The Future Is in the Younger Generations: Baka Children in Southeast Cameroon Have Extensive Knowledge on Medicinal Plants

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Abstract In the context of global change, understanding the knowledge and values given to plants is crucial for choosing relevant approaches towards a more sustainable future. Children are central holders of ethnobotanical knowledge, yet they are still under-considered in ethnobotany. Our study explored the medicinal knowledge of children of the Baka, forager-horticulturalists from Cameroon. We assessed the diversity of medicinal plants they know, the different ailments treated, and whether they could name complete herbal recipes. Using a mixed-methods approach, we combined ex situ interviews (freelisting and knowledge surveys) with in situ methods (walk-in-the-woods trips with voucher collection) with 106 children from 5 to 16 years old. They listed 128 local names of medicinal plants, which we linked to 126 different plant species. While the ex situ and in situ methods had some overlap in the diversity of medicinal plants reported, they also revealed substantial knowledge unique to each method. Our insights provide further evidence of children's considerable ethnobotanical knowledge and the extent to which different field methods can retrieve such knowledge. We discuss the methodological tools to be developed with and for children to put childhood at the center stage of ethnobotanical approaches for the future.

Key Words: Ethnobotany, Indigenous Peoples, Congo Basin, Ethnomedicine, Pygmies

Introduction

In the context of global change, human connection with nature is considered as a leverage point for conservation initiatives and choosing relevant approaches towards a more sustainable future (Balding and Williams 2016; Beery et al. 2023). Understanding the many dimensions behind this connection embraces values, knowledge, practices, and beliefs. It requires an interdisciplinary approach, in which ethnobiologists have a significant role to play (Fernández-Llamazares et al. 2021). Within this disconnection with nature, plants suffer from an increasing human ignorance, which impacts not only the individual but also society, restraining, for instance, the achievements of political initiatives like the Sustainable Development Goals (Amprazis and Papadopoulou 2020). This phenomenon, known as plant blindness or plant awareness disparity (Parsley

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2020), is driven by many factors, including a lack of experiences and knowledge sharing related to plants during childhood (Lohr and Pearson-Mims 2005).

Children are not only future adults, but as they relate with, experience, and know their surroundings, they are also active holders of ethnobotanical knowledge. This is especially true in small-scale societies that heavily depend on their access to the natural environment for their subsistence. In different socio-cultural contexts, ecological and botanical knowledge is acquired early during childhood (Lew-Levy et al. 2017). Specific children's knowledge exists that is not shared with adults, and the effect of age and gender on knowledge distribution within childhood varies according to the domain (Gallois and Reyes-García 2018; Porcher et al. 2022; Wyndham 2010). For instance, among the Baka and the Betsileo from Madagascar, knowledge on wild edible plants do not vary according to children's gender, but Baka boys tend to know more about animals than girls because of their higher involvement in hunting (Gallois et al. 2017; Porcher et al. 2022).

Many small-scale societies are facing serious changes in their culture and livelihood, (potential) erosion and loss of ecological knowledge and a decreasing interest of the youth towards their own culture (Fernández-Llamazares et al. 2021; Gallois and Reyes-García 2018). Also, children are often overlooked in ethnobotanical research. Their knowledge is underestimated, and little attention is given to their relation, perception, and knowledge of plants (Gallois and Reyes-García 2018). There is a need to explore how children relate to nature and to develop research methods adapted to them, embracing the multidimensionality of human-nature interrelations. Collecting empirical evidence of children's medicinal plant knowledge helps to understand how the people-plant relation builds up during childhood. Mixed-methods approaches seem to be the most appropriate here, as they catch a larger diversity of knowledge than only ex situ or in situ methods (Flachs 2018). While both methods have strengths and limitations (Nolan and Turner 2011; Quinlan 2019; Stepp 2010), there is still little known on the differences in qualitative and quantitative data collected with these methods in the same group of respondents, and whether a mixed-methods approach is relevant for working with children.

Here, we compare different methods to document Baka children's medicinal plant knowledge in southeast Cameroon. Medicinal plants form the most explored domains in ethnobotany (Torres-Avilez et al. 2016), but their use is seldom studied among children (Lew-Levy et al. 2017). The few studies on children's medicinal knowledge, for instance, those among Caribbean horticulturalists in Dominica (Quinlan et al. 2016), the Raramuri in Mexico (Wyndham 2010), rural communities in Niger (Guimbo et al. 2011), or Maroons in Suriname (Van't Klooster et al. 2019), concluded that children did not know that much, compared to adults. Intracultural distribution of medicinal knowledge is shaped by different factors within adulthood, such as prestige, age, and gender (Díaz-Reviriego et al. 2016; Torres-Avilez et al. 2016; Wyndham et al. 2010), but the influence of such factors is not clearly known within childhood.

Our study aimed to explore medicinal plant knowledge among Baka children (floristic diversity, health issues, and recipes) and to assess how different methods best capture such knowledge. We expected Baka children to have limited knowledge of medicinal plant species, recipes to prepare herbal remedies and diseases. We hypothesized that their knowledge would vary according to gender and age and would be restricted to childhood ailments, as reported among Mexican children (Jiménez-Balam et al. 2019). We predicted finding variation in the amount and diversity of medicinal knowledge collected through ex situ and in situ methods. We hypothesized that ex situ interviews would yield less information on medicinal plants, as they are based on memory, while in situ walk-in-the-woods trips in the biodiverse environment with many visual stimuli would result in more reported plant species and uses (Miranda et al. 2007; Gallois et al. 2021).

Methods

The Baka

Formerly known as "Pygmies," the Baka are forager-horticulturalists of about 30,000 people living mainly in Cameroon, and to a lesser extent in the Republic of the Congo, the Central African Republic, and the Democratic Republic of the Congo (Leclerc 2012). This region has evergreen and moist semi-deciduous forest between 300 and 600 m.a.s.l. with a tropical humid climate, an average temperature of 25 °C, and 1500 mm of annual precipitation, divided in two rainy and two dry seasons (Leclerc 2012). The Baka used to live as nomadic foragers in small camps, interacting with sedentary Bantu farmers for trade and agricultural labor. For about 60 years, the Baka were forced to reduce their mobility and change their subsistence strategies. They settled along logging roads, closer to Bantu populations and natural resources traders, adopted agriculture, and gained access to school and health services (Leclerc 2012). Despite the recognition by the Cameroon state as Indigenous People, the Baka still suffer from discrimination, the lack of land tenure, and having no voice in the political decision-making processes (Pyhälä 2012). While the Baka still largely rely on foraging and game and wild plants play a crucial role in their diet and livelihood (Gallois et al. 2020), their access to the forest depends on the conservation and economic interests approved at the state level. Baka health is challenged by changes in their livelihood, as sedentarization introduced new diseases (Dounias and Froment 2006), and decreased their access to natural resources, while access to modern health care and education is still limited due to economic constraints, large distances to the health posts, and discrimination (Carson 2019). The presence of external actors, prostitution, alcohol abuse, and drug consumption have negatively affected their fertility, health, and well-being (Carson et al. 2019; Gallois et al. 2021; Ramirez-Rozzi 2018). Therefore, it is important to know how the Baka maintain their health and comprehend the social, economic, and ecological changes that influence their health.

Most Baka children are fully engaged in adults' daily life, participating in subsistence activities and domestic care. School attendance is generally low, mostly due to the mismatch of educational programs and schedules with the livelihoods of the Baka and teachers' absenteeism. Learning ecological knowledge is done through observation, imitation, and playful activities. Also, as children are autonomous from an early age and get involved in peer group activities without adult supervision, horizontal transmission between children is an important pathway for exchanging knowledge related to wild plants and animals (Gallois et al. 2018).

Study Sites

We collected data during two fieldwork periods: June–July and October–November 2022, in two different Baka settlements of the Haut Nyong Province: Le Bosquet and Kungu (Fig. 1). We chose these settlements to represent the variability in settlements' size, access to healthcare, integration into the market, and contact with the Bantu-speaking Nzime population. Le Bosquet is the largest Baka village in the area, with about 800 inhabitants (half of them children) and was built around a Catholic mission (Ramirez-Rozzi 2018). It has a primary school only for Baka children, a health post with a few nurses and basic medicines, and about seven small shops owned by forest products traders. The closest Nzime village is about 8 km away. Kungu is smaller, with about 300 Baka inhabitants (around 100 children) and located within the Nzime village Nkeadinako (Gallois et al. 2020). Baka and Nzime children attend school together in Nkeadinako, and the closest health center and shops are about 7 km away in Messok, the local administrative town of the district.

Ethics

Before the onset of our research, we received the approval of the ethics committee of the Autonomous University of Barcelona (CEEAH5926) and obtained a research permit from the Cameroon Ministry of Scientific Research and Innovation (00098/MINRESI/B00/C00/C10/C13). We followed the Code of Ethics of the International Society of Ethnobiology

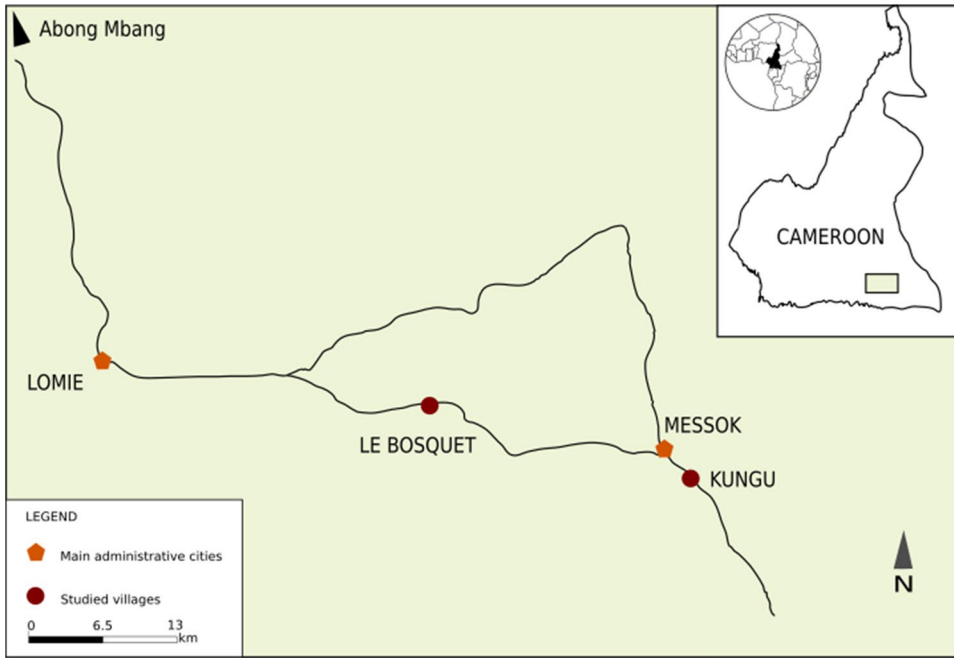

Fig. 1. Map of the study sites Le Bosquet and Kungu in southeast Cameroon

(ISE 2006) and the Charter of Ethical Research Involving Children (Graham et al. 2013). After arrival in each settlement, we first explained the aim of our study in a village meeting and obtained free, prior, and informed consent from all participating children and their parents. Once parental consent was received, we specifically explained the research aim and methods to the children, asked for their consent, and made sure that their willingness to participate was independent of their parental influence. During the research, we ensured the children's physical and psychological safety and integrity (see Supplementary Material A). Since Baka adults profit from the sale of herbal medicine and provide medical services to non-Baka Cameroonians, they specifically asked us not to publish the recipes together with the scientific and vernacular names of the medicinal plants. We followed their request and did not provide a link between plant names and uses in our results. We sent a complete database linking plant names, preparation methods, and uses to the Baka communities we worked with, as previously agreed.

Data Collection

We used a mixed methods approach, combining structured interviews with walk-in-the-woods trips to gather children's knowledge both at the group and individual levels. We considered children from newborns up to 16 years old, following the Baka classification (Gallois et al. 2017). We recruited participants from both genders and three age groups: 5–8 (middle childhood), 9–12 (preadolescence), and 13–16 years (adolescence). We included children from each of the extended families of the settlements, so potential interfamilial knowledge variation was covered by our sample.

In June–July 2022, we conducted freelisting interviews with children and asked them to report all the medicinal plants they knew. We recorded local plant names in Baka, Nzime, and French, but did not ask the children to provide information on the diseases treated with herbal medicine or detailed recipes. In October–November 2022, we conducted walk-in-the-woods trips (Phillips and Gentry 1993) with 2 to 5 children per trip and asked them to show

us the medicinal plants they knew (Van Bemmel 2023). All trips departed from children's homes and were directed by the children, so each trip was different (Van Bemmel 2023). As soon as a child showed us a plant, we asked for the entire recipe: the local plant name (in Baka, Nzime and/or French), plant part used, preparation method, and health issue for which the plant was used. Once the child finished his/her explanation, we asked whether anyone else in the group knew another use or recipe for this species. We collected two vouchers of each specimen, took photographs, and recorded GPS coordinates, life form, vegetation type, and any additional information. The forest trips lasted between 2.5 and 4 h. Duplicates were deposited at the National Herbarium of Cameroon in Yaoundé (YA) and Naturalis Biodiversity Center in Leiden, the Netherlands (L). Initial plant identification took place at YA and was continued at L, using botanical literature and herbarium specimens. Scientific names were updated following the Plants of the World Online database (POWO 2019).

Between 4 and 24 h after the forest trips, we conducted individual knowledge surveys with the participants, in which we asked them to report the natural remedies they knew for 18 previously selected, frequently occurring health issues. We based these 18 health issues on earlier collected datasets on the emic Baka perspective of health, including physical and socio-cultural health issues (Supplementary Material B).

We conducted all in situ and ex situ interviews in Baka language, with the help of a research assistant-interpreter, co-author of this study. For the spelling of Baka names, we used Brisson (2010). Local names recorded during the interviews for which no vouchers could be collected were checked with Baka adults and (ethnobotanical) literature on the Baka (Betti et al. 2004; Betti and Lejoly 2009; 2013a; 2013b; Brisson 2011; Hattori 2020). Local names of well-known crops were identified directly in the field (Supplementary Material C).

Data Analysis

We conducted a three-step approach to assess children's knowledge of medicinal plants. First, we explored the knowledge of children as a group by assessing the diversity of medicinal plant species gathered with the three methods. With the walk-in-the-woods data, we calculated the number of different health issues and unique recipes, defined here as a unique combination of a local name, plant part, preparation, and application (Martin 2004). Regarding recipes' diversity, we calculated the percentages of plant parts used and preparation methods. Regarding the completeness of the recipes, we explored the occurrence of missing information: a lack of accurate knowledge on plant name, plant part, preparation and/or application.

Second, we used the answers of the freelistings and the individual knowledge surveys to explore knowledge variation within childhood. We analyzed whether the number of plants collected by each method related to gender and age categories, using Wilcoxon ranking and Kruskal–Wallis tests, respectively, with Stata14 for Windows.

Third, to assess the complementarity of the three methods, we focused on the plant species mentioned, as recipes were not reported during the freelisting and knowledge surveys. We produced accumulation curves for the number of new plant species provided per day or participants interviewed to evaluate whether the different methods reached saturation regarding data retrieval, using Flame software (Pennec et al. 2012). We then compared the unique and overlapping medicinal plant species mentioned during each method and the frequency with which children mentioned them.

Results

Children's Medicinal Plant Knowledge

In this study, 106 children (46 boys and 60 girls) participated: 53 participated in the freelisting interviews (23 boys and 30 girls; 28 in Le Bosquet and 25 in Kungu) and 53 different children participated in the walk-in-the-woods trips and knowledge surveys (23 boys and 30 girls; 32 in Le Bosquet and 21 in Kungu).

A total of 128 different medicinal plant species were recorded during the three methods together, 120 with a Baka name, including 13 domesticated food crops and 115 wild species, of which two *Dioscorea* species were taken

from the wild and planted in provision fields (Supplementary Material B). Twelve species could only be identified to genus level. For the eight Baka names we could not collect a voucher, we identified six using additional information from Baka adults and the literature (Brisson 2011), but two remained unidentified. The Fabaceae were the most species-rich family (11 species), followed by Annonaceae (7 spp.), Euphorbiaceae, Malvaceae, Irvingiaceae, Rubiaceae, and Asteraceae (each 5 spp.). Most of the identified species were trees (65 spp.), followed by herbs (32 spp.), climbers (18 spp.), and shrubs (11 spp.).

By far the most frequently mentioned species reported during the interviews and forest walks was *Alstonia boonei* De Wild (Apocynaceae), a common tree in secondary forest and used for many different health issues. Table 1 presents the most frequently reported medicinal plants elicited with the three research methods. Half were forest trees, indicating children's knowledge of (primary) forest species (Supplementary Material C). The three methods differed regarding the frequently mentioned species. For example, the herb *Asystasia gangetica* (L.) T. Anderson, often mentioned in the knowledge survey, did not appear during the other two methods.

Table 1. The 10 most frequently reported medicinal plants of each research method (walk-in-the-woods, freelisting, and knowledge surveys), overall and by method ($N = 106$ children)

Species	Baka name	Overall (sum)	Walk-in-the-woods (number of unique recipes)	Freelisting (times mentioned)	Knowledge surveys (times mentioned)
Alstonia boonei De Wild	gùgà	78	7	30	41
Clerodendrum cf. *umbellatum* Poir	nyisoso	41	1	12	28
Annickia affinis (Exell) Versteegh & Sosef	epue	37	6	13	18
Cylicodiscus gabunensis Harms	boluma	29	3	12	14
Greenwayodendron suaveolens (Engl. & Diels) Verdc	botunga	29	9	7	13
Pentaclethra macrophylla Benth	mbalaka	28	3	17	8
Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill	pèke	27	4	11	12
Myrianthus arboreus P. Beauv	ngàta	25	11	3	11
Tabernaemontana crassa Benth	pando	22	4	5	13
Microdesmis puberula Hook.f. ex Planch	pipi	20	9	2	9
Sida acuta Burm.f	tandanda	19	2	4	13
Chromolaena odorata (L.) R. M. King & H. Rob	bokasa	19	3	2	14
Anonidium mannii (Oliv.) Engl. & Diels	ngbe	18	5	5	8
Tetrorchidium didymostemon (Baill.) Pax & K. Hoffm	njene	17	8	1	8
Aframomum sp.	njiyi	16	2	7	7
Asystasia gangetica (L.) T. Anderson	kpa na nje	16	0	0	16
Erythrophleum sp.	ngbanda	12	0	8	4
Alchornea floribunda Müll. Arg	yàndo	12	7	1	4
Rourea obliquifoliolata Gilg	tukusà	11	3	1	7
Manniophyton fulvum Müll. Arg	kusa	11	7	1	3
Millettia soyauxii Taub	monyoko	6	5	0	1
Elephantopus mollis Kunth	yokokome	2	2	0	0

Individually, children reported, on average, five species during freelisting (SD = 2.6) and eight during the knowledge surveys (SD = 5.2). These averages did not differ significantly between age and gender, except that the age group 9–12 years reported more species in the knowledge surveys (average = 9.25 species) than other age categories (3.9 for the youngest category and 8.5 for the oldest, $Z = 11.28$, $p > 0.01$) (Fig. 2).

Children's Knowledge on Treating Diseases

Our Baka informants knew medicinal plants to treat all 18 health issues queried during the knowledge surveys and reported 4 to 34 different species per health issue. Children responded more frequently and with the highest number of species to common ailments such as cough, stomachache, and "jiyo," a combination of symptoms including fever, body pain, and shaking (Table 2). Interestingly, children also knew how to cure adult-specific diseases and problems related to social cohesion: about 25% listed plants used to protect people from potential conflicts in the community. Some children reported medicinal plants to protect a newborn baby in case of adultery by its parents, which can cause several illnesses or growth problems from the Baka perspective.

The answers provided during the knowledge survey slightly varied according to gender and age. Girls knew significantly more often herbal remedies than boys for women-specific issues such as improving breastmilk quality or treating menstruation pain. Children under 9 knew medicinal plants for 15 of the 18 health issues; they did not report herbal medicine for child protection, menstruation pain, or impotency. Our data showed no clear knowledge increase with age, except for plants related to breastmilk quality, intestinal worms, and stomachache. However, children between 9 and 12 years old

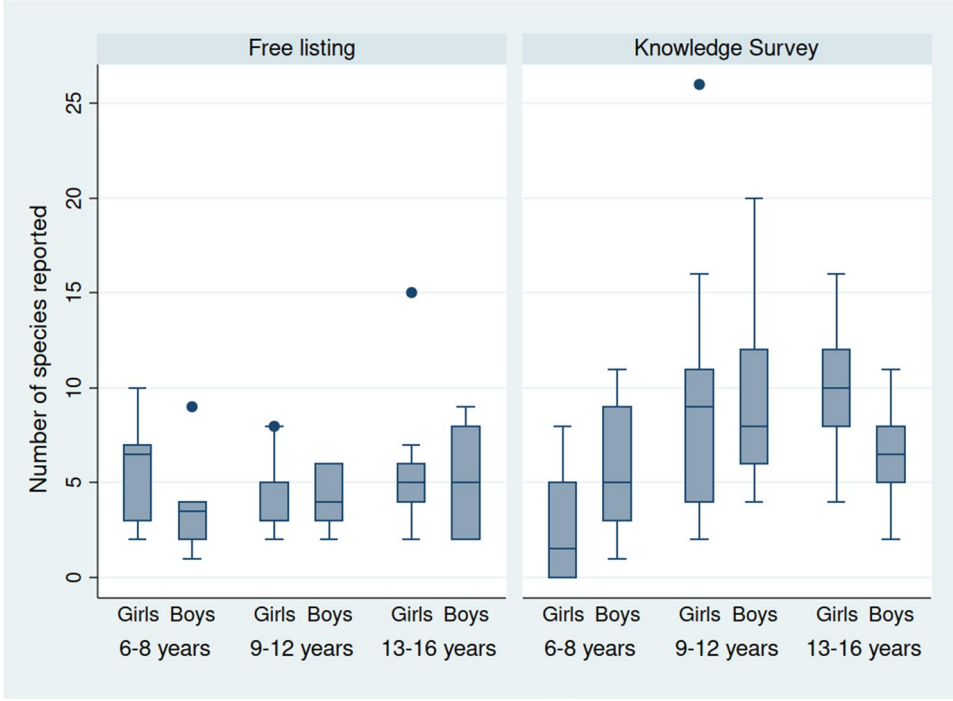

Fig. 2. Individual average number of medicinal plant species reported by age, gender, and ex situ methods ($n = 106$ children)

Table 2. Answers to the 18 health issues of the knowledge surveys. Per health issue: Number of informants listing at least one medicinal plant species to treat it, total number of reported species, and average number reported per informant ($n = 53$ children)

Disease category	Health issue	Number of informants ($n = 53$) [%]	Total number of species reported	Average number of species reported per informant [range]
High frequency	"Jiyo"	44 [83]	34	1.55 [0–7]
	Cough	41 [77]	31	1.06 [0–3]
	Body pain	27 [51]	18	0.53 [0–2]
Medium frequency	Stomachache	39 [74]	23	0.98 [0–4]
	Lack of blood	29 [55]	8	0.57 [0–2]
	Back pain*	22 [42]	14	0.42 [0–1]
Low frequency	Intestinal worms	36 [68]	12	0.72 [0–2]
	Hepatitis	27 [51]	10	0.51 [0–1]
	Avoiding conflict*	14 [26]	7	0.28 [0–2]
Children specific	Children's diarrhea	22 [42]	20	0.51 [0–3]
	Scabies*	27 [51]	10	0.53 [0–2]
	Child protection*	5 [9]	4	0.09 [0–1]
Men specific	Groin hernia	11 [21]	8	0.23 [0–2]
	Venereal diseases	14 [26]	8	0.30 [0–2]
	Impotency*	9 [17]	8	0.17 [0–1]
Women specific	Labor complications	16 [30]	11	0.34 [0–2]
	Menstruation pain*	9 [17]	12	0.25 [0–3]
	Breastmilk quality	23 [43]	12	0.51 [0–2]

*Health issues not mentioned during the walk-in-the-woods trips

knew significantly more often medicinal plants for child protection and hepatitis than other age groups (Supplementary Material D).

During the walk-in-the-woods trips, children did not show us any plant for six of the 18 health issues of the knowledge survey (Table 2). However, these trips yielded remedies for 42 health issues not present in the knowledge survey, reaching a total of 53 different health issues and 172 unique recipes (Supplementary Material E). The nine most frequent health issues mentioned spontaneously by children were also covered by the previously designed knowledge survey. While the health issues reported mostly represented general symptoms of frequent diseases, children also listed recipes for more specific ailments, such as pain in the heart and "pimi," described as pain felt in the spleen. Also, children shared 15 recipes for cultural health issues, including remedies against sorcery and bad spirits or for attracting luck (Supplementary Material E).

Children shared a diversity of preparation methods, using most often leaves (44% of the recipes) and bark (41%). In most recipes (139 out of 172), plants were used internally, mainly mixed with warm or cold water, and squeezed, boiled, eaten raw, or burned (Fig. 3).

Plant extracts were either drunk or inserted via a funnel made from a rolled leaf to the ear, nose, or eyes (Fig. 4) or inserted as an enema using a rubber syringe. Some plant parts were eaten raw or prepared as a meal. When taken externally, the plants were applied on the skin, either directly or chewed, crushed, boiled, or as ashes, or in an herbal bath. Plant-based charms, worn as amulets (Fig. 4), kept near the human body, or rubbed between the hands were mostly used for attracting good luck and protection against sorcery, but also against cough, "jiyo," or pain in the spleen.

Regarding the accuracy of children's knowledge, 158 of the 172 unique recipes were

Fig. 3. Proportion of medicinal plants' preparation methods reported in children' recipes (172 unique recipes reported during the walk-in-the-woods trips, $n = 53$ children)

Fig. 4. **a** Baka adult dripping an herbal extract in the eye through a funnel made of a Marantaceae leaf; **b** Baka adolescent preparing a plant-based string to foster child's growth. Photographs: S. Gallois

complete (local name, plant part, preparation, application). Our informants could not provide a Baka name for 11 of the 61 plant species collected during the walk-in-the-woods, but they always knew the plant part used, its preparations, and applications (Supplementary Material C). So, the (few) gaps in children's knowledge occurred in the correct naming of plants, rather than in their uses.

Complementarity of Field Methods

Before analyzing any overlap in data retrieved by the different methods, it is important to verify whether each sufficiently captured the available information. The accumulation curves of the freelisting and knowledge surveys flattened completely: no more new plant species were reported after interviewing 29 children (Fig. 5). The accumulation

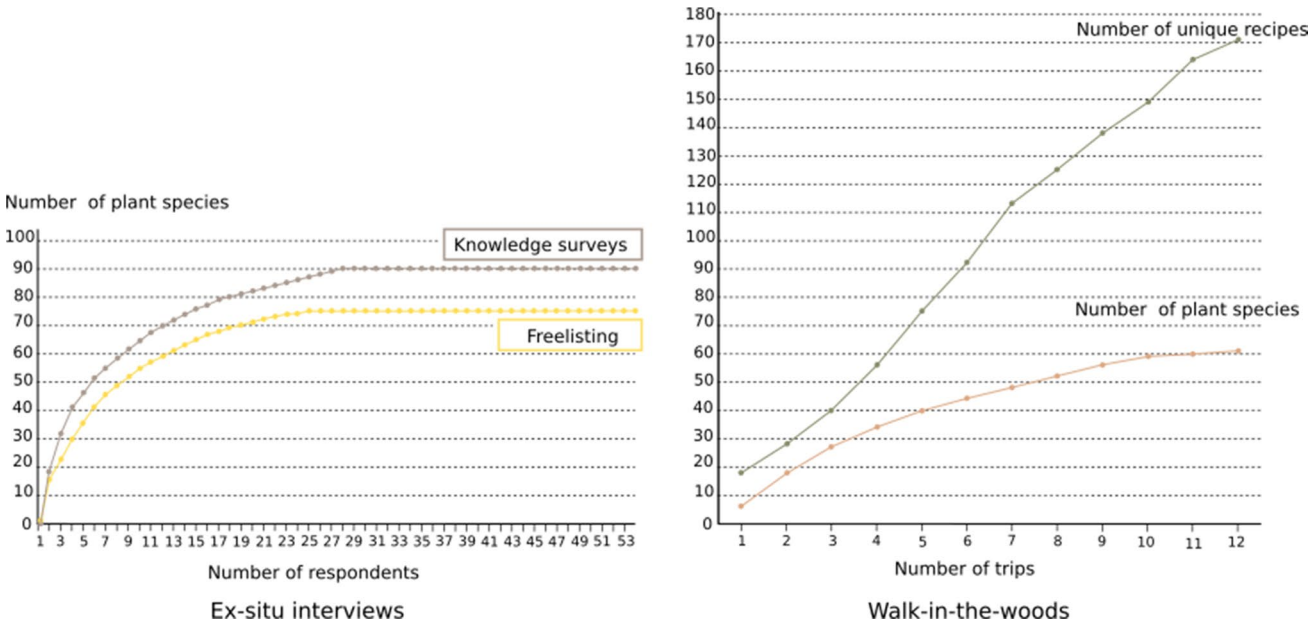

Fig. 5. Accumulation curves for the number of plant species mentioned during the three methods and the number of unique recipes during the walk-in-the-woods method ($n = 106$ children)

curve for the walk-in-the-woods method almost reached the asymptote about plant species; however, the number of recipes was still increasing. We would have gathered more data on herbal preparations and applications if we had continued our forest walks.

From the 128 medicinal plant species reported, most (90 species) were reported during the knowledge surveys (Fig. 6, Supplementary Material C). Only 30 species (about 25%) were reported in all three methods; 39 species were only shared by two methods and 59 species were unique to one of the methods. Therefore, we would have missed much of the Baka children's knowledge of medicinal plants if we had limited ourselves to only one method. During forest trips, our informants saw plants that would not have come to their mind during interviews, including species for which they did not know a local name. The ex situ interviews, however, shared more species with each other, as they provided data on the most frequently used medicinal plants, which did not surface during the walk-in-the-woods trips.

Discussion

Extensive Knowledge Held by Baka Children

Baka children know a considerable amount of medicinal plant species, belonging to different life forms and forest types, and a diversity of health issues, with a high precision of recipes. The children's expertise sheds light on the ethnobotanical knowledge distribution in Baka communities and their general health status. To our knowledge, this is the highest diversity of medicinal plants reported by children in the world: more than three times as much as reported by Saramaccan children in Suriname (36 species, Van't Klooster et al. 2019), and many times higher than reported in rural Niger (15 species, Guimbo et al. 2011), for Yucatan Maya (15 species, Jiménez-Balam et al. 2019), Vale do Catimbau, Brazil (22 species, Sousa et al. 2022), or Tremezzina in Italy (36 species, Bruschi et al. 2019). This high number could be related to the biodiverse forest of the Congo Basin and to the Baka's background as hunter-gatherers. Baka children knew many medicinal trees, which is coherent with the Baka's cultural perception of the power of forest trees (Betti 2004), but contrasts with the predominance of weeds in other settings (Stepp 2004). About 81 of the 172 unique recipes provided by Baka children were not known by our Baka co-author, possibly because medicinal knowledge is diverse and varies according to extended families. Still, whether Baka children's medicinal plants knowledge differs from that of adults, as is the case with animals and wild edible plants (Gallois et al. 2017), should be further explored, preferably also by using a mixed-methods approach.

In contrast with our expectations, we saw a permeable division of knowledge and practices beyond age, gender, and health issues. Age and gender had a limited effect on the medicinal knowledge of children. Even though Baka boys did not know much herbal medicine to ease

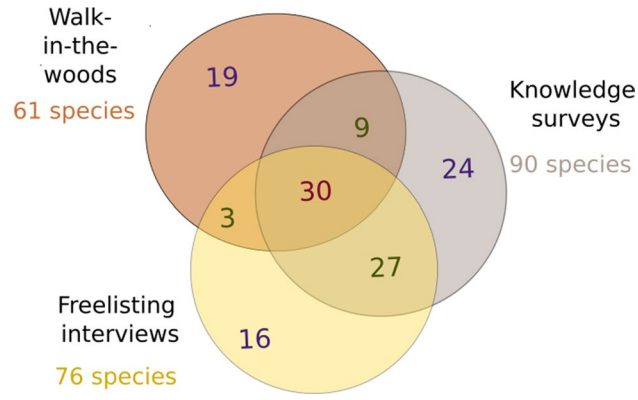

Fig. 6. Overlap in medicinal plant species reported ($n = 128$) between the three methods ($n = 106$ children)

menstruation pains or childbirth problems, they knew how to improve the quality of breastmilk. Baka children hold a common pool of recipes and medicinal plants, and some have specified knowledge, which may echo their parents' world. Baka children not only knew how to treat common childhood illnesses but also diseases that mostly occur during adulthood, such as sexually transmitted diseases, groin hernia and complications during childbirth. Their knowledge is thus not limited to their own health experience, as we hypothesized earlier based on a study among Mexican children (Jiménez-Balam et al. 2019). This probably relates to the importance of sharing in the egalitarian Baka community, in which sexuality and supernatural aspects are not kept secret or discussed only during adulthood. These findings echo insights from other forager groups of the Congo Basin, in which sexual life is not placed apart from childhood (Hewlett and Hewlett 2010). Thus, other social and individual factors may be involved in the distribution of medicinal knowledge, such as kinship, friendship, and familiar medical history, as shown in other settings (Quinlan et al. 2016).

The richness of Baka children's medicinal knowledge suggests they still learn about the forest and their culture. Such skills appear to be acquired early during childhood, in line with previous studies showing that children are proficient in such knowledge realms before adolescence (Soldati et al. 2015). This can be explained by Baka's limited access to education and modern health and children's involvement in subsistence and forest-orientated activities. Baka children take care of their siblings and are asked to collect medicinal plants by adults and thus passively and actively participate in healing sick persons. This participation contributes to an early acquisition of medicinal knowledge (Jiménez-Balam et al, 2019; Quinlan et al. 2016; Van't Klooster et al, 2019). More study is needed on this acquisition process, exploring the knowledge transmission pathways and whether experimentation and "playing" healing by imitating adults' activities occur, as observed for hunting or collecting edible plants (Gallois et al. 2018). Also, further research should explore how cultural erosion is influenced by social and individual factors, such as school attendance and market integration, which was beyond the scope of this study.

Our research also brings relevant insights on the Baka's state of their health and the potential factors that affect their healthcare system. The diversity and high frequency of plants used to treat "jiyo" and mentioning spleen problems stands out. "Jiyo" is a combination of symptoms that is often translated as malaria (Betti et al. 2013a, Carson et al. 2019), while malaria infection constitutes a detrimental factor in the still immature spleen function of young children, putting children with malaria at a high risk of developing life-threatening bacterial infections (Gómez-Pérez et al. 2014). Malaria prevalence in Cameroon is high (Antonio-Nkondjio et al. 2019), so medical and anthropological research should evaluate the symptoms and potential causes of "jiyo" and spleen problems, considering that the Congo Basin is a hotspot of emerging infectious diseases (Allen et al. 2017). Children's detailed knowledge on adult-specific and previously considered less common diseases also caught our attention. The fact that children often reported sexually transmitted infections and groin hernia shows the importance of those diseases in the Baka communities. Baka health and well-being are negatively affected by loggers and natural resource traders, among other external actors. Children especially suffer from increasing alcohol and drug consumption and sexual abuse from non-Baka people such as logging truck drivers and their Bantu neighbors (Gallois et al. 2021; Ramirez-Rozzi 2018). Baka adults working as wage laborers for timber companies often carry tropical hardwood from the forest. Lifting heavy loads may result in groin hernia (Fitzgibbons and Forse 2015), and Baka laborers are often given addictive painkillers such as Tramadol by illegal loggers (Gallois et al. 2021). The unsustainable exploitation of timber and wildlife and ongoing deforestation may further weaken Baka health, while adequate medical facilities remain scarce and undeveloped in this region (Carson et al. 2019). Therefore, further anthropological and ethnobotanical research should take an emic perspective, taking into consideration Baka's access to natural resources and Western medical facilities, to better understand the adaptive capacity of the Baka healthcare system to cope with such pressures.

Methodological Approaches for Putting Children at the Center Stage

Our data clearly show that our ex situ interviews and in situ forest walks are largely

complementary: they resulted mostly in different medicinal plants and associated knowledge, each bringing unique information. The species shared by the three methods probably represent the pool of medicinal plants commonly used by children, echoing the concept of the structural core (Sousa et al. 2022) of children's health system. Therefore, our results support previous claims of the importance of a mixed-methods approach to cover the richness of ethnobotanical knowledge (Flachs 2018; Stepp 2010). The strength of this approach also relies on botanical voucher collection (Gallois et al. 2020; Nolan and Turner 2011). Relying on local names only does not accurately estimate the diversity of natural resources used, and thus negatively affects local people's position in forest conservation and territorial land rights (Gallois et al. 2021). Contrary to our expectations, the ex situ methods yielded larger numbers of medicinal plant species than the in situ method. By comparing three methods in the same study group, we show differences in quantitative and qualitative data retrieved by each method and that more commonly used species were shared between the ex situ methods. The selection of the health issues for the knowledge survey, aimed at embracing Baka's health conception and practices, influenced the richness of our data. Previous ethnographic study is key, and valid for any ethnoecological realm (Flachs 2018; Stepp 2010).

Our mixed methods approach is adapted to working with children, for several reasons. Children's age is an important decision factor in choosing research methods (Sullivan et al. 2018). In our case, we reached participants as young as 6 years old. When interviewed, children could answer without elaborating complex verbal knowledge. We experienced that using active in situ methods such as forest walks is a powerful way to enter children's world, as it takes place in their own familiar environment. Asking children to guide researchers puts them on center stage and permits them to introduce outsiders to their world. It also breaks away from artificial research settings like schools, where biases often occur (Gallois and Reyes-García 2018). Going to the forest made Baka children feel comfortable and even enjoy the trips to play around. We noticed an adequate amount of time was about 3 h, after which the children's attention decreased. The forest trips with groups of children of varying ages seemed a relevant strategy for including young and shy children and stimulating them to participate. If the researcher ensures that older children stimulate the younger ones to share and not overrule them, this is a suitable method to gather children's knowledge as a whole. It is somewhat similar to focus group discussions, but forest walks provide the researcher and the participants with (unexpected) visual props (in our case medicinal plants) that stimulate discussion, knowledge exchange, and revitalization.

Not only the setting and the length of the methods are essential when working with children but also the researchers' own approach (Adler et al. 2019). Being an adult foreigner puts the researcher into a particular category of naïve newcomer close to children. Ethnobotanists may gain from this particular position to enter children's world easily, especially if they maintain a respectful attitude and follow local rules. Creating a space of trust is fostered mainly by the researchers' behavior, such as flexibility, warmth, a friendly attitude, and the use of humor (Adler et al. 2019). The previous long-term interaction of the first author with the Baka communities, the children's appreciation of the second (Baka) author as a former teacher, and the time spent by the last author playing with kids every afternoon largely contributed to gaining their trust. Potential interference by other adults, such as teachers, parents, interpreters, and research assistants, needs special attention (van't Klooster et al. 2019). Researchers should think beforehand about where the interviews will take place, ensuring that adults do not interfere or limit what children would like to share. If interpreters or research assistants are needed during data collection, researchers should ensure beforehand that their relationship with children is respectful and that children are not ashamed of talking in their presence. Children tend to share information more easily without adults, but understanding their language and expressions can be challenging. Taking along an adult from the local community is, therefore, a trade-off between obtaining better-verified information and losing some typical children's knowledge that the adult may dismiss as "nonsense."

Conducting ethnobotanical research with children is not only relevant for scientists and conservationists but also has impacts at the community

level. Working with groups of different children fosters knowledge sharing among them, which fits their cultural way of knowledge acquisition and transmission (Gallois et al. 2017). Documenting plant use practices also fosters the revitalization of knowledge and interest in the community's culture. After showing interest in recording Baka children's knowledge, adults first told us it would be difficult because they assumed that children knew little. When looking for participants, adults seldom say that their children knew about plants, and when it was the case, they mostly referred to adolescents. However, after seeing the amount of plant vouchers we brought back for identification, Baka adults were surprised and curious to know what information was shared by their children. This type of research has the potential to intrinsically increase the recognition of children's knowledge within a community.

Conclusion

Our research provides evidence of the extensive expertise of Baka children regarding health knowledge and practices. The diversity of medicinal plants reported indicates that despite the grave social and ecological pressures suffered by the Baka in southeast Cameroon, their children are active holders of ethnobotanical and cultural knowledge, and learn from their peers, parents, and the time spent in the forest. Using a mixed methods approach, well adapted to children, is a powerful tool to capture this knowledge, foster the maintenance of biocultural diversity, and create a framework for a more sustainable future. Huge efforts are still needed to elucidate how marginalized small-scale societies use their natural environment in the face of global change and transmit this knowledge to younger generations. Children should therefore be placed at the center stage of research on the sustainable use of natural resources.

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Author Contribution S. v. B, T. v. A., and S. G. participated in the design of the study, plant identification, data analysis, and writing the manuscript. S. v. B, A. A., and S. G. collected the data. A. A. verified the data collected and commented on the analysis. All authors have read the submitted manuscript.

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Data Availability The data supporting the findings of this study are available within the article and its supplementary materials. The whole disaggregated raw dataset will be available at the CORA. Research Data Repository (CORA.RDR; https://dataverse.csuc.cat/) labeled with the first author's name.

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