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Characterization of traditional healers in the mountain forest region of Kahuzi-Biega, South-Kivu, DR Congo

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Description of the subject. Several ethnobotanical studies have demonstrated links between traditional medicine practices and the ethnicity and geographical location of healers, while many others have concluded the opposite. This study deals with the typology of traditional healers in the mountain region of Kahuzi-Biega.
Objectives. The goal is to understand whether the typology of traditional healers is related to their inter-ethnic and inter-zonal differences, based on diseases treated and plants used.
Method. Ethnobotanical surveys were conducted using the "PSSVV" method. This involved 88 traditional healers recognized as "specialists" in 33 villages adjacent to the forest of Kahuzi-Biega, in DR Congo. Multivariate analysis (clustering, ordination, Mantel test, IndVal) were applied to establish typologies of traditional healers.
Results. Multivariate analyses showed that ethnicity and geographical location did not explain the practices and knowledge of healers. However, by using the IndVal method, differences were observed in their degree of specialization. Non-specialized healers (70%) could be distinguished from specialized healers (30%). Two clear groups of specialists emerged; those who treat bone trauma and those who treat obstetric-gynecological complaints. The Mantel correlation test revealed a positive association ($r = 0.134$, $p < 0.05$) between the "healers-plants" and "healers-diseases" matrices. This indicates that healers who treat similar diseases use similar herbs. Both typologies have shown their preferences for forest species (81%), especially trees (51%).
Conclusions. This exploratory study suggests that traditional healers are characterized based on their specializations. This result helps in creating strategies to preserve local traditional knowledge and apply it to the conservation of species.
Keywords. Ethnobotany, forest resources, drug plants, indigenous knowledge, typology, human pathology, Democratic Republic of Congo.

Caractérisation des tradipraticiens de la région de forêt montagneuse de Kahuzi-Biega, sud-Kivu, RD Congo

Description du sujet. Plusieurs études ethnobotaniques ont démontré des liens entre les pratiques de la médecine traditionnelle et l'identité ethnique et géographique des tradipraticiens, de nombreuses autres ont montré l'inverse. Cette étude porte sur la typologie des tradipraticiens de la région de forêt montagneuse de Kahuzi-Biega.
Objectifs. L'objectif est de comprendre si la typologie des guérisseurs traditionnels est liée à leurs différences inter-ethniques et inter-zonales sur base des maladies traitées et des plantes utilisées.
Méthode. La méthode « PEEVV » a permis de mener des enquêtes ethnobotaniques auprès de 88 tradipraticiens de 33 villages de la région de Kahuzi-Biega en RD Congo. Les analyses multivariées (classification, ordination, *Mantel test*, IndVal) ont permis d'établir la typologie des tradipraticiens.

Résultats. L'origine ethnique et géographique n'explique pas les groupements des tradipraticiens. La méthode IndVal a montré que leur typologie est basée sur leurs « spécialités » : les tradipraticiens modérément spécialisés (70 %) et les tradipraticiens hautement spécialisés (30 %). De ces derniers, deux groupes se distinguent nettement, ceux qui traitent le traumatisme des os et ceux qui traitent les troubles des organes reproducteurs. La corrélation positive de Mantel ($r = 0{,}134$, $p < 0{,}05$) entre les matrices « tradipraticiens-plantes » et « tradipraticiens-maladies » a suggéré que les tradipraticiens qui soignent les mêmes maladies utilisent en grande partie les mêmes plantes dans leurs pratiques médicales. Les deux typologies ont montré une préférence pour les espèces forestières (81 %), en particulier les arbres (51 %).

Conclusions. Cette étude exploratoire suggère que la typologie des tradipraticiens est basée sur leurs niveaux de spécialisations et non sur leurs différences ethniques et géographiques. Ce résultat est utile pour préserver les connaissances locales et les rendre utiles pour la conservation des espèces.

Mots-clés. Ethnobotanique, ressource forestière, plante médicinale, connaissance indigène, typologie, pathologie humaine, République Démocratique du Congo.

1. INTRODUCTION

Throughout the world, traditional medicine is regarded as a precious heritage, particularly for communities in developing countries. Its importance is well established on the African continent where about 80% of the population mainly relies on herbs for their primary health care (WHO, 2002). Despite large amounts of natural resources, people in the Democratic Republic of Congo (DRC) are still marked by poverty and insecurity (PNUD, 2009). The use of traditional medicine increased in the area since the start of the armed conflict in Eastern DR Congo in 1996 (Shalukoma, 2008). Indeed, in the province of South-Kivu in general, access to a modern healthcare system is limited. While World Health Organization (WHO) standards prescribe at least one doctor per 10,000 inhabitants, in South-Kivu there is one doctor per 27,699 inhabitants (PNUD, 2009). However, the population's demand for medicinal herbs exerts considerable pressure on vegetation, especially in protected areas (Mbayngone et al., 2011). Loss of plant species and biodiversity could be a direct consequence of the lack of regulation of the plants used in traditional medicine in many African countries. Thus, ethnobotanical studies are essential for understanding needs and helping decision-making when it comes to sustainable conservation of local flora.

Traditional medicine remains a complex field. It is based on traditions, pragmatism and knowledge, transmitted orally without being scientifically proven. Over time, however, pharmacological and clinical studies have researched and shown the effectiveness of many traditional practices (Sofowora, 2010). Fassin (1990) pointed out this complexity of traditional medicine. It is focused on disease but also involves institutions and players beyond the scope of the body and health.

To unravel the complexity of traditional medicine when compared with conventional medicine, anthropologists developed different typologies of medicine, depending on the knowledge they were referring to. Dunn (1976) developed an interesting typology that talked about medicine as being "local" (*e.g.* which can re-group traditional African practices), "regional" (*e.g.* comprising Arabic, Chinese and Indian medicines) and "cosmopolitan" (those based on a modern understanding of biology). Compared with Dunn, Kleinman (1980) classified:

- "popular medicine" as based on the family circle and neighbors to whom self-medication is primordial;
- "folk medicine" as practiced by traditional healers who are non-professionals, but specialists in their field;
- "professional medicine", like Ayurveda and Unani in Asia.

Unlike popular traditional medicine, specialized traditional medicine is used for certain specific health issues that are chronic and difficult to treat (Shalukoma, 2008).

Specialized traditional healers are recognized as such by their communities, due to their competence in the care of a given category of diseases (Fassin, 1990; Sofowora, 2010). Often, their knowledge is acquired through apprenticeship, however, they protect certain knowledge they consider too "secrets" in their practices. This secrecy limits the transmission of knowledge between healers, even along bloodlines (Pfeiffer et al., 2005; Kouakou, 2013). A paradox was pointed out in literature on discriminatory factors among traditional healers. Some ethnobotanical studies made the link between traditional medicine and culture on the one hand (Phillips et al., 1993; Reyes-Garcia et al., 2006; Signorine et al., 2009; Kasika et al., 2015) and between traditional medicine and geographical location on the other (Pardo-de-Santayana et al., 2007; Mutheeswaran et al., 2011). Moerman et al. (1996, 1999) and Heinrich et al. (1998) pointed out that studies were often focused on one ethnic group, one taxonomic group or botanical genus, and rarely considered the use of plants across cultures. Pfeiffer et al. (2005) argued that transmission of knowledge is influenced by geographical origin, local culture and gender. Finally, Augereau (2008) pointed out that each ethnic group has its own medicine deferential to the local flora and environment, and establishes its own rules regarding the recognition of plants properties.

However, there is also a body of research showing that significant links between culture and medicinal practices do not exist. Moerman et al. (1999) showed a remarkable trend of similarity in the use of certain medicinal plants, regardless of geographical location, of traditional healers in Chiapas, North America, Korea and Kashmir. Sop et al. (2012) demonstrated that the use of herbs as medicine was not culturally influenced among the Fulani, Samo and Mossi groups in Burkina Faso.

This study focuses on the knowledge and practices of specialist traditional healers from four ethnic groups, Batwa, Havu, Shi and Tembo, located in Kalehe and Kabare territories, respectively, around the mountain forest of Kahuzi-Biega. This forest is home to many flora and fauna species, including the endangered lowland gorilla (*Gorilla berengei graueri*) and the threatened eastern chimpanzee (*Pan troglodytes schweinfurthii*). It also possesses a very important ethno-medicinal potential. An understanding of the local practices of healers will help in defining conservation priorities and implementing long-term management strategies for species in a forest region heavily burdened by human activities (Sop et al., 2012).

The main objective of this study is to understand the factors structuring the basic organization of healers through the traditional medicinal practices recorded in the area, in order to preserve local knowledge and make use of it in the implementation of strategies for sustainable species conservation. We hypothesize that the ethnic affiliations and geographical locations of healers are significant structuring factors.

2. MATERIALS AND METHODS

2.1. Study site

Surveys were conducted around the mountain forest of Kahuzi-Biega in the province of South-Kivu, in Eastern DRC (**Figure 1**). The 600 km^2 park, created in 1970 to protect the lowland gorillas, covers lowland forest (600 m-1,200 m a.s.l.) and rainforest mountain (1,700 m-3,308 m a.s.l.), which are connected by an ecological corridor (ICCN, 2009). The park, a world heritage site, has been endangered since 1997 (ICCN, 2009) due to the human pressure. The highland region of the park is characterized by mountains. The climate is of the afromontane type, with a maximum annual precipitation of up to 1,900 mm (Fischer, 1993). The main ethnic groups are Havu (Kalehe territory), Shi (Kabare territory and Kalehe territory, Kalonge axis), Tembo (Kalehe territory, Bunyakiri axis) and Batwa (located in both localities).

2.2. Ethnobotanical surveys

An ethnobotanical survey was conducted between 2010 and 2012 to collect data on traditional healers, pathologies treated and plants used. To ensure the reliability of data, we developed a methodology that is helpful, but demanding in terms of resources and time. This so-called "PSSVV" study was conducted in four steps (**Figure 2**): Pre-survey (PS), Survey (S), Data Verification (V) and Data Validation (V). The field investigations were affected by the precarious security situation in the study region. The sampling was exhaustive because the number of specialist healers in the region is limited. A total of 88 recognized healers was identified during pre-survey sessions. They all agreed to collaborate on the study. At their request, interviews were done individually. To motivate respondents, the purpose of the study was largely explained. A cash gift of appreciation was given after interviews, generally up to 50 USD, representing the value of a goat with reference to the culture. Interviews comprised questions relating to the identification of healers, the main diseases they treat and the plants they use to heal these diseases. The triangulation method, which enables the cross-checking of data (Guillemont, 2006), was used to check the reliability of data collected in different localities. Data relating to diseases and diagnosis (symptoms and/or physiological effects) were verified and, when necessary, clarified by health agents in hospitals and local health centers.

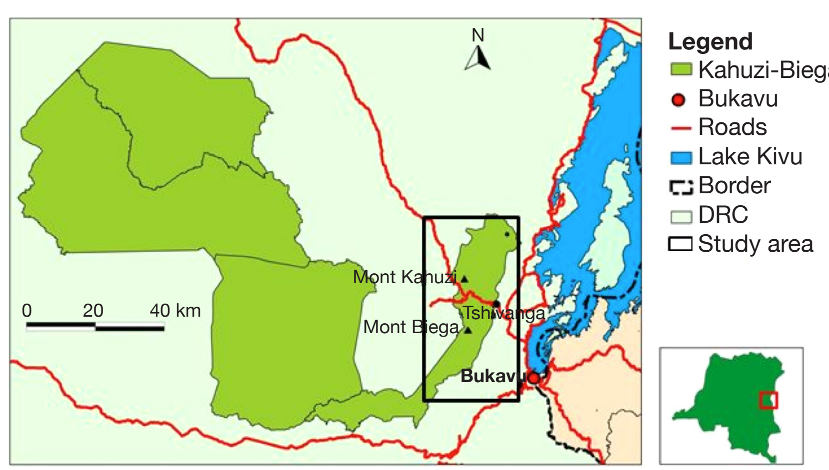


Figure 1. Study area: Kahuzi-Biega National Park — *Zone d'étude : Parc National de Kahuzi-Biega*.

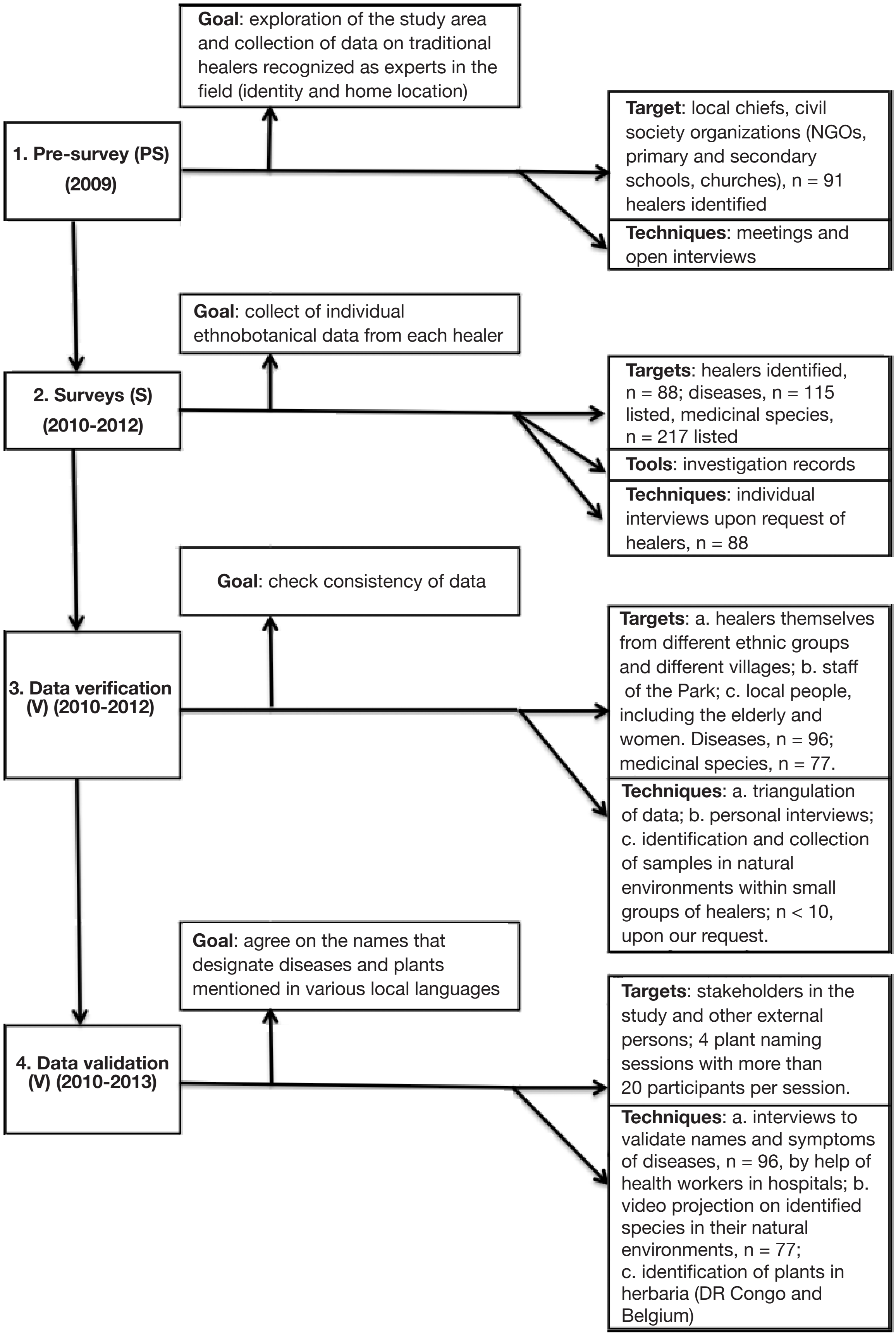


Figure 2. Schematic presentation of the ethnobotanical method "PSSVV" used around the Kahuzi-Biega National Park — *Présentation schématique de la méthode ethnobotanique « PEEVV » utilisée autour du Parc National de Kahuzi-Biega.*

"Diseases" were then classified into the different "use categories" according to Cook (1995). In contrast with the very complex WHO system for the International Classification of Diseases (ICD), this practical categorization serves to group diseases depending on whether they affect a given system of the human body, allowing an easier understanding of healers' descriptions of treated diseases and symptoms. During interviews concerning herbs, a citation was considered as a "use score" (Treyvaud-Amiguet et al., 2005). These "use scores", once recorded from healers, were verified with different sources and through different channels to ensure correspondence with listed plants, their scientific names and their vernacular names. Species mentioned in the various local languages, including Mashi, Kitembo, Kihavu, and sometimes Kirega, had to be identified and collected during forest excursions. Following Ichikawa et al. (2003), the correct identification of species can only be done in their natural environment. Forest excursions were conducted with small groups of healers, depending on the affinities between them. Other village members and park technical staff were consulted on the names of cited herbs. Slides of identified herbs were projected with different groups of healers to confirm and complete the botanical list. The identification of samples was done in herbaria of the Centre de Recherche en Sciences Naturelles, CRSN/Lwiro (DRC) as well as in the Herbarium and Library of African Botany, BRLU/ULB and in Meise Herbarium (Belgium). The naming system of the flora of Rwanda and from the lists of flowering plants of tropical Africa was applied (Lebrun et al., 2006). Formal and informal interviews with healers, various discussions with all study stakeholders and excursions into the forest were made possible by the collaboration established during the work.

2.3. Data analysis

To determine whether there is a significant difference between healers on the basis of diseases treated and plants used, we performed cluster analysis and ordination, identified indicator species through the IndVal method and carried out a Chi^2 test based on the ethnicity and geographical location of healers. The analyses were based on two distance matrices, a binary matrix of 88 healers x 96 diseases and a semi-quantitative matrix of 88 healers x 77 plants. For the binary matrix, data were represented by values "1" or "0," depending on whether the healer treated the disease or not. For the second matrix, the numbers at the intersection of a plant and a healer represented the number of times one and the same species was mentioned to treat one or several diseases. The mentions of organs used for each species were collected qualitatively for documentation purposes.

The survey information was summarized by multivariate analysis using the software for ecology, PC-Ord 5.0 (McCune et al., 2002). In ecology, classification organizes community types depending on their calculated similarities or dissimilarities with distance measures and ordination methods, to improve the understanding of relations between species and environments (McCune et al., 2002). In this study, the relations concern healers with their plants used and diseases treated. The groups were discriminated by ascending hierarchical classification with the flexible-beta clustering method ($\beta = - 0.25$) associated with the Sørensen similarity index. Non-Metric Multidimensional Scaling (NMMS) was applied to both matrices, healers x diseases and healers x plants. The autopilot mode of the NMMS enabled 50 iterations of real data to be compared with 50 iterations of random data to select the dimensionality. To find an acceptable solution, 200 iterations were performed on the stability criterion of 0.00001, with two dimensions. Indicator species and indicator diseases were identified for each group of healers, based on the IndVal method (Dufrêne et al., 1997) available in the software PC-Ord, 5.0 (McCune et al., 2002). In ecology, this procedure combines the relative abundance and relative frequencies of species to identify in each group the indicator species and their values (0-100%). In this study, the statistical significance of these indicator values for each species or disease was evaluated by a Monte Carlo method with 5,000 randomizations, with a threshold $\alpha = 0.05$. Healer groups were named based on their indicator species or diseases which obtained maximum and significant indicator values. The top two were considered for diseases and the top three for plants.

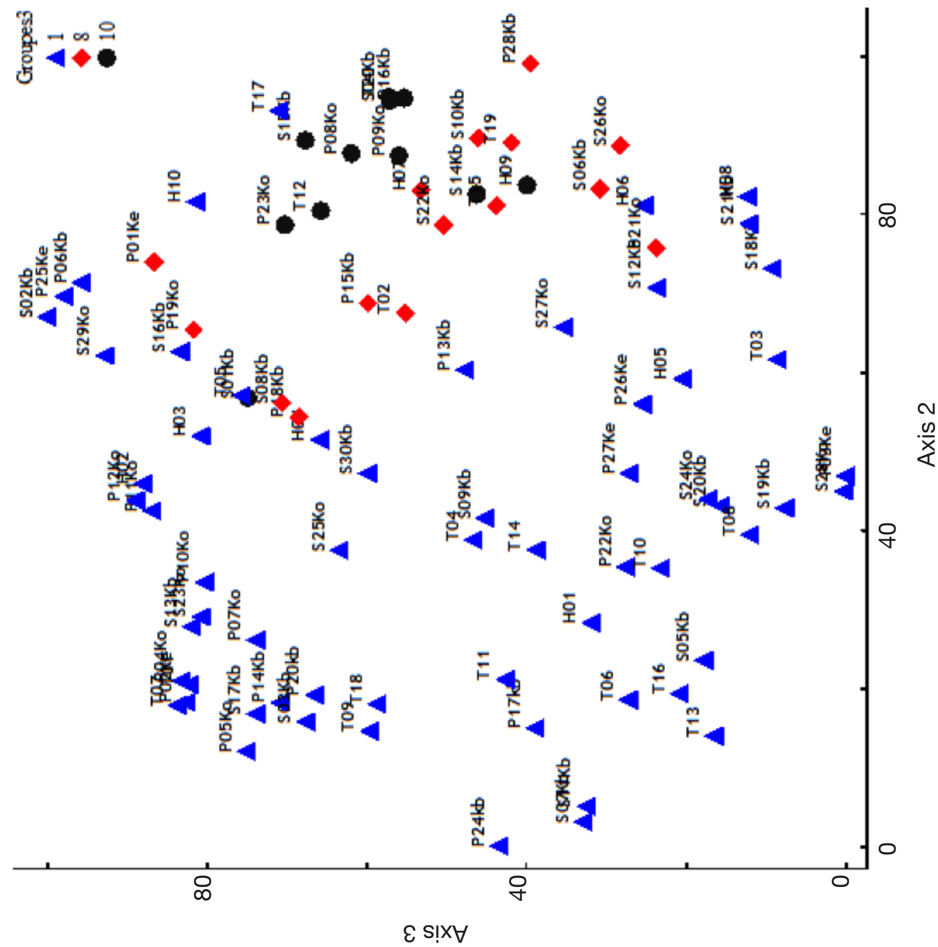
Correlations between distance matrices of healers-diseases (binary) and healers-plants (abundance) were calculated using a Mantel test (Mantel, 1967; McCune et al., 2002) and the Sørensen distance measure.

3. RESULTS

3.1. Diversity of diseases treated as a basis for healers' typology

A total of 96 diseases grouped into 18 categories (**Appendix 1**) were reported to be treated by specialized healers around the park. The most important disease classes were infectious (14%), digestive (14%) and genitourinary disorders (13%).

Three groups of healers were identified from cluster analysis (**Figure 3**): group 1 was correlated to the two NMMS ordination axes, while groups 2 and 3 showed a better correlation with axis 2 (**Figure 3**). The two extracted axes represent 20% of the total variance, 9%



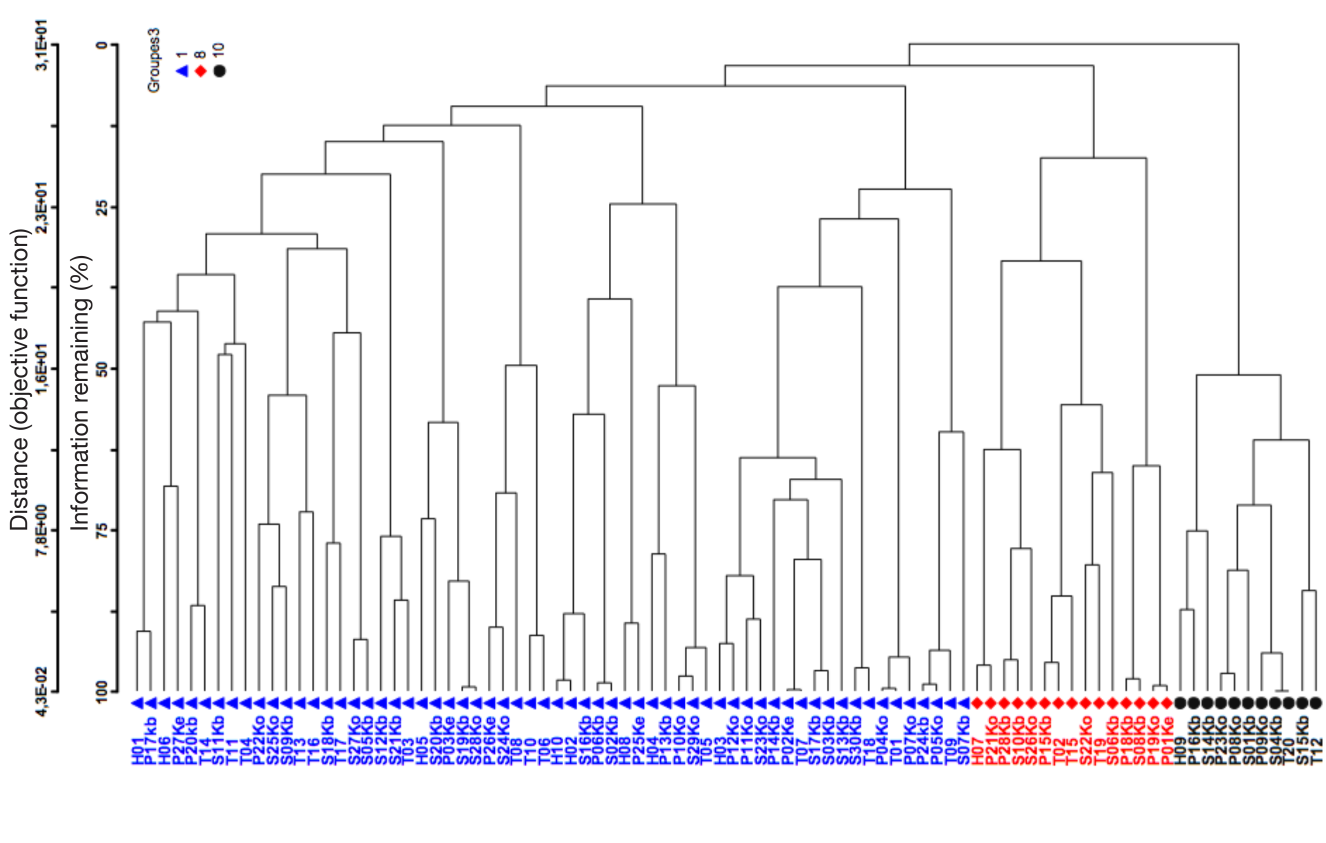


Figure 3. Classification and ordination of healers based on treated diseases: dendrogram (with the flexible-beta method and the Sørensen distance measure) and ordination (non-metric to the multidimensional scale, NMMS) separating three groups of healers — *Classification et ordination des tradipraticiens sur base des maladies soignées : dendrogramme (avec la méthode flexible-béta et la distance de Sørensen) et ordination (non métrique à l'échelle multidimensionnelle, NMMS) séparant trois groupes de tradipraticiens.*

Group 1 blue: healers moderately specialized (HMS); group 2 red: healers highly specialized in obstetrics and gynecology (SOG); group 3 black: healers highly specialized in bone trauma (SBT) — *Groupe 1 bleu : tradipraticiens moyennement spécialisés (HMS); groupe 2 rouge : tradipraticiens hautement spécialisés en troubles obstétriques et gynécologiques (SOG) ; groupe 3 noir : tradipraticiens hautement spécialisés en traumatologie osseuse (SBT).*

being explained by axis 2 and the remaining 11% being expressed by axis 3.

Indeed, the three identified groups of healers were not related to their ethnic affiliation ($x^2 = 1.33$; $df = 6$; $p > 0.05$) or to the geographic location of their homes ($x^2 = 1,86$; $df = 6$; $p > 0.05$). The differentiation of these three groups is instead explained by the specialization of healers in the treatment of the diseases, according to the indicator value analysis (**Table 1**).

Group 1 contains healers moderately specialized (HMS). They are recognized specialists but treat a wide range of diseases (51% of diseases treated; zero indicator disease).

Group 2 consists of healers highly specialized in obstetrics and gynecology (SOG), treating about 25% of diseases, mainly sexual impotence (*IV [indicator value]* = 38.8%), uterine prolapse (*IV* = 37.6%), gastric ulcer (*IV* = 31.3%) and threatened abortion (*IV* = 28.0%).

Group 3 consists of healers highly specialized in bone trauma (SBT). The SBT cares for 24% of diseases, mainly comprising fontanel anomalies (*IV* = 21.2%) and fractures (*IV* = 92.2%).

3.2. Diversity of medicinal plant species as the basis for identifying typology of healers

A total of 77 medicinal species was recorded from the healers involved in the study. These species represented 72 genera and 41 botanical families (**Appendix 2**). The Asteraceae family was the most important, with 10 genera and 13 species, representing 17% of the total diversity. Among the morphological types identified in the practices of healers, trees were the most used (51%), followed by herbaceous plants (22%), shrubs (21%) and vines (6%) (**Figure 4**). With about 81% of the species being extracted from the Kahuzi-Biega, this forest was the harvesting location most frequented by healers. The remaining plants were collected from fallows (17%) and fields (2%). Among the medicinal species cited, *Prunus africana* and *Autranella congolensis* are listed as endangered species, due to their heavy exploitation for timber and bark for medicinal purposes (IUCN, 2015). However, not indicator species of any group.

Four groups of healers were identified from the cluster analysis of the 88 healers x 77 plants matrix (**Figure 5**). The two extracted axes represent 24% of the total variance, 11% being explained by axis 2, and the remaining 13% being expressed by axis 3.

Again, the relationship of these groups with ethnic affiliation ($x^2 = 6.62$; $df = 9$; $p > 0.05$) as well as with geographic location ($x^2 = 6.82$; $df = 9$; $p > 0.05$) of healers was insignificant. Instead, the species harvest site seemed to differ between these groups of healers.

Group 1 comprises healers using cultivated multi-use species (UCMUS). The indicator species of this group are *Aloe barbadensis* Mill. (*IV* = 28.6%), *Baissea multiflora* A.DC. (*IV* =14.7%) and *Plantago palmata* Hook.f. (*IV* = 19.2%). The first two species have multiple uses in traditional medicine and are widely accessible. *Plantago palmata* is cultivated and sometimes used as an ornamental plant.

Group 2 comprises healers using forest multi-use species (UFMUS). It is indicated by 11 species

Table 1. Indicator diseases for discriminated groups of healers — *Maladies indicatrices des groupes de tradipraticiens*.

Group	Indicator diseases	Indicator value (%)	*p*
HMS	-	0	0
SOG	Sexual impotence	38.8	0.001
	Uterine prolapse	37.6	0.003
	Threatened abortion	28.0	0.006
SBT	Fontanelle	21.2	0.013
	Fracture	92.2	0.001

HMS: healers moderately specialized — *tradipraticiens moyennement spécialisés*; SOG: specialists of obstetrics and gynecology — *tradipraticiens spécialistes des troubles obstétriques et gynécologiques*; SBT: specialists of bone trauma — *tradipraticiens spécialistes des traumatismes des os*.

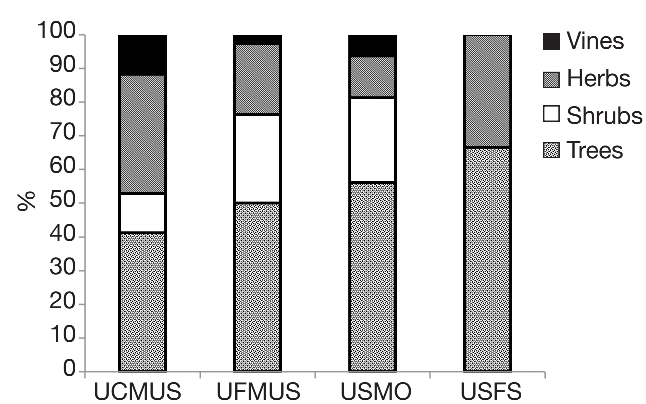


Figure 4. Proportions of morphological types of medicinal species used by discriminated groups of healers around the Park — *Proportions des types morphologiques des espèces médicinales utilisées par les groupes de tradipraticiens dans le Parc*.

UCMUS: healers using cultivated multiple uses species — *tradipraticiens utilisant des espèces cultivées à usages multiples*; UFMUS: healers using forest multiple uses species — *tradipraticiens utilisant des espèces forestières à usages multiples*; USMO: healers using species of mixed origins — *tradipraticiens utilisant des espèces d'origine mixte*; USFS: healers using species from secondary forests — *tradipraticiens utilisant des espèces de forêts secondaires*.

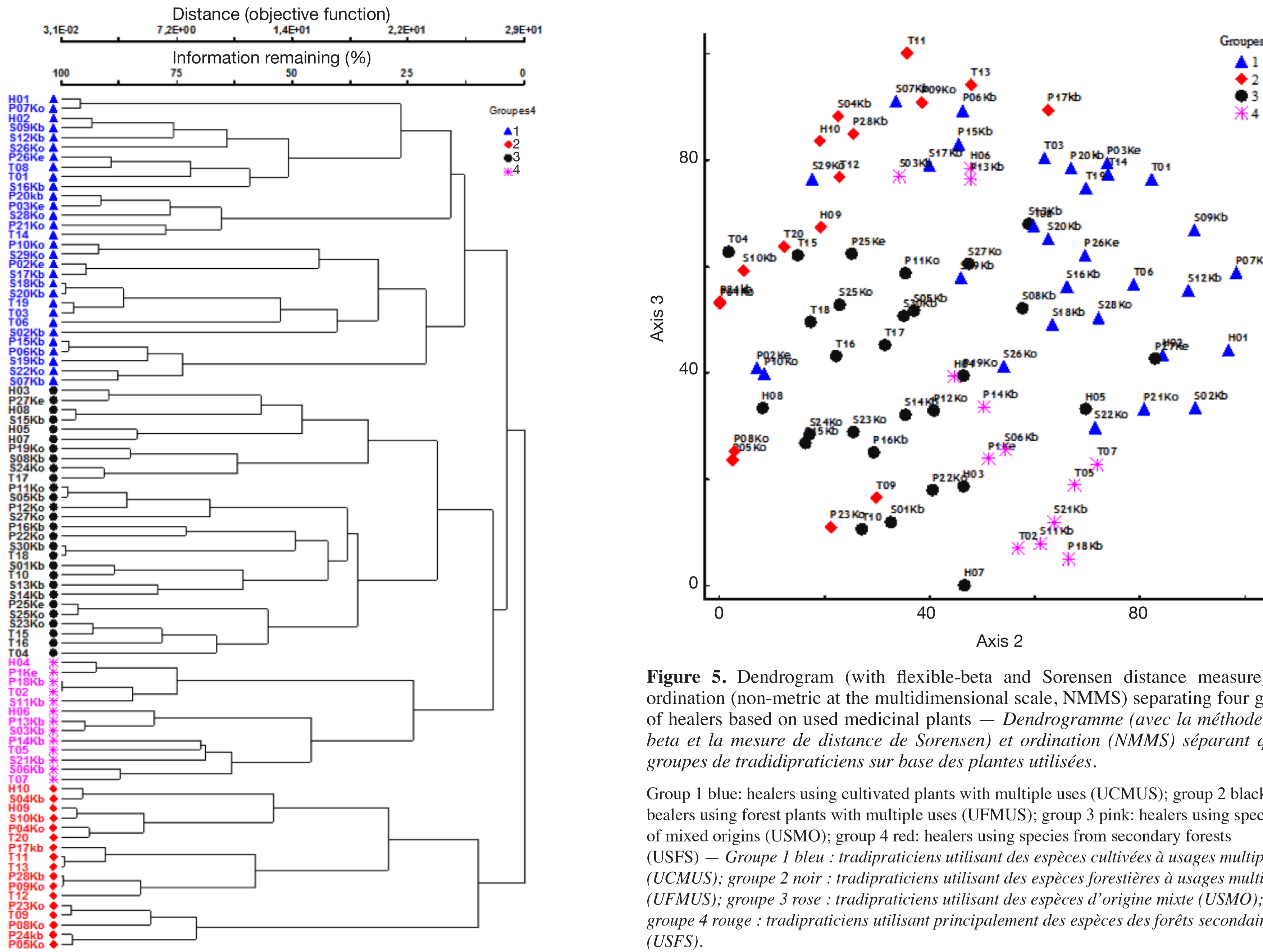


Figure 5. Dendrogram (with flexible-beta and Sorensen distance measure) and ordination (non-metric at the multidimensional scale, NMMS) separating four groups of healers based on used medicinal plants — *Dendrogramme (avec la méthode flexi-beta et la mesure de distance de Sorensen) et ordination (NMMS) séparant quatre groupes de tradidipraticiens sur base des plantes utilisées*.

Group 1 blue: healers using cultivated plants with multiple uses (UCMUS); group 2 black: bealers using forest plants with multiple uses (UFMUS); group 3 pink: healers using species of mixed origins (USMO); group 4 red: healers using species from secondary forests (USFS) — *Groupe 1 bleu : tradipraticiens utilisant des espèces cultivées à usages multiples (UCMUS); groupe 2 noir : tradipraticiens utilisant des espèces forestières à usages multiples (UFMUS); groupe 3 rose : tradipraticiens utilisant des espèces d'origine mixte (USMO); groupe 4 rouge : tradipraticiens utilisant principalement des espèces des forêts secondaires (USFS)*.

(**Table 2**) most of which are forest species (62%) including *Carapa grandiflora* Sprague (*IV* = 26.2%), *Piper capense* L.f. (*IV* = 21.9%) and *Anisopappus africanus* (Hook.f.) Oliv. & Hiern (*IV* = 21.4%).

Group 3 consists of healers using species of mixed origins (USMO). The indicator species of this group are *Tragia brevipes* Pax (*IV* = 35.4%), *Syzygium cordatum* Hochst. ex Krauss (*IV* = 27.0%), *Ensete ventricosum* (Welw.) Cheesman (*IV* = 21.2%), *Hibiscus noldeae* Baker f. (*IV* = 20.2%), *Zanthoxylum lemairei* (De Wild.) (*IV* = 17.8%) and *Kirkia acuminata* Oliv. (*IV* = 15.8%). Half of all the species used by this group are wild and the remainder is ruderal.

Group 4 consists of healers using secondary forest plant species (USFS). Two indicator species are secondary forest species: *Maesa lanceolata* Forssk. (*IV* = 31.8%), *Trema orientalis* (L.) Blume (*IV* = 37.1%) and *Drymaria cordata* (L.) Willd. ex Schult. (*IV* = 41.0%).

3.3. Consistency between typologies of healers identified from diseases treated and medicinal plants used

The Mantel test revealed a significant correlation between the two typologies of healers based on diseases treated and medicinal species used ($r = 0.134$, $p < 0.05$).

The superposition of typologies indicated that most healers using multi-use species (UCMUS and UFMUS) were healers moderately specialized (HMS). A large proportion of healers specializing in bone trauma (about 64% of SBT) corresponded to healers exploiting secondary forest plant species (USFS). About 27% of healers specializing in obstetrics and gynecology (SOG) were exploiters of species of mixed origins (USMO).

Table 2. Indicator species of four groups of healers — *Espèces indicatrices de quatre groupes de tradipraticiens*.

Group	Indicator species	Indicator value (%)	*p*
UCMUS	*Aloe barbadensis* Mill.	28.6	0.002
	Plantago palmata Hook.f.	19.2	0.033
	Baissea multiflora A.DC.	14.7	0.049
UFMUS	*Carapa grandiflora* Sprague	26.2	0.003
	Bidens pilosa L.	23.9	0.012
	Ageratum conyzoides L.	22.1	0.004
	Piper capense L.f.	21.9	0.016
	Anisopappus africanus (Hook.f.) Oliv. & Hiern	21.4	0.004
	Parinari excelsa Sabine	18.5	0.016
	Clerodendrum welwitschii Gurke	17.9	0.006
	Entandrophragma excelsum (Dawe&Sprague) Sprague	17.9	0.020
	Myrianthus holstii Engl.	17.9	0.010
	Alchornea hirtella Benth.	14.3	0.036
	Begonia meyeri-johannis Engl.	17,3	0.020
USMO	*Tragia brevipes* Pax	35.4	0.001
	Syzygium cordatum Hochst. ex Krauss	27.0	0.007
	Ensete ventricosum (Welw.) Cheesman	21.2	0.011
	Hibiscus noldeae Baker f.	20.2	0.028
	Zanthoxylum lemairei (De Wild.) P.G.Waterman	17.8	0.016
	Kirkia acuminata Oliv.	15.8	0.022
USFS	*Drymaria cordata* (L.) Willd. ex Schult.	41.0	0.001
	Maesa lanceolata Forssk.	31.8	0.002
	Trema orientalis (L.) Blume	37.1	0.001

UCMUS, UFMUS, USMO, USFS : see **figure 4** — *voir **figure 4***.

4. DISCUSSION

Rather than ethnicity or geographic factor, healers were differentiated according to their degree and type of specialization. The plants they use are correlated with diseases they are specialized in.

4.1. Diversity of diseases treated and the typology of traditional healers

This study revealed the existence of two categories of healers around the mountain forest of Kahuzi-Biega: healers moderately specialized and healers highly specialized. The first category represents a large majority of healers (70%), while the second represents a minority (30%). Most moderately specialized healers have an expertise that encompasses many kinds of diseases, while healers highly specialized generally focus on only one group of diseases or on a specific mode of traditional practices. In districts of Abidjan, Manouan et al. (2010) found a similar pattern of a high proportion of non-specialized healers (79%) and a low proportion of specialists. According to Kouakou (2013), many healers often lengthen their list of skills in order to be considered useful and honorable in their communities. However, the financial benefits of the profession also encourage people with limited knowledge to masquerade as healers. Accordingly, it is therefore important, with the help of the commitment of local communities, to differentiate real healers from those particularly motivated by money and power. This need for money might also encourage them to become more specialized in some category of diseases. The result is that they will not be so good at diagnosing and treating the variety of diseases prevalent in their communities.

4.2. Diversity of medicinal plant species and typology of traditional healers

In Kahuzi-Biega region, the use of trees by healers is a reality compared with other morphological types. This trend was reported in other regions in Africa, *e.g.* in Zinguinchor in Senegal (Diatta et al., 2013), for healers in South Omo, Ethiopia (Tolossa et al., 2013) and in Limpopo province, South Africa (Potgieter et al., 2012). This is explained by the fact that woody species generally present a higher concentration of secondary metabolites, notably alkaloids or saponins, compared with herbaceous species (Hladick et al., 1997). According to Bitsindou (1996), the significant use of bark in traditional medicine is linked to its often important role in the biosynthesis and storage of secondary metabolites, but also for its ease of collection and/or preservation, compared with other parts like roots, leaves or latex.

Healers prefer collecting plants from the forest, even when some species are available in villages. A similar attitude was reported in Madagascar by Rasoanaivo (2005), who found that plants have a high content of active ingredients as a result of growing in natural habitats. Collins et al. (2006) also noted that in Timor-Leste cultures, healers prefer species from the forest. The trend is similar in Morocco, where medicinal species from forests have a higher cultural value than those collected in the village (Mehdioui et al., 2007). In other countries where forests are uncommon, such as Burkina Faso, healers prefer to collect medicinal plant species in gallery forests (Olivier et al., 2012).

4.3. Consistency of typologies of traditional healers based on diseases treated and plants used

Among the four ethnic groups studied around the forest of Kahuzi-Biega, the findings of this study suggest that medicinal practices are not influenced by either the ethnic group or geographical location of healers. Healers often use almost the same species to treat the same identified diseases. A similar observation was made in Beni and Lubero territories, where Kasika et al. (2015) found that specialist healers showed the convergence of use of species against recurrent diseases among Bantus and Pygmies groups. This may be explained by their expert knowledge of useful plants. Also, geographical proximity can enable similar access to the whole biodiversity in the area, including low forest and mountain rainforest. According to Saslis-Lagoudakis et al. (2014), the distribution and availability of plant species are controlled by local environmental conditions so that differences in culture and language represent no predispositions to the differences in practices and uses of medicinal plants.

4.4. Implications of traditional healer typologies for species conservation

Traditional medicine practitioners, moderately or highly specialized, are often consulted by local people for healthcare. They all use drugs from plants and a large proportion of these plants are obtained from wild sources and particularly from the forest. Thus, they can negatively impact species when plant collection methods do not respect sustainable harvesting requirements. According to Richter (2015), mechanical injuries caused by humans to trees left unharvested, in the long term, usually reduces wood quality because injuries often lead to fungal infection with subsequent wood discoloration and decay. During the harvesting of plant parts, in most cases, wounds and injuries can further increase the vulnerability of species by preventing recovery, while the forests are in the process of disappearing. Traditional practitioners also have a positive role to play as one of the stakeholders in the conservation of plant diversity. Their contribution is demonstrated and recognized through the practice of cultivating medicinal plant species (Cunningham, 1993). As long as a plant is known and successfully used by healers, it will be harvested. This suggests highlighting best practices and knowledge of traditional healers based on their specialties. Active involvement in *ex situ* conservation efforts is an alternative to protect a wide variety of plant species. Providing support for planting medicinal species in community gardens or incorporating them into crop fields constitutes some of the pathways for preserving wild woody species.

5. CONCLUSIONS

This study reveals the importance of knowing the basis of the organization of traditional practitioners in order to better understand localized traditional medicine. It has revealed that in the Kahuzi-Biega highland region, traditional medicine is not influenced by the ethnic affiliation or geographical location of healers. Based on diseases and plants used, this traditional medicine is mainly dependent on the healer's specialization. The study also suggests that traditional healers can be characterized on the basis of the type of their knowledge; as healers moderately or highly specialized. Healers moderately specialized use several plants to treat a great number of diseases and healers highly specialized use particular plants to treat a limited group of diseases. Two clear groups of healers highly specialized emerge: those who treat bone trauma and those who treat obstetric-gynecological complaints. Both typologies have associated preferences for forest species, especially trees.

The fact that (i) neither ethnic origin nor geographical location could structure the group of traditional healers and that (ii) plant use and disease specialization were correlated suggests we should consider them as one community sharing a common set of practices and a single body of knowledge. This result begs the question: to what degree of ethnic or geographical distance can knowledge be shared? In other words, from which point do these factors come into play. This exploratory study also raises context-specific questions, such as why no other specializations have been encountered, how knowledge is shared between ethnic groups and different localities and if specific practices can be linked to the endangerment of specific species, such as endemic forest trees.

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Appendix 1. List of diseases — *Liste des maladies*.

Classe	Disease	Vernacular name	Group	Indicator value (%)	*p**
Infectious disorders	Amoebiasis	Eamibe	1	22.5	0.0751
	Oral candidiasis	Chaminyagu	2	4.2	0.9640
	Cholera	Mukunguru	2	6.7	0.3173
	Immunodeficiency	Muzirho	3	6.4	0.5145
	Fever	Ihoma	1	1.6	10.0000
	Gastroenteritis	Kadurha	1	4.8	0.7628
	Hepatitis	Budiku	3	8.7	0.3824
	Helminthiasis	Nzoka y'omunda	1	8.1	0.4084
	Jaundice	Ensiko	1	1.6	10.0000
	Leprosy	Bibenzi	2	20.0	0.0060*
	Gingivitis	Ndwala y'ekanwa	1	1.6	10.0000
	Taeniasis	Tegu	3	9.1	0.1461
	Tuberculosis	Chigoholo ch'ikulu	2	6.7	0.2933
Circulatory disorders	Elephantiasis	Birimbo	3	9.1	0.1251
	Blood pressure	Ndwala yo murhima	3	5.0	0.6316
Digestive disorders	Tonsillitis	Bilimi	2	6.7	0.3253
	Appendicitis	Pandisi	1	1.6	10.0000
	Painful bloating of the abdomen	Mukungulo	1	3.2	10.0000
	Constipation	Kurhanya	1	1.6	10.0000
	Diarrhea	Mushole	2	18.2	0.0561
	Bloody diarrhea	Kunya omuko	3	11.9	0.1942
	Hyper gastritis	Lurholero lukulu	1	5.7	0.6797
	Hypo gastritis	Lurholero lurho	1	3.2	10.0000
	Ulcer gastritis	Lurholero lwe chihulu	2	31.3	0.0040*
	Hemorrhoids	Kukunuka	2	11.9	0.1181
	Disc herniation	Omugongo	3	5.9	0.5716
	Toothaches	Ndwalay'aminu	2	5.4	0.4885
	Painful Bloody diarrhea	Mukunguru	3	4.6	0.6907
Genito-urinary disorders	Adnexitis	Mwanamimba	1	4.8	0.7588
	Gonorrhea	Chikagasi	1	3.2	10.0000
	Cystitis	Buganga	2	11.9	0.1061
	Persistent dysmenorrhea	Ndwala g'Omuko gw'omwezi	1	1.6	10.0000
	Frigidity	Kumasha	1	1.6	10.0000
	Sexual dysfunction	Kurahasha obuhya	2	38.8	0.0010*
	Hydrocele	Mishiha	3	6.7	0.2132
	Prostate	porositati	1	1.6	10.0000
	Uterine prolapse	Ibanzi	2	37.6	0.0030*
	Male infertility	Kugumba kwe chilume	1	1.6	10.0000
	Female infertility	Kugumba kwe chikazi	3	5.6	0.6176
	Itchy vaginitis	Chilondatumbu	2	10.7	0.1612
Inflammatory diseases	Burns	Kuhya n'omuliro	1	6.5	0.4875
	Nephritis	Nfiko	1	1.6	10.0000

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Appendix 1 (continued 1). List of diseases — *Liste des maladies*.

Classe	Disease	Vernacular name	Group	Indicator value (%)	*p**
Inflammatory diseases	Sciatic Nerve	Ihasha	3	9.1	0.1251
	Rheumatism	Kugogombaemisi	1	4.1	0.8859
Wounds and injuries	Wounds and injuries	Chihulu chikulu	3	15.7	0.0641
	Wounds ulcer	Lukero	1	3.2	10.0000
Metabolic disorders	Diabete	Chisukari	1	6.5	0.4394
Muscle disorders	Low back pain	Omugongo	3	9.1	0.1221
	Sprain	Kuteguka	1	3.2	10.0000
	Fracture	Buvune	3	92.2	0.0010*
Nerve disorders	Headache	Irhwe kuluma	3	13.4	0.0931
	Epilepsy	Lungungu	1	3.4	0.9630
	Madness	Isirhe	1	9.1	0.6096
	Migraine headaches	Fumba	2	20.2	0.0340*
Poisoning	Poisoning	Oboge	1	10.6	0.3423
	Snake bite	Kajokajoka	2	4.5	0.7157
Disorders of pregnancy	Dystocia	Ukurhagwisa	3	4.8	0.6226
	Voluntary termination of pregnancy	Kukulaizimi	3	9.1	0.1221
	Threatened abortion	Lumomyo	2	28.0	0.0060*
	Hypogalactia	Kukumbwa	1	9.7	0.3564
	Fontanel	Lukunga	3	21.2	0.0130*
	Fetal death	Chibolwe	2	6.7	0.2933
Respiratory disorders	Anginas	Bigoga	1	3.2	10.0000
	Asthma	Obuhema	1	3.2	10.0000
	Coryza	Kufuneka	1	1.6	10.0000
	Cough	Chikoholo	2	4.5	10.0000
	Pain of chest	Kashiha	3	6.7	0.3263
	Pneumonia	Mwijimbwe	1	3.2	10.0000
	Sinusitis	Muzerezi	2	6.7	0.2933
Sensory disorders	Cataracts	Nshongo	1	4.8	0.6396
	Conjunctivitis	Ndwala ya masu	1	6.5	0.4384
Skin and subcutaneous disorders	Abscess	Muhama	1	8.1	0.4124
	Dermatosis	Kuyaga	1	8.1	0.4284
	Furunculosis	Mahurehure	3	6.7	0.3063
	Cyst	Muziha	2	5.4	0.4795
	Fungus	Lubenja	3	8.0	0.1361
	Panari	Mududu	3	6.7	0.3073
	Psoriasis	Pessé	2	5.4	0.4625
Abnormal blood organs	Anemia	Kubulaomuko	2	3.9	10.0000
	Splenomegaly	Lusingu	3	4.9	0.6697
	Tumor Breast	Chimokomoko, Mpanga	1	3.2	10.0000
	Cancer unidentified seat	Kafinjo	1	1.6	10.0000
Nutritional disorders	Anorexia	Kurhahasha kulya	2	6.7	0.3173
	Emaciation	Njorwe	1	1.6	10.0000

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Appendix 1 (continued 2). List of diseases — *Liste des maladies*.

Classe	Disease	Vernacular name	Group	Indicator value (%)	*p**
Nutritional disorders	Malnutrition	Obwaki	1	3.2	10.0000
Poorly defined syndromes	Epistaxis	Muledu	1	1.6	10.0000
	Vertigo	Chizunguzungu	1	3.2	10.0000
Cultural syndromes	Kivubo	Chivubo	1	3.2	10.0000
	Iseke	Iseke	1	1.6	10.0000
	Kunde	Kunde	2	6.7	0.2903
	Curses	Mugereko	1	1.6	10.0000
	Evil spirit	Mudorho	1	4.8	0.7618
	Mpivu	Mpivu	1	1.6	10.0000
	Mulonge	Mulonge	1	6.5	0.5075
	Mukinje	Mukinje	1	1.6	10.0000

* : indicator species of the groupe (Indval method) — *espèce indicatrice du groupe (méthode Indval)*; meaning of the groups — *signification des groupes*: see **figure 5** — *voir **figure 5***.

Appendix 2. Floral list — *Liste floristique*.

Family	Species	Vernacular name	Group	Indicator value	*p**	Morpho-logical type	Habitat
Alangiaceae	*Alangium chinense* (Lour.) Harms	Mulemera	1	3.3	10.000	tree	forest
Apocynaceae	*Baissea multiflora* A.DC.	Mpango	1	14.7	0.049*	shrub	forest
Apocynaceae	*Pleiocarpa pycnantha* (K.Schum.) Stapf	Kintangondo	2	3.9	0.672	tree	forest
Apocynaceae	*Tabernaemontana johnstonii* (Stapf) Pichon	Muberebere	3	16.6	0.076	tree	forest
Araliaceae	*Polyscias fulva* (Hiern) Harms	Ntongi	1	2.2	0.988	tree	forest
Asclepiadaceae	*Periploca linearifolia* Quart.-Dill. & A.Rich.	Kanondonondo	2	1.8	10.000	vine	ruderal
Asteraceae	*Mikania cordata* (Burm.f.) B.L.Rob.	Muhombia mashaka	1	12.5	0.163	herb	forest
Asteraceae	*Ageratum conyzoides* (L.) L.	Kahyola	2	22.1	0.004*	herb	fallow
Asteraceae	*Alchornea hirtella* Benth.	Lulerhalerha	2	14.3	0.036*	shrub	forest
Asteraceae	*Anisopappus africanus* (Hook.f.) Oliv. & Hiern	Nyamwasamuza	2	21.4	0.004*	herb	fallow
Asteraceae	*Bidens pilosa* L.	Kashisha	2	23.9	0.012*	herb	fallow
Asteraceae	*Conyza aegyptiaca* (L.) Dryand. ex Aiton	Nyambuba	2	5.7	0.647	herb	fallow
Asteraceae	*Lactuca attenuata* Stebbins	Luvunanga	2	9.3	0.130	herb	forest
Asteraceae	*Vernonia amygdalina* Delile	Mwibirizi	2	3.6	0.645	tree	ruderal
Asteraceae	*Vernonia hochstetteri* Sch.Bip. ex Hochst.	Ivumovumo	2	10.1	0.141	shrub	forest
Asteraceae	*Vernonia kirungae* R.E.Fr.	Ivumo	2	7.3	0.305	shrub	forest
Asteraceae	*Alchornea cordifolia* (Schumach. & Thonn.) Müll. Arg.	Lungusu	3	4.1	0.469	shrub	forest

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Appendix 2 (continued 1). Floral list — *Liste floristique*.

Family	Species	Vernacular name	Group	Indicator value	p*	Morpho-logical type	Habitat
Asteraceae	*Dichrocephala integrifolia* (L.f.) Kuntze	Chitundambuga	3	12.1	0.2710	herb	fallow
Asteraceae	*Crassocephalum bumbense* S.Moore	Chifubula	4	9.9	0.1850	herb	forest
Basellaceae	*Basella alba* L.	Ndelama	1	13.7	0.0640	herb	forest
Begoniaceae	*Begonia meyeri-johannis* Engl.	Kahulula	2	17.3	0.0200*	herb	forest
Burseraceae	*Canarium schweinfurtii* Engl.	Bwaga	1	7.4	0.3280	tree	forest
Caryophyllaceae	*Drymaria cordata* Willd. ex Schult.	Bwahulo	4	41.0	0.0010*	herb	ruderal
Chrysobalanaceae	*Parinari excelsa* Sabine.	Mwinga	2	18.5	0.0160*	tree	forest
Clusiaceae	*Harungana montana* Spirlet	Kadwamuko	1	12.4	0.2200	shrub	forest
Clusiaceae	*Symphonia globulifera* L.f.	Muzimba	1	3.3	1.0000	tree	forest
Clusiaceae	*Lebrunia bushaei* Staner	Bushahi	2	7.1	0.1620	tree	forest
Convolvulaceae	*Ipomoea involucrata* P.Beauv.	Kadwamonka	1	10.0	0.1210	herb	forest
Cyatheaceae	*Cyathea manniana* Hook.	Bishembegere	1	3.5	0.7420	shrub	forest
Euphorbiaceae	*Macaranga kilimandscharica* Pax	Lushasha	2	4.9	0.3140	tree	forest
Euphorbiaceae	*Neoboutonia macrocalyx* Pax	Chibirabira	2	8.2	0.1990	tree	forest
Euphorbiaceae	*Tragia brevipes* Pax	Ishusha	3	35.4	0.0010*	shrub	ruderal
Euphorbiaceae	*Neoboutonia africana* Müll. Arg.	Kitubutubu	4	5.2	0.5880	tree	forest
Fabaceae	*Piptadeniastrum africanum* (Hook.f.) Brenan	Libuyu	1	3.3	10.0000	tree	forest
Fabaceae	*Millettia psilopetala* Harms	Nshungurhi	2	8.7	0.1300	tree	forest
Fabaceae	*Newtonia buchananii* (Baker) G.C.C.Gilbert & Boutique	Lukundu	2	1.8	10.0000	tree	forest
Fabaceae	*Albizia gummifera* (J.F.Gmel.) C.A.Sm.	Mushebere	3	3.3	0.6690	tree	forest
Fabaceae	*Erythrophleum guineense* G.Don	Chikubwekubwe	3	2.9	0.9130	tree	forest
Labiataceae	*Clerodendrum welwitschii* Gürke	Nfubya	2	17.9	0.0060*	shrub	forest
Lamiaceae	*Pycnostachys erici-rosenii* R.E.Fr.	Mwizunguluka	2	7.2	0.3650	shrub	forest
Lauraceae	*Persea americana* Mill.	Ivocati	2	9.5	0.2890	tree	cultivated
Lobeliaceae	*Lobelia giberroa* Hemsl.	Mwirumbu	3	5.4	0.3910	shrub	forest
Malvaceae	*Hibiscus noldeae* Baker f.	Mukerashungwe	3	20.2	0.0280*	herb	forest
Meliaceae	*Carapa grandiflora* Sprague	Bugwerhe	2	26.2	0.0030*	tree	forest
Meliaceae	*Entandrophragma excelsum* (Dawe & Sprague) Sprague	Libuyu	2	17.9	0.0200*	tree	forest
Moraceae	*Ficus oreodryadum* Mildbr.	Mulehe	2	8.2	0.2030	tree	forest
Moraceae	*Ficus thonningii* Blume	Kahura	2	3.6	0.6930	tree	forest
Moraceae	*Milicia excelsa* (Welw.) C.C.Berg	Muvula	2	1.8	10.0000	tree	forest

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Appendix 2 (continued 2). Floral list — *Liste floristique*.

Family	Species	Vernacular name	Group	Indicator value	*p**	Morpho-logical type	Habitat
Moringaceae	*Moringa oleifera* Lam.	Muringa	3	5.3	0.4470	tree	cultivated
Musaceae	*Ensete ventricosum* (Welw.) Cheesman	Chirembo	3	21.2	0.0110*	herb	forest
Myrsinaceae	*Embelia schimperi* Vatke	Kashalulabahivi	1	5.5	0.5850	vine	forest
Myrsinaceae	*Rapanea melanophloeos* (L.) Mez	Chishorhe	1	3.3	1.0000	tree	forest
Myrsinaceae	*Maesa lanceolata* Forssk.	Mparhi	4	31.8	0.0020*	tree	forest
Myrtaceae	*Syzygium guineense* (Willd.) DC.	Chikobarhi	2	7.1	0.1470	tree	forest
Myrtaceae	*Syzygium cordatum* Hochst. ex Krauss	Mugorhe	3	27.0	0.0070*	tree	forest
Olacaceae	*Strombosia scheffleri* Engl.	Busika	3	4.1	0.5610	tree	forest
Oleaceae	*Jasminum abyssinicum* Hochst. ex DC.	Kafufula	2	3.6	0.6590	vine	forest
Phyllanthaceae	*Bridelia micrantha* (Hochst.) Baill.	Mujimbu	2	8.1	0.2520	tree	forest
Piperaceae	*Piper capense* L.f.	Muborobondo	2	21.9	0.0160*	shrub	forest
Plantaginaceae	*Plantago palmata* Hook.f.	Chibarama	1	19.2	0.0330*	herb	ruderal
Polygonaceae	*Rumex bequaertii* De Wild.	Muberanaga	1	7.8	0.3050	herb	forest
Rhamnaceae	*Gouania longispicata* Engl.	Muvurha	2	8.4	0.2670	vine	forest
Rosaceae	*Prunus africana* (Hook.f.) Kalkman	Muhumbahumba	4	12.7	0.0500	tree	forest
Rubiaceae	*Galiniera coffeoides* Delile	Chintindi	2	7.1	0.1460	shrub	forest
Rubiaceae	*Rubia cordifolia* L.	Lukerabatuzi	2	7.1	0.1510	herb	forest
Rubiaceae	*Tricalysia niamniamensis* Schweinf. ex Hiern	Nkongo	2	10.7	0.1040	shrub	forest
Rubiaceae	*Coffea kivuensis* Lebrun	Akahwa	3	6.2	0.3710	shrub	forest
Rubiaceae	*Hallea rubrostipulata* (K.Schum.) J.-F.Leroy	Muzibaziba	3	3.5	0.8610	tree	forest
Rutaceae	*Zanthoxylum macrophyllum* Nutt.	Kashabumbu	2	9.0	0.2310	tree	forest
Rutaceae	*Zanthoxylum lemairei* (De Wild.) P.G.Waterman	Kashabumbu	3	17.8	0.0160*	tree	forest
Sapotaceae	*Autranella congolensis* (De Wild.) A.Chev.	Mulungu	2	7.1	0.1550	tree	forest
Simaroubaceae	*Kirkia acuminata* Oliv.	Mulumear-hashonwako	3	15.8	0.0220*	tree	forest
Tiliaceae	*Triumfetta cordifolia* A.Rich.	Chahunga	2	7.1	0.1460	shrub	forest
Ulmaceae	*Trema orientalis* (L.) Blume	Mushakushaku	4	37.1	0.0010*	tree	forest
Urticaceae	*Urera hypselodendron* (Hochst. ex A.Rich.) Wedd..	Mushebere	1	11.0	0.0950	vine	forest
Urticaceae	*Myrianthus holstii* Engl.	Bwamba	2	17.9	0.0100*	tree	forest
Xanthorrhoeaceae	*Aloe barbadensis* Mill.	Chigaka	1	28.6	0.0020*	herb	cultivated

* : indicator species of the groupe (Indval method) — *espèce indicatrice du groupe (méthode Indval)*; meaning of the groups — *signification des groupes*: see **figure 5** — *voir* ***figure 5***.