Annales des sciences agronomiques 22(1) : 33-52, 2018 ISSN 1659 - 5009

USE DIVERSITY AND FARMER'S PREFERENCE OF 48 LOCAL MULTIPURPOSE FODDER TREES : A COMPARATIVE ANALYSIS OF THREE SOCIOLINGUISTIC GROUPS OF BENIN

C. SÈWADÉ, B. E. LOKONON**, A. F. AZIHOU*, G. S. AKOUÈHOU***, G. A. MENSAH****, R. L. GLÈLÈ KAKAÏ** & M. R. B. HOUINATO**

**Laboratoire d'Ecologie Appliquée (LEA), FSA-UAC - République du Bénin - e-mail : sewadec@yahoo.fr*

***Laboratoire de Biomathématiques et d'Estimations Forestières (LABEF), FSA-UAC - République du Bénin*

****Centre d'Etudes, de Recherches et de Formation Forestières (CERF), Direction Générale des Forêts et des Ressources Naturelles, République du Bénin*

*****Centre de Recherches Agricoles -CRA-Agonkanmey (INRAB), République du Bénin*

RÉSUMÉ

Les espèces végétales contribuent de manière significative aux besoins quotidiens des humains et des animaux, dans les pays en développement. Cette étude a été conduite dans la zone de transition Guineo-Congolaise/Soudanienne du Bénin auprès des populations riveraines des forêts classées des Monts Kouffé, de Wari-Maro et de l'Ouémé supérieur. Elle vise à (i) analyser l'impact de l'âge, du sexe et des groupes socio-culturels sur la perception de la valeur d'usage des espèces ligneuses fourragères ; (ii) identifier les préférences d'usage pastoral des ligneux suivant les groupes socio-culturels et (iii) identifier les ligneux surexploités ou sous-utilisés suivant les groupes socio-culturels. Un échantillon de 220 personnes appartenant à trois groupes socio-culturels majoritaires (Bariba, Nago et Peulh) a été interviewé au moyen d'une enquête semi-structurée. Les différentes catégories d'usages à l'échelle de la zone d'étude et sur le plan international ont été définies et utilisées pour calculer les taux d'usage. Les résultats montrent que les préférences des espèces fourragères varient suivant les groupes socio-culturels. Six catégories d'usage ont été notées : aliment, médicine traditionnelle, construction, combustible, vétérinaire et fourrage. *Afzelia Africana*, *Khaya senegalensis* et *Pterocarpus erinaceus* sont les espèces les plus utilisées dans l'alimentation des animaux chez les Peulhs et les Baribas alors qu'au niveau des Nagos, *Mangifera* indica vient en tête suivie de loin par *Ficus umbellata, Ficus platyphylla et Pterocarpus erinaceus*. Suivant les différentes catégories d'usage, les espèces surexploitées ou sous-utilisées varie selon les groupes socio-culturels. Mais globalement, *A. Africana, K. senegalensis*, *P. erinaceus* et *Mangifera indica* sont des espèces surexploitées alors que *Ficus sycomorus, Combretum micranthum, Combretum molle, Balanites aegyptiaca, Crossopteryx febrifuga, Sarcocephalus latifolius* sont sous-utilisées. Pour une exploitation rationnelle des ligneux fourragers, nous suggérons : (i) une évaluation de la disponibilité des espèces surexploitées et (ii) leur utilisation dans les plans d'aménagement des parcours naturels au cours des activités d'afforestation/reforestation et de reboisement.

Mots clés : Biodiversité, Ethnobotanique, groupe socio-culturel, ligneux fourragers, usages.

DIVERSITÉ DES USAGES ET PRÉFÉRENCE DES POPULATIONS POUR 48 LIGNEUX FOURRAGERS À USAGES MULTIPLES : ANALYSE COMPARATIVE DE TROIS GROUPES SOCIOLINGUISTIQUES DU BÉNIN

ABSTRACT

Native plant species in general and fodder trees in particular contribute significantly to the daily needs of both human and animal especially in developing countries. However, these important species are often neglected leading to the erosion of their diversity and usefulness. This study aimed to (i) quantify the impact of age, gender and ethnicity on the use and perceived value of local woody fodder species; (ii)

identify the most important and preferred woody fodder species across sociolinguistic groups and (iii) identify the overharvested and underutilized woody fodder species across sociolinguistic groups. A total of 220 informants belonging to three sociolinguistic groups (Bariba, Nago and Peulh) were interviewed through a semi-structured survey on the fodder trees that they use for different purposes. The most cultural important fodder species ranked by the local people were determined for each sociolinguistic group. The species were categorized into six use categories by the informants: food, medicine, construction, fuel, veterinary and fodder. *Afzelia africana, Khaya senegalensis* and *Pterocarpus erinaceus* are the most widely used species by Peulhs and Bariba to feed animals, while for the Nagos, *Mangifera indica* comes first followed by *Ficus umbellata, Ficus platyphylla* and *Pterocarpus erinaceus*. Combining the different use categories, overharvested or underutilized species depend on the sociolinguistic group. But globally, *A. africana*, *K. senegalensis, P. erinaceus* and *Mangifera indica* are overharvested species whereas *Ficus sycomorus, Combretum micranthum, Combretum molle, Balanites aegyptiaca, Crossopteryx febrifuga, Sarcocephalus latifolius,* are underutilized species. For a sustainable management of pasture lands, it is suggested (i) an assessment of the availability of the overexploited species in the study area; (ii) their use in restoration, afforestation/reforestation and plantation activities.

Keywords : Biodiversity, Fodder trees, Local knowledge, Sociolinguistic group, Use.

INTRODUCTION

Local vegetation provides livestock fodder and people food, fuel and medicine, as well as materials for construction and the manufacturing of crafts and many other products (Ayantunde *et al.*, 2008). Much of the fodder species contribute to the high socioeconomic values (Gina *et al.* 2014) leading to their over exploitation (Belem *et al.*, 2008). Local fodder trees and shrubs are both affordable to local communities (Salem *et al.*, 2006), adaptable to local environmental conditions, and are resistant to diseases and parasites (Rosales & Gill 1997). They require little or no management input (Roothaert & Franzel, 2001), and are resistant to diseases and parasites (Rosales & Gill, 1997). Moreover, most of these species remain green at critical times of the year, providing thus a good source of dry season fodder for ruminants in arid and semiarid areas where annual grasses and other herbaceous plants do not produce year round (Balehegn *et al.*, 2012). Despite their obvious and intriguing potential, there are however, used for many purposes compared to 'improved' and exotic forage plants (Balehegn *et al.* 2012). According to Le Houérou (1980), of over 5 000 trees and shrubs listed as being suitable for feeding livestock in Africa, only 80 were used. This indicates clearly that there is a lack of relevant information on the values of many of these local trees and shrubs.

In Benin, Sèwadé *et al.* (2016) inventoried 48 indigenous fodder trees species used by the local people. However, the traditional value and the multipurpose benefits of these species were not assessed. Understanding local knowledge of indigenous fodder species can guide the identification of research priorities for better, sustainable management of natural resources (Ayantunde *et al.*, 2008). Earlier studies carried out on local knowledge and use of different multipurpose species such as *Milicia excelsa* (Ouinsavi *et al.*, 2005), *Tamarindus indica* (Fandohan *et al.*, 2010) and *Dialium guineense* (Lokonon *et al.*, 2013) showed significant differences in use values and uses patterns among sociocultural groups and gender. However, in the Guineo-Congolese transition/Sudanian zone of Benin, only a few of these studies focused on the

communities (Sèwadé *et al.*, 2016), and most did not explicitly address the variability of local knowledge of sociolinguistic groups regarding indigenous fodder species. Exploring this aspect could greatly advance the understanding of the local people preferences. Moreover, it is useful to involve the needs of all of the local communities in designing management plans and focus attention on the most important species (Vodouhè *et al.*, 2009).

Following insights from previous research showing that the valuation of plant resources depends on factors such as ethnicity, gender and age, we assume that the use patterns of local fodder species as multipurpose trees may differ between age, gender and the sociolinguistic groups. Based on preliminary results and knowledge of cultural differences among sociolinguistic groups in the study area, we also hypothesized that value given to each species varies among different sociolinguistic groups (Lawrence *et al.*, 2005). Moreover, knowing that only 1.6 % of local fodder species in Africa are currently used (Le Houérou, 1980), we consider that these species are underused in the study area. In fact, neglected and underutilized species are those to which little attention is paid or which are entirely ignored by agricultural researchers, plant breeders and policymakers (Padulosi *et al.*, 2013). The objectives of this paper are: (1) to quantify the impact of age, gender and ethnicity on the use and perceived value of local fodder trees species; (2) to identify the most important and preferred fodder tree species across sociolinguistic groups and (3) to identify the overharvested (overutilized) and underutilized fodder tree species across sociolinguistic groups.

METHODS

Study area

The study area (Monts Kouffé, Wari Maro and Ouémé Supérieur forest reserves) is located between latitudes 8° 28' and 9° 47' North and between longitudes 1° 55' and 2° 30' East (Figure 1). It is included in the Guineo-Congolese/Sudanian transition zone according to White (1983).

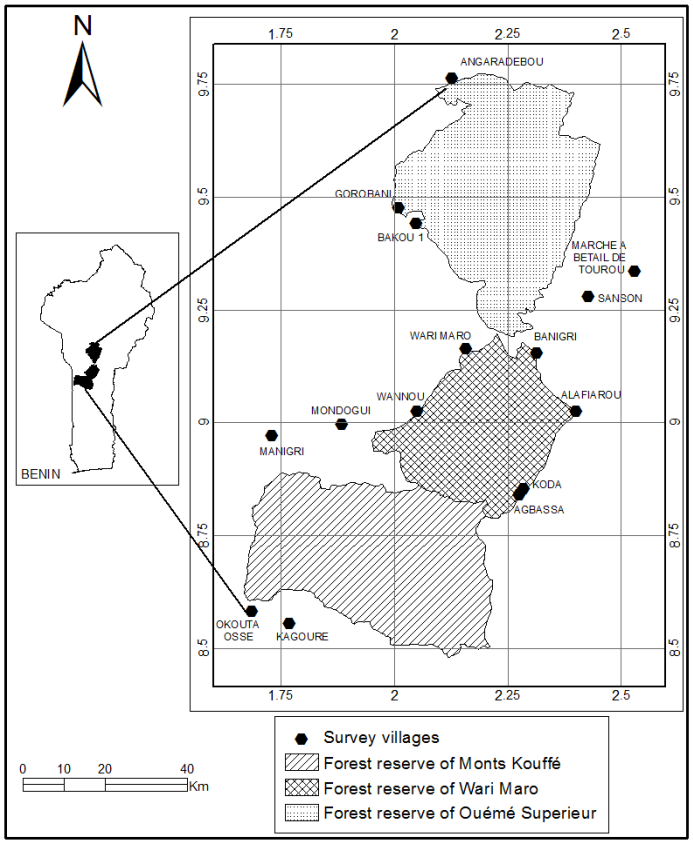

Figure 1. Location of the study area

It is characterized by one rainy season from May to October with 1152 mm per year on the average and one dry season of six months (November to April) (data from 1975 to 2015; ASECNA Parakou). The annual mean temperatures vary between 26 to 27° C with extremes ranging from 21° C (December-January) to 40° C (February-April). The relative humidity is low (10 to 40 %) in December and January but high (85 to 98 %) from July to August. The natural vegetation is constituted of gallery forests, woodlands, wood and shrub savannas generally established on tropical lateritic soils and ferruginous soils (Houinato, 2001). The main livelihoods of local people are livestock breeding and traditional subsistence agriculture. During the dry season, the study area receives transhumant herds of North Benin, Nigeria, Niger and Burkina Faso. These transhumant herds exploit with sedentary herds, the ligneous forage resources in the region (Teka *et al.* 2007). After vegetation fires, the grassy forage is no more available and pastoralists defoliate wood fodder species like *K. senegalensis*, *D. oliveri*, *P. erinaceus* and *A. africana* to feed cattle (Teka *et al.* 2007; Sèwadé *et al.* 2016). Peulhs are principally cattle-breeders (sheep, goat, cow) with a large number of animals to feed whereas the Nago and Bariba sociolinguistic groups are principally farmers and have et few number of sheeps and goats and rarely cows.

Majority of Peulhs are traditionally nomadic people moving from rangelands to rangelands looking for fodder and water resources. Nagos and Baribas are sedentary people and their women collect fodder from trees for animals at home as a complementary diet. For Peulhs' community, women generally stay at home and manage the collected milk from cow to produce cheese for sale. Only their men bring animal to pasture.

Sociolinguistic groups and cultural settings

The population in the study area, which is estimated to be 1,047,204 inhabitants (INSAE, 2016), is composed of three main sociolinguistic groups which are Peulh, Nago and Bariba. The Peulhs are historically nomadic livestock breeders and pastoralists (goats, sheep, cows and donkeys). Over time, they have become increasingly involved in subsistence agriculture (cereals), moving into a seminomadic or even a sedentary way of life. Some nomadic Peulhs from Burkina Faso, Niger and Nigeria also come seasonally to exploit the fodder trees in the study area during the dry season. Nago and Bariba are sedentary sociolinguistic groups mainly farmers who practice the breeding of small ruminants and poultry as secondary activity with low livestock. Thus, their impact in the exploitation of fodder from trees can be insignificant. The people from the three sociolinguistic groups exploit fodder trees as multipurpose species.

Sampling and data collection

We conducted semi-structured interviews with the household heads using a questionnaire. The number n of the surveyed individuals was estimated using the normal approximation of the binomial distribution (Dagnelie, 1998) :

$$n = U^2_{1-\alpha/2} [P(1-P)/d^2] \quad (1)$$

where :

- n is the total number of surveyed people within a locality ;

- $U_{1-\alpha/2} = 1.96$ for $\alpha = 0.05$;

- P ≈ 83.33 % is the estimated proportion of informants that use the indigenous fodder species.

- d is the expected error margin of any parameter to be estimated from the survey and is considered as 5 %.

By computing with the formula, the number n was 214.45, which is rounded to 220.

In each household, we established contact with each participant and introduced the objective of the study. Respondents to the questionnaires were all over 25 years old. The reason is that young people lack experience and this probably limits their knowledge of the natural resources (Sop *et al.*, 2012). Before executing the intensive household survey, the questionnaire was pre-

tested and was improved. The interview was conducted entirely in the informants' local languages with translation when necessary. The informants were invited to list the species that they used as fodder and for other purposes. Participants listed all the useful plants with which they were acquainted as well as the specific use of each. In addition, we asked participants to list the 10 most significant species that they harvested from the reserve. Then we invite them to rank the 10 species from the most to the less used for fodder purpose. During the interviews, participants were asked to list the species using their local names. The species were later identified taxonomically using the Analytic Flora of Benin (Akoègninou *et al.*, 2006). Moreover, the PROTA4U (http://www.prota4u.org/) has been consulted to obtain information related to the list of uses of each species at international level.

Data analysis

Differences in use category based on gender, age and ethnicity

The species were categorized by the informants into six use categories namely food, human medicine, fodder, construction, fuel and veterinary. This number of the field use categories of fodder trees is lower than the eight defined at an international level (see PROTA4U (http://www.prota4u.org/). The number of species mentioned by each informant in each of the use categories, as well as the total number of species was computed. In order to assess differences in the use categories and local knowledge of species based on two age categories (below and above 50 years old belonging to the young and the elders according to the informants of the focus groups organized in the study area), gender (male and female) and sociolinguistic groups (Bariba, Nago, Peulh), the mean number of species in each use categories reported per informant was compared. Differences based on age and gender were assessed using the Mann-Whitney non-parametric test for the data which were not normally distributed. Differences between sociolinguistic groups were analyzed through a one-way analysis of variance (ANOVA) followed by a Student-Newman-Keuls test for mean classification. Moreover, to determine the relationship among the sociolinguistic groups, the most important species and the use categories, a Canonical Correspondence Analysis (CCA) was carried out. All these analyses were performed using R software version 3.3.2 (R Core Team, 2016).

Cultural importance and preference of fodder species per sociolinguistic group

The ranks given for species by each informant were considered as scores (from 10 to 1, i.e from the most to the less important species). This method was based on the assumption supporting that when people are asked to freely recall things, they tend to list the most significant one first (Martin, 1995). In addition, prominent categories are cited by almost everybody, while less significant ones are mentioned by a minority of informants. Therefore, to

identify the most culturally important species ranked by participant in each sociolinguistic group, we computed the average order in which each species was mentioned by adding together the order in which each participant mentioned the species and dividing it by the total number of participants (Martin, 1995). This method has been successfully used by several authors (Lawrence *et al.*, 2005; Vodouhè *et al.*, 2009). Regarding the fodder use in relation to the sociolinguistic groups, a Canonical Correspondence Analysis (CCA) was performed on the cross-tabulation of data related to sociolinguistic groups and the most cited fodder tree species. This lead to the identification of the species preferred by each sociolinguistic group for animal feeding.

Identification of the overharvested and underutilized

For each species, the proportion P (%) of use is computed by dividing the number of use categories mentioned by the informant per the number of use categories recognized for each species at an international level. The use categories at an international level is obtained from literature principally from the WEBSITE (http://www.prota4u.org/) database. In order to have the same bases of comparisons, the focus groups were organized in the study region to identify the real use categories as follows:

- Food: fruits, spices, condiment, vegetable oils, vegetable, alimentation, drinking, seeds, and roots consumed by humans;
- Construction: Trees used in construction of houses, fences, doors, and other constructions wood building, general carpenter;
- human medicine: trees used for treating human pains and illnesses (human medicine, medico-magic, anti-poison, stimulant);
- veterinary: trees used to treat animal diseases (animal medicine, veterinary purpose);
- fodder: trees used as forage for feeding domestic animals;
- ornamental: Handicraft uses, trees plantation for ornaments;
- industry: wide category of usages including trees used to elaborate tools (such as wood handles for machetes, shoes, hammers, shotgun, pickaxes), for cosmetic, textile industry, fertilizer, dyes, tannins, exudates, fibers, insecticide, coloring, indelible ink, Gum or Source of gum;
- Fuel: trees used as fuel wood, charcoal, firewood, fuelwood, for direct use or commercialization.

Ornamental and Industry use categories are not common in the study area according to the focus groups informants. It's the raison why they are not integrated in the data collection. All these use categories were adapted from those defined by Lucena e*t al.* (2008) and recently used by Trindade *et al.* (2014). We also take into account the use categories obtained in the study

area and those collected at an international level for the studied fodder trees from WEBSITE (http://www.prota4u.org/).

The citation rate (frequency of citation) is calculated by dividing the number of respondents citing the species by the total number of respondents. The use rate (proportion of use categories) is obtained for each species by dividing the number of use categories cited by the informants for each species by the total number of use categories at an international level. The mean use rate is calculated per species for all the informants and then for each ethnic group. A graph is drawn in the R 3.3.2 environment by positioning the species following their citation rate (x-axis) and mean use rate (y-axis). This allowed us to distinguish 4 categories of species on the graph: (1) underutilized species: lower left corner; (2) widely used species: upper right; (3) species widely used by few breeders: lower right angle and (4) species with few use categories but exploited by many breeders: upper left.

For Jaenicke & Höschle-Zeledon (2006), the underutilized species are the species with under-exploited potential for contributing to food security, health (nutritional/medicinal), income generation, and environmental services. They are also called 'neglected', 'orphan', 'minor' species. In this paper, this concept designs the species that both have low citation rate and low mean use rate. Contrary to that, overharvested species designates the species that have both high citation rate and high mean use rate. They are so cited for many use categories by a large number of informants. The mean use rate gives more precision in the real use pressure of each species because it integrates the use categories number cited by each informant contrary to versatility index described by Ahoyo *et al.* (2017). Versatility concerns the variation of species used through use categories (Ahoyo *et al.*, 2017). Mulugeta & Admassu (2014) evaluated in North West of Ethiopia the mean importance value of species in order to take account this potential variability in the ecological importance value of tree species (SIVI).

RESULTS

Use categories and use patterns of the fodder species following age, gender and ethnicity

A total of 6 use categories was obtained in the study area: food, construction, medicinal, veterinary, fodder, fuel. Considering data from all sociolinguistic groups, 100 % of the total number of species were used for fodder, 61.22 % for food, 51.02 % for human medicine, 28.57 % for construction and 18.37 % for fuel (Figure 2). Less than 15 % of the fodder tree species are used for veterinary purposes. The Peulhs sociolinguistic group listed a higher proportion of species used for fodder, medicine and construction than the Nago and the Bariba sociolinguistic groups. Baribas and Nagos listed the same proportion of species used for fodder. The Nagos listed more species

used for food and veterinary while Baribas mentioned a greater number of species used as fuel.

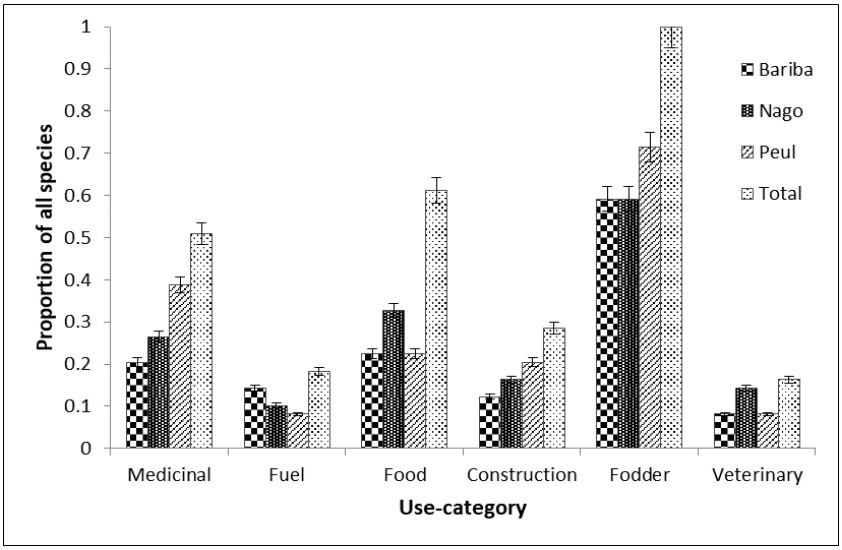

Figure 2. Distribution of fodder species in each use category for the three sociolinguistic groups

The Table 1 shows the mean number of fodder species reported by the informants for different use categories following age, gender and sociolinguistic groups. The total number of the multipurpose fodder species significantly differs following age (older people cited more species than young), gender (Female more species than male) and sociolinguistic groups (Peulh and Nago more species than Bariba). The number of species listed by respondents of the different age groups showed significant difference in the fodder use category (Table 1).

Table 1. Mean number of fodder species (±SD) reported by the informants for different categories of use following age, gender and sociolinguistic groups

	veterinary	medicinal	fuel	construction	fodder	food	Total species
age							
≤50	1.82±0.87	2.22±1.40	2.7±1.57	2.71±1.01	5.08±1.99	2.34±1.65	9.65±6.16
>50	1.97±1.45	3.11±3.34	3.13±3.00	3.79±2.64	7.15±4.31	1.83±1.04	24.62±10.92
P-value	0.6615	0.365	0.891	0.098	0.004	0.06	<0.001
Gender							
Female	1.81±1.17	2.48±1.85	3.63±3.07	3.06±2.24	7.02±3.78	3.45±2.63	17±7.50
Male	1.88±1.04	2.53±1.73	2.88±3.40	3.13±1.14	5.67±3.46	2.07±1.58	12.62±12.26
P-value	0.574	0.709	0.415	0.15	0.007	0.001	<0.001
Ethnicity							
Bariba	1.6±0.71a	1.92±1.52a	4.25±1.75a	2.63±1.05a	5.16±2.50a	1.74±1.12a	11.13±6.25a
Nago	1.47±0.76a	1.83±0.94a	2.00±0.63b	2.27±1.10a	5.70±2.21a	2.78±1.90b	12.00±4.84ab

Peulh	2.14±1.06b	3.00±1.98b	1.50±1.00b	3.58±1.56b	5.65±3.24a	1.74±0.86a	13.95±7.15b
P-value	0.003	0.000	0.005	0.000	0.485	0.001	0.028

The number of species listed by respondents of the different genders revealed significant differences in the following categories: food and fodder (Table 1). The number of species listed by respondents of the different sociolinguistic groups showed significant differences in all categories of use except fodder. Generally, the Peulhs listed a greater total number of species in veterinary, medicine and construction use categories. The Nagos listed more number of species in the food categories while the Bariba reported a greater total number of species in the fuel use categories. In order to assess the most important species for the local people in each use category, the CCA showed that the Bariba prefer *Annona senegalensis* for their fuel requirement. The Nagos prefer *Balanites aegyptiaca*, *Ficus platyphylla*, *Ficus umbellata* and *Vitellaria paradoxa* for the food while the Peulhs use *Khaya senegalensis* and *Afzelia africana* for medicinal, veterinary, fodder and construction purposes (Figure 3).

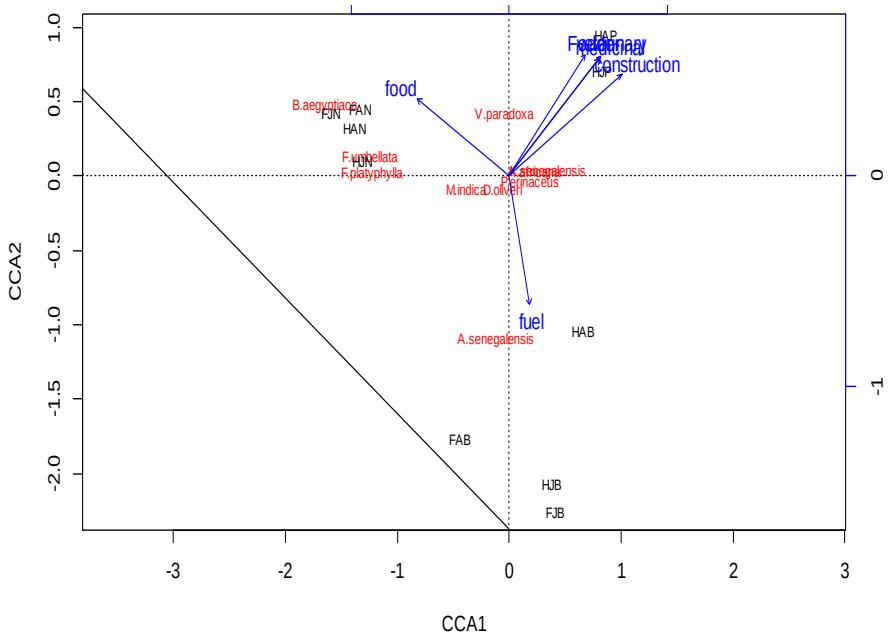

Figure 3. Canonical Correspondence Analysis diagram representing the first two axes that explained 86 % (axis 1: 74.6 % and axis 2 : 11.4 %) of all variance explained by the CCA

Legend: HAB : adult man Bariba ; FAB: adult woman Bariba ; JHB : young man Bariba ; JFB : young woman Bariba ; HAN : adult man Nago ; FAN : adult woman Nago ; JHN : young man Nago ; JFN : young woman Nago ; HAP: adult man Peulh ; JHP : young man Peulh

Most culturally important fodder use per ethnic group

The finding showed that the most culturally important species for fodder use are different among sociolinguistic groups (Figure 4). *Pterocarpus erinaceus*

is valued as the most important fodder species by the Baribas. *Mangifera indica* has the highest cultural importance for the Nagos while *Afzelia africana*, *Kaya senegalensis* and *Pterocarpus erinaceus* are the most significant for the Peulh.

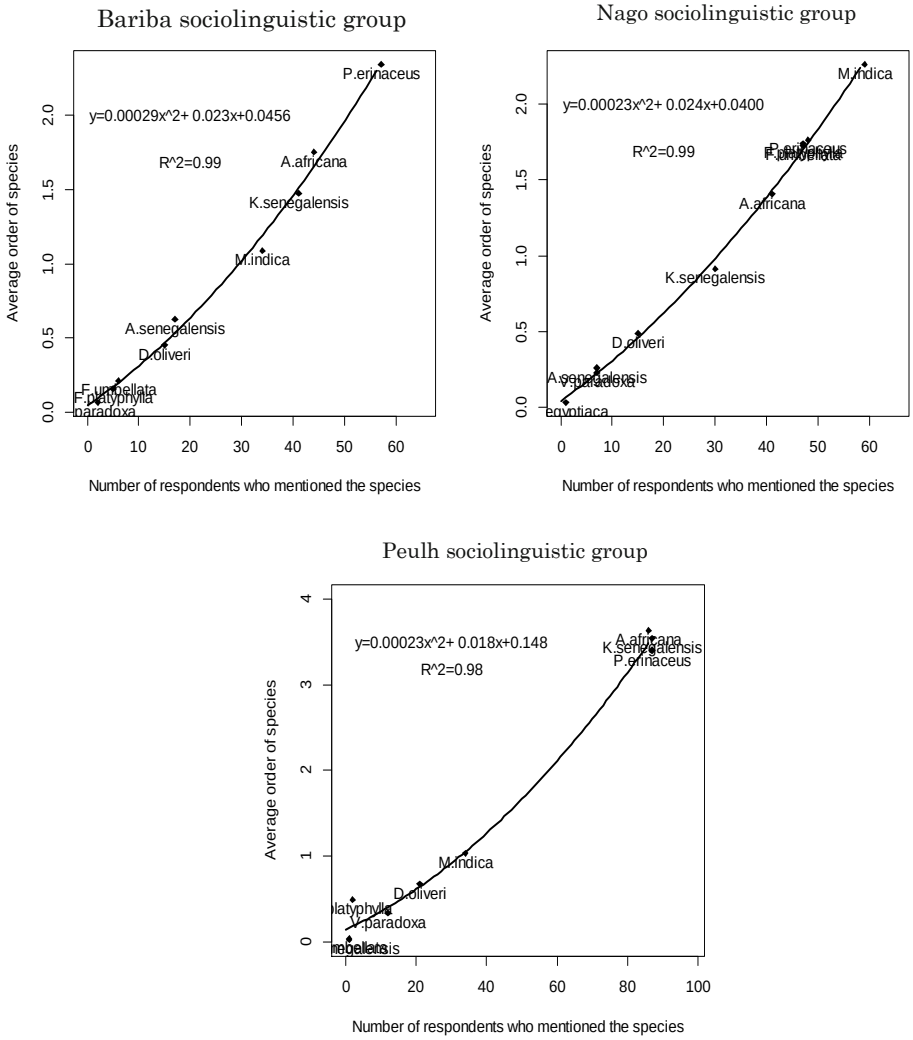

Figure 4. Most culturally important fodder species to Bariba, Nago and Peulh sociolinguistic groups

Classification of the fodder trees following their proportion of use categories

The Table 2 presents the specific uses categories of the species in the study area and at an international level with the related proportions. All these species are considered as multipurpose species at an international level because they have at least three specific use categories. In the study area, 68.75 % of the inventoried species are considered as multipurpose species

because having at least two specific use categories. The other species (31.25 %) are only used as fodder in the study area.

Considering all sociolinguistic groups, three categories of species can be distinguished (figure 4). The first one concerns the species cited by a large number of respondents (70-90 %), who used them for different purposes (use rates ranged from 30 to 50 %). These include *K. senegalensis*, *A. africana* and *P. erinaceus*. The second category concerns the species cited by less than 30 % of the respondents but with high use rates (40 to 55 %). The third category includes the species (*C. micranthum*, *D. cinerea*, *P. thonningii*) used by a small number of informants and this with a few use rates (less than 20 %). Between 60 and 80 % of the informants from Bariba sociolinguistic groups cited *K. senegalensis*, *A. africana* and *M. indica* and exploit them at 30 to 50 % of their potential use rate (figure 4). Species like *C. micranthum*, *C. pentandra*, *F. thonningii* are cited by few people with low use rates. For 40-80 % of the Nago sociolinguistic groups, *F. umbellata*, *M. indica*, *F. platyphylla*, *P. erinaceus* and *K. senegalensis* are the most used species (mean use rate from 30 to 55 %). On the other hand, *E. camaldulensis* has a high value of mean use rate but is cited by less than 10 % of the Nago sociolinguistic groups. Other species such as *D. oliveri*, *F. sycomorus*, *C. micranthum*, *Ficus sur* are cited by few Nagos (less than 20 %) who use them very little (mean use rate under 20 %). *I. doka, A. indica, B. sapida* and *A. occidentale* are exploited in several uses categories but cited by few Peulhs. Other species such as *A. senegalensis*, *S. kunthianum*, *C. micranthum*, *F. virosa* had a mean use rate less than 20 % (Figure 5).

Table 2. Specific use categories of the fodder species in the study area and at an international level and proportion of use categories

Species	Use categories in the study area	Uses categories at an international level	Global use proportion (%)
Ficus umbellata Vahl	Vet, HM, C, F, food	Ind, food, fuel, HM, O	100
Isoberlinia doka Craib & Stapf	HM, C, F, food	C, fuel, HM, F	100
Mangifera indica L.	Vet, HM, fuel, C, F, food	C, fuel, O, HM, V, food	100
Afzelia africana Pers.	Vet, medicinal, fuel, C, F, food	Ind, HM, C, F, O, fuel, V	85.71
Khaya senegalensis (Desr.) A.Juss.	Vet, HM, fuel, C, F, food	C, fuel, O, HM, V, F	85.71
Pterocarpus erinaceus Poir.	Vet, medicinal, fuel, C, F, food	Ind, C, fuel, F, HM, food, Os	85.71
Anacardium occidentale L.	Medicinal, fuel, F, food C	Food, C, fuel, Ind, F, C	85.33
Daniellia oliveri (Rolfe) Hutch. & Dalziel	Vet, HM, fuel, C, F	Fuel, HM, F, C, Ind, food	83.33
Ficus platyphylla Delile	HM, fuel, C, F, food	Ind, Fs, food, fuel, medicinal, C	83.33
Vitex doniana Sweet	F, food, HM	F, C, food, fuel, HM, Ind	66.66
Gmelina arborea Roxb.	HM, C, F	C, fuel, HM, F, Ind	60
Moringa oleifera Lam.	HM, C, F, food	Ind, Fs, food, fuel, HM, O, C	57.71
Azadirachta indica A.Juss.	Medicinal, C, F, food	Ind, F, fuel, HM, O, C, food	57.14
Flueggea virosa (Roxb. Ex Willd.) Voigt	HM, fuel, C, F	Ind, F, food, C, fuel, HM	57.14
Vitellaria paradoxa C.F.Gaertn.	Vet, HM, F, food	F, C, food, fuel, HM, Ind, fuel	57.14
Ceiba pentandra (L.) Gaertn.	C, F, food	Ind, fuel, HM, C, F, food	50
Eucalyptus camaldulensis Dehnh.	HM, F	Fuel, O, F, HM	50
Annona senegalensis Pers.	Medicinal, F, food	Ind, F, fuel, HM, Os, C, food	42.85
Ficus thonningii Blume	HM, F, food	Ind, F, food, fuel, HM, O, C	42.85
Parkia biglobosa (Jacq.) R. Br. ex G.Don	HM, F, food	Ind, O, F, food, fuel, C, HM	42.85
Stereospermum kunthianum Cham.	HM, fuel, F	C, fuel, medicine, food, F, Ind, O	42.85
Acacia auriculiformis Benth.	F, fuel	HM, O, F, C, fuel	40
Acacia sieberiana DC.	Médicinal, F	C, fuel, HM, Ind, F	40
Blighia sapida K.D.Koenig	F, food	C, fuel, O, HM, food	40
Burkea africana Hook.	Medicinal, F	C, fuel, HM, O, F	40
Strychnos spinosa Lam.	HM, F	F, food, fuel, HM, C	40
Anogeissus leiocarpa (DC.) Guill. & Perr.	F, C	Fuel, C, HM, Ind, F, O	33.33
Pericopsis laxiflora (Benth.) Meeuwen	F	Food, HM, F	33.33
Prosopis africana (Guill. & Perr.) Taub.	HM, F	Ind, HM, O, Food, C, F	33.33
Ficus sycomorus L.	F, food	Ind, Fs, food, fuel, HM, O, C	28.57
Ficus sur Forssk.	F, food	Ind, fuel, O, HM, Food, F, C	28.57
Piliostigma thonningii (Schumach.) Milne-Redh.	HM, F	Ind, F, food, C, fuel, HM, V	28.57
Psidium guajava L.	F, food	Ind, food, fuel, HM, C, O, F	28.57
Spondias mombin L.	F, food	Ind, food, HM, V, C, F, O	28.57
Combretum micranthum R. Br. ex G. Don	F	C, fuel, HM, F	25
Combretum molle R. Br. ex G. Don	F	F, C, fuel, Ind	25
Ficus polita Vahl	F	Ind, food, HM, O	25
Acacia ataxacantha DC.	F	HM, O, F, C, fuel	20
Bombax costatum Pellegr. & Vuill.	F	Fuel, F, food, HM, V	20
Crossopteryx febrifuga (Afzel. Ex G.Don) Benth.	F	Ind, fuel, HM, C, F	20
Ficus lutea Vahl	F	Ind, food, HM, O, C	20
Ficus trichopoda Baker	F	Ind, food, HM, F, C	20

Species	Use categories in the study area	Uses categories at an international level	Global use proportion (%)
Gardenia erubescens Stapf & Hutch.	F	Ind, F, food, HM, C	20
Gardenia ternifolia Schumach. & Thonn.	F	Ind, F, food, fuel, HM	20
Terminalia avicennioides Guill. & Perr.	F	Ind, F, fuel, HM, C	20
Balanites aegyptiaca (L.) Delile	F	Ind, F, fuel, HM, food, C	16.16
Dichrostachys cinerea (L.) Wight & Arn.	F	Ind, F, fuel, HM, O, C	16.66
Sarcocephalus latifolius (Sm.) E. A. Bruce	F	Ind, F, food, fuel, HM, C	16.66

Legends: V: Veterinary; F: Fodder; HM: Human medicine; C: construction; Ind: Industry; O: Ornamental

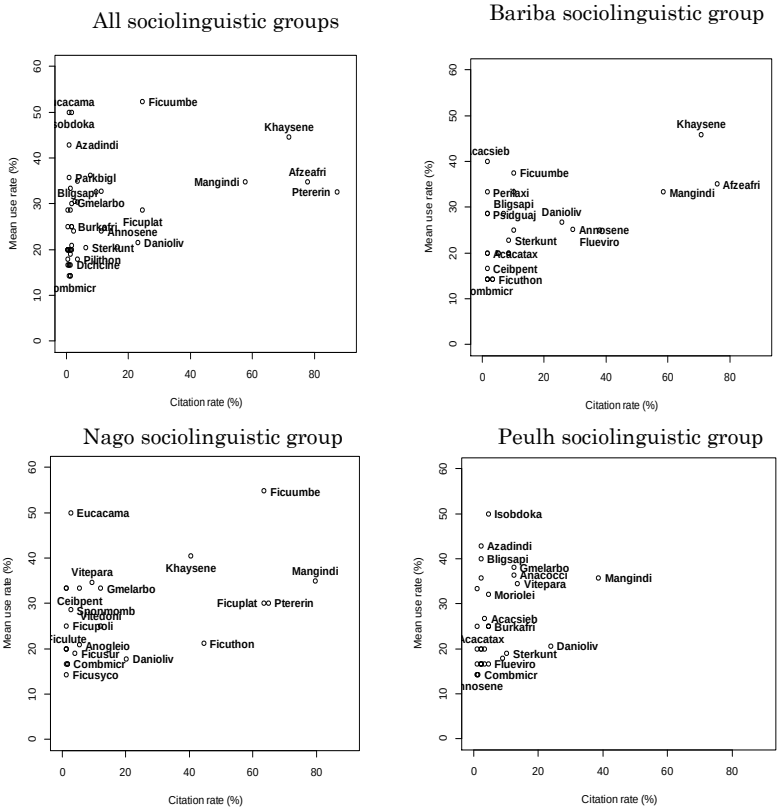

Figure 5. Distribution of species according to their citation rate and mean use rate following the all informants' perception and the sociolinguistic groups.

Legend: The species codes are the first four letters of the genus associated with the first four letters of the species. For example, *Afzelia africana* is represented by Afzeafri

DISCUSSION

Impact of age, gender and ethnicity on the use and knowledge of the fodder trees

In general, this ethnobotanical survey showed that the use and knowledge of the plants vary according to age, sex and ethnic group. Older people cited more species than the younger, especially for fodder use. Many studies in West Africa reported that age affects traditional knowledge and determines the choice of useful plant species (Camou-Guerrero *et al.*, 2008; Sop *et al.* 2012). Ayantunde *et al.* (2008) remarked a significant effect of age on botanical knowledge confirming the hypothesis that indigenous knowledge is positively correlated with age. They also noted that a lower age group (10 to 30 years) identified lower number of species compared to other age categories. This can be explained by the experiences gained by the time in the fodder tree usage. However, our finding did not reveal a difference in number of species used for medicinal, veterinary, fuel, food and construction according to age which is similar to previous findings of Houehanou *et al.* (2011). These studies reported that age was not an important determinant of plant knowledge.

There was no significant difference in knowledge of plants between genders for veterinary, fuel, medicinal and construction uses. This can be explained by the fact that men and women use together some fodder trees for these purposes. However, the study showed that the women have more knowledge about fodder and food uses of the trees than the men which lead to the traditional conception that the women are the persons who prepare food for the families. So as they have a habit to use some fodder trees as food, their knowledge about them are strong than the men's. Lucena *et al.* (2007) reported that women tend to know more non-woody species, especially fruit trees and medicinal plants, whereas men cited more species used for energy generation and construction. This gender variation of knowledge may be explained by the gender division of labor in traditional societies (Camou-Guerrero *et al.*, 2008). Indeed, women are in charge of household nutrition and therefore, have the responsibility of cooking food which makes it necessary for them to have more knowledge (Houehanou *et al.,* 2011). The Peulhs are mainly breeders; so they need more fodder species for their animal feeding. They are regularly on the move, building temporary huts and without doubt using a high diversity of plants for numerous purposes (Sop *et al.*, 2012), such as veterinary and construction. Moreover, the Bariba and Nago socio-culturel groups being sedentary people, can be expected to prefer a more selective range of plant species including woody species with hard-wearing properties suitable for fuel and construction. This appears to confirm the occurrence of intracultural variations of plant species knowledge associated with gender, as reported by other authors (Camou-Guerrero *et al.*, 2008).

Most important and priority plants for fodder use

The finding showed that the most culturally important species for fodder use differ among sociolinguistic groups. The Peulhs listed three species *A. Africana*, *K. senegalensis* and *P. erinaceus* as most significant for fodder use while Baribas and Nagos listed respectively only one species, *P. erinaceus* and *M. indica*. In the Sahelian zone of Niger, Ayantunde *et al*. (2009) also noted that the Peulhs use more fodder species than Zarma ethnic group who are mainly farmers (Hamidou *et al*., 2015). The finding is consistent with that reported by Silue *et al*. (2014) who found that *A. africana*, *P. erinaceus* and *K. senegalensis* were classified as the most important fodder species in Côte d'Ivoire. Sèwadé *et al*. (2016) reported that the preference is accorded to *A. africana*, *P. erinaceus* and *K. senegalensis* because these species not only provided a good health to their cows but also increase the milk yield. Ayantunde *et al*. (2008) reported in Niger that generally, the Peulhs recognized more species than the Djerma, particularly at the younger age, between 10 and 30 years. As the peulhs usually exploit these species to feed their animals in the dry season by pruning all the leaf biomass, they cause a damage to the regeneration of these plants by reducing the seed production.

Assessing of the use situation of local multipurpose fodder tree species

The results from objective 3 of this study clearly notified that the potential of the local fodder species is not well exploited. In fact, 64.58 % of the fodder trees are used under 50 % of their use capacity as multipurpose trees. This outcome is consistent with the work of Le Houérou *et al*. (1980) who reported that only 1.6 % of local fodder species are currently used. These species, however, has the potential to contribute to improve incomes, food security and nutrition. Between the 9 species which are classified as very used species in this work, we have *A. africana*, *K. senegalensis*, *P. erinaceus*, *F. umbellate, A. occidentale* and *D. oliveri which* were listed between the ten priority species for conservation (Sèwadé *et al*, 2016). Other researchers identified also *K. senegalensis, A. africana* and *P. erinaceus* as a threatened species (Brisso *et al.,* 2007; Teka *et al*, 2007). All this justify that a key attention must be payed for the rational uses of these species. These species are recognized to be the most used species for pastoralism in some African countries such as Sénégal (Sarr *et al*., 2013), Cameroun (Onana *et al*., 2002) and Ivory Coast (Silue *et al*., 2014). Our results show that *A. africana, K. senegalensis, P. erinaceus* faced the high number of uses categories not only in the study area but also at an international level (Table 2). This justifies well their classification in the category of a very used species (overharvested species). Species of low rate of use may face a greater threat of disappearance. For example, a fodder tree species with low regeneration capacity and which are completely pruned in each dry season to feed the animals cannot produce seeds for regeneration. In other words, the resilience of each species to

different pressures of use and their degree of adoption in agroforestry systems determine their evolution in the environment. This illustrates that the local population can be associated to the definition of the rational use strategies. So they will adopt naturally and apply all recommendations related to the better valorization of the fodder multiple purpose trees of the study area.

Implications for sustainable management of rangelands

The studied fodder species are useful both for animals and humans (Silue *et al.* 2014; Ahoyo *et al.* 2017). They are used for different purposes (Sarr *et al.* 2013). But a highly used species is not necessarily the most threatened species. The degree of threat on fodder trees' species depends on the forms and frequencies of harvest, the harvested organs, the cutting intensity and the regeneration capacities of each species (Papanastasis *et al.* 1998). Species of low rate of use may face a greater threat of disappearance. For example, a fodder tree species with low regeneration capacity and which are completely pruned in each dry season to feed the animals cannot produce seeds for regeneration. In other words, the resilience of each species to different pressures of use and their degree of adoption in agroforestry systems determine their evolution in the environment. This situation revealed that the notion of the underutilized specie needs to be conceptualized when resources are being characterized. Following the same trend, Khanal *et al.* (2014) suggest that promoting local underutilized plant species is one alternative for conservation of agrobiodiversity and it will prove successful in improving the food sufficiency and economic wellbeing of the local population particularly the herders.

CONCLUSION

The present study showed that the local people of the study area preferred the inventoried species differently according to their ethnic group, age and gender. It also proved that the potential of some local species is weakly used whereas other are very used. *A. africana*, *K. senegalensis*, *P. erinaceus* and *M. indica* are the overharvested species. So they are the most threatened species as they are used by a large number of informants for several use categories. Contrary to them, *F. sycomorus, C. micranthum, C. molle, B. aegyptiaca, C. febrifuga, S. latifolius, D. cinerea, V. doniana, F. sur, and B. costatum* are weakly used. They can be considered as underutilized species. In order to make the domestication process more effective, local people cultural group, gender and age should be taken into account. This paper lends also to an extension of the formal literature on the knowledge of local three sociolinguistic groups and explores their interactions with fodder trees species used as multipurpose plants. The overused/overharvested species are locally very useful plant that needs attention for future research that can help to promote their sustainable utilization.

BIBLIOGRAPHY

AHOYO C. C., HOUÉHANOU D. T., YAOÏTCHA S. A., PRINZ K., ASSOGBADJO E. A., ADJAHOSSOU G. S. C., HELLWIG F. & HOUINATO M. R. B., 2017. A quantitative ethnobotanical approach toward biodiversity conservation of useful woody species in Wari-Maro forest reserve (Benin, West Africa). *Environ Dev Sustain*. DOI : 10.1007/s10668-017-9990-0.

AKOÈGNINOU A, VAN DER BURG W.J., & VAN DER MAESEN L. J. G., 2006. *Flore analytique du Bénin*. Backhuys Publishers, Netherlands, 1033 p.

AYANTUNDE A. A., BRIEJER M., HIERNAUX H., HENK M., UDO J., & TABO R., 2008. Botanical knowledge and its differentiation by age, gender and ethnicity in South-western Niger. *Hum Ecol*. 36 : 881-889.

AYANTUNDE A. A., HIERNAUX P., BRIEJER M., UDO H., & TABO R., 2009. Uses of local plant species by agropastoralists in South-western Niger. *Ethnobot. Res. Appl.* 7 : 53-66.

BALEHEGN M. ENIANG E. A. & HASSEN A., 2012. Estimation of browse biomass of *Ficus thonningii*, an indigenous multipurpose fodder tree in northern Ethiopia. *African Journal of Range & Forage Science, 29(1): 1–6.*

BELEM B., SMITH-OLSEN C., THEILADE I., BELLEFONTAINE R., GUINKO S., LYKKE A. M., DIALLO A. & BOUSSIN J. I., 2008. Identification des arbres hors forêt préférés des populations du Sanmatenga (Burkina Faso). *Bois et Forêts des Tropiques*. 298 : 53-64.

BRISSO N., HOUINATO M., ADANDÉDJAN C. & SINSIN B., 2007. Dry season woody fodder productivity in savannas. *Ghanaian J. Anim. Sci.*, 2-3(1) : 181-185.

CAMOU-GUERRERO A., REYES-GARCIA V., MARTINEZ-RAMOS M., & CASAS A., 2008. Knowledge and use value of plant species in a Rarámuri community: a gender perspective for conservation. *Human Ecology* 36 : 259-272.

DAGNELIE P., 1998. *Statistiques théoriques et appliquées*. Brussels : De Boeck et Larcier.

FANDOHAN B., ASSOGBADJO A. E., GLÈLÈ KAKAI R., KYNDT T., De CALUWÉ E. & CODJIA J. T. C., 2010. Women's traditional knowledge, use value, and the contribution of Tamarind to rural households' cash income in Benin. *Economic botany*, 64 (3) : 248 - 259.

GAOUE O. G. & TICKTIN T., 2008. Impacts of bark and foliage harvest on *Khaya senegalensis* (Meliaceae) reproductive performance in Benin. *Journal of Applied Ecology* 45 : 34-40.

GAOUE O. G., HORVITZ C., TICKTIN T., STEINER U. & TULJAPURKAR S., 2013. Defoliation and bark harvesting affect life history traits of a tropical tree. *Journal of Ecology*. 101: 1563-1571.

GINA T. G., NIGATU L. & ANIMUT G., 2014. Biodiversity of Indigenous Multipurpose Fodder Trees of Wolayta Zone, Southern Ethiopia: Ecological and Socio-Economic Importance. *International Journal of Emerging Technology and Advanced Engineering*, 4(5): 494-503.

HAMIDOU A., BOUBE M., MAHAMANE L., ALI M., MAHAMANE S. & BELLEFONTAINE R., 2015. Uses and preferences of woody species in two protected forests of Dan Kada Dodo and Dan Gado in Niger. *Journal of Horticulture and* Forestry, 7(6) : 149-159

HOUEHANOU, T. D., ASSOGBADJO, A. E., GLÈLÈ KAKAÏ, R., HOUINATO, M., & SINSIN, B., 2011. Valuation of local preferred uses and traditional ecological knowledge in relation to three multipurpose tree species in Benin (West Africa). *Forest Policy and Economics.* 13 : 554–562.

HOUINATO M., 2001. *Phytosociologie, écologie, productivité et capacité de charge des formations végétales pâturées dans la région des Monts-kouffé (Bénin).* Thèse de Doctorat. Fac. Sc. Lab. Bot. Syst. et Phyt. Uni.Lib. Bruxelles, Belgique : 219p.

INSAE., 2016. Effectifs de la population des villages et quartiers de ville du Bénin (RGPH-4, 2013). Cotonou, Bénin: INSAE. 85 p.

JAENICKE, H. & HÖSCHLE-ZELEDON, I. (eds) 2006. *Strategic Framework for Underutilized Plant Species Research and Development, with Special Reference to Asia and the Pacific, and to Sub-Saharan Africa*. International Centre for Underutilised Crops, Colombo, Sri Lanka and Global Facilitation Unit for Underutilized Species, Rome, Italy. 33 pp.

KHANAL R., TIMILSINA A., POKHREL C. P. & YADAV R. K P., 2014. Documenting abundance and use of underutilized plant species in the mid hill region of Nepal. *ECOPRINT* 21 : 63-71.

LAWRENCE, A., O. L. PHILIPS, A. R. ISMODES, M. LOPEZ, S. ROSE, D. WOOD, & A. J. FARFAN. 2005. Local Values for Harvested Forest Plants in Madre de Dios, Peru: Towards a More Contextualised Interpretation of Quantitative Ethnobotanical Data. *Biodiversity and Conservation.* (14) : 45-79.

Le HOUÉROU H. N., & CORRA M., 1980. Some browse plants of Ethiopia. In: Le Houérou HN (ed.), *Browse in Africa: the current state of knowledge*. Addis Ababa: International Livestock Centre for Africa. pp 109–114.

LOKONON E. B., BONOU W.N., KASSA B., AZIHOU A.F., ASSOGBADJO A. E. & GLÈLÈ KAKAÏ R., 2013. Structural and ethnobotanical characterization of velvet tamarind (*Dialium guineense* willd), a multipurpose tree species. *Agron. Afr.* 25(2) : 121-131.

LUCENA R. F.P., NASCIMENTO V. T., ARAÚJO E. L. & ALBUQUERQUE U. P., 2008. Local uses of native plants in Na area of Caatinga vegetation (Pernambuco, NE Brazil). *Ethnobotany Research and Applications* 6 : 3–13.

LUCENA R.F.P., ARAUJO E.L. & ALBUQUERQUE U.P., 2007. Does the local availability of woody Caatinga plants (Northeastern Brazil) explain their use value? *Eco. Bot.* 61(4) : 347-361.

MARTIN, G. J., 1995. Ethnobotany: A Methods Manual. Earthscan, London.

MULUGETA G. &ADMASSU M., 2014. Woody Species Diversity and Their Preferences on Farmers'Land Holding. *Journal of Natural Sciences Research*. 4(9) : 96-108.

ONANA J. & DEVINEAU J.-L., 2002. *Afzelia africana* Smith ex Persoon dans le Nord-Cameroun. État actuel des peuplements et utilisation pastorale. *Rev. Élev. Méd. Vét. Pays Trop.* 55(1) : 39-45.

OUINSAVI C., SOKPON N. & BADA O. 2005. Utilization and Strategies of *in situ* conservation of *Milicia excelsa* Welw, C. C. Berg, in Benin. *Forest Ecology andManagement*. 207: 341 - 350.

PADULOSI S., THOMPSON J., RUDEBJER P., 2013. *Fighting poverty, hunger and malnutrition with neglected and underutilized species (NUS): needs, challenges and the way forward.* Bioversity International, Rome. 60 p.

PAPANASTASIS V. P., PLATIS P. D. & DINI-PAPANASTASIB O., 1998. Effects of age and frequency of cutting on productivity of Mediterranean deciduous fodder tree and shrub plantations. *Forest Ecology and Management,* 110(1-3) : 283-292.

R CORE TEAM, 2016. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

ROOTHAERT R., & FRANZEL S., 2001. Farmers' preferences and use of local fodder trees and shrubs in Kenya. *Agroforestry Systems* 52 : 239–252.

ROSALES M., & GILL M., 1997. Tree mixtures within integrated farming systems. *Livestock Research for Rural Development* 9(4). Available at http://www.lrrd.org/lrrd9/4/mauro941.htm.

SALEM A. Z. M., SALEM M. Z. M., EL-ADAWY M. M., & ROBINSON P. H., 2006. Nutritive evaluations of some browse tree foliages during the dry season: secondary compounds, feed intake and *in vivo* digestibility in sheep and goats. *Animal Feed Science and Technology* 127 : 251–267.

SARR O., DIATTA S., GUEYE M., NDIAYE P. M., GUISSE A., & AKPO L. E., 2013. Importance des ligneux fourragers dans un système agropastoral au Sénégal (Afrique de l'Ouest). *Rev. Méd. Vét.*, 164(1) : 2-8.

SÈWADÉ C., AZIHOU A. F., FANDOHAN A. B., HOUÉHANOU D. T., & HOUINATO M., 2016. Diversité, priorité pastorale et de conservation des ligneux fourragers des terres de parcours en zone soudano-guinéenne du Bénin. *Biotechnologie Agronomie Société et Environnement.* 20 (2) : 113-129.

SILUE N., FOFANA J. I., SILUE S., DIARRASSOUBA N., KOUASSI A. F. & KOUAKOU K., 2014. Identification des espèces ligneuses utilisées dans l'alimentation des bovins dans la région du Poro (nord de la Côte d'Ivoire). *Agron. Afr.*, 26(3) : 217-229.

SOP T. K., OLDELAND J., BOGNOUNOU F., SCHMIEDEL U. &THIOMBIANO A., 2012. Ethnobotanical knowledge and valuation of woody plants species: a comparative analysis of three sociolinguistic groups from the sub-Sahel of Burkina Faso. *Environment development and sustainability*. 14 (5): 627-649.

TEKA O., VOGT J. & SINSIN B., 2007. Impacts de l'élevage sur les ligneux fourragers et contribution à la gestion intégrée de *Khaya senegalensis* et *Afzelia africana*, deux espèces menacées d'extinction dans la région des Monts-Kouffé au Bénin. *Bull. Rech.Agron. Bénin.* 55 : 25-35.

TRINDADE M. R. de O., JARDIM J. G., CASAS A., GUERRA N. M. & LUCENA, R.F.P., 2014. Availability and Use of Woody Plant Resources in Two Areas of Caatinga in Northeastern Brazil. *Ethnobotany Research & Applications*. 14: 313-330.

VODOUHÈ G. F., COULIBALY O., GREENE C. & SINSIN B., 2009. Estimating the local value of non-timber forest products to Pendjari Biosphere Reserve Dwellers in Benin. *Eco. Bot.* 63: 397-412.

WHITE F., 1983. *The vegetation map of Africa south of the Sahara*. 2nd ed. Paris: UNESCO.