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Local Ecological Knowledge: A Tool for the Conservation of an Endangered Species? The Example of the Bonobo (*Pan paniscus*)

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Abstract: This study used Local Ecological Knowledge (LEK) to document awareness about the bonobo and its ecology by local communities in the Mbali River Local Community Forest Concession (LCFC). The objective was to collect LEK on the bonobo and compare it to ecological knowledge resulting from research in order to provide the Batéké population with information relating to the effective implementation of hybridization and co-construction of knowledge combining scientific ecological knowledge and local knowledge. Exploratory and qualitative LEK was mobilized to document bonobo ecology. We administered a questionnaire on this knowledge to 120 people living in the six village areas that make up the LCFC with twenty people per village. The results of this study show that the local population knows the bonobo, also called pygmy chimpanzee or "ébubu" in the local language. All of the respondents claimed to have seen bonobos and each gave an estimate of the size of the groups seen. They described their habitats and indicated the species of trees they use for nest building and the types or categories of food they consume. All respondents acknowledged the threats to this species. The ecological knowledge of the Batéké population on the ecology of bonobos is consistent with the results of studies carried out on the species in this site and in other sites in its range. This knowledge is a very valuable source of reference for conservation of the bonobo. It can be used either as a basic tool for the planning and monitoring-evaluation of conservation activities in an area where scientific studies have not yet been carried out, or as a complement to research in areas where these studies have already taken place. The correlation of the observations of LEK with those of scientists on the bonobo shows that the combination of this type of knowledge with the research carried out by modern science is of great importance in a multidisciplinary approach necessary both for the effective conservation of the bonobo and for the sustainable management of the LCFC.

Key words: Local Ecological Knowledge, conservation, endangered species, bonobo, *Pan paniscus*

INTRODUCTION

In conservation ecology, knowledge of parameters such as the density, distribution, population size of animal species, and the ecology of their feeding in a given environment or in a protected area is very important (Royle & Nichols 2003; McKechnie *et al.* 2007; Küehl *et al.* 2008). These data make it possible to assess the trends and impacts of human activities on these species and their vulnerability to threats of extinction. They allow effective management actions and the implementation of the most appropriate conservation strategies (Cowlishaw & Dunbar 2000; McKechnie *et al.* 2007). Access to this essential information has experienced unprecedented growth in recent decades. This is, on the one hand, due to

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progress in monitoring or sampling techniques and methods (geomatic, genetic signaling, geolocation, imagery, etc.) and, on the other hand, progress in statistical analysis techniques and the considerable development of computer science (Bousquet *et al.* 2010). But these methods and tools are generally expensive and difficult to implement by people with little financial means and/or a limited level of training. Such is particularly the case for local populations and non-governmental organizations in developing countries that do not have large budgets and/or adequate levels of training. Also, for many global wildlife populations, the scientific information required to move towards sustainable management remains insufficient. To remedy this very detrimental deficit for conservation projects, it is necessary to seek other approaches by evaluating and integrating other possible sources of information on populations and their habitats. For these approaches, the key element is the reliability of the data because bad data can lead to inaccurate interpretations and poor decision-making (Walters & Hilborn 1978, Ludwig *et al.* 1993).

It is increasingly recognized internationally that ecological knowledge held by local residents can be a useful source of information to complement "Western scientific approaches" to resource management (Chemilinsky 1991; Berkes *et al.* 2000). This knowledge, called "Local Ecological Knowledge (LEK)", provides reasonably reliable estimates of the relative presence and relative encounter rates of species, as well as quantification of the main factors that threaten them (Chaldes *et al.* 2008; Spehar *et al.* 2010; Meijaard *et al.* 2011). LEK is knowledge acquired through in-depth observation of an area or species. This type of knowledge is transmitted from generation to generation by culture and observation, generally incorporating anecdotes and the oral tradition of a people over several generations (Huntington 2000). It is recognized to play a major role in contributing to the conservation of biodiversity (Gadgil *et al.* 1993) and rare species (Colding & Folke 1997); in the management of protected areas (Johannes 1998); in the assessment of ecological processes (Alcorn 1993) and the sustainable use of resources in general (Schmink *et al.* 1992; Berkes 1998). Recourse to this knowledge can be achieved relatively quickly and economically (Sugiyama & Soumah 1988; Hoppe-Dominik 1991). It has been applied to various scientific disciplines (Gadgil *et al.* 1993; Johannes 1998; Krupnik & Jolly 2002) and can be particularly useful for the management of wildlife populations in areas where in-depth scientific studies may prove difficult to achieve (Barsh 1997; Ferguson *et al.* 1998; Wilhere 2002).

Throughout the world, most primates are at risk, in particular the great apes: chimpanzees, bonobos, gorillas, and orangutans (Mittermeier *et al.* 2007; Estrada *et al.* 2019). Human interactions with these animals are influenced by various cultural, ecological, economic, political, and social components which may be specific for one region or another and are fundamental for the survival of the remaining populations (Setchell *et al.* 2016). According to Raubenheimer *et al.* (2009), information on the nutritional ecology of primates is still limited due to the difficulties of collecting data in the wild. Yet, improving our knowledge of the ecology of their diet and the plasticity of their diets is essential in the current context of global environmental change. Indeed, most primate species are currently facing profound changes in the distribution of their habitats and associated food resources (Serckx 2014). Thus, knowledge of the interactions between humans and great apes and of the nutritional ecology of these animals seems to be essential for a true conservation strategy.

On the African continent, a growing number of studies address these questions for the safeguarding of great apes in danger of extinction (chimpanzees, bonobos and gorillas). However, compared to chimpanzees, gorillas and orangutans, very few studies on bonobos question the use of habitats for nesting with the availability of food species. These studies require not only that the animals be continuously monitored but also that they are accustomed to human presence.

The bonobo (*Pan paniscus*), a close relative of the common chimpanzee (*Pan troglodytes*), is a great ape native to the Democratic Republic of Congo (DRC). Its historical range extends over more than 560,000 km² (IUCN & ICCN 2012), from the Lualaba River in the east, to the Kasaï and Sankuru rivers in the south, the Congo River constituting the northern and western limits of this space. The species occupies a wide variety of habitats, including dense humid forests, swamp forests, dry forests, secondary forests, or forest/savannah mosaics as is the case in the LCFC. Classified as an "Endangered" species in appendix 12, class A of CITES, it is fully protected by Congolese law (IUCN & ICCN 2012). It is currently estimated that there is a population of between 15,000–20,000 individuals in the wild (IUCN & ICCN 2012). Bonobo populations are mainly threatened by deforestation and the degradation of their habitats, by poaching, as well as by epidemics which sometimes decimate them

(IUCN & ICCN 2012). The political instability and the armed conflicts that have weakened the DRC for decades, the poverty, and the sustained demographic growth of its human population can only accentuate these threats.

However, in the Territory of Bolobo in the Province of Mai-Ndombe, this species has been able to survive so far within a forest-savannah mosaic ecosystem thanks to a food taboo which provides it with protection from local populations of indigenous people belonging to the Mbee-Nkuru group of the Batékés-north chiefdom-sector (MMT 2015). The bonobo is considered in the region as a close relative, a human who would have fled to the forest to escape his creditors, the old customary law making an insolvent debtor the slave of his creditor. Its consumption is therefore taboo among the Batéké because there can be no question of eating the flesh of a parent. Indeed, the disengagement of the local (indigenous) workforce as workers in these companies as a result of the low wages compared to the income from their agricultural activities has resulted in the recruitment of the largely allochthonous workforce (Congolese nationals from other provinces) unwilling to respect the local taboo on bonobo (MMT 2015).

In search of nature-based initiatives to fight against poverty and ensure land tenure security in their forest lands, the local communities of the Mbee-Nkuru group are aware of the interest in preserving the natural and cultural heritage represented by these bonobos. They therefore decided to act and mobilized to promote the presence of bonobos on their territory as a driver of local socio-economic development. Thus, based on Article 22 of the Forest Code, they requested and obtained from the Congolese State in the mid-2010s the creation of a community conservation area of 500 km² of forests called "Mbali river Local Community Forest Concession" (LCFC). It should be noted here that these were the first community forests in the DRC relating to a community biodiversity conservation project and not artisanal logging, as is often the case for the creation of community forests. The objective is to promote the emergence of effective conservation policies and optimized monitoring programs for this species with high heritage value through the development of a viable conservation plan which must be part of a sustainable development perspective. For this purpose, it is essential to better document the habitats and trees used by the bonobo in the construction of nests and for food, as well as to identify the threats that weigh locally on the groups still present. To achieve this, we collected information on the spot from Local Ecological Knowledge concerning the bonobo. They were compared with those obtained during a study conducted to assess the abundance and distribution of bonobos in the LCFC (Omasombo *et al.* 2022). The idea is to enrich as much as possible the information base that scientists and managers need to develop a sustainable management plan for this forest concession. This also makes it possible to provide the local Batéké population with information relating to the effective implementation of hybridization and the co-construction of knowledge combining scientific knowledge and local knowledge.

METHODS

Study site

This study was carried out in a community conservation area, the Mbali River Local Communities Forest Concession (LCFC) (Figure 1). Covering an area of 500 km², it brings together the land of the villages of Bodzuna, Embirima, Mbee, Mpelu, Makaa, and Nkala in the territory of Bolobo in the province of Mai-Ndombe, about 300 km north of the capital Kinshasa (Omasombo *et al.* 2022). The choice of the LCFC to study the contribution of Local Ecological Knowledge in our understanding of an endangered species like the bonobo had a double advantage:

- This study was conducted in parallel with scientific observations,
- The collection of this local knowledge was facilitated by the fact that the local population is motivated to conserve this species in its territory.

Collection of data

The methodology used in this study was a combination of quantitative and qualitative participatory methods, which were based on ethno zoological and biological approaches (Martin 1995; Newing *et al.* 2011; Iskandar 2012). Quantitative methods were used in the form of structured interviews carried out on the basis of a pre-established questionnaire. Respondents were randomly selected using the sampling technique described by FAO (1992). According to this technique, on a population of between 500 and 1000 people, we can work on an average sampling rate of between 5 and 10%. Inspired by this model, out of a total population of 697 households, approximately 4800 people (Omasombo *et al.* 2022), we investigated a sample of 120 respondents randomly selected from households from the space of these 6 forest concessions. For

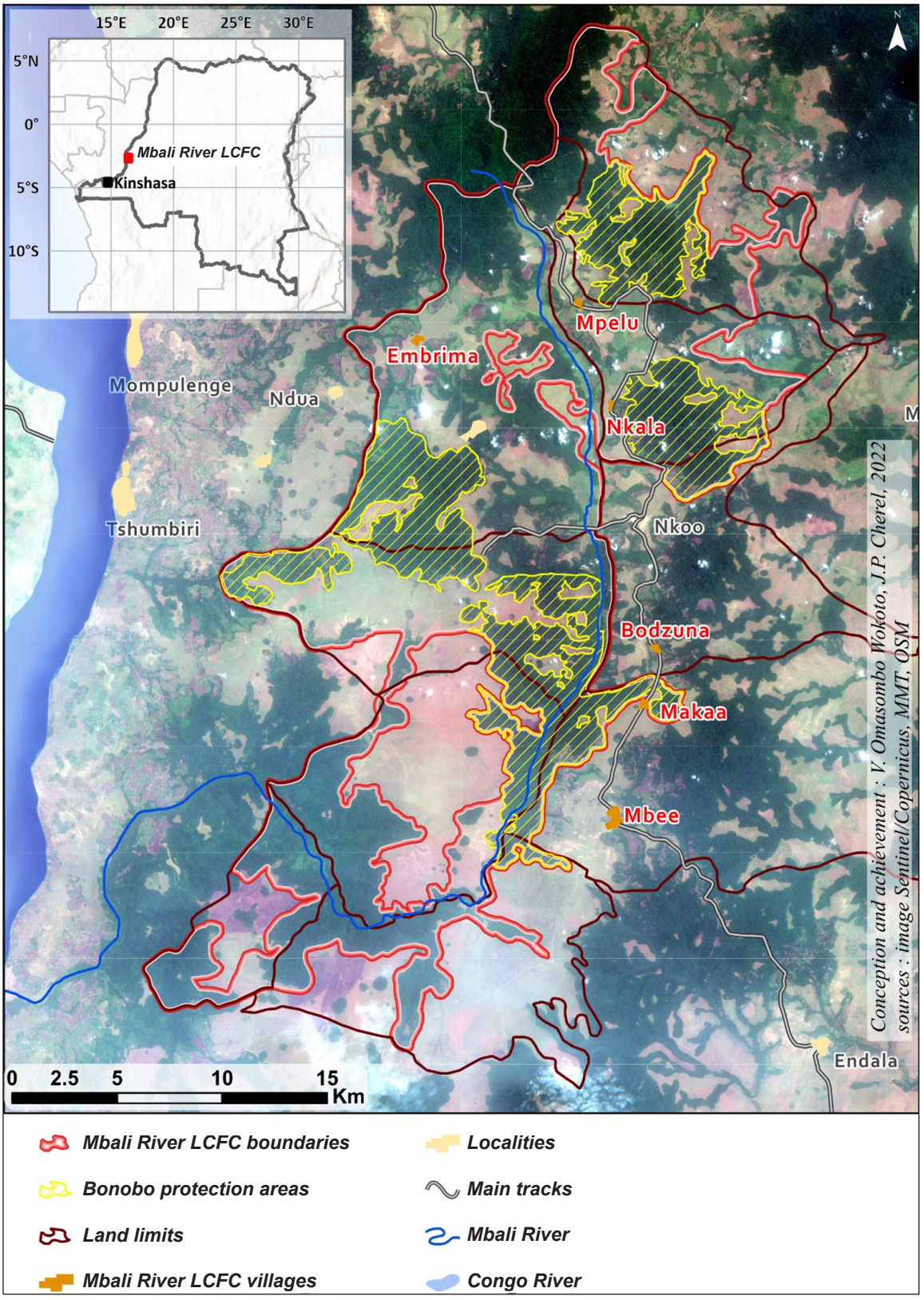

Figure 1. Map of Mbali River Local Community Forest Consession.

the purpose of comparison, we surveyed as many women as men, and as many young people (under 35) as old (over 35) according to the Institut National de la Statistique et de Fonds de Nations Unis pour l'Enfance (2011). During the tours to make contact with the population and prepare for the interviews, field visits were made to farmers chosen by the villages of Nkala and Bodzuna. These peasant guides knew and mastered the land well. The observations made during these visits made it possible to test the questionnaire in order to better administer it during the interviews (Mace & Pétry 2000). They also made it possible to support, confirm, and complete the information collected during the actual surveys (FAO 2002). In addition, during these trips and participant observation sessions, the questionnaire was tested on 9 people in the village of Nkala and on 7 others in the village of Bodzuna. This made it possible to check the clarity of the questions, the ease of answering them, the duration and the fluidity of the questionnaire.

At the end of this pre-test, the questionnaire submitted to the respondents consisted of two sections: the first focused on knowledge of the bonobo and its ecology, the second focused on the threats to the species. This attached questionnaire was submitted in Lingala by the researcher Valentin Omasombo and translated into the local Kitéké language by an interpreter, from July 7 to August 11, 2015. The duration of each interview was 45 minutes maximum. Each respondent had the option of giving more than one answer to each question. We did not register any major constraints in the implementation of the questionnaire, not only because the planning (time and place) was up to the respondent but also because the questionnaire was addressed in a nominal way; we had assured the participants that the opinions and answers would be examined in a strictly confidential manner and would only be used for scientific purposes. Qualitative data, including focus groups and participatory observations, were also used to supplement these data. A total of six focus group meetings were held, one per village, with all heads of households interviewed. The household is here defined as "a group of people living in a single house, or several houses on the same plot, and having in common the same food provisions and other lifestyles" (Kideghesho *et al.* 2007). These focus groups made it possible to obtain additional information by cross-checking with information from the questionnaire survey (Geoffrion 2009).

The local knowledge of the Batékés on bonobos existed before the arrival of researchers. They made it possible to set the limits of the LCFC and the rules for its management (Narat *et al.* 2015). According to Huntington and colleagues (2004), comparing specific observations of LEK with those of scientific research can increase confidence and in-depth knowledge of both approaches and strengthen collaboration between scientists and villagers. In this study, we set up the hybridization and the co-construction of both knowledge sets for the management of the LCFC and the conservation of the bonobo. Thus, the data collected by LEK are compared with data collected by empirical scientific methods concerning the same populations of bonobos, during the same periods. Scientific estimation of bonobo populations using the line transect technique yielded an average of 375 individuals throughout the area and 10 habitat types were identified (Omasombo *et al.* 2022).

Data analysis

The information collected from the survey questionnaires was compiled in an Excel table and analyzed using the software Statistics for the Social Sciences (SPSS) version 20. Descriptive statistics were used to generate means, medians, and modes on the different data. The Pearson chi-square test was used to evaluate the knowledge of the bonobo and its ecology according to the sex and age of the respondents (female or male, young or old). To assess the types of food consumed by bonobos and identified by the different categories of respondents, the Mann-Whitney test was used. Finally, the Kruskal-Wallis test was chosen to compare the different types of food mentioned in the different villages. The degree of significance was established for $p < 0.05$ (Zar 1999).

RESULTS

Do you know the bonobos?

Since the forest is a hunting ground, fishing ground, and place for collection of non-timber forest products, all the respondents declared knowing the bonobos and having observed them several times, in more or less large groups depending on the abundance of fruits in the forest. By stating that they have seen bonobos in small or large groups, respondents have the notion of the fission-fusion behavior found in great apes. While the majority of those over 35 years (90%, N = 60) reported having seen groups of up to 21 individuals (chi-square = 7.471, df = 1, $p < 0.05$), the youngest (63, 3%, N = 38) report having seen smaller groups, up to 9 individuals (chi-square = 5.111, df = 1, $p < 0.05$). Beyond these differences, the results of this study

confirm the presence of bonobos in this area and also shares knowledge that local communities have about bonobos. The results also indicate that the oldest residents have a long experience of the forest, which allows them to observe larger groups, for example.

In which habitat does the bonobo build its nests?

Based on the classification of White and Edwards (2000), the observations of the scientists revealed that there are ten types of forest habitats in the LCFC which can be differentiated as follows:

- mixed forest with open undergrowth (MFOU)
- mixed forest with closed undergrowth (MFCU)
- mono-dominant forest with *Gibertiodendron dewelvrei* (MDFG)
- mono-dominant forest with *Uapaca guinéensis* (MDFU)
- marantaceae forest (MAF)
- liana forest (LIF)
- swamp forest (SWF)
- periodically flooded forest (PFF)
- mature secondary forest (MSF)
- young secondary forest (YSF)

Based on the flora and the structure of the soils, the people questioned recognize nine types of habitats designated here by their vernacular names: Envoo, Lesee, Lokoso, Mobero, Mohuna, Mobua, Monsio, Nkaro, and Nkulu. A correspondence between these two classifications of tropical riverine forests can be established (White & Edwards 2000); Table 1 identifies the types of environments identified in the LCFC and the correlation with their local names. This table also summarizes the nest sites observed in each of these biotopes during our own observations using the transect method.

Among these different types of habitats, the linear transect method used by researchers and confirmed by surveys on Local Ecological Knowledge shows that bonobos are selective in establishing their nests. Nesting sites are located in 5 types of environments among these 10, namely: Marantaceae forests (MAF), the most popular, mixed forests with open or closed undergrowth (MFOU and MFCU), liana forests (LIF), and forests with mono dominance of *Gibertiodendron dewelvrii* (MDFG). Table 2 summarizes these data and indicates the percentage of use of these different types of habitats according to the 2 types of observation.

These results show a similarity between the observations of researchers and those of community members. There is in fact no significant difference between the uses of the habitats measured according to these two methods (chi-square = 3.436, df = 3, p = 0.394). We wanted to differentiate this knowledge according to the gender and age of the respondents (Figure 2).

Reading this figure reveals that the local community has real Local Ecological Knowledge on the use of habitats by bonobos. Based on responses to survey questionnaires, this study shows that it is the

Table 1. Correspondence between the types of habitats recognized in the Local Community Forest Consession and the number of nest sites observed.

N°	Habitat types identified in the LCFC	Local name of habitat type	Number of nest sites observed
1	Marantaceae forest (MAF)	Nkulu	16 sites
2	Mixed forest with open undergrowth (MFOU)	Lesee	10 sites
3	Mixed forest with closed undergrowth (MFCU)	Mohuna	6 sites
4	Liana forest (LIF)	Nkaro	3 sites
5	Mono-dominant forest with *Gibertiodendron dewelvrei* (MDFG),	Monsio	1 site
6	Periodically flooded forest (PFF),	Mbua	0
7	Swamp forest (SWF)	Mobero	0
8	Mono-dominant forest with *Uapaca guinéensis* (MDFU)	Lokoso	0
9	Mature secondary forest (MSF)		0
10	Young secondary forest (YSF)	Envoo	0

Table 2. The percentages of habitat use according to the field study and the Local Ecological Knowledge.

Habitat type	Percentage of use observed by researchers	Percentage of respondents citing the use of this type of habitat
Marantaceae forest (MAF)/ Nkulu	44%	58 %
Mixed forest with open undergrowth (MFOU)/ Lesee	28%	22%
Mixed forest with closed undergrowth (MFCU)/ Mohuna	17%	14%
Liana forest (LIF) / Nkaro	8%	5%
Mono-dominant forest with *Gibertiodendron dewelvrei* (MDFG)/ Monsio	3%	1%
Total	**100%**	**100%**

oldest who best know the habitats used by bonobos, ahead of women (Mann-Whitney test, $Z = -3.016$, $p < 0.01$); men know better than women (Mann-Whitney test, $Z = -3.792$, $p < 0.01$) and women more than young people (Mann-Whitney test, $Z = -1.985$, $p < 0.01$).

Where do bonobos sleep?

In the nesting sites, we inventoried 547 trees, grouped into 75 species and 31 families. Of this total, bonobos used 208 trees, grouped into 17 families and 32 species for the construction of non-integrated nests (a non-integrated nest is a nest built in a single tree) according to Tutin and Fernandez (1984), modified by Fruth and Hohmann (1993). Calculation of the Chesson-Manly (CI) selectivity index of trees used in nest construction revealed that bonobos prefer 14 species. At the same time, observations made according to local knowledge reveal that bonobos prefer 13 species of trees in the construction of nests. Of the 14 species most used in the construction of nests identified by the researchers, 13 were cited by more than 70% by the local population as nesting species among bonobos. Only one (*Symphonia globulifera* L) has not been identified for nest building. Table 3 summarizes the similarities and differences between the observations made by researchers and local knowledge.

What are the different types of food used by the bonobos?

The 120 respondents identified 7 main types of food including leaves, flowers, barks, stems, animals, and honey (Figure 3).

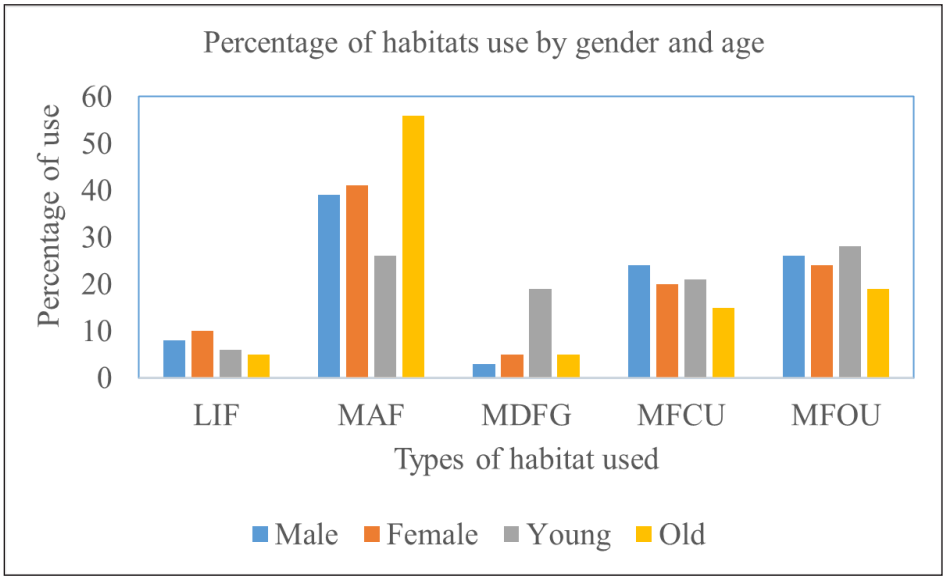

Figure 2. Differentiation of Local Ecological Knowledge on the use of bonobo habitats according to the sex and age of the respondents.

Table 3. Correspondence and differences between the observations made by the researchers and the LEK.

Species	Scientific observation	Order according to the selectivity index	Local Ecological Knowledge	% citation of a species according to LEK
Polyalthia suaveolens Engl. & Diels	inventoried	1	quoted	76%
Pancovia laurentii (De Wild.) Gilg ex De Wild	inventoried	2	quoted	5%
Strombosiopsis zenkeri Engl.	inventoried	3	quoted	43%
Anonidium mannii Oliv	inventoried	4	quoted	56%
Dialium pachyphyllum Harms	inventoried	5	quoted	12 %
Plagiostyles africana (Müll.Arg.) Prain	inventoried	6	quoted	
Strombosiopsis tetrandra Engl.	inventoried	7	quoted	
Camptostylus mannii (Oliv.) Gilg	inventoried	8	quoted	27%
Petersianthus macrocarpus (P. Beauv.) Liben	inventoried		quoted	1%
Strombosiopsis tetrandra Engl.	inventoried		quoted	
Polyalthia suaveolens Engl. & Diels	inventoried		quoted	
Picralima nitida (Stapf) T. Durand & H	inventoried		quoted	
Scorodophloeus zenkeri Harms	inventoried		quoted	
Symphonia globulifera L	inventoried		quoted	

The 7 main food types consumed by bonobos includes 72 foods, 46 of which were cited at least 10 times, and 14 were cited by more than 50 respondents. Men cited a greater number of foods (animals, flowers, fruits, herbs, honey, leaves, insects, mushrooms, and shrubs) than women (animals, fruits, herbs, herbs, leaves, and shrubs) (Mann-Whitney test, $Z = -4.816$, $p < 0.01$) and those over 35 cited a greater number of foods than young people (fruits, herbs, herbs, and leaves) (Mann-Whitney test, $Z = -3.512$, $p < 0.01$). There is no significant difference between the foods mentioned in the different villages (Kruskal–Wallis test, chi-square = 2.314, df = 5, p = 0.442). Foods of plant origin (leaves, flowers, bark, fruits, and stems) are the major constituent of the bonobo diet. The most important are listed in Figure 4.

What are the threats to the bonobos?

According to respondents, hunting, slash-and-burn agriculture, and disease are the main threats to bonobos in LCFC (Figure 5).

These three types of threat are recognized by all categories of respondents, with higher proportions among men than among women and among the elderly than among the young. According to the respondents, it is hunting – by firearm or by trapping – which constitutes the main risk for these great apes, although it is prohibited in this area. Traps intended for other animals are particularly dangerous because a trapped bonobo risks at least amputation (fingers, toes, or even an entire limb) to get out. Slash-and-burn agriculture, which was listed as second, deprives them either of the trees in which they build their nests or of the trees they use for food (or even both). Finally, diseases are seen as another threat following two respiratory epidemics which claimed 3 bonobos in the Mpelu forest and 7 bonobos in the Nkala forest. It is the women who testify the most to this risk because they are present almost every day in the forest and see the sick bonobos.

DISCUSSION

Throughout its range, local human populations have a good knowledge of the bonobo and its ecology, as reported by Fruth & Hohmann (2002) and Thompson *et al.* (2008). Among the Batéké, Narat *et al.* (2015) and Inogwabini *et al.* (2015) documented and highlighted local knowledge about bonobos (Ebubu in kitéké) as well as the existence of the bonobo-human relationship around the origin of this animal in the LCFC, without giving details. This knowledge was present long before the arrival of scientists; the existence of the cultural relationship between humans and bonobos is an obvious source of the development of LEK, and the announcement of the existence of bonobos in this area to scientists and conservationists and the driving of scientists into the forest by communities to show them the

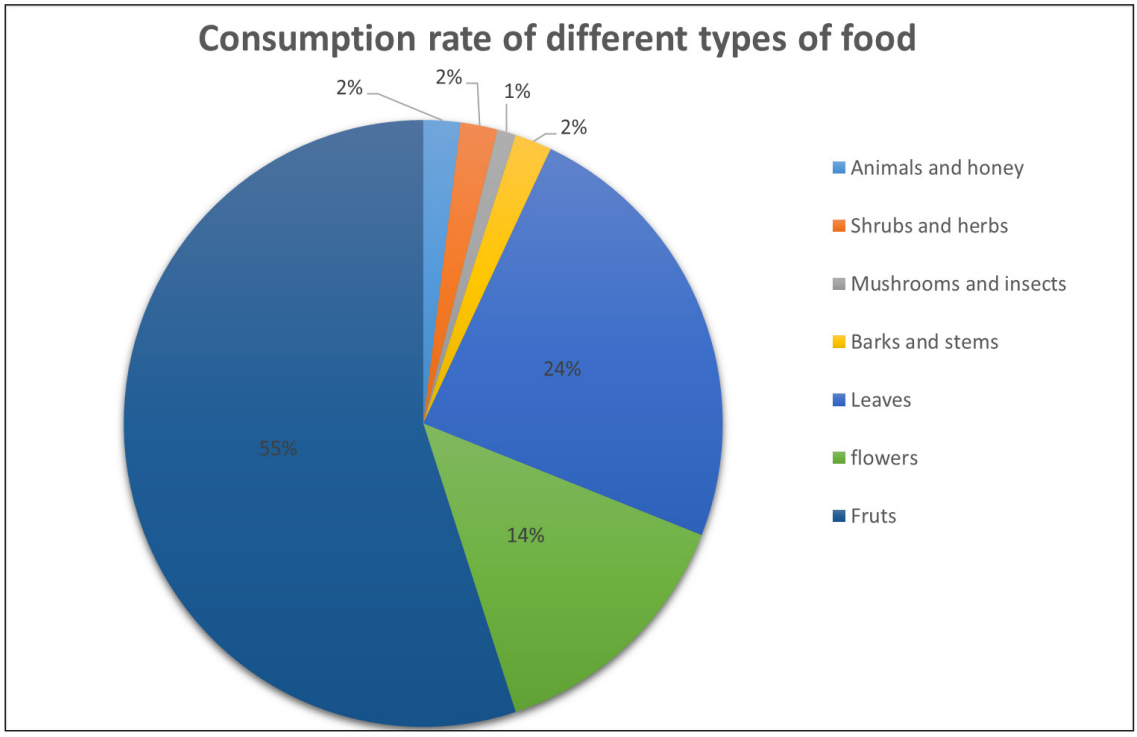

Figure 3. The main types of food consumed by the bonobo. This figure confirms that the bonobo consumes more food of vegetable origin than animal and it consumes more fruits, followed by leaves and flowers.

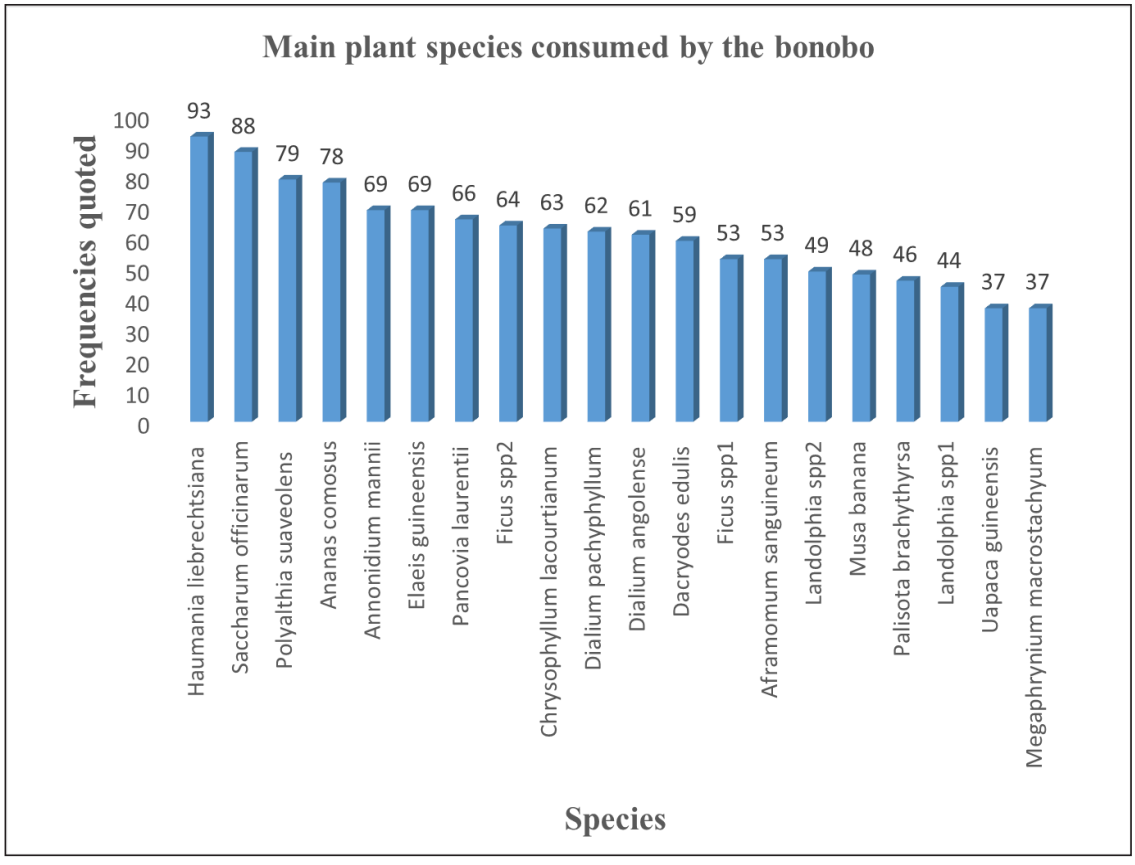

Figure 4. The main plant species eaten by the bonobo.

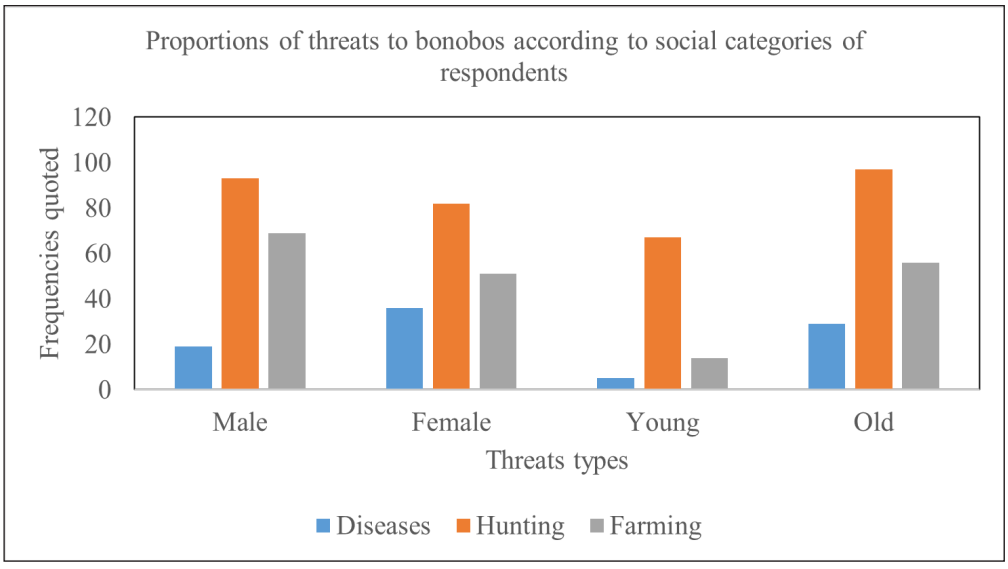

Figure 5. Classification of the different types of threats weighing on bonobos according to respondents.

bonobos are elements that can justify the knowledge of the species and its ecology before the arrival of scientists (Narat *et al.* 2015).

Our study confirms the existence of this local knowledge of the northern Tékés about the great ape that shares their territory: knowledge of its different habitats, knowledge of the food and nesting trees it uses, and awareness of the threats hanging over it. This very valuable local knowledge has in fact guided the choices made by the different villages to set limits and rules useful for development and management of the LCFC.

Although the LEK data collected in the LCFC was generally qualitative, the LEK observations are confirmed by the results of the study on the estimation of bonobo populations and habitat use in the same area. If the random sampling on which we worked, without taking into account the size of each village, can constitute the limits of our research, the results obtained by the LEK are nevertheless very encouraging and can effectively help in the conservation of the bonobo in situ.

Knowledge of the bonobo and its ecology

The results of this study show that the local human population of this territory lives in permanent contact with the bonobo with which it coexists in the same ecosystem. The local population understands the bonobo and can easily give details not only about the fission-fusion behavior, the size of the groups, and the ecology of the species (nesting habitat, food tree, and nesting trees) but also describes the threats to the bonobo. Fission-fusion behavior in bonobos has been reported by several authors (e.g., Fruth 1995; Mulavwa *et al.* 2010; Terada *et al.* 2015). LEK observations describe this same fission-fusion behavior. Respondents note that bonobos live in more or less large groups depending on the abundance of fruit available in a place. These observations tally with information on variations in bonobo group size described in scientific studies carried out at different sites (Fruth 1995; Reinartz *et al.* 2006; Monheke & Fruth 2008; Inogwabini 2010; Mulavwa *et al.* 2010; Serckx *et al.* 2014).

The concordance between the classification of habitats obtained by LEK and that of scientific studies is an interesting observation that can be the subject of in-depth research as was the case in a study carried out on the naming systems of birds of the Akans of Ghana (Deikumah *et al.* 2015). The use of these different habitats has been reported by many other authors: on the Lac Tumba site (Inogwabini 2010), in the Wamba forest (Mulavwa *et al.* 2010), in the Embirima and Nkala forests (Maloueki *et al.* 2013), in the Lomako forest (Fruth 1995), in the forests of Mpelu and Nkala (Serckx *et al.* 2014), in Salonga National Park (Reinartz *et al.* 2006), and at the Lui-kotal in Salonga National Park (Monheke & Fruth 2008).

The use of primary forests on terra firma (FAM, FPMSO, FPMSF, FAL and FMDG) for nest construction has also been observed in chimpanzees (Tutin & Fernandez 1984; Furuichi *et al.* 1997; Basabose & Yamagiwa 2002). The 13 tree species identified by the local knowledge of our respondents as nesting trees for bonobos have all been described

for the same role by Serckx and colleagues (2014) in the forests of Mpelu and Nkala (LCFC), and Pennec *et al.* (2016) in the Embirima forest (LCFC). The correlation between the results of the LEK and those of the studies carried out by these authors in the same area where the LEK was used highlights the fact that the LEK can serve as a basic tool for the conservation of an endangered species in the areas where scientific data are not available as reported (Ferguson *et al.* 1998).

However, of all the species observed by the LEK as bonobo nesting species in the LCFC, only 7 play the same role among the 24 described in the Lomako forest (Fruth 1995) and 7 from the 49 described in Wamba forest (Mulavwa *et al.* 2010). With regard to the food categories mentioned by the respondents, they are all described to varying degrees in the scientific studies carried out on the different sites (Badrian & Badrian 1984; Conklin-Brittain *et al.* 2001; McGrew *et al.* 2007; Surbeck *et al.* 2009; Hohman *et al.* 2010; Serkcx *et al.* 2014). On the other hand, the correlation between the nomenclature of habitats by local people and that used by scientists confirms the hypothesis that LEK and scientific data can be complementary (Huntington *et al.* 2004). However, these arguments can be truly confirmed only after studies are conducted to compare local knowledge and scientific data in the various study sites mentioned above.

Threats to bonobos in LCFC

Respondents cited slash and burn agriculture, hunting, and disease as the main threats to bonobos in LCFC.

Slash-and-burn agriculture is practiced there by the local population in search of arable land. This type of land-clearing agriculture practiced in a forest-savannah mosaic ecosystem leads to the modification of the forest structure and the scarcity of plant species used by bonobos (Pennec *et al.* 2016). It is also the basis of the degradation of the forest and the destruction of forest corridors between the different forest islands which already have sizes smaller than those of the home range of a community of bonobos, which is estimated at about 750 meters in radius (Serckx 2014). All of these observations clearly indicate that slash-and-burn agriculture poses a threat to the bonobo throughout its range (Thompson-Handler *et al.* 1995; Walsh *et al.* 2003; Junker *et al.* 2012; IUCN & ICCN 2012; Hickey *et al.* 2013).

Concerning hunting, the response of the community is as follows: "*although consumption or contact with the bonobo is prohibited in the LCFC by a customary law relating to the prohibition of food, this customary law is not respected by the non-natives who have settled in the area to find not only employment opportunities in active and non-active logging and livestock companies in the area, but also an area conducive to the practice of hunting subsistence and commercial, the bushmeat being sold either in Kinshasa or in Brazzaville, the two twin capitals on either side of the Congo River*". Hunting therefore constitutes a real threat to the bonobos in this area, as it undoubtedly is throughout its range (IUCN & ICCN 2012). We witnessed this reality ourselves during the data collection that we conducted as part of the population estimation and habitat inventories. A non-indigenous, living in the Ndua village on the western outskirts of the concession, 7 km from the Manzono site, killed a bonobo used to this site. This hunter was denounced by the trackers, arrested by the police, brought to justice, and sentenced to 8 months in prison with a fine.

In the case of the health risk that threatens these animals, the statements of the respondents and our personal observations documented two unfortunate episodes of a respiratory disease which caused the death of 3 known bonobos in the Mpelu forest in 2014 and 7 bonobos in the Nkala Forest in 2015 (Grutzmacher *et al.* 2018). These episodes of respiratory disease are part of a series of outbreaks that threaten the species in what remains of its range (Inogwabini & Leader-Williams 2012; IUCN & ICCN 2012; Williamson *et al.* 2013).

CONCLUSION

This study confirms that the local Teke population lives in permanent contact and interaction with the bonobo, both sharing the same forest-savannah ecosystem. This proximity nurtures a profound Local Ecological Knowledge on everything related to this species that is in danger of extinction. The Batékés of the LCFC know the different habitats where the bonobos live, as well as the trees used for their food and those selected for the construction of their nests. They can also identify the main threats to this species. This local knowledge forms the basis of the choices made by the different villages to set the limits and management rules of the LCFC. It turns out that these decisions were made with discernment because this knowledge is confirmed by the study we conducted on the estimation of populations and the use of bonobo habitats. This local knowledge is therefore a valuable aid to this type of *in situ* bonobo conservation project.

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