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Wild medicinal and food plants used by communities living in *Mopane* woodlands of southern Angola: Results of an ethnobotanical field investigation

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ABSTRACT

Ethnopharmacological relevance: *Mopane* woodlands play an important role in the livelihood strategies of local populations; however, they have been scarcely investigated by ethnobiologists and very little is currently known about plants traditionally used by local communities, especially about medicinal plants.
Aim of the study: Our investigation was aimed to document ethnobotanical knowledge in seven communities living in conditions of extreme poverty in a *Mopane* area of southern Angola (Namibe province). We focused on plants used as medicines and/or food, in order to highlight the role of wild plants in the livelihood of local communities, and possibly to find out plants with potential pharmacological interest.
Methods: Ethnobotanical data were recorded through semi-structured interviews, filed in a database and quantitatively analyzed. The following synthetic indexes were used: Cultural Importance index (*CI*), Informant Consensus Factor (*FIC*), Fidelity Level (*FL*).
Results: Sixty-six informants (26 males, 40 females) were interviewed. A total of 1247 citations were recorded, concerning 132 *ethnospecies* (folk taxonomic units not necessarily corresponding to single botanical species); 104 were identified at different taxonomic levels. For medicinal purposes, 116 ethnospecies and 20 different uses (650 citations) were reported; for food purposes, 33 ethnospecies and 8 different uses (597 citations). The main used parts resulted to be fruit (471 citations; 21 ethnospecies), followed by underground organs (288, 82) and leaves (175, 41). According to *CI* values, *Berchemia discolor*, *Ximenia americana* var. *americana* and *Adansonia digitata* have the highest cultural value in the investigated communities. All of them are woody plants, as well as most of the identified ethnospecies (trees 34.6%, shrubs 32.7%, perennials 21.2%, annuals 8.7%, others 2.8%). Medicinal plants are especially used to treat disorders of the gastrointestinal tract (52 ethnospecies, 205 citations), obstetric/gynecological troubles (27, 40) and colds and respiratory tract diseases (25, 54). The highest values of *FIC* were recorded for body care (*FIC*=1.0), circulatory diseases (*FIC*=0.91), malaria (*FIC*=0.81) and digestive disorders (*FIC*=0.55). The plants showing the highest informants' consensus (*FL*) were *Myrothamnus flabellifolia* used to treat colds and respiratory diseases (*FL*=100%), *Terminalia prunioides* for digestive diseases (93%) and *Euphorbia subsalsa* for backache (86%). For five plants cited as medicinal by the informants, no reports were found in the consulted ethnobotanical and ethnopharmacological literature; many uses of several already known medicinal plants were also unrecorded. Food products obtained from wild plants include fresh fruit (20 ethnospecies, 287 citations), alcoholic (11, 107) and non-alcoholic (10, 44) beverages, *massa*, i.e. a kind of mash, (4, 65), vegetables (10, 40), and others.
Conclusions: Results show that people living in *Mopane* communities of southern Angola hold a valuable knowledge of the uses of plant resources and that some of the plants cited by the informants represent an important component of the local livelihood strategies. We also found some plants worthy of more in-depth investigations on their possible pharmacological activity, including: (i) those used to treat diseases which reached the highest *FIC*, like malaria and various disorders of the gastrointestinal tract; (ii) plants with a high *FL*; (iii) plants not previously reported in ethnomedical literature, especially those cited by different informants; (iv) plants with possible nutraceutical or pharma-food properties, i.e. plants with considerable contents in vitamins and/or micronutrients and plants whose food and medicinal uses are closely related.

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1. Introduction

Traditional Ecological Knowledge (TEK) reflects the perception of local environment by indigenous people, as well as important aspects of their history, culture and socio-economic organization. TEK can be interpreted as a complex of cultural tools developed by local communities through the centuries in accordance with their natural and social environment, owned and controlled by them. It proved to be an important component of the adaptation dynamics-that is, the ability of a living system, also including socio–ecological systems, to adjust responses to changes in internal demands and in external factors. This means that TEK may play an important role in minimizing the impact of disturbances, therefore affecting resilience of human communities, especially those living in harsh environments (Begossi, 1998; Gómez-Baggethun et al., 2012). It is estimated that 68% of Angolan population lives below the poverty line and 15% in conditions of extreme poverty; the situation is particularly severe in rural areas, where 94% of households can be categorized as poor (IFAD, 2014). Moreover, child and maternal mortality rates are among the highest in the world, and are nearly 70% higher in rural than in urban areas (UNICEF, 2013). Because of widespread malnutrition, more than one-quarter of Angolan children are physically stunted. Malaria, diarrhea, respiratory infections and neonatal diseases compounded by low birth weight are major killers of children; hemorrhages, obstetric infections, obstructed labors are responsible for 80% of deaths of women during pregnancy or immediately after birth (UNICEF, 2013). Within this context, biological resources offered by the environment can act as a safety net in poor people livelihoods, providing food, medicine and other resources. The potential relative contribution of forest products to livelihood is higher for poor and marginalized people living in remote communities of southern regions of Angola, where a markedly dry and variable climate undermines the viability of agriculture as a livelihood option.

The aim of this study was to assess local knowledge related to traditional plant uses in the *Mopane* woodlands located in Bibala and neighboring zones, an area of the south-east part of Namibe province poorly explored from an ethnobiological point of view, and to discuss their role in the health practice and the livelihood of local communities. Although different kinds of ethnobotanical uses were recorded during field work, in this paper only results concerning plants used for medicine and nutrition are presented. As observed by Heywood (2011): “approaches to issues of human nutrition and health have become increasingly interdisciplinary, reflecting the linkages between biodiversity, agriculture, food production, nutrition, diet and human health”. *Mopane* woodlands are scrub or savannah woodlands dominated by *Mopane* trees-*Colophospermum mopane* (Kirk ex Benth.) Kirk ex J. Léonard-occurring in the arid lowlands of southern Africa, between latitudes 9°S and 25°S (Makhado et al., 2014). In Angola, *Mopane* trees grow over wide areas, in a low, thorny bushveld along the border between southern Angola and northern Namibia at around 700–1000 m in elevation. The dry climate of these environments is not favorable to agriculture and most farmers work as nomadic pastoralists, moving about both on a daily and seasonal basis according to fodder availability.

Despite its ecological importance (Mittermeier et al., 2003), until now the *Mopane* ecosystem has only received marginal attention by biologists and by ethnobiologists in particular. Few studies have described the multifunctional role of these woodlands (Sebego, 1999; Makhado et al., 2009, 2012), providing a list of local NTFPs (Non-Timber Forest Products) and discussing their importance in the livelihood of rural populations. The lack of ethnobotanical information is particularly pronounced for the Angolan *Mopane* ecoregion; some data can be obtained from Davies (1994), Bossard (1996), Melo and Conceição (2005), Melo (2008) and from studies carried out in northern Namibia (Chisembu and Hedimbi, 2010; Cheikhyoussef et al., 2011a, b; Cheikhyoussef and Embashu, 2013).

Three factors make the Angolan *Mopane* ecoregion a particularly interesting area for recording traditional botanical uses and assessing their role in sustaining the adaptive capacity of local communities: (i) the remarkable floristic richness of the biogeographical context, with a relatively high number of endemic species (Mittermeier et al., 2003); (ii) the historical isolation of local communities, only marginally affected by the civil war (1975–2002); such isolation facilitated the conservation of local cultural heritage; (iii) the extreme drought conditions, which make agriculture a high-risk, low-return activity in this area, emphasizing the importance of wild plants as a source of food, medicines and other primary necessities. Repeated droughts experienced in recent years negatively impacted livelihoods in the south-western parts of Angola, particularly in the provinces of Namibe and Cunene (UNICEF, 2013). In these areas, agricultural harvests in the period 2012–2014 were estimated to range from 50% to 70% below average. More than 20% of households in Namibe province suffered from food shortage caused by reduced agricultural production; moreover, people were also unable to purchase several non-food items, such as medicines, blankets, clothes and personal hygiene items.

2. Materials and methods

2.1. Study area

All the investigated communities (Fig. 1) lie in the municipality of Bibala, approximately 200 km NE from Namibe, the administrative center of the province. According to Le Houérou (2009), this is an arid to hyper-arid tropical region with relatively low temperatures and little annual variation in temperature, shaped by the local effects of the cold Benguela current. In the study area, the climate is strongly seasonal, with an average annual temperature of 21.6 °C and an average annual rainfall ranging from 300 to 600 mm. The rainy hot season occurs from January to March, while the long dry winter lasts nine months. The soils are paraferralitic of medium or coarse texture (Diniz, 1991). The vegetation is mostly composed of *Mopane* woodlands, with *Colophospermum mopane* as the dominant species.

Farming is hard in these communities, due to the uncertainty of rainfall and the low levels of technology. It is typically conducted by hand, using simple tools and no chemical inputs; ‘milho’ (*Zea mays* L.), ‘massambala’ (*Sorghum bicolor* (L.) Moench), ‘massango’ (*Pennisetum glaucum* (L.) R.Br.) and ‘feijão macunde’ (*Vigna unguiculata* (L.) Walp.) are the main crops. For their subsistence, people depend mainly on livestock breeding and charcoal production. Livestock is considered by people as their main survival means and income source, but is also regarded as a wealth symbol. Although making and selling charcoal is prohibited in most

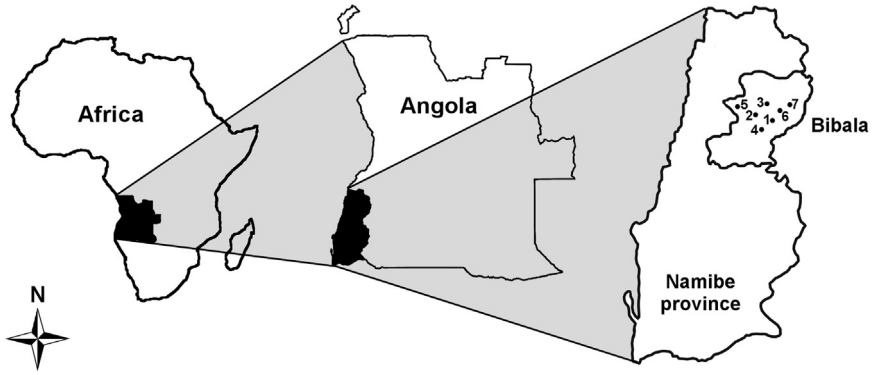

Fig. 1. Investigation area. Numbers identify the studied communities: 1=Garganta (9 informants); 2=Haukulu (6 informants); 3=Assunção (19 informants); 4=Katuvo (10 informants); 5=Munhengo (13 informants); 6=Bibala (5 informants); 7=Rio d'Areia (4 informants).

villages, the income generated from this activity – important for many households – is considered worth the risk of getting caught and fined. A common problem in this area is the lack of health infrastructures. The nearest hospital, located at Bibala, is 20–40 km far from the other studied communities. To reach the health center, people have to pay for means of transport, which are difficult to find and expensive. Thus, traditional medicine is often the only accessible and affordable treatment available, and people go to the hospital only in case of extreme necessity.

The interviewed informants belong to three main ethnic groups: *Mumwila* (sub-ethnic group *Nyaneka-Humbe*), *Nguendelengo* and *Mucuval* (sub-ethnic group *Herero*); less numerous are *Quimbala* (sub-ethnic group *Ovimbundu*) and *Nyaneka-Humbe* (Redinha, 1975).

2.2. Data collection

Fieldwork was carried out in the years 2010–2012, during both dry and rainy seasons. Field data on plants and traditional uses were collected mainly through interviews. A total of 66 informants were interviewed in seven accessible communities (Fig. 1). Informants were contacted as follows: after a preliminary meeting introducing the aims and the methodology of the research, local leaders (called *soba* and *seculo*) were asked to indicate all people belonging to families living in the study area for generations, holding traditional knowledge about the use of wild plants and willing to be interviewed. Further informants were contacted through 'snowball' sampling, i.e. asking an informant to suggest other informants belonging to different family units. Our interest was basically to investigate how common and spread ethnobotanical uses are within local communities and to understand their role in satisfying basic needs of the inhabitants; accordingly, only laypeople were interviewed and no key informant (e.g. traditional healers, locally known as *quimbandeiros*, and herbalists, locally known as *ervaneiros*) was specially selected. Information on plants and ethnobotanical uses was mostly collected through semi-structured individual interviews. The main demographic and social features of the participants (gender, age, ethnic group, education rate, occupation) were also recorded. Interviews were carried out complying with the ethics guidelines commonly followed in ethnobotanical studies (ISE, 2006) and the informants consent was obtained prior to the interviews. Informants were requested to indicate plants, vernacular names, uses, used plant parts, ways of preparation and administration (in the case of medical remedies), possible mixture with other plants, plant availability in the area (scarce, sufficient, abundant) and harvesting season (rainfall season, dry season, yearlong). All the interviews were carried out in dialects spoken in the studied communities and were subsequently translated in Portuguese by the help of local interpreters. Information was also obtained through participant observation by one of the authors of this paper (VU), who spent long periods living in the communities, sharing everyday routine with the informants and taking part in traditional practices (Table 1).

In order to identify the plants mentioned during the interviews, informants were asked to show them to us *in situ*. This was not possible for some plants, which were merely quoted by the informants with their local names, without being shown to the researchers (see below). All the plants shown by the informants were photographed, and plant samples were collected, dried and mounted as herbarium specimens. Only in the case of a few very common or cultivated plants (e.g. *Carica papaya*, *Adansonia digitata*) samples were not collected. Voucher specimens are deposited in the herbarium FT (Erbario Tropicale, University of Florence) (see Table 2), except for some samples badly damaged during preparation and/or transport from Africa to Italy, that had to be discarded. For these plants, photographic vouchers are available on request (Table 2). For plant identification, the following floristic works were consulted: *Conspectus florae angolensis* (Carrisso, 1937–1970), *Flora of Southern Africa* (1963–1983), *Trees of the Southern Africa* (Coates Palgrave, 2002), *Plants of Angola* (Figueiredo and Smith, 2008). Botanical nomenclature is in accordance with *The Plant List* (2015). For the sake of brevity, authors' names of species are wholly reported in Table 2 but are omitted in the text.

2.3. Data analysis and quantitative indexes

Field data were filed in a data-base (raw table), consisting in a spreadsheet (Microsoft Excel). Each row (elementary record) represents a *citation*, defined as a single use reported for a single plant by a single informant (Signorini et al., 2009). According to the methods already adopted in previous investigations (Signorini et al., 2009; Bruschi et al., 2011, 2014), uses were classified into primary and secondary categories, these last intended as detailed usages within each primary category. For the aims of this study, only two primary categories were considered, namely medicinal and food plants. In Table 1, secondary categories pertaining to each primary one are listed. Medicinal uses are arranged in secondary categories basically according to the affected organ/apparatus; fever (accompanied or not by other symptoms) is considered apart, as it is usually treated by specific remedies. When a plant remedy is used to cure different symptoms, these have been considered as separated uses (e.g.: cold and fever). In the raw table, columns contain the following attributes for each citation: botanical identification, botanical family, vernacular plant name/s,

Table 1
Categories of use and main quantitative results.

Primary category of use	Secondary category of use	Species		Informants		Citations (n.)	*FIC*
		n.	%	n.	%		
Medicinal		116	*87.9*	65	*98.5*	650	–
	Body care	2	*1.7*	43	*66.2*	44	0.98
	Childhood diseases	7	*6.0*	17	*26.1*	21	0.70
	Circulatory system diseases	5	*4.3*	43	*66.2*	47	0.91
	Colds and respiratory tract diseases	25	*21.6*	29	*44.6*	54	0.55
	Digestive system diseases	52	*44.8*	63	*96.9*	205	0.75
	Ear diseases	2	*1.7*	4	*6.2*	4	0.67
	Eye diseases	6	*5.2*	16	*24.6*	17	0.69
	Fever	7	*6.0*	18	*27.7*	23	0.72
	General malaise	10	*8.6*	19	*29.2*	25	0.62
	Gynecological, obstetric and puerperal troubles	27	*23.3*	23	*35.4*	40	0.33
	Headache	8	*6.9*	23	*35.4*	28	0.74
	Malaria	6	*4.5*	24	*36.9*	28	0.81
	Metabolic diseases (diabetes)	2	*1.7*	2	*3.0*	2	0.00
	Muscular and skeletal system diseases	5	*4.3*	16	*24.6*	17	0.75
	Sexual/fertiliy stimulant	15	*12.9*	10	*15.4*	20	0.26
	Sexually transmitted diseases	12	*10.3*	10	*15.4*	17	0.31
	Skin diseases	12	*10.3*	23	*35.4*	30	0.62
	Snake and scorpion bites	6	*5.2*	11	*16.9*	12	0.55
	Toothache and mouth inflammations	2	*1.7*	2	*3.1*	2	0.00
	Urinal tract diseases	11	*9.4*	8	*12.3*	14	0.23
Food		33	*25*	64	*97*	597	–
	Alcholic beverages	11	*33.3*	52	*81.3*	107	0.91
	Dry fuit	4	*12.1*	31	*48.4*	35	0.91
	Fresh fruit	20	*60.6*	64	*100*	287	0.93
	Massa (mash made of fruit or tubers/roots)	4	*12.1*	46	*71.8*	65	0.95
	Non alcoholic beverages	10	*30.3*	34	*53.1*	44	0.79
	Oil and seasoning	2	*6.1*	9	*14.1*	13	0.92
	Raw roots/tubers	1	*3.0*	6	*9.3*	6	1.00
	Cooked vegetables	10	*30.3*	22	*34.4*	40	0.77

FIC: Informant Consensus Factor, according to Trotter and Logan (1986).

informant name, primary use category, secondary use category, used plant part, other information on how the plant is used. Derived tables were obtained from the raw table using the program 'EBtools', a collection of scripts in Visual Basic for Applications (VBA) in Microsoft Excel, performing advanced sorting, filtering and counting of data according to specific user requirements (Signorini and Ongaro, unpubl.).

Statistical analyses were carried out to point out the distribution of ethnobotanical knowledge among informants according to their gender, age, ethnic group and education rate, the informants' consensus and the perceived relevance of different plants and uses.

In analyzing data collected through the interviews, some quantitative indices commonly adopted in ethnobotanical studies were used. The cultural importance of each mentioned ethnospecies was assessed by the Cultural Importance index (*CI*) proposed by Tardìo and Pardo-de-Santayana (2008). As pointed out by these authors, *CI* takes into account not only the spread of use (number of informants), but also the diversity of uses (number of use categories); in this way it better highlights the real relative importance of each plant in the community. *CI* allows to point out plants with a high agreement level in the culture of the whole studied area and, hence, to identify the shared knowledge. Informant Consensus Factor (*FIC*) (Trotter and Logan, 1986) was used to test the homogeneity of knowledge about plants uses. *FIC* values range from 0 to 1. High values indicate a well-structured selection pattern in the community, or that information is homogeneously shared among informants (Gazzaneo et al., 2005). Informants' consensus on medicinal uses was calculated for each ethnospecies with the Fidelity Level index (*FL*) reported by Alexiades (1996).

Spearmann correlation analyses were used to test the relationship between the number of mentioned plants/uses and (i) age; (ii) education level; (iii) ethnic group of informants. The Mann–Whitney test was performed to compare ethnobotanical knowledge in male and female informants.

Medicinal and food uses cited by the informants were compared to the uses of the same plants reported in African ethnobotanical literature, in order to point out if and to which extent ethnobotanical knowledge is shared in the continent. To this purpose, a search on the main online databases was conducted (namely, Google Scholar, Science Direct, Scopus and Web of Science). The results of our research were also compared with data reported in some previous papers dealing with traditional uses of medicinal and food plants in neighboring and/or partially overlapping areas (Davies, 1994; Bossard, 1996; Melo and Conceição, 2005; Melo, 2008; Chisembu and Hedimbi, 2010; Cheikhyoussef et al., 2011a, b; Cheikhyoussef and Embashu, 2013).

Some aspects of local abundance and conservation status of plants mentioned by the informants were also investigated, in the perspective of assessing the sustainability of traditional uses of plants.

3. Results and discussion

3.1. Distribution of knowledge between informants

A total of 66 informants (26 males and 40 females) were interviewed. Age ranged from 27 to 85 years, with a mean age of 50 ($\pm$ 14) years for men and of 57 ($\pm$ 13) years for women. Fifty percent were housewives, 23% charcoal burners, 18% shepherds, 6% farmers and 3% teachers. Most informants belonged to the sub-

Table 2
List of plants used in seven communities living in *Mopane* woodlands (southern Angola). Voucher specimens are listed as follows: FT = Erbario Tropicale, University of Florence; PVM =photographic vouchers; Dash = no voucher. Ba = Bark; HO = Hypogeous Organs; EP = Epigeal Part; Fr = Fruit; L = Leaves; S = Seed; Sa = Sap; Tw = Twig; W = Whole plant.

Botanical *taxon*	Botanical family	Local name(s)	Voucher number	Informants	Citations	Uses (used part)
Abrus precatorius L.	Leguminosae	Omehobungu	FT004042	1	1	Medicinal: cough (HO), stomachache (HO)
Acacia senegal (L.) Willd.	Leguminosae	Mukondo	FT004043	1	2	Medicinal: diarrhea (HO), mouth inflammations (HO)
Acanthospermum hispidum DC.	Compositae	Kilianguelenguendja	PVM0001	2	3	Medicinal: emetic (LT, HO, WP)
Adansonia digitata L.	Malvaceae	Mukua, Imbondeiro	PVM0002	60	88	Food: beverage (Fr), fresh fruit (Fr), mash (Fr), oil (S)
Aframomum alboviolaceum (Ridl.) K.Schum.	Zingiberaceae	Jinguenga, Matundo, Issambia, Omungenhe	PVM0003	2	3	Food: fresh fruit (Fr); Medicinal: anthelmintic (Fr)
Aloe littoralis Baker	Xanthorrhoeaceae	Endombo, Otchindombo	FT004045 FT004046	28	50	Medicinal: backache (L), burns (L), cough (HO), cholera (HO), eye inflammations (L), diabetes (HO), diarrhea (L, HO), liver diseases (HO, Sa), fever (Sa, HO), gonorrhea (HO, L, Sa), malaria (HO, Sa), urinary tract inflammations (HO), antiabortive (HO), wounds (L)
Aloe sp.	Xanthorrhoeaceae	Makundi	PVM0004	1	3	Medicinal: liver diseases (HO), pain in legs (L), scalp troubles (L)
Amaranthus spinosus L.	Amaranthaceae	Jimboa	PVM0005	2	2	Food: cooked vegetable (L)
Annona stenophylla Engl. & Diels subsp. *nana* (Exell) N.Robson	Annonaceae	Mayolo, Nhungo	PVM0006	3	3	Medicinal: stomachache in children (HO), to help fetal movements (HO)
Aptosimum gossweileri Skan	Scrophulariaceae	Otchitumba-Veta	FT004047	1	1	Medicinal: toothache (L, HO, BA)
Aristolochia albida Duch.	Aristolochiaceae	Kwanana, Onjilo	FT004048	41	57	Medicinal: abortive (HO), depurative for intestine (HO), diarrhea (HO, BA), fever (HO), general malaise (HO), malaria (HO, L), stomachache in children (HO), urinary tract inflammations (HO)
Aristolochia heppii Merxm.	Aristolochiaceae	Kaquanana	FT004049 FT004050	1	1	Medicinal: anthelmintic (HO)
Artemisia afra Jacq. ex Willd.	Compositae	Eliminiomba	PVM0046	1	1	Medicinal: cough (HO)
Asparagus sp.	Asparagaceae	Epimpa	FT004051	3	3	Medicinal: pregnancy troubles (HO)
Barleria prionitis L.	Acanthaceae	Ndundumai, Ndumahina, Ososene	FT004052	2	2	Medicinal: eye inflammations (L)
Berchemia discolor (Klotzsch) Hemsl.	Rhamnaceae	Omumbe	FT004107 FT004108	50	77	Food: alcoholic beverage (Fr), fresh fruit (Fr); Medicinal: diarrhea, stomach-ache (BA), burns (BA), stomachache (BA), to facilitate fontanelle closure (BA)
Bidens pilosa L.	Compositae	Onkholokohò	PVM0007	8	8	Food: cooked vegetable (L)
Boscia gossweileri Exell	Capparaceae	Mutampassokota	PVM0008	4	6	Food: fresh fruit (Fr); Medicinal: eye inflammations (L), gonorrhea (HO), sexual stimulant for men (HO), urinary tract inflammations (HO)
Boscia mossambicensis Klotzsch	Capparaceae	Muvissa Tupia	FT004069	3	4	Medicinal: anthelmintic (HO), sexual stimulant for men (HO), stomachache (HO)
Boscia polyantha Gilg	Capparaceae	Omutunda	PVM0009	32	32	Food: mash (HO)
Brachystegia spiciformis Benth.	Leguminosae	Omanda, Mupanda, Omumwen, Onduko	FT004075	1	1	Medicinal: wounds (BA)
Brachystegia sp.	Leguminosae	Thyandiati	PVM0009	2	2	Medicinal: pregnancy troubles (HO)
Bridelia atroviridis Müll.Arg.	Phyllanthaceae	Ukuliungo	PVM0010	1	1	Medicinal: to improve women's fertility (HO)
Bridelia scleroneura Müll.Arg. subsp. *angolensis* (Müll.Arg.) Radcl.-Sm.	Phyllanthaceae	Nguelenguele, Ukelekele	PVM0011	7	9	Food: alcoholic beverage (Fr), fresh fruit (Fr); Medicinal: diarrhea (L)
Buxus benguellensis Gilg	Buxaceae	Omuchengo/A, Omunhenga	FT0040101	17	19	Medicinal: diarrhea, stomach-ache (L), general malaise (L)
Carica papaya L.	Caricaceae	Omamao, Papaya	PVM0012	2	2	Medicinal: gonorrhea (HO), to improve women's fertility (HO)
Carissa spinarum L.	Apocynaceae	Mirangola, Omunhongola/O	PVM0013	5	8	Food: alcoholic beverage (Fr), fresh fruit (Fr); Medicinal: diarrhea (HO, Fr, L), urinary tract inflammations (HO), stomachache in children (HO)
Cassia abbreviata Oliv.	Leguminosae	Muntchakatchaca, Ossakasaka	FT004076	2	3	Medicinal: bronchitis (HO), heart troubles (HO)
Cassine transvaalensis (Burtt Davy) Codd	Celastraceae	Omuchilia	FT004103	1	2	Food: cooked vegetable (L), fresh fruit (Fr)
Celtis zenkeri Engl.	Cannabaceae	Omungilopuka, Mutampa, Omunamba, Olonamba	FT004055 FT004058	35	54	Food: alcoholic beverage (Fr), fresh fruit (Fr)
Chaetachme aristata Planch.	Ulmaceae	Omunguendjo-A	PVM0014	2	2	Medicinal: pregnancy troubles (HO)
Cissampelos mucronata A.Rich.	Menispermaceae	Enyati, Onyati	PVM0015	2	2	Medicinal: hemorrhoids (HO), to regulate blood pressure (HO)
Cleome gynandra L.	Cleomaceae	Ompungu	PVM0016	14	14	Food: cooked vegetable (L); Medicinal: fever (WP), headache (HO)
Cochlospermum angolense Welw. ex Oliv.	Bixaceae	Burtutu, Kipulupulu, Uchilongongo	FT004118	1	1	Medicinal: food poisoning (HO)

Colophospermum mopane (Benth.) Léonard	Leguminosae	Omutuate, Omuthyati	FT004073 FT004074	13	16	Medicinal: burns and wounds (BA), cough (BA, L), diarrhea (BA), stomachache (L)
Combretum imberbe Wawra	Combretaceae	Omumpupu	PVM0044	3	4	Medicinal: diarrhea (BA), pregnancy troubles (BA), stomachache (BA)
Commiphora mollis (Oliv.) Engl.	Burseraceae	Omulenda, Muwowo, Mulemawowo, Munjiali	FT004085	3	3	Medicinal: wounds (BA), eye inflammations (BA), stomachache (BA)
Cordia monoica Roxb.	Boraginaceae	Omukoio	FT004124 FT004126	20	21	Food: alcoholic beverage (Fr), dry fruit (Fr), fresh fruit (Fr), non alcoholic beverage (Fr)
Croton gratissimus Burch.	Euphorbiaceae	Kapembai, -Panguena	FT004093	10	15	Medicinal: snakes and scorpions bites (HO), cough (BA, HO), depurative for intestine (HO), fever (HO), gonorrhea (HO), headache (BA, WP), malaria (HO), stomachache (HO)
Croton mubango Müll.Arg.	Euphorbiaceae	Mumbango, Kamombala, Mbango	FT004094	9	10	Medicinal: cough (HO), depurative for intestine (HO), stomachache (HO)
Cynanchum viminale (L.) L.	Apocynaceae	Ontumbo	FT004122	6	8	Medicinal: diarrhea (HO), general malaise (BA), pregnancy troubles (HO), stomachache (HO)
Cyperus esculentus L.	Cyperaceae	Noheva	PVM0017	2	2	Food: cooked vegetable (EP), mash (HO)
Cyperus sp.	Cyperaceae	Vipuihe	FT004054	1	1	Medicinal: tuberculosis (HO)
Dalbergia nitidula Baker	Leguminosae	Utone, Mutona	PVM0018	1	1	Medicinal: liver diseases (BA)
Dicoma sp.	Compositae	Kaundu	PVM0019	2	3	Medicinal: diarrhea (HO), emetic (HO), heart troubles (HO)
Dicoma tomentosa Cass.	Compositae	Katchapula	PVM0020	1	1	Medicinal: diarrhea (EP)
Diospyros mespiliformis Hochst. ex A.DC.	Ebenaceae	Omunhandi	FT004120 FT004121	7	10	Food: alcoholic beverage (Fr), fresh fruit (Fr); Medicinal: diarrhea (BA), joint pain (BA)
Diospyros sp.	Ebenaceae	Omunhonho	PVM0047	2	3	Food: beverage (Fr), fresh fruit (Fr)
Duranta erecta L.	Verbenaceae	Omumpianena	PVM0021	6	8	Medicinal: antiabortive (HO), fever (L), malaria (L)
Entandrophragma spicatum (C.DC.) Sprague	Meliaceae	Ndumbili	PVM0022	1	1	Medicinal: sexual stimulant for men (HO)
Euclea divinorum Hiern	Ebenaceae	Omunhime	FT004130	1	1	Food: alcoholic beverage (Fr)
Euphorbia subsalsa Hiern	Euphorbiaceae	Ohai	FT004096 FT004098	7	7	Medicinal: snakes and scorpions bites (Sa), backache (EP)
Faidherbia albida (Delile) A.Chev.	Leguminosae	Omuwè, Onowetu	FT004070 FT004072	1	1	Medicinal: cough (BA)
Ficus sycomorus L.	Moraceae	Mukuyo	FT004059	1	1	Medicinal: diarrhea (HO)
Ficus tettensis Hutch.	Moraceae	Diangulu, Iangulu, Tchangulu	PVM0023	1	1	Medicinal: anthelmintic (HO)
Ficus thonningii Blume	Moraceae	Omukuiunda	FT004060	1	2	Food: fresh fruit (Fr); Medicinal: body care (Fr)
Fockea multiflora K.Schum.	Apocynaceae	Otchinkuyu	F 0041230	3	3	Medicinal: wounds (Sa)
Gardenia volkensii K.Schum. subsp. *spatulifolia* (Stapf & Hutch.) Verdc.	Rubiaceae	Mulavi, Xilavi	FT004127	1	1	Medicinal: sexual stimulant for men (HO)
Geigeria acaulis (Sch.Bip.) Benth. & Hook.f. ex Oliv. & Hiern	Compositae	Tchisamu	PVM0024	2	2	Medicinal: wounds (L), diarrhea (L)
Grewia cyclopetala Wawra & Peyr.	Malvaceae	Mukonda (Makonda)	PVM0025	19	21	Food: alcoholic beverage (Fr), fresh fruit (Fr)
Grewia flavescens Juss.	Malvaceae	Omumbole, Munama	FT004109 FT004110	28	41	Food: alcoholic beverage (Fr), fresh fruit (Fr); Medicinal: gonorrhea (HO)
Grewia monticola Sond.	Malvaceae	Omumpapu	FT004111 FT004114	25	30	Food: alcoholic beverage (Fr), fresh fruit (Fr); Medicinal: diarrhea (BA)
Grewia villosa Willd.	Malvaceae	Ominkota	FT004115 FT004117	32	45	Food: alcoholic beverage (Fr), fresh fruit (Fr), non alcoholic beverage (Fr); Medicinal: cough (HO), diarrhea (BA)
Gyrocarpus americanus Jacq.	Hernandiaceae	Omuxiria, Musiria	PVM0026	9	10	Medicinal: diarrhea, stomach-ache (BA, L), urinary tract inflammations (BA), headache (L), general malaise (BA)
Heteromorpha stenophylla Welw. ex Schinz	Apiaceae	Omulunda	FT004129	8	8	Medicinal: cough and breast pain (L), pregnancy troubles (HO), sexual stimulant for men (HO)
Indigofera spicata Forssk.	Leguminosae	Etumbanjali	PVM0027	3	4	Medicinal: food poisoning (HO), liver diseases (HO), urinary tract inflammations (HO)
Kirkia acuminata Oliv.	Kirkiaceae	Omukunduti, Omuhoho	FT004084	1	2	Medicinal: eye inflammations (L), headache (L)
Lannea angolensis R.Fern. & Mendes	Anacardiaceae	Omunthiwi	FT004102	1	1	Medicinal: colds, cough (BA)
Lepisanthes senegalensis (Poir.) Leenh.	Sapindaceae	Omungolo	PVM0028	1	1	Medicinal: diarrhea (BA)
Mentha sp.	Lamiaceae	Orterao	PVM0029	1	2	Medicinal: stomachache (L)
Mikania natalensis DC.	Compositae	Ossivi	PVM0030	3	3	Medicinal: postpartum hygiene (L)
Mucuna stans Baker	Leguminosae	Eyumbi	FT004082	2	2	Medicinal: eye inflammations (L), cough (HO)
Myrothamnus flabellifolia Welw.	Myrothamnaceae	Tchengueti	PVM0031	6	6	Medicinal: cold, cough, breast pain (HO, L)
Ocimum sp.	Lamiaceae	Onjilulu, Onhululu	PVM0032	3	6	Medicinal: cough (L, EP), fever (L, EP), malaria (WP)
Pavetta schumanniana F.Hoffm. ex K. Schum.	Rubiaceae	Otchinhe	FT004104	1	1	Medicinal: antidiarrheal (L)

Table 2 (*continued*)

Botanical *taxon*	Botanical family	Local name(s)	Voucher number	Informants	Citations	Uses (used part)
Peltophorum africanum Sond.	Leguminosae	Omumpalala	FT004080 FT004081	7	9	Medicinal: food poisoning (BA), diarrhea (HO), general malaise (BA), gonorrhea (HO), pregnancy troubles (BA), impotence (BA)
Phyllanthus welwitschianus Müll.Arg.	Phyllanthaceae	Kandombe	PVM0033	1	1	Medicinal: antiabortive (HO)
Polystachya sp.	Orchidaceae	Hukahuka, Sukasuka, Hukahuka, Sukasuka	PVM0034	3	3	Medicinal: otitis (Sa)
Portulaca oleracea L.	Portulacaceae	Tchintchankala	PVM0045	1	1	Medicinal: burns (WP)
Pseudeminia benguellensis (Torre) Verdc.	Leguminosae	Ombundi	FT004083	1	1	Medicinal: pregnancy troubles (HO)
Ptaeroxylon obliquum (Thunb.) Radlk.	Rutaceae	Omubungurulu	FT004086 FT004089	40	55	Medicinal: cough (Tw), food poisoning (BA), diarrhea (BA, L), fever (BA, HO, L), general malaise (BA), gonorrhea (HO), headache (Tw), haemostatic (L), liver diseases (BA), malaria (BA), stomachache (BA, HO), to improve women's fertility (BA), vaginal infections (BA)
Ricinus communis L.	Euphorbiaceae	Jjimonu, Ximolo, Omulianguéle	PVM0035	2	2	Medicinal: diarrhea (BA)
Rotheca sp.	Lamiaceae	Omukuatamapongo	PVM0036	2	2	Medicinal: headache (Tw)
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	Omungongo	FT004099 FT004100	39	104	Food: alcoholic beverage (Fr), dry fruit (Fr), fresh fruit (Fr), non alcoholic beverage (Fr), oil (S)
Securidaca longipedunculata Fresen.	Polygalaceae	Musasa, Utata	FT004090 FT004092	1	2	Medicinal: pregnancy troubles (HO), tuberculosis (L)
Senna occidentalis (L.) Link.	Leguminosae	Omuntcheketchè	FT004077 FT004079	10	12	Food: coffee surrogate (S); Medicinal: snakes and scorpions bites (HO), cough (L), diarrhea (BA), fever (S), gonorrhea (BA, HO), restorative in pregnancy (Tw), urinary tract inflammations (HO)
Solanum incanum L.	Solanaceae	Matumbili	PVM0037	1	1	Medicinal: stomachache in children (HO)
Spirostachys africana Sond.	Euphorbiaceae	Omumpapa, Jiliti	FT004095	10	17	Medicinal: cholera (BA, Tw), wounds (BA, HO), general malaise (BA, Tw), headache (BA, Tw)
Strophanthus amboensis (Schinz) Engl. & Pax	Apocynaceae	Mahuhu, Ehuvo	PVM0038	13	13	Food: cooked or fresh vegetable (HO), non alcoholic beverage (HO)
Strychnos cocculoides Baker	Loganiaceae	Maboke, Mukulangola, Amuini	PVM0039	1	1	Medicinal: sexual stimulant for men (HO)
Terminalia prunioides M.A.Lawson	Combretaceae	Omuhaina	FT004119	14	14	Medicinal: cough (BA), diarrhea and stomach-ache (BA, HO)
Terminalia sericea Burch. ex DC.	Combretaceae	Omuhendjolo, Muhondjolo	PVM0040	2	4	Medicinal: diarrhea (L), to improve women's fertility (HO), vaginal infections (HO)
Terminalia sp.	Combretaceae	Omuhainyampala, Omunhampala	FT004105	2	2	Medicinal: diarrhea (L)
Triumfetta sp.	Malvaceae	Omwambolanji	PVM0041	14	16	Medicinal: diarrhea (HO, L), headache (HO, L, Tw)
Vangueria cyanescens Robyns	Rubiaceae	Omunkamulola	PVM0042	13	14	Food: fresh fruit (Fr), non alcoholic beverage (Fr); Medicinal: labor pain (HO), regulation of menstrual bleeding (HO), urinary tract inflammations (HO)
Ximenia americana L. var. *americana*	Olacaceae	Omumpeke	FT004061 FT004065	48	128	Medicinal: snakes and scorpions bites (BA, L), body and hair care (S), burns and wounds (S), cough (BA, L), food poisoning (L), joint pain (S), measles (L, S), otitis (L), stomachache (S), varicose veins (S)
Ximenia americana L. var. *microphylla* Welw.	Olacaceae	Omumingua, Omunkalamulola	FT004066 FT004068	10	11	Food: fresh fruit (Fr); Medicinal: diarrhea (HO)
Xylopia odoratissima Welw. ex Oliv.	Annonaceae	Eliandele, Uliandele	PVM0043	1	1	Medicinal: stomachache in children (HO)
Ziziphus mucronata Willd. subsp. *mucronata*	Rhamnaceae	Omunkekete	FT004106	2	2	Food: fresh fruit (Fr); Medicinal: diarrhea (HO)
	Apocynaceae	Upelaçongo	–	1	1	Medicinal: to improve women's fertility (HO)
	Compositae	Endiango	–	1	1	Medicinal: anthelmintic (WP)
	Lamiaceae	Onkenda	–	1	1	Medicinal: general malaise (L)
	Rubiaceae	Suambanda	–	1	1	Medicinal: gonorrhea (HO)
	Sapindaceae	Dumbilo	FT004131	1	2	Medicinal: cough (L), spleen pain (HO)
		Epele		1	1	Medicinal: pregnancy troubles (HO)
		Exelenè		1	1	Medicinal: cough (HO)
		Filankopo		4	4	Food: cooked vegetable (L)
		Kabaliasungo		1	1	Medicinal: to improve women's fertility (HO), postpartum hygiene (HO)
		Kalomkampela, Kambassola		5	5	Medicinal: diarrhea, stomachache (L)
		Kalumekontchilo		2	2	Medicinal: snakes and scorpions bites (S, HO)
		Kambunke		1	1	Medicinal: snakes and scorpions bites (HO)
		Katchalo		1	1	Medicinal: food poisoning (HO)
		Kavandambeli		1	1	Medicinal: urinary tract inflammations (HO)

Kolambala	1	1	Medicinal: anthelmintic (HO), stomachache (HO)
Matchinenki	1	2	Medicinal: pregnancy troubles (HO), sexual stimulant for men (HO)
Muchonkela	1	1	Medicinal: bronchitis (HO)
Muendagongololo	1	1	Medicinal: sexual stimulant for men (HO)
Munikenike	1	1	Medicinal: sexual stimulant for men (HO)
Nantchipunini	1	2	Medicinal: anthelmintic (HO), gonorrhea (HO), stomachache (HO)
Ombwà	7	7	Food: cooked vegetable (L)
Omutetempa	1	2	Medicinal: postpartum hygiene (HO), to improve women's fertility (HO)
Ontito, Omuntito	2	3	Medicinal: pregnancy troubles (HO); Food: cooked vegetable (L)
Ontunga, Onhanga	2	2	Medicinal: stomachache (HO); Food: cooked vegetable (L)
Tchava	1	1	Medicinal: stomachache in children (HO)
Tchikangua	1	1	Medicinal: sexual stimulant for men (HO)
Tchikulu	1	1	Medicinal: stomachache in children (HO)
Tchingole	1	1	Medicinal: wounds (W)
Tembua-Tchilongo	1	1	Medicinal: anthelmintic (HO), stomachache (HO)
Tichandambolo	1	1	Medicinal: sexual stimulant for men (HO)
Tyhumbe	2	2	Food: cooked vegetable (L)
Ukali	1	1	Medicinal: HIV (BA)
Utchopotavaso	1	1	Medicinal: urinary tract inflammations (HO)

ethnic group *Mumwila* (41.7%), followed by *Nguendelengo* (40.3%) and *Mucuval* (8.4%). *Nyaneka-Humbe*, *Quibala* and *Ovimbundo* represented the remaining 9.5% of informants' ethnic groups. Eighty-three percent of informants were illiterate (85% men, 82% women); 14% had received some primary education (class one to four) and 3% some higher technical education. In the interviews, a total of 1247 citations were collected. Of these, 1198 (96% of all citations) concern plants identified at least at family level. Plants cited by the informants were referred to 132 *ethnospecies*, intended as basic folk taxonomic units corresponding either to botanical species or to different *taxa* (Signorini et al., 2008, 2009). Of these, 104 were identified at different taxonomical level: 87 at specific or infraspecific level, 12 at genus level and five at family level. Some plants (28 ethnospecies) could not be identified, as they were merely mentioned by the informants with their local names, without being shown to the researchers; for these plants, no specimen could be collected for botanical identification. Yet, most of the plants identified only to family level or not identified at all were cited by only one or two informants (30 ethnospecies); the remaining three unidentified ethnospecies were cited by three to seven informants (Table 2). Uses were grouped into two primary (medicinal and food) and 28 secondary categories of use (Table 1). The ethnospecies used in both primary categories were 19 (14%).

Each informant mentioned on average 13.2 ($\pm$5.1) ethnospecies and 10.1 ($\pm$3.8) different uses (intended as secondary categories of use). No significant differences could be found in ethnobotanical knowledge between male and female informants ($P > 0.05$). Men mentioned 14.6 ($\pm$7.2) ethnospecies and 11.3 ($\pm$5.1) secondary use categories; women mentioned 12.3 ($\pm$2.9) ethnospecies and 9.4 ($\pm$2.4) secondary use categories. Spearmann's correlation analyses showed no significant relationship between socio-cultural variables and number of plants/number of use categories.

Distribution of knowledge resulted to be heterogeneous. Most plants (81, 61% of the total) were cited by only one or two informants; only seven plants (5%) were mentioned by 35 or more informants, i.e. more than half the number of informants: *Adansonia digitata* (60 informants, 88 citations), *Berchemia discolor* (50, 77), *Ximenia americana* var. *americana* (48, 128), *Aristolochia albida* (41, 57), *Ptaeroxylon obliquum* (40, 55), *Sclerocarya birrea* (39, 104), and *Celtis zenkeri* (35, 54) (Table 3). These plants proved to be widely known within the whole studied area. Moreover, products obtained from some of them (e.g. fruits of *Adansonia digitata*, oil extracted from seeds of *Ximenia americana* var. *americana*) are sold by people in local markets, playing therefore an important role in the socio-economic sustainability of local communities. This is confirmed by Cultural Importance index (*CI*): *Berchemia discolor* resulted to be the plant with the highest cultural importance ($CI=0.94$), followed by *Adansonia digitata* ($CI=0.91$) and *Ximenia americana* var. *americana* ($CI=0.73$) (Table 3). These three plants can be considered as a cultural unifying force among local people, who are dispersed in small communities and belong to different ethnolinguistic groups. All of them are woody plants and, according to the informants' judgment, they grow abundantly in the area. This means that these plants combine the cultural value pointed out by our study with a high ecological and landscape importance. These findings are also in accordance with the 'apparency hypothesis' proposed by Almeida et al. (2005), who suggest that the abundance of a species within an area can determine its frequency of use and its use versatility, as people are supposed to accumulate more experience and knowledge about plants they see every day.

3.2. Botanical families, biological forms and used parts

Malvaceae resulted to be the most mentioned family (241 citations, i.e. 19.3% of the citations concerning plants identified at least at family level), followed by Ximeniaceae (128, 10.2%), Anacardiaceae (105, 8.4%), Rhamnaceae (79, 6.3%), Aristolochiaceae (58, 4.6%), Leguminosae (55, 4.4%) and Rutaceae (55, 4.4%). The family including the higher number of ethnospecies was Leguminosae (13 ethnospecies, 12.5% of the plants identified at least at family level), followed by Compositae (8, 7.7%) and Malvaceae (6, 5.8%). These findings mean that Malvaceae include both plants well known within the communities, cited by most informants (e.g. *Adansonia digitata*) and multi-purpose plants, i.e. plants used in different use categories (e.g. *Grewia* sp. pl.). On the contrary, plants belonging to Leguminosae were generally cited by few informants and/or for only one or few uses. Other families with a high number of citations include either fewer plants (Anacardiaceae, with 104 citations for *Sclerocarya birrea* and only one citation for *Lannea angolensis*), or many plants less frequently cited by the informants (Compositae: eight ethnospecies, only 22 citations), as confirmed by their low *CI* values.

Of the identified plants, 34.6% were trees, 32.7% shrubs, 21.2% herbaceous perennials, 8.7% annuals and 2.8% lianas. This means that in the investigated area the use of perennial woody plants is more frequent than the use of herbs, as it is generally found in areas characterized by a strongly seasonal rainfall regime (e.g. Almeida et al., 2005; Ladio and Lozada, 2009; Bruschi et al., 2011). This finding could be related to the floristic composition and structure of *Mopane* vegetation; additionally, woody perennials can provide different useful products throughout the year, even during the dry season. *Mopane* is an ecosystem which is grazed by large herbivores and undergoes frequent fires (Kennedy, 2000; Shorrocks, 2014). Compared to herbaceous plants, woody perennials are in general more resistant to both these disturbances (Campbell, 1996): see, for example, the ability of *Colophospermum mopane* to coppice and resprout (Makhado et al., 2014).

The main used parts were fruits (471 citations; 21 ethnospecies), leaves (175, 41) and underground organs (roots, bulbs, tubers, rhizomes) (288, 82), with some differences according to primary use categories. In food plants, prevalence of fruit is particularly evident, with 468 citations (78.4% of all the citations in food category of use) and 20 ethnospecies (60.6%). The second most used part in this category was represented by underground organs, with 48 citations (8.0%) and four ethnospecies (12.1%).

Table 3
Results of quantitative analyses of the 12 most important species cited by the informants. *CI*: Cultural Importance Index.

Species	Informants mentioning the species (n.)	Use categories (n.)	Secondary use categories (n.)	*CI*
Berchemia discolor	50	2	6	0.94
Adansonia digitata	60	1	5	0.91
Ximenia americana var. *americana*	48	1	9	0.73
Sclerocarya birrea	39	1	5	0.61
Ptaeroxylon obliquum	40	1	10	0.61
Aristolochia albida	41	1	8	0.59
Celtis zenkeri	35	1	3	0.53
Grewia villosa	32	2	5	0.52
Boscia polyantha	32	1	1	0.48
Grewia flavescens	28	2	3	0.42
Aloe littoralis	28	1	11	0.42
Grewia monticola	25	2	3	0.39

Wild fruits and tubers (and other underground parts) may supply water, carbohydrates and other nutrients during transhumance in the dry season, integrating the nutritional needs of nomadic pastoralists. Moreover, the availability of underground organs is continuous throughout the year; despite their taste – frequently reported by the informants as unpleasant – underground organs play a key role in satisfying the minimum food requirements, especially in the long dry season, when it is not possible to collect fruits or leafy vegetables.

Underground organs were cited as the main used parts in the preparation of medicinal remedies, with 240 citations (36.9% of all the citations in medicinal category of use) pertaining to 73 ethnospecies (62.9%). Roots and other hypogean structures normally have a high content of secondary metabolites (Balick and Cox, 1996); these chemical compounds are involved in complex plant-to-plant and plant-to-animals relations – including defense against a variety of pests and predators and allelopathy – and most of these substances are of medicinal value.

3.3. Medicinal plants

Medicinal category of use includes 650 citations (52.2% of all the citations), pertaining to 116 ethnospecies, reported by 65 informants (98.5% of all informants) as used to treat 20 different disease types (corresponding to secondary categories of use) (Table 1). The most cited family of medicinal plants resulted to be Aristolochiaceae (58 citations, two ethnospecies), followed by Rutaceae (55, 1), Xanthorrhoeaceae (53, 2) and Euphorbiaceae (51, 5). Besides underground organs, the most used parts are leaves (31 ethnospecies, 111 citations) and barks (28, 137). The most cited plants (≥ 15 citations) resulted to be *Ximenia americana* var. *americana* (48 informants, 128 citations), *Aristolochia albida* (41, 57), *Ptaeroxylon obliquum* (40, 55), *Aloe littoralis* (28, 50), *Buxus benguellensis* (17, 19), *Triumfetta* sp. (14, 16), *Colophospermum mopane* (13, 16) and *Spirostachys africana* (10, 17) *Croton gratissimus* (10, 15).

Most plants (71) are used in only one (45) or two (26) disease categories, but the great majority of them are cited by only one or two informants; only a few of them are mentioned by several informants, like *Buxus benguellensis* (17), *Terminalia prunioides* (14) and *Triumfetta* sp. (14) and can be regarded as quite specific remedies. A number of more versatile plants (19) are used to heal more than one type of disease; the following, used in more than seven categories, can be interpreted as multipurpose remedies or even virtual panaceas (= all healing): *Aloe littoralis* (11 uses), *Ptaeroxylon obliquum* (10), *Ximenia americana* var. *americana* (9), *Aristolochia albida* (8), *Senna occidentalis* (8) (see Table 2). The majority of them are also quoted by a high number of informants, but with some exceptions, namely *Aloe littoralis* and especially *Senna occidentalis* (10 informants, 11 citations). Yet, none of these plants seem to be perceived by local people as folk preventive medical remedies.

Medicinal plants were mainly used to treat disorders of the gastrointestinal tract (52 ethnospecies, 205 citations), followed by obstetric and gynecological troubles (27, 40) and respiratory diseases (25, 54) (Table 1).

For the following five species (5% of medicinal plants identified at specific or infraspecific level), no previous report about therapeutic properties was found in the consulted literature: *Aptosimum gossweileri*, *Buxus benguellensis*, *Ficus tettensis*, *Heteromorpha stenophylla* and *Lannea angolensis*. Among these, *Buxus benguellensis* and *Heteromorpha stenophylla* probably deserve more accurate investigations about their possible pharmacological activity, as they were cited by a considerable number of informants (17 and eight, respectively).

All the remaining plants resulted to be already included in the

African traditional pharmacopeia, but many of the uses reported by our informants were nevertheless previously unknown. The relatively high amount of original (i.e. not known) uses recorded in the studied communities (37%) confirm the importance of ethnomedicinal research, also when dealing with already known medicinal plants. As an example, the use of *Aloe littoralis* sap to treat eye inflammations (11 citations in present study) and other similar problems has already been documented (Grace et al., 2008), but other uses recorded in this study were not previously reported for this plant, in particular the use of roots and leaves to treat gastrointestinal disorders (11 citations), even if similar uses are known for other *Aloe* species (Grace et al., 2008).

The results of this survey also provide new insights into the knowledge about medicinal plants of Angola and of neighboring regions of northern Namibia, as 42 medicinal plants cited by our informants have not been previously reported for this area (Melo and Conceição, 2005, Melo 2008; Davies, 1994; Bossard, 1996; Chisembu and Hedimbi, 2010; Cheikhyoussef et al., 2011a, b; Cheikhyoussef and Embashu, 2013).

The Informant Consensus Factor (*FIC*) calculated for each category ranged from 0 to 0.98. The highest values were recorded for body care (*FIC*=0.98), followed by circulatory system diseases (*FIC*=0.91), malaria (*FIC*=0.81), digestive system disorders (*FIC*=0.75), muscular and skeletal system diseases (*FIC*=0.75) and headache (*FIC*=0.74); the lowest values for toothache (*FIC*=0), metabolic diseases (*FIC*=0) and urinal tract diseases (*FIC*=0.23) (Table 1). The oil extracted from the seeds of *Ximenia americana* var. *americana* was used as a hair conditioner and to improve skin tone and elasticity (41 citations), but also to treat varicose veins (42). For further information on this oil, its cosmetic uses in southern Angola, traditional extraction technique and potential economic interest of the plant for local communities, see Urso et al., 2013. According to Heinrich et al. (1998), informants' consensus within a community can aid in the selection of plants for pharmacological and phytochemical studies. In the investigated communities, some of the highest agreement levels were recorded for diseases reported as the most widespread in rural communities of tropical and subtropical Africa and included in the most important leading cause of death in that area, such as malaria and digestive disorders (WHO, 2010; UNICEF, 2013). The most used remedies for malaria were bark of *Ptaeroxylon obliquum* (10 informants) and underground organs of *Aristolochia albida* (8); for gastro-intestinal diseases, underground organs of *Aristolochia albida* (29), followed by bark/leaves/underground parts of *Ptaeroxylon obliquum* (25), leaves of *Buxus benguellensis* (13) and bark/underground parts of *Terminalia prunioides* (13). As a rule, *FIC* values resulted to be high for medicinal uses cited by many informants, confirming that people generally tend to agree on plants to be used in the treatment of common illnesses.

The informants' consensus about therapeutic uses of plants was assessed through the adopted Fidelity index (*FL*) (Table 4). Among the plants with the highest *FL* values, some can be found that are not used as medicinal plants in Africa, or that are used in the treatment of different diseases. Here are some examples: *Euphorbia subsalsa* is known as a remedy to alleviate pain caused by tattoos (PROTA4U, 2014), but has not been previously reported as a treatment for backache; *Buxus benguellensis* (for diarrhea and stomach-ache) and *Heteromorpha stenophylla* (sexual stimulant for men) were not cited at all as medicinal plants in the consulted literature.

In particular, *Buxus benguellensis* seems to play an important role in local pharmacopeia, as its use proved to be rather common in the studied communities (19 citations). A decoction of leaves is used to treat gastrointestinal problems (13 citations) and symptoms of general malaise (6 citations). Many species of the genus *Buxus* are a rich source of steroidal alkaloids (Matochko et al., 2010), a group of substances known for their pharmacological value in treating gastrointestinal, respiratory and vascular disorders (Hussain et al., 2015). A decoction of *Heteromorpha stenophylla* roots is used in the studied communities as an aphrodisiac (6 citations) and to heal chest pain and cough (2 citations). An infusion of the root of *H. arborescens*, a closely related species, is used to treat colds in Zimbabwe (Williamson, 1955) and as an aphrodisiac in Botswana (Plantzafrica, 2003).

In the studied area most remedies involve the use of a single plant, while those made up of mixtures are quite rare (6%). This finding deviates from what reported in other studies carried out in southern Africa; Bruschi et al. (2011) report that 57% of medicinal plants recorded in Muda (central Mozambique) were used in mixtures. In the studied communities, plant remedies were mostly prepared as decoctions (274 citations, 62 ethnospecies), followed by the use of raw (i.e. not prepared) plant parts (79, 23), and by infusions (51, 20). These results are in line with the most frequently adopted preparations in African traditional medicine (see, for example, Bruschi et al., 2011; Seleteng Kose et al., 2015). The most frequent way of administration was by oral route (406 citations, 98 ethnospecies), followed by direct application (66, 22) and inhalation (36, 10).

3.4. Food plants

Our results confirm that wild plants represent an important diet component for communities living in semiarid environments, as it has already been shown in several studies (Morgan, 1981; Lockett et al., 2000; Ladio and Lozada, 2009). A total of 597 citations (47.8% of the total) were recorded, concerning 33 food plants and eight secondary categories of use (Table 1). The most cited family for food plants was Malvaceae (220 citations, 5 ethnospecies), followed by Anacardiaceae (104 citations for the single species *Sclerocarya birrea*) and Rhamnaceae (65, two ethnospecies). The highest Informant Consensus Factor (*FIC*) values were obtained for raw root/tubers (*FIC*=1.0), followed by *massa*, a kind of mash made with fresh fruit or roots/tubers (*FIC*=0.95), by fresh fruit (*FIC*=0.93) and by oil or seasoning (*FIC*=0.92). Undomesticated woody plants providing edible products play an important role in local diet, as it is shown by the use of 24 tree ethnospecies (73% of all the food plants cited), belonging to 14 botanical families. In particular, a predominant use of fruit was recorded. This plant part is eaten in the form of fresh (20 ethnospecies, 287 citations) or dry fruit (4, 35), but it can be also processed, especially to prepare beverages-both alcoholic (12, 107) and non-alcoholic (10, 44)-and to produce *massa* (1, 26). These results are in accordance with findings reported by Cheikhyoussef

Table 4
Medicinal plants with high Fidelity Level (*FL* > 60%). Only plants cited by five or more informants are considered.

Ethnospecies	Medicinal use	*FL* (%)	lp	lu
Myrothamnus flabellifolia	colds and respiratory tract diseases	100	6	6
Terminalia prunioides	digestive system diseases	93	13	14
Euphorbia subsalsa	muscular and skeletal system diseases	86	6	7
Triumfetta sp.	headache	81	13	16
Gyrocarpus americanus subsp. *africanus*	digestive system diseases	70	7	10
Berchemia discolor	digestive system diseases	69	9	13
Buxus benguellensis	digestive system diseases	68	13	19
Heteromorpha stenophylla	sexual stimulant for men	62	5	8

FL: Fidelity Level; lp: number of informants citing the use of the plant for treating a particular disease; lu: total number of informants citing any medicinal use of the plant.

and Embashu (2013) who, in comparable environmental conditions occurring in northern Namibia, found that 18 indigenous wild fruit trees played an essential role in the livelihood of local communities. As already shown in other studies (Maroyi, 2011; Bruschi et al., 2014), consumption of fresh fruits as 'rural snacks' is a common practice during the hours spent working in the field or looking after grazing livestock, but fruit can also be collected in the wild and brought home for family consumption. Production and use of home-made beverages is widespread in the area and in some cases can supply an additional income. Production of alcoholic beverages is generally carried out by women through distillation, with rudimentary stills, of fruit previously macerated for three-four days. The most cited fruit trees were: *Sclerocarya birrea* (104 citations, 39 informants), *Adansonia digitata* (88, 60) and *Berchemia discolor* (64, 46). Fruits of these plants are rich in water, sugar and other macro- and micronutrients and most of them are available throughout the year; the importance of their contribution to the livelihood of communities living in arid and semi-arid lands has been underlined in many studies (Lockett et al., 2000; Feyssa et al., 2011, 2012).

Wild food plants are used to prepare a mash (*massa*) during periods of limited food availability, or in the case of drought or famine (4 ethnospecies, 65 citations). In addition to the fruit of *Adansonia digitata*, *massa* can be prepared with hypogeous organs of *Boscia polyantha* (32 citations, 32 informants), *Strophanthus amboensis* (6, 6) and *Cyperus esculentus* (2, 2). Consumption of edible underground organs (of both wild and cultivated plants) is common in many African countries (Ruffo et al., 2002; Bruschi et al., 2014) and represents an important survival strategy to cope with starvation and thirst in dry areas. Alimentary use of roots of different species of *Boscia* is widely known by *Herero* people living in southern Angola and northern Namibia, who use these plants to prepare a fermented milky beverage rich in nutritional and nutraceutical substances (Bille, 2013). In particular, roots of *Boscia albitrunca* are used to hasten the fermentation process, to add flavor and to improve the viscosity of this beverage, due to their high carbohydrates content (Bille, 2013). According to the informants, in the communities investigated in the present study the mash prepared by cooking and chopping roots of *Boscia polyantha* can be stored and preserved to be used during the long periods spent far from home, looking after the herd or attending to charcoal production. *Cyperus esculentus* tubers are also cooked and chopped to produce a mash. This food is known to be highly energetic and diuretic, rich in phosphorus and potassium, proteins and also vitamins C and E (Ejoh and Ndjouenkeu, 2006). To our knowledge, this is the first ethnobotanical study reporting any alimentary use of *Strophanthus* roots. Yet, many species belonging to this genus are known to be rich in cardenolide glycosides, an important class of natural products traditionally used by different populations either as drugs or as toxins. It is known that many famine foods, especially roots or tubers, are poisonous unless properly prepared (see for example tubers of some *Dioscorea* species used as food in a rural community of Mozambique, as reported by Bruschi et al., 2014) and this is also true for some tropical and subtropical crops, like cassava (*Manihot esculenta* Crantz). Informants reported that *Strophanthus amboensis* roots are debarked, washed and eaten raw (6 citations) or cooked to prepare a *massa* (6). Washing and cooking probably remove a great part of the toxic substances from the roots, to avoid accumulating toxic levels of the cardiac glycoside strophantin and other dangerous substances in the gastrointestinal system. Traditional wild vegetables consumed in the studied communities include *Cleome gynandra* (12 citations), *Bidens pilosa* (8) and *Amaranthus spinosus* (2), as well as five not identified species (14 citations, 12 informants in total). The three identified species are widely distributed in tropical or subtropical regions all over the world in disturbed and/or ruderal habitats, and in some areas are currently regarded as noxious invasive weeds. In many African countries, they are considered a rich source of food and medicine for both humans and animals (Njume et al., 2014).

As for the gathering season, 378 citations (66%) concern food products obtained from 27 different ethnospecies collected and consumed mainly during or immediately after the rainy season (from January to May), while 106 citations (18%) pertain to ten plants collected mainly during the dry season. Food products obtained from *Adansonia digitata*, *Boscia polyantha*, *Sclerocarya birrea*, *Strophanthus amboensis* and one unidentified plant (91 citations in total, 16%) are available roughly during the whole year. These data show that wild edible plant products can satisfy energy and nutritive requirements throughout the year, including periods of limited availability of food, when hidden hunger and related health problems (e.g. malnutrition caused by deficiencies of vitamins and minerals) are common in rural communities.

The importance of edible wild plants products as nutraceuticals in local diet and their usefulness in preventing nutritional deficiencies should also be considered. Deficiencies of vitamin A, iron, zinc and iodine are considered the most severe micronutrient deficiencies affecting human health in Africa (Keatinge et al., 2010). Although often regarded as poor people food, wild fruits, vegetables and roots/tubers can provide substantial amounts of some of them, namely vitamin A (*Berchemia discolor*, *Grewia* spp., *Sclerocarya birrea*), vitamin B complex (*Adansonia digitata*), vitamin C (*Adansonia digitata*, *Berchemia discolor*, *Bidens pilosa*, *Cyperus esculentus, Grewia* spp., *Sclerocarya birrea*), vitamin E (*Cyperus esculentus*), iron (*Berchemia discolor*, *Bidens pilosa*, *Cleome gynandra*, *Grewia* spp.), phosphorus (*Adansonia digitata*, *Berchemia discolor*, *Bidens pilosa*, *Cyperus esculentus, Sclerocarya birrea*), potassium (*Cyperus esculentus*) and calcium (*Adansonia digitata*, *Amaranthus spinosus*, *Bidens pilosa*, *Grewia* spp., *Sclerocarya birrea*) (Tengnäs, 1994; Ejoh and Ndjouenkeu, 2006; Njume et al., 2014). Consumption of wild food products obtained from these plants can possibly give a significant contribution to the general health of the studied communities.

Many studies (Etkin, 2006; Leonti, 2012; Leonti and Casu, 2013; Sõukand and Kalle, 2013) have pointed out the partial overlap between medicinal and food plants, showing that in many traditional cultures wild and/or cultivated plants can be considered a food and a medicine at the same time. In the studied communities, 15 plants (11.4% of all the ethnospecies recorded in our study) have been reported by the informants to have both medicinal and food uses; yet, only in the following three cases the same plant part is consumed as a food and is also used as a medical remedy through oral administration: *Aframomum alboviolaceum* (fresh fruit to treat intestinal parasites), *Carissa spinarum* (fresh fruit to treat diarrhea) and *Senna occidentalis* (roasted seeds decoction as a coffee surrogate and as an antipyretic). These species seem to deserve some special interest as a possible 'pharma-foods' or 'folk nutraceuticals' (food products ingested in order to maintain a status of health, Pieroni and Quave, 2006). In particular, the decoction of *Senna occidentalis* seeds can be regarded as a kind of 'recreational tea' with therapeutic properties. As reported in Sõukand et al. (2013) for Europe, many traditional hot plant beverages consumed within a food context are believed also to be 'healthy', that is, to have some preventive or curative properties.

3.5. Conservational issues in the study area

Collection activity may play an important role in the resilience of local communities, but a high utilization rate of non-timber forest products can lead to an over-exploitation of biological resources, with a strong impact on plant diversity and eventually to the conservation of the whole ecosystem (Cunningham, 2001).

Romeiras et al. (2014) observed that lack of recent reliable data about flora and species distribution is an important problem affecting biodiversity conservation in Angola. Although none of the plants cited by the informants in the present study is reported in the IUCN Red List (IUCN, 2015), the lack of detailed information on spatial distribution of useful plants and on size/trends of existing plant populations does not allow us to draw correct inferences from a conservation standpoint. Yet, subjective data recorded in the interviews are quite encouraging: according to the informants' perception, 33 mentioned ethnospecies (33.3%) are abundant in the area, 56 (56.6%) are available in sufficient amount and only 10 (10.1%) are perceived as scarcely available. No answer was given by the informants on the abundance of the remaining 34 cited ethnospecies. All the ethnospecies with the highest *CI* values were reported by the informants to be either abundant (*Adansonia digitata*, *Aloe littoralis*, *Aristolochia albida*, *Berchemia discolor*, *Colophospermum mopane*, *Grewia* ssp., *Ptaeroxylon obliquum, Sclerocarya birrea*, *Terminalia prunioides*, *Ximenia americana* var. *americana*) or rather abundant (*Boscia polyantha*) in the area. Among the most frequently recorded medicinal plants (i.e. cited by more than five informants), only *Heteromorpha stenophylla*, *Cynanchum viminale* and an unidentified plant (local name: *kalomkampela*) were reported to be scarce in the area.

Yet, it must be considered that *Mopane* is an extremely fragile ecosystem, rich in endemic species and in many cases endangered by intense exploitation by human communities (Makhado et al., 2012). For this reason, in the management of these plants a sustainable approach including preliminary floristic inventories and the involvement of local communities is recommended.

4. Conclusions

Collecting documents on local knowledge of plants and plant uses, ethnobotanical studies can provide valuable information on locally available biological resources which can act as potential sources of food, medicines and other primary necessities. This is particularly true in areas poorly investigated from this perspective, as the *Mopane* communities of south Angola where our study was carried out. The high number of medicinal plants (42) reported by our informants and not previously documented for Angola and northern Namibia and the five plants not previously known in ethnomedical literature provide a clear evidence of this. Our results show that people living in this area hold a valuable knowledge of the use of plant resources and that some of the used plants are an important component of both cultural identity and livelihood strategies of the surveyed households. Informants reported that the use of wild food plants assumed a strategic role during the serious food shortage of 2011–2013 caused by a prolonged mid-season dry spell followed by excessive rains which damaged food crops and destroyed entire villages. The importance of wild food plants will possibly increase in the next future due to the expected climate changes (Lotz-Sisitka and Urquhart, 2014), which will make agriculture a more and more high-risk and low-return activity in this area, fostering the recourse to wild food. Similarly, reduced access to public health structures, caused by the substantial cut in the health budget recently proposed by the Angolan government as a consequence of falling oil prices (Kristof, 2015) will possibly improve self-medication practices in the future. In this framework, medicinal plants and wild food resources will play a crucial role.

From an ethnopharmacological point of view, knowledge of medicinal plants proved to be widely spread in the investigated communities (over 98% of the informants mentioned plant remedies; over 52% of citations concern this use category).

Some medicinal plants reported by the informants appear to be particularly worthy of more in-depth investigations on their possible pharmacological activity. These include:

i) Plants not previously reported in ethnomedicinal literature: *Aptosimum gossweileri* (toothache), *Buxus benguellensis* (diarrhea and stomach-ache, general malaise), *Ficus tettensis* (anthelmintic), *Heteromorpha stenophylla* (cough and breast pain, pregnancy troubles, sexual stimulant for men) and *Lannea angolensis* (colds and cough). Among these, *Buxus benguellensis* and *Heteromorpha stenophylla*, which were cited by a considerable number of informants, seem to deserve a particular interest.
ii) Plants used to treat quite severe diseases, which obtained the highest Informant Consensus Factor (*FIC*): among these, malaria (*Ptaeroxylon obliquum*, *Aristolochia albida* and others) and gastrointestinal disorders *(Aristolochia albida*, *Ptaeroxylon obliquum*, *Buxus benguellensis*, *Terminalia prunioides*).
iii) Plants with a high Fidelity index (*FL*), that is, the informants' agreement about therapeutic uses of each plant: *Myrothamnus flabellifolia* (cold, cough and breast pain), *Terminalia prunioides* (diarrhea and stomach-ache), *Euphorbia subsalsa* (backache), *Triumfetta* sp. (headache), *Gyrocarpus americanus* subsp. *africanus* (diarrhea, stomach-ache), *Berchemia discolor* (diarrhea, stomach-ache), *Buxus benguellensis* (diarrhea, stomach-ache), *Heteromorpha stenophylla* (sexual stimulant for men).
iv) Plants with possible nutraceutical or pharma-foods properties. These include, among the others, the following plants with a known considerable content in vitamins and/or micronutrients: *Adansonia digitata* (vit. C, B complex; P, Ca), *Berchemia discolor* (vit. A and C; Fe, P), *Bidens pilosa* (vit. C; Fe, P, Ca), *Cyperus esculentus* (vit. C and E; P, K), *Grewia* spp. (vit. A and C; Fe, Ca), *Sclerocarya birrea* (vit. A and C; P, Ca). Plants where the same part is used both as food and as medicine through oral administration, like *Aframomum alboviolaceum*, *Carissa spinarum* and *Senna occidentalis* are also worth of further investigations.

In addition, some wild plant products traditionally harvested, processed and sold in local markets can be regarded as promising potential economic resources for local communities. This is the case of the cosmetic oil extracted from seeds of *Ximenia americana* subsp. *americana* and of the edible fruit of *Adansonia digitata*. For these plants, improvements in different phases of production process and/or possible cultivation experimentations could be tried out.

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