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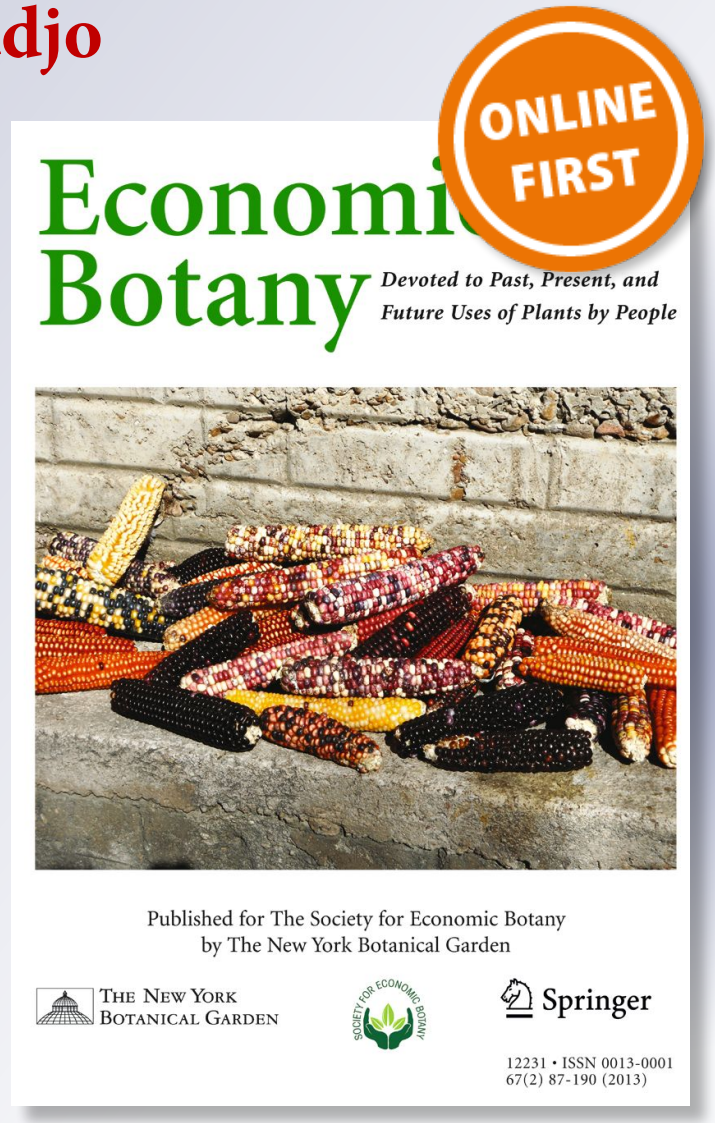

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Local Knowledge, Uses, and Factors Determining the Use of *Strychnos spinosa* Organs in Benin (West Africa)

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Green monkey orange (*Strychnos spinosa*) is an important multipurpose tree in rural communities in sub-Saharan Africa, including Benin. The objectives of this study were to (i) examine the various indigenous uses of *Strychnos spinosa*, (ii) assess local perception of the major threats to *Strychnos spinosa*, and (iii) identify the conservation strategies adopted by local communities to ensure its sustainable use in Benin. A participatory rural appraisal study was undertaken across three climatic zones in Benin. Data were collected through structured questionnaires involving 733 informants from 22 ethnic and 7 sociolinguistic groups. Correspondence analysis (CA) showed that *S. spinosa* is most widely used in the Sudanian zone (20 uses). About 73% of the informants used *Strychnos spinosa* as food, and 68% used it for medicine. The most valued organs were fruits, leaves, bark, and seeds. The major threats to *Strychnos spinosa* were human activities rather than climatic factors. Religion and cultural values were the main strategies adopted by local communities to conserve the species. The value of *Strychnos spinosa* is well appreciated in Benin, and local knowledge depends on the particular climatic zone, ethnic group, study level, and gender.

L'oranger de singe (*Strychnos spinosa*) est un arbre à usage multiple important pour les communautés rurales d'Afrique subsaharienne dont le Bénin. Les objectifs de cette étude étaient de (i) examiner les différentes utilisations indigènes de *Strychnos spinosa*, (ii) évaluer la perception locale des principales menaces pesant sur l'espèce et (iii) identifier les stratégies de conservation adoptées par les communautés locales pour assurer son utilisation durable au Bénin. Une recherche participative a été entreprise en milieu rural dans trois zones climatiques du Bénin. Les données ont été collectées au moyen de questionnaires structurés auxquels ont participé 733 personnes appartenant à 22 groupes ethniques et de 7 groupes sociolinguistiques. L'analyse factorielle de correspondance (AFC) a montré que *S. spinosa* est plus largement utilisé dans la zone soudanienne (20 utilisations). Environ 73% des personnes interrogées utilisent *S. spinosa* à des fins alimentaires et 68% l'utilisent à des fins médicinales. Les organes les plus prisés étaient les fruits, les feuilles,

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l'écorce et les graines. Les principales menaces pesant sur *S. spinosa* sont plus liées aux activités humaines qu'aux facteurs climatiques. Les principales stratégies adoptées par les communautés locales pour conserver l'espèce sont d'ordre religieux et culturels. L'étude a montré que les populations locales accordent de la valeur à *Strychnos spinosa* au Bénin et que les connaissances locales dépendent de la zone climatique, du groupe ethnique, du niveau d'étude et du sexe des enquêtés.

Key Words: *Strychnos spinosa*, Ethnobotany, Local knowledge, Traditional uses, Wild edible fruits, Benin.

Introduction

Forest ecosystems provide local people with a variety of products among which are non-timber forest products (NTFPs). These are valuable resources for local communities and play vital roles in the livelihood of people especially in developing countries (Shackleton and Shackleton 2004). NTFPs are not only an important source of food but also an important ingredient of traditional medicine. Their socioeconomic importance is recognized worldwide. Indeed, a large number of indigenous people derive a substantial part of their subsistence and income from NTFPs (Suleiman et al. 2017). Dadjo et al. (2012) indicated that NTFPs are essential components of sociocultural rituals of many rural communities, especially during festive periods. Despite their usefulness, NTFP resources were underutilized until recently and their potential to enhance the livelihoods of poor people has not been well appreciated (Nahayo et al. 2013). With increasing food shortages brought by global climate change and human-induced factors, it is expected that the demand for NTFPs by rural people will likely increase (Berihun and Molla 2017; Bruschi et al. 2014; Johns and Eyzaguirre 2006; Nebel et al. 2006). However, to continuously reap the benefits of NTFPs in the face of these threatening factors, investigation is needed regarding their usage and conservation.

Strychnos spinosa Lam. (Loganiaceae) is one of the most important edible tree species in the wild (Madzimure et al. 2013), particularly as a food resource by local people during periods of food shortage (Bruschi et al. 2014). Like other species of the genus (*Strychnos aculeata* Soler. and *Strychnos innocua* Delile), which have been introduced into agroforestry systems in Sahelian Africa (Alexandre 2002), *S. spinosa* is a good candidate for domestication in sub-Saharan Africa. The value of the species as food for humans and feed for livestock has been well documented in previous studies (Isa et al. 2014; Madzimure et al. 2013; World Agroforestry Centre 2018). In West Africa for instance, Thiombiano et al. (2013) reported that, *S. spinosa* is one of the most widely preferred food tree species of rural dwellers in Burkina-Faso. Unfortunately, subsequent information that could ensure the sustainable use of the species in the West African subregion is lacking.

During the past decade, several studies have been carried out to evaluate the use patterns of different local species in Africa (e.g., *Adansonia digitata* L., *Afzelia Africana* Sm., *Caesalpinia bonduc* (L.) Roxb., *Khaya senegalensis* A. Juss., *Milicia excelsa* (Welw.) C.C. Berg, *Parkia biglobosa* (Jack.) R. Br. ex. G. Don., *Sclerocarya birrea* Hochst., *Vitex doniana* Sweet), particularly in Benin (Assogbadjo et al. 2010; Balima et al. 2018; Camou-Guerrero et al. 2008; Dadjo et al. 2012; De Caluwé et al. 2009; Gouwakinnou et al. 2011; Houehanou et al. 2011; Koura et al. 2011; Ouinsavi et al. 2005). However, to the best of our knowledge, information available on the quantitative description of *Strychnos spinosa* and the threats to its survival is scanty in West Africa in general and particularly in Benin. Information on the use forms, use values, management practices, and local perceptions on the introduction of the species into agroforestry systems will be valuable in addressing issues surrounding its valorization and domestication (Balima et al. 2018; Koura et al. 2011). It may also be helpful in setting a general framework for the conservation and sustainable use of the species (Gouwakinnou et al. 2011).

The present study combines quantitative and qualitative ethnobotanical approaches to assess the different uses and major threats to *Strychnos spinosa*, as well as the local conservation strategies for its sustainable use in Benin. Specifically, the study assesses (i) the important usages and the most used organs of *S. spinosa* by different sociolinguistic groups, (ii) the factors (ethnic group, sex, and age) influencing the different usage of the species, and (iii) the local people's perception of the species' dynamics and the local conservation strategies of the species.

Two assumptions were made in the frame of this study. Given the plant's presence in several climatic

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zones of the country and the ethnic diversity of the peoples of its distribution range, we assume that the relationship to the plant varies according to these sociolinguistic groups as well as within them. Also, considering the multipurpose status of the species, we assume that there are local conservation measures employed in favor of its perpetuation over time through sustainable use practices.

Materials and Methods

Description of Study Area

The study was conducted during February to December of 2017 in three climatic zones (Sudanian—9° 45′–12°25′ N, Sudano-Guinean—7° 30′–9° 45′ N, and Guinean—6° 25′–7° 30′ N) in Benin (Fig. 1). These zones are known for the occurrence of the species. Twenty-two (22) villages were selected from the Sudano-Guinean zone, while 12 and 7 villages were included from the Sudanian and Guinean zones, respectively, making a total of 41 villages.

The Sudanian and Sudano-Guinean zones have a unimodal rainfall pattern, which varies from 900 to 1,100 mm per year. The main rainy season in these zones starts in May and ends in October. The Guinean zone, on the other hand, has a bimodal rainfall pattern with mean annual rainfall of 1,200 mm. Temperatures range between 24 and 31 °C in the Sudanian and vary from 25 to 29 °C in Sudano-Guinean and Guinean zones. The Sudanian zone with ferruginous soils is an undifferentiated woodland devoid of *Isoberlinia*, except in few small pockets, and characterized by *Combretum* spp., *Acacia* spp. *Hyparrhenia* spp., *Loudetia* spp., and *Andropogon* spp. as the most common species (Adomou 2005). The Sudano-Guinean zone is a transition between the sub-humid Guinean zone and the Sudanian zone, and is characterized by a vegetation mosaic of forest islands, gallery forests, and savannas (Koura et al. 2011). The zone is occupied by *Isoberlinia*-dominated woodlands associated with *Anogeissus leiocarpa* Guill. & Perr., *Pterocarpus erinaceus* Poir., *Monotes kerstingii* Gilg., and *Uapaca togoensis* Pax. It is also the favorable zone for *Vitellaria paradoxa* C.F.Gaertn., *Parkia biglobosa*, *Khaya senegalensis*, and *Afzelia africana* parklands (Adomou 2005). In the Guinean zone, dense semi-deciduous forests and Guinean savannas represent the dominant vegetation types (Dadjo et al. 2012). The common species include *Triplochiton scleroxylon* K.Schum., *Celtis zenkeri* Engl., *Cola gigantea* A.Chev., *Milicia excelsa*, *Antiaris toxicaria* (Pers.) Lesch., *Ceiba pentandra* (L.) Gaertn., and *Albizia spp* (Adomou 2005). The Sudanian zone is composed of the following sociolinguistic groups: Bariba, Dendi, Ottamari, and Peulh. The Sudano-Guinean zone consists of the Bariba, Fon, Yoa-lokpa, and Yoruba; the Fon and Yoruba dominate in the Guinean zone. The people in the three study zones are mainly farmers, except the Peulh, who are animal breeders. The major crops grown include cereals (finger millet, maize, and sorghum), legumes (cowpea, groundnut, Bambara groundnut, and soybean), root and tubers (yam, cassava, and potato), horticultural crops (chili pepper and tomato), and cotton. These crops are mainly grown for cash and home consumption.

Sampling Procedure and Data Collection

An exploratory survey was first conducted to confirm the occurrence of the species in the selected sites. The choice of the selected sites was based largely on previous knowledge and the suspected presence of the species either in agroforestry systems or protected areas (PAs) or in fallows, and, to some extent, on the diversity of sociolinguistic groups, and their probable knowledge of the species. This survey led to the selection of 13 protected areas (PAs) and 41 neighboring villages. The PAs were randomly sampled and encompassed parks and hunting zones (Pendjari complex and W National Park of Benin), and gazetted forests (Trois rivières, Bassila, Pénessoulou, Wari-Maro, Monts-kouffè, Toui, Agoua, Ouémé-Boukou, Atcherigbé, Dogo, and Kétou). In total, 22 ethnic groups were sampled from seven sociolinguistic groups (Bariba, Dendi, Fon, Ottamari, Peulh, Yoa-lokpa, and Yoruba) (Table 1). Participants were randomly selected from all professional groups (farmers, traditional healers, cattle herdsmen, artisans, and students), gender (male and female), and generations (< 30 years: young; 30–59 years: adult; > 59 years: old) to ensure representativeness of the informants.

In each study village, the number of informants (n) was determined using the approach described by Dagnelie (1998) as

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

where n = sample size; $U_{1-\alpha/2}$= 1.96: value of the normal random distribution at probability of 1–α/2

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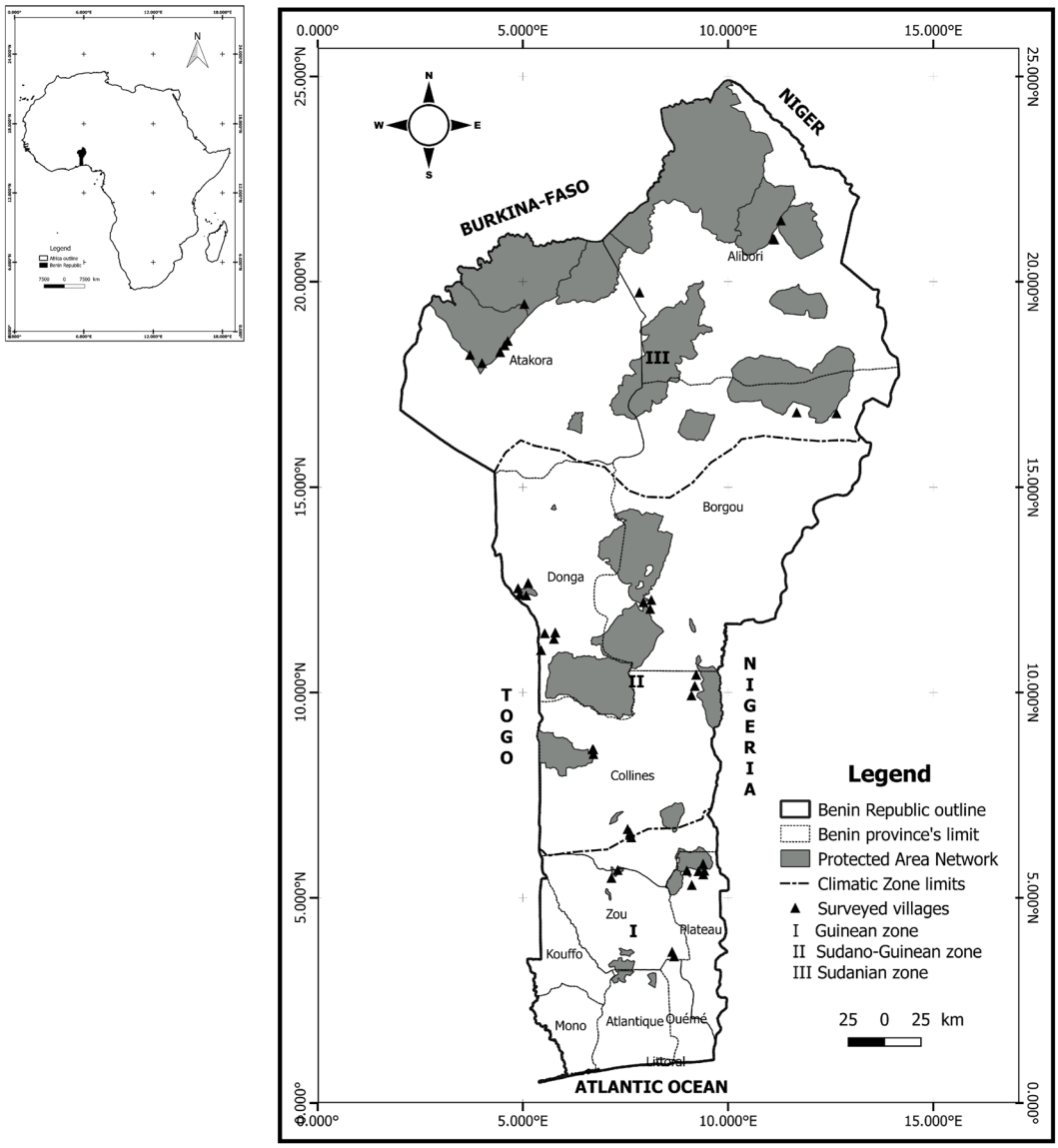

Fig. 1. Map showing the study area and the climatic zones

= (0.975); p = proportion of people who had already used the species (this was determined during the exploratory phase); d = margin of error of a parameter estimated from the sample fixed at 0.1.

In total, 733 people were randomly selected for the key informant interviews based on their locally recognized experience in the management and utilization of NFTPs. Among them, 158 were females and 575 were males. The small number of females was because they were not too enthusiastic to be interviewed. In addition, chiefs, traditional healers, and local opinion leaders were involved in focus group discussions as key informants. Semi-structured questionnaires were designed on topics related to the local names and meaning, the uses and used parts, the processing methods, local perception of the species dynamics over time, and the major conservation strategies.

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TABLE 1. SAMPLE SIZE PER CLIMATIC ZONE, ETHNIC GROUP, SEX, AND AGE

Climatic zone	Sample size	Ethnic group	Sex		Age			Total per ethnic group	Percentage per climatic zone (%)
			Men	Women	Young	Adult	Old		
Guinean Zone	82	Aïzo	2	–	–	1	1	2	2.44
		Holi	21	8	8	14	7	29	35.37
		Mahi	38	13	5	26	20	51	62.19
Sudano-Guinean zone	375	Anii	54	25	19	40	20	79	21.07
		Bariba	16	1	3	11	3	17	4.53
		Biali	1	–	–	–	1	1	0.27
		Dendi	1	–	–	–	1	1	0.27
		Ditamari	3	–	1	2	–	3	0.8
		Fon	30	11	–	31	10	41	10.93
		Idaasha	46	2	6	34	8	48	12.8
		Kotocoli	13	7	4	10	6	20	5.33
		Lokpa	16	–	3	11	2	16	4.27
		Mahi	11	4	2	10	3	15	4
		Nago	110	14	1	96	27	124	33.07
		Peulh	5	1	3	2	1	6	1.6
		Yom	4	–	–	4	–	4	1.07
Sudanian zone	276	Aïzo	2	–	–	1	1	2	0.72
		Bariba	9	1	1	7	2	10	3.62
		Biali	15	6	6	9	6	21	7.61
		Bôo	31	1	5	12	15	32	11.6
		Bourba	16	14	10	17	3	30	10.87
		Dendi	10	5	4	9	2	15	5.43
		Fulfude	12	8	7	9	4	20	7.25
		Gando	30	13	15	26	2	43	15.58
		Gourmantché	7	8	5	7	3	15	5.43
		Holi	21	3	3	14	7	24	8.69
		Mahi	12	1	1	7	5	13	4.71
		Mokole	18	2	3	11	6	20	7.25
		Nago	6	–	–	3	3	6	2.17
		Waama	–	10	11	8	6	25	9.058

DATA ANALYSIS

In order to measure the distribution and uses of the species, the fidelity level (FL), which expresses the response rates per specific use or the degree of consensus between informants, was computed for each study zone using the formula (Gouwakinnou et al. 2011):

$$FL\ (\%) = n^{*}100/N \quad (2)$$

where n is the number of informants related to a specific use and N is the total number of informants. The fidelity level is significant when it is above 5% (FL >5%).

The use value or importance of the species in each climatic zone was also assessed using the method described by Phillips and Gentry (1993) as:

$$UV = \Sigma UVi/N \quad (3)$$

where UVi represents the use value of the species for a single informant. UVi is obtained as the sum of the number of different uses mentioned by the informant i and where N is the total number of informants.

Correspondence analysis (CA) was performed to better describe the links between sociolinguistic groups, plant part uses, and use categories. In addition, Generalized Linear Models (GLM, negative binomial) were used to assess the factors that influence the choices of organs and their different use category. The CA and GLM were performed using R software.

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Results

Local Names

Table 2 summarizes the various names referred to *Strychnos spinosa* in local communities. Thirty-four (34) local names were recorded from seven sociolinguistic groups. The majority of the informants (75.22%) did not respond to questions regarding the meaning of the local names given to the species. However, about 16.43% link it to the roundish shape of the species.

Organs Uses

Table 3 presents the main parts of *Strychnos spinosa* and their utilization in local communities. These parts are used for a wide range of purposes that were grouped into five broad use categories: food (72.99%), medicine (68.35%), fodder (7.09%), magic (2.86%), and cultural (2.46%).

Knowledge Diversity and Use Patterns

Among the 49 uses of the species recorded in the study, 28 were common to the three climatic zones (Table 4). The highest number of uses was found in the Sudanian zone (20 uses), followed by the Guinean zone (14 uses) and the Sudano-Guinean zone (11 uses). The proportion of uses of the different organs varied between climatic zones (Fig. 2).

Across the three climatic zones, 36 different uses of *Strychnos spinosa* were reported. Many of the informants in the Sudanian zone (96.59%), the Guinean zone (76.83), and the Sudano-Guinean (62.87%) used it primarily as food. The informants also mentioned that it can be used to cure about 28 diseases. Other uses included carving, kitchen tool, soil fertility improvement, timber for joinery, and fuel (firewood and charcoal). The organs involved, the modes of preparation, and administration are presented in Table 4.

The proportion of usage of *S. spinosa* varied between sociolinguistic groups and between use categories (Fig. 3). Overall, the species was mostly used for medicinal and food purposes and it was least valued for magic purposes. Whereas the Yoruba and Ottamari were the sociolinguistic groups that used it more for medicinal and alimentary purposes, the Fon used it mostly for magic purposes.

Factors Influencing the Species Usages

Factors influenced differently the use of the species organs and its use categories. The negative

Table 2. Common names of *Strychnos spinosa* and informant number by ethnic group surveyed in Benin

Sociolinguistic group	Ethnic group	Species' local name	Number of informants
Bariba	Bariba	Akotii/Akotim	27
	Bôo	Bissili/Bissinan	32
Dendi	Dendi	Kouloukoulou	16
Fon	Aïzo	Tchanka	4
	Fon	Amilimon/Monkè–monkè	41
	Mahi	Amilimon	78
Ottamari	Biali	Boborka/Boborke	22
	Bourba	Boboreyonke/Boborelaha	30
	Ditamari	Niboumbolo/Ebounbola	3
	Gourmantché	Kpenkpenlinhou/Kpenkpenlindjaga	15
	Waama	Pokounpore/Pokounpoya	25
Peulh	Gando	Mamantalahi	43
	Fulfudé	Mamautara/Mantalahor	26
Yoa-lokpa	Anii	Gakaka/Gakakao	79
	Kotokoli	Kongofira/Kpagba–burudjo	20
	Lokpa	Kpakpaha	16
	Yom	Bambiaha/Nanna	4
Yoruba	Holi	Tchaounka	53
	Idaasha	Agogo/Goungo	48
	Mokolé	Koukoulou/Gbegbeako	20
	Nago	Goungodo/Goungo	130

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TABLE 3. MEAN VALUE AND STANDARD DEVIATION OF REPORTED USES PER ORGAN WITHIN CLIMATIC ZONES

Climatic zone	Fruit	Leaf	Root	Bark	Seed
Guinean	0.95 ± 0.22	0.44 ± 0.49	0.29 ± 0.46	0.18 ± 0.39	0.05 ± 0.22
Sudanian	0.96 ± 0.20	1.16 ± 0.95	0.48 ± 0.63	0.33 ± 0.64	0.14 ± 0.59
Sudano-Guinean	0.82 ± 0.38	0.27 ± 0.47	0.27 ± 0.49	0.05 ± 0.22	0.03 ± 0.17

binomial models showed that the choice for particular parts of the species depends on the climatic zone, the ethnic group, and the level of educational. This latter refers to the level of education that a particular informant reaches at school. Modalities are as follows: illiterate, primary level, secondary level, or university level. It appears that the climatic zone, the ethnic group, the study level, and the marital status were the factors that affect the use of the leaf, whereas the climatic zone, age category, ethnic group, and sex affect the root use. The factors affecting the use of the bark were climatic zone, study level, ethnic group, age category, and marital status. The choice for seed was influenced by climatic zone, sex, ethnic group, and study level. The total reported use value of the organs was influenced by the climatic zone, the study level, ethnic group, and age category.

The choice of using the species across different use categories was also influenced by different variables (Table 5). Only climatic zone affected the use of the species as food while climatic zone and age category influence its choice for cultural purposes. Climatic zone, ethnic group, and sex were the variables affecting the use of the species as fodder, and climatic zone and sex affect its use for magic purpose. Therefore, the use categories were generally affected by the climatic zone and sex of the informant.

STRUCTURE OF LOCAL KNOWLEDGE BETWEEN SOCIOLINGUISTIC GROUPS

Organs Used and Sociolinguistic Groups

A correspondence analysis of the link between sociolinguistic groups and used organs of *S. spinosa* showed that the first two axes explained 83.25% of the observed variation, whereas the first three axes explained 97.47% of the total variation. The Dendi and Ottamari ethnic groups used the bark, while the Bariba and Peulh preferred the seed. Yoa-Lokpa and Ottamari people mostly used the leaves and the fruits (Fig. 4).

Use Categories and Sociolinguistic Groups

Correspondence analysis on sociolinguistic group and the different use categories of *S. spinosa* showed that 92.83% of the total variation observed is explained with the two first axes, but in order to have information on more variables, the third axis was added to have 99.61% of the global information explained (Fig. 5). The partial contributions and correlations between *S. spinosa* characteristics and the three CA axes were calculated. From the CA, we can conclude that the Fon, Ottamari, and Peulh use the plant for cultural and magic purposes. The Dendi, Yoa-Lokpa, and Yoruba use the species for cultural purpose and as fodder, whereas the Bariba use it as medicine and food.

LOCAL PERCEPTION ON THE SPECIES' INTRODUCTION IN AGROFORESTRY SYSTEMS, MAIN THREATS, AND LOCAL CONSERVATION STRATEGY

Most of the informants (75.3%) reported that the species reproduces by itself. About 89.1% of them cited the seed as the main reproductive organ while 6.3% asserted that it can be reproduced by cuttings. About 46.4% of the informants were willing to plant *S. spinosa* in their farms or home gardens.

The majority of informants (67.4%) acknowledged the decline of *S. spinosa* in their environment over time. They linked this decline more to anthropogenic causes rather than climatic factors. Slash and burn agriculture, urbanization, the species excessive exploitation, its cutting down by Fulani (Fulfudé) for fodder, the clearing for new farmland, its multiple usage in traditional medicine, bushfires, and charcoal making were mentioned as the main factors responsible for this decline. The large plantation of teak and *Gmelina arborea* by the National Wood Office of Benin in the Bassila and Penéssoulou region and cashew tree plantations in the Sudano-Guinean zone were also cited as threats to the species, together with yam cultivation in the

Table 4. Main uses of *Strychnos spinosa* according to climatic zone

Organ used	Description of the use	Administration mode and/or posology	Purpose of use	FL (%)	Climatic zone
Ripe fruit	Pick, break the hull, then suck the pulp	Consume at will	Food	76.83; 62.87; 96.59	Guinean; Sudano-Guinean, and Sudanian, respectively
Ripe fruit	Pick, break the hull, then suck the pulp while pronouncing incantations	Consume once a year	Bulletproof against firearm	9.76	Guinean
	Pulp	Use until satisfaction	Foot crevice	22.48	Sudano-Guinean
	Calcinate and reduce in powder	Put a pinch in porridge or lap	Facilitates milk production for the new mom	5.76	Sudanian
Non-ripe fruit + one pod of *Aframomum melegueta*	Calcinate and reduce in powder	Consume every time while feeling stomachache	Stomachaches	5.38	Sudanian
Non-ripe fruit	Reduce in paste	Lap before entering the convent	Voodoo ritual	36.11	
Leaves alone or leaves + some ingredients	Infusion	Bath + drink in the morning and evening for three months	Solidification of babies	50.00	Guinean
Leaves	Decoction with simple water	Drink a glass of water morning and evening until satisfaction	Stomachaches	30.43	Sudano-Guinean
	Picking	Eat fresh leaves	Fodder	24.77	Sudanian
	Infusion	Drink morning and evening until healed	Malaria	16.67	
Leaves + roots	Infusion	Drink and/or bath	Weariness	12.61	Sudanian
	Maceration	Have a drink as needed	Unblocking respiratory insufficiencies	7.14	
Root + ingredients	Maceration	Drink one Madeira glass[a]	Fever	28.57	Guinean
Root + ingredients	Maceration	Drink as needed with incantations	Voodoo ritual	21.43	Guinean
Root + ingredients	Infusion	Drink between two menses	Dirty and painful periods	10.71	Guinean
Root	Soak in water for two days	Bath morning and evening	Strengthening	8.89	Guinean
	Soak in water for two days	Drink one water glass per day until satisfied	Hypertension	6.67	Sudano-Guinean
	Infusion	Drink morning and evening until satisfied	Stomachaches	34.55	Sudanian
	Infusion or Reduce in Powder		Slows venom (anti-venom)	14.54	

(Continued)

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TABLE 4. (CONTINUED).

Organ used	Description of the use	Administration mode and/or posology	Purpose of use	FL (%)	Climatic zone
		Drinking or lapping after the snakebite or drink after the scorpion sting			
Bark + mature fruit	Decoction of bark and sliced fruit in half	Make the patient drink and wipe the body with water	Cures swelling of feet and prevents paralysis	13.33	Guinean
	Infusion	Make the baby drink	Children's fever	13.33	
Bark + root	Reduce in powder	Lapping when you feel pain	Stomachaches	60.00	
Bark + root of wild banana tree	Decoction	Drink at will	Constipation	28.00	Sudano-Guinean
Bark	Decoction or infusion	Drink at will	Painful menstrual period	52.00	Sudano-Guinean
	Decoction	Give at will to cows	Stimulation of milk production	32.00	
	Reduce in powder or infuse	Put a pinch in mush or lapping or drinking	Antibiotic	14.71	
	Reduce in powder or infuse	Make the oxen consume	Fever and trembling of oxen	32.35	Sudanian
Bark + salt	Pound and reduce in powder	Give to the oxen	Fever and trembling of oxen	22.06	Sudanian
	Pound and reduce in powder	Give to the oxen	Diarrhea and stomachache	17.65	

[a] The madeira glass is a small glass of about 12–20 cc of content, which is used by the local population for liquor consumption or for traditional medicine dosage

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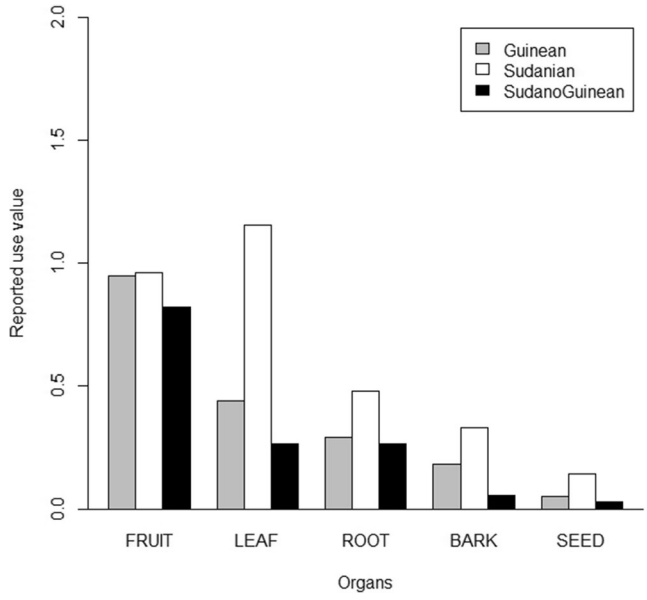

Fig. 2. Reported use value of used organs in Guinean, Sudano-Guinean, and Sudanian zone

Wari-Maro and Kalalé regions in the Sudano-Guinean and the Sudanian zone, respectively.

Across the country, few traditional conservation strategies of *S. spinosa* were mentioned. Indeed, in some sociolinguistic groups of the Sudano-Guinean zone, the species was known to protect hunters and boost agricultural production (crop yield). Apart from taboo, the traditional conservation strategies of the species can be summed up as the preservation of a few individuals in the field of some farmers/breeders as it is observed in the agroforestry parks with néré or shea butter tree. Even though it was not that common, some individuals were found planted next to houses.

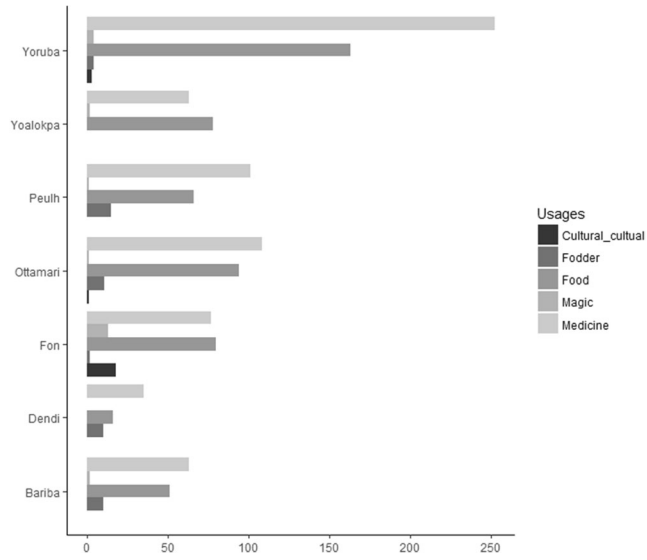

Fig. 3. *S. spinosa* usage by sociolinguistic group

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TABLE 5. VARIABLES AFFECTING *S. SPINOSA* USES IN BENIN

	Reported use value of different organs	Variables influencing the model	*p* value
Used organs	Leaf	Climatic_zone	<0.000[c]
		Ethnic_group	<0.000[c]
		Study_level	0.002[b]
		Marital_status	0.038[a]
	Root	Climatic_zone	<0.000[c]
		Age_Cat	<0.000[c]
		Ethnic_group	0.001[c]
		Sex	0.041[a]
	Bark	Climatic_zone	<0.000[c]
		Study_level	<0.000[c]
		Ethnic_group	<0.000[c]
		Age_Cat	0.047[a]
		Marital_status	0.03[a]
	Seed	Climatic_zone	<0.000[c]
		Sex	0.000[c]
		Ethnic_group	<0.000[c]
		Study_level	0.013[a]
	Total reported use value	Climatic_zone	<0.000[c]
		Study_level	0.000[c]
		Ethnic_group	<0.000[c]
		Age_Cat	0.031[a]
Use categories	Food	Climatic_zone	0.000[c]
	Cultural	Climatic_zone	<0.000[c]
		Age_Cat	0.002[b]
	Fodder	Climatic_zone	<0.000[c]
		Ethnic_group	0.002[b]
		Sex	0.021[a]
	Magic	Climatic_zone	<0.000[c]
		Sex	0.008[b]

[a] Significant at $p \leq 0.1$
[b] Significant at $P \leq 0.05$
[c] Significant at $p \leq 0.01$

Discussion

IMPORTANCE OF *S. SPINOSA* AND DIVERSITY OF USES

The theory of ethno-taxonomic diversity refers to the richness and relative abundance of vernacular names used for a given species of plant included within a folk taxonomy of a particular cultural group. The theory predicts that species identified by several traditional names within a native language are likely to be culturally important (Gaoué et al. 2017). The present study revealed that *S. spinosa* was referred to by 34 folk names in the 22 ethnic groups across Benin. This diversity of folk names suggests that the species is of great cultural value in Benin. The folk names varied greatly from one ethnic group to another based on the value and organ used. Nevertheless, most informants were unable to give the exact meaning of the name of the species in their respective languages. This could be attributed to knowledge erosion (Gaoué et al. 2017), as most people are likely to depart from their culture due to modernization (Idohou et al. 2014). As such, ancestral cultural values are abandoned for modern ones; thus, leading to low effective transmission of knowledge to future generations. Urgent efforts are needed to reverse that tendency and capture the existing knowledge of the species in order to ensure their transmission to future generations.

In Benin, the species is mostly used for medicinal purposes. As evidenced among the 36 registered uses, 28 were medicinal. This is in agreement with previous studies (Isa et al. 2014; Plantz Africa 2017; von Maydell 1990; World Agroforestry Centre 2018) that reported the value of the species in traditional medicine to treat infectious diseases, including snake bites, uterine problems, male organs disorders, colds fever, earache, and inflamed eyes, because of the presence of strychnine and many other alkaloids in its organs. It was also reported that the species can be used to combat ticks and tsetse flies; to cure diarrhea, fever, and trembling; and to improve milk production of animals and particularly in oxen. This is consistent with the findings of several authors (Bero et al. 2011; Hoet et al. 2006; Hoet et al. 2007; Salifou et al. 2017). This importance of the species in the traditional medicine constitutes an asset to be exploited for healing locally. However, this should be taken with care as no toxicological tests have been carried out to certify the effectiveness of the formulation in disease treatments. Within this use category, leaves appeared to be the most used organ. This is consistent with the results of some previous studies. For example, Bero et al. (2009) showed the importance of the species in curing malaria, Isa et al. (2014) revealed its importance to treat infectious diseases, and Arbonnier (2002) showed its importance in curing colic, diarrhea, menorrhagia, ophthalmia, conjunctivitis, and trachoma. This high use of the leaves in medicine may be due to the fact that the leaf extracts and fractions have good antimicrobial functions and low cytotoxicity levels (Isa et al. 2014).

The fruits were the second most used organ. It was widely known from the surveyed populations that the fruit can be used as food for both humans

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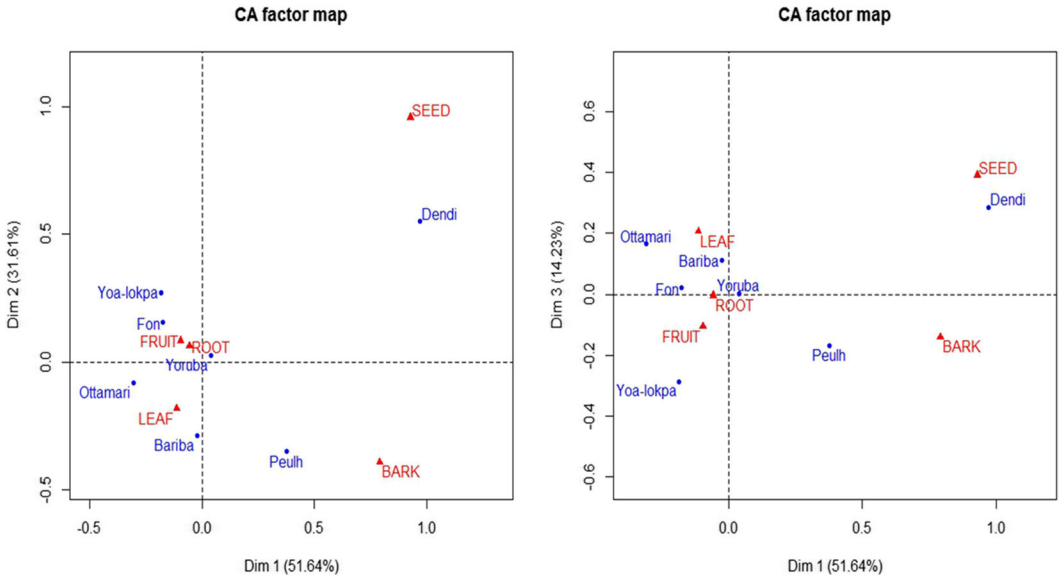

Fig. 4. Projection of sociolinguistic groups and the different used organs of *S. spinosa* (left: Dim 1 and Dim 2; right: Dim 1 and Dim 3)

and animals (rodents, elephants, monkeys, etc.). In the localities around Pendjari park and W National park, the competition between humans (hunters, children, farmers) and animals is such that instead of leaving the fruits to ripen, men will pick them once they are mature enough and keep them prior

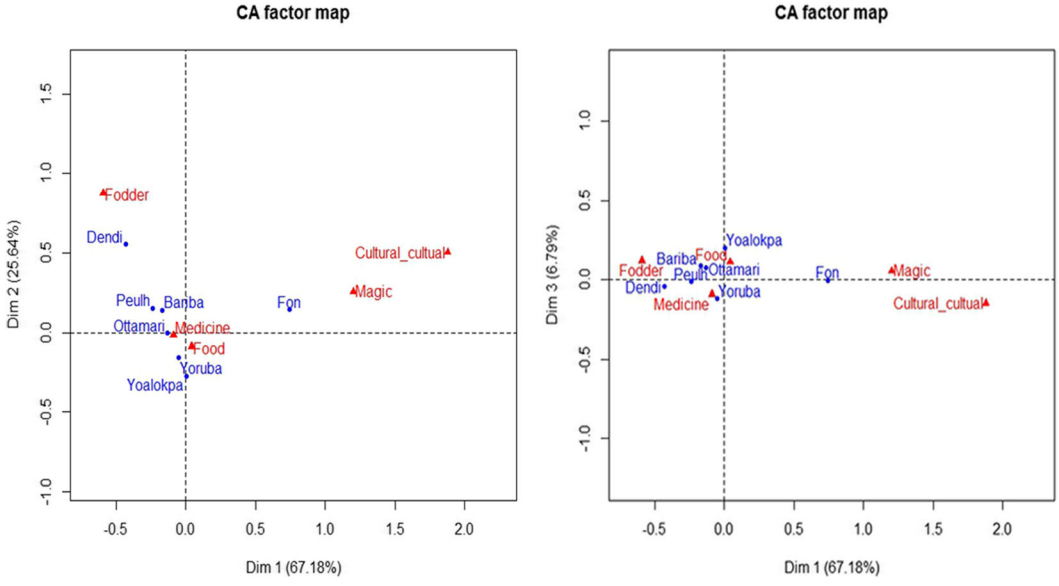

Fig. 5. Projection of use categories and sociolinguistic group (left: Dim 1 and Dim 2; right: Dim 1 and Dim 3)

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to ripening. Additionally, it can also be used magically as bulletproofing against firearms, as memory assistance, to treat dried/cracked feet and stomachaches, and to facilitate milk production for nursing mothers. It is also used for Voodoo rituals. This is consistent with the earlier reports that the pulp of the fruit, which is somehow acidic and delicious, is commonly eaten by local people wherever it grows (Useful Tropical Plants 2017).

Due to the hardness of its wood, it is used in carving and joinery as well as for firewood and charcoal. This agrees with the finding that the wood provides firewood and charcoal and is used in general carpentry, furniture making, and carving (Arbonnier 2002; Madzimure et al. 2013; Ruffo et al. 2002; Useful Tropical Plants 2017; von Maydell 1990). The reported uses of *S. spinosa* roots and barks match those reported by other studies (Arbonnier 2002; Isa et al. 2014; Madzimure et al. 2013; Useful Tropical Plants 2017; von Maydell 1990).

From an ecological view, *S. spinosa* is mostly used in the Sudanian zone where savanna ecosystems are dominant (Madzimure et al. 2013). This suggests a positive relationship between plant abundance and use, thus verifying the "ecological apparency hypothesis," which describes dominant, large, and more abundant plant species as having the highest use values (Gouwakinnou et al. 2011). In contrast, the plant is less present in the Guinean zone. Indeed, it is found only in a small area of this zone located in the southeast of the country, around Kétou and Zagnanado cities. Interestingly, the study revealed a significant knowledge of the species in this area after the Sudanian zone. This can be explained by the fact that the Yoruba and Fon people of this region are among the sociolinguistic groups that have a high knowledge of *S. spinosa* countrywide. Other reasons include the used index itself. Indeed, it has been shown by Da Silva et al. (2006) that one of the weaknesses of the Use-Value is that it places more emphasis on the species that have many uses (like the studied species), even if these uses are only known to a few people (like what is observed in that small area). In other words, the Use-Value technique is greatly influenced by the number of people citing the uses of a species, and a plant may be highly rated even if its many uses were cited by only a small number of people (Albuquerque et al. 2006).

The leaves of the species were most solicited in the Sudanian zone, probably to provide livestock with fodder as breeders could not rely on grass grazing to meet cattle's feeding requirements during the lean season. The preferred woody species such as *Afzelia africana* Sm. and *Pterocarpus erinaceus* Poir. have become rare due to excessive logging and uncontrolled harvesting for animal feed (Houehanou et al. 2011). Consequently, *S. spinosa* is increasingly becoming the only available choice for livestock feed. Similar findings were reported by Arbonnier (2002).

Drivers of *S. spinosa* Knowledge in Benin

The knowledge dynamics in communities were driven by several factors. According to Gouwakinnou et al. (2011), one of the most widely reported factors likely to result in a difference in the use value of plants between communities is ethnicity. However, Koura et al. (2011) and Gaoué et al. (2017) showed that this factor alone is not enough. For these authors, the variation of ethnobotanical knowledge may not be due to ethnicity alone but added to the influence of individual attributes such as age, gender, religion, and education level. Moreover, Hoffman and Gallaher (2007) have shown that plant use can be influenced by seasonality, resource scarcity, age, sex, traditions, management practices, knowledge loss, and cultural degradation. In the framework of this study, climatic zone, ethnic group, study level, and sex were the main drivers of the dynamics of knowledge about *S. spinosa*. Therefore, in addition to individual attributes, the place where one lives can greatly influence his/her knowledge about plants as shown by Gouwakinnou et al. (2011).

These drivers could be split into drivers affecting the physical availability of the plant resource and drivers affecting the preferences of local communities (Pasquini et al. 2018). The deforestation process through farm development and climate variability also affects the availability of the species. Because the abundance of the species varies from one climatic zone to another, and the influence of climate does not affect it equally, the level of knowledge of the plant may be affected. Availability and proximity of the resource to local users is of considerable interest to secure knowledge. However, agriculture intensification coupled with deforestation causes a regression of the species population and possibly the knowledge associated to it.

According to Pasquini et al. (2018), as people start to abandon the way of life associated with the rural landscapes, food preferences change because of lack of exposure to resources that were typically used in the recent past. Based on this, one could note a tendency of the youth, who are now going to

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school, to abandon local knowledge related to plants. Several studies have shown that younger generations stop using traditional plant resources, not just because of lack of exposure, but also because they are affected by social beliefs that teach them to view traditional foods and customs as shameful and culturally inferior (Reyes-García et al. 2013; Thomas 2012; Turner and Turner 2008) or as poverty (or famine) foods (Arias Toledo et al. 2009). Pasquini et al. (2018) have also found indications of a negative perception of certain food plants (mainly a connotation of poverty foods), leading to their rejection. Thus, young people are less available to open up to learn this endogenous knowledge from seniors.

S. spinosa Dynamics, Local Conservation Strategies, and Valorization

The declining population of *S. spinosa* was found to be more a result of anthropogenic factors than climate. According to the informants, among the major threats to the species in Benin were agriculture, urbanization, excessive exploitation for medicine, and animal breeding. Similarly, Houehanou et al. (2011) reported that in West Africa, wild or indigenous plant species are still widely used and many of them are endangered due to various human activities such as logging, cutting, and land clearance.

In Benin, there is almost no taboo concerning *S. spinosa*, yet taboo is one of the conservation strategies most widely used by local people to protect their resources (Gaoué et al. 2017). Indeed, taboo as a conservation strategy suggests that certain plant and animal species are seldom harvested in order to protect them from overexploitation and extinction (Gaoué et al. 2017). Most people across the country do not see the need for sustainable management of the species. They believe that the species is a gift from nature to humanity and as such can be used at will. As shown by Gouwakinnou et al. (2011), they consider the species to be an open access resource and that they have unrestricted access to it. They are unwilling to plant the species in their farms or home gardens, arguing that they do not have enough space or that the species is thorny. This attitude may be justified by the fact that very few (15.7%) of the informants were aware of the fertilizing effect of *S. spinosa* through mycorrhizal symbiosis with fungi in the soil (Akinnifesi 2008). Despite this, few people (46.4 %) want to plant it because they perceive that the species may disappear over time due to overexploitation and expansion of farmlands.

In the Sudano-Guinean zone, for example, especially in Yoa-lokpa sociolinguistic group, it is believed that the presence of an individual of the species attracts blessings from the gods of the earth for increased crop yields, especially yams (FL = 4.85). Some Yoruba hunters in the Sudano-Guinean zone recognize the species as protecting against ferocious animal attacks (FL = 4.44). Indeed, they suggested that, simply running backwards towards the direction of a standing *S spinosa* tree and clinging to it can prevent them from been noticed and attacked by dangerous animals. For this reason, it is highly revered and regarded as sacred by hunters.

Although relatively well known by the rural populations, the species remains relatively unknown and not valued by a large number of Beninese. This suggests that only rural populations exploit it when the need for it arises. In addition, because of the wide range of wild fruits that they take from the nature for consumption or for sale, people do not pay much attention to it and oftentimes harvest or destroy it for firewood or charcoal. That is why some surveyed women felt they did not have enough knowledge of the species and that it is the men, especially the hunters and the traditional healers, who hold more knowledge on the species. The fact that women had little knowledge about the studied species indicated that *Strychnos spinosa* is less valued by women in Benin. It can therefore be said that the species is not yet sufficiently known and exploited in Benin compared to southern and eastern Africa, where its various organs are valorized and marketed in different forms (Adebowale 2014; Madzimure et al. 2013; Ngadze et al. 2017; Plantz Africa 2017). Its underutilization and sparse attention given to its potential commercialization may be due to limited knowledge and dissemination of information about propagation, agronomic practices, and product processing techniques (Ngadze et al. 2017). It is therefore important to educate local people and increase their awareness for better promotion and valorization of *Strychnos spinosa* in Benin.

Conclusion

The study provided important insights into the knowledge held by local people on green monkey orange (*Strychnos spinosa)* in Benin. The results showed that it is a multipurpose species mostly used in traditional medicine and as food for humans and livestock. Local knowledge on the species is highly diversified and dependent on the climatic zone,

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ethnic group, educational level, and gender. The most widely used organs were fruits, leaves, roots, bark, and seeds. Of all the sociolinguistic groups studied, the Yoruba and Ottamari held high knowledge on the species whereas the Dendi held the least knowledge. Over time, the population of the species declined according to the informants and yet it receives very little attention in terms of conservation measures. In addition, it was found that most of the local population destroy the individuals in their farmlands despite its high value. This demonstrates the need for conservation measures to ensure its sustainability over time. Regarding the important role played by *Strychnos spinosa* in the daily life of local people, it would be interesting to look at the nutritional, biochemical, and toxicological properties of the plant extracts to confirm or invalidate the so-called virtues attributed to the plant and its derivatives. It would be also advisable, therefore, that appropriate investigations be conducted for its domestication and introduction on the list of agroforestry species.

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Ethics Research Standards

We strictly followed all the research ethics during this study. The objectives of the study were initially explained to the local authorities of the surveyed villages to obtain their approval regarding contents of the questionnaire that was asked to the population. After the completion of study, the preliminary result was presented to the opinion leaders of each village to ensure absence of any information that is a matter of community secrecy and/or indigenous knowledge whose divulgation would pose a threat to community survival. So, we assure that the outcome of this research is shareable with the scientific community.

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