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First Ethnobotanical Analysis of Useful Plants in Cuanza Norte, North Angola

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Research Article

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ABSTRACT

Objective: This study addresses the diverse use of plants in the unexplored Province of Cuanza Norte, Angola. The joint survey between the University Kimpa Vita, N'dalatando, Angola and the Technische Universität Dresden, Germany was to collect, identify and verify different plants and their utilisations in order to analyse the current state of biodiversity by saving the traditional knowledge of the local population.

Methods: Semi-structured interviews were conducted in the rainy season October/November 2014 and 2015 in the Province Cuanza Norte. For a better quantification and in order to estimate the value of the plants, the Cultural Importance Index (CI) and the Relative Frequency of Citation (RFC) were calculated.

Results: Ninety-two persons were interviewed, resulting in 533 data records for 162 different plants (58 families). According to the first calculation of the CI and the RFC, the neophytes *Chenopodium ambrosioides* and *Chromolaena odorata* are the most important species and the most frequently utilised parts are leaves (47.5%). Twenty utilisations are reported for the first time not only for Angola but are also not mentioned in literature before (12.4%). The utilisations of *Hymenostegia laxiflora* and *Perichasma laetificata* seem to be interesting due to their multiple mentioning. The medical treatments comprised a high range of 32 different symptoms, among which stomach ache are the most common (27%). The creation of seven use categories showed that most plants are used in one category, the medical sector (79.2%). Nevertheless, several plants were used in up to four different categories (*Adansonia digitata*, *Annona muricata*, *Passiflora quadrangularis* and *Ceiba pentandra)*.

Conclusion: This first ethnobotanical analysis serves as a basis for further studies illustrating plants with a high potential for pharmaceutical studies and confirms results from adjacent regions. Especially the difficult reachable areas in the north and west are of particular interest finding new species and utilisation patterns.

INTRODUCTION

Mankind knows and depends on the therapeutic effects of plants since ancient times. As a result, plant classifications, e.g. from around 300 B.C., were based on the benefit of a certain plant for humans and various application methods unlike today where classifications are based on morphological characteristics and DNA sequence data [1]. Their ability to assist in the treatment of illnesses and the healing of wounds and bites resulted in the establishment of herbal gardens. All over the world, especially in Europe, they were introduced starting in the 6th century, as the earliest form of a pharmacy [2].

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Even today, traditional medicine is of great importance for the development of new medications. Most of the pharmaceutically available drugs are based on plants or animals. Especially in developing countries, traditional medicine is still essential for health care and well-being [3]. The availability and accessibility to qualified medical doctors in Africa is limited, just one doctor for a population of 40,000 whereas the ratio of traditional healers to population amounts 1:500 [4]. Hence native healers are important for primary health needs in rural areas. Nowadays training programmes are implemented, strengthening the knowledge of traditional health practitioners for which a comprehensive scientific knowledge is needed [4].

Biodiversity in tropical regions is particularly high. According to Barthlott (2005) the number of vascular plant species in Angola comprises about 2,000-3,000 per 10,000 km² placing the country on a worldwide scale into the 7th highest diversity zone out of ten [5]. The total number of vascular plants in Angola is currently summing up to 7,296 species, 1,000 of which are believed to be endemic [6]. Subsequently Angola is the second richest country with respect to endemic plants in continental Africa [7]. Most of the plant descriptions for the whole country are based on the rather old collections of Friedrich Welwitsch (1853-1860), John Gossweiler (1900-1950) and Hugo Baum (1899-1901) [6]. Hence, it is crucial to conduct ethnobotanical studies, especially in regionally diverse regions such as Angola. However, in recent years ethnobotanical field studies are rare. Bossard (1987), Van-Dúnem and Costa (2013) worked in the centre of Angola but their studies are only valid for a small part of Angola´s vegetation and no quantitative data are available [8–11]. Especially the work of Bossard focussed more on the ethnological side of traditional medicine. Urso *et al.* (2016) published the first quantitative plant data for the south-west of Angola, however the vegetation there is completely different to the Province of Cuanza Norte, thus a comparison is not feasible [12]. Current investigations from different institutions focus more on the southern provinces of the country, wherefore the northern part is under-represented and more diverse studies are required [13,14].

One study over the vegetation and usage of disturbed savannah has been performed in the surrounding area north to the Province of Cuanza Norte, in the Province of Uíge [15]. The majority of the records from Göhre *et al.* (2016) belongs to medicinal plants (72.1%). Nevertheless, a comparison is feasible just in parts because the vegetation zones of Cuanza Norte are more diverse and the different forest formations occur in smaller proportions [15]. The vernacular names differ as well due to the utilisation of different traditional languages, Kikongo in the north and mostly Kimbundu in the studied area [16].

Local biodiversity is essential for the well-being of the Angolan people providing among others various kinds of food, traditional medicine, construction material and energy. In the past, the long civil war in Angola affected the biodiversity on all levels from genes to ecosystems [17]. Current human impacts like slash-and-burn farming, deforestation, road construction and urbanization still threaten these natural resources to a great extent. Trees especially those from the few remaining rainforests are profitably logged for timber, firewood and charcoal resulting in severe forest degradation [18]. The IUCN, *International Union for Conservation of Nature,* classifies 339 plant species of Angola as threatened [19].

Determining the actual state of biodiversity is essential and a diverse work field needing the cooperation of many different scientific areas, so far realised in the Province of Uíge [20].

The MINUA of Angola reacted to this process, developing a six-year reaching National Biodiversity Strategy and Action Plan (NBSAP) with long-term strategies for a sustainable use of natural resources [7]. The NBSAP established fundamentals for the knowledge transfer and conservation of Angolan biodiversity, but the implementation is far from being effective: only 25% of the suggested actions have been put into practice [21].

Angola has a high economic potential. The mineral resources reach from oil over natural gas to diamonds. With $128 billion per year (2014), Angola has the fifth highest GDP in Africa following Egypt, Algeria, Nigeria and South Africa [22]. Beside this enormous economic growth, tremendous differences between the cities and the rural areas still exist. Even today problems such as malnutrition, a lack of comprehensive health care and a high infant mortality are widespread in the country [23].

The aim of this first joint survey of the University Kimpa Vita in N'dalatando/Angola and the Technische Universität Dresden/Germany (TUD) was to collect, identify and verify different plant utilisations in the Province Cuanza Norte. The obtained results indicate the current status and diversity of useful plants. This assessment serves as a basis for further studies. The local population receives an initial impression of the collaborative effort, leading to value their own traditional knowledge. Creating an enhanced respect by reflecting the actual handling of products gained from nature lead to a strengthened sustainability.

Location

The study area is located in the north-west of Angola, in the province of Cuanza Norte **(Figure 1)**. Cuanza Norte covers 24,200 km² and has a population of about 430,000 inhabitants (18 inhabitants/km²) thus belonging to the five

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Provinces with the lowest population densities in Angola [24]. The 40 data sampling points are located in seven of the ten municipalities, covering nearly all occurring vegetation zones.

The highest data sampling point (1,268 m) is located in the highland of Ambaca, which is situated in the north of Cuanza Norte. The lowest point visited is Mucoso in the south at an altitude of 39 m.

Due to the higher density of population and the better accessibility in the proximity of N'dalatando most of the sampling points are situated there. The encountering of different vegetation zones in the surrounding of the town results in a spread utilisation of the manifold plants for food and pharmaceuticals.

Vegetation zones

According to the climate classification of Köppen and Geiger (1953), Cuanza Norte belongs to the tropical savannah climate [25,26]. N'dalatando has an average annual temperature of 22.2˚C and an annual precipitation of 1,143mm. The rainy season lasts from October to April, where all field trips took place [27].

Based on differences in altitude and soil condition Cuanza Norte shows seven vegetation zones illustrated in **Figure 1** [28]. A large part of the data sampling points are located in the forest-savannah mosaic. Drier forests and savannah of low crown height characterize this zone. The tree and shrub savannah located in the eastern part of Cuanza Norte was frequently visited as well. The occurrence of veld and xerophytic scrubland is typical for this vegetation zone. Eleven sampling points are situated in the closed forest formations that were formerly widespread in the north-western part of the Province. The northern forest formations of Cuanza Norte are belonging to the Congo Basin [29]. Today they are under severe pressure due to slash-and-burn farming. Scrubland dominates the thicket-savannah mosaic in the north-east, represented by nine sampling points. The areas of woodlands and grasslands in the southwest of the Province are relatively small and data there were collected only once. Small trees, shrubs, high grasses and wetland plants are typical life forms in these areas [28].

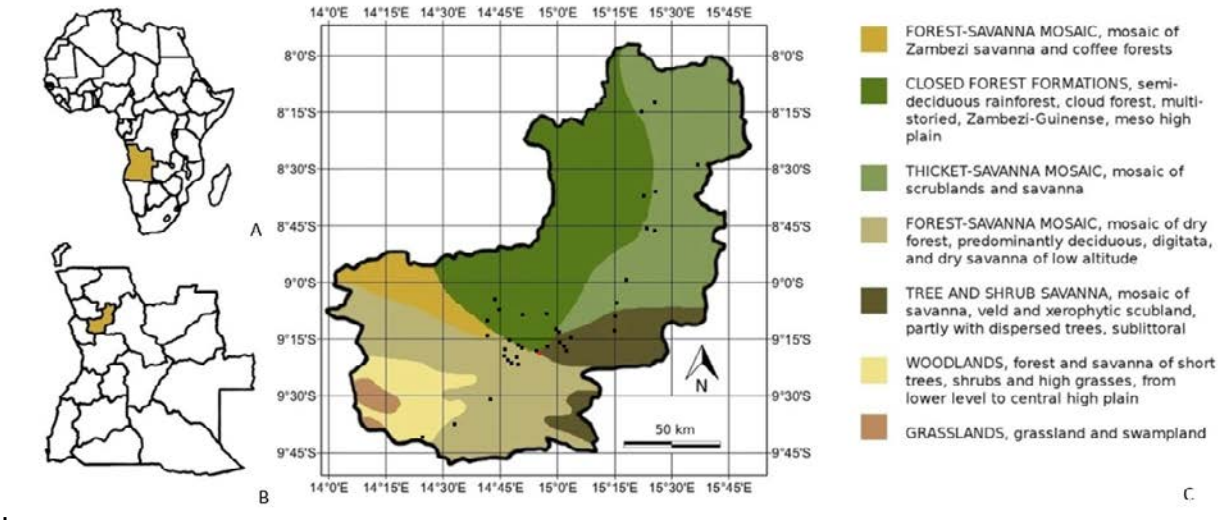

Figure 1. A: Location of Angola in Africa; B: Location of Cuanza Norte in Angola; C: Vegetation zones of Cuanza Norte according to the phytogeographic Chart of Angola by Barbosa (1970) with the 40 data sampling points, red dot highlights N'Dalatando. Graphic: A. Kempe.

Population

Different Bantu tribes are distributed all over the country. The Mbundu tribe mainly inhabits Cuanza Norte. As a result of slavery, restrictions during Portuguese colonialism, 12 years of independence war and the 27 years of civil war a lot of traditional cultural knowledge of the Mbundu tribe already got lost. Actually most of the Mbundu live in rural areas and are subsistence farmers [30]. Today, migration of the young generation to the urban centres as Luanda heavily affects the traditions of the Mbundu [31].

Communication

Portuguese is the official language of Angola, however, a total number of forty-one languages is listed for Angola [32]. Additionally, most of the different ethnic groups use their traditional tongues, especially in rural areas. The language of the Mbundu tribe is called Kimbundu. The languages Kikongo farther to the north and Umbundu south of Cuanza Norte are also frequently spoken [16]. The overlapping of different languages in the study area results in large variation of plant names.

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The majority of interviews took place in rural areas and villages, where the elders prefer to speak Kimbundu. The accompanying team of students from the University Kimpa Vita assisted translating Kimbundu into Portuguese and presenting the project to the local authorities.

As a result of the different dialects, communication and recording of the vernacular names of the plants is rather complicated. Orthography and pronunciation of one plant name may differ from village to village even if they are close to each other [30]. There is no uniform spelling of the words and in some cases you may find up to nine words for one meaning [30].

METHODS

The fieldwork in the rural areas and villages took place in October and November 2014 and 2015. Semi-structured interviews focusing on medical treatments of plants (utilisation, application, utilised part) were applied [33]. Local and administration authorities from each community were asked for work permit and mediated to meet informants with a broad knowledge about useful plants depending on their time availability and cooperativeness. Accordingly, the selected informants guided us to the sampling points in the adjacent vegetation. All participants were informed about the aim of our project and their rights (prior informed consent).

For every plant, herbarium specimen were prepared if possible and transported with a collection and export permit to the TUD. The vouchers are stored in the Herbarium Dresdense at the TUD, with regard to store the duplicates of each species as soon as the necessary conditions are implemented on-site at the University Kimpa Vita. The identification took place at the Institute of Botany of the TUD, where various field guides of savannah plants, medicinal plants and floras of adjacent tropical regions served as basis for the plant identification [10,34–41]. All scientific names were checked with African Plant Database (version 3.4.0) [42].

The fieldwork took place in forty different sampling points, interviewing ninety-two informants. The majority of them were traditional healers, nominated by local authorities, 53% were male and 47% were female. The average age is 50 with a range of 25 to 79 years of age.

For a better quantification and in order to estimate the value of the plants for the local people the Cultural Importance Index (CI) and the Relative Frequency of Citation (RFC) was calculated. The CI shows the cultural significance of a plant considering the frequency mentioning the uses of each plant species by the informants [43]. This term refers to the use-categories (u), the informants (i), the total number of informants (N), the number of use-categories (NC) and the use report of informant i in use (UR_{ui}).

$$CI_s = \sum_{u=u_1}^{u_N c} \sum_{i=i_1}^{i_N} \frac{UR_{ui}}{N}$$

Calculation of the Cultural Importance Index (CI)

Focussing on the local importance of each plant species, the RFC is a good parameter. It is calculated as the quotient of the frequency of citations (FC) and the total number of informants (N) [44].

$$RFC = \frac{RF}{N} \qquad (0 < RFC < 1)$$

Calculation of the relative frequency of citation (RFC)

Upon determination, the previously described utilisations for all plants were subsequently compared with “A Dictionary of Plant Use and Applications in the African Traditional Medicine” [45], “Handbook of African Medicinal Plants” and other specific literature [10,36,37,46]. Based on “Plants of Angola”, including a list of all previously referred plants for the whole country relating to each province, the classification is divided in naturalised, endemic, listed and not listed [47]. Determine plants of particular interest, a PubMed scan was performed in March 2016, focussing on medical and chemical publications for every identified plant species (http://www.ncbi.nlm.nih.gov/pubmed).

RESULTS

The interviews generated 533 use reports corresponding to 162 plant specimens representing 58 different plant families. The identified species are presented with regard to their scientific as well as vernacular names, and characterised according to their use, use category, their application as well as the utilised part of the plant, the CI and the RFC. Furthermore, the herbarium number/photographic voucher (F) and the GPS point of each species is listed **(Supplementary Table 1)**.

Figure 2 illustrates the distribution of the most frequent plant families based on the number of identified species. The predominant families are Fabaceae (11.6%), Asteraceae (5.5%) and Euphorbiaceae (5.5%), belonging to the five most common families in the whole country [6]. Twenty-eight families are represented by a single species only, indicating high plant diversity in the studied area. The growth forms are evenly distributed (38.3% annual and perennial herbs, 29.6% Trees, 21% shrubs and 11.1% climbers).

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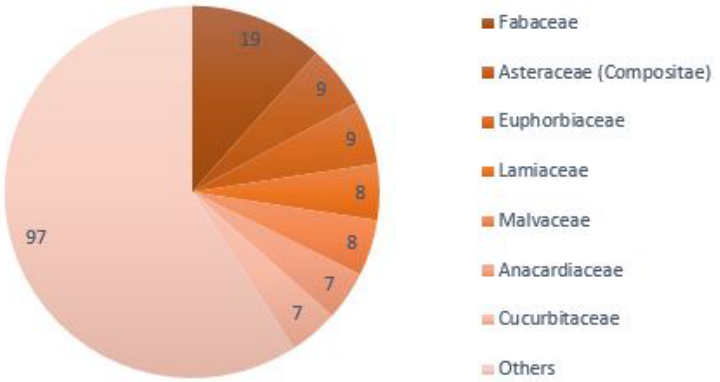

Figure 2. Frequency of the different plant families among the determined species, expressed as total numbers.

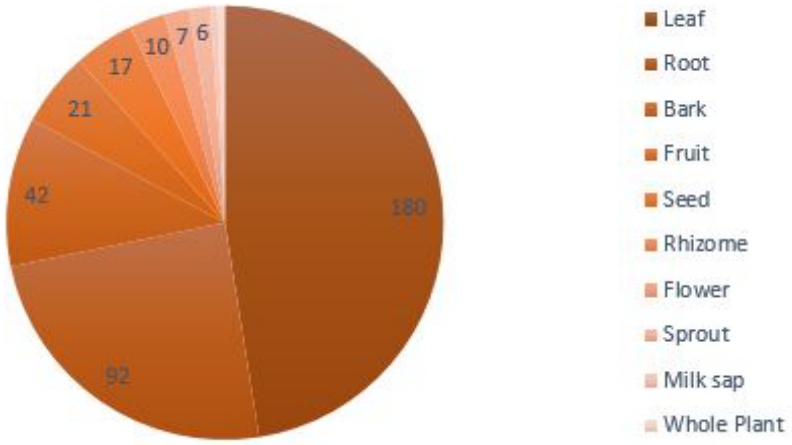

Figure 3. Frequency of the different plant parts utilised, expressed as total numbers.

Any parts of plants are used in traditional medicine. Leaves are the most commonly used parts (47.5%), followed by roots (24.3%) and bark (11.1%) while reports about the use of other plant parts were rare **(Figure 3)**. The utilisation of the whole plant or the milk sap was mentioned only a few times. The informants indicated diverse application methods as well. Frequently mentioned practices are infusion (27%), chewing (13%) and the utilisation as an ointment (13%).

Parallel to the occurrence of various diseases the utilisation of the plants shows a huge range. **Figure 4** illustrates the different treated diseases (32). Stomach ache are mentioned most frequently (112) while specific diseases such as paralysis, appendicitis or typhoid fever are referred just a few times. All specific symptoms (up to five mentions) are summarized in the category *Others*. General diseases combine general complaints such as discomfort or weakness.

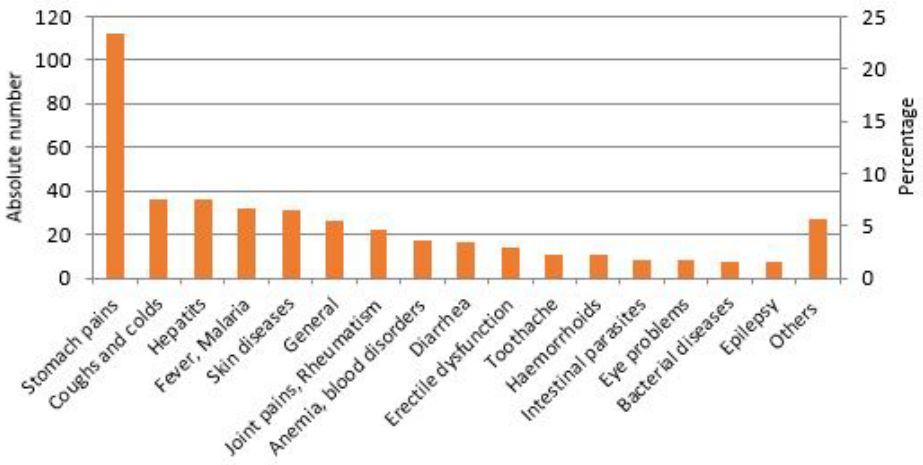

Figure 4. Overview of the different treated diseases, expressed in absolute numbers and as percentage.

Table 1 shows the species with the highest CI and RFC. The PubMed Scan of these species was positive in all cases, indicating data about their chemical composition and/ or medical effect. Seven different use categories, medical (79.2%),

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nutrition (11.1%), construction (3%), tea (1.3%), ritual/magic (0.8%), fuel (0.8%) and others (3.9%), served as basis for the calculation. The average CI is 0.03 with a range from 0.01 to 0.19. *Chenopodium ambrosioides* has the highest CI of all collected plants (0.19). It was mentioned in 17 different interviews with various medical applications.

Table 1. Ordered presentation of the 11 species with the highest CI (number of applications in brackets behind the CI, number of informants mentioning the plant in brackets behind the RFC, results of the PubMed Scan and utilised part in absolute numbers (B = bark; Fl = flower; Fr = fruit; L = leaf; Ms = Mild sap; P = whole plant; Rh = rhizome; R = root; Rh = Rhizom; Se = seed; Sh = shoot).

Species	CI	RFC	PubMed	Part
Chenopodium ambrosioides L.	0. 19 (17)	0. 19 (17)	+	L (17)
Chromolaena odorata (L.) R: M: King & H. Rob.	0. 17 (19)	0. 17 (16)	+	L (17); L, R (2)
Manihot esculenta Crantz	0. 15 (14)	0. 11 (10)	+	L (7); R (7)
Mondia whitei (Hook. f.) Skeels	0. 13 (16)	0. 11 (10)	+	L (3); R (13)
Adansonia digitata L.	0. 13 (12)	0. 1 (9)	+	B (3); Fr (4), L (3), Sh (2)
Ocimum gratissimum L	0. 12 (11)	0. 12 (11)	+	L (11)
Cymbopogon densiflorus (Steud.) Stapf	0. 12 (13)	0. 1 (9)	+	Fl (13)
Alchornea cordifolia (Schumach. & Thonn.) Müll. Arg.	0. 11 (10)	0. 09 (8)	+	L (2), R (6), Se (2)
Moringa oleifera Lam.	0. 11 (10)	0. 09 (8)	+	L (4); L, B (3); Se (3)
Piliostigma thonningii (Schumach.) Milne-Redh.	0. 1 (12)	0. 1 (9)	+	B (2); L (3); L, B, R (4); L, R (2); R (1)
Aframomum alboviolaceum (Ridl.) K. Schum.	0. 1 (10)	0. 08 (7)	+	Fr (4); L (1), Rh (5)

The majority of plants were referred for just one UC (84.1%), only 26 plants show various applications across the applied categories. The utilisation of *Adansonia digitata* shows the highest variety, it is used for medical treatment, construction, nutrition and as a spice paste (*Others*) showing a high importance for the Angolan population. This tree is native to Africa and therefore plays a crucial role in several traditions over hundreds of years [48]. *Annona muricata*, *Passiflora quadrangularis* and *Ceiba pentandra* are mentioned for three different categories, showing a widespread usage as well.

Twenty of the recorded medical utilisations are reported for the first time (8.2% of medical category). Moreover, eleven of these plants showed no hits by the PubMed search, indicating a high potential for further analysis because until now no chemical or medical study is performed concerning these plants (*Acacia* cf. *goetzei*, *Eriosema griseum*, *Eriosema* cf. *pauciflorum*, *Hymenostegia laxiflora*, *Hibiscus rhodanthus*, *Perichasma laetificata*, *Ochna* cf. *multiflora*, *Antidesma membranaceum*, *Antidesma venosum*, *Lippia plicata*, *Stachytarpheta* cf. *angolensis*). Most utilisations for the new records were referred just once (64%). Nevertheless, *H. laxiflora* and *P. laetificata* were mentioned up to three times independently for one application. *Stachytarpheta* cf. *angolensis* is the only endemic plant with a new record. The proportion of neophytes with 27.9% (36 plants) is very high [47]. Just two of the 162 collected plants are endemic to Angola, 18 plants were not listed for the Flora of Angola (11%). Moreover, the CI of naturalised plants is higher (0.05 whereas the average is 0.03) as well as the above average of UR with 4.3 per plant, whereas the average UR for endemic plants amounts 3.

DISCUSSION

The majority of the 162 identified plant species are used against stomach pain (112) a symptom that most probably is a result of various diseases as for instance constipation, virus, food poisoning, menstrual cramps and others. The frequent appearance of stomach ache encourages traditional healers to focus their therapies on these illnesses. Providing further evidence for this concept, fever, coughs and general pain are often reported as well. The study of Urso *et al.* (2016) concluded similar results, with most recorded disorders belonging to the gastrointestinal tract followed by obstetric/gynaecological troubles and colds/respiratory tract diseases. Contaminated drinking water and food are frequent vectors for virus diarrhoeal diseases or cholera in Angola [49]. Astonishing is the recording of specific symptoms as typhoid fever, spotted fever or appendicitis. The wide range of treated diseases shows the potential and necessity of traditional healers in curing various disease patterns.

The plant with the highest CI, *Chenopodium ambrosioides* (0.19*),* native to Central-America has a lot of different medical applications and is common in other provinces as well [15,50]. Compared to other studies in Angola the general CI of the study is low (average of 0.03, average of savannah vegetation Uíge: 0.09) [15] with maximum of 0.39, explainable by the high number of informants, the wide diversity of plant families and the huge study area. The mentioned plants usually are used in the medical sector (79.2%), which also reduces the CI, however showing the high importance of plants for the rural health care in Cuanza Norte.

The distribution of the predominant families (Fabaceae, Asteraceae and Euphorbiaceae) is similar to the results from the adjacent Province Uíge as well as compared to the whole country [15,47]. Nevertheless, the total number of recorded

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plant families in Cuanza Norte is higher due to the more diverse vegetation zones visited (Cuanza Norte:6 zones; Uíge:4 zones) [15].

The availability, accessibility and the related effort influences the utilisation of the different plant parts. Leaves are present during the whole year whereas fruits, seeds or flowers occur in a limited period only. Roots especially from large trees are additionally more difficult to obtain than leaves. Furthermore, the obtaining of the bark, bulbs or the whole plant is diminishing the survival, whereas the use of fruits, leaves or seeds is more sustainable [51]. In this study leaves are the most common used parts, showing similar distributions to surveys in Ethiopia [52,53]. Due to the fact that all field trips were performed at the beginning of the rainy season (October/November), the rare occurrence of fruits could be explained.

Just two species, *Cochlospermum angolense* and *Stachytarpheta* cf. *angolensis*, are endemic in Angola while a large part is naturalised. In most cases agriculture or ornamental usage of non-native plants was of paramount importance for their introduction [54]. For example, *Allium sativum, Chenopodium ambrosioides* or *Chromolaena odorata* are used for medical purposes worldwide. Garlic is well-known for its antimicrobial effects and various laboratory tests were conducted indicating an inhibitory activity against bacteria [55,56]. The utilisation of the noxious weed *C. odorata* is widespread, nevertheless its wound healing effects are well known from Asia [57]. Furthermore, our study reveals a high potential curing stomach pain, which effectiveness is at the moment not analysed in detail. Concerning the utilisation of *D. ambrosioides,* the majority of informants indicated the use as an enema or infusion against intestinal parasites. Originally from Mexico and probably spread by man because of its medicinal value, this species is used similarly against intestinal parasites, colics, fever and diarrhea [58,59]. Ornamental purposes, as for *Lippia adoensis,* are an additional reason introducing plants. According to an analysis of useful home garden plants from Ethiopia, *L. adoensis* is one of the most commonly used fragrant species [60]. Despite their diverse utilisation possibilities, these neophytes are a threat for indigenous plants similar to deforestation, urbanisation and climate change [61]. It is very likely that recording the usage of indigenous plants in further studies would lead to new medical treatments and applications. Endemic plants are important for traditional rituals but due to the high deforestation rate in Africa they are threatened and further investigations are urgent [62]. Furthermore, in this study 18 new records for the Flora of Angola were mentioned, suggesting that the actual data are not sufficient at all and additional investigations in the whole country are needed.

Twenty uses assigned to the recorded 162 species have not previously been documented. Despite of the low frequency of mentioning, two plant applications were referred more than once. *Hymenostegia laxiflora* and *Perichasma laetificata* seem to be particularly interesting for further pharmaceutical analyses. Moreover, new applications, e.g. of *Manihot esculenta* against hepatitis could be attractive. This plant is mainly cultivated for nutrition and in many interviews the medical application fell into oblivion. More ethnobotanical studies in Cuanza Norte are needed evaluating the new records with low frequency and visiting the denser forest formations in the north, where to this day no study is performed.

CONCLUSION

This first ethnobotanical study demonstrates the importance plants have for the rural population in Angola and why further investigations are obligatory. Twenty new utilisations out of 162 mentioned plants were reported and show the high potential of studies in this area. Furthermore, 11% of the mentioned plants are new records for the Flora of Angola [47]. The utilisation of plants is widespread and the occurrence of seven different vegetation zones in Cuanza Norte makes this Province an area of particular interest. No comparable data for useful plants are available, wherefore this study represents a beginning, serves as basis for further studies and enables plant comparisons to other areas.

Due to the rapid deforestation and the environmental pollution, the Angolan biodiversity needs urgent and intensive investigation saving the traditional knowledge and the biodiversity. Directing the attention of the local communities to these problems as well as the sustainable use of natural resources should be one goal of future activities. One possible measure could be the establishment of botanical gardens, which is currently undertaken by the University Kimpa Vita in Uíge and could also be realised in N´dalatando in the former Botanical Garden of Quilombo. Such a program not only provides the protection of plant species *in situ* but could keep crucial species in *ex situ* collections. The latter then may serve as a basis for a sustainable cultivation. Transferring and adapting this approach to other cities in the country could help the local population adopt a respectful attitude toward its environment.

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