



# Ethnobotanical study of the competition between humans and baboons (*Papio kindae*) for wild fruit trees in the fringe of the Kundelungu National Park, D.R. Congo

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## Research

### Abstract

**Background:** This study is the first step of a project addressing the under-researched human-nonhuman primate competition for forest resources.

**Methods:** Ethnobotanical surveys conducted in Lukafu and Mulenga, two villages adjacent to the Kundelungu National Park (K.N.P.), Democratic Republic of Congo, involved 139 purposively selected informants. With a particular emphasis on baboon (*Papio kindae* Lönnberg)-edible fruit trees, we collected and analyzed information on the most utilized indigenous trees of the area. These included used parts, types of utilizations, acquisition, and perceptions of availability.

**Results:** A total of 26 indigenous tree species, nine of which are baboon-edible, were utilized the most by respondents. Tree products are collected from surrounding miombo woodlands of the K.N.P. mainly for energy (firewood and charcoal) supply and medicinal purposes. Of the nine baboon-edible species, four are used for two or more purposes and three do not have alternative resources.

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**Conclusions:** We conclude that the local people: (i) depend on indigenous trees, mainly for energy supply and medicinal uses, and (ii) observe a multipurpose and indispensable character, as well as decreasing tendencies in the main fleshy-fruited trees of food interest for baboons. Therefore, tackling tree cover losses in such a context implies the improvement of access to both non-wood renewable energy sources and quality health services. Towards the alleviation of the anthropogenic pressure on forests resources at the periphery of the K.N.P., two species of both multipurpose status for humans and high food interest for Kinda baboons deserve a particular attention. As an alternative to wild fruits collection, the domestication of the Wild loquat tree *Uapaca kirkiana* and the Monkey orange tree *Strychnos cocculoides* will not only improve households' livelihoods, but also contribute to mitigating the competition for forest resources between humans and baboons.

**Keywords:** Miombo woodlands, Indigenous trees, Wild fruit trees, Ethnobotanical uses, Kinda baboon, Human-Wildlife Conflicts, Park-adjacent Communities, Kundelungu National Park.

## Résumé

**Contexte:** Cette étude constitue une première étape d'un projet de recherche portant sur la compétition humain-primat (non-humain) pour les ressources forestières.

**Méthodes:** Les enquêtes ethnobotaniques menées à Lukafu et Mulenga, deux villages périphériques au Parc national de Kundelungu (P.N.K.) en République démocratique du Congo, ont impliqué 139 répondants. Avec un accent particulier sur les arbres à fruits comestibles pour les babouins de Kinda (*Papio kindae* Lönnberg), nous avons rassemblé et analysé des informations sur les arbres locaux les plus utilisés. Ces informations concernaient les parties utilisées, les types d'utilisation, les modes d'acquisition et les perceptions de la disponibilité.

**Résultats:** Un total de 26 espèces ligneuses, dont neuf d'intérêt alimentaire pour les babouins, sont les plus utilisées dans les deux villages. Ces arbres sont exploités dans les forêts claires environnantes, y compris celles situées dans le P.N.K., principalement pour satisfaire des besoins énergétiques et fournir des produits médicinaux. Aussi, sur les neuf espèces comestibles pour les babouins, quatre sont à usages multiples et trois n'ont pas de ressources alternatives dans le terroir.

**Conclusions:** Cette étude montre: (i) la dépendance des humains vis-à-vis des espèces ligneuses locales, principalement pour l'approvisionnement en

énergie et en produits médicinaux, et (ii) le caractère multiusages et indispensable pour les humains de certaines espèces d'intérêt alimentaire pour les babouins. Ainsi, dans un tel contexte, le maintien du couvert forestier devrait inclure l'amélioration de l'accès à des sources d'énergie non ligneuses et à des services de santé de qualité. Afin d'atténuer la pression anthropique sur les ressources forestières en périphérie du P.N.K., deux espèces à la fois multiusages pour les humains et d'intérêt alimentaire pour les babouins méritent une attention particulière. Comme alternative à la cueillette de fruits sauvages comestibles, la domestication de *Uapaca kirkiana* et de *Strychnos cocculoides* améliorera non seulement les moyens de subsistance des ménages, mais contribuera également à atténuer la compétition pour les ressources forestières entre humains et babouins.

**Mots-clés:** Forêts claires, Miombo, Arbres multiusages, Fruits charnus, Babouin de Kinda, Conflits humains-faune, Parc national de Kundelungu.

## Background

Tropical forests provide a variety of goods and services, which make them an important resource for many countries worldwide. In Southern Africa for example, miombo woodlands, a type of dry and open tropical forest (Frost 1996, Malaisse 1997), are important sources of income for rural households (Deweese *et al.* 2011, Njana *et al.* 2013). Indeed, miombo trees provide timber, fuelwood (Chidumayo 2019), and a variety of other products of nutritional, medicinal and economic significance (Akinnifesi *et al.* 2006, Dewees *et al.* 2011, Haule & Mwamfupu 2016, Mgumia *et al.* 2017, Mpasiwakomu *et al.* 2017; Ngadze *et al.* 2019).

In the last few decades, the overexploitation of miombo woodlands led to several social and environmental challenges throughout Southern Africa (Abbot & Homewood 1999, Chidumayo & Kibwisa 2003, Gonçalves *et al.* 2017, Jew *et al.* 2015), including in the south of the Democratic Republic of Congo (D.R.C.) (Kabulu *et al.* 2008, Munyemba & Bogaert 2014), a country with vast, wet and highly diversified miombo woodlands. Assessing the effects of forest exploitation is key for conservation. The environmental impacts arising from the utilization of forest products have been investigated before, but most studies focused on tree felling for woody parts, namely timber and fuelwood (Abbot & Homewood 1999, Chidumayo 2019, Hofstad 1997), among other drivers of forest degradation and deforestation. However, the effects of the exploitation of indigenous trees through the harvest of other tree parts such as roots, barks,

flowers and fruits have been rarely examined, and mainly from a floristic perspective (Ahossou *et al.* 2017, Dao & Hölscher 2018, Murali *et al.* 1996). Also, as pointed out by Chapman and Onderdonk (1998), and still observed recently (Waller & Pruetz 2016), there is a dearth of information on the effects of the extraction of non-timber forest products on forest-dependent animals.

About 90% of primate (the term is used in reference to nonhuman primates) species depend on tropical forests (Mittermeier and Cheney 1987), mainly for wild fruits they consume and disperse seeds. Primates are among the mammals affected the most by human-driven tree cover losses (Estrada *et al.* 2017). Also, due to the encroachment on their habitats, some primates are pushed to survive in increasingly human-dominated environments, where they share space and resources with human populations. Fuentes and Hockings (2010) highlighted that understanding why primates are able to interface with humans and increasingly human-disturbed landscapes is a burgeoning frontier for primatology. Nevertheless, this relevant conservation matter is still rarely addressed by the research.

This study provides a first insight into the under-researched human-primate competition for forest

resources in a particular context: a forest area shared by local people and Kinda baboons (*Papio kindae* Lönnberg), at the fringe of the resurgent Kundelungu National Park (K.N.P.), southeast of the D.R.C. Kinda baboons are diurnal monkeys relying on diverse miombo tree species for survival. With a particular emphasis on indigenous fruit trees of food interest for these baboons and assessing whether the respondents' perception of the availability of tree products depend on their age, this exploratory study aimed at identifying: (i) the main utilizations of trees and the causes of local people's dependence on these resources, and (ii) multipurpose trees and species without alternative resources, given their significance to local people.

## Materials and Methods

### Study Area

The study was conducted at the fringe of the K.N.P., a protected area of the south of D.R.C. Ethnobotanical surveys involved Lukafu (10°30'35.03"S; 27°32'55.36"E) and Mulenga (10°40'20.15"S; 27°38'40.02"E), the two main villages located between the Integral Zone and the Annex of the Park (Figure 1).

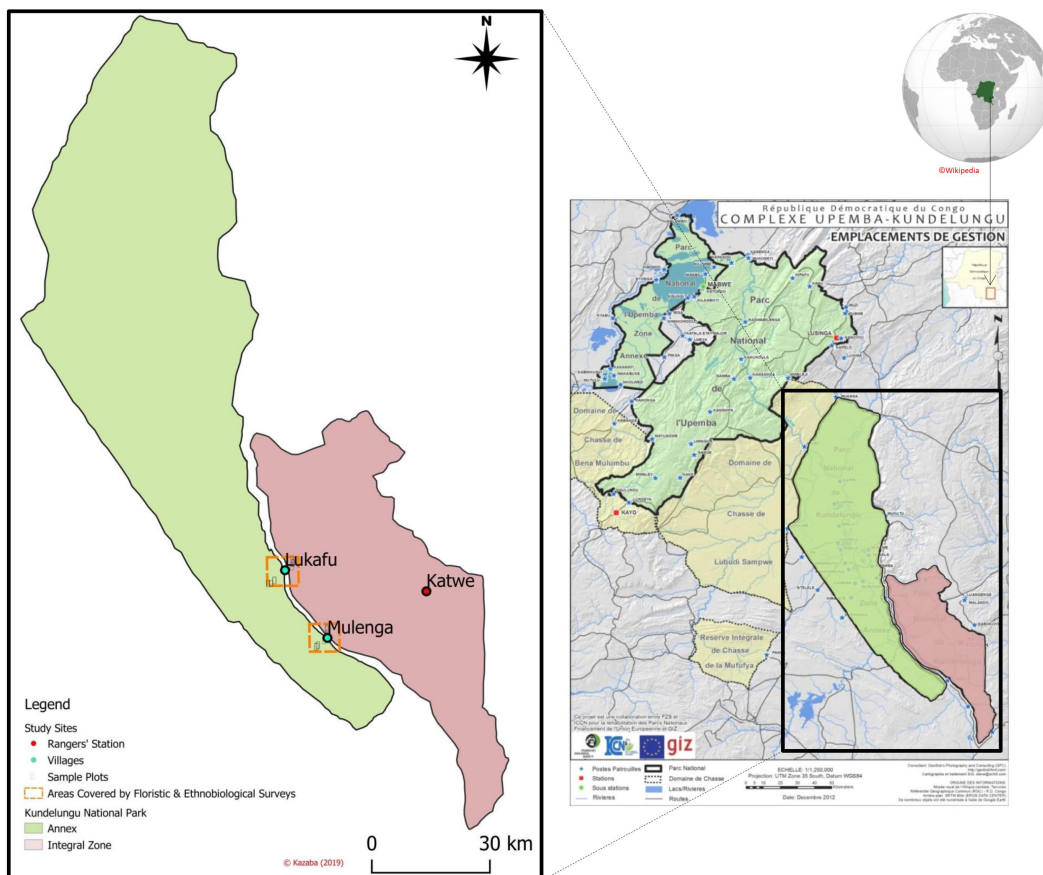


Figure 1. Location of the Kundelungu National Park and the study sites in the south of the Democratic Republic of Congo.

The area is under a tropical climate with two seasons: a dry season lasting from April to October, and a rainy season (November-March). The average rainfall is 1260 mm. Lowest temperatures (15-17 °C) are recorded in July and highest (31-33°C) between September and October (Saad *et al.* 2012). The vegetation is characterized by miombo woodlands (Malaisse 1997), the main forest type of the Zambezi Phytogeographic Region (White 1983). The vicinities of the two villages, including some parts of the K.N.P., are also covered by anthropogenic savannas, resulting from deforestation and forest degradation. The two phenomena are driven predominantly by the fuelwood exploitation alone or combined with slash-and-burn agriculture.

Mulenga and Lukafu are part of the Kasenga administrative Territory, in the Haut-Katanga Province. This Territory comprises seven ethnic groups, of which Bemba and Sanga are the two most dominant (CAID 2019). Subsistence farming is the source of income for the majority of households. Cassava and rice, as well as maize (predominantly cropped under slash-and-burn agriculture), are the main crops of the two park-adjacent villages.

#### Collection and Analysis of Data

Ethnobotanical surveys of tree species were conducted in the two villages from May to June 2019. Owing to the nature of information needed, the lack of reliable data on the human population size of these villages and the logistic limitations, we used the purposive sampling technique (Tongco 2007). A total of 139 adult (aged 18 years or above) respondents from different households were purposively selected and participated in the semi-structured interviews.

The survey questionnaire consisted of both open-ended and close-ended questions. Interviews were conducted mainly in Swahili. Bemba and Sanga, two other local languages, were also used at some respondents' request. In addition to socio-demographic data (gender, age, level of education...), each respondent was asked to provide information on the indigenous tree he/she utilized the most in the 12 months preceding the survey period. These included the last use (tree part used and its utilization), mode of acquisition, and the respondent's perception of availability. We have chosen the 12-months period in order to cover the key stages of the phenological cycles of trees in the area, given the seasonality of some of their useful products like young leaves, lowers, and fruits.

The identification (at the species level) of trees mentioned by respondents relied on two

complementary approaches. Firstly, an illustrated field guide describing some trees and shrubs of the region (Meerts & Hasson 2016) was used along with the survey questionnaires. After giving local names (in Swahili, Sanga or Bemba) of the most utilized tree species, respondents were asked to select the relevant tree in the field guide based on the illustration of the entire tree, trunk, fruits, flowers, and so forth. Secondly, in order to confirm such a preliminary identification, beside capitalizing the researchers' identification skills and knowledge of indigenous trees, floristic surveys were conducted in neighboring forests with two key informants (one per village) purposively selected among traditional healers with a reputable knowledge of indigenous trees of the study area. The selection of these informants was guided by both local rulers and representatives of the traditional healers' association of the administrative Territory.

In order to identify the tree species of food interest for baboons, we used the scan sampling technique (Altmann 1974) and carried out an observational study of their feeding behavior, along with the macroscopic analysis of feces. These involved a troop of free-roaming Kinda baboons in the vicinities of Katwe Station (Figure 1), within the K.N.P.

The significance of tree species to local people was estimated on the basis of their versatility, indispensableness and interest. Useful species were ranked based on their Relative Frequency of Citation, (R.F.C., Tardío & Pardo-de-Sanatayana 2008), calculated as follows:

$$RFC (\%) = \frac{n}{N} \times 100$$

With:

RFC: Relative Frequency of Citation

n: Number of respondents who mentioned the species

N: Total number of respondents

Descriptive statistics served for presenting relative frequencies (proportions) of responses to close-ended questions. Some responses were cross-tabulated with socio-demographic information and other parameters for statistical analysis. A Chi-square test was performed in the R programming language (Version 3.6.1) to statistically determine whether the respondents' perception of the availability of tree products depended on their age categories.

## Results

### Sociodemographic Characteristics of the Respondents

Of the total of 139 respondents who participated in the survey, the table 1 presents a synthesis of data on age, education and sources of income. It should be noted that majority of respondents were in the 18-30-years age class, and less than 30% of them

(mainly men) attained a post-primary level of education. The majority of female respondents declared to have never benefited of any formal education. Among the main sources of income, farming was mentioned by nearly 60% of the surveyed people, while the collection of forest products (timber and non-timber products) was among the least-cited.

Table 1. Sociodemographic characteristics of the 139 respondents who participated in the ethnobotanical surveys.

Parameter	Number and % (in parentheses) of respondents					
	Men		Women		Total	
Age class						
18-30 years	35	(25.2)	28	(20.1)	63	(45.3)
31-50 years	27	(19.4)	27	(19.4)	54	(38.8)
> 50 years	13	(9.4)	9	(6.5)	22	(15.9)
Educational level attained						
Not educated	18	(12.9)	39	(28.1)	57	(41.0)
Primary school	23	(16.5)	21	(15.1)	44	(31.7)
Secondary school	26	(18.7)	3	(2.2)	29	(20.9)
University	8	(5.8)	1	(0.7)	9	(6.5)
Main source of income						
Farming	33	(23.7)	52	(37.4)	85	(61.2)
Collection of forest products	11	(7.9)	0	(0.0)	11	(7.9)
Handicrafts	17	(12.2)	5	(3.6)	22	(15.8)
Small business and trade	5	(3.6)	3	(2.2)	8	(5.8)
Employment in the public sector	5	(3.6)	2	(1.4)	7	(5.0)
Employment in the private sector	4	(2.9)	2	(1.4)	6	(4.3)
<b>Total</b>	<b>75</b>	<b>(54.0)</b>	<b>64</b>	<b>(46.0)</b>	<b>139</b>	<b>(100.0)</b>

### Diversity and Uses of Indigenous Trees

A total of 26 indigenous tree species, nine of which are baboon-edible, were listed from the synthesis of the 139 responses to the question "Which indigenous tree have you utilized its part or product the most within the last 12 months?" These 26 species belong to a total of 23 genera and 12 families and are ranked in decreasing R.F.C. (Table 2). With its 11 tree species mentioned by 57% of the respondents, Fabaceae is the most useful family.

With a total R.F.C. close to 50%, pod-bearing trees of less food interest for baboons such as the Bloodwood *Pterocarpus angolensis* D.C. (Fabaceae), the Julbernardia *Julbernardia globiflora* (Benth.) Troupin (Fabaceae) and the Horn-pod tree *Diplorhynchus condylocarpon* (Müll.Arg.) Pichon (Apocynaceae) are ranked among the most useful native trees of the two villages. Apart from these species, some fleshy-fruited trees of high food interest for baboons are also among the most used species. These include the Monkey orange tree *Strychnos cocculoides* Baker (Loganiaceae), the Wild loquat tree *Uapaca kirkiana* Müll.Arg. (Phyllanthaceae), the Mobola plum tree *Parinari curatelifolia* Planch. ex Benth. (Chrysobalanaceae),

Fig trees *Ficus spp.* (Moraceae) and the Kudu berry tree *Pseudolachnostylis maprouneifolia* Pax (Phyllanthaceae). Species such as the Mongongo tree *Schinziophyton rautanenii* (Schinz) Radcl.-Sm., the Buffalo thorn *Ziziphus mucronata* Willd., *Acacia polyacantha* Willd. and the Large-leaved Sterculia *Sterculia quinqueloba* Schum. were among the least-mentioned (Table 2).

Data on the types of uses (Figure 2) suggest that indigenous trees are exploited mainly for energy (firewood and charcoal) supply (for 45% of respondents) and medicinal purposes (37%) in the two villages. Of the total 26 species mentioned, 11 were used for two or more purposes (Table 2) during the 12 months prior to the survey period. Species with only one type of use include: *J. globiflora*, *Brachystegia boehmii* Taub., *Pterocarpus tinctorius* Welw., *Z. mucronata* and *A. polyacantha* (energy supply); *Ficus spp.*, *Dalbergia nitidula* Welw. ex Baker, *P. maprouneifolia*, *Cassia abbreviata* Oliv., *Schrebera trichoclada* Welw., *Piliostigma thonningii* (Schum.) Milne-Redh. and *S. quinqueloba* (medicinal trees); *P. curatelifolia* and *Strychnos innocua* Delile (food trees), and *S. rautanenii* (handicraft manufacturing).

Table 2. Useful indigenous trees, their uses and Relative Frequencies of Citation (R.F.C.) by 139 respondents of Lukafu and Mulenga villages, in the periphery of the Kundelungu National Park (K.N.P.), Democratic Republic of Congo.

Species Scientific name	Local names	Family	Types of uses by local people				R.F.C. (%)	Fruit consumption by baboons
			Food tree	Fuelwood	Handicraft	Medicinal tree		
<i>Pterocarpus angolensis</i> D.C.	Mulombwa	Fabaceae	-	W	W	B, R	22.3	-
<i>Julbernardia globiflora</i> (Benth.) Troupin	Sandwe	Fabaceae	-	W	-	-	17.3	-
<i>Diplorhynchus condylocarpon</i> (Müll.Arg.) Pichon	Mwenge	Apocynaceae	-	W	-	B, E, L	7.9	-
<i>Strychnos cocculoides</i> Baker	Kisongole	Loganiaceae	F	-	-	R	5.8	+++
<i>Uapaca kirkiana</i> Müll.Arg.	Masuku	Phyllanthaceae	F	W	-	R	4.3	++++
<i>Parinari curatellifolia</i> Planch. ex Benth.	Mpundu, Mupundu	Chrysobalanaceae	F	-	-	-	3.6	++
<i>Brachystegia spiciformis</i> Benth.	Musase, Muputu	Fabaceae	-	W	-	B, L, R	3.6	-
<i>Terminalia mollis</i> M.A.Lawson	Kibobo	Combretaceae	-	W	-	R	3.6	-
<i>Ficus</i> spp.	Mukuyu	Moraceae	-	-	-	B, L, R	3.6	+
<i>Dalbergia nitidula</i> Welw. ex Baker	Kalongwe	Fabaceae	-	-	-	B, R	2.9	-
<i>Pseudolachnostylis maprouneifolia</i> Pax	Musaria	Phyllanthaceae	-	-	-	R	2.9	+
<i>Annona senegalensis</i> Pers.	Mulolo	Annonaceae	-	W	W	-	2.9	+
<i>Azelia quanzensis</i> Welw.	Mupapa	Fabaceae	-	W	-	R	2.2	-
<i>Pericopsis angolensis</i> (Baker) Meeuwen	Mubanga	Fabaceae	-	W	-	L	2.2	-
<i>Cassia abbreviata</i> Oliv.	Kafungunashia, Ndulwekyulu	Fabaceae	-	-	-	R	2.2	-
<i>Combretum adenogonium</i> Steud. ex A. Rich	Mufuka	Combretaceae	-	W	-	R	2.2	-
<i>Thespecia garckeana</i> (F. Hoffm.) Exell & Hillcoat	Mukole	Malvaceae	F	-	-	R	1.4	+
<i>Schrebera trichoclada</i> Welw.	Karikoyengele	Oleaceae	-	-	-	R	1.4	-
<i>Strychnos innocua</i> Delile	Kakomekome, Rinkolonkolo	Loganiaceae	F	-	-	-	1.4	++
<i>Brachystegia boehmii</i> Taub.	Musamba	Fabaceae	-	W	-	-	1.4	-
<i>Piliostigma thonningii</i> (Schum.) Milne-Redh.	Kifumbe	Fabaceae	-	-	-	B, L	1.4	-
<i>Pterocarpus tinctorius</i> Welw.	Mukula	Fabaceae	-	W	-	-	0.7	-
<i>Schinziophyton rautanenii</i> (Schinz) Radcl.-Sm.	Mukusu	Euphorbiaceae	-	-	W	-	0.7	-
<i>Ziziphus mucronata</i> Willd.	Kankona	Rhamnaceae	-	W	-	-	0.7	+
<i>Acacia polyacantha</i> Willd.	Kiombwe	Fabaceae	-	W	-	-	0.7	-
<i>Sterculia quinqueloba</i> Schum.	Mwemwe	Malvaceae	-	-	-	L	0.7	-
<b>TOTAL</b>							<b>100.00</b>	

**Legend:**

Plant parts used: B (bark); E (exudates); F (fruits); L (leaves); R (roots), and W (wood).

Fruits consumption by baboons: not yet observed or reported in the study area (-); reported but not yet recorded during behavioral observations (+); observed during 1-10 days (++); 11-20 days (+++), and more than 20 days (++++). Behavioral observations were carried out on a troop of free-ranging Kinda baboons (*Papio kindae*) in the vicinities of Katwe Station (10°33'54.62"S; 27°51'31.52"E), in the K.N.

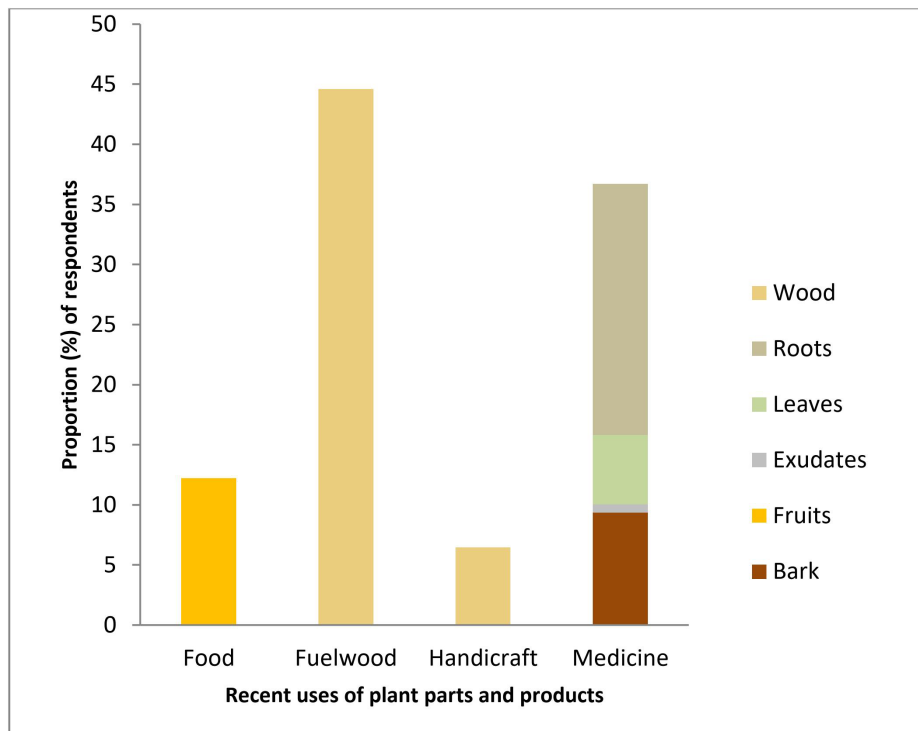


Figure 2. Use types and frequently utilized parts of indigenous trees by 139 respondents in two villages neighboring the Kundelungu National Park, Democratic Republic of Congo.

Regarding the used plant parts (Figure 2), most (72%) of the respondents mentioned the wood. Woody parts were mentioned as being used for fuelwood and as raw materials in carpentry and handicraft manufacture, while nearly all plant parts were used for medicinal purposes. In addition, only three respondents recognized non-consumptive uses of indigenous trees: some ecosystem services such as soil enrichment (for *A. polyacantha*), hosting (edible) caterpillars (*B. boehmii*) and making shelterbelts (*Ficus spp.*) were mentioned.

Human-edible fleshy fruits of Monkey orange trees *S. cocculoides* and *S. innocua*, the Wild loquat tree *U. kirkiana*, the Mobola plum tree *P. curatelifolia* and the Snot-apple tree *Thespecia garckeana* (F. Hoffm.) Exell & Hillcoat were used by 17% of the respondents. Different parts of the nine indigenous fruit tree species of food importance to baboons had 27% of users among the 139 respondents in the two park-adjacent villages.

For the majority (52%) of respondents, when available in the neighboring forests, the tree products mentioned are used repeatedly (once or more than once per month). Also, 12 species, including three producing fleshy fruits edible by baboons (*P. curatelifolia*, *S. innocua*, and *Z. mucronata*), of the total 26 species listed have no alternative indigenous species to be used for the same purposes in case of depletion. Fruit parts (mainly seeds) of *P. curatelifolia* and *S. innocua* have been recorded in a

significant proportion of fecal samples analyzed during behavioral observations on free-ranging baboons as part of this study.

#### **Acquisition and availability of indigenous tree products**

The respondents mentioned different ways of obtaining tree products. The main ones include direct collection in the neighboring forests (mentioned by 88% of the respondents) and purchasing from collectors (12%). Only one respondent claimed to frequently use fruits harvested from Snot-apple trees *T. garckeana* maintained with crops in his farm.

When considering harvested plant parts and the fate of exploited trees, the human utilizations of indigenous trees can be grouped into three categories: (i) highly destructive (requires the felling of the whole tree, for the extraction of fuelwood and/or timber); (ii) moderately destructive (involves the removal of vital parts such as roots, bark and leaves, but the tree keeps its better chance of survival after harvest); and non-destructive (collection of fruits). Highly destructive utilizations relate to 51% of the respondents, while moderately destructive and non-destructive relate to 37% and 12%, respectively. Many of the indigenous fleshy-fruited trees of high food interest to baboons are not subject to highly destructive methods of harvest. In addition, for the 26 species used the most, 25% of the respondents considered tree products as stable; 36 % as increasing, and 39% as decreasing. The

results of a Chi-square test ( $\chi^2=4.94$ ;  $p=0.29$ ) suggest that respondents' perceptions of the availability of these products did not depend on age categories.

## Discussion

The results from this study indicate that Fabaceae tree species, namely *P. angolensis*, *J. globiflora* and *Brachystegia spiciformis* Benth. are some of the most targeted indigenous trees by users in Lukafu and Mulenga. The high proportion of users of Fabaceae species in these two park-adjacent villages may be explained not only by the presence of Fabaceae trees near villages, but also by their abundance in the surrounding forests, as suggested by a number of studies (Gonçalves *et al.* 2017, Ilunga *et al.* 2017, Jew *et al.* 2015, Sangeda & Maleko 2018, Useni *et al.* 2019) throughout the Zambezi Regional Center of Endemism. Indeed, this phytogeographic region (to which belongs the study area) is characterized by miombo woodlands, a vegetation type with the tree layer dominated by Fabaceae species belonging to the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (Frost 1996). In addition, according to Syampungani *et al.* (2016) and Chidumayo (2019), Fabaceae is the Family affected the most by fuelwood exploitation in Zambia. Similarly, Sangeda and Maleko (2018) recorded Fabaceae trees, namely *B. boehmii* and *B. spiciformis*, among the preferred species for charcoal in Kilosa, eastern Tanzania.

Unlike the works of Bruschi *et al.* 2014, Haule and Mwamfupe 2016, Mgumia *et al.* 2017, and Mpasiwakomu *et al.* 2017 reporting the preponderance of food-related uses for miombo trees, this study indicates that these trees are exploited predominantly for energy and medicinal purposes. The high proportion of mentions of fuelwood and medicinal uses expresses the dependence on forest resources to meet local households' energy needs and health challenges. This dependence can be both explained and accentuated by the very poor level of access of these households to other renewable energy sources such as the hydropower, as well as the scarcity of viable public health structures in the two park-adjacent villages. Indeed, the DRC has very low electrification access rates, especially in rural areas (Gnassou 2019). The human pressure on forests due to trees felling is accentuated nowadays by the fact that urban areas also depend on fuelwood, like over 90% of the Congolese households (Marijnen & Schouten 2019). The situation of Congo's forests, especially at the fringe of protected areas, may also be worsened by low levels of access to good-quality primary health care for the majority of the population (Manitu 2017) and the growing interest in traditional medicine

(Chenge *et al.* 2014, Ilunga *et al.* 2015). This study suggests another perspective in addressing interlinked environmental challenges such as biodiversity conservation and poverty alleviation. Tackling tree cover and biodiversity losses at the fringe of protected areas in the context of K.N.P. (and some other parks throughout the world) should include parallel actions such as the improvement of access to non-wood energy sources (such as hydropower, as done in the Virunga National Park, Eastern D.R.C., Marijnen & Schouten 2019) and to good-quality public health services.

Concerning respondents' perceptions on the availability of indigenous trees, it should be noted that answering "increasing" was certainly influenced by the abundance of some species in the forests surrounding the villages. Dominant species were perceived as increasing or stable in certain cases. As suggested by Kunwar *et al.* (2019) in far western Nepal, the availability of indigenous trees, and thus the anthropogenic pressure on them, may be illustrated by the proportion of users. The levels of human population and thus the number of potential users of indigenous trees in Lukafu and Mulenga, the two park-adjacent villages, are relatively low. However, the high demand for tree products in neighboring large and fast-growing cities like Lubumbashi (Munyemba & Bogaert, 2014, Useni *et al.* 2018) is likely to worsen the situation of forests and tree species, including those of food interest for baboons, at the fringe of protected areas.

The high frequency of destructive harvesting regimes for tree products expresses the unsustainability of the use of some indigenous trees, especially those with low production rates of useful sprouts for regeneration after harvest. In relation to the fleshy-fruited trees of food interest for baboons, even though fruits are among the lesser-consumed products and their collection does not imply forcibly the felling of trees (when compared to many pod-bearing trees cut predominantly for fuelwood), the situation may be worsened due to their significance to local people. This significance is illustrated by the multipurpose character and frequency of utilizations, as well as the lack of alternative resources. Indeed, on the total 26 listed, a notable number of tree species, including three baboon-edible, have no other species with the same uses in the villages. Also, when available in the neighboring forests, most of the products from multipurpose trees are harvested repeatedly (on a daily, weekly or monthly basis). In this respect, indigenous multipurpose trees without alternative resources should be regarded as of particular conservation values. Therefore, identified multipurpose trees, such as *D. condylocarpon*, *U. kirkiana* and *S. cocculoides*



should be allocated a high priority in reforestation or agroforestry initiatives concerning the vicinities of the two park-adjacent villages. Moreover, as an alternative to wild fruits collection, the domestication of the last two forest trees (*U. kirkiana* and *S. cocculoides*) of both multipurpose character for humans and high food interest for baboons will not only improve households' livelihood as also indicated by Akinnifesi *et al.* (2006) and food security (Ngadze *et al.* 2017), but also certainly contribute to mitigating the competition for forest resources between baboons and humans in shared environments.

## Conclusions

This study addressed human-baboon competition for forest resources at the fringe of the K.N.P. From the results of ethnobotanical surveys conducted in two villages neighboring this park we can conclude that the local people: (i) depend on indigenous trees, mainly for energy supply and medicinal uses, and (ii) observe a multipurpose and indispensable character, as well as decreasing tendencies in the main fleshy-fruited trees of food interest for baboons. The following are lessons learnt and conservation implications from these results:

1. Even though the human population and demographic growth in some rural areas are relatively low, the demand for fuelwood and medicinal products in fast-growing cities is likely to worsen the situation of indigenous trees. Therefore, tackling tree cover and biodiversity losses at the fringe of some protected areas should include actions such as the improvement of access to both non-wood renewable energy sources and good-quality public health services.
2. The versatility of some fleshy-fruited trees indicates both their significance to the local population and likelihood to be intensely exploited. Given the preference for indigenous species and the indispensableness of some of them for both baboons and local people, multipurpose trees and species without alternative resources should be allocated high conservation interests. Towards the alleviation of anthropogenic pressure on forests and addressing the human-baboon competition for forest resources, two indigenous tree species deserve a particular attention and should be regarded as priority species for domestication in the area: the Wild loquat tree *U. kirkiana* and the Monkey orange tree *S. cocculoides*.

## Declarations:

### List of abbreviations:

C.A.I.D.: *Cellule d'Analyse des Indicateurs de Développement*

D.R.C.: Democratic Republic of Congo

K.N.P.: Kundelungu National Park

R.F.C.: Relative Frequency of Citation

### Ethics approval and consent to participate:

The need for approval was waived. As part of the survey introduction, all the respondents have been explained about the purposes of the study and the utilization of data. Each respondent has given an oral free consent prior to participating in the interviews. The study was conducted in compliance with the Protocol of Nagoya on Access and Benefit Sharing.

**Consent for publication:** Not Applicable

**Availability of data and materials:** The data was not deposited in public repositories but is available from the authors upon request.

**Competing interests:** The authors declare that they have no competing interests.

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