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Strategies towards sustainable bark sourcing as raw material for plant-based drug development: a case study on *Garcinia lucida* tree species

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ABSTRACT
Objectives: To appraise the amount of sustainable bark stripped and time to complete bark recovery as basis for sourcing of raw materials for plant-based drugs
Methodology and Results: A two-year experiment was conducted and several local harvest practices were tested on *Garcinia lucida (*named Essok in Boulou language*)*. For each harvest method, 20 healthy trees were selected and harvested. Tree health was monitored every month and the total bark regrowth was calculated using planimetric techniques. The mean bark mass was 2.54 kg/tree (range, 0.5-15 kg/tree; SD, 2.40; n=80) and increased with bark thickness, ranging from 1.28 kg tree^{-1} (0.4-0.8 cm thin) to 4.38 kg tree^{-1}(1.2 – 1.8 cm thick). The mean rate of bark regeneration was 787±601 cm²/tree/year (range, 452±166-1870±1042 cm²/tree/yr; n=53) and positively correlated to harvest method ($p < 0.01$) and surface debarked ($p < 0.05$). Standard Deviation values were higher, suggesting that each tree had its proper bark growth rate patterns, and that bark regrowth process may be tree-specific and strongly correlated to intrinsic factors.
Conclusions and application of findings: Peeling off pieces of bark using a machete and debarking over 1/3 of the stem circumference at breast height, once every 3 years for small trees or every 5 years for large trees, has been found to be the best harvest method for *G. lucida* species. This is to tackle the challenge of availability of raw material and harvest sustainability. As the increased trade and processing of bark has shifted from subsistence use to large-scale commercial use, posing a threat to supply of raw material and species conservation, sustainable harvesting methods should constitute important tools of the guidelines on good collection practices for medicinal plants that would help to ensure safety and quality at the first and most important stage of the harvest of medicinal plants. This study has provided information on the species-specific bark harvest prescriptions to assist in developing such guidelines, thereby promoting the processing and trade of the most valued medicinal species for plant-based drug development in Africa.
Keywords: *Garcinia lucida*, medicinal plant, bark, raw material, sustainable bark stripping.

INTRODUCTION

Nowadays, as many African countries are trying to deal with pandemic diseases such as malaria, tuberculosis, diabetes, hypertension, health reproduction, HIV/AIDS in a wide range of population with limited access to health care and pharmaceutical drugs, active compounds of many medicines from the pharmacy or the traditional pharmacopeia are still obtained from bark harvested from a range of tree species. In South Africa, *Warbugia salutaris* bark is used to treat opportunistic fungal infections resulting from HIV/AIDS (Cunningham, 2014a). The potent psychotropic ibogaine from the root bark of *Tabernanthe iboga* is increasingly used for the treatment of heroin, cocaine and amphetamine addiction (Mash *et al*., 1998; Fleurentin *et al*., 2011). The bark of *Prunus africana*, a nationally and internationally protected tree species, is widely harvested all over Africa and sold in pharmaceutical shops worldwide for the treatment of prostate cancer (Cunningham, 2014b; Ingram *et al*., 2015). The bark of *Pausinystalia johimbe* has long been used in traditional health care and cultural systems for its aphrodisiac properties in Cameroon and Central Africa. In international trade for a long time, the efficacy of it bark in treating organic male impotence has led to the development of a worldwide market for yohimbe-based products (Sunderland *et al*., 2014). The analgesic and anti-inflammatory effects of *Mitragyna ciliate* bark are still of great medical interest (Dogmo *et al*., 2003). The bark of *Annickia chlorantha,* used to cure hepatitis has led to the development of a drug sold in pharmacies in Cameroon and its neighbouring countries. Bark products not only have saved lives and influenced history but can also change landscapes, particularly where intensive production of bark products results in characteristic production systems, such as those for cork, bark cloth, paper or raw materials for phytomedicine (Cunningham, 2014a). These bark species make significant contributions to livelihoods and economies, such that if their abundance or supply is jeopardized, it can have measurable repercussions on the well-being of local communities and households (Shackleton, 2015). In regard to these bark multiple uses and values, posing a threat of resource overexploitation and depletion, valuable efforts have been made to establish good quality assurance and standardization (WHO, 2004; Kasilo *et al*., 2010; Cordell, 2011, Kunle *et al*., 2012; van Damme & Delvaux, 2012; Pandey & Das, 2013), as well as specific guidelines for sustainable bark harvesting (Romero *et al*., 2014; Costa *et al*., 2015; Geldenhuys *et al*., 2007; Delvaux *et al*., 2009; Baldauf & dos Santos, 2014; Guedje, 2014; Mariot *et al*., 2014). However, as stated by Cunningham (2014a), methods of studying bark use and production are poorly known and rarely taught. Worldwide forester training has concentrated on timber production (Philip, 1994), with little emphasis on studies of medicinal species, almost classified as non-timber forest products. Furthermore, there are few accounts in the literature on bark yield for medicinal tree species. According to Williams *et al*. (2014), reliable estimates of bark mass as function of tree size are necessary for analysis of the impact of the traditional medicinal plant trade on resources of indigenous tree species. If the potentially harvestable bark mass per stem-diameter class of trees as well as the amount of bark used or sold annually is known, the number of trees harvested annually may be estimated and assessed, and the species-specific management prescriptions or plans may be adopted. There are two commonly used methods for estimating bark yield. The first is to fell and debark selected trees and carefully measure them to obtain an estimate of the size-specific bark volume and mass (Peters 1996). The second, less destructive, is to consider the stem a cone or a cylinder and estimate the surface area of its bark accordingly, thereafter, yield is estimated from data on bark thickness direct measurement or models and mass from stem samples. Refinements of the two methods involve relating yield, through the regression equations, to one or more predictor variables such as stem diameter dbh (diameter at breast height), tree height or stem length. However, in many cases, diameter measurements at dbh (1.3m) were correlated with mass to predict potential bark stock, resulting with more or less greater degree of accuracy in estimating harvestable bark mass per tree or species. However, different tree species behave differently to bark stripping, in terms of both wound closure and susceptibility to insect and fungal attack (Chungu *et al*., 2007; Geldenhuys *et al*., 2007; Delvaux *et al*., 2009; Baldauf & dos Santos, 2014; Mariot *et al*., 2014). Thus, the systems of sustainable bark harvesting for medicinal uses should be species-specific (Pandey & Mandal, 2012). Based on data from *in situ* experimental assessment of traditional harvest practices and tree response to bark removal, the present study appraises the amount of harvestable bark mass that can be sustainable removed from a stem tree and the time needed to complete bark recovery. This will be a basis for providing species-specific management prescriptions for good sourcing of raw materials for plant-based industry prospects in the African region, as recommended by WHO (2004; 2007; 2013).

MATERIAL AND METHODS

Study site and species: The study was carried out within an area located in the South Cameroonian Atlantic humid forests in the Bipindi - Lolodorf - Akom II region, in Nkouékouk, Nyangong, Meka'a II and Mefak villages (Fig. 1).

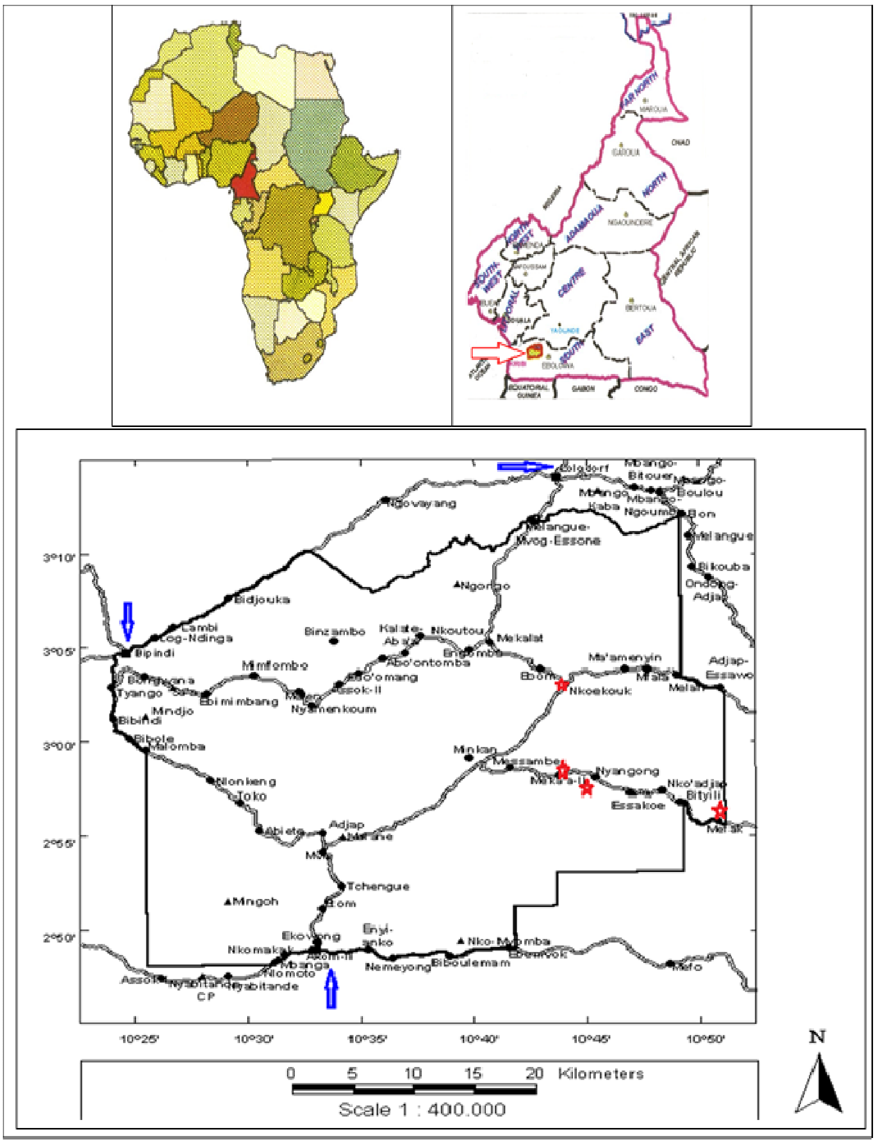

Fig. 1: Map of the Bipindi–Lolodorf-Akom II region (South Cameroon) showing study villages (★)

The climate is humid tropical with two rainy and two drier seasons, with a yearly rainfall of about 2000 mm, and with an average annual temperature of around 25°C. Biodiversity in this part of Cameroon ranks among the highest in Africa. The forest cover is still largely intact, but due to human influence, it is alternated with a mosaic of fields, fallow lands, secondary forest and logged-over forest. *Garcinia lucida* Vesque (Clusiaceae), named Essok in Boulou language, is a small understory dioecious tree, standing sometimes on stilt roots, reaching 25 - 30 cm in diameter at breast height (dbh) and 12–15 m in height, growing in high-density stands in the humid Atlantic forests of South Cameroon, Equatorial Guinea and Gabon (Fig. 2). The bark and the seeds are widely used in Central and West Africa as additive to palm wine production, and for multiple medicinal purposes against poisoning, gastritis, snakebite, gynaecological pains and infections, sexual diseases and cancers (Guedje *et al*., 2017). The results from pharmacological studies using diverse plant parts of this species have found it to be potential good sources of numerous therapeutic agents (Nguedia & Nsagha, 2014), and have supported its popular use as antibacterial, antimicrobial, anti-inflammatory, antacids, curare antidote or inhibitory effect, β-lactamase inhibition have been found in its diverse plant parts (Kamanyi *et al*., 1990; Nyemba *et al*., 1990; Fotie *et al*., 2007; Gangoué-Piéboji *et al*., 2009; Momo *et al*., 2011; Lacmata *et al*., 2012).

Fig. 2: *Garcinia lucida* Vesque (Clusiaceae) photographs. A = Small and large size trees stripped, B = Bags of bark to be sold in Ebolowa town city (South Cameroon), Gabon or Guinea Equatorial, C= Bark retail in Mvog-Mbi market (Yaoundé).

Experimental bark stripping design, data collection and analysis: The following treatments (Fig. 3), illustrating the local bark harvesting system, were applied: Control (C): no debarking. Partial debarking of the stem, with three sub-treatments:

(a) Peeling off pieces of bark with a machete and debarking over 1/3 of the tree circumference at breast height (P 1/3),

(b) Hammering on the tree with a stick and debarking over 1/3 of the tree circumference at breast height (H 1/3), and (c) hammering with a stick and debarking over 2/3 of the tree circumference at breast height (H 2/3);

Ring-barking of the stem (R 3/3);

Felling the tree at approximately 1 m height above the ground and thereafter harvesting the bark on the felled tree part (F).

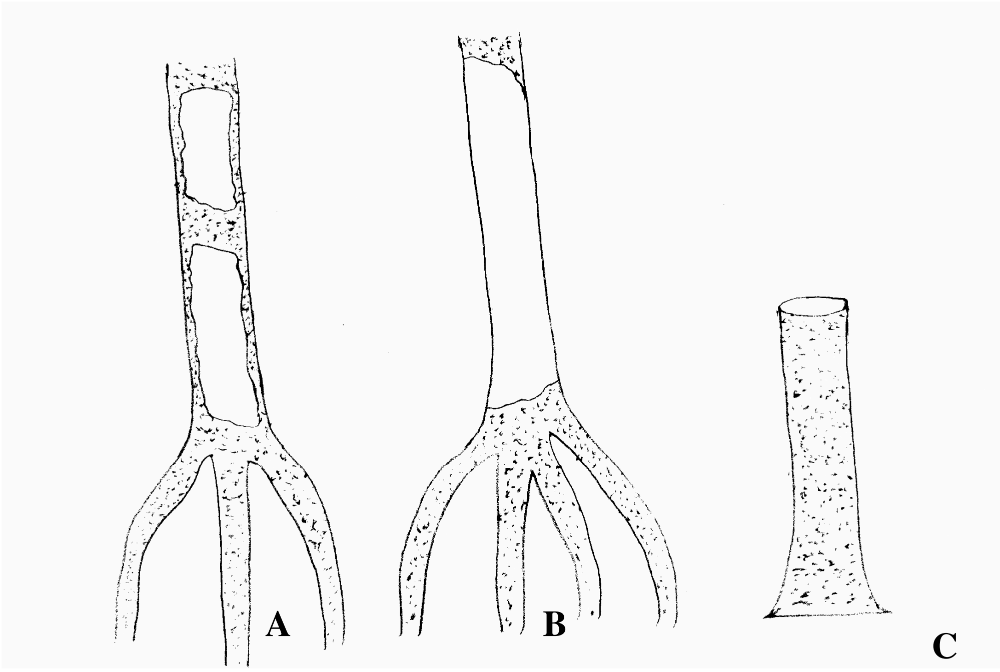

Fig. 3: Bark stripping experimental design.
A = Partial debarking of the stem, by peeling off pieces of bark with a machete (P 1/3) or by hammering on the tree with a stick and debarking over 1/3 (H 1/3) or 2/3 of the tree circumference (H 2/3), B = Ring-barking of the stem (R 3/3); C = Felling the tree at approximately 1 m height above the ground and thereafter harvesting the bark on the felled tree part (F).

For each harvest method or treatment and each sub-treatment, 20 healthy trees (no scars and previous bark harvest) were selected, marked with numbers, equally distributed in two size classes : [10 - 17[cm diameter at breast height (DBH) for small trees and [17 – 26[cm DBH for large trees. The sample was restricted to this number of trees and size classes as healthy trees were scarce, and as many *G. lucida* forest stands in the area mostly composed of harvested trees or unharvested trees but covered with many scars. Later, over the two-year study period, 16 trees (13.33%) were illegally stripped by unknown local community members and struck out from the sample. Bark was extracted from 0.3 m from the ground (or above stilt roots) in a vertical strip up to 1.5 m stem height. For each treated tree, “bark easiness” to be removed from wood like "cassava peel", or “bark hardness” to be removed from wood were noted. Bark thickness was measured at the trunk base with a ruler while total bark extracted from each tree was measured with scales. Health parameters (survival, sprouting, bark re-growth, stilt-root development) were monitored every month over a period of two years. Insect holes were noted, new sprouts and shoots around the wound was counted. Re-growth of bark was monitored, and at 6, 12 and 24 months, tracing papers were used to copy the surface area of edge growth on the wound. The total bark area regrowth was calculated using planimetric techniques. Variance (ANOVA) and regression analysis techniques using Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL, USA) have been used to compare the different harvest methods and to evaluate the contribution of each factor in determining the sustainable bark mass.

RESULTS

Mean bark wet mass yielded: Data on bark biomass from standing trees stripped experimentally are presented in Table 1. Part of sample trees felled (F) were not debarked. The mean bark mass was 2.54 kg/tree (range, 0.5-15 kg/tree; SD, 2.40; n=80). Mean bark mass per small trees partially debarked varied between 0.85±0.34 kg/tree (H 1/3) to 1.42±0.57kg/tree (P 1/3), while it was 2.3±0.79 kg/tree for ring-barked trees (R 3/3). Mean bark mass (values printed in bold in Table 1) per large trees partially debarked ranked between 1.5±0.47 (H 1/3) to 3.45±1.32 kg/tree (H 2/3), while it was 6.7±4.04 kg/tree for ring-barked trees. The mean mass of fresh bark per harvest method was 2.1±1.40 kg/tree for P 1/3; 1.18±0.52 kg/tree for H 1/3; 2.4±1.54 kg/tree for H 2/3 and 4.5±3.62 kg/tree for R 3/. However, peeling off pieces of bark with a machete (P 1/3) yields more bark mass (2.1±1.40 kg/tree) than hammering on the tree with a stick (1.18±0.52 kg/tree for 1/3 debarking and 2.4±1.54 for 2/3 debarking).

Table 1: Mean quantity of *Garcinia lucida* bark wet mass per size-classes for different debarking methods.

Treatments	Size categories (cm DBH)	Fresh bark mass obtained (kg)				
		Minimum	Maximum	Total	Mean±StdDev	N
P 1/3	[10 - 17[	0.5	2	18.5	1.42±0.57	13
	[17 - 26[	2	6.5	23.5	3.36±1.65	7
	Sub-Total	0.5	6.5	42	*2.1±1.40*	20
H 1/3	[10 - 17[	0.5	1.5	8.5	0.85±0.34	10
	[17 - 26[	1	2.5	15	1.5±0.47	10
	Sub-Total	0.5	2.5	23.5	*1.18±0.52*	20
H 2/3	[10 - 17[	0.5	3	13.5	1.35±0.91	10
	[17 - 26[	2	6	34.5	3.45±1.32	10
	Sub-Total	0.5	6	48	*2.4±1.54*	20
R 3/3	[10 - 17[	1	3.5	23	2.3±0.79	10
	[17 - 26[	3	15	67	6.7±4.04	10
	Sub-Total	1	15	90	*4.5±3.62*	20
Total		0.5	15	203.5	2.54±2.40	80

As stem diameter increased, the mean bark mass also increased in overall harvest methods (Fig. 4).

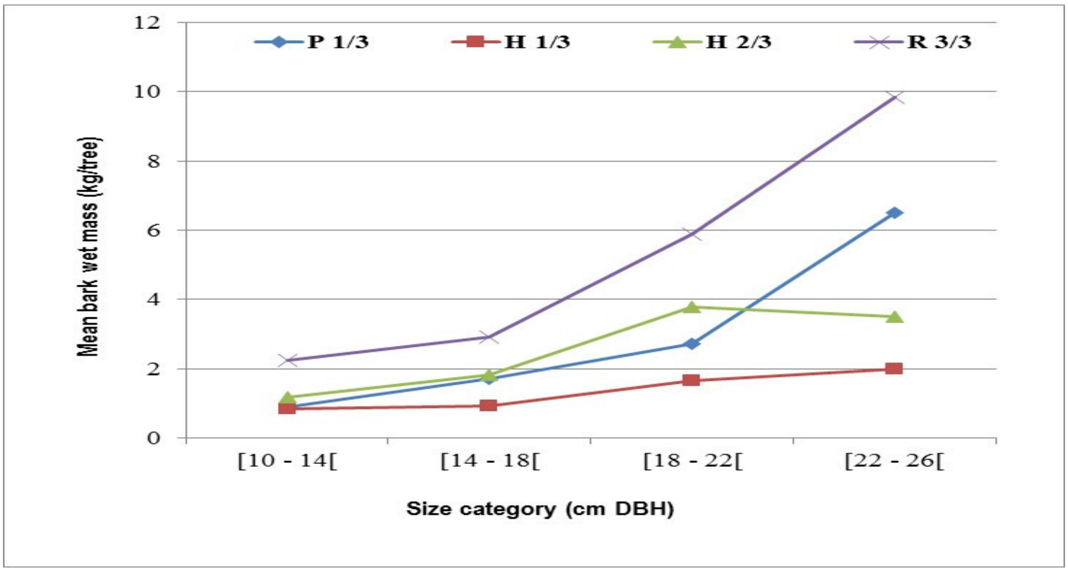

Fig. 4: Comparative mean bark wet mass per diameter size category and per harvest method.

The relationship between bark wet mass stripped and stem diameter was y = 0.389x – 3.8742 (R^2 = 0.4053), where y was the bark wet mass and x the stem diameter (Fig. 5).

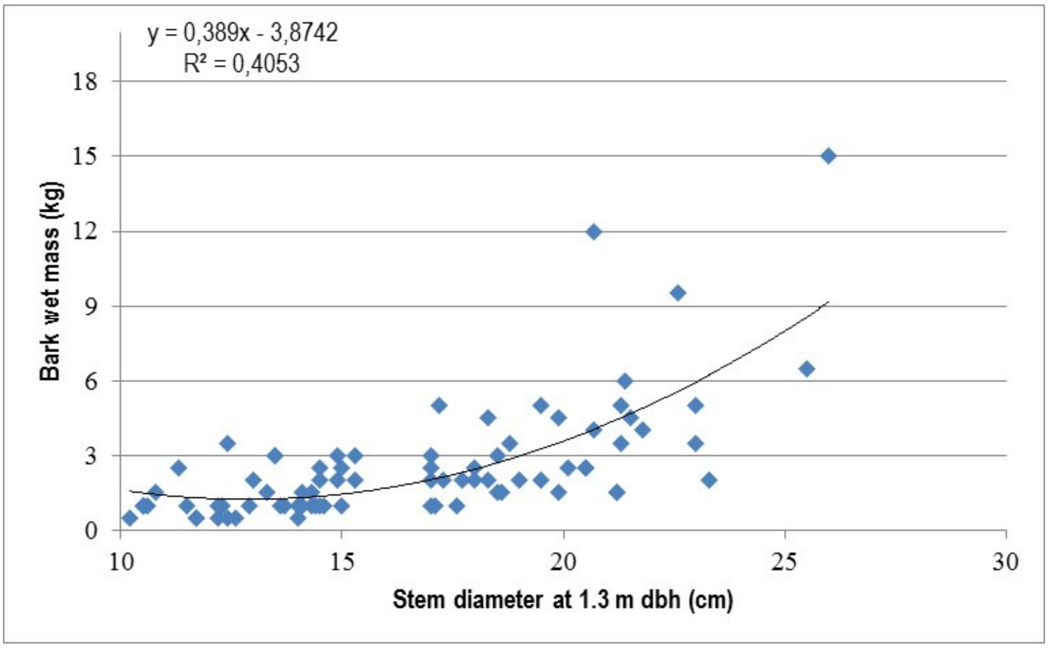

Fig. 5: Regression relationship between bark wet mass and stem diameter at 1.3 m dbh (cm).

Factors affecting bark mass stripped: An important factor influencing bark mass yielded was the bark thickness (Table 2). In fact, bark weight increased with bark thickness, with mean values ranging from 1.28 kg tree^{-1} (0.4-0.8 cm thin) to 4.38 kg tree^{-1}(1.2 – 1.8 cm thick). Another parameter affecting bark mass yielded was the physiological status of the tree. When the sap was rising upward during harvesting, the bark was easily removed from the wood like "cassava skin", and then bark weight extracted was higher. More than half of the sample trees (51%) had sap rising upward and their bark was more or less easily removed and accounted for 60.69% of the total bark mass obtained. Regression of bark wet mass stripped against bark thickness, harvest methods and stem diameter was significant ($y = 0.97x_1 + 0.84x_2 + 1.37x_3 – 3.53$; $p < 0.01$; where y was the bark wet mass stripped, x_1 the bark thickness, x_2 the harvest methods and x_3 the stem diameter). This significant relation explained why bark gatherer usually selected trees to be harvest after testing the thickness of the bark and if it will easily be detached from the wood. It also highlighted the efficiency of selection criteria used by harvester as important parameters to be taken in account when formulating guidelines for sustainable harvest system.

Table 2: Mean quantity of *Garcinia lucida* bark wet mass per bark thickness category and per bark removal easiness category.

		Fresh bark mass obtained (kg)				Individuals	
		Minimum	Maximum	Total	Mean±StdDev	N	%
Bark thickness size category (cm)	[0.4 - 0.8[	0.5	3.5	2.5	1.28±0.80	23	29
	[0.8 - 1.2[	0.5	5	69	2.09±1.08	33	41
	[1.2 - 1.8[	0.5	15	105	4.38±3.49	24	30
	Total	0.5	15	203.5	2.54±2.40	80	100
Bark removal easiness category	Very easy	1	1	15	2.5±1.41	6	8
	More or less easy	0.5	2	124	3.01±3.05	41	51
	Very difficult	0.5	3	65	1.97±1.29	33	41
	Total	0.5	3	204	2.54±2.40	80	100

Bark re-growth rates and harvest frequency appraisal: The mean surface recovered per year and per tree ranked for small size-class trees between 452 cm² year^{-1} (H 1/3) and 1870 cm² year^{-1} (R 3/3); and for large-size trees, from 563 (H 1/3) to 730 cm² year^{-1} (H 2/3). In term of percentage of recovering, those values represented 45% (H 1/3) to 64% (R3/3) of the initial surface debarked for small trees and between 25% (H2/3) and 38% (P 1/3) for large trees (Table 3). Bark recovering process was faster in small or young trees than large ones, likewise peeled trees (P 1/3) exhibited high percentage of recovering than hammered trees (H 1/3). Standard Deviation values were higher, suggesting that each tree had its proper bark growth rate pattern, and that bark regrowth process may be tree-specific and strongly correlated to intrinsic factors such as the physiological status of trees. Variance analysis (with LSD at 5%) of the mean surface recovered by tree in each debarking method showed a significant difference between treatment R 3/3 and treatments P 1/3, H 1/3, H 2/3 ($p < 0.001$), while no significant difference was recorded between size-classes in overall treatments. Furthermore, the mean surface recovered was positively correlated to the harvest method ($r = 0.40$; $p < 0.01$) and to the initial surface debarked ($r = 0.35$; $p < 0.05$). But a multi linear regression analysis showed that bark surface recovered was mainly a function of the harvest method ($y = 494.82x + 491.36$; $p < 0.01$; where y was the bark surface recovered in cm² and x was the harvest method or treatment). These analyses highlighted the importance of defining the level or intensity of bark stripping, which then constituted an important parameter to be taken in account in resource management planning. Dividing the mean surface debarked per tree for each harvest method with the mean surface re-growth per year and per tree resulted in an estimate of the time interval needed for trees to recover after previous harvest, also seen as time interval between consecutive bark strips on a given tree. It ranked between 3 years (P 1/3 and R 3/ 3) to 9 years (H 2/3), with an average of five years. This time interval was short for small trees than for large trees, indicating that bark regeneration was faster in younger trees.

Table 3: Estimate mean time interval between consecutive bark harvest on *Garcinia lucida*

Harvest method	Size class (cm)	N	Surfaces of bark extracted (cm²)		Surfaces of bark recovered (cm²)		% of bark cm² recovered	Mean cm²/tree/yr recovered ±StdDev	Harvest interval (year)
			Total	Mean/tree	Total	Mean/tree			
P1/3	10 - 17	9	20324	2258	12513	1390	62%	695±287	3
	17 - 26	7	27561	3937	10164	1452	37%	726±428	5
	Sub-Total	16	47885	2993	22676	1417	47%	709±343	4
H 1/3	10 - 17	8	16011	2001	7238	905	45%	452±166	4
	17 - 26	8	24842	3105	9015	1127	36%	563±312	6
	Sub-Total	16	40853	2553	16252	1016	40%	508±248	5
H 2/3	10 - 17	9	33133	3681	15595	1733	47%	866±541	4
	17 - 26	7	43436	6205	10214	1459	24%	730±590	9
	Sub-Total	16	76570	4786	25809	1613	34%	807±548	6
R 3/3	10 - 17	5	30064	6013	18704	3741	62%	1870±1042	3
Total		53	195371	3686	83442	1574	43%	787±601	5

A comparison of the harvest method performances according to mean bark wet mass yielded and bark recovering has shown that the sustainable level of extraction at tree-level is debarking over 1/3 of the stem circumference at breast height (Table 4). In this case, the mean desired sustainable quantity of bark mass expected will be around 2.1 kg/tree, corresponding to vertical strip or a rectangular area of wide range between 1/3 to 2/3 of the circumference and of length comprise between 0.3 m from the ground (or above stilt roots) and up to 1.5 m stem height.

Table 4: Comparison of the harvest method performances according to mean bark wet mass yielded and bark recovering

		Bark harvest method			
	Size class (cm DBH)	**P 1/3**	**H 1/3**	**H 2/3**	**R 3/3**
Mean bark mass stripped kg/tree	[10 - 17[	1.42±0.57	0.85±0.34	1.35±0.91	2.3±0.79
	[17 - 26[	3.36±1.65	1.5±0.47	3.45±1.32	6.7±4.04
	Total	2.1±1.40	1.18±0.52	2.4±1.54	4.5±3.62
Bark recovered cm²/tree/year	[10 - 17[	62% (695±287)	45% (452±166)	47% (866±541)	62% (1870±1042)
	[17 - 26[	37% (726±428)	36% (563±312)	24% (730±590)	-
	Total	47% (709±343)	40% (508±248)	34% (807±548)	-

(expressed as a percentage of re-growth area and as a mean surface recovered cm²/tree/yr ± StdDev).

DISCUSSION

The bottle-neck for sustainable exploitation of bark is not only the species survival, but also the quantity of bark mass yielded or available from individual trees, sufficient to make repeated bark harvests economically viable from a management plant-based drug development prospects. The results of this study indicated that peeling off pieces of bark with a machete yielded more bark mass than hammering on the tree with a stick. Bark mass values for ring-barked trees were higher than those for partially debarked trees; however, this practice has been proved in previous study (Guedje *et al*., 2016) to lead to high tree mortality, rendering this practice unsuitable for bark stripping as a method of long-term bark harvesting. Another practice expecting to provide high yield of bark harvested was felling tree at 1 m above ground, something not done in this investigation. However, flowering and fruiting processes, as well as productivity would completely be suppressed in that case, although the high sprouting capacity of stumps gave the tree a greater chance to reproduce in a vegetative way in natural stands and suggested that this species could be cloned (with desirable "genetic" characteristics or qualities such as the thickness of the bark) and easily brought into domestication or cultivation (Guedje *et al*., 2016). Bark mass obtained per *G. lucida* tree increases with stem diameter. This trend was also found for six tree species used medicinally in South Africa by Williams *et al*. (2014), while the quadratic regressions derived for *Prunus africana* in Cameroon (Cunningham *et al*., 2002; 2014b) and *Rytigynia* spp. in Uganda (Kamatenesi *et al*., 2014) appear to show no levelling out of bark mass with increased dbh. Bark regrowth patterns, expressed as a percentage of re-growth area, varied between harvest methods with highest values recorded for peeling off 1/3 of the stem circumference. Guedje *et al*. (2016) have found that a high rate of bark-regrowth was found on trees that bark has been hardly removed (narrow strips of bark tissues remained on stem wood), due physiologically or intrinsically, to the predominance of a downward sap flow and poor water supply. Furthermore, when trees were peeling off with machete, narrow strips of bark tissues, which always remained on stem wood, allowed for sap flow to the roots, thereby contributing substantially to tree stability, as well as serving to protect the stem from insect or pathogen attack, and triggering bark regeneration. Therefore, the practice of peeling off pieces of bark with machete seem to be more suitable for tree survival and bark regeneration as damages due to peeling with machete may be superficial and affect only the outer bark and the old phloem and phlegm, permitting trees treated by this way to survive and to further recover from wounds (Camefort, 1977; Romero, 2014; Senkoro *et al.,* 2014). The highest values recorded for ring-barked trees that bark was hardly stripped, however, does not provide conclusive evidence and was of limited value to evaluate the sustainability of ring-barking practice, as the analysis was based on a limited sample of trees. Based on bark wet mass and bark regrowth rates estimated and refined by relating yield, through the regression equations, to predictor variables (such as stem diameter, bark thickness, harvest method), the sustained time interval between consecutive bark extraction (or the harvest frequency) on a given tree was estimated at once every five years, using the harvest methods tested. However, this time interval between consecutive harvests is a rough estimate, as the bark re-growth process varied considerably, partly because of intrinsic determinisms of each tree as shown with the higher SD values (this study), the edge growth patterns, as well as the physiological status (downward sap flow) of the tree at the time of bark stripping. Also partly because of exogenous factors such as rainfall, soil nutrient or water soil availability. Furthermore, bark recovered after a second harvest on the same tree has not been taking in account in the estimation of this time interval. Further studies needed to investigate bark-regrowth patterns after a second harvest on the same tree. To illustrate the bark re-growth variability, Pandey & Mandal (2012) have found that a sustainable bark harvesting could be done after every 2 years for Arjuna (*Terminalia arjuna*) and 1 year for Maida (*Litsea glutinosa*) by removing opposite quarters of trunk bark. They have recommended that for sustainable harvest, mature bark from only one fourth to one third of the total girth of the tree should be stripped by removing only outer and middle bark, leaving the inner bark for regeneration. Baldauf & dos Santos (2014) have indicated that three years were not sufficient for a total recovery of the rhytidome of *Himatanthus drasticus*. According to Ingram *et al*. (2015), the 'two quarters' method (which are intermediate between the 1/3 and 2/3 debarking stem circumference in the present study) appears to be a sustainable harvesting technique for *Prunus africana* wild trees, as bark from trees with at least 30 cm diameter at breast height is peeled gently from the cambium between breast height and the first branch from two opposite panels of the circumference, removing one-half of the bark over this part of the tree, once every seven years. These authors recommended that repeat harvesting should be done only if the bark has re-grown since the previous harvest (harvesting from the alternate quarters from any previous stripping) and the tree is otherwise healthy. Previous study has discussed the main findings on the experimental debarking of *G. lucida* and found that bark strip harvesting requires species-specific parameters to make it sustainable, taking into account: (i) the bark regeneration capacity (edge growth), which may allow repeated harvest on the same tree; and (ii) the physiological status (downward sap flow) of the tree at the time of harvest, as decisive factor triggering bark regrowth (Guedje *et al*., 2016). Partial bark strip harvesting has shown good prospects for the implementation of long-term sustainable strip harvesting prescriptions. Hence, as discussed throughout this paper, and based on those species-specific characteristics requirements, it can be deducted that the sustainable bark stripping technique is peeling off 1/3 of bark stem circumference, once every 3 years for small trees or every 5 years for large trees, as it yielded sufficient bark mass and allowed bark recovery in a reasonable time span. According to Pandey & Das (2013), Hall & Bawa (1993), sustainable harvesting can be defined as collection or harvest of resources in such a way that it does not led to long term decline of these resources, thereby maintaining its potential to meet the need and aspirations of future generations. However, according to Farnsworth *et al*. (1985), Cordell (2011), twenty-five years ago until now, a WHO-associated group provided a frequently cited guesstimate that 80% of the population in the developing world relies on plants for their primary health care. As the natural resources for these medicinal agents become scarcer, and because of the long-term public health requirement of relying on plant-based traditional medicines, this strategically important number merits rigorous scientific determination on a global basis in order that more accurate assessments of continuing resource need can be made for future health care. Also in the European and North American countries, use of medicinal plants is expected to rise globally, both in allopathic and herbal medicine (WHO, 2002; 2013). This upward trend is predicted not only because of population explosion, but also due to increasing popularity for natural-based, environmentally friendly products. Simultaneously, a growing international market for standardized herbal products is adding to pressure on selected high-demand species (Bodeker *et al*., 2014). With the visibility of medicinal plant species growing globally, the number of products emerging in the market, derived from medicinal plants is on the rise. There is great demand for raw materials even as medicinal plants are facing the threat of becoming extinct or endangered; and it has been well established that the harvesting of medicinal plants on such a scale is not sustainable (Ram-Manohar, 2012). Therefore, sustainable harvesting methods should constituted an important tools of the WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants (WHO, 2003; 2007), as its seem to be one among the most relevant approaches to tackle the challenge of availability of medicinal plants even as efforts have been put to cultivate some species on a large scale for commercial use. As stated by WHO, Good agricultural and collection practices for medicinal plants is only the first step in quality assurance, on which the safety and efficacy of herbal medicinal products directly depend upon, and will also play an important role in the protection of natural resources of medicinal plants for sustainable use. Therefore, high priority should be given to the development of globally applicable guidelines to promote the safety and quality of medicinal plant materials through the formulation of codes for good agricultural and good collection practices for medicinal plants. Envisaging that such guidelines would help to ensure safety and quality at the first and most important stage of the harvest of plants and production of herbal medicines, this study has provided scientific information on the species-specifics bark harvest prescriptions to assist in developing regional or national guidelines for good collection practices for medicinal plants in Central Africa, thereby promoting processing and trade of the most value medicinal species for plant-based drug development in Africa.

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CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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