Endogenous knowledge and uniqueness of traditional communities in Northern Léfini Reserve (Republic of Congo)

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Research

Abstract

Background: This study was carried out in three traditional communities in the northern sector of the Léfini reserve (Banga, Edzouala and Mpoh). The aim of this research is to capitalise on the secular achievements of the socio-cultural foundations of traditional communities, with a view to preserving the societal values associated with herbal medicine. The study was prompted by the observation that traditional knowledge of medicinal plants is dying out in Africa, particularly in the Congo.

Methods: In addition to bibliographic compilation, the methodological approach is based on a floristic inventory using walk-in-the-woods and show-and-tell methods, as well as an ethnobotanical survey. Informants were at least 15 years old and divided according to gender and socio-professional group. The sample was selected using a stratified probabilistic method. Prior to the fieldwork, a literature review provided information on the phytogeographical distribution and known uses of the species in their area of distribution. Depending on the circumstances, the ethnobotanical survey consisted of individual or group interviews.

Results: The floristic inventory revealed 64 species from 35 families. The Asteraceae and Fabaceae are the most represented in the medicinal flora. The most widely used species, to varying degrees, are *Nauclea latifolia* Sm., *Dysphania ambrosioides* (L.) Mosyakin & Clemants, *Chromolaena odorata* (L.) R.M.King & H.Rob., *Costus afer* Ker Gawl., *Garcinia kola* Heckel, *Psidium guajava* L., *Uraria picta* (Jacq.) Desv. ex DC., *Gymnanthemum amygdalinum* (Delile) Sch.Bip., *Senna occidentalis* (L.) Link and *Cissus aralioides* (Baker) Planch.. Of the taxa surveyed, 39.06% are at risk due to non-ecological logging (felling, uprooting and debarking). The high values of the ethnobotanical indices (ethnobotanical use value (UV), informant consensus factor (ICF) and fidelity level (FL)) show a strong involvement of the taxa and parts used in recipe preparation, within these traditional societies. The study highlights fourteen therapeutic indications that vary according to locality and socio-professional category. Infectious and parasitic diseases, as well as ill-defined symptoms, signs and morbid states, are the most frequent ailments in the communities. The groups with the most diversified knowledge are women, individuals aged 15 to 25 years and over 45 years, and the Tékés.

Conclusions: The use of flora for medicinal purposes is unique among the communities surveyed. Despite modernization, endogenous values have been preserved, and empirical knowledge has been passed down from generation to generation. However, given the vulnerability of prized taxa and ecosystems, endogenous knowledge is under serious threat. The domestication of certain taxa can be seen as a way of perpetuating them and preserving endogenous knowledge. However, this domestication mainly concerns non-native taxa.

Keywords: Ethnobotany, endogenous knowledge, medicinal plants, Léfini reserve, traditional communities, Traditional use.

Background

Plants are a fundamental element of biological diversity and an indispensable resource for human well-being (CBD 2002, Güneş *et al.* 2018). Worldwide, between 3.5 and 5.8 billion people of all socio-economic classes use the virtues of plants. Recent studies have shown that the majority of new drugs and even molecules come from plants. (Farnsworth *et al.* 1986).

In Africa and around the world, plants are a concentrate of benefits, particularly phytotherapeutic (Farnsworth *et al.*, 1986; Akan *et al.*, 2024). Despite the proven evidence of modern medicine, around 75% of Africans assiduously exploit the therapeutic virtues of plants, and make particular use of traditional medicine (Tchatat & Ndoye 2006, Diatta *et al.* 2016, Obilela *et al.* 2022). For others, the exploitation of plant active ingredients is the main source of household income (Tchatat & Ndoye 2006, Diatta *et al.* 2016; Sambou 2017, Bassene *et al.* 2020).

In the Republic of Congo, the population's dependence on plant resources to meet daily needs is well established (Mialoundama Bakouetila *et al.* 2020). Although these plant resources are the basis for diversifying socio-economic and cultural activities, they are highly threatened by anthropization, essentially agriculture and the exploitation of woody and non-woody resources.

Given their remoteness from urban centers, where health infrastructures are located, the virtues of plants are at the forefront of the daily primary health care coverage of local residents. In addition to the lack of health services, the prohibitive cost of medicines in relation to the population's purchasing power is one of the key factors in the survival of the socio-cultural foundation, which is based on the therapeutic values of plants. However, we must recognize that ancestral values are eroding concomitantly with the high degree of anthropization of ecosystems, the corollaries of which affect all three levels of biodiversity (Kimpouni *et al.* 2018). In addition to the facts of anthropization, the grip of worldliness on traditional societies, which amplifies the level of rural exodus, coupled with the ageing of the possessors or custodians of knowledge, drastically affect the transmission of knowledge between generations (Ilumbe 2010, Kimpouni *et al.* 2018). Documenting the empirical knowledge of traditional societies is thus a necessity for the sustained perpetuation of man and his environment. In this particular case, the age-old intimacy between man and the virtues of plants, within the traditional communities of the northern sector of the Léfini reserve.

Taking into account the cultural values of plants in the Congo, several ethnobotanical, phytochemical and floristic studies have been carried out. These studies are very fragmented and often limited in scope (national or regional), and do not sufficiently reveal the ethnic-linguistic particularities of the inhabitants sharing the territory (Bouquet 1969, Bouquet & Jacquot, 1967, Adjanohoun *et al.* 1988, Kimpouni 2001, Malela *et al.* 2016, Miabangana & Hondjuila Miokono 2016, Kimpouni *et al.* 2018). At this scale, grasping the full cultural scope of the therapeutic value of traditional societies is utopian. This observation is all the more plausible when we look at populations living in and/or adjacent to protected areas. Since the profound dimension of endogenous knowledge associated with man and his environment is not always highlighted, immersion in communities better reflects the uniqueness of empirical knowledge acquired by ethnic-linguistic groups.

The aim of the study is to promote and safeguard the socio-cultural values associated with phytotherapeutic properties, which form the basis of the knowledge of traditional communities in the northern sector of the Léfini reserve.

Materials and Methods

Study area

The Léfini Reserve is a natural wildlife reserve in the Republic of Congo, created by Arrêté n° 3671 of November 26, 1951. With an initial surface area of 4,000 km², the reserve now covers 6,300 km², following Arrêté n° 0046/MAEEFGR-CH-CN of January 7, 1963. The Léfini reserve is located in southeastern Congo, about 140 km from Brazzaville. It straddles the Pool department, notably the Ngo district (northern sector) and the Plateaux department (southern sector), specifically the Ngabé district. The study was carried out in the northern sector, covering the traditional communities of Banga, Edzouala and Mpoh (Figure 1).

The climate, characterized by average rainfall of between 1600 and 2000 mm/year and a temperature of 25°C, is Aw-type with alternating seasons (Köppen 1936). The dry season, characterized by mild temperatures, generally extends from June to August, with a pronounced slowdown in rainfall, from 25 to 50 mm/month to almost zero. The rainy season is characterized by heavy rainfall and high temperatures. The rainiest months (March, April and November) also excel in heat. The rainy season is the longest, covering the period from September to May, notwithstanding the slowdown in rainfall from December to January (Figure 2).

The vegetation of the Léfini reserve is divided into two major biomes: the forest-savanna mosaic and the gallery forests (Hecketsweiler 1990). Savannahs cover almost 70% of the reserve's surface area, with the remainder covered by the forest-savannah mosaic and forests. The savannah flora, dominated by *Trachypogon thollonii* (Franch.) Stapf, *Hyparrhenia diplandra* (Hack.) Stapf and *Loudetia demeusei* (De Wild.) C.E.Hubert, is dotted with shrubs, notably *Hymenocardia acida* Tul., *Annona senegalensis* Pers. and *Bridelia ferruginea* Benth.. Forests, generally found in drained valleys and on river banks, are rich in rattans (*Laccosperma* spp. and *Eremospatha* spp.). The undergrowth is dominated by *Palisota* sp. and *Megaphrynium macrostachyum* (Benth.) Milne-Redh.

Populations are located (i) in villages and encampments, (ii) along national road no. 2, (iii) the Ngo - Lékana road and (iv) to a lesser extent inside the reserve (Ikamba-Nkulu & Tsoumou, 2009). Human density in the Léfini reserve area is around 2 to 3 inhabitants/km² (Hecketsweiler 1990). The Téké and Atswa ethnic groups (indigenous populations) dominate in terms of population numbers (Bouquet 1969). In addition to these two majority groups, nationals of other groups and foreigners have been recorded (PNUD 2016).

The inhabitants' main activities are farming, gathering, fishing and hunting (in its illegal form). Following the introduction of mechanical means into the production system, farmland has increased exponentially. This mechanization has greatly increased the pressure on farmland in the region. Poaching pressure is so marked that it has encouraged the proliferation of weapons of all kinds. The weakness of the surveillance system and, above all, its proximity to the city of Brazzaville provide a very buoyant market (Ikamba-Nkulu & Tsoumou 2009).

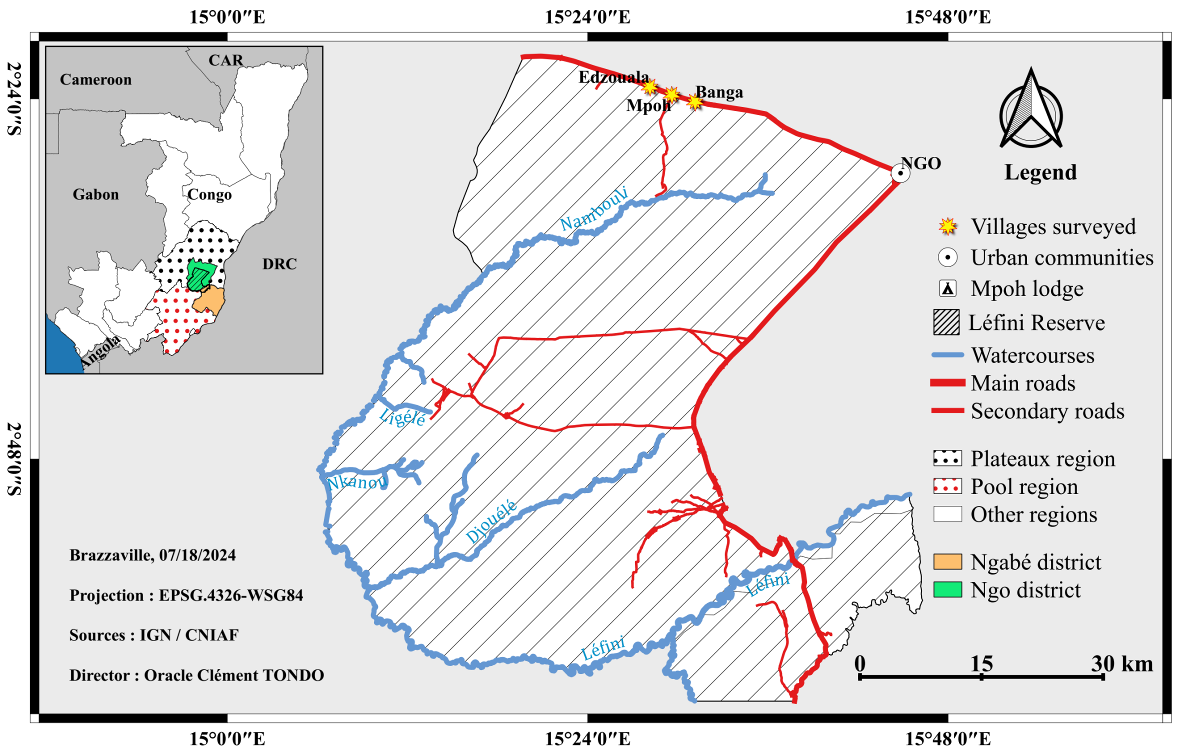

Figure 1. Location of study sites

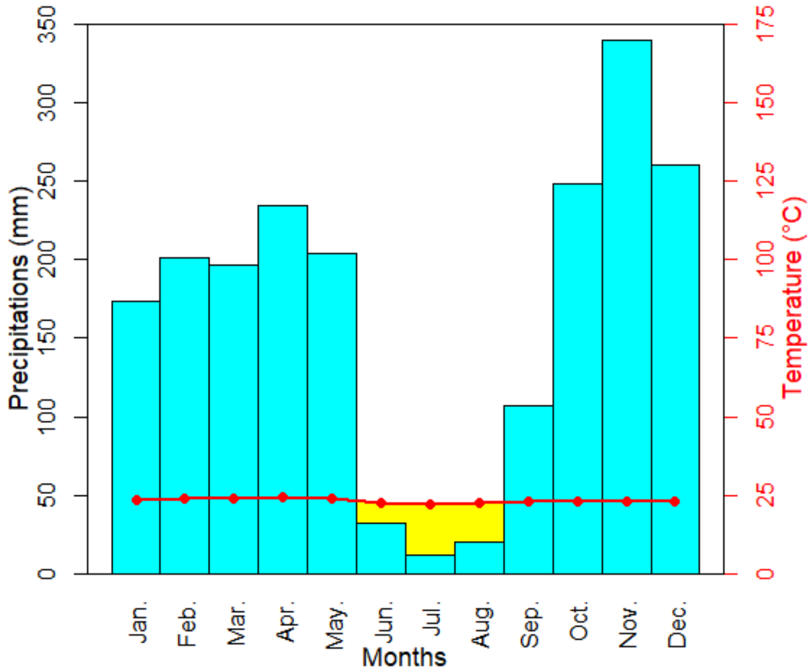

Figure 2. Djambala umbrothermal diagram (data from 2011 to 2021)

Material

The study material consists of the various plant organs used daily by the local population. These elements contribute to satisfying therapeutic needs. The target organs are vegetative (stem and root bark, roots, rhizomes, leaves, buds, stems, or even the whole plant) and generative (part or whole flower, fruit, kernel). Species are identified in situ for the most common ones, and ex situ by consulting the IEC herbarium at IRSEN, for the unidentified ones. The classification of Spermatophytes is based on APG IV (2016) and PPG I (2016) for Pteridophytes. Taxonomic nomenclature is in line with Lebrun & Stork (1991-2015). The ecological parameters monitored, for each taxon, are habitat types (TH) and phytogeographical types (TG).

Habitat type refers to the environment where the plant is harvested. The selected habitats are: forest (F), secondary forest (Fse), savannah (Sav), fallow land (Jach), cultivated land (Cul), edge (L), ruderal environment (Rud).

Phytogeographic types (TG), on the other hand, show the distribution of plants across the globe. Chorological spectra of flora provide information on the range of different species. White's classification (1979, 1986) highlights Cosmopolitan (Cosmo), Pantropical (Pant), Paleotropical (Paleo), Afro-American (AfAm), Afrotropical (Aftr), Afromalgache (Afma), Guineo-Congolian-Zambezian (GC-Z), Guineo-Congolese-Soudanian (GC-S), Guineo-Congolian (GC), Lower Guinean (BG), Lower Guineo-Congolian (BGC), Zambezian (Z).

Data collection

Data collection consisted of a literature review to establish the current state of the issue; an ethnobotanical survey coupled with individual or group interviews, depending on the circumstances; and a floristic inventory. All these interventions involved the three traditional communities (Banga, Edzouala and Mpoh). The ethnobotanical data was collected in two phases, taking into account the seasons and the activities of the populations, and after a pre-survey. The timetable was as follows: (i) pre-survey from 13 to 30 May 2023; (ii) first survey phase from 17 September 2023 to 15 November 2023; and (iii) second data collection phase from 15 February 2024 to 15 March 2024.

Ethnobotanical survey

The data collection technique involved a combination of questionnaire surveys and door-to-door interviews. Respondents were selected based on their level of knowledge and everyday use of plants. The sample was selected using the stratified probabilistic method. This method involves dividing the study area into different strata (villages) according to predefined criteria (Houéhanou 2016). The work is conducted in Teke for the region's natives and in Lingala for the others.

The questionnaire, which included both closed and open-ended questions, was subdivided into three parts: respondent identification, use of harvested plants and; how knowledge is acquired.

Since the pathologies treated are numerous and diverse, 14 categories of use (or therapeutic indications) have been defined on the basis of the Pharmel classification (Adjanohoun *et al.* 1994): Complications of pregnancy, childbirth and the post-partum period (CPCP); Medico-magical effects (M-M); Traumatic injuries and poisoning (TLP); Diseases of the circulatory system (DCS); Diseases of the digestive system (DDS); Diseases of the respiratory system (DRS); Diseases of the skin and subcutaneous cellular tissue (DSST); Diseases of the genitourinary organs (DGUO); Diseases of the blood and hematopoietic organs (DBHO); Diseases of the nervous system and sense organs (DNSO); Diseases of the osteoarticular system, muscles and connective tissue (DOSMS); Infectious and parasitic diseases (IPD); Ill-defined symptoms, signs and morbid states (IDSSM); Mental disorders (MD).

Floristic inventory

The floristic inventory was carried out using the "Walk-in-the-woods" and "Show-and-tell" methods (Evert 2008). The "Walk-in-the-woods" method involves walking in the company of previously identified knowledge-holders or a guide in the surrounding ecosystems in order to recognize plants. During this exercise, the parameters recorded wase the names in local languages and the uses to which they are put. This operation was repeated with different guides and/or informants to cross-check information. The "show-and-tell" method shows herbarium or fresh plant samples, or even iconographies, to informants. The information sought remains the same as for "Walk-in-the-woods".

Ecological spectra

De Foucault (1995) defines a spectrum as a description of the elementary syntaxon based on classifications other than floristic: phytogeographical elements, biotopes, systematics (at a higher rank than the species), etc. The raw spectrum (RS) considers the percentage of species, which is the ratio between the number of species considered and the total number of species within the grouping. The weighted spectrum (WS) is based on citation frequency. It is the percentage ratio between a given category's citations and the total number of citations.

$$RS\ (\%) = \frac{\text{Number of species in a category}}{\text{Total number of species}} \times 100$$

$$WS\ (\%) = \frac{\text{Number of citations for a given category}}{\text{Total number of citations}} \times 100$$

Biodiversity indexes

The biodiversity indices calculated were:

Jaccard similarity coefficient

Jaccard's similarity coefficient gives the same rating to the presence and absence of a species. This index compares the similarity between two sets.

$$J\ (\%) = \frac{C}{A + B - C} \times 100$$

A = number of species in the first group, B = number of species in the second group; C = number of species common to both groups.

Shannon Biodiversity Index

This index provides a measure of biological diversity, highlighting abundant species (Legendre & Legendre 1984, Magurran 2004).

$$H' = -\sum_{i=1}^{S} pi\ln pi$$

Where pi = ni/n; ni = number of individuals of the species and n = total number of individuals.

Maximum diversity index (H'max)

This index provides information on the degree of diversity that a phytocenosis can reach in the case of a homogeneous distribution of the individuals making up the flora.

$$H'max = \ln(S)$$

S = total number of species

Pielou equitability index

The Pielou index indicates the type of distribution (regular and/or aggregative) of the taxa in a community (Legendre & Legendre 1998, Magurran 2004). This index, which varies from 0 to 1, tends towards 0 when almost all the numbers correspond to a single species in the stand, and towards 1 when each species is represented by a similar number of individuals. In other words, when its value is high, the distribution of individuals between species is regular. On the other hand, a low value indicates the dominance of one of the taxa.

$$P = \frac{H'}{H'max}$$

Ethnobotanical indices

For the present study, several ethnobotanical clues were considered, including the following:

Frequency of citations

The frequency of citation (FC) is used to assess the credibility of the information received and the level of knowledge of plants in the survey population. It is the number of informants who cited a given species, organ, preparation method, administration method or preparation vehicle (Dossou *et al.* 2012).

Relative frequency of citations

Relative citation frequency (RCF) is calculated to emphasize the importance of knowledge. It is the percentage of citations for a given therapeutic indication or species. To identify and detect differences, relative citation frequency (RCF) calculations were carried out using the Dossou *et al.* (2012) formula:

$$RCF\ (\%) = \frac{FC}{N} \times 100$$

N is the total number of people interviewed during the survey.

The relative frequency of citation is a good index for assessing the credibility of the information received and the level of knowledge of the survey population (Schrauf & Sanchez 2008). It indicates the species, organs, preparation methods, administration methods and preparation vehicles most commonly used in the environment, and ranges from 0 to 100. A value of 0 indicates that the item is not used and 100 indicates that the organ is used by all respondents (Dossou *et al.* 2012).

Ethnobotanical use value

Use value (UV) is used to identify species whose use is important to the local population. Use value is the number of uses attributed by informants in relation to the number of informants.

$$UV = \frac{\Sigma Ui}{N}$$

Ui = Number of uses mentioned by each informant for a species; ΣUi = Total number of uses given by all informants for a species; N = Total number of informants interviewed. The use of species with a high UV value (close to 1) is important to informants (Albuquerque *et al.* 2006; Boudaoud 2021).

Fidelity level

The Fidelity Level (FL) is the percentage of informants who agree that a species is used predominantly for a sub-category of use (Friedman *et al.* 1986). FL values range from 0 to 100%. For each therapeutic indication, the higher the FL (> 60%), the greater the plant's consensus. The lower the FL (< 40%), the lower the consensus (Boudaoud 2021). This index is calculated using the formula:

$$FL\ (\%) = \frac{Np}{Nu} \times 100$$

Np = Number of informants reporting a single use of the species; Nu = Number of informants citing the same species as useful.

Informant consensus factor

The Informant Consensus Factor (ICF) was calculated for both therapeutic indications and species. The ICF value varies from 0 [a wide variety of species is cited for the same particular therapeutic indication / the number of diseases treated is equal to the number of citations recorded] to 1 [only one or a small number of species is cited by a large proportion of informants for a particular therapeutic indication / all participants agree on the exclusive use of the species for a particular disease] (Nzuki Bakwayé *et al.* 2013). This factor is calculated using the Heinrich *et al.* (1998) formula.

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Nur: number of citations for each therapeutic indication / number of citations for each species; Nt: number of species used for each therapeutic indication / number of therapeutic indications for each species.

Vulnerability index

The vulnerability index for species i (IVi) is calculated using Betti's formula (2001). This index is based on the average values of 3 parameters representing major indicators of pressure and threat on species. The value of each parameter (P) varies from 1 to 3 according to Betti's (2001) vulnerability scale (Table 1). IVi are interpreted according to thresholds: for IVi < 2 the species is said to be weakly vulnerable; for 2 ≤ IVi< 2.5 the species is moderately vulnerable and for IVi ≥ 2.5 the species is very vulnerable.

Table 1. Important parameters taken into account when calculating the vulnerability index

Parameters	**Vulnerability to uncontrolled use**		
	Low (scale =1)	Average (scale = 2)	Strong (scale = 3)
N1. Frequency of use	F.U ≤ 20%	20% ≤ F.U ≤ 60%	High F.U ≥ 60%
N2. Number of uses	Nu < 2	2 ≤ Nu ≤ 4	Nu ≥ 5
N3. Plant organ used	Leaf, latex	Fruit, branch	Wood, seed, bark, root, flower, whole plant

Knowledge diversity and equity indices

The diversity index (ID) measures the diversity of species use categories and presents how this knowledge is distributed among respondents (Byg and Baslev 2001, Lougbegnon *et al.* 2015). This index is used to measure respondents' level of knowledge about different plant use categories and is based on Shannon's diversity index. It is low if the species is widely used in one or two use categories, and high when the species is multi-use. It ranges from [0 to n]. The value of the respondent's diversity index (ID) by gender and social category was calculated using the formula:

$$ID = -\sum \frac{n_i}{N} \ln \frac{n_i}{N}$$

ni: number of citations for a use category; N: total number of citations for all use categories.

The knowledge equitability index is the value of the diversity index (ID) divided by the maximum diversity index (IDmax). This index is given by:

$$IE = \frac{ID}{IDmax}$$

With IDmax = ln(I); where I is the total number of therapeutic indications.

This index measures the degree of homogeneity of respondents' knowledge, and ranges from 0 to 1. If IE < 0.5 the diversity of respondents' knowledge is not homogeneous, but if IE ≥ 0.5 this diversity is homogeneous.

Data Analysis

Data were processed using Excel (v. 2016) and R software (v. 4.2.3.). In order to identify the factors influencing the use of plant species, a chi-square test of independence at significance level α = 0.05 was applied. To understand the relationship between therapeutic indications and plant parts used, a Pearson correlation nullity test at significance level α = 0.05 was performed. This test was followed by a visualization of the data in a correlation matrix highlighting the data trend curves, the correlation coefficients whose effect size is interpreted according to Cohen's (1988) markers, and the significance of the p-values marked by asterisks.

Results

Taxonomic and floristic data

The survey authenticated 64 species belonging to 35 families (Table 2). The average number of citations was 225.67 ± 87.57. The most represented family is Asteraceae with 8 species, followed by Fabaceae (6 species), Euphorbiaceae, Rubiaceae and Solanaceae with 4 species each (Table 3). The Poaceae, with 3 species, are followed by the Annonaceae, Arecaceae, Hypericaceae, Malvaceae, Phyllanthaceae and Zingiberaceae with 2 species each. The other families are monospecific.

Table 2. Summary of floristic inventory and taxonomic data

Localities	Families	Species	Number of citations
Banga	30	47	124
Edzouala	29	45	153
Mpoh	34	61	400
Average ± ES	31 ± 1.53	51 ± 5.03	225.67 ± 87.57
Total	35	64	678

Phytogeographical spectrum

The raw and weighted spectra (Figure 3) show, in unequal proportions, that the medicinal flora recorded in the three traditional communities is dominated by the very broadly distributed element, followed by the endemic element, the broadly distributed element, the link element and the transgression element. The dominance of the broadly and very broadly distributed elements shows that endogenous knowledge, the foundation of the communities' socio-cultural base, has been enriched by external contributions. In fact, the associated knowledge is not only derived from the sociocultural base of the natives, but also from the intermingling of populations.

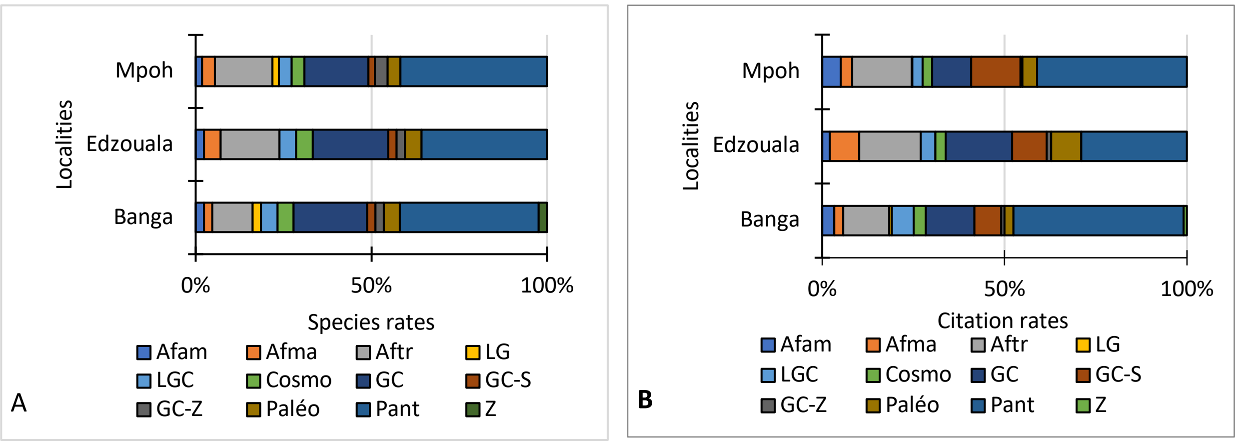

Figure 3. Phytogeographic spectra. Legend. A: Raw spectrum; B: Weighted spectrum

Biotope spectrum

The raw spectrum (Figure 4A) shows that the study area is dominated by ruderal species, followed by forest, crop and savannah species. Other habitats account for less than 8% each. The weighted spectrum (Figure 4B) shows ruderal species ahead of forest, savanna and secondary forest species. These results highlight the population's greater dependence on nearby ecosystems, particularly taxa within easy reach.

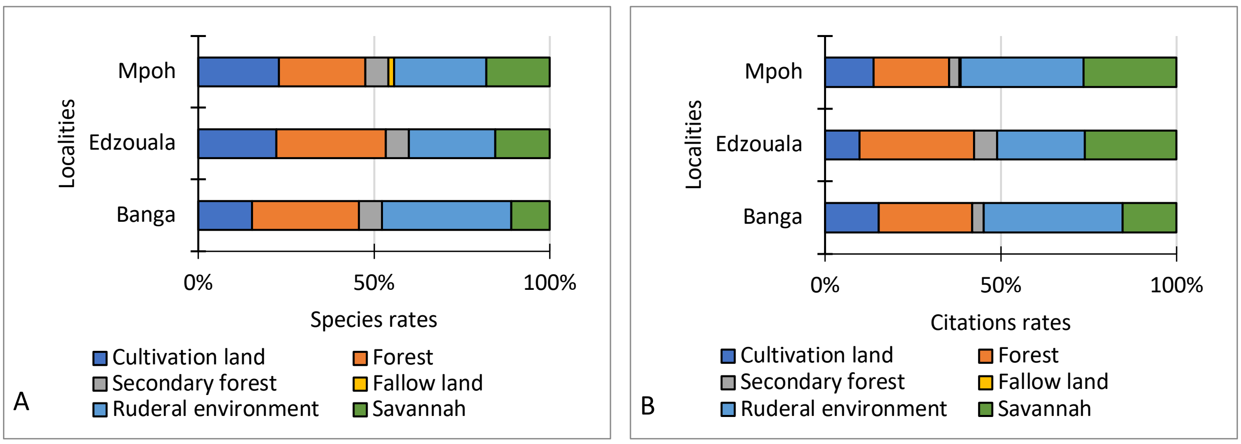

Figure 4. Spectra of biotope types. Legend. A: Raw spectrum; B: Weighted spectrum

Table 3. Taxonomic and ethnobotanical data on plants in therapeutic use

Families	Species	Vernacular names	Part used	Therapeutic indications	Preparations	Vehicles	Routes	CF	RCF (%)	UV	ICF	IVi
Acanthaceae	*Acanthus montanus* (Nees) T.Anderson	Ubuyangué	Le	TLP, M-M	Tri	nv	La	3	4.29	0.04	0.50	1.33
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin &Clemants	Ompfu	Wp, Le	IDSSM, M-M, DSST, IPD	Mac, Tri, Inf, Cal, Dig	wat, nv, po	Sib, Vr, Mas, La, Bb, Fr, Or	25	35.71	0.49	0.93	2.67
Annonaceae	*Annona senegalensis* Pers.	Elolo	Ro	TLP, DOSMS	Tri, Inf	nv, wat	La, Or	16	22.86	0.24	0.94	2.33
	Monodora myristica (Gaertn.) Dunal	Oyiyini	Se	M-M	Asp	nv	Or	9	12.86	0.13	1.00	1.67
Arecaceae	*Elaeis guineensis* Jacq.	Bâ	Fr	TLP	Sof	nv	La	1	1.43	0.01	0.00	1.33
	Laccosperma secundiflorum (P.Beauv.) Kuntze	Mukawa	Le +St	DGUO	Dec	po	Or	3	4.29	0.04	1.00	1.33
Asparagaceae	*Chlorophytum* sp.	-	Le	IDSSM	Sof	nv	Mas	1	1.43	0.01	0.00	1.00
Asteraceae	*Ageratum conyzoides* L.	Ozintso	Wp	DOSMS, DSST	Dec, Sof	wat, nv	Or, La	5	7.14	0.07	0.75	2.00
	Bidens pilosa L.	Angonion / Anganion	Le, Wp	IPD, DSST, DGUO	Tri, Inf	nv, wat	Eyi, La, Or	13	18.57	0.19	0.83	2.00
	Chromolaena odorata (L.) R.M.King & H.Rob.	-	Le	IDSSM, TLP, DDS, IPD	Inf, Tri	wat, nv	Or, La	29	41.43	0.54	0.92	1.67
	Emilia coccinea G.Don	Dia	Wp	M-M	Cal	po	Or	1	1.43	0.01	0.00	1.67
	Erigeron floribundus (Kunth) Sch.Bip.	Intsotso	Wp, Le	DGUO, DOSMS, IPD	Dec, Sof	wat, nv	Or, Eyi	9	12.86	0.13	0.75	2.00
	Gymnanthemum amygdalinum (Delile) Sch.Bip.	-	Le, Ro	IDSSM, IPD, DSST	Inf, Tri, Lin	wat, nv, po	Or, Fr, Cat, Sib	23	32.86	0.37	0.92	2.33
	Stomatanthes africanus (Oliv. & Hiern) R.M. King & H. Rob.	Elengakué	Le	DDS	Dig	nv	Or	5	7.14	0.07	1.00	1.00
	Tithonia diversifolia (Hemsl.) A. Gray	Apipon	Le	TLP, IDSSM	Tri, Inf	nv, wat	La, Or	11	15.71	0.16	0.90	1.33
Burseraceae	*Dacryodes edulis* (G.Don) H.J.Lam.	Safu	Ro	MD	Mac	wat	Or	3	4.29	0.04	1.00	1.67
Cannaceae	*Canna indica* L.	Tsalanga	Ro	MD	Dig	wat	Or	2	2.86	0.03	1.00	1.67

Caricaceae	*Carica papaya* L.	-	Ro, Se	IDSSM, IPD	Dec, Dig	wat, nv	Or	5	7.14	0.13	0.88	2.00
Caryophyllaceae	*Drymaria cordata* (L.) Willd. Ex Schult.	Onani / Munani	Wp	DSST, IDSSM	Lin, Mac	po, wat	La, Sib	2	2.86	0.06	0.80	2.00
Clusiaceae	*Garcinia kola* Heckel	Oyali / Ngadiadia	Se, Ba, Le, St	IPD, DOSMS, DNSO, IDSSM, TLP, M-M, MD, DGUO, DDS	Tri, Inf, Dec	nv, wat, po, rw	Or, Stb, Eai, Vr, Rr	17	24.29	0.41	0.75	2.67
Commelinaceae	*Floscopa* sp.	Ulolo	Wp	IPD, CPCP	Tri	nv	Fr, Mas	3	4.29	0.09	0.80	2.00
Costaceae	*Costus afer* Ker Gawl.	Esani	Le, St	IDSSM, IPD, M-M, DDS	Inf, Tri, Pou, np, Dig	wat, nv, -	Or, Eyi, Fr, -	27	38.57	0.41	0.91	2.00
Cucurbitaceae	*Cucurbita* sp.	-	Le	DDS	Mac	wat	Or	3	4.29	0.04	1.00	1.00
Dilleniaceae	*Tetracera* sp.	Olouelé	Le	DGUO	Tri	nv, wat	Vr	5	7.14	0.07	1.00	1.00
Euphorbiaceae	*Alchornea cordifolia* (Schum.&Thonn.) Müll.Arg.	Ebuni	Le	DBHO, IDSSM	Inf	wat	Or	8	11.43	0.14	0.90	1.33
	Euphorbia candelabrum Welw.	-	Wp	M-M	np	-	-	1	1.43	0.01	0.00	1.67
	Euphorbia hirta (L.) Millsp.	Tsielatsina	Le, Ba	DSST, IPD, IDSSM	Tri, Mac	nv, wat	Fr, Or	7	10.00	0.13	0.75	2.00
	Manihot esculenta Crantz	Akuo / Ekuo	Le	IPD	Pou	nv	La	1	1.43	0.01	0.00	1.00
Fabaceae	*Albizia adianthifolia* (Schumach.) W.Wight	Olu	Le	TLP	Sof	nv	La	1	1.43	0.01	0.00	1.00
	Albizia zygia (DC) J.F.Macbr.	Nguulu	Ba	DDS	Inf	pw	Or	4	5.71	0.06	1.00	1.67
	Millettia versicolor Welw. ex Baker	Oboro	Ba	TLP	Tri	nv	Cat	4	5.71	0.06	1.00	1.67
	Senna alata (L.) Roxb.	Andu	Ro, St	IDSSM, IPD, DDS	Pou, Tri	wat, pw	Or	5	7.14	0.10	0.67	2.00
	Senna occidentalis (L.) Link	Nkalawala	Le, Ro, Sap, Le + Ro	IPD, IDSSM, DDS	Inf, Dec, Tri	wat, nv	Or, Fr	20	28.57	0.31	0.90	2.33
	Uraria picta (Jacq.) DC.	Magalie	Ro, Wp	MD, DGUO	Dig, Tri	nv	Or	23	32.86	0.36	0.96	2.33

Gnetaceae	*Gnetum africanum* Welw.	Mfumi	St	DDS	Mac	wat	Or	2	2.86	0.03	1.00	1.33
Hypericaceae	*Harungana madagascariensis* Lam. ex Poir.	Antsatsa	Le	M-M, DGUO	Cal, Tri	po, nv	La, Vr	8	11.43	0.11	0.86	1.33
	Psorospermum febrifugum Spach	Eninga	Le, Fr	DDS, IPD, DSST	Dig, Tri	nv	Or	14	20.00	0.20	0.85	2.00
Undetermined 1	Undetermined 1	Munâ	Rh	DDS	Lin	po	Rr	1	1.43	0.01	0.00	1.67
Lamiaceae	*Ocimum gratissimum* L.	Dzonandzon / Lumba lumba	Le	IDSSM, DRS, DNSO	Mac, Tri, Inf	wat, nv	La, Inh, Or, Eai	13	18.57	0.26	0.88	1.67
Malvaceae	*Grewia coriacea* Mast.	Oshui	Le, Ba	IDSSM, MD	Inf, Dec	wat	Or	3	4.29	0.04	0.50	2.00
	Sida acuta Burm.f.	Ngapala	Le	IDSSM, TLP, DOSMS	Mac, Tri	wat, nv	La, Mas	13	18.57	0.19	0.83	1.33
Marantaceae	*Trachyphrynium braunianum* (K. Schum.) Baker	Iban / Ngatsieré	Ro	IDSSM	Inf	wat	Or	4	5.71	0.06	1.00	1.67
Moraceae	*Trilepisium madagascariense* DC.	Ompo	Le	CPCP	Dec	wat	Or	3	4.29	0.04	1.00	1.00
Musaceae	*Musa × sapientum* L.	Kuo	Suc	M-M	Tri	nv	La	2	2.86	0.03	1.00	1.67
Myrtaceae	*Psidium guajava* L.	-	Le	IPD, IDSSM	Pou, Inf, Tri, Dig, Dec	wat, nv	Or	27	38.57	0.41	0.96	1.67
Olacaceae	*Ongokea gore* (Hua) Pierre.	Otru	Ba	MD, IDSSM, DDS	Dec, Inf, Mac	wat	Or	16	22.86	0.26	0.88	2.33
Phyllanthaceae	*Bridelia ferruginea* Benth.	Eko	Le, Ba, Ro	DDS, IDSSM, TLP, DBHO	Tri, Dec, Inf	nv, wat	Or, Stb, La	10	14.29	0.16	0.73	2.00
	Hymenocardia acida Tul.	Eweré	Ba	IPD	Inf	wat	Or	1	1.43	0.01	0.00	1.67
Poaceae	*Bambusa vulgaris* Schrad.	-	Le	IDSSM	Inf	wat	Or	1	1.43	0.01	0.00	1.00
	Eleusine indica (L.) Gaertn.	Etié	Wp, Le, Inf, Ro	IDSSM, IPD, TLP, DSST, M-M, DDS	Inf, Sof, Tri, Mac	wat, nv	Or, Mas, La, Stb, Cat, Sib	12	17.14	0.26	0.72	2.67
	Imperata cylindrica (L.) P.Beauv.	Atieré	Ro	IPD	Inf	wat	Or	3	4.29	0.04	1.00	1.67
Rubiaceae	*Gardenia ternifolia* Schum.Thom	-	Le	IPD	Mac	wat	Or	2	2.86	0.03	1.00	1.00
	Morinda lucida Benth.	Oshuo	Le, Ba	IDSSM, DDS,	Mac, Inf, Dec,	wat, nv	Or, Sib	14	20.00	0.23	0.73	2.67

				MD, CPCP, IPD	Dig							
	Nauclea latifolia Sm.	Obuabuo	Le, Ro, Ba + Ro, Fr, St	IDSSM, IPD, DOSMS, MD, DBHO, DGUO, DDS, DCS	Dec, Inf, Dig, Tri	wat, pw, nv	Or, Stb, Rr	46	65.71	1.00	0.91	3.00
	Spermacoce sp.	-	Le	IPD	Tri	nv	Eyi	2	2.86	0.03	1.00	1.00
Simaroubaceae	*Quassia africana* (Baill.) Baill.	Kinkia/Opompon	Le, Ro	IDSSM, MD	Inf, Mac	wat, pw	Or, Sib	6	8.57	0.09	0.80	2.00
Solanaceae	*Nicotiana tabacum* L.	Aké	Le	DRS, DDS	Cal	nv	Ni, Or	4	5.71	0.07	0.75	1.33
	Schwenckia americana L.	Uyuya	Wp	IDSSM	Inf	wat	Or	5	7.14	0.07	1.00	1.67
	Solanum lycopersicum L.	-	Le	DDS, DOSMS	Tri	nv	Rr	2	2.86	0.03	0.00	1.33
	Solanum villosum Mill.	Ompoko	Wp	CPCP	Mac	wat	Or	3	4.29	0.04	1.00	1.67
Urticaceae	*Musanga cecropioides* R.Br.	Osié	Sep, Le	CPCP, IPD	Dig, Dec	nv, wat	Or	3	4.29	0.04	0.50	2.00
Vitaceae	*Cissus aralioides* (Baker) Planch.	Elubé	Wp, Le, St, Fr	DOSMS, DGUO	Lin, Tri, Dec	po, nv, wat	La, Mas, Cat, Or	20	28.57	0.29	0.95	2.33
Zingiberaceae	*Aframomum stipulatum* K.Schum.	Antunu	Le	DDS, IDSSM	Mac, Dec	wat	Or, Bb	5	7.14	0.07	0.75	1.33
	Zingiber officinale Roscoe	-	Rh	DDS	Pou	wat	Or	1	1.43	0.01	0.00	1.67

Legend: Part used: Ba = Bark, Fr = Fruit, Inf = Inflorescence, Le = leaf, Rh = Rhizome, Ro = Root, Sap = Sap, Se = Seed, Sep = Sepal, St = Stem, Suc = Sucker, Wp = Whole plant. Preparations: Cal = Calcination, Dec = Decoction, Dig = Digestion, Infusion = Inf, Lin = Liniment, Mac = Maceration, np = No preparation, Pou = Pounding, Sof = Softening, Tri = Trituration. Vehicles: nv = No vehicle, po = Palm oil, pw = Palm wine, pd = red wine, wat = water. Routes: Bb = Body bath, Cat = Cataplasm, Eai = Ear instillation, Eyi = Eye instillation, Fr = Friction, Inh = Inhalation, Mas = Massage, Ni = Nasal instillation, Or = Oral ingestion, Rr = Rectal route, Sib = Sitz bath, Stb = Steam bath, Vr = Vaginal route.

Biodiversity indexes

Biodiversity indices (Table 4) show that the medicinal flora is diversified and the distribution of citations by species is homogeneous. Jaccard's similarity coefficient, ranging from 68.52% to 70.97%, shows that the three companies depend on the same plants to cover their health needs.

Table 4. Medicinal flora diversity indices

Indices	Banga	Edzouala	Mpoh	Average ± ES
Shannon (H')	3.52	3.51	3.45	3.49±0.02
Maximum diversity (H'_{max})	3.83	3.81	4.11	3.91±0.10
Pielou (P)	0.92	0.92	0.84	0.89±0.03

Sociodemographic profile

The number of informants in the present study was 70 individuals. These 70 people are distributed at the rate of 12.86% in Banga, 22.86% in Edzouala and 64.29% in Mpoh. In terms of gender, 67.14% of respondents were male compared to 32.86% female. Individuals aged between 26 and 35 are the most numerous (27.14%), while the other age groups of 15 to 25, 36 to 45 and those over 45 each represent 24.29 % of the workforce. Married people are the most represented with 57.14%, followed by singles and finally widowed people. Overall, 91.43% of respondents are nationals compared to 8.57% foreigners, all from the Democratic Republic of Congo. The vast majority of respondents are from the Téké ethnic group (58.57%) and indigenous (28.57%) followed by other ethnic groups with a total of 12.86% of the workforce. As for socio-professional activities, most of the people interviewed are multi-active. Cultivators come first with 91.40%, followed by gatherers (15.70%) and hunters/fishermen (11.40%), while the other activities each represent less than 16% of the workforce.

Degree of consensus among informants on groups of pathologies treated

There was a high degree of consensus among respondents on the target therapeutic indications for medicinal flora (Table 5). Informants use more than one medicinal plant for several therapeutic indications, the use of which is valid for all. In the specific case of diseases of the circulatory system, only *Nauclea latifolia* Sm. is cited by all respondents.

Table 5. Informant consensus factor for therapeutic indications

Therapeutic indications	Nur	Nt	ICF
Complications of pregnancy, childbirth and the post-partum period	14	5	0.69
Traumatic injuries and poisoning	72	11	0.86
Diseases of the skin and subcutaneous cellular tissue	23	8	0.68
Diseases of the circulatory system	3	1	1.00
Diseases of the digestive system	65	20	0.70
Diseases of the respiratory system	7	2	0.83
Diseases of the genitourinary system	49	9	0.83
Diseases of the blood and hematopoietic organs	13	3	0.83
Diseases of the nervous system and sense organs	6	2	0.80
Diseases of the osteoarticular system, muscles and connective tissue	45	8	0.84
Infectious and parasitic diseases	133	23	0.83
Medicinal effects	51	10	0.82
Ill-defined symptoms, signs and conditions	159	27	0.84
Mental disorders	38	9	0.78

Importance of using medicinal plants

The use value of medicinal plants ranges from 0.01 to 1. *Nauclea latifolia* Sm. is the medicinal plant with the highest use value in the study area (Table 3). This use value quantifies its importance in the communities investigated. *Chromolaena odorata* (L.) R.M.King & H.Rob. (0.54) and *Dysphania ambrosioides* (L.) Mosyakin & Clemants (0.49) are two other plants of proven importance. The other species, whose use value is very low, appear to be of little importance in the community. The medicinal virtues associated with this group of plants are less well known to the respondents.

The informants' consensus factor varies from 0 to 1. Table 3 shows that 28.12% of species have a consensus of use in the traditional pharmacopoeia of the communities surveyed. These include: *Monodora myristica* (Gaertn.) Dunal*, Stomatanthes africanus* (Oliv. & Hiern) R.M. King & H. Rob*., Tetracera* sp., *Schwenckia americana* L., *Albizia zygia* (DC) J.F.Macbr., *Millettia versicolor* Welw. ex Baker, *Trachyphrynium braunianum* (K. Schum.) Baker, *Laccosperma secundiflorum* (P.Beauv.) Kuntze, *Dacryodes edulis* (G.Don) H.J.Lam., *Cucurbita* sp., *Trilepisium madagascariense* DC., *Imperata cylindrica* (L.) P. Beauv., *Solanum villosum* Mill., *Canna indica* L., *Gnetum africanum* Welw., *Musa × sapientum* L., *Gardenia ternifolia* Schum.Thom, *Spermacoce* sp.; In addition, 54.69% of species are distinguished by an average or even near-average consensus of phytotherapeutic use. This cohort includes: *Psidium guajava* L., *Uraria picta* (Jacq.) Desv. ex DC., *Cissus aralioides* (Baker) Planch., *Annona senegalensis* Pers., *Dysphania ambrosioides* (L.) Mosyakin & Clemants, *Gymnanthemum amygdalinum* (Delile) Sch.Bip., *Chromolaena odorata* (L.) R.M.King & H.Rob., *Nauclea latifolia* Sm., *Costus afer* Ker Gawl., *Senna occidentalis* (L.) Link, *Tithonia diversifolia* (Hemsl.) A. Gray, *Alchornea cordifolia* (Schum.&Thonn.) Müll.Arg., *Ocimum gratissimum* L., *Ongokea gore* (Hua) Pierre, *Carica papaya* L., *Harungana madagascariensis* Lam. ex Poir., *Psorospermum febrifugum* Spach, *Bidens pilosa* L., *Sida acuta* Burm.f., *Floscopa* sp., *Quassia africana* (Baill.) Baill., *Drymaria cordata* (L.) Willd. ex Schult., *Garcinia kola* Heckel, *Erigeron floribundus* (Kunth) Sch.Bip., *Euphorbia hirta* (L.) Millsp., *Ageratum* conyzoides L., *Nicotiana tabacum* L., *Aframomum stipulatum* K.Schum., *Morinda lucida* Benth., *Bridelia ferruginea* Benth., *Eleusine indica* (L.) Gaertn., *Senna alata* (L.) Roxb., *Acanthus montanus* (Nees) T.Anderson, *Grewia coriacea* Mast., *Musanga cecropioides* R.Br.. The remainder (17.19%) of the taxa do not meet the consensus of the communities investigated.

Fidelity levels show a high degree of consensus in the use of taxa associated with treatment indications:

- Medico-magical effects: *Acanthus montanus* (Nees) T.Anderson, *Emilia coccinea* G.Don, *Eleusine indica* (L.) Gaertn., *Harungana madagascariensis* Lam. ex Poir., *Euphorbia candelabrum* Welw.;
- Diseases of the digestive system: *Aframomum stipulatum* K.Schum., *Albizia zygia* (DC) J.F.Macbr., *Cucurbita* sp., *Gnetum africanum* Welw., Undetermined 1, *Senna alata* (L.) Roxb., *Stomatanthes africanus* (Oliv. & Hiern) R.M. King & H. Rob., *Zingiber officinale* Roscoe;
- Diseases of the skin and subcutaneous cellular tissue: *Ageratum conyzoides* L., *Drymaria cordata* (L.) Willd. ex Schult., *Dysphania ambrosioides* (L.) Mosyakin &Clemants;
- Diseases of the blood and blood-forming organs: *Alchornea cordifolia* (Schum.&Thonn.) Müll.Arg.;
- Traumatic injuries and poisoning: *Annona senegalensis* Pers., *Albizia adianthifolia* (Schumach.) W.Wight., *Chromolaena odorata* (L.) R.M.King & H.Rob., *Elaeis guineensis* Jacq., *Millettia versicolor* Welw. ex Baker, *Tithonia diversifolia* (Hemsl.) A. Gray;
- Ill-defined symptoms, signs and disease states: *Carica papaya* L., *Eleusine indica* (L.) Gaertn., *Grewia coriacea* Mast., *Bambusa vulgaris* Schrad., *Chlorophytum* sp., *Drymaria cordata* (L.) Willd. ex Schult., *Ocimum gratissimum* L., *Schwenckia americana* L., *Trachyphrynium braunianum* (K.Schum.) Baker;
- Diseases of the osteoarticular system, muscles and connective tissue: *Cissus aralioides* (Baker) Planch., *Erigeron floribundus* (Kunth) Sch.Bip.;
- Infectious and parasitic diseases: *Carica papaya* L., *Costus afer* Ker Gawl., *Euphorbia hirta* (L.) Millsp., *Floscopa* sp., *Gardenia ternifolia* Schum.Thom, *Hymenocardia acida* Tul., *Imperata cylindrica* (L.) P. Beauv., *Manihot esculenta* Crantz, *Psidium guajava* L., *Psorospermum febrifugum* Spach, *Spermacoce* sp.;
- Complications of pregnancy, childbirth and the post-partum period: *Musanga cecropioides* R.Br., *Floscopa* sp., *Solanum villosum* Mill., *Trilepisium madagascariense* DC.;
- Diseases of the respiratory system: *Nicotiana tabacum* L.;
- Diseases of the genitourinary organs: *Uraria picta* (Jacq.) Desv. ex DC., *Laccosperma secundiflorum* (P. Beauv.) Kuntze, *Tetracera* sp..

Vulnerability of medicinal taxa

A total of 39.06% of species have a vulnerability index greater than or equal to 2.00. These species form the group of taxa classified as vulnerable (Table 3). Of these 25 species, 5 are highly vulnerable (IVi ≥ 2.5), namely: *Nauclea latifolia* Sm., *Dysphania ambrosioides* (L.) Mosyakin & Clemants, *Garcinia kola* Heckel, *Eleusine indica* (L.) Gaertn. and *Morinda lucida* Benth.. 60.94% of species appear to be slightly vulnerable. The main cause is the method of collection, with 57.81% of species being felled or uprooted, or even completely debarked.

Organs used in traditional pharmacopoeia

In all the communities surveyed, the part most used in recipe preparation is unanimously the leaf (Table 6). The other parts used do not command the same sympathy from informants. In Banga, leaves are followed, in descending order of importance, by the whole plant (88.89%), roots and bark (66.67%). In Edzouala, roots (81.25%), bark (75%) and the whole plant (56.25%) are the most important. In Mpoh, leaves are followed by roots (91.11%), whole plant (62.22%) and stem (42.22%). The Chi-square test (p-value = 0.799) shows that the use of the various organs does not depend on the communities surveyed.

Table 6. Frequency of organs used in traditional pharmacopoeia

Parts used	Banga		Edzouala		Mpoh		Average	
	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)
Leaf	9	100.00	16	100.00	44	97.78	23.00	99.26
Root	6	66.67	13	81.25	41	91.11	20.00	79.68
Whole plant	8	88.89	9	56.25	28	62.22	15.00	69.12
Bark	6	66.67	12	75.00	17	37.78	11.67	59.82
Stem	5	55.56	4	25.00	19	42.22	9.33	40.93
Seed	2	22.22	5	31.25	7	15.56	4.67	23.01
Fruit	1	11.11	2	12.50	8	17.78	3.67	13.80
Sap	0	0.00	0	0.00	5	11.11	1.67	3.70
Sucker	0	0.00	1	6.25	1	2.22	0.67	2.82
Rhizome	0	0.00	0	0.00	2	4.44	0.67	1.48
Sepal	1	11.11	0	0.00	1	2.22	0.67	4.44
Inflorescence	0	0.00	0	0.00	1	2.22	0.33	0.74

Recipe preparation methods and vehicles

Trituration, infusion and decoction are the preparation methods most commonly used in the design of phytomedicines on a global scale. The same is true of the communities investigated. However, maceration has a significant share in Banga (77.78%) and Edzouala (62.50%) (Table 7). The Chi-square test (p-value = 0.494) reveals that recipe preparation methods do not depend on the communities surveyed.

Table 7. Frequency of recipe preparation methods

Preparation methods	Banga		Edzouala		Mpoh		Average	
	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)
Trituration	8	88.89	16	100.00	40	88.89	21.33	92.59
Infusion	9	100.00	10	62.50	33	73.33	17.33	78.61
Decoction	6	66.67	7	43.75	27	60.00	13.33	56.81
Digestion	4	44.44	9	56.25	20	44.44	11.00	48.38
Maceration	7	77.78	10	62.50	12	26.67	9.67	55.65
Pilage	3	33.33	3	18.75	8	17.78	4.67	23.29
Softening	1	11.11	3	18.75	10	22.22	4.67	17.36
Calcination	2	22.22	6	37.50	3	6.67	3.67	22.13
Liniment	3	33.33	2	12.50	6	13.33	3.67	19.72
No preparation	1	11.11	0	0.00	1	2.22	0.67	4.44

In terms of vehicles used to prepare recipes, water (97.14%) is the main solvent for extracting active ingredients, both globally and within communities (Table 8). Palm oil ranks second, ahead of palm wine and red wine. However, the majority of informants (84.29%) do not use solvents for phytotherapeutic preparations. The Chi-square test (p-value = 0.341) shows that vehicles are not dependent on the communities surveyed.

Table 8. Frequency of use of vehicles in potions

Preparation vehicles	Banga		Edzouala		Mpoh		Moyenne	
	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)
Water	9	100.00	16	100.00	42	93.33	22.33	97.78
Palm oil	9	100.00	13	81.25	37	82.22	19.67	87.82
No vehicle	4	44.44	4	25.00	9	20.00	5.67	29.81
Palm wine	3	33.33	6	37.50	3	6.67	4.00	25.83
Red wine	1	11.11	0	0.00	1	2.22	0.67	4.44

Routes of administration and revenue targets

A total of 14 modes of administration were recorded. In first place was oral ingestion (per os) with 92.86% of respondents, followed by local application (65.71%), friction (32.86%) and ocular instillation (28.57%). This trend, which emerged at the global level of the survey, is also valid at the level of traditional communities. As for the other routes of administration of phytomedicines, with less than 25% of respondents survey-wide, they appear to be occasional (Table 9). The Chi-square test (p-value = 0.494) indicates that the ways in which the recipes are administered are independent of the farming communities.

Table 9. Frequency of revenue administration channels

Method of administration	Banga		Edzouala		Mpoh		Average	
	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)
Oral ingestion	9	100.00	16	100.00	40	88.89	21.67	96.30
Local application	8	88.89	11	68.75	27	60.00	15.33	72.55
Friction	3	33.33	6	37.50	14	31.11	7.67	33.98
Eye instillation	3	33.33	6	37.50	11	24.44	6.67	31.76
Massage	4	44.44	3	18.75	7	15.56	4.67	26.25
Rectal route	0	0.00	4	25.00	10	22.22	4.67	15.74
Vaginal route	2	22.22	7	43.75	4	8.89	4.33	24.95
Body bath	2	22.22	2	12.50	4	8.89	2.67	14.54
Sitz bath	3	33.33	0	0.00	5	11.11	2.67	14.81
Cataplasm	2	22.22	2	12.50	4	8.89	2.67	14.54
Inhalation	1	11.11	1	6.25	6	13.33	2.67	10.23
Steam bath	3	33.33	0	0.00	3	6.67	2.00	13.33
Ear instillation	1	11.11	2	12.50	3	6.67	2.00	10.09
Nasal instillation	2	22.22	1	6.25	1	2.22	1.33	10.23

As for target populations, over 95% of informants mentioned recipes not specifically aimed at a given category, both within communities and on a global scale (Table 10). However, some recipes are gender-specific (men or women), or take account of an individual's physiological state (children, pregnant women or adults only). The Chi-square test (p-value = 0.464) shows that the categories of people targeted by the recipes are independent of communities.

Table 10. Frequency of recipe targets

Targets	Banga		Edzouala		Mpoh		Average	
	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)	FC	FRC (%)
All	9	100.00	16	100.00	44	97.78	23.00	99.26
Adults	8	88.89	7	43.75	26	57.78	13.67	63.47
Old	6	66.67	7	43.75	26	57.78	13.00	56.07
Men	4	44.44	9	56.25	19	42.22	10.67	47.64
Women	4	44.44	9	56.25	14	31.11	9.00	43.93
Children	7	77.78	4	25.00	9	20.00	6.67	40.93
Pregnant women	1	11.11	4	25.00	4	8.89	3.00	15.00

Diversity of respondents' knowledge of medicinal plants

The index of diversity of respondent knowledge (Table 11) highlights the importance of women in the Banga informant group. Indeed, women in the community have more knowledge of medicinal plants than men. In Edzouala, on the other hand, knowledge of therapeutic indications is homogeneous within the community. As for Mpoh, men outnumber women in terms of knowledge of the virtues associated with plants.

An analysis by age group reveals that the 15-25 and 45+ age groups have the most knowledge in Banga. Despite this observation, a homogeneity of knowledge is noted in the rest of the age groups. However, in Edzouala and Mpoh, 15-35 year-olds are the most knowledgeable, while a homogeneity is noted from age 35 onwards. This inversion could be due to cultural mixing, or even the appropriation of the specificities of neighboring cultural bases. With the exception of Mpoh, where the natives dominate the other ethnic groups, the sum of endogenous knowledge distinguishes the Teke throughout the region. Over the entire study region, Tékés knowledge is below that of the indigenous peoples. Finally, the distribution of knowledge within ethnic groups is very homogeneous.

Table 11. Diversity of medicinal plant knowledge within communities

Categories	Informants	Banga		Edzouala		Mpoh		Average	
		ID	IE	ID	IE	ID	IE	ID	IE
Genre	Female	2.21	0.86	2.40	0.93	1.98	0.80	2.20	0.86
	Male	1.90	0.79	2.21	0.86	2.26	0.86	2.12	0.84
Age range	15 - 25 years	2.02	0.88	2.07	0.90	2.30	0.90	2.13	0.89
	26 - 35 years	1.62	0.83	2.31	0.93	2.08	0.84	2.00	0.87
	36 - 45 years	1.66	0.85	2.03	0.92	2.15	0.90	1.95	0.89
	Over 45	2.41	0.94	2.05	0.89	2.18	0.85	2.21	0.89
Ethnic group	Native	0.00	0.00	1.96	0.89	2.38	0.93	1.45	0.61
	Gangulu	0.00	0.00	0.00	0.00	1.86	0.96	0.62	0.32
	Koongo	0.00	0.00	0.00	0.00	1.95	0.94	0.65	0.31
	Luba	0.00	0.00	1.56	0.97	0.00	0.00	0.52	0.32
	Mbochi	1.97	0.86	0.00	0.00	0.00	0.00	0.66	0.29
	Ngala	0.00	0.00	2.22	0.97	0.00	0.00	0.74	0.32
	Téké	2.13	0.83	2.32	0.90	2.04	0.79	2.16	0.84

Correlation between therapeutic indications and organs used

The correlation matrix (Figure 5) shows that the bark-root combination is widely used in the treatment of diseases of the circulatory and digestive systems; ill-defined symptoms, signs and disease states; diseases of the osteoarticular system; muscles and connective tissue. The leaves are often used in the treatment of infectious and parasitic diseases, traumatic lesions and poisoning; ill-defined symptoms, signs and disease states, as well as diseases of the osteoarticular system. The use of fruit is important in the therapy of diseases of the digestive and circulatory systems; symptoms, signs and ill-defined morbid states, diseases of the osteoarticular system, muscles and connective tissue. The populations surveyed make extensive use of bark in the treatment of mental disorders. Use of the whole plant is mainly associated with medicinal and magical practices, and with diseases of the skin and subcutaneous cellular tissue. The roots are mainly used to treat diseases of the circulatory and digestive systems, ill-defined symptoms, signs and conditions, and diseases of the osteoarticular system, muscles and connective tissue. The sepals are used for complications of pregnancy, childbirth and the aftermath of childbirth. The stem is used to treat diseases of the skin and subcutaneous cellular tissue.

Discussion

Floristic and ethnophytogeographic analysis

The strong presence of Fabaceae, Euphorbiaceae and Rubiaceae in the useful flora indicates that the floriculture studied belongs to the tropical region of Central Africa (Kimpouni 2009, 2017, Kimpouni *et al.* 2021, Gnagne *et al.* 2017). The plants used in traditional pharmacopoeia are predominantly indigenous, a trait that reflects a close link between the dependence of communities and the surrounding flora (Kimpouni *et al.* 2018). The medicinal flora, similar for all the traditional communities studied, is a unanimous recognition of the associated virtues. This observation is evidence highlighting the common exploitation of the same ecosystems. Moreover, this observation may be due to the predominance of the Téké and Atswa (indigenous) ethnic-linguistic groups, who share the same cultural base (Bouquet 1969). Although mainly indigenous, the non-negligible allochthonous portion of plants with therapeutic properties could justify the introduction, as a result of intra- and transcontinental migrations of populations, of mores extrinsic to the sociocultural base (Kimpouni *et al.* 2017a). Indeed, the choice of these taxa that have become subspontaneous, for the most part, is guided by economic and cultural factors (Fleury 1994). The latter fact authenticates the recognition of the medicinal virtues of most of the plants cited in this study by other traditional communities sharing their geographical range (Bouquet 1969, Nzuki Bakwayé *et al.* 2013, Miabangana & Hondjuila Miokono 2016, Kimpouni *et al.* 2018, 2019, Rivero-Guerra 2021, Obilela *et al.* 2022). Despite the fact that the virtues of plants are exploited for the same, therapeutic purpose, this analogy of pharmaceutical use should not obscure the particularities that are the foundation of belonging to the sociocultural base.

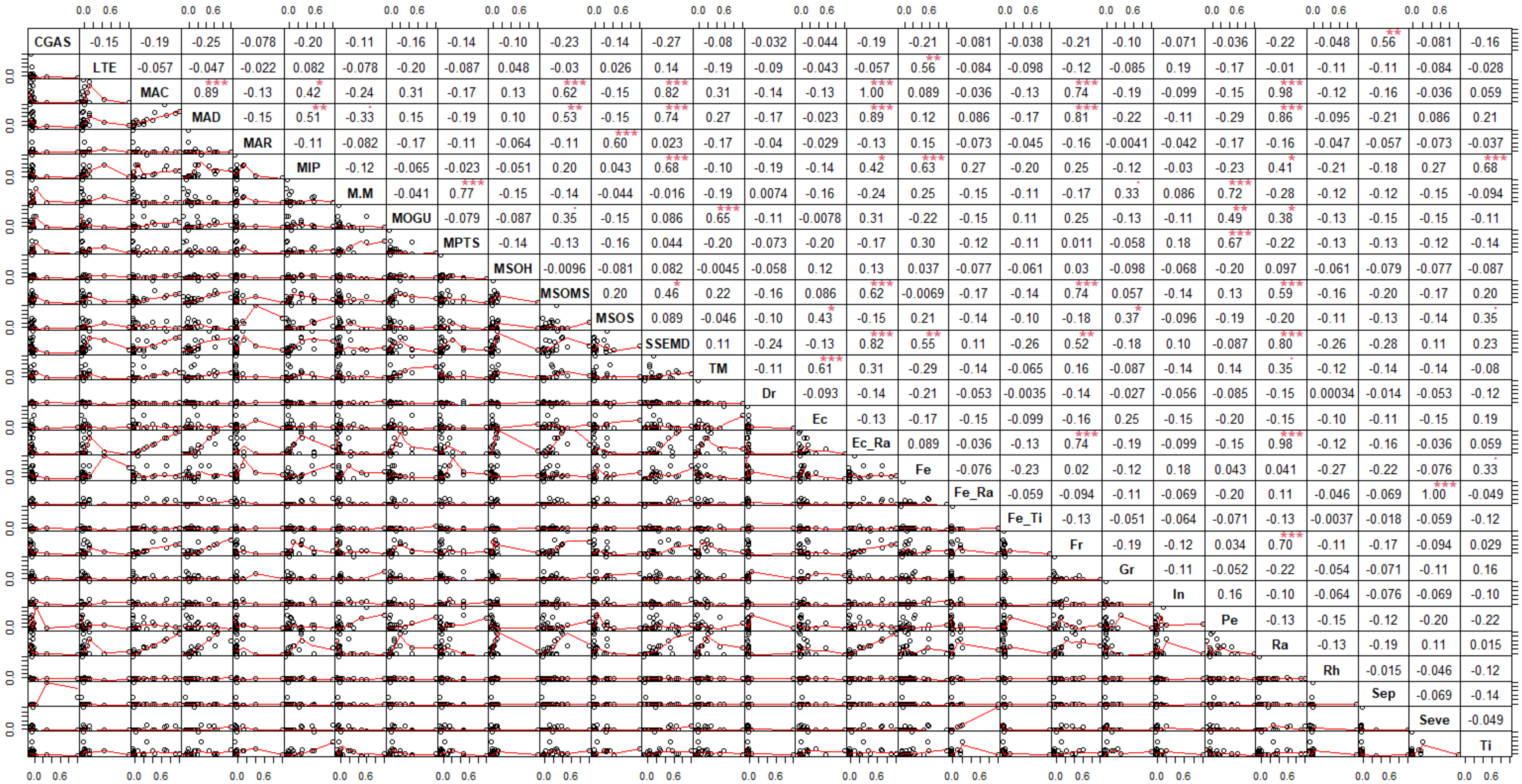

Figure 5. Correlations between therapeutic indications and organs used

Analysis of medicinal use

Many of the recipes cited are identical across Africa, indicating the overall effectiveness of most recipes in treating the diseases and symptoms encountered (Bouquet 1969, Kimpouni *et al.* 2019, Ngbolua *et al.* 2019, Bassène *et al.* 2020). The spectrum of diseases and symptoms treated highlights ill-defined symptoms, signs and morbid states, as well as infectious and parasitic diseases. The predominance of these therapeutic indications is associated with precarious hygiene and sanitation conditions, a source of contamination and food poisoning (Kimpouni *et al.* 2012, 2019, Bokatola Moyikola 2013). Indeed, as the populations of Banga, Edzouala and Mpoh do not have access to drinking water, they consume unsuitable water, stagnating in rare, poorly permeable soils or stored in containers. In addition to this water, people also use the raw sap of plants such as *Tetracera alnifolia* Willd. or *Musanga cecropioides* R.Br., collected in unhygienic conditions.

Nauclea latifolia Sm. is the most important species in the site's communities, as it is used in a number of therapeutic indications. It is also the only species listed for the treatment of circulatory diseases. The importance of its use is not specific to the communities of the Léfini reserve, but an African reality due to the many known therapeutic properties of its range (Badiaga 2011, Kimpouni *et al.* 2018, 2019). All these therapeutic indications meet with a high degree of consensus among informants. The reason is the existence of diseases or symptoms in the community, but also because of the knowledge of a range of useful plants that can help treat them.

The interest shown in leaves and roots by all communities is explained by the fact that these organs are the site par excellence for the biosynthesis and/or storage of secondary metabolites, responsible for pharmacological properties (Doussou *et al.* 2012). In addition, the high frequency of use of these organs is as much due to the ease of harvesting, in the context of a forest-savanna-crop-fallow mosaic (Doussou *et al.* 2012, Gnagne *et al.* 2017, Kimpouni *et al.* 2019, Ngbolua *et al.* 2019).

The importance of trituration and digestion is based on the fact that these processes would enable natural extracts to be obtained, without any trace of solvent, for which all the compounds, even the most fragile, would be preserved. The considerable interest shown in infusion and decoction, and all other processes involving heat (catalyst), would have the advantage of warming the body, disinfecting the plant, collecting more active principles from the organs, and attenuating or cancelling out the toxicity associated with the recipes (Logbo *et al.* 2019). The majority of recipes are administered per-os (oral route) or by local application. The administration of recipes by oral ingestion is said to result from the fact that most of the diseases or symptoms treated are internal, and the route through the digestive tract facilitates blood assimilation of the drugs (Adjanohoun *et al.* 1988, Gnagne *et al.* 2017, Kimpouni *et al.* 2019).

Availability of medicinal taxa

In the context of everyday use, due to their various virtues, *Nauclea latifolia Sm., Dysphania ambrosioides* (L.) Mosyakin & Clemants*, Garcinia kola* Heckel*, Eleusine indica* (L.) Gaertn*.* and *Morinda lucida* Benth*.* constitute the bulk of the area's most vulnerable taxa. Generally speaking, the degree of disturbance to a species' population and its vulnerability depends on demand, supply, parts used and type of growth (Cunningham 1996, Traoré 2011). Notwithstanding the negligible impact of leaf removal on plant vulnerability, the removal of generative organs (fruits, flowers, seeds), stump removal, uprooting, debarking and felling of all or part of the stem apparatus have a negative impact on the regeneration and physiology of the taxa removed (Kimpouni *et al.* 2020, Ouattara *et al.* 2021).

Apart from the strict harvesting of species for therapeutic purposes, human predatory action on ecosystems contributes to the eradication of taxa not adapted to new environmental conditions (Bergonzini & Lanly 2000, Kimpouni *et al.* 2013, 2018, 2020). Among the key factors responsible for the modification or even degradation of ecosystems are bushfires, deforestation associated with slash-and-burn agriculture, demographic pressure on agricultural land, and so on.

Diversity of knowledge

Knowledge of useful plants in the northern sector of the Léfini reserve comes mainly from family members, through observation and initiation. This shows that empirical knowledge is transmitted not only for the sake of preserving the knowledge specific to a particular group, but also for the preservation and perpetuation of ancestral practices by future generations (Bouquet 1969, Orch *et al.* 2015). Women are said to hold more knowledge of the medicinal virtues of plants than men. The basis for this observation is linked to the social role of women in traditional communities. Due to tradition, women are the guarantors of children's health and education, and are at the center of all activities related to the family's well-being (Bouquet 1969, Kimpouni *et al.* 2017b). Knowledge is diversified for all age groups and significantly better for those aged 45 and over; demonstrating that knowledge transmission is effective from generation to generation. Among ethnic groups, the Tékés and indigenous people, originally from the localities studied, are more knowledge-rich and more inclined to perpetuate ancestral knowledge. Knowledge specific to introduced taxa from the area of origin of allochthonous ethnic groups is an authentication of the confirmation of ethnic-linguistic mixing (Kimpouni *et al.* 2017b, 2019).

Conclusion

The study focuses on improving knowledge of medicinal plants in the northern sector of the Léfini reserve. The research is based on two inventories, floristic and ethnobotanical, which have shown the intimacy between man and his environment. The floristic analysis reveals a high degree of diversification and homogeneity of distribution, in relation to therapeutic uses, within the three traditional communities (Banga, Edzouala and Mpoh). The fine-tuning of the floristic analysis of medicinal plants indicates the integration of exotic knowledge into the sociocultural base, and even of new knowledge unknown in the area of origin. To meet their primary healthcare needs, traditional communities exploit the flora that is readily available and thrives in all ecosystems. These facts point to a uniqueness in the exploitation and use of flora for therapeutic purposes, within the socio-cultural groups of the investigated area.

Despite the pressure of the mundane on the socio-cultural base of traditional societies, populations remain attached to the parsimonious management of the virtues associated with plants. This is not only the result of their own experience, but also of ancestral habits handed down from generation to generation. In the traditional communities of the northern sector of the Léfini reserve, empirical knowledge is still alive and well, and is safeguarded to meet the daily needs of the local population.

In terms of therapeutic scope, traditional communities in the northern sector of the Léfini reserve use the power of plants to treat ailments affecting all spheres of illness and symptoms. Despite the wide spectrum of ailments involved, infectious diseases and parasitosis top the list. This observation is synonymous with precarious hygiene conditions, which remain a source of concern for the societies surveyed. The populations unanimously admit to drawing on plants to cover their primary health care needs, while recognizing the specificity of each taxon for each sphere of disease.

Given the vulnerability of prized taxa and the state of degradation of natural ecosystems, endogenous knowledge is bound to disappear. Notwithstanding this eventuality, domestication can be seen as a desire for the sustainability of taxa, the corollary of which is the perpetuation of endogenous knowledge. However, since culture is almost exclusively focused on indigenous taxa, anthropic pressures are a factor in the erosion of ancestral knowledge.

Declarations

List of abbreviations: Not applicable.

Ethics approval and consent to participate: The purpose of the study was explained to the community members interviewed, and they were asked to give an explicit oral consent. The study adheres to the Nagoya Protocol under the Convention on Biological Diversity, ensuring fair and equitable benefit sharing.

Consent for publication: Not applicable.

Availability of data and materials: The data was not deposited in public repositories.

Competing interests: The authors do not have any competing interests.

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Authors' contributions: VK: Conceptualization, Methodology, Supervision, Validation. GBB, JCM and MM: Methodology, Data collection, Interviews, Writing–original draft. OCTBN: Data curation, Formal analysis, Writing–original draft. All authors read, reviewed and approved the final version of the manuscript.

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