Traditional Classification, Perception, and Preferences for Tallow Tree (*Pentadesma butyracea* Sabine) Organs in Benin: Implications for domestication and conservation

Serge S. Houédjissin, Paulin Azokpota, Achille Assogbadjo, Corneille Ahanhanzo, and Joseph D. Hounhouigan

Research

Abstract

The present study examined farmer's indigenous knowledge on morphological variation, preference in product traits, management practices, and regeneration of *Pentadesma butyracea* Sabine. Surveys were conducted on a total of 131 users of different ages randomly selected from seven different sociocultural groups (Anii, Kotocoli, Nagot, Boo, Ditamari, Natimba and Waama) taking into account gender differences in Benin. Principal component analysis was carried out to identify correlations between the characteristics of *P. butyracea*. Local people in the twelve villages investigated used 13 criteria (height, trunk diameter, trunk color, trunk structure, distance from water, tree age, fruit pulp color, fruit size, fruit shape, number of seeds per fruit, seed color, seed size, and seed shape) to differentiate *P. butyracea* trees growing in traditional agroforestry systems. Older people were found to have greater knowledge than younger people to distinguish *P. butyracea*. Importantly, 77% of respondents of all ethnic groups confirmed that no protection measure was taken to conserve *P. butyracea* trees. This identified knowledge can constitute a guarantee for the development of strategies for conservation, domestication, and sustainable use of *P. butyracea* genetic resources because one of the best ways to validate our results to local people is to consider their knowledge and to promote the development of their experiences.

Résumé

La présente étude a mis en évidence les connaissances endogènes des populations locales sur la variation morphologique, **leurs préférences** (**traits désirables et non désirables**), **les procédures de gestion locale et la régénération de** *Pentadesma butyracea* Sabine **au Bénin**. **Au total**, **131 personnes**, **de différents âges et sexes**, **appartenant à sept groupes ethniques différents** (Anii, Kotocoli, Nagot, Boo, Ditamari, Natimba **et** Waama) **ont été aléatoirement interviewées**. **L'analyse en composante principale (ACP) a été effectuée pour expliquer la corrélation entre les caractéristiques de** *P. butyracea*. **Dans les douze localités enquêtées**, **les populations utilisent** 13 **critères** (**taille**, **dimension du tronc**, **couleur du tronc**, **structure du tronc**, **distance de l'arbre de l'eau**, **âge de l'arbre**, **dimension du fruit**, **nombre de graines par fruit**) **pour différencier les arbres de** *P. butyracea*. **Cependant**, **l'arbre de** *P. butyracea* **est plus connu par les personnes âgées**. **Cette étude a également prouvé que 77.2% des interviewés**, **toutes ethnies confondues**, **ont confirmé qu'aucune mesure de protection n'a été prise pour conserver les arbres de** *P. butyracea*. **Les savoirs paysans recensés ici**, **peuvent constituer un gage pour le développe-**

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ment de stratégies de conservation, **de domestication et d'utilisation durable des ressources génétiques de** *P. butyracea*, **car l'une des voies pour mieux valider nos résultats auprès des populations rurales est de tenir compte de leurs savoirs**, **et cela favorise la valorisation de leurs expériences**.

Introduction

Pentadesma butyracea Sabine (Clusiaceae) is an endemic species of the dense forests of West Africa. It is spread from Guinea to the Democratic Republic of Congo, Sierra Leone, Côte d'Ivoire, Togo, Tanzania, and Uganda (Sacandé & Sama 2007). In Benin, the species grows in gallery forests and on river banks (Natta *et al*. 2010).

Pentadesma butyracea is particularly known for its use as a food and for health, social, cultural, cosmetic, and pharmaceutical purposes (Avocevou-Ayisso *et al*. 2009). Taking into account the increasing demand for **shea** butter and strong pressure exerted on **shea** trees (Sanou & Lamien 2011), alternative sources to **shea** butter are increasingly required. *Pentadesma butyracea* is one of the many non-timber forest products from which seed butter of organoleptically excellent quality is extracted, an important substitute for **shea** butter (N'Klo 2001), which is used by local people for cooking as well as for the preparation of certain therapeutic treatments.

Despite its socio-economic importance in Benin, this species is threatened because of over-exploitation of the seeds, expansion of agricultural areas, and seasonal fires caused by farmers and hunters (Natta *et al*. 2011). This degradation is likely to cause major difficulties for the socio-economic life of local people today and future generations. Thus, if no measures for the sustainable management of resources and protection of *P. butyracea* are taken, man himself poses a significant risk to its survival in the millennia to come. It is therefore important to broaden and deepen the local knowledge for its sustainable use and *in situ* and *ex situ* conservation.

Understanding indigenous knowledge of exploiting and managing local natural resources is recognized as crucial for the development of management strategies for the sustainable use of those resources (Fandohan *et al*. 2010). Ethnobotanical studies have shown that indigenous knowledge is important for the conservation of biological and cultural diversity as well as for the sustainable use of these resources (Luoga *et al*. 2000). The integration of ethnobotanical knowledge in the development of management strategies and conservation of endogenous plant resources is essential to ensure effectiveness of their conservation (Kouyate 2005). Participatory approaches place producers and consumers in the center of decisions about conservation and promotion of ethnobotanical resources. It is therefore necessary to evaluate the needs and knowledge of local peoples, identify their preferred species, and evaluate the cultural importance of their resources in order to allow their integration in conservation programs (Lougbegnon *et al*. 2011).

In Benin, research has been conducted on ethnobotanical knowledge of the socio-economic importance of *P. butyracea* and uses of the different parts (Avocèvou-Ayisso *et al*. 2011, Houngbédji 1997, Natta *et al*. 2010, Sinsin & Sinadouwirou 2003). However, very little information is available on local perceptions about the morphological variations of *P. butyracea*. Ambé (2001) pointed out that it is advisable to identify the species that local people know and appreciate, and that local perceptions must guide the choice of the morphotype to be preserved and develop. According to Assogbadjo *et al*. (2005), farmers have enough specialized knowledge about their botanical resources and use different criteria for their characterization. We postulate that folk classification of *P. butyracea* according to morphological variations can help better characterize the biodiversity of the species and contribute to the development of efficient models for its management and conservation.

Objectives

The main objective of this study was to provide a basis for the development of an efficient strategy for the management and conservation of *P. butyracea* in Benin. Specifically, the study involved an ethnobotanical survey among local people in Benin to: (1) understand their perceptions of *P. butyracea* variations; (2) identify their preferences (both desirable and undesirable) regarding *P. butyracea* traits; (3) assess their perceptions about distribution, modes of reproduction, and management of *P. butyracea*; and (4) understand correlations between various traits according to local people.

Methods

Study area

The study was conducted in northern Benin (6–12°50'N, 1–3°40'E) in four phytogeographical zones: Bassila, Atacora chain, South Borgou, and North Borgou. Data were collected in the municipalities of Tchaourou, Bassila, Kandi, Natitingou, and Toucountouna which are recognized as the most important in terms of distribution of *P. butyracea* in Benin (Avocèvou-Ayisso *et al*. 2011, Natta *et al*. 2010). The characteristics of these different phytogeographical areas and municipalities are shown in Figure 1 and Table 1. Different phytogeographical zones, locations, climate, soil type, and vegetation were defined according to Adomou (2005).

Sampling and ethnobotanical survey

An ethnobotanical survey was conducted in twelve villages where people exploit parts and products of *P. butyra-*

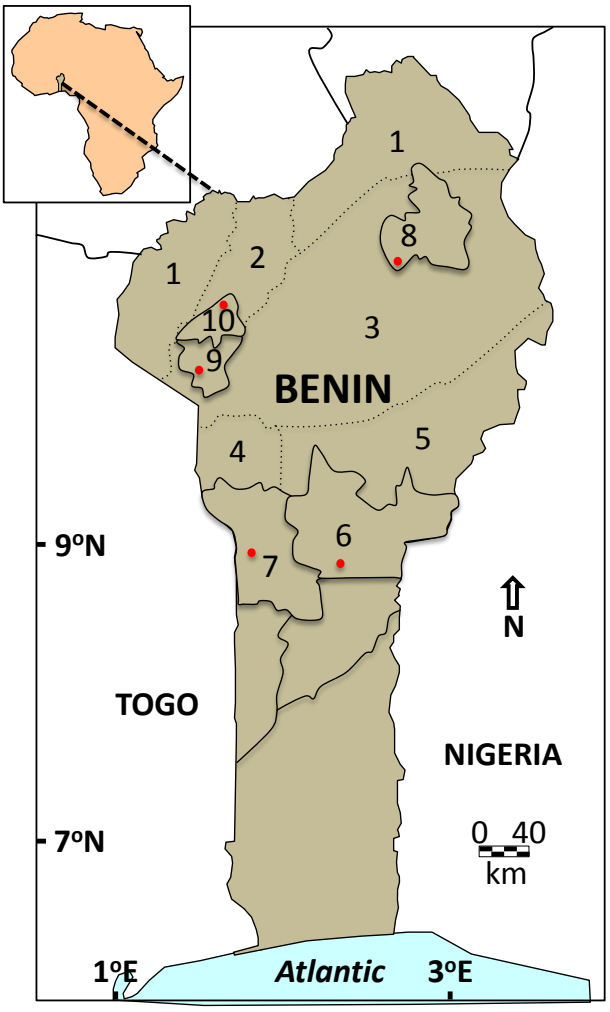

Figure 1. Northern Benin phytogeographical zones: (**1**) Mekrou-Pendjari, (**2**) Atacora Chain, (**3**), North Borgou, (**4**) Bassila, (**5**) South Borgou, and municipalities: (**6**) Chaourou, (**7**) Bassila, (**8**) Kandi, (**9**) Natitingou, and (**10**) Toucountouna, with study site villages as red dots. Based on field work in 2013-2014 and DIVA-GIS database.

cea: Agbassa (Tchaourou); Bensékou (Kandi); Tandaffa, Peperkou, Kouba, Kouaffa, and Bouyagnidi (Toucountouna); Manigri, Pénessoulou, and Bakababka (Bassila); Ourbouga and Yimporima (Natitingou). We conducted the study in these villages because *P. butyracea* is more and more threatened by the exploitation of its parts in these areas (Natta *et al*. 2011). Ethnobotanical data were collected from these villages using individual interviews to prevent informants from being influenced by each other. Interviews were conducted from May to June 2013 and from February to April 2014. Respondents were drawn using the proportional stratified random sampling method (Waksberg 1978). A preliminary survey revealed that in the study area, half of the people had used *P. butyracea*. Sample size for the study was based on the following formula of Dagnelie (1998):

$$n = \frac{U^2_{1-\alpha/2} \times p\,(1 - p)}{d^2},$$

where, n is the total number of surveyed people in the study; $U_{1-\alpha/2}$ is the value of the normal random variable for a probability value of $\alpha = 0.05$, $U_{1-\alpha/2} = 1.96$; p is the proportion of people who had used *P. butyracea* (p = 0.5; result from a preliminary survey); and d is the expected error margin of any parameter to be computed from the survey, which is fixed at 9%.

The computed sample size was 119. For practical reasons, 131 people were used in our study. The number of people surveyed per phytodistrict was proportionally determined taking into account the registered total number of users of *P. butyracea*.

Local knowledge is shared, but it varies from one sociocultural group to another and from one individual to another in a given sociocultural group (Assogbadjo *et al*. 2008, Monteiro *et al*. 2006). Accordingly, we collected information from people of different ages and genders from different sociocultural groups and different phytogeographical zones (Table 2). In each sociocultural group, interviews were conducted with men and women of different ages (youth <30 years; adults 30–60 years; older persons >60 years). Local informants participated and provided information on a voluntary basis.

Although the questionnaire was in French, the interviews were conducted in local languages of the informants, with the researcher accompanied by a translator should the need arise. Interviews focused on recognition of the species, its name, and its meaning, morphological variations (trees, seeds, and fruit), desirable and undesirable traits, and mode of reproduction as well as distribution and local management measures. Data relating morphological traits with habitat of the species were also collected.

Data recorded in the survey sheets were transferred to a database and processed using the statistical software Sphinx V 4.5. To determine the distribution of local knowledge, respondents were grouped according to sociocultural group, age, and gender. Frequency distribution was used to compare response rates between these social factors. Principal Component Analysis (PCA) was carried out to explain correlation between characteristics of *P. butyracea*. Factor analysis was used to identify the structure of the variables characterizing the study population (Hair *et al*. 2010) and reduce the number of variables to those that provide sufficient expression of the total variability. Chi-square test was also performed to detect possible as-

Table 1. Location, climate, soils and vegetation of the study circles. PZ = phytogeographical zone (area). H = average % humidity. PU = pluviometry (mm) uninodale.

PZ	Surveyed commune & location	Temp. (°C)	H	PU	Major types of soil	Plant formations
Bassila	Bassila 8°30′–9°30′ N, 1°00′–2°30′ E	19–33	45.5–87.1	900–1300	Lateritic soils with concretions and breastplates	Semi-deciduous forests, woodland and gallery forest
South Borgou	Tchaourou 10°19’ N, 1°23’ E	27–36	45.5–87.1	1100–1200	Ferruginous tropical soils young with low concretions	Forest dries woodland and forest gallery
North Borgou	Kandi 8°53’ N, 2°36’ E	28–37		1000–1200	Ferruginous grounds with concretion on sedimentary rocks	Savanna raised and shrubby with forests gallery, dry forest
Atacora Chain	Natitingou 10°18’14” N, 1°22’46” E	17–35	54.9	1000–1200	Ferruginous muddy-sandy grounds and grounds of silt	Forest gallery, dry forest & woodland
	Toukountouna 10°20′–10°45′ N, 1°10′–1°40′ E	19–38				

Table 2. Distribution of respondents interviewed during the ethnobotanical study of *Pentadesma butyracea* Sabine by phytogeographic zone and sociocultural group.

Phytogeographic zones (areas)	Municipalities	Sociocultural groups	Number of informants	Frequency (%)
Bassila	Bassila	Anii	16	12.2
		Kotocoli	7	5.3
		Nagot	7	5.3
South Borgou	Tchaourou	Nagot	14	10.7
North Borgou	Kandi	Boo	22	16.8
	Natitingou	Ditamari	5	3.8
Atacora Chain	Toukountouna	Natimba	16	12.2
		Waama	44	33.6
Total			**131**	**100**

sociation between repondents’ knowledge and their sociocultural group or gender.

Results

Local names and significance

P. butyracea has a local name in each language. Table 3 shows the local names with their particular meanings. The Boo, Anii, Natimba, Nagot, and Kotokoli designate the species according to its position relative to a watercourse (river or creek), and the Waama describe the species based on ability of the seeds to produce oil (butter) while the Ditamari appraise *P. butyracea* trees according to the hardness of the seeds.

Recognition of P. butyracea tree among sociocultural groups, age category, and gender

The study revealed that 97% of the respondents were acquainted with *P. butyracea*. Variations of the recognition of *P. butyracea* tree were not significant among sociocultural groups (χ^2 = 4.32, df = 7, p > 0.74). This means that sociocultural group seems to have no influence on the level of recognition of *P. butyracea* (Table 4). The same was observed for gender (χ^2= 1.56, df = 1, p > 0.21).

However, the data showed that recognition of *P. butyracea* tree varies according to age (<30 years 80%; 30–60 years 98.9%; >60 years 100%). From one age group to the other, significant differences were detected on recognition of *P. butyracea* tree (χ^2 = 16.5%, df = 2, p < 0.000). The elderly (>60 years) and middle-aged (30–60 years)

Table 3. Local names of *Pentadesma butyracea* Sabine and significance.

Sociocultural groups	Local names	Significance
Anii	**N'wourounmè**	Tree which gives oil.
Boo	**Swaluku**	River or backwater **shea** tree.
	Ken	Seeds that last.
Ditamari	**Dikpecheponi**	
	Ekpéchèkpo	
Kotokoli	**Akpoto**	Tree which gives living oil. Tree at the edge of water.
Nagot/ Agbassa	**Kpangnan**	**Shea** tree of the river or backwater. Oil of good quality.
Nagot/ Manigri	**Kpangnin**	Oil of good quality. Tree living at the edge of the backwater.
Natimba	**Kontoga, kontodi, kontori**	River or backwater **shea** tree. Tree living at the edge of the backwater.
Waama	**Kounbota, kounboo, kounbonan**	Prepare oil / river shea tree
	Kounbowou, koubobou, nangaka	Prepare oil / river or backwater shea tree / tree which gives oil

Table 4. Local perception of *Pentadesma butyracea* Sabine according to different sociocultural groups from the northern Benin. Σn = total number of answers per age and gender, n = number of interviewees, Y=Yes, N= No, F% = frequence of answer, NS = P>0.05, * = P<0.05, ** = P<0.01, *** = P<0.00.

		Sociocultural groups															
		Anii		Boo		Ditamari		Kotokoli		Nagot/ agbassa		Nagot/ manigri		Natimba		Waama	
Traits	Statistics	n	F%	n	F%	n	F%	n	F%	n	F%	n	F%	n	F%	n	F%
Recognition of the tree	Y	16	12	21	16	5	3.8	7	5.3	14	11	7	5.3	16	12	41	31
	N	-	-	1	0.8	-	-	-	-	-	-	-	-	-	-	3	2.0
	Σn	16	-	22	-	5	-	7	-	14	-	7	-	16	-	44	-
	χ^2	4.32															
	P value	>0.74 ^{NS}															
Differentiation in fruit traits	Color	-	-	2	1.5	-	-	-	-	-	-	-	-	1	0.8	-	-
	Size	16	12	18	14	5	3.8	7	5.3	12	9.2	6	4.6	13	9.9	35	27
	Form	12	9.2	12	9.2	5	3.8	7	5.3	6	4.6	3	2.3	11	8.4	34	26
	Seed number	12	9.2	16	12	5	3.8	7	5.3	6	4.6	5	3.8	13	9.9	39	30
	Σn	40	-	49	-	15	-	21	-	24	-	14	-	38	-	108	-
	χ^2	18.6															
	P value	>0.91 ^{NS}															
Differentiation in seed traits	Color	-	-	2	1.5	-	-	-	-	-	-	-	-	-	-	2	1.5
	Size	16	12	12	9.2	5	3.8	7	5.3	9	6.9	7	5.3	8	6.1	26	20
	Form	15	12	8	6.1	5	3.8	7	5.3	3	2.3	6	4.6	8	6.1	21	16
	Σn	31	-	22	-	10	-	14	-	12	-	13	-	16	-	49	-
	χ^2	34.8															
	P value	<0.03*															

Traits	Statistics	Sociocultural groups															
		Anii		Boo		Ditamari		Kotokoli		Nagot/ agbassa		Nagot/ manigri		Natimba		Waama	
		n	F%	n	F%	n	F%	n	F%	n	F%	n	F%	n	F%	n	F%
Differentiation in whole tree traits	Size	14	11	9	6.9	4	3.1	7	5.3	3	2.3	7	5.3	8	6.1	20	15
	Trunk size	16	12	9	6.9	4	3.1	7	5.3	3	2.3	7	5.3	10	7.6	15	12
	Bark color	4	3.1	3	2.3	-	-	3	2.3	1	0.8	1	0.8	-	-	-	-
	Bark structure	1	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σn	35	-	21	-	8	-	17	-	7	-	15	-	18	-	35	-
	χ^2	58.2															
	P value	<0.000***															
Preference in fruit traits	Large & small fruit	15	12	15	12	5	3.8	7	5.3	12	9.2	6	4.6	7	5.3	40	31
	Large fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Small fruit		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σn	15	-	18	-	5	-	7	-	12	-	6	-	7	-	40	-
	χ^2	20.0															
	P value	>0.13 NS															
Propagation & regeration practices	Vegetative	-	-	-	-	-	-	1	0.8	-	-	-	-	-	-	-	-
	Suckering	-	-	1	0.8	-	-	-	-	4	3.1	-	-	8	6.1	8	6.1
	Sowing	16	12	12	9.2	5	3.8	7	5.3	13	9.9	7	5.3	14	11	37	28
	No idea	-	-	9	6.9	-	-	-	-	1	0.8	-	-	1	0.8	6	4.6
	Σn	16	-	22	-	5	-	8	-	18	-	7	-	23	-	51	-
	χ^2	39.8															
	P value	<0.000***															

informants knew more *P. butyracea* than younger people (<30 years).

Local perception of** P. butyracea **tree variation

Local perceptions of *P. butyracea* vary from one phytogeographic zone to another. Local people in the four phytogeographic zones investigated used 13 criteria to differentiate individual *P. butyracea* trees growing in their traditional agroforestry systems. These criteria are related to the characteristics of the whole tree (height, trunk diameter, color and structure of the bark, position relative to watercourse, age), fruit (color of pulp, size, shape, number of seeds), and seeds (color, size, shape). Table 4 shows the percentage of respondents using different criteria and variations to identify and distinguish *P. butyracea* individual trees in each of the four phytogeographic zones.

Traditional identification criteria of Pentadesma tree

Farmers use six criteria (height and diameter of tree trunk, color of the bark, bark structure, the position relative to watercourse, and age of the tree) to distinguish *P. butyracea*. Sociocultural groups seem to have an influence on the different criteria for distinguishing individual *P. butyracea* (χ^2 = 58.24, df = 28, p < 0.007). The Waama, Natimba, and Ditamari use height and diameter of the trunk to differentiate individual *P. butyracea*. All other socioculturral groups (Nagot/Agbassa, Anii, Nagot/Manigri, Kotokoli, and Boo) distinguish individual trees according to height and diameter of the trunk and color and structure of the bark. Moreover, local people distinguish three types of *P. butyracea* tree according to height and diameter of the trunk: small, medium, and large diameter trees. Based on the color of the bark, the farmers identified five types of *P.*

butyracea as black, clear black, ash, white, and red and black with white spots. Using the structure of the bark, local people distinguish three types of *P. butyracea*: smooth, pretty rough, and rough. Based on the position of the tree relative to the water, local populations classified *P. butyracea* into two categories: the trees near water are large-diameter and produce many large fruit compared to those located far from water which are very tall, have small diameter and produce small fruit. With respect to age, farmers distinguish two types: older trees that produce fewer fruit and younger trees produce more fruit.

Traditional identification criteria of Pentadesma fruit

Four traditional criteria (color, size, shape, and number of seeds) are used to differentiate the fruit. All of the different sociocultural groups differentiate fruit by size, shape, and number of seeds. In addition, the Boo and Natimba use color to differentiate the fruit. The chi-square test indicates that there are no significant differences between sociocultural groups and distinction of fruit (χ^2 = 18.59.17, df = 14, p > 0.91) (Table 4).

Moreover, the chi-square test indicates that gender seems to have no influence on the recognition of the existence of morphological variability between fruit (χ^2 = 1.42, df = 2.1, p > 0.84) (Table 5). Considering the different age groups, the chi-square test showed that the dependence between response rate compared to recognition of the existence of variability between fruit and different age classes is not significant (χ^2 = 11.11, df = 4, p > 0.19) (Table 5). Regarding color, three main criteria are used by all sociocutur-

Table 5. Perception of knowledge, variability, propagation, and management practrices of *Pentadesma butyracea* Sabine by age and gender in northern Benin. Σn : total number of answer per age and gender, n = number of respondents, Y = yes, N = no, F% = frequencey of answer, NS = P >0.05, * = P <0.05, ** = P <0.01, *** = P <0.001.

		Age (years old)						Gender			
	Statistics	<30		30–60		>60		Male		Female	
		n	F%	n	F%	n	F%	n	F %	n	F%
Recognition of the tree	Y	12	9.2	88	67	27	21	36	28	91	97
	N	3	2.3	1	0.8	-	-	-	-	4	3.1
	Σn	15	-	89	-	27	-	36	-	95	-
	χ^2	16.5						1.56			
	P value	<0.000***						>0.21 NS			
Differentiation in fruits traits	Color	-	-	3	2.3	-	-	1	0.8	2	1.5
	Size	10	7.6	79	60	23	18	35	27	77	59
	Form	6	4.6	67	51	17	13	25	19	65	50
	Seed number	8	6.1	74	57	21	16	30	23	73	56
	Σn	24	-	223	-	61	-	91	-	217	-
	χ^2	11.1						1.42			
	P value	>0.19 NS						>0.84			
Differentiation in seeds traits	Color	1	0.8	3	2.3	-	-	1	0.8	3	2.3
	Size	6	4.6	64	49	20	15	25	19	65	50
	Form	3	2.3	58	44	12	9.2	20	15	53	41
	Σn	10	-	125	-	32	-	46	-	121	-
	χ^2	14.0						0.02			
	P value	<0.03*						>0.99 NS			
Differentiation in trees traits	Size	5	3.8	55	42	12	9.2	22	17	50	38
	Trunk diameter	5	3.8	56	43	10	7.6	21	16	50	38
	Bark color	-	-	10	7.6	2	1.5	3	2.3	9	6.9
	Bark structure	-	-	1	0.8	-	-	-	-	1	0.8
	Σn	10	-	122	-	24	-	46	-	110	-
	χ^2	13.7						0.97			
	P value	<0.09*						>0.91			

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	Statistics	Age (years old)						Gender			
		<30		30–60		>60		Male		Female	
Preference in fruits traits	Large & small fruits	9	6.9	79	60	25	19	27	21	86	66
	Large fruits	-	-	2	1.5	1	0.8	2	1.5	1	0.8
	Small fruits	-	-	-	-	-	-	-	-	-	-
	Σn	9	-	81	-	26	-	29	-	87	-
	χ^2	14.5						5.81			
	P value	<0.005**						<0.05*			
Propagation & regeration practices	Vegetative	-	-	-	-	-	-	-	-	-	-
	Suckers	3	2.3	12	9.2	7	5.3	8	6.1	14	11
	Sowing	6	4.6	83	63	22	17	32	24	79	60
	No idea	8	6.1	5	3.8	4	3.1	3	2.3	14	11
	Σn	17	-	100	-	33	-	43	-	107	-
	χ^2	29.0						1.65			
	P value	<0.000***						>0.44 NS			
Management practices to conserve *P. butyracea*	Forbid to collect all fruits	-	-	1	0.8	1	0.8	2	1.5	-	-
	Forbid to cut the trees	1	-	2	1.5	-	-	4	3.1	21	16
	Afforestation	-	-	19	15	5	3.8	-	-	2	1.5
	Assisted tree regeneration	-	-	2	1.5	-	-	-	-	-	-
	No measure	11	8.4	1	0.8	-	.	1	0.8	70	53
	Σn	12	-	25	-	6	-	7	-	93	-
	χ^2	16.1						10.6			
	P value	>0.09 NS						>0.06 NS			

al groups: red, brown, and gray fruit. Regarding fruit size and shape, three types of fruit can be distinguished: small, medium, and large.

Traditional identification criteria of Pentadesma seeds

The respondents distinguish *P. butyracea* seeds according to color, size, and shape. Significant differences (χ^2 = 24.76, df = 14, p < 0.03) were detected between sociocultural groups and seed variations they recognized. Thus, 34% of Waama, 17% of Boo, 12% Anii, 12% Natimba, 11% Nagot/Agbassa, 5% Nagot/Manigri, and 4% of Kotokoli Ditamari respondents recognized on variations in seed morphology. It emerged that sociocultural group has influence on seed variations recognized. The Waama and Boo identified seeds as red, light red, and black seeds. All sociocultural groups differentiate seeds as small, medium, and large. This significant dependence (χ^2 = 14.56, df = 4, p < 0.03) was also observed between the different age groups (Table 5). Gender, however, seems to have no influence on the recognition of seed variations (χ^2 = 0.02, df = 2, p > 0.99).

Preference for P. butyracea products

All sociocultural groups pick up the large fruit because they believe that large fruit contain many large seeds which, in turn, produce more butter. All sociocultural, ages, and gender groups collect large and small fruit (Table 5). Local people's main reasons for wild foraging included "how far the trees are from home," "non-availability of seeds," and "to collect many seeds." In contrast, they don't sort the seeds to make butter but rather mix large and small seeds. Our investigations revealed that the quality of butter extracted does not depend on the shape or the size of the seeds, but on the maturity, decay state, and the processor.

No significant differences were observed for the preference of *P. butyracea* products according to the sociocultural groups (χ^2 = 19.95, df = 44, p < 0.13) (Table 4). Preferences for *P. butyracea* products differed significantly

among age (χ^2 = 14.53, df = 4, p < 0.005) and gender (χ2 = 5.81, df = 14, p < 0.05) groups. Men and middle-aged people preferred larger fruit than women and older people.

Propagation and indigenous regeneration practices

The respondents are aware of the different modes of reproduction of *P. butyracea*, namely by suckering and by seed. However, planting *P. butyracea* from germinated seeds in the nursery is unknown. Consequently, there are no plantations of *P. butyracea* from seedlings raised in nurseries. Moreover, 92% of respondents have never tried to plant *P. butyracea*. The 8% who tried to raise the species (Table 4) in nurseries commented that *P. butyracea* is a very demanding species compared to other local tree species: seed germination is very slow (it could take more than one month), seedlings cannot withstand heat, the seedlings need watering every day, and growth is slow. Thus, they are forced to abandon raising *P. butyracea* in the nursery and turn to other less demanding forest species.

Traditional management pratices to conserve P. butyracea trees

In general, 77% of respondents of all sociocultural groups confirmed that no protection measure is taken to conserve *P. butyracea* trees. However, some of the respondents revealed that forbidding cutting of the trees (19%) and collecting all fruit (1.6%) are management practices that they take to conserve *P. butyracea* trees. Forbidding cutting of the trees is the most important practice in all sociocultural and gender groups (Table 4 and 5). Significant differences were observed among sociocultural groups (χ^2= 57.21, df = 35, p < 0.01). Loglinear analysis showed that management practices to conserve *P. butyracea* trees didn't vary significantly among age (χ^2= 16.07, df = 10, p > 0.09) or gender (χ^2 =10.60, df = 5, p > 0.06) groups.

Links between the characteristics of P. butyracea as perceived by local people

In rural areas, the links between different traits of *P. butyracea* are well known by local people. Some criteria are related to the whole tree (age, height, and diameter of the trunk, color and texture of the bark, position relative to the water) and soil characteristics (moisture, fertility).

Very old trees produce less fruit. In contrast, younger trees produce larger fruit. According to respondents, trees more proximate to water produce very large fruit while those distant from the water give large and small fruit. In addition, the respondents reported that trees which are closer to water are shorter and have a larger diameter than those which are distant from the water, which are taller and have smaller diameter. Trees on poor soils produce small fruit, but those on fertile soils produce large fruit.

The results also showed that respondents are able to establish a link between the color of the bark *P. butyracea* and fruit size. According to them, black bark trees produce larger fruit than those with clear black bark, while those with white and red barks give fewer fruit.

Moreover, it was revealed that fruit size and the fruit form are associated with the number of seeds. In contrast, the quality of the butter extracted from the seeds does not depend on the morphological characters of the trunk, fruit, or seeds, but on the physiological characteristics (mature, not rotten) of the seeds and methods of making butter.

The principal component analysis performed on the relationship between the characteristics of *P. butyracea* perceived by local people pointed out that the first component explains 63% of basic information and the first three axes, 98% of the information contained in the original variables. This is sufficient to ensure accurate interpretation of the relationship between characteristics. We noted that height and diameter of the trunk, number of seeds, and seed size and shape are positively correlated with axis 1 (Table 6). There is a correlation between the height and diameter of

Table 6. Correlation between *Pentadesma butyracea* Sabine characteristics and principal component analysis (PCA) factors in northern Benin.

Variables	PCA1	PCA2	PCA3
Cut of the tree	0.403	-0.160	-0.167
Trunk diameter	0.354	-0.379	-0.191
Bark color	-0.006	-0.765	0.535
Fruit size	0.256	0.398	0.762
Seed number	0.396	0.188	-0.075
Fruit form	0.401	0.174	-0.053
Seeds cut	0.409	0.018	0.165
Seeds form	0.402	-0.147	-0.184

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the trunk and the number, size, and shape of the seeds. Fruit size and bark color are positively correlated with the third axis, which means that the color of the trunk has a positive influence on fruit size (Table 6). The second axis does not explain well the correlation between the different characteristics of *P. butyracea*.

Discussion

Indigenous knowledge of respondents on P. butyracea

In order to provide the basis for an efficient strategy for the domestication and conservation of *Pentadesma butyracea* in Benin, the current study provides important information on the perceptions and traditional knowledge of *P. butyracea* by seven sociocultural groups (Anii, Kotocoli, Nagot, Boo, Ditamari, Natimba, and Waama) in northern Benin. In general, this ethnobotanical survey showed that *P. butyracea* is well known by the sociocultural groups studied. Each sociocultural group has a different name for the species, indicating age-old knowledge. However, old people have greater knowledge than youths to distinguish *P. butyracea*. The young people confirmed that they have never seen a *P. butyracea* tree. Therefore, the transmission of knowledge about *P. butyracea* is very threatened. For instance, Ewèdjè (2012) reported that *P. butyracea* butter is consumed much more by older people. It is therefore necessary to educate the young about the importance of the *P. butyracea* tree for a sustainable transmission of information on the species from generation to generation. According to Eyssartier *et al*. (2008) participatory activities can be encouraged within the communities which could enhance traditional knowledge horizontal transmission, particularly among elder adults and youngsters. Morever, it is important to involve old people in the research/development programs related to germplasm sampling and improvement of *P. butyracea*.

Folk classification and local people preferences of P. butyracea products

The criteria for differentiation of *P. butyracea* varied from one farmer to another. Local people consider that some criteria are related to the whole tree (age, height, and diameter of the trunk, color and texture of the bark, position relative to water), while others are related to the characteristics of tree products (fruit, seeds) and to the soil (moisture, fertility). According to local people, the productivity and fruit size depend on the tree's age and distance from the water as well as the fertility of the soil.

In general, the survey revealed that local people distinguish nine morphotypes (Table 7). Previous studies reported that farmers have always used their own criteria to differentiate phenotypes (Assogbadjo 2006). According to Assogbadjo *et al*. (2012), local people identify individual *Adansonia digitata* L. according to the fruit (color and seed size, early maturity, tree productivity, as capsules, taste of the flesh) and leaves (color, taste, and shape). This is also the case of *Parkia biglobosa* in West Africa where farmers distinguish ecotypes according to the trunk, fruit, seed, pulp, and inflorescence (Ouedraogo 1995).

The farmers did not mention any preference for particular *P. butyracea* traits and parts (fruit and seeds). The fruit and seeds are mixed regardless of their origin. However, some would pick up only larger fruit for more seeds while others prefer larger seeds because they give more butter. The various criteria of *P. butyracea* mentioned above demands investigation for the existence of varieties and their appropriate characterization. The differences identified by farmers will be also of interest in terms of selection after confirmation of this variability by genetic characterization. In Benin, the morphometric variables were genetically determined (Ewèdjè *et al*. 2012), but since no large-scale information is available on *P. butyracea* tree variation combining both molecular data and local perceptions, it is not

Table 7. Folk classification of *Pentadesma butyracea* Sabine morphotypes in northern Benin.

Folk morphotypes classification	Plant characteristics				
	Trees height	Trunk dimension	Fruit size/shape	Seed number	Fruit productivity
Trees distant from water	Tall	Small	Small	Few	Few
Trees close to water	Short	Large	Large	Many	Many
Old trees	-	-	Small	Few	Few
Younger trees	-	-	Large	Many	Many
Trees with black bark	-	-	Large	Many	-
Trees with less black bark	-	-	Medium	Few	-
Trees with white bark	-	-	Small	Few	-
Trees on fertile soil	-	-	Large	Many	Many
Trees on poor soil	-	-	Small	Few	Few

known whether the morphotypes of *P. butyracea* as defined by local people, are purely genetycally defined.

Traditional management and domestication of P. butyracea

With regard to the traditional management of *P. butyracea*, no particular action is carried out by the local people. In Kouba (Toucountouna), the respondents told us that the researchers who had worked on the tree were forbidden to collect all the fruit and cut *P. butyracea* trees. They revealed that before researchers came to the area, loggers had felled all the big *P. butyracea* trees, and this had decreased their density. According to our observations, we believe that these actions alone are not sufficient because people are always in search of land for the expansion of their farm areas. Indeed, in this area, cotton farms rival lands with *P. butyracea* trees. We also note the practice of slash and burn wherein young *P. butyracea* are cut and burned. Therefore fires constitute a threat to the species (Avocevou-Ayisso *et al*. 2009, Natta 2003, Sinsin & Sinadouwirou 2003).

In Bakabaka (Bassila), due to the total destruction of the forest and the proximity of people to the reforestation area, afforestation measures were taken. Unfortunately, these measures have not solved the problem because people have not yet mastered the regeneration of the species unlike other tree species such as *Tectona grandis* L.f.

In Pénessoulou (Bassila), we noticed that *P. butyracea* trees are not cut because the trees are in the forest reserve where it is strictly forbidden. Residents refrain from cutting trees for fear of being fined or jailed. So we can say at first glance that in Penessoulou *P. butyracea* trees are spared from uncontrolled cuts. However, another danger looms over these populations such as the uncontrolled collection of fruit. Consequently, there is a notable absence of young *P. butyracea*. Within a few years, if no action is taken, there will be no renewal of this forest.

The most dramatic case that we have observed in the field is that of Ourbouga (Natitingou) where the gallery forest is completely destroyed and has given way to human habitats. The municipality of Natitingou in partnership with non-governmental organizations and development partners has ordinances prohibiting the cutting of trees and vegetation fires. But this action of the city council does not prevent people in search of space to occupy, thereby destroying trees. These observations confirmed those of Sinsin *et al*. (2011) which revealed that the chain of Atacora is not protected. Therefore, if nothing is done in the next five years with the growing population, there will be few or no *P. butyracea* in this area.

The same observations were made in Peperkou (Toucountouna) where proximity of *P. butyracea* trees to human populations does not allow natural regeneration of the trees. Our own investigations show that local people collect all the fruit that fall, yet the trees are aging. In our opinion, this phenomenon is a consequence of local people's behavior towards nature which is, unfortunately, to considere it as a gift of God and thus inexhaustible.

The respondents are aware of the different reproduction modes of *P. butyracea* such as suckering and seed. However, the farmers surveyed have never tried to plant the tree. It was seen that *P. butyracea* trees are wild. According to Ewédjè Eben-Ezer (2012), the wild population has a low frequency of producing saplings to replace old trees. We can conclude from then that it is time for the spread of *P. butyracea* by planting with seeds germinated in the nursery. Kouyate (2005) suggests that new approaches should be explored, such as controlled mycorrhiza and the contribution of compost in planting holes dug several months before planting. According to the author, this practice has the advantage of creating a favorable microclimate, allowing the roots to survive during the dry season.

Implications for management and conservation of** P. butyracea **genetic resources

In general, the ethnobotanical survey revealed that indigenous knowledge about *P. butyracea* varies according to sociocultural group and gender. Selection or breeding programs should focus on *P. butyracea* trees with important features for local populations. For instance, when looking at preferred fruit traits, the present work showed that *P. butyracea* fruit size is the most important trait appreciated by all the respondents. But the Boo and Natimba differentiate *P. butyracea* fruit by color, form, and number of seeds while the Waama, Nagot, Ditamari, Anii, and Kotokoli differentiate the fruit by size, form, and number of seeds. These differences need to be taken into account in any research/development program related to germplasm sampling for *P. butyracea* improvement.

Conservation of *P. butyracea* genetic resources can be done effectively through production of the species in agroforestry systems, maintenance on protected areas where they occur, and maintenance of seeds in gene banks. Since preferred traits vary among the sociocultural groups and gender, the strategy should be specific and target not only the morphotypes recognized by local populations but also integrate the population genetics information. The results also showed that the main cause of degradation of natural populations of *P. butyracea* in Benin is due to anthropogenic activities.

Conclusion

The study provides important information on the perceptions and indigenous knowledge on *Pentadesma butyracea* of seven ethnic groups (Anii, Kotocoli, Nagot, Boo, Ditamari, Natimba, and Waama) in northern Benin. This

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ethnobotanical survey showed that *P. butyracea* is well known by the different ethnic groups. The criteria for differentiation of *P. butyracea* varied from one farmer to another. Local people consider some criteria related to the whole tree, others related to the characteristics of the fruit and seeds and the soil. In general, the survey revealed that local people distinguish nine morphotypes. The farmers did not mention any preference for particular *P. butyracea* traits or parts (fruit and seeds). Except in Kouba, where the respondents told us that the researchers who had worked on the tree were forbidden to collect all the fruit or cut the trees, no particular conservation action has been carried out by the local people. The farmers' knowledge can constitute a guarantee for the development of strategies for the conservation and sustainable use of *P. butyracea* genetic resources. One of the best ways to validate our results to local people is to consider their knowledge and to promote the development of their rich experiences and adoption of technologies. Future research must used quantitative descriptors to assess morphological variation of traditionally classified *P. butyracea* trees and its relation to ecological conditions. It would also be interesting to study the possible morphological differences among wild and planted trees of this species in order to document if these practices have had some effect on the features of the trees.

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Literature Cited

Adomou, A.C. 2005. *Vegetation Patterns and Environmental Gradients in Benin: Implications for biogeography and conservation.* Ph.D. dissertation, Wageningen University, Wageningen, The Netherlands.

Ambé, G.A. 2001. Les fruit sauvages comestibles des savanes guinéennes de Côte d'Ivoire: Etat de la connaissance par une population locale, les Malinké. *Biotechnologie, Agronomie Société et Environnement* 5(1):43–58.

Assogbadjo, A.E. 2006. *Importance Socio-Économique et Etude de la Variabilité Ecologique, Morphologique, Génétique et Biochimique du Baobab (Adansonia digitata L.) au Bénin*. Ph.D. dissertation, Faculty of Bioscience Engineering, Ghent University, Belgium.

Assogbadjo, A.E., R. Glèlè Kakaï, F.J. Chadare, L. Thomson, T. Kyndt, B. Sinsin & P. Van Damme. 2008. Folk classification, perception, and preferences of baobab products in West Africa: Consequences for species conservation and improvement. *Economic Botany* 62(1):74–84. dx.doi.org/10.1007/s12231-007-9003-6

Assogbadjo, A.E., B. Sinsin & P. Van Damme. 2005. Caractères morphologiques et production des capsules de baobab (*Adansonia digitata* L.) au Bénin. *Fruit* 60:327–340. dx.doi.org/10.1051/fruits:2005039

Avocevou-Ayisso, C., B. Sinsin, A. Adegbidji, G. Dossou & P. Van Damme. 2009. Sustainable use of non-timber forest products: Impact of fruit harvesting on *Pentadesma butyracea* regeneration and financial analysis of its products trade in Benin. *Forest Ecology and Management* 257:1930–1938. dx.doi.org/10.1016/j.foreco.2009.01.043

Avocèvou-Ayisso, C., T.H. Avohou, M. Oumorou, G. Dossou & B. Sinsin. 2011. Ethnobotany of *Pentadesma butyracea* in Benin: A quantitative approach. *Ethnobotany Research and Applications* 10:151–166. http://journals.sfu.ca/era/index.php/era/article/view/447

Dagnelie, P. 1998. *Statistiques Théoriques et Appliquées*. De Boeck et Larcier, Brussels, Belgium.

Ewédjè Eben-Ezer, B.K. 2012. *Bilogie de la Reproduction, Phylogéographie et Diversité de l'arbre à Beurre Pentadesma butyracea Sabine (Clusiaceae): Implication pour sa conservation*. Ph.D. dissertation, Université Libre de Bruxelles, Brussels, Belgium.

Eyssartier, C., A.H. Ladio & M. Lozada. 2008. Cultural transmission of traditional knowledge in two populations of North-western Patagonia. *Journal of Ethnobiology and Ethnomedicine* 4:25. dx.doi.org/10.1186/1746-4269-4-25

Fandohan, B., A.E. Assogbadjo, R. Glèlè Kakaï, T. Kyndt, E. DeCaluwé, J.T.C. Codjia & B. Sinsin. 2010. Women's traditional knowledge, use value, and the contribution of tamarind (*Tamarindus indica* L.) to rural households' cash income in Benin. *Economic Botany* 64(3):248–259. dx.doi.org/10.1007/s12231-010-9123-2

Hair, J.F., W.C. Black, B.J. Babin & R.E. Anderson. 2010. *Multivariate Data Analysis*. 7th edition. Prentice Hall, Upper Saddle River, New Jersey, U.S.A.

Houngbédji, A. 1997. *Étude Phytotechnique, Ecologique et des Technologies Endogènes de Transformations de Pentadesma butyracea, Espèce des Galeries Forestières de la Région de Bassila*. Ph.D. dissertation, Lycée Technique Agricole, Médji de Sékou, Porto-Novo, Benin.

Kouyate, A.M. 2005. *Aspects Ethnobotaniques et Etude de la Variabilite Morphologique, Biochimique et Phenologique de Detarium microcarpum Guill. & Perr. au*

Mali. Ph.D. dissertation, Faculty of Bioscience Engineering, University of Ghent, Ghent, Belgium.

Lougbegnon, T.O., B.A.H. Tente, M. Amontcha & J.T.C. Codjia. 2011. Importance culturelle et valeur d'usage des ressources végétales de la réserve forestière marécageuse de la vallée de Sitatunga et zones connexes. *Bulletin de la Recherche Agronomique du Bénin* 70.

Luoga, E.J., E.T.E. Witkowski & K. Balkwill. 2000. Differential utilization and ethnobotany of trees in Kitulanghalo forest reserve and surrounding communal cands, Eastern Tanzania. *Economy Botany* 54(3):328–343. dx.doi.org/10.1007/BF02864785

Monteiro, J.M., U.P. Albuquerque, E.M.F. Lins Neto, E.L. Araújo & E.L.C. Amorim. 2006. Use patterns and knowledge of medicinal species among two rural communities in Brazil's semi-arid northeastern region. *Journal of Ethnopharmacology* 105:173–186. dx.doi.org/10.1016/j.jep.2005.10.016

N'Klo, O. 2001. *Situation des Ressources Génétiques Forestières de la Côte d'Ivoire (Zone de Savanes): Service de la mise en valeur des ressources forestières*. Division des Ressources Forestières, Food and Agriculture Organization, Rome, Italy.

Natta, A.K., A.C. Adomou, V.I. Tchabi, A.R. Sogbegnon, G.A. Mensah & B.A. Sinsin. 2011. Inventaire, typologie et structure des populations naturelles de *Pentadesma butyracea* (Clusiaceae) de la chaîne de l'Atacora au Nord-Ouest du Bénin. *Bulletin de la Recherche Agronomique du Bénin* 70.

Natta, A., R. Sogbegnon & F. Tchobo. 2010. Connaissances endogènes et importance du *Pentadesma butyracea* (Clusiaceae) pour les populations autochtones au nord ouest Bénin. *Fruit, Vegetable, and Cereals Science and Biotechnology* 4:18–25.

Natta, A.K. 2003. *Ecological Assessment of Riparian Forests in Benin: Phytodiversity, phytosociology and spatial distribution of tree species*. Ph.D. dissertation, Wageningen University, Wageningen, The Netherlands.

Ouédraogo, A.S. 1995. *Parkia biglobosa* (Fabaceae) *en Afrique de l'Ouest. Biosystématique et amélioration*. Thesis, Wageningen University, Institute for Natural Resources, Wageningen, The Netherlands.

Sacandé, M. & B. Sama. 2007. *Pentadesma butyracea* Sabine. *Seed Leaflet* 131.

Sanou, H. & N. Lamien. 2011. *Vitellaria paradoxa*, *Shea Butter Tree*. Conservation and sustainable use of genetic resources of priority food tree species in sub-Saharan Africa. Bioversity International, Rome, Italy. http://citarea.cita-aragon.es/citarea/bitstream/10532/1689/1/2011_342EN.pdf

Sinsin, B. & T.A. Sinadouwirou. 2003. Valorisation socio-économique et pérennité du *Pentadesma butyracea* Sabine en galeries forestières au Bénin. *Cahiers Agricultures* 12:1–5.

Sinsin, B., B. Kassa & F. Kidjo. 2011. Reseau des Aires Protégeés du Benin. Pp. 522–529 in *Atlas de la Biodiversite de l'Afrique de l'Ouest*. Volume 1. Edited by B. Sinsin & D. Kampmann. Biota, Cotonou, Benin.

Waksberg, J. 1978. Sampling methods for random digit dialing. *Journal of the American Statistical Association* 73:40–46. dx.doi.org/10.1080/01621459.1978.10479995

http://dx.doi.org/10.17348/era.14.0.491-503