

Traditional knowledge on ethno-veterinary and fodder plants in South Angola: An ethnobotanic field survey in Mopane woodlands in Bibala, Namibe province

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Abstract: Livestock is a critical resource to improve income and household livelihoods in many rural areas. To date, very few studies have investigated farmers' local knowledge on plants used in managing animal health and welfare in Angolan *Mopane* woodland. This is a very dry ecosystem where animal husbandry (mostly cattle and goats breeding) is highly widespread and is often the main form of subsistence, greatly contributing to local communities food security, especially in periods of resources shortage. An ethnobotanical research project was carried out in Bibala (Namibe province – Angola) in 2010 – 2012, in order to collect information on different traditional uses of plants, involving an interviewed sample of 66 informants. Fifty-eight of them (87.9%) listed a total of 39 species used as ethno-veterinary and/or fodder plants. Ten ethno-veterinary species (28 citations) were reported by 20 informants as used to treat diseases commonly affecting animals in the studied area, namely respiratory tract problems (*Laphangium luteoalbum*, *Gyrocarpus americanus*, *Craibia brevicaudata* subsp. *baptistarum*, *Lepisanthes senegalensis*, *Ptaeroxylon obliquum*, *Ximenia americana*) and skin diseases and wounds (*Aloe littoralis*, *Blepharis* sp., *Ficus thonningii*), or acting as a general tonic (*Faidherbia albida*). Thirty-four plants (235 citations) were cited by 58 informants as fodder. In this category of use, the most cited species were *Terminalia prunioides* (30 citations), *Faidherbia albida* (28 citations) and *Spirostachys africana* (21 citations). Our study shows that communities living in South Angola *Mopane* woodlands still retain a valuable traditional knowledge about plants used to maintain animal health and welfare. This body of knowledge and related skills can play a crucial role in the resilience of livestock systems facing present environmental and socioeconomic changes.

Keywords: *Mopane* woodland, fodder plants, ethno-veterinary plants, ethnobotany, traditional knowledge, Angola.

Introduction

Animal husbandry plays a key role in rural economy of tropical areas as a source of cash income and employment (Herrero *et al.*, 2013). Moreover, livestock and derived products act as a buffer against climatic unpredictability, greatly contributing to food security especially in periods of agricultural resources shortage. In Angola, agro-pastoral activities are crucial for local economy development, particularly in the southern province of Namibe where they account for 97% of total national bovine livestock production (Angola, 2013). In this area, the main vegetation type is the Angolan *Mopane* woodland, a kind of savanna woodland ecosystem dominated by the tree *Colophospermum mopane* (J. Kirk ex b  J. Leonard (also called *mopane* in local languages) (Makhado *et al.*, 2012; Makhado *et al.*, 2014). *Mopane* woodlands are a highly seasonal environment, with a sparse and scattered vegetation, facing water deficit and high temperatures for most of the year. Due to dry climate and poor soil conditions, land cultivation is difficult and farmers deal basically with livestock, which is the main and often sole possible survival mean and income source. Most farmers are nomadic pastoralists, whose activity is regulated by a distribution of resources varying in space and time; they move with their herds both on a daily and seasonal basis, according to fodder availability. These pastoralists hold a deep Traditional Ecological Knowledge (TEK) reflecting an ancient cultural heritage developed by local communities through the centuries in accordance with their natural and social environment (Bainbridge, 2012). TEK is an important source of environmental information helping people to cope with perturbations, variability and randomness of resources due to factors like lack of rain, climatic changeability and consequent variable amounts of biomass (Little, 2003). As pointed out by several studies (Begossi, 1998; Gómez-Baggeth *et al.*, 2012), transmission of this biocultural heritage is at the base of human adaptive strategies and can play a critical role in minimizing the impact of disturbances on livelihood of local communities, especially those living in highly unpredictable systems like *Mopane* woodlands (Eisold *et al.*, 2006). The aim of this study was to record and analyze traditional ethnobotanical knowledge concerning ethno-veterinary medicine and fodder plants in some communities living in *Mopane* woodlands surrounding the municipality of Bibala in Namibe province, southern Angola (Fig. 1). Some recent studies have shown that people living in this area still hold a valuable knowledge on food and medicinal plants and that some of these plants can act as crucial factors in livelihood strategies of indigenous communities (Urso *et al.* 2016); however, to date no systematic information has been gathered on plants locally used in maintaining livestock health and welfare. Accordingly, there is a compelling need to collect information about local ethnobotanical knowledge concerning animal husbandry before it can be lost and become unavailable for future generations. *Mopane* woodlands are generally considered an important source of

browse feed for many wild and domestic herbivores (Eisold *et al.*, 2006; Makhado *et al.*, 2014), especially during dry season, when little other forage is available. These savanna woodlands are also believed to host a high diversity of plants with potential ethno-veterinary applications (Luseba and van der Merwe, 2006; Luseba and Tshisikhawe, 2013; Chinsebu *et al.*, 2014). Wild fodder plants and traditional ethno-veterinary practices based on medicinal plants can help local communities to cope with environmental and socioeconomic disturbances on livestock systems. On the other hand, these biological resources could be expected to play an increasingly critical role in securing feed and health for livestock in the next future. Events related to climate changes severely impacted Southern Angola in the last years, causing dramatic food shortage and starvation. Since 2008 agropastoralist communities are facing recurrent cycles of droughts and floods that negatively affected quality of pasture and rangeland, access to water for human and animal consumption, and livestock health (OCHA, 2016). In an area where about 80 % of the people rear livestock and where most farmers have a limited access to markets, such events can have disastrous effects on the livelihood of local communities.

Material and methods

Study area

The study has been carried out in the *Mopane* woodlands surrounding Bibala, a municipality lying in Namibe province. The province is localized in South-Western part of Angola, covering a total area of about 57 sqkm. It includes five municipalities, with an estimated population of 1,195,779 in 2012 (Angola, 2013). This region has an arid to hyper-arid climate, with little annual variation in temperature. Average annual temperature is 21.6 °C and average annual rainfall ranges from 300 to 600 mm. Rainy hot season occurs from January to March, while the long dry season lasts about nine months. According to a survey carried out by the Provincial Administration of Namibe in 2013, cattle population has been estimated to be 500,400 heads distributed in approximately 849 herds (Angola, 2013); about 70% of these occur in Bibala and Cumucuio municipalities, where animals are mainly bred for meat production (Daniel *et al.* 2016). Besides cattle, animals reared in Namibe province also include about 1,250,000 goats, 570,000 sheep and 36,800 pigs (Angola, 2013). Nhaneka Umbi and Mucubal are the main ethnic groups in the area. They are known to be very skilled in cattle rearing; herders use traditional routes of transhumance, generally moving from May to September and covering distances ranging from 50 to 200 km. Competition for limited access to water and land resources, lack of food stocks, outbreaks of livestock disease, as consequences of the climate change events occurring in this area, have prolonged the transhumance period up over one year (OCHA, 2016).

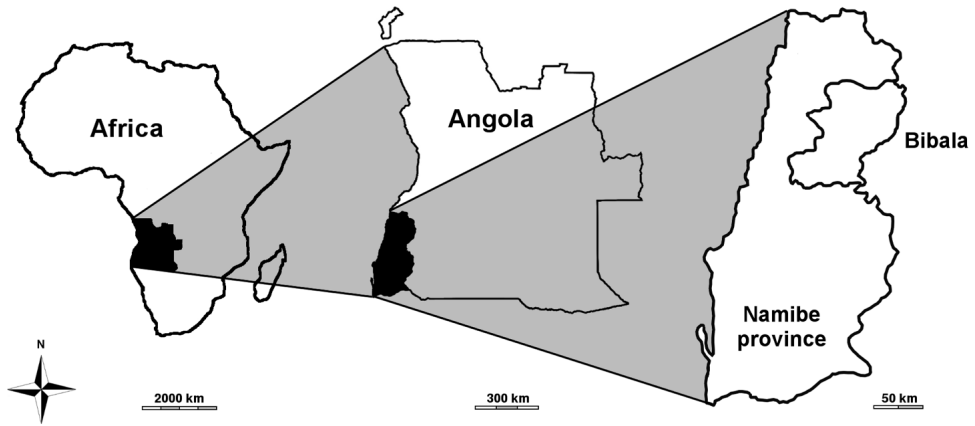


Figure 1 - Investigation area: Bibala, Namibe province, Angola.

Data collection

Information on ethno-veterinary medicine and fodder plants was collected within the frame of a wider ethnobotanic survey carried out in the area in three different periods: from July to August 2010 (dry season), from February to April 2011 (wet season) and from April to June 2012 (between the end of the wet season and the beginning of the dry season). A total of 66 informants (40 females and 26 males) living in seven communities (see Urso *et al.*, 2016 for a detailed description of the involved communities) were contacted through “snowball” sampling (Albuquerque *et al.*, 2014) and interviewed. Personal and demographic data concerning the informants are reported in Urso *et al.* (2016). Information on plants and traditional uses was gathered through semi-structured individual interviews and group discussions. Both interviews and discussions were conducted in local dialects and later translated into Portuguese, thanks to the assistance of local interpreters and cultural mediators. 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 interview. As far as possible, specimens of all the plants cited by the informants were collected under their assistance and supervision, and later deposited at the Tropical Herbarium of Florence, University of Florence (FT). Only a few plants could not be sampled, due to the age or health conditions of the informants. In plant identification, the following floristic works were consulted: *Trees of the Southern Africa* (Coates Palgrave, 2003) and *Plants of Angola* (Figueiredo and Smith, 2008). Botanical nomenclature of species and families comply with *The Plant List* (<http://www.theplantlist.org>).

Data analysis

Ethnobotanical data collected through the interviews with local informants were filed in a Microsoft Excel spreadsheet. Each row of the table represents a *citation*, defined as a single use reported by a single informant for a single species (Signorini *et al.*, 2009). In the columns the following attributes are reported for each citation: botanical species, botanical family, vernacular plant name/s, informant identification code, primary use category (etho-veterinary or fodder), secondary use category (detailed usage within each primary area of use, see table 1), used plant part(s). To perform sorting, filtering and counting of data, these were processed with the aid of the 'EBtools' program (Signorini and Ongaro, unpubl.), consisting in a collection of scripts in VBA (Visual Basic for Applications) in Microsoft Excel.

In order to estimate the relative importance of each plant species, the Use Value (UV) index (Rossato *et al.*, 1999) was applied:

$$UV = \Sigma U / N$$

where:

U = number of generic uses (ethno-veterinary or fodder or both) mentioned by each informant for a specific species; N = total number of informants.

UV values are high when many uses are reported for a given plant, and approach zero when few uses are mentioned.

Results and discussion

Fifty-eight informants (87.9% of all the informants interviewed during the whole ethnobotanical survey) mentioned plants locally used to feed livestock and to maintain its health and welfare, listing a total of 39 ethno-veterinary and fodder plants (Table 1). Thirty-six informants were females and 22 were males. Out of the 39 cited species, 33 (84.6%) could be identified at different taxonomical level: 30 at specific or infraspecific level, two at genus level and one at family level. Six plants, for which samples could not be collected, were not identified. Each informant cited on average 4.53 (\pm 2.18) species and 1.33 (\pm 0.47) different generic uses; most plants (76.9%) were listed by less than ten informants; only the following five plants were cited by more than 16 informants (about $\frac{1}{4}$ of the sample): *Faidherbia albida* (Delile) A. Chev. (46 informants; UV = 0.70), *Terminalia prunioides* M. A. Lawson (30 informants; UV = 0.52), *Blepharis* sp. (21 informants; UV = 0.36), *Spirostachys africana* Sond. (21 informants; UV = 0.36) and *Colophospermum mopane* (17 informants; UV = 0.29) (Table 1). The relatively high UV values of these five plants point out their importance for the livelihood of the studied communities. With the exception of *Blepharis* sp., all these plants are multipurpose trees providing different useful products. *Spirostachys africana* and *Colophospermum mopane* are locally used in the production of poles,

handcrafted artifacts, fuelwood, medicinal drugs. *Terminalia prunioides* and *Faidherbia albida* provide fuelwood and medicines. Moreover, *C. mopane* and *F. albida* belong to the botanical family of Leguminosae and, like most leguminous plants, have the potential to improve soil fertility thanks to nitrogen enrichment.

Plants used as ethno-veterinary medicine

A total of ten plants (28 citations; 10.6% of all the citations) were cited by 20 informants (30.3% of all the people interviewed in the whole ethnobotanical survey) as used to heal different animal diseases. This result is comparable to those reported in other studies carried out in similar environments (19 species cited by 200 informants in Luseba and van der Merwe, 2006; 16 species cited by 42 informants in Chinsembu *et al.*, 2014). However, the amount of knowledgeable informants is rather small when compared to the 58 informants citing fodder (see below) and the 66 citing food and/or medicinal plants (Urso *et al.*, 2016) in the same communities. Yet, we can hypothesize that ethno-veterinary knowledge in the studied area was once higher, but due to changing socioeconomic and cultural values is currently disappearing, and only survives in the minds of a few informants. The relatively recent introduction of public policies aiming to promote animal vaccination largely contributed to prevent and control the most serious animal diseases in Angola (Parodi *et al.*, 2016). On the contrary, this could have adversely affected the system of traditional knowledge concerning livestock health and welfare, as vaccines have become easily accessible for most farmers, and livestock health is currently primarily assured by prevention. As a matter of fact, interviews revealed that in general most informants prefer to rely on modern veterinary practices rather than on traditional herbal remedies (see also Collins, 2011). However, ethno-veterinary practices may still act as an important low-cost alternative to 'western' veterinary approach in the treatment of less serious health problems and also in more isolated areas, where access to medical care/facilities is impossible or scarce (Martin, 2001). Many small-scale farmers living in the surveyed areas do not know how to obtain, handle and administer vaccines to their herds and/or cannot afford the cost of veterinary medicines. In the next future this condition could even extend and get worse, as the government need to contain public expenditure is causing a strong staff reduction in veterinary services, especially with regard to veterinary officers directly involved in health education and information activities within pastoralist communities (Parodi *et al.*, 2016).

We did not find any gender-based trend in ethno-veterinary knowledge: fifteen females and six males informants cited an average of 1.28 ± 0.61 and of 1.66 ± 0.74 species respectively but this difference was not statistically significant (Mann-Whitney test: $p > 0.05$).

Plants cited by the informants were used to treat ailments and health troubles

Table 1 - List of the species with ethno-veterinary and fodder uses in the studied area. UV = Use Value index; Ba: bark; Fr: fruit; Le: leaves; Tw: twigs; Sh: shoot; Wp: whole plant.

BOTANICAL SPECIES	LOCAL NAME	BOTANICAL FAMILY	NUMBER OF INFORMANTS	UV	USE (USED PART)	DETAILED USE
<i>Acacia nilotica</i> (L.) Willd. ex Delile	Omukete, Omuloi	Leguminosae	1	0.017	Fodder (Fr, Le)	goats
<i>Acacia senegal</i> (L.) Willd. var. <i>rostrata</i> Brenan	Mukondo	Leguminosae	11	0.190	Fodder (Fr, Le, Tw)	cattle, goats
<i>Aloe littoralis</i> Baker	Endombo, Otchindombo	Xanthorrhoeaceae	2	0.034	Ethno-veterinary (Sap)	nodular dermatitis (cattle)
<i>Barleria spinulosa</i> Klotzsch	Ompinti	Acanthaceae	9	0.155	Fodder (Le)	cattle, goats
<i>Berchemia discolor</i> (Klotzsch) Hemsl.	Omumbe	Rhamnaceae	2	0.034	Fodder (Le)	cattle, goats
<i>Blepharis</i> sp.	Ompinti	Acanthaceae	21	0.362	Fodder (Le); Ethno-veterinary (Sh)	cattle, goats; wounds (cattle)
<i>Colophospermum mopane</i> (J. Kirk ex Benth.) J. Léonard	Omutuate, Omuthyati	Leguminosae	17	0.293	Fodder (Fr, Le, Tw)	cattle, goats
<i>Combretum imberbe</i> Wawra	Omumpupu	Combretaceae	3	0.051	Fodder (Le)	cattle, goats
<i>Commiphora mossamedensis</i> Mendes	Omuxiti	Burseraceae	2	0.034	Fodder (Le)	goats
<i>Craibia brevicaudata</i> (Vatke) Dunn subsp. <i>baptistarum</i> (Büttner) J. B. Gillett	Mutoko	Leguminosae	7	0.120	Fodder (Le); Ethno-veterinary (Le)	goats; nodular dermatitis (cattle)
<i>Cyperus esculentus</i> L.	Noheva	Cyperaceae	1	0.017	Fodder (Le, Wp)	cattle, goats
<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	Omupandji	Leguminosae	10	0.172	Fodder (Fr, Le)	goats
<i>Eragrostis</i> sp.	Otchikata	Poaceae	2	0.034	Fodder (Le, Wp)	cattle, goats
<i>Faidherbia albida</i> (Delile) A. Chev.	Omuwè, Onowetu	Leguminosae	46	0.793	Fodder (Fr, Le)	cattle, goats
<i>Ficus sycomorus</i> L.	Usolo, Mukuyo	Moraceae	9	0.155	Fodder (Fr)	Pigs
<i>Ficus tettensis</i> Hutch.	Tchangulu	Moraceae	2	0.034	Fodder (Fr)	Pigs
<i>Ficus thonningii</i> Blume	Omukuiunda	Moraceae	10	0.172	Fodder (Fr); Ethno-veterinary (Ba)	pigs; wounds (cattle);
<i>Grewia cyclopetala</i> Wawra	Mukonda	Malvaceae	3	0.052	Fodder (Le)	cattle, goats

Table 1 - continued

BOTANICAL SPECIES	LOCAL NAME	BOTANICAL FAMILY	NUMBER OF INFORMANTS	UV	USE (USED PART)	DETAILED USE
<i>Grewia flavescens</i> Juss.	Omumbole, Munama	Malvaceae	3	0.052	Fodder (Le)	cattle, goats
<i>Grewia monticola</i> Sond.	Omumpapu	Malvaceae	8	0.138	Fodder (Le)	cattle, goats
<i>Grewia villosa</i> Willd.	Ominkota	Malvaceae	3	0.052	Fodder (Le)	cattle, goats
<i>Gyrocarpus americanus</i> Jacq.	Omuxiria	Hernandiaceae	1	0.017	Ethno-veterinary (Le)	contagious pleuropneumonia, (cattle, goats)
<i>Jasminum fluminense</i> Vell.	Okalondo	Oleaceae	6	0.103	Fodder (Le)	goats
<i>Laphangium luteoalbum</i> (L.) Tzvelev	Otchimbwangongo	Asteraceae	10	0.172	Fodder (Le); Ethno-veterinary (Le)	cattle, goats; contagious pleuropneumonia, (cattle, goats)
<i>Lepisanthes senegalensis</i> (Poir.) Leenh.	Omungolo	Sapindaceae	1	0.017	Ethno-veterinary (Le)	contagious pleuropneumonia, (cattle, goats)
<i>Monotes africanus</i> A.DC. var. <i>hypoleucus</i> Oliv.	Osui, Mubuanza-bwanza	Dipterocarpaceae	1	0.017	Fodder (Le)	cattle, goats
<i>Ptaeroxylon obliquum</i> (Thunb.) Radlk.	Omubungurulu	Rutaceae	1	0.017	Ethno-veterinary (Le)	contagious pleuropneumonia, (cattle, goats)
<i>Salvadora persica</i> L.	Omukambi	Salvadoraceae	3	0.052	Fodder (Le)	cattle, goats
<i>Spirostachys africana</i> Sond.	Omumpapa, Jiliti	Euphorbiaceae	21	0.362	Fodder (Le)	goats
<i>Tephrosia oxygona</i> Welw. ex Baker	Heveve	Leguminosae	6	0.103	Fodder (Le)	cattle, goats
<i>Terminalia prunioides</i> M. A. Lawson	Omuhaina	Combretaceae	30	0.517	Fodder (Le)	goats
<i>Ximenia americana</i> L.	Omumpeke		1	0.017	Ethno-veterinary (Le)	contagious pleuropneumonia (cattle)
	Omunganga	Melastomataceae	1	0.017	Fodder (Le)	cattle, goats
Unknown	Filankopo		2	0.034	Fodder (Le)	cattle, goats
Unknown	Kalomkampela, Kambassola		1	0.017	Fodder (Le)	cattle, goats
Unknown	Omunhele		2	0.034	Fodder (Le)	cattle, goats
Unknown	Omutetempa		2	0.034	Fodder (Le)	goats
Unknown	Tchikulu		1	0.017	Fodder (Le)	cattle, goats

commonly affecting livestock in the studied area, namely respiratory tract problems and skin diseases and wounds, or as a general tonic. As frequently observed in other studies (see for example Bonet and Vallès, 2007; Akerreta *et al.*, 2010; Chinsebu *et al.*, 2014), data collected in this investigation showed that some plants are used by people to heal both themselves and their animals. Seven out of the ten species used to treat veterinary diseases (*Aloe littoralis* Baker, *Faidherbia albida*, *Ficus thonningii* Blume, *Gyrocarpus americanus* Jacq., *Lepisanthes senegalensis* (Poir.) Leenh., *Ptaeroxylon obliquum* (Thunb.) Radlk., *Ximenia Americana* L.) were also cited as drugs in local human medicine (Urso *et al.*, 2016) and three of these seven species were used to treat skin (*A. littoralis* and *X. americana*) and respiratory diseases (*A. littoralis*, *P. obliquum* and *X. americana*) in both animals and humans. Plants with both medicinal and ethno-veterinary uses are a significant fraction (8.6%) of the pool of medicinal plants constituting the pharmaceutical ethnoflora reported in Urso *et al.* (2016). Humans and livestock interact closely in this environment, often competing for the same resources and sharing some similar pathogens and parasites (see for example, Ayele *et al.*, 2004 and Parodi *et al.*, 2006). Based on their experience and adaptation to the local ecosystem, traditional communities have identified similar measures to deal with similar problems affecting both humans and animals.

The ten cited species were distributed among nine different botanical families. The most used plant part is represented by leaves (6 citations, 6 species) and fruit (18 citations, 1 species). The most common route of administration is oral (82.3%), followed by direct application (17.7%). Contagious bovine and caprine pleuro-pneumonia (both locally known as *kawenha*) are among the most important infectious diseases affecting livestock in this area. A study recently conducted by Daniel *et al.* (2016) shows that 64% of the farmers interviewed in three municipalities of Namibe province cite contagious bovine pleuro-pneumonia as one of the main causes of animals death. Bibala resulted to be the most affected municipality in the whole province, and bovines were the livestock category showing the highest mortality rates (Daniel *et al.*, 2016). Our informants reported the treatment of *kawenha* with the following species: *Laphangium luteoalbum* (L.) Tzvelev, *Gyrocarpus americanus*, *Craibia brevicaudata* (Vatke) Dunn subsp. *baptistarum* (Büttner) J. B. Gillett, *Lepisanthes senegalensis*, *Ptaeroxylon obliquum*, *Ximenia americana* (Table 1). The biological effects of some of these plants could be associated with their antibacterial activity. For example, extracts of *P. obliquum* leaves have been shown to have a strong antibacterial effect against multidrug-resistant strains associated with wound infections (Oyedemi *et al.*, 2016). James *et al.* (2007) observed that methanolic extracts from roots, bark and leaves of *X. americana* have activity against several bacteria including *Staphylococcus aureus* and *Klebsiella pneumoniae*, commonly associated with pneumonia in humans. In a review of the phytochemistry and biological activities of the genus *Gnaphalium* (*Pseudognaphalium*), it was pointed out that extracts from many species of this

genus are active against Gram-positive bacteria including *Staphylococcus aureus* and *Streptococcus pneumoniae* (Zheng et al. 2013). The hexane and ethanol extracts of the roots of *L. senegalensis* have been reported to exhibit moderate antimicrobial activity against *Bacillus cereus*, *Escherichia coli*, and *Staphylococcus aureus* (Wutithamawech et al., 2014). Sap extracted from *Aloe littoralis* leaves is used to heal a bovine nodular dermatitis, probably identifiable as LSD (Lumpy Skin Disease), a viral, eruptive disease of cattle characterized by nodules on skin and other parts of the body. The use of many species of the genus *Aloe* in the treatment of different livestock skin diseases has been reported for several southern African countries (see Grace et al., 2008). With regards to the Angolan *Mopane* ecoregion, Chinsebu et al. (2014) found that *Aloe esculenta* and *A. zebrina* were used to treat cattle skin ailments by Ndonga pastoralists living in northern Namibia. The results of the study carried out by Hajhashemi et al. (2012) point out that the leaf sap of *Aloe littoralis* has potential wound-healing and anti-inflammatory activities in rats. The polysaccharides of mucilaginous gel are considered to be the active molecules inducing the anti-inflammatory and immune modulatory effects in this species. According to our informants, *Ficus thonningii* bark and *Blepharis* sp. herbaceous stem are chopped and applied on the skin of injured animals to facilitate wounds healing, also acting as flies repellents. *F. thonningii* bark extracts are known to contain glycosides, flavonoids, tannins and alkaloids having anti-microbial (Usman et al., 2009) and anti-inflammatory properties (Otimenyin et al., 2004). *Faidherbia albida* fruit - cited by the informants also as fodder, see below - is commonly considered as a kind of general tonic, used to increase cattle health and vitality (18 citations). This ethno-veterinary use has been reported in other studies (Konè and Atindehou, 2008) and is probably related to the high content of crude protein in *F. albida* leaves and pods.

Fodder plants

The results of our research show that *Mopane* woodland plays an important role in livestock rearing especially during the dry season, when the quantity and quality of herbaceous cover significantly declines and supplementary rations of nutritious food are therefore needed to satisfy the nutrient requirements of animals. Starvation frequently occurs in dry season and it is considered by local shepherds as one of the main causes of animals death (Collins, 2011). In the course of this study, 34 plants were cited by 58 informants (87.9% of all the people interviewed in the whole ethnobotanical survey) for livestock feeding, for a total of 235 citations (89.4% of all the citations). Males (average number of cited species: 4.60 ± 2.08) showed to be more knowledgeable on the use of fodder plants than females (average number of cited species: 3.72 ± 1.92); however, this difference was not statistically significant (Mann-Whitney test: $p < 0.05$). As we could personally observe, men usually

spend much part of their time moving in the *Mopane* woodland with their herds, while in the same environment women are more frequently involved in food and firewood collecting. Leaves were the most cited plant part (211 citations, 90.2% of all citations in this category of use, 31 species), followed by fruit (63 citations, 26.7% of all citations in this category of use, 8 species). In general, leaves have a higher crude protein content than fruits, but the latter are considered to have higher organic matter and digestibility (Goehl, 1981). The identified plants belong to 15 different botanical families, with Leguminosae being the most cited (79 citations, 7 species). Leguminosae are generally highly appreciated by livestock and are regarded as forage of good quality due to their high protein content (25 to 50% higher than in other plants according to Nitis, 1989). For its relative abundance of Leguminosae, *Mopane* ecosystem is considered to be able to support a quite high concentration of herbivores (Shorrocks, 2014). It is not surprising that most of the plants reported by our informants as fodder are woody (85.7%). Eisold *et al.* (2006) observed a clear preponderance of woody species when studying fodder plants used by OvaHerero pastoralists in the *Mopane* savanna in north-western Namibia. In local perception of OvaHerero communities, indigenous trees and shrubs are more important than grasses as fodder plants because they are considered as a crucial source for animal nutrition in times of scarcity. Compared to grasses, woody species are less affected by seasonal climatic changes because they have a deep root system enabling the extraction of water and mineral nutrients from deep in the soil profile. Moreover, according to Boitumelo (2000), tree leaves usually have a protein content of 12-30 % compared to mature grasses having a protein content of only 3-10 %. Therefore, this preference does not reflect either the ecological importance (i.e. the abundance) or the grazing value of the fodder plants, but rather their relevance for livestock under the stressful conditions occurring in that extremely variable environment. This is probably the reason why in our study only one plant (*Eragrostis* sp.) belonging to the family Poaceae was cited as important in animal feeding, and only by two informants, in spite of the fact that grasses are generally plants of basic importance as fodder.

The most cited tree species in our study were *Terminalia prunioides* (leaves, 30 citations), *Faidherbia albida* (fruits and leaves, 28 citations) and *Spirostachys africana* (leaves, 21 citations), all of them used for feeding goats and/or cattle (Table 1). In particular, *F. albida* is considered one of the most important trees for African farmers, as it keeps its leaves also in the dry season, in this way providing some food for livestock when little or no other fodder is available. At the end of the dry season, pods fallen to the ground are also used as a protein-rich fodder. According to Hassan *et al.* (2007), pods of *F. albida* contain a relatively high amount of crude protein ($20.63 \pm 1.2\%$), crude fat ($13.3 \pm 0.1\%$) and carbohydrates ($40.1 \pm 0.1\%$). The crude protein content is considered sufficient to support the maintenance requirement of small ruminants (8.90%) and the average requirements (9.70%) of

lactating cows (Shiawoya and Adeyemi, 2003). Very few data exist in the literature about the nutritional values of *Terminalia prunioides*. Dambe *et al.* (2015) report that bark collected from *T. prunioides* plants growing in a semi-arid mixed *Mopane* bushveld is a good source of crude protein for livestock. An *in vitro* study showed that *T. prunioides* leaves provide forage of valuable quality for goats, due to the low content of acid and neutral fibers (Sebata *et al.*, 2011). Other fodder plants of local importance are *Blepharis* sp. (leaves, 20 citations), *Colophospermum mopane* (leaves, 17 citations), *Acacia senegal* var. *rostrata* (fruits, leaves and twigs, 11 citations), *Dichrostachys cinerea* (fruits and leaves, 10 citations), *Barleria spinulosa* (leaves, 9 citations) and *Pseudognaphalium luteoalbum* (leaves, 9 citations). Many *Blepharis* species are reported to be economically important fodder plants in tropical and South Africa, despite their spiny habit (Vollesen, 2000). *Colophospermum mopane* is the most abundant species in *Mopane* woodlands and can provide high quality forage for browsers and intermediate feeders (Legendijk *et al.*, 2005; Kos *et al.*, 2012). Most of the interviewed informants reported that livestock prefer to feed on *C. mopane* leaves during the dry season. This finding confirms what other studies have shown about the relationship between browsers and *C. mopane*: leaves are mainly consumed in the dry period, when their content of chemical deterrents such as tannins and phenols is at lower concentrations (see Makhado *et al.*, 2016 and also references there reported).

Leaves and pods of *Acacia senegal* (L.) Willd. var. *rostrata* Brennan and *Dichrostachys cinerea* (L.) W & Arm. are reported to play an important role in agropastoral systems as protein supplements to low quality diets (Sanon *et al.*, 2008; Yayneshet *et al.*, 2008). As pointed out in some studies conducted in different semi-arid areas, leaves and fruits of several *Grewia* species produce a valuable nutritious fodder (see for example Saleem *et al.*, 2012). Fruits, in particular, are a good source of vitamins and mineral elements. In the studied area, people use leaves of *Grewia cyclopetala* Wawra (3 citations), *G. flavescens* Juss. (3 citations), *G. monticola* Sond. (8 citations) and *G. villosa* Willd. (3 citations) as animal feed; fruits of the same species are consumed as part of human diet (Urso *et al.*, 2016).

As for pigs feeding, some informants cited the use of the fruit of three species of *Ficus* (Moraceae): *F. thonningii* Blume (9 citations), *F. sycomorus* L. (9 citations) and *F. tettensis* Hutch. (2 citations). To our knowledge, no report exists in literature on the nutritional value of *F. thonningii* and *F. tettensis* fruit. Only few studies report that fruit of *F. thonningii* is considered highly palatable to domestic animals in some African countries (Audru, 1980; Le Houerou and Cobra, 1980). *F. sycomorus* fruit is instead well known as a good source of protein, vitamin C and minerals in human nutrition (Acipa *et al.*, 2013).

It's worthy to point out that five plants used as fodder (*Blepharis* sp., *Craibia brevicaudata*, *Faidherbia albida*, *Ficus thonningii* and *Laphangium luteoalbum*) are also used for ethno-veterinary purposes, according to our informants (see above).

Only in two of these species, however, the same plant part (i.e. leaves) is employed for the same animals both as fodder and as an orally administered drug: *Faidherbia albida* and *Acacia senegal*. Further studies on these two plants could shed more light on their possible role as medicinal foods (i.e. food products consumed in order to maintain a status of health) in animal husbandry.

Conclusions

The results of ethnobotanic investigations carried out by our research group in some indigenous communities living in *Mopane* woodlands of southern Angola show that these communities have developed through their history a cultural heritage reflecting the complex inter-relationships between humans and local environment. This body of local traditional knowledge can be regarded as a result of the adaptive capacity of rural people over thousands of years; but in a local economy mainly based on agro-pastoralism at a family scale, it is also a crucial tool to face scarcity and variability of agricultural resources. In order to fight the impact of forest degradation on the availability of the most used ethno-veterinary and fodder species, farmers should be subsidized to protect these plants around the homestead or to introduce them in silvo-pastoral systems and/or in animal production farms.

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