Uses and Management Strategies of the Multipurpose Tree
Anogeissus leiocarpa in Eastern Burkina Faso

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Summary: Many people in the semi-arid tropics strongly depend on non-timber forest products (NTFPs) for livelihood. Increasing threats on NTFP-providing tree species, due to land-use intensification and over-harvesting, require ecological studies as well as additional information provided by local people. One important NTFP-providing tree in West Africa is *Anogeissus leiocarpa*. Even though this species is highly used, ethnobotanical studies on *A. leiocarpa* are scarce and address mainly qualitative aspects. Our study investigates uses, perceptions of the population development, and management strategies of *A. leiocarpa* among the *Gulimanceba* people in eastern Burkina Faso. We conducted a quantitative ethnobotanical survey and investigated distribution of traditional ecological knowledge related to the species on a local scale, i.e. difference in knowledge between villages, genders, and generations. Interviews reveal that *A. leiocarpa* is harvested by local people for 18 different uses and emphasize its high importance for local people. Ethnobotanical knowledge of *A. leiocarpa* was mostly evenly spread between genders and generations, while it slightly differed between villages. Although local people did not actively protect *A. leiocarpa*, current local harvesting modes and management resulted in sustainable use. However, ongoing land-use intensifications require adapted management strategies to guarantee the persistence of this important species. Our results provide, in combination with ecological results of our previous study, appropriate management recommendations. Our study emphasizes the importance of ethnobotanical studies on a local scale level in order to develop management strategies that are reliable in the specific area under the specific circumstances.

Keywords: ethnobotany, *Gulimanceba*, traditional knowledge, sustainable use

USAGES ET STRATÉGIES DE GESTION D'*ANOGEISSUS LEIOCARPA*, UNE ESPÈCE À USAGE MULTIPLE DANS L'EST DU BURKINA FASO

Résumé: Les populations des zones semi-arides dépendent fortement des produits forestiers non ligneux (PFNLx) pour la subsistance. L'augmentation des menaces sur les arbres pourvoyeurs de PFNLx en raison de l'intensification de l'utilisation des terres et la surexploitation, nécessitent des études écologiques ainsi que des informations supplémentaires fournies par la population locale. *Anogeissus leiocarpa* est un des plus importants arbres, pourvoyeur de PFNLx en Afrique de l'Ouest. Malgré sa forte utilisation, les études ethnobotaniques sur *A. leiocarpa* sont rares et traitent principalement des aspects qualitatifs. Notre étude examine les usages, les perceptions de l'évolution de la population, et les stratégies de gestion d'*A. leiocarpa* chez les *Gulimanceba* dans l'Est du Burkina Faso. Nous avons mené une enquête ethnobotanique quantitative et étudié la distribution des connaissances écologiques traditionnelles relatives à l'espèce à une échelle locale; à savoir la différence dans la connaissance entre les villages, le genre et les générations. Les interviews révèlent que *A. leiocarpa* intervient dans 18 usages différents d'où son importance pour la population locale. Les connaissances ethnobotaniques sur *A. leiocarpa* étaient équitablement réparties entre le genre et les générations, mais légèrement différentes entre les villages. Bien que *A. leiocarpa* ne bénéficie pas d'une protection active de la part de la population locale, les modes actuelles de récolte et la gestion qui en résulte, concourent à une utilisation durable. Toutefois, l'intensification de l'utilisation des terres en cours nécessitent des stratégies de gestion adaptée pour garantir la persistance de cette importante espèce. Nos résultats fournissent, en combinaison avec nos études écologiques antérieures, des recommandations pour une gestion appropriées d'*A. leiocarpa*. Notre étude souligne l'importance des études ethnobotaniques à une échelle locale afin de développer des stratégies de gestion fiables et spécifiques à une zone donnée compte tenu des circonstances spécifiques.

Mots clés: ethnobotanique, *Gulimanceba,* connaissance traditionnelle, utilisation durable

VERWENDUNGEN UND MANAGEMENTSTRATEGIEN DER NUTZHOLZART *ANOGEISSUS LEIOCARPA* IM OSTEN BURKINA FASOS

Zusammenfassung: Für die ländliche Bevölkerung in tropischen Gebieten sind Nichtholzprodukte verschiedenster Baumarten von essenzieller Bedeutung. Die durch Übernutzung und Landnutzungsintensivierungen hervorgerufenen Bedrohungen dieser Nutzholzarten erfordern sowohl ökologische als auch ethnobotanische Studien. Eine wichtige und stark genutzte Nutzholzart in Westafrika ist *Anogeissus leiocarpa*. Trotz starker Nutzung gibt es erstaunlicherweise kaum detaillierte ethnobotanische Studien über diese Art. In der vorliegenden Studie dokumentieren wir Verwendungen und Managementstrategien von *A. leiocarpa* bei der *Gulimanceba* Bevölkerung im Osten Burkina Fasos. Dazu haben wir quantitative ethnobotanische Befragungen bei den *Gulimanceba* durchgeführt und Unterschiede im Wissen zwischen den Geschlechtern, Generationen und zwischen Bewohnern verschiedener Dörfer untersucht. Die Ergebnisse der Umfragen zeigen, dass *A. leiocarpa* für 18 verschiedene Zwecke genutzt wird und verdeutlichen die Bedeutung dieser Art für die lokale Bevölkerung. Das Wissen über *A. leiocarpa* unterschied sich kaum zwischen den Geschlechtern und Generationen, wohingegen geringfügige Unterschiede zwischen den Befragten verschiedener Dörfer ermittelt werden konnten. Obwohl *A. leiocarpa* nicht aktiv von der lokalen Bevölkerung geschützt wird, lässt sich feststellen, dass die gegenwärtigen lokalen Sammeltechniken und Managementstrategien von *A. leiocarpa* nachhaltig sind. Allerdings erfordern anhaltende Landnutzungsintensivierungen angepasste Sammel- und Managementtechniken, um das Fortbestehen dieser wichtigen Art zu gewährleisten. Mit Hilfe unserer Ergebnisse und in Kombination mit den Ergebnissen unserer vorherigen ökologischen Studie können angemessene Managementempfehlungen für eine nachhaltige Nutzung von *A. leiocarpa* formuliert werden. Unsere Studie verdeutlicht die Bedeutung von lokalen, ethnobotanischen Untersuchungen. Mit Hilfe solcher Studien können konkrete Managementstrategien entwickelt werden, die unter den spezifischen Bedingungen anwendbar und tragbar sind.

Schlagworte: Ethnobotanik, *Gulimanceba*, Traditionelles Wissen, Nachhaltige Nutzung

1 INTRODUCTION

Many people in the semi-arid tropics strongly depend on non-timber forest products (NTFPs) for livelihood (FAO 1995). In recent years, there has been growing concern that populations of NTFP-providing trees are declining due to land-use intensification and over-harvesting. Consequently, several studies assessed the impact of land-use and harvesting on the population status of important NTFP-providing tree species (e.g. GAOUE & TICKTIN 2007; SCHUMANN et al. 2010). However, these studies on their own may not adequately justify the conservation assessment of the status of species (DOVIE et al. 2008). Important additional information to these studies can be provided by local people. Their knowledge and opinions on use-preferences, management strategies, and their impact on the natural resource are crucial elements for producing rational conservation and management strategies (LYKKE et al. 2004; GAOUE & TICKTIN 2009).

In Africa, knowledge and perceptions of local people living in natural environments are based on experience gathered over generations (LYKKE 2000; PARÉ et al. 2010). Local management practices were developed by people who have been harvesting these species for hundreds of years (TICKTIN et al. 2002) and are usually based on both ecological and cultural/socio-economic considerations. Age, ethnicity, gender, and several other socioeconomic factors shape knowledge of plant use and management. Moreover, knowledge can even vary within one ethnic group on a local level. LYKKE et al. (2004) found significant differences from village to village when it came to the knowledge on uses and dynamics of woody species in Burkina Faso as a consequence of different natural and cultural conditions. Therefore, knowledge should not emanate only from and for large-scale but also from the finest micro level i.e. local contexts (DOVIE et al. 2008). Proposals for changes in management on a larger-scale may be impractical or impossible to apply for local harvesters. Thus, management recommendations should focus on adaptation of management strategies currently practiced locally (TICKTIN 2004).

One important NTFP-providing tree in West Africa is *Anogeissus leiocarpa* (DC.) GUILL. & PERR. NTFPs of this tree are widely used for household and medicinal purposes (BURKILL 1985-2000; ANDARY et al. 2005; SACANDE & SANOGO 2007). Even though this species is highly used, ethnobotanical studies on *A. leiocarpa* are scarce and address mainly qualitative aspects (LYKKE et al. 2004; BELEM et al. 2007; PARÉ et al. 2010). There is no detailed quantitative analysis of the utilization, harvesting modes, and conservation strategies of this important species. Therefore, we conducted a quantitative ethnobotanical survey among the *Gulimanceba* people, the dominant ethnic group of eastern Burkina Faso, in order to identify uses, perceptions of population development, and management strategies of *A. leiocarpa* on a local level. The *Gulimanceba* are a minority group in Burkina Faso (7% of the total population, TLFQ 2011), who mainly live from agriculture (cotton, maize, millet, and sorghum), and who use several NTFPs on a daily basis. The specific objectives of the study were to (i) document uses of the different plant parts, (ii) describe harvesting modes of the local communities, (iii) reflect local perceptions about the population status, and (iv) assess the local conservation status of *A. leiocarpa*. In this context, we also aimed to investigate traditional ecological knowledge distribution on a local scale, i.e. differences in knowledge between gender, generations, and villages.

In a previous study, we had documented the impact of harvesting and land-use on the population structure of *A. leiocarpa* in the same area (SCHUMANN et al. 2011). By combining these results with the findings of our ethnobotanical study, we aimed, as an overarching result, to achieve a coherent synergy between traditional ecological knowledge and ecological findings on *A. leiocarpa* in order to provide appropriate management recommendations that are reliable under currently practiced management strategies.

2 METHODS

2.1 Study area and species

The study area is located in a semi-arid area in the province Tapoa in Burkina Faso, West Africa (Fig. 1) in the vicinity of the trans-boundary W National Park. The study area belongs to the North Sudanian vegetation zone, with an average annual rainfall of 750-950 mm and a rainy season from May to October followed by a dry season from November to April (GUINKO 1984). The vegetation is characterized by shrub, tree, and woodland savannas. The dominant ethnic group is represented by the *Gulimanceba* (85% of the total population in the Tapoa province), who are autochthon and mainly live from agriculture (cotton, maize, millet, and sorghum). The farming system consists of alternating cycles of cultivation and fallows. Human population density is relatively low with 16 inhabitants per km² (Tapoa province, INSD 2007).

Anogeissus leiocarpa (DC.) GUILL. & PERR. belongs to the Combretaceae family. The deciduous tree can grow up to a height of 15–18 m (ARBONNIER 2002), has a slightly grooved bole, and an open crown with drooping, pubescent branches. Flowering occurs during the dry season, or the beginning of the rainy season, just after leaf flushing (SACANDE & SANOGO 2007). Seeds ripen during the dry season and germinate mainly at the beginning of the rainy season.

It has a wide geographical distribution ranging from the borders of the Sahara down to the humid tropical forests. Depending on the vegetation zone, it can be found in savannas, dry forests, and gallery forests (COUTERON & KOKOU 1997; MÜLLER & WITTIG 2002; THIOMBIANO et al. 2006). It is typically found at altitudes between 450 and 1900 m and can grow on a range of different soil types (THIOMBIANO et al. 2006).

2.2 Data collection

For the structured interviews, six villages adjacent to the W National Park were chosen (Tapoa Djerma, Barpoa, Toptiagou, Kabougou, Kotchari, and Kombongou, Fig. 1). All villages show similar cultural and social structure. Interviews were conducted between September and October 2008. In total, 49 *Gulimanceba* people (28 men and 21 women) were interviewed individually. Men and women and different age-classes (< 30 years, 31-50 years, and > 50 years) were
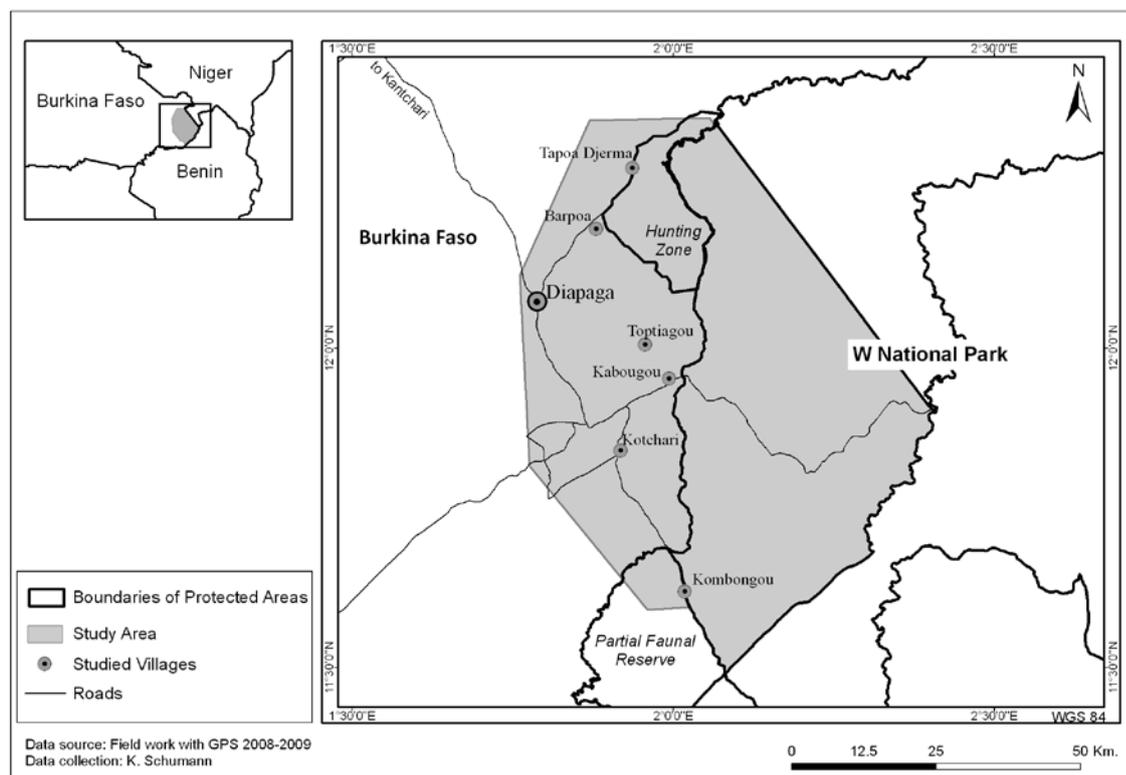
Fig. 1: Study area / Zone d'étude / Untersuchungsgebiet

equally represented within the villages. Informants were asked to describe:

- the uses of each plant part of *A. leiocarpa* for food, household, and medicine as well as their preparations and applications,
- the harvesting modes of *A. leiocarpa* (area, season, used tools, and preferences for special trees),
- the population development of *A. leiocarpa* (decreasing, increasing, or stable and reasons for this),
- applied conservation practices for *A. leiocarpa*.

2.3 Data analysis

To detect similarities and discrepancies among informants, answers were coded as binary variables and were merged by means of a Principal Component Analysis (PCA) for each category. To detect the explaining variables of the first two PCA-axes for each category, we calculated correlations between PCA-scores of the first two axes and each answer. For each category, we examined the ordination diagrams for patterns and we used linear models (LM) to test whether knowledge and perception differed between age-classes, between men and women, and between people from the six different villages. Thus, age-classes, gender, and villages were used as independent variables and the PCA-scores of the first two axes were used as the dependent variable. LMs were run with a maximum fitted model. The non-significant explanatory variables (including interactions) were removed until a reduced final model was achieved, containing only significant explanatory variables.

Statistical analyses were performed using PC-ORD (McCune & Mefford 2006), PASW Statistics 18.0.0 (SPSS Inc., Chicago, IL, USA) and R 2.10.1 (R Development Core Team 2009).

3 Results

3.1 Uses of *A. leiocarpa*

Interviews reveal that *A. leiocarpa,* called *bu siebu* in *Gulimancema*, is harvested by local people for 18 different uses. The different plant parts are used for 13 medicinal uses and for 5 household uses (Table 1). The preparations and applications of all medicinal and household uses are presented in Table 2. The mean number of mentioned uses of *A. leiocarpa* per respondent was 4.89 ($\pm$ 0.31).

The bark (Fig 2a) and the leaves (Fig 2b) were the plant parts with the highest number of medicinal uses, e.g. they were used to heal diarrhea, hemorrhoids, stomach ache, and yellow fever. The fruits (Fig 2c) were mainly applied against parasites. Different parts were used against the same diseases. The wood (Fig 2d) and the bark of *A. leiocarpa* were the most important plant parts for household uses. Nearly all respondents reported that the wood was used as fuel and nearly three-fourths mentioned its use for construction, e.g. for huts, roofs, and sheds. Furthermore, the ash of the wood was used to prepare soap and the bark was used as surrogate for potash and for dyeing of clothes.

In regard to knowledge distribution, there was no distinct pattern in the ordination diagram (Fig. 3). This indicates that the use of *A. leiocarpa* did not clearly differ between respondents.

Table / Tableau / Tabelle 1: Uses of *A. leiocarpa* NTFPs for traditional medicine and for household purposes. / Utilisations des PFNLx d'*A. leiocarpa* dans la médecine traditionnelles et les ménages. / Verwendungen von *A. leiocarpa* Produkten in der traditionellen Medizin und im Haushalt.

	% of respondent				
	Bark	Fruits	Leaves	Roots	Wood
Medicinal uses					
Stomach ache	61.2	4.1	26.5	38.8	
Diarrhea	24.5	2.0	14.3	6.1	
Yellow fever	14.3	4.1	20.4	4.1	
Hemorrhoids	28.6		12.2	6.1	
Parasites		16.3	4.1		
Wounds		2.0		2.0	
Cough	2.0				
Eye disease	6.1				
Fatigue	4.1				
Tooth ache	2.0				
Vomiting			2.0		
Vitamins for new-borns and babies			4.1		
Dysentery			2.0		
Household uses					
Firewood					95.9
Construction wood					61.2
Soap					10.2
Surrogate for potash	6.1				
Dyeing of clothes	2.0				

The first axis of the ordination correlated mostly with three medicinal uses of *A. leiocarpa*. For these uses (= 1.axis), we found significant differences between villages (Table 3). They were mainly explained in different medicinal uses of *A. leiocarpa* in Tapoa Djerma in comparison to all other villages. The use of the leaves to heal yellow fever was well-known in Tapoa Djerma, while it was less mentioned in all other villages. Furthermore, the uses of bark and leaves to heal diarrhea and stomach ache were never mentioned by respondents in Tapoa Djerma, while they were often reported in all other villages. The second axis correlated mostly with two other medicinal uses and one household use. For these uses (= 2.axis), we found also significant differences between villages (Table 3). The use of the wood to prepare soap was only mentioned in one village, Toptiagou. Furthermore, the use of bark and roots to heal hemorrhoids was mentioned only by respondents of three villages (Topiagou, Kotchari, Kombongou).

3.2 Harvesting modes of *A. leiocarpa*

Wood, bark, and roots were harvested at any time of the year (90%, 80%, and 31% of respondents, respectively). Bark was mainly harvested with a hoe (86% of respondents), but sometimes also with an axe (33% of respondents), or a machete (locally called *coupe-coupe* or in *Gulimancema gu handagu*) (10% of respondents). Roots were also harvested with a hoe (33% of respondents) or an axe (6% of respondents). Leaves and fruits were collected by hand (53% and 33% of respondents, respectively).

Fig. 2: Bark (a), leaves (b), fruits (c), and wood of (d) *A. leiocarpa*. / Ecorce (a), feuilles (b), fruits (c), et bois (d) de *A. leiocarpa*. / Borke (a), Blätter (b), Früchte (c), und Holz (d) von *A. leiocarpa*.
(Fig. 2a and 2d by Katharina Schuman; Fig. 2b and 2c by Arne Erpenbach).

Table / Tableau / Tabelle 2: Preparations and applications of the different medicinal and household uses of *A. leiocarpa*. / Préparations et applications des différentes recettes en médicine et dans les ménages d'*A. leiocarpa*. / Zubereitungen und Anwendungen der verschiedenen medizinischen und Haushaltsnutzungen von *A. leiocarpa*.

	Preparation and application
Medicinal uses	
Cough	The decoction of the bark is served as drink.
Diarrhea	**Bark:** The decoction is served as drink (often with *bouillie**). **Fruits:** The decoction is served as drink. **Leaves:** The decoction is served as drink (often served with *bouillie*). Roots: The decoction is served as drink.
Dysentery	The decoction of the leaves is served as drink.
Eye disease	The eyes are washed with the decoction of the bark.
Fatigue	The body is washed with the decoction of the bark.
Hemorrhoids	**Bark:** The decoction is served as drink (often with *bouillie*) or used for washing. **Leaves:** The decoction is served as drink (often with *bouillie*) or used for washing. **Roots:** The decoction is served as drink (often with *bouillie*).
Parasites	**Fruits:** The roasted and crushed fruits are prepared with *bouillie* and served as drink. **Leaves:** The decoction is served as drink.
Stomach ache	**Bark:** The decoction is served as drink (often with *bouillie*). **Fruits:** The decoction is served as drink. **Leaves:** The decoction is served as drink (often served with *bouillie*). **Roots:** The decoction is served as drink.
Tooth ache	The teeth are washed with the decoction of the bark.
Vitamins for newborns and babies	The decoction of the leaves is served as drink and the babies are washed with the decoction.
Vomiting	The decoction of the leaves is served as drink.
Wounds	**Fruits:** The fruits are pounded and applied on the wound. **Roots:** The wound is washed with the decoction.
Yellow fever	**Bark:** The decoction is served as drink (often with *bouillie*) or used for washing. **Fruits:** The decoction is served as drink or used for washing. **Leaves:** The decoction is served as drink or used for washing. **Roots:** The decoction is served as drink or used for washing.
Household uses	
Construction wood	The poles and branches are used to build cases, roofs, sheds etc.
Dyeing of clothes	The decoction of the bark is used for dyeing of clothes.
Firewood	The branches are used to produce fire.
Soap	The wood is burned, the ash is filtered and deposed in a vessel, boiled, and mixed with she-abutter.
Surrogate for potash	The bark is burned and the ash is filtered and the potash is removed. The potash is used to prepare beans.

* *Bouillie* = a local porridge based on millet or sorghum
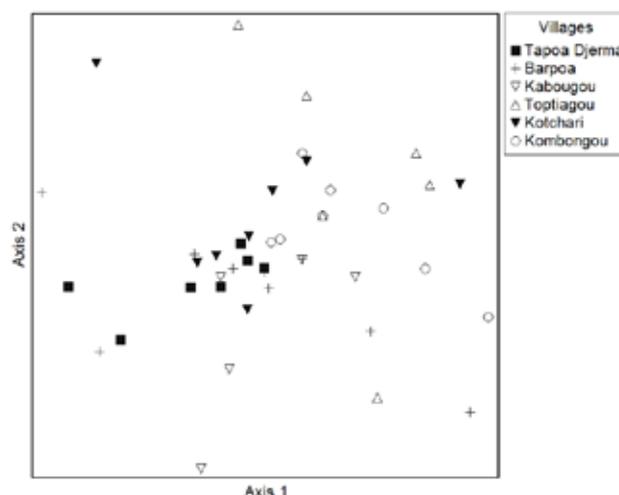
Fig. 3: PCA-scores along the first two axes of PCA analysis of *A. leiocarpa* uses. / Scores issus de l'analyse de la PCA suivant les deux premiers axes des usages d'*A. leiocarpa*. / PCA-Werte der ersten beiden Achsen der PCA Analyse über die Verwendungen von *A. leiocarpa*. Each dot represents one informant (n = 46). Eigenvalue of first axis: 3.12 and of second axis: 2.93, explained variance of first axis: 11.6% and of second axis: 10.8%. Informants are indicated with symbols marking the village (correlation of village with first axis: t = 2.841, d.f. = 44, p < 0.01, r = -0.394).
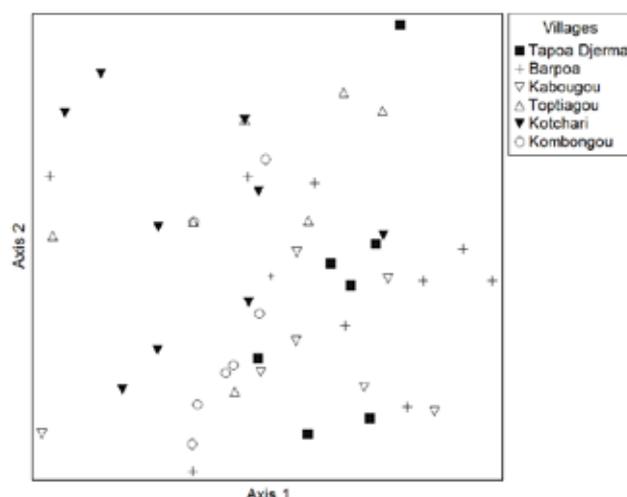
Fig. 4: PCA-scores along the first two axes of PCA analysis of harvesting modes. / Scores issus de l'analyse de la PCA suivant les deux premiers axes des modes de récoltes d'*A. leiocarpa*. / PCA-Werte der ersten beiden Achsen der PCA Analyse über die Sammelpraktiken von *A. leiocarpa*. Each dot represents one informant (n = 49). Eigenvalue of first axis: 3.41 and of second axis: 2.51, explained variance of first axis: 18.9% and of second axis: 14.0%. Informants are indicated with symbols marking the village (correlation of village with first axis: t = -3.685, d.f. = 47, p < 0.001, r = -0.473).

Three-fourths of the informants declared that they use an axe or a machete to chop the wood. Often they also used a hoe to chop the branches. Some of the respondents (14%) reported that they do not chop all trees of *A. leiocarpa*, but prefer certain trees due to their wood quality, i.e. hard and resistant wood. According to harvesting areas, most respondents (90%) stated fallows as the main area of harvesting. Villages were less mentioned as harvesting area (12% of respondents) and croplands were never mentioned.

Table / Tableau / Tabelle 3: Results of LM, testing whether knowledge of *A. leiocarpa* uses differs between age, gender, and villages. / Résultats du model linéaire, testant si la connaissance des usages d'*A. leiocarpa* diffère entre l'âge, le genre et les villages. / Ergebnisse des LM; Unterschiede im Wissen über die Verwendungen von *A. leiocarpa* zwischen Generationen, Geschlechtern und Bewohnern verschiedener Dörfer.

	1. axis					2. axis				
	Diarrhea (bark, leaves), stomach ache (bark), yellow fever (leaves)					Hemorrhoids (bark, roots), soap (wood)				
	Estimate	S.E.	t value	p-value		Estimate	S.E.	t value	p-value	
Intercept	-1.42	0.56	-2.55	0.014	*	-1.31	0.54	-2.40	0.021	*
Village	0.39	0.14	2.84	0.007	**	0.36	0.14	2.68	0.010	*

*p < 0.05, **p < 0.01, S.E. = Standard error. All non-significant explanatory variables were removed.
Eigenvalue of first axis: 3.12 and of second axis: 2.93, explained variance of first axis: 11.6% and of second axis: 10.8%. Correlations of axes with variables: Diarrhea (bark): r = 0.697, p < 0.001; diarrhea (leaves): r = 0.650, p < 0.001; stomach ache (bark): r = -0.585, p < 0.001; yellow fever (leaves): r = -0.552, p < 0.001; hemorrhoids (bark): r = 0.714, p < 0.001; hemorrhoids (roots): r = 0.549, p < 0.001, soap (wood): r = 0.514, p < 0.001.

Table / Tableau / Tabelle 4: Results of LM, testing whether harvesting modes of *A. leiocarpa* differ between age, gender, and villages. / Résultats du model linéaire, testant si les modes de récoltes d'*A. leiocarpa* diffèrent entre l'âge, le genre et les villages. / Ergebnisse des LM; Unterschiede bei den Sammeltpraktiken von *A. leiocarpa* zwischen Generationen, Geschlechtern und Bewohnern verschiedener Dörfer.

	1. axis					2. axis				
	Axe (bark, wood), hands (fruits), all the year (wood), fruiting period (fruits)					Hands (leaves), hoe (roots), all the year (roots), foliage period (leaves)				
	Estimate	S.E.	t value	p-value		Estimate	S.E.	t value	p-value	
Intercept	75.15	7.29	10.32	<0.001	***	43.65	3.56	12.26	<0.001	***
Village	-6.75	1.83	-3.69	0.001	***					

***p < 0.001, S.E. = Standard error. All non-significant explanatory variables were removed.
Eigenvalue of first axis: 3.41 and of second axis: 2.51, explained variance of first axis: 18.9% and of second axis: 14.0%. Correlations of variables with axes: Axe (bark): r = 0.561, p < 0.001, axe (wood): r = 0.581, p < 0.001; hands (fruits): r = 0.728, p < 0.001; all the year (wood): r = 0.641, p < 0.001; fruiting period (fruits): r = 0.728, p < 0.001; hands (leaves): r = 0.578, p < 0.001; hoe (roots): r = 0.766, p < 0.001; all the year (roots): r = 0.752, p < 0.001; foliage period (leaves): r = 0.585, p < 0.001.

Table / Tableau / Tabelle 5: Results of LM, testing whether perception to population development of *A. leiocarpa* differs between age, gender, and villages. / Résultats du model linéaire, testant si la perception du développement de la population d'*A. leiocarpa* diffère entre l'âge, le genre et les villages. / Ergebnisse des LM; Unterschiede bei den Einschätzungen über die Populationsentwicklung von *A. leiocarpa* zwischen Generationen, Geschlechtern und Bewohnern verschiedener Dörfer.

	1. axis					2. axis				
	Population development (decrease), population development (stable)					Regression (due to destructive harvesting modes and due to lower rainfall)				
	Estimate	S.E.	t value	p-value		Estimate	S.E.	t value	p-value	
Intercept	119.02	65.71	1.81	0.077		76.87	12.77	6.02	<0.001	***
Village	28.52	11.10	2.57	0.014	*					
Age	-74.74	25.90	-2.89	0.006	**	-10.33	4.92	-2.10	0.041	*
Gender	-64.38	43.40	-1.48	0.145						
Village * gender	-14.88	7.29	-2.04	0.047	*					
Age * gender	51.01	17.10	2.98	0.005	**					

*p < 0.05, **p < 0.01, ***p < 0.001, S.E. = Standard error. All non-significant explanatory variables were removed.
Eigenvalue of first axis: 2.27 and of second axis: 1.15, explained variance of first axis: 32.4% and of second axis: 16.5%. Correlations of variables with axes: Population development (decrease): r = -0.967, p < 0.001; population development (stable): r = 0.934, p < 0.001; regression (due to destructive harvesting modes): r = 0.772, p < 0.001; regression (due to lower rain fall): r = -0.740, p < 0.001.

Table / Tableau / Tabelle 6: Results of LM, testing whether conservation strategies for *A. leiocarpa* differ between age, gender, and villages. / Résultats du model linéaire, testant si les stratégies de conservation d'*A. leiocarpa* diffèrent entre l'âge, le genre et les villages. / Ergebnisse des LM; Unterschiede bei Schutzpraktiken von *A. leiocarpa* zwischen Generationen, Geschlechtern und Bewohnern verschiedener Dörfer.

	1. axis				
	None protection, protection of trees in croplands				
	Estimate	S.E.	t value	p-value	
Intercept	6.665	13.275	0.50	0.618	
Village	8.273	3.336	2.48	0.017	*

*p < 0.05, ***p < 0.001, S.E. = Standard error. All non-significant explanatory variables were removed.
Eigenvalue of first axis: 2.29, explained variance of first axis: 76.4%. Correlations of variables with axes:
None protection: r = -0.967, p < 0.001; protection of trees in croplands: r = 0.771, p < 0.001.

There was no pattern in the ordination diagram (Fig. 4). The first axis of the ordination correlated mostly with harvesting tools. For these harvesting modes (= 1.axis), we found significant differences between villages (Table 4). While the use of a hoe for bark harvesting was mentioned by respondents of all villages, the use of the axe was never mentioned in the two southernmost villages. For the second axis, we found no significant differences.

3.3 Population development of *A. leiocarpa*

More than half of the informants (55%) claimed that the number of *A. leiocarpa* trees decreased in this area, while 39% stated that the population is stable. Respondents attributed the decline to destructive harvesting modes (14% of respondents), poor rainfall (12% of respondents), human population growth (6% of respondents), and destructive fire (4% of respondents).

Regarding knowledge distribution, the first axis of the ordination correlated strongest with the perception that the population is decreasing or stable. For these perceptions (= 1.axis), we found significant differences between age-classes, gender, and villages (Table 5). People from the southernmost village Kombongou did not see a decline of *A. leiocarpa*, but thought that the population is stable. In contrast, most respondents from the other five villages reported a decline of the *A. leiocarpa* population. Furthermore, younger people and men mostly saw a decrease of *A. leiocarpa*. The second axis of the ordination correlated mostly with the perception that the population is decreasing due to lower rainfall and destructive harvesting modes. For this perception (= 2.axis), we found significant differences between age-classes (Table 5). While younger people attributed the decline of *A. leiocarpa* to destructive harvesting modes, older people attributed it to lower rainfall.

3.4 Conservation practices for *A. leiocarpa*

Half of the informants (55%) declared that they do not protect trees of *A. leiocarpa*. However, one third of respondents (37%) affirmed that they spare individuals of this species in croplands. Planting or transplanting seedlings of *A. leiocarpa* was never mentioned.

The first axis of the ordination correlated most strongly with these two declarations. For these statements (= 1.axis), we found significant differences between villages (Table 6). A high proportion of people from the two northernmost villages stated that they do not protect or spare individuals of *A. leiocarpa* in croplands. In contrast, one third of the respondents from the four other villages declared that they spare individuals of *A. leiocarpa* in croplands. Overall, there was no significant difference between men and women and between age classes in conservation practices.

4 DISCUSSION

4.1 Uses of *A. leiocarpa*

Interviews reveal that villagers harvest NTFPs of *A. leiocarpa* for multipurpose and emphasize its importance for local people, especially as construction and firewood and for me-

dicine. This is consistent with other studies in West Africa (LYKKE et al. 2004; THIOMBIANO 2005; BELEM et al. 2007; PARÉ et al. 2010). In our study, the high number of mentioned uses indicates that *Gulimanceba* people have a deep knowledge about uses of *A. leiocarpa*. Especially the use of *A. leiocarpa* as construction- and firewood were mentioned by a high proportion of respondents. The wood is well appreciated for construction due to its very hard, fast growing, and fairly insect and termite resistant properties (SOBEY 1978; SACANDE & SANOGO 2007). The density of the wood is high (720–1200 kg/m³) and the moisture content is low (15%). It is excellent firewood because it provides great heat and good charcoal (BURKILL 1985-2000; ANDARY et al. 2005). Furthermore, interviews reveal that many household uses of *A. leiocarpa* that have been reported in literature - e.g. dyeing of clothes, tanning of hides to leather, using as mordant (e.g. ANDARY et al. 2005; SACANDE & SANOGO 2007) - were not of importance for villagers in this area.

Among the interviewed *Gulimanceba* people, the number of medicinal uses of *A. leiocarpa* was higher than that of the household uses. The antimicrobial and anthelmintic activity of its plant parts, based on its tannin content (up to 17%, based on dry matter), explain the medicinal properties of *A. leiocarpa* (ANDARY et al. 2005). GANSANÉ et al. (2010) showed that the bark and leaves could even be used for the treatment of malaria. However, our interviews reveal that this use of *A. leiocarpa* was not of importance for *Gulimanceba* people in this area. In addition, the use of the bark to treat skin problems was also not mentioned by local people, though research has shown that the bark shows a specific activity on skin, called *anogelline*, which is now used in France in cosmetic anti-aging/smoothness skin creams (ANDARY et al. 2005).

4.2 Harvesting modes of *A. leiocarpa*

According to harvesting tools, our results suggest that leaf and fruit harvesting techniques resulted in sustainable use in this area as most people collected them by hand. Harvesting by hand causes less damage than with tools as it is more specific and removes less shoots and flower buds. However, chopping with an axe or a hoe to gain the branches is less specific and causes more damage. Nevertheless, SCHUMANN et al. (2011) showed that *A. leiocarpa* is fairly resilient to chopping by producing a high number of sprouts and thus, secondary trunks.

In regard to preferences of tree individuals, our interviews reveal that some people prefer certain trees due to their wood quality. Further studies should investigate which criteria people use to differentiate *A. leiocarpa* individuals as a guide for harvesting and if the locally-recognized morphotypes seem to include a substantial amount of genetic variation.

Regarding the harvesting area, respondents stated fallows as their main areas of harvesting of *A. leiocarpa* which corresponds with results from SCHUMANN et al. (2011).

4.3 Population development of *A. leiocarpa*

Presumably due to its high uses in this area, one would expect that the population of *A. leiocarpa* is declining. However, only half of the interviewed *Gulimanceba* people saw a decline of *A. leiocarpa* in this area. The results of SCHUMANN et al. (2011) support the view of the respondents: Despite the high land-use and harvesting impact, the population of *A. leiocarpa* is still well preserved in this area, especially in fallows, due to its species ability of fast growing and high sprouting, and due to indirect positive influences of human activities by providing better environmental conditions for its recruitment. For Northern Burkina Faso, it was also shown that people did not see a decline of *A. leiocarpa* (LYKKE et al. 2004). However, increasing pressure on *A. leiocarpa* due to current land-use intensifications may lead to a decline of the population in the future.

4.4 Conservation practices for *A. leiocarpa*

Even though respondents of our study did not actively protect and plant *A. leiocarpa*, one third of them declared that they spare some adult individuals of *A. leiocarpa* on croplands, when chopping the vegetation for agriculture. Nevertheless, most adult individuals on croplands are removed and recruiting individuals are generally removed. In fact, SCHUMANN et al. (2011) demonstrated that individuals of bigger size classes (dbh >25 cm) were present on croplands, while saplings (dbh: 1-5 cm) and individuals of small size classes (dbh: 5-15 cm) were absent. Although local people did not spare seedlings (dbh: 0-1 cm) of *A. leiocarpa* on croplands, SCHUMANN et al. (2011) found a high number of seedlings on croplands. This is explained by the fact that *A. leiocarpa* is a fire-sensitive and shade intolerant pioneer species (HENNENBERG et al. 2005; SOBEY 1978) and thus, the survival and the growth of seedlings of *A. leiocarpa* is favored on open areas. The absence of saplings and individuals of small size classes gives evidence of a declining population in croplands. However, the fact that *A. leiocarpa* has the ability to establish successfully during the fallow period (SCHUMANN et al. 2011) permits a current maintenance of this important species in the agricultural cycle of cultivation and fallows. Even though, ongoing land-use intensifications due to strongly increasing cash-crop cultivation may lead to an increasing pressure on *A. leiocarpa* in the future. In fact, shortening or absence of fallow periods may prevent successful establishment of *A. leiocarpa* during the fallow period.

Overall, *Gulimanceba* people have a more passive attitude concerning the conservation of trees as they did not see the sparing of *A. leiocarpa* individuals on croplands as an active management and that sowing or planting of *A. leiocarpa* was never mentioned. Similarly, several studies across West Africa (e.g. KRISTENSEN & LYKKE 2003) showed that local people have no tradition for planting of indigenous trees, as they are considered as "wild".

4.5 Distribution of knowledge

Knowledge and perceptions of *A. leiocarpa* were fairly similar between men and women as well as between young and old people. However, harvesting and preparation were partly linked to gender as for instance, women are mainly responsible for chopping of branches of *A. leiocarpa* for fuel as they are in charge of cooking. In contrast, men are responsible for chopping of trunks and performing of construction works (personal observation). The lack of age differences suggests that the traditional knowledge about *A. leiocarpa* is not disappearing and that knowledge is passed on from one generation to another. Nevertheless, it has to be considered that the questions were relatively broad, whereas more detailed questions on medicinal use, for instance, could probably have revealed age differences (LYKKE et al. 2004).

The informants' village origin influenced slightly knowledge and perception of *A. leiocarpa* even though villages are not situated far away from each other. KRISTENSEN AND LYKKE (2003) also found more differences in knowledge between villages than between genders and age-classes. Particularly people from the northernmost village Tapoa Djerma and southernmost Kombonou had slightly different knowledge and perceptions of *A. leiocarpa* in comparison to people from the other villages. These differences might be explained by influences resulting from the close neighborhood of these villages to the countries Niger and Benin. The fact that people did not spare individuals of *A. leiocarpa* on croplands in Tapoa Djerma might have led to a lower density of *A. leiocarpa* individuals in comparison to the other villages (personal observation). Furthermore, people from the southernmost village Kombongou did not see a decline of *A. leiocarpa*. This is in concordance with our field observations that individuals of *A. leiocarpa*, and especially recruiting individuals, are very common around this village.

4.6 Implication for conservation and sustainable management of *A. leiocarpa*

Our results provide, in combination with the results of SCHUMANN et al. (2011) and other literature, appropriate management recommendations that are reliable under currently practiced management strategies in this area. Current local harvesting modes and management strategies resulted in sustainable use. Due to ongoing land-use intensifications, adapted harvesting and management techniques are required to guarantee the persistence of this species and to secure the harvesting for future generations. This might include the use of leaves instead of the bark of *A. leiocarpa* for the four most mentioned medicinal purposes in this area as leaf harvesting has less effect on the plant vitality and survival than bark removing. For instance, GANSANÉ et al. (2010) showed that the leaves of *A. leiocarpa* could be alternatively used for the treatment of malaria instead of the bark as they display similar antiplasmodial activities. In our study area, the bark of *A. leiocarpa* was mainly harvested with a hoe. This tool seems appropriate as far as only small pieces are removed and if regeneration time is long enough. The National Forestry Department of Burkina Faso issued "good harvesting practices" for bark harvesting of *A. leiocarpa* to limit the damage to the trees; they include rules for the maximum quantity of bark that can be harvested (1–1.5 kg fresh bark per tree) (ANDARY et al. 2005). Regarding the harvesting period, the bark of *A. leiocarpa* was harvested at any time of the year in our study area. ANDARY et al. (2005)

declared that the best period to harvest the bark of *A. leiocarpa* is at the end of the dry season because of the optimum concentration and condition for exploitation of the active principle *anogelline* present in the bark. However, DELVAUX et al. (2010) demonstrated for other tree species that bark regeneration depends on humidity as the moisture content of the exposed wound is the most important factor allowing the start of the bark recovery process. Thus, bark harvesting during the rainy season is more adequate to allow bark regeneration.

With regard to wood harvesting, chopping of branches can even exceed 50% of total branches per individual due to the high sprouting ability (SCHUMANN et al. 2011). However, individuals with a dbh > 25 cm that have significantly higher seed production should be chopped to a lower degree. This would secure sufficient seed production. Furthermore, manual thinning of sprouts could be important to reduce the number of sprouts on the stump and encourage faster development of stems.

5 CONCLUSION

Our study is the first detailed quantitative ethnobotanical study of *A. leiocarpa*. Our interviews reveal that many uses of *A. leiocarpa* that have been reported in other parts of West Africa, e.g. dyeing of clothes, treatment of malaria and skin problems, were not of importance for villagers in this area. Therefore, we conclude that local people could

even more benefit from this important species given that the harvesting is carried out in a sustainable way. Furthermore, our study demonstrates how traditional ecological knowledge and perceptions combined with ecological background information can help to design appropriate management recommendations. Hereby, our study emphasizes the importance of ethnobotanical studies on a local level in order to develop management strategies that are reliable in the specific area under the specific circumstances.

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