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Local communities' perception and willingness on sustainable management of a natural threatened resource: case study of *Baillonella toxisperma* Pierre in Eastern Cameroon

Makueti JT[1], Tchoundjeu Z[1], Tsobeng A[1,2], Numbisi F[1], Tsafack S[1]

[1]*World Agroforestry Centre, Yaoundé, Cameroon*

[2]*Faculty of Bioscience Engineering, University of Gent, Belgium*

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Abstract

Baillonella toxisperma is a multipurpose tree that provides non-timber forest products. In particular, fruit kernels can be transformed into buffer for cooking and cosmetics and its bark is used to cure many ailments in local communities. Unfortunately, natural stands of *B. toxisperma* are seriously threatened in Cameroon. The objectives of the study were to document uses of the targeted species, its management patterns and assess its population structure. Ethnobotanical and quantitative ecological methods were used. The results showed that the species was found to be multipurpose and produced several products and services. The most mentioned services were conservation of foodstuffs and medicine. Community responses indicated that the species became rare and there were no strategies developed to preserve it. The quantitative inventory supported this community view: the species had a low density (0.02 individual/ha) and a weak size class distribution. The species appeared to be threatened by illegal logging, overexploitation and poor attitude to its conservation. Due to the high value of the species, respondents claimed that they were interested in conserving it but they lacked appropriate propagation techniques, materials and skills. Thus, the sensitization and the domestication of the species should urgently be considered in the farmer environment with strong sound of policy.

***Corresponding Author:** Makueti JT ✉ jmakueti@cgiar.org

Introduction

Eradication of extreme poverty and hunger within rural communities is a great concern for Sub-Saharan countries including Cameroon. In eastern Cameroon, there is a great deal of variation in livelihood strategies and relationships to the forest within and between villages. Many individuals will mine species when commercial opportunity presents itself, as in the case of bush meat, timber or the different parts of many medicinal species (Betti, 2002; Ingram, 2010). In the area, as an overwhelming majority of the poor live in rural areas and depend heavily on nature-based goods and services, their livelihood security depends greatly on the status and condition of the natural resources available in the forest and their optimum utilization through enterprise development (Cunningham *et al.*, 2008; Vermeulen *et al.*, 2009).

This paper examines these aspects with regard to the use and management of locally, available and economically valuable natural species. This is the case of *Baillonella toxisperma* Pierre (Sapotaceae) commonly known as Moabi, which is a multipurpose species very present in the livelihood of the indigenous people living in this area. The species is considered vulnerable according to the 1994 International Union for the Conservation of Nature and Natural Resources (IUCN) threats categories (IUCN 2006; Hewitt, 2007). Despite its importance and the threat represented mostly by illegal logging and illegal trade (Alemagi and Kozak, 2010), little work has been undertaken on *B. toxisperma* in the perspective of its domestication (Ngo-Mpeck and Atangana, 2007; Fotso *et al.*, 2008).

Hence, the present study reports on ethno-ecological study that examines the role of Moabi in the livelihoods of Baka and Bantu indigenous villagers in eastern Cameroon. The objective was to investigate on the threat to Moabi. Specifically, the study sought to answer the following questions: (i) To what extent are Baka and Bantu livelihoods dependent on Moabi? (ii) What is the range of the skills and knowledge of the people on the targeted species management i.e production, domestication, sustainable harvesting, processing, packaging, cooperative development and marketing; (iii) Do they have access to quality planting materials i.e high-quality seed and seedlings; (iv) What are the existing strategies in the processing or marketing Moabi products? (v) Are there stems of Moabi on farming lands and what is its distribution in the sampled areas? Information presented herein, would help breeders to develop high yielding and good quality seedlings for breeding, clonal selection and cultivars development.

Material and methods

Study sites

The study was conducted at the eastern region of Cameroon (Fig. 1). The explored villages were Nomedjoh (3°18'09.44"N; 13°35'24.84"E) and Djenoun (3°16'20.36"N; 13°35'59.45"E) in Lomie Subdivision while Massea (3°09'33.84N; 14°51'20.76"E) and Gribe (2°48'32.58"N; 14°36'22.75"E) were the explored villages in Yokadouma Division. This region is characterized by the alternation of two dry seasons and two rainy seasons. The climate is called wet equatorial Guinean.

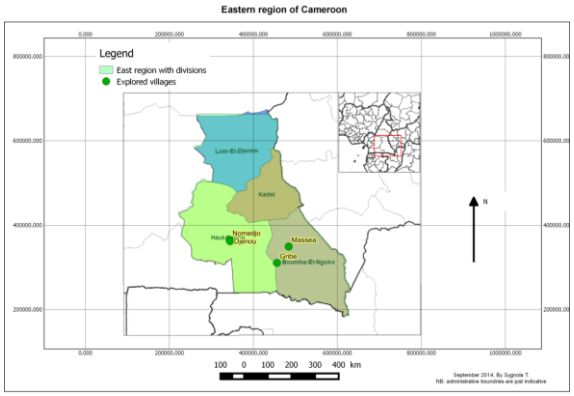

Fig. 1. Study area.

Instead, there is a long dry season from December to April, a light wet season from May to June, a short dry season from July to October, and a heavy wet season from October to November. The annual rainfall varies between 1550 and 2000 mm. Average temperatures range between 22.8 and 24.6 °C and the relative humidity is also high (80-90%) (Mengue,

2012). The soil is predominantly ferralitic, rich with iron and red in colour. It is not particularly fertile due to leaching caused by the humid environment. The land consists largely of monotonous and gently undulating hills.

The population density is less than five persons/km² and the majority of the population is primarily situated in villages and towns along the few major roads that traverse the region (Tchoumba, 2005). The major ethnic groups in the area are Bantu and Pygmy people. Approximately 90% of the population are Baka (or Bagyeli/Babinga) pygmies while approximately five percent of the population are Bantus, belonging to the Fang tribe (Ngoufo *et al*., 2012). Within the Bantu population, the Bulu form the most important group and they dominate the southern part of the area. They are mainly forest dwelling hunters and gatherers, although they seem to be in the process of sedentarization. People earn their livelihood from hunting, fishing, gathering and practicing shifting cultivation. Apart from the towns of Abong-Mbang and Lomie, which offer medical facilities (e.g. hospitals, pharmacies), drinking water, electricity and secondary roads, the rest of the area still suffers from lack of these facilities. In addition, many smaller roads have been constructed for timber exploitation. The state of these roads is, however, variable as maintenance is carried out by the logging companies and ceases once their activities are transferred to other regions.

Research method

The fieldwork took place from September 2012 to January 2014 using both some ethnobotanical and ecological studies in four villages named above. We held focus groups discussion within each community before conducting interviews, to discuss research plans and request group permission to undertake work in the area and record traditional knowledge and know-how of local communities on the use and management of *B. toxisperma*. The ethnobotanical investigations entailed structured interviews that were conducted using questionnaires. These were administrated face to face. The household was the sampling unit and its head was the target respondent often assisted by any other adult in the household. Surveyed households were selected randomly from village registries or lists of existing households. A household was considered in the Cameroonian context and comprised people living under the same compound, using the same kitchen and sharing meals, cultivating the same land and recognizing the authority of one person, the head of the household. In total, due to the low population density, 80 households head living in the localities cited above since a long time were randomly interviewed. The interviewed people had aged that ranged between 20 and 60 years and those had a good knowledge of local plant species. The questions asked concerned the habitat of the species, the patterns of harvest and sale, and the different uses of the species and the attitude of the local community towards its domestication and/or conservation.

For the ecological part, in each explored village, the species niche was identified and geo-referenced (altitude, longitude and latitude). The species distribution survey was based on non-timber forests products study methodologies developed by Hall and Bawa (1993), recommending transects of 10 meters wide and 1 km long to study the distribution and abundance of a species. Application of this approach can be seen in Guedje *et al*. (2003) for *Garcinia lucida*, a medicinal plant with gregarious tendency and in Tasse (2007) for *Prunus africana*. In each village, a reconnaissance survey was undertaken in collection sites with Baka guides offered by the community village. Once these collection sites usually frequented by farmers in each village were covered, a transect grouping them was installed. The width of each transect was 20 m, but the length was not fixed in advance. It was equivalent to the distance measured from the first to the last collection site identified by the guides. The transect runs through the various land use systems present in collection sites (home garden, fallow, community forest). Adult stems and seedlings of Moabi within the transect

plots installed in each village were numbered as follows:

- in contiguous plots of 100 m x 20 m, adult stem with Diameter at Breast Height (DBH) greater than 10 cm were identified;
- seedlings less than 1m in height were counted under the crown of the mother tree in quadrats of 2 m × 2 m.

The studied species

Botanical description

B. toxisperma is an important commercial forest tree distributed in Africa from Nigeria to Cabinda (Guillaumet *et al.*, 2010. The monotypic genus *Baillonella* is endemic to the Guineo-Congolian region (Vivien and Faure, 1996; White, 1983). It is called "mabe" by Pygmies Baka while pygmies Badjoues called it "odjo" and Ewondo (Bantu) people called it "adjap". *B. toxisperma* is limited to the dense primary evergreen rain forests. *B. toxisperma* (Fig. 2) is a very large tree, (60-70 m) tall (Plenderleith and Brown, 2004); bole up to (300-500 cm) in diameter, straight and cylindrical, sometimes expanded at the bottom, reaching a height of 30 m below the first branches, without buttresses; bark 4-5 cm thick, reddish-brown to dark gray, deeply fissured longitudinally, exuding a sticky latex; crown umbrella-shaped, very large, up to 50 m in diameter, large spread and sinuous branches; very thick terminal branches in many leaf scars. Spirally arranged leaves and tufts at the end of branches, simple; stipules lanceolate, large, persistent; petiole 3-4 cm long, slender; blade narrowly obovate, 15-30 cm × 5-10 cm, cuneate at base. Flowers: in fascicles dense at the end of branches, bisexual, regular; pedicel 2-3 cm long, pubescent. Fruit: berry large and globular, smooth, 5-8 cm in diameter, gray-green, becoming greenish yellow when ripe, 1-2 (-3) seeds in a pale yellowish pulp. Seeds: ellipsoid, slightly compressed laterally, about 4 cm long, thin seed coat smooth and shiny on the dorsal part, rough and bumpy on the ventral part (scar); albumen late or absent. Seeds are dispersed by bat (*Chriroptera* sp.), elephant (*Loxodonta africana* Cuvier), chimpanzee (*Pan troglodytes* Oken), gorilla (*Gorilla gorilla* Sagave) and mankind. Seedling: with epigeal germination, hypocotyl short, 0.5-1.5 cm long, epicotyl 15-26 cm long, reddish brown to greyish brown hair, cotyledons thick, sessile, about 4 cm × 1 cm, greens.

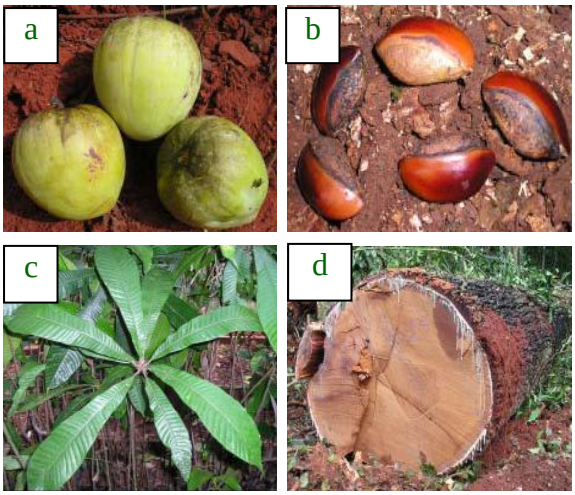

Fig. 2. Moabi a multipurpose tree (a) fruit; (b) nut; (c) leave and (d) timber (Adapted from Rougeron, 2012).

Socio-economical importance of B. toxisperma

Moabi is heavily exploited from the wild in West Africa, and the primary threat to the species survival is logging (Betti, 2002; Doucet and Kouadio, 2007). Its timber is used for furniture, cabinet work, decorative flooring, turnery and carving, decorative veneers, joinery, and stove fittings. *B. toxisperma* is also valued for the edible oil extracted from the seeds and the medicinal properties of its bark. The oil (locally known as "moabi butter") is of great importance to local people because it is used as a substitute for palm oil in cooking and for the revenues derived from its sales. Offem (1990) found that *B toxisperma* seeds contain nutritional, toxic and others components. In fact, they contain about 613 g crude fat/kg, while defatted seeds contain 219.6 g crude protein/kg, corresponding to 85 g/kg whole seeds. The silica-free ash and crude fiber contents were 73.8 g/kg and 34.6 g/kg of the defatted seed meal, respectively. The value of non-timber products (NTPs) of *B. toxisperma* has also been recognized by

the French cosmetics industry, which has shown an interest in the oil. This oil is rich in palmitic, stearic and oleic acid (Pampou *et al.*, 1992; Fotso, 1995). Therefore, emphasis will be directed on the use of fruit for oil production. The pulp of the ripened fruit is eaten, and the bark used for ethnobotanical purposes (Schneemann, 1995).

Conceptual framework

One of the essential pieces of information for developing sustainable management strategies and actions for a species is the description of its current management including diverse local knowledge and uses associated to it (Assogbadjo *et al.*, 2009; Feyssa *et al.*, 2012). Indeed, by incorporating local knowledge and practices in the process of scientific research (Fig. 3), new hypotheses can be developed for research experiments relevant to management (Chia, 2004; Dawson *et al.*, 2009; Hamawa *et al.*, 2010).

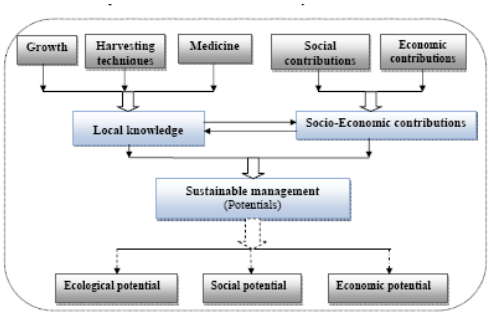

Fig. 3. Conceptual framework illustrating local communities' interventions on the sustainable management of environmental resources (Adapted from Lawas, 1997; Yakeu, 2012).

Characteristics of surveyed respondents

The results (Table 1) indicated that respondents were both men and women. For each village surveyed in this study, the majority of respondents were peasant and the age group most involved in activities ranged from 25 to 50 years.

Table 1. Snapshot of survey respondents (N=20 per village).

Division/Subdivision	**Lomie**		**Yokadouma**	
Demographics and assets	**Nomedjoh**	**Djenou**	**Massea**	**Gribe**
Individual variables				
Sex				
Male	12	14	13	11
Female	08	06	07	09
Age groups (years)				
<18	1	1	4	0
25-50	19	16	12	19
>60	0	03	04	01
Education				
No formal education	0	0	0	01
Primary	15	13	09	09
Secondary	04	07	11	09
University Degree	01	0	0	01
Marital status				
Married	15	12	14	13
Single and never married	3	05	03	3
Separated	0	0	0	1
Divorced	0	0	0	0
Widow	02	03	03	3
Professional status				
Peasant	17	19	19	19
Civil servant	0	0	0	01
Retired	0	0	01	0
Others (hunter, traditional healer, etc)	04	01	0	0

Source: Authors' calculations from study findings.

Data analysis

The Statistical Package for Social Sciences (SPSS) was used to process the data. Cross tabulation of descriptive statistics and graphics were used to present the results from data analysis. From the quantitative inventory, the species density was calculated. A size class frequency distribution plot (SCD) was drawn by plotting the number against size class. The SCD slope summarizes in a single number, the shape of the SCD as previously pointed out by Tabuti and Mugula (2007). It is worth noting that if a population has a strong negative slope, it is interpreted like a stable and naturally able to replace itself whereas the weak negative slopes or flat slopes show a poor restoration and declining population (Hall and Bawa, 1993).

Results

Different uses of B. toxisperma non timber products

Ninety fifth percent of the respondents indicated that the sweaty fruit pulp, seeds, leaves and the bark of *B. toxisperma* harvested by local populations are used in different categories. They are used as food or remedy for the treatment of many ailments (Fig. 4). In fact, the pulp of the ripened fruit is sucked unchanged despite the latex. This latex is used to heal wounds. Dried seeds are crushed to extract oil called "Moabi butter" for food consumption and for further drug manufacturing.

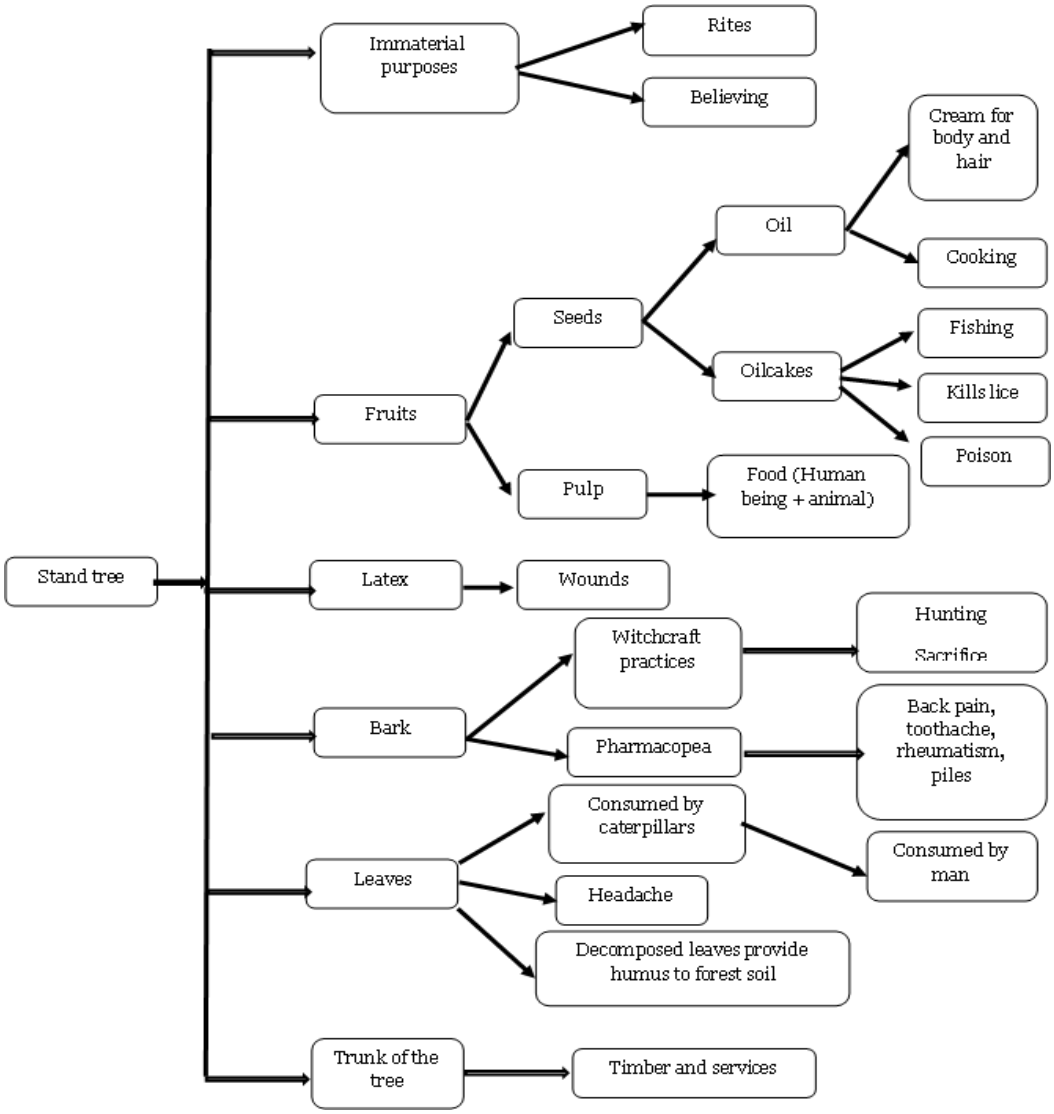

Fig. 4. Synthesis of socio-economic and ecological advantages of Moabi.

After oil extraction, oilcakes are used to treat hair loss and to kill lice. They are also used for fishing because they content poisonous substances. Warmed decoction of the bark is administrated as an enema to treat piles and backache, clean kidneys. This warmed decoction is also taken per-os to treat rheumatism. It is also used as gargle (mouthwash) to treat toothache. The bark is also useful for spiritual purposes (it is retained in the tray to avoid cockroaches; it is planted around home gardens to prevent hedgehogs eating crops; it is kept in the house to avoid witches). Five percent of respondents indicated that its leaves are used to treat headache. In fact, respondents stated that the juice from macerated leaves is instilled as a nasal drops to treat headache. Bush meat and fish, for example, are the most important sources of protein in the daily diet of local people in the study areas. For the construction of houses and for household and agricultural equipment, people depend completely on forest products.

Traditional technique of Moabi oil extraction

Indigenous people have knowledge of the use and management of many plants, especially multipurpose tree species like Moabi. Its phenology provides fruiting from July to August. As we approach this period, operators clean the undergrowth around the targeted adult trees to facilitate the collection of fruits. Both men and women could spend about six days in the community forest for fruits gathering. These are gathered in piles for at least two weeks to let the mesocarp rot, thereafter, the seeds are extracted. They will be washed and then dried for about two months in the sun or on a rack over a wood fire. Nuts are extracted and dried a few days before being crushed in a mortar and then crushed on a stone. The resulting paste is mixed with a little water and put in a pot and bring to a boil and constantly stirred until complete evaporation of water and the appearance of the oil. The cooked paste is purplish gray. After cooling, it is pressed by hand or with a press timber to extract the oil. The use of wooden press improves efficiency and reduces the difficulty of the task. The oil thus obtained is to be heated over a wood fire, then decanted and filtered to remove the foam that floats and impurities. Likewise, local people know the toxicity of the seed, for they take care that the residue is not consumed by domestic animals. The final residue contains a considerable amount of oil and is used to light fires (like the fiber of palm nuts), or is thrown in streams or pools to stupefy fish, the effect being probably due to saponin (Keay, 1989; Offem, 1990).

Moabi: a great mean of trade

Key informants asserted that they were involved in the use of the species since more than 10 years (50.69%). Sixty three percent of respondents stated that they earned about 25% of their household income from the sale of *B. toxisperma* products (mainly dried seeds, oil and bark). A bucket (5 liter) of dried seeds is sold 500 FCFA (see Abbreviation). A liter of extracted oil is sold about 1500-2000 FCFA. Eighty two percent of key informants asserted that they use to sale these products at home. On a whole, 3.7% of the products were used for the household needs while 96.3% were sold to resellers or middle traders coming from surrounding cities like Abong-Mbang, Bertoua and Yaoundé. Women were more involved (60%) in "local associations" for oil extraction processing, storage and market. They are also in charge of sharing the Moabi oil among beneficiaries' members of the group. Among the four villages explored for the study, only one Common Initiative Group (CIG) involved in the exploitation of Moabi NTPs was established at Nomedjoh village since 2002.

Farmers' perception on sustainable management of the studied species

The management and the conservation of *B. toxisperma* in the survey area remained a preoccupying subject in peasant environment. In fact, 59% of respondents stated that it is "a gift of God" and the resource is abundant and will always be available (Table 2). Nevertheless, others become aware that with the overexploitation coupled to illegal logging and high shifting cultivation, the resource

becomes more and more depleted and the communities ignored what strategies to adopt for solve this problem.

Table 2. Farmers' perception on the management of *B. toxisperma*.

Variables	Farmers' opinions (%)
No definite schedule	100
Conservation/domestication willingness	
Wish sustainable management	45
Don't know or don't need	12
Free exploitation of the resource (because is a gift from God)	28
Controlled exploitation of the resource	15

About 83% of informants attested that *B. toxisperma* is a communal property, people collect it and use from the wild. Like the exploitation of these species is done at the wild state, some opinions are different on its conservation. Twenty eight percent of the interviewed people thought that the exploitation of these species must stay free whereas 15% of them agree on the controlled exploitation of the resource. Those who wished a sustainable exploitation through domestication represented 45% of the whole interviewed population. The remaining 12% argued that they do not know.

Density, distribution and population structure of the studies species

A total of 35 individuals were recorded from the four study sites. Determination of density reflected the occurrence of 0.02 individual/ha. With regard to *B. toxisperma* population structure, it was noted that its diameter varied from 50 to 800 cm (Fig. 5). Individuals belonging to the class diameter 150-300 cm were the most abundant (31.42%). These were followed by those belonging to the diameter class of 300-600 cm (25.71% of the total population). The adult individuals represented approximately 11.42% of the population of *B. toxisperma*. Mortally of seedlings was high (about 90%).

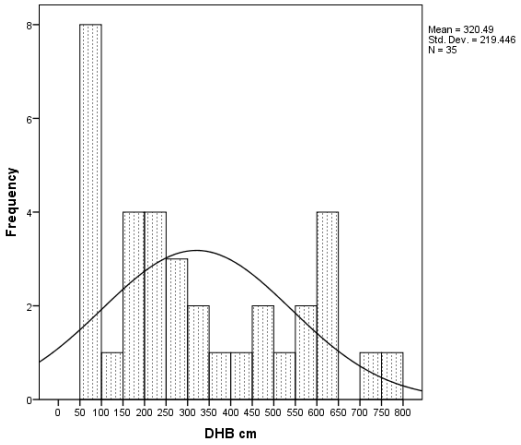

Fig. 5. Distribution of *B. toxisperma* trees by diameter classes (cm) in east Cameroon.

Major factors threatening B. toxisperma in the study areas

Key informants revealed that export-oriented logging, conflict between pygmies and forestry companies, intensification of commercial hunting (massif poaching) and political will are the main factors that threatening this species. The Cameroonian forestry law constitutes another threat to this species. In fact, the minimum exploitable diameter of Moabi in Cameroon is 1 m whereas in both Gabon and Congo whereas it is decreed to be 0.8 m.

The pressures being led by uncontrolled logging, expansion of 'slash and burn' agriculture to marginal lands, over-harvesting and poverty has resulted in rarity of this species due to its habitat destruction. Key informants explained that in early years, this species was currently found near their rich and use as food and medicine, but today, they are obliged to work for more than 10 Km to find a single stand stem. Hence, the rarity of the species can be attributed largely to anthropogenic factors and exacerbated by climate change is this area. In fact, the vegetation in this area has been really destroyed for the plantation of the most cultivated crops such as cocoa, coffee and

tobacco. Nonetheless, anarchic logging remained the most important threat to the species.

Perception of local people on current status of B. toxisperma

Within the study sites, field inventories of *B. toxisperma* clearly showed that the species was found very far from Bantu houses and Pygmies camps at about 9 to 10 km away in the Community Forest. Nonetheless, a few stems which have been retained during forest clearing for shifting cultivation were found in fallows. Key informants indicated that the species is highly sought for its fruits and timber. About 83% of respondents asserted that in the early times, the species was abundant in the local vegetation, road sides and easily accessible to collect fruits and or bark. In fact, the key informants responded that the elderly people were telling them the species was abundant in the past. Due to this rarity, respondents said that they were not aware of what has happened. Nonetheless, the perception of local people on current status of this species strongly pointed out the decline in status of the species (see Table 1). This indicated the need for conservation and domestication of this species which has multipurpose uses for people to improve their livelihoods.

Key informants also indicated that they do not plant the species for two main reasons: (i) the species has a very slow growth rate (in fact, the species started fruiting at the age of fifty or more, therefore, "someone who plants the tree will never harvest the fruits, only his children will"); (ii) wild seedlings are very rare at the foot of the mother tree. This is due to the undergrowth three clearances for fruits collection. However, farmers would like to grow this species in their home gardens if they have access to high quality planting material and appropriate techniques to master it.

Discussion

Different uses of B. toxisperma non timber products

The inhabitants of all the four villages explored during this study use common known plant treatments in addition to those prescribed by specialist healers. Many common medicines used regularly as first aid are found in the village periphery or in bush fallow rather than in the undisturbed forest. However, for a particular ailment, or at the request of a healer, people will travel great distances to find specific forest medicines. As highlighted from the current study, *B. toxisperma* is the most important plant in the treatment of lumbago among the Baka pygmies. This result is consistent with the findings of Association Coeur de Forêt (2009) and Betti & LeJoly (2010). This usage is also well-known in the Cameroonian pharmacopoeia (Adjanohoun *et al.*, 1996; Jiofack *et al.*, 2010; Betti *et al.*, 2013). Its bark contents a great quantity of alkaloid known as 'yahimbine' (Yinyang *et al.*, 2014). Alkaloids represent a large group that share their many biological benefits, therapeutic, pharmaceutical and food. They are heterocyclic nitrogen and basic chemicals or compounds that derived from amino acids. They have an antiplasmodial, antispasmodic and anti-cancer activity (N'Guessan *et al.*, 2009; Mbah *et al.*, 2011). Their laxative and antirheumatic, analgesic and analgesic effects are also known (Zirihi *et al.*, 2007). These results could explain the wide use of this species by local populations in the study area (IUCN, 2002; Nelson and Hossack, 2003). With regard to *B. toxisperma* toxicity, respondents stated that after oil has been expressed from the seeds, an oily residue is left. This residue has been found to contain saponin (Keay, 1989; Offem, 1990), thus described by various authors as being poisonous to fowls and animals in general.

Population structure of the studies species

From the present study, it appeared that local population of *B. toxisperma* is threatened. The density of the species in the study area was very low. This observation was confirmed by farmers who asserted that the individuals of large size had all or nearly extinct. According to the respondents, the adult individuals of the species were very scattered. The quantitative inventory supported the respondents view**.** They also declared that this species became

more and more rare. The analysis of SCD indicated that *B. toxisperma* population distribution presented an appearance of a disrupted "*L*" shape slope. Such shape suggested that the population of *B. toxisperma* regenerated well but that the old individuals are little represented. This result implied that the species was overexploited by the local population in the study area. This result is consistent with that of a study carried out by Phelps *et al.* (2013). Indeed, species with weak slopes generally have a poor generation potential and may be declining (Tabuti and Mugula, 2007). The perception of the local communities was confirmed by the analysis of the population structure which showed weak size class distribution.

The SDC plots (Fig. 5) showed a higher number of young individuals (excepting those of 0-50 cm) but these were died out of the population before they had recruited into sapling or mature individuals. This loss of young individuals weakened thus the population. The wide mortality of seedlings may be explained by the frequent disturbance of overexploitation for different uses. For population to maintain itself, it needs to have abundant juveniles which will recruit into adult size class (Bationo *et al.*, 2001). Similarly, the rarity of adult individuals affects recruitment into the population by lack of seed. Most respondents outlined the precarious status of *B. toxisperma* to overexploitation and mostly uncontrolled logging and land clearance for shifting cultivation. This result is fairly in line with those reported by Cerutti and Tacconi (2006), Alemagi and Kozak (2010) and Phelps *et al.* (2013).

Threat to B. toxisperma

B. toxisperma is a locally threatened food and multipurpose plant in eastern Cameroon due to: (i) over-harvesting for food, medicine and other uses. Informants indicated that bark, leave, latex and extracted oil from the seeds were used for medicine. The use of bark and leave were detrimental to the plant's continuity as it affects vascular system of the whole plant. In fact, bark removal induces internal stress and may lead to progressive or instant death depending on the extent of harvest (Delvaux *et al.*, 2010); Intense collection of seeds limits the natural regeneration and could explain the rarity or absence of seedlings under the mother-tree; (ii) Fuel wood, illegal logging and illegal trade, commercial charcoal production, construction material, massif poaching and clearance for shifting cultivation have threatened the species and its habitats.

In Cameroon, with regard to logging, timber from *B. toxisperma* represents 10% of companies' total production and between 3.4% and 5% of the total export value of logs of all species (Clark and Sunderland, 2004; De Wasseige *et al.*, 2012). To satisfy the strong demand for Moabi timber that comes mostly from Southern Europe (Schneemann, 1995; Kouadio and Doucet, 2009), trees are felled before reaching the required diameter which is 1 m (Assembe-Mvondo, 2009; De Waseige *et al.*, 2012). Moreover, the species is further threatened because it requires shade for regeneration to occur (UNEP-WCMC 2006; Doucet and Kouadio, 2007). This threat is related to species' slow growth; It takes between 50 and 70 years before *B. toxisperma* starts to flower, and regular fruit production does not occur until the tree is 90-100 years old (Pleinderleith and Brown, 2004; Mpeck, 2006). The duration of concessions is sometimes too short to permit a sustainable population (Kouadio and Doucet, 2009).

In central Africa, deforestation (removal of wood cover for domestic use) was identified among major causes of degradation (De Wasseige *et al.*, 2012). The resultant effect was water erosion 74% and wind erosion 26%. The resultant effect of all these is habitat fragmentation and gene pool loss with consequent impact on precipitation rate of the region. Hence, there exists link between species existence, its habitat and human activities. An increase in population density of study area indicated increased demand for natural resource including high value species such as *B. toxisperma*. Therefore, it indicated that people have been vulnerable to food insecurity due to declining ecosystem services as evidenced by this

species. Hence, the species is a priority wild edible plant to be considered in humid tropic agroforestry conservation to save the species from extinction and for sustainable use. Local management practices alone cannot save the species unless further sustainable measures are complemented (Chia, 2004; Laird *et al.*, 2011). In fact, constraints that inhibit this process are lack of germplasm, knowledge regarding propagation and management, slow growth rates, habitat loss, gene-pool erosion and policy disincentives/ambiguities.

Financial potentialities of B. toxisperma

Formerly, Moabi oil was a product of consumption. In the surveyed villages, the trade date was barely twenty years. Due to high demand for this oil in the boundaries cities of the country, a new kind of traders who buy in the villages to be sold in town is born. In urban areas, the price of a liter of Moabi oil can reach 3000 FCFA and the producer can increase his income through direct sales in town. Despite its interest, Moabi's oil industry is becoming a secondary activity for various reasons. This study showed that 48% of respondents said that the exploitation and processing of Moabi seeds is a very laborious activity (long distances in the forest, heavy seeds to transport, strong smell). Another constraint is the considerable reduction in the number of fruiting trees due to logging. The existence of new alternative sources of fat such as palm oil and refined imported oils (Boffa, 2000) coupled to the increase in agricultural activities at the expense of harvesting activities are also obstacles to the development of the oil industry.

A previous study undertaken by Debraux (1998) showed that a Moabi tree aged about 200 years has an average diameter of 1 meter and can produce about 9 m^3 of wood. This wood costs about 1.08 million FCFA when exporting as logs. Of this amount, you must deduct operating expenses and transportation. This amount cannot be obtained only one time in 200 years. From Debraux (1998) and Pleinderleith & Brown (2004) studies, if we assume that a Moabi tree starts fruiting when its diameter is 70 cm (i.e 150 years), it could die at 660 years and fruited every three years. Therefore, it could fruit about 170 times during his lifecycle. Hence, with regard to a comparative analysis between the importance of Moabi oil or timber for rural communities, Mbile *et al.*, (2007) stated that a 13-liter basket of un-cracked Moabi seeds produced 4 liters of oil kernel. One hundred and fifty five liter baskets averaged out from 8 trees produced (155 x 4) 620 liters of oil kernel. At a ratio of 2 liters of oil kernel to 1 liter of oil as is feasible using hand pressing methods locally, 620 liters of oil kernels thus yield (620/2) 310 liters of oil. One liter of oil sells for 1500 FCFA in the village, thus under the 2004/2005 estimates, monitored production had an estimated gross total revenue of 465 000 FCFA or approximatively $ 900US. Based on a 75% fruiting rate, 71 mature trees, sampled as 53 fruiting trees, are thus capable of producing ([53/8] x 465 000) or 3,080,625 FCFA, or $ 6000 US. The authors also indicated that this is part of the revenue that in principle should accrue mainly to women and girls. Results of our study at Nomedjoh village are fairly in line with those of these authors.

According to Ngueguim *et al.* (2011), a mean of 80 liters of oil is produced by an adult Moabi tree every three years. Therefore, a Moabi tree could produce 13600 liters of oil during its life cycle. For these authors, a liter of Moabi oil was sold 1000 FCFA under the 2011 estimates that is 2.022 USD. Thus, a Moabi tree could yield 80.000 FCFA (161.80 USD) every three years or 1.360.000 FCFA (2750.64 USD) during its life cycle. Following these calculations, after 13 fruiting seasons, (39 years), incomes earned from Moabi oil production are far superior to those from its timber exploitation.

It is worth noting that oil production appears more profitable over time than the felling of the tree. Because of its long life cycle, oil extraction produces regular income for rural communities and the resource remains available for future generations. Although the oil is highly appreciated and very

valuable, not many people are involved in the exploitation due to the tedious and time consuming work. Keeping standing trees also perpetuates other medical and socio-cultural practices. In addition, it promotes the natural regeneration of the species. The production of Moabi oil is ecologically, economically and socially profitable to small scale farmers compared to income from logging whose most important part does not return to the villagers.

Farmers' perception on sustainable management of the studied species

The perception of local people on current status of *B. toxisperma* strongly pointed out the decline in status of the species. In whole zone of study, the measures of collective management of the trees of *B. toxisperma* were remarkably absent and the individual initiatives were timid or even non-existent. About 45% of the interrogated persons show their interest for the sustainable management of the species. Although some respondents do not recognize the necessity to protect *B. toxisperma*, they somehow confirmed the importance of this species in their different activities. For those who show a desire to domesticate the species, they declared that they have little knowledge on the propagation techniques. Some do maintain wild seedlings when met during forest clearance for shifting cultivation. Sometimes, the introduction of *B. toxierperma* in farmers' farms or home gardens consists mainly in harvesting some seeds; the management of the species can also be made by transplanting the young wild seedlings when met. The same approach was particularly reported at Nomedjoh village. This result is consistent with that reported by Zapfack *et al.*, (2002) and Mapongmestem *et al.*, (2011). Unfortunately, these techniques do not ensure the quality of the planting materials for farmers. Moreover, with regard to seeds availability, they are also searched by many animals such as bat, elephant, chimpanzee, gorilla and some rodent species. Therefore, vegetative propagation patterns at weak cost (Tchoundjeu *et al.*, 2006) could be considered in farmer environment. These methods included rooting of leafy stem cuttings (already initiated by Ngo-Mpeck and Atangana, 2007), grafting and layering to be assessed in further work for cultivars development.

The above description indicated the need for conservation and domestication of this species which has multipurpose uses for people to improve their livelihoods. In fact, "mother trees" that ensure regeneration to take place should be conserved (Tchoundjeu *et al.*, 2008; Asaah *et al.*, 2011). Some of the viable options include: (i) the government must force the forests companies to establish and implement the Simple Management Plan in order to control logging activities as mentioned in most of MOU; (ii) improving welfare of local people through the development of community-based enterprise; (iii) enhancing their skills and knowledge on natural resource management; (iv) increase resilience of people to climate change adaptation by promoting indigenous knowledge of people, diversify food sources and biocultural heritage (cultural values and practices attached to the species and their habitats). Such options have previously been proposed by authors as Cocks (2006); Laird *et al.*, (2011) and Minang *et al.*, (2015). Some argue that there should be a total ban on logging of *B. toxisperma*. Furthermore, it is worth nothing that the best approach to the sustainable management of *B. toxisperma* is to develop an *in-situ* conservation strategy with the participation of local communities as proposed by Kouadio and Doucet (2009).

On the whole, local, regional and international markets for Agroforestry Tree Products (AFTPs) are crucial for promoting adoption of agroforestry species on a sufficiently large scale to have meaningful economic, social and environmental impacts. Therefore, making high quality germplasm available to farmers (Tchoundjeu *et al.*, 2010; Ndzomo, 2012; Degrande *et al.*, 2013; Takoutsing *et al.*, 2013) opens the way for new niche market developments creating opportunities for rural communities to enter the cash economy (Leakey and van Damme, 2014).

State of community-based enterprise development

With regard to the existence of the community-based enterprise development or other technology available for processing and market facilities, Nomedjoh village showed a typical example. Here, there was a Common Initiative Group called "ASSOCIATION BAKA BIOSPHERE" whose main goal is the education of the young pygmy and Bantu girl. Its members also work for the sustainable management of their Community Forest and also protect their medicinal plants, including *B. toxisperma*. This result is in line with that reported by Debraux (1998) and Doucet and Kouadio (2007) in the same area. Similar results were also outlined by Cox *et al.*, (2010) and by Seixas (2010). Group members are more involved in crops cultivation such as cassava (*Manihot esculenta* Crantz), cocoyam (*Xanthosoma* spp.), plantain (*Musa paradisiaca* L), maize (*Zea maize* L) and groundnut (*Arachis hypogea* L). Generally, the income earned from the sale of different products in the group is distributed to group members. This may help to purchase the machine for Moabi oil extraction, pots, plates and wrappers. In order to reduce poverty in the rural milieu, this approach should be developed in the three other villages in the study area (Djenou, Massea and Gribe).

As far as enhancing local populations' skills and knowledge on natural resource management, coupled to community-based enterprise development is concerned, government, national institutes and Non-Governmental Organizations must build strong partnerships (Ntenwu, 2000; Dkamela, 2001;). For instance, the World Agroforestry Centre has implemented a lot of activities on community-based stock assessment and monitoring system for non-wood forest products in the study area since 2004 (Mbile *et al.*, 2007). The World Agroforestry Centre as also developed and implemented the concept of Rural Resource Centre (Takoutsing *et al.*, 2014; Tsafack *et al.*, 2014). This concept focuses on farmer innovation and emphasizes access to knowledge, interactive learning and networking. Furthermore, emphasis should be directed on supporting local people with appropriate extension services and technology to properly use the species. This system should be made profitable to local people through linkage to market opportunities and transformation of their produce to value added fruit products under sound policy environment.

Conclusion

The survey permitted to identify the different uses of *B. toxisperma* among which the conservation of the foodstuffs and medicine were the most cited. The present study also highlighted that women were more dependent on Moabi products that men. The structure of *B. toxisperma* individuals showed a dominance of young individuals. The conservation of the species still timid, or in the worse of the cases non-existent among the local communities, due to lack of knowledge on appropriate techniques to be used. It was therefore necessary and urgent to develop a program of participatory domestication of this plant in the interest of the present and future generations. The implication of the local communities in the management of the species is a key of arch of its conservation. The resident communities have need to be sensitized in general on the true value of the multifunctional local genetic resources and of *B. toxerpema* in particular. In order to optimize the use and sustainability of these genetic resources, it is necessary to: (i) assess the resources available in the rural populations' environment; (ii) promote the establishment of nurseries with high quality seeds/seedlings; (iii) promote the planting or maintenance of multipurpose species during forest clearance for shifting cultivation; (iv) strengthening and backstopping the organizational capacity of farmers Associations; the case of Nomedjoh village is a model of sustainable development with the presence of a functioning Common Initiative Group; (v) vulgarizing simple techniques; (vi) support rural communities by helping them obtain the necessary little equipment for processing, packaging, storage and marketing of their products.

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Abbreviation
FCFA: CFA francs, where CFA stands for Communauté Financière Africaine (African Financial Community); 656 FCFA≈1€ and 500 FCFA≈1 USD.

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