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Valuation of local preferred uses and traditional ecological knowledge in relation to three multipurpose tree species in Benin (West Africa)

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ABSTRACT

Afzelia africana Sm., *Pterocarpus erinaceus* Poir. and *Khaya senegalensis* (Desv.) A. Juss are multipurpose trees widely used in Africa, but endangered in their natural environments. Therefore, there is an urgent need to define and promote conservation strategies for these key species. In this study we analyzed the current patterns of their use preferences by means of a cultural importance index. Local ecological knowledge on their conservation was investigated among local people living around Pendjari Biosphere Reserve in Benin. In total, 160 informants belonging to four ethnic groups (Gourmantche, Waama, Berba and Peulh) were interviewed in twelve villages. Male and female informants, aged between 20 and 90 years, were randomly selected in each ethnic group. For each species, a cultural importance index was calculated combining frequency and importance of use. This index allowed us to identify differences in use intensity within and among ethnic groups. Traditional ecological knowledge was tested as a dependent variable of ethnicity. *A. africana* was widely used as medicine, fodder and crafting by most communities, whereas *P. erinaceus* was the preferred source of fodder for all local people. *K. senegalensis* was mostly used as medicine and fuel wood by most communities, except by the Peulh who preferably used it as fodder. The use of these trees as source of fuel wood was mostly reported by women while religious uses of these species were reported by old men from the Gourmantche ethnicity. Medicinal and fodder use of *A. africana*, fodder use of *P. erinaceus* and medicinal use of *K. senegalensis* had the highest overall cultural importance index value. Knowledge related to local extinction of the target species and their sustainable use varied among socio-cultural groups. The findings of the present study should be considered in future management plans towards an effective conservation of these tree species.

1. Introduction

To date, many people depend on wild plants for their livelihoods in Africa (Lykke, 2000; Obiri et al., 2002; Lykke et al., 2004; Assogbadjo et al., 2008). In West Africa, wild or indigenous plant species are still widely used and many of them are endangered due to various human activities such as logging, cutting and land clearing. An increasing intensity of these activities in combination with drought induces a decreasing availability of grass and trees in savanna ecosystems in West Africa (Scoones, 1995).

The tree species *Afzelia africana* Sm. (Leguminosae–Caesalpiniodeae), *Pterocarpus erinaceus* Poir. (Leguminosae–Papilionoideae) and *Khaya senegalensis* (Desv.) A. Juss (Meliaceae) are well known for their multipurpose uses in the traditional livestock systems in West Africa (Bayer, 1990; Petit, 2000) and experience a continuously degradation in their natural habitat. These three species are used as medicine, fuel and fodder (Eyog-Matig et al., 2002; Gautier et al., 2005; Ouédraogo-Koné et al., 2006). These uses are expressing high pressure on their populations, which in turn are declining throughout West Africa (Adomou et al., 2009; Lykke, 1998; Hahn-Hadjali and Thiombiano, 2000). As a consequence, these species should have priority for biodiversity conservation. Therefore, there is an urgent need for developing appropriate management strategies. Several methods such as population genetics, structure and dynamics and ethnobotany are commonly combined to develop and/or define sustainable conservation strategies for plant species.

Ethnobotany has become a complementary tool for management and conservation strategies of vegetation resources in tropical regions (Albuquerque et al., 2009). Some ethnobotanical studies have highlighted the need to integrate the perspective of traditional knowledge into ecological research (Lykke, 2000; Albuquerque et al., 2009). Additionally, several authors reported increasing efforts to describe traditional ecological knowledge (Donovan and Puri, 2004; López-Hoffman et al., 2006; Gaoue and Ticktin, 2009). In fact, integrating local people's perception in management strategies is important to guarantee local acceptance of the management plans of natural resources. Therefore, the documentation of ecological knowledge and the perception local people have on the target species is an important issue to be addressed.

Moreover, the number of ethnobotanical studies using quantitative methods increased over the last decades and some introduced quantitative indices to analyze the relative cultural importance of plant species. For example, Phillips and Gentry (1993) developed a use-value index,

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defined as the proportion of uses of plant species within a sample of interviewed people and this is calculated directly from the number of informants mentioning a certain species during free-listing interviews (Lykke et al., 2004; Camou-Guerrero et al., 2008).Other indices were developed depending on the research objectives (Camou-Guerrero et al., 2008; Hoffman and Gallaher, 2007). For instance, use-value index helps to identify plant species with multipurpose uses which are locally considered of high importance in different use-categories, such as construction, food, medicine, firewood, crafts, rituals, coloring agent, and others (Phillips and Gentry, 1993; Vandebroek, 2010). Although the relative importance of each use among multiple uses of target tree species is seldom assessed, doing so would be helpful for better analyzing the impact of human pressure on plant populations and understanding the dynamics of tree species populations.

In addition, social factors such as ethnicity, age and gender affect traditional knowledge and determine the choice of useful plant species (Luoga et al., 2000; Camou-Guerrero et al., 2008; Müller-Schwarze, 2006; Chadare et al., 2008). Among these factors, age and gender have been documented to determine intracultural variation (Camou-Guerrero et al., 2008; Müller-Schwarze, 2006). Indeed, preferences for useful plant species and general interest for forest resources can differ among men and women and are due to the division of labor which is gender-associated in traditional societies (Camou-Guerrero et al., 2008; Müller-Schwarze, 2006; Vodouhê et al., 2009). Moreover, elderly men and women proved to have more traditional knowledge than younger ones (Luoga et al., 2000; Begossi et al., 2002; Case et al., 2005; Gemedo-Dalle et al., 2005; Müller-Schwarze, 2006). Thus, it is important to take these variations into consideration when conducting ethnobotanical surveys. Based on the findings from literature, we hypothesized that intercultural and intracultural differences will influence the use preference of target species. We also suppose that local people will not perceive the decline in target species in the same way. In addition, we assume that local people have ecological knowledge, which we suppose will be shared differently between ethnic groups. The present study addresses the following questions: (1) What are the most important uses of the target species according to ethnicity, gender and age? (2) What perception do local people have about the decline in the target species and does this perception differ between ethnic groups? (3) What traditional ecological knowledge do local people have about the conservation of the target species and does this knowledge differ between ethnic groups?

2. Methods

2.1. Study species

The studied species are *A. africana* (African mahogany bean), *P. erinaceus* (African rosewood) and *K. senegalensis* (Savannah mahogany). Table 1 shows the vernacular names of the species. These species are found in the dry and wet Sudanian regions of Africa (White, 1983) and are all endangered in their natural habitats (IUCN, 2008). *A. africana* spreads from Senegal to Cameroun, and is present in Uganda and Tanzania; it occurs in tree savannas, humid and dry forests and grows up to 30 m height (Arbonnier, 2000). *P. erinaceus* is widely distributed in savannas from Senegal to Cameroun and Central African Republic and grows up to 12 m height (Arbonnier, 2000). *K. senegalensis* is naturally widespread from Senegal to Uganda and Sudan; it is found in savanna, dry and gallery forests and grows up to 35 m height (Arbonnier, 2000).

Table 1
Local name of each species according to ethnic group.

Plant species	Gourmantche	Waama	Berba	Peulh
A. africana Smith ex Pers.	Bounankpabou	Kparkabou	Koureï	Wariyaï
P. erinaceus Poir.	Bounantombou	Soouga	Nouark	Banouhi
K. senegalensis(Desv.) A. Juss	Boukobou	Kourbou	Weibou	Kahi

2.2. Study area

This study was conducted in 12 villages surrounding the Pendjari Biosphere Reserve (10°30′–11°30′N and 0°50′–2°00′E) (Fig. 1). The population of the localities surrounding the Reserve is estimated at 30,000 inhabitants distributed in 20 villages, with an average density of 13 inhabitants/km². The Reserve is located in the Sudanian zone of Benin (West Africa) and its vegetation is dominated by forest, woodland, tree and shrub savannas. The climate is of the Sudanian type, characterized by a unimodal rainfall pattern with a seven-month dry period and annual rainfall of 900–1000 mm (Adomou, 2005). The soil is ferruginous and the mean annual temperature is 27 °C. Local people living around the Pendjari Biosphere Reserve are among the poorest people in Benin (Martin, 2000; CENAGREF, 2005) and wild plants are indispensable for their daily life. Among these people, the Berba (65%), the Gourmantche (23%) and the Waama (7%) are the dominant ethnic groups (CENAGREF, 2005). The Berba are established along the Tanguieta–Porga axis while the Gourmantche and the Waama are settled in some villages located along the Tanguieta–Batia axis (Fig. 1). Besides these ethnic groups, there are sedentary Peulh who live in interaction with the other groups. The main activities of local people are agriculture (Berba, Gourmantche and Waama) and livestock keeping (Peulh). In addition, the Peulh cultivate also some crops, whereas the Berba, the Gourmantche and the Waama keep often a small herd of cattle for agricultural activities. Since the designation of this "protected area" (in 1954), exploitable land for agriculture has been significantly reduced, and this combined with human demographic pressure have increased degradation of natural resources in the non-protected lands. In this latter area, women of Berba, Gourmantche and Waama ethnic groups often prefer non-timber forest products with high commercial and nutritional value, while men prefer plant species that provide construction material and medicine (Vodouhê et al., 2009).

2.3. Ethnobotanical surveys

2.3.1. Sampling

This study was conducted in 4 ethnic groups located in twelve surrounding villages of Pendjari Biosphere Reserve, namely Batia, Koualegou, Sangou and Tanougou for the Gourmantche ethnic group; Tchanwassaga and Nanebou for the Waama ethnic group; and, Tiele, Sepounga, Mamoussa, Nagassega, Pouri and Porga for the Berba ethnic group. The sample size of each ethnic group was determined taking into account the representation of the ethnic group within overall Pendjari Biosphere Reserve people. Men and women belonging to the different ethnic groups (43 Gourmantche, 33 Waama, 69 Berba and 15 Peulh) were randomly selected, with ages ranging from 20 to 90 years and individual interviews were conducted at their living place. In each household, one or two persons willing to participate in the investigation were interviewed.

2.3.2. Data collection

Information was collected through two methods: focus group discussions and individual interviews. Two focus group discussions were organized in the Waama, the Berba and the Gourmantche ethnic groups and one focus group discussion in the Peulh ethnic group due to limited access of the latter. The focus groups allowed us to inventory the various uses of target species, the main five being medicinal, fodder, fuel, craft and religious use. The traditional ecological knowledge that may eventually improve the species conservation was identified during the focus groups. The focus group discussions allowed us to understand that local people have ecological knowledge on the methods for debarking and pruning

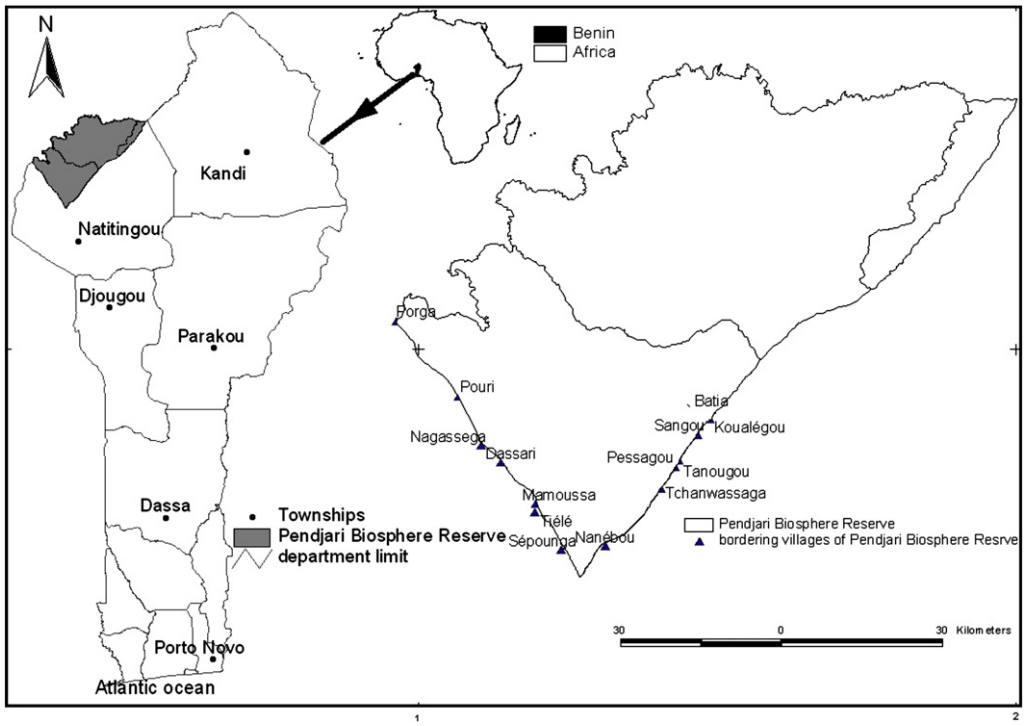

Fig. 1. Study area showing localization of Benin in Africa (above), localization of Pendjari Biosphere Reserve in Benin (left) and localization of bordering villages of Pendjari Biosphere Reserve (right).

these species, and questions on this type of knowledge were included in individual structured investigations that were the second step of the data collection. The focus groups took place in the dry season, during the agricultural inactivity period, to make the participation of people easier. Interviews were conducted in the local language of the informant with a translator when needed. Each focus group was made up of 5 to 15 participants aged from 30 to 70 years. Informants were interviewed over the decline of the target species, their uses and their exploitation method that might have led to the current species' conservation status.

Individual structured interviews were conducted with 160 people randomly selected from those living in the surroundings of the Reserve. A structured questionnaire was used to collect data on socio-cultural characteristics of the respondents and on the uses of the target species. Informants were asked to answer the questions related to the two most important uses, their knowledge about the decline of species and the sustainable use of species.

2.3.3. Data analysis

The interviewees were grouped according to their ethnic group, gender and age, defining six subgroups for each ethnic group: young men (M1), adult men (M2), old men (M3), young women (F1), adult women (F2) and old women (F3). Twenty four subgroups (4 ethnic groups × 6 subgroups) were expected, but because of the absence of some subgroups (Table 2) a total of 20 subgroups were considered. Within a subgroup for a given tree species, the use frequency was determined using the formula:

$$UV_{is} = \frac{\sum U_{is}}{n_i}$$

where U_{is} is the number of informants in the subgroup i who use the species s and n_i the total number of informants in the subgroup i (Camou-Guerrero et al., 2008).

In order to identify the preferred use of each species s, the cultural importance index ($IP_{i,k}$) value was computed for each subgroup and for a given type of use (medicinal, religious, fuel etc.) through the following formula:

$$IP_{i,k} = UV_{is} \frac{\sum_{j=1}^{ni} x_j}{n_i}$$

where x_j is the score of importance of the considered type of use according to the informant j ($j = 1,\ldots,n_i$) in the subgroup i. Three levels of score were defined: high importance (scored 3), medium importance

Table 2
Sample composition according to ethnic group, gender and age.

	Gourmantche		Waama		Berba		Peulh		Total
	Men	Women	Men	Women	Men	Women	Men	Women	
Young (age ≤ 35)	6	8	5	6	14	5	5	5	54
Adult (35 < age ≤ 60)	13	6	9	8	16	15	5	–	72
Old (age > 60)	5	5	5	–	13	6	–	–	34
	24	19	19	14	43	26	10	5	160
Total	43		33		69		15		

Table 3
Correlation between linked uses and Principal Component Analysis axes.

Uses	*A. africana* Smith ex Pers.		*P. erinaceus* Poir.		*K. senegalensis* Desr. A. Juss	
	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Medicinal	0.88	−0.07	0.47	0.58	0.66	0.32
Fodder	0.71	0.24	0.74	−0.13	−0.50	0.39
Fuel	0.01	0.80	−0.82	0.16	0.88	0.22
Craft	0.69	0.13	0.31	0.40	−0.34	0.52
Religious	0.33	−0.64	0.20	−0.86	0.04	−0.84

(scored 2) and low importance use (scored 1). These score levels were obtained by converting the ranking of each informant into score. Scores of 3 and 2 were attributed respectively to the first and second most important use according to the informant.

The other remaining uses were scored 1. This formula of cultural importance index value has been developed considering the method used by Camou-Guerrero et al. (2008) to build the use value index. It was expected from cultural importance index to amplify differences in use patterns of target species. Indeed, during the focus group discussions, we observed that local people use the target species almost in the same way. Therefore this amplification allowed us to identify the intercultural and intracultural differences that were hidden by the utilization of the use frequency.

For each species, a subgroup *x* use matrix was constructed. Lines were the 20 subgroups and columns were related to the 5 different types of use inventoried during the survey: medicinal, fodder, fuel, craft and religious uses. Principal Component Analysis (PCA) was performed with these matrices. This statistical method groups subgroups according to the cultural importance index value computed for each subgroup with

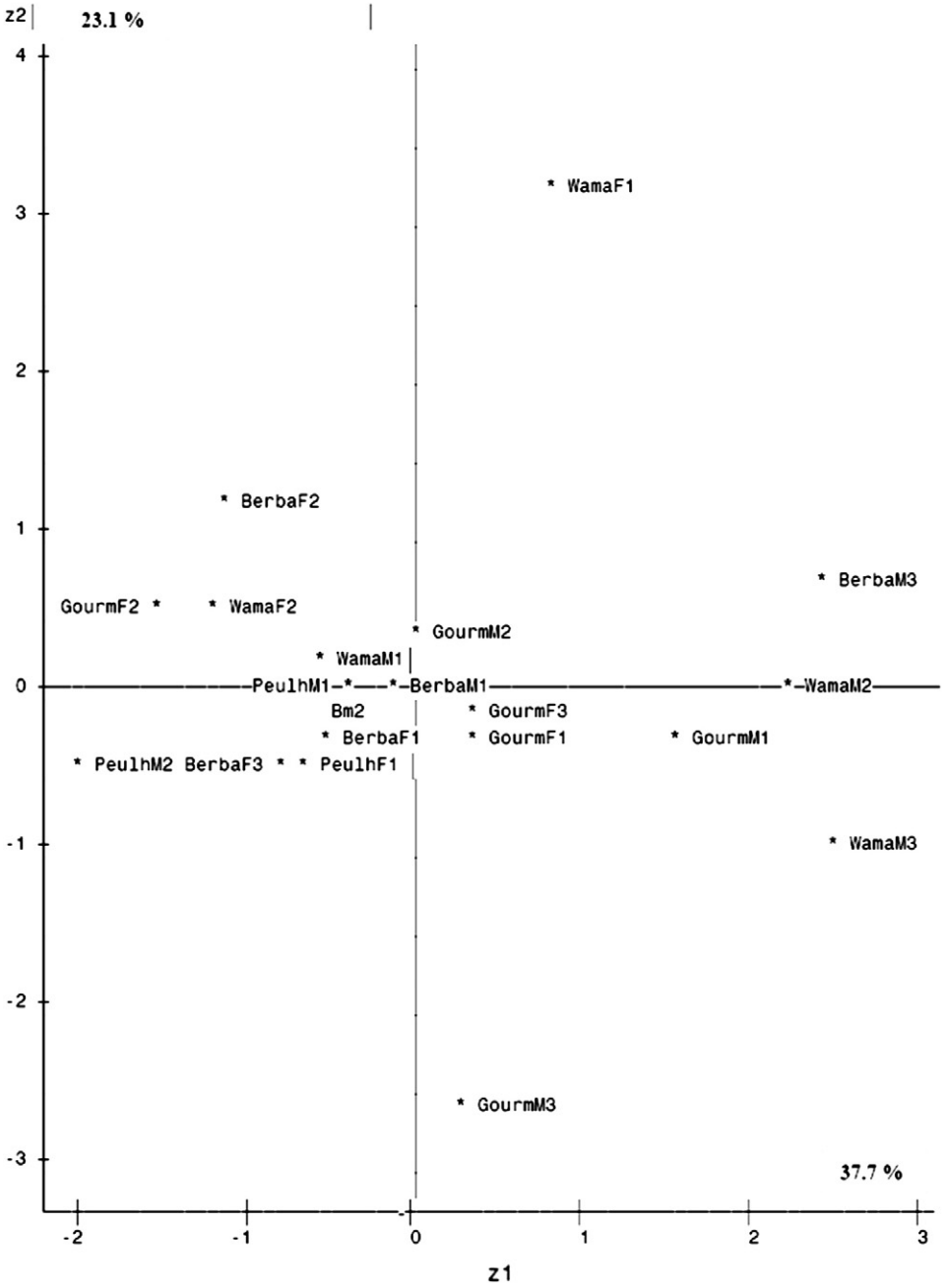

Fig. 2. Principal Component Analysis (PCA) to identify uses of *A. africana* that best explain the patterns of variation according to the perception of local people: Projection of socio cultural groups in the first two axes.

the vectors indicating the preferred uses of the subgroup (Höft et al., 1999). For a given species use, the overall cultural importance index was computed as:

$$IP_t = \sum_{i=1}^{k} IP_{i,k}$$

with k being the number of subgroup(Camou-Guerrero et al., 2008). Kruskall–Wallis tests (Höft et al., 1999) were used to test the quantifiable ethnobotanical local knowledge as a dependent variable of ethnicity.

3. Results

3.1. Patterns of plant use by local people

3.1.1. A. africana

Results of PCA analysis indicated that the first two axes explained 60.8% of the observed variation of the use patterns of the species. Correlations between the first two axes (Table 3) and the use patterns (Fig. 2) of the species revealed that medicinal, fodder and craft uses are known by most of the people interviewed and were not consequently grouped according to their religious and fuel uses which are only known by limited number of people and are not associated with the other uses. The projection of sub-groups on the two axes (Fig. 2) revealed that on axis 1, the ethnic groups Waama, Gourmantche and Berba, especially men, regardless of their age, use *A. africana* mostly for medicine, fodder and craft purposes. Axis 2 showed the preference of Waama young women for fuel uses and Gourmantche old men for religious purposes.

3.1.2. P. erinaceus

The two first axes explained 58.2% of the observed variation of the use patterns of the species. Correlations between the first two axes (Table 3) and the use patterns (Fig. 3) of the species revealed that fodder and fuel uses known by most of the people were separated from the religious and the medicinal use which are known by few people. Considering axis 1, the projection of subgroups on the axis (Fig. 3) revealed that *P. erinaceus* is used as fodder by men and women of all ethnic groups (Waama, Gourmantche, Berba and Peulh) regardless of their age while fuel use is preferred by adult and elderly women of the Gourmantche and the Berba people, respectively. Considering axis 2, young and old men belonging to the Gourmantche ethnic group preferred the species for medicinal and religious uses respectively.

3.1.3. K. senegalensis

A total of 58.1% of the observed variation among the uses were explained by the two first axes. Correlations between the first two axes (Table 3) and the use patterns (Fig. 4) of the species revealed

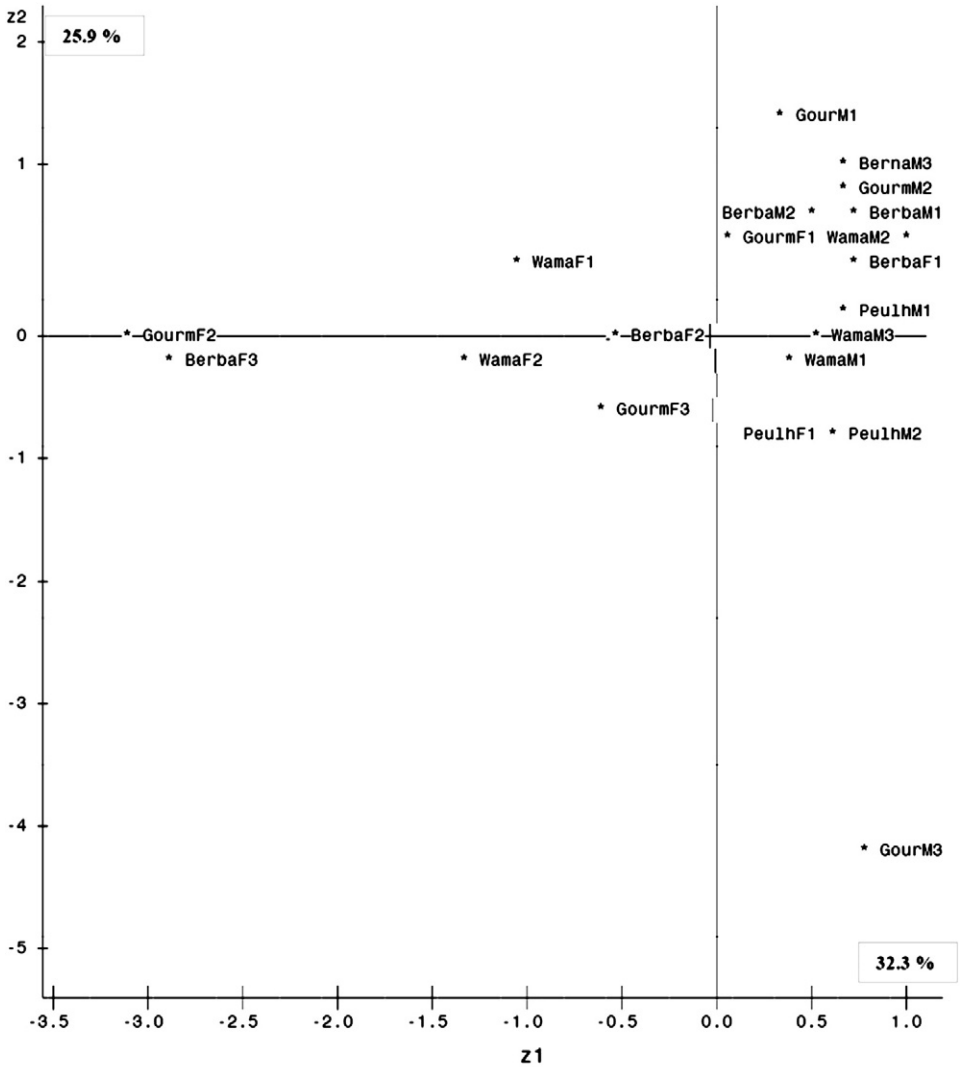

Fig. 3. Principal Component Analysis (PCA) to identify uses of *P. erinaceus* that best explain the patterns of variation according to the perception of local people: Projection of socio cultural groups in the first two axes.

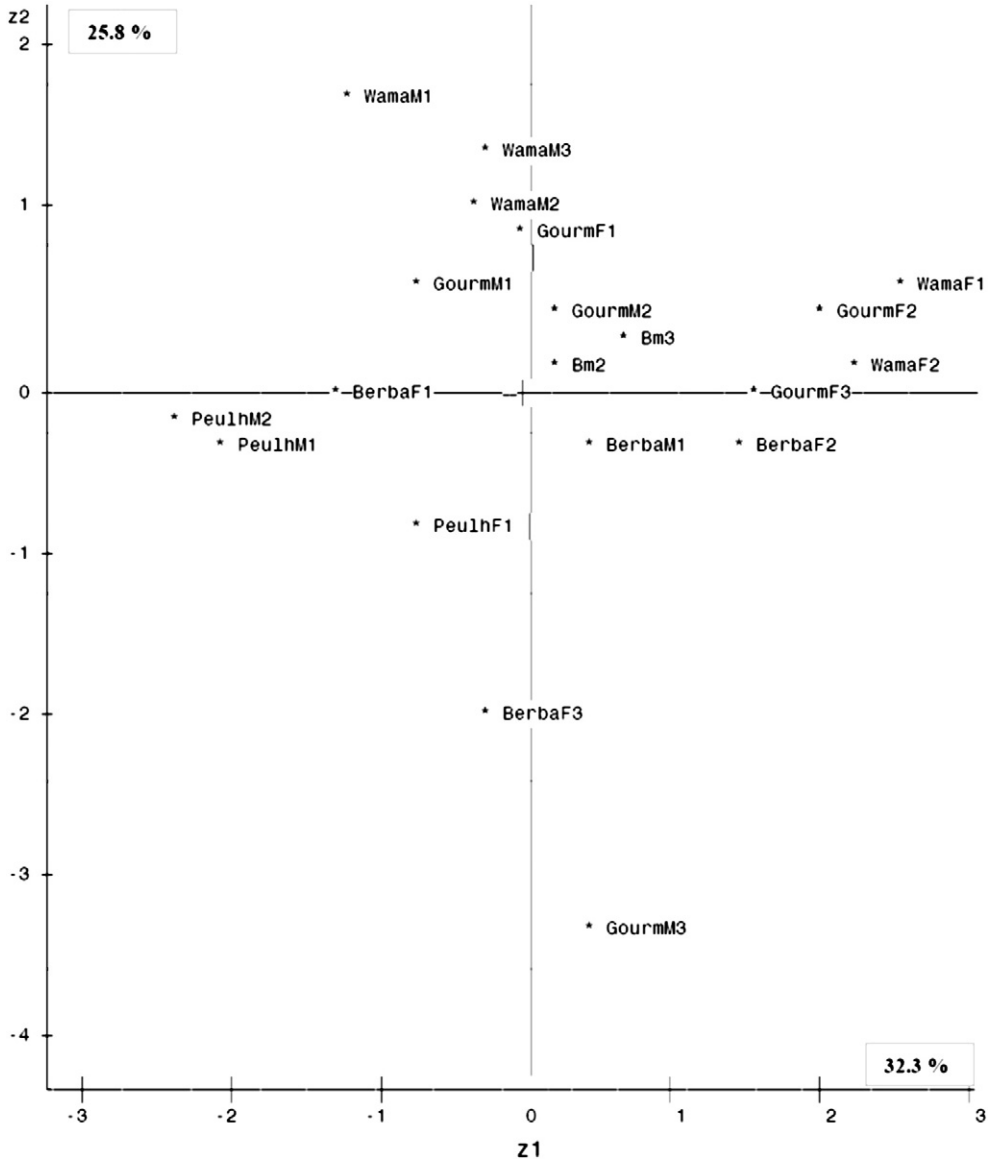

Fig. 4. Principal Component Analysis (PCA) to identify uses of *K. senegalensis* that best explain the patterns of variation according to local people perception: Projection of socio cultural groups in first two axes.

that medicinal and fuel uses known by most people interviewed were separated from religious, fodder and craft uses known by few people.

Projection of subgroups on axis 1(Fig. 4) highlighted that medicinal and fuel uses of *K. senegalensis* are considered as important by women of a wide range of ages belonging to the Waama, the Gourmantche and the Berba ethnic groups. The same axis revealed that only Peulh men use *K. senegalensis* mostly for fodder. Concerning axis 2, craft use of the species is preferred by Waama men of different age categories while Gourmantche old men use *K. senegalensis* for religious practices.

3.2. The total cultural importance index value

It can be noticed in Table 4 that medicinal and fodder uses have the highest total cultural importance index value for *A. africana*: 21.33 and 20.68 respectively while fodder use is the most important for *P. erinaceus* (total cultural importance index value: 53.73). Medicinal use has the highest total cultural importance index for *K. senegalensis* (45.12). By considering the average of the total cultural importance index, it can be concluded that for local people, the most important uses are: medicinal for *K. senegalensis* and *A. africana*, fodder for *P. erinaceus* and *A. africana*, fuel for *P. erinaceus* and *K. senegalensis*, and craft for *K. senegalensis* and *A. africana* (Table 4).

3.3. Knowledge on local extinction of tree species

Local people are aware of the jeopardized status of the studied species and this awareness varies significantly from one ethnic group to another ($H = 14.01$; $P = 0.003$). Informants belonging to the Peulh ethnic group are weakly aware of the eventual local extinction of these species compared to the others. According to some Berba informants, the present declining status of *A. africana* in Kouorou village (village located on Tanguieta–Porga axis) is a proof of an eventual extinction of

Table 4
Total importance index value of each use for target species.

Species	Medicinal	Fodder	Fuel	Craft	Religious
A. africana Smith ex Pers.	21.33	20.68	3.71	4.37	2.65
P. erinaceus Poir.	11.88	53.73	12.46	2.34	0.75
K. senegalensis Desr. A. Juss	45.12	5.49	9.36	7.26	1.06

this species. In fact, the example of this village is instructive since the name of the village means in Berba "many individuals of *A. africana*" which was inspired from the high density of the species (in the past) in the village. The informants estimated that the species may become extinct in less than 20 years (Berba, Gourmantche and Waama) or in 20–30 years (Peulh).

3.4. Knowledge of sustainable use of tree species

Local people have knowledge on the conditions for a sustainable use of the species studied, but it varies significantly from one ethnic group to another ($H = 3.62$, $P = 0.036$). According to the majority of Gourmantche, Waama and Berba, pruning and debarking were practiced only on adults' tree. A weak proportion (22%) of Peulh participants reported this knowledge in the case of debarking while 68% of the same ethnic group reported that the pruning was practiced on adult trees. The Gourmantche (65%), the Waama (57%) and the Berba (35%) reported that the debarking method depends on the tree species. The debarking of *A. africana* and *P. erinaceus* is not as intense as that practiced on *K. senegalensis*. Indeed as reported by local people the high proportion and frequency of bark removal may not be detrimental for *K. senegalensis* survival while it is for *A. africana* and *P. erinaceus*. Fig. 5 shows an example of debarking in relation to studied tree species in the study area. In the debarking process, the bark of *A. africana* and *P. erinaceus*was not totally removed around the tree while all the bark of the trunk of *K. senegalensis* may be removed. For a given individual of *A. africana* and *P. erinaceus*, bark harvesting is practiced once or twice per year on the same individual whereas the same individual of *K. senegalensis* may be debarked several times per year and intensively. According to these local people, *K. senegalensis* debarked trees regenerate fast and are less sensitive to fire and diseases compared to *A. africana* and *P. erinaceus*. Another reason for using this debarking method is the mystical character of *A. africana*. The Gourmantche, the Berba and the Waama ethnic groups reported that a severe debarking of *A. africana* has a negative religious effect on the harvester. The same mystical character justified the fact that *A. africana* is excluded from fuel use according to the Gourmantche people.

In relation to pruning, according to the majority of people interviewed (77 to 94%), it must be practiced on the same individuals only once per season on the tertiary branches, to ensure the conservation of pruned trees. The Peulh justified the practice of transhumance life style as consistent with the practice of this pruning method. Indeed, after pruning once the individual trees in a given area, the herders used to move to another area.

4. Discussion and conclusion

4.1. Species use patterns in relation to social factors

The preferred use pattern for the species under consideration in the present study revealed an intercultural variation and is consistent with previous studies (Assogbadjo et al., 2008; Vodouhê et al., 2009; Case et al., 2005; Lawrence et al., 2005; Chadare et al., 2008). Indeed, *A. africana* and *P. erinaceus* are preferred as fodder by almost all the ethnic groups, and this information contrasts with the use of *K. senegalensis* as fodder, preferred only by the Peulh people. This ethnic difference in the use pattern could be related to the life style and the activities of each ethnic group. According to local people, sheep and goat consume leaves of *P. erinaceus* while *K. senegalensis* leaves are consumed only by cattle and this local knowledge is consistent with researches of Omokanye et al. (2001) in Nigeria. The Berba, the Gourmantche and the Waama ethnic groups are sheep and goat breeders while Peulh are almost strictly cattle breeders. The preference of *A. africana* for fodder use by the other ethnic groups (non-Peulh) may be explained by the fact that these ethnic groups have also a small herd size of cattle (2–3 animals) for agricultural activities. Moreover, the Gourmantche is the only group that preferred all investigated tree species for religious uses and this may be explained by their tradition as healers and specialists of geomancy science, which is a form of divination based on the interpretation of objects such as pebbles thrown to the ground (Kiansi, 2008; Vodouhê et al., 2009).

The present study also showed that medicinal use of *K. senegalensis* is preferred by the women compared to men. This result is similar to the one observed by Camou-Guerrero et al. (2008) who pointed out that men had more knowledge on construction and domestic goods, while women had more knowledge on medicinal plants. The preference of *K. senegalensis* for medicinal use by women may be explained by the vicinity of *K. senegalensis* populations (generally artificial populations) with local people. In contrast, *A. africana* is preferred for medicinal use by men who are involved in the debarking of this species usually located far from the habitations.

In addition, this study showed that fuel use is generally taken up by women as similarly reported by Faye et al. (2008) in Senegal. This intracultural variation may be explained by the gender division of labor in traditional societies (Camou-Guerrero et al., 2008; Müller-Schwarze,

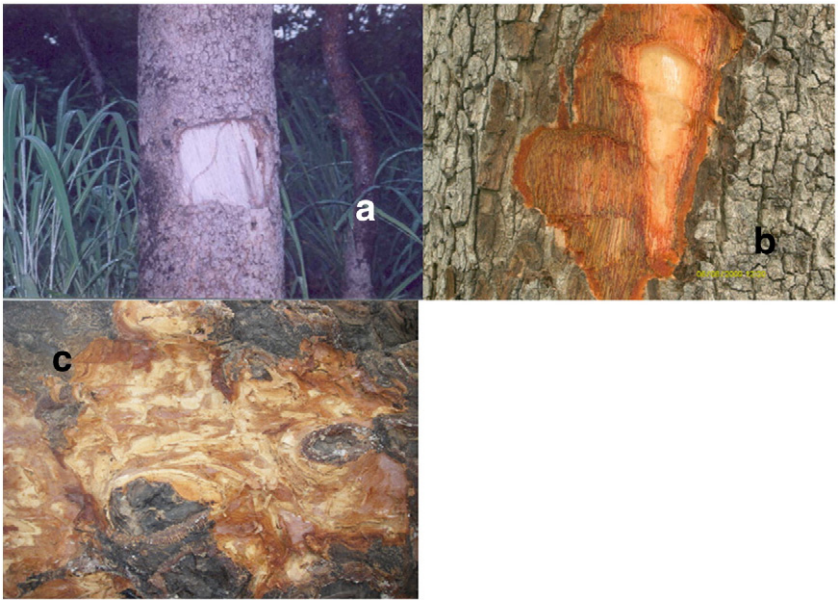

Fig. 5. Pictures showing the difference in the practice of debarking according to species. a: *A. africana*, b: *P. erinaceus* and c: *K. senegalensis* in the study area.

2006; Vodouhê et al., 2009).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 about fuel use of the trees.

Another social factor that could be considered is age. However, the present study did not reveal a difference in preferred use patterns according to age which is similar to previous findings in Burkina Faso and in Tanzania (Kristensen and Lykke, 2003; McMillen, 2008 respectively). These studies reported similar local knowledge between young and old people on the selected woody species. In contrast the religious use was preferred by older people in this study which is in accordance with other researches conducted elsewhere that reported greater knowledge for older people (Cotton, 1996; Case et al., 2005; Luoga et al., 2000).

4.2. Traditional ecological knowledge and species conservation

Based on traditional ecological knowledge, the present study revealed that *A. africana* is rejected as fuel use due to its mystical character according to the Gourmantche ethnic group. This traditional knowledge is similar to the one reported by Kristensen and Balslev (2003) in south-central Burkina Faso. Indeed, these authors also reported that *A. africana* has been rejected as firewood by some informants belonging to the Gourounsi ethnic group. Such a traditional knowledge may be integrated in the management plan of this tree species and it is likely to strengthen conservation strategies of *A. africana* in open access lands.

Traditional knowledge also indicated that *K. senegalensis* is debarked more severely than *A. africana* and *P. erinaceus* due to the fast regeneration of *K. senegalensis* bark; a finding which is consistent with that reported by Delvaux et al. (2009) who found that *K. senegalensis* and *Lannea kerstingii*, showed complete wound recovery by edge growth while *A. africana*, *Burkea africana* and *Maranthes polyandra* had very poor edge growth. Local people by empirical experience have some knowledge that could be considered for scientific researches. However, it might be challenging to conserve the traditional knowledge since their progressive loss together with taboos linked to the use of natural resources was already reported by Benz et al. (2000) and Shanley and Rosa (2004).

Moreover this study revealed that local people did not equally view the eventual extinction of species. Indeed, the Peulh ethnic group was found to be weakly informed on the current decline of target species compared to the other ethnic groups (Berba, Waama, Gourmantche). This should be explained by the fact that the Peulh people are not native of the area and consequently have not had enough time to observe the change in population dynamic of species.

4.3. Assessing validity of methodology

The method used in this study for identifying the main use for a given species is based on ethnobotanical approaches similar to those used by Kristensen and Lykke (2003) and Camou-Guerrero et al. (2008). The method belongs to the group of 'informant consensus' in quantitative ethnobotany (Kristensen and Lykke, 2003). The cultural importance index used in this study allowed amplifying the intercultural and intracultural variations in the preferences for a given use of the studied multipurpose species. Indeed, the use frequency matrix subject to the same PCA analysis (results not shown) attenuated the differences between subgroups compared to that was observed in the case of the cultural importance index. The multiplication of use frequency by the use importance involved this amplification (Pieroni, 2001; Camou-Guerrero et al., 2008). The use ranking has the advantage to let informant rate uses for a given species and therefore is less subjective (Kristensen and Lykke, 2003). According to these latter, this method has several advantages such as simple data collection and suitable data for statistical analysis. The use of this method to quantify key uses for a given multipurpose species requires the following conditions: (1) the target species must be a useful species that local people consider for multiple goals and (2) the construction of relevant categories of use according to local people. The present method of the cultural importance index may be mostly investigated and applied for larger group of plant to identify key uses that could be considered for developing conservation strategies of multipurpose species. Moreover, this index did not integrate the reason why each informant preferred a given use and may help to better understand the drivers of preference use for a given species.

4.4. Conclusion and management implications

The study showed that inhabitants of Pendjari Biosphere Reserve preferred the target species differently according to their ethnic group and sex. They are informed on declining of target species but differently. The study also revealed that local people have some traditional ecological knowledge that could be considered for species conservation. We conclude also that the cultural importance index developed in this study is necessary to understand some intracultural and intercultural differences in uses of target species. Also this index has advantage to offer a more comprehensive valuation of the significance of target species use for local people than the use of only use frequency.

Based on these above outcomes, broad management strategies could be developed.

The prohibition of fuel use of these species in non-protected lands should be developed by making sensitive women (Berba, Waama, Gourmantche) aware, particularly for *P. erinaceus* and *K. senegalensis*. The logging of natural populations of these studied trees could be prohibited also and men (Berba, Waama, Gourmantche) should be associated in implementing this decision.

The promotion of *K. senegalensis* and others rapid growth species (for fuel use) planting among women of Berba, Waama and Gourmantche ethnic groups should be developed.

The promotion of *A. africana* and *P. erinaceus* preservation among men in their cultivated lands is also necessary. In this case, Berba, Waama and Gourmantche men should be targeted since agriculture is their professional specialization and they preferred these two species for fodder use.

The awareness of local people on the declining of these tree species may favor their positive behavior towards adopting these above management strategies since it has been demonstrated that people's perceptions of biodiversity conservation can strongly reinforce their positive attitude toward conservation strategies (Alexander, 2000; Ormsby and Kaplin, 2005; Vodouhê et al., 2010).

By considering the traditional ecological knowledge, this study found that the debarking of *A. africana* and *P. erinaceus* should be practiced once per individual trees while *K. senegalensis* individual bark could be removed several times without significant damages. This local knowledge may be promoted in all socio cultural groups (men and women whatever their age) since the knowledge was not equally distributed among ethnic groups. As education is one of the factors which has positive impact on people perception generally, it should be necessary for protected area managers to integrate this traditional knowledge in environmental education, which could be addressed to children and young people in school.

Another traditional knowledge that could be promoted concerns the reject of *A. africana* as fuel use by Gourmantche because of its mystical character. It is important to share this knowledge with the young Gourmantche since old people generally hold similar knowledge. This strategy could contribute to avoid loss knowledge in Gourmantche traditional culture and also it could reinforce the conservation of *A. africana* in the long term.

Moreover the cultural importance index could be examined in future studies and relevant hypotheses should be tested. Among these latter the following hypothesis is very relevant: is significant difference between patterns made by frequency use and that made by cultural importance index developed?

The findings of this study may support the study of the impact of use on the population dynamics of the target species. Moreover, the implementation of these suggested management strategies should reinforce the availability of these tree species in the open access lands and should avoid eventual pressure on the protected population of these tree species.

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