	0.009		
33	*Swartzia madagascariensis*	0.207	0.093	0.088							0.026		
34	*Afzelia africana*	0.190	0.066	0.048			0.066			0.009			
35	*Pericopsis laxiflora*	0.154	0.057	0.044			0.044				0.009		
35	*Erythrophleum africanum*	0.154	0.022	0.057			0.053				0.022		
37	*Pseudocedrela kotschyi*	0.150			0.009		0.009			0.009	0.123		
38	*Uapaca togoensis*	0.145	0.044				0.101						
39	*Crossopterix febrifuga*	0.110					0.062			0.013	0.035		
39	*Bombax costatum*	0.110		0.066						0.026			0.009
41	*Dichrostachys cinerea*	0.106		0.106									
42	*Ceiba pentandra*	0.101	0.009					0.044	0.040				0.009
43	*Annona senegalensis*	0.097						0.040		0.022	0.018		0.018
44	*Sarcocephalus latifolius*	0.093					0.009	0.018		0.048	0.018		
44	*Entada africana*	0.093			0.013					0.035	0.044		

Table 9 (continued)

			UV_S				UV_{SC}						
			Construction material				Firewood	Human food		Health care		Colour	Commerce
	Species per category		CW 35	TW 29	C 19	M 4	FW 37	EF 29	EL 3	MP 55	TT 44	CM 14	CU 22
46	*Ficus spec.*	0.088			0.013		0.009	0.013		0.044		0.009	
46	*Manilkara multinervis*	0.088	0.009	0.066			0.013						
48	*Lannea acida*	0.084						0.018				0.062	0.004
48	*Combretum spec.*	0.084					0.053			0.013	0.018		
48	*Elaeis guineensis*	0.084			0.018			0.040					0.026
51	*Acacia spec.*	0.075		0.009			0.009			0.018	0.040		
52	*Saba senegalensis*	0.070						0.044					0.026
53	*Bridelia microcantha*	0.066	0.013				0.053						
54	*Syzigium guineense*	0.062	0.009							0.009	0.044		
55	*Saba comorensis*	0.057			0.031			0.018		0.009			
55	*Gmelinia arborea*	0.057		0.009						0.048			
57	*Trichilia emetica*	0.053	0.009							0.026	0.018		
57	*Securidaca longepedunculata*	0.053	0.031							0.009	0.013		
57	*Desmodium velutinum*	0.053									0.053		
60	*Vitex simplicifolia*	0.048						0.018		0.031			
60	*Bridelia scleroneura*	0.048									0.026	0.022	
60	*Pavetta crassipes*	0.048								0.048			
63	*Maytenus senegalensis*	0.044								0.044			
64	*Lannea microcarpa*	0.040			0.031							0.009	
64	*Combretum molle*	0.040	0.013				0.013			0.013			
64	*Ximenia americana*	0.040						0.026					0.013
64	*Securinega virosa*	0.040								0.022	0.018		
68	*Haematostaphis barteri*	0.035	0.026								0.009		
69	*Combretum collinum*	0.031		0.013						0.018			
69	*Cussonia barteri*	0.031					0.031						
71	*Opilia celtidifolia*	0.031								0.031			
72	*Gardenia erubescens*	0.026						0.018					0.009
72	*Gardenia ternifolia*	0.026						0.018					0.009
72	*Erythrina senegalensis*	0.026								0.018	0.009		
72	*Stereospermum kunthianum*	0.026	0.013	0.013									
76	*Vernonia colorata*	0.022								0.013	0.009		
77	*Stercularia setigera*	0.018	0.009		0.009								
77	*Flueggea virosa*	0.018								0.018			
77	*Jatropha curcas*	0.018								0.000	0.018		
77	*Vernonia amygdalina*	0.018								0.018			
81	*Lannea barteri*	0.013			0.013								
81													
	Lannea velutina	0.013			0.013								
81	*Cassia sieberiana*	0.013								0.013			
81	*Paulinia pinnata*	0.013					0.013						
85	*Spondias monbin*	0.009						0.009					
85	*Calotropis procera*	0.009					0.009						
85	*Senna siamea*	0.009								0.009			
85	*Combretum microcanthum*	0.009								0.009			
85	*Heeria insignis*	0.009								0.009			
85	*Ochna schweinfurthiana*	0.009								0.009			

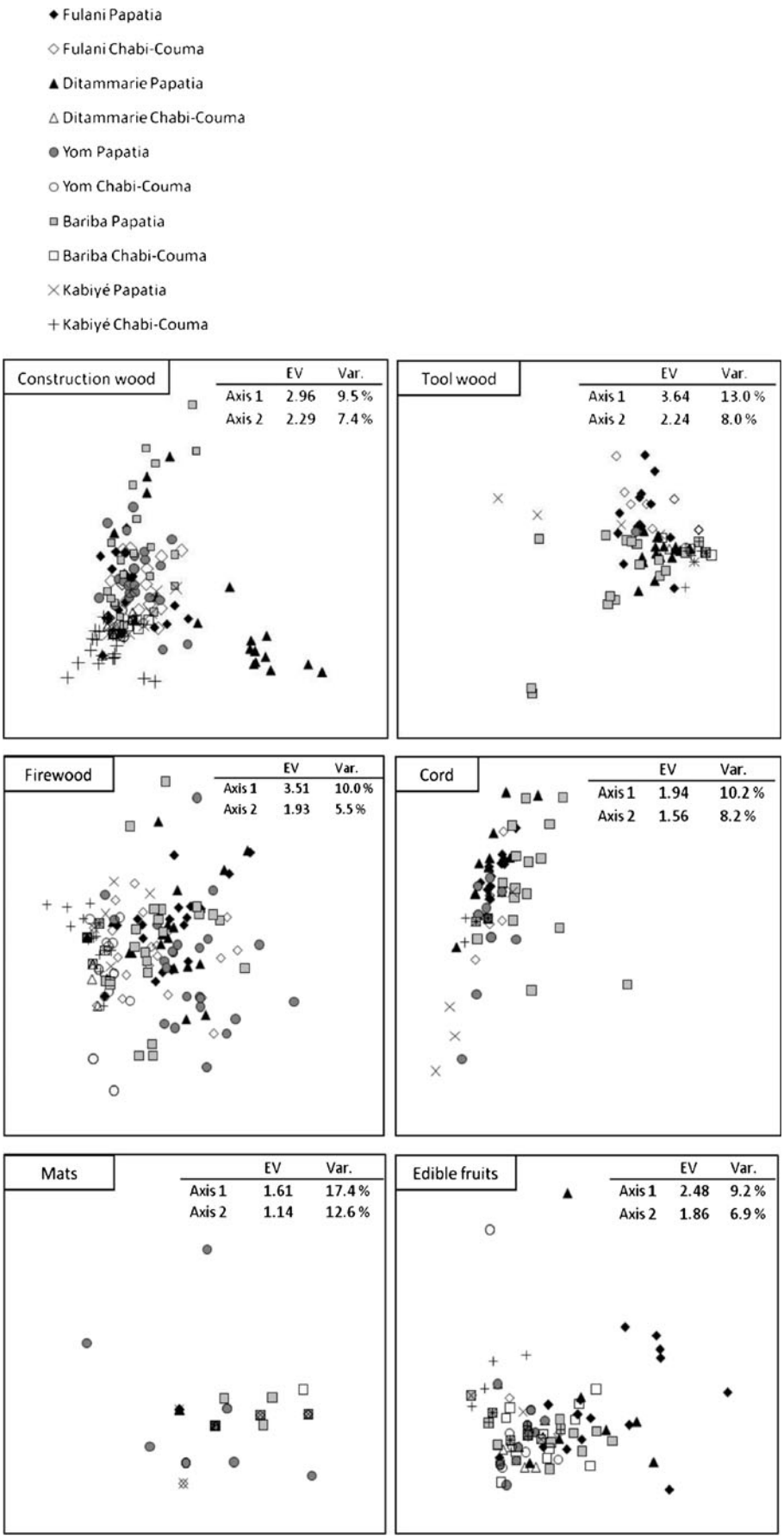

Fig. 3 Ordination plots for each of the eleven use categories. Shown are Eigenvalues and variance of the axes

Fig. 3 (continued)

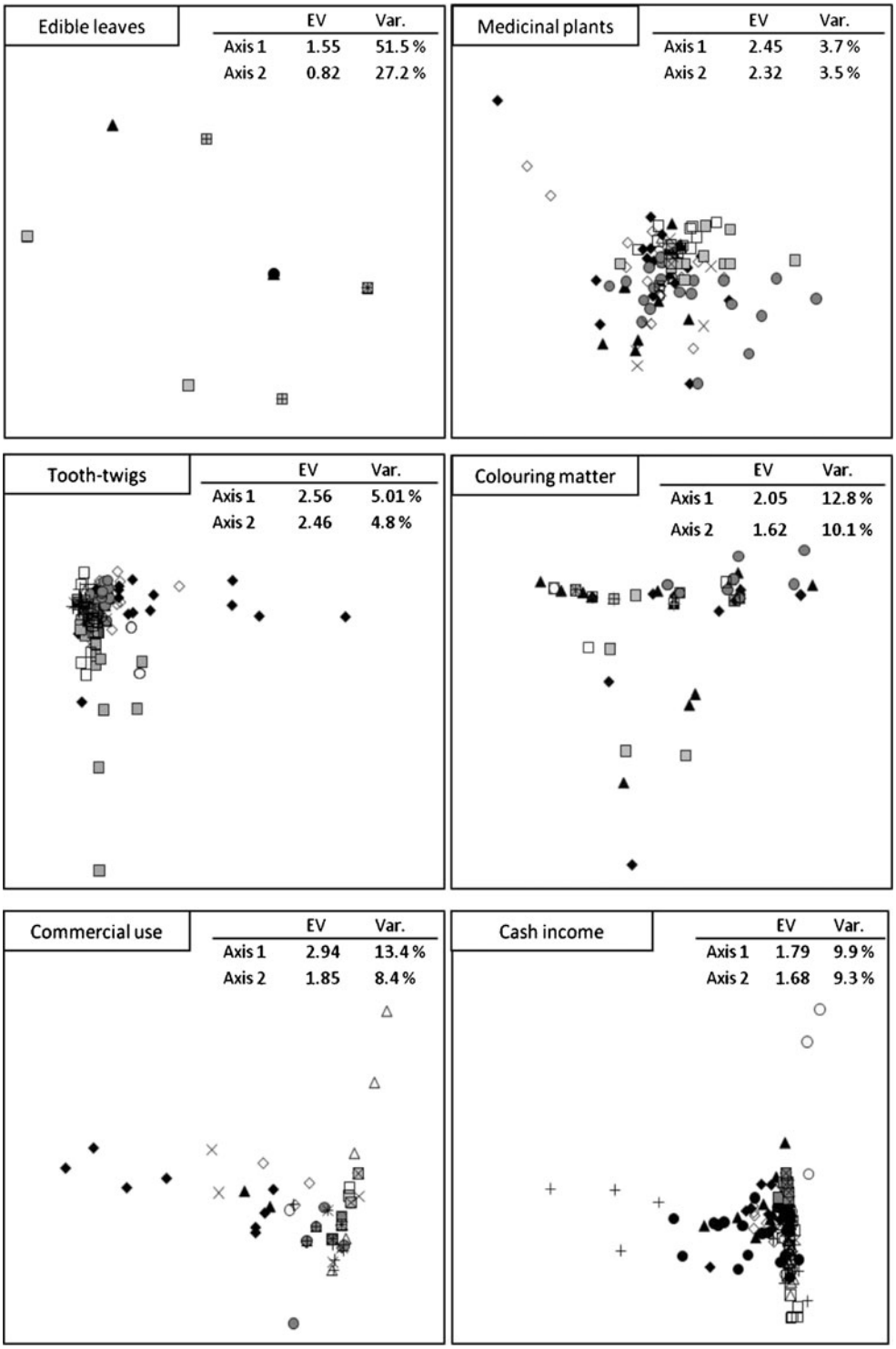

Table 10 Results of regressions, testing whether local provenance (village) and ethnic affiliation are affecting informants' choices for plant species used in the eleven investigated use categories. (***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; SE = Standard error)

Construction wood

	1. Axis (*Afzelia africana, Swartzia madagascariensis, Prosopis africana, Tamarindus indica*)				2. Axis (*Pericopsis laxiflora*)			
Term	Coefficient	SE	Beta	*t*-value	Coefficient	SE	Beta	*t*-value
(Intercept)	(3.024)	(0.400)		(7.552***)	(2.503)	(0.357)		(7.013***)
Village	−1.439	0.208	−0.418	−6.935***	−1.270	0.185	−0.419	−6.865***

Ethnicity	−0.277	0.074	−0.224	−3.716***	−0.189	0.066	−0.174	−2.849**

First axis: N=215; R^2=0.226; R^2adj=0.218; F=31.031; Eigenvalue: 2.96; Explained variance: 9.5 %; Correlation with species: *A. africana*: r=0.751**, *S. madagascariensis*: r=0.698**, *P. africana*: r=0.686**, *T. indica*: r=0.665**; Second axis: N=215; R^2=0.206; R^2adj=0.199; F=27.684; Eigenvalue: 2.29; Explained variance: 7.4 %; Correlation with species: *P. laxiflora*: r=0.607**

Firewood

	1. Axis (*Hymenocardia acida, Isoberlinia doka, I. tomentosa*)				2. Axis (*Vitellaria paradoxa)*			
Term	Coefficient	SE	Beta	*t*-value	Coefficient	SE	Beta	*t*-value
(Intercept)	(4.912)	(0.358)		(13.727***)	(0.410)	(0.367)		(1.118)
Village	−2.197	0.184	−0.586	−11.930***	−0.370	0.189	−0.133	−1.961
Ethnicity	−0.518	0.066	−0.384	−7.819***	−0.051	0.068	−0.051	−0.751

First axis: N=215; R^2=0.487; R^2adj=0.482; F=101.061; Eigenvalue: 3.51; Explained variance: 10.0 %; Correlation with species: *H. acida*: r=0.604**, *I. doka*: r=0.737**, *I. tomentosa*: r=0.800**; Second axis: N=215; R^2=0.020; R^2adj=0.011; F=2.216; Eigenvalue: 1.93; Explained variance: 5.5 %; Correlation with species: *V. paradoxa*: r=0.661**.

Material for cord

	1. Axis (*Entada africana*)			
Term	Coefficient	SE	Beta	*t*-value
(Intercept)	(1.755)	(0.346)		(5.074***)
Village	−0.896	0.179	−0.322	−5.006***
Ethnicity	−0.130	0.064	−0.130	−2.020*

First axis: N=216; R^2=0.120; R^2adj=0.112; F=14.568; Eigenvalue: 1.94; Explained variance: 10.2 %; Correlation with species: *E. africana*: r=0.606**;Second axis: N=216; R^2=0.147; R^2adj=0.143; F=36.842; Eigenvalue: 1.56; Explained variance: 8.2 %.

Material for mats

	1. Axis (*Borassus aethiopum, Hyphaene thebaica*)			
Term	Coefficient	SE	Beta	*t*-value
(Intercept)	(1.583)	(0.296)		(5.343***)
Village	−0.952	0.157	−0.376	−6.078***
Ethnicity	−0.050	0.056	−0.056	−0.899

First axis: N=227; R^2=0.142; R^2adj=0.138; F=37.200; Eigenvalue: 1.61; Explained variance: 17.8 %; Correlation with species: *B. aethiopum*: r=0.768*, *H. thebaica*: r=0.777*. Second axis: N=227; R^2=0.015; R^2adj=0.006; F=1.723; Eigenvalue: 1.14; Explained variance: 12.6 %

Edible fruits

	1. Axis (*Diospyros mespiliformes, Vitex doniana*)				2. Axis (*Saba comorensis*)			
Term	Coefficient	SE	Beta	*t*-value	Coefficient	SE	Beta	*t*-value
(Intercept)	(2.085)	(0.377)		(5.533***)	(0.324)	(0.351)		(0.924)
Village	−0.335	0.070	−0.298	−4.774***	−0.129	0.183	−0.047	−0.705
Ethnicity	−0.714	0.197	−0.227	−0.3634***	−0.043	0.065	−0.044	−0.658

First axis: N=224; R^2=0.140; R^2adj=0.133; F=18.056; Eigenvalue: 2.48; Explained variance: 9.2 %; Correlation with species: *D. mespiliformes*: r=0.651**, *V. doniana*: r=0.679**; Second axis: N=224; R^2=0.004; R^2adj=−0.005; F=0.467; Eigenvalue: 1.86; Explained variance: 6.9 %; Correlation with species: *Saba comorensis*: r=0.750**; Correlation with species: *S. comorensis*: r=0.750**.

Edible leaves

	1. Axis (*Adansonia digitata, Ceiba pentandra, Vitex doniana*)				2. Axis (*Vitex doniana*)			
Term	Coefficient	SE	Beta	*t*-value	Coefficient	SE	Beta	*t*-value
(Intercept)	(−2.971)	(0.282)		(−6.982***)	(−0.356)	(0.227)		(−1.570)
Village	0.982	0.149	0.395	6.581***	0.224	0.120	0.124	1.868
Ethnicity	0.165	0.053	0.187	3.112**	0.006	0.043	0.010	0.148

First axis: N=227; R^2=0.194; R^2adj=0.186; F=26.900; Eigenvalue: 1.55; Explained variance: 51.5 %; Correlation with species: *A. digitata*: r=−0.734**, *C. pentandra*: r=−0.657**, *V. doniana*: r=−0.605**; Second axis: N=7R^2=0.015; R^2adj=0.007; F=1.761; Eigenvalue: 0.82; Explained variance: 27.2 %. Correlation with species: *V. doniana*: r=−0.611**.

Dental care (chew sticks)

	1. Axis (*Acacia spec., Securinega virosa, Vernonia colorata)*				2. Axis (*Erythrina senegalensis, Swartzia madagascariensis)*			
Term	Coefficient	SE	Beta	*t*-value	Coefficient	SE	Beta	*t*-value
(Intercept)	(2.037)	(0.368)		(5.530***)	(0.230)	(0.394)		(0.584)
Village	−0.503	0.195	−0.157	−2.583**	0.083	0.208	0.026	0.399
Ethnicity	−0.430	0.069	−0.378	−6.208***	−0.119	0.074	−0.107	−1.611

First axis: N=227; R^2=0.170; R^2adj=0.162; F=22.917; Eigenvalue: 2.56; Explained variance: 5.0 %; Correlation with species: *A. spec.*: r=0.663**, *S. virosa*: r=0.657, *V. colorata*: r=0.652**; Second axis: N=219; R^2=0.012; R^2adj=0.003; F=1.366; Eigenvalue: 2.46; Explained variance: 4.8 %; Correlation with species: *E. senegalensis*: r=−0.625**, *S. madagascariensis*: r=−0.687**.

Colouring matter

	1. Axis (*Cochlospermum planchonii, Piliostigma thonningii*)				2. Axis (*Terminalia avicennioides*)			
Term	Coefficient	SE	Beta	*t*-value	Coefficient	SE	Beta	*t*-value

(Intercept)	(2.488)	(0.321)		(7.752***)	(−0.512)	(0.324)		(−1.583)
Village	−0.366	0.060	−0.358	−6.094***	0.159	0.170	0.062	0.935
Ethnicity	−0.923	0.169	−0.322	−5.478***	0.091	0.060	0.101	1.507

First axis: N=224; R^2=0.235; R^2adj=0.228; F=34.017; Eigenvalue: 2.05; Explained variance: 12.8 %; Correlation with species: *C. planchonii*: r=0.780**, *P. thonningii*: r=0.666**; Second axis: N=219; R^2=0.014; R^2adj=0.005; F=1.591; Eigenvalue: 1.62; Explained variance: 10.1 %; *T. avicennioides*: r=−0.866**.

Commercial use

	1. Axis (*Vitex doniana*)			
Term	Coefficient	SE	Beta	*t*-value
(Intercept)	(−1.388)	(0.426)		(−3.258***)
Village	0.606	0.224	0.177	2.703**
Ethnicity	0.159	0.080	0.130	1.908*

First axis: N=226; R^2=0.049; R^2adj=0.040; F=5.704; Eigenvalue: 2.94; Explained variance: 13.4 %; Correlation with species: *V. doniana*: r=−0.676*; Second axis: N=226; R^2=0.085; R^2adj=0.080; F=20.687; Eigenvalue: 1.85; Explained variance: 8.4 %.

Table 11 Cash income: list of species covering the five most important tree species generating cash income by ethnic group. Shown are the absolute and mean (in parentheses) annual incomes by ethnic group and species as well as their respective share in total household income. Species were ordered according to their importance within the use category. Colours indicate the three most important species per category (dark grey=1. rank; middle grey=2. rank; light grey=3. rank)

		Fulani (Species=10)		Ditammarie (Species=6)		Yom (Species=9)		Bariba (Species=4)		Kabiyé (Species=4)	
R	Species	Mean income per aeu	Share in total income per aeu (%)	Mean income per aeu	Share in total income per aeu (%)	Mean income per aeu	Share in total income per aeu (%)	Mean income per aeu	Share in total income per aeu (%)	Mean income per aeu	Share in total income per aeu (%)
1	*Vitellaria paradoxa*	45.5	6.46	104.2	15.01	114.9	16.65	97.2	13.30	97.2	15.09
2	*Parkia biglobosa*	34.9	4.96	89.1	12.84	82.0	11.88	72.6	9.93	72.6	11.27
3	*Blighia sapida*	26.1	3.71	11.6	1.67	25.7	3.72	–		–	
4	*Adansonia digitata*	6.9	0.98	4.4	0.63	45.2	6.55	2.0	0.27	2.0	0.31
5	*Vitex doniana*	4.6	0.65	4.0	0.58	–		0.7	0.10	0.7	0.11
6	*Tamarindus indica*	–		–		6.1	0.88	–		–	
7	*Pterocarpus erinaceus*	–		–		2.7	0.39	–		–	
8	*Diospyros mespiliformes*	2.4	0.34	–		–		–		–	
9	*Annona senegalensis*	0.3	0.04	–		2.1	0.30	–		–	
10	*Hyphaene thebaica*	–		–		1.6	0.23	–		–	
11	*Parinari curatellifolia*	–		–		1.8	0.26	–		–	
13	*Detarium microcarpum*	0.2	0.03	–		–		–		–	
14	*Saba senegalensis*	0.2	0.03	–		–		–		–	
15	*Ceiba pentandra*	–		0.6	0.09	–		–		–	
17	*Ximenia americana*	0.1	0.01	–		–		–		–	

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