Ethno-botanical survey of medicinal plants species traditionally used for the treatment of diseases in Kasangulu Territory, DRC

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Abstract

In Africa, much knowledge is lost due to lack of transmission, which does not promote resource conservation by local populations. It is therefore obvious to assess people's knowledge on the importance of resources to develop conservation and sustainable management strategies. This study was conducted to identify medicinal plants used in traditional medicine to treat common diseases in the Kasangulu Territory of the Democratic Republic of the Congo. To achieve this objective, an ethnobotanical survey was carried out through an open-ended questionnaire that was administered to herbal therapists in the local language to obtain more reliable informations. Some ethnobotanical parameters have been compiled for the identified medicinal plants. A total of 66 species belonging to 33 families and 59 genera have been recorded. The results showed that married and unmarried people have a shared medicinal knowledge, with a slight priority for the married. Sterility is the predominant disease with a rate of 15%. The leaf is the most commonly used organ and the infusion is the most common method of preparation in traditional medicine. There is a predominance of mesophanerophytes and pantropical. Bushfires and agricultural practices are increasing the pressure on medicinal resources, which is believed to be at the root of the loss of some more vulnerable species. There is an urgent need for a sustainable management approach to safeguard and preserve these plant species. This study of the medicinal plants used in Kasangulu constitutes a reservoir of information that contributes to build knowledge to protect the medicinal flora and safeguard local popular know-how.

Keywords: Traditional healers, medicinal plants, folk medicine, biodiversity, sustainable management

INTRODUCTION

In African countries, much endogenous knowledge is lost due to the lack of transmission, which does not allow local populations to promote resource conservation. Therefore, there is an urgent need to assess the population's knowledge on the resource importance in order to develop conservation and sustainable management strategies (Ghislain *et al.*, 2007). Furthermore, the World Health Organization (WHO) reported a high rate of dependence of Africans on traditional medicine for primary health care. The socio-economic benefits of the use of this medicine are that they allow the treatment of various diseases at once, thus the need of developing this medicine (Nbgolua *et al.*, 2019; Inkoto *et al.*, 2018; Muthu *et al.*, 2006). The Democratic Republic of Congo (DRC) constitutes a real rich and highly diverse reservoirs of biodiversity allowing it to be a privileged place amongst the countries of the Congo Basin, in which the traditional know-how is based on the use of medicinal plants (Inkoto *et al.*, 2018; Asimonyio *et al.*, 2015; Ngbolua *et al.*, 2016). Yet, a literature research in phytotherapy indicated that data on medicinal plants in the DRC is very fragmented and dispersed (Katemo *et al.*, 2012). Moreover, the accelerated human destruction of natural areas is making it increasingly difficult to conserve these plant genetic resources. Several studies have been carried out on the inventory of medicinal plants used in the treatment of several ailments in traditional medicine throughout the DRC, precisely in Kinshasa, Bikoro (Equateur amongst Pygmies), South Kivu and Gbado-Lite (Ngbolua *et al.*, 2016; Ilumbe *et al.*, 2014). The general objective of this study is to valorize medicinal plants used in traditional Congolese medicine in Kongo Centrak province, precisely in Kasangulu city. The specific objectives are to conduct an ethnobotanical survey of the population to inventory the plants used in the treatment of different diseases in this region, identify the ecological characteristics of each listed species, identify the medicinal plant use agreement factor and identify the informant consensus factor in the use of these medicinal plants.

METHODS

Study area

The Territory of Kasangulu is located in Kongo Central Province, between 4° and 6° south latitude and 12 and 16° east longitude over a 53,920 km^2 area. Kongo Central has a tropical Sudanese type climate, which is subdivided into two types: the first that extends along the coast, is a steppe type climate having a high variability which lasts four months (from May 15 to September 15), while the other type of climate lasts eight months. The Lower River is an area where the risk of drought is very high and we can observe off the coast an ecological

niche of Mangrove. In the coastal zone, the minimum temperature can be between 15 and 17°C while the maximum is 27°C (Kalombo *et al*., 2016).

Field studies

Ethno-botanical information on the different species inventoried in this study was obtained by interviewing traditional practitioners and medicinal plant suppliers in Kongo Central Province, specifically in the city of Kasangulu (Figure 1).

The fieldwork was conducted between December 2016 and May 2017. It consisted in surveying people with proven knowledge of traditional Congolese pharmacopeia. This survey made it possible to inventory and identify people using medicinal plants in the treatment of common diseases in Kasangulu. This study was carried out using an open-ended questionnaire that was interviewed by herbal therapists in the local language (Lingala) to obtain information that was too reliable. This questionnaire was divided into three sections: (i) personal information (name, age, sex, marital status, level of study) and reason for the use of traditional medicine; (ii) plant material (vernacular and scientific name of the plant); (iii) practice of traditional medicine (diseases treated, diagnosis of diseases, parts used in the plant, condition of the plant, methods of preparation and conservation of recipes, method of administration and dose of recipes, results of post-treatment care, knowledge of toxic plants in the study area).

The study followed the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Biology Department of the University of Kinshasa in accordance with the laws governing access to genetic resources, their derivatives, associated traditional knowledge and the fair and equitable sharing of benefits arising from their use in Democratic Republic of the Congo. Thus, all participants voluntarily agreed to be included in the study (free and informed consent).

Data processing and Data analysis

Microsoft Excel version 2010, SPSS version 20, and Origin version 8.5 Pro were used for data processing and analysis.

The voucher of collected plants was conserved and identified by comparing the samples with specimen conserved at Kinshasa University Herbarium. Scientific names were updated to currently accepted names according to the plant list (www.theplantlist.org), and the Angiosperm Phylogeny Group (APG IV) was consulted in order to update the family names (APG IV, 2016). In addition, the ecological spectra were determined using the classification of Raunkiaier (Raunkiaer, 1934) adapted for tropical Africa by Schmitz (Schmitz, 1988). The phytogeographical distribution types defined in this study were established using the work of Lebrun (Lebrun, 1947). The conservation status all recorded plant species was checked online using the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2019).

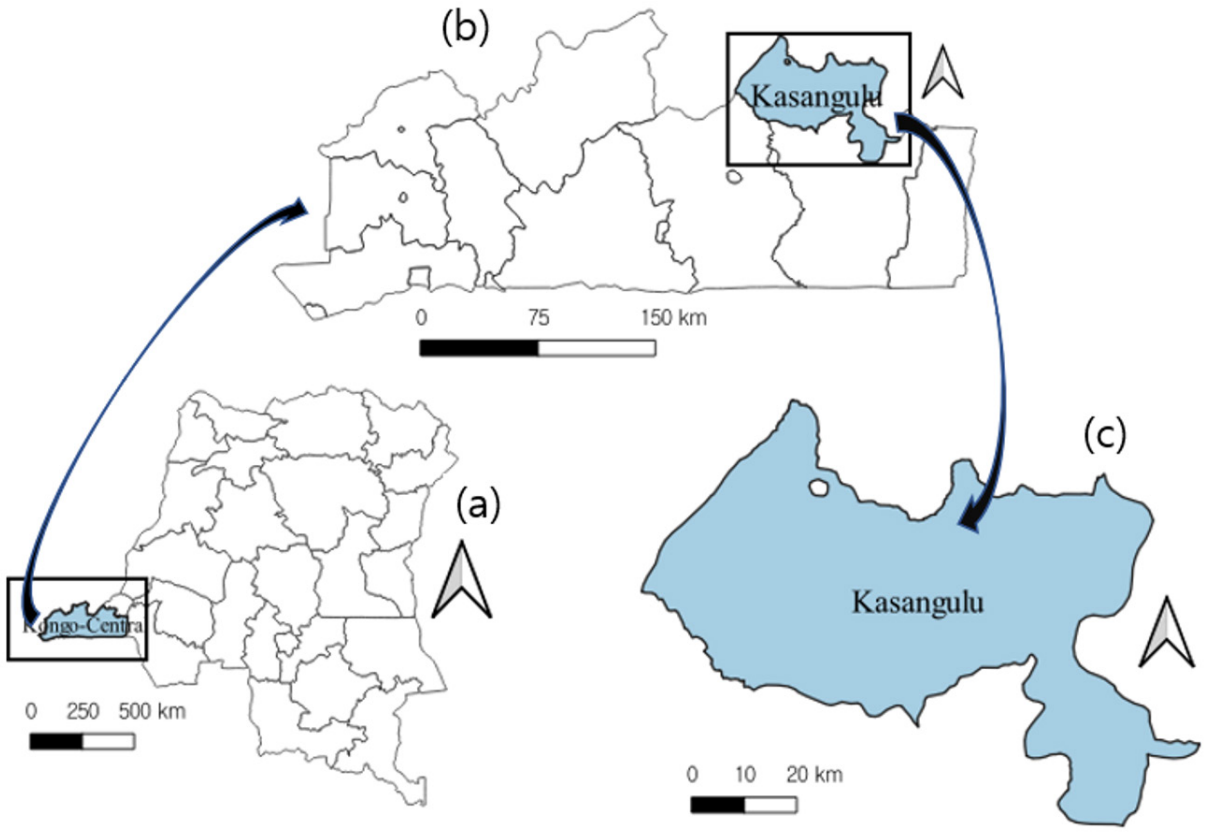

Figure 1: The location of the study area shows (a) the site in the Democratic Republic of Congo; (b) the study area in Kongo-Central Province; (c) the Kasangulu Territory

Voucher specimens were prepared and deposited in the herbarium of the Department of Biology (Faculty of Science, University of Kinshasa) under Prof Ngbolua collection name.

Quantitative data analysis

After the survey sheets were reviewed, several parameters were calculated such as the number of plant taxa, the number of citations, Informant Consensus Factor, Confirmation Index, Use Agreement Value (Ngbolua *et al.*, 2016; Ilumbe *et al.*, 2014). The Value of Agreement to Use (VAUs), an index for assessing the medicinal and cultural value of plants, has been calculated as previously reported.

$$VAU = UV \times IC \ (1) \ [\text{with } UVs = \frac{\sum_{i=1}^{n} Uis}{Ns} \ (2) \text{ and } ICs = \frac{Ni}{Nt} \ (3)]$$

Where UVs: use-value, ICs: confirmation index, Uis: the number of uses of the species cited by the informant, Ns: number of species, Ni: number of informants who cited this species, Nt: total number of informants. Value of use agreement is useful while identifying plants most commonly used (most frequently mentioned) in the treatment of a disease with a given informant (Ilumbe *et al.*, 2014).

Informant consensus factor (ICF) was obtained by using the formula:

$$ICF = \frac{nur - nt}{nur - 1} \text{ (Muthu } et\ al.\text{, 2006)}$$

Where n_{ur} is the number of citations and n_t is the number of plant species used for disease.

ICF is used to infer homogeneity in information on the use of a given plant to treat several diseases, and it ranges from 0 to 1. A high ICF value (nearly 1) means that a small number of plant species is cited by a large number of informants for a specific type of treatment (Lawal *et al.*, 2022).

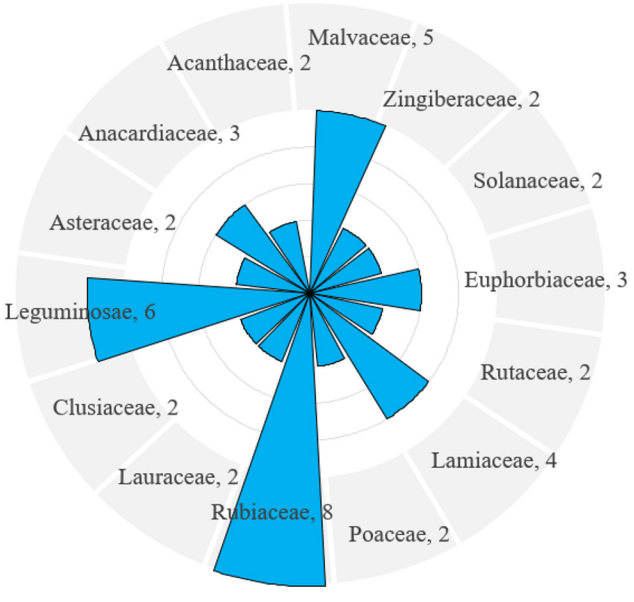

Figure 2: Medicinal plants diversity

Jaccard index (JI): studies conducted in other Territories of DRC and others from neighboring countries were compared with this study. It is calculated according to the presence or absence of the species (Faruque *et al.*, 2019).

$$JI = \frac{C \times 100}{A + B - C}$$

Where A is the recorded number of species of the present study, B is the number of species of another study, and C is the common number of species in A and B.

RESULTS AND DISCUSSION

Socio-demographic profile

Socio-demographics by age, gender, profession, education, marital status is summarized in Table 1.

Medicinal diversity of the listed plants and their ecological characteristics are shown in Figure 2, 3 and table 1.

Parts of the medicinal plants used, preparation method, and administration mode

Data on the use of the listed plants are shown in Figure 4.

Quantitative analysis

Data from the quantitative analyses including the UV, ICs, VAUs, ICF, JI are shown in Tables 3 and 4.

A total of 50 informants including traditional healers, housewives, state employees, lectures, and students were interviewed comprised 58 % of males and 42% of females in the age range from 18-73 years old, with 82% under 50 years old. From the total respondents, more than half

Table 1: Socio-demographic profile of respondents

Factors	Category	Frequency	Percent
Sex	Male	29	58
	Female	21	42
Age	18-25	4	8
	26-33	17	34
	34-41	10	20
	42-49	10	20
	50-57	1	1
	58-65	4	8
	66-73	4	8
Marital status	Single	10	20
	Married	40	80
Education level	Illiterate	6	12
	Primary	7	14
	Secondary	33	66
	Superior	4	8
Profession	Traditional healers	18	36
	Retired workers	4	8
	Traders	2	4
	Bricklayers	2	4
	Housewives	11	22
	State employee	4	8
	Lectures	5	10
	Dressmakers	2	4
	Students	2	4

Table 2: Ethnobotanical and ecological data of listed plants

Scientific name (Family): Voucher no	Vernacular name	Ecological characteristics			Used parts	Treated diseases	Dose	UVs[d]	ICs[e]	VAUs[f]
		MT[a]	BT[b]	PD[c]						
Abrus precatorius L. (Leguminosae): H. Breyne 2850	Maike	Lia	Phgr	Pan	Roots	Gastritis	2 glasses/day (Oral route)	0.25	0.03	0.007
Acacia auriculiformis Benth. (Leguminosae)	Acacia	T	Msph	Pan	Leaves	Malaria	A spoon (Oral route)	1.5	0.01	0.01
Aframomum alboviolaceum K. schum (Zingeberaceae)	Tondolo	Hv	Grh	Pan	Seed	Haemorrhoids	½ glass/morning-evening (Oral route)	0.3	0.02	0.06
Aframomum melegueta (Roscoe) K. Schum (Zingeberaceae)	Mundungo	Hv	Grh	Pan	Leaves	Flu	1 glass/morning-evening (Oral route)	5.5	0.01	0.05
Alchornea cordifolia (Schumach Et Thonn) (Euphorbiaceae)	Kibuzila	Sh	Mcph	GC	Leaves	Anaemia	3 glasses/day (Oral route)	3	0.009	0.02
Aloe congolensis De Wild Et Durand (Aloaceae)	Badi Nseke	Sh	Nph	Pan	Leaves	Spleen	1 glass/morning-evening (Oral route)	1	0.009	0.009
Anacardium occidentale L. (Anacardiaceae): H. Callens 1049	Mboto	T	Mcph	Pan	Barks	Tooth decay	Pinch (Local application)	1	0.009	0.009
Annona muricata L. (Annonaceae)	Cœur De Bœuf	Ssh	Nph	At	Leaves	Cough	2 glasses/day (Oral route)	1	0.04	0.04
Bidens pilosa L (Asteraceae)	Nsolo Koto	Sh	Mcph	Pr	Leaves	Gastritis	2 glasses/day (Oral route)	0.3	0.02	0.006
Brillantaisia patula T. Anderson (Acanthaceae): P.Compère 403	Lemba Lemba	Sh	Chd	GC	Leaves	Body pain	2 glasses/morning-evening (Oral route)	1.6	0.02	0.04
Cajanus cajan (L.) Millsp. (Leguminosae): H.Breyne 3006	Wandu	Sh	Nph	Pan	Leaves	Amoeba	1 glass/morning-evening (Oral route)	0.5	0.01	0.005
Carica papaya L. (Caricaceae)	Papayer	Sh	Msph	Pan	Leaves	Amoeba	1 glass/ morning-evening/3 days (Oral route)	0.6	0.02	0.01
Dyspphania ambrosioides (L.) Mosyakin & Clemants (Amaranthaceae): Devred 671	Nyoka Nyoka	Hv	Thd	Cosm	Leaves	Cough, (Fever)	Drink like tea (2 glasses/day) (Oral route)	4	0.009	0.03
Cinnamomum verum J.Presl (Lauraceae)	Arbre De Bonheur	T	Mgph	GC	Leaves	Spleen	1 pump each day (Anal route)	1.6	0.2	0.04
Citrus grandis (L.) Osbeck (Rutaceae)	Pamplemousse	T	Msph	Pan	Leaves	Yellow fever, (Cough)	3 cups/day (Oral route)	1	0.009	0.009
Citrus sinensis (L.) Osbeck (Rutaceae)	Orangier	T	Msph	Pan	Leaves	High blood pressure	1 glass/morning-evening (Oral route)	0.25	0.03	0.009
Combretum racemosum P. Beauv (Combretaceae) : Devred 231	Nsumbala	Lia	Lph	GC	Leaves	Tooth decay (Hemorroids)	2 drops morning/ evening (2 pumps per day) (Local application/Anal route)	0.25	0.03	0.007
Costus phyllocephalus K. Schum. (Costaceae)	Minkeni	Hv	Grh	GC	Leaves	Headaches	1 glass morning-evening (Oral route)	1	0.009	0.009
Crossopteryx febrifuga (Afzel. Ex G.Don)Benth (Rubiaceae): Chalier 42	Kihala	Sh	Mcph	At	Barks	Haemorrhoids	2 pumps/day (Anal route)	2	0.009	0.01
Cymbopogon citratus (DC.) Stapf (Poaceae)	Sinda	Hv	Grh	Pan	Bulbs	Haemorrhoids	1 pump/morning-evening for 7 days (Anal route)	1	0.009	0.009
*Dacryodes edulis G.Don Hj.Lam (*Burseraceae*)*: E. Maudoux 1355	Nsafu	T	Msph	Pan	Leaves	Anaemia	2-3 cups/day (Oral route)	1	0.02	0.02
Discorea smilacifolia De Wild & T.Durand (Discoreaceae):H. Breyne 3050	Kisadi	Sh	Msph	Cguin	Roots	Sexual weakness	2 glasses/day (Oral route)	0.5	0.3	0.15
Dorstenia psilurus Welw. (Moraceae): Kalanda 28	Kitamba	Ssh	Nph	GC	Stem	Hemorrhoids	1 pump each morning (Anal route)	1	0.009	0.009
Eleusine indica (L.) Gaertn (Poaceae): Van Oosten 5	Kimbanzi	Ha	Thd	Pan	Stem	Luckiness	To crunch (Local application)	1	0.009	0.009
Eleutherine bulbosa (Mill.) Urb (Iridaceae): M. Mambuana 135	Litungulu Ya Zamba	Hv	Gb	Pan	Bulbs	Malaria	1 pump/morning-evening (Anal route)	1	0.01	0.01
Euphorbia tirucalli L. (Euphorbiaceae)	Kidisa	Ha	Thd	Pan	Leaves	Poison	3-4 glasses per day (Oral route)	0.5	0.001	0.005

Table 2: Ethnobotanical and ecological data of listed plants (Cont'd)

Scientific name (Family): Voucher no	Vernacular name	Ecological characteristics			Used parts	Treated diseases	Dose	UVs[d]	ICs[e]	VAUs[f]
		MT[a]	BT[b]	PD[c]						
Garcinia kola Heckel. (Clusiaceae): Mambuana 400	Ngadiadia	T	Msph	Guin	Leaves	Cough	Drink like tea (Oral route)	0.3	0.02	0.006
Garcinia huillensis Welw.Ex Oliv. (Clusiaceae): H. Breyne 3661	Kisima	Sh	Mcph	At	Roots	Sexual weakness	1 glass/morning-evening (Oral route)	1	0.01	0.010
Gardenia termifolia Schumach Et Thonn. (Rubiaceae): Michel 3714	Kilemba Nzau	Sh	Msph	Cguin	Leaves	Spleen	1 pump each morning (Anal route)	2	0.001	0.002
Gossypium barbadens L. (Malvaceae): H. Breyne 4737	Cotonnier	Ssh	Mcph	Pan	Leaves	Cough	A spoon (Oral route)	1	0.009	0.009
Hallea stipulosa (Dc.) O. Kuntze (Rubiaceae)	Longo (Nlongo)	Sh	Msph	Guin	Barks	Hemorrhoids (Infertility)	1 glass morning/evening (Oral route)	1	0.02	0.002
Heinsia crinata (Afzel.) G. Taylor (Rubiaceae): H. Breyne 357	Matakita	T	Msph	Guin	Leaves	Obesity	2 glasses/ 3 days (Oral route)	0.5	0.001	0.002
Hibiscus acetocella L. (Malvaceae): Dumont 4	Ngai Ngai	Ha	Thd	Pan	Leaves	Anaemia	3 cups/day (Oral route)	1	0.02	0.02
Hibiscus sp. (Malvaceae)	Hibiscus	Ha	Thd	Pan	Leaves	Gastritis	1/2 glass/morning-evening (Oral route)	0.25	0.03	0.009
Hymenocardia acida Tul. (Phyllanthaceae): P. Compère 202	Peti (Kiyeti)	Sh	Msph	At	Roots	Malaria (Haemorrhoids)	2 glasses/day (Oral route)	1.5	0.01	0.020
Hyptis suaveolens (L.) Poit. (Lamiaceae) : H. Breyne 3655	Kamasongo	Sh	Thd	Aa	Leaves	Body pain	1 glass: morning/ evening (Oral route)	0.4	0.04	0.010
Ipomoae batatas (L.) Lam (Convolvulaceae)	Matembele	Ha	Thd	Pan	Leaves	Anaemia	1 glass morning/evening (Oral route)	0.66	0.02	0.005
Jathropha curcas L. (Euphorbiaceae): H. Breyne 3633	Mapuluka/Puluka	Sh	Mcph	At	Leaves (Barks)	Gastritis	2 glasses/day (Oral route)	2	0.009	0.018
Justicia secunda L. (Acanthaceae)	Nzete Ya Johva	Ssh	Nph	At	Leaves	Haemorrhoids	1 pump morning-evening (Anal route)	1	0.009	0.009
Lycopersicum esculentum Mill (Solanaceae)	Tomate	Ha	Chgr	At	Barks	Haemorrhoids	2 glasses/day (Oral route)	1.5	0.01	0.020
Mangifera indica L. (Anacardiaceae)	Manguier	A	Msph	Pan	Barks	Haemorrhoids	2 glasses/day (Oral route)	6	0.009	0.050
Manihot esculenta Cranz (Euphorbiaceae)	Pondu Ya Kongo	Ssh	Gt	Pan	Leaves	Chicken pox	2 pump/day each morning (Anal route)	0.3	0.02	0.006
Millettia drastica Baker (Leguminosae)	Ngilo	T	Msph	GC	Roots	Infertility	1 pump each morning for a week (2 glasses/ day) (Anal route)	0.5	0.01	0.030
Millettia macroura Harms (Leguminosae)	Mbota Mbota	T	Mcph	At	Barks	Measles	Apply on the skin (Massage)	0.3	0.02	0.008
Mitracarpus villosus (Sw) Dc. (Rubiaceae) : H. Breyne 3659	Bandanzanzi	Ha	Chd	At	Leaves	Worms	2 cups/morning-evening (Oral route)	0.5	0.01	0.005
Morinda lucida Benth. (Rubiaceae): Wagemans 750	Nsiki/ Siki	T	Msph	GC	Leaves	Malaria	2 glasses/day (Oral route)	1.5	0.01	0.010
Morinda morindoides (Baker) Milne-Redhead (Rubiaceae): P. Bamps 382	Kongo Bololo	Lia	Lph	At	Leaves	Malaria	1 glass/day morning-evening for 3 days (Oral route)	3	0.009	0.009
Moringa oleifera Lam. (Moringaceae)	Moringa	Sh	Msph	At	Flower	Blurr vision	A drop (Ocular route)	0.04	0.04	0.010
Musa sapientum L. (Musaceae)	Bananier	T	Gb	Pan	Leaves	Haemorrhoids	2 pumps/day (Anal route)	0.6	0.02	0.010
Ocimum americanum L. (Lamiaceae): Devred 425	Linzudi	Sh	Chd	Pal	Leaves	Filaria	Pinch (Oral route)	1	0.01	0.010
Ocimum gratissimum L. (Lamiaceae): R. Dechamps 8016	Lumba Lumba	Ssh	Chd	Pal	Leaves	Anaemia	1 cup/morning-evening (Oral route)	1.4	0.004	0.060
Persea americana Mill. (Lauraceae)	Avocatier	T	Lph	Pan	Leaves	Diarrhea	1 glass/day (Oral route)	1.8	0.04	0.080

(66 %) had been to secondary school while 14% and 8% respectively finished primary level and superior level.

A total of 66 plants species was inventoried and belonged to 35 families and 59 genera. Of these, one species (*Hibuscus sp*) was identified only to the genus level and 65 were identified to species level.

Fourteen families (out of 35) provided 71.2 % of all inventoried plants. The dominant families were Rubiaceae (12.1 %), followed by Fabaceae (9.0 %), Malvaceae (7.6 %), and Lamiaceae (6.0 %), Euphorbiaceae, and Anacardiaceae (4.5 % each), Acanthaceae, Asteraceae, Clusiaceae, Lauraceae, Poaceae, Rutaceae, Solanaceae, and Zingiberaceae (3 % each) (Figure 2). The remaining families were represented only one species (1.5 %). Fifty-two genera were represented by only one species, while the remaining seven genera were represented by 2 species each (*Aframomum, Citrus, Gardenia, Hibiscus, Milletia, Morinda, Ocimum*) (Table 2).

Regarding the morphology type, our study area has shown a predominance of shrubs with 30.3%, followed by trees (27.3%) and Herbs (25.8%) (Figure 3A).

Table 2: Ethnobotanical and ecological data of listed plants (Cont'd)

Scientific name (Family): Voucher no	Vernacular name	Ecological characteristics			Used parts	Treated diseases	Dose	UVs[d]	ICs[e]	VAUs[f]
		MT[a]	BT[b]	PD[c]						
Phragmanthera capitata (Spreng.) Balle (Loranthaceae): H. Breyne 895	Nki-kunda	T	Msph	Pan	Leaves	Angina	A spoon (Oral route)	0.5	0.01	0.005
Piper nigrum L. (Piperaceae): H. Breyne 830	Ketshu	Lia	Lph	Pal	Leaves	Malaria	1 glass/morning-evening during 7 days (Oral route)	2	0.009	0.01
Psidium Guajava L (Myrtaceae): M. Mambuana 302	Goy-avier/ Lipela	Sh	Mcph	Pan	Leaves	Amoeba (Worms)	1 glass morning-evening for 3 days (Oral route)	2	0.01	0.02
Pteridium aquilinum (L.) Kuhn (Dennstaedtiaceae)	Misili	Ha	Grh	GC	Leaves	Gastritis	1 cup morning-evening (Oral route)	1	0.009	0.009

[a]*MT: Morphological types: T: Trees. Sh: Shrubs. Ssh: Sub-shrubs, Ha: annual herbs, Hv: Vivace herbs, Lia: Liana*
[b]*BT: Biological types: (Phanerophytes (Ph): meso-phanerophytes (Msph), micro-phanerophytes (Mcph), nanophanerophytes (Nph), megaphanerophytes (Mgph), lianous phanerophytes (Lph), climbing phanerophytes (Phgr)); (Chameophytes (Ch): dressed chameophytes (Chd), climbing chamephytes (Chgr)); (Geophytes (Ge): rhizomatous geophytes (Grh), bulbous geophytes (Gb), and tuberous geophytes (Gt)); Therophytes (Th).*
[c]*PD: Phytogeographical distribution: Pan: Pantropical, At: Afro-tropical, GC: Guinea-Congolese, Cguin: Central Guinea, Guin: Guinea, Pal: Paleotropical, Aa: Afro-American, Cosm: Cosmopolite);*
[d]*UV: Use-Values*
[e]*ICs: Confirmation Index*
[f]*VAUs: Value of Agreement to Use*

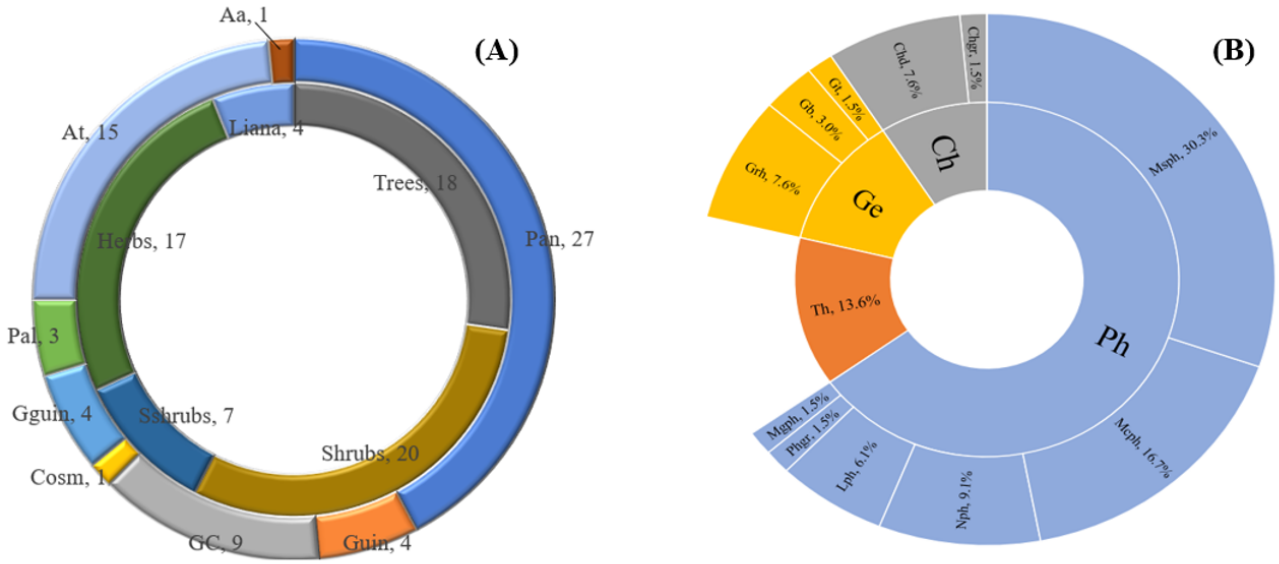

Figure 3. (A) Distribution of medicinal plants according to the Morphological type (inner circles) and phytogeographical distribution (outer circles) (Pan: Pantropical, At: Afro-tropical, GC: Guinea-Congolese, Cguin: Central Guinea, Guin: Guinea, Pal: Paleotropical, Aa: Afro-American, Cosm: Cosmopolite. **(B)**: Biological type (Phanerophytes (Ph): meso-phanerophytes (Msph), micro-phanerophytes (Mcph), nanophanerophytes (Nph), megaphanerophytes (Mgph), lianous phanerophytes (Lph), climbing phanerophytes (Phgr)); (Chameophytes (Ch): dressed chameophytes (Chd), climbing chamephytes (Chgr)); (Geophytes(Ge): rhizomatous geophytes (Grh), bulbous geophytes (Gb), and tuberous geophytes (Gt)); Therophytes (Th).

The prevalence of woody species is explained by the fact that most of the medicinal plants used in the Kasangulu pharmacopeia come from forest areas.

The inventoried medicinal flora consists of several biological types such as phanerophytes (Ph: 43 species) followed by therophytes (Th: 9 species), geophytes (Ge: 8 species), and chameophytes (Ch: 6 species) (Figure 3B).

The phytogeographic distribution was dominated by pantropical species (Pan: 40.9%) followed by Afro-tropical species (At: 22.7%), Guinea-Congolese (GC: 13.6%), Central Guinea (Cguin), and Guinea (Guin): 6.1% each (Figure 3A).

Leaves were the commonly used part accounting for 67.6 %, followed by bark and roots with 11.8 % each (Figure 4B). Numerous studies conducted in various countries pointed out the common use of leaves (Amjad *et al.*, 2015; Azam *et al.*, 2014; Bano et al., 2014), as they are less destructive to the plant (Asiimwe et al., 2013), and they store various active compounds with medicinal properties (Lara *et al.*, 2018). Several methods of recipe preparation are used for medicinal plants. However, the most frequent mode is an infusion (54%), followed by maceration (9%), and decoction (8%). Massage is the least common practice (5%) (Figure 4A). This result is in line with Oliveira *et al.* (Oliveira *et al.*, 2011) and Angulo *et al.*, (Kasika *et al.*, 2015), who mentioned the infusion as principal recipes preparation in their study area. However, on comparing with a few other studies conducted in DRC (Katemo *et al.*, 2012; Kasika *et al.*, 2015; Manya *et al.*, 2018; Okombe *et al.*, 2014) and with ethnomedicinal works published in other countries (Axiotis *et al.*, 2018; Leso *et al.*, 2017; Ngezahayo *et al.*, 2015), we noted decoction was the most used as recipes preparation. The majority of plant parts were used fresh (80%), while 20% were dried. As far as the drying method, the plants were exposed either to the sun, the open, or in the shade. These results are similar to those of Ngbolua *et al.* (2019; 2016) who report that the population in different markets in Kinshasa prepares their recipes from fresh plants.

Considering the administration method of plants mentioned by the inhabitants, report consist of oral, anal, massage, cutaneous application, and eyes drop. Among the oral route (75.4 %) was the predominant mode of administration of the recipes, followed respectively by the anal route (16.4%), local application (4.9 %) (Figure 4C). On comparing our data with a few studies so far published, we noted that oral route was the most used to administrate the recipes (Alqahtani *et al.*, 2021).

The plants were used to treat 30 illnesses. The UV ranged between 6 and 0.04. Based on this result, 24 plant species predominate with values greater than or equal to 1.5. The four high UV recorded were *Mangifera indica* (6), *Aframomum melegueta* (5.5), Carica papaya (4), *Sarcocephalus latifolius* (4). The lowest UV was obtained for *Abrus*

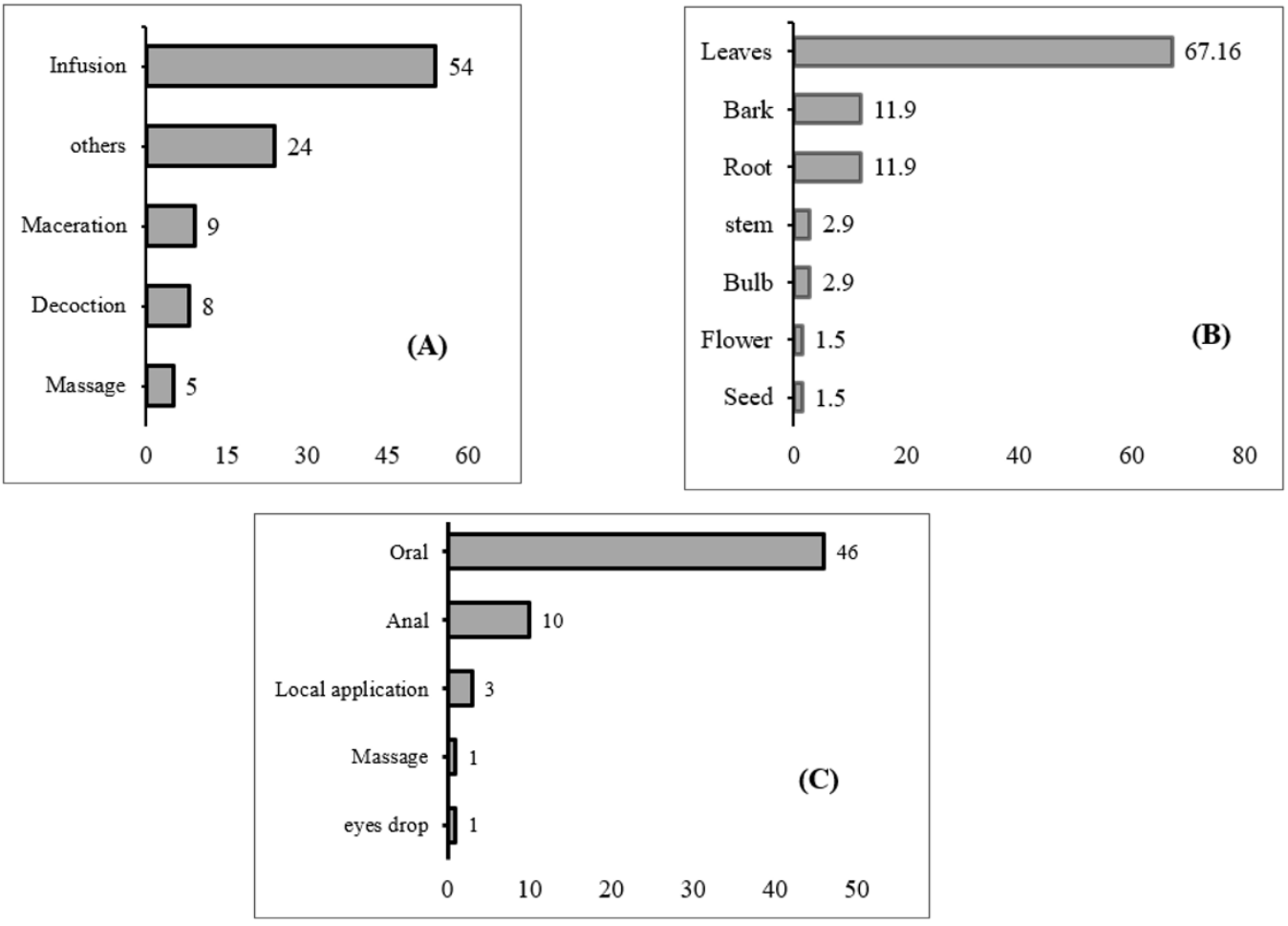

Figure 4. (A) frequency of recipes preparation mode, and **(B)** used parts of the plants, (**C**) Route administration

precatorius, Citrus aurantium, Citus maxima, and *Hibiscus acetosella* (0.25 each), *Moringa oleifera* (0.04) (Table 2). These species were used to treat different illnesses including Hemorrhoids, flu, Amoeba Hernia, and infertility, while the lowest UV (*M. oleifera*) was used for glue vision.

In the present study, ICs values ranged from 0.3 to 0.001. The highest ICs was *Dacryodes edulis* (0.3), followed by *Chenopodim ambrosioides* (0.2). The highest VAUs values *Dacryodes edulis* (0.15), followed by *Persea americana* (0.08), while the lowest was *Tephrosia vogelii* (0.001).

The table shows that the 66 medicinal plants listed in this study treat 30 diseases grouped into 13 categories. The four most-cited ailment categories are "Infectious and parasitic diseases" (17 uses report), "Diseases of the circulatory system" (16 uses report), "Diseases of the digestive system" (11 uses report), and "Symptoms, signs, and ill-defined disease states" (10 uses report). However, the "Diseases of the genitourinary organs" was the one with a high ICF value (ICF 0.50) followed by "Circulatory system diseases" (ICF 0.27), and "Symptoms, signs, and ill-defined disease states" (ICF 0.22).

21.2% of inventoried plant species were used to treat infectious and parasitic diseases followed respectively by circulatory system diseases (18.2%); Symptoms, signs, and ill-defined disease states (12.1%); Diseases of the blood and blood-forming organs (10.6%); Respiratory system diseases (6.1%) (Table 3).

Jaccard index was compared between this study and either other studies done in other parts of the Democratic Republic of the Congo or neighboring countries. In total 15 papers were analyzed. The highest degree of similarity in the neighboring countries was with studies conducted in Kayes and Madingou in the Republic of Congo (Kimpouni *et al*., 2019). The lowest similarity was with Novotna *et al.* (Novotna *et al*., 2020) (Table 4).

Comparing the present study with other studies done in DRC, the JI between Ngbolua *et al.* (Ngbolua *et al*., 2016), and our area were 19.15 and 18.88. The low similarity was with Mongeke et al. (2018); a study conducted in Nord-Ubangi Province.

Table 3: Informant consensus factor (ICF) by ailments category in the study area, Kasangulu Territory

Ailments category	Description of ailments	n_{ur}	n_t	ICF
Undefined category	Luckiness	1	1	0
Traumatic injuries and poisoning	Poison	1	1	0
Circulatory system diseases	Haemorrhoids, High blood pressure	16	12	0.27
Digestive system diseases	Constipation, Diarrhea, Gastritis, Hernia, Tooth decay	11	10	0.1
Respiratory system diseases	Angina, Asthma, Flu	4	4	0
Diseases of the skin and subcutaneous cellular tissue	Skin disease	2	2	0
Diseases of the genitourinary organs	Infertility	3	2	0.5
Diseases of the blood and blood-forming organs	Anaemia, Spleen	8	7	0.14
Diseases of the nervous system and sense organs	Blurr vision	1	1	0
Endocrine, nutritional and metabolic diseases and immune disorders	Obesity	1	1	0
Infectious and parasitic diseases	Amoeba, Chicken pox, Filaria, Malaria, Measles, Worms, Yellow fever	17	14	0.19
Symptoms, signs and ill-defined disease states	Body pain, Cough, Fever, Headache	10	8	0.22
Mental disorders	Sexual weakness	2	2	0

Legend: n_{ur} is the number of use reports in each ailment category, and n_t is the number of plant species used

Table 4: Comparison between our study and previous studies at Countries neighboring the DRC

Previous study area	Total species in this study	Total documented species	Common plants to both areas	Jaccard index (JI)	References
Zouénoula/ Ivory Coast	65	17	4	5.13	(41)
Madingou/ Republic of Congo	65	80	17	13.3	(38)
Kayes/ Republic of Congo	65	60	19	17.9	(39)
Libreville/ Gabon	65	24	5	5.95	(42)
Bié Province / Angola	65	87	5	3.40	(40)
Uíge Province / Angola	65	30	4	4.40	(43)
Lobaye Prefecture/ Central African Republic	65	31	7	7.86	(44)

According to Raven *et al.* (2009), about 13 million hectares of forest are lost annually on Earth and this deforestation results in a net annual loss of about 12 million hectares of forest area, of which about 8 million hectares are tropical forests. Thus, about 1% of tropical forests are cleared or severely degraded each year. Among the causes of this deforestation is slash-and-burn agriculture (Kpula *et al*., 2021), a practice that can lead to the reduction of the population or stand of plant taxa. It should also be noted that the vulnerability of a plant also depends on its frequency of use in traditional medicine, its morphological type, its abundance in the environment, the uses made of it, the organs used, the biotope, the mode of dissemination of diaspores, the stage of development of the plant and the mode of collection (Ngbolua, 2020; Masengo *et al*., 2021a, b). Hence the need to know the conservation status of the listed plant species to propose strategies for their sustainable use. The Red List of Threatened Species revealed that 46 of our studied plants are not listed, while 17 namely *Aframomum alboviolaceum*, *Alchornea cordifolia*, *Annona muricata*, *Crossopteryx febrifuga*, *Eleusine indica*, *Euphorbia tirucalli*, *Gossypium barbadens*, *Hymenocardia acida*, *Millettia drastica*, *Millettia macroura*, *Morinda lucida*, *Moringa oleifera*, *Persea americana*, *Psidium guajava*, *Securidaca longepedunculata*, *Tephrosia vogelii* and *Tetradenia riparia* are "least concern" (LC), two species (*Carica papaya* an *Mangifera indica)* are "data deficient"(DD) and one (*Garcinia kola)* is "vulnerable"(VU).

It is well established that in Africa, in addition to the fact that more than 80% of the population uses medicinal plants for health care (WHO, 2002), these biological resources remain a product of gathering and the period of gathering is variable and extends practically throughout the year in their natural habitat, thus demonstrating the pressure exerted by the population on these resources and the need to integrate them into agricultural activity to develop sustainable peasant agriculture, This demonstrates the pressure exerted by the population on these resources and the need to integrate them into agricultural activity to develop a reasoned, multifunctional and sustainable peasant agriculture to ensure the resilience of the population to climate change on the one hand and improving human health on the other (Sustainable Development Goal 3).

Agro-ecology, which can be defined as the science of natural resource management for the benefit of the poorest people facing an unfavorable environment, is a discipline that should be developed and popularized to achieve this objective in the DRC (Altieri, 1996).

Study strengths and weaknesses

The present research has inventoried a good number of value-added medicinal plants and associated traditional knowledge necessary for the effective implementation of the Nagoya Protocol on access and benefit sharing in Democratic Republic of the Congo. It should be noted, however, that the inventory of these plant genetic resources concerns only a tiny part of the national territory.

CONCLUSION

The purpose of this study was to make an ethnobotanical inventory of medicinal plants used in Congolese pharmacopeia. The results obtained in this study showed that herbal remedies are widely used in Kasangulu Territory. We found that married and single people have shared medical knowledge, with a slight predominance of married people; infertility is the most cited disease, dominance among people with high school education. However, the analysis of the recipes has allowed us to show that the leaf is the most commonly used organ and an infusion is the most common method of preparation in traditional medicine. In addition, the analysis of the ecological spectrum showed the predominance of phanerophytes while the chronological spectrum shows the predominance of pantropical species. This study of the medicinal plants used in Kasangulu constitutes a reservoir of information that contributes to knowledge to protect the medicinal flora and safeguard local popular know-how.

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